Aug. 8, 1944. A. E. BAAK 2,355,041

HEAT MOTOR

Original Filed Jan. 2, 1941

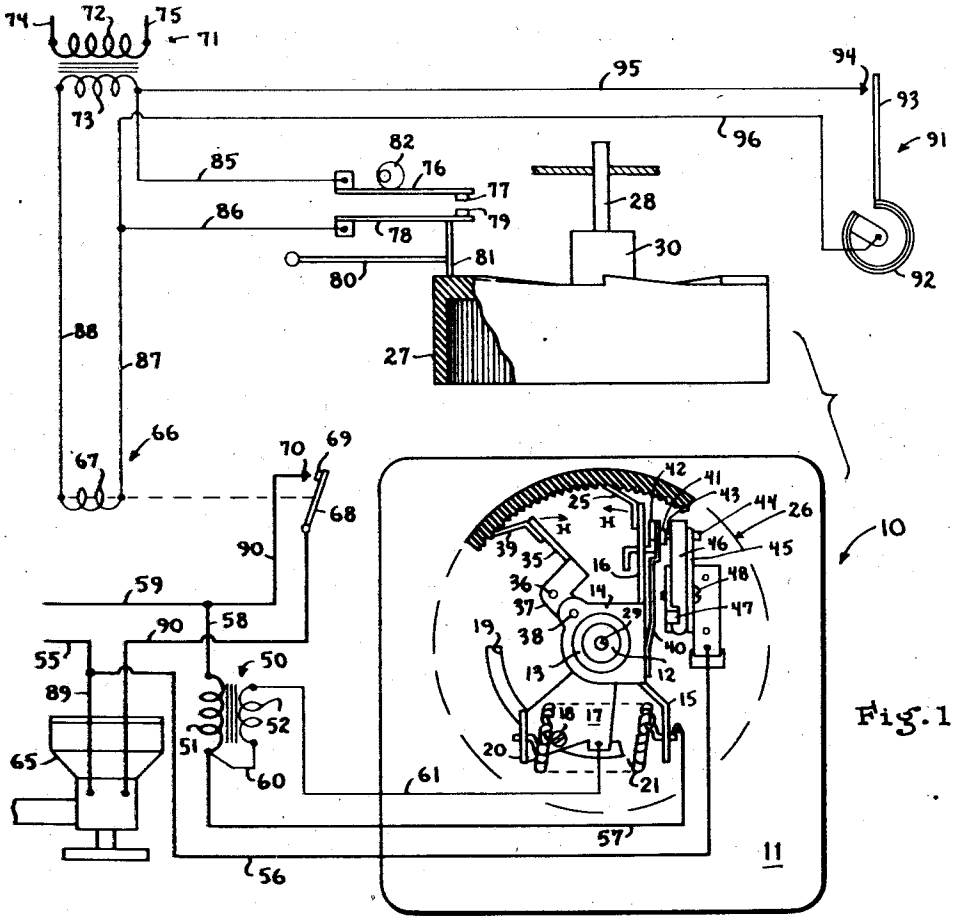


Fig. 1

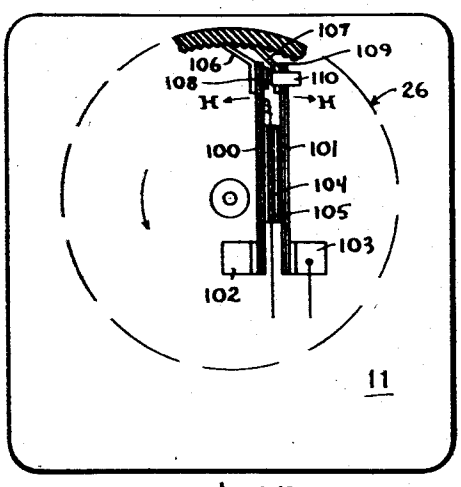


Fig. 3

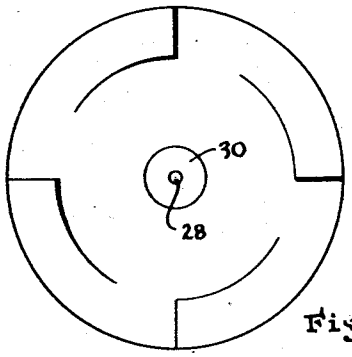


Fig. 2

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HEAT MOTOR

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13 Claims. (Cl. 172—126)

This invention is concerned with a heat actuated motor, particularly a motor adapted to produce rotary motion.

