

[54] **INSULATOR WITH RESIN-BONDED FIBER ROD AND ELASTOMERIC WEATHERSHEDS, AND METHOD OF MAKING SAME**

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H01B 19/00

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174/169, 176, 177, 178, 179, 186, 209;
29/631

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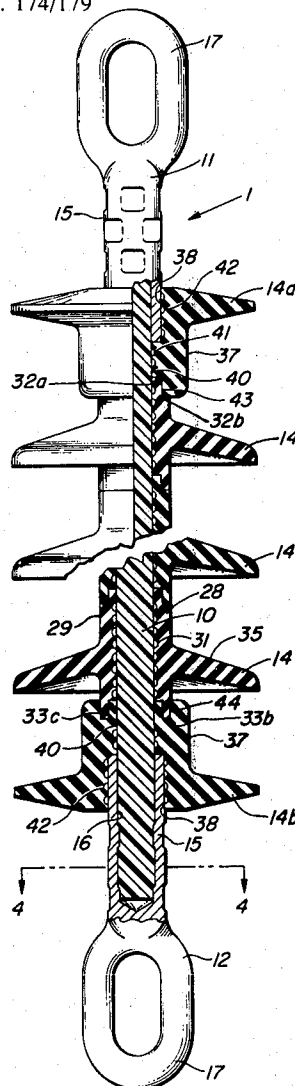
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[57] **ABSTRACT**

Insulators made up of insulating rods surrounded by elastomeric weathersheds. The weathersheds are separately formed with central apertures having inside diameters less than the outside diameter of the rod, which is illustrated as made up of resin-bonded glass fibers, so that the weathersheds must be stretched to be placed on the rod. The required number of weathersheds are positioned on a rod and are compressed between metallic end fittings that are secured to the ends of the rod. The inner surfaces of the weathersheds are provided with annular grooves which are filled with an insulating grease. Suspension and post insulators embodying the invention are disclosed.

