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 [73] Assignee **General Electric Company**

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[54] **LOAD BREAK DEVICE WITH ARC-EXTINGUISHING MATERIAL**
1 Claim, 6 Drawing Figs.

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[50] Field of Search 200/144.3,
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ABSTRACT: High voltage arc-interrupting load break device with gas-actuated apparatus for closing the contacts of the device incorporates gas-evolving arc-extinguishing material comprising cycloaliphatic epoxy resin and hydrated alumina for producing optimum amount and rate of gas evolution.

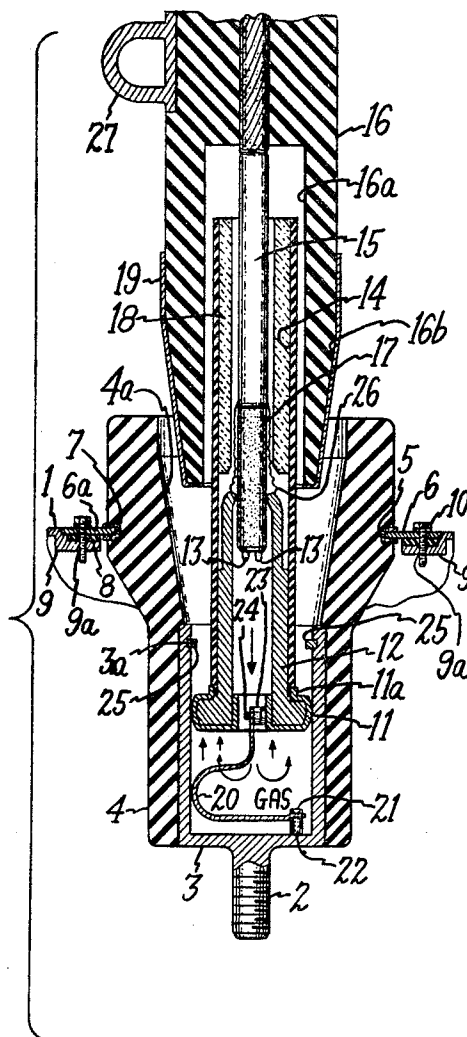


Fig. 1.

