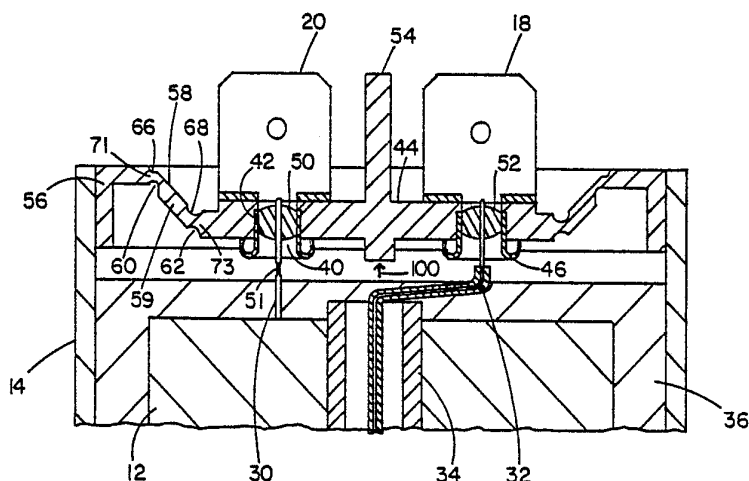




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(54) Title: CAPACITOR CIRCUIT INTERRUPTION



(57) Abstract

A circuit interrupter in electrical capacitors is activated by an interruption mechanism that moves an actuator (44) in response to a predetermined physical condition within the capacitor to cause electrical disconnection. The actuator has a range of motions through a limited number of stable positions and is mechanically pre-biased to move towards one of the stable positions when not already in one of the stable positions. Previously, pressure sensitive interrupters would be reconnected when the cover and terminals settled back due to pressure drop which could cause arcing. The present capacitor (12) is quickly and effectively disconnected when pressure builds up and stably remains in its popped up position to reduce the chance of reconnection. Capacitor terminals (18 and 20) are mounted on the actuator which is attached to a housing (54) by hinge regions (58) which provide a stable position upon build up of a pressure.

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- 1 -

Capacitor Circuit InterruptionBackground of the Invention

This invention relates to circuit interruption in electrical capacitors.

5 Deterioration of a capacitor typically generates gasses that increase the internal pressure within the sealed capacitor case, eventually causing rupture and leakage of the liquid dielectric. Pressure sensitive interrupters are sometimes used within the
10 capacitor case to prevent rupture by breaking the electrical connection to the capacitive element in response to the internal pressure, thus stopping the gas buildup.

 Published European patent application
15 0-093-455-A2 shows an interrupter in which the capacitor has terminals attached to a central disk that is part of the plastic can cover. The central disk is connected to the peripheral rim of the cover by an intermediate deformable "annular wall portion or web of reduced wall
20 thickness" that permits the central disk to move away from the can in response to internal pressure. The capacitive element is held down by a rim around the inside of the plastic can so that as the central disk moves upward it eventually breaks the metal conductors
25 that connect the terminals to the capacitive element.

 Sometimes, after a pressure sensitive interrupter has broken the electrical connections, the internal pressure drops and the cover and terminals settle back to their original positions where electrical
30 reconnection or arcing may occur.

Summary of the Invention

A general feature of the invention is a capacitor in which the interruption mechanism includes

- 2 -

an actuator that moves in response to a predetermined physical condition within the capacitor to cause electrical disconnection, and in which the actuator has a range of motion through a limited number of stable positions and is mechanically pre-biased to move toward one of the stable positions when not already in one of the stable positions.

Preferred embodiments of the invention include the following features. The physical condition is internal gas pressure within the capacitor, and the actuator moves in response to the pressure. The actuator comprises a portion of a wall (e.g., the lid) of the housing; the actuator is attached to the housing by a support having at least one rigid section connected to the wall portion and the housing by hinge regions. The wall portion is a disk, the support is a rigid annular rim, and the hinge regions are flexible annular rings. In some embodiments, there is one rigid section, two hinge regions, and two stable positions. In other embodiments, there are two rigid sections interconnected by a hinge region, and three stable positions. In other embodiments, there is an annular rim that is thinner than the wall portion. The capacitor terminals are mounted on the actuator. The electrical connections include conductors between the terminals and the capacitive element and the interruption mechanism further comprises means for retaining each conductor in a fixed position relative to motion of the actuator. The capacitive element includes a core that is ultrasonically welded to the inside of the housing. In other embodiments, a panel is interposed between the capacitive element and the terminals. The housing is plastic and includes a lid on which the actuator is located. The actuator is polypropylene. The capacitor

- 3 -

element includes a dielectric impregnant (i.e., a blend of polybutene and polyethylene) having a drop point that is above the normal operating temperature of the capacitor, and is below a temperature that would occur following failure of the capacitor winding. In other embodiments, there is a liquid dielectric impregnant (e.g., polybutene) that is compatible with the plastic of the housing.

