

Oct. 3, 1967

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Filed Aug. 9, 1965

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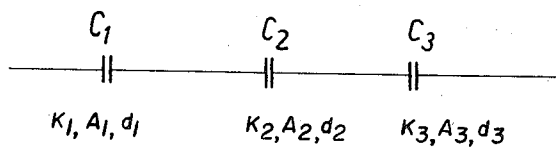


Fig. 1

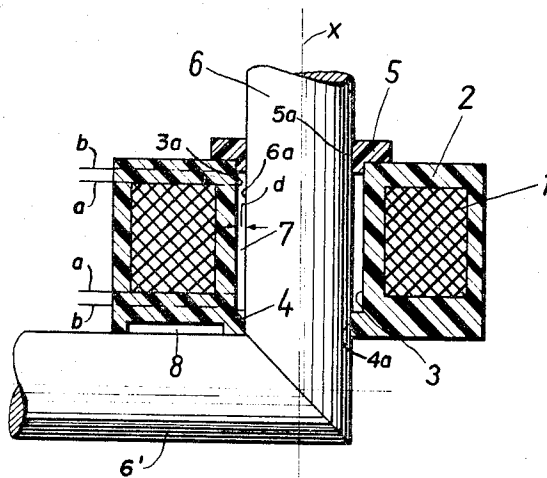


Fig. 2

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HIGH-VOLTAGE COIL FOR GENERATING THE HIGH VOLTAGE IN A TELEVISION RECEIVER

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Filed Aug. 9, 1965, Ser. No. 478,067

Claims priority, application Germany, Aug. 8, 1964, T 26,762

5 Claims. (Cl. 336—69)

The present invention relates to an electrical device, and, more particularly, to a high-voltage coil whose winding is carried by a carrier, especially a high-voltage coil for use as the sweep transformer in a television receiver. Such high-voltage coil usually comprises a ferrite or iron core which passes through a central opening of the coil carrier.

In high-voltage coils of the above type, there is the danger of a voltage breakdown or arc-over between the windings and the core, the latter usually being at ground potential and already the start of the high-voltage coil is at the rather high voltage of about 6 kilovolts.

One way of preventing such arc-overs is to provide a large number of insulating layers between the inner surface of the winding—the same having the shape of a hollow cylinder—and the surface of the core. This way of preventing arc-overs, however, has the drawback that it entails additional costs, besides not affording any truly reliable protection against arc-overs.

Another way of preventing such arc-overs is to provide a metal surface, for example, a perforated copper foil, at the wall of the central opening of the coil carrier. This metal foil lies directly against the inner wall. In this way, there will be no air gap between the winding and the metal cylinder which itself is at ground potential, and there will be no voltage across the metal cylinder and the core which could lead to arc-overs. This way of preventing arc-overs is also an expensive solution for the problem at hand, one reason for this being that much meticulous work is needed to apply the metal foil. Also, care has to be taken that the foil lies snugly against the coil carrier at all points.

Still another way in which arc-overs have been sought to be avoided involves coating or spraying a conductive layer onto the wall of the inner opening, for example, a conductive graphite layer which is grounded by a suitable connection so that there will be no difference in potential between this layer and the core. This way of solving the problem has, however, a number of drawbacks as well, one of them being manufacturing difficulties inasmuch as it is hard to apply a uniform layer onto the wall. Furthermore, such a layer is readily susceptible to damage. Besides, even this layer has, in practice, been found not to produce wholly satisfactory results.

Conceivably, the core and the winding could be molded together in one plastic body, and this would eliminate air gaps between the coil and the core and therefore the strong electric fields that could arise in such air gaps. The practical drawback of this solution is that, especially in the case of a high-voltage transformer for use in television receivers, the core has to be adjustable. Were the core to be cast in with the carrier and winding, and were the requisite air gap in the magnetic circuit between the two halves of the core not absolutely precise, the mass-production of this item would, if there were no way in which to adjust the air gap subsequent to the casting step, inevitably result in an excessively high number of rejects.