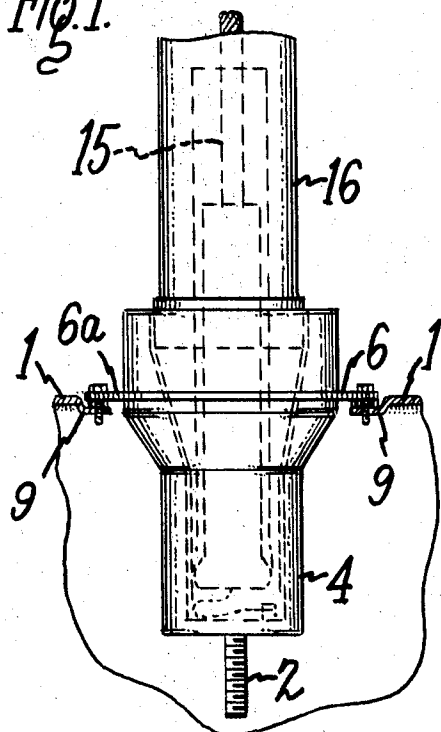
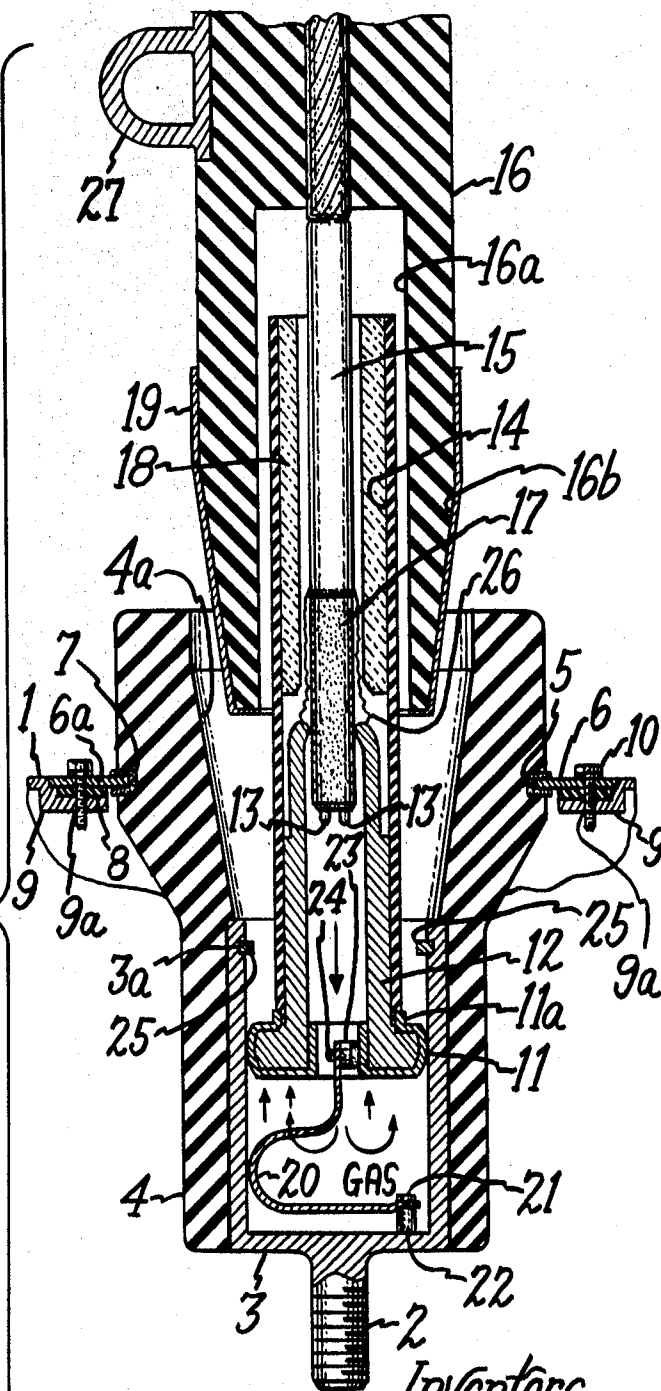
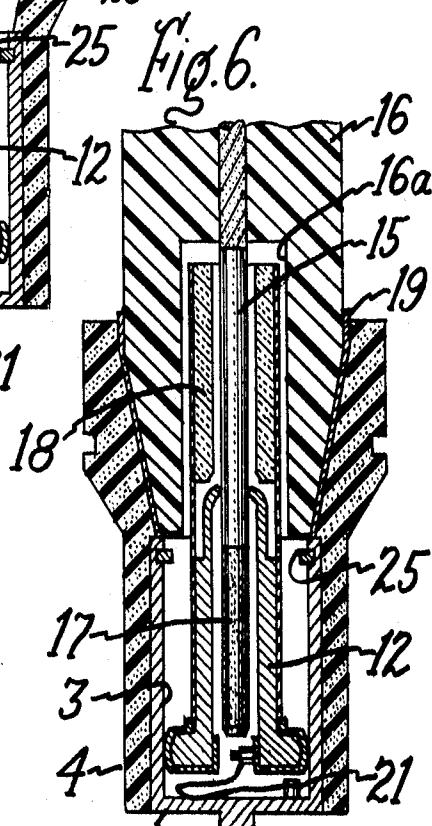
