Sept. 20, 1960 C. D. FLANAGAN 2,953,723

CONTROL DEVICE

Filed May 8, 1957

FIG. 1.

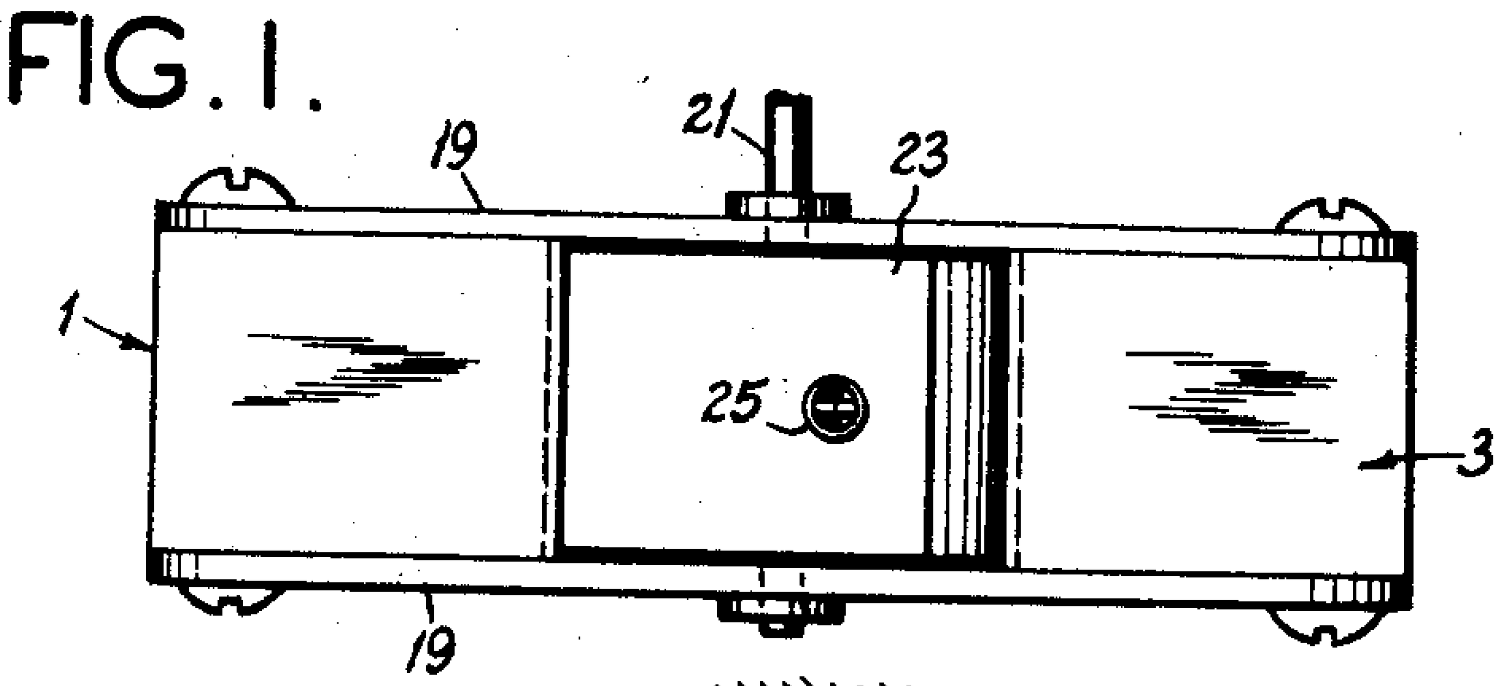


FIG. 2.