It is, therefore, the primary object of the present invention to overcome the drawbacks of the prior art by providing an uncomplicated way in which to reduce the

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danger of arc-overs between the winding and the core of a high-voltage coil, and, with this object in view, the present invention resides, basically, in a high-voltage coil, incorporating a carrier and a core passing through this carrier, in which a basically very simple means, namely, an air gap, is provided for preventing arc-overs between the winding and the core.

More particularly, the present invention resides in a high-voltage coil which comprises a carrier having an opening and carrying a winding, and a core passing through this opening of the carrier, there being, in the region of the winding, an air gap between the inner wall of the carrier and the outer surface of the core, the thickness of this air gap being such that the air gap forms an insulating means for preventing arc-overs between the winding and the core.

In a practical embodiment of the present invention, the winding carrier is annular and has a central opening, especially a cylindrical opening, through which the core passes.

Additional objects and advantages of the present invention will become apparent upon consideration of the following description when taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a circuit showing the serial connection of three capacitors, this circuit being referred to in the course of an explanation of the theoretical aspects underlying the present invention.

FIGURE 2 is a sectional view of a high-voltage coil according to the present invention.

Before proceeding with a detailed description of a coil according to the present invention, there will first be set forth the theory underlying the present invention.

There are generally several insulating media which are located between the core and the winding, and among these insulating media is a narrow air gap between the inner wall of the winding carrier and the core. Such an air gap has to be there in any event, in order to provide some tolerance in the dimensions of the core thereby to make it possible for the core to be passed through the carrier. It is this air gap which is the most dangerous for the above-mentioned arc-overs.

The stack of insulating materials between the core and the winding can be considered as a series-circuit of capacitors C_1 , C_2 , C_3 , shown in FIGURE 1, each having its own respective dielectric constant k , its respective plate area A in square meters, and its respective thickness d in meters, this being the distance between the plates of the capacitor. The capacitance C , in farads, of each capacitor is therefore

$$\frac{Ak\epsilon_0}{d}$$

where ϵ_0 is the permittivity of empty space with the numerical value 8.85×10^{-12} coul.²/newton-m.². The number of these capacitors is the same throughout the length of the winding. Since the same current i flows through all of these capacitors, all of the capacitors will, after a time interval t , carry the same charge Q . From this, the following equation can be derived:

$$Q = i \cdot t = V \cdot C_{\text{total}} = V_1 \cdot C_1 = V_2 \cdot C_2 = V_3 \cdot C_3 \quad (1)$$

where V is the voltage across the ends of the series-circuit of the capacitors and C_{total} is the equivalent capacitance of the series-circuit. VC_{total} is equal to V_1C_1 , or V_2C_2 , or V_3C_3 because the same current i flows through the equivalent capacitance C_{total} for the same time t as through each individual capacitor. The correctness of Equation 1 can also be established in the following purely mathematical manner:

It is known that the equivalent capacitance C_{total} of the series circuit of FIGURE 1 can be expressed as follows:

$$C_{\text{total}} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}} \quad (1a)$$

or

$$C_{\text{total}} = \frac{1}{\frac{C_2 C_3}{C_1 C_2 C_3} + \frac{C_1 C_3}{C_1 C_2 C_3} + \frac{C_1 C_2}{C_1 C_2 C_3}} \quad (1b)$$

or

$$C_{\text{total}} = \frac{C_1 C_2 C_3}{C_2 C_3 + C_1 C_3 + C_1 C_2} \quad (1c)$$

By definition,

$$V = V_1 + V_2 + V_3 \quad (1d)$$

Therefore:

$$V \cdot C_{\text{total}} = (V_1 + V_2 + V_3) \cdot \left[\frac{C_1 C_2 C_3}{C_2 C_3 + C_1 C_3 + C_1 C_2} \right] \quad (1e)$$