16 Claims, 5 Drawing Figures



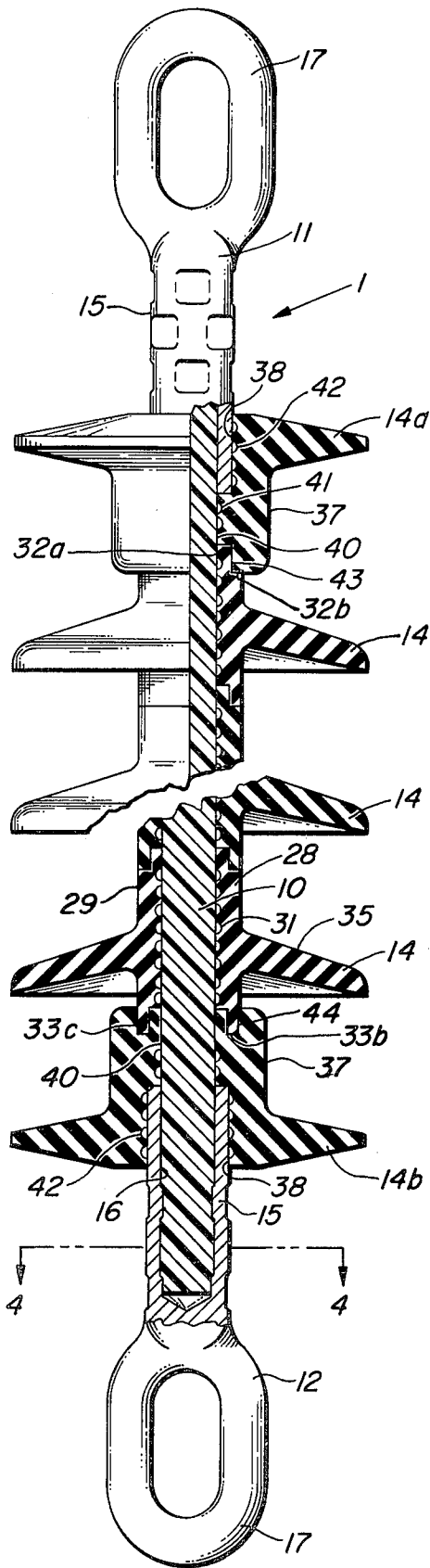


FIG. 1

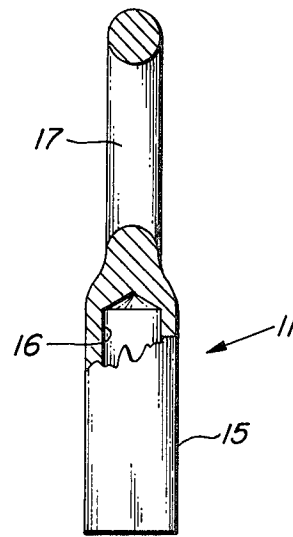


FIG. 2

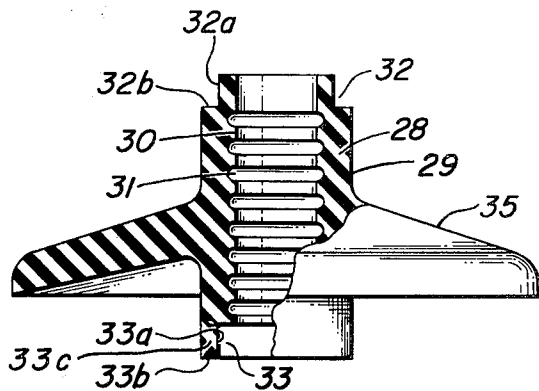


FIG. 3

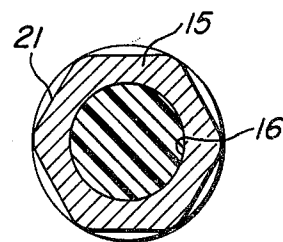
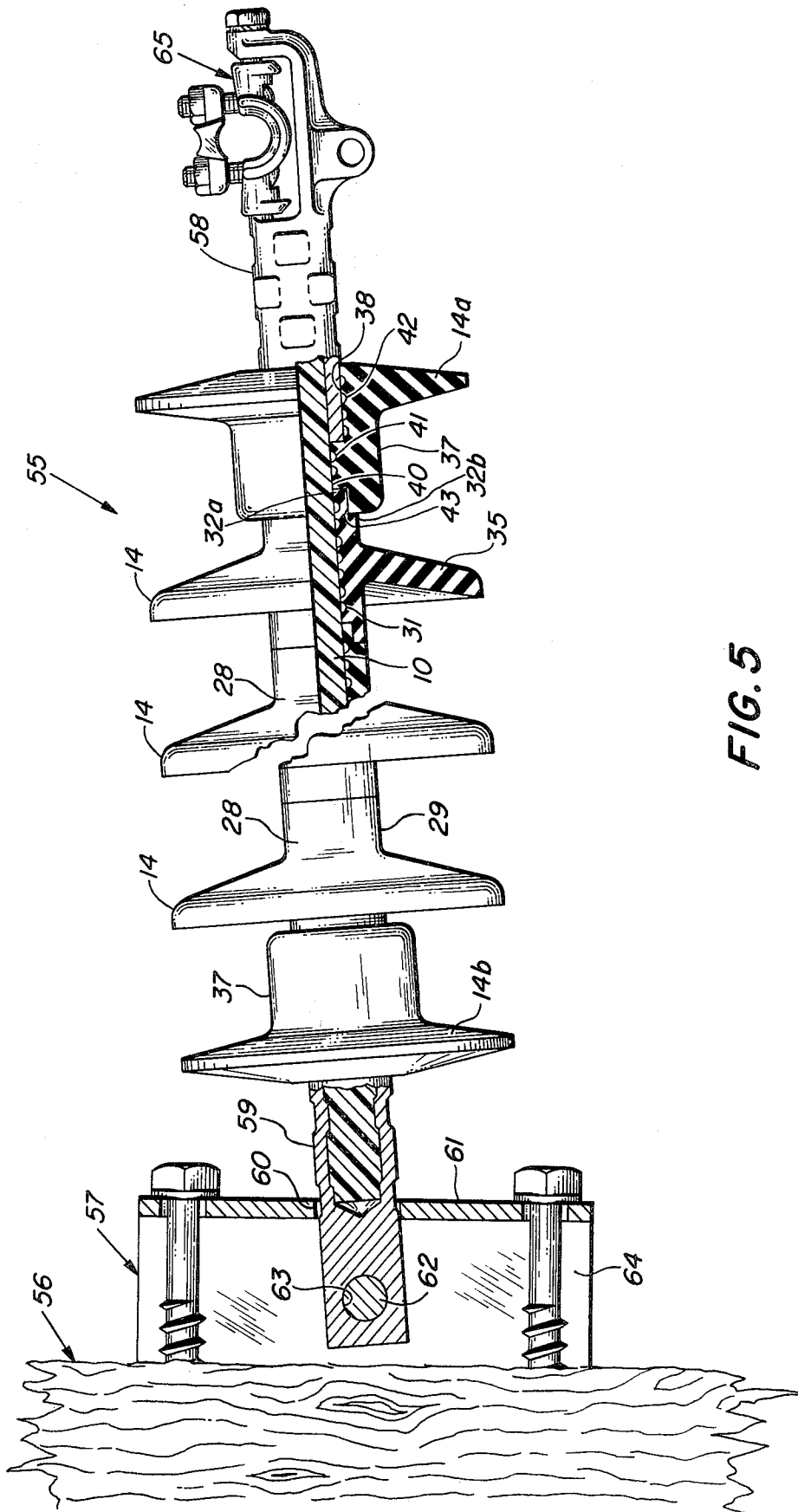


FIG. 4



INSULATOR WITH RESIN-BONDED FIBER ROD AND ELASTOMERIC WEATHERSHEDS, AND METHOD OF MAKING SAME

BACKGROUND OF THE INVENTION

This invention relates to insulators and more particularly to insulators that are extensively used to support the conductors in electric power transmission lines, and to methods of making such insulators. As the voltages of powder transmission lines increase, the length of the insulators must be increased. One type of insulator used, often termed a suspension insulator, suspends the power transmission line from an overhead support such as a cross member on a pole or tower. At the present time, most suspension insulators consist of strings of porcelain insulators having the size and shape required to provide the necessary mechanical strength, dielectric strength, and creepage distance. The individual insulators are connected together into strings. These strings of insulators are satisfactory from an electrical standpoint, but they are heavy. For example, a single string for an extra high voltage transmission line may be made up to 40 or more individual porcelain insulators each weighing 25 pounds or more. Because of their bulk and weight, such strings are expensive to install and require stronger towers than would be the case if the weight of the insulators could be reduced. The porcelain is also brittle and can be subject to damage during shipment and installation unless due care is exerted.

