United States Patent

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[45] Feb. 29, 1972

[54] METHOD OF TUNING HIGH-VOLTAGE TRANSFORMER FOR TELEVISION RECEIVER

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[52] **U.S. Cl.** **29/593**, 323/61

[51] **Int. Cl.** **G01r**, G05f

[58] **Field of Search** 29/593; 323/60, 61; 336/198, 336/208

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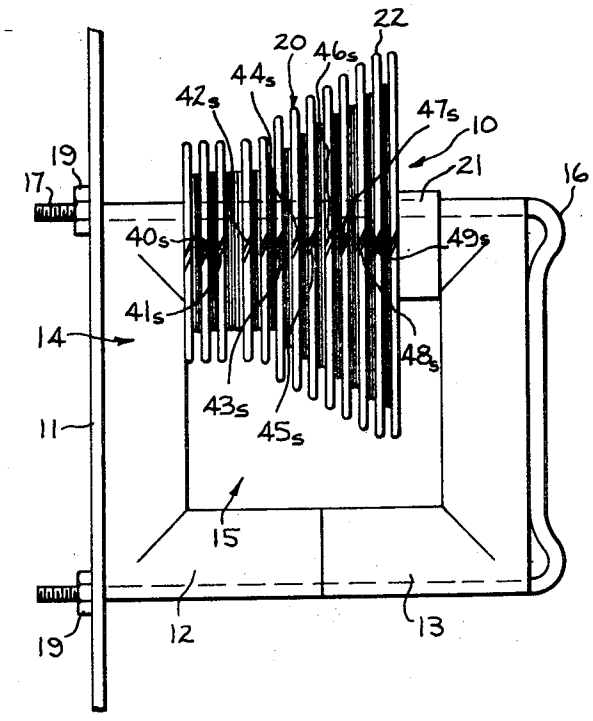
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[57] **ABSTRACT**

A method of tuning a high-voltage transformer for television receivers and the like wherein the primary and high-voltage windings are wound around and axially spaced from one another in a plurality of axially spaced circumferential slots provided on the exterior of hollow, electrically insulative coil form means, the interior of which surrounds a portion of the transformer core means. The axial spacing of the primary and high-voltage windings that is provided by the unique construction of the novel slotted coil form means permits the coefficient of coupling between the primary and high-voltage windings novel to be made both ideal and constant. This, in turn, allows tuning of the transformer in accordance with the novel method of the present invention which represents considerable simplification over the complex method previously required to tune the prior art, layer-wound transformers.

