

Sept. 18, 1928.

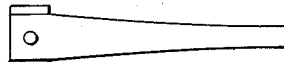
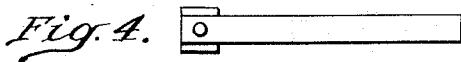
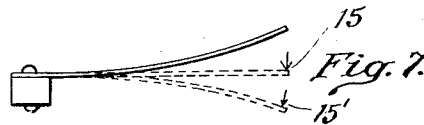
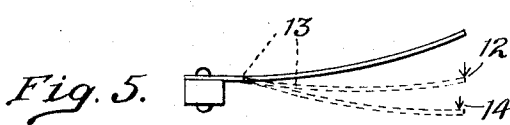
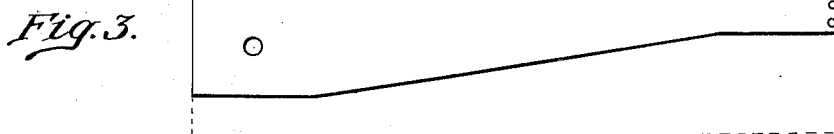
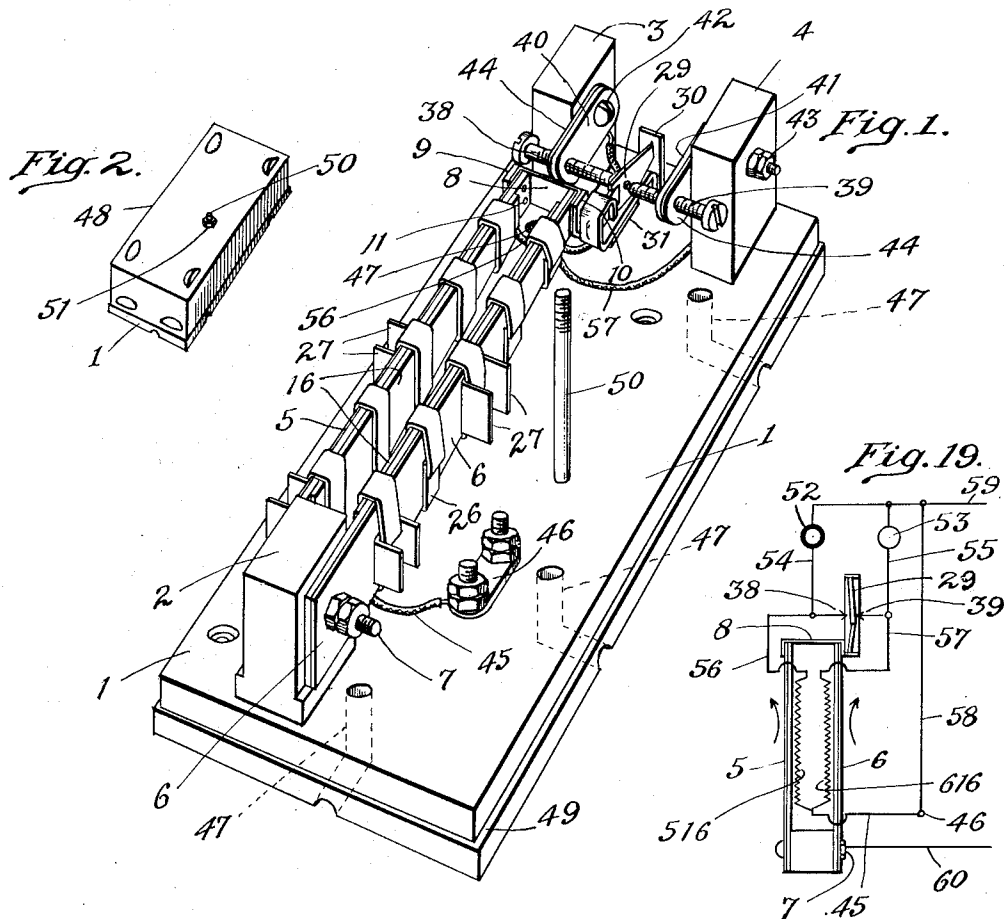
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H. F. LÖWENSTEIN

INTERMITTENT THERMAL SWITCH

Filed April 14, 1920

3 Sheets-Sheet 1



Inventor

Fig. 6. H. Howenstein.

Sept. 18, 1928.

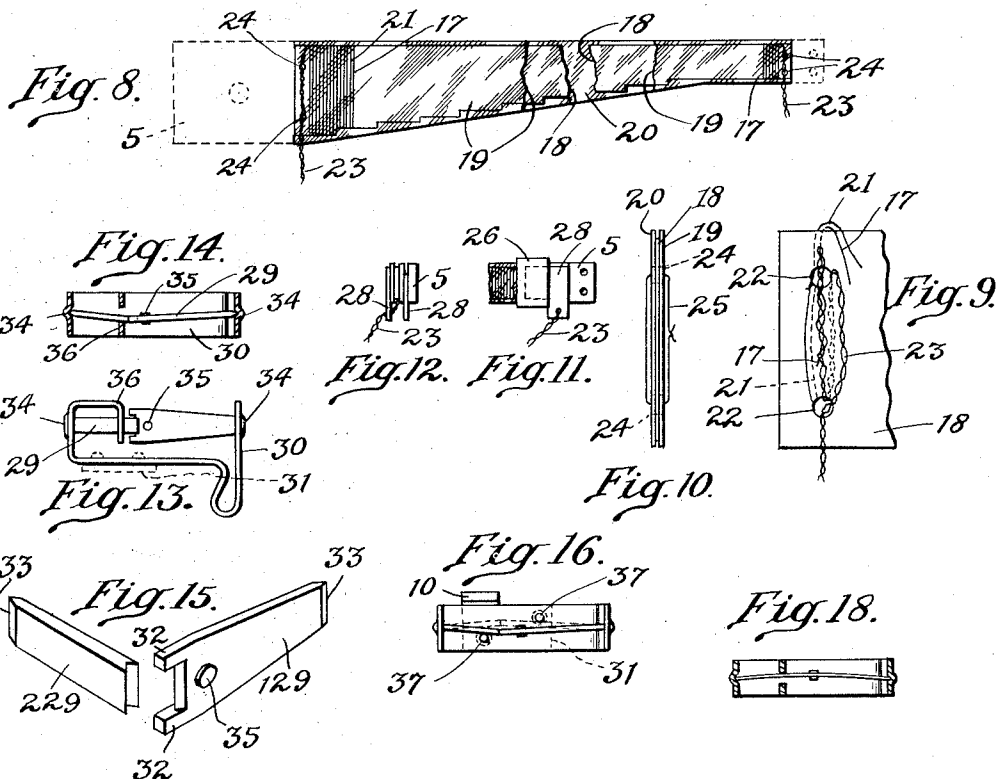
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H. F. LÖWENSTEIN