It has been proposed to make suspension insulators by using fiberglass rod surrounded by weathersheds of insulating material (see, for example, Hocks U.S. Pat. No. 3,134,164). A common approach has been to mold epoxy or other polymeric weathersheds separately and bond them to the rod. These proposals and approaches have a common disadvantage of generating high shear loads at the rod interface when the rod is stretched under load in service, which can cause the insulator to fail. The present invention eliminates this problem.

Another type of insulator, often termed a post insulator, is maintained in a generally horizontal or vertical position, as on a pole or on a cross arm of a pole or tower. Such insulators must have substantial strength to support the substantial transverse loads imposed on such insulators by the weight of, and wind forces on, the power transmission lines carried by the insulators.

Both types of insulators must have necessary weather-resistant and insulating properties, resistance to damage or deterioration from flashovers or other electrical causes, and high mechanical strength.

SUMMARY OF THE INVENTION

A general object of the present invention is the provision of improved insulators that are built up of a central insulating, high strength member composed of fiberglass or the like surrounded by weathersheds made of an elastomeric material.

Other objects include the provision of improved insulators that are light in weight as compared to conventional porcelain insulators and that can be manufactured at reasonable cost; the provision of insulators that have excellent resistance to weathering and to deterioration under the conditions that are encountered in service in high voltage and extra high voltage transmission lines; the provision of insulators that can be shipped and installed without requiring unusual precautions against damage to the insulators, and the provision of

insulators that are less likely to damage by vandalism and sabotage than conventional porcelain insulators of the type widely used heretofore. Another object is the provision of an improved elastomeric composition having good weathering and tracking resistance and suitable for the manufacture of weathersheds for such insulators. A further object is the provision of an improved method and means for securing metal and fittings to the ends of the fiberglass rods constituting the central members of the insulators. Another object is the provision of an economical and efficient method of manufacturing such insulators. Another object is the provision of insulators of which each component is capable of being manufactured on modern high speed equipment.

Briefly, a preferred form of insulator made according to the invention comprises a rod of substantial mechanical strength formed of dielectric material such as a rod composed of fibers of glass or other material capable of being formed into long continuous fibers of high tensile strength and having electrical insulating properties comparable to or greater than those of glass, bonded by a resin such as an epoxy or polyester resin and surrounded by a series of individually formed weathersheds or petticoats of an elastomeric material, for example, EPM (ethylene propylene copolymer) rubber, preferably with inorganic fillers to impart tracking resistance and resistance to ultraviolet radiation. Metallic fittings are secured to the ends of the rod to provide for mechanical connections between the insulators and a supporting element at one end and an element to be supported at the other end. In order to prevent contaminants from creeping between the weathersheds and the tension member, or the formation of voids in this zone, the interfaces of the weathersheds and the tension member are coated with a plastic dielectric filling material such as a silicone grease. Preferably, the interior surfaces of the weathersheds are provided with recesses that are filled with and act as reservoirs for the filling material. The recesses effectively retain the filling material in position in contact with both the weathersheds and the exterior of the rod.

An effective seal between the weathersheds and the rod is assured by forming the openings of the weathersheds with a diameter less than the external diameter of the rod with which they are to be used so that the weathersheds must be stretched to apply them to the rod. After assembly, the hoop tension in the weathersheds insures that the weathersheds exert a pressure inwardly against the outer surface of the rod. This inward pressure, as well as compressive forces applied to the entire series of weathersheds by the end fittings secured to the ends of the rod, prevent leakage or entrance of contaminants between adjacent weathersheds and between the end weathersheds and the end fittings. This compression may be sufficient to shorten the total length of the weathersheds approximately 5 to 10% as compared to their length before installation. This creates a seal between adjacent weathersheds and between the end weathersheds and the end fittings, and insures that the elongation of the rods under tensile forces exerted on them in service will always be substantially less than the amount that the weathersheds are compressed so that the longitudinal compression of the weathersheds will be maintained under all conditions likely to be encountered in service throughout the normal life of the insulator.

According to a preferred method of manufacturing such an insulator, the required number of weathersheds are arranged in axial alignment in a column, the column is compressed by an amount greater than the final longitudinal compression to provide some working clearance at each end, and the internal grooves in the weathersheds are filled with the plastic filling material. A rod of the above indicated characteristics of appropriate diameter, with its ends protected from contact with the plastic filling material, preferably by a very thin, tight-fitting covering such as a cap, is inserted through the central aperture through the weathershed column formed by the aligned openings of the weathersheds while stretching each weathershed until the rod extends through the entire column and each end of the rod is projecting sufficiently to allow securing of the end fittings. The protective coverings are removed and the end fittings then secured to each end of the rod. The compression previously applied to the weathershed column is then released, allowing the column of weathersheds to expand into firm contact with the end fittings but still maintain a residual compression of about 5 to 10%.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 of the drawings is an elevational view, with parts broken away, and parts in section, of a preferred form of suspension insulator embodying the invention;

FIG. 2 is an elevation, partly in section, of one of the end fittings of the insulator before being secured to the rod;

FIG. 3 is an elevation, partly in section, of a weathershed of the insulator before it has been placed on the rod;

FIG. 4 is a transverse sectional view of an enlarged scale taken along line 4—4 of FIG. 1;

FIG. 5 is an elevation, partly in section of a post insulator embodying the invention, parts being broken away to show the mounting means.