Another general feature of the invention is a capacitor in which the terminals are mounted on and project from the housing and the housing includes a rim that surrounds the terminals and is filled with a dielectric material that insulates the terminals.

The capacitive element is quickly and effectively disconnected when pressure builds up. The actuator pops up to aid in the disconnection and stably remains in its popped up position to reduce the chance of reconnection. The entire capacitor is easily made. Mounting the terminals on the actuator assures positive motion of terminals away from the capacitive element. When the terminals are fully insulated, the capacitor can be used safely in tight quarters.

Other advantages and features will become apparent from the following description of the preferred embodiment and from the claims.

Description of the Preferred Embodiment

We first briefly describe the drawings.

Drawings

Fig. 1 is a perspective view of a capacitor.
Fig. 2 is a diagrammatic sectional side view at 2-2 of the capacitor of Fig. 1.
Fig. 3 is an enlarged sectional side view, broken away, along 2-2 of the capacitor of claim 1.

- 4 -

Fig. 4 is a sectional side view of a fragment near the bottom of the capacitor case of Fig. 1.

Fig. 5 is a partial top view of the floor of the capacitor case of Fig. 1.

5 Figs. 6, 7 are sectional side view and plan view respectively of the capacitive element core of Fig. 3.

Fig. 8 is a view like Fig. 3 after disconnection.

10 Figs. 9A, 9B, 9C are a sequence of sectional side views of a fragment of the capacitor lid of Fig. 1, showing three discrete positions of a lid using an alternative hinge arrangement.

15 Fig. 10 is a sectional side view of one-half of an alternative embodiment to Fig. 3.

Fig. 11 is a sectional side view of a portion of an alternative capacitor cover.

Fig. 12 is a sectional side view of a portion of an alternative capacitive element core.

20 Figs. 13, 14 are isometric and sectional side views of an alternative capacitor cover.

Structure

Referring to Fig. 1, a capacitor 10 includes a capacitor roll 12 inside an injection molded round polypropylene plastic case 14 having an injection molded polypropylene cover 16 (made, e.g., from polypropylene product no. PP-402 available from Monmouth Plastics, or Polyflam RPP 1058 available from A. Schulman) in which two terminals 18, 20 are mounted. Case 14 has a segmented outer rim at the top end for mounting the capacitor.

Referring to Fig. 2, terminal 20 is electrically connected (in a conventional manner) to the top of capacitor roll 12 via an uninsulated tinned

- 5 -

copper or tinned copperweld wire 30; terminal 18 is electrically connected (also in a conventional manner) to the bottom of roll 12 via an insulated wire 32 which passes through a hollow polypropylene capacitor core 34 or around the outside of the capacitive element. Capacitor roll 12 is surrounded by and embedded in a dielectric material 36.

Referring to Fig. 3, terminals 18, 20 are of eyelet design and include tubular portions 40 inserted through access holes 42 in a rigid central disk section 44 of cover 16. The ends 46 of tubular portion 40 are bent back against the underside of disk 44 to hold terminals 18, 20 in place.

Wire 30 is pulled taut and attached to terminal 20 by solder 50 and includes a carefully machined nick 51 by which the amount of tension (e.g., 15 lbs) needed to sever the wire can be carefully controlled. Insulated wire 32 is stripped to expose an uninsulated tinned copper conductor (which may also be nicked) that is similarly pulled taut and attached to terminal 18 by solder 52. If wire 32 is not nicked, it is not pulled taut, but is left with slack to allow cover 16 to move and break the nick in wire 30.

In addition to central disk 44, cover 16 includes a rigid L-shaped (in cross-section) peripheral portion 56 ultrasonically welded to the inner wall of case 14. A panel 54 on cover 16 forms an insulative barrier between terminals 18 and 20. A hinged portion 58 connects peripheral portion 56 and central disk 44. Hinged portion 58 is ring-shaped, disposed at an angle of preferably 30-45° (a) with respect to the vertical, and includes a rigid part 59.

Extending around the outer edge of rigid part 59 (where it joins peripheral portion 56) and around the

- 6 -

inner edge of part 59 (where it joins central disk 44) are interior grooves 60, 62 and exterior grooves 66, 68.

Grooves 60, 62, 66, 68 are arranged in pairs with the interior groove and the exterior groove of each pair, e.g., 60, 66, vertically aligned, thus defining
5 two flexible annular rings (hinge regions) 71, 73 which bend when the internal pressure in the can rises.

In one example, central disk 44 is 0.062" thick, part 59 is 0.044" thick, and grooves 60, 62, 66,
10 68 have typical radii of 0.031". The centers of radius of grooves 60, 62, 66, 68 lie at the intersections of planes that extend from the upper and lower surfaces of part 59, central disk 44, and peripheral portion 56.

Referring to Fig. 4, capacitor 10 includes
15 equally spaced vertical ribs 70 along inside wall 72 of case 14 and an ultrasonic energy directing grid 74 molded into the bottom 76 of case 14.

