Nov. 1, 1955 R. J. CULBERTSON ET AL 2,722,613

THERMAL-ELECTRIC MOTOR

Filed June 25, 1954

Fig. 1.

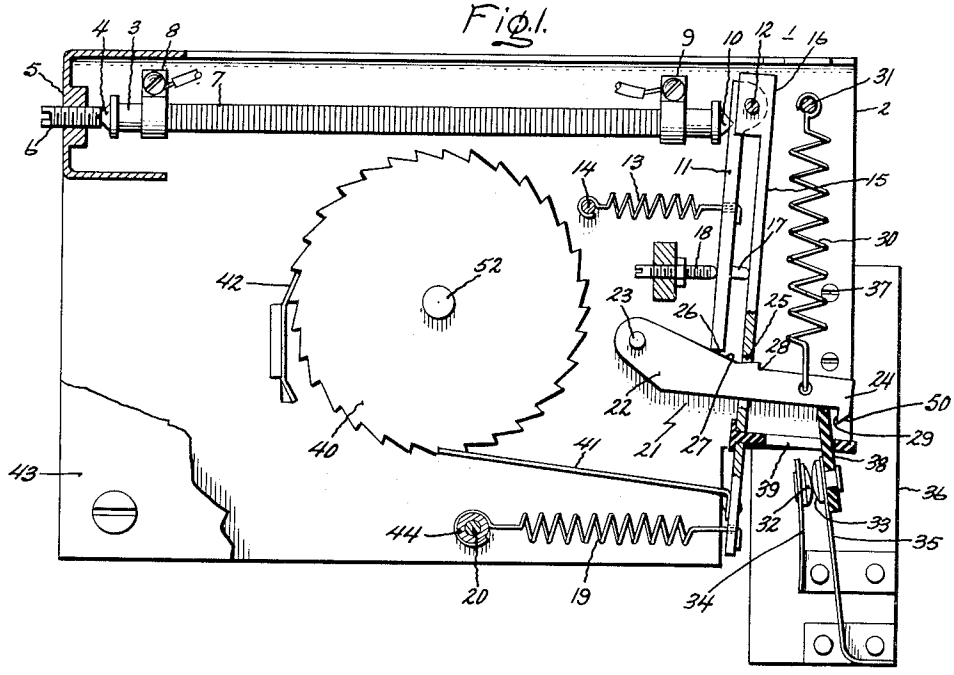


Fig. 2.

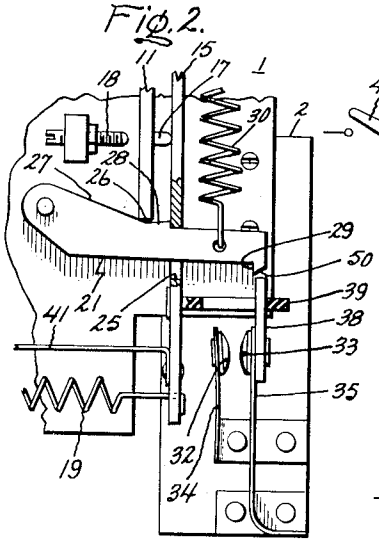
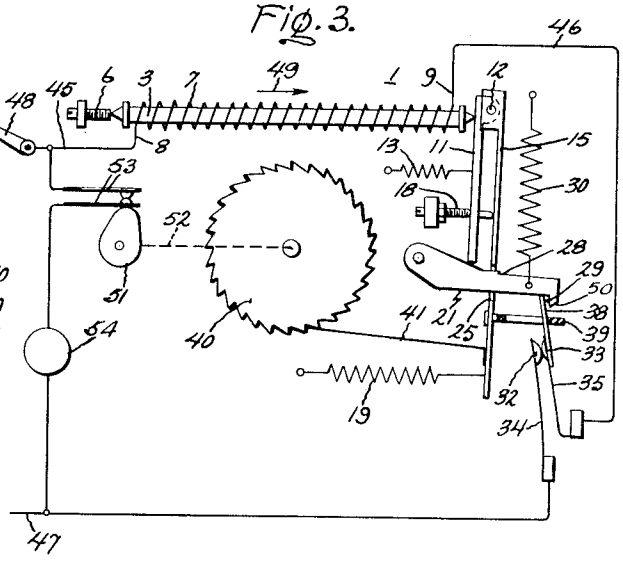


Fig. 3.