INTERMITTENT THERMAL SWITCH

Filed April 14, 1920

3 Sheets-Sheet 2



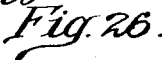
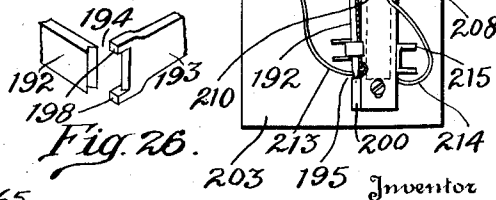
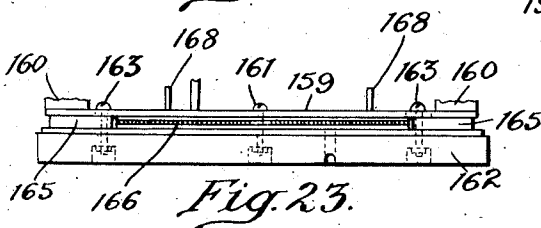
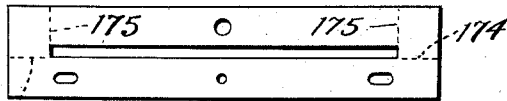
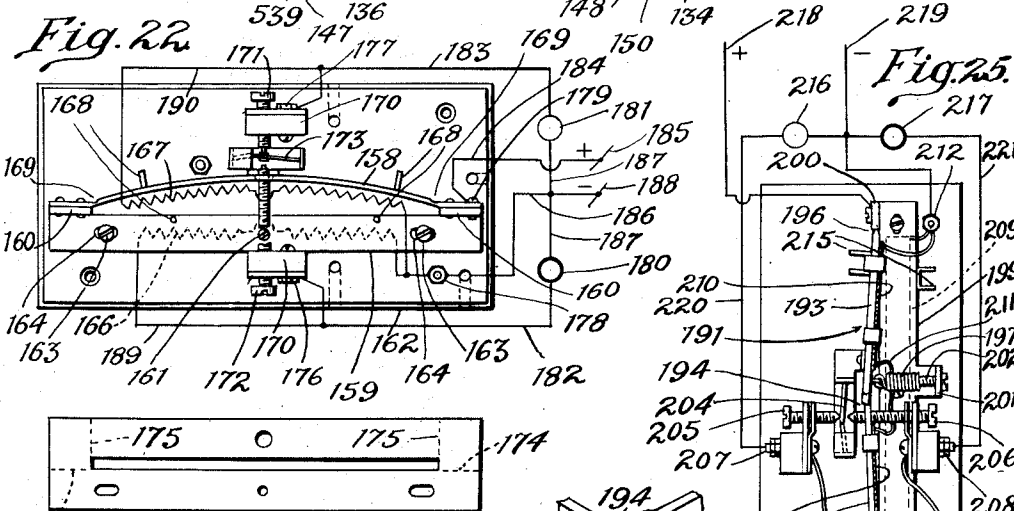
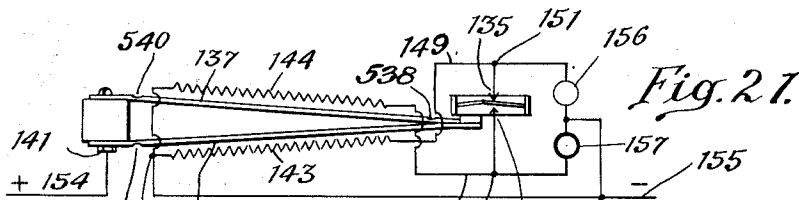
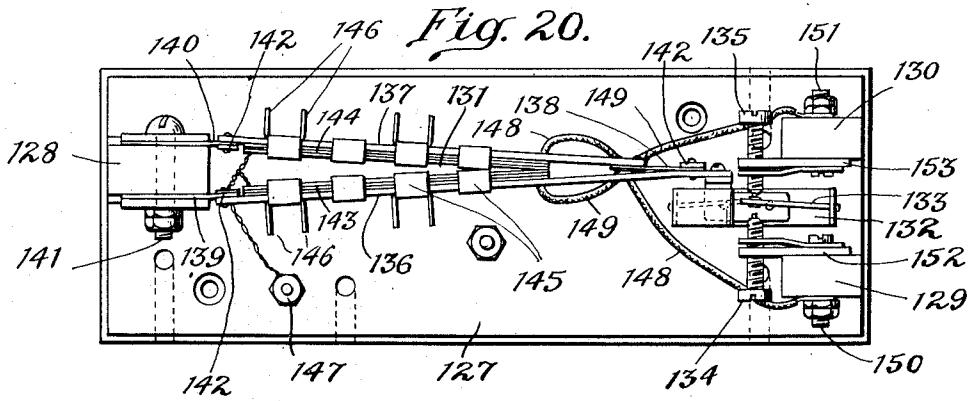
80 Inventor

H. F. Löwenstein

1,684,709

INTERMITTENT THERMAL SWITCH

3 Sheets-Sheet 3



203 195 Inventor

H Löwenstein

UNITED STATES PATENT OFFICE.

HARRY F. LÖWENSTEIN, OF WASHINGTON, DISTRICT OF COLUMBIA.

INTERMITTENT THERMAL SWITCH.

Application filed April 14, 1920. Serial No. 373,768.

My invention relates to intermittent thermal switches and more particularly to the type known as thermal flashers for intermittently switching on and off electrical circuits such as electric light circuits for advertising display.

The general object of the invention is to provide a switch of the above type for either single or double circuits which will be reliable in operation, unaffected by external temperature changes and capable of rapid operation at a comparatively low operating temperature.

Another object of the invention is to provide a thermal switch capable of operating with substantially the same period for both connection and disconnection of a circuit whether working at low or high temperature or fast or slow.

