

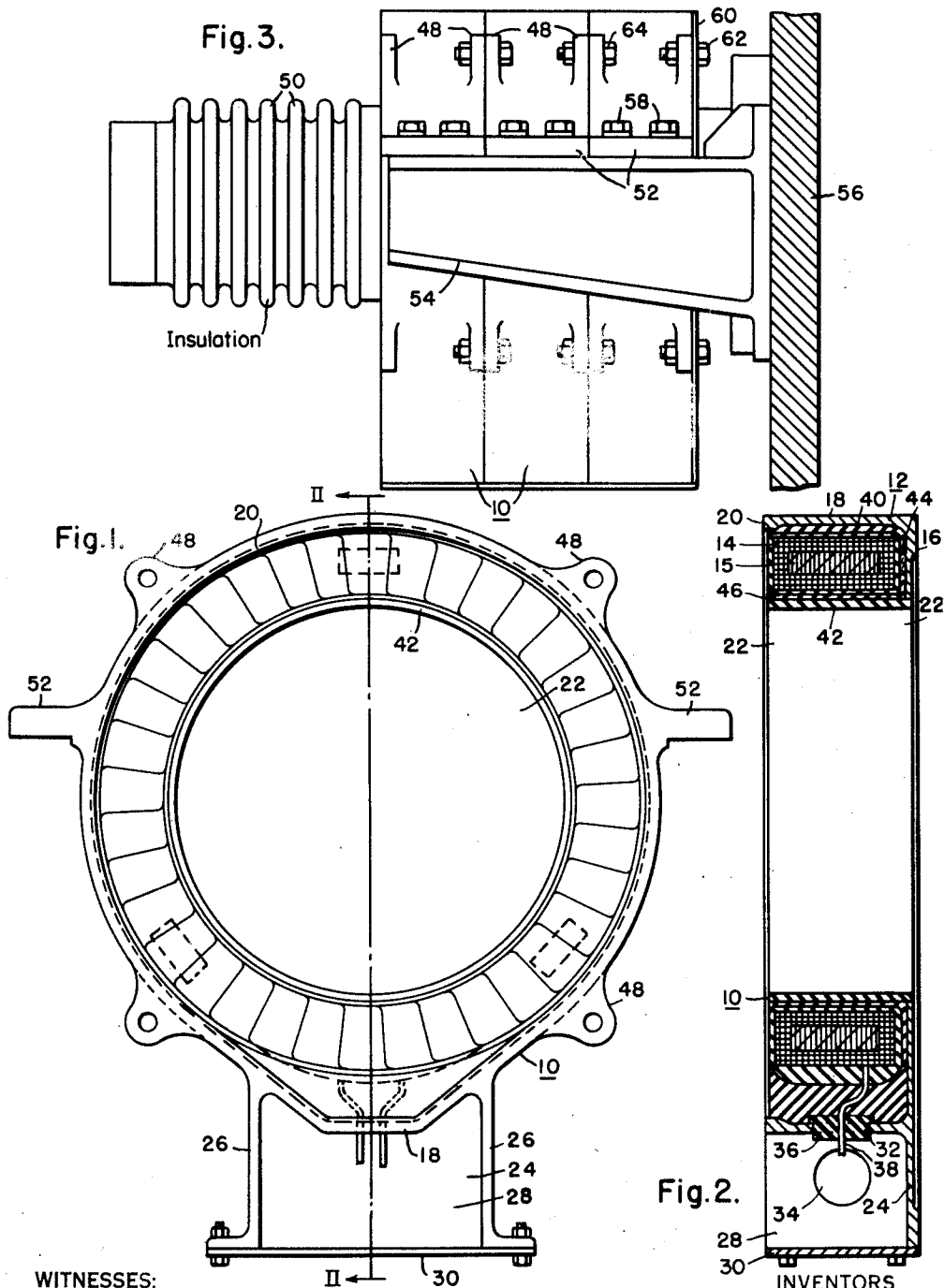
May 26, 1953

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2,640,102

CURRENT TRANSFORMER

Filed Dec. 6, 1950



WITNESSES:

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Fig. 2.

