United States Patent [19]

Riendeau

[11] **3,868,614**

[45] **Feb. 25, 1975**

[54] **IMPROVED CIRCUIT BREAKER TRIP MECHANISM**

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[73] Assignee: **Aiken Industries, Incorporated,** New York, N.Y.

[22] Filed: **Aug. 8, 1973**

[21] Appl. No.: **386,588**

Related U.S. Application Data

[62] Division of Ser. No. 159,930, July 6, 1971, Pat. No. 3,771,087.

[52] **U.S. Cl.** **337/66,** 337/68, 337/72

[51] **Int. Cl.** **H01h 71/16**

[58] **Field of Search** ..... 337/66, 72, , 75, 65, 68, 337/85, 86, 342, 358; 335/145, 150, 171

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Primary Examiner—Arthur T. Grimley

Attorney, Agent, or Firm—St.Onge Mayers Steward & Reens

[57] **ABSTRACT**

A miniature circuit breaker which is wholly contained within a screw-type envelope for a type S fuse. The breaker trip mechanism is of the type which has a resetting plunger, and a current sensing device which moves relative to the plunger. In order to limit the travel of the current sensing device under trip conditions, stop shoulders are formed on the body of the plunger. The current sensing device takes the form of a bimetallic member formed with a leading latch edge and a trailing edge. In order to prevent the trailing edge from engaging a cooperating latch member during resetting of the circuit breaker, a tang projects from the trailing edge across the cooperating latch member. The circuit breaker housing is of one-piece construction, and has an open end through which the trip mechanism is inserted. The trip mechanism incorporates a plunger-biasing coil spring at the bottom of the trip mechanism. In order to retain the compression spring in assembly with the plunger while the trip mechanism is dropped into the open end of the breaker housing, the spring is frictionally received within a recess formed at the bottom of the plunger. The current sensing device includes a pair of bimetallic pincers embracing the plunger, and one of these pincers is formed with a through cut in order to divert all of the current to the opposed pincer, at least under trip conditions. One of the external electrodes of the breaker is formed of inexpensive round wire stock.

