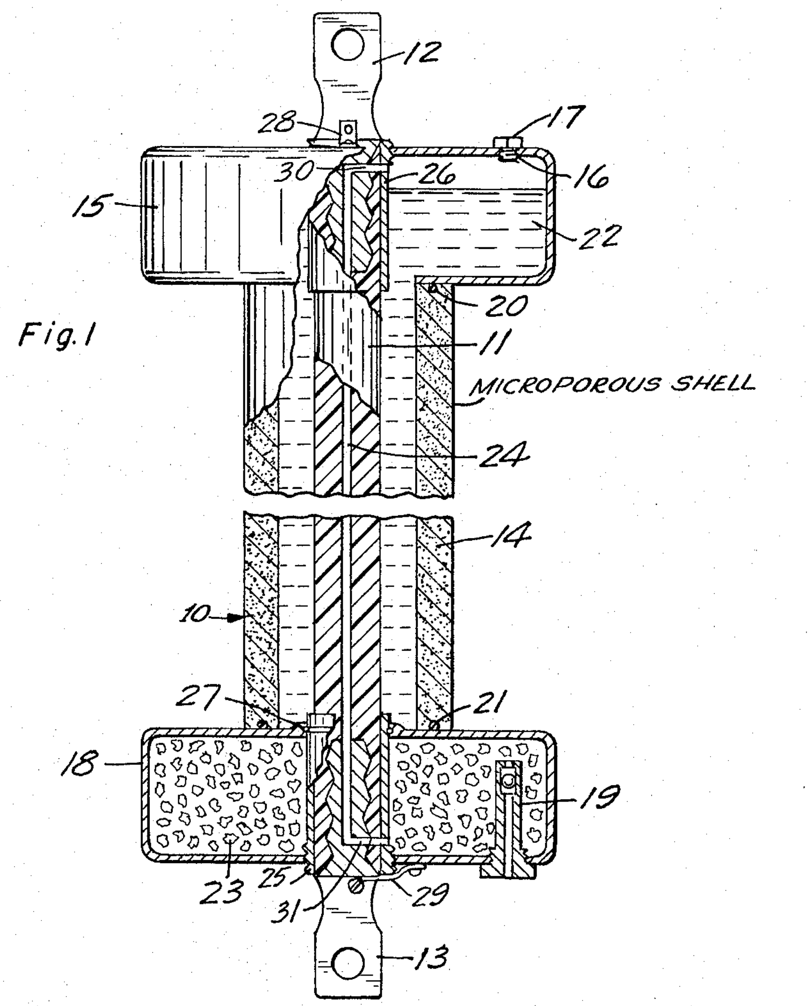
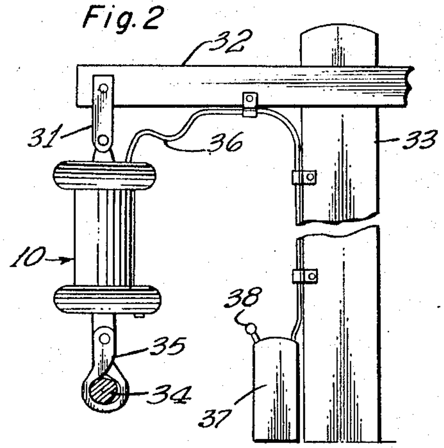
June 6, 1967 E. W. BOLLMEIER 3,324,223

SELF-CLEANING HIGH TENSION INSULATOR

Filed Sept. 20, 1965





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United States Patent Office

3,324,223

Patented June 6, 1967

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3,324,223

SELF-CLEANING HIGH TENSION INSULATOR

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Filed Sept. 20, 1965, Ser. No. 488,496

7 Claims. (Cl. 174—30)

This invention relates to high voltage insulation, as for example in the insulation of electric power transmission lines. In one illustrative embodiment the invention relates to suspension insulators useful on high tension transmission lines passing through areas of severe atmospheric pollution.

Insulators for overhead high tension electric power transmission lines frequently fail to perform their assigned duty because of conductive surface contamination due to deposition of conductive particles carried by the atmosphere and including soot, metal dusts, salts sprays and other pollutants. The conductive paths formed on the surface of the insulator by such materials permit arcing and flashover to occur under the intense electrical pressures of the high voltages employed.

