

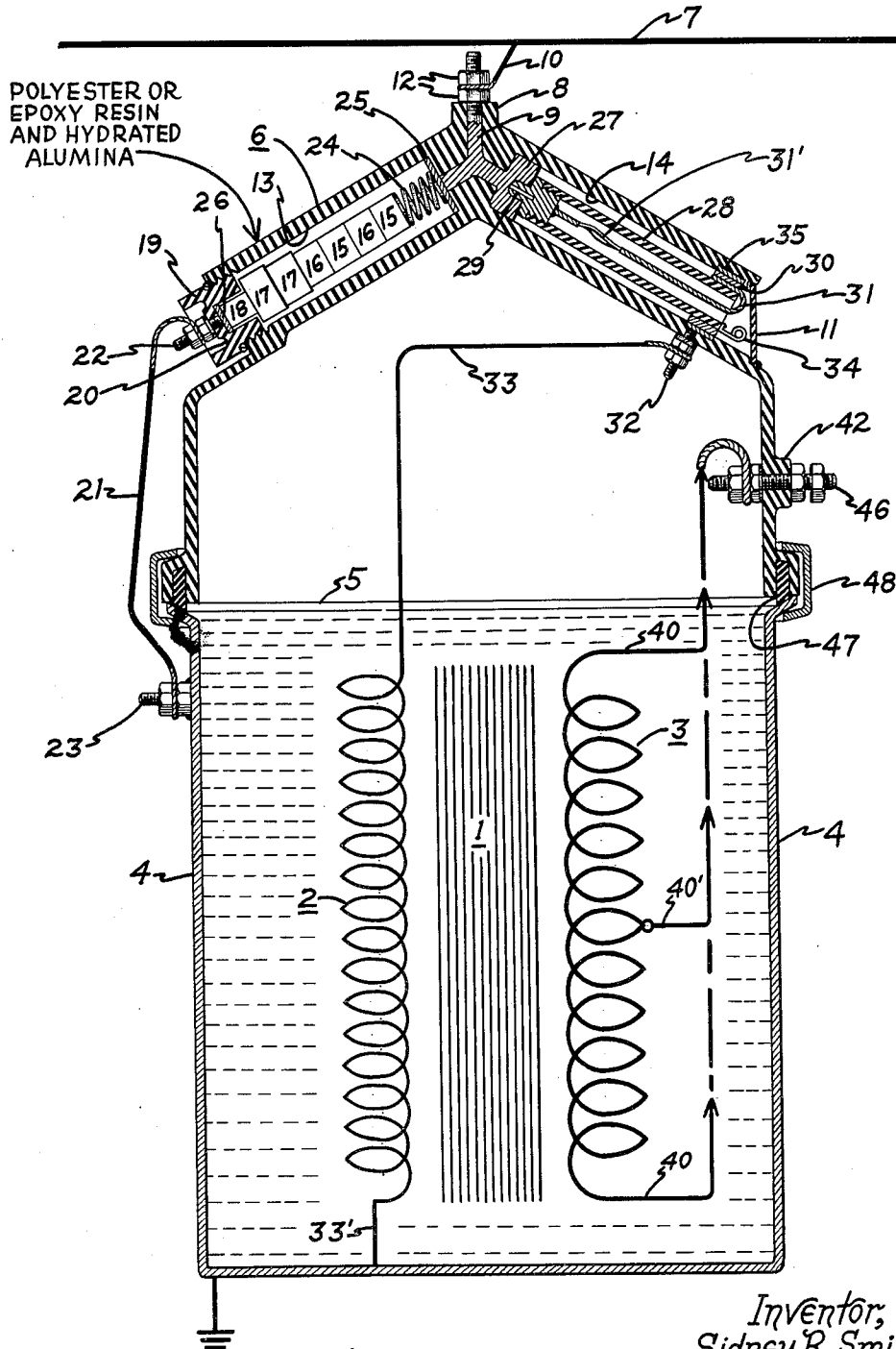
May 15, 1962

S. R. SMITH, JR
TRANSFORMER COVER

3,035,209

Filed Oct. 11, 1957

2 Sheets-Sheet 1



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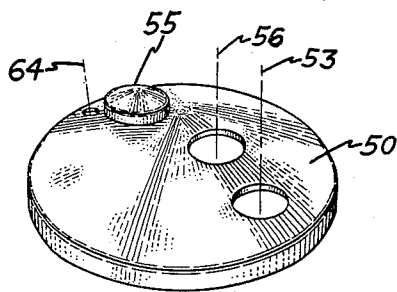
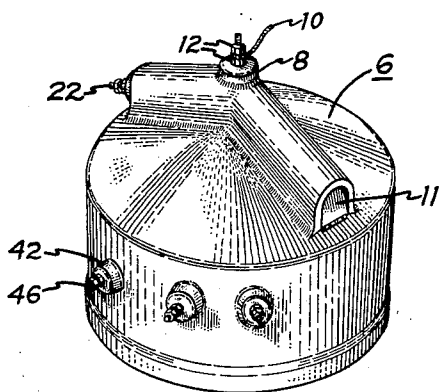
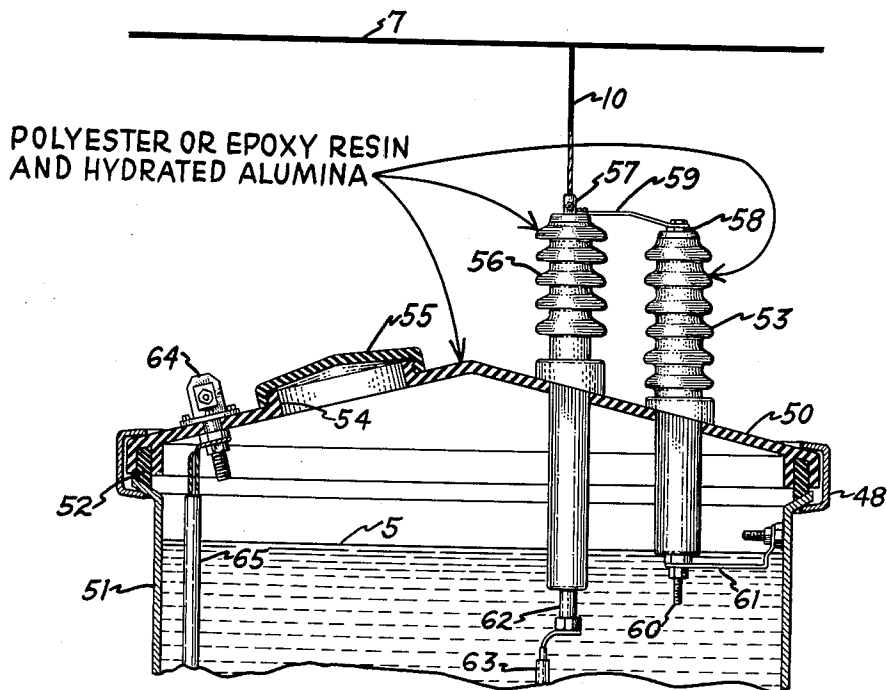
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2 Sheets-Sheet 2



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3,035,209

TRANSFORMER COVER

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6 Claims. (Cl. 317-15)

This invention relates to transformers, and more particularly, to transformer tank covers for outdoor type voltage step down transformers for electrical distribution and transmission systems.

Such transformers are conventionally housed in a tank which is closed by a metallic cover. The high voltage bushing for the incoming line generally speaking is located on the cover. Frequently outages are caused by squirrels or other small animals standing on the cover and reaching up and touching the live parts of the high voltage bushing. As the tank and its cover are usually grounded a short circuit of line current to ground is caused and also the animal is electrocuted.

Such outages have been partially avoided by making the bushing tall enough so that the animal cannot reach its terminal, or the terminal has been shielded. However, increasing the size of the bushing increases the cost of the transformer and providing shielding has not always been effective.

Additionally, aside from the problem of outages caused by animals both the high and low voltage bushings may need to have large dimensions in order to provide the necessary insulation between these two parts and the tank and metallic cover. The low voltage bushings are commonly mounted on the side of the tank. However, when the cover as well as the tank are made from metal, the insulation and in turn the size of the high and low voltage bushings is largely depended upon to avoid a flashover between their live parts along the conducting tank and cover.

