

H. L. GIWOSKY  
DEFROST CONTROL MEANS RESPONSIVE TO SPEED  
OF EVAPORATOR BLOWER  
Filed April 21, 1967

**H. L. GIWOSKY**  
CONTROL MEANS RESPONSIVE  
OF EVAPORATOR BLOWER  
Filed April 21, 1967

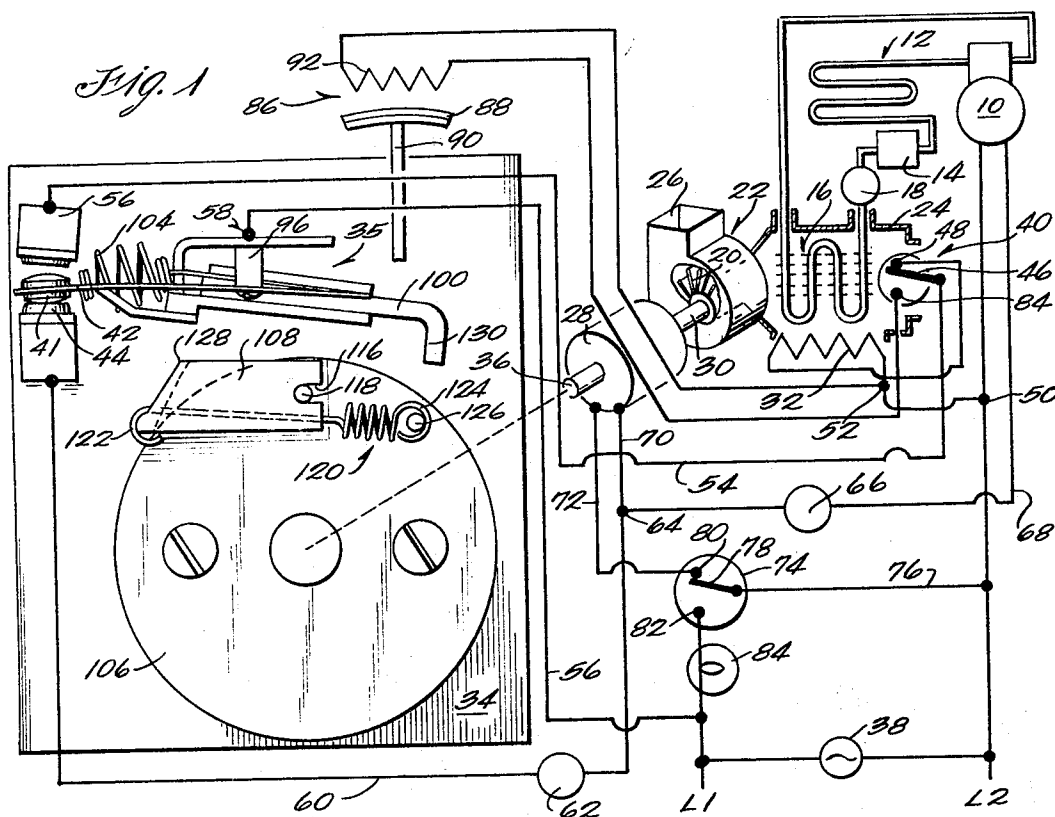
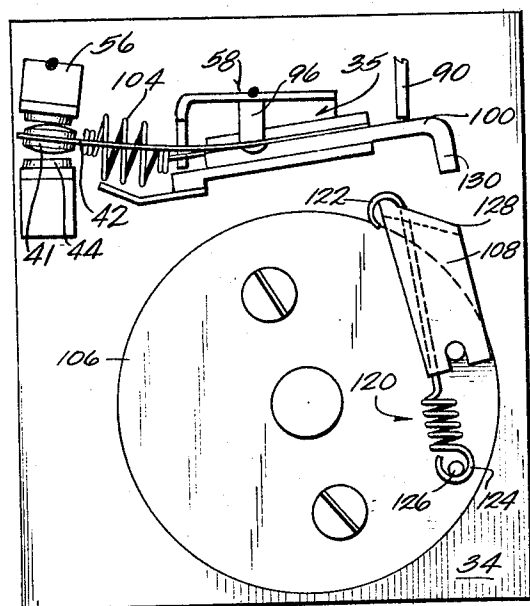