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THERMAL-ELECTRIC MOTOR

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15 Claims. (Cl. 310—4)

This invention relates to thermal-electric motors and has particular reference to the mechanism for transmitting the motion produced by such devices.

A thermal-electric motor is one in which a thermally sensitive element is employed which is alternately heated and cooled with the resultant movement of the element being connected through suitable linkages to provide the requisite motion. In one such device disclosed in a copending application of John L. Slonneger and George M. Euler Serial No. 452,396 filed August 26, 1954, and assigned to the present assignee, a column or rod formed of expansible material is utilized as the thermally sensitive element. This element is connected through a toggle mechanism to actuate a ratchet wheel which in turn may be connected to suitable cam actuated switches to perform the control function desired. A heating coil is arranged adjacent the column and is deenergized when the column is expanded a predetermined amount and again reenergized when the column has contracted a predetermined amount. The toggle exerts a force opposed to the force of expansion exerted by the column and thus when the column has expanded a predetermined amount, it will overcome the toggle which will move to another position and, conversely, when the column has contracted a predetermined amount, its force will fall below that applied by the toggle which will return to its original position.

A motion transmitting linkage incorporating a toggle for a thermal-electric motor is suitable for many applications. However, the toggle mechanism does require an initial movement to build up sufficient force to transmit the required motion and finishes its movement with more force than may be necessary. This build up of force may tend to spin the ratchet wheel which is actuated by the toggle mechanism. It is therefore desirable to provide a thermal-electric motor in which the required output force is immediately available and does not rise as the linkage moves through its required distance. It is further desirable that the force drop off slightly as the linkage moves from its one extremity to the other in order further to reduce the energy of the snap-action and thus eliminate the possibility of spinning the ratchet wheel actuated thereby. It is, of course, still desirable that the thermal-electric motor be simple, relatively accurate over its required cycle of operation, and inexpensive.

It is therefore an object of this invention to provide an improved thermal-electric motor incorporating the desirable features set forth above.

Further objects and advantages of this invention will become apparent by reference to the following description and the accompanying drawing and the features of novelty which characterize this invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

This invention in its broadest aspects provides a thermally sensitive member adapted to move responsive to temperature changes with means being provided for heating the member which is deenergized in response to predetermined movement thereof in one direction and reenergized in response to a predetermined movement in the opposite direction. Operating means are provided adapted intermittently to transmit motion and arranged to be moved from a first position to a second position in response to movement of the thermally sensitive member in one direction. The operating means is biased toward its first position and latching means are provided for holding it in its second position. The latching means is arranged to be disengaged from the operating means in response to movement of the thermally sensitive member in the other direction whereby the operating means returns to its first position thereby transmitting motion.

In the drawing, Fig. 1 is a side elevational view, partly in section and partly broken away, illustrating the improved thermal-electric motor of this invention with the heating contacts closed at the end of the motion transmitting operation;

Fig. 2 is a fragmentary view of the device of Fig. 1 showing the heating contacts open and the device ready to begin a motion transmitting operation; and

Fig. 3 is a schematic illustration showing an application of the improved thermal-electric motor of Figs. 1 and 2.

Referring now to Figs. 1 and 2, there is shown a thermal-electric motor, generally identified as **1**, having a base member **2** which may be formed of any material, such as relatively stiff sheet metal. An expansible column or rod **3** is provided having one end **4** supported to mounting portion **5** of base **2** by means of a suitable set screw **6**. Set screw **6** serves to calibrate the device, as will be hereinafter more fully described. Column **3** is formed of suitable expansible metal, such as stainless steel, and has a heating coil **7** positioned thereon. Heating coil **7** terminates in terminals **8** and **9** which are connected in the circuit to be hereinafter more fully described.