Prior attempts to alleviate the problem have involved the use of waxy or greasy soil-resistant coatings, the use of specially shaped or contoured insulator bodies, periodic washing or cleaning of the insulator surfaces, and perhaps other palliatives. Temporary coatings must be periodically removed and renewed. Air-borne dusts and the like eventually become deposited over even the least accessible areas of flanged, slotted, convoluted and other special forms of insulator bodies. Washing and cleaning operations normally require temporary shutdown and are both expensive and time-consuming.

It has now been found possible to obtain long continued excellence of insulation on transmission lines operating in areas of extreme atmospheric pollution, by employing insulator components having self-cleaning surface characteristics. More specifically, there is provided an insulator having a microscopically porous outer shell which is kept filled and covered with a thin film of a contamination-resistant non-conductive liquid which is continuously or periodically renewed from an internal or external reservoir.

In the drawing, FIGURE 1 illustrates an insulator in detail, and FIGURE 2 illustrates an insulator installation including an external source of oil.

An example of a self-cleaning high voltage suspension insulator is illustrated in the appended drawing in partial cut-away and partial axial section. A central tension member **11** terminating in upper and lower attachment lugs **12** and **13** and provided with terminally exteriorly threaded ferrules **25**, **26** is surrounded with a microscopically porous insulating shell **14** supported and capped at its upper end with a smoothly rounded chamber **15** provided with a fill opening **16** and plug **17** and at its lower end with a similarly shaped chamber **18** having a valve **19**, the chambers being sealed to the shell through sealing means represented by O-rings **20**, **21**. The shell **14** and the upper chamber **15** contain a non-conductive fluid **22**. The lower chamber **18** contains a desiccant **23** and is connected to the upper chamber **15** by a tubular axial passage **24** and radial bores **30**, **31** in tension member **11** and in lugs **12**, **13**, and ferrules **25**, **26**. The structure is assembled by means of the screw threads outlining the central openings in the outer faces of the chambers **15**, **18** and the intermeshing threads formed at the outer ends of the metal ferrules. The ferrules assist in reinforcing the ends of the central tension member **11** as shown. An O-ring **27** supported within a circumferential groove at the upper end of the lower ferrule **25** forms a liquid-proof seal between the interior of the lower chamber **18** and the interior of the shell **14**. Metallic connectors **28**, **29** connect the lugs **12**, **13** with the chambers **15**, **18** respectively.

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In a specific illustrative embodiment the tension member **11** is 1⅛ inch in diameter and is constructed of epoxy resin reinforced with a high loading of longitudinally extending glass filaments. The total length of the tension member and connecting lugs is 27 inches. The chambers **15**, **18** are each two inches thick and 6 inches in diameter and are each formed of two shallow cup-like members of spun aluminum plate of about 1/16 inch thickness, welded together in edge-to-edge relationship. The porous shell or tube **14** is 20 inches in length, 2½ inches outside diameter, and of ⅜ inch wall thickness and is constructed of aluminum oxide as will now be described in detail, all proportions being in parts by weight unless otherwise indicated.

To make the tube, a slurry is first produced by mixing together 95 parts of aluminum oxide grain having an average particle size of about four microns, three parts of talc, two parts of clay, two parts of methyl cellulose, five parts of aqueous wax emulsion containing 45% of wax, and sufficient water to provide a sprayable mass. The mixture is spray dried, producing a quantity of small porous pellets. The pellets are pressed together under a pressure of 20,000 lbs./sq. in. into the desired tubular shape, and the tube is fired, for example for three hours at 1200° C. Other temperatures, e.g. from 800° C. to 1600° C., may be employed in obtaining different porosities, the higher porosities being obtained with the lower temperatures. The tube is then carefully machined to the desired size and shape in order to provide uniform surface characteristics and smooth flat end surfaces. It is next waterproofed by prolonged immersion in a solution, in 100 parts of heptane, of 50 parts of polymerizable silicone fluid (GE SF 99 silicone) and one part lead naphthenate as a curing agent, followed by draining, drying, and heating for one-half hour at 300° F. The thus treated tube is then vacuum impregnated with low viscosity silicone oil, and is ready to be installed in the insulator structure.

