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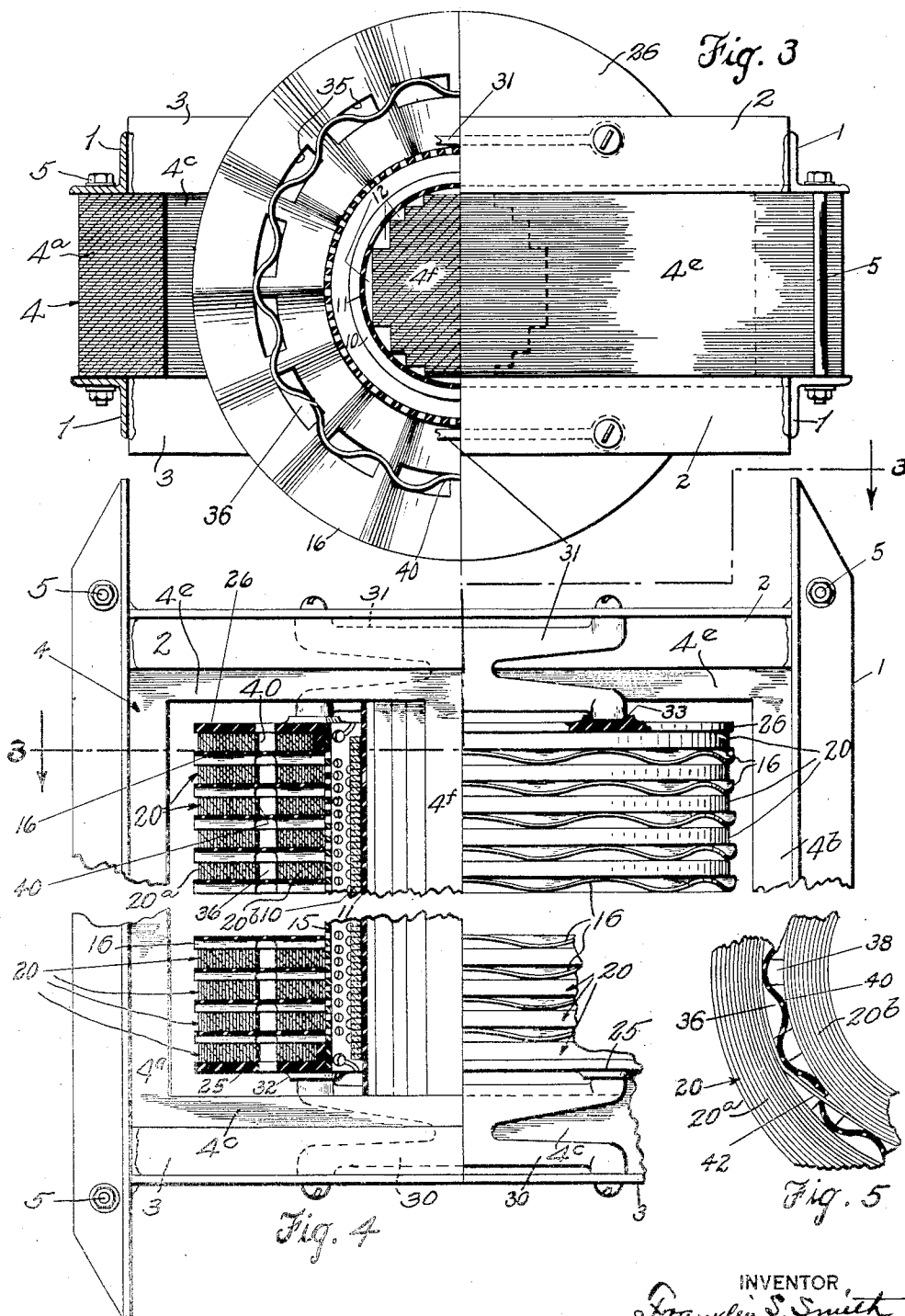
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ELECTRIC TRANSFORMER

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UNITED STATES PATENT OFFICE.

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ELECTRIC TRANSFORMER.