Multiplication of the terms yields:

$$V \cdot C_{\text{total}} = \frac{(V_1 C_1)(C_2 C_3) + (V_2 C_2)(C_1 C_3) + (V_3 C_3)(C_1 C_2)}{C_2 C_3 + C_1 C_3 + C_1 C_2} \quad (1f)$$

It is known from Equation 1 that:

$$Q = V_1 C_1 = V_2 C_2 = V_3 C_3 \quad (1g)$$

Substituting the equalities of Equation 1g into Equation 1f yields:

$$V \cdot C_{\text{total}} = \frac{Q(C_2 C_3) + Q(C_1 C_3) + Q(C_1 C_2)}{C_2 C_3 + C_1 C_3 + C_1 C_2} \quad (1h)$$

or

$$V \cdot C_{\text{total}} = \frac{Q[C_2 C_3 + C_1 C_3 + C_1 C_2]}{C_2 C_3 + C_1 C_3 + C_1 C_2} = Q \quad (1j)$$

Precisely the same type of derivation and reasoning can be employed to show that the charge Q on the equivalent capacitance of the series arrangement of capacitors C_2 and C_3 is equal to $V_1 C_1$ or $V \cdot C_{\text{total}}$, the equivalent capacitance C' of the series arrangement of capacitors C_2 and C_3 being represented by:

$$C' = \frac{1}{\frac{1}{C_2} + \frac{1}{C_3}} \text{ or } C' = \frac{C_2 C_3}{C_2 + C_3}$$

From this there is obtained

$$V \cdot C_{\text{total}} = (V_2 + V_3) \cdot \frac{C_2 \cdot C_3}{C_2 + C_3} = V_1 \cdot C_1 \quad (2)$$

If the term

$$\frac{C_2 \cdot C_3}{C_2 + C_3}$$

which is the capacitance of the capacitors C_2 and C_3 connected in series, is replaced by C' , so that

$$C_{\text{total}} = \frac{C_1 \cdot C'}{C_1 + C'}$$

there is obtained

$$\frac{V}{V_1} = \frac{C_1}{C_{\text{total}}} = \frac{C_1 \cdot [C' + C_1]}{C_1 \cdot C'} = 1 + \frac{C_1}{C'} \quad (3)$$

$$\frac{V}{V_1} = 1 + C_1 \left[\frac{1}{C_2} + \frac{1}{C_3} \right] = 1 + \frac{k_1 \cdot \epsilon_0 \cdot A_1}{d_1} \left(\frac{d_2}{k_2 \cdot \epsilon_0 \cdot A_2} + \frac{d_3}{k_3 \cdot \epsilon_0 \cdot A_3} \right) \quad (4)$$

If all of the capacitors are assumed to have the same area A , the field strength E_1 in an insulator in the form of an air gap is

$$E_1 = \frac{V}{d_1 + \sum_{n=2}^{n=n} \frac{d_n}{k_n}} [V/cm] \quad (5)$$

where n is the number of successive insulating media. The winding carrier of the high-voltage coil has a dielectric constant k of about 4, and this means that a change in the thickness of the air gap (d_1) is substantially more effective than increasing the thickness of the winding carrier. For this reason, the air gap, in accordance with the present invention, is not made as small as possible, but is intentionally enlarged to a definite value. It is thus apparent from Equation 5 that an air gap of 1 mm. has the same effect as increasing by 4 mm. the thickness of the winding carrier which itself is made of insulating material.