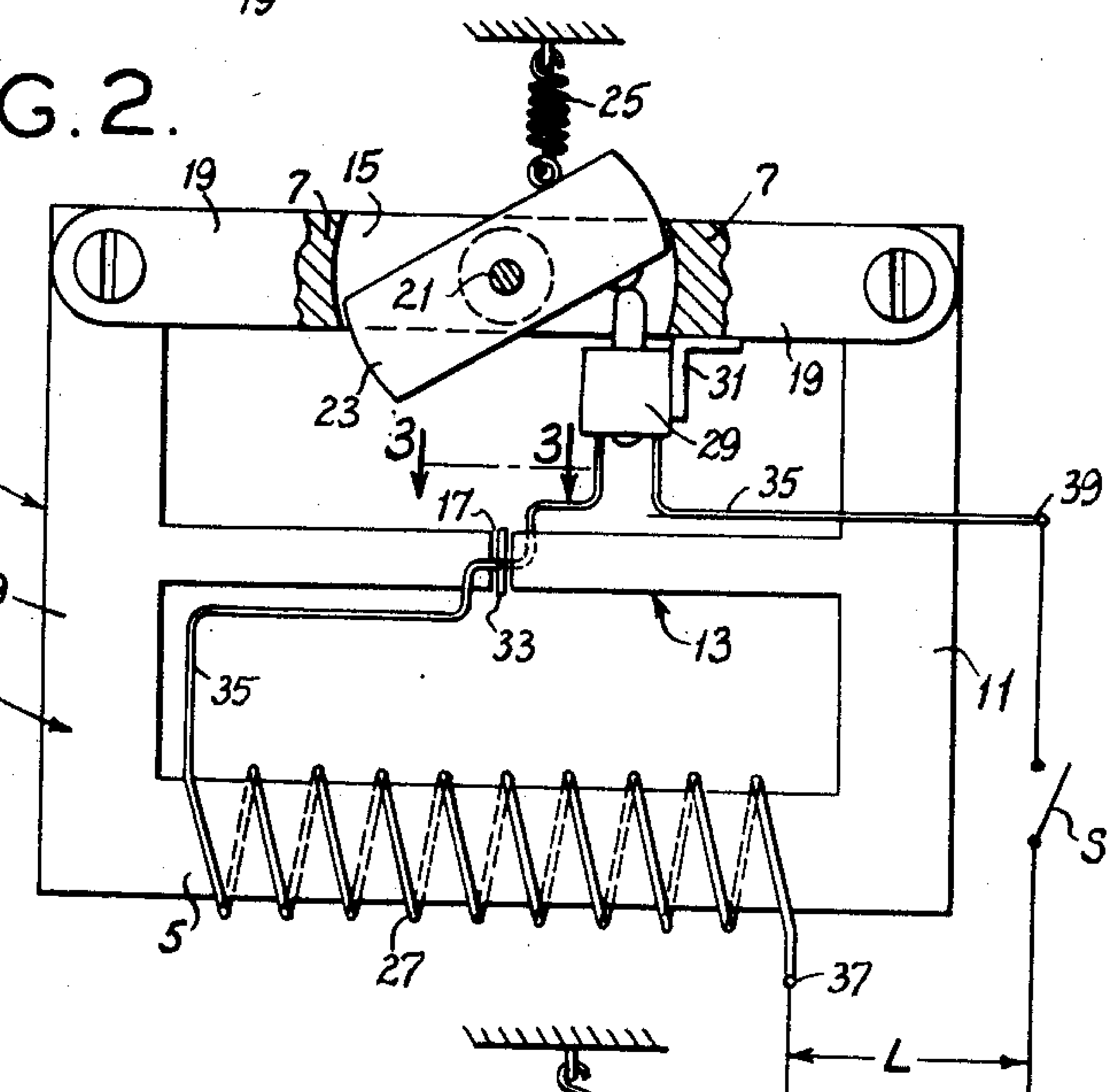


FIG. 3.

