

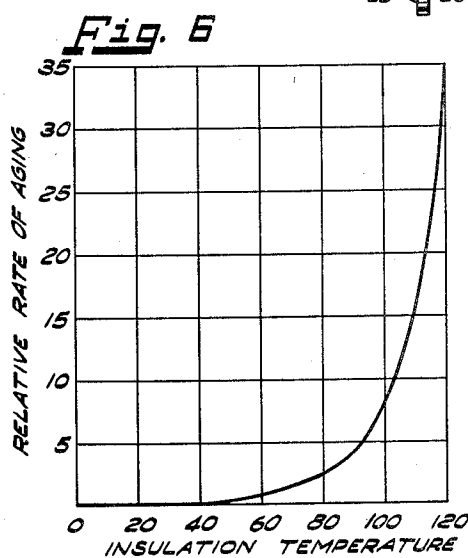
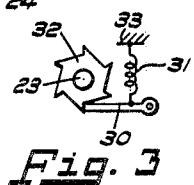
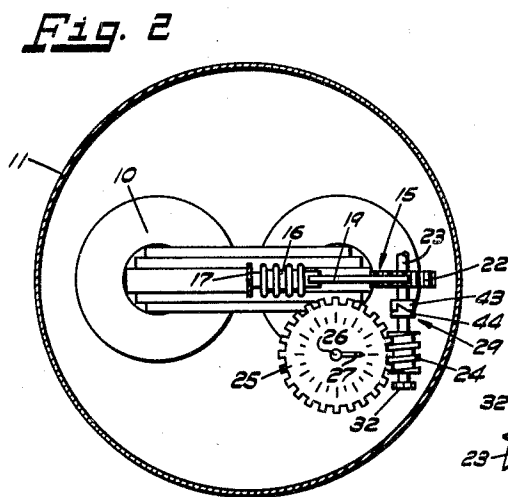
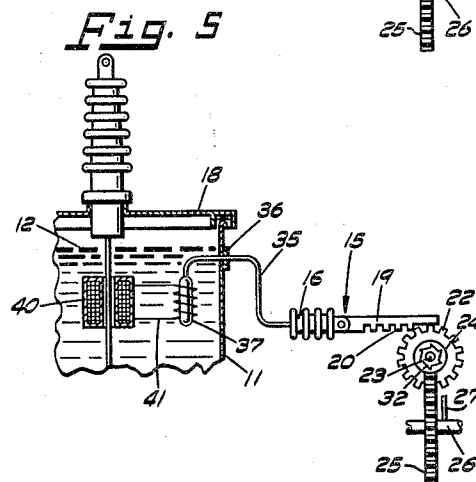
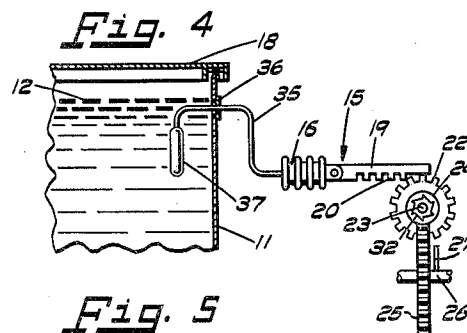
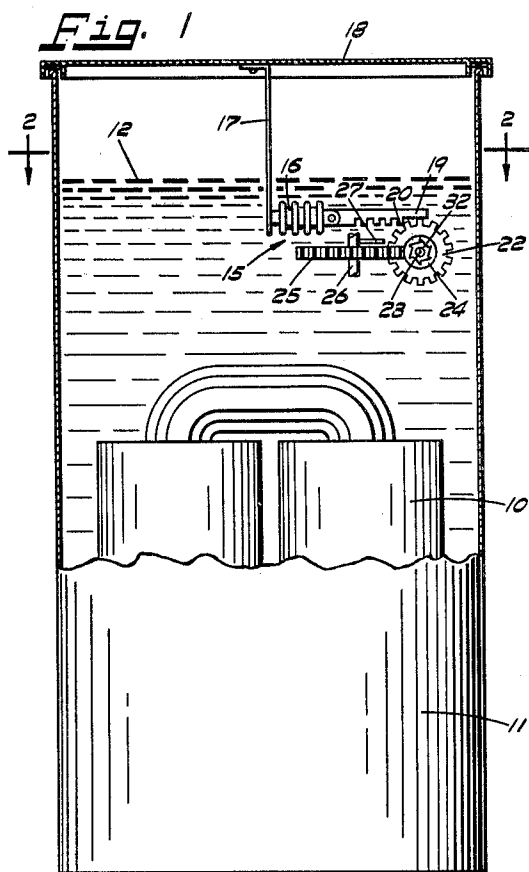
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APPARATUS FOR INDICATING AGE OF INSULATION