6 Claims, 12 Drawing Figures

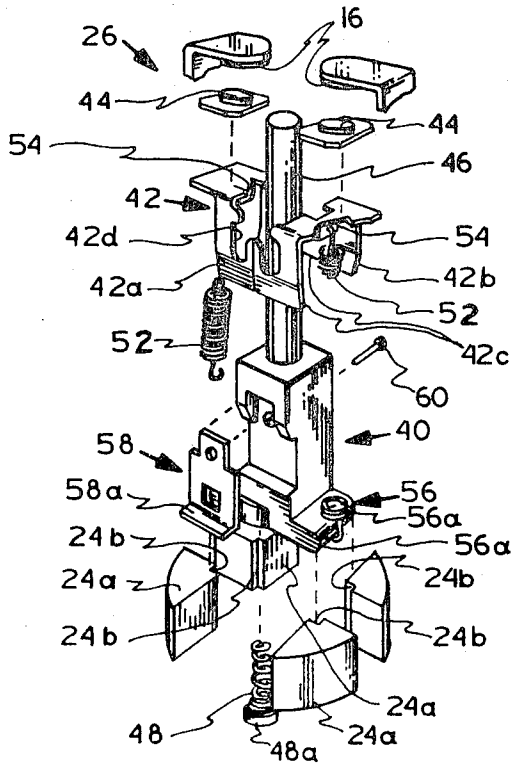


FIG. 2

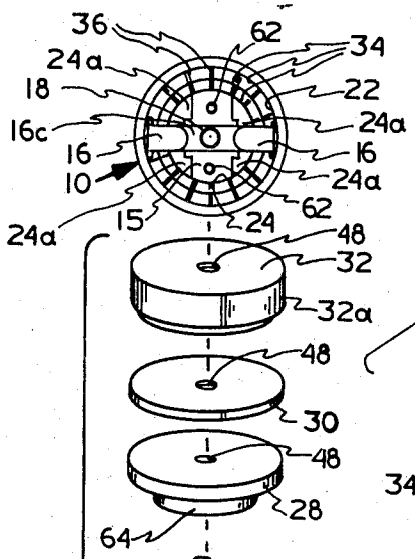


FIG. 3

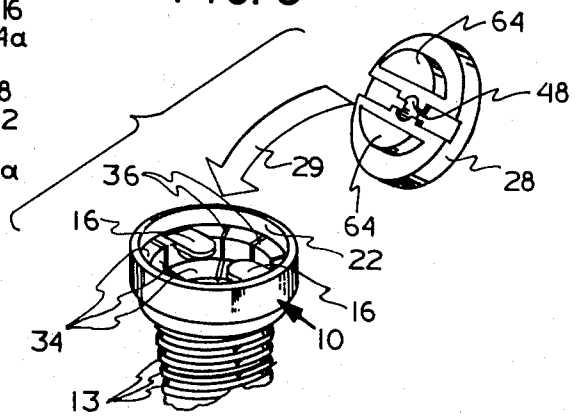


FIG. 1

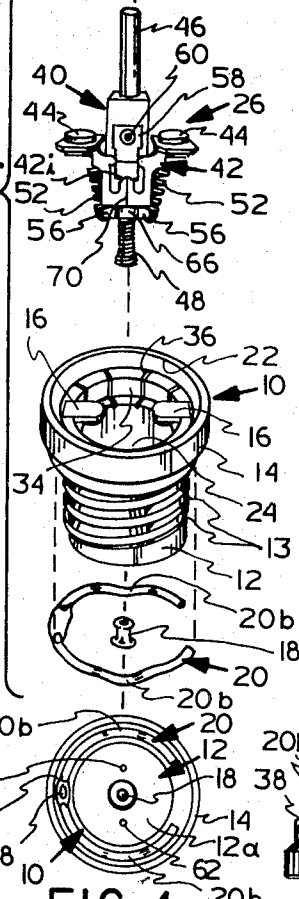


FIG. 6

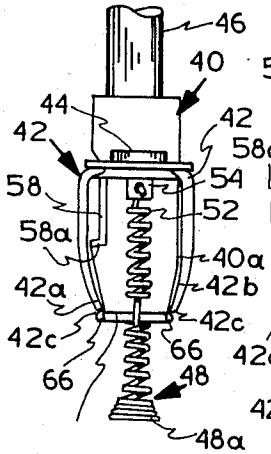


FIG. 7

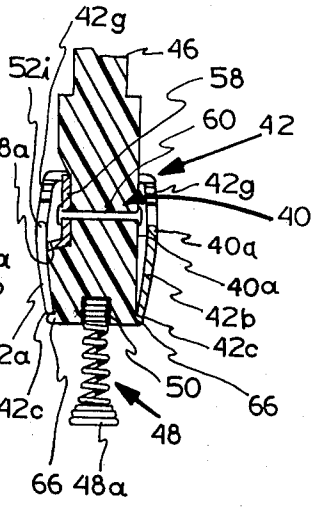
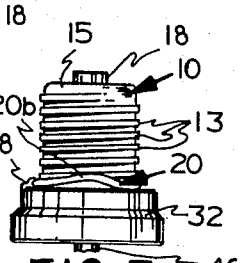


FIG. 4

FIG. 5



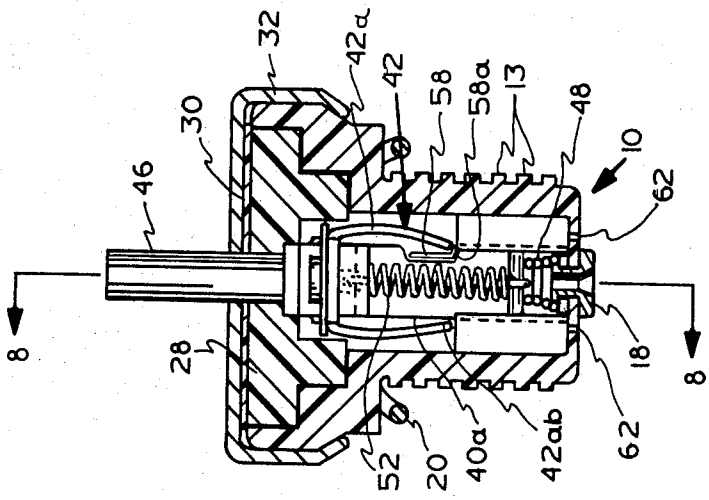
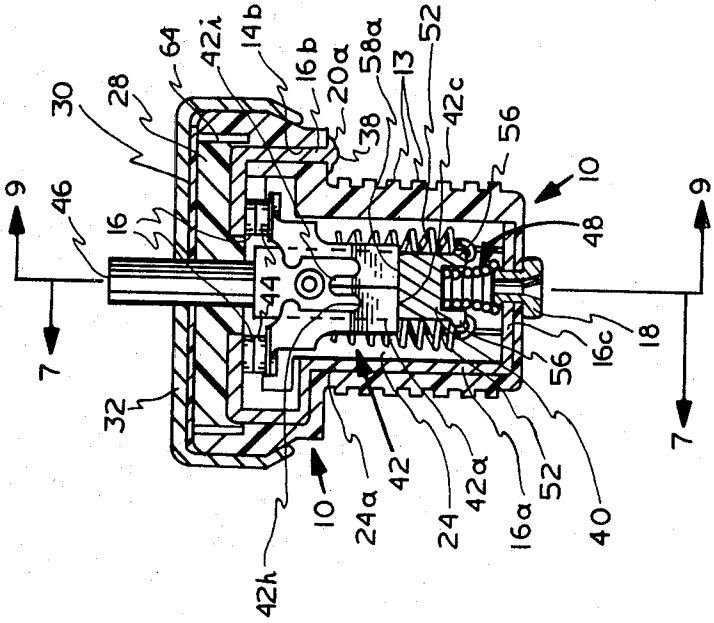

32
42a
42
58
58a
13
48
30
10
46
62
8
8
28
18
52
20
40a
42ab
62

FIG.9


64
42i
14b
16b
20a
58a
13
52
28
30
38
42c
56
10
9
46
16
48
9
44
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16c
56
7
32
10
42h
24a
42
24
42a
16a
52
40