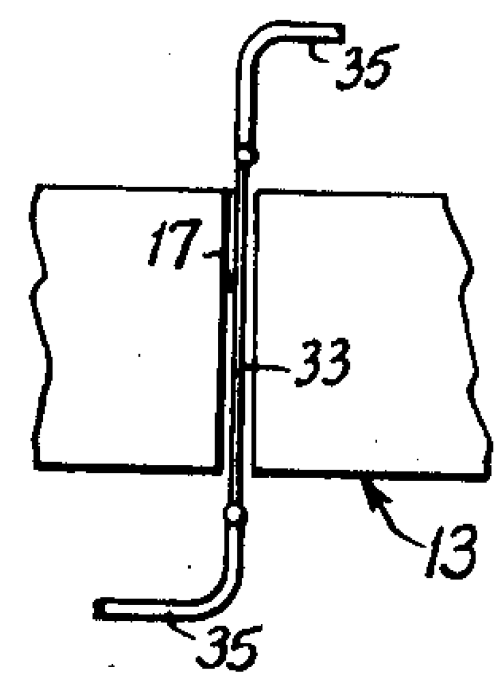
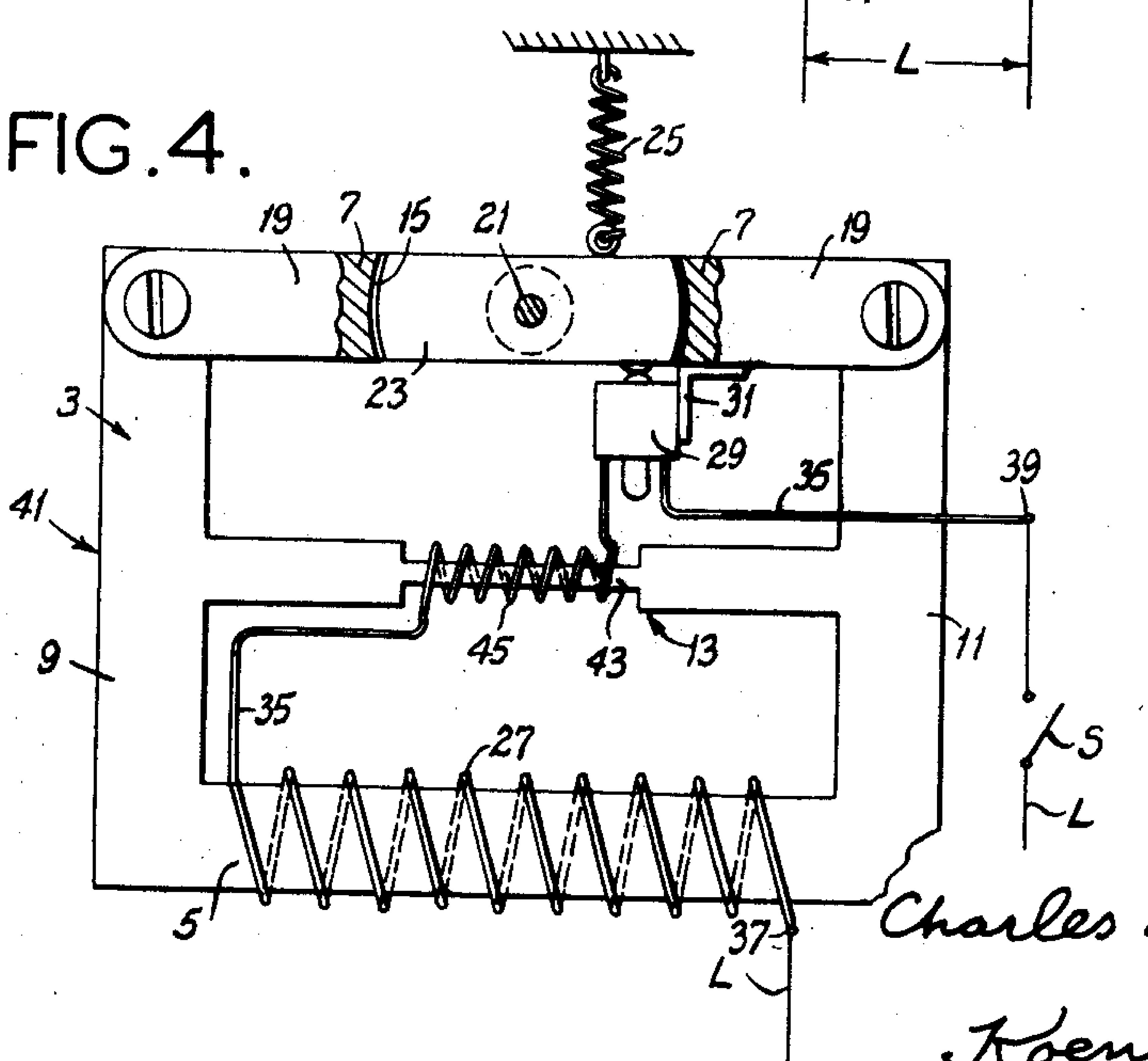


FIG. 4.