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My invention relates to electric transformers, particularly the high voltage windings thereof and the means for supporting and insulating the same, and it has for one of its objects to provide a novel and thoroughly practical construction whereby a fluid dielectric and cooling medium within the tank of the transformer is brought, in a simple, dependable and efficient way, in contacting or impinging relation to the metal of the windings of the transformer for the purpose of lowering the temperature gradient between the windings and the circulating cooling medium. The mechanical features of my construction are particularly well suited and adapted for use in connection with a gaseous dielectric and cooling medium under pressure greater than atmospheric pressure, and in such coacting relation I achieve many thoroughly practical and important advantages.

Another object of the invention is to provide a solid dielectric for association with the high voltage winding in which the parts employed are of a character that can be readily standardized and may be readily molded or stamped and formed, thereby facilitating quantity production.

Another object of the invention is to provide a high voltage transformer construction in which the dielectric strength between turns of the high tension winding between coils, between the end coils and core, between the high and low voltage windings, and between the winding and core is much greater than heretofore has been attained, as far as I am aware, in any transformer structure of like volume, capacity and voltage.

Other objects are to provide a high voltage winding structure in which the coils are spaced and supported by solid dielectric parts or members of such configuration that the said solid dielectric is in series with fluid dielectric in the path of higher voltage gradient, and in which the path of surface leakage on said solid dielectric is in a path of lower voltage gradient.

Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, and arrangements of parts as will be exemplified in the structure to be hereinafter described and the scope of the application of

which will be indicated in the following claims.

In order that the invention may be readily understood and its advantages from a practical standpoint fully appreciated, reference may be had to the accompanying drawings in which certain convenient forms of embodiment thereof are shown.

In the drawings:

Fig. 1 is a view partly in top plan and partly in transverse section showing certain mechanical features of a transformer embodying my invention, taken on the line 1—1 of Fig. 2;

Fig. 2 is a view partly in elevation and partly in central vertical section;

Fig. 3 is a view partly in plan and partly in transverse section taken on the line 3—3 of Fig. 4 depicting a modified form of transformer construction embodying the invention;

Fig. 4 is a view partly in elevation and partly in central vertical section of the transformer shown in Fig. 3; and

Fig. 5 is a fragmentary view of a portion of a coil of a high voltage winding showing a detail of construction.

Referring to the drawings, and particularly to Figures 1 and 2, it will be noted that the core, windings, etc., of the transformer are supported upon a metal frame structure comprising vertical angle iron members 1 and top and bottom angle iron members 2 and 3 secured at their opposite ends to the upper and lower end portions of the angle iron members 1. The core generally indicated at 4 is clamped and held between the angle iron members 1 by means of bolts 5. The core 4 may be and preferably is built up of suitable laminations, as is clearly shown in Figure 1, and may be of any suitable form or shape; conveniently and illustratively I have shown the core 4 to be of the shell type and accordingly it has two vertically extending legs 4^a and 4^b joined by the horizontal or transversely extending portions 4^c and 4^d, with a middle or central vertically extending leg 4^e joining the portions 4^c and 4^d. About the middle leg 4^e are the windings. The low voltage winding 10 is wound upon a tubular solid dielectric support 11 which incloses the central leg 4^e of the core and is supported upon or by the said core. The adjacent turns (clearly shown

in cross-section in Figure 2) of the low voltage winding, which are of bare wire, are spaced by a solid dielectric, for example, bakelized cord.

The cross-section of the central leg 4' is substantially as shown in Figure 1, and this cross-section results from the manner in which the laminations of the core 4 are dimensioned and assembled; with the tubular support 11 about the central leg 4' passageways, as indicated at 12 in Figure 1, are formed, and these are preferably also utilized, as will be made more clear hereinafter, in the circulation of the fluid dielectric and cooling medium which, as above noted, is preferably a gas under pressure greater than atmospheric pressure.

For the purpose of supporting the coils of the high voltage winding of the transformer, I have provided a support comprising the tubular part or section 15 of solid dielectric material having at its lower and upper ends outwardly extending annular disks 25 and 26 of solid dielectric material which are arranged substantially at right angles to the axis of the said tubular part or section 15. These disks are each provided with annular flanges at their inner edges which fit closely against the outer lower and upper surface portions of the tubular part 15 and are secured thereto. Preferably the said tubular part or section 15 and the horizontally extending annular disks 25 and 26 are formed of molded bakelite or of bakelized paper, hot pressed. However, it will be understood that these parts may be constructed of other suitable material.