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APPARATUS FOR INDICATING AGE OF INSULATION

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9 Claims. (Cl. 340—253)

This invention relates to electrical apparatus subject to aging, for example oil filled transformers, and in particular to electrical apparatus having insulation subject to accelerated deterioration when overheated.

In transformers and other oil filled electrical apparatus, gradual aging of the insulation occurs which decreases the ability of the transformer to withstand overload. It is generally accepted that a transformer which has aged should not be as heavily loaded as when new. In the past, it has been customary to estimate the age of electrical equipment in terms of either the duration or the magnitude of its service output.

It is well accepted that the true age of a transformer is essentially the age of its insulation. Heating accelerates the deterioration of the insulation, and organic fibrous insulations age approximately twice as fast for each 10° C. increase in temperature. Any device for indicating transformer age should therefore take into account both the number of overloads to which a transformer has been subjected and the degree of such overloads.

It is an object of the invention to provide apparatus for indicating the extent to which a transformer has aged due to overloading.

It is a further object of the invention to provide an overload indicating device for electrical apparatus which is responsive to both the degree of overtemperature to which the electrical apparatus is subjected and the number of times the overtemperature occurs.

A still further object of the invention is to provide such an overload indicating device which furnishes a permanent record of the service to which the electrical apparatus has been subjected.

Further objects and advantages of the invention will become apparent from the following description taken in conjunction with the accompanying drawing in which:

Fig. 1 is a vertical elevation view of a transformer casing which is partially broken away to show a preferred embodiment of the invention mounted internally therein;

Fig. 2 is a horizontal sectional view taken along line 2—2 of Fig. 1;

Fig. 3 is an enlarged partial view of the star wheel and ratchet means for preventing return of the indicating dial;

Fig. 4 is a vertical section view of an embodiment of the invention which permits mounting externally of the transformer casing;

Fig. 5 is a vertical section view of an embodiment of the invention where the registration is directly dependent upon the load current through the electrical apparatus; and

Fig. 6 is a curve showing how the relative aging of transformer insulation increases with rise in temperature.

Referring to Figs. 1 and 2 which show elevation and plan views respectively of a preferred embodiment of the invention, a transformer core and coil assembly 10 is shown submerged in a liquid dielectric such as oil within the tank, or casing, 11. The oil extends above the transformer core and coil assembly 10 to approximately the

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level indicated by the reference character 12. The insulation of the core and coil assembly 10 deteriorates rapidly with increase in temperature, and as shown in Fig. 6, the organic fibrous insulation such as cotton ages approximately twice as fast for each 10° C. rise in temperature. In order to provide a record of the service to which the transformer has been subjected, an overload indicating device indicated generally by the reference character 15 is mounted internally of the casing 11 above the core and coil assembly 10.