FIGURE 2 shows a practical embodiment of a high-voltage coil according to the present invention, the same including a winding 1 molded to a winding carrier 2 which has the shape of a hollow cylinder and a wall thickness of, for example, 2 mm. The carrier 2 also has a central cylindrical opening 3 and is provided, near the lower end of this opening 3, with an inwardly directed annular shoulder 4 so as to form a constriction 4a. A sleeve 5, which itself is provided with an opening, is set into the upper end of the opening 3 so that here, too, the opening 3 is constricted as shown at 5a. A cylindrical core 6 passes through the opening 3. As shown in FIGURE 2, the inner diameter of the opening 3 is greater than the outer diameter of the core 6. However, the core 6 is held in place by the shoulder 4 and sleeve 5 such that an air gap 7 is formed between the inner wall 3a of the opening 3 and the outer surface 6a of the core 6. As described above, the thickness d of the air gap is such that it forms an insulating means for preventing arc-overs between the winding 1 and the core 6.

It will be seen from FIGURE 2 that the winding 1 is located between two limit planes a which are at right angles to the axis x of the central opening 3 and that the restrictions formed by the shoulder 4 and the sleeve 5 are located outside of the space between the limit planes and on opposite sides of this space. In practice, each of the constrictions is spaced from the limit plane nearest to it, as shown by the spacing between the planes a and the planes b which are also at right angles to the axis of the central opening and which are the planes within which lie the inner ends of the shoulder 4 and sleeve 5. In this way, the air gap 7 will be located in the region of the winding 1.

FIGURE 2 also shows a branch of the core 6 as being at right angles to the branch of the core which passes through the opening 3. This right-angle branch, identified at 6', passes under the left-hand portion of the carrier 2. Accordingly, the bottom face of the carrier 2 has a recess so that also in this region of the winding 1 will there be an air gap 8 between the surface of the carrier 2 and the core.

While there is no air gap at the restrictions formed by the shoulder 4 and the sleeve 5, the path through the insulating carrier 2 from the winding to the core is, at those points, sufficiently long to prevent arc-overs.

It was found that by making the high-voltage coils for television receivers in accordance with the present invention, the number of rejects that were due to arc-overs from the winding to the core was significantly less, while at the same time the overall thickness of the carrier was reduced. Comparative tests have shown that, in coils according to the present invention, arc-overs between the start of the winding and the core did not appear until a voltage equal to 1.7 times the rated voltage was applied, whereas in heretofore conventional, prior art transformer coils such arc-overs were found to start when a voltage of only 1.3 times the rated voltage was applied.

It will thus be seen that, in accordance with the present invention, there is provided a very simple and yet

reliable way of preventing arc-overs. Moreover, the various component parts can be easily mass-produced at low cost, nor does the assembly of the parts pose any problem.

It will be understood that the above description of the present invention is susceptible to various modifications, changes, and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

What is claimed is:

1. A high-voltage coil for generating the high voltage in a television receiver, comprising, in combination:
 - (a) an annular carrier having an inner wall defining a central opening and carrying a winding surrounding said opening, said winding being located between two limit planes which are at right angles to the axis of said central opening;
 - (b) a core passing through said central opening, there-being, in the region of said winding, an air gap of substantial thickness between the inner wall of said carrier and the outer surface of said core, the thickness of said air gap being such that the voltage gradient produced therein by the high voltage in said coil does not exceed the dielectric strength of air, thereby preventing arc-overs from occurring between said winding and said core; and
 - (c) means forming a constriction at each end of said opening and holding said core in axially centered relationship with respect to said opening, said con-

striction means being located outside of the space between said limit planes and one of said constriction means constituting an inwardly extending shoulder of said carrier.

2. A high-voltage coil as defined in claim 1 wherein said shoulder is integral with said carrier.

3. A high-voltage coil as defined in claim 1 wherein one of said constriction means is a sleeve set into said opening, said sleeve itself being provided with an opening within which said core is received.

4. A high-voltage coil as defined in claim 1 wherein said core has two mutually perpendicular branches one of which passes through said opening, there being a further air gap of substantial thickness between the surface of said carrier and the outer surface of the other of said branches.

5. A high-voltage coil as defined in claim 1 and for use in a high-voltage transformer in a television receiver, the thickness of said air gap being approximately 1 mm.

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