FIG.8

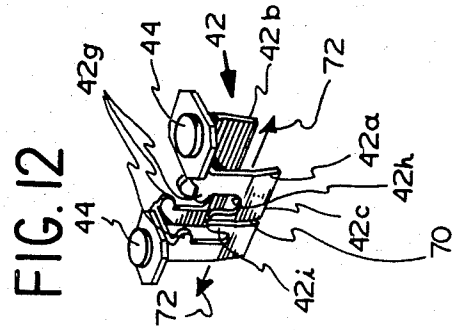

FIG. 12

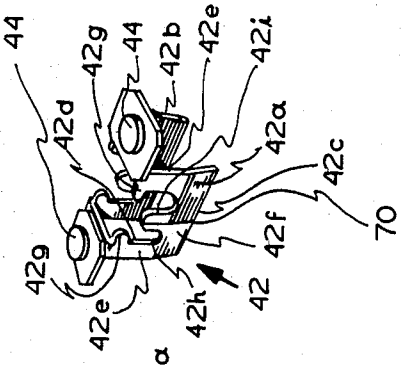

FIG. 11

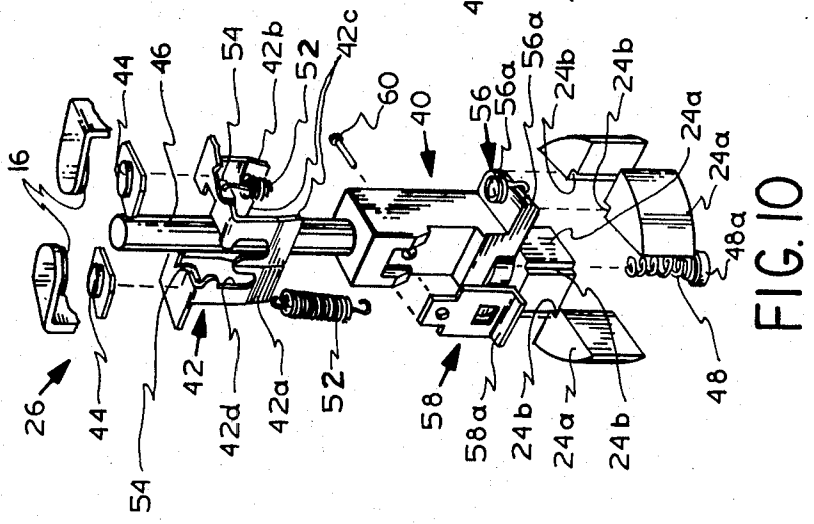

FIG. 10

IMPROVED CIRCUIT BREAKER TRIP MECHANISM

This is a division of application Ser. No. 159,930, filed July 6, 1971, now U.S. Pat. No. 3,771,087.

FIELD OF THE INVENTION

This invention relates to improvements in circuit breakers, particularly the type of breaker which incorporates a bimetallic trip mechanism within a standard fuse envelope.

BACKGROUND

For some years there has been on the market a miniature circuit breaker which fits into a standard Edison base screw-type fuse envelope. Details of the construction and operation of this type of breaker are fully disclosed in the following U.S. Pats. of Ingwersen: Nos. 2694122, 2689895, 2665347, 2514545, Re23971, 2513564, and 2639348. Circuit breakers employing the same type of trip mechanism, although not in a fuse envelope, are seen in Ingwersen U.S. Pat. Nos. 2824931, 2639349, 2587162, 2816192, and 2968709.

Until the present time, to my knowledge no one has incorporated a satisfactory circuit breaker within the confines of the substantially smaller S type of fuse envelope. The S type has screw thread variations which are related to current rating, and therefore is preferred for certain applications in order to prevent the unsafe substitution of higher rated fuses.

One of the reasons why circuit breaker movements have not been successfully incorporated into type S fuse envelopes in the past, may be because in previous attempts the type S breaker was assembled in the same manner employed in the production of Edison base breakers; i.e. the fuse-shaped circuit breaker housing is separated into two halves along an axial center plane, and the trip mechanism is inserted sidewardly into one of these housing halves. This split housing approach works well with the Edison base envelope, which apparently is large enough to dissipate the energy released under the most severe fault conditions Underwriters Laboratories, Inc. requires such breakers to withstand. But if the same tests were applied to the smaller type S devices having split housings, it is believed that they would suffer various failures. The breaker envelopes would crack or be blown apart, or carboning of the outer surface of the breaker envelope would take place, thus decreasing the tracking path for current leakage during subsequent fault tests. Thus it is believed that no split-housing circuit breaker of the S type could successfully pass the entire series of tests required by U.L., Inc.

Apart from the difficulties introduced by the small size of the type S envelope, prior art miniature circuit breaker trip mechanisms in the past have suffered from certain other problems. For example, trip mechanisms, which are tension-spring-biased to open the contacts under trip conditions, permit the moveable portion of the mechanism to travel so far during tripping that the trip springs are entirely relaxed and there is danger of the springs' becoming disassembled therefrom. If that happens, the circuit breaker is non-functional, and can not be reset and re-used. Clearly, the point of putting a circuit breaker in a fuse socket is to have a resettable device which does not need to be replaced.

Another problem encountered by prior art breakers has to do with the relationship between the bimetallic

current sensing element and the latching member with which it cooperates for latching and releasing the trip mechanism. The bimetallic element has leading and trailing edges. The leading edge is intended to have latching engagement with a latch member on the circuit breaker plunger, but the trailing edge is not intended to engage with the latch member. Nevertheless, the trailing edge often does catch the latch member, which interferes with proper resetting of the breaker.

Occasionally it is desirable to de-rate a miniature circuit breaker trip mechanism of the bimetallic clip type; i.e. to make it trip under one half the normal fault current. Ingwersen U.S. Pat. No. 2821601 discloses a scheme for de-rating a circuit breaker trip mechanism to half the original fault current by connecting the two pincer members of the bimetallic clip element in a series circuit configuration, so that each pincer member carries the full fault current. That approach entails a certain amount of added manufacturing expense for the extra parts and assembly operations which are required to isolate the two bimetallic pincer clip members from each other electrically, and then to connect them into series circuit relationship by the use of a suitable intermediary circuit element.

Finally, one of the external electrodes of the prior art fuse envelope circuit breaker devices is stamped from flat sheet metal stock, which is somewhat more expensive than comparable wire stock of round cross section. Until now, it appears that no one has found a way to employ such round wire stock as an external circuit breaker electrode.