The high tension winding is preferably made up of a plurality of coils 20 extending about the tubular insulating member 15 and hence about the central leg 4' of the core; the coils 20 are spaced from one another in an axial direction by parts 16 which are situated between the adjacent coils of the high voltage winding. The parts 16, which I shall for convenience designate as washers, are of sinuous form, as is clearly indicated in the several figures of the drawings, so that the opposite edges of the wires of the coils 20 touch the washers at intervals only. The sinuous parts 16 of solid dielectric are in series with the fluid dielectric within the tank (not shown) of the transformer in the path of higher voltage gradient while the leakage along the surface of the said solid dielectric between the points of contact thereof with the opposing coils is in a path of lower voltage gradient. This is due to the fact that the annular parts 16 of dielectric material, previously referred to as washers, are of corrugated or sinuous formation so that the points of contact of opposing sides or edges of adjoining coils 20 with an interposed washer are arranged in staggered relation to each other, as shown in Fig. 2. By reason of such relationship it is apparent that

the leakage between adjoining coils along the said interposed washer of dielectric material must be along inclined paths which are of greater length than the vertical distance between the said coils with the result that the relation of the voltage gradients is as just stated. The inner tubular portion or part 15 of the support for the high voltage windings is provided with perforations through which the fluid dielectric and cooling medium, preferably gas, may pass. These perforations, in the construction shown, are circular and may be regarded as arranged in groups of three, the axes of the perforations of each selected group being located with respect to each other at the three corners of equilateral triangles. The diameters of the perforations are of such length that a line drawn from a point outside of any such group of openings cannot pass straight through such group without cutting at least one of the perforations. It follows, therefore, that the leakage along the surface of the tube 15 cannot be in straight paths or lines. It is to be understood, however, that perforations of other configuration and relative position may be employed.

The bottom coil of the high voltage winding is supported upon the upper side of the annular disk 25 of solid dielectric while the bottom side of the disk 26 contacts with the top edges of the uppermost of the coils of the high voltage winding.

The opposite edge portions of the flat wire of the high voltage coils are bare and rounded, and the opposite sides thereof are coated with enamel, or may be spaced or separated by bakelized paper or other suitable material.

The high voltage winding structure is supported from the cross-wise extending angle iron members 2 at the upper part of the core structure and angle iron members 3 at the bottom part of the core structure, by means of X-shaped members 30 and 31. The ends of the bars on one side of the X-shaped members 30 and 31 are secured to the horizontal flanges of the angle iron members 2 and 3 respectively, while the ends of the said bars at the opposite sides of said X-shaped members are in engagement with the outer faces of the disks 25 and 26. In order to prevent displacement laterally of the disks 25 and 26 with respect to the supports 30 and 31 the disks are provided with raised portions 32 each of which has a recess 33 therein into which the ends of the bars at the inner sides of the said X-shaped members 30 and 31 extend, as is shown in Figs. 2 and 4 of the drawings. As is clearly shown in Figure 1, I preferably employ these X-shaped members in pairs and in Figure 1 will be seen an X-shaped member 31 on each side of the upper transverse portion 4' of the core, and as is clear from Figure 2, there is an X-shaped

member 30 on each side of the lower transverse portion 4° of the core.

As already hereinabove noted, the fluid dielectric and cooling medium which I prefer to use is a gas under pressure greater than atmospheric pressure and with such a gas under pressure in coaction with certain of the structural features hereinabove described, I achieve many important and thoroughly practical advantages. The gaseous dielectric under pressure impinges upon and contacts with the exposed edges of the windings and is thus brought into intimate thermal contact therewith; it also contacts with the solid dielectric members above noted and coacts therewith in achieving such a high efficiency and dependability of insulation between parts of the apparatus that differ in potential that it is possible to shorten the magnetic circuit, space the various parts more closely together, lessen the amount of copper necessary and thus materially diminish the iron and copper losses and achieve better regulation of the transformer. As illustrative of how such advantages as the above are achieved, I might point out, for example, that the space (see Figure 2) between the uppermost coil 20 of the high tension winding and the upper transverse portion 4° of the transformer core is occupied by the member 26 which is of solid dielectric material and a layer of gaseous dielectric under pressure. These two dielectrics are thus combined in series and the total dielectric stress is distributed between them inversely as their respective permittivities.

