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Braunstein

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[54] **FUSE ASSEMBLY FOR OIL-FILLED TRANSFORMERS**

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[73] Assignee: **Westinghouse Electric Corporation,** Pittsburgh, Pa.

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[52] **U.S. Cl.** **337/276,** 337/204, 337/279, 337/280, 337/281, 337/282

[51] **Int. Cl.** **H01h 85/18**

[58] **Field of Search** 337/203, 204, 249, 250, 337/276, 278, 279, 280, 281, 282, 274, 275

[56] **References Cited**

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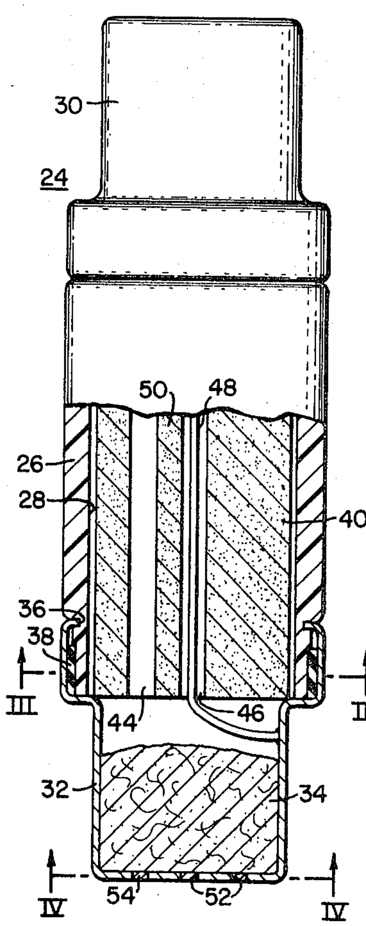
Attorney, Agent, or Firm—J. R. Hanway

[57] **ABSTRACT**

A fuse assembly including a body member with condenser caps attached to each end thereof. A fuse wire is connected to the condenser caps and extends through one opening in a block of arc-extinguishing material which is contained within the body member. Another opening in the block is positioned parallel to the opening containing the fuse wire. With moderate fault currents, arcing as the fuse wire melts is confined within the opening containing the fuse wire. With large fault currents, the arc-extinguishing material between the two openings ruptures, thus enlarging the arcing passageway to reduce the arc energy. Hot gases and vapors generated during arcing melt solder which seals openings in the condenser caps, thus the gases and vapors may pass through the unsealed openings to relieve pressure within the fuse assembly.

1 Claim, 4 Drawing Figures



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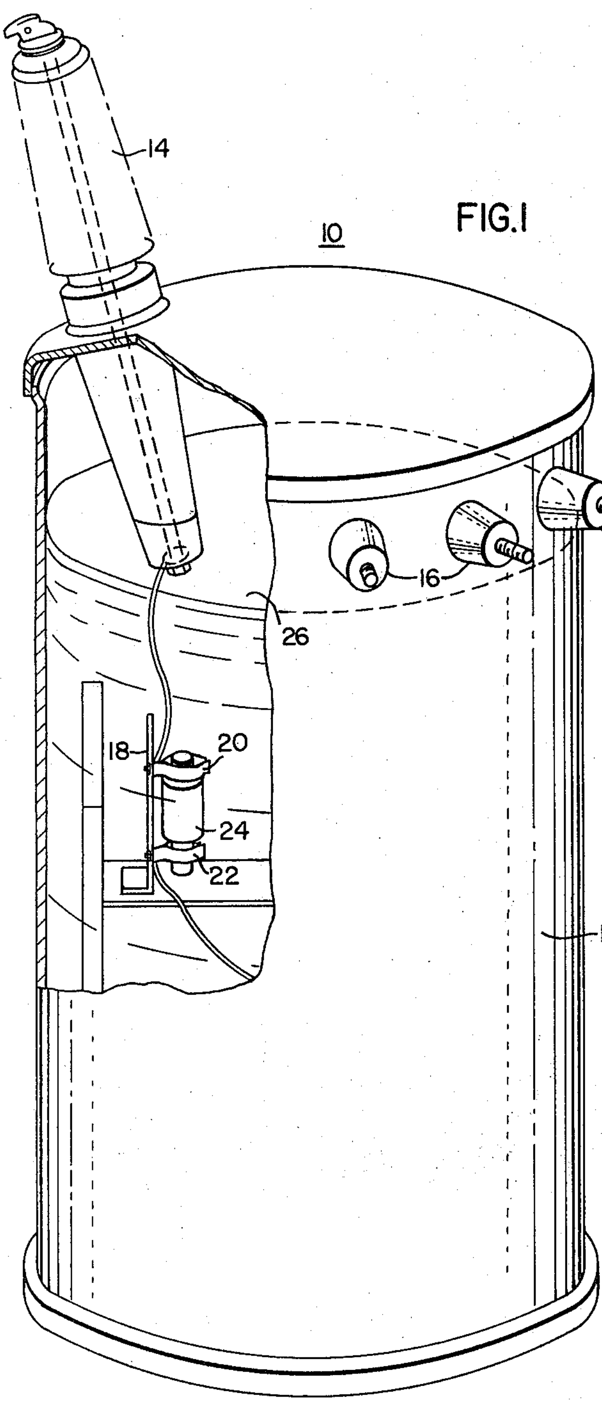
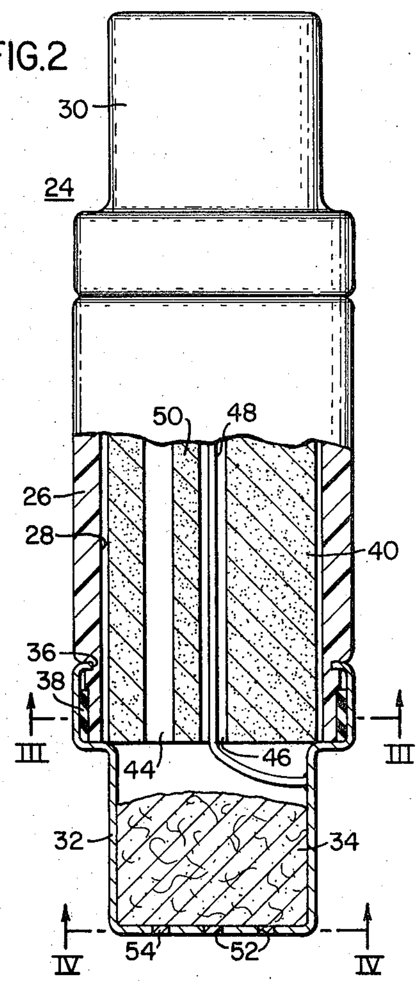