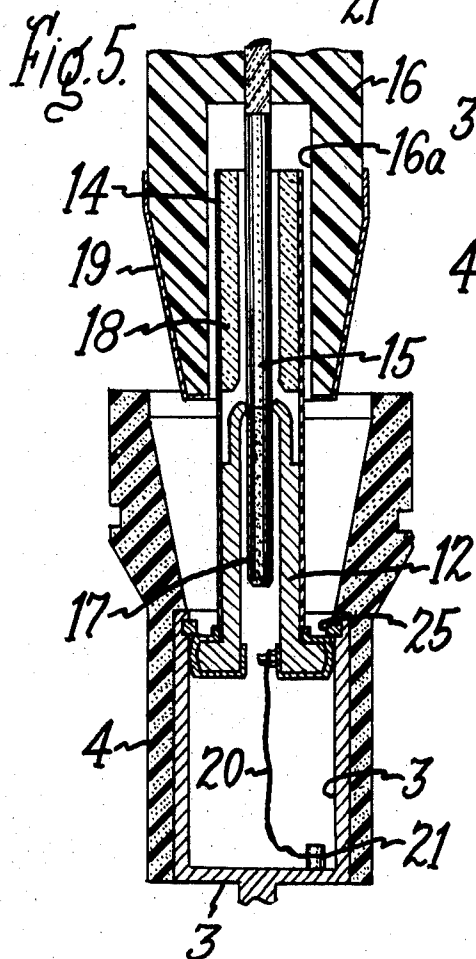
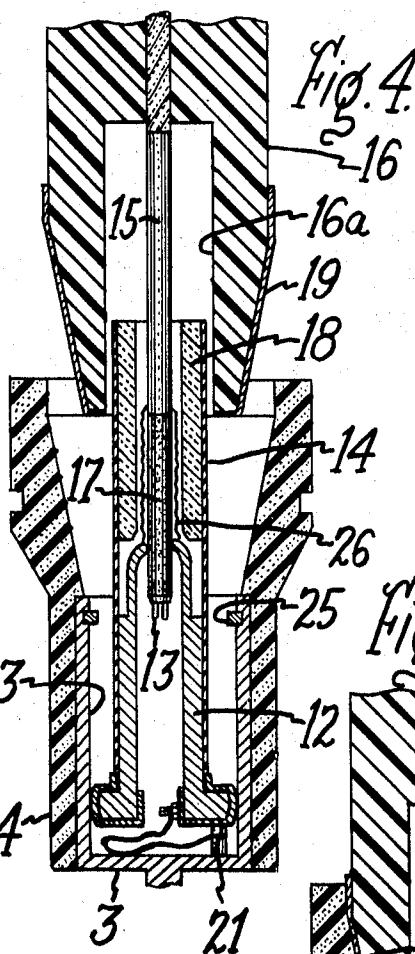
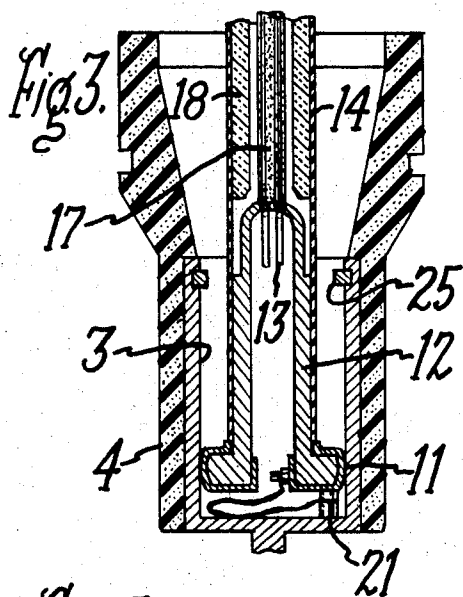