Fig. 2

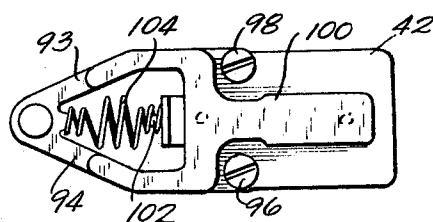


Fig. 3

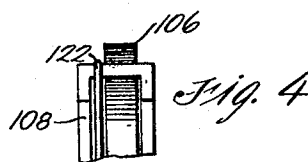


Fig. 4

Inventor  
Harry L. Givovsky  
By Joseph A. Lemigami  
Attorney

1

2

3,397,550

## DEFROST CONTROL MEANS RESPONSIVE TO SPEED OF EVAPORATOR BLOWER

Harry L. Giwosky, Milwaukee, Wis., assignor to Controls Company of America, Melrose Park, Ill., a corporation of Delaware

Filed Apr. 21, 1967, Ser. No. 632,788  
12 Claims. (Cl. 62—140)

### ABSTRACT OF THE DISCLOSURE

This disclosure is directed to an arrangement for automatically initiating defrost of an evaporator coil in a forced air cooling system on the basis of the speed of the blower motor which causes air flow through the coil. As the refrigeration cycle proceeds, frost accumulates on the evaporator coil and restricts air flow through the coil. This results in a reduction in the air being moved by the blower thereby decreasing the torque load on the motor and causing an increase in the speed of the motor driving the blower. A speed responsive control arrangement senses this increase in motor speed and at a preselected speed, or in other words a control point in the refrigeration cycle, automatically initiates a defrost cycle, the control being further effective to automatically reestablish the refrigeration cycle when defrosting has been completed.

### BACKGROUND OF INVENTION

(I) *Field of invention.*—This invention relates to defrost controls.

(II) *Description of prior art.*—The accumulation of frost on a cooling coil effects air flow through the coil and it has been recognized that the change in air flow occurring as a result of frost accumulation can be used as a basis for controlling the start of a defrost cycle. In this connection, various defrost controls have been proposed which function on the basis of this change in air flow.

One proposal has placed mechanical sensing elements in the air stream to directly sense changes in air flow, examples of such arrangements can be found in Patents Nos. 1,984,053, 1,984,054, 2,962,870 and 3,077,747. Another proposal achieved control on the basis of the change in the amount of current drawn by the blower motor as a result of the change in air flow. Patents Nos. 2,001,027, 2,001,028 and 2,505,201 contain examples of such arrangements. Another type of arrangement relied on a pressure responsive arrangement which used, as a basis of control, the pressure drop which occurs across a frost accumulating member disposed in the air stream, examples of such arrangements are shown in Patents Nos. 2,992,542 and 3,004,399. For a number of reasons these prior arrangements have not been entirely satisfactory, for example they have not possessed the necessary reliability and/or have required complex circuitry. In this connection, some of the arrangements have required rather involved circuitry to sense the change in air flow and to convert the sensed condition into a usable control signal and others have relied on the proper functioning of mechanical elements exposed directly to the air flow and the environment of the evaporator coil.

### SUMMARY OF THE INVENTION

It has been discovered that the speed of the motor driving the blower which influences air flow through the cooling coil will vary as the obstruction to air flow through the coil varies and that this variation in motor speed can be used as the basis for control of a defrost cycle. As frost accumulates on the coil the load on the motor

changes due to the change in air flow occasioned by the frost accumulation, where the blower is drawing air through the coil there will be a decrease in air flow which results in a corresponding decrease in load on the blower. This decreased load causes an increase in motor speed. This invention proposes a control arrangement which responds to this change in speed and initiates a defrost cycle when the motor speed indicates that a desired control point has been reached, i.e. an excessive amount of frost has accumulated on the coil. Such an arrangement does not require involved circuitry, either to sense the control point or to convert the sensed condition into a usable control signal, and it permits the control elements to be arranged remote from the air stream and the environment of the cooling coil. Accordingly, the control of this invention affords a simplicity and reliability which could not be achieved from prior proposals.

### DESCRIPTION OF DRAWINGS

FIG. 1 is a semischematic illustration of a refrigeration system and a blower motor speed responsive control and control circuit;

FIG. 2 is a view illustrating the speed responsive switch in its defrost position;

FIG. 3 is a partial plan view of the switch portion of the control; and

FIG. 4 is a view of the centrifugal weight.

