Oct. 8, 1957 W. C. BROEKHUYSEN 2,809,253

ELECTRICAL CONTROL DEVICES

Filed Nov. 28, 1952 2 Sheets-Sheet 1

Fig. 1.

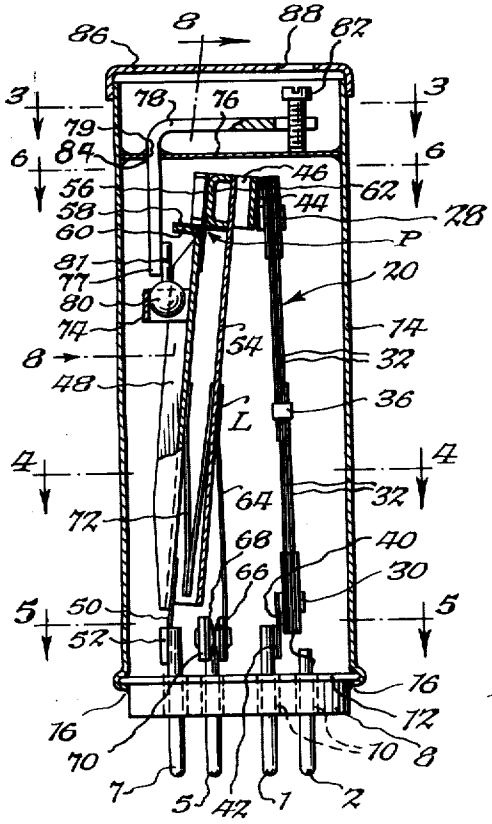


Fig. 2.

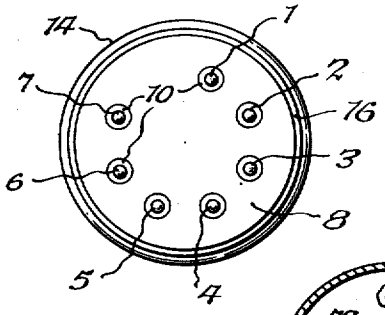


Fig. 3.

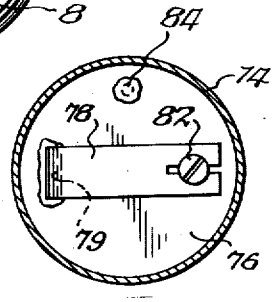


Fig. 4.

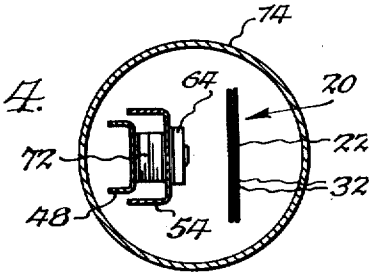


Fig. 5.

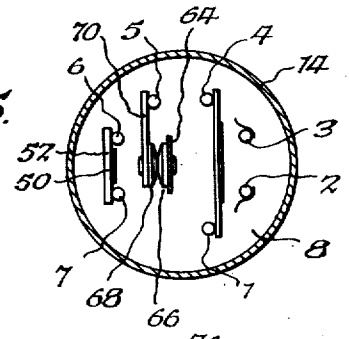


Fig. 6.

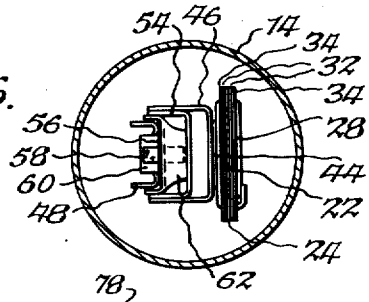
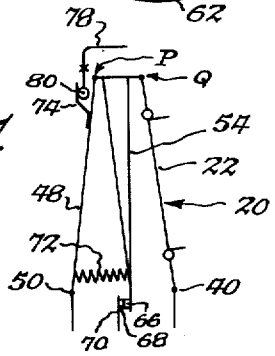


Fig. 7.



INVENTOR.
William C. Broekhuysen
BY
Nathaniel R. Clapham
Attorney.

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ELECTRICAL CONTROL DEVICES

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Fig. 8.

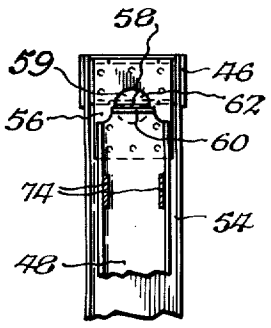


Fig. 9.

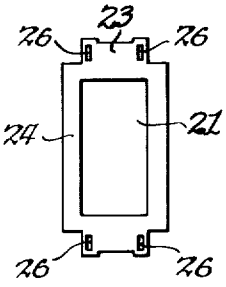


Fig. 10.