DESCRIPTION OF PREFERRED EMBODIMENTS

As shown in FIG. 1 of the drawings, a suspension insulator 1 made according to a preferred form of my invention comprises a central member 10 composed of resin-bonded glass fibers to which metallic end fittings 11 and 12 are secured, preferably by crimping. The central member 10 is protected by a series of weathersheds 14 which are identical except for the end weathersheds 14a and 14b which, as described below, are of slightly different construction to receive the inner ends of the fittings 11 and 12. The weathersheds 14, 14a and 14b cover the entire surface of the central member 10 between the end fittings 11 and 12 and are circumferentially stretched over the central member 10 and are longitudinally compressed between the fittings 11 and 12.

Since the elongated central member 10 must support the entire tension load on the insulator, it is important that this member be of high mechanical strength as well as high dielectric strength. Preferably, the central member is made up of longitudinally extending high strength, insulating fibers that extend substantially parallel to each other and to the axis of the member. The fibers are resin-bonded into a cylindrical rod having a smooth exterior surface of substantially uniform diameter throughout. The bonding resin must provide a good mechanical bond and must have high dielectric

strength to insure that the completed rod will have the desired insulation capability. The tensile strength of the rod, however, is imparted to it in large measure by the fibers and, accordingly, it is desirable to have the fibers constitute a large part of the cross section of the rod. Preferably, the resin-bonded rods are about 60% glass fibers by volume, as glass fibers presently provide the best combination of desired properties including cost. This percentage of glass fibers, which is high as compared to the percentage found in the usual resin-bonded fiber-glass rods, makes it possible to obtain the required tensile strength while keeping the diameter of the rods at a minimum. Other known fibers, that may be resin-bonded into satisfactory rods, have the desired mechanical and electrical properties, but at this time usually are more costly than glass fibers.

Any suitable resin may be employed to bond the fibers so long as the resin has the desired mechanical bonding ability, temperature stability and dielectric strength. Resistance to erosion and weathering are not of great importance inasmuch as the entire outer surface of the rod is protected in the completed insulator. Suitable bonding resins are polyester resins, bisphenol epoxy resins and cycloaliphatic epoxy resins. Other known resins undoubtedly can be employed. At present, bisphenol resins are preferred because of strength, toughness, and cost consideration. By careful control of manufacturing operations and by the incorporation of a high percentage of the fibers in the rods, rods and fittings made according to the present invention can be given an ultimate tensile strength in excess of 100,000 pounds per square inch.

In order to take advantage of the high tensile strength of the resin-bonded fiber rod 10, the fittings 11 and 12 must be secured thereto in such a manner as to provide joints that will make it possible to develop a large percentage of the ultimate strength of the fiberglass rod itself. To accomplish this, fittings constructed as shown in the drawings are preferred. As shown in FIGS. 1 and 2, the fittings are identical, and each comprises a socket portion or sleeve 15 having a recess 16 that, in its original state, is cylindrical and closely engages the outer surface of the rod 10. Each fitting also has, at its outer end, an integrally formed securing or connecting means 17 that may be of any ordinary or desired construction which is satisfactory at one end for attachment to a supporting element such as a tower and at the other end to a supported element such as conductor-supporting hardware, or which permits several such insulators to be connected together in strings if desired. However, since the present invention makes possible the manufacture of insulators of long lengths, it usually is not necessary to connect insulators in strings, with consequent savings in manufacturing and installation costs.

In order to secure the fittings 11 and 12 to the ends of the rod 10, each sleeve 15 of each fitting, which is preferably formed of steel, is deformed inwardly preferably by dies circumferentially spaced around the sleeve and exerting large radial forces sufficient to deform the rod 10 elastically in compression radially, and to strongly stress the steel between the dies and the rod. The deformation is carried out so that, in the completed structure, after the dies are released, the rod is attempting to expand against the sleeve but is restrained and remains under compression, and the metal of the sleeve adjacent to the interface between the rod and

sleeve is in hoop tension because of the forces exerted by the rod as it attempts elastically to regain its original shape. The interaction of these forces results in forces normal to the interfaces between the rod and the sleeve which causes a large frictional resistance to relative movement of the rod and socket portion. These large forces, with adequate joint length, make it possible to develop strength in the joint up to nearly 90% of the ultimate strength of the rod. It is necessary to select a compression pressure that is as great as possible but will not displace the sleeve material sufficiently to break so many of the fibers in the rod that the strength of the rod will be materially reduced, but which will furnish a sufficiently strong frictional grip between the fitting and the rod. This strong grip ordinarily can be readily accomplished so long as the length of the sleeve that is compressed into engagement with the outer surface of the rod is sufficient. In the illustrated embodiment, this length is very nearly four times the diameter of the rod; preferably the length should be at least twice the diameter of the rod.

As shown particularly in FIGS. 1 and 4, the sleeves 15 are deformed inwardly by several circumferentially spaced dies that have flat end surfaces that engage the exposed exterior of the sleeve substantially throughout such length.