The principal object of the invention is to provide an improved heat actuated device for producing rotary motion utilizing a minimum of parts and occupying a minimum of space.

Another object is to provide an improved heat motor comprising a rotary element actuated by expansible and contractible heat responsive means located within the element.

Another object is to provide an improved heat motor for a timer or the like having an expansible and contractible heat responsive element so arranged that the element rotates a member about a shaft both when the element cools and when it heats.

Another object of the invention is to provide improved adjusting means associated with the heat motor for adjusting the speed at which the rotary element is driven.

Numerous other objects of the invention and many of its advantages will become apparent from the following detailed description and annexed drawing, wherein

Figure 1 is a diagrammatic view of the preferred form of my invention embodied in a system wherein the heat motor drives a timing mechanism controlling a stoker,

Figure 2 is a plan view of the timer cam driven by the heat motor,

Figure 3 is a view of a modified form of heat motor.

This application is a division of my previously filed application Serial No. 372,783, filed January 2, 1941, now Patent Number 2,326,002, August 3, 1943.

Referring to Figure 1 of the drawing, the heat motor is designated generally by the numeral 10, the parts being mounted on a base or panel 11. Carried on the base 11 is an arbor 12 and on the arbor is a cylindrical "Bakelite" member having a flange 13. Rotatably supported on the "Bakelite" member and the arbor 12 is a member 14 having an integral downwardly extending arm 15. The member 14 has an integral upwardly extending arm 16. Numeral 17 designates a normally fixed arm member pivotally carried on the arbor 12 but having a screw 18 attached thereto which extends through an arcuate slot 19 in the base or panel 11, which screw carries a nut on the opposite side of the base for securing the arm 17 in position. The arm 17 has an ear 20 and between this ear and the arm 15 is secured a bimetal element 21 of the double helix type as shown and described in detail in the patent of Parsons, No. 2,121,259. The bimetal element 21 is formed of a strip of bimetal which is first coiled into a spiral and this spiral is then coiled into a second spiral as shown. This arrangement of the bimetal makes it possible to have a relatively large amount of bimetal arranged in a small and compact space, the amount of bimetal being sufficient to provide a relatively large amount of movement when the bimetal expands and contracts in response to temperature changes. This particular arrangement of bimetal expands and contracts in response to temperature changes along a straight line in the direction of its axis.

At the end of the arm 16 is attached a finger 25 which forms a pawl. Numeral 26 designates a cylindrical, more or less cup-shaped member having a downwardly extending skirt portion 27 as shown in the upper portion of Fig. 1. The interior of the skirt portion is grooved or serrated as may be seen in Fig. 1 and the finger 25 which forms a pawl is adapted to engage the serration. The member 26 is rigidly fastened to a shaft 28, the lower end of which extends into a hole 29 in the arbor 12 so that the member 26 is rotatable with respect to the arbor, the various parts of the heat motor being enclosed in the skirt portion of the member 26. A cover may be provided so as to enclose the elements of the heat motor including the cup-shaped member 26, the cover fitting down on the base 11 and the upper end of the shaft 28 extending through the cover as shown in the upper portion of Fig. 1. The member 26 has a portion 30 of relatively small diameter adjacent its upper face. The upper face of the member 26 is shaped so as to form a cam surface, the plan view of the cam surface being shown in Fig. 2. The cam surface comprises four gradually rising dwells as shown which are equally spaced angularly near the outer edges of the face of the member 26.

The finger 25 is flexible and when the arm 16 is moved to the left in a manner which will be presently described the finger 25 engages the serrations on the inner surface of the skirt 27 moving the cam member 26 in a counterclockwise direction. When the arm 16 is moved to the right the finger 25 slides over the serrations without moving the member 26.