Another object of the invention is to provide a device of the present type in which the amount of work required to effect a given amount of movement of the movable parts is reduced to a minimum.

Another object is to provide a novel form of heating element and means for mounting the same in operative relation to the thermo-motor element such that the heat insulating effect of the heating element itself is reduced to a minimum, and the space occupied by the heating element is substantially reduced.

A further object is to provide an improved, quick-acting, two-way, make and break contact device.

Various other objects of the invention will be apparent from a perusal of the following specification and the drawings accompanying the same.

Applicant is aware of the following patents in the art to which the present invention pertains:

United States Patents; No. 451,520 granted May 5, 1891, to E. W. Rice Jr.; No. 908,679 granted Jan. 5, 1909, to W. V. D. Kelly; No. 921,625 granted May 11, 1909, to W. J. Phelps; No. 1,030,207 granted June 18, 1912, to Rawlings and Sweetser; No. 1,150,001 granted August 10, 1915, to A. H. Miller; and No. 1,150,706 granted August 17, 1915, to M. C. Ryan. Also British patent to Seabrook No. 21,131 of 1904, and British patent to Kelly No. 8231 of 1907.

My invention is illustrated in the accompanying drawings in which:—

Fig. 1 is a perspective view of a double circuit switch embodying the principles of my invention.

Fig. 2 is a perspective view, on a reduced scale, of a cover for the apparatus shown in Fig. 1.

Fig. 3 is a side view of one of the thermostat bars of Fig. 1 with a second bar indicated in dotted lines.

Figs. 4 to 7 are diagrams illustrating the principle governing the design of the thermostat bars of Fig. 1.

Fig. 8 is a detail view of the heating element.

Figs. 9 and 10 are enlarged fragmentary views showing the method of assembling certain parts of the heating element.

Figs. 11 and 12 are detail views illustrating the manner in which the leading-out wires of the heating element are insulated.

Fig. 13 is a side view of the quick make and break contact device.

Fig. 14 is a top plan view of the quick make and break contact device, partly in section.

Fig. 15 is an enlarged perspective view of the toggle-joint element of Figs. 13 and 14, separated to clearly show the structure.

Fig. 16 is a top plan view of a modified form of contact device.

Fig. 17 is a side view of the resilient holder of Figs. 13 and 14 used with the usual bowed spring contact plate.

Fig. 18 is a top plan view of the same.

Fig. 19 is a circuit diagram for the apparatus of Fig. 1.

Fig. 20 is a modified form of my invention using a thermo-motor element of the triangular bracket type.

Fig. 21 is a circuit diagram for the same.

Fig. 22 is a top plan view of a double circuit switch using a novel form of thermo-motor element, the heating elements or coils being shown diagrammatically.

Fig. 23 is a side elevation of the same with portions omitted for the sake of clearness.

Fig. 24 shows a metal blank for a modified form of the thermo-motor element of Fig. 22.

Fig. 25 is a further modification of the form shown in Fig. 22.

Fig. 26 is a fragmentary detail view of a portion of the device illustrated in Fig. 25.

Referring to the drawings in detail, and first to Figs. 1 to 18, 1 represents a base made of insulating material, preferably porcelain,

Fig. 25 is a further modification of the form shown in Fig. 22.

Fig. 26 is a fragmentary detail view of a portion of the device illustrated in Fig. 25.

Referring to the drawings in detail, and first to Figs. 1 to 18, 1 represents a base made of insulating material, preferably porcelain,

with a set of three mounting lugs or posts 2, 3 and 4 extending upwardly therefrom. A pair of compound metal thermostatic bars 5—6 are clamped rigidly to the post 2 by means of a bolt 7, and extend from the post toward the opposite end of the base in substantial parallelism to each other and to the base. The thermostatic bars are connected at their free ends by a strap 8 of flexible material such as thin, sheet spring-brass which overlaps the ends of the bars and a portion of their outer sides where its ends are fastened tightly to the bars by means of the plates 9 and 10, and threaded or riveted bolts 11 as shown in Fig. 1, the plates 9 and 10 serving to evenly distribute the clamping pressure throughout the width of the connecting band where it ends connect with the thermostatic bars as will be readily understood by those skilled in the art.

The thermostatic bars 5 and 6 are arranged so as to move in opposite directions in response to a like change in temperature in both and are preferably arranged so that they will tend to move away from each other upon an increase in temperature as indicated by the arrows in Fig. 19. In assembling the parts, the bars 5 and 6 are arranged to have a tension away from each other at the lowest probable temperature at which the device is to be operated so as to take up any lost motion that might exist in the connection through the strap 8 or in the connection of the bars with the part 2. The flexible connection of the movable ends of the thermostatic bars in a manner to prevent lost motion between them is an important feature of the present invention as it enables all the motion produced to be applied to useful work.

The bars 5 and 6 are shaped as indicated in Fig. 3, and are mounted with their larger ends attached to the post 2 to prevent the bars from assuming the form of a reflex curve when tending to bend under a load which would result in loss of movement at the free ends. Such a reflex curve as would result if a bar of uniform width were used is indicated in Figs. 4 and 5, where Fig. 4 is a side view showing the shape of a test strip of metal fixed at one end, and Fig. 5 is a top edge view of the same. It was found that if the lower bar were given a set in the form of a continuous curve as shown in Fig. 5, such as a bi-metallic thermostatic bar would assume when heated, it would, upon the application of a downward force at the free end as indicated at 12, assume the form of a reflex curve as indicated in dotted lines at 13, and would assume a more exaggerated reflex curve when moved further as indicated at 14. Upon further investigation it was found that a metal bar or strip shaped as indicated in Fig. 6 and curved as indicated in Fig. 7, will simply straighten out when the free end is bent down to the point 15, and will assume a con-

stant downward curve when sufficient force is applied to carry the end to the point 15', as indicated in the dotted line position. The form of bar shown in Fig. 3 is made to approximate that of Fig. 6, but is composed of straight lines in order to prevent waste of material in cutting the blanks, two blanks forming a rectangle as indicated in dotted lines. Thus the tendency to form a reflex curve with consequent loss in efficiency is avoided.

