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[73] Assignee **General Electric Company**

[54] **LIQUID-FILLED ELECTRICAL CIRCUIT INTERRUPTER HAVING A FLUID PRESSURE-RESISTANT INSULATING COATING**
5 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** ..... **200/150 R,** 200/149 A, 337/204 R
[51] **Int. Cl.** **H01h 33/68**
[50] **Field of Search** ..... 200/150 D, 150 F, 150 A, 150 B, 150 C, 149, 149 A

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ABSTRACT: An electric circuit interrupter having a metal container partially filled with insulating liquid and housing arc-developing circuit interrupting means characterized by having a coating of thermal-setting epoxy resin-insulation material immovably bonded to the surface of said container adjacent the arc-developing means thereby to permanently insulate that surface from arcs developed by the arc-developing means. The insulating coating and bonding arrangement of the invention are particularly resistant to displacement by high-pressure liquid circulated in the container by arc-generated gases.

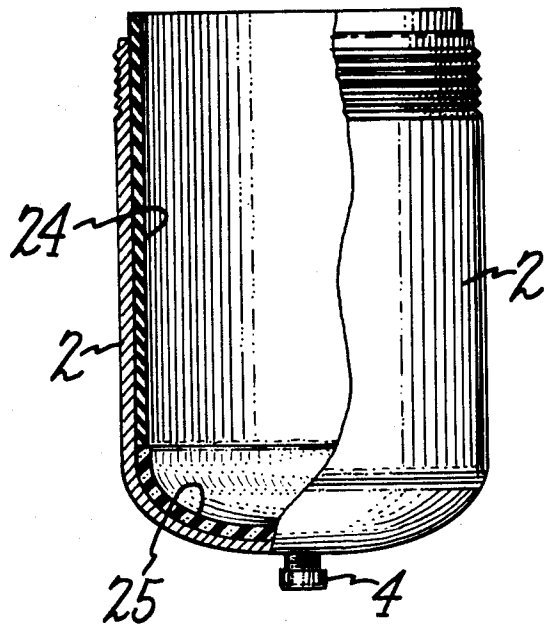


Fig. 1.

