Aug. 13, 1968 G. F. WOODWARD 3,397,352

FAN SPEED CONTROL MEANS EMPLOYING A VIBRATING CONTACT

Filed March 19, 1965

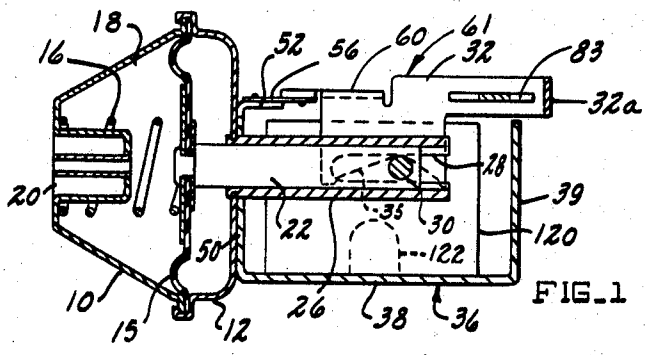


FIG_1

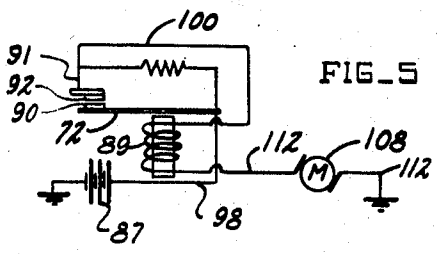


FIG_5

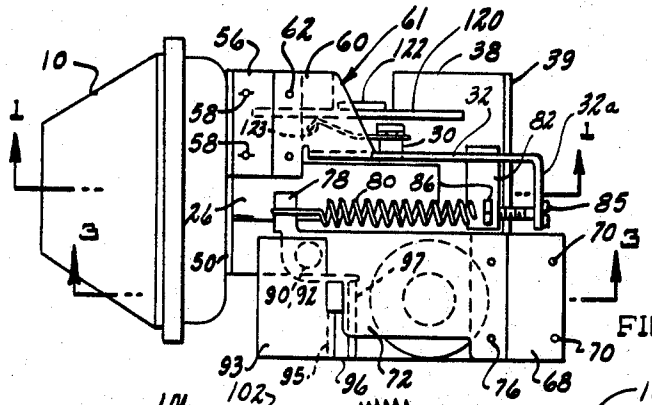


FIG_2

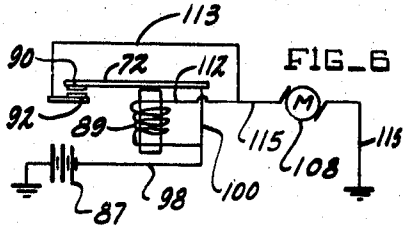


FIG_6

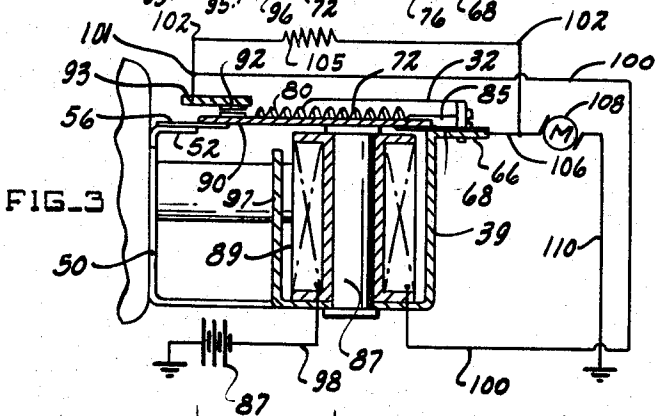


FIG_3

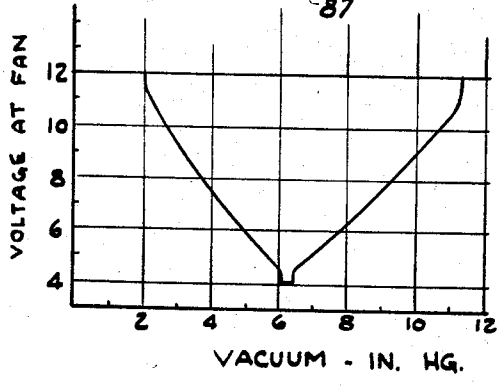


FIG_4

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FAN SPEED CONTROL MEANS EMPLOYING A VIBRATING CONTACT

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ABSTRACT OF THE DISCLOSURE

A set of electrical contacts operably arranged to feed current to a fan motor, one of said contacts being located on a vibratory leaf whose amplitude of vibration is varied by condition-responsive power means. The amplitude variation is effective to vary the duration of each contact-closed period relative to the duration of each contact-open period. Varying the relative durations of these two periods can effectively vary the resistance across the contacts to thus vary the fan motor voltage and motor speed.