Numeral 35 designates an angular arm pivoted on a fixed pivot 36 and having a slotted portion 37, the slot engaging a pin 38 carried by a portion of the member 14. At the end of the arm 35 is a finger 39 corresponding to the finger

25, this finger also forming a pawl engaging the serrations on the inner surface of the skirt 27 of member 26. As will presently be described, the arm 35 may be moved to the left so as to rotate the member 26 in a counterclockwise direction in the same manner as it is rotated by the pawl 25.

Numeral 40 designates a flexible blade, the lower end of which is attached to the member 14 and the upper end of which carries a contact 41, the upper end being slightly spaced from the arm 16. Attached to the upper end of the blade 40 is an angular member 42 which extends through an opening in arm 16 and which has a downwardly extending projection adapted to engage the arm 16 and limit the extent to which the blade 40 can be flexed away from the arm 16. Numeral 43 designates a contact carried at the end of a contact screw 44 which extends through a bracket member 45 which is suitably secured to the panel or base 11 by rivets or the like as shown. The contact screw 44 is disposed between the legs of a permanent magnet 46 which is attached to the bracket 45 by means of a clamp 47 and a screw 48. Member 42 forms an armature and when it is brought to a position adjacent the legs of the magnet 46 it is attracted by the field of the magnet and contacts 41 and 43 are brought together with a snap action, the blade 40 flexing away from the arm 16 which is not affected by the snap action.

Electric current for the expansible and contractible element 21 is supplied from a step down transformer 50 having a primary winding 51 and a secondary winding 52, the primary winding having a greater number of turns.

With the parts of the heat motor in the position shown in Fig. 1, the element 21 is cold and is therefore in its contracted position, it being understood that as the element 21 contracts the arm 15 of member 14 and of course the arm 16, are moved in a clockwise direction. When member 14 moves in a clockwise direction, by reason of the engagement of pin 38 in the slot in portion 37 of arm 35 the arm 35 is moved in a counterclockwise direction. Thus, during the time that element 21 is contracting the pawl 39 is moving the cam member 26 in a counterclockwise direction while the pawl 25 is sliding over the serrations on the interior of the skirt 27. With the parts as shown in Fig. 1, the cooling cycle has just been completed and contacts 41 and 43 have just been snapped into engagement. Engagement of these contacts completes a circuit for the primary 51 of transformer 50 as follows: from line conductor 55 through a wire 56, bracket 45, contact screw 44, contacts 43 and 41, blade 40, member 14, arm 15, wire 57, primary 51, and wire 58 back to a line conductor 59, line conductors 55 and 59 being connected to any suitable source of power not shown. Completion of this circuit energizes the transformer and current now flows in a circuit extending through the element 21 and through the secondary of the transformer, this circuit being as follows: from the secondary 52, through a wire 60, wire 57, element 21, ear 20 and arm 17 and wire 61 back to secondary 52. Energization of this circuit causes heating of the element 21 which causes it to expand longitudinally of its axis thereby rotating the arms 15 and 16 in a counterclockwise direction about the arbor 12. The pawl engages the serrations on the inner surface of the skirt 27 of member 26 rotating it in a counterclockwise direction. Counterclockwise movement of member 14 now rotates the arm 35 in a clockwise direction about its pivot so that this arm moves towards the arm 16 with the pawl 39 sliding over the serrations on the inner surfaces of the skirt 27. The contacts 41 and 43 stay in engagement with each other until the arm 16 engages the downwardly extending projection of member 42 and when this occurs, further leftward movement of arm 16 pulls armature 42 away from magnet 46, thus moving the flexible blade 40 to the left so as to disengage the contacts 41 and 43 with a snap action and interrupt the circuit of transformer 50. When the circuit of the the transformer 50 is thus interrupted winding 52 is de-energized and heating of element 21 discontinues and it begins to cool and contract. As it contracts, member 14 is now rotated in a clockwise direction and pawl 25 now slides over the serrations on the inner surface of skirt 27 while the arm 35 is now rotated in a counterclockwise direction, arms 35 and 16 moving away from each other with pawl 39 engaging the serrations on the inner surface of skirt 27 and rotating the member 26 again in a counter clockwise direction. The arms 35 and 16 continue moving away from each other until armature 42 approaches magnet 46 sufficiently close that contact 41 is again snapped into engagement with contact 43 with the parts again in the position shown in Fig. 1 wherein the circuit of transformer 50 is completed. It is to be noted that the flexible blade 40, because of its operation as a resilient support for contact 41, provides some freedom of relative movement between arm 16 and contact 41, that is, lost motion, so that considerable movement of arm 16 is required to affect opening and closing of contacts 41 and 43. By reason of the flexible blade, 40, arms 16 and 35 can move with a smooth back and forth motion inasmuch as they are free from the effects of the magnetic snap action with which contact 41 is operated.