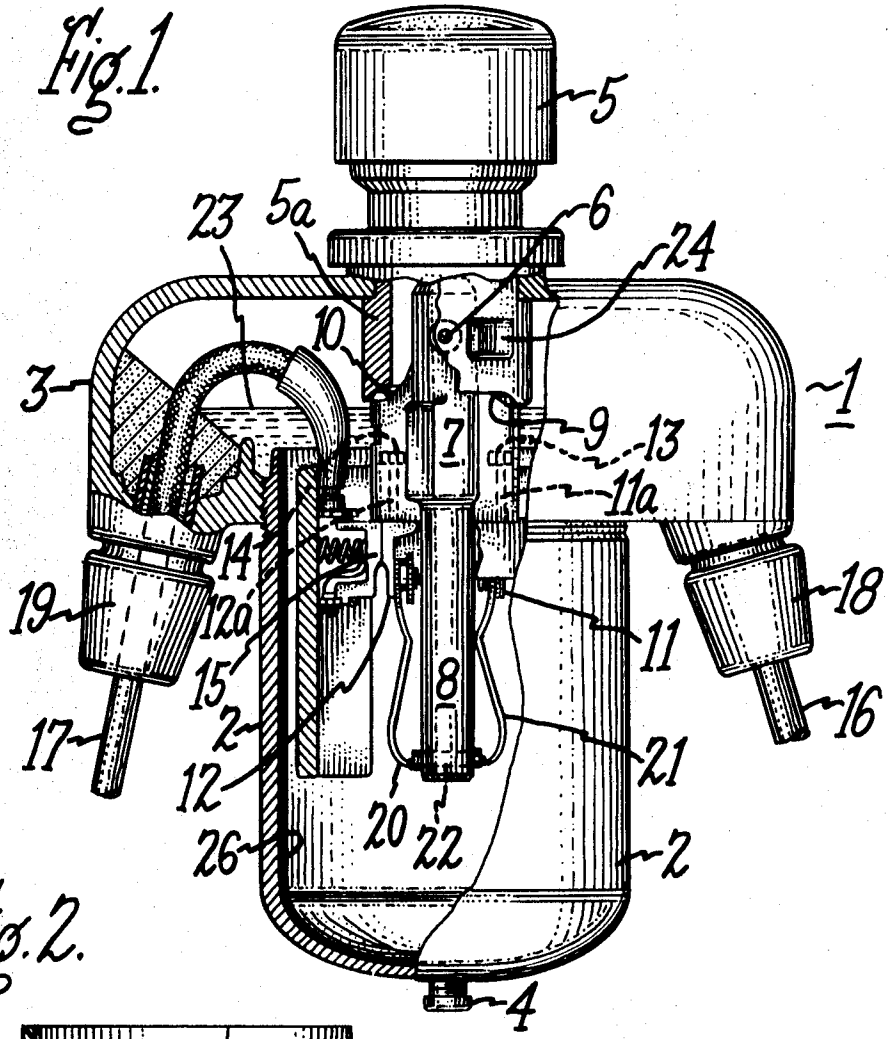
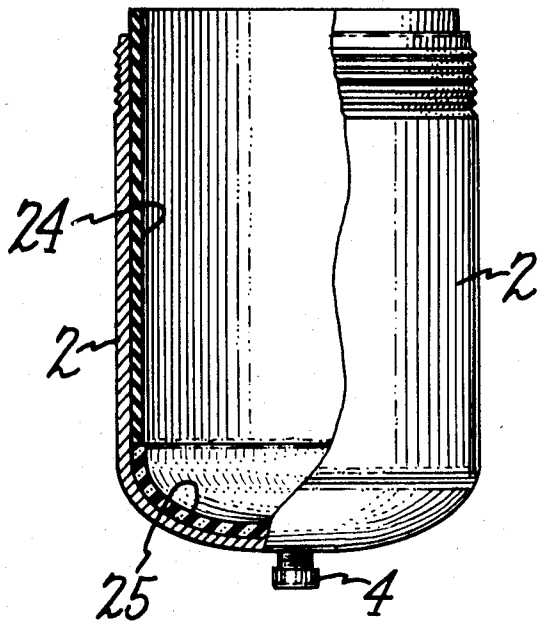


Fig. 2.



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LIQUID-FILLED ELECTRICAL CIRCUIT INTERRUPTER HAVING A FLUID PRESSURE-RESISTANT INSULATING COATING

It is well known in the prior art to insulate the interior surface of the metal housing of an oil-filled fuse cutout in a suitable manner to prevent electric arcs formed within the cutout from shorting to ground by coming in contact with the interior metal surfaces of the housing. Heretofore, such insulation has conventionally taken the form of a Herkolite liner for the cylinders or some other form of pressed organic insulating fiber liner that is shaped to conform closely to the dimensions of the cylindrical cutout housing in which it is mounted. In addition, a cup-shaped pressed-fiber-insulating member is usually positioned over the bottom of the interior surface of the cutout housing. Thus, when a circuit is broken within the cutout either by a fuse blowing or by the opening of the cutout contacts, any resultant arc that is developed is prevented from going to ground on the interior surface of the housing by the combined insulating effects of these two members of fiber-insulating material.