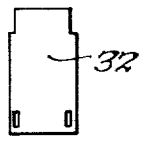


Fig. 11.

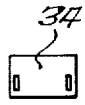


Fig. 12.

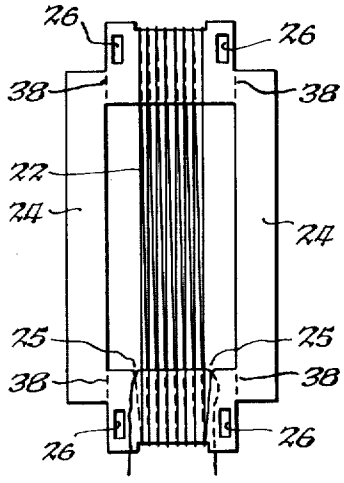


Fig. 13.

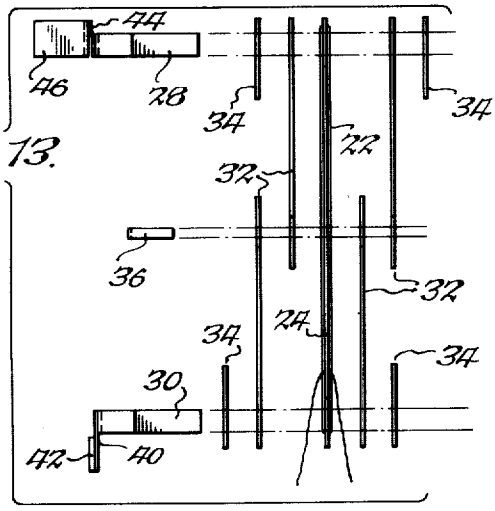


Fig. 14.

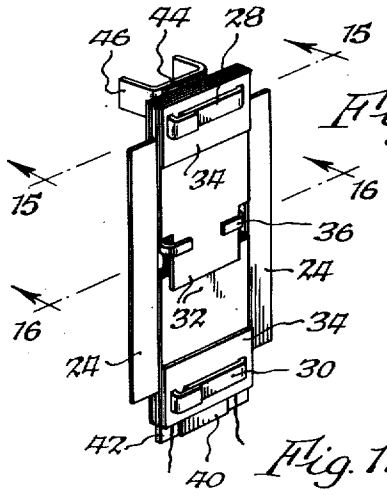


Fig. 15.

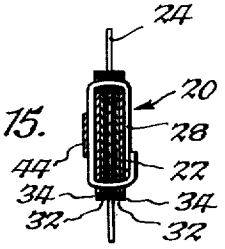


Fig. 16.

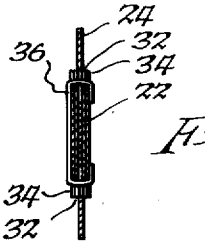
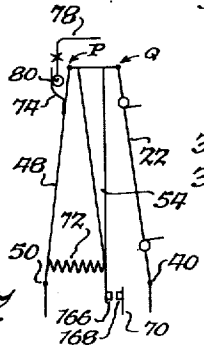


Fig. 17.



INVENTOR.
William C. Broekhuysen
BY
Whitworth & Clapham
Attorney.

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2,809,253

ELECTRICAL CONTROL DEVICES

William C. Broekhuysen, Brooklyn, N. Y., assignor to G-V Controls Inc., a corporation of New Jersey

Application November 28, 1952, Serial No. 322,905

25 Claims. (Cl. 200—113)

This invention relates to electrical control devices, and more particularly to electro-thermally actuated relays of the directly heated type, known as hot wire relays.

On account of the difficulty in obtaining and maintaining adequate spacing between several strands of resistance wire which are connected electrically in series but mechanically in multiple, hot-wire relays heretofore known in the art have usually been limited for use with relatively low voltages requiring only a single loop of wire. The construction of this type of relay for higher voltages involved a more or less complicated arrangement of pulleys over which the wire was strung back and forth. The use of this type of relay has also been limited because they were not suitable for timing periods of more than two to three seconds. Thermal relays of the so-called indirectly heated type are not satisfactory for many uses because they cannot be used below ten seconds if reasonably fast recycling is required. This left a range in which thermal relays could not be used effectively except under certain limitations.

The above limitations are substantially completely overcome by my invention. The construction of my novel relay enables me to use many loops of resistance wire due to my novel method of forming the heating assembly or expanding element, which method is simple and lends itself readily to quantity production. The construction of a relay made in accordance with my invention also provides means for increasing the time constant of the directly heated expanding assembly or element so that the relay can be used efficiently for timing periods as high as twenty seconds without sacrificing the fast recycling characteristic of a hot-wire relay.

In addition my novel relay can also be compensated substantially completely for wide variations in ambient temperature, and it can be adjusted externally for a wide range of timing periods even though it is enclosed in an hermetically sealed housing or casing.