Once the several components have been assembled, the lower chamber **18** is first filled loosely with a desiccant, such as silica gel, introduced through the valve opening, and the valve **19** is then inserted and screwed into place. Next the insulator is inverted and the porous tube **14** and upper chamber **15** filled with light silicone oil through the opening **16** which is then sealed with plug **17**. The insulator is now ready for hanging. When suspended in a polluted atmosphere it maintains full insulation over long periods, the oil slowly exuding from the surface of the tube to maintain a clean insulative surface.

An alternative structure may be provided by first waterproofing the ceramic tube with a liquid fluorochemical treating agent and employing a fluorocarbon oil as the insulative fluid. The fluorocarbon oils have the disadvantage of relatively large variations in viscosity with changes in temperature, but at the same time are themselves highly repellent to both water and oil so that extremely low rates of exudation are sufficient to maintain full insulating effect.

Mineral oil may likewise be used in these self-cleaning insulator structures when the microporous shell is appropriately constructed or treated so as to permit the oil to wet and be exuded from the shell surface.

The porous shell **14** permits the gradual exudation of the fluid **22** which forms a thin continuous coating over the exterior surface of the shell. As conductive particles accumulate on the surface they are surrounded by the fluid and are thus prevented from forming a conductive path along the shell surface. The slow oozing of fluid from the shell tends to displace the fluid and particles and to renew the clean surface. Periods of heavy rainfall may assist in the cleaning action by washing away the contaminated fluid.

Substantial quantities of insulating fluid may be stored in the structure so that prolonged periods of effective operation are made possible. The stored fluid is protected from the effects of changes in atmospheric and internal pressures and from moisture by connection to the atmosphere through the lower end chamber **18** and valve **19**.

In addition to serving as reservoirs or containers for insulating fluid and desiccant, chambers **15** and **18** provide improved insulating characteristics by more uniformly distributing the lines of flux at the terminals, thereby to avoid arcing and corona effects such as might be experienced in the absence of such shielding means. It will be apparent that spherical, hemispherical, flat circular disc, ring, and other shapes may likewise be employed for their electrical shielding or stress relief function where other means for supplying or storing fluid are provided.

Particularly in insulators of larger diameter, a source of fluid supply may consist of a sponge-like absorbent porous filler or packing placed between the central tension member and the outer porous shell. The fluid is retained throughout the length of the filler by capillary action until drawn into and exuded from the microporous shell.

A still more effective way of supplying additional fluid to the insulator body is by means of pressure tubing extending from an external source. The tubing may be connected to the upper chamber through the fill opening **16** or through an external connection with the bore **24**, in which case neither of chambers **15** and **18** need be accessible to the fluid. A central source of fluid under pressure may then serve a number of insulators. An advantage of this system is that pressure may be periodically temporarily increased so as to force quantities of fluid through the microporous shell whereby to obtain a positive cleaning action. As an example, several insulators suspended from a single pole or tower may be connected to a single fluid supply tank on the same pole or tower. During periodic inspection and refilling of the tank, hydraulic pressure is temporarily applied to the fluid at the tank to flush the insulator surfaces. Between inspections, gravity feed is sufficient to keep the insulators filled and permit gradual exudation of fluid.

FIGURE 2 illustrates an insulator installation wherein an insulator **10** is suspended by a connecting link **31** from a cross-arm **32** attached to a pole **33**. From the insulator is suspended a high tension conductor **34** by means of link **35**. A flexible tube **36** carries oil from a pressure source **37** to the insulator, in this instance being connected to the upper hollow shielding member **15**. Pressure is supplied as needed by means of pump **38**.

As with more conventional forms of insulators, the microporous shell **14** may have any desired surface configuration, such for example as a plurally convoluted surface as shown in U.S. 1,502,829 or U.S. 2,986,595, or a cylindrical surface with periodic disc-like or saucer-like interruptions as in U.S. 2,732,423 or U.S. 3,001,005, or various other arrangements. A right-cylindrical shape as illustrated in the drawing offers advantages in ease of manufacture over the more complex structures, whereas the latter tend to minimize any possibility of the temporary formation of conductive paths along the entire surface by rain or heavy fog.