In securing a fitting to one end of the rod steps are taken to insure that the interior surface of the sleeve and the exterior surface of the rod are both clean and free from grease or other friction reducing contaminant. The rod is then inserted with a fairly snug fit into the sleeve and that sleeve is then deformed along the length that contains the rod, by the above described dies forced radially inwardly against the sleeve as by hydraulic pressure. As indicated in FIG. 4, in the illustrated embodiment the outside of the sleeve is deformed by the dies into a cross section corresponding generally to the polygonal form of the dies which, in the present case, is generally hexagonal as shown at 21; however, the outside of the rod remains substantially circular in cross section.

While development of the required grip of the sleeve on the rod requires that the sleeve exert high pressure on the rod, the pressure exerted during and after compression of the sleeve must not be so high that the deformation of the rod is such that an appreciable number of the fibers in the cross section of the rod are damaged, since the fibers furnish nearly all of the tensile strength of the rod. As an example, it has been found that with rods having a diameter of three-quarters of an inch and composed of about 60% by volume of glass fibers, sleeves composed of forged steel having internal diameters of three-quarters of an inch to fit the rods and wall thicknesses of about one-quarter inch, and dies having a longitudinal dimension of about five-eighths inch and a transverse dimension of about five-eighths inch, the application of pressures of about 150,000 pounds per square inch by the dies on the exterior of the sleeves gives satisfactory results. The application of such pressures to the exterior of the rod causes an elongation of the rod in the areas or in zones engaged by the dies and a corresponding reduction in the cross sectional area of the rod. Connections made in this manner can have a strength of about 90% of the ultimate strength of the rod.

As noted above, the rod is protected against the elements and the required creepage distance is provided

by a series of intermediate elastomeric weathersheds 14 and end weathersheds 14a and 14b. As shown in FIGS. 1 and 3, each weathershed 14 comprises a generally tubular body portion 28 having a smooth substantially cylindrical outer surface 29 and an inner through opening 30, preferably of cylindrical configuration, that is provided with a series of annular grooves 31. The opposite or upper and lower ends 32 and 33 of the body portion are of complementary shapes, that is, end 32 has an axially projecting portion 32a of reduced diameter terminating in a radially extending shoulder 32b, and end 33 has an axially extending opening 33a of diameter and length matching those of portion 32a, a radially extending end surface 33b, matching shoulder 32b, and a projecting flange 33c. Therefore, when adjacent weathersheds 14 are fitted together, their ends 32 and 33 interfit to form offset joints, such as the stepped joints shown in FIG. 1, that prevent ingress of air, moisture, and other contaminants that could reduce insulating properties or have other deleterious effects. The same type of joint is provided between the uppermost weathershed 14 and the end weathershed 14a and between the lowermost weathershed 14 and the end weathershed 14b, as explained below.

A frustoconical petticoat or shield portion 35 projects downwardly and outwardly from the body portion. The dimensions of portions 35 may be varied and are designed in accordance with known principles to meet the requirements of the service for which the insulator is intended.

As a typical example, for a tension insulator having a rod three-quarters of an inch in diameter, the weathersheds 14 are made, preferably by molding, with an unstressed internal diameter of inner bore 30 of about eleven-sixteenths of an inch, and the minimum wall thickness of the body portion between the end portions is about one-quarter of an inch. The petticoat 35 extends outwardly and downwardly at an angle of about 20° to 25° from the horizontal, and has an outside diameter of about 4¼ inches and thickness of about one-quarter inch. The internal annular grooves 31 have a width and depth of about one-sixteenth of an inch and are spaced about three-sixteenths of an inch on centers.

The end weathersheds 14a and 14b, which also may be made by molding, are preferably modified slightly to accommodate the bottom end of upper fitting 11 and the top end of lower fitting 12. As shown in FIG. 1, the body portions 37 of weathersheds 14a and 14b are thicker than the body portions 28 of weathersheds 14 and are recessed as at 38 to receive the end fittings 11 and 12. The internal bores 40 of weathersheds 14a and 14b are provided with annular grooves 41, and the recesses 38 are provided with annular grooves 42. The grooves 41 and 42 may have the same widths, depths and spacing as grooves 31.

In order to provide the desired substantially weather-tight engagement between the uppermost weathershed 14a and the adjacent weathershed 14, the lower portion of the bore of the weathershed 14a is recessed as at 43 to receive the axially projecting portion 32a of the weathershed 14 that is disposed immediately beneath the weathershed 14a, and the shoulder 32b of the weathershed 14 engages the lower end of the weathershed 14a. At the opposite end of the insulator, the weathershed 14b has an annular groove 44 at its upper end that receives the downwardly projecting end flange 33c that surrounds opening 33a of the lowermost

weathershed 14, the end surface 33b of that weathershed 14 engaging the annular surface at the bottom of the groove 44.

This construction in which the end weathersheds 14a and 14b extend over the ends of fittings 11 and 12 provides important advantages. In service, if the insulators should be flashed over from surges, arcing from power system circuit current is likely to follow until corrected, as by opening of circuit breakers in the transmission system. This arc current, which may be several thousand amperes, is likely to terminate on the metal portions of the insulator or its connections. If the end weathersheds did not extend over the end fittings 11 and 12, the arc terminations could burn directly through to the rod 10 through a completely radial juncture, if one was present, between the end fitting and end weathershed nearest the arc termination, destroying the mechanical strength of the insulator. The possibilities of such an occurrence are prevented or greatly reduced when, as described above, the ends of the fittings extend substantially into the weathersheds.

