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F. E. TERMAN

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COIL CONSTRUCTION

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Fig. 1

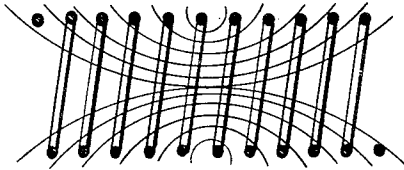


Fig. 2

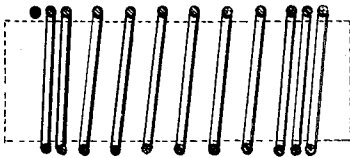


Fig. 2a

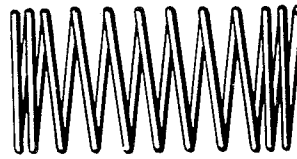


Fig. 3

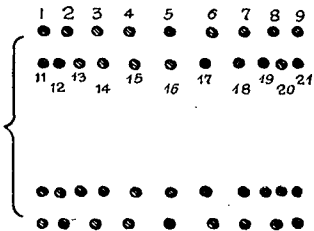


Fig. 4

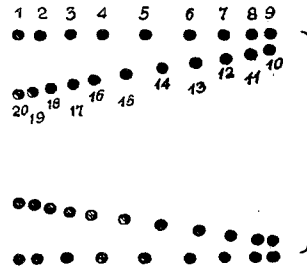
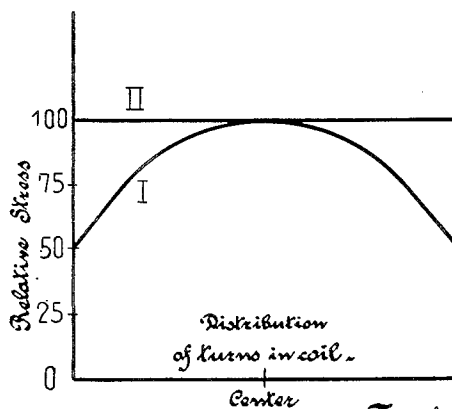


Fig. 5



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## UNITED STATES PATENT OFFICE

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## COIL CONSTRUCTION

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My invention relates in general to methods of constructing coils or solenoids and in particular to methods of constructing air cored inductance coils.

5 One of the objects of my invention consists in providing an improved form of coil construction whereby the voltage rating of the coil is increased without increasing the over all dimensions of the coil.

10 Another object contemplated by my invention consists in providing a method of constructing air cored coils of smaller dimensions for a given voltage rating than that hitherto possible.

15 Still another object of my invention comprises providing a method whereby a coil may be constructed to have a uniform voltage stress in all parts of the dielectric which separates and insulates the adjacent turns thereof.

20 I accomplish the above and other desirable features, which will hereinafter be pointed out and discussed, by a novel graduated spacing of adjacent turns in single layer coils and by the graduated spacing of adjacent turns in each layer and the relation of the layers in multi-layer coils.

In the drawings accompanying and forming a part of this specification:

30 Fig. 1 illustrates diagrammatically the flux distribution in an ordinary single layer air cored coil or solenoid with uniform spacing between turns;

Figs. 2 and 2a illustrate diagrammatically a single layer air cored coil wound in accordance with my invention and show the relative spacing between turns;

Fig. 3 illustrates diagrammatically my improved construction method as applied to multi-layer coils;

Fig. 4 illustrates an alternative form of applying my method of construction to multi-layer coils;

Fig. 5 shows graphically the distribution of the voltage stress on the dielectric between turns in the coils shown in Figs. 1, 2 and 2a.