The permittivity of solid dielectric material such as the bakelite of the member 26 is relatively high being on the order of 6, while the permittivity of the gaseous dielectric under pressure is relatively low being substantially unity. Due to such characteristics as these and due to the serial arrangement of the two dielectrics, I am enabled to space the uppermost coil 20 of the high tension winding much more closely to the portion 4° of the transformer core than would otherwise be possible and, moreover, I am enabled also to use a much smaller thickness of solid dielectric, in such a relation, than would otherwise be necessary for the solid dielectric is made to assume a relatively small fraction of the total stress while the great dielectric strength of the gas under pressure well adapts the latter to assume the remaining and relatively much greater fraction of the total stress. Were the two members to be insulated from each other by solid dielectric alone, the spacing between the two members and the thickness of the solid dielectric would have to be much greater than the small spacing I am enabled to achieve by reason of such features as immediately above mentioned.

A similar series relation between solid

dielectric and the gaseous dielectric under pressure with resultant features of action and advantages like those above-mentioned will be seen to exist for insulating the high tension winding from the middle leg 4' of the transformer core, and by way of further example will also be seen to exist for insulating adjacent coils 20 of the high tension winding from each other. Thus, I am enabled to achieve better insulation between parts of the construction which are of different potentials, and I am also enabled to achieve great compactness of construction with other advantages that will be clear in view of what has hereinabove been set forth.

As further conducive to a clearer understanding of certain other features of my invention, I might note that the gaseous dielectric under pressure coacts with the solid dielectric in still a further high advantageous manner in that leakage along the solid dielectric material is greatly reduced. Considering, for example, the sinuous solid dielectric members 16 that extend between the adjacent coils 20 of the high tension winding (see the right-hand portion of Figure 2), it might first be pointed out, as has already above been noted, that the construction of the members 16 greatly lengthens the leakage path from one coil 20 to an adjacent coil 20, that is, the leakage path along the curved or inclined portion or portions of the sinuous members 16. This feature alone achieves many advantages, but in coaction with the gaseous dielectric under pressure the latter acts to prevent leakage even along such a lengthened inclined path and due to this action of the gaseous dielectric under pressure, I am again enabled much more closely to space adjacent coils 20 of the high tension winding than would otherwise be possible. Moreover, due to the confirmation of the sinuous members 16, the leakage path available is along inclined paths which are of greater length than the spacing between the coils and hence is in a path of lower voltage gradient. Thus, leakage between adjacent coils of the high tension winding is effectively prevented while the spacing between the coils is made much smaller than would otherwise be possible.

The coaction of the gaseous dielectric under pressure with the tubular member 15 of solid dielectric material and about which are supported the coils 20, will be better understood in view of the foregoing, but it may at this point be noted that leakage along the member 15 between parts such as coils 20 that are of different potential is effectively cut down, while the perforations 21 in the member 15 insure that any leakage paths are longer than the shortest distance between these two points.

It may also be noted at this point that the

members 30 and 31 which support the high voltage winding structure are so shaped that the leakage path from the winding structure to the core structure (such as the angle iron members 3 or 2 to which the members 30 and 31 respectively are secured) is longer than the shortest distance between the winding structure and the angle iron members, and the above-noted feature of the gaseous dielectric under pressure in affecting or controlling leakage may here also be utilized in preventing leakage and in permitting the use of members such as 30—31 which are shorter in a vertical direction, as viewed in Figure 2, than would otherwise be necessary.

Aside from the above-mentioned coaction of the gaseous dielectric under pressure with the solid dielectric, it may here be pointed out that the gaseous dielectric in being brought into intimate thermal contact with those portions of the apparatus in which heat losses occur also insures the withdrawal of heat from such portions and makes it possible to effectively guard against abnormal temperature rises.

The construction as shown in Figs. 3 to 5 inclusive is identical with that shown in Figs. 1 and 2 of the drawings except for certain features of construction, such as the provision in the laterally and outwardly extending washers 16 of openings 35 at intervals therein, which openings are situated practically or approximately one above the other, as shown in Fig. 4.

In the construction, as shown in Figs. 3 to 5 inclusive, the respective coils 20 of the high voltage winding are subdivided; that is, they are divided into two parts 20^a and 20^b separated from each other by an annular passage-way 38 in which is situated a strip 40 of solid dielectric of corrugated or sinuous form and which is of general circular form, as clearly shown in Figs. 3 and 5. The outer wire of the inner subdivision 20^b of each complete coil 20 situated between the washers 16 extends between the opposing adjacent ends of the annular strip 40 and continuous forwardly upon the outer side of said strip to form the inner turn of the outer subdivision 20^a of each coil as indicated at 42 in Fig. 5. It will be noted that the outer turns of wire of the inner subdivisions of the coils and the inner turns of wire of the outer subdivisions of the coils contact at intervals only with the said strip 40, as is clearly shown in the drawings.