Accordingly it is an object of my invention to provide a novel method of constructing a hot-wire thermal relay having a heating element employing a plurality of loops of resistance wire, which method is simple and readily adaptable for quantity production.

The invention also consists of a simple and novel method of forming a hot-wire relay heating element having a plurality of loops of resistance wire, and wherein all strands lie in substantially the same plane.

Another object of the invention is to provide a novel hot-wire relay having means for extending the timing range or the time constant thereof to as high as ten times the normal range or constant of hot-wire relays heretofore known in the art, without sacrificing its fast recycling characteristics.

An additional important object of the invention is to provide a novel highly efficient hot-wire thermal time-delay relay which is smaller in size than other devices of this type, and yet one which is rugged and substantially vibration resistant.

Another object of the invention is to provide an hermetically sealed hot-wire relay which can be adjusted

simply and repeatedly over a wide range, not only when and where it is made, but also wherever it is in use, without destroying the hermetic seal, and wherein the adjustment remains unchanged at all times even under adverse operating conditions.

The invention also consists in the provision of a device of the type described which is fully compensated for changes in ambient temperature over a wide range. The invention is also characterized by the provision of a device in which, if desired, the timing or regulation can vary with ambient temperature in a predetermined manner.

Other objects of my invention will be set forth in the following description and drawings which illustrate preferred embodiments thereof, it being undertsood that the above statement of the objects of the invention is intended generally to explain the same without limiting it in any manner.

Referring now to the following detailed description taken in conjunction with the accompanying drawings, which form a part of this specification, and in which like characters of reference indicate the same or like parts:

Figure 1 is a vertical central sectional view, with parts in elevation, showing a preferred form of my invention.

Figure 2 is a bottom view of the structure shown in Figure 1.

Figure 3 is a sectional view taken along line **3—3** of Figure 1.

Figure 4 is a sectional view taken along line **4—4** of Figure 1.

Figure 5 is a sectional view taken along line **5—5** of Figure 1.

Figure 6 is a sectional view taken along line **6—6** of Figure 1.

Figure 7 is a diagrammatic representation of the operative elements of the form of invention shown in Figure 1.

Figure 8 is a sectional view taken along line **8—8** of Figure 1.

Figures 9, 10, and 11 are face views of insulating parts.

Figure 12 is a face view of the heating element as first wound.

Figure 13 is a side or edge view of heater and mounting and clamping parts in exploded relationship.

Figure 14 is a perspective view of a completed heater element ready for assembly with the remainder of the structure.

Figure 15 is a sectional view taken along line **15—15** of Figure 14.

Figure 16 is a sectional view taken along line **16—16** of Figure 14.

Figure 17 is a diagrammatic representation of the structure of a relay having normally open contacts.

The structure made in accordance with the invention, is referred to herein as a thermal time-delay relay. However, it may also find application in other functions, such as for example, a discriminator or regulator for potential, current or frequency in electrical circuits. Therefore, wherever in the following specification the device embodying the invention is referred to as a time-delay relay, such other functions are meant to be included, since the construction of the device is substantially the same for all purposes.

In a preferred embodiment of the invention selected for purposes of illustration and shown in Figures 1–16, the entire internal operating structure is supported on seven pins, numbered **1** to **7**. Unless otherwise specified, all mechanical and electrical connections may conveniently be made by spotwelding. Pins **1** to **7** are insulated from, and hermetically sealed into a suitable base, such as a disc-shaped metal base **8** by glass beads **10**. Base **8** is provided with a rim **12**, Figure 1, which is rigidly crimped in the lower edge of casing **14**, preferably cylindrical in form. The seam is hermetically sealed by solder as at 16.

The heated timing member designated generally **20** consists of a grid of fine resistance wire **22** wound originally on a frame **24** of suitable shape and thickness made of a suitable insulating and heat resistant material with high mechanical strength and rigidity, such as mica (Figures 9 and 12). As illustrated in Figures 9 and 12, frame **24** is substantially rectangular in shape and is provided with an extension **23** at each end. Frame **24** is also formed with a central cut out portion, such as window **21**, which in the preferred form is rectangular in shape. The wire **22** is wound around the full length of frame **24** back and forth over end projections **23**, and between ears formed on projections or extensions **23**, as many times as is required for the desired resistance. The two ends of the winding are secured in V-shaped notches **25** as shown in Figure 12.

Each end extension **23** of frame **24** is provided with two spaced slots **26**. The frame is supported at top and bottom on two flat staples **28** and **30** made of a suitable material, such as stainless steel, which extend through the slots. Staple **30** is connected to a short flexible leaf spring **40** secured to a strip **42**. Staple **28** is connected to another flexible leaf spring **44** attached to a U-shaped bracket **46**. Parts **40—46** preferably are also made of stainless steel.