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2,640,102

CURRENT TRANSFORMER

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Application December 6, 1950, Serial No. 199,463

5 Claims. (Cl. 175—358)

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This invention relates to transformers, and in particular to current transformers of the bushing type.

Bushing type current transformers have been used for many years in conjunction with circuit breaker, disconnecting switch and power transformer bushings. Recently another application has been found in connection with hydrogen-cooled generators, and attempts have been made to apply the known bushing current transformers to the terminal bushings of such apparatus.

In practice, however, it has been found to be quite difficult to apply the known current transformers to such rotating apparatus because of the restricted working space and the fact that the continuous vibration of the rotating apparatus requires a more substantial transformer and secure mounting thereof. The high ambient temperature at such transformer locations on the generators also has a detrimental effect on the insulation of the known current transformers, making it necessary to provide better heat dissipation.

An object of this invention is to provide a bushing type current transformer that is resistant to vibration.

Another object of this invention is to provide a bushing type current transformer having the windings thereof assembled in a lightweight housing and secured therein by means of a solidified thermoset resinous composition.

A more specific object of this invention is to provide in a bushing type current transformer means for securing the electrical windings in a lightweight housing by embedding the windings in a thermoset resinous material, the housing having a projection thereon which cooperates with the resinous material in locking the embedded windings in assembled position.

Other objects of this invention will become apparent from the following description when taken in conjunction with the accompanying drawing, in which:

Figure 1 is a view in elevation of a current transformer embodying the teachings of this invention,

Fig. 2 is a view in section of the current transformer taken along the line II—II of Fig. 1, and

Fig. 3 is a view in side elevation illustrating the assembly of a plurality of the current transformers in operative relation about a bushing of an electrical apparatus such as a generator.

Referring to the drawing, and in particular to Figs. 1 and 2 thereof, this invention is illustrated by reference to a current transformer shown gen-

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erally at 10. In this embodiment the current transformer 10 comprises a housing 12 formed of a lightweight nonmagnetic material such as aluminum, and in the confines of which suitable electrical windings 14 are disposed about a suitable core 15.

The housing 12 comprises a back plate portion 16 and outwardly extending flange or side wall portion 18 disposed preferably about the periphery of the back plate portion 16. In a preferred embodiment, the back plate portion 16 and the side wall member 18 are one casting, the outer edge of the side wall member 18 being provided with a projection or lip 20, the purpose of which will be more fully explained hereinafter.

As illustrated, the back plate portion 16 is provided with a central opening 22 therein, the central opening 22 being of a suitable size for receiving a bushing when the transformer is mounted in operative relation therewith, as will be explained more fully hereinafter. The back plate portion 16 is also provided with an extension or depending section 24 which carries extensions 26 of the side wall member 18 at the outer edges thereof for forming a terminal or lead box 28 when the ends of the extensions 24 and 26 are covered with a cover plate 30, as illustrated in the drawing. The side wall member 18 and the side wall extensions 26 are provided with suitable openings 32 and 34 for passage of the leads from the windings 14 therethrough. It is to be noted, however, that the opening 32, as more clearly shown in Fig. 2, is provided with a stopper 36, preferably of insulating material, for filling the opening 32, the stopper 36 having a small passage for the leads 38 to extend therethrough.

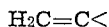
In order to form a channel 40 in the housing 12 for receiving the windings 14, a cylinder 42 of insulating material is positioned about the periphery of the central opening 22 of the back plate portion 16 and disposed to extend substantially parallel with the major portion of the side wall member 18. The cylinder 42 is preferably formed of laminated fibrous material impregnated with a resinous binder, such as phenol-formaldehyde or urea formaldehyde and consolidated under heat and pressure. In practice the cylinder 42 is of a length substantially equal to the length of the side wall member 18, the channel 40 thus formed being of a size to accommodate the windings 14.

In assembling the windings 14 in the channel 40, spacer members 44 are disposed in spaced relation about the base of the channel 40 to seat against the back plate portion 16. The spacer

members 44 are also preferably of insulating material and may also be formed of the fibrous material impregnated with a resinous binder. In practice, three spacer members are found to be satisfactory for supporting the windings 14 out of engagement with the back plate portion 16.