Highest electrical gradients tend to occur off the closest corners of metal parts such as the fittings, creating corona which is undesirable in causing radio interference and in deteriorating organic insulating material. Since these corners of the metal fittings 11 and 12 are buried in the solid insulating material of the end weathersheds, such harmful corona generation is suppressed.

Moreover, since the weathersheds extend substantial distances over the end fittings, the strike distance between the fittings is increased, thus increasing flashover voltage and reducing possibilities of flashover.

While various elastomeric compositions can be employed, excellent results have been achieved in tests of insulators embodying weathersheds made, as by molding, of a composition including hydrated alumina and commercially available EPM rubber in a proportion of approximately one and one-half parts to one by weight, together with minor amounts of zinc oxide, a coupling agent, a peroxide accelerator, and coloring material such as carbon black or titanium dioxide. The presence of the hydrated alumina in fairly large quantities is desirable to impart tracking and weather-resistance to the composition, and the titanium dioxide colors the composition and assists in protecting it from deterioration by ultraviolet rays. A rubber as compounded above has a hardness of about 70 on the Shore (A) scale, an elongation of about 300% and a tensile strength of about 1,200 pounds per square inch. Compositions embodying the above materials by test results display the ability to maintain the original characteristics without great change for long periods of time under the adverse conditions ordinarily encountered in high voltage and extra high voltage power transmission lines where the rubber is subjected not only to the deteriorating effects of weather but also to severe electrical stresses. Other known elastomeric compositions can be used.

It is important that the ingress of air, moisture, and other contaminants between the weathersheds and the rod and between the weathersheds and each other be prevented since any spaces or contaminants between the rod and the weathersheds can result in reduction of the dielectric strength of the insulator in such areas, in localized arcing and in corona discharges, which as indicated can have damaging effects on both the rod and the weathersheds and may result in the generation of

unacceptable levels of radio noise. The higher the voltage to which the insulator is subjected the more severe the problem. According to the present invention, as briefly noted above, these difficulties are substantially eliminated by providing interlocking offset or stepped joints between adjacent weathersheds and between the end weathersheds and the end fittings, and by filling the grooves 31, 41, 42 and 43 of the weathersheds with an insulating oil or grease or other plastic dielectric filling material which will remain in position for long periods of time under varying conditions of temperature and barometric pressure, and of movement and flexing of the insulators. The filling material should occupy and cover the interfaces between the rod and the interior of the weathersheds and the adjoining surfaces of the adjacent weathersheds. The grooves should be filled completely so that no voids will be present in the completed insulator. A plastic dielectric filling material that has been found to be suitable for this purpose is commercially available silicone grease. This material appears to have no deleterious effect on the elastomeric composition of the weathersheds and, because it is substantially viscous and highly adherent, remains in position under varying conditions encountered in service. The grooved surfaces of the weathersheds and the cooperating surfaces of the rod and end fittings, together with the filling material, thus provide labyrinth seals at these places.

In order to assure that contaminants are prevented from entering the interfaces and that the dielectric filling material is retained in position, the preferred method of assembly of the insulators entails circumferential stretching and longitudinal compression of the weathersheds. According to the preferred method, the rod, except for its end portions to be secured in the end fittings, is coated with the selected dielectric filling material, preferably the silicone grease mentioned above.

The application of the weathersheds to the rod requires that they be stretched. The bores of the illustrative weathersheds have an unstretched diameter of about eleven-sixteenths of an inch and hence must be stretched to three-quarters of an inch, the diameter of the illustrative rod. The amount that the body of the weathershed is circumferentially stretched thus is about 7%. While the amount of stretch can be varied, it should be enough to insure that a substantial hoop tension will be created in the body of the weathershed on assembly of the insulator so that the inner surface of the weathershed bore will be held firmly against the fiberglass rod.

Similarly, the internal diameters of the recesses 38 and 39 of the end weathersheds 14a and 14b in the unstretched condition are sufficiently smaller than the external diameters of the end fittings 11 and 12 and the body portions 28 of weathersheds 14 so that they are also stretched about 7% on assembly of the insulator to insure a firm engagement.

In a preferred method of manufacturing the insulator as many weathersheds 14, 14a and 14b as are necessary to cover and enclose the entire length of the rod between the lower end fitting 12 and the upper end fitting 11 are arranged axially in a column with their ends interfitted as in the final assembly and their central openings aligned, the annular grooves in all the weathersheds being filled, and the ends 32 and 33 of all weathersheds being coated, with the plastic dielectric filling

material such as grease before such arrangement, if desired.

Compressive forces is then externally applied to the end weathersheds 14a and 14b to compress the entire column of weathersheds by about 10% of its original length. While the weathersheds are retained in compressed condition, the rod 10 is forced through the column of weathersheds, while stretching the weathersheds as indicated above.

Prior to this, at least the leading or first inserted end, and preferably each end, of the rod, is protected from the plastic filling material, as by a suitable tight-fitting covering such as a cap of thin synthetic resin or other suitable material. If desired, a tapered pilot member may be mounted on the leading end of the rod to facilitate its entry through, and stretching if necessary, of the openings through the weathersheds.