FIG.1

FIG.2



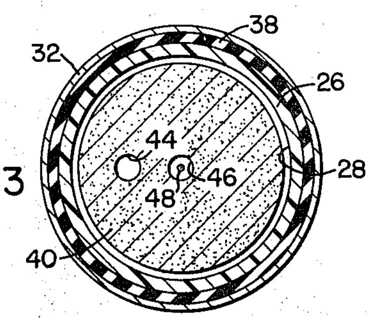


FIG.3

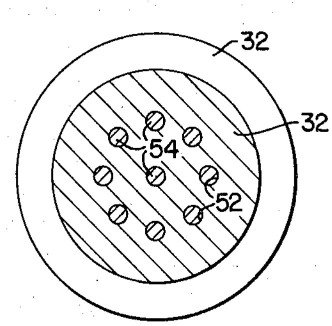


FIG.4

FUSE ASSEMBLY FOR OIL-FILLED TRANSFORMERS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates, in general, to electrical inductive apparatus and, more specifically, to fuse assemblies containing an arc-extinguishing material.

2. Description Of The Prior Art

Fuse links and current-limiting fuses are used in power distribution transformers either separately or in a serial combination thereof to protect the electrical distribution system and to prevent explosion of the distribution transformer. Normally, the fuses are connected in series with the primary of high-voltage winding of the transformer. When a major fault occurs within the transformer, the fuse interrupts the extremely high fault current which is developed.

Fuses or protective devices for such applications necessarily offer a compromise between current interrupting capability, refusing feasibility, coolant contamination levels, construction costs, and other factors. Generally, it is desirable to protect a transformer economically with a fuse capable of interrupting the maximum amount of primary fault current which could flow through the transformer.

Fuse links capable of interrupting 3,500 amperes are economically available. However, since the possibility of a fault current of 8,000 amperes at 7,200 volts exists with modern power distribution transformers, prior art protective links are inadequate. Current-limiting fuses rated at 8,000 amperes are relatively expensive. Therefore, it is desirable, and it is an object of this invention, to provide an economic fuse assembly which will interrupt at least 8,000 amperes of fault current.

Fault current magnitudes are dependent on several factors, including the type of fault. Protective devices for use in interrupting fault currents must be capable of proper operation regardless of the magnitude of the fault current, provided the current does not exceed the maximum operating current of the protective device. However, it is desirable that the arc produced while interrupting the current dissipate an amount of energy which is within a workable range. Without enough arc energy, the arc-extinguishing material does not function properly. With too much arc energy, the fuse assembly may explode. Therefore, it is also desirable, and it is another object of this invention, to provide a fuse assembly which is constructed to maintain the arc energy within suitable limits.