Each of the thermostatic bars 5 and 6, Fig. 1, is provided with a heating element 16, shown in detail in Fig. 8. The heating elements consist generally of a heating coil 17, wound upon a strip of mica 18 and provided on each side with cover strips 19 and 20 also of mica, the whole assemblage being shaped to conform to the shape of the thermostatic bar as illustrated in Fig. 8, where the thermostatic bar is indicated in dotted lines at 5. Any suitable heat resisting, insulating material may be used in place of the mica, but I prefer mica because, in addition to the qualities above mentioned, it will permit the rapid transmission of heat from the coil to the metal bar by radiation, and because the cover strip between the coil and the bar can be made very thin to reduce the path of conduction and make the heat insulating effect of the mica negligible. It will be noted that the cover strips 19 and 20 are made as wide as the thermostatic bar while the core or central strip 18 lies well within the upper and lower edges of the cover strips so as to shield the heating coil. It is also to be observed that the core strip 18 is stepped along the lower or inclined edge so as to form sections parallel to the upper edge and thus avoid the use of a gradually tapering core with its obvious disadvantages. In practice I have found that the heating coil may be wound very close by winding it with a fine thread of cotton (No. 100) interposed between the convolutions of the resistance wire. Cotton thread is preferable to silk as it requires a higher temperature to char or carbonize. As all the various modifications of my invention, herein shown, are capable of working at a temperature below that required to char or scorch such materials as cotton, it is possible to use this simple method of insulating the heating coil without lessening the reliability of operation of the apparatus.

The manner in which the terminals of the heating coil and the separating thread 21 are anchored is shown in Fig. 9 which is an enlarged fragmentary view of one end of the central or core strip 18. Each end of the strip is provided, as shown with perforations 22 through which the ends of the spacing thread are looped and tied, and through which is also looped a suitable flexible lead in the form of one or more twisted strands of fine copper wire 23 having one end connected with one

terminal of the resistance wire 17 and the other end leading out for circuit connections. As indicated in Fig. 10, the cover strips 19 and 20 are provided at the ends with perforations 24 which register with the perforations 22 when the parts of the heating element are assembled, and through these registering perforations a suitable binder is looped and tied as indicated at 25, thus holding the various parts of the heating element together as a unit which may be easily handled without injury to the coil.

As indicated in Fig. 1, the heating elements 16 are held in place on the thermostat bars 5 and 6 by means of metal clamps 26, some of which serve to hold radiating flanges 27. While any metal may be used for these clamps, I prefer to use aluminum because it is a good conductor of heat and is malleable and lacks resiliency which enables the clamps to be easily bent around and pressed into intimate contact with the thermostat bar. This makes the radiating flanges effective in cooling the thermostat bar and holds the heating element snugly against the bar while permitting relative longitudinal movement between the bar and heating element. I use this form of heating element, with suitable variation in shape, in all the various modifications of the invention herein disclosed. Its advantage is that it reduces to a minimum the heat insulating effect of the heating element and its accessories, which makes for an increased rate of heat dissipation and thus enables more energy to be usefully consumed by the apparatus with a given mean operating temperature. The end clamps on each bar serve also to hold in place suitable means for holding the lead wires 23 out of contact with the metal parts as indicated in Figs. 11 and 12, where a pair of L-shaped pieces 28 of insulating material is shown positioned on each side of the end of the heating element with one arm of each extending downwardly and the lead wires leading out between them and through a perforation in one of them.

A buckling contact plate 29 is carried at the movable ends of the thermostat bars in a spring holder 30 fastened to one of the thermostat bars by means of a laterally projecting extension 31 of the clamping plate 10. The buckle plate and its spring holder are shown in detail, approximately actual size, in Figs. 13 and 14. As shown in the enlarged detail in Fig. 15, the buckle plate is made in two parts and in the form of a toggle lever, the arms 129 and 229 of which are connected at the center through a knife edge bearing. In order to prevent accidental displacement of the toggle members, one of them is provided with a pair of horns 32 which extend over the side edges of the other member. The members 129 and 229 have knife edges 33 formed on their outer ends which nest in the V-shaped recesses 34 in the

spring holder 30. A contact in the form of a rivet 35 of platinum or other suitable metal is carried by the member 129. The spring holder 30 is made of resilient material and given a set so as to tend to move the bearing members 34 toward each other and cause the buckle plate to buckle with a quick and snappy movement to one side or the other when moved past its dead-center position. In order to prevent the buckle plate 29 from becoming unseated by buckling out too far, suitable limiting means are provided preferably by bending one end of the holder 30 inwardly and downwardly and bifurcating the end as indicated at 36, the opening in the bifurcated portion being proportioned to limit the movement of the buckle plate to an amplitude slightly greater than the maximum required in operation. A modified arrangement for limiting the movement of the buckle plate is shown in Fig. 16, in which a pair of limiting studs in the form of screw bolts 37 are threaded up through the bottom of the holder on opposite sides of the buckle plate and suitably spaced to limit the movement of the buckle plate as indicated in the dotted and full line positions. In this form the screw bolts serve also to clamp the holder on the member 31.

This idea of means for limiting the amplitude of movement of a buckling plate may be advantageously applied to the ordinary spring buckle plate as shown in Figs. 17 and 18 where the spring buckle plate of the usual form is shown fitted in the same holder as that of Figs. 13 and 14. The advantage of the limiting means will be seen when it is remembered that as the lateral displacement of the center of the buckle plate becomes greater, the greater is the force required to move it back toward the central or straight position and consequently a limitation of the amount of displacement limits the maximum force required to operate the buckle plate.

The mounting posts 3 and 4 support a pair of adjustable contacts in the form of platinum pointed screws 38 and 39, threaded into the metal plates 40 and 41 which are mounted on the posts by means of suitable bolts 42 and 43, respectively. A thinner plate 44 of spring metal is attached to one side of each of the plates 40 and 41 and suitably threaded and tensioned away from the plates to act as a lock-nut for holding the contact screws in adjusted position.

The bolts 42 and 43 are in electrical contact with the contacts 38 and 39 through the plates 40 and 41, respectively, and electrical connection is made between one set of terminals of the heating elements and the contacts 38 and 39 through the flexible leads 56 and 57 which connect with the bolts and plates as indicated. Connection is made with the other terminals of the heating elements through a flexible lead 45 and lock-nut

strip 46. Connection is made with the buckling plate 29 through the thermostat bars 5 and 6 and the bolt 7. Channels 47 are provided in the base member 1 through which
 5 conductors may lead in from the outside through the bottom of the base to the outer ends of the bolts 42 and 43, the bolt 7 and the lock-nut strip 46. A suitable cover 48, shown in Fig. 2, is provided which rests on
 10 the ledge 49 on the base 1 and is held down in position thereon by means of the threaded post 50 and nut 51.