SUMMARY OF THE INVENTION

This invention contemplates a circuit breaker having a trip mechanism of the general type disclosed in the Ingwersen patents above. But in order to limit the trip movement of the mechanism, and thereby keep tension on the trip springs so that the remain in assembly, shoulders are provided on the plunger body which engage the edges of the bimetal element to limit its travel under trip conditions. Also, a trailing edge of the bimetal is formed with a tang which projects across the latch member and thereby prevents undesirable engagement or hang-up during resetting. The bimetal limiting position defined by the stop shoulders mentioned above are so chosen that the aforesaid tang cannot move past the latching member.

The circuit breaker of this invention may be mounted within a screw-threaded fuse envelope of the S type. In that event, the housing has a cover member which is provided with one or more bosses and/or vent holes at opposite ends of the breaker, so as to avoid the exploding, cracking and charring effects which have afflicted previous type S circuit breaker devices under severe fault conditions.

In contrast to the split-case construction of Edison base fuse envelope circuit breakers, the type S breaker in accordance with this invention has a one-piece housing which is open at one end. The breaker is assembled by dropping the trip mechanism into the housing through the open end, while simultaneously rotating it to obtain clearance for the breaker contacts. An appropriate friction fit is provided between the plunger and its biasing spring so that the spring does not disengage itself from the bottom of the plunger as the trip mechanism is dropped into the housing. A non-twist socket is formed in the interior of the housing, to prevent rotat-

ing of the trip mechanism after it is dropped into place.

If it is desired to de-rate the circuit breaker of this invention, that is easily and economically achieved by using parallel current paths and unbalancing the resistance in the two parallel circuit branches so that the total heat dissipated in the bimetallic elements, and hence their thermal responsiveness for a given fault current, is increased. This imbalance may be achieved by forming a through cut in one of the bimetallic elements. Such a cut is effective, at least under trip conditions, to divert all of the fault current to the other element.

Finally, a circularly shaped external electrode of the circuit breaker is easily and economically formed from wire stock of round cross-section, which is less expensive than stamping from flat sheet stock, especially when one considers the waste entailed in stamping a circular configuration defining a central disc which is discarded. The wire stock is bent into the required circular configuration, without waste, and formed with resilient axially projecting bights to define resilient electrical contacts. Finally, since a flat surface is required for staking the electrode to the circuit breaker and establishing electrical connection to the contacts inside the breaker, the wire stock is stamped flat at least at one location.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded perspective view of an S type fuse envelope circuit breaker in accordance with this invention.

FIG. 2 is a top plan view of the empty screw-base housing of the circuit breaker.

FIG. 3 is an exploded perspective view of the same empty housing and the cover thereof, illustrating the manner in which the two are assembled in manufacturing a circuit breaker according to this invention.

FIG. 4 is a bottom plan view of the circuit breaker of FIG. 1, fully assembled.

FIG. 5 is an elevational view of the same circuit breaker.

FIG. 6 is a side elevational view of the trip mechanism of this circuit breaker.

FIG. 7 is a sectional view of the same trip mechanism taken along the lines 7—7 of FIG. 8, looking in the direction of the arrows.

FIG. 8 is a sectional view, taken along the lines 8—8 of FIG. 9 looking in the direction of the arrows, of the same circuit breaker.

FIG. 9 is a sectional view of the same breaker taken along the lines 9—9 of FIG. 8, looking in the direction of the arrows.

FIG. 10 is an exploded perspective view of the trip mechanism and selected components of this circuit breaker.

FIG. 11 is a perspective view of the bimetallic current sensing element of the trip mechanism, in a cool condition.

FIG. 12 is a similar view of the same sensing element in a hot condition, such as would be achieved under trip conditions.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The illustrated screw base circuit breaker in accordance with this invention is designed to thread directly into a type S fuse socket. It has a fuse-like envelope which comprises a molded plastic housing **10** having an elongated, generally cylindrical lower portion **12** formed with type S fuse threads **13.** The upper portion of the housing **10** forms an enlarged circular ring **14** by which the breaker may be gripped for threading it into and out of fuse sockets. A pair of fixed electrical contacts **16** are mounted in the housing **10.** These contacts extend a short distance radially across the interior of the housing **10,** and include downwardly extending shanks **16*a*** and **16*b*** respectively (see FIG. **8**) which make electrical connections to central and peripheral external circuit breaker electrodes **18** and **20** respectively.

The top of the circuit breaker housing **10** has a circular opening **22,** which provides access to a generally cylindrical hollow interior **24** of the lower portion **12.** A trip mechanism **26** is received within the interior **24,** and the top opening **22** is covered by a disc-shaped molded plastic member **28.** A gasket **30** in the shape of a washer formed of electrically insulating material goes over the cover **28.** A circular metal cap **32** goes over the gasket **30,** and has a flange **32*a*** which surrounds the housing ring **14** and is crimped thereto.

Three terraced surfaces **34** in the interior of the housing ring **14** are provided with grooves **36** which increase the electrical tracking path for leakage currents. The insulating gasket **30** serves the same purpose.

Previous fuse envelope type circuit breakers differ in their construction and method of assembly. The housing of such prior art devices (corresponding to the present housing **10**) was split into two separately molded parts, divided along an axial plane. During assembly, the contacts and the trip mechanism were inserted sidewardly into one half of the split housing, after which the two halves of the housing were assembled and the external cap crimped in place to complete the breaker.