Such transformers also usually have protective apparatus such as lightning arresters and fuses associated therewith. In many outdoor installations the transformer tanks are mounted on line poles. The protective apparatus may be mounted on the cross arms of the line pole or on the tank. Regardless of their place of mounting special mounting brackets and the like are required for this protective apparatus.

It is an object of this invention to provide a transformer cover which will overcome the above discussed disadvantages of conventional transformers.

It is a further object of this invention to provide a transformer having an improved transformer cover and associated transformer bushings and transformer protective apparatus which will overcome the above discussed disadvantages.

In my invention the transformer cover is made from electrical insulating material. Therefore, if an animal does stand on the cover and touch live parts such as the high or low voltage terminals no outage results.

Furthermore, in my invention the cover is made from organic electrical insulating material which is resistant to carbon tracking due to power arcs and surface creepage due to atmospheric contaminants. This type of material makes it possible to utilize the cover as insulation between live elements. In this manner the size of the transformer bushings can be considerably reduced.

In outdoor installations or others where there may be accumulations of dust, rain and other environmental contaminants random surface discharges or arcing known as surface creepage are promoted between insulated elements. The discharge conditions occasion the formation of carbonaceous deposits in conventional organic insulation, ultimately yielding low-resistance paths or tracks

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which destroy further utility of the insulation. Discharges of the creepage type are to be distinguished from those caused by the establishment of a power arc through or directly between two elements having different potentials. Under arcing conditions, while the organic insulation adjacent to the arc is carbonized, the arc track so formed is not random in character but forms a direct path along the line of the arc. On the other hand, tracks due to creepage are random in effect and produce a tree-like path. The difference between tracking due to arcing and tracking due to creepage is further pointed out in A.S.T.M. Test D495-48T in which it is stated specifically that the test directed to determining the resistance of insulating material to arcs does not in general permit conclusions to be drawn as to the resistance of the material to other types of arcs such as those promoted by conducting contaminants. It is further pointed out that in the creepage type of electrical failure, failure of the material can occur not only due to surface failure but to subsurface failure. In other words, even if the surface of the organic insulation is devoid of carbonaceous or conducting material tracking due to surface creepage may nevertheless occur between two points of different potential beneath the surface of the insulation itself. It is evident from the above that materials which are effective in protecting against the effects of direct arcing are not necessarily effective in protecting against creepage breakdown.

The improved materials hereinafter set forth as being resistant to arc tracking and surface creepage are not part of my invention but are claimed and disclosed in copending Norman and Kessel patent application Serial No. 633,356 for Electrical Apparatus Insulation which was filed January 9, 1957 and is assigned to the same assignee as the instant invention. However, as far as I know I am the first to have invented transformer covers which utilize these improved materials, and said improved transformer covers in combination with associated transformer protective devices and bushings in the manner and for the purposes herein disclosed.

Organic insulating materials have been avoided in the construction of electrical equipment wherein such materials would be subjected to the influences of electrical discharges, even though these materials would otherwise have been attractive because of other considerations. Some organic insulating materials which experience this limitation are epoxy and polyester resins.

By way of summary, critical amounts of hydrated alumina are incorporated in the organic insulation of the transformer cover. This may also be done for the organic insulation of other transformer parts such as bushings and housings for the lightning arrester and fuse. Also, these bushings and housings may be formed as integral parts of the transformer cover or they may be separately formed and then mounted on the transformer cover in such a manner that the special mounting brackets required by the prior art may be eliminated. Uniquely, the creepage discharges occurring across the surface of the insulation even under the most severe contaminating conditions do not occasion tracking and breakdown inasmuch as low-resistance carbonaceous deposits are not permitted to form. Generally, the organic materials which may be combined with hydrated alumina with particular advantage include epoxy and polyester resins. It is believed that the combined water in the hydrated alumina serves to oxidize the carbonaceous particles formed under arcing and creepage conditions and that the alumina oxide component itself acts as a catalytic agent to indirectly promote this oxidation. While unhydrated aluminum oxide is useful in delaying tracking under surface creepage conditions, it is not effective in oxidizing carbonaceous

materials or in preventing the eventual failure of insulation due to creepage tracking.