In Fig. 19 are shown the circuit connections for the two circuit flasher of Fig. 1 above described. The lights 52 and 53 are connected through conductors 54 and 55 to the binding posts 42 and 43 which connect through conductors 56 and 57 with one set of terminals of the heating elements 516 and
 20 616 and with the contacts 38 and 39, respectively. The other terminals of the heating elements are connected through conductor 45 binding post 46 and conductor 58 to a line wire 59. The line wire 59 is also connected
 25 direct to one terminal of each of the lamps 52 and 53. Connection is made with the other line wire 60 and the movable contact 29 through the thermostat bars and the bolt 7.

The operation of the device when connected as indicated in Fig. 19, is as follows: With the parts in the position shown and current being supplied over the line wires 59 and 60, the lamp 52 will be extinguished while
 35 the lamp 53 will be lighted by current flowing from line wire 60 through the thermostat bars 5 and 6, contact plate 29, contact 39, conductor 55 and through lamp 53 back over line wire 59. At this time a circuit is also
 40 established for the heating element 616 which may be traced from line wire 60, over the thermostat bars, contact 35, contact 39, conductor 57, heating element 616, conductor 45, binding post 46, conductor 58, and back over
 45 line wire 59. The energization of the heating element 616 heats the thermostat bar 6 which warps over in the direction indicated by the adjacent arrow, carrying with it the other bar 5 and the holder of the movable
 50 contact 35. As the contact holder is moved toward the stationary contact 39, the contacts 35 and 39 remain in contact maintaining the circuit connections of the lamp 53 and coil 616, until contact 35 is buckled just to
 55 the left of its dead-center position, whereupon it snaps over to the left into contact with the stationary contact 38 and out of contact with 39. This breaks the circuit through 35 and 39, extinguishing the lamp 53 and de-
 60 energizing the heating element 616, and completes a circuit through the lamp 52 and heating element 516. The lamp 52 now becomes lighted by current flowing from line conductor 60 through the thermostat bars, con-
 65 tact 35, contact 38, conductor 54, lamp 52 and

back over line conductor 59, while the heating element 516 becomes energized by current from line wire 60 to contact 38, over the path previously traced, and thence through
 70 conductor 56, heating element 516, conductors 45, 58 and back over line wire 59. The energization of the heating element 516 heats the thermostat bar 5 which warps over in the
 75 direction indicated by the adjacent arrow, the other bar 6 moving with it, due to its cooling and the pull exerted through the connection 8, carrying the holder of the movable contact 35 toward the stationary contact 38. As the contact holder moves toward
 80 the stationary contact 38, the contacts 35 and 38 remain in contact maintaining the circuits established therethrough until the movable contact is buckled to the right of its dead-center position whereupon it snaps over to
 85 the right into contact with 39 opening the circuits through the lamp 52 and heating element 516 and again establishing the circuits through lamp 53 and heating element 616, thus completing a cycle of operation
 90 which is repeated indefinitely. It is to be noted that the use of two opposed thermostat bars has two advantages. It makes the device self compensating for external temperature changes and makes it possible to obtain
 95 the same time period for each circuit at different speeds of operation and at different mean operating temperatures. The circuit periods may be varied in relation to each other by varying the amount of current supplied to one or the other of the heating elements and the total period may be varied
 100 without varying the relative periods by varying the amount of current supplied to both heating elements equally, such current variations being effected in a manner well known
 105 in the art. However, I prefer the more simple way of varying the total period by varying the distance between the fixed contacts 38 and 39, the greater the distance the longer the period, and varying the relative periods
 110 by moving both fixed contacts to one side or the other, movement to the right (Fig. 19) making the lighted period of lamp 53 longer and movement to the left increasing the light-
 115 ed period of lamp 52.

The provision of means such as the heat radiating flanges 27, for increasing the rate of cooling of the thermostat bars is an important part of the invention, as it makes for certain improvements in the art to which
 120 the invention pertains, namely, that it enables a device of the present type to be operated at a much lower temperature than has heretofore been attained, other factors such as the amount of work performed, rate of
 125 movement, energy consumed, size of instrument, etc., being the same. With the types of flashers heretofore known, it is necessary to work at an undesirably high temperature when a comparatively rapid movement uni- 130

form in both direction is desired. This is due to the fact that with a low, mean working temperature the rate of heating is greater than that of cooling while as the mean working temperature is increased the rate of cooling increases because of increased radiation and greater difference in temperature between the heated member and the adjacent atmosphere. By an undesirably high temperature in apparatus of this type is meant a temperature sufficient to char or scorch wood, cotton or like substances.

By blackening the surfaces of the thermostat bars, clamps 26 and flanges 27, their ability to rapidly absorb and radiate heat is much improved, resulting in increased efficiency in operation.

The arrangement of Fig. 20 is similar to that of Fig. 1 except that the thermo-motor element, instead of being of the compound metal type, is in the form of a cantilever or bracket built up of rods of a single kind of metal. The base 127 is made of suitable insulating material such as porcelain and is provided with upstanding mounting posts 128, 129 and 130. The post 128 serves as an anchorage or abutment for the thermo-motor element 131 which is mounted thereon and carries at its free end a contact holder 132 and contact plate 133 which holder and plate are the same as that shown in Figs. 13 to 15 and for which may be substituted the modified forms of Figs. 16 to 18. Mounted on the posts 129 and 130 are the normally fixed, adjustable contacts 134 and 135, respectively, which are arranged to be engaged by the contact rivet in the contact plate 133 as it snaps to one side or the other of its dead-center position.