Referring to Fig. 5, ribs 72 extend 0.02 inches into case 14 and are spaced 15° apart about the central
20 axis of case 14. Grid 74 is 0.75 inches in diameter and is concentric with the bottom of case 14. Grid 74 includes upwardly extending peaks 80 and recessed rectangular regions 82.

Referring to Fig. 6, 7, the lower section of
25 core 34 includes hexagonal bore 90 and circular bore 92. Energy directing flange 94 extends around the bottom of core 34, and, when placed in case 14, contacts the top of peaks 80 of grid 74 at a limited number of sharply defined contact points at which ultrasonic
30 welding can be accomplished.

Dielectric material 36 may be liquid polybutene as described in copending patent application, U.S. Serial No. 762,542, filed August 2, 1985, assigned to the same assignee as this application, and incorporated

- 7 -

herein by reference. Polybutene has an advantage of not attacking the polypropylene material of case 14.

Alternatively, the capacitor may be formed as a "dry" capacitor by substituting a waxlike blend for dielectric material 36. For example, the blend can be a mixture of polyethylene and polybutene chosen to be non-liquid at normal operating temperatures. As the capacitor begins to fail, the resulting temperature rise causes softening of the mixture, allowing gas to escape to the upper part of the interior of the capacitor case, to trigger operation of the disconnection mechanism. Additional details concerning the blend are set forth in patent application, Bentley, U.S. Serial No. 870,717, Impregnation and Encapsulating Material, filed on the same day as this application, assigned to the same assignee, and incorporated herein by reference.

Assembly

Terminals 18, 20 are mounted on cover 16 by inserting unbent tubular portions 40 through access holes 42 and bending ends 46 of portions 40 back against the underside of disk 44.

Roll 12 and hollow core 34 are fixed inside case 14 by ultrasonically welding the flange 94 of core 34 to the peaks 80 of grid 74. The sharp lower edge of flange 94 and the sharp upper edges of peaks 80 serve to direct the ultrasonic energy to the contact points between peaks 80 and flange 94, creating a strong weld.

Next, roll 12 and core 34 are encased in material 36.

Cover 16 is then placed into the top of case 14 and wires 30, 32, previously connected to roll 12, are fed up through tubular portions 40. Peripheral portion 56 is ultrasonically welded to case 14. Finally, wires 30, 32 are pulled taut and soldered into place.

- 8 -

Operation

Referring to Fig. 3, when the internal pressure inside case 14 increases, an outward force is exerted on central disk 44 (in the direction indicated by arrow 100.)

Eventually the internal pressure becomes large enough to cause central disk 44 to pop outward to occupy a second stable position as shown in Fig. 8.

As disk 44 moves to its new position, it pulls on wire 30, causing it to break at nick 51. Wire 32 may also break if taut and nicked. This halts the flow of electric current through roll 12 and in turn the generation of gasses and the building of increased internal pressure. Rupture of case 14 is thus prevented.

The effect of the design is to provide an actuator that has two stable positions, and is pre-biased to move toward one or the other stable position when not already in one of the stable positions. Thus, as the central disk 44 rises under pressure it reaches a point in its travel where it pops up to its upper position thus aiding rapid and complete disconnect. Once in the upper position the central disk resists downward movement except under a force that exceeds the pre-bias force.

Other Embodiments

Other embodiments are within the following claims.

For example, referring to Fig. 9A, hinged portion 200 could include three (or more) interior grooves 202, 204, 206 and three (or more) exterior grooves 208, 210, 212. Referring to Fig. 9B, as central disk 214 moves outward portion 200 may bend first at grooves 204, 210, 206, 212 to form a V-shape. Referring to Fig. 9C, as disk 214 continues to move outward

- 9 -

additional force on portion 200 causes it to bend at grooves 202, 208. Eventually disk 214 reaches the final position shown in Fig. 9C and portion 200 is once again fully extended.

5 Referring to Fig. 10, in other embodiments, terminal 318 may be electrically connected to capacitor roll 312 via tinned steel terminal rivets 330 spot welded to tinned copper tabs 332. Terminals 318 are mounted on cover 316 by inserting rivets 330 through
10 cover 316 and welding terminals 318 to rivets 330 while applying a clamping force between rivet shoulders 338 and terminals 318. Rivet tips 340 are then inserted through holes 342 in panel 344. Tabs 332 (previously connected to capacitor rolls 312) are spot welded to
15 tips 340. Panel 344 and cover 316 are ultrasonically welded to the inner wall of case 314. As central disk 336 moves outward terminals 318 and rivets 330 also move outward causing an outward force to be exerted on foil tabs 332 and on the welds connecting tabs 332 to rivet
20 tips 340. Tabs 332 are drawn outward until they come in contact with interrupter panel 344. As central disk 336 continues outward, the force exerted on the welds between tips 340 and tabs 332 causes tabs 332 to tear away from tips 340. This breaks the electrical
25 connection between terminals 318 and capacitor roll 312. In the embodiment of Fig. 10, it is not necessary to attach the capacitor roll to the bottom of the case since panel 344 will prevent roll 312 from rising.