The approach, however, does not work for a type S circuit breaker, since the energy liberated by fault currents must be dissipated within a much smaller space, i.e. the hollow interior **24.** If the breaker housing **10** were split into two parts these would have a tendency to blow apart, and to allow carbon material to seep out along the seam line between the housing halves under severe fault conditions, such as are encountered in standard U.L. qualification testing for household circuit breakers. Such carbon leakage would be deposited on the exterior of the breaker, and would reduce the electrical tracking path for subsequent fault current leakage. Accordingly, a way had to be found to manufacture the type S breaker with the one-piece housing **10** of this invention; and a way had to be found of assembling the breaker, in place of the side loading procedure permitted by the split housings of the prior art devices. Accordingly, in the assembly of the present breaker all internal parts are inserted into housing interior **24** through the top opening **22.**

Contacts **16** are inserted first. Vertical contact leg **16*a*** fits within an open vertical channel **24*a*** formed on the interior wall of receptacle **24,** and horizontal contact leg **16*c*** is secured to the housing **10** by means of the central external electrode **18,** which takes the form of a rivet.

The peripheral external electrode **20** is fabricated of round wire stock, as seen in FIGS. **1, 4, 5** and **9,** instead of being stamped from flat sheet stock as was done in prior art circuit breakers of the fuse envelope type. In order to develop the proper configuration for use as a

peripheral external electrode **20**, the round wire stock is bent into the generally circular arc seen in FIG. **4**, so as to embrace the tubular lower portion **12** of breaker housing **10**. It is also bent in an axial direction to form a pair of resilient bights **20***b* (FIGS. **1**, **4** and **5**) which make resilient pressure contact with the cooperating electrode inside the fuse socket when the circuit breaker is in use. In addition, the central portion of the wire is stamped to form a short flat region **20***a* (see FIGS. **4** and **8**) where the electrode **20** can be staked to the circuit breaker, just as flat sheet electrodes have been staked in place in the past. Leg **16***b* of the other fixed contact is then inserted downwardly through a channel **14***b* molded in the housing ring **14**, and staked to the outer peripheral electrode **20** as seen at **38**. This secures the contact **16**, its leg **16***b*, and electrode **20** to the housing **10**.

The trip mechanism **26** is of the same general type described in the Ingwersen patents above. It includes a vertically reciprocating molded plastic reset plunger **40** which serves as a carrier for a bimetallic clip **42** and a pair of moveable circuit breaking contacts **44** mounted on the clip. The upper end of the plunger **40** terminates in a cylindrical reset button **46** which extends upwardly through suitable openings **48** formed in the cover member **28**, gasket **30** and cap **32**. A plunger biasing coil spring **48** is in compression between the bottom of the plunger **40** and the bottom of the interior recess **24** to bias the plunger **40** upwardly, thereby normally keeping the moveable contacts **44** in engagement with the fixed contacts **16** under non-fault conditions.

Installation of the plunger biasing spring **48** between the plunger **40** and the bottom of recess **24** is something of a problem in view of the one-piece construction of the breaker housing **10**. The biasing spring **48** must be maintained in the proper orientation relative to the plunger **40** as the trip mechanism **28** is inserted downwardly through the opening **22** and into the tubular recess **24**. In previous circuit breakers of this type a cylindrical recess has been formed in the bottom of the plunger to embrace the upper end of the biasing spring, and thereby retain the spring in proper alignment with the plunger after assembly. See for example, the Ingwersen patents cited above, as well as Arey U.S. Pat. Nos. 3042776 and 2912546 and Clarke U.S. Pat. No. 3210501. But in those patents there is no indication as to the tightness of fit between the plunger biasing spring and the plunger recess within which it is received.

The present invention contemplates that there be a friction fit between the upper end of coil spring **48** and a recess **50** (see FIG. **7**) which is formed in the bottom of the plunger **40**. Before the trip mechanism **26** is inserted into the circuit breaker housing **10**, the upper end of the biasing spring **48** is force-fit into the recess **50** and is retained in the recess by virtue of the tight fit. Thereafter, as the trip mechanism **26** is inserted downwardly into the tubular interior **24** of the breaker housing **10**, the spring **48** will not fall out. It will retain the proper orientation relative to plunger **40** during assembly, as well as thereafter.

In fitting the trip mechanism **26** through the top opening **22** of housing **10**, it is necessary first to rotate the trip mechanism 90° from its normal operating position, so that the sidewardly extending moveable contacts **44** can slip past the fixed contacts **16**. After contacts **44** slip past contacts **16**, and as the trip mechanism **26** continues to be inserted into the tubular interior **24**, the mechanism is then rotated 90° back to its operating position so that the moveable contacts **44** turn directly under the fixed contacts **16** and into operating relationship therewith.

After assembly is completed, however, it is essential that the trip mechanism **26** no longer rotate to any significant extent relative to the fixed contacts **16**, because if that happened the contacts **44** and **16** would move out of operative relationship with each other. Even a slight misalignment of contacts **16** and **44** would result in a smaller current-carrying contact interface, which would increase the contact resistance and produce a higher level of heat dissipation within the circuit breaker under fault conditions.

In order to prevent such undesirable rotation of the trip mechanism **26**, the interior surface of the tubular hollow **24** is formed with four radially inwardly extending bosses **24***a* spaced 90° apart around the periphery of the interior **24** (see FIGS. **2** and **10**). Each of the bosses **24***a* is shaped in the form of a right angle wedge, the corner of which is cut away to form a right angle recess **24***b*, as best seen in FIG. **10**. These four recesses **24***b* together define a socket into which the bottom of the plunger **40**, specifically the corners **56***a* of shoulders **56**, are received. The engagement between shoulders **56***a* of plunger **40** and the rectangular socket defined by the recesses **24***b* prevents the plunger **40** and thus the entire trip mechanism **26** from turning to any substantial degree once the trip mechanism is lowered into place within the tubular interior **24**.

Note that the lower end of the plunger biasing spring **48** has a conically widened portion **48***a* at its lower end. This permits the lower end of the biasing spring **48** to fit over and encircle the inner end of the rivet **18**, as seen in FIGS. **8** and **9**. The effect of this engagement between spring **48** and rivet **18** is automatically to center the trip mechanism **26** within the tubular interior **24**, and thereby to insure that the corners **56***a* of the plunger shoulders **56** will be guided smoothly into their sockets **24***b* during assembly.