Fig. 2.



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LOAD BREAK DEVICE WITH ARC-EXTINGUISHING MATERIAL

The present invention relates generally to arc-interrupting circuit breaker or load break devices, and particularly to such devices having arc-extinguishing material incorporated therein.

It is an object of the invention to provide a circuit breaker device of the above type having an improved arc-extinguishing material.

A particular object of the invention is to provide a load break device which reduces the risk of injury to the operator and to the apparatus during the load connecting and disconnecting operations.

Another object of the invention is to provide a load break device of gas operated-type having an improved arc-extinguishing material which during arcing produces gas of optimum amount and at optimum rate to effectively operate the load break device while minimizing the risk attendant on excessive or improper gas evolution.

Other objects and advantages will become apparent from the following description and the appended claims.

With the above objects in view, the present invention relates to an arc-interrupting load break device comprising conductor means for establishing an arc, means for confining the arc, and gas-evolving arc-extinguishing material comprising a mixture of cycloaliphatic epoxy resin and hydrated alumina arranged adjacent the conductor means.

In a particular application of the present invention, the load break device is of a type including gas-actuated operating means for making and breaking the load connection, wherein the arc-extinguishing material evolves gas for operating the gas-actuated operating means.

The invention will be better understood from the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a side elevation, partly in phantom, of a gas-actuated load break device embodying the invention;

FIG. 2 is a side elevation, partly in cross section, of the FIG. 1 device in enlarged scale;

FIGS. 3, 4, 5 and 6 are fragmentary views of the operating components of the FIG. 2 device shown at various positions in the operating cycle of the load break device.

Referring now to the drawings, and especially to FIGS. 1 and 2, there is shown a portion of the casing wall 1 of a distribution transformer of a type adapted for underground installation. A high voltage electrical conductor 2, shown in the form of a threaded terminal, is affixed in any suitable manner to the bottom of a metallic cylinder 3, which in turn is mounted coaxially in a high voltage bushing 4 of insulating material. In the embodiment shown in FIGS. 1 and 2, threaded terminal 2 comprises an integral part of metallic cylinder 3. Annular groove 5 around the circumference of bushing 4 (see FIG. 2) seats the matching halves of a split mounting ring 6 and 6a which is sealed in the groove with a suitable resin material 7. An annular gasket 8 is mounted on the recess flange 9 of the casing wall 1. In order to form an airtight seal at the junction between the annular mounting ring 6-6a and seating flange 9, a plurality of threaded bores 9a are provided at equally spaced points in flange 9, and a plurality of bolts 10 are threaded into bores 9a for compressing sealing gasket 8. When thus assembled in operating position on the wall of transformer 1, bushing 4 forms an airtight seal between the inside and outside of wall 1 on the transformer.

Within the well defined by cylinder 3, there is disposed a slidable piston 11 comprising an annular aluminum member having an elongated electrical contact 12 mounted thereon. Contact 12 is preferably formed of copper, with the upper portion thereof silver coated from the bottom of vertical slits 13 to the top of contact 12. In addition to contact 12, an insulating cylinder 14 formed, for example, of pressed organic fiber is mounted on the upper surface of piston 11 by having

the ears 11a on the piston crimped against the bottom end of sleeve 14 to compress it against contact 12 to retain it in position. Although not shown in FIG. 2, a plurality of slits are provided in the walls of contact 12, such as the longitudinal slits 13, extending from equally spaced points on the uppermost end of contact 12 to a point thereon adjacent the bottom of slits 13 that are shown in FIG. 2. This slitted construction of the upper end of contact 12 causes it to be relatively flexible and the upper ends of the fingers thus formed on contact 12 are resiliently biased inward to the position shown in FIG. 2. There is thus assured firm electrical conducting engagement of contact 12 with a second high voltage contact 15, which is mounted in a high voltage conductor termination 16, formed of epoxy or other suitable insulating material. The interior of termination 16 is hollowed to form a cylindrically shaped well 16a adapted to receive the insulating sleeve 14 when the termination 16 and the bushing 4 are moved into juxtaposition to engage the fingers on contact 12 with the second contact 15.

On the end of contact 15, there is mounted an elongated rod-shaped block of gas-evolving, arc-quenching material 17 having a composition disclosed more fully below, which cooperates with a cylinder 18 of similar material mounted on the upper portion of the inside wall of insulating sleeve 14, for the purpose of evolving arc-quenching gas when an arc is formed between contacts 15 and 12. Typically, block 17 is formed with a hollow top portion which is threaded internally for threadably engaging the lower end of contact 15. The mating surfaces of conductor termination 16 and bushing 4 are formed, respectively, as a frustoconical cone portion 16b and a complementary cup-shaped conical surface 4a, to provide a voltage grading seal between these surfaces 4a and 16b. A coating of resilient elastomeric material 19 is bonded by a suitable heat treating process to frustoconical surface 16b of termination 16. Elastomeric material 19 forms a resilient gasket to make a watertight electrically insulated junction between the mating termination 16 and bushing 4 when they are in their contact engaging position.