The dimensions of the central disk 44
30 (actuator), part 59, and grooves 60, 62, 68 can be varied to change the flexibility of the hinges and thus control the dynamic characteristics of the interruption mechanism.

- 10 -

When the dielectric impregnant is liquid, other impregnants can be substituted for polybutene, e.g., dioctyl phthalate (DOP), castor oil, or mineral oil, provided that it is not a liquid that will attack the capacitor case.

Other materials can be used for case 14 and core 34 provided that they are chosen from the same organic polymer family to permit ultrasonic welding. More than two terminals could be used. The externally exposed parts of the terminal could be encased in an insulator.

Referring to Fig. 11, hinged portion 58 may simply be a thinned down region 400 without grooves defining separate hinge regions.

Referring to Fig. 12, the capacitive element core may be formed by countersinking 402 the end of the core.

Referring to Figs. 13, 14, cover 16 may include an annular rim 404 that rises above the level of terminals 406. Wires 408 are attached to terminals 406, and passed through ports 410. Then the space within rim 404 is potted with a dielectric resin material 412, thus eliminating all exposed conductive elements. Such a capacitor is especially useful in close quarters to prevent unintentional contacts, e.g., in HID type lamp ballasts.

Other materials can be used for the cover provided that they have appropriate physical, thermal, and electrical properties to provide the required mechanical operating features and also to satisfy the requirements of the particular application.

- 11 -

Claims

1. A capacitor comprising
a capacitive element,
a housing containing said element,
5 terminals on said housing for making electrical
connection to said capacitive element, and
an interruption mechanism for electrically
disconnecting said capacitive element in response to a
predetermined physical condition within said capacitor,
10 said mechanism including an actuator that moves
in response to said condition to cause said electrical
disconnection,
said actuator having a range of motion through
a limited number of stable positions, said actuator
15 being mechanically pre-biased to move toward one of said
stable positions when not already in one of said stable
positions.
2. The capacitor of claim 1 wherein said
physical condition comprises internal gas pressure
20 within said capacitor, and said actuator moves in
response to said pressure.
3. The capacitor of claim 1 wherein said
actuator comprises a portion of a wall of said housing.
4. The capacitor of claim 1 wherein said wall
25 portion is attached to said housing by a support.
5. The capacitor of claim 4 wherein said
support comprises at least one rigid section connected
to said wall portion and said housing by hinge regions.
6. The capacitor of claim 5 wherein said wall
30 portion comprises a disk, said support comprises a rigid
annular rim, and said hinge regions comprises flexible
annular rings.

- 12 -

7. The capacitor of claim 5 wherein there is one said rigid section, two said hinge regions, and two said stable positions.

5 8. The capacitor of claim 5 wherein there are two said rigid sections interconnected by a said hinge region, and three said stable positions.

9. The capacitor of claim 1 wherein said terminals are mounted on said actuator.

10 10. The capacitor of claim 1 wherein said electrical connections include conductors between said terminals and said capacitive element and said interruption mechanism further comprises means for retaining each said conductor in a fixed position relative to motion of said actuator.

15 11. The capacitor of claim 10 wherein said capacitive element includes a core that is ultrasonically welded to the inside of said housing.

20 12. The capacitor of claim 10 wherein said means for retaining comprises a panel interposed between said terminals and said capacitive element.

13. The capacitor of claim 1 wherein said housing is plastic and includes a lid on which said actuator is located.

25 14. The capacitor of claim 1 wherein said actuator is polypropylene.

30 15. The capacitor of claim 1 wherein said capacitive element comprises a dielectric impregnant having a softening point above the normal operating temperature of said capacitor, and below a temperature that would occur following failure of the capacitor winding.

16. The capacitor of claim 15 wherein said impregnant comprises a blend of at least two components one of which is polybutene.

- 13 -

17. The capacitors of claim 16 wherein a second said component comprises polyethylene.

18. The capacitor of claim 13 wherein said capacitive element comprises a liquid dielectric
5 impregnant that is compatible with said plastic.

19. The capacitor of claim 18 wherein said impregnant comprises polybutene.

20. A capacitor comprising
a capacitor element,
10 a housing containing said element,
terminals mounted on and projecting from said housing for making connection to said capacitive element,
said housing comprising an integral rim
surrounding said terminals and projecting from said
15 housing, said rim projecting further from said housing,
than said terminals, and

a dielectric material filling the space within said rim, whereby said terminals are insulated from the space surrounding said housing.