The use of such fiber insulating members has two major drawbacks, the most important of which is their inherent susceptibility to movement within the cutout housing to a position where portions of the metal surface of the housing may be exposed to an arc formed by either of the above-mentioned arc-developing means. By extensive tests, the present inventor has discovered that interruption of large currents in oil-filled cutouts causes rapid circulation of the oil within the cutout in response to the development of arc-generated gases during such interrupting operations. It has been found that this rapid movement of oil is in such a direction within the cutout housing that it tends to move the preshaped-fiber-insulating members from their desired protective positions to a point where portions of the housing that they are designed to protect are, in fact, exposed to contact by the area formed during the interrupting cycle. The second major problem inherent in the use of organic fiber-insulating members to protect the interior metal surfaces of oil-filled cutouts from high-current arcs is due to an inherent property of such fibers that causes them to absorb moisture. If a significant amount of moisture is present in the oil used to fill oil-filled cutouts, as may occur particularly in vented cutouts that may allow moisture into the housing, the organic fiber-insulating members tend to absorb such moisture and thus tend to lose their insulating properties. Such a reduction in insulating ability causes the safe rating of the cutout to be lowered. This problem is particularly apparent in the fiber-insulating linings of cutouts that have been in service for an extended period of time during which repeated oil changes have occurred, thus, introducing added quantities of moisture into the housing where it can be absorbed by the fiber-insulating linings.

Because of the increased manufacturing costs involved in making oil-filled cutouts that have enlarged housings necessitated by providing adequate clearance between the circuit interrupting, arc-developing means therein and the outer walls of the housing to prevent arcs from grounding against the housing through its protective insulating barriers which may have been displaced, or weakened by moisture absorption, it is desirable to provide an improved insulation arrangement for such cutouts that will allow these tolerances to be reduced and thus allow relatively small oil-filled cutouts to be upgraded in current interrupting rating so that a higher rating can be provided at lower cost.

Accordingly, an object of the present invention is to provide an improved liquid-filled circuit interrupter having a liquid container insulation arrangement that enables heretofore unattainable close tolerances to be achieved between the operating components of the interrupter and its outer sidewalls thereby affording a reduction of the cost of manufacture of circuit interrupters having high interrupting ratings.

Another object of the invention is to provide an insulating coating on the interior surface of a liquid-filled circuit interrupter which is characterized by being bonded to said surface so that it cannot be moved by high pressure fluids developed in response to the formation of an arc within the interrupter.

A further object of the invention is to provide a circuit interrupter having an insulating coating on a surface thereof adjacent arc-developing means in the interrupter which is characterized by being resistant to moisture absorption.

Still another object of the invention is to provide a circuit interrupter with an insulating coating on a surface thereof adjacent arc-developing means which affords improved resistance to electrical breakdown of the insulating coating when the coating is subject to repeated contact by high-current arcs.

Other objects and advantages of the invention will become apparent from the following description taken in conjunction with the drawings in which:

FIG. 1 is a side elevation view, partly in cross section, of a liquid-filled circuit interrupter embodying a preferred form of a invention.

FIG. 2 is a side elevation view, partly in cross section, of a liquid-filled cutout housing oil container illustrating a prior art type of insulating members for protecting he interior of such a housing container from electric arcs.

Briefly stated, in one preferred form of the invention, a liquid-filled fuse cutout having a cup-shaped liquid-containing body portion and an end cap seal therefore is provided with a coating of thermally cured epoxy resin immovably bonded on the inner surface of the cup-shaped container to prevent arcs developed within the interrupter from going to ground on the coated surface. The bonded coating of the present invention cannot be moved by the rapid circulation of oil within the cutout responsive to the development of arc-generated gases when the circuit-interrupting means of the cutout operate to develop arcs within the housing. Moreover, the bonded coating of the invention does not absorb moisture which could lower its dielectric strength and its composition is such that its dielectric strength is improved when it is contacted repeatedly by electric arcs.