From the foregoing, it is to be seen that the arms 16 and 35 alternately move toward and away from each other so as to "walk" around the inner surface of the member 27 so as to rotate it substantially uniform by and continuously in a counterclockwise direction.

By loosening the screw 18 which extends through slot 19, the position of arm 17 may be adjusted and such an adjustment of course adjusts the position of element 21 and the actuator arms 16 and 35. If arm 17 is adjusted to the right it is to be seen that the arm 16 is adjusted in a counterclockwise direction bringing it closer to the downwardly extending projection of member 42 so that a smaller amount of lengthening of the element 21 is required to cause arm 16 to engage the downwardly extending projection of member 42 for opening the contacts. On the other hand, if the arm 17 is adjusted to the left arm 16 is brought closer to the armature portion of member 42 and consequently greater lengthening of element 21 is required to cause opening of the contacts and subsequent cooling of the element 21. In other words, the length of the "step" taken by the arms or rather legs 16 and 35 is adjusted by adjusting the position of arm 17. Thus by adjusting the position of arm 17 the length of time required for the member 26 to make one complete revolution may be adjusted. Arm 17 is normally so adjusted that the member 26 makes one complete revolution per hour.

While the heat motor of my invention may have many different applications where it is desirable to produce rotary motion, in the present instance I have used it as a part of a timing

mechanism which is arranged to intermittently operate a fuel feeding device which in this instance is an automatic stoker. The stoker is generally designated by the numeral 65 and it is controlled through a relay designated by the numeral 66, the relay 66 comprising a winding 67 having an armature associated therewith which is attached to a movable switch blade 68 having a contact 69 which is moved to the left by the armature into engagement with a fixed electrical contact 70 when the winding 67 is energized.

Power for operation of the relay is supplied by stepdown transformer 71 comprising a primary winding 72 and a secondary winding 73, the primary winding having a greater number of turns and being supplied with power through conductors 74 and 75 connected to any suitable source of power, not shown.

The relay 66 may be energized by contacting means actuated by the cam member 26 driven by the heat motor. Numeral 76 designates a contact bracket carrying a contact 77 and numeral 78 designates a second contact bracket carrying a contact 79 cooperable with the contact 77. Numeral 80 designates a pivoted arm member carrying at its right end a portion 81 forming a cam follower which rides on the cam surface of the member 26. The cam follower portion 81 has an upwardly extending portion which engages the contact bracket 78. The bracket 78 normally engages a manually adjustable eccentric or cam 82 and by adjusting the eccentric 82 the position of bracket 76 and contact 77 relative to contact 79 may be adjusted.

As the cam member 26 rotates in a counterclockwise direction, the cam follower member 81 rises up on the dwells upon the face of the cam member, and as it rises the bracket member 78 and contact 79 are lifted until contact 79 engages contact 77, this occurring at a point on any one of the dwells depending upon the adjustment of bracket member 76. When contacts 77 and 79 are brought into engagement a circuit for energizing the winding 67 of relay 66 is completed as follows: from secondary 73 through wire 85, bracket 76, contacts 77 and 79, bracket 78, wire 86, wire 87, winding 67 and wire 88, back to secondary 73. When winding 67 is energized, contacts 69 and 70 are brought into engagement completing a circuit for the motor of the automatic stoker as follows: from line conductor 55 through wire 89, the motor of the stoker, wire 90, switch blade 68, contacts 69 and 70, wire 90 back to line conductor 59. Contacts 77 and 79 remain in engagement keeping the relay 66 energized and the stoker in operation until the cam follower 81 drops off the dwell by which it was raised. When the cam follower drops off the dwell, the contacts 77 and 79 are of course disengaged so as to interrupt the circuit of relay 66. With the cam member 26 constructed as shown, the contacts 77 and 79 are brought into engagement four times during each revolution of the cam member. Of course any number of dwells could be provided and thus any number of intermittent operations of the stoker during one cycle or revolution of the cam member could be provided for. As mentioned above, the duration of each intermittent operation is determined by adjusting the point on the dwell at which the contacts are brought into engagement, and this is determined by adjustment of the position of bracket 76 by means of the manually adjustable eccentric 82.