21. The capacitor of claim 4 wherein said support comprises an annular rim that is thinner than said wall portion.

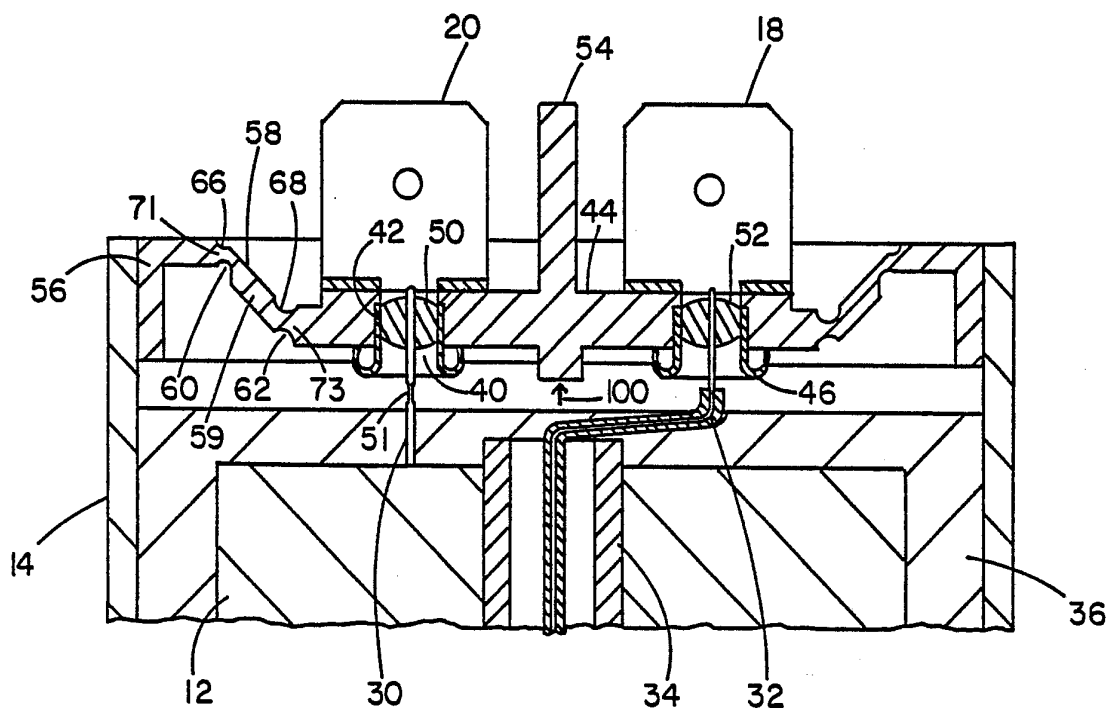
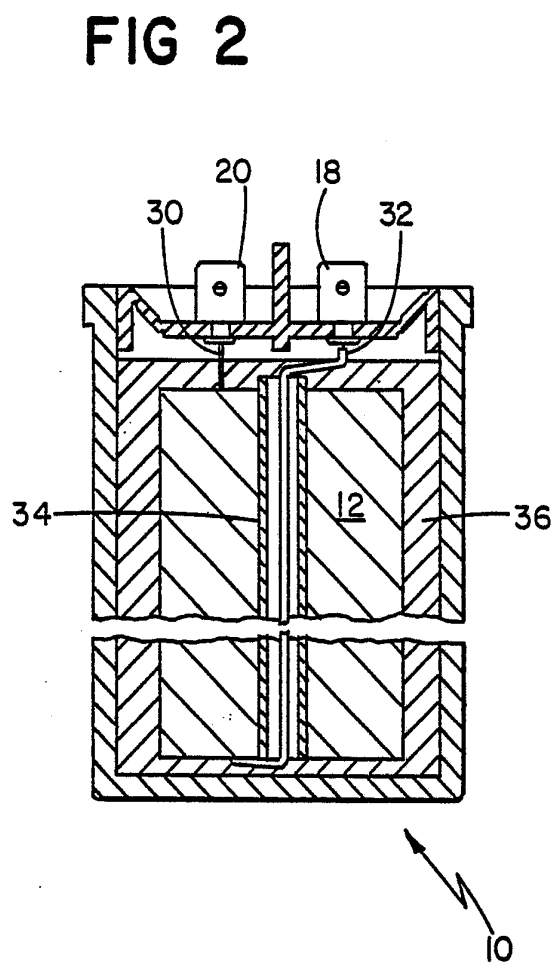
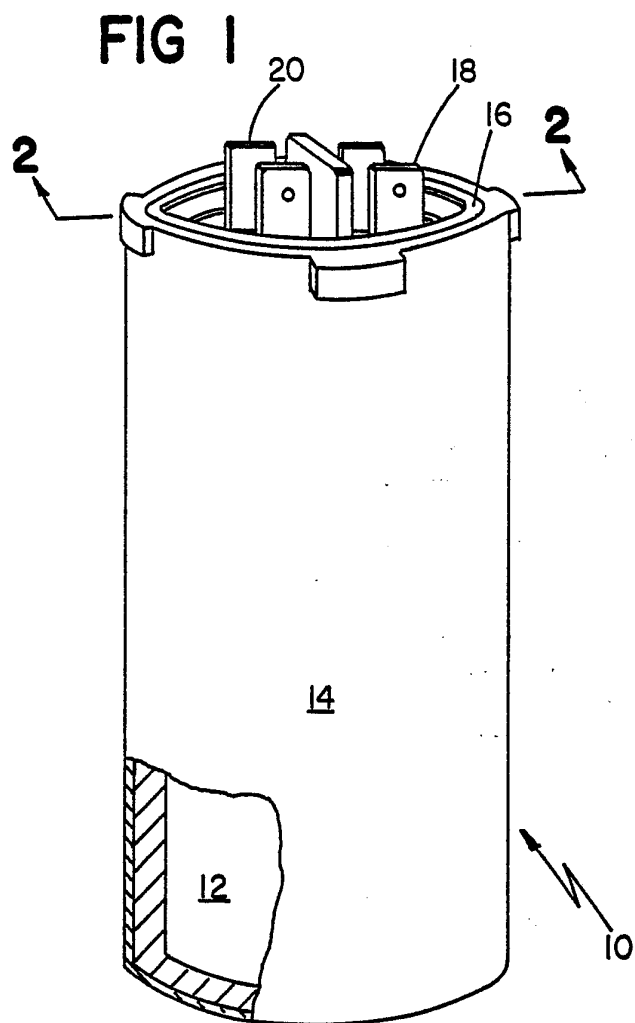