Referring now to FIG. 1 of the drawing, there is shown a liquid-filled cutout **1** having a drawn steel container **2** that is threaded into a cast iron cover **3** and which is provided with a threaded drain plug **4** at its lower end. The interior of the cutout **1** is vented through top cover **5** of a fuse carrier support means that is mounted on and sealed in any suitable conventional manner to the top of the cutout cover **3**. The lower portion of the support means **5** is shown in cross section at **5***a* and a fuse carrier retaining pin **6** is positioned in two oppositely facing apertures in this extended portion of the support means **5**. An elongated fuse carrier **7** formed of moldable epoxy material, or other suitable electrical insulating material such as wood, is suspended from the pin **6** in a predetermined relatively fixed position within the housing **1**. The fuse carrier **7** has an elongated body portion **8** and a pair of shoulders **9** and **10** projecting laterally therefrom. The shoulders **9** and **10**, respectively, support a pair of contacts **11** and **12** that are locked in position with respect to the shoulders by a pair of threaded nuts **13** and **14** (shown in phantom) that threadably engage shank portions **11***a* and **12***a* of these contracts.

It will be understood that when the contacts **11** and **12** are in operating position they engage cooperating contacts that form part of an electrical circuit through the cutout. One such contact is designated by the numeral **15**, and these contacts are connected, respectively, to the power conductors **16** and **17** through which electric power is transmitted to and from the cutout **1**. These conductors, **16** and **17**, are suitably insulated by bushings **18** and **19** that are mounted in any conventional manner in fluidtight relationship with the cast iron cover **3** of the cutouts. Electrically connected in series with the contacts **11** and **12** by resilient links **20** and **21** is a fuse **22** that is adapted to rupture when a predetermined excess of current passes through it thereby to interrupt the circuit formed between the conductors **16** and **17**.

It will be understood by those skilled in the art that the mechanical strength of the drawn steel container 2 and the cast iron cover 3 is normally much greater than necessary to withstand the internal pressures that are developed when the fuse 22 ruptures or the contacts 11 and 12 are opened thereby causing an arc that generates gas within the container 2. One purpose of the present invention is to provide an optimum insulating arrangement for the cutout 1 that will allow the current interrupting rating of the cutout to be increased to a level closer than normal to the safe mechanical tolerances possible with the drawn steel construction of the cutout housing.

It will be understood that when the fuse 22 ruptures, an arc is formed between the resilient links 20 and 21 and this arc suddenly generates a substantial volume of gas that forces the insulating liquid 23 within the container to circulate rapidly through the various passages around the component parts of the cutout confined within container 2. Since such a gas volume is initially formed near the bottom of container 2, the gases force the oil 23 to circulate rapidly toward the top of the cover 3, with most of the oil flowing upward adjacent the walls of the container 2 and then flowing downward generally parallel to the portion 8 of fuse carrier 7 back toward the bottom of container 2. By a careful study of the action of oil 23 under such arc-developed, gas-generating conditions, the applicant has found that in prior art devices very high liquid pressures are created on the surfaces of the insulation protecting the inner surface of cup-shaped container 2. Thus, an important design limitation of prior art cutout interrupting ratings has been found by the applicant to be the ability of such an insulating surface to withstand movement by this hydraulic force of the circulating fluid caused by arc-generated gases.

There is shown in FIG. 2 of the drawing, a cup-shaped body portion 2 of a cutout such as cutout 1 shown in FIG. 1. In prior art cutouts the inner surface of cup-shaped container 2 was conventionally insulated from the arc developing contacts 11, 12 and 15, and the fuse 22 by a pressed organic fiber-insulating member such as the illustrated member 24 shaped in the form of a cylinder that closely compliments the inner sidewalls of container 2. In addition, a second pressed, organic fiber member 25 having a cup-shaped configuration that generally compliments the bottom of the cup-shaped container 2 was conventionally provided to insulate the bottom surface of the container 2 from such arcs. When an insulating arrangement similar to that illustrated in FIG. 2 was utilized in combination with a liquid-filled cutout such as that shown in FIG. 1, the applicant has found that high-pressure fluids circulated within the cutout in response to the formation of repeated arcs caused the insulating member 24 to be driven upward with respect to the container 2 so that a portion of the surface of container 2 became exposed to arcs formed by the arc-developing means, such as fuse 22.