This invention relates to mechanism for providing a varying electrical resistance in response to movement of a condition-responsive power mechanism. It is applicable in the field of automotive air conditioning where it is desired to automatically vary the voltage at the motor of an air circulating fan in response to the need for air heating or cooling.

The objects

One object of the invention is to provide a resistance device whose value can be increased and then decreased during a single stroke of a condition-responsive power device, thereby permitting the device to run a fan motor at varying speeds as the air temperature strays varying amounts above or below the control temperature.

Another object of the invention is to provide variable resistance means which can be used to regulate a fan motor during both an air heating and an air cooling cycle.

A further object of the invention is to provide variable resistance means which has a continuous modulating action without steps or discrete increments.

A further object is to provide a variable resistance device which utilizes a fixed contact and a vibratory contact, together with special mechanism to prevent excessive arcing across the contacts during the make and break periods.

A still further object is to provide a variable resistance device which can be operated by a vacuum signal without significant hysteresis.

Other objects of this invention will appear from the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

In the drawings:

FIGURE 1 is a sectional view of one embodiment of the invention taken on line 1—1 in FIG. 2;

FIG. 2 is a top plan view of the FIG. 1 embodiment;

FIG. 3 is a sectional view taken substantially on line 3—3 of FIG. 2;

FIG. 4 is a chart illustrating the performance of the FIG. 1 embodiment;

FIG. 5 is an electric circuit diagram of a second embodiment of the invention; and

FIG. 6 is an electric circuit diagram of a third embodiment of the invention.

Before explaining the present invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

Referring more particularly to FIG. 1, there is shown an assembly comprising two facing hollow housing structures 10 and 12 arranged to have a flexible diaphragm 15 clamped therebetween. A rightward biasing force is applied to diaphragm 15 by a compression coil spring 16, and a leftward biasing force is applied to the diaphragm by vacuum admitted to the defined chamber 18 through a non-illustrated hose which is attached to fitting 20. The hose is connected to a suitable temperature-sensing device which produces a vacuum output directly proportional to the sensed temperatures in one or more areas of an automotive vehicle. Thus the diaphragm automatically moves leftwardly upon an increase in the sensed temperature condition and rightwardly upon a decrease in the sensed temperature condition.

Connected with the diaphragm is a shaft 22 which slides axially in a fixed tubular guide 26. The right end portion of the tubular guide is provided with a slot 28 which accommodates a pin 30 carried by shaft 22. As best shown in FIG. 2, pin 30 extends beyond a vertical plate 32. As seen in FIG. 1, plate 32 has its lower edge 35 riding on the upper surface of pin 30. Edge 35 is of generally V-shaped configuration so that back and forth movement of shaft 22 causes plate 32 to rise and fall. In the illustrated position of the shaft the high point of edge 35 is resting on pin 30, and plate 32 is in its lowermost position. As shaft 22 moves leftwardly or rightwardly from the illustrated position plate 32 is raised in a graduated manner.

Plate 32 is supported by a mechanism which includes a magnetically permeable frame 36 having a web portion 38, a right flange 39 and a left flange 50. As shown in FIG. 1, a portion of flange 50 is turned rightwardly to provide a flat arm 52, said arm serving to mount a leaf spring 56, as by means of two screws or rivets 58. The right portion of leaf spring 56 underlies the left portion of a plate 60 which is formed integrally with the aforementioned plate 32, said plates preferably being stamped from a single sheet of metal and being bent at right angles to one another to provide a lever designated by the numeral 61. Two screws or rivets 62 may be utilized to secure plate 60 to the left portion of leaf spring 56. From the above discussion it will be seen that spring 56 serves as a pivotal mounting means for lever 61 so that back and forth movement of pin 30 causes the lever to move in a vertical arc about a horizontal pivotal axis located approximately midway between screws 58 and 62.