By reason of the provision of the openings 35, which are situated the same distance radially from the axis of the tubular part 15 as are the annular spaces 38 between the inner and outer subdivisions of the coils 20, vertical ducts 36 are provided through the high voltage winding as shown. The corrugated or sinuous form of the separating strip between the subdivisions 20^a and 20^b of the

coils 20 will be seen to substantially unobstruct the vertical ducts 36 formed by the substantially aligned openings 35. Thus, the fluid dielectric and cooling medium within the tank of the transformer can freely pass through the vertical ducts 36 and withdraw heat from the coil subdivisions with which it is thus brought into intimate thermal contact. This medium, as above noted, is preferably a gaseous dielectric under pressure greater than atmospheric pressure.

It will thus be seen that by reason of the employment of such features as the serial relation of solid dielectric material with a gaseous dielectric under pressure for insulating the high tension winding from the horizontal portions 4^a and 4^b of the transformer core and the X-shaped members 30 and 31 for spacing and supporting the high voltage winding structure in substantially the manner indicated in the drawings, a construction is provided in which the distances between the end coils and the horizontal portions of the core are less than would be possible if the spaces between said coils and the said horizontal portions of the core were bridged by solid dielectric material. As has already been described hereinabove and is clearly indicated in the several figures of the drawings, the solid dielectrics 25 and 26 are in series with the fluid dielectric between said end coils and said horizontal portions of the core. The coaction and advantages of this serial relation where the fluid dielectric is a gas under pressure will be clear and readily understood in view of what has hereinabove been set forth. It will be seen, therefore, that on account of such features of coaction as above-noted and in which the high dielectric strength of the fluid dielectric and cooling medium where the latter is a gas under pressure, and the form of construction hereinbefore described and illustratively shown in the drawings, the core dimensions in the paths of magnetic flux are decreased. The decrease in the core dimensions not only makes possible the use of less iron in the magnetic circuit but also effects a decrease in the iron losses. Also, the closer spacings made possible between other portions of the transformer construction which are of different potential, all as have already hereinabove been pointed out, makes possible the achievement of such advantages as lessening the amount of copper necessary, closer linkage between the windings and the magnetic circuit, better regulation of the transformer, and improved and more dependable and lasting insulation. Further efficiency results from the fact that a lower temperature gradient between the end coils and the fluid dielectric and cooling medium is obtained than would be the case if the spaces between the end coils and the horizontal portions of the core were bridged by solid dielectric.

It will be understood that the transformer as illustrated is adapted to be inclosed and supported within a hermetically sealed casing or tank, which, however, is not shown in the drawings.

In constructing the high voltage winding structure one of the annular disks 25 or 26 will first be secured to the tubular part 15. If it be assumed that the disk 25 is first secured to the part 15 then the bottom coil of the winding will be wound upon the part 15, then a washer 16 will be placed in position upon said coil with the part 15 projecting therethrough, after which the next adjacent coil will be wound upon the part 15 and so on until the required number of coils have been wound after which the annular disk 26 will be placed in position upon the topmost coil and secured at its inner edge to the upper outer end portion of the part 15.

As many possible embodiments may be made of the above invention, and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth is to be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. In apparatus of the character described, in combination, a high voltage winding for a transformer made up of a plurality of coils positioned one above the other to form substantially a stack, and a member of solid dielectric material extending substantially lengthwise of said stack of coils for holding the latter in substantial alinement, said member being provided with perforations shaped and positioned so that a line drawn along the surface of said member in the general direction of the axis of said coils and between any two spaced points is greater in length than the straight line distance between said two points, whereby the leakage path along the surface of said member and in a general direction along which said coils make effective a potential difference is other than in a straight line.

2. In apparatus of the character described, in combination, a high voltage winding for a transformer made up of a plurality of coils positioned one above the other to form substantially a stack, and a member of solid dielectric material extending substantially lengthwise of said stack of coils for holding the latter in substantial alinement, said member being provided with perforations shaped and positioned so that a line drawn along the surface of said member in the general direction of the axis of said coils and between any two spaced points is greater in length than the straight line distance between said two points, whereby the leakage path along the surface of said member and

in a general direction along which said coils make effective a potential difference is other than in a straight line, and a gaseous dielectric under pressure contacting said member and filling said perforations.