Unlike the prior art insulating arrangement shown in FIG. 2, pursuant to the present invention, the container 2 illustrated in FIG. 1 of the drawing is provided with an insulating coating 26 bonded on the inner surface thereof to protect that surface from arcs developed by the arc-developing means. Coating 26 may be bonded to container 2 by being sprayed onto the container, or by using a suitable dip-forming process to develop a coating of desired thickness. After extensive tests with various insulating materials, the applicant has found that thermal-setting epoxy resins can be used to form a suitable insulating coating 26 so that it will have the necessary electrical insulating properties and resistance to mechanical erosion or movement by the action of rapidly circulating liquids within the container 2. In the preferred form of the invention, the coating 26 is formed of one of the synthetic coating materials disclosed and claimed in U.S. Pat. No. 3,058,951, issued Oct. 16, 1962 and assigned to the assignee of the present invention. It will be understood that the present invention is not intended to be limited to particular compounds or proportions thereof described in that patent, however, by way of example, it has been found that a particularly preferred composition for coating 26 comprises 75.5 percent by weight epoxy resin formed as the reaction product of a polyhydric phenol and an epihalohydrin, 5.6 percent by weight polyvinyl formal and 18.9 percent by weight polybutylacrylate. As taught in the above-identified patent, a suitable polyacrylate resin selected from the group consisting of homopolymers and copolymers of esters selected from the group consisting of methylacrylate, methylmethacrylate, ethylacrylate, ethylmethacrylate, butylacrylate, isobutylacrylate, butylmerthacrylate and isobutylmethacrylate may be used for the polyvinyl formal in the preferred composition. Moreover, it can be noted, by way of example, that it has been found that for a cutout rated 5 kilovolts and 200 amperes to have a current-interrupting rating of 10,000 amperes asymmetrical, the coating 26 should be a minimum of 4 mils thick over the entire surface area thereof. Preferably coating 26 falls in a range between 18 and 50 mils in thickness to afford adequate protection for a 15-kilovolt-rated cutout having an interrupting rating of 14,000 amperes asymmetrical.

The applicant has found that the foregoing preferred thermally cured epoxy resin composition used in the unique combination of the present invention to form-insulating coating 26 is particularly suitable for this application because it is resistant to moisture absorption and so it does not cause concentrations of moisture adjacent the surface of container 2 that could impair the insulating properties of the coating 26. In addition, it has been found that when a coating 26 of this preferred material is repeatedly subjected to contact by electrical arcs, the surface of the coating 26 becomes charred but, surprisingly, rather tan than having its electrical insulating properties reduced by such charring, as would normally be expected, the electrical insulating properties of this material would appear to improve under these conditions. Therefore, unlike the prior art organic-insulating linings that were usually fatally damaged by repeated circuit interruptions within the cutout 1, the coating 26 of the present invention not only resists such deterioration but improves in its dielectric properties during normal use.

In the operation of the present invention, it will be seen that due to the unique permanent bonding between the coating 26 and the inner surface of container 2, this insulating coating 26 is immovably mounted on the surface 2 and thus is prevented from moving in relation thereto responsive to the circulation of high-pressure fluids within the housing of cutout 1; thus, there is no danger of the housing 2 being exposed to an arc formed by the arc-developing means within the cutout after repeated circuit-interrupting operations, as was the case with prior art cutout insulating means, such as those depicted in FIG. 2.