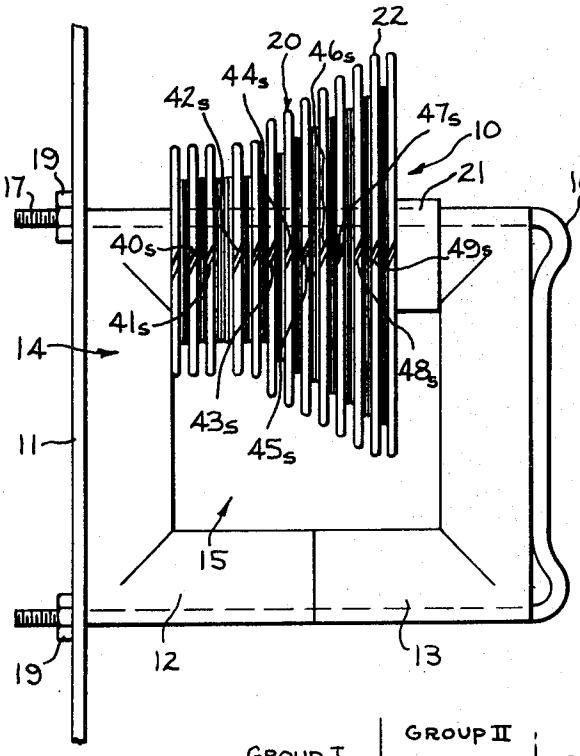
6 Claims, 6 Drawing Figures



Patented Feb. 29, 1972 3,644,986

2 Sheets-Sheet 1

FIG. 1



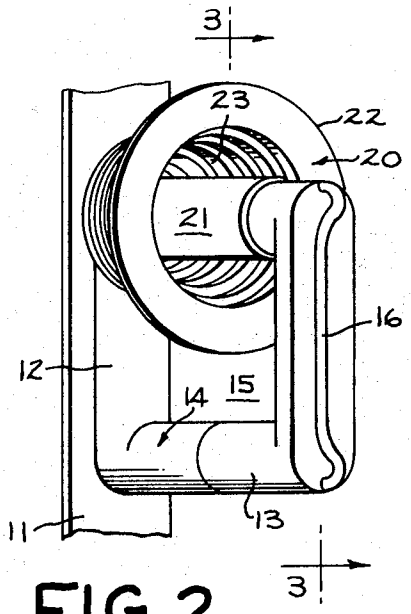


FIG. 2

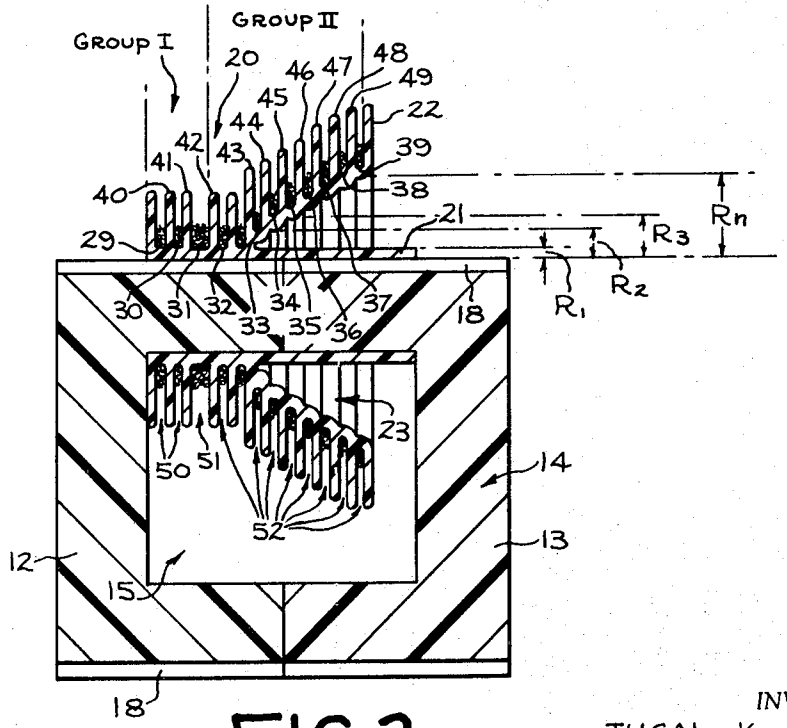
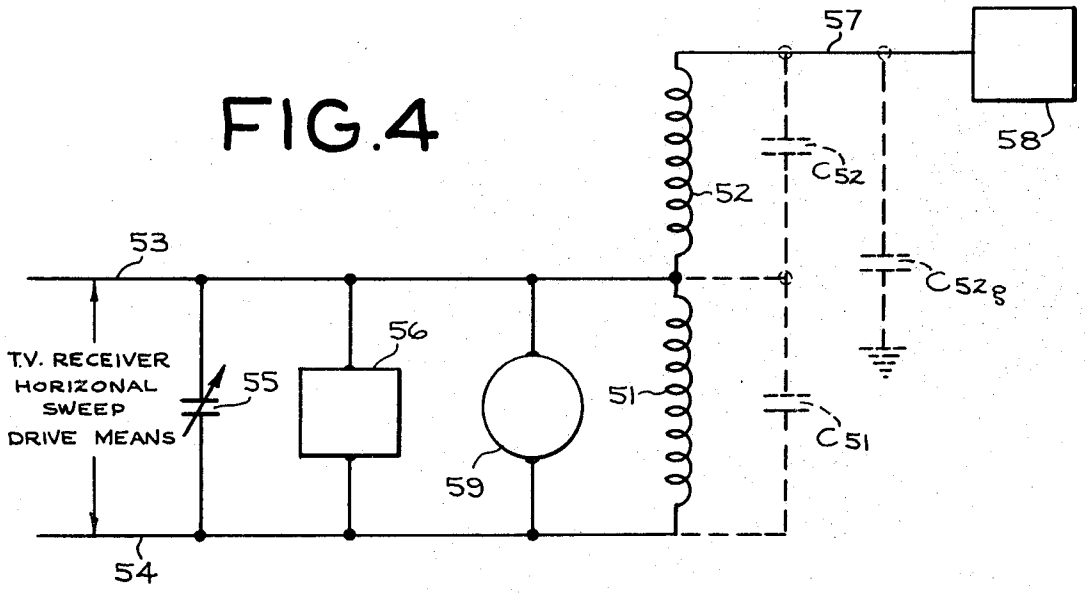