The control arrangement of this invention can be used with a conventional refrigeration system and is illustrated in connection with a system which includes compressor 10, condenser 12, receiver 14, evaporator 16 and valve 18 for controlling flow of refrigerant into the evaporator coil. At this point it should be noted that the control arrangement of this invention is applicable to refrigeration systems in general but, for convenience, it will be discussed as though incorporated in a system supplying cold air to a walk-in cooler or the like. In such an application air is cooled by passage through the evaporator coil and is delivered to the cooler.

In the illustrated arrangement blower 20 is arranged within a scroll housing 22 which is in turn connected to housing 24 enclosing evaporator coil 16. Air is drawn through evaporator housing 24 over coil 16 and into scroll housing 22. The air is cooled as it passes over the evaporator coil and is then discharged through scroll housing outlet 26 for delivery to the chill area through suitable conduits. The cooler, or chill area, and the conduits for delivering cold air thereto form no part of this invention and therefore have not been shown and will not be described.

Motor 28 is connected to and drives blower 20 by means of shaft 30. The motor is of a type such that its speed varies with the torque load on the motor, preferably the motor is an induction type motor and can be a shaded pole or permanent split capacitor motor. The motor is thus sensitive to variations in torque load on its output shaft and, in this connection, it is also preferred that blower 22 be of the radial type having forward curved blades. This blower arrangement is desirable as it affords greater sensitivity to variations in torque load.

As the refrigeration cycle progresses condensation collects and freezes on the evaporator coil. The coil frosts up and as it does air passage through the coil is obstructed thereby restricting the amount of air which can flow through the coil. In this connection a finned evaporator coil is generally used to provide optimum heat transfer between the air flow and the coil and such a coil assembly is illustrated in FIG. 1. Frosting and resulting obstruction to air flow is more significant in connection with the finned evaporator coil but it will be appreciated that even without the fins the frost condition and restricted air flow can occur. As the amount of air flowing through

the coil and into the scroll housing 22 decreases the torque load on blower 20 decreases and the speed of motor 28 experiences a corresponding increase. At this point it should also be noted that as frost builds up on the coil and fins the frost tends to retard heat transfer between the coil and the air so that as frost accumulates the cooling effect on air passing through the coil is reduced and the air being drawn into the scroll housing is at a progressively higher temperature. This results in the density of the air moved by the blower becoming progressively less which is also a factor in reducing the torque load. Therefore, in a sense the control arrangement of this invention not only senses the reduction in air flow volume due to frost accumulation but it is also, in a sense, temperature sensitive thereby giving a further, or more accurate, indication of the frost condition of the coil.

This invention is concerned with sensing the change in motor speed due to the frost condition and initiating a defrost cycle at a control point in the refrigeration cycle indicating that an excessive amount of frost has accumulated on the evaporator coil. This is accomplished by coupling a speed responsive mechanism to the motor and, in the illustrated embodiment, energizing defrost heater 32 at the designated control point. Although the speed responsive mechanism can take any of a number of forms it is preferably a centrifugal switch assembly 34 which, in a manner to be described more completely hereinafter, is connected to shaft extension 36 of motor 28.

Heater 32 is positioned adjacent evaporator coil 16 and when energized will heat the coil to remove frost. The heater is connected to source 38 through switch 35 of the speed responsive assembly 34 and a temperature sensitive switch 40. During the normal refrigeration cycle switches 35 and 40 are in the positions illustrated, contact 41 on movable switch blade 42 of switch 35 in engagement with fixed contact 44 and movable switch blade 46 of switch 40 engaging fixed cold contact 48. With this arrangement the electrical circuit to heater 32 is open so that the heater is not energized during the refrigeration cycle. Tracing the electrical circuit from L<sub>2</sub> through junctions 50, 52, heater 32, contact 48, switch blade 46 and lead 54 to fixed contact 56 of switch 35 it will be seen that the circuit to L<sub>1</sub> is open at switch 35 and therefore heater 32 is de-energized. However, the appropriate circuits are completed for carrying out the refrigeration cycle. More specifically, a circuit is made from L<sub>1</sub> through lead 56, terminal assembly 58 to movable switch blade 42 and from the movable switch blade through fixed contact 44, lead 60, thermostat 62, junction 64, start relay assembly 66 and lead 68 to compressor 10 and L<sub>2</sub>. A parallel circuit is also completed through blower motor 28, namely from junction 64 through leads 70 and 72 to door switch 74 and through lead 76 to L<sub>2</sub>. When the door of the cooler is closed, switch blade 78 engages contact 80 completing the just-described parallel circuit. When the door is open, switch blade 78 is moved into engagement with contact 82 thereby interrupting delivery of cold air by the blower and automatically turning on lights 84 within the cooler. Accordingly, the necessary electrical circuits are made to the various operational elements to carry out the refrigeration cycle.