When hydrated alumina comprises 20 to 70% by weight of the combined epoxy resin hydrated alumina insulation, failure due to creepage is substantially eliminated. When the hydrated alumina constitutes from about 40 to 70% by weight of the composition failure due to creepage or trackage is wholly eliminated. When polyesters are used, the hydrated alumina is used in the proportion of from 20 to 70% by weight of the insulation, and preferably 30 to 70%.

The features of my invention which I believe to be novel are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, my best be understood by reference to the following description taken in connection with the accompanying drawings, in which

FIGURE 1 is a diagrammatic illustration of one form of my invention;

FIGURE 2 is a perspective view of the transformer cover of FIGURE 1;

FIGURE 3 is an illustration of another form of my invention; and

FIGURE 4 is a perspective view of the transformer cover of FIGURE 3.

Referring now particularly to FIGURE 1, illustrated therein is an outdoor step down voltage distribution transformer. The invention is not necessarily restricted to this type of transformer. However, the invention is particularly useful with this form of transformer since it is conventionally used outdoors where surface creepage due to atmospheric contaminants is encountered. Also, since they are used in large quantities and lend themselves to a high degree of standardization my invention can make many economies in the cost of this type of transformer.

The transformer comprises a magnetic core 1 and linked high and low voltage windings or coils 2 and 3 respectively. Since the invention is being explained with reference to a step down voltage transformer, the high voltage side 2 is the primary side. This form of transformer is commonly mounted on a line pole in a manner well known in the art. The core and windings are placed inside a metal tank 4 which may be filled with an insulating liquid as indicated by the liquid surface line 5. However, the transformer could be gas cooled or vented to the atmosphere.

The tank 4 is closed by a cover 6 which is made from an organic electrical insulating material which has been molded or cast into the desired shape. This insulation is resistant to carbon tracking due to power arcs and surface creepage due to atmospheric contaminants by the dispersion of critical amounts of hydrated alumina therein in the proportions heretofore discussed. The transformer is energized from a source of electrical energy such as by high voltage line 7. The cover 6 has a high voltage terminal bushing 8 integrally formed therewith. The conductor of the terminal bushing 8 may comprise a stud 9 which has been inserted into the cover and bushing during their forming operation. The transformer is connected to the line 7 by bringing a primary lead 10 from line 7 to the terminal end of conductor 9. The lead 10 can be connected to the terminal of the bushing conductor 9 by a pair of nuts 12 or other appropriate means.

The cover 6 has formed therein a pair of cavities 13 and 14 so that the cover 6 can serve as a housing for protective apparatus for the transformer. These cavities can be formed during the cover molding or casting operation. The cavity 13 is adapted to receive an elongated lightning arrester assembly and the cavity 14 is adapted to receive an elongated primary fuse assembly. Since these assemblies are housed in the cover they are generally laterally disposed, that is they lie along the surface of the cover 6, as contrasted with the vertical position. This reduces the height of the transformer. In some prior art installations, the lightning arrester assembly is mounted

on the side of the transformer tank. Therefore, my invention also reduces the amount of side space required by the transformer and its associated apparatus. Additionally, with these assemblies being housed in the cover the need for special housings and mounting brackets for them are eliminated.

A magnetic and valve action form of lightning arrester is illustrated but other forms of arresters may be used. The illustrated arrester comprises one or more stacked gap, magnetic coil and non-linear resistance units 15, 16 and 17 respectively. The coil units 16 are for the purpose of moving the arcs in the gap units 15 and the valve units 17 are for the purpose of limiting the power follow current in a manner well known in the art. One construction of this form of lightning arrester is described in detail in Crouch et al. Patent 2,728,016 which is assigned to the same assignee as the instant invention.