After the windings 14 are positioned on the spacer members 44 in the channel 40, a completely reactive fluid resinous composition 46, capable of solidifying when heated, is introduced into the channel 40 to completely embed the windings 14 and fill the channel 40 to the outer edges of the side wall member 18 and the cylinder 42. Completely reactive compositions which are suitable for this purpose may include any fluid polymerizable composition that upon being heated to a predetermined temperature polymerizes into a relatively hard resinous body. Thus, the fluid resinous composition may comprise a single polymerizable component, such for example, as diallyl phthalate, diallyl succinate, diallyl maleate, diallyl adipate, allyl alcohol, methallyl acrylate, allyl crotonate, or a partially condensed organosiloxane having a ratio of R to Si of from 1:1 to 1:1.5. It will be noted that many suitable compositions comprise at least one unsaturated group $>C=C<$ capable of vinyl-type additive polymerization. Best results can be secured with monomers containing two or more of these unsaturated groups capable of polymerization upon being subjected to heat. It will be understood that mixtures of any two or more of the polymerizable monomers may be employed. Numerous other multi-component completely-reactive compositions are known to the art. Such compositions include in many cases an unsaturated resinous component, particularly an unsaturated alkyd resin and an unsaturated polymerizable liquid monomer. Particularly good results have been secured by employing as the resinous alkyd resin the reaction product of an ethylenic dicarboxylic acid, or anhydride thereof, such for example, as maleic acid, fumaric acid, maleic anhydride, monochloromaleic acid, itaconic acid, itaconic anhydride, citraconic acid, and citraconic anhydride. The unsaturated dicarboxylic acid or anhydride or mixtures thereof are reacted with a polyhydric alcohol such as glycol, glycerol, or pentaerythritol or mixtures thereof. Castor oil has been employed successfully in reactions with maleic anhydride and the resultant castor oil maleate ester admixed with a polymerizable unsaturated monomer, for example, monostyrene, in the proportions of from 10 to 95 parts by weight of the monostyrene, and from 90 to 5 parts by weight of the ester. In the preparation of the unsaturated alkyd esters, the unsaturated alpha beta dicarboxylic acid or aryl dicarboxylic acid or anhydride, such for example as succinic acid, adipic acid, sebacic acid, phthalic acid, phthalic anhydride, or the like, may be used. Also, mixtures of polyhydric alcohol may be employed. In some instances epoxides have been employed in lieu of glycols, particularly with dicarboxylic acids instead of their anhydrides.

The alkyd esters may be dissolved in a liquid unsaturated monomer having the group



Suitable liquid unsaturated polymerizable monomers are: monostyrene, alpha methyl styrene, 2,4-dichlorostyrene, paramethyl styrene, vinyl acetate, methyl methacrylate, ethyl acrylate, diallyl phthalate, diallyl succinate, diallyl maleate, allyl alcohol, methallyl alcohol, acrylonitrile,

methyl vinyl ketone, diallyl ether, vinylidene chloride, butyl methacrylate, allyl acrylate, allyl crotonate, 1,3-chloroprene and divinyl benzene, or mixtures of two or more of any of these monomers.

The unsaturated, reactable composition preferably contains a polymerization catalyst. Suitable catalysts include peroxides, ozonides, perhalides, and peracids. Examples of suitable catalysts are benzoyl peroxide, tert-butyl perbenzoate, tert-butyl hydroperoxide, di-t-butyl peroxide, di-t-butyl diperphthalate, 1-hydroxy cyclohexyl hydroperoxide-1 and ascaridol. One-tenth per cent (0.1%) or less of the polymerization catalyst, based on the weight of the composition, may be employed, but more rapid reaction is obtained if the amount of the catalyst is higher—preferably from 1/2% to 2% by weight. The polymerization catalyst, when admixed in the completely-reactive composition, may cause it to increase in viscosity slowly at ordinary temperatures; and, therefore, it may be desirable to maintain the catalyzed composition to a temperature of 10° C. or lower, thereby increasing the tank life of the composition.