As the refrigeration cycle progresses frost accumulates on the evaporator coil. As a result of frost accumulation the amount of air which can be drawn through the evaporator coil is reduced thereby reducing the torque load on blower 20. As mentioned previously, the frost accumulation also tends to insulate the air flow from the primary cooling members, namely the coil and fins, so that the temperature of the air entering scroll housing 22 is relatively higher as the accumulation of frost progresses. The reduced volume of air and to a lesser extent the increased temperature thereof, reduces the torque load on blower 22 and produces a corresponding increase in the speed of motor 28. At a preselected control point

in the refrigeration cycle indicating an excessive amount of frost accumulation on the evaporator coil, centrifugal switch assembly 34 is operated, in a manner to be described more completely hereinafter, to switch movable blade 42 and contact 41 from contact 44 to contact 56. This switching action deenergizes the blower motor and compressor thereby terminating the refrigeration cycle and simultaneously energizes defrost heater 32 to initiate the defrost cycle. More specifically and with reference to the above described circuits, it will be seen that movement of switch blade 42 away from contact 44 opens the circuit through lead 60 to both motor 28 and compressor 10 and, simultaneously, movement into engagement with contact 56 completes the circuit through switch assembly 40 to defrost heater 32.

The defrost cycle progresses with heater 32 melting the frost accumulated on the evaporator coil. Any suitable, conventional liquid collecting arrangement can be utilized with the evaporator coil to collect and remove moisture resulting from the melting frost.

Any of a number of arrangements can be used to establish the termination of the defrost cycle. As illustrated, temperature sensitive defrost switch assembly 40 is used and is exposed to the temperature ambient evaporator coil 16 so as to monitor the defrost cycle. When a preselected control point in the defrost cycle is reached indicating the desired amount of melting of frost from the evaporator coil, movable blade 46, which can be a bimetal member, of switch assembly 40 moves from cold contact 48 to hot contact 84, this switching action being in response to the temperature ambient the evaporator coil and interrupting the circuit to heater 32 to initiate termination of the defrost cycle and set up a circuit for reestablishment of the refrigeration cycle. In a more specific aspect of this invention it is proposed to provide a time delay between termination of the defrost cycle and reestablishment of the refrigeration cycle. In the illustrated embodiment this time delay is achieved utilizing a reset mechanism 86 associated with centrifugal switch assembly 34. More specifically, reset mechanism 86 includes bimetal member 88 connected to rod 90. Bimetal 88 is in heat transfer relation with reset heater 92, the reset heater being connected in circuit with and controlled by defrost switch assembly 40. With reference to switch assembly 40, it will be noted that when movable blade 46 is in engagement with cold contact 48, thereby establishing the defrost heater circuit, the circuit to reset heater 92 is open. When movable blade 46 is switched to hot contact 84 to initiate termination of the defrost cycle, the circuit to reset heater 92 is completed thereby energizing heater 92 to straighten bimetal 98 and through rod 90 switch movable blade 42 from contact 56 back to contact 44 and reestablish the refrigeration cycle. This switching action to reestablish the refrigeration cycle is thus accomplished with a sufficient time delay to insure completion of the defrost cycle.