Also supported on staples **28** and **30** are four pieces **32** (Figure 10), two on each side of grid **22**, and four pieces **34** (Figure 11), two on each side of grid **22**. Parts **32** and **34** are made of a suitable insulating and heat resistant material, such as mica. These parts are assembled or stacked on staples **28** and **30** in the order shown in Figure 13, after which the long arms, and then the short arms of the staples are bent over, tightly clamping pieces **32** and **34** together with frame **24**.

Bent over arms of staples **28** and **30** also secure the strands of grid **22** in proper spaced relationship on frame **24**. The overlapping central parts of mica leaves **32** are held together by a small flat staple of nickel ribbon or other suitable material **36**. After this assembly, shown complete in Figure 14, has been attached to the rest of the structure, which holds it under tension, as will be explained hereinafter, the two sides of frame **24** are cut off along broken lines **38** shown in Figure 12. This leaves the wire grid **22** as the only member to take up this tension. This completes the formation of heating element **20**.

From a reference to Figures 1, 12 and 14 to 16, it will be evident that the heating element **20** may be termed substantially uniplanar. Thus when a current is passed through the wire of grid **22**, the elongation thereof is longitudinal only, and there is substantially no flexing.

Pins **6** and **7** support the lower end of compensating member **48**. This member preferably is channel shaped for rigidity. A flat leaf spring **50** forms a flexible connection between compensating member **48** and strip **52**, rigidly fixed to pins **6** and **7**. For complete ambient temperature compensation member **48** is made of a metal having substantially the same coefficient of thermal expansion as the wire of grid **22**. Compensating member **48** is substantially the same length as the free length of wire grid **22**.

The structure includes movable arm **54** which, as shown in the illustrated embodiment, consists of an open channel partly surrounding member **48**. See Figures 1, 4 and 6. One end of arm **54** is pivotally connected to the top of member **48** at a point designated P by two crossed springs **56** and **58**. Spring **58** is positioned substantially horizontally, and extends through a suitable opening **59** formed in the center of spring **56**. As shown in Figure 8, opening **59** may be circular, and of a size such as to prevent any engagement between springs **56** and **58**. One end of spring **58** is secured to a bent over tip **60** of member **48**. The other end of spring **58** is attached to a flange of bracket **62** rigidly secured to movable arm **54**. Spring **56** is arranged substantially at right angles to spring **58**, and is also secured to member **48** and bracket **62**. Bracket **46** of heated timing member or heater assembly **20** likewise is secured to the upper end of arm **54**. Bracket **42** at the lower end of heated timing member **20** is rigidly secured to pins **1** and **4**. The two ends of wire grid **22** are connected to pins **2** and **3**.

A leaf spring **64** carrying at its lower free end a contact **66**, is connected to the outer face of arm **54**, at a point designated L. Spring **64** is biased in such manner that, when free, it bears with a positive resilent pressure against the lower edge of arm **54**. Normally, as shown in Figure 1, it is held a sort distance away from this edge of arm **54** because of the engagement of contact **66** with fixed contact **68** on bracket **70** rigidly attached to pin **5**.

A V-shaped leaf spring **72**, the free ends of which are secured to the inner face of movable arm **54** and the outer face of compensating member **48**, respectively, tends to push the lower end of arm **54** away from member **48**. A U-shaped bracket **74**, made of a suitable metal such as stainless steel, is secured to the open side of member **48** or the back face thereof a short distance below the top. See Figure 1.

At a suitable distance below the upper rim of casing **14**, as shown in Figure 1, a diaphragm **76** is brazed to the inner wall thereof, forming an hermetic closure for the operating parts of the structure. An L-shaped lever **78** having an arm **77** extending downwardly into casing **14**, is brazed into an opening **79** in diaphragm **76** and near its edge. A glass bead **80** mounted on a short wire **81** secured to the lower tip of downwardly extending arm **77** of lever **78** engages the inner face of U-bracket **74**. The other arm of lever **78** extends substantially horizontally above diaphragm **76** and is drilled, tapped, and slotted at its end in such manner that adjusting screw **82** can be clamped sufficiently tightly therein in order to prevent it from turning due to vibration. However, screw **82** can be easily adjusted with a suitable tool, such as a screwdriver. A small hole **84** in diaphragm **76** provides an opening to the interior of casing **14**. This opening makes its possible to evacuate casing **14** and fill it with a dry atmosphere such as nitrogen or other inert gas, or with dry air, after which opening **84** is sealed off with a drop of solder. Cover **86** closes off the top of casing **14**, and protects lever **78** and adjusting screw **82**. The latter can be adjusted by inserting the end of a screwdriver through opening **88** formed in cover **86**.