The other end **10** of column **3**, which may be conical in configuration as shown, engages an actuating lever **11** which is pivoted to base member **2**, as at **12**. Actuating member **11** is biased to oppose expansion of column **3** by means of a suitable coil spring **13** having its one end engaging actuator lever **11** and its other end secured to base **2** as at **14**. An operating lever **15** is provided having one end **16** pivotally mounted on base **2** by means of the same pivot **12** which mounts the actuating lever **11**. Actuating member **11** is provided with a projection **17** engaging operating lever **15** and movement of actuating member **11** under the influence of spring **13** is limited by a suitable adjustable stop **18**. Operating member **15** is biased into engagement with projection **17** of actuating lever **11** by means of a suitable coil spring **19** having one end engaging operating lever **15** and its other end secured to base **2** as at **20**.

A latching lever **21** is provided having one end **22** pivoted to base member **2** as at **23** and having its other end **24** extending through a suitable opening **25** in operating lever **15**. It will be seen that in the position shown in Fig. 1, the end **26** of actuating lever **11** is in engagement with a camming surface **27** of latching lever **21** and that latching surfaces **28** and **29** are respectively formed on either side of the latching lever **21**. The end **24** of latching lever **21** is biased upwardly as viewed in Fig. 1 by means of a suitable coil spring **30** having its one end engaging end **24** of latching lever **21** and its other end secured to base **2**, as at **31**.

A pair of contacts **32** and **33** are provided adapted to be connected in circuit with the heating coil **7** as will be hereinafter more fully described. Contacts **32** and **33** are mounted on flexible elements **34** and **35** respectively, which in turn are secured to a mounting member **36**, preferably formed of suitable insulating material. Mounting member

36 in turn is secured to base member 2 in any suitable manner, as by screws 37. Contacts 32 and 33 are normally biased to their open position by flexible elements 34 and 35, as best seen in Fig. 2. Flexible element 35 is provided with an extension portion 38, preferably formed of suitable insulating material, which is adapted to be engaged by latching notch 29 of latching lever 21, as will be hereinafter described. Extension portion 38 of flexible member 35 is also adapted to be engaged by a link 39, also preferably formed of insulating material, which is attached to operating lever 15.

In order to transmit motion, a ratchet wheel 40 is rotatably mounted on base 2 and is adapted to be engaged and moved by a suitable pawl 41 attached to operating lever 15. A suitable spring 42 attached to base member 2 prevents rotation of ratchet wheel 40 in the wrong direction. A cover 43 may be provided for the device and is spaced from base member 2 in any suitable manner, as by spacers 44.

Referring now to Figs. 2 and 3 in addition to Fig. 1, the operation of the improved thermal-electric motor of this invention will be described. It will be seen in Fig. 3 that the terminal 8 of coil 7 on column 3 is connected to an external line 45 while the terminal 9 is connected to flexible element 35 and contact 33 by means of a line 46. The other flexible element 34 and contact 32 is connected to the other supply line 47. Supply lines 45 and 47 are adapted to be connected to an external source of power, which may be either alternating current or direct current. Assume now that switch 48 in supply line 45 has been open and that column 3 is thus cool and contracted to substantially its maximum degree. Under this situation, contacts 32 and 33 will be closed and thus, if switch 48 is closed, current will flow through supply line 45, heating coil 7, line 46, contacts 32 and 33, and line 47 to heat coil 7. As coil 7 is heated, column 3 expands longitudinally in the direction shown by the arrow 49 thus moving actuating lever 11 to the right as viewed in Figs. 1, 2 and 3. This movement is transmitted to operating lever 15 by actuating lever 11 through its projection 17 and thus operating lever 15 also moves to the right under the influence of the expansion of the column 3.