After the resinous composition 46 is applied about the windings 14 in the channel 40, it is caused to react to the solidified stage by subjecting it to sufficient heat to effect the polymerization thereof. This may be done by connecting the leads 38 of the winding 14 to a source of current, either alternating or direct current, of a sufficient magnitude to generate heat at a rapid rate internally in the winding to effect polymerization of the resinous composition which has penetrated the insulation of the windings 14. This heat may not be sufficient to effect the polymerization of the body of the resinous composition, and in such case the housing 12 with the components assembled as described, may be placed in a suitable oven where the assembly is heated to a temperature of from 80° C. to 130° C. for a sufficient period of time to effect the polymerization of the resinous composition into a solid body. In practice the polymerization is usually effected by subjecting the assembly to heat in the oven without the initial heating by passing current through the windings. When the resinous composition 46 is solidified, it is found that the embedded windings 14 are securely locked in position in the channel 40 by means of the projecting lip 23 carried at the end of the side wall member 18. The resulting solidified thermostat resinous material is void-free and completely fills the channel 40 without applying excessive or damaging pressure to the windings 14.

In practice the housing 12 is also provided with a plurality of lugs 48 spaced about its periphery, the lugs 48 being disposed at both of the edges of the housing 12 for facilitating assembly of a plurality of the current transformers 10 in assembled relation about a bushing 50, as illustrated in Fig. 3 of the drawing. Again, referring to Fig. 1, the housing 12 is also provided with a pair of outwardly extending flanges 52 on opposite sides of the housing so disposed that when the transformer 10 is assembled about the bushing 50, as in Fig. 3, the flanges 52 will seat on the upper edge of a bracket 54 carried on the frame 53 of a generator, not shown. When the transformers 10 are assembled about the bushing 50, the flanges 52 seat against the brackets 54 and are secured thereto as by means of bolts 58. In making such an assembly, an end plate 60

of non-magnetic metal is disposed across the open face of the housing 12 to cover the exposed surface of the resinous composition and to enclose the terminal compartment 28, the end plate being secured to the lugs 48 of the transformer as by means of bolts 62. By covering the housing in this manner, the entire enclosing housing is at ground potential when the metallic housing is supported by the brackets 54. The leads 38 of the first transformer 10 are carried through the opening 34 of the terminal compartment 28 so as to make suitable connections with the other current transformers whether on the same bushing or adjoining bushings. Where a series of transformers are mounted about one bushing, the second transformer is positioned so that its open face abuts against the back plate portion 16 of the first current transformer 10, the two transformers being secured as by means of bolts 64 passing through the spaced lugs 48. In a similar manner the third transformer of an assembly such as that illustrated in Fig. 3 may be assembled in operative relation with respect to the first two transformers 10. It is to be noted that in such assemblies or where the end plate 60 is secured to the assembly, the insulating cylinder 42 also prevents an external short-circuited turn around the transformer while providing adequate support for the windings and resinous material in the channel.

In practice where the transformer is constructed as described, it is found that damage to the transformer caused by vibration of the generator (not shown) is prevented. The thermostat resinous composition in the channel 40 contains and maintains the transformer core and windings so firmly in assembled position as to prevent damage thereto due to movement of the components. The resinous composition also prevents excessive pressure being applied to the windings 14. The resulting transformer is resistant to shock, it being found that the transformer can be handled for testing, shipping and installation without any damage thereto. Since the resinous composition completely fills the channel about the windings, it is found that a better heat dissipation is obtained, the resinous composition being capable of resisting the ambient temperatures encountered, such composition having a very high thermal stability at the elevated temperatures encountered in service. Further, the resinous composition completely protects the windings against moisture such as may be encountered during long shutdown periods of the equipment.