The thermo-motor element 131 consists of a pair of converging expansion bars 136 and 137, flexibly connected at their convergent ends through a section 138 of thin sheet spring metal, thinner and more flexible than the material of the expansion bars and at the same time having a sufficient elastic limit to avoid buckling under any strain to which the parts are ordinarily subjected. The divergent ends of the expansion bars are connected to the post 128 through flexible strips 139 and 140 of the same or similar material as the member 138, by means of the clamping bolt 141. The flexible strips or sections 138, 139 and 140 may be fixed to the expansion bars in any well known secure manner as by soldering or riveting. The manner of fastening shown in the drawing has been found satisfactory in practice and consists simply in riveting on the small binding plates 142 with the end of the flexible strip interposed between the plate and the expansion bar. The purpose of the binding plate is to extend the clamping surface and make a straight line of connection between the flexible and non-flex-

ible members. The expansion bars are provided with electrical heating elements 143 and 144 similar to those of Fig. 1, the heating elements being held in place by bands 145, preferably of aluminum, which also serve to hold the radiating flanges 146 in contact with the expansion bars. The ends of the heating elements toward the mounting post 128 are connected in multiple through a suitable flexible conductor to the binding post 147, as shown. The other terminals of the heating elements are connected individually through flexible conductors 148 and 149 to the binding posts or bolts 150 and 151, respectively. It will be observed that the binding posts 150 and 151 are in electrical contact with the adjustable contacts 134 and 135 through the mounting bars 152 and 153, respectively.

The operation of the arrangement of Fig. 20 is as follows, reference being had to Fig. 21 for the circuit connections. Assuming the parts to be in the position shown and current supplied over the mains 154 and 155, current will flow from main 154 to binding post 141, expansion bars 136 and 137, contact plate 133, contact 135 to binding post 151 where the circuit divides, one branch passing by way of conductor 149 through heating element 143 to binding post 147 and back over main 155, the other branch passing through lamp 156 to main 155. The lamp 156 is thus lighted and the heating element heats up the expansion bar 136 which expands, moving the holder of the contact plate 133 over in the direction of the contact 135, the contact 135 remaining in contact with the contact plate and maintaining the heating element 143 and lamp 156 energized until the plate 133 is bucked past its dead-center position, whereupon it snaps over into engagement with contact 134 which interrupts the circuits of the heating element 143 and lamp 156. Engagement of the contact plate 133 with the contact 134 completes the circuit of the heating element 144 and lamp 157 over the following path; main 154, binding post 141, expansion bars 136 and 137, contact plate 133 to binding post 150 where the circuit divides, one branch passing over conductor 148 through heating element 144, binding post 147 to main 155, the other branch passing through lamp 157 to main 155. The lamp 157 is thus lighted and the heating element 144 energized to heat the expansion bar 137. The expansion bar 137 heating up causes the holder of the buckling contact plate 133 to move toward the contact 134 maintaining the circuits of the heating element 144 and lamp 157 completed until the contact plate is buckled past dead-center toward the contact 135, whereupon it snaps over into contact with the contact 135 and out of contact with 134, opening the circuits of lamp 157 and heating element 144 and again clos-

ing the circuits of lamp 156 and heating element 143. This completes one cycle of the operation which is repeated indefinitely.

Some of the novel features of the present device which result in certain advantages over known devices of the same general type will now be pointed out. In the present device greater movement of the free end of the thermo-motor element for a given amount of energy expended is attained by the use of the flexible connections 138, 139 and 140 at the angles of the triangular figure formed by the convergent expansion bars and their support. It will be clear that due to the saving of such extra force as would be required to bend all three angles of the triangle if the joints at the angles were of the same degree of stiffness required for the expansion bars, the bars may be substantially reduced in thickness without liability of buckling, which reduction in thickness reduces the amount of energy necessary to raise their temperature a given amount. The use of the flexible joints also permits the expansion bars to be arranged at a more acute angle than would be practicable with the known form of stiff joint structure. This decrease in the vertex angle of the convergent bars increases the ratio of the extent of lateral movement of the vertex to the variation in length of one of the expansion bars. Such a small or acute angle as applicant uses could not be used where the whole structure is of uniform cross-section because the increased ratio of movement would require a very great increase of force to bend the structure at all three angles against the decreased leverage which would result in buckling the expansion bar. Consequently it was sought heretofore to multiply the movement by various mechanical expedients in which it was difficult if not impossible to eliminate lost-motion, the existence of which in the least degree greatly decreases the efficiency and reliability of devices of this type. In the present device an angle of 10° or less between the expansion bars of the thermo-motor element is practicable, and an angle of approximately 6° has given satisfactory results in practice. It is found that the ratio of the amplitude of swing of the free end of the triangle to an increase in length of one of the long sides is substantially the same as the ratio of the length of one of the long sides (in an isosceles triangle) to the base, and as the base angles approximate a right angle when the apex angle is small, the ratio of increased movement is substantially equal to the cotangent of the angle between the long sides. Thus in the present case where the angle is about 6° the ratio is substantially 1 to 9.5144, the cotangent of 6° .

Where a cheaper structure is desired, the flexible joints at the corners of the triangle may be formed by thinning out the expansion

bars as indicated at 538, 539 and 540 in Fig. 21. However, where long life is a more important factor than cheapness, it is preferable to form the flexible joints of separate pieces of metal because it enables the use of a different kind of metal which may be selected for such qualities as flexibility and lack of brittleness or a tendency to crystalize under frequent bending.

In the form illustrated in Figs. 22 and 23, the thermo-motor element is of the arched or bowed type which by the novel construction shown is rendered self compensating for external temperature changes. This is accomplished by mounting the bowed expansion bar 158 on a second expansion bar 159 forming a cord, the cord being of the same material or having substantially the same coefficient of expansion as the bow. The preferred material is brass because of its high coefficient of expansion although other metals such as copper or iron may be used. The bowed member 158 is attached at its ends to the ends of the cord member 159 by means of the upstanding ears 160 at the ends of the cord member, the parts being firmly held in any suitable manner as by the rivets shown. By arranging the cord member with the plane of its width parallel to the direction of movement of the bow member it is strengthened against bending under the forces applied thereto in operation. To hold the cord member flat during operation it is fastened at its center by a bolt 161 to a base 162 of suitable insulating material such as porcelain. The ends of the cord member are thus free to expand and shrink away from and toward the center, in which movement the ends are held down on the base by the heads of the bolts 163 whose shanks pass through longitudinal slots 164 in the cord member. The cord member is spaced slightly above the base by the elevated portions 165 through which the bolts 163 pass, the purpose of the spacing being to accommodate a suitable electrical heating element 166. A suitable heating element 167 is also provided for the bowed member 158. These heating elements are shown only diagrammatically in Fig. 22, for the sake of clearness, it being understood that they may be in the form of coils of resistance wire wound on strips of mica or other insulating material and faced or covered on each side with other strips of insulating material, which form of heating element has been described in detail in reference to Figs. 8 to 12.