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CONTROL DEVICE

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7 Claims. (Cl. 317—37)

This invention relates to electrical control devices, and more particularly to thermomagnetic control devices, including circuit breakers.

Among the several objects of the invention may be noted the provision of a thermomagnetic electrical control which utilizes the phenomenon exhibited by a magnetic material of becoming substantially nonmagnetic above a certain temperature, known as the Curie point; the provision of a circuit breaker utilizing this phenomenon which is adapted to operate as a thermal breaker with time delay in response to prolonged low overloads in a load circuit and to operate substantially instantaneously as a magnetic breaker upon occurrence of a relatively high overload in the load circuit; and the provision of a control such as described which is of simple and economical construction and reliable in operation. Other objects and features will be in part apparent and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, features of constructions, and arrangements of parts which will be exemplified in the structures hereinafter described, and the scope of which will be indicated in the following claims.

In the accompanying drawings, in which several of various possible embodiments of the invention are illustrated,

Fig. 1 is a plan view of a circuit breaker made according to this invention;

Fig. 2 is a view in elevation of Fig. 1, with parts broken away and shown in section, showing an armature of the breaker in retracted position;

Fig. 3 is a view taken on line 3—3 of Fig. 2; and,

Fig. 4 is a view similar to Fig. 2 illustrating a modification, with the armature shown in moved position.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

Referring to Figs. 1 and 2 of the drawings, a first type of circuit breaker constructed in accordance with this invention is designated in its entirety by the reference character **1**. As shown, it comprises an electromagnet comprising a magnetic core **3** for establishing a magnetic loop. This core is, for example, of hollow rectangular shape having main legs **5** and **7** and yokes **9** and **11** joining the main legs. An intermediate leg **13** extending between yokes **9** and **11** establishes a fixed magnetic shunt across the loop. Leg **7** has a gap therein at **15**. Shunt leg **13** has a gap therein at **17**. Nonmagnetic straps **19** are secured on the side faces of leg **7** bridging the gap **15** in this leg. These straps provide journals for a shaft **21** carrying a magnetic armature **23** for pivotal movement in the gap **15**, the shaft extending crosswise of the gap. The armature is biased by a spring **25** to an angled retracted position such as illustrated in Fig. 2. A coil **27** is wound around leg **5** for magnetizing the core **3**. The armature is adapted to swing clockwise from the angled retracted position shown in Fig. 2 into a position in alignment with leg **7** on development of mag-

netizing force thereon sufficient to overcome the bias of the spring (i.e., in response to development of flux density in leg **7** above the value required for armature actuation). When it swings, it operates a manual reset type of switch **29** which may be mounted on a bracket **31** carried by the leg **7**.

The shunt leg **13** is preferably of smaller cross-sectional area than main legs **5** and **7** and yokes **9** and **11**. In the gap **17** in the shunt leg is a member **33** composed of magnetic material which is adapted to be heated by passage of current therethrough, and which becomes substantially nonmagnetic upon becoming heated above a temperature high enough to provide the necessary ambient de-rating characteristics. For example, a strip **33** of pure nickel may be used (see Figs. 2 and 3), which is magnetic up to a temperature (Curie point) of about 350° C. Other useful materials are, for example, nickel-iron alloys, platinum alloys, et cetera. Member **33** constitutes means for controlling the reluctance of the shunt leg **13**. It is shown as connected in series with the coil **27** and the switch **29** in a circuit **35**. Points **37** and **39** denote the terminals of the device, whereby it may be connected in series with a load circuit L in which may be located a manual switch S.

To illustrate the above, in an actual physical embodiment of the device in which the core loop **3** (made of cold-rolled steel) was two inches long, one and one-half inches high and one-half inch deep, with the legs **5** and **7** and yokes **9** and **11** one-quarter inch thick and the shunt leg **13** one-eighth inch thick, the gap **17** in the shunt leg was 0.010 inch wide and the member **33** has a strip of pure nickel 0.006 inch thick centered in the gap **17** so as to be in nonconductive relation to the shunt leg. The armature **23** was approximately three-quarters inch long, and the air gaps between the armature ends and the leg **7** were 0.005 inch wide. Coil **27** consisted of ten turns of insulated copper wire.