FIG. 3

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FIG. 4



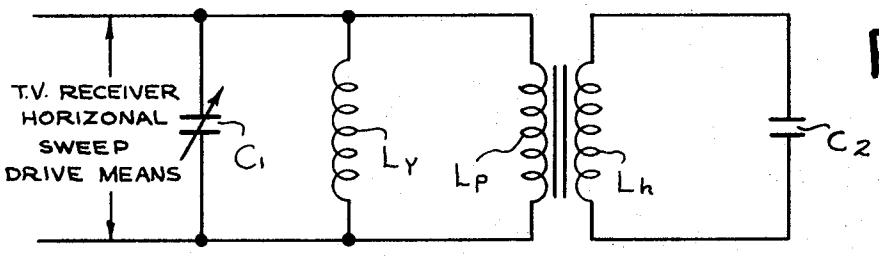


FIG. 5

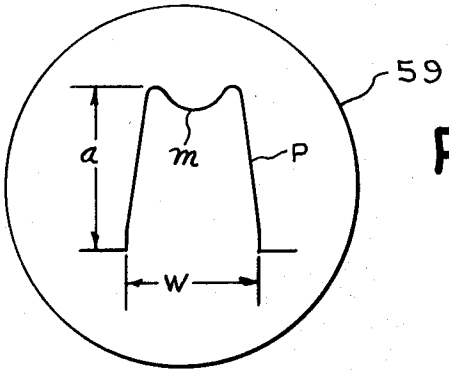


FIG. 6

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METHOD OF TUNING HIGH-VOLTAGE TRANSFORMER FOR TELEVISION RECEIVER

CROSS-REFERENCE TO RELATED APPLICATION

The instant application describes a novel method of tuning a transformer generally similar in construction to the novel transformer described in detail in copending, commonly assigned U.S. application Serial No. 870,039, now U.S. Pat. No. 3,573,694, filed by Eugene K. Von Fange et al. on Oct. 28, 1969 for Improved High Voltage Transformer For Television Receivers.

BACKGROUND OF THE INVENTION

This invention relates to high-frequency pulse transformers and, more particularly, to a novel method of tuning an improved transformer of the aforedescribed type which can be used as a high-voltage transformer for television receivers and the like. Heretofore, layer-wound transformers have been employed in this service. U.S. Pat. Nos. 2,500,766 and 2,612,545 describe typical versions of such conventional layer-wound transformers. With these prior art transformers, the tapes and insulating sheets that have been used between the layers of wire forming the coils, and the overlapping of the coil layers over one another, have retarded the transfer of heat away from the coil to the surrounding atmosphere. Furthermore, it has been difficult to obtain consistency in operating characteristics with these conventional layer-wound transformers and their production has required a slow and tedious manufacturing process, as well as a complex tuning operation.