Referring specifically to Fig. 2, it will be seen that as opening 25 in operating lever 15 passes latching notch 28 in latching lever 21, the latching lever will be pulled upwardly by means of its biasing spring 30. This movement of latching lever 21 disengages the latching notch 29 from the end of extension 38 of flexible element 35 thus allowing the contacts 32 and 33 to open, as shown in Fig. 2. With contacts 32 and 33 open, the circuit of heating coil 7 will be open, and column 3 will begin to contract. It will be noticed that during the heating cycle with contacts 32 and 33 closed, operating lever 15 moved from a first or initial position as shown in Fig. 1 to a second position as shown in Fig. 2 and pawl 41 has been moved a corresponding distance to the right. It will be also noticed that the engagement of latching notch 28 of latching lever 21 with the underside of operating lever 15 is holding the operating lever 15 in its second position against the influence of its associated spring 19.

With the circuit of heating coil open, column 3 will begin to contract. As has been noted above, coil spring 13 biases actuating lever 11 against the expansion of column 3 and thus as the column contracts, actuating lever 11 will move to the left as viewed in Fig. 1 under the influence of spring 13. As the contraction of column 3 continues accompanied by the leftward movement of actuating lever 11, end 26 of actuating lever 11 will engage camming surface 27 of latching lever 21 and force it downwardly, thus disengaging latching notch 28 from operating lever 15. Operating lever 15 will then snap to the left under the influence of spring 19 and pawl 41 will engage a tooth of ratchet wheel 40 moving the wheel a predetermined distance in a clockwise direction. As operating lever 15 moves to the left, its associated link 39 pulls extension 38 of flexible element 35 to the left thus again closing contacts 32 and 33. A tapered surface 50 is formed on the end of latching lever 21 adjacent latching notch 29 to aid the sliding extension portion 38 of flexible element 35 over the tapered surface 50 as it is pulled leftwardly by link 39. Flexible element 35 flexes to permit extension portion 38 to slide into latching notch 29 of latching lever 21. The contacts 32 and 33 are thus held closed during another heating cycle by the engagement of extension portion 38 under latching notch 29 of the latching lever.

It will be readily seen that the duration of the heating cycle may be controlled by the adjustment of set screw 6, the screw being moved inwardly and thus placing column 3 under initial compressive stress reducing the heating time. Conversely, adjustment of set screw 18 is used to calibrate the cooling time of the device.

It will be readily apparent that ratchet wheel 40, having a rotating motion, may be connected to any desired type of control device. For example, ratchet wheel 40 may be connected to a suitable cam 51 by means of shaft 52 which actuates contacts 53 in circuit with the device to be controlled, such as a motor 54. It will be readily understood that any number and configuration of cams may be operated from ratchet wheel 40 and that the connection shown is by way of illustration only. It will also be readily seen that by constructing the base member 2 of material with thermal expansion characteristics similar to those of the expansible column 3, compensation for operating the device in different ambient temperatures is accomplished.

It will be seen that movement of the ratchet wheel 40 is effected during the cooling cycle and that it takes place with a snap action under the influence of spring 19. By virtue of the latching arrangement shown, all of the force required for movement of the ratchet wheel 40 is thus immediately available, and as spring 19 moves operating lever 15, this force falls off thus eliminating the tendency for the pawl 41 to spin the ratchet wheel 40.

It will now be readily apparent that this invention provides an improved thermal-electric motor in which there is no tendency for the driven ratchet wheel to be spun by the actuating linkage and further characterized by its simplicity in ease of assembly.

While we have shown and described a particular embodiment of this invention, further modifications and improvements will occur to those skilled in the art. We desire that it be understood therefore that this invention is not limited to the form shown and we intend in the appended claims to cover all modifications which do not depart from the spirit and scope of this invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. A thermal-electric motor comprising a thermally sensitive member adapted to move responsive to temperature change, means for heating said member, means for deenergizing said heating means in response to a predetermined movement of said member in a first direction and for reenergizing said heating means in response to a predetermined movement of said member in the opposite direction, operating means adapted intermittently to transmit motion and arranged to be moved from a first position to a second position in response to movement of said member in one of said directions, means biasing said operating means to one of said positions, latching means for holding said operating means in the other of said positions, and means arranged to disengage said latching means from said operating means in response to movement of said member in the other of said directions whereby said operating means returns to said first position thereby to transmit motion.