In all single layer coils of the air cored type such as those illustrated in Fig. 1, the end turns of the coil, or the turns nearer the ends of the coil, link with a smaller amount

of magnetic flux than do the turns nearer the center. Inasmuch as the voltage per turn of a coil is proportional to the flux linkages per turn, it is readily apparent that in single layer coils with uniform spacing between turns as shown in Fig. 1, the stress on the dielectric separating turns will be greatest at the center and least at the ends of the coil, as indicated by curve I, Fig. 5. The voltage rating of the coil is accordingly determined by the maximum allowable voltage per turn at the center of the coil and with this maximum voltage the potential between the outer turns is much below the maximum value that will be safe for them. In my improved winding, I propose to make the spacing between the turns proportional to the magnetic flux linking the turn. For single layer coils this leads to a type of construction such as shown in Figs. 2 and 2a in which the spacing between the center turns is as indicated approximately twice as great as that between the end turns, the spacing between adjacent turns progressively decreasing from the center towards the ends of the layer in substantially the ratio indicated. Such spacing may, of course, be accurately determined mathematically or experimentally by anyone skilled in the art for any type of coil under construction. With this construction all of the dielectric between turns is stressed at the same voltage gradient irrespective of whether the turn is at the center or the ends of the coil, as shown by curve II, Fig. 5.

A further advantage of the type of construction shown in Fig. 2 is that full use is made of the insulating properties of all of the dielectric instead of only that part of the dielectric which is at the center as in the case of construction illustrated in Fig. 1. The consequence is that my proposed type of construction permits a higher voltage rating for a coil of given inductance and size than has been hitherto possible.

Viewed from another angle, my method of construction enables one to construct a somewhat smaller sized coil for a given voltage than would otherwise be possible by methods hitherto known.

Figs. 3 and 4 show the general application

of my idea to multi-layer coils. In air cored coils or solenoids having more than one layer of turns, the inner layers will not have as many flux linkages per turn as the outer layers so that such coils may be made with more turns per layer as one goes to layers nearer the center. The individual turns in each layer can also be separated from each other in accordance with the distribution of flux linkages over the different parts of the layer. This in general means fewer turns per inch at the center of a layer than at the ends as previously described. It is also possible to make the distribution of the voltage gradation in the dielectric more uniform in a multi-layer coil by properly spacing the layers, making the spacing smaller where the voltage difference between layers is at a minimum and making the separation between the layers larger where the voltage differences are considerable. The way the adjacent layers are to be arranged depends to a large extent upon how the coil is wound. Figs. 3 and 4 show two cases of multi-layer coils utilizing these general principles. The difference between the constructions shown in Figs. 3 and 4 resides in the connections used between layers as indicated by the numerals designating the turns, which by their numerical sequence define the order of winding.

My method of constructing air cored coils may be applied with advantage to inductance coils used in high powered radio transmitters where the voltage stresses between turns are sufficiently high to make the problem of insulation an important one. Such inductance coils are often required to handle heavy currents and their size, for that reason, becomes considerable. This increase in size increases the necessity for greater housing space and the magnetic flux tends to extend to greater distances thus interfering with the operation of adjacent apparatus. By my improved construction coils adapted to carry heavy currents at high voltages may be considerably decreased in size thus simplifying the problem of their housing and interference with adjacent apparatus.

It will, of course, be realized that my method of coil construction is not limited to coils used for radio purposes but applies equally well to all coils with nonmagnetic cores. Such coils or inductances are used in power networks as current limiting reactors to limit short circuits. By taking advantage of my method of construction, it will be possible to reduce the size of such current limiting reactors appreciably below their present dimensions without changing their voltage rating or the inductances of the coils.

Having thus completely described my invention, I claim:

1. An inductance coil comprising a plurality of turns of conductor separated by a dielectric in which the separation between

turns is a maximum at the center of each layer of winding and progressively decreases toward the ends thereof, the separation per turn being a maximum in the outer layers of the coil and progressively decreasing toward the axis of the coil.

2. An air cored inductance coil comprising a plurality of turns of conductor separated by a dielectric in which the separation between turns is a maximum at the center of each layer of winding and progressively decreases toward the ends thereof, the separation per turn being a maximum in the outer layers of the coil and progressively decreasing toward the axis of the coil.

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