After the rod 10 has been thus passed through the column of weathersheds, the surface of each end of the rod beyond the adjacent end weathershed 14a or 14b is stripped of its protective covering and an end fitting 11 or 12 is placed in position on one end of the rod. The sleeve 15 of such fitting is then secured to the rod, preferably by crimping as described above. An end fitting is similarly secured to the other end of the rod, and the externally applied compressive force on the column of weathersheds is released, allowing the weathersheds to contact the end fittings, thus completing the construction of the insulator.

The column of weathersheds is thus compressed axially or longitudinally by an amount substantially greater than the normal elongation of the rod 10 in service.

The result of this axial or longitudinal compression of the weathersheds between the end fittings is to create substantial sealing pressure between the ends of the bodies of the weathersheds and between the end fittings 11 and 12 and the end weathersheds. This compression insures that the end surfaces of adjacent weathersheds, and of end weathersheds and end fittings, will remain in contact throughout substantially their entire areas even though the insulator is bent in service or during installation. Furthermore, the longitudinal compression of the weathersheds is sufficient to insure that adequate sealing pressure between adjacent weathersheds and between the weathersheds and the end fittings will be maintained in service.

FIG. 5 shows an illustrative post insulator 55 embodying the invention, mounted on a pole 56 by known bracket 57.

Insulator 55 is identical to that previously described except that end fittings 58 and 59 are different from the end fittings 11 and 12 of the previous embodiment. Fitting 59 differs from fitting 12 of the previous embodiment by being shaped to enable it to be connected to known U-shaped bracket 57 by extending through opening 60 in front wall 61 of the bracket and by being held in place by bolt 62 extending through the bracket and opening 63 in the fitting, and corresponding openings in the side walls 64 of the mounting bracket. These openings are so located relatively to each other that the insulator 55 extends at a slight upward angle to the horizontal, in accordance with known practice.

At the other end of the insulator, fitting 58 differs from former fitting 11 in that it is shaped to carry known clamp 65 adapted to carry a conductor.

All other parts of the post insulator 55 are identical with those of the previous embodiment and hence bear identical reference characters. The post insulator is assembled in a manner similar to that of the previous embodiment. For these reasons, it requires no further description.

Post insulators embodying the invention can be made of substantially longer length than is practical with those embodying porcelain. While post insulator 55 has been disclosed as mounted in a generally lateral position, post insulators of the invention may be mounted in various other positions, including those in which they extend either upwardly or downwardly.

While the above description discloses the rod 10 in each embodiment as including glass fibers, it is to be understood that the fibers may be made of other materials, either inorganic or organic, provided that the fibers have the characteristics of glass fibers of high tensile strength, low elongation, ability to be formed into fibers of small cross sections and substantial lengths, ability to be bonded into strong rods, satisfactory electrical insulating properties, and good weather resistance. The term "fiberglass" in the appended claims is intended to include such materials as well as those including glass fibers as such.

Moreover, while the metal end fittings are shown as secured to the tension rod by crimping, they may also be secured by other means, as by suitable adhesives that provide joints of sufficient strength when hardened.

Moreover, while the embodiments discussed above disclose the use of oil or silicone grease as the dielectric filling material used on the interfaces between the rod and weathersheds, between adjoining surfaces of the weathersheds, and in the grooves of the weathersheds, other plastic filling materials may be used at all or some of these locations; such other filling material may be a suitable synthetic resin having adhesive properties, even a hardenable synthetic resin such as an epoxy resin of suitable characteristics.

While specific examples have been mentioned of sizes of insulators or parts thereof, it will be appreciated that larger or smaller insulators or parts can be constructed according to the principles of the present invention. The proportions preferably are generally similar to those shown in the drawings although these can be varied in accordance with design requirements. However, it is important to create substantial hoop tension in the bodies of the weathersheds and to maintain the weathersheds under substantial longitudinal compression in the completed insulators.

Variations may be made in the disclosed method of assembling the insulator. Thus, the aligned openings of the column of weathersheds and their grooves may be covered with grease or other dielectric filling material and the rod not covered with such material, or the filling material could be applied to all appropriate surfaces of both the rod and openings.

Because of their excellent mechanical and electrical properties, insulators made according to the present invention are highly advantageous over the conventional porcelain strain insulators that are presently widely employed. Insulators made according to the present invention can be manufactured at reasonable cost, and the lightness of the insulators as compared to the conventional porcelain insulators of similar capability greatly reduces the cost of handling, shipment,

and installation of the insulators as compared to conventional porcelain insulators.

Furthermore, the great reduction in weight obtainable with the present insulators makes possible the design of lighter towers and supporting structures than are required with conventional porcelain insulators. Another important advantage is that insulators made according to the present invention are much more resistant to damage in shipment and handling and to damage by sabotage and vandalism than conventional porcelain insulators.

Various changes and modifications, other than those indicated above, in the preferred forms of the invention described herein will be apparent to those skilled in the art. The essential characteristics of the invention are defined in the appended claims.