Referring now to FIG. 3, it will be seen that the upper end portion of flange 39 is turned rightwardly to define a horizontal arm 66 which mounts a leaf spring 68, as by two screws or rivets 70. The left end portion of leaf spring 68 underlies the right end portion of a flat plate 72 and is secured thereto by two screws or rivets 76. Thus plate 72 is mounted to swing in a vertical plane about a horizontal axis located slightly leftwardly of the screws or ribets 70. As best seen in FIG. 2, plate 72 is provided with a laterally projecting extension 78 which has the left end of a tension spring 80 trained therearound. The right end portion of spring 80 is extended through openings in a flat rectangular plate 82, said plate extending parallel to the aforementioned pin 30 and through a slot 83 in plate 32. To adjust the position of plate 82 there is provided a screw 85 which extends through an opening in flange portion 32*a* of plate 32. The left threaded portion of screw 85 extends through a nut 86 which is located in a slot in plate 82, whereby the nut and screw cooperate to adjustably anchor plate 82 on plate 32. Thus, plate 82 can, by turning nut 86, be slid back and forth in the slot 83 to vary the loading on tension spring 80.

From the above description it will be seen that spring **80** establishes a mechanical connection between lever **61** and lever **72**. Thus, as an increasing vacuum in chamber **18** moves pin **30** leftwardly from its FIG. 1 position lever **61** is pivoted upwardly about the right edge of arm **52**, and spring **80** applies an upward biasing force on lever **72** to cause said lever to pivot about its pivotal axis rightwardly of rivets **76**.

It will be noted that the line of action of spring **80** lies in the same plane as lever **61**, and that the left anchorage point for spring **80** is substantially in line with the pivotal axis for lever **61**. With this arrangement the spring exerts no vertical force on the lever, either up or down. Therefore the lever rides substantially frictionlessly on pin **30** such that shaft **22** can be effectively controlled by vacuum **18** with minimum hysteresis or motion loss.

Lever **72** is of magnetically permeable material whereby to form an armature for movement toward and away from the magnetic core **87** of the electro-magnet coil **89**. Thus, with current flowing through coil **89** armature **72** is drawn downwardly toward core **87** against the bias of spring **80**. With no current flow through coil **89**, spring **80** is effective to draw armature **72** away from core **87**. As shown best in FIG. 3, the left end of armature **72** carries an electrical contact **90** which underlies a contact **92** carried on a stationary plate **93**. Plate **93** includes a horizontal portion and a vertical portion **95** which is facially engaged with an insulator plate **96** carried by upstanding portion **97** of frame **36**.

In the arrangement shown in FIG. 3, coil **89** is connected with a conventional twelve volt automotive vehicle battery **87** by a line **98**. An additional line **100** connects the coil to plate **93**, whereby closing of contacts **90** and **92** against one another energizes the coil through a circuit comprising battery **87**, line **98**, coil **89**, line **100**, plate **93**, contacts **92** and **90**, plate **72**, leaf **68**, arm **66**, line **106**, fan motor **108**, and line **110**. Upon completion of this circuit the current flow through coil **89** produces a magnetic field in core **87** which causes armature **72** to be drawn downwardly, thus breaking the aforementioned circuit by opening contacts **90** and **92**. The magnetic field thus collapses and allows spring **80** to draw armatures **72** upwardly to again close contact **90** against contact **92**. Thus, there is produced a vibrating movement of armature **72** and a varying flow of current through fan motor **108**.

During the periods when contacts **90** and **92** are open, substantially no current flows thereacross; however, a small current flow takes place from junction **101** through line **102** and resistance **105**. The resistance is sufficient to restrict the current to a materially lesser flow than that taking place when contacts **90** and **92** are closed. For this reason coil **89** is constructed to introduce vary little resistance into the circuit. Coil **89** can for example be formed of 27 turns of #12 enamel-covered copper wire, and resistance **105** can be 1.9 ohms.

In the FIG. 3 arrangement the average resistance in the motor-energizer circuit is a function of the amplitude of the armature vibration; thus as the vibrational amplitude increases the maximum gap across contacts **90** and **92** increases, and the proportion of contact-closed time to contact-open time decreases. The maximum gap between contacts **90** and **92** is a functional of lengths and masses of lever arms **32** and **72**, as well as the strength of coil **89** and the travel angle of lever **61** produced by cam surface **35**. Preferably the maximum gap should be relatively small, as for example a maximum of about .005 inch. When the gap is much greater than this amount the control action produced by the device is somewhat impaired, although increasing the number of turns in coil **89** will permit some increase in the gap. A large gap is also undersirable because of the arcing which it produces, even though the FIG. 3 circuit is noteworthy in that it includes special arc suppressor means. Thus, during service as contacts **90** and **92** separate from one another line **102** provides a current path which is more conducive to current flow than the gap across the contacts; there is therefore a lessened tendency for arcs to be developed across the gap. There is some slight arcing action as the contacts begin to separate; however this action is not objectionable and will not shorten the contact life if a suitable contact material such as silver tungsten alloy is employed.