The relay 66 may also be energized by a thermostat responsive to the temperature of a space, the air of which is heated by means of the plant to which fuel is fed by the stoker. This thermostat is designated by the numeral 91 and comprises a circular bimetal element 92 arranged to actuate a switch blade 93, the switch blade 93 being movable to the left into engagement with a fixed electrical contact 94 when the temperature of the air affecting the thermostat falls to a predetermined value, such as 70° F. for example. When the temperature rises above this value, the blade 93 is moved out of engagement with the contact 94. When the blade 93 engages contact 94, a circuit for winding 67 is completed as follows: from secondary 73 through a wire 95, contact 94, blade 93, element 92, wire 96, wire 97, winding 67, and wire 88 back to secondary 73. The relay 66 will remain energized in response to the thermostat for operating the stoker as long as blade 93 remains in engagement with contact 94.

From the foregoing, it is to be seen that the heat motor of my invention provides for continuous uniform rotary motion of the cam member whereby the fuel feeding device is intermittently operated at periodic intervals. As already mentioned, the heat motor of my invention may be used in many other capacities, in fact, wherever uniform rotary motion is required.

In Figure 3 of the drawing, I have shown a slightly modified form of heat motor for driving the timing mechanism. In Figure 3 the heat motor is mounted on a panel 11 the same as Figure 1 and the rotary member 26 is the same as that of Figure 1. In the present embodiment there are two bimetal elements 100 and 101 which are rigidly mounted in the position shown, being attached to brackets 102 and 103 respectively. A heating element 104 is disposed within insulating material 105 and is carried on the bimetal element 100, and one end of the heating element is connected to the element 100 while the other end is connected to the source of power. At its upper end the element 100 carries an arm or finger 106 which forms a pawl engaging the serrations on the inner surface of the skirt of member 26. At its upper end the element 101 carries a similar finger 107 forming a pawl also engaging the inner surface of the skirt of member 26. Numeral 108 designates a contact carried at the upper end of element 100 and numeral 109 designates a contact carried at the upper end of element 101. 110 is a permanent magnet. The circuit for heating element 104 extends through the heating element, part of the bimetal element 100, the contacts 108, 109, the bimetal element 101 and the bracket 103 to which the other side of the circuit from the power source is connected. When the heating element 104 is energized to heat the bimetal element, the element 100 warps to the left and the element 101 warps to the right. When the elements cool they warp toward each other so as to bring the contacts 108 and 109 into engagement.

With the parts in the position shown, the heating element 104 has been deenergized so as to allow the elements 100 and 101 to cool so that they have warped toward each other bringing the contacts 108 and 109 together the contacts snapping together when the end of element 100 is brought into the field of magnet 110. A circuit for the heating element is now completed as described above. The heating element 104 being insulated, as long as it is energized its temperature rises as the heat therein accumulates.

The heat causes the bimetal elements 100 and 101 to warp away from each other, contacts 108 and 109 snapping apart when the tension in the bimetal elements overcomes the attraction of the magnet and element 100 causing pawl 106 to rotate the member 26 in a counterclockwise direction in the same manner as this member is rotated in the previous embodiment. The upper end of element 101 warps to the right, with the pawl 107 sliding over the serrations on the inner surface of the member 26. The heat which accumulates in the heater during the time it is energized causes the bimetal elements to continue to warp to some extent after the contacts are opened. When the accumulated heat has been sufficiently dissipated so as to permit the bimetal elements to begin to cool, they warp toward each other with the pawl 107 now rotating the member 26 in a counterclockwise direction and the pawl 106 sliding over the serrations. When the bimetal elements have cooled sufficiently the parts again assume the position shown in Figure 3 and the cycle is repeated. It is to be seen therefore that the arms or pawls 106 and 107 walk around the inner surface of the skirt of member 26 similarly to the operation of the previous embodiment.