Although good electrical contact is provided between the conductive sidewalls of cylinder 3 and piston 11, which is in electrical and mechanical contact with contact 12, there is provided a flexible pigtail-type conductor 20 secured by bolt 21 to threaded boss 22 welded on the top surface of the floor of cylinder 3. The other end of pigtail 20 is electrically and mechanically connected to a threaded boss 23 on the inner surface of piston 11 by another bolt 24. Piston 11 is slidably mounted within cylinder 3 and is adapted to have a predetermined range of movement defined by its engagement with screw 21 at one extremity of the range of movement, and by its engagement at the other extremity of the range of movement with a restraining ring 25, which is resiliently mounted in an annular groove 3a near the uppermost end of cylinder 3.

From the foregoing discussion, it can be seen that when contact 15 in termination 16 is moved into engagement with contact 12, an electrical circuit is completed from the junction of the contacts 12 and 15 through aluminum piston 11 and pigtail 20 to high voltage conductor 2 that forms an integral part of cylinder 3.

In the operation of the disclosed device, assuming that both contact 15 and high voltage conductor 2 are connected in respective energized electrical distribution circuits, and further assuming that these contacts are completely disengaged, the coupling operation is as follows. An operator manually moves conductor termination 16, by use of a conventional hot stick or other like means engaging ring 27 secured to termination 16, toward engagement with bushing 4. In this operation contact 15 is moved axially with respect to contact 12, and as a result arc-extinguishing block 17 affixed to the end of contact 15 will be inserted into the cylindrical bore of gas-evolving cylinder 18. As gas evolving block 17 engages the fingers on contact 12, these fingers grip block 17 tightly enough to cause piston 11 to be moved into contact with bolt 21 as the movement of block 17 toward contact-closing position continues. This phase of the closing cycle is illus-

treated in FIG. 3 (assuming the normal forces of gravity had not already moved piston 11 to that position). Further manual movement of termination 16 toward bushing 4 brings the respective contacts 12 and 15 to the relative position as shown in FIG. 4. At this point, an arc, illustrated in FIG. 4 by the lines 26, is formed between contact 12 and contact 15. This arc is confined between arc-quenching block 17 and the coaxially disposed gas-evolving material 18 so that the arc is forced to play along the respective surfaces of these components and thereby causes a substantial amount of arc-quenching gas to be developed. It will be seen that the hollow cylindrical sleeve 14 defines a gas-confining passageway that extends longitudinally along arc-quenching block 17, through slots 13 and contact 12, and thence through the hollow center of contact 12 into the bottom of cylinder 3. Since the bottom surface of piston 11 has a substantially greater area than the area exposed to the arc-generated gas by the upper surfaces of contact 12, the increasing gas pressure exerts a net upward thrust on piston 11 which causes it to move rapidly toward the opposite extremity of its predetermined range of movement through the intermediate position shown in FIG. 2, to thereby bring contact 12 quickly into electrical conducting engagement with contact 15, as shown in FIG. 5, thus quenching arc 26.

The contact-closing operation is completed by further movement of termination 16 toward bushing 4 to seat surface 16*b* in sealing engagement on surface 4*a*, as shown in FIG. 6. This last portion of the operation also serves to move piston 11 back toward its lower extremity of movement adjacent bolt 21. Preferably, piston 11 is seated on the walls of cylinder well 3 with a loose enough fit so some of the gases in the cylinder can pass around the outer circumference of piston 11, while the remaining gases flow through the bore in contact 12 and the slits 13 at its upper end, when piston 11 is moved toward contact with bolt 21. As the gases are forced out of cylinder 3 by continued movement of piston 11 toward bolt 21, they are largely exhausted from the space between bushing 4 and termination 16 before these members are sealed by seating of elastomeric material 19 on surface 4*a* of bushing 4.

In the reverse procedure for disconnecting the load, when termination 16 is manually withdrawn from bushing 4 by an operator using a hot stick or the like, any arcs formed between contacts 12 and 15 as they are separated are likewise quenched by the gas-evolving material of components 17 and 18.