The lightning arrester assembly may also have a disconnect or isolator unit 18 which will disconnect the lightning arrester from ground in the event it fails to interrupt the power follow current within several half cycles of 60 cycle power current. The disconnect unit 18 may be of the explosive type. It will withstand the lightning surge and one or two half cycles of power follow current. If power follow current is not interrupted by the arrester then an explosive in unit 18 will be detonated. This will result in breaking of the end plug 19 along the weakening groove 20 and blowing of the ground lead 21 away from the bottom of the arrester. When the ground lead 21 and the ground terminal 22 of the lightning arrester fall away this will serve as an indication of a faulty arrester. One construction of this form of lightning arrester isolator or disconnect is described in detail in copending Hedlund et al. patent application 518,118 which is assigned to the same assignee as the instant invention.

If the tank 4 is grounded then the lead 21 can be connected to ground by connecting it to the tank as at the ground terminal 23 which may be welded to the tank side. The line end of the lightning arrester can be connected to the line by a spring 24 and a contact plate 25 which may be an integral part of a left-hand extension of the stud 9. The ground end of the lightning arrester assembly is in electrical contact with the ground terminal 22 by virtue of a contact plate 26 which may be integral with or welded to the stud of terminal 22. The plug 19 may be a molded part and closes cavity 13 by threading into the left-hand end of the cavity.

The stud 9 also has a right-hand extension which may provide a socket 27 for a bayonet type primary expulsion fuse. However, other types of primary current interrupters such as fuseless interrupters and mechanical circuit breakers having separable contacts could be used in the cavity 14. The bayonet fuse may comprise a gas evolving fuseholder tube 28 which has a slotted male member 29 at its left-hand end and a contact collar 30 at its right-hand end. A fuse link 31 can be connected to the member 29 as by a soldering. The other end of the fuse link 31 is brought out of tube 28 and electrically connected to collar 30 by forcing collar 30 over the right-hand end of the tube and fuselink.

The cavity 14 may have a molded in contact insert 35 for the contact 30, and a molded in stud 32 for connecting the primary lead 33 of the winding 2 to the fuse. The other end of the winding 2 can be connected to ground as by lead 33' which is connected to tank 4. In some installations the other end of the winding 2 is not grounded but is connected to another line similar to line 7. In such a case the lead 33' can be brought out of the transformer tank through another bushing similar to bushing 8, and another lightning arrester and primary fuse can be provided on the transformer cover to give complete protection to the transformer.

Besides operating as an automatic primary overcurrent interrupter, the fuse can also be operated manually

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to break the load. For this purpose means such as an eyelet 34 can be attached to the right-hand end of fuseholder 28. If a lineman wishes to manually interrupt the circuit a conventional switch stick can be used to pull on the eyelet 34 to extract the fuseholder. The contacts 27 and 29 and 30 and 35 will have an arc drawn therebetween when the fuseholder is withdrawn. However, the arc will be extinguished by virtue of the gas generating characteristics of the insulation of cover 6.

Indicating means may be incorporated in the primary fuse to give indication of automatic circuit interruption. This indicating means is illustrated as comprising a hinged cover 11 for the open end of cavity 14. When the fuse operates the gases generated by the fuseholder 28 will open cover 11 which indicates that the fuse has operated automatically.

The opposite ends of the secondary winding 3 are brought out of the transformer tank by connecting their leads 40 to the terminals an outer pair of three adjacent secondary bushings 42. The three adjacent secondary bushings 42 are best seen in FIG. 2. The midpoint of the coil 3 is connected to the central secondary bushing 42 by a lead 40'. This is to facilitate connecting the two halves of the coil 3 in series or parallel. In some cases the midpoint of the secondary is not brought out of the transformer tank but is connected directly to ground. This can be accomplished by connecting lead 40' to the grounded tank, if it is to be grounded, as with the primary lead 33'.

The bushings 8 and 42 are illustrated as comprising raised bosses on the cover. They in fact can comprise merely apertures formed in the cover such as is used for the secondary terminal 64 of FIGS. 3 and 4. The significant thing is that the insulating cover with its superior electrical characteristics makes it possible to eliminate the heretofore used insulating bushings which had to have relatively large dimensions and complicated surfaces.