3. In apparatus of the character described, in combination, a high voltage winding for a transformer made up of a plurality of coils positioned in spaced relation one above the other, and insulating means between adjacent coils comprising solid dielectric material and a gaseous dielectric under pressure, said solid dielectric material and said gaseous dielectric under pressure being combined so as to be in series in the path of higher voltage gradient between adjacent coils and so that surface leakage along said solid dielectric and between adjacent coils is in a path or paths of lower voltage gradient.

4. In apparatus of the character described, in combination, a high voltage winding for a transformer made up of a plurality of coils arranged in spaced relation one above the other, means interposed between adjacent coils comprising a corrugated member of solid dielectric material, said member acting to hold adjacent coils in spaced relation and contact therewith only at intervals, and a gaseous dielectric under pressure filling the space between the corrugations of said solid dielectric member and adjacent coils whereby said corrugated member and said gaseous dielectric under pressure are in series in the path of higher voltage gradient between adjacent coils and whereby any surface leakage between adjacent coils and along said solid dielectric member is in a path or paths of lower voltage gradient and whereby said adjacent coils may be closely spaced.

5. The high voltage winding of an electric transformer, comprising a plurality of coils situated one above the other, a tubular member of dielectric material upon which said coils are wound, said tubular member being provided with perforations, the centers of which are coincident with the apices of substantially equilateral triangles and the diameters of which are of such relation to the altitude of the said triangles that a straight line cannot be drawn, except for a limited distance, along the surface of the said tubular member from one point to another, and annular washer-like members of dielectric material situated between adjacent coils and contacting at intervals therewith to support the said coils in spaced relation to each other.

6. The high voltage winding of an electric transformer, comprising a plurality of coils situated one above the other, a tubular member of dielectric material upon which said coils are wound, said tubular member being provided with perforations, the centers of which are coincident with the apices of substantially equilateral triangles and the diameters of which are of such relation to the alti-

tude of the said triangles that a straight line cannot be drawn along the surface of the said tubular member from one point to another, and annular washer-like sinuous members of dielectric material situated between the said coils and supporting the same in spaced relation with respect to each other.

7. In apparatus of the character described, in combination, a high voltage winding of an electric transformer made up of a plurality of coils positioned in spaced relation one above the other, a substantially tubular member of solid dielectric material upon which said coils are wound, substantially washer-shaped members of solid dielectric material positioned between adjacent coils for holding the latter in spaced relation, said members being corrugated and extending in a direction away from said substantially tubular member of solid dielectric material, said last-mentioned member having apertures therein forming communications between the interior thereof and the spaces between the corrugated members and coils spaced thereby, and a gaseous dielectric under pressure filling said spaces and said apertures.

8. In apparatus of the character described, in combination, a transformer core having a leg for receiving a winding and having a portion extending substantially transversely thereto, a high voltage winding about said core leg, and means comprising a substantially X-shaped member for supporting the end portion of said winding from said transversely extending portion of said core, whereby the leakage path between the end portion of said winding and along said X-shaped member is materially greater than the shortest straight line distance between the end portion of said winding and said transversely extending portion of said core.

9. The high voltage winding of a transformer, comprising a plurality of coils situated one above the other each of which coils is subdivided into inner and outer portions, said portions being separated from each other, a sinuous member substantially circular in outline situated in the annular space between the said inner and outer portions of the said coils, sinuous washer members of dielectric material situated between the said coils and supporting the same in spaced relation to each other, and solid dielectric means for supporting the said coils and spacing means.

10. The high voltage winding of a transformer, comprising a tubular part of dielectric material having annular disks situated at the upper and lower end portions thereof, coils wound upon the said tubular part, which coils are situated one above the other, and each of which is subdivided into inner and outer portions, which portions are separated by an annular space, sinuous strips of dielectric material situated in said spaces and contacting at intervals with the turns of

wire at the opposite sides of said spaces, sinuous washer members of dielectric material between the said coils, which members support said coils in spaced relation to each other, and the said washer members being provided with openings situated at intervals therein, which openings are located in vertical alinement with the spaces between the subdivisions of said coils whereby vertical conduits through the said washers are provided.