2. A thermal-electric motor comprising a column

formed of expansible material, means for heating said column, means for deenergizing said heating means in response to a predetermined change of volume in said column in a first direction and for reenergizing said heating means in response to a predetermined change of volume of said column in the opposite direction, operating means adapted intermittently to transmit motion and arranged to be moved from a first position to a second position in response to a change in volume of said column in one of said directions, means biasing said operating means to said first position, latching means for holding said operating means in said second position, and means arranged to disengage said latching means from said operating means in response to a change in volume of said column in the other of said directions whereby said operating means returns to said first position thereby to transmit motion.

3. A thermo-electric motor comprising a column formed of expansible material, means for heating said column, means for deenergizing said heating means in response to a predetermined expansion of said column and for reenergizing said heating means in response to a predetermined contraction of said column, operating means adapted intermittently to transmit motion and arranged to be moved from a first position to a second position in response to a change in volume of said column in one direction, means biasing said operating means to said first position, latching means for holding said operating means in said second position, and means arranged to disengage said latching means from said operating means in response to a change in volume of said column in the other direction whereby said operating means returns to said first position thereby to transmit motion.

4. A thermal-electric motor comprising a column formed of expansible material, means for heating said column, means for deenergizing said heating means in response to a predetermined expansion of said column and for reenergizing said heating means in response to a predetermined contraction of said column, a pivotally mounted operating lever adapted intermittently to transmit motion and arranged to be moved from a first position to a second position in response to a change in volume of said column in one direction, spring means engaging said lever and biasing the same to said first position, latching means for holding said lever in said second position, and means arranged to disengage said latching means from said lever in response to a change in volume of said column in the other direction whereby said operating means returns to said first position thereby to transmit motion.

5. A thermo-electric motor comprising a column formed of expansible material, means for heating said column, means for deenergizing said heating means in response to a predetermined expansion of said column and for reenergizing said heating means in response to a predetermined contraction of said column, operating means adapted intermittently to transmit motion and having a first position and a second position, means biasing said operating means to said first position, actuating means engaged by said column, means biasing said actuating means to oppose a change in volume of said column in one direction, said actuating means being adapted to move said operating means to said second position in response to a change in volume of said column in said one direction, and latching means for holding said operating means in said second position, said actuating means being adapted to disengage said latching means from said operating means in response to a change in volume of said column in the other direction whereby said operating means returns to said first position thereby to transmit motion.

6. A thermo-electric motor comprising a column formed of expansible material, means for heating said column, means for deenergizing said heating means in response to a predetermined expansion of said column and for reenergizing said heating means in response to a predetermined contraction of said column, a pivotally mounted operating lever adapted intermittently to transmit motion and having a first position and a second position, spring means engaging said operating lever and biasing the same to said first position, a pivotably mounted actuating lever engaged by said column, spring means engaging said actuating lever and biasing the same to oppose a change in volume of said column in one direction, said actuating lever being arranged to engage said operating lever and to move the same to said second position in response to a predetermined change in volume of said column in said one direction, and latching means arranged to engage and hold said operating lever in said second position, said actuating lever being arranged to engage said latching means and to disengage the same from said operating lever in response to a predetermined change in volume of said column in the other direction whereby said operating lever returns to said first position thereby to transmit motion.