Referring now to the diagrammatic representation in Figure 7, it is apparent that the pressure exerted by spring **72** serves not only to maintain bracket **74** in contact with bead **80** at all times, but also functions to maintain heating element **20** under tension at all times. Hence, when member **20** expands longitudinally due to a current passing through and heating wire grid **22**, arm **54** will pivot around P and move contact **66** on spring **64** out of engagement with fixed contact **68**. When current through wire grid **22** is cut off and member **20** starts to cool, contact **66** is again brought into engagement with contact **68** by means of spring **72**. Further cooling of grid **22** results in arm **54** moving away from spring **64** and returning to the position shown in Figure 1. Thus the stresses that can be set up in the structure are limited to safe values by the bias tension of spring **64**.

Turning screw **82** so as to raise the horizontal arm of lever **78** moves the lower edge of arm **54** closer to spring **64**, thereby reducing the time required for contacts **66** and **68** to be disengaged when current is passed through wire grid **22**. It will be clear that, since members **20** and **48** are nearly parallel, the horizontal movement of the lower end of arm **54** as a result of adjustment of lever **78** is substantially equal to the horizontal movement of P. On the other hand, the vertical movement of point Q, which is the point on member **20** opposite P, due to the thermal expansion of member **20** causes a horizontal movement of the lower end of arm **54** which is amplified in the ratio of distance P–**66** to PQ. As the crossed-

spring pivot at P is free from backlash and friction this ratio can be made quite substantial.

So long as grid 22 and member 48 are substantially equal in effective length and are made of materials having substantially the same coefficients of thermal expansion, a change in ambient temperature causes no appreciable change in the relative positions of P and Q, and in the position of arm 54. Therefore, there will be no change in the time delay between the application of heating current to grid 22 and the opening of contacts 66 and 68. If it is desired that the time delay should vary in a certain manner with changes in ambient temperature, this can be accomplished by making grid 22 and member 48 of different metals, having substantially different coefficients of thermal expansion.

The rate of longitudinal thermal expansion of grid 22 when a fixed current is passed through it, is determined not only by the size of wire and its resistivity, but also by the thickness and the number of overlapping mica leaves 32. If these leaves are omitted entirely, the time constant of grid 22 is essentially that of the wire of the grid. The function of the mica leaves 32 is not so much to provide thermal insulation around the grid 22, but to increase the thermal capacity of grid 22 without interfering with its thermal expansion. This requires a fair degree of physical contact between the grid and the mica leaves which is assured by clamping ribbon 36. The minimum number of mica leaves 32, disregarding total omission, is two. For example, the lower one on one side of the element or member 20, and the upper one on the other side thereof. This will still provide the necessary electrical insulation between clamp 36 and grid 22. To obtain longer delays, any multiple of two pieces or leaves 32 may be used, or their thickness may be increased. Or if desired, metal leaves of the same shape as mica leaves 32 may be added to the outside of element 20. Mica pieces 34 are used only for additional electrical insulation between grid 22 and staples 28 and 30.

As the wire of grid 22 is always at least as hot or hotter than any other part of heating member 20, its expansion will cease instantly when the heating current is cut off, thus eliminating any tendency to overshoot which is usually encountered in thermal relays of the indirectly heated type with considerable time constants.

The structure shown in Figures 1–16 may be modified in many ways within the scope of my invention. For example, it is quite possible to reverse the positions of contacts 66 and 68 so that the circuit between them is normally open, and is closed as the result of passing a current through and heating grid 22. This modification is shown diagrammatically in Figure 17 in which contacts 166 and 168 are normally open. For this purpose spring 64 is placed between bias spring 72 and the inner face of movable arm or channel 54.

The invention above described may be varied in construction within the scope of the claims, for the particular embodiments selected to illustrate the invention are but a few of the possible concrete forms which my invention may assume. The invention, therefore, is not to be restricted to the precise details of the structure shown and described.

What I claim is:

1. A thermal time delay electrical control device comprising supporting means, a fixed contact secured to said supporting means, a movable arm, a contact on said arm adapted to coact with said fixed contact, an elongated compensating member spaced from and generally parallel with said arm and having one end mounted on said supporting means, an elongated heated timing member, means mounting said heated timing member on said supporting means in generally parallel relationship with said movable arm, resilient means pivotally connecting said movable arm and the other end of said compensating member and said heated timing member, and a wire grid in said heated timing member, said grid comprising a plurality of continuous loops of resistance wire, said grid being operative in response to a current passing therethrough to elongate longitudinally and swing said arm on said resilient pivot means, and effect a displacement of one of said contacts relative to the other.