OF THE INVENTION

To overcome the aforenoted shortcomings of these conventional layer-wound transformers, an improved transformer has been developed and is described in detail in the aforenoted copending, commonly assigned application. Basically, this improved transformer performs the same operation as the conventional layer-wound transformer which it replaces, differing mostly therefrom in that it employs novel slotted coil form means around which the transformer coils are wound. The novel coil form means comprise hollow, electrically insulative means, the interior of which surrounds a portion of the transformer core means and the exterior of which is provided with a plurality of axially spaced circumferential slots. The primary and high-voltage windings are wound around and axially spaced from one another in the slots that are provided on the exterior of the novel coil form means. AS set forth in the aforenoted, commonly assigned application, this novel slot-wound transformer presents improvements over the conventional layer-wound transformer, which it replaces, in relation to such factors as more efficient transfer of heat away from the coil windings to the surrounding atmosphere, greater ease and lower costs of manufacture and increased reproducibility and reliability.

Furthermore, the axial spacing of the primary and high-voltage windings that is provided by the unique construction of the novel coil form means also permits the coefficient of coupling between the primary and high-voltage windings to be made ideal and constant. The present invention provides a novel method of tuning such as improved slot-wound transformer which represents a considerable simplification over the complex method which has previously been required to tune the layer-wound transformers which have heretofore been employed in this type of service.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated in the accompanying drawings, wherein:

FIG. 1 is a side elevational view of an assembled transformer which can be tuned in accordance with the method of the present invention;

FIG. 2 is a right end elevational perspective view of the transformer illustrated in FIG. 1;

FIG. 3 is an enlarged, somewhat schematic sectional view taken along line 3—3 of FIG. 2, with the U-bolt removed to show details;

FIG. 4 is a schematic circuit diagram showing the transformer illustrated in FIG. 1, adapted for use as a horizontal sweep and high-voltage transformer for a television receiver;

FIG. 5 is a simplified equivalent diagram of the circuit illustrated in FIG. 4; and

FIG. 6 illustrates a typical shape of the primary winding wave pulse of the transformer of FIGS. 1–5, which can be evaluated with means such as an oscilloscope and adjusted in accordance with the method of the present invention.

DESCRIPTION OF THE PREFERRED METHOD

Referring now to the drawings and particularly to FIG. 1 thereof there is shown a presently preferred form of a transformer **10** which can be tuned in accordance with the presently preferred method of the present invention. The transformer **10** is mounted on a portion of shielding wall or other suitable support **11** that is provided within the housing of a television receiver or similar device (not shown). A pair of U-shaped sections **12** and **13**, which may be molded of a ferrite or other suitable magnetic material, are assembled such that the legs of the U-shaped sections **12** and **13** confront each other. When so assembled, these magnetic sections form generally rectangular core means **14** for the transformer **10** and define a core window **15** at the center of the rectangle.

In order to hold the transformer **10** in its assembled position, a U-bolt **16** is provided. The U-bolt **16** has a pair of legs **17**, which are threaded at their distal ends and extend through matching grooves **18** provided in legs of the core members **12** and **13**. The legs of U-bolt **16** may be passed through apertures provided in the support plate **11** and the entire transformer **10** retained in its assembled position by means of a pair of nuts **19**.

As illustrated in FIGS. 1–3, the transformer **10** is provided with novel slotted coil form means **20** around which the transformer coils are wound.

Heretofore, the windings for such a transformer have been concentrically wound in layers, one layer directly over another, around an electrically insulative hollow cylindrical coil form that surrounded a portion of the core means. The windings have been concentrically arranged on the prior art cylindrical coil forms with the higher voltage windings located radially farthest from the core and thus having the greatest insulative gap between them and the core in order to inhibit electric arcing between the coil and the core. While such prior art concentric layer-wound construction has served to inhibit electric arcing between the coil and the core, the tapes and insulating sheets which have been used between the layers of wire forming the coils and the overlapping of the coil layers one over another have retarded the transfer of heat away from the coil to the surrounding atmosphere. Furthermore, it has been difficult to obtain consistency in operating characteristics with these conventional layer-wound transformers, and their production has required a slow and tedious manufacturing process, as well as a complex tuning operation.