Most arc-extinguishing materials are considered contaminants to transformer cooling and dielectric oil. Therefore, during normal operation, the arc-extinguishing material must be sealed from the transformer oil. However, the fuse assembly must be vented when a fault current is interrupted to prevent explosion of the fuse assembly. Therefore, it is also desirable, and it is a further object of this invention, to provide a fuse assembly which is properly sealed when normal current is flowing therethrough and which is vented properly when a fault current is being interrupted.

SUMMARY OF THE INVENTION

There is disclosed herein a new and useful fuse assembly for use in oil-filled transformers. The fuse assembly includes an insulating body member which is sealed at each end with a condenser cap. A block of arc-extinguishing material is disposed within an opening in the body member. Two longitudinal openings extend through the block. A fuse wire extends through one of the openings and is attached to the condenser caps. With moderate size fault currents, the arc which occurs when the fuse wire melts is contained within the one opening. Due to the small size of the opening, the arc energy is sufficient to cause the block to evolve arc-extinguishing gas or vapor. When the fault current is large, the region of the block located between the openings therein ruptures and effectively increases the size of the arc path. This decreases the arc voltage to limit the amount of arc energy and to prevent explosion of the fuse assembly. Openings in the condenser caps are plugged with solder to seal the arc-extinguishing material from the oil. When an arc develops, the hot gases and vapors melt the solder to allow the gases and vapors to flow through the openings and into the transformer tank.

BRIEF DESCRIPTION OF THE DRAWING

Further advantages and uses of this invention will become more apparent when considered in view of the following detailed description and drawing, in which:

FIG. **1** is a cutaway view of an oil-filled transformer containing a fuse assembly constructed according to this invention;

FIG. **2** is a view, partly in section, of a fuse assembly constructed according to this invention;

FIG. **3** is a sectional view taken along the line III—III of FIG. **2**; and

FIG. **4** is a sectional view taken along the line IV—IV of FIG. **2**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Throughout the following description, similar reference characters refer to similar elements or members in all the figures of the drawing.

Referring now to the drawing, and to FIG. **1** in particular, there is shown an oil-filled transformer **10** constructed according to this invention. The transformer tank **12** supports the high-voltage bushing **14**, the low-voltage bushings **16**, and the core and coil assembly which is not illustrated. The bracket **18** supports the clips **20** and **22** which are electrically connected to the bushing **14** and to the transformer winding, respectively. The fuse assembly **24** is held by the clips **20** and **22** below the oil level **26**. The fuse assembly **24** interrupts the current flowing therethrough when the current exceeds a predetermined value.

FIG. **2** illustrates details of the fuse assembly **24**. A substantially tubular body member **26** is constructed of an insulating material such as glass reinforced epoxy or polyester resins. The body member **26** includes an opening **28** extending between the ends of the body member **26** to which are attached the condenser caps **30** and **32**.

The condenser cap **30** is constructed similar to the condenser cap **32**. Condenser cap **32** is thimble-shaped and is constructed of an electrical conducting material such as brass or copper. A suitable condenser material having a high specific heat is placed within the condenser caps **30** and **32**, such as the copper wool **34** in condenser cap **32**.

The condenser cap **32** is attached to the end of the body member **26** by forming the end of the condenser cap 32 in a groove 36 extending around the outside of the body member 26. A flat or tubular gasket 38 is disposed between the condenser cap 32 and the body member 26 to provide an oil-tight seal. A fluoro-silicon rubber gasket material is especially suitable due to its excellent thermal and oil-resistant properties.

A slug or block 40 of arc-extinguishing material is disposed within the body member 26. The arc-extinguishing material may be a water vapor evolving material such as boric acid (H_3BO_3). The block 40 is cylindrically shaped and extends substantially between the condenser caps 30 and 32.

As illustrated in FIGS. 2 and 3, two longitudinal openings 44 and 46 extend through the block 40. A suitably rated fuse wire 48 extends through the opening 46 and is attached to the condenser caps 30 and 32 by brazing, welding, or by another suitable process.

The openings 44 and 46 in the block 40 cooperate to provide a desirable fuse action with different magnitudes of overload current. When the overload current flowing through the fuse wire 48 is relatively low, the block 40 functions as a thermal insulator positioned around the fuse wire 48. This helps melt the fuse wire 48 to interrupt the overload current. Since the arc voltage increases as the diameter of the passageway through which the arc travel decreases, the small diameter of the opening 46 provides a relatively high arc voltage. This is desirable since at least a minimum amount of arc energy must be developed to permit proper action of the arc-extinguishing material in block 40. Since arc energy is a function of the arc voltage and the overload current, with low overload currents a high arc voltage is desirable. When the overload current is relatively high but still within the operating limits of the fuse assembly 24, the arc voltage should be relatively low to reduce the arc energy generated. If the arc energy is too high, the fuse assembly 24 fails to function as desired and may explode.