2. A thermal time delay relay comprising supporting means, a fixed contact mounted on said supporting means, an elongated timing member, said timing member including opposed wire supporting elements movable relative one to the other, a plurality of loops of resistance wire passing back and forth over said elements and forming an elongated wire grid, means supporting one of said elements on said supporting means, a movable contact, an arm supporting said movable contact, a compensating member, means mounting one end of said compensating member on said supporting means, pivotal means connecting the other end of said compensating member with said arm and the other of said elements of said timing member, means operatively connected to said arm and to said compensating member for biasing said arm away from said compensating member, and for continuously maintaining said grid of said timing member under tension, whereby when said grid is heateed by a current passing therethrough, said grid elongates and effects a movement of one contact relative to the other.

3. A device of the type described comprising an elongated heated timing member, said member having a fixed end and a free end, an elongated compensating member substantially equal in length to said timing member, a resiliently pivoted member linking said free end of said timing member and one end of said compensating member, a movable arm having one end rigidly connected to said resiliently pivoted member and the other end free, a movable contact on the free end of said movable arm, a fixed contact adapted to coact with said movable contact, fixed support means for said heated timing member, said compensating member, and said fixed contact, and a device in said heated timing member for heating and elongating said timing member, said device including a wire grid consisting of a plurality of continuous loops of resistance wire, and opposed longitudinally movable supports holding said wire, and means seecuring said grid and opposed supports in assembled arrangement for elongation when a current is passed through said wire.

4. The invention defined in claim 3, including spring means engaging said movable arm and said compensating member for biasing said arm and said compensating member apart, means engaging the top of said compensating member for preventing substantial movement of the top of said compensating member, said spring means being adapted to maintain said heated timing membere constantly under tension.

5. The invention defined in claim 4 including an adjusting mechanism for moving said connected end of said movable arm in a direction substantially at right angles to the direction of elongation of said heated timing membeer, said adjusting mechanism being so constructed and arranged that the movement transmitted to the free end of said arm in adjusting the position of the connected end of said arm is substantially unamplified as compared with the movement of said free end due to the elongation of said timing member.

6. A hot-wire type of electro-thermal control device having a casing and a base, comprising a fixed contact supported on said base, an elongated substantially uniplanar heated timing member having one end supported on said base, a movable operating arm having one end attached to the other end of said heated timing member, a movable contact mounted on said arm, a heater in said heated timing member, said heater including opposed flat supports, at least one of which is movable relative to the other, a wire grid formed of a plurality of continuous loops of resistance wire wound about said spaced opposed flat supports,

means connected to said flat supports to maintain them continuously spaced apart, and thereby maintaining said wire grid under tension, and means for securing said flat supports and said wire grid together in a unitary assembly, said grid being operative in response to the passing of a current therethrough to expand longitudinally and cause said arm to move and effect a movement of said movable contact relative to said fixed contact.

7. A hot-wire type of electro-thermal control device having a casing and a base, comprising a fixed contact supported on said base, an elongated substantially uniplanar heated timing member having one end supported on said base, a movable operating arm having one end attached to the other end of said heated timing member, a movable contact actuated by said arm, means continuously maintaining said heated timing member under tension, a heater in said heated timing member, said heater including opposed movable flat supports, and a wire grid formed of a plurality of continuous loops of resistance wire wound about said flat supports, and means for securing said flat supports and said wire grid together as a unitary assembly, said grid being operative in response to the passing of a current therethrough to expand longitudinally and move said arm to effect a relative movement of one contact relative to the other, said first-named means including a compensating member having an end supported on said base and an end attached to said movable arm, a spring located between said movable arm and said compensating member adapted to bias said arm away from said compensating member and to place said heated timing member under tension, and means engaging the end of said compensating member adjacent the point where it is attached to said heated timing member for maintaining said compensating member against substantial lateral movement.

8. A hot-wire time delay electrical control device comprising a base, a fixed contact mounted on said base, an elongated substantially uniplanar heated timing member mounted on said base, an elongated compensating member mounted on said base and coacting with said heated timing member, said timing member including an elongated wire grid formed from a plurality of continuous laterally spaced loops of resistance wire, said compensating member being substantially equal in length to the length of said grid, a movable arm resiliently connected at one end to said timing member and said compensating member, said grid being longitudinally expansible when a current is passed therethrough for swinging said arm towards said heated timing member, and a contact carried by said arm and movable out of engagement with said fixed contact when said grid is heated and expands.

9. The hot-wire control device defined in claim 8 including a positioning element on said compensating member, and adjustable means engaging said element for controlling the position of said arm before said heater grid is energized.

10. The device defined in claim 8 including a positioning element carried by said compensating member, an adjusting lever having an arm engaging said element, and adjustable means on said lever for controlling the extent of movement of said contact carried by said movable arm into engagement with said fixed contact.