The vibrator action produced by coil **89** and spring **80** can take place at different frequencies, depending on the physical dimensions and operating characteristics of the component parts. I have found, however, that a very satisfactory control action is provided when the vibrational frequency is about 120 cycles per second. At larger frequencies the voltage drop across the coil becomes so large that the operating characteristics at the ends of the vacuum range (i.e. near 2 inches Hg and 11 inches Hg) provide lower fan motor voltages than depicted in FIG. 4. Thus the vertical steps at the ends of the curve become too large, and the control action thus suffers.

FIG. 4 illustrates the control action achieved with the device of FIGS. 1 through 3. In the illustrated embodiment the vacuum in chamber **18** is proportional to sensed temperature, and movement of shaft **22** is in turn proportional to the vacuum. The voltage at the fan motor is an inverse function of the average resistance across contacts **90** and **92**, and fan motor speed is in turn a function of fan motor voltage. FIG. 4 may thus be considered as a plot of fan motor speed versus sensed temperature. When the control device is used in an automotive air conditioning system relatively high temperatures corresponding to two inches vacuum will cause the fan motor to operate at high speed for high volume cooling. As the control temperature corresponding to six inches vacuum is reached the fan motor speed drops down to provide minimum air circulation.

The dip in the curve at the six inch vacuum mark is caused by the action of resistance **105** in locking contacts **90** and **92** open when pin **30** is in its FIG. 1 position. Thus the small current flow across resistance **105** energizes motor **108** for slow speed movement, and at the same time prevents arcing across the contacts which would tend to draw them together. The lock open action is advantageous in that it increases the contact life and minimizes hunting of the system when the control temperature is attained.

Looking at FIGS. 1 and 4, it will be seen that a low vacuum in chamber **18** in the neighborhood of two inches causes pin **30** to be displaced rightwardly from its FIG. 1 position such that lever **61** is elevated to cause a relatively biasing force to be applied by spring **80** to armature **72**. The large biasing force causes the contact-closed periods to be relatively long in relation to the contact-open periods so that contacts **90** and **92** provide a relatively low effective or average resistance path for current flow through motor **108**. The fan motor voltage is therefore relatively high as shown by FIG. 4. As the vacuum in chamber **18** increases to about six inches pin **30** moves to its FIG. 1 position. In such a position a small or negligible upward biasing force will be provided by spring **80**, and the contacts will remain open such that the motor will be energized solely through line **102**. The fan motor voltage will therefore be relatively low as shown by FIG. 4.

In the event the temperature should decrease sufficiently to provide a vacuum approaching eleven inches pin **30** will be moved leftwardly to elevate lever **61** a sufficient distance for causing spring **80** to apply a relatively large upward biasing force on armature **72**. The proportion of contact-closed time to contact-open time will thus be increased to lower the average resistance in the motor energizer circuit and to provide a sufficient fan motor voltage to drive the fan at increased speed for vehicle heat circulation purposes.

It will be noted that in the two inch through six inch vacuum range the system operates on a cooling cycle, and in the seven inch through eleven inch vacuum range the system operates on a heating cycle. Pin **30** in conjunc-

tion with levers **61** and **72** operates to correctly vary the motor speed as the sensed temperatures stray from the control temperature. The heater and cooler can be controlled by vacuum motors to correlate the air temperature with fan speed in the desired manner. Certain other control functions such as air dampering and defrost or defog control may be controlled in conjunction with the fan speed, as by switch means operated by shaft **22**. In FIG. 2 the switch means takes the form of a printed circuit board **120** suitably mounted on an ear **122** struck out of the web portion **38** of frame **36**. The circuit board has suitable printed circuit tracks which can be connected with the devices being controlled. As best shown in FIG. 2, the printed circuit board is arranged to be traversed by a series of reed-like switch elements **123**. For example there may be provided four connected reed elements traversing four staggered conductive tracks on the board.

FIG. 3 illustrates an arrangement in which coil **89** is connected directly to battery **97**. A functionally similar but structurally different arrangement is shown schematically in FIG. 5. As shown in FIG. 5, coil **89** is located in direct connection with the fan motor, said coil being energized through a circuit which comprises battery **87**, line **98**, armature **72**, contacts **90** and **92**, lines **91** and **100**, the coil, line **112**, and fan motor **108**. Line **102** and resistance **105** serve the same function in the FIG. 5 arrangement as they do in the FIG. 3 arrangement.