Both the bow and cord members are provided with radiating flanges which for simplicity are shown as consisting of projecting lugs or studs 168 of heat conducting material, but which may be of any form such for example as that shown in Figs. 1, and 20. To reduce the amount of force required to bend the bow member at the line of junction with its support, it is thinned out at these places

as indicated at 169 to make it more flexible. It will be obvious that in lieu of this thinning out of the metal I may use extra pieces of flexible material as in the arrangement of Fig. 20. Mounting posts 170 are formed on the base 162 on which are mounted the adjustable contacts 171 and 172. The bow member 158 carries a two way snap movement contact member 173 positioned between the adjustable contacts, the adjustable contact 172 passing through an opening in the bow member into operative relation with the contact 173.

In Fig. 24, is shown a blank formed of a single piece of metal from which the thermomotor element of Fig. 22 may be formed by bending the upper portion at right angles to the lower portion along the dotted lines 174 and bowing or curving the upper portion between the dotted lines 175 with a suitable die or by hammering or other known method.

The left hand terminals of the heating elements 166 and 167 are connected to the binding posts 176 and 177 which are electrically connected with the adjustable contacts 172 and 171, respectively. The right hand terminals of the heating elements are connected in multiple to the binding post 178. The contact member 173 is electrically connected with the binding post 179 through the metal body of the bow element 158.

The outside circuit connections for a double circuit control such as the two lamps 180 and 181, consists of the conductors 182 and 183 connecting one terminal of each of the lamps 180 and 181 with the binding posts 176 and 177, respectively, a conductor 184 connecting binding post 179 with one of the power mains 185, conductors 186 and 187 connecting the binding post 178 and the other terminals of the lamps in multiple to the other power main 188, and conductors 189 and 190 connecting the left hand terminals of the heating coils 166 and 167 with the binding posts 176 and 177, respectively.

The operation of the arrangement of Fig. 22 is as follows: Assuming the parts to be in the position shown, the heating element 167 will be energized and the lamp 181 lighted by current from main 185, over conductor 184, through binding post 179, bow member 158, contact member 173, stationary contact 171 to binding post 177 where the circuit branches, one branch passing by way of conductor 190 through the heating coil 167, connection 178, 186 to main 188, the other branch passing over conductor 183 through lamp 181, conductor 187 (common to both lamps) to main 188. Heating element 167 becoming energized raises the temperature of the bow member 158 which moves upwardly causing the contact member 173 to bear against the fixed contact 171 until the contact 173 is buckled downwardly just past its straight or dead-center position when it snaps down into en-

gagement with the fixed contact 172 and out of engagement with contact 171. This opens the circuits of the lamp 181 and heating element 167, and closes the circuits of the lamp 180 and heating element 166. The lamp 181 now becomes extinguished and the bow element 158 is permitted to cool and so move downwardly. The circuit connection now completed for the lamp 180 and heating element 166 may be traced as follows; main 185, binding post 179, 158, 173, 172 to 176, where the circuit branches, one branch passing by way of 189, 166, 178, 186 to main 188 and the other branch passing by way of 182, 180, 187 to main 188. Heating element 166 becoming energized, raises the temperature of the cord member 159 which expanding accelerates the downward movement of the bow member 158. The bow member moving downwardly causes the contact member 173 to bear against the contact 172 maintaining the closure of the circuits last traced until the contact member is buckled upwardly past its straight or dead-center position whereupon it snaps up into engagement with the adjustable contact 171. This opens the circuits of lamp 180 and heating element 166 and again closes the circuits of lamp 181 and heating element 167, completing a cycle of operation which is then repeated indefinitely.

It is to be understood that the curvatures of the arc or bow member in Fig. 22 is exaggerated for the sake of illustration, but that in practice it can be made very slight with a consequent multiplication of the amount of movement of the movable contact member. This is possible only when the flexible joints are used, for reasons which will be obvious.

The device shown in Fig. 25 is in the nature of a modification of that of Fig. 22, differing therefrom in that the bow member 191 is in the form of a toggle-lever composed of the members 192 and 193 with knife-edge bearings 194, 195 and 196 maintained seated by the retractile spring 197. The bearing 194 is formed as shown in Fig. 26 with horns 198 at the ends of the knife edge member arranged to overlap the ends of the socket member to prevent the knife edge from sliding out of the socket. The cord member 199 is made of the same material, or a material having substantially the same coefficient of expansion, as the toggle-lever member and is similar in shape to the cord member 159 of Fig. 22 except that the abutments 200 are provided with troughs or V-sockets forming one member of the knife-edge bearings 195 and 196. A mounting post 201 is formed on the side of the cord member 199 to which the retractile spring 197 is anchored by means of the adjusting screw 202 which threads into the convolutions of one end of the spring, the other end of the spring being attached

to the member 193 of the toggle. The cord member 199 is mounted on the base 203 in identically the same manner as that of Fig. 22. A quick make-and-break two way contact member 204 is carried by the member 193 of the toggle and plays between the two adjustable contacts 205 and 206 which are mounted on the base 203 and electrically connected with the binding posts 207 and 208 in a manner similar to that of Fig. 22 and which will be obvious to those skilled in the art from an inspection of Fig. 25. A suitable heating element 209 is provided for the cord member 199, mounted beneath the same in the same manner as that of Fig. 22. The toggle 191 is provided with a pair of heating elements 210, one for each of the members 192 and 193, connected across the middle joint of the toggle by a flexible conductor 211. One terminal of each of the heating elements is connected to the binding post 212, while the other terminals are connected individually through the flexible conductors 213 and 214 with the contacts 205 and 206, respectively, as shown. To increase the rate of cooling, all the expansion members 192, 193 and 199 are provided with radiating flanges 215.

For controlling a pair of circuits such as the circuits of the lamps 216 and 217, the circuit connections are as indicated in the drawing and will be clearly understood from the following description of operation.