In the final assembly steps for a circuit breaker in accordance with this invention, the cover **28** is placed over the trip mechanism **26** and inserted into the top opening **22** of housing **10** as indicated by arrow **29** in FIG. **3**; after which first the gasket **30** and then the cap **32** are put in place over the cover **28**, and the cap flange **32***a* is crimped over the housing ring **14**.

Whenever an electrical fault condition occurs, the entire assembly of the moveable contacts **44** and bimetallic clip **42** is pulled downwardly to open the contacts **16**, **44**, by a pair of trip springs **52** which are tensed between respective lugs **54** on the bimetallic clip **42** and respective shoulders **56** formed at the bottom of the plunger **40**. The mechanism is prevented from tripping under normal conditions by the bimetallic clip **42**, which at ambient temperature is restrained by a latch member **58** assembled to one side of the plunger **40** by means of a rivet **60**. The latch member **58** is formed with a latching shelf **58***a* against which one side **42***a* of the bimetallic clip **42** rests, to restrain downward movement of the clip, as seen in FIGS. **8** and **9**. The other side **42***b* of the clip **42** rests against the smooth reverse side **40***a* of the plunger. As described in the Ingwersen patents cited above, the spacing between sides **42***a* and **42***b* of the clip is a function of temperature, the distance between them decreasing at cooler temperatures

and increasing at higher temperatures. The clip is placed so that sides **42***a* and **42***b* thereof embrace the plunger **40**, as best seen in FIGS. **6** and **7**. Thus the sides **42***a* and **42***b* constitute a pair of opposed pincers which clasp the plunger to an extent dependent upon temperature. When the bimetallic clip **42** is in its normal operating position (illustrated by FIGS. **8** and **9**) and its temperature is not elevated, the sides **42***a* and **42**b approach each other closely enough so that side **42***a* engages the latching shelf **58***a* and thereby retains the clip **42** in that position against the pull of trip springs **52**.

The current path through the breaker goes from the central exterior electrode **18** through elements **16***c* and **16***a* to one of the fixed contacts **16**. Then it enters one of the moveable contacts **44** and flows into the bimetallic clip **42**. At that point the current flow divides into two parallel paths, one of which passes through sides **42***a*, and the other of which flows through side **42***b*, of the clip **42**. The two parallel current paths are rejoined at the opposite contact **44**, and then proceed to the associated fixed contact **16**. Thereafter the current flow exits from the circuit breaker via element **16***b* and the peripheral exterior electrode **20**.

Under fault conditions, the current passing through the bimetal clip **42** is of such proportions that the heat dissipated in the clip expands the distance between sides **42***a* and **42***b*. When the expansion proceeds to the point at which side **42***a* slips off the edge of latching shoulder **58***a*, then the clip **42** becomes unlatched, and the trip springs **52** pull the clip **42** and movable contacts **44** down into the tripped position illustrated by FIGS. **6** and **7**. This separates movable contacts **44** from fixed contacts **16**, and opens the circuit to interrupt the fault current. During the downward trip motion of clip **42**, side **42**b thereof guides against the adjoining smooth side of plunger **40**.

The fault currents which U.L. requires household circuit breakers to tolerate are as high as 5,000 amperes. Such large currents cause extreme heating, and the effect upon a circuit breaker of fuse envelope dimensions can be catastrophic. The problem is particularly severe when a trip movement of this type is crammed into the small confines of a type S envelope. Previous attempts to employ an envelope of these small dimensions were unsuccessful, apparently due to the tendency of expanding hot gasses inside the breaker housing to blow the housing apart, and spread carbon over the exterior surfaces of the breaker, thus laying down undesirable electrical tracking paths for leakage currents.

The one-piece integral housing **10** of the present circuit breaker has several advantages in this respect; it has greater resistance to the internal pressure of expanding gasses, and it has no axial seam lines through which the carbon material can escape. But in addition, the circuit breaker of this invention incorporates certain extra features which help to defeat the destructive effect of excessive heating inside the breaker. One of these features is the provision of a pair of vent holes **62** (see FIGS. **2, 4** and **9**) on the bottom surface **12**a of the lower portion **12** of circuit breaker housing **10**. In one embodiment, these holes **62** were each roughly 3/64 inch in diameter. Experiments have established that these vent holes play an important role in enabling the type S circuit breaker of this invention, for the first time, to withstand the internal pressures generated under fault conditions encountered in some of the more severe U.L. tests. It is believed that the vent holes function by providing an escape for the internal pressure built up by hot expanding gas in the interior of the breaker.

In addition, the plastic molded cover **28**, which closes the top opening **22** of housing **10**, is integrally formed with a pair of D-shaped bosses **64**, which project into the interior of the circuit breaker housing **10**, on either side of the fixed contacts **16** (see FIGS. **3, 8** and **9**). These bosses **64** also permit the type S circuit breaker of this invention to withstand the high internal pressures to which it is subjected during severe U.L. test procedures. Here it is believed that the bosses function by redirecting the force of the hot expanding gasses inside the breaker, downwardly toward the holes **62**, thereby enhancing the ventilating effect of those holes.

In prior art circuit breakers employing trip mechanisms of the bimetallic clip type, the clip was allowed to move downwardly under trip conditions without limit, until the trip springs were completely relaxed. In certain cases, this would permit the relaxed trip springs to escape from their anchoring lugs or shoulders, and thereby become disassembled from the trip mechanism. When this happens, the circuit breaker is then rendered useless for further operation, since it will not function properly the next time it is required to trip.