11. In an electric transformer, the combination of primary and secondary windings, the said windings being concentric and the primary winding being located inwardly of the secondary winding, a tubular support for the secondary winding, the said support enclosing the primary winding and being spaced therefrom and also being provided with perforations, and annular corrugated washer-like members of dielectric material located between the secondary windings, the alternate grooves and ridges formed by said corrugations extending radially from the axis of the said transformer.

12. In apparatus of the character described, in combination, a transformer core having a leg for receiving a winding and having a portion extending substantially transversely thereto; a high voltage winding about said core leg; means for insulating said winding from said transverse portion of said core, said means comprising solid dielectric material and a gaseous dielectric under pressure in series with said solid dielectric material across the space between the end portion of said winding and said transverse portion of said core; and means extraneous of the space between the end portion of said winding and said transverse portion of said core for holding said winding relative to the latter.

13. In apparatus of the character described, in combination, a high voltage winding having relatively adjacent portions thereof lengthwise of its axis at different potentials, and a member of solid dielectric material extending along said portions of the winding for mechanically holding the latter, said member being provided with perforations shaped and positioned so that a line drawn along the surface of said member in the general direction of the axis of said winding and between any two spaced points is greater in length than the straight line distance between said two points, whereby the leakage path along the surface of said member and in a general direction along which said portions of the winding make effective a potential difference is other than in a straight line.

14. In apparatus of the character described, in combination, a high voltage winding having relatively adjacent portions thereof lengthwise of its axis at different potentials, and a member of solid dielectric material extending along said portions of the

winding for mechanically holding the latter, said member being provided with perforations shaped and positioned so that a line drawn along the surface of said member in the general direction of the axis of said winding and between any two spaced points is greater in length than the straight line distance between said two points, whereby the leakage path along the surface of said member and in a general direction along which said portions of the winding make effective a potential difference is other than in a straight line, and a gaseous dielectric under pressure contacting said member and filling said perforations.

15. In apparatus of the character described, in combination, a high voltage winding of an electric transformer made up of a plurality of coils positioned in spaced relation one above the other, a substantially tubular member of solid dielectric material about which said coils extend, and insulating means between adjacent coils comprising solid dielectric material and a gaseous dielectric under pressure, said solid dielectric material and said gaseous dielectric under pressure being combined so as to be in series in the path of higher voltage gradient between adjacent coils and so that surface leakage along said solid dielectric and between adjacent coils is in a path or paths of lower voltage gradient, said tubular member being provided with perforations shaped and positioned so that a line drawn along the surface of said member in the general direction of the axis of said coils and between any two spaced points is greater in length than the straight line distance between said two points.

16. In apparatus of the character described, in combination, a transformer core having a leg for receiving a winding and having a portion extending substantially transversely thereto; a high voltage winding about said core leg and having its end portion spaced from said transverse core portion; and means for insulating said winding from said transverse core portion and for supporting said winding from said core, said

means including a member of solid dielectric material resting against the end of said winding and having a lesser thickness than the spacing between said end portion of the winding and said transverse core portion, a gaseous dielectric under pressure interposed between said solid dielectric member and said transverse core portion so that said two dielectrics are in series, and means secured to said core and engaging said solid dielectric member extraneously of the space between the latter and said transverse core portion for holding said winding in place.

17. In a transformer, in combination, a high voltage winding, a low voltage member in the form of a low voltage winding, a core member with which said windings coact, said high voltage winding being spaced from both of said members; and means for insulating said high voltage winding from one of said members, said means including a layer of solid dielectric material and a layer of gaseous dielectric under pressure in the space between said high voltage winding and said one of said members.

18. In a transformer, in combination, a transformer core member, a coil member about said core member, another coil member about said core member and adapted to operate at a voltage relatively higher than that of said first-mentioned coil member and spaced from both of said other members, and means for insulating said relatively higher voltage member from one of said other members, said means comprising solid dielectric material and a gaseous dielectric under pressure, both of said dielectrics being in the space between said members to be insulated and being combined so as to be in series in the path of higher voltage gradient between said members to be insulated and so that surface leakage along said solid dielectric between said members is in a path or paths of lower voltage gradient.

In testimony that I claim the foregoing as my invention I have hereunto signed my name this 4th day of March, 1922.

FRANKLIN S. SMITH.