When of sufficient strength and toughness, the microporous hollow shell or tube may itself serve as the tension element. The metal connecting lugs **12**, **13** may be replaced by equivalent extensions of the insulative element **11**. The advantageous properties described hereinbefore in connection with suspension insulators are also available in terminal bushings and the like, e.g. of the type illustrated in U.S. 3,001,005 and wherein the microporous shell envelops a conductor rather than an insulative tension member. Various other modifications are contemplated as coming within the scope of the invention.

An important requirement for insulators that are subject to moisture or rainfall is that the microporous shell be water-resistant or hydrophobic rather than hydrophilic, so that water will not displace the insulative liquid and form a conductive path. Ceramic microporous shells are excellent insulators when clean and dry and are easily constructed to desired porosity, but are hydrophilic and must therefore be waterproofed when intended for use in the possible presence of moisture. Resinous or polymeric shells avoid this requirement, and are somewhat lighter in weight, but are less easily controlled as to porosity and are usually more expensive.

The viscous flow characteristics of the insulative fluid and the porosity of the shell wall are so correlated as to permit slow exudation of the fluid through the shell at a rate sufficient to maintain a self-cleaning action while still providing a useful working life. The application of constant pressure, e.g. by gravity feed from a suitable reservoir, may be relied on to increase the rate of flow. Partial plugging of the porous wall, or introduction of additional layers of microporous material adjacent the inner surface of the shell, may serve to decrease the rate of flow. In most cases, however, shell porosities and fluid viscosities may be selected so as to require no additional control measures.

It is also desirable that the rate of flow or exudation be relatively constant during seasonal temperature changes. Silicone oils are particularly low in viscosity variation with change in temperature and, since they are also available in a wide range of viscosities and offer excellent insulating properties, this class of materials is ordinarily preferred in the practice of the invention. The silicone oils are essentially polydimethyl siloxane, the viscosity being a function of the molecular weight or degree of polymerization. Oils of this character having viscosities of from five to as high as 100,000 centistokes are useful in these structures.

An example of a non-ceramic tube may be constructed by blending together on mill rolls a composition containing 100 parts of silicone rubber gum, 100 parts of diatomaceous earth, and two parts of benzoyl peroxide catalyst. The batch is extruded in the desired tubular form and cured for one hour at 300° F. It is then cut to shape and incorporated into a suspension insulator otherwise as previously described and which is filled with low viscosity silicone oil. The oil slowly exudes through the tube walls to maintain full insulation value during prolonged periods of service in polluted atmosphere.

The effect of a number of variables on the operation of insulators as herein described will be illustrated in terms of test samples and results using for convenience small porous ceramic tube sections prepared by essentially the procedures hereinbefore described and subjected to accelerated laboratory test procedures.

In a preliminary test to show the effect of oil viscosity, measurements were made of the rate of oil flow through a section of waterproofed aluminum oxide insulator shell made as hereinbefore described. Using silicone oil of 1000 centistokes viscosity, a flow of 8.4 ml. per day was obtained. At 2600 centistokes the flow was 3.1 ml. per day; at 5500 centistokes it was reduced to 1.4 ml.

Resistance to electrical failure was determined on test specimens placed in a salt spray chamber and under 6000 volts, the tests being terminated when the leakage current along the specimen reached a value of 25 milliamperes. The chamber had a capacity of two cubic yards and was continuously supplied with a fog of 10% NaCl solution at the rate of one liter per hour. The test specimens were tubes four inches in length and 1⅛ inch in outside diameter. The oil used was electrical grade polydimethyl siloxane having a viscosity of 20 centistokes. Aluminum oxide tubes were used, prepared as previously described but sintered at different temperatures to provide a range of porosities.

A first test was made on tubes which had not been waterproofed. A tube which showed no measurable exudation of oil failed in 0.4 hour. A slightly more porous tube having an exudation rate of 0.14 ml./hour failed in four hours. A third tube exhibited an exudation rate of 0.23 ml./hour and was effective for 22 hours.