When the bimetallic clip **42** releases itself from the latching shoulder **58***a* and is pulled down by the trip springs **52**, it continues to move downwardly until the lower edges **42***c* of sides **42***a* and **42***b* strike a pair of limiting shoulders **66** which are integrally molded on opposite sides of the plunger **40** at the lower end thereof. These limiting shoulders **66** are positioned to halt the downward travel of bimetallic clip **42** at a lever such that the trip springs **52** are not completely contracted; i.e., they are still under some slight tension between the lugs **54** and shoulders **56**. This minimizes the possibility that the trip springs **52** can become disassembled either from the lugs **54** or the shoulders **56**.

Another problem encountered by previous circuit breaker trip mechanisms of this type has been interference between the bimetallic clip **42** and the edge of the latching shoulder **58***a* when the circuit breaker is reset. As best seen by reference to FIGS. **10, 11** and **12**, each side **42***a* and **42***b* of the bimetallic clip is cut out to form a window **42***d* which reduces the cross-sectional area of the path through which the fault current flows, raises the electrical resistance, and thereby permits the breaker to trip at the desired current rating. A much higher current level would be required to produce the same degree of bimetal heating if the current path through the bimetallic clip included the area of windows **42***d*. The removal of the central window area **42***d* forms each side **42***a* and **42***b* of the bimetallic clip into a U-shaped member. Each U-shaped member comprises a pair of vertical legs **42***e* on opposite sides of the window **42***d*, and a horizontal cross-bar **42***f* extending across the bottom of the window **42***d*. Note that tangs **42***g* extend horizontally from each of the vertical legs **42***e*, part way into the adjoining window **42***d*, and contact the plunger **40** in order to guide the motion of the bimetallic clip **42**.

Because of the described configuration of the bimetallic clip **42**, the horizontal cross-bars **42***f* have lower or leading edges **42***c* (one of which was described above in connection with the latching function) and upper or trailing horizontal edges **42h**. This latter edge

42*h* of side 42*a* has a tendency to interfere with the latching shoulder 58*a* during reset of the circuit breaker after tripping.

The resetting of the circuit breaker is accomplished by pressing on the reset button 46, and thus driving the entire plunger 40 downwardly. The latch member 58 then moves downwardly with the plunger 40, until the shelf 58*a* thereof comes under the leading edge 42*c* of side 42*a* of the bimetallic clip. This motion recaptures and relatches the clip 42. Thereafter the reset button 46 is released, and the biasing spring 48 drives the plunger back up to its normal operating position, carrying the clip 42 and moveable contacts 44 with it. In prior art devices, during the downward stroke of the plunger the edge of the latching shoulder had a tendency to catch the trailing edge of the adjacent horizontal cross-bar, thus preventing smooth resetting of the circuit breaker.

In order to prevent this from happening, the circuit breaker of the present invention provides an additional tang 42*i* which extends vertically upwardly from the horizontal trailing edge 42*h*, and projects into the cut-out window area 42*d*. As seen in FIG. 7, the height of the tang 42*i* is such that when the bimetallic clip 42 is in its tripped position defined by the limiting shoulders 66, the top of the tange 42*i* adjacent the latching shelf 58*a* is somewhat above the level of the latching shelf. Thus the upper end of the tang 42*i* can not move past the latching shelf 58*a*. As a result, during resetting of the circuit breaker, the vertical tang 42*i* guides against the edge of the latching shelf 58*a*. This prevents the trailing horizontal edge 42*h* from catching against the latching shelf 58*a* and interfering with smooth resetting of the breaker.

Note that both sides of the bimetallic clip 42 have the vertical tangs 42*i*, even though there is only one latching shelf 58*a* in the circuit breaker illustrated herein. In another embodiment of the invention it might be desired to provide latching members on both sides of the plunger 40, in which case the two tangs 42*i* would serve to prevent interference with both of the latching shelves 58*a* during resetting.

Under certain circumstances it is desirable for a circuit breaker manufacturer to modify a particular trip mechanism of a given current rating so that it trips under less than the fault current ordinarily required. This can be a simple and inexpensive way of producing two different circuit breakers with different trip current ratings. This result is accomplished in Ingwersen U.S. Pat. No. 2821601 mentioned above, by separating the two sides of the bimetallic clip and connecting them in series circuit relationship, so that the full fault current is passed through each side of the clip. However, the manufacturing and assembly difficulties encountered by that approach to some extent defeat the objective of a simple and inexpensive modification.

In accordance with the present invention, the trip current rating of the mechanism 26 is reduced with extreme simplicity and economy by simply making a through cut 70 across one side, e.g., 42*a*, of the bimetallic clip 42. The cut 70 extends vertically from the upper tip of vertical tang 42*i* all the way down to the lower edge 42*c*, and also extends completely through the depth of side 42*a* of the bimetallic clip.

Two different approaches are possible, both within the contemplation of this invention. The through cut 70 may be made wide enough, as illustrated by FIG. 12, so that even at ambient temperature it effectively interrupts the current path which would otherwise be provided by side 42*a* of the metallic clip. As a result, at all times all the current between contacts 44 must flow exclusively through side 42*b*.

In the preferred embodiment of the invention, in order to make the trip mechanism modification even simpler and more economical, the through cut 70 is formed not by removing any material and leaving the sides of the cut separate from each other, but simply by shearing through the material of side 42*a*, thereafter leaving the sides of the cut in intimate contact with each other, as illustrated in FIG. 11. This means that under normal conditions, the current will divide into two parallel paths and flow through both sides of the bimetallic clip 42*a* and 42*b* in the manner described above. Experiments have shown, however, that when the current rises toward the trip rating of the modified breaker, the warping of the bimetallic material in response to heating causes the bimetallic clip 42 to pull the edges of the cut 70 apart. This action is illustrated in FIG. 12, which shows side 42*a* pulling apart in both directions (see arrows 72) in order to widen the cut 70 and thereby prevent any further current from flowing through side 42*a*. As a result, as the current rises to fault proportions, it is shunted exclusively to side 42*b*.