The opening 44 is suitably dimensioned and positioned to lower the arc voltage when the overload current is relatively high. Opening 44 is separated from opening 46 by the portion 50 of the block 40. The portion 50 has a mass small enough to be ruptured by the arc energy developed by a large overload current. This effectively increases the size of the arcing passageway and, therefore, lowers the arc voltage. Thus, when the overload current is large and tends to develop too much arc energy, the size of the arcing passageway is increased to keep the arcing energy within workable limits. In a fuse assembly 24 having a boric acid block 40 and an operating limit of 8,000 amperes at 7,200 volts, suitable diameters for the openings 44 and 46 are 0.125 inch. A suitable spacing between centers of the openings 44 and 46 is 0.25 inch.

It is necessary that the fuse assembly 24 be sealed to prevent the boric acid block 40 from contaminating the transformer oil. However, some pressure release means must be included in the fuse assembly 24 to permit the escape of high-pressure gases and vapors generated primarily by the reaction of the block 40 within the arc. Condenser caps 30 and 32 contain openings 52 therein which are sealed with tin-lead solder 54 or by another suitable thermoplastic material. The solder 54 has a melting point which allows the solder 54 to remain hard and seal the openings 52 when the transformer temperature is within normal and moderately overloaded ranges. The melting point of the solder 54 is low enough to permit the solder to melt when heated by the hot gases generated by arcing within the fuse assembly 24. Other sealing means may also be used, such as a diaphragm placed over the openings 52.

When the fuse assembly 24 interrupts an overload current, the hot vapors and gases flow into the condenser caps 30 and 32. As is best illustrated with reference to condenser cap 32, the hot vapor flows through the copper wool 34 which, due to its high specific heat and lower temperature, causes water in the vapor to condense thereon, thus reducing the pressure of the vapor after it flows through the copper wool 34. The hot vapor quickly melts the solder 54 in the openings 52 and allows the vavapor to escape from the fuse assembly 24, thus preventing the explosion of the fuse assembly 24.

FIG. 4 illustrates the position of the openings 52 in the end of the condenser cap 32. The size and position of the openings 52 is important to achieve the proper melting characteristics although opening arrangements other than the one illustrated are within the contemplation of this invention. If the openings 52 are too small, insufficient exhaust area will cause the pressure to increase within the fuse assembly 24 and rupture the body member 26. Openings too large are difficult to solder properly and the melting characteristics of the solder 54 therein cannot be controlled sufficiently because of the non-uniformity of the conduction of heat from the solder by the condenser cap material. An opening diameter of ¼ inch has been found satisfactory for use in fuse assemblies rated for 8,000 amperes at 7,200 volts.

Present protective links for distribution transformers are capable of interrupting a 3,500-ampere fault overload current. To achieve 8,000-ampere capacity, current limiting fuses have been required according to the prior art. With the fuse assembly 24 taught by this invention, a protective device capable of interrupting 8,000 amperes can be constructed with the economy herebefore realizable only with protective links. Thus, current limiting fuse performance can be obtained with protective link economy.

Since numerous changes may be made in the above-described apparatus and since different embodiments of the invention may be made without departing from the spirit thereof, it is intended that all of the matter contained in the foregoing description, or shown in the accompanying drawing, shall be interpreted as illustrative rather than limiting.

I claim as my invention:

1. A fuse assembly suitable for serial connection in the primary circuit of an oil-filled transformer, comprising:
   - a tubular body member having first and second ends with an opening extending between said ends;
   - a first cap sealingly attached to the first end of said body member by a fluoro-silicon rubber gasket;
   - a second cap sealingly attached to the second end of said body member by a fluoro-silicon rubber gasket;
   - said first and second caps containing copper wool and a plurality of openings plugged by tin-lead solder which melts and opens said openings when the current through the fuse assembly is greater than a first predetermined value;
   - a block of boric acid material disposed within said body member opening and extending substantially

between said first and second caps, said block containing first and second openings therein; and

a fuse wire connected to said first and second caps and extending through only the first opening in said block;

said first and second openings in said block being substantially parallel to each other and spaced from each other a predetermined amount which allows the portion of said block separating said openings to rupture when the current through said fuse assembly is greater than a second predetermined value, said second predetermined value being within the operating limits of the fuse assembly.

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