In another series of tests, a group of smooth-surfaced tubes of the same dimensions but which were first waterproofed with cured silicone polymer were found to remain effective for an average of 42 hours in the salt spray test under an average oil exudation rate of only 0.1 ml./hour. Another group of identical tubes was first machined with a series of twelve evenly spaced circumferential grooves each ¼ inch wide and 1/16 inch deep prior to waterproofing; these tubes showed an average useful life of 135 hours in the accelerated salt spray test.

Still another microporous shell structure, which can be easily produced in any desired shape and porosity, is prepared by uniformly mixing together in a ball mill components consisting of

Zirconia sand of .001–.004 inch particles size		100
Mixture of:		
Solid epoxy resin	60	
Powdered mica	50	
Amine catalyst for epoxy resin	1.5	
Dihydrazide	5	
Wetting agent	0.5	
		5
Water sufficient to make a compactable mass		

The mass is pressed into a suitable mold to provide a green shell of desired shape and is then cured in an oven at 300° F. for one-half hour. Porosity may be reduced to any desired extent by incorporation of hydrated silica or other pore-plugging inert material in the batch to the extent required.

What is claimed is as follows:

1. A self-cleaning insulator structure useful in high voltage electric power transmission operations and comprising: a central elongate supporting member having external mechanical connection means at each end; a microporous tubular water-repellent insulating shell spaced from and surrounding a portion of said central member intermediate the ends; conductive shielding members one at each end of said shell for closing the open ends of said shell and for supporting said shell on said central member; and means for continuously supplying insulating oil over the entire interior surface of said shell to replace oil exuded through said shell.

2. A self-cleaning insulator structure useful in high voltage electric power transmission operations and comprising: a central elongate supporting member having opposing external mechanical connection means at the ends thereof; a microporous tubular water-repellent insulating shell spaced from and surrounding a portion of said central member intermediate said ends; conductive shielding members one at each end of said shell for closing the open ends of said shell and for supporting said shell on said central member, a first one of said shielding members having a hollow interior connected with the space between said tension member and said shell; and means for supplying insulating oil to the hollow interior of said first one of said shielding members and said shell.

3. A self-cleaning insulator structure as defined in claim 2 wherein said central member is interiorly channeled between points adjacent its two ends.

4. A self-cleaning insulator comprising a central elongate supporting member having external mechanical connection means at each end; a microporous tubular water-repellent insulating shell spaced from and surrounding a portion of said tension member intermediate the ends; hollow conductive shielding members one at each end of said shell for closing the open ends of said shell and for supporting said shell on said tension member, the hollow interior of the upper shielding member being connected with the space between said tension member and said shell; said shell and interconnected upper shielding member containing a quantity of an insulating oil.

5. An insulator installation including at least one self-cleaning insulator comprising: a central elongate supporting member having external mechanical connection means at each end, a microporous tubular water-repellent insulating shell spaced from and surrounding a portion of said tension member intermediate the ends, conductive shielding members one at each end of said shell for closing the open ends of said shell and for supporting said shell on said tension member, and, permanently interconnected with each said insulator, an external source of insulating oil for continuously supplying said oil over the entire interior surface of said shell to replace oil exuded through said shell.

6. The insulator installation defined in claim 5 and wherein said external source includes means for applying hydraulic pressure to said oil.

7. A self-cleaning insulator structure useful in high voltage electric power transmission operations, comprising: a central elongate supporting member terminating in upper and lower electrically conductive attachment lugs and provided with terminally exteriorly threaded upper and lower ferrules; a microporous tubular water-repellent insulating shell spaced from and surrounding a portion of said central member intermediate said ferrules; an upper smoothly rounded hollow electrically conductive chamber having an upper central opening fitting the threaded portion of said upper ferrule, a lower central opening interconnecting with the interior of said shell, and a closable fill opening for introduction of insulating oil into said upper chamber and said shell; a lower smoothly rounded hollow electrically conductive chamber having upper and lower openings for receiving said lower ferrule and being tightly sealed to said lower ferrule; said shell being supported and sealed between said upper and lower chambers; and each said chamber being electrically connected to the corresponding said attachment lug.

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