In order to trip the mechanism 26 at a given ambient temperature, a given heat power P must be dissipated in the bimetallic clip 42 by the fault current. In a prior art, parallel current path device (i.e., one which has no cut 70), a fault current I is divided into two equal components $I/2$ flowing through two equal resistances R presented by the respective sides of the bimetallic clip. Thus the total heat power P dissipated in the clip is

$$P = (I/2)^2R + (I/2)^2R = 2(I/2)^2R = I^2R/2$$

In order to trip a circuit breaker in accordance with this invention, the same heat power P must be dissipated by a current which, at the time of tripping, is I' and flows through a single path of the same resistance R. Thus

$$P = I'^2R = I^2R/2$$
$$I'^2 = I^2R/2R = I^2/2$$
$$I' = I/\sqrt{2}$$

Thus it is proven that the trip current I' required by a breaker with the through cut 70 is less than the trip current I required by a parallel path breaker of otherwise similar design.

It will now be appreciated that the circuit breaker of this invention provides numerous advances over breakers of the same general type known to the prior art. The movement of the current sensing clip upon tripping is limited by a pair of stop shoulders which are positioned so that the trip springs are never allowed to become completely relaxed, and this avoids the danger of disassembly. In addition a tang is provided on the bimetallic clip which remains in position across the latch shoulder when the bimetallic clip bottoms on the limiting shoulders, and thereby prevents undesirable engagement between the edge of the bimetallic clip and the latch member during resetting of the breaker. The fuse-shaped circuit breaker envelope includes a housing of onepiece, hollow, open-ended construction, and has vent holes at one end and a cover member with D-shaped bosses at the other end, all of which has advantages in permitting a type S circuit breaker to withstand U.L. qualification testing. Accordingly, a new method of assembling the breaker is provided, in which all the internal parts are inserted through the open end of the

hollow housing. During this operation it is advantageous for the plunger biasing spring to be frictionally received within an appropriate recess at the bottom of the plunger. The bimetallic clip may be formed with a through cut, in order to de-rate the breaker easily and economically. Finally, further economies are achieved by forming the peripheral external electrode of inexpensive round wire stock, appropriately flattened at one location to permit staking for mechanical and electrical connection thereto.

Since the foregoing description and drawings are merely illustrative, the scope of protection of the invention has been more broadly stated in the following claims; and these should be liberally interpreted so as to obtain the benefit of all equivalents to which the invention is fairly entitled.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a circuit breaking trip mechanism of the type having a plunger for resetting the mechanism after tripping, a current sensing device movable relative to said plunger, means anchored to the plunger for biasing said current sensing device relative to said plunger for tripping movement, and latching means arranged to arrest said tripping movement until said current sensing device senses a current tripping condition; the improvement comprising stop shoulder means on said plunger selectively located relative to the anchor place of the biasing means to engage and seat said current sensing device during its tripping movement after escape of said current sensing device from said latching means, said stop shoulder means further being located on the plunger to maintain said trip spring under tension when the current sensing device is in the current tripped position to inhibit spring disassembly.

2. A mechanism as in claim **1** wherein said plunger is formed with a body having opposing guide surfaces arranged to guide the current sensing device and said current sensing device being provided with pincer members located to respectively move along the guide surfaces of the plunger, said guide surfaces being provided with said stop shoulders to seat the pincer members upon current tripping movement thereof.

3. In a current breaking trip mechanism of the type having a latch member formed with a latching edge, a current sensing device including a crossbar which is movable across said latching edge and having leading and trailing edges generally parallel to said latch edge, said cross-bar being arranged for said leading edge thereof to engage said latching edge to latch said sensing device, and to release from said latching edge in response to a sensed current condition, biasing means effective upon such release to drive said current sensing device sufficiently far from the latched position thereof so that said cross-bar trailing edge crosses said latching edge, said current sensing device having a limiting position when released, and means for resetting said current sensing device to its latched position whereby to move said trailing edge back across said latching edge; the improvement comprising a tang projecting sufficiently far from said trailing edge to maintain said tang extended across said latching edge when said current sensing device is in said limiting position whereby to prevent undesirable engagement of said trailing edge with said latching edge during resetting.

4. The improved circuit breaking trip mechanism as in claim **3** wherein said resetting means includes a plunger, with said biasing means connected between said current sensing device and said plunger, said latch member being mounted on said plunger, and stop shoulder means formed on said plunger for engaging said cross-bar leading edge to establish said limiting position for the current sensing device.

5. In a circuit breaker having a pair of fixed electrical contacts and a trip mechanism of the type having a carrier member and switching means including a pair of contacts movable on said carrier member from a position for closing an electrical circuit between said fixed contacts to a position for breaking said electrical circuit, and current sensing means in the form of a current responsive metal element including two oppositely located pincer members which both extend between said movable contacts of said switching means and embrace said carrier member therebetween, a latch on at least one carrier member surface, and wherein at least one of said pincer members engages and disengages said latch as a function of the current flowing through at least one of said pincer members; the improvement wherein one of said pincer members is formed with a through cut which is effective to divert electric current to the other of said opposed members at least under trip conditions.

6. A breaker as in claim **5** wherein the ends of said through cut are normally in contact with each other, and said current responsive element has the property of distorting in response to current overloads in such a way that the ends of said cut then become separated from each other.

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