In operation, at load currents insufficient to heat member **33** to its Curie point, flux is diverted from leg **7** of the device by the fixed shunt leg **13**, the reluctance of the shunt leg **13** being relatively low due to the magnetic characteristic of member **33**. Accordingly, the magnetizing force on armature **23** is relatively low, and insufficient to cause it to pivot to operate the switch **29**. However, if the load current increases to a value sufficient to cause heating of the member **33** above its Curie point, whereby member **33** in time becomes substantially nonmagnetic, the reluctance of shunt leg **13** is increased to the point at which sufficient flux is supplied to leg **7** of the core loop, so as to provide sufficient magnetizing force on the armature **23** to cause it to pivot and operate the switch **29** to break the circuit. When the circuit is broken, the member **33** cools below the Curie point so that it again becomes magnetic to restore the shunting function of the shunt leg and allow the armature to be spring returned to its retracted position so that switch **29** may be reclosed, if as shown, it is of the manual reset type. On low overloads the time delay action is useful as, for example, in motor protection application. For example, a motor upon starting may draw a heavy overload current for a shorter time than it takes for element **33** to reach its Curie point and, as desired, this condition being very temporary, will not cause armature **23** to trip open the switch **29**.

In the event of very high fault or short circuit current, the shunt leg **13** will rapidly saturate before the Curie point of element **33** is reached (due to its relatively small cross-sectional area), and the majority of the flux will at once pass through the leg **7** to actuate the armature to break the circuit. Thus, the device operates essentially as a thermal breaker for small overload currents and as a magnetic breaker for fault currents or short circuits.

It will be understood that the switch 29 may be of the automatic reset type, and some suitable means provided for delaying its resetting to give element 33 time to cool, thereby providing for automatic reclosure of the circuit upon cooling of the element 33 and maintaining it closed, provided the overload or fault currents have in the meantime disappeared. For example, a dashpot may be provided for delaying the return of the armature sufficiently to permit element 33 to cool before the automatic reset switch resets.

Fig. 4 illustrates a second type of circuit breaker constructed in accordance with this invention, and designated in its entirety by the reference character 41 to distinguish it from the circuit breaker 1 above described. As shown, it is the same as the circuit breaker 1 with the exception that, instead of providing a gap in the fixed shunt leg 13 and a separate piece of current-heated magnetic material in this gap having a predetermined Curie point, the shunt leg is formed with an integral portion 43 of reduced cross-sectional area, and this portion is provided with external heating means such as a resistance wire coil 45. This resistance wire coil 45, as shown in Fig. 4, may be connected in series with the coil 27 in circuit 35 in the same manner as member 33 in the case of circuit breaker 1. It will be seen that in this form of the invention the portion 43 is heated by radiation and convection from the current-heated coil 45 which in general tends to increase the time delay with which operation of switch 29 occurs. Since the element 43 has a predetermined Curie point, the adjacent materials in the leg 13, if integral, will likewise be composed of such material. This is satisfactory in many cases. On the other hand, the element 43 having the predetermined Curie point may be welded into the adjacent portions of the leg 13, so that the remainder of the material of the magnetic circuit may be of material which is not required to have this same Curie point.

The operation of the breaker 41 shown in Fig. 4 is similar to the operation described in connection with the form shown in Fig. 2, as will be understood, except that the element 43 is indirectly and radiantly heated from the circuit, instead of being directly current-heated, as in the Fig. 2 form.

It will be understood that the motion of the armature 23 may be employed to control items other than the electrical switch 29 in the circuit of coil 27. For example, the switch 29 may be eliminated from this circuit and the latter simply used, by means of switch S, to supply current for heating the element 33 or 43, as the case may be, with the resulting time-delay action in operating the armature 23, the shaft 21 of the latter then operating the desired item with the desired time delay between operation of the switch 5 and operation of the item controlled by the shaft. It will also be understood that magnetization of the magnetic loop established by the parts 5, 7, 9 and 11 may be accomplished by making the parts constituting this loop of permanent magnetic material, in which event the circuit L feeding the thermomagnetic element 33 in the case of Fig. 2 or 45 in the case of Fig. 4 needs not to include in it any electromagnetic coil such as 27.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A thermomagnetic control operable substantially instantaneously upon occurrence of a relatively high overload in a load circuit and operable with time delay in response to prolonged low overloads in said load circuit, comprising an electromagnetic core establishing