In operation, starting with the various parts in the position shown and current supplied over the mains 218 and 219 from a suitable source not shown, the heating elements 210 and the lamp 216 will be energized by current over the following path; main 218, body of toggle member 193, contact 204 to contact 205, where the circuit divides, one branch passing over conductor 213, through heating elements 210, binding post 212, to main 219, the other branch passing through binding post 207, conductor 220 lamp 216 to main 219. The lamp 216 is thus lighted while the heating element 210 heats up the toggle-lever bow member 191 which expanding buckles toward the contact 205 causing the contact member 204 to bear thereagainst and maintain the continuity of the circuit just described, until contact 204 is buckled past its dead-center position whereupon it snaps over into engagement with the contact 206 and out of engagement with contact 205 which opens the circuit just traced, extinguishing the lamp 216, deenergizing the heating element 210, and completing the circuits of the heating element 209 and lamp 217. The heating element 209 and lamp 217 are now energized by current over the following path; main 218, body of toggle member 193, contact 204, contact 206, where the circuit divides, one branch passing through conductor 214, heating element 209, binding post

212 to main 219, the other branch passing through binding post 208, conductor 221, lamp 217 to main 219. Energization of the heating element 209 causes the cord member 199 to heat up, and expanding, separates the abutments 200 which permits the toggle or bow member 191 to straighten and move toward the right by force of the spring 197, the rate of which movement being augmented by the shrinkage of the toggle or bow member due to cooling. As the bow member moves toward the right, the contact member 204 bears against contact 206 maintaining the continuity of the circuit just traced until the contact member 204 is buckled past its dead-center position whereupon it snaps over into engagement with contact 205 and out of engagement with contact 206, opening the circuits last traced and again closing the circuits of the lamps 216 and heating element 210. This completes one cycle of the operation which is repeated indefinitely as long as the current supply is maintained.

It is to be noted that the operation may start from a point in the cycle other than that above described. For example, it may start with the movable contact 204 in engagement with the contact 206, in which case the first movement would be a movement of the toggle or bow member 191 to the right caused by expansion of the cord member 199. In either case, after the first cycle of operation, the movement of the bow-member to the right is accelerated by the combined effects of its cooling and the heating of the cord member, while movement to the left is accelerated by the combined effects of the heating of the bow member and the cooling of the cord member. By anchoring the retractile spring 197 to a post 201 carried by the cord member 199, the process of assembling is simplified, but if desirable the post 201 may be made separate from the cord member in any suitable manner to constitute a stationary support for the spring as would suggest itself to those skilled in the art.

While I have herein shown and described certain specific embodiments of my invention for the purpose of disclosure, it is to be understood that I do not limit myself to such specific embodiments, but contemplate all such variants and modifications thereof as fairly fall within the scope of the appended claims.

Having thus described my invention what I claim and desire to secure by Letters Patent is:—

1. In an intermittent thermal switch, a thermo-motor element therefor having relatively movable parts of homogeneous material flexibly connected with each other through a piece of flexible material fixedly joined to said parts.

2. In an electrically operated time element switch, the combination of an expansion ele-

ment, electrical heating means operatively associated with one side of said expansion element, and a radiating flange of heat conducting material operatively connected with the other side of said expansion element.

3. In an electrically operated time element switch having a thermo-motor element comprising two divergent bars connected together at one end and to separate points on a base at the other end, an electrical heating element attached to and covering each of the adjacent surfaces only of the bars, whereby the heating element of each bar will tend to shield it from the heat of the heating element of the other, and the function of dissipating heat from the bars is delegated to the remote surfaces of the bars.

4. In an intermittent thermal switch, a thermo-motor element and a quick make and break contact comprising a buckle plate in the form of a toggle lever, a spring holder arranged to carry and hold the buckle plate under tension applied at its ends through trough and knife edge connections and tending to buckle said lever formed of two substantially rigid members hingedly joined through a trough and knife edge connection, and opposed engaging means arranged at opposite sides of said toggle to be alternately engaged by the same, in the movement of said motor element, to move the center pivot of said lever past center against the force of said tension means whereby the lever is caused to move from one engaging member to the other with a snap movement.

5. In an intermittent thermal switch, a quick make and break contact comprising a toggle lever formed of two substantially rigid members hingedly joined through a trough and knife edge connection, tension means tending to move the extreme pivots of the toggle toward each other to buckle the center portion to either side of the line of the extreme pivots, a pair of contact members situated at opposite sides of the toggle and arranged to alternately bear thereagainst at a point near the central pivot between the center pivot and one of the extreme pivots to cause the center pivot of said lever to move from one of said contact members to the other with a quick snappy movement.

6. In a thermostatic switch, a thermo-motor element, and a quick make and break contact member operated thereby and comprising a toggle lever, tension means tending to move the extreme ends toward each other and cause the lever to buckle to either side, a pair of contact members situated at opposite sides of the toggle and means for limiting the

throw of said toggle lever independently of said pair of contact members.

7. In an intermittent thermal switch, a quick make and break contact device in the form of a buckle plate adapted to buckle with a snap movement from one side to the other under tension applied at its ends, and a spring holder arranged to hold the buckle plate under tension applied at its ends and directed inwardly to cause the plate to buckle to either side, and limiting means carried by said spring holder for limiting the movement of the buckle plate.

8. In an intermittent thermal switch, a thermo-motor element and a quick make and break contact device comprising a toggle lever formed of two substantially rigid members pivotally connected together at one end each and at the other ends to spring pressed abutments through trough and knife edge connections.

9. In an intermittent thermal switch, a thermo-motor element comprising a fixed abutment, and a pair of expansion members connected at one end each to said abutment and hingedly connected together at the other ends through a strip of relatively flexible material.

10. In an electrically operated time element switch having a thermo-motor element comprising a pair of bars arranged side by side, an electrical heating element attached to and substantially covering each of the adjacent surfaces only of the bars, whereby the heating element of each bar will tend to shield it from the heat of the heating element of the other, and the function of dissipating heat from the bars is delegated to the remote surfaces of the bars.

11. An intermittent thermostatic switch comprising a thermo-motor element in the form of a V-shaped bracket with the arms of the bracket set at an angle to each other of less than ten degrees, a heater for each arm, a double throw switching element secured to the convergent end of the thermo-motor element arranged to be moved through an appreciable space against resistance and connected to alternately connect said heaters for effecting the heating of one arm of the bracket while simultaneously permitting the cooling of the other arm to expand one and contract the other, and means for preventing buckling of an arm of the bracket during expansion of one and contraction of the other comprising flexible joints situated at the three angles of the V-shaped bracket.

In testimony whereof I affix my signature.

HARRY F. LÖWENSTEIN.