The forms of my invention which I have disclosed are representative of manners in which its principles may be applied. There are other forms that it may take and various changes and modifications may be made by those skilled in the art which fall within the spirit and scope of the invention. The invention therefore is to be limited not by my disclosure but only by the claims appended hereto.

I claim as my invention:

1. A heat motor comprising in combination, a movable element, actuating means for the element comprising an arm having a pawl adapted to engage said element, a second arm having a pawl adapted to engage said element, heat responsive means for actuating said arms, a single heater for periodically heating said heat responsive means so that it alternately heats and cools so as to cause it to expand and contract, and means whereby said heat responsive means actuates said arms so as to cause one pawl to move the element in a given direction by reason of the expansion of the heat responsive means and to cause the other pawl to move the element in said given direction by reason of the contraction of the heat responsive means.

2. A heat motor comprising in combination, a rotary cylindrical element, actuating means for the element comprising an arm having a pawl adapted to engage said element, a second arm having a pawl adapted to engage said element, heat responsive means for actuating said arms, a single heater for periodically heating said heat responsive means so that it alternately heats and cools so as to cause it to expand and contract, and means whereby said heat responsive means actuates said arms so as to cause one pawl to move the element in a given direction by reason of the expansion of the heat responsive means and to cause the other pawl to move the element in said given direction by reason of the contraction of the heat responsive means, said arms being arranged within said rotary cylindrical element.

3. A heat motor comprising in combination, a rotary element, actuating means for the element comprising an arm having a pawl adapted to engage said element, a second arm having a pawl adapted to engage said element, heat responsive means for actuating said arms, said heat responsive means comprising a bimetal element of the double helix type, means whereby said heat responsive means alternately heats and cools so as to cause it to expand and contract, and means whereby said heat responsive means actuates said arms so as to cause one pawl to move the element in a given direction when the heat responsive means expands and to cause the other pawl to move the element in said given direction when the heat responsive means contracts, said rotary element being relatively small and said actuating means including the bimetal element being located within the rotary element, the element and actuating arms forming a sufficiently compact device to permit such location but the element by reason of its double-helix formation being capable of producing sufficient motion of the rotary element.

4. A heat motor comprising in combination, a rotary cylindrical element having an annular wall, actuating means for the element comprising an arm having a pawl adapted to engage the interior of said annular wall, heat responsive means for actuating said arm, means whereby said heat responsive means alternately heats and cools so as to cause it to expand and contract, and means whereby said heat responsive means actuates said arm so as to cause said pawl to rotate said element, said actuating means being arranged within the rotary cylindrical element.

5. A heat motor comprising in combination, a movable element, actuating means for the element comprising an arm having a pawl adapted to engage said element, heat responsive means for actuating said arm, means whereby said heat responsive means alternately heats and cools so as to cause it to expand and contract, and means whereby said heat responsive means actuates said arm so as to cause said pawl to move said element, said third means comprising a flexible blade attached to said arm and having one end relatively free to move, a contact carried near said end of the blade, means whereby snap movement is imparted to said contact, said flexible blade permitting snap movement of the contact without corresponding movement of the arm, and switch means including said contact controlling the heating of said heat responsive means.

6. A heat motor comprising in combination, a rotary cylindrical element having an annular wall, actuating means for the element comprising an arm having a pawl adapted to engage the interior of said annular wall, heat responsive means for actuating said arm, means whereby said heat responsive means alternately heats and cools so as to cause it to expand and contract, and means whereby said heat responsive means actuates said arm so as to cause said pawl to rotate said element, said actuating means being arranged within the rotary cylindrical element, and said rotary element being relatively freely rotatable in one direction.