Additional advantages are obtained when it is considered that the lightweight housing of the transformer has only one end open, thus requiring only one top or end plate for the transformer assembly which is utilized with each bushing. This also effects a reduction in weight of the assembly where a plurality of the transformers are required in a particular installation. The projection or lip 20 carried by the side wall member 18 further definitely functions to maintain the embedded windings 14 in the assembly, and by mounting the embedded windings in the assembly insures a good bond between the resinous composition and the metal housing of the transformer to thereby aid in effecting a dissipation of heat generated in the assembly.

We claim as our invention:

1. In combination, a bushing for the leads of electrical apparatus, a current transformer mounted on the bushing, the current transformer

comprising, an annular housing of lightweight non-magnetic metal, the housing having a back plate portion and a flange member extending outwardly therefrom about the outer periphery thereof, the back plate portion having a central opening therein for receiving a bushing, a cylinder of laminated fibrous material impregnated with a resinous binder disposed to extend outwardly from the periphery of the central opening in the back plate portion to cooperate therewith and with the flange member to provide a channel, windings disposed in the channel, and a completely reactive solidified thermoset resinous composition completely embedding and in intimate contact with the windings to fill the channel and maintain the windings in assembled relation in the housing.

2. In combination, a bushing for the leads of electrical apparatus, a current transformer mounted on the bushing, the current transformer comprising, an annular housing of lightweight non-magnetic metal, the housing comprising a back plate portion with a central opening therein and a flange member extending outwardly about the outer periphery of the back plate, a cylinder of insulating material disposed to extend outwardly from the periphery of the central opening in the back plate portion to cooperate therewith and with the flange member to provide a channel, the flange having a lip at the outer edge thereof disposed to extend towards the cylinder, windings disposed in the channel and a completely reactive solidified thermoset void-free resinous composition completely embedding and in intimate contact with the windings to fill the channel and maintain the windings in assembled relation in the housing, the lip cooperating in the housing to lock the solidified resinous composition and windings in the channel.

3. In combination, a bushing for the leads of electrical apparatus, a current transformer mounted on the bushing, the current transformer comprising, an annular housing of lightweight non-magnetic metal, the housing having a back plate portion and a flange member extending outwardly therefrom about the outer periphery thereof, the back plate portion having a central opening therein of a size sufficient to accommodate the bushing, a cylinder of insulating material disposed to extend outwardly from the periphery of the central opening in the back plate portion to cooperate therewith and with the flange member to provide a channel, a projection carried by the flange disposed to extend within the channel, windings disposed in the channel, and a completely reactive solidified thermoset void-free resinous composition completely embedding and in intimate contact with the windings to fill the channel and maintain the windings in assembled relation in the housing, the projection cooperating in the assembly to lock the solidified resinous composition in the channel.

4. In combination, a bushing for the leads of electrical apparatus, a current transformer mounted on the bushing, the current transformer comprising, a cast housing of aluminum, the casting having a back plate portion and an outer side wall portion extending outwardly therefrom, the back plate portion having a central opening therein for accommodating the bushing, a cylinder of insulating material disposed to extend outwardly from the periphery of the central opening in the back plate portion to cooperate therewith and with the side wall portion to provide a substantially annular channel, windings disposed in

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the channel in spaced relation to the members forming the channel, and a completely reactive solidified void-free thermoset resinous composition completely embedding and in intimate contact with the windings to fill the channel and maintain the windings in assembled relation in the housing.

5. In combination, a bushing for the leads of electrical apparatus, a current transformer mounted on the bushing, the current transformer comprising, a cast housing of aluminum, the casting having a back plate portion and an outer side wall portion extending outwardly therefrom, the back plate portion having a central opening therein for accommodating the bushing, a cylinder of insulating material disposed to extend outwardly from the periphery of the central opening in the back plate portion to cooperate therewith and with the side wall portion to provide a substantially annular channel, the side

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5 wall portion having a lip at the outer edge thereof disposed to extend inwardly of the channel, windings disposed in the channel in spaced relation to the members forming the channel, and a completely reactive solidified void-free thermoset resinous composition completely embedding and in intimate contact with the windings to fill the channel and maintain the windings in assembled relation in the housing, the lip cooperating in the housing to lock the solidified resinous composition and windings in the channel.

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