The bushings 42 are shown as being integrally formed with the cover 6 and positioned off to one side on a rim of the cover. They are positioned off to one side since this is a convenient place to connect the customer's lines. However, these bushings could be positioned on the upper surface of cover 6, or they could be separately formed and mounted in a side of tank 4 as in the prior art. The conductor members of terminal bushings 42 may comprise molded in threaded studs 46 having nuts at opposite ends for clamping the leads 40 and 40' and the customer's lines.

A gasket 47 may be interposed between the upper end of the tank and the cover 6 to seal the joint therebetween. This seal may be compressed by means such as a clamping band 48 which is tightened around the adjacent portions of the tank and cover.

In normal operation the electrical circuit on the primary side is from line 7 through elements 10, 9, 27, 29, 31, 30, 35, 32, 33, 2, and 33' to ground. If a primary overcurrent develops the fuse link 31 melts at a fusible portion 31' and the transformer is thereby taken off the line. If lightning strikes the line 7 the lightning surge will bypass the fuse link 31 and coil 2. The bypass path is from line 7 through elements 10, 9, 25, 24, 15 to 18, 26, 22, 21 and 23 to ground. After the surge is dissipated the arrester will seal off the power follow current to ground. If the arrester is defective then the disconnecter 18 will operate to blow the ground lead 21 away from the lightning arrester. In this manner power follow current to ground is interrupted and the hanging lead 21 indicates the arrester is faulty.

Since the organic insulation-hydrated alumina which is used in the cover is resistant to arc tracking no carbon tracks will be formed in the lightning arrester housing 13 when it fails. For a similar reason no carbon tracks will be formed in the housing 14 when an arc is drawn between contacts 27 and 29 and 30 and 35 when the fuse

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is manually opened. The fuseholder 28 can also be made from organic insulation and hydrated alumina to make it resistant to arc tracking and surface creepage. Since this type of insulation is resistant to arc tracking and surface creepage the design engineer is given greater latitude in positioning the various electrically live parts with respect to each other. This makes it possible to make the transformer and its various components and protective apparatus more compact. The structural rigidity and strength of the organic insulation which is used with hydrated alumina can be increased by using fillers such as fibrous material or glass mat, or inserted metallic or non-metallic reinforcing ribs can be utilized.

Referring now to FIGURE 3, in this form of the invention some of the bushings are separately formed and the transformer protective devices are separately contained in their own housings and then these parts are inserted in apertures formed in the cover and are supported by the cover without the need for special mounting brackets. The cover, bushings and housings utilize the improved insulation which is resistant to arc tracking and surface creepage.

The cover 50 closes the tank 51. The joint between the cover and tank can be sealed by a gasket 52 and this gasket can be compressed by appropriate clamping means such as a clamping band 48. The lightning arrester assembly is enclosed in its own housing 53 which is inserted in an aperture formed in the cover. About half of the housing 53 can be disposed inside the tank so as to reduce the height of the installation. The cover 50 has a handhole opening 54 which is closed by a cover 55. The terminal bushing 56 is also inserted in an aperture formed in cover 50. The openings in the cover 50 for the parts 53 and 56 can be sealed by suitable gaskets and clamping means or cement can be employed between the parts 50, 53 and 56. Since the terminal bushing 56 and covers 50 and 55 are constructed from material which is resistant to arc tracking and surface creepage the height of bushing 56 can be considerably less than those of prior art installations which utilize metallic covers and ceramic bushings.

The line terminal 57 of bushing 56 and the line terminal 58 of the lightning arrester are electrically connected by means such as a lead 59. This lead can be blown away from the lightning arrester to isolate or disconnect the lightning arrester from the line by providing means such as the explosive isolator or disconnecter 18 of FIG. 1 in the upper end of lightning arrester housing 53. The blown away lead 59 will be readily visible to indicate that the arrester has failed. The lower terminal 60 of the lightning arrester is grounded by connecting a ground lead 61 to the grounded tank.

The primary side automatic current interrupter may comprise a fuse 62 which is housed in the bushing 56. It is connected to one end of the primary coil of the transformer by a lead 63. Conventionally this type of fuse is renewed by first removing the bushing 56 from the cover, although a fuse which can be withdrawn from the top of the bushing 56 without removing it from the cover 50 could be provided.