What is claimed is:

1. An insulator comprising a generally cylindrical elongated member composed of dielectric material and having substantial mechanical strength, end fittings secured to said elongated member, and a series of weathersheds enclosing said elongated member and covering the entire surface of said elongated member between said fittings, the weathersheds being composed of an elastomeric insulating material, each weathershed having a through opening of a cross section in the unstressed state that is smaller than the cross section of said elongated member, whereby the weathersheds are under hoop tension at the surface of said elongated member, and the weathersheds being longitudinally compressed between said fittings, whereby the inner surfaces of the openings of the weathersheds exert pressure on said elongated member and adjacent weathersheds exert pressure on each other.

2. An insulator according to claim 1 wherein the interfaces between said elongated member and the weathersheds are coated with plastic dielectric filling material.

3. An insulator according to claim 2 in which said dielectric filling material is a viscous, adherent material.

4. An insulator according to claim 2 wherein the openings in at least some of the weathersheds are grooved to retain and provide reservoirs for said dielectric filling material and provide labyrinth seals at these locations.

5. An insulator according to claim 4 wherein adjacent weathersheds have complementary surfaces that seal against each other.

6. An insulator according to claim 4 wherein the interfaces between adjacent weathersheds are coated with said plastic dielectric filling material.

7. An insulator according to claim 1 wherein said elongated member is composed of resin-bonded glass fibers.

8. An insulator according to claim 1 wherein the weathersheds are composed of elastomeric material containing a substantial percentage of hydrated alumina.

9. An insulator according to claim 1 wherein the weathersheds are composed of EPM rubber containing hydrated alumina in the proportion of about one and one-half parts by weight of hydrated alumina to one part by weight of EPM rubber.

10. An insulator according to claim 9 wherein said EPM rubber containing hydrated alumina has a hardness of about 70 on the Shore (A) scale, an elongation

of about 300% and a tensile strength of about 1,200 pounds per square inch.

11. An insulator according to claim 9 wherein each fitting has a body portion having means for securing the fitting to a supporting or a supported element and a sleeve portion surrounding an end of said elongated member that is crimped into a generally polygonal cross section extending longitudinally of the sleeve.

12. An insulator according to claim 1 wherein each said fitting is composed of metal and has a body portion provided with a sleeve portion crimped into firm engagement with the elongated member.

13. An insulator comprising an elongated generally cylindrical high strength tension member composed of resin-bonded glass fibers, a metal fitting secured to each end of the tension member, each fitting having a body portion provided with means for securing the fitting to a supporting element or a supported element and a sleeve portion that surrounds an end of said elongated member and is crimped into firm engagement with it, and a series of weathersheds enclosing said elongated member and covering the entire surface of said elongated member between the fittings, the weathersheds being composed of elastomeric material, each weathershed having a body portion with an opening of circular cross section and having a shield portion projecting outwardly from the body portion, the opening having a diameter in the unstressed state that is substantially less than the diameter of said elongated member whereby the weathersheds are under hoop tension when disposed on said elongated member, and the weathersheds having end surfaces that contact complementary end surfaces of adjacent weathersheds, the entire series of weathersheds being longitudinally compressed between said fittings by an amount substantially greater than the normal elongation of said elongated member in service, whereby the inner surfaces of the openings of the weathersheds exert pressure on said elongated member and adjacent weathersheds exert pressure on each other, the interfaces between the tension member and the weathersheds being coated with a dielectric filling material and the openings of the weathersheds being grooved to retain and provide reservoirs for dielectric filling material.

14. An insulator according to claim 13 wherein the weathersheds are composed of EPM rubber containing hydrated alumina in the proportion of about one and one-half parts by weight of hydrated alumina to one part by weight of EPM rubber and the EPM rubber containing hydrated alumina has a hardness of about 70 on the Shore (A) scale, an elongation of about 300% and a tensile strength of about 1,200 pounds per square inch.

15. A method of manufacturing an insulator comprising a column of a plurality of weathersheds made of elastomeric material each having an axial opening therethrough surrounding an elongated member of dielectric material of substantial mechanical strength, which process comprises arranging the weathersheds in a column in which adjacent weathersheds abut and said axial openings are aligned to form an aperture through said column, compressing said column by an amount greater than the amount of longitudinal compression of said weathersheds in the assembled insulator, inserting through said aperture formed by the aligned axial openings of said weathersheds an elongated member of dielectric material of essentially similar cross sectional

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shape as said openings but of a larger cross section and of a length greater than the column of weathersheds to stretch said weathersheds, arranging said elongated member in said column so that its ends project therefrom, and rigidly securing to each of said ends a fitting member the ends of which are so located that when the compressive force on said column of weathersheds is released, said end fittings hold said weathersheds between the ends thereof under compression on said elongated member and so that there is hoop tension in said weathersheds that causes them firmly to grip said

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elongated member.

16. The method of claim 15 including the step of covering at least the end of said elongated member that first enters said column with a protective covering to protect said end against plastic filling material on the elongated member or in said axial aligned openings as it passes through said column, and thereafter removing said protective covering to permit securing of said end fittings to said elongated member.

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,898,372

DATED : August 5, 1975

INVENTOR(S) : John W. Kalb

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 8, after metal, change "and" to --end--.

Signed and Sealed this

thirtieth **Day of** *September 1975*

[SEAL]

Attest:

RUTH C. MASON

Attesting Officer

C. MARSHALL DANN

Commissioner of Patents and Trademarks

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