FIG 3

SUBSTITUTE SHEET

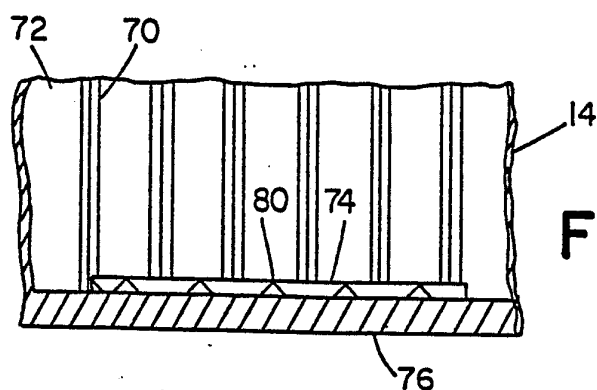


FIG 4

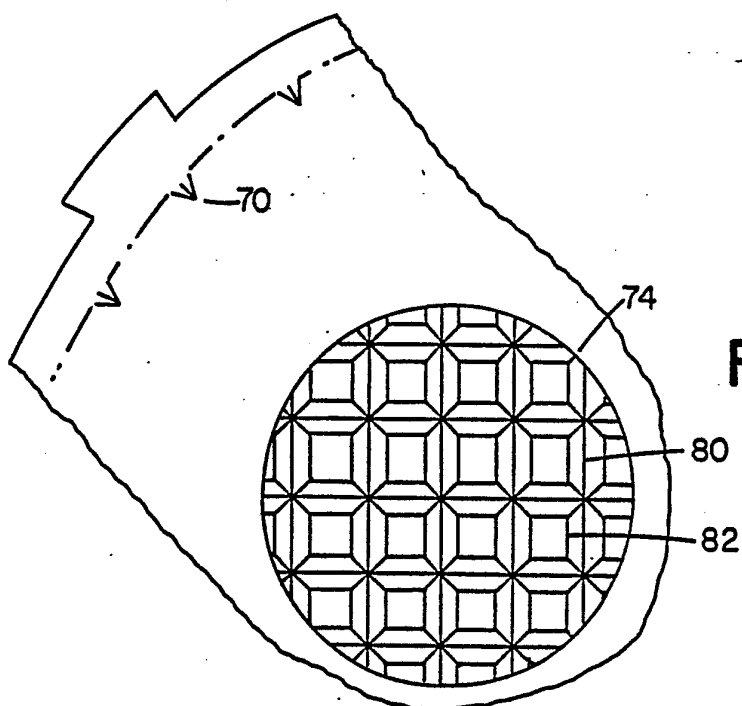


FIG 5

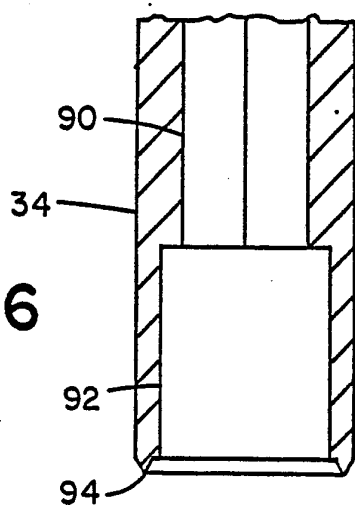


FIG 6

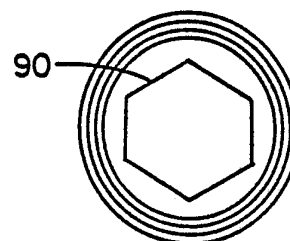


FIG 7

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FIG 8

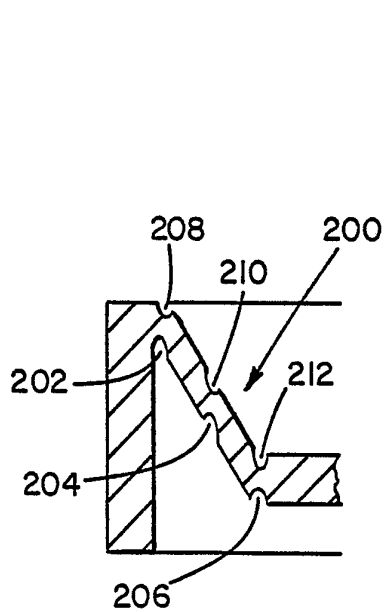