The overload indicating device 15 includes an expandible, liquid filled bellows 16 immersed in the liquid dielectric and mounted at one end upon a bracket 17 secured to and depending from the cover 18. At the opposite end, the bellows 16 is connected to the rack 19 of a conventional rack and pinion. A plurality of teeth 20 on the bottom of rack 19 are adapted to engage the corresponding teeth of a pinion 22, which may be a spur gear, secured to a rotatable shaft 23. A worm gear 24 rigidly affixed to the end of the rotatable shaft 23 opposite the pinion 22 engages the external teeth of a rotatable overload indicating dial 25 in the manner of a conventional worm and wheel gearing. The dial 25 is rotatably mounted on a stationary vertical shaft 26 carrying a pointer 27 which cooperates with indicia on the dial 25 to register the aging of the transformer. A clutch coupling 29 is inserted in the shaft 23 between the pinion 22 and the worm gear 24 to permit driving in one direction only. A spring 31 secured at one end to a stationary support 33 and at the opposite end to a pawl 30 resiliently urges the pawl 30 into engagement with the teeth of a ratchet wheel 32 (see Fig. 3) on the driven end of the shaft 23 to provide a positive stop to prevent rotation of the worm gear 24 in the reverse direction, thus insuring that the dial 25 gives a permanent record of the aging of the transformer due to overloading. In order to simplify the drawing and aid in the understanding of the invention, the elements which do not constitute an essential part of the invention, for example, the bearings for mounting the shaft 23, the means for mounting the stationary shaft 26, and the resilient means bearing against the shaft 23 to keep the male and female members of clutch 29 in engagement, have been omitted from the drawing.

The expandible bellows 16 is partially filled with a suitable fluid such as methyl alcohol having marked expansion-contraction characteristics, and the remainder of the bulb is filled with the vapor of the same liquid so that upon an increase in the oil temperature the bellows 16 will be extended. Thus, it will be seen that the rack 19 is movable in accordance with the temperature of the oil.

In the embodiment of Fig. 4 the overload indicating apparatus 15, including the bellows 16, is mounted externally of the transformer casing 11 and the bellows 16 is connected by means of a capillary tube 35 passing through a suitable gasket 36 in the sidewall of the casing 11 to a bulb 37 which is immersed in the body of oil contained in the transformer casing 11. In this embodiment, it will be understood that the thermally responsive element, or bulb 37, the capillary tube 35, and the bellows 16 are filled with an expansive medium in accordance with well known practice so that the vapor pressure of the medium, which is a function of the temperature, is transmitted hydraulically by the capillary tube 35 to the expansive bellows 16. The change of hydraulic pressure as transmitted through the capillary tube 35 from the thermostatically sensitive bulb 37 acts to compress or expand the bellows 16.

In the embodiment of Fig. 5, the overload indicating apparatus 15 is responsive to hot spot temperature. In transformer operation, overloading results in excessive internal heating with consequent danger of insulation

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and dielectric breakdown. Normally breakdown occurs at the point of most intense heating within a transformer coil, and the hot spot temperature is a direct indication of the overload to which the transformer is subjected. A measure of the overload and the resulting heating within the windings is accomplished in the embodiment of Fig. 5 by employing a current transformer 40 whose secondary winding is connected to a heating element 41 mounted on the thermally responsive bulb 37 which is immersed in the transformer oil. The heater element 41 thus carries a current which is proportional to the transformer load current and raises the temperature of the bulb 37 above the liquid dielectric temperature just as the load current raises the actual hot spot temperature.

In all of the embodiments, the movement of the bellows 16 is transmitted to the rack 19. If desired, a suitable motion multiplying linkage (not shown) may be utilized to augment the travel of the rack 19. In all of the embodiments, if the temperature of the transformer increases due to overload, the hydraulic pressure increases due to heating of the thermostatic fluid, causing the bellows 16 to expand and move the rack 19 to the right. Movement of the rack 19 rotates the pinion 22 and through the clutch coupling 29 drives the worm gear 24 to rotate the overload indicating dial 25. The angle of rotation of the shaft 23, and thus the rotation of registering dial 25, is dependent upon the degree of expansion of the bellows 16 and thus upon the degree of overload to which the transformer is subjected. When the overload is removed and the transformer cools, the bellows 16 retracts and pulls the rack 19 in the opposite direction. If desired, spring means (not shown) may be utilized to resiliently retain the bellows 16 in retracted condition. The spring biased pawl 30 prevents rotation of the worm gear 24 in the reverse direction, thus preventing return of the overload indicating dial 25 to its original position. The clutch coupling 29 drives in one direction only, and when the bellows 16 retracts and pulls the rack 19 back to its original position, the teeth of the driving member 43 of the clutch coupling 29 slide over the teeth of the driven member 44 to permit the rack 19 to return.