The secondary terminal clamps 64, only one of which is illustrated, may be mounted directly in and clamped to the cover 50. They need have no special insulating bushing since the insulating cover 50 will provide the necessary insulation and serves the function of insulating bushings. The secondary terminal clamps 64 are connected to the secondary coil of the transformer by leads 65, only one of which is illustrated.

In FIGURE 3 it is feasible to encapsulate the lightning arrester assembly by molding the housing 53 around the assembly to provide a sealed lightning arrester. However, encapsulation is not practical in FIGURE 1. In FIGURE 1 it is preferable to be able to manually open the lightning arrester housing 13 so that a new arrester assembly can be installed while reusing the same trans-

former cover. However, in FIGURE 3 the transformer cover can be reused even with an encapsulated lightning arrester since the sealed housing 53 can be readily bodily detached from the transformer cover.

In the second form of the invention since the cover has a simpler configuration than in the first form of the invention, it is possible to form the cover by punching and pressing sheets of insulation as well as by molding or casting methods. Obviously the insulated covers of this invention do not have to be painted since they are more resistant to attack from the weather and atmospheric contaminants. They will be factory fresh almost indefinitely as compared to metallic covers which may need to be repainted periodically and therefore raise upkeep and maintenance costs.

In both forms of the invention the heretofore employed porcelain lightning arrester and primary overcurrent interrupter housings and porcelain bushings are eliminated. Although separate bushing 56 and housing 53 are utilized in the second form of the invention these members are superior to porcelain bushings and housings in several respects.

For instance, satisfactory porcelain bushings and housings have large dimensions and are not light weight. On high impact they are apt to fracture into small sharp flying pieces, and if they are arced over their petticoats will be chipped and their surfaces scorched. Additionally, due to their long manufacturing cycle they must be stocked in large quantities.

If the bushings and housings are made from the improved organic insulation the above mentioned disadvantages of porcelain members are overcome. For instance, since complicated surfaces can be readily formed with the improved insulation, the members can be made smaller and lighter in weight than equivalent porcelain members. Also, they will not fracture into sharp flying pieces at high impact, and a power arc will not chip their petticoats or scorch their surfaces. With porcelain a power arc tends to play along the surface of the insulation. However, with the improved insulation the gases and vapors evolved therefrom forces the arc away from the surface of the insulation. Additionally, with the improved insulation the members do not have to be stocked in large quantities since they have a shorter manufacturing cycle than porcelain. Also, since the members can be readily formed to close tolerances it is possible to mold or cast the bushing, lightning arrester and overcurrent interrupter parts in the insulation, whereas this has been impossible with porcelain due to its high shrinkage.

While there have been shown and described particular embodiments of the invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention, and therefore it is intended by the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

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

1. In a transformer which is housed in a tank, a cover for said tank, said cover being constructed from elec-

trical insulating material which is resistant to arc tracking and surface creepage, and electrical protective apparatus for said transformer, said apparatus being enclosed in electrical insulating material housing means which is resistant to arc tracking and surface creepage and which is supported by said cover, said insulating material housing means being elongated and generally laterally disposed and lying along the surface of said cover to thereby provide a transformer of reduced height.

2. In a transformer as in claim 1, wherein said cover and housing means are integrally formed members, said apparatus comprising a lightning arrester assembly.

3. In a transformer as in claim 1, wherein said cover and housing means are integrally formed members, said apparatus comprising an overcurrent protective device.

4. In a transformer as in claim 1, wherein said cover and housing means are integrally formed members, said apparatus comprising a lightning arrester assembly and a fuse assembly.

5. In a transformer which is housed in a tank, a cover for said tank, said cover being constructed from organic electrical insulating material which is resistant to arc tracking and surface creepage, a generally elongated lightning arrester and fuse assembly for protecting said transformer, said cover having a pair of generally laterally disposed and elongated cavities formed therein, and said assemblies being housed in said cavities.

6. In a transformer which is housed in a tank, a cover for said tank which is constructed from organic electrical insulating material which is resistant to arc tracking and surface creepage, said cover comprising a lightning arrester housing a fuse assembly housing, and bushings for bringing the transformer leads out of said tank.

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