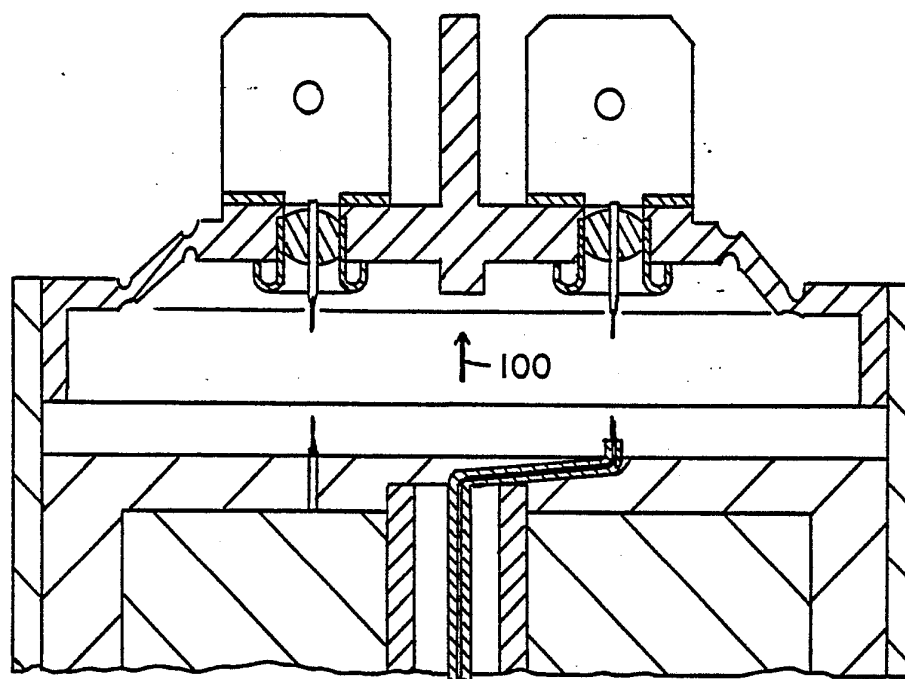


FIG 9A

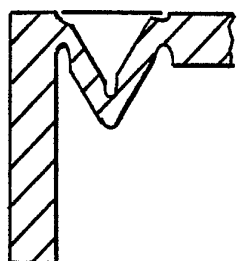


FIG 9B

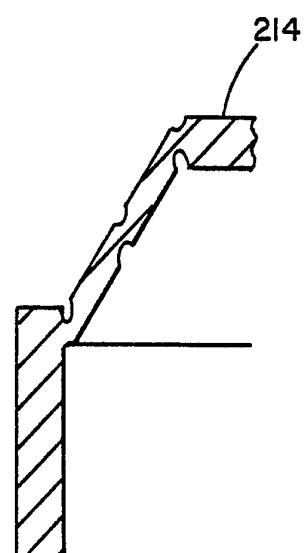


FIG 9C

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FIG 10

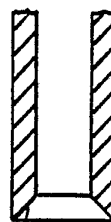
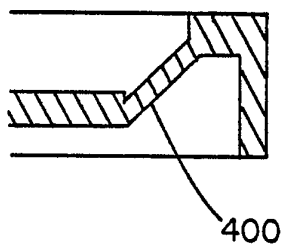
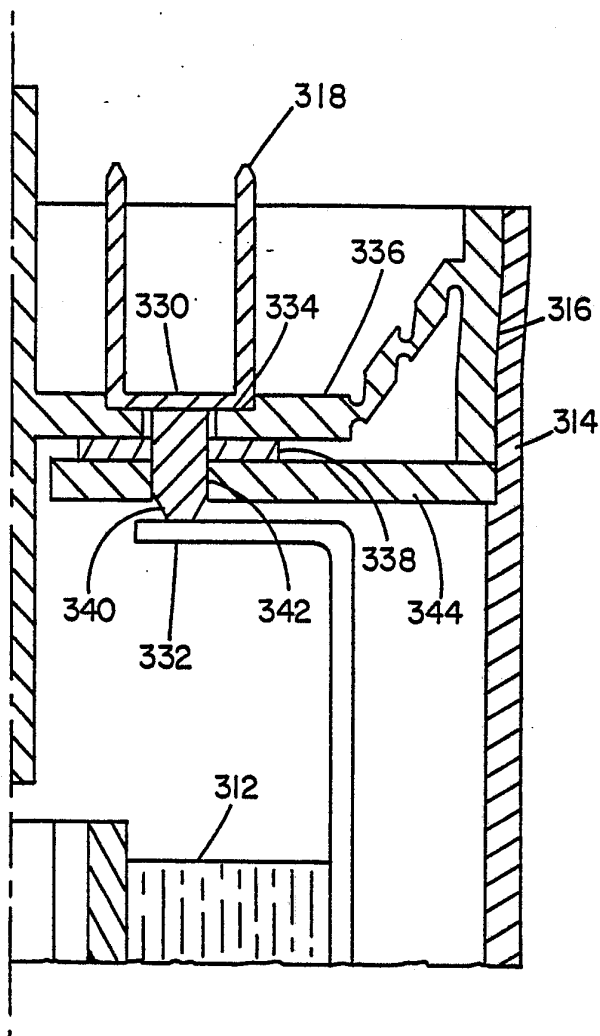