Under normal operating temperatures of the transformer, the teeth of rack 19 do not engage the teeth of pinion 22. Whenever an overload occurs raising the temperature of the transformer the expansive medium exerts hydraulic pressure to expand the bellows 16. Movement of the bellows 16 causes the teeth of rack 19 and pinion 22 to engage and rotate the overload indicating dial 25 which is calibrated in units proportional to the number of overloads and to the degree of overload. Fig. 6 is an approximate curve illustrating the relative rate of aging of organic fibrous solid insulating materials plotted versus temperature and shows that the aging approximately doubles with each 10° C. rise in temperature. The desirability of a record of both the number of overloads and the degree of overload to which a transformer is subjected is apparent from Fig. 6. The device of the present invention integrates both of these factors and gives a permanent record which is a direct measure of the extent to which a transformer has aged due to overloading.

It is obvious that a different calibration will be required for the registering dial in the embodiment of Fig. 5 wherein the expansive medium is responsive to overload current than in the embodiments of Figs. 1 to 3 wherein the medium is responsive to the temperature of the liquid dielectric.

It will be apparent that the indicating means of the invention can take many forms, only one of which has been shown, in different mounting arrangements and responsive to different conditions of heating within the transformer. It is obvious that the thermally responsive device can be a bimetallic element to provide the desired mechanical movement instead of an expansible bellows, or the bulb and bellows, as shown. Further, it is apparent other means than the rack and pinion may be utilized

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to translate the linear motion of the thermally responsive element into rotation and that means equivalent to the clutch, e. g., pawl and ratchet wheel, may be substituted therefor to provide unidirectional drive. The invention having been described clearly with the help of several embodiments thereof, various modifications will appear to those skilled in the art and it is intended to cover in the appended claims all such 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 encased electrical apparatus insulated with solid insulation and immersed within a dielectric liquid within the casing of said apparatus, the rate of deterioration of said solid insulation increasing with temperature rise, in combination, a thermally responsive actuator immersed at least in part in said dielectric liquid and including an expansible bellows partially filled with an expansible liquid movable in response to heating caused by load current in said apparatus, a rotatable indicia carrying dial, a rack and pinion connected to said bellows for deriving rotational motion from the movement of said bellows, unidirectional motion transmitting means providing a driving connection in one direction only between said pinion and said dial, and means for preventing rotation of said dial in a direction opposite to that in which it is driven by said motion transmitting means.

2. In encased electrical apparatus insulated with solid insulation and immersed in a dielectric liquid within the casing of said apparatus, the rate of deterioration of said solid insulation increasing rapidly with rise in temperature, in combination, a thermally responsive actuator immersed in said liquid dielectric and movable in response to heating caused by load current in said apparatus, a rotatable dial carrying indicia indicative of overload to which said apparatus is subjected, means permitting rotation of said dial in one direction only, and unidirectional motion transmitting means including a rack and pinion connected to said thermally responsive actuator for deriving rotational motion directly from the movement of said actuator and providing a driving connection in one direction only between said thermally responsive actuator and said dial.