a magnetic loop, means for magnetizing the loop in response to flow of current in said load circuit, a member actuable in response to development in a portion of the loop of a flux density above a predetermined value, a fixed magnetic Curie point shunt for said portion of the loop, said shunt acting at temperatures below its Curie point and below flux saturation at normal load and low overload in said load circuit to shunt flux from said portion of the loop thereby to maintain the flux density at said portion below said value, said shunt becoming magnetically saturated upon occurrence of a high overload in the load circuit and the flux density at said portion of the loop thereby substantially instantaneously exceeding said value to actuate said member, and means for heating the shunt above its Curie point in response to prolonged low overload in said load circuit thereby to increase the reluctance of said shunt with attendant increase of flux density in said portion of the loop to actuate said member, said fixed shunt remaining in position to shunt flux from said portion of the loop upon actuation of said member.

2. A thermomagnetic control operable substantially instantaneously upon occurrence of a relatively high overload in a load circuit and operable with time delay in response to prolonged low overloads in said load circuit, comprising an electromagnetic core loop having a gap therein, means for magnetizing said loop in response to flow of current in said load circuit, an armature at the gap actuable in response to development of a flux density at the gap above a predetermined value, a magnetic shunt connected between portions of said loop on opposite sides of the gap having a thermomagnetic portion of predetermined Curie point therein adapted to control the reluctance of said shunt, said shunt acting when said thermomagnetic portion is at a temperature below its Curie point and below flux saturation at normal load and low overload in said load circuit to shunt flux from said gap thereby to maintain the flux density at said gap below said armature-actuating value, said shunt becoming saturated upon occurence of a high overload in the load circuit and the flux density at the gap thereby substantially instantaneously exceeding said value to actuate said armature, and means for heating said thermomagnetic portion of said shunt above its Curie point in response to prolonged low overload in said load circuit thereby to cause said thermomagnetic portion to become substantially nonmagnetic and to increase the reluctance of said shunt with attendant increase of flux density at the gap to actuate the armature.

3. A thermomagnetic control as set forth in claim 2 wherein said thermomagnetic portion of the shunt is constituted by a separate thermomagnetic element positioned in a gap in the shunt.

4. A thermomagnetic control as set forth in claim 2 wherein said thermomagnetic portion of the shunt is constituted by an integral constricted portion of the shunt.

5. A thermomagnetic circuit breaker comprising a magnetic core having two main legs, two yokes joining said main legs, and a shunt leg extending between said yokes, one of said main legs having a gap therein, a coil wound around a portion of said core for magnetizing said core in response to flow of current in said coil, an armature at the gap actuable in response to development of a flux density at the gap above a predetermined value, a switch actuable by said armature, said shunt leg having a thermomagnetic portion of predetermined Curie point therein adapted to control the reluctance of said shunt leg, a load circuit serially connecting said coil and switch and having a portion so related to said thermomagnetic portion as to heat said thermomagnetic portion in response to flow of current in said load circuit, said shunt leg acting when said thermomagnetic portion is at a temperature below its Curie point and

below flux saturation at normal load and low overload in said load circuit to shunt flux from said gap thereby to maintain the flux density at said gap below said value, said shunt leg becoming saturated upon occurence of a high overload in the load circuit and the flux density at the gap thereby substantially instantaneously exceeding said value to actuate said armature, said thermomagnetic portion being heated above its Curie point in response to prolonged low overload in said load circuit thereby to cause said thermomagnetic portion to become substantially nonmagnetic and to increase the reluctance of said shunt leg with attendant increase of flux density at the gap to actuate the armature.

6. A thermomagnetic circuit breaker as set forth in claim 5 wherein said thermomagnetic portion of said shunt leg is constituted by a separate thermomagnetic element positioned in a gap in said shunt leg and connected in said load circuit and adapted to heat in response to flow of current therethrough.

7. A thermomagnetic circuit breaker as set forth in claim 5 wherein said thermomagnetic portion of said shunt leg is constituted by an integral constricted portion of said shunt leg and said portion of said load circuit comprises an electrical resistance heater adjacent said constricted portion.

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