7. A thermo-electric motor comprising a column formed of expansible material, means for heating said column, means for deenergizing said heating means in response to a predetermined expansion of said column and for reenergizing said heating means in response to a predetermined contraction of said column, a pivotally mounted operating lever adapted intermittently to transmit motion and arranged to be moved from a first position to a second position in response to a change in volume of said column in one direction, spring means engaging said lever and biasing the same to said first position, a pivotally mounted latching lever adapted to engage and hold said operating lever in said second position, spring means engaging said latching lever and biasing the same into engagement with said operating lever, and means arranged to disengage said latching lever from said operating lever in response to a change in volume of said column in the other direction whereby said operating lever returns to said first position thereby to transmit motion.

8. A thermo-electric motor comprising a column formed of expansible material, means for heating said column, means for deenergizing said heating means in response to a predetermined expansion of said column for reenergizing said heating means in response to a predetermined contraction of said column, a pivotally mounted operating lever adapted intermittently to transmit motion and having a first position and a second position, spring means engaging said operating lever and biasing the same to said first position, a pivotally mounted actuating lever engaging said column, spring means engaging said actuating lever and biasing the same to oppose a change of volume of said column in one direction, said actuating lever being arranged to engage said operating lever and to move the same to said second position in response to a predetermined change of volume of said column in said one direction, a pivotally mounted latching lever adapted to engage and hold said operating lever in said second position, spring means engaging said latching lever and biasing the same into engagement with said operating lever, said actuating lever being arranged to engage said latching lever and to disengage the same from said operating lever in response to a predetermined change of volume of said column in the other direction whereby said operating lever returns to said first position thereby to transmit motion.

9. A thermo-electric motor comprising a column formed of expansible material, a heating coil arranged adjacent said column for heating the same, operating means adapted intermittently to transmit motion and arranged to be moved from a first position to a second position in response to a change in volume of said column in one direction, means biasing said operating means to one of said positions, latching means for holding said operating means in the other of said positions, means arranged to disengage said latching means from said operating means in response to a change in volume of said column in the other direction whereby said operating means returns to said one position thereby to transmit

motion, a circuit for said heating coil, contacts in said circuit, and means for closing said contacts when said operating means is in one of said positions and for opening said contacts when said operating means is in the other of said positions.

10. A thermo-electric motor comprising a column formed of expansible material, a heating coil arranged adjacent said column for heating the same, operating means adapted intermittently to transmit motion and arranged to be moved from a first position to a second position in response to a change in volume of said column in one direction, means biasing said operating means to said first position, latching means for holding said operating means in said second position, means arranged to disengage said latching means from said operating means in response to a change in volume of said column in the other direction whereby said operating means returns to said first position thereby to transmit motion, a circuit for said heating coil, and contacts in said circuit, said contacts being normally open, said operating means being adapted to close said contacts in one of said positions and to permit said contacts to open in the other of said positions.

11. A thermo-electric motor comprising a column formed of expansible material, a heating coil arranged adjacent said column for heating the same, operating means adapted intermittently to transmit motion and arranged to be moved from a first position to a second position in response to expansion of said column, means biasing said operating means to a first position, latching means adapted in a first position to hold said operating means in said second position thereof, means arranged to move said latching means to a second position thereby to disengage said operating means in response to contraction of said column whereby said operating means returns to said first position thereby to transmit motion, a circuit for said heating coil, contacts in said circuit, said contacts being normally open, said operating means being adapted to move said contacts to their closed position responsive to movement of said operating means to said first position thereof, said latching means being adapted in said second position thereof to hold said contacts in said closed position, and means biasing said latching means to said first position thereof.

12. A thermo-electric motor comprising a column formed of expansible material, a heating coil arranged adjacent said column for heating the same, a pivotally mounted operating lever adapted intermittently to transmit motion and having a first position and a second position, spring means engaging said operating lever and biasing the same to said first position, a pivotally mounted actuating lever engaging one end of said column, spring means engaging said actuating lever and biasing the same to oppose expansion of said column, said actuating lever being arranged to engage said operating lever and to move the same to said second position in response to a predetermined expansion of said column, a pivotally mounted latching lever adapted in a first position to engage and hold said operating lever in said second position thereof, spring means engaging said latching lever and biasing the same to said first position thereof, said actuating lever being arranged to engage said latching lever to move the same to a second position thereof to disengage the same from said operating lever in response to a predetermined contraction of said column whereby said operating lever returns to said first position thereof to transmit motion, a circuit for said heating coil, contacts in said circuit, and means biasing said contacts to the normally open position, said operating lever being arranged to engage said contacts to move the same to their closed position responsive to movement of said operating lever to said first position thereof, said latching lever being arranged in said second position thereof to engage said contacts and to hold the same in said closed position, said latching lever being adapted to disengage said contacts responsive to movement of said latching lever to said first position thereof.