FIG 11 SUBSTITUTE SHEET FIG 12

FIG 13

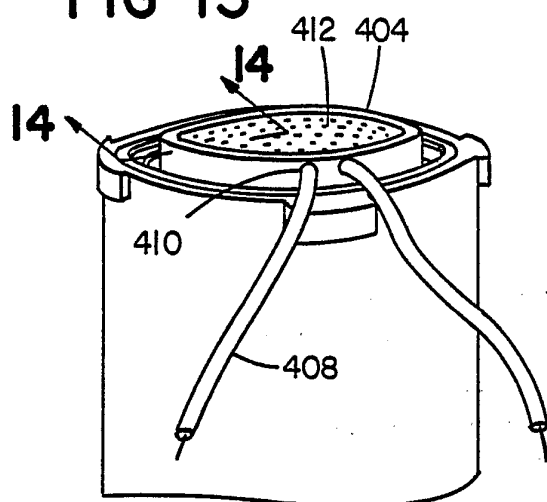
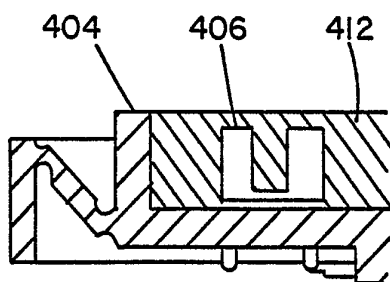


FIG 14



INTERNATIONAL SEARCH REPORT

International Application No. PCT/US87/01325

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ³		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC (4): H02H 7/16, H01G 1/10		
U.S. Cl: 361/15, 272		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁴		
Classification System	Classification Symbols	
U.S.	361/15, 16, 17, 37, 38, 272, 274, 314	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴		
Category [*]	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸
X Y	EPO, 0093 455 (DU CATI ELETTRONICA) 09 November 1983, See entire document.	1-6 7-21
A	US, A, 3,248,617 (SPRAGUE ELECTRIC COMPANY) 26 April 1966, See Figures 2 and 3.	1-21
A	US, A, 3,553,542 (SPRAGUE ELECTRIC COMPANY) 05 January 1971, See column 2, lines 37-42.	1-21
A	US, A, 4,059,848 (U.S. PHILIPS CORPORATION) 22 November 1977, See column 2, lines 33-42.	1-21
A	US, A, 4,106,068 (GENERAL ELECTRIC COMPANY) 08 August 1978, See column 1, lines 22-53.	1-21
A	US, A, 4,107,758 (SPRAGUE ELECTRIC COMPANY) 15 August 1978, See Figures 1 and 12.	1-21
A	US, A, 4,186,417 (GENERAL ELECTRIC COMPANY) 29 January 1980, See column 2, lines 42-50.	1-21
[*] Special categories of cited documents: ¹⁵ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search ²	Date of Mailing of this International Search Report ³	
07 July 1987	06 AUG 1987	
International Searching Authority ¹	Signature of Authorized Officer ¹⁰	
ISA/US	Jeffery A. Gaffin	

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No ¹⁸
A	US, A, 4,209,815 (JARD, INC.) 24 June 1980, See Figures 2 and 3.	1-21
A	US, A, 4,240,126 (ICAR INDUSTRIA CONDENSATORI APPLICAZIONI) 16 December 1980, See column 2, lines 41-44	1-21
A	US, A, 4,283,750 (U.S. PHILIPS CORPORATION) 11 August 1981, See abstract.	1-21
A	US, A, 4,286,302 (GENERAL ELECTRIC COMPANY) 25 August, 1981, See column 1.	1-21
A	US, A, 4,486,809 (EMHART INDUSTRIES, INC.) 04 December 1984, See abstract.	1-21
A	US, A, 3,221,225 (TELEFON AKTIEBOLAGET) 30 November 1965, See column 2, lines 9-19	1-21