The structure of the illustrated centrifugal switch assembly will now be explained. Movable blade 42 is part of an over-center or toggle switch arrangement which can be of any conventional construction. As illustrated, movable blade 42 includes a pair of side rails 93 and 94, these side rails being connected to fixed posts 96 and 98 which provide a pivot about which blade 42 is movable. The side rails are also connected to a rigid member 100 and through that member to a centrally located tongue 102. An over-center or toggle spring 104 extends between tongue 102 and the forward or contact carrying portion of blade 43. In a conventional manner, toggle spring 104 holds the movable contact in engagement with either contacts 44 or 56 as illustrated in FIGS. 1 and 2 and will cooperate in producing switching action of the movable contact when the point of engagement between tongue 102 and spring 104 has been moved overcenter with respect to rails 93 and 94. The centrifugal actuator for the just-described toggle switch includes a disk 106

which is connected to shaft 36 on blower motor 28. Disk 106 rotates with the shaft. A weight 108 is arranged at the periphery of wheel 106. Weight 108 includes a pair of spaced arms 110 and 112 which straddle wheel 106 and are connected by web 114. Each arm 110 and 112 is provided with an open slot 116 engaged on pin 118 fixed to wheel 106. A tension spring 120 has an end 122 thereof engaged on web 114 and its opposite end 124 engaged on pin 126 fixed to wheel 106. The tension spring biases weight 108 in a counterclockwise direction as viewed in the drawings. Engagement between web 114 and the periphery of wheel 106 limits counterclockwise movement of the weight. Corner 128 of weight 108 projects radially outwardly from wheel 106 and the projection is such that it clears turned end 130 of rigid member 100 of the switch assembly as long as blower motor 28 is below a preselected speed. As the blower motor speed increases wheel 106 will rotate correspondingly faster. Rotation of wheel 106 results in a centrifugal force acting on weight 108 tending to pivot the weight against the bias of spring 120 and in a clockwise direction. Spring 120 overcomes this centrifugal force so long as the speed of blower motor 28 is below a preselected value. At the control point in the refrigeration cycle indicating a defrost cycle is required, the speed of motor 28 will have increased such that the centrifugal force exerted on weight 108 overcomes tension spring 120 sufficiently to displace the weight angularly and position corner 128 thereof such that it will engage turned end 130 and move rigid member 100 upwardly as viewed in the drawings. This movement of member 100 upwardly produces corresponding downward movement of tab 102 moving spring 104 overcenter with respect to side rails 93 and 94 and movable blade 42 switches contact 41 from contact 44 to contact 56. As described above, this initiates the defrost cycle and also de-energizes the blower motor to thereby stop wheel 106 and allow spring 120 to return weight 108 to the position illustrated in FIG. 1. Thus the switch assembly is reset as described above at the end of the defrost cycle and the centrifugal switch has been returned to its rest position so that the refrigeration cycle will progress until the control point is again reached indicating defrost is necessary.

With the just-described control arrangement a particularly effective defrost control is provided which responds to the increase or decrease in speed of the blower and its drive motor in accordance with accumulation of frost on the evaporator coil. As stated above, induction motors, such as shaded pole and permanent split capacitor motors, offer satisfactory operating characteristics for use in this control but it should be appreciated that any electric motor having the characteristic of changing speed with changing torque load can be used in the control incorporating this invention. Assuming a substantially constant voltage input to the motor, motor speed varies inversely with the torque load on the motor; this can be shown by plotting motor speed against percentage of blockage in the coil, for a particular voltage motor speed increases as blockage increases and, correspondingly, torque decreases. The response to changes in air flow can be optimized by refinement in selection and design of the motor, blower and scroll housing. For this reason the blower design mentioned above is preferred, i.e., with forward curved blades.

The control of this invention requires relatively simplified circuitry as compared to heretofore available control arrangements and does not rely for effective operation on the proper functioning of any mechanical elements directly exposed to the environment of the evaporator coil.

Thermostat 62 is merely an auxiliary control thermostat which can be exposed to the temperature in the area to be chilled and relay 66 is merely intended to insure starting of compressor 10.

Furthermore, defrost systems other than an electrical heater could be used without departing from the spirit or scope of this invention.

Although but one embodiment of the present invention has been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

I claim:

1. In a cooling system including a cooling coil and motor driven blower means for moving air through said cooling coil and wherein said cooling coil is susceptible to accumulation of frost which obstructs air flow through said cooling coil, the combination of:

selectively energizable means for defrosting said cooling coil,

and control means connected to said motor driven blower means and said means for defrosting said cooling coil, said control means being directly responsive to the speed of said motor driven blower means and, in response to a preselected blower means speed corresponding to a preselected change in air flow through said cooling coil, operating said means for defrosting said cooling coil to initiate a defrost cycle.