13. A thermo-electric motor comprising a column formed of expansible material, means for heating said column, means for deenergizing said heating means in response to a predetermined expansion of said column and for re-energizing said heating means in response to a predetermined contraction of said column, operating means adapted intermittently to transmit motion and arranged to be moved from a first position to a second position in response to a change in volume of said column in one direction, means biasing said operating means to said first position, latching means for holding said operating means in said second position, and means arranged to disengage said latching means from said operating means in response to a change in volume of said column in the other direction whereby said operating means returns to said first position, and a ratchet wheel adapted to transmit power, said operating means having a pawl formed thereon arranged to engage said ratchet wheel and to move the same a predetermined distance in response to movement of said operating means to said first position.

14. A thermo-electric motor comprising a column formed of expansible material, means for heating said column, means for deenergizing said heating means in response to a predetermined expansion of said column and for re-energizing said heating means in response to a predetermined contraction of said column, a pivotally mounted operating lever adapted intermittently to transmit motion and having a first position and a second position, spring means engaging said operating lever and biasing the same to said first position, a pivotally mounted actuating lever engaging said column, spring means engaging said actuating lever and biasing the same to oppose a change in volume of said column in one direction, said actuating lever being arranged to engage said operating lever and to move the same to said second position in response to a predetermined change in volume of said column in said one direction, a pivotally mounted latching lever adapted to engage and hold said operating lever in said second position, spring means engaging said latching lever and biasing the same into engagement with said operating lever, said actuating member being arranged to engage said latching lever and to disengage the same from said operating lever in response to a predetermined change in volume of said column in the other direction whereby said operating lever returns to said first position thereof, and a ratchet wheel adapted to transmit power, said operating lever having a pawl formed thereon arranged to engage said ratchet wheel and to move the same a predetermined distance in response to movement of said operating lever to said first position.

15. A thermal-electric motor comprising a base member, a column formed of expansible material having one end secured to said base member, a heating coil wound on said column for heating the same, an operating lever pivotally mounted on said base member and adapted intermittently to transmit motion, said operating lever having a first position and a second position, spring means engaging said operating lever and biasing the same to said first position, an actuating lever pivotally mounted on said base member and engaging the other end of said column, spring means engaging said actuating lever and biasing the same to oppose expansion of said column, said actuating lever being arranged to engage said operating lever and move the same to said second position thereof in response to a predetermined expansion of said column, a latching lever pivotally mounted on said base member and adapted in a first position thereof to engage and hold said operating lever in said second position thereof, spring means engaging said latching lever and biasing the same to said first position thereof, said actuating lever being arranged to engage said latching lever to move the same to a second position thereof thereby to disengage the same from said operating lever in response to a prede-

termined contraction of said column whereby said operating lever returns to said first position thereof, a circuit for said heating coil, contacts in said circuit, means biasing said contacts to the normally open position, said operating lever being arranged to engage said contacts to move the same to their closed position responsive to movement of said operating lever to said first position thereof, said latching lever being arranged in said second position thereof to engage said contacts and to hold the same in said closed position, said latching lever being

adapted to disengage said contacts responsive to movement of said latching lever to said first position thereof, and a ratchet wheel rotatably mounted on said base member and adapted to transmit power, said operating lever having a pawl formed thereon arranged to engage said ratchet wheel and to move the same a predetermined distance in response to movement of said operating lever to said first position thereof.

No references cited.