7. In apparatus of the character described, in combination, a movable member, actuating means comprising an expansible and contractible heat responsive element, an arm movable by the element having means forming a pawl engaging the member for rotating it, contacting means controlling the heating of said element, said contacting means being operable by said element to cause it to alternately heat and cool, and means whereby a predetermined amount of ex-

pansion or contraction of the element is required to operate said contacts, said amount of expansion or contraction of the element imparting a predetermined amount of movement to the movable member, and means for adjusting the position of the element whereby a different amount of expansion or contraction is required to operate the contacts and the consequent movement imparted to the movable member is different so as to thereby vary its speed of movement.

8. A heat motor comprising in combination, a movable element, actuating means for the element comprising an arm having a pawl adapted to engage said element, a second arm having a pawl adapted to engage said element, heat responsive means for actuating said arms, means whereby said heat responsive means alternately heats and cools so as to cause it to expand and contract, and means whereby said heat responsive means actuates said arms so as to cause one pawl to move the element in a given direction when the heat responsive means expands and to cause the other pawl to move the element in said given direction when the heat responsive means contracts, said heat responsive means comprising a bimetal element associated with each of said arms, and said means for causing alternate heating and cooling of the heat responsive means including an electrical heater disposed adjacent both bimetal elements so as to simultaneously heat both elements and allow both elements to cool.

9. A heat motor comprising in combination, a movable element, actuating means for the element comprising an arm having a pawl adapted to engage said element, a second arm having a pawl adapted to engage said element, heat responsive means for actuating said arms, means whereby said heat responsive means alternately heats and cools so as to cause it to expand and contract, and means whereby said heat responsive means actuates said arms so as to cause one pawl to move the element in a given direction when the heat responsive means expands and to cause the other pawl to move the element in said given direction when the heat responsive means contracts, said heat responsive means comprising a bimetal element associated with each of said arms, and said means for causing alternate heating and cooling of the heat responsive means including an electrical heater, said heater being arranged between the bimetal elements, and the elements being so constructed and arranged as to alternately warp toward and away from each other.

10. A heat motor comprising, in combination, a movable element, thermosensitive means, means for alternately heating said thermosensitive means and allowing it to cool, a first connecting means between said thermosensitive means and said movable element effective to move said element in a given direction by reason of the movement of said thermosensitive means when it is being heated, and a second connecting means between said thermosensitive means and said movable element effective to move said element in said given direction by reason of the movement of said thermosensitive means in the opposite direction when it is cooling.

11. A heat motor comprising, in combination, a movable element, thermosensitive means, a single electric heater for heating said thermosensitive means, means including contacts positioned by said thermosensitive means for periodically interrupting the energization of said heater so as to allow said thermosensitive means to cool, a first connecting means between said thermosensitive means and said movable element effective to move said element in a given direction by reason of the movement of said thermosensitive means when it is being heated, and a second connecting means between said thermosensitive means and said movable element effective to move said element in said given direction by reason of the movement of said thermosensitive means in the opposite direction when it is cooling.

12. A heat motor comprising, in combination, a movable element, a thermosensitive element, a single electric heater for heating said thermosensitive element, means for periodically energizing and deenergizing said heater to cause said thermosensitive element to be alternately heated and cooled, a pivoted connecting arm between said movable element and said thermosensitive element, said arm being connected to said thermosensitive element so as to be moved in one direction when said thermosensitive element expands upon heating and in the opposite direction when said thermosensitive element contracts upon cooling, and a second arm pivotally mounted on a fixed support and pivotally connected to said first named arm so as to move in a direction opposite to that in which said second named arm is moved, said first and second arms each having one-way connections with said movable element so that each is effective to move said element in the same direction, one of said arms moving said movable element as a result of said thermosensitive element heating and the other moving said movable element as a result of said thermosensitive element cooling.

13. In apparatus of the character described, in combination, means comprising a rotary cylindrical element adapted to rotate about a pivot, said element having an annular wall, means including a member rotatable about the pivot and engageable with the annular wall of said element for rotating the element in one direction, means for oscillating said member to rotate the element, said last means comprising a single heat responsive expansible and contractible device adapted to alternately expand and contract, electrical means including contacts for causing said device to alternately heat and cool, and means whereby said contacts are operated with a snap action by said device.

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