11. A hot-wire time delay comprising fixed supporting means, a fixed contact on said supporting means, an elongated expansible heated timing member mounted on said supporting means, an elongated compensating member mounted on said supporting means and coacting with said timing member, said timing member consisting of a plurality of continuous loops of resistance wire, longitudinally spaced movable supports mounting said loops of wire, means securing said loops against movement on said supports, a movable arm having one end pivotally and resiliently connected with an end of said timing member, a flat spring carried by the other end of said arm, a contact on the free end of said flat spring, means engaging said movable arm and said compensating member for tensioning said heated timing member to prevent buckling of said loops of wire, and means for adjusting said arm to control the extent of movement of said movable contact on said flat spring when a current is passed through said loops of wire thereby elongating said timing member.

12. A hot-wire thermal time delay device comprising fixed supporting means, a fixed contact mounted on said supporting means, a flat substantially uniplanar timing member mounted on said supporting means, a compensating member mounted on said supporting means, said compensating member being substantially equal in length to the heating element of said timing member, said heating element including an elongated wire grid consisting of a plurality of laterally spaced loops of resistance wire, opposed longitudinally movable supports for said loops of wire, means securing said loops of wire on said supports, a movable arm, a spring located between and having its ends connected to said movable arm and said compensating member and tensioning said timing member, resilient pivot means connecting one end of said timing member and an end of said compensating member to an end of said movable arm, a resilient elongated member attached to said movable arm, a movable contact carried by the free end of said resilient member, said grid being operative when energized by a current passing therethrough for swinging said arm and separating said contacts, said resilient member being so biased that said movable contact is maintained in engagement with said fixed contact during a portion of the movement of said arm as a result of the elongation and contraction of said grid of said timing member.

13. A device of the type described comprising fixed supporting means, an elongated timing member mounted on said supporting means, said member having a fixed end and a free end, an elongated compensating member substantially equal in length to said timing member having one end mounted on said supporting means, a resiliently pivoted member linking said free end of said timing member and the other end of said compensating member, a movable arm having one end rigidly connected to said resiliently pivoted member and the other end free, a movable contact, a flat spring mounting said movable contact, said spring being attached to the inner face of said movable arm, a fixed contact mounted on said supporting means, and a device in said timing member for heating and elongating said timing member, said device including a wire grid consisting of a plurality of continuous loops of resistance wire, and opposed longitudinally movable supports holding said loops of wire, and means securing said grid and opposed supports in assembled arrangement for elongation when a current is passed through said grid, whereby said movable arm is swung and said movable contact is brought into engagement with said fixed contact.

14. A thermal time delay electrical control device comprising a base, a fixed contact supported on said base, a movable arm, a contact mounted on said movable arm adapted to coact with said fixed contact, an elongated compensating member supported by said base spaced from and generally parallel with said movable arm, resilient means pivotally connecting said movable arm and said compensating member, a heated timing member assembly having an end connected to said base and an end attached to said resilient pivot means, said assembly including a frame provided with a cut out portion, a plurality of continuous spaced loops of resistance wire extending longitudinally about said frame, said frame having portions adapted to be served therefrom, whereby said loops of wire remain operatively supported on two opposed residual frame elements, means engaging said compensating member and said movable arm and operative in response to the separation of said portions from said frame for biasing one of said frame elements away

from the other and maintaining said loops of wire supported by said elements constantly under tension, said wire being operative when a current is passed therethrough to elongate and swing said arm and close or open said contacts.

15. The device defined in claim 14 wherein said assembly includes a plurality of leaves of electrical insulating material positioned at the ends and on opposite sides of said assembly, and wherein said frame is formed of a thin mica sheet, means for securing said leaves in fixed relationship in full physical contact with substantially all of the wire forming said loops, a bracket attached to one of said securing means, and means attaching said bracket to said resilient pivot means.

16. A device of the type described comprising a base, a compensating member, means connecting one end of said compensating member to said base, a movable arm, resilient pivot means connecting the other end of said compensating member and said arm, whereby the free end of said arm can swing relative to said compensating member, spring means engaging said compensating member and said arm and tending to separate said arm from said compensating member, a timing member having one end connected to said base and the other end thereof connected to said resilient pivot means, said timing member comprising an elongated insulating material frame having a central cutout portion, an elongated wire grid formed of a plurality of loops of wire wound back and forth along the length of said frame and extending over said cutout portion, said frame overcoming the tendency of said spring means to move the free end of said movable arm away from said compensating member, portions of said frame adapted to be removed therefrom whereby the residual portions support the loops of said wire grid, said spring means then being operative to maintain said residual portions of said frame separated longitudinally and said wire of said grid continuously under tension, a fixed contact, a movable contact operatively associated with the free end of said movable arm, the ends of said wire forming said grid providing leads for connecting said grid in an electric circuit for the passage of a current therethrough, said current heating and elongating said grid to cause said free end of said arm to swing said movable contact relative to said fixed contact.