A modification of the preferred form of my invention is achieved by positioning a conventional fiber-insulating member, such the cup-shaped insulating member 25 shown in FIG. 2, over the insulating coating 26 in the container 2 (shown in FIG. 1). Such an arrangement assures insulating protection over the threaded drain plug 4 to make sure that electrical contact is not established between the threads of plug 4 and an arc developed by the arc-developing means such as fuse 22 within cutout 1. It will be appreciated that the above-mentioned fluid pressures developed by arc-generated gases within container 2 are not as likely to move such a fiber-insulating member 25 with relation to the bottom surface of container 2 as they are to move fiber members upward along the walls of container 2, because the initial gas pressure and resultant hydraulic pressure is directed straight down toward the bottom of the container 2 and thence upwardly along the sidewalls. Consequently, in cutouts having relatively low interrupting ratings, no auxiliary means is needed to retain the member 25 in position. However, to guard against such possible movement of the member 25 in cutouts of higher rating using this embodiment of the invention, the fiber member 25 can be glued in position during assembly with any conventional glue that will not contaminate the oil in container 2. In such applications, drain ports must be formed in the member 25 near the peripheral edges thereof, and it is also usually desirable to put a small spacer between the bottom of cup-

shaped container 2 and member 25 to allow the fluid to flow through the aperture that is normally closed by plug 4.

It will be understood that no claim is made herein to the specific invention disclosed and claimed per se in U.S. Pat. No. 3,058,951 but rather the present invention is limited to the novel circuit interrupter insulating coating disclosed herein in the unique combination described above and defined with particularity in the following claims.

What is claimed is:

1. In an oil-filled cutout comprising an oil-confining metal container at least partially filled with arc-quenching oil, arc-developing means mounted in said container and electric circuit means connected to supply electric power to said arc-developing means, the improvement comprising a coating of insulating material of predetermined thickness bonded to an inner surface of said container adjacent the arc-developing means to insulate the container from an arc developed by said arc-developing means, said coating being prevented by its bonding with the container from moving relative to said container responsive to rapid movement of oil therein, said coating of insulating material being formed of a heat-cured epoxy resin that is resistent to water absorption, said predetermined thickness exceeding 4 mils over substantially the entire area thereof, and said coating being formed of a composition that has its insulating properties improved by being subjected to repeated contact by electric arcs and the effect of very high liquid pressures being created on the coating surface by said rapid movement of oil responsive to arcs being formed in the container, whereby the dielectric capability of the coating is improved during normal operation of the cutout.

2. A device as defined in claim 1 wherein said container comprises a cup-shaped body portion and an end cap member secured in position on said body portion to seal it, and wherein said inner surface said container coated by said coating of insulating material comprises substantially all of the inner walls of said cup-shaped body portion of the container.

3. The invention defined in claim 1 wherein said coating of insulating material is bonded directly to said container, and said predetermined thickness is in a range from 4 to 50 mils over substantially the entire area thereof.

4. The invention defined in claim 2, including a preformed member of organic insulating material mounted over the inner bottom surface of said cup-shaped portion above said coating, thereby to further insulate said bottom surface from an arc formed by said arc-developing means.

5. An oil-filled electric circuit interrupter comprising a hollow metal housing, an arc-developing circuit interrupting means operably mounted in said housing, said interrupting means being operable to develop an arc adjacent an inner surface of said housing thereby to suddenly generate a substantial volume of gas and cause oil to move rapidly at very high liquid pressures along said surface of said housing, a coating of insulating material bonded to said surface to insulate it from such an arc, said coating being formed of a composition of matter comprising; an epoxy resin comprising the reaction product of a polyhydric phenol and an epihalohydrin, a polyvinyl acetal resin and a polyacrylate resin selected from the group consisting of homopolymers and copolymers of esters selected from the group consisting of methylacrylate, methylmethacrylate ethylacrylate, ethylmethacrylate, butylacrylate, isobutylacrylate, butylmethacrylate and isobutylmethacrylate, whereby the dielectric capability of the coating is improved during normal operation of the cutout due to the improvement of the insulating properties thereof resulting from the coating being subjected to burning contact with electric arcs developed by said circuit and the effect of very high liquid pressures being created on the coating surface by said rapid movement of oil responsive to arcs being formed in the container.