2. The combination of claim 1 wherein said control means include:

centrifugal switch means,

means connecting said centrifugal switch means to said blower means and transmitting rotational movement of said blower means to said centrifugal switch means,

and wherein said centrifugal switch means responds to said rotational blower means movement to initiate said defrost cycle at said preselected blower means speed.

3. The combination of claim 1 wherein:

said motor driven blower means draws air through said cooling coil and includes blower means and motor means driving said blower means, the load on said blower means decreasing as frost accumulates on said cooling coil and the speed of said motor means increases an amount corresponding to the decrease in load on said blower means, and said control means connected to and responsive to the speed of said motor means.

4. The combination of claim 1 wherein said control means is further operative to continue said defrost cycle and at a preselected control point in said defrost cycle being operative to initiate termination of said defrost cycle and initiate reestablishment of a cooling cycle.

5. The combination of claim 1 wherein:

said means for defrosting said cooling coil comprises heating means,

and said control means initiates operation of said heating means to heat said cooling coil at a control point in the cooling cycle indicating a change in blower means speed corresponding to a preselected amount of obstruction to air flow through said cooling coil due to frost accumulation on said cooling coil.

6. The combination of claim 5 wherein:

said control means is operative at said control point in said cooling cycle to terminate said cooling cycle and initiate operation of said heating means to initiate said defrost cycle,

and wherein said control means further includes means operable at a control point in said defrost cycle to initiate termination of said defrost cycle and initiate reestablishment of said cooling cycle, said last-mentioned means further operative to reestablish said cooling cycle with a predetermined lapse of time after deenergizing said heating means.

7. The combination of claim 1 wherein:

7

said means for defrosting said cooling coil comprises electrical heating means,

and said control means includes speed responsive switch means having a first position opening an electrical circuit to said heating means and a second position closing an electrical circuit to said heating means so that said speed responsive switch means selectively controls energization and deenergization of said heating means, said speed responsive switch means connected to said motor driven blower means and, at said preselected blower means speed, switching to said second position to energize said electrical heating means.

8. The combination of claim 7 including system means for activating said cooling coil to produce a cooling cycle and wherein:

said speed responsive switch means also controls said system means and in said first position is operative to complete an energizing circuit to said system means and in said second position opens said energizing circuit so that said cooling cycle and defrost cycle occur alternatively.

9. The combination of claim 8 including reset means operative at a control point in said defrost cycle to initiate deenergization of said heating means, said reset means operatively associated with said speed responsive switch means and operative to switch said speed responsive switch means to said first position and reestablish said cooling cycle with a predetermined time delay after said control point is reached.

10. The combination of claim 9 including:  
defrost termination and reset switch means responsive in circuit with and controlling said defrost heating means,

reset heating means in circuit with and controlled by said reset switch means,  
said reset switch means, at said control point in said defrost cycle, opening the circuit to said defrost heating means and closing the circuit to said reset heating means,

and thermoresponsive actuating means in heat transfer relationship with said reset heating means and engageable with said speed responsive switch means, said actuating means responding to said reset heating means to switch said speed responsive switch means

8

to said first position with said predetermined time delay.

11. The combination of claim 10 wherein:

said motor driven motor means draws air through said cooling coil and includes blower means and motor means driving said blower means,

the load on said blower means decreases as frost accumulates on said cooling coil and the speed of said motor means increases an amount corresponding to the decrease in load on said blower means, and said speed responsive switch means connected to and responsive to the speed of said motor means.

12. The combination of claim 7 wherein said motor driven blower means includes blower means and motor means connected to and driving said blower means,

said speed responsive switch means includes a movable contact carrying member movable selectively to said first and second switch positions, a rotatable member, and means connecting said rotatable member for rotation by said motor means so that the rotational speed of said rotatable member corresponds to that of said motor means,

said rotatable member disposed adjacent said movable contact carrying member and including a weight portion and means supporting said weight portion on said rotatable disk and biasing said weight portion in a first position with respect to said rotatable member and supporting said weight portion for radial outward movement against said bias and with respect to said rotatable disk in response to the rotational speed of said rotatable member, said movable contact carrying member in said first position being disposed out of the path of rotation of said weight portion when said weight portion is in its first position and said weight portion moving radially for engagement with said movable contact carrying member as the rotational speed of said rotatable member increases.

#### References Cited

#### UNITED STATES PATENTS

2,001,028 5/1935 Kitzmiller ----- 62-140

MEYER PERLIN, *Primary Examiner.*