3. In electrical apparatus insulated with solid insulation and immersed in dielectric liquid within the casing of said apparatus, the rate of deterioration of said solid insulation increasing rapidly with rise in temperature, in combination, a thermally responsive actuator immersed in said dielectric liquid and movable in response to heating caused by load current in said apparatus, a rotatable indicia carrying dial having a plurality of teeth in the external periphery thereof, and means actuated by the movement of said thermally responsive actuator for unidirectionally rotating said dial, said means including a rotatable shaft, a pinion on said shaft, a spur gear on said shaft engaging the teeth of said dial, and a rack connected to and actuated by said thermally responsive actuator and adapted to engage said pinion.

4. In encased electrical apparatus immersed in dielectric liquid within the casing of said apparatus and having insulation subject to deterioration at a rate which increases with rise in temperature, the combination of a thermally responsive actuator immersed at least in part in said dielectric liquid and movable in response to heating caused by load current in said apparatus, a rotatable shaft, a pinion on said shaft, a rack directly actuated by the movement of said thermally responsive actuator and adapted to engage said pinion, a rotatable registering dial, a plurality of teeth on said dial, a worm gear on said shaft and engaging the teeth of said dial, and a clutch coupling in said shaft between said pinion and said worm gear permitting rotation of said dial in one direction only.

5. In encased electrical apparatus insulated with solid insulation and immersed in a dielectric liquid within the casing of said apparatus, the rate of deterioration of said solid insulation increasing rapidly with rise in tempera-

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ture, in combination, a thermally responsive actuator movable in response to heating caused by load current in said apparatus and including a member immersed in said dielectric liquid and an expansible liquid partially filling said member, a rotatable indicia carrying dial, and means actuated directly by the movement of said thermally responsive actuator for rotating said dial in one direction only, said means including a pinion operatively connected to said dial and a rack connected to said thermally responsive actuator and adapted to engage said pinion.

6. In apparatus in accordance with claim 5 wherein said thermally responsive actuator includes a heating coil immersed in said dielectric liquid adjacent said member and a current transformer, the secondary of said current transformer being connected in series with said heating coil, the primary of said current transformer being connected so as to carry a current which is a function of the load current in said apparatus.

7. In encased electrical apparatus insulated with solid insulation and immersed within a dielectric liquid within the casing of said apparatus, the rate of deterioration of said solid insulation increasing rapidly with rise in temperature, the combination of a thermally responsive actuator including a bulb immersed in said liquid dielectric within said casing, an expansible bellows exterior of said casing, a capillary tube connecting said bulb and said bellows, an expansible liquid partially filling said bulb, said tube, and said bellows, a rotatable registering dial carrying indicia indicative of overload to which said apparatus is subjected, unidirectional motion transmitting means directly actuated by movement of said bellows for rotating said dial in one direction only, said means including a pinion operatively connected to said dial and a rack connected to said bellows and adapted to engage said pinion, and means for preventing rotation of said registering dial in a direction opposite to that in which it is driven by said motion transmitting means.

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8. In encased electrical apparatus insulated with solid insulation and immersed within a dielectric liquid within the casing of said apparatus, the rate of deterioration of said solid insulation increasing rapidly with temperature rise, in combination, an expansible bellows immersed within said liquid dielectric, an expansible liquid partially filling said bellows, a rotatable indicia carrying dial and unidirectional motion transmitting means actuated directly by movement of said bellows for rotating said dial in response to thermal expansion of the liquid in said bellows, said means including a pinion operatively connected to said dial, a rack secured to said bellows and adapted to engage said pinion, and means for preventing rotation of said dial in a direction opposite to that in which it is driven by said motion transmitting means.

9. The combination with electrical apparatus immersed in a dielectric liquid within a casing and having insulation subject to deterioration at a rate which increases with rise in temperature, of an insulation age indicating device comprising a thermally responsive actuator immersed at least in part in said liquid dielectric and movable in response to heat caused by current in said apparatus, a rotatable registering dial, unidirectional motion transmitting means for deriving rotational motion directly from the movement of said actuator and providing a driving connection in one direction only between said thermally responsive actuator and said dial, and means for preventing rotation of said registering dial in a direction opposite to that in which it is driven by said motion transmitting means.

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