In accordance with the invention, the gas-evolving arc-extinguishing material of which elongated block 17 and cylinder 18 are made is composed of a cycloaliphatic epoxy compound having a substantial amount of hydrated alumina incorporated therein. This material, by virtue of its composition as disclosed more fully hereinafter, is such as to provide a suitable amount and rate of gas evolution for effective operation of the contact-moving assembly and for quickly extinguishing the arc formed when the contacts are separated, while reducing the risk of injury to the operator or damage to the circuit interrupter device.

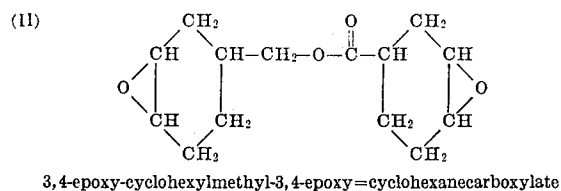
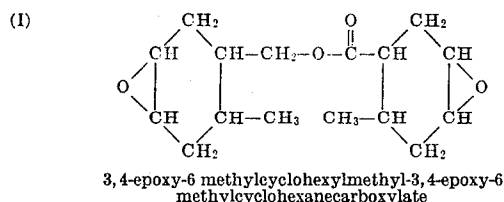
The composition of the arc-quenching material is as follows, in parts by weight:

	Parts by weight
Cycloaliphatic epoxy resin-----	100
Anhydride curing agent-----	25-115
Flexibilizer-----	0-200
Curing catalyst-----	0-5
Hydrated alumina ($\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$)-----	40-780

The hydrated alumina content is generally about 25 to 65 percent of the total weight of the composition.

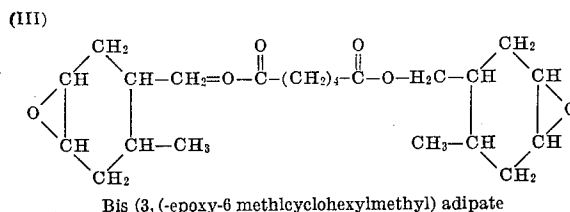
The cycloaliphatic epoxy resin is defined as a compound containing two or more epoxy groups attached directly or indirectly to at least one saturated cycloaliphatic ring. Examples of such compounds which may be used in practicing the inven-

tion are dicyclo diepoxy monocarboxylates, such as the following:

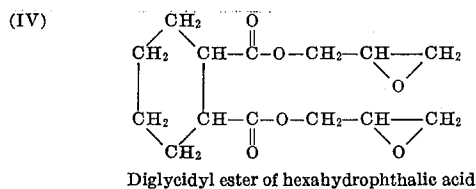


The epoxy resins of formula I and II are commercially known under the designations ERL 4201 and ERL 4221, respectively.

Dicyclo diepoxy dicarboxylates may also be employed, and an example of such a compound is the following, which is commercially available under the designation ERL 4289:



Other examples of cycloaliphatic epoxy compounds which may be employed are diglycidyl esters of cycloaliphatic dicarboxylic acids, of which the following is illustrative:



The curing agent for the epoxy resin is typically a dicarboxylic anhydride compound, examples of which are hexahydrophthalic anhydride, phthalic anhydride, and maleic anhydride.

A flexibilizer compound is preferably, although not necessarily, included in the described composition for the purpose of making the cured material sufficiently tough and nonbrittle to permit forming or shaping to the desired configuration by machining or like operations and to impart improved mechanical strength to the final resin product. Various known flexibilizer compounds may be used for this purpose, as, for example, polyesters obtained by the reaction under heat of dicarboxylic acids with dialcohols. Such compounds are disclosed in the U.S. Pat. No. 2,712,535, to Fisch and the description thereof is accordingly incorporated herein by reference. A particularly satisfactory compound of this nature is a carboxyl terminated polyester obtained as the reaction product of 6 moles of adipic acid, 4 moles of 1,4 butanediol,

and 1 mole propylene glycol. Examples of other suitable flexibilizers are polyethylene glycol and polypropylene glycol.

A catalyst is also preferably included in the composition to accelerate the curing reaction of epoxy resin and the anhydride curing agent. Such a catalyst may, however, be dispensed with, especially if maleic anhydride is used as the curing agent. Various known accelerators for curing epoxy resins may be used for this purpose, as, for example, tertiary amines. Preferred tertiary amines for catalyzing the curing reaction are tris (dimethylaminomethyl) phenol (DMP-30) and benzyldimethylamine (BDMA). Other compounds which may be found useful as catalysts in the described composition are stannous octoate, thioglycols, and phenols, among others.