17. The method of forming a timing member for a hot-wire relay comprising forming from a heat-resistant insulating material a flat elongated frame having a central cutout portion, winding resistance wire back and forth on said frame with the loops of wire passing about the ends of said frame and extending longitudinally thereof over said cutout portion, attaching the ends of said wire wound frame to two spaced supports, biasing one of said supports away from the other support, and then separating said frame into two end frame portions capable of relative longitudinal separating movement when a current is passed through said wire elongating said wire.

18. The method defined in claim 17, including applying to the opposite opposed portions of said loops of wire leaves of insulating material, and securing said leaves, wire loops and end frame portions firmly together before said frame is separated into two separate parts.

19. The method of forming a heated timing member comprising forming an elongated thin frame from a sheet of insulating material, providing an elongated cutout portion in said frame and centrally thereof, winding a continuous length of resistance wire back and forth on said frame over the ends of said frame with portions of said loops of wire extending longitudinally of said frame and over said cutout portion, placing on opposite sides of said wire wound frame and adjacent the ends thereof, elongated leaves of mica having free end portions overlapping substantially centrally of the length of said frame, securing said overlapping portions of said leaves loosely together for endwise movement one relative to the other, securing said frame and said loops of wire and the other ends of said leaves firmly together whereby to prevent lateral movement of said loops of wire on said frame, mounting said wire wound frame on spaced relatively tensioned members, and then cutting said frame into two longitudinally movable parts held apart under tension.

20. A heated timing member assembly for a hot-wire relay comprising an elongated mica frame having a central opening, and an ear at each end, a plurality of continuous loops of resistance wire wound back and forth about said frame with longitudinal portions of said loops extending over said opening, a leaf of insulating material extending lengthwise of said wire wound frame from a point adjacent an ear of said frame to a point beyond the central point of said frame, one of said leaves being positioned on each side and at each end of said frame, means attaching said leaves to said frame, a centrally located element loosely holding the free ends of said leaves together, said frame having portions adapted to be removed therefrom, whereby upon removal of said portions said assembly comprises two end frame parts supporting said loops of wire and said leaves, and means for holding said end frame parts against longitudinally inward movement towards each other.

21. The invention defined in claim 20 including a fixed support for one of said end frame parts, a resiliently pivoted support mounting the other of said end frame parts, and means for placing said resilient pivoted support under continuous longitudinal tension to maintain said wire on said frame parts continuously tensioned.

22. A thermal relay having a fixed and a movable contact comprising a heatable expanding member, said member including a plurality of elongated lengths of a continuous resistance wire arranged substantially in a single plane, means for maintaining said lengths of wire continuously under tension, said wire when a current is passed therethrough being adapted to expand longitudinally and effect a relative movement between said contacts, and strips of insulating material forming a permanent part of said expanding member supported in substantially full physical contact with all of said lengths of wire over a substantial portion of their length without interfering with the thermal elongation or contraction thereof, thereby increasing the thermal capacity of said elongated lengths of said resistance wire, the number and positioning of said strips being operative to control the rate of temperature change of said lengths.

23. A thermal relay having a fixed and a movable contact, comprising a heatable expanding member, said member including a plurality of elongated lengths of a continuous resistance wire arranged substantially in a single plane, means for maintaining said lengths of wire continuously under tension, said wire when a current is passed therethrough being adapted to expand longitudinally and effect a relative movement between said contacts, and one or more strips of insulating material arranged in substantially full slidable physical contact with all of said lengths of wire over a substantial portion of their length without interfering with the thermal elongation or contraction thereof, thereby increasing the thermal capacity of said elongated lengths of said resistance wire, the number and positioning of said strips being operative to control the rate of temperature change of said lengths.

24. A hot-wire type of electro-thermal control device comprising a base, a fixed contact supported on said base, an elongated substantially uniplanar heated timing member having one end supported on said base, a movable operating arm having one end attached to the other end of said heated timing member, a movable contact actuated by said arm, a heater in said heated timing member, said heater including opposed relatively movable flat supports and a wire grid formed of a plurality of continuous loops of resistance wire wound about said flat supports, means maintaining said flat supports continuously spaced apart

and thereby maintaining said wire grid under tension, and means clamping said loops of wire and said flat supports together and securing said loops of wire mechanically in parallel and electrically in series, whereby if the electrical continuity of said grid is broken the mechanical integrity of said grid is unaffected, said grid being operative in response to the passing of a current therethrough to expand longitudinally and cause said arm to move and effect the movement of said movable contact relative to said fixed contact.

25. The device defined in claim 24, including at least one strip of an insulating material attached to opposite sides of said flat opposed relatively movable supports and in slidable physical contact with said loops of resistance wire, whereby to increase the thermal capacity of said resistance wire, the number and thickness of said strips being operative to control the rate of temperature change in said loops.

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