FIG. 6 illustrates an arrangement in which the magnetic field of coil **89** urges armature **72** to a position closing contact **90** against contact **92**. A spring **80** (not shown in FIG. 6) would urge the armature upwardly in the same fashion as the FIG. 3 spring. Energization of coil **89** is effected through a circuit which includes battery **87**, line **98**, the coil, lines **112** and **115**, and motor **108**. After coil **89** has been energized a sufficient length of time to close contacts **90** and **92** a second circuit is completed from battery **87** through lines **98** and **100**, armature **72**, contacts **90** and **92**, line **113**, line **115** and motor **108**. This second low resistance circuit deprives coil **89** of sufficient current to hold same energized; the magnetic field thereby collapses, and spring **80** biases armature **72** upwardly to open contacts **90** and **92**. There is thus provided a vibratory armature movement which varies the current in line **115** to give variable fan motor speed in the fashion illustrated by FIG. 4. In the FIG. 6 arrangement the fan motor voltage is highest when contacts **90** and **92** are closed; when the coil is energized the fan motor voltage is very low. The coil preferably has a greater number of turns and of finer wire than the coil of FIG. 3, since the FIG. 6 coil in effect incorporates resistance **105** within itself.

It will be understood that some minor variations from the illustrated arrangements may be resorted to while practicing the invention as pointed out in the attached claims.

What is claimed is:

1. Fan speed control means comprising a fixed contact and a movable contact operable to control current fed to a fan motor; means for vibrating the movable contact to provide a resistance across the contacts; and control means responsive to a temperature condition for varying the amplitude of the vibration to thus vary the contact resistance and fan motor speed; said vibrating means comprising an electromagnet which is energized intermittently in response to opening and closing of the contacts.

2. The combination of claim **1** wherein the electromagnet is energized through a circuit which includes the contacts, said electromagnet being arranged to open the contacts, whereby said electromagnet is self-deenergized.

3. The combination of claim **1** wherein the electromagnet is energized through a high resistance circuit which parallels the contacts; said electromagnet being arranged to close the contacts, whereby closure of said contacts deprives the electromagnet of sufficient current to maintain said electromagnet energized.

4. The combination of claim **1** and further comprising means for suppressing arcs across the contacts when the contact gap exceeds a predetermined value.

5. The combination of claim **1** and further comprising a high resistance circuit arranged in parallel with the contacts, whereby when the contact gap exceeds a predetermined value current flows through the high resistance circuit instead of arcing across the contacts.

6. Fan speed control means comprising a stationary electrical contact; a swingable armature; a second electrical contact carried by the armature in registry with the fixed contact; an electromagnet arranged to draw the armature in one direction; a condition responsive means having a movable output member; a swingable lever movable by the output member; and tension spring means trained between the lever and swingable armature to apply a force on the armature in opposition to the action of the electromagnet; said tension spring having the same effective length and path of motion as the lever, whereby the spring exerts substantially no force tending to affect the driving connection between the output member and lever.

7. Fan speed control means comprising a fixed electrical contact; a swingable armature; a second electrical contact carried by the armature in registry with the fixed contact; an electromagnet arranged to draw the armature in one direction; a vacuum motor having an output member reciprocable in a rectilinear path; a swingable lever having a cam surface riding on the output member of the vacuum motor; and tension spring means trained between the lever and swingable armature to apply a force on the armature in opposition to the action of the electromagnet; said tension spring having the same effective length as the lever and having the same path of motion, whereby the spring exerts substantially no force tending to affect the engagement force between the cam surface and output member.

8. Fan speed control means comprising a vacuum motor having an output shaft reciprocable in a rectilinear path in response to variations in motor vacuum; an electromagnet located adjacent the vacuum motor with its axis arranged crosswise of the motor output shaft; an armature lever swingably mounted for movement toward and away from the electromagnet; a second lever extending generally in the same plane as the armature lever and having a depending portion provided with a cam surface; a cam element carried by the aforementioned output shaft and engaging the cam surface on the second lever, whereby movement of the shaft effects swinging movement of the second lever in a plane generally normal to the aforementioned plane of the two levers; a tension spring interconnecting portions of the two levers, whereby movement of the second lever causes the spring means to apply a variable biasing force on the first lever tending to move said lever away from the electromagnet; a pair of openable and closable contacts arranged to feed current to a fan motor; one of said contacts being a stationary contact, and the other contact being a movable contact carried by the aforementioned armature lever; and means for energizing the coil of the electromagnet, said coil energizer means being variably effective in accordance with the position of the movable contact, whereby during the contact-closed periods the coil is in one of its conditions and during the contact-open periods the coil is in its other condition.

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