The presence in the composition of hydrated alumina in the stated proportions is particularly significant for the purposes of the invention. While the precise function of this ingredient is not fully known, it appears that the hydrated alumina serves not only to avoid burning of the resin product under arcing conditions when used in operation, but also contributes in large measure to the rapid quenching of the arc which may be formed during closing and opening of the contact assembly as described. A particular arc-extinguishing composition which has been found especially satisfactory in practicing the invention is as follows, in parts by weight, it being understood, however, that the invention is not intended to be limited to the specific ingredients or proportions set forth below:

	Parts by weight
Cycloaliphatic epoxy—ERL-4221.....	100
Hexahydrophthalic anhydride.....	70
Flexibilizer-carboxyl terminated polyester.....	130
Catalyst—DMP-30.....	1
Hydrated alumina (Al ₂ O ₃ ·3H ₂ O).....	464

The following is an illustrative process for preparing the described composition. After melting the anhydride curing agent and the polyester flexibilizer compound under heat, all of the liquid ingredients including the epoxy resin and the tertiary amine catalyst are mixed together, the mixture is heated to about 80° C, and the hydrated alumina in finely divided form is then incorporated in the mixture while stirring. The material is then deaerated and poured into a suitable mold, and is there heated at 125° C for about 4 hours. The actual cure time and temperature will, of course, depend on the type and amount of curing agent and catalyst employed. The resulting cured product is a thermoset material. The mold may be designed to produce a part of the desired configuration, or this configuration can be attained by machining.

The gas-evolving, arc-extinguishing material of the invention, when used in a circuit breaker device such as described and shown, provides marked advantages. It has been found very effective in extinguishing the arc formed between the

separated contact members without generating excessive quantities of gas which might develop explosive pressures and result in excessive thrust of the piston which may cause injury to the operator. It has also been observed that the use of this material minimizes generation of flames which occasionally occur upon normal separation of the contacts, apparently as a result of the reaction of the hot gases formed by arcing with the oxygen in the atmosphere. A further advantage of the described material is that the surface thereof is smooth and nonabrasive and hence minimizes wear of the conductive plating normally provided on the surfaces of the contact fingers.

Although the invention has been described in connection with its application in a particular type of load break device having a gas-actuated contact assembly, it will be understood that the invention may be embodied in other devices, such as in various types of circuit breakers or interrupters, including fuses, cutouts, arc chutes, and the like.

While the present invention has been described with reference to particular embodiments thereof, it will be understood that numerous modifications may be made by those skilled in the art without actually departing from the scope of the invention. Therefore, the appended claims are intended to cover all such equivalent variations as come within the true spirit and scope of the invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. An arc-interrupting gas-actuated circuit maker and breaker device comprising, in combination, a first hollow electrically insulating member having a closed and an open end and defining a chamber, a first electrode at said closed end of said hollow member, an electrically conductive piston slidably mounted in said first hollow member for axial movement in said chamber relative to said first electrode and being always electrically connected to said first electrode during said movement, said piston having an elongated passage formed therein opening on opposite ends thereof, a second hollow electrically insulating member movable toward the open end of said first hollow member and into fluid tight engagement therewith, a second elongated electrode secured at one end to said second hollow member and projecting therefrom at its opposite end, said second electrode being movable toward and into engagement with said electrically conductive piston, whereby an arc may be formed between said second electrode and said piston prior to engagement thereof, and means on at least one of said piston and said second electrode comprising gas-evolving arc-extinguishing material for producing an arc-quenching gas in the presence of an electrical arc, whereby an arc formed between said piston and said second electrode generates gas which passes through said passage in said piston to the end thereof remote from said second electrode and exerts a thrust on said piston for moving the latter rapidly toward electrical contact with said second electrode, said arc-extinguishing material comprising a mixture of cyclo-aliphatic epoxy resin and about 25—65 percent by weight of hydrated alumina.

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