As described in detail in the aforenoted co pending, commonly assigned application, it has been found that novel slotted coil-form means, such as the coil-form means **20** shown in FIGS. 1–3, provide a solution to the prior art problem of retarded heat transfer from the transformer coils to the surrounding atmosphere while avoiding any new problem with electric arcing between the coil high-voltage windings and the core means **14**. In the form illustrated in the drawings, the novel coil form means **20** is formed of an electrically insulative material. While various electrically insulative materials may be utilized to produce the coil form means **20**, good results have been obtained with flame-retardant polypropylene material, such as Escon 185 or Avisun 2356. And, although it might also be made of a plurality of parts, the novel coil form means illustrated in FIGS. 1–3 comprises a

lone hollow member, the interior of which surrounds a portion of core means **14** and the exterior is provided with a plurality of axially spaced circumferential slots **29–39** in which the coil windings are wound.

As illustrated in FIGS. **1–3**, the interior of the coil form means **20** comprises a hollow tubular portion **21** that is adapted to be slipped over and to surround the portion of the core means **14** that is defined by the legs of the core members **12** and **13** which comprise the upper "wall" of the core window **15**. The exterior of the coil form means **20** comprises a generally frustoconical portion **22** having its convergent end joined to one end of the tubular interior portion **21** of the coil-form means **20** and its divergent end being spaced apart from the tubular interior portion **21** by a gap **23** containing air or some other gaseous material. A plurality of axially spaced, circumferential, coil-receiving slots **29–39** are provided in the generally frustoconical exterior portion **22** of the coil-form means **20** and are separated from one another by partition members or ribs **40–49**.

As best shown in FIG. **3**, the slots **29–39** in the exterior of the coil form means **20** may be considered as being divided into two groups, Groups I and II. Group I includes two narrow slots **29** and **30** and one wide slot **31**. The two narrow slots **29** and **30** receive the transformer auxiliary windings **50** for such auxiliary functions as boost voltage, AFC pulse, AGC keyer pulse, etc. The wide slot **31** receives the transformer primary windings **51**. Group II includes the remaining slots **32–39** which receive the transformer high-voltage windings **52**. The sizes of the slots **29–39** are of course determined by the size of the wire to be used and the number of turns required.

As illustrated in FIG. **3**, the first three slots **29–31** adjacent the convergent end of the novel coil-form means **20** receive the auxiliary windings **50** and the primary windings **51** for the transformer **10**. These three slots **29–31** and at least one slot for the high-voltage windings **52** (the slot **32** nearest the primary winding slot **31** as shown in the drawings) are spaced at substantially the same radial distance R_1 from the portion of the core means **14** which the coil-form means **20** surrounds, while the remaining high-voltage winding slots **33–39** are located at progressively increasing radial distances R_2, R_3,— R_n from that portion of the core means **14** such that a sufficiently great insulative barrier is provided between the transformer coil high-voltage windings **52** and the core means **14** to prevent electric arcing therebetween.

As further shown in FIG. **1**, each of the partitions or ribs **4–49** on the exterior **22** of the coil-form means **20** is provided with a narrow slit **40*s*–49*s*** to permit continuous winding of the coil-forming wires from slot to slot.

From the foregoing, it can be seen that, in accordance with the teachings of the aforenoted, copending, commonly assigned application, it is now possible to construct a suitable, in fact an improved, high-voltage transformer, such as the transformer **10**, for television receivers and the like wherein the primary windings **51** and high-voltage windings **52** can be wound around and axially spaced apart from one another in a plurality of axially spaced circumferential slots **31–39** provided on the exterior **22** of hollow, electrically insulative coil-form means **20**, the interior of which **21** surrounds a portion of the transformer core means **14**.

The present invention is particularly concerned with providing a novel method of tuning a slot-wound transformer which is generally similar in construction to the novel transformer **10** illustrated in FIGS. **1–3**.

FIG. **4** schematically illustrates a circuit diagram wherein a novel slot-wound transformer, generally similar in construction to the transformer **10**, has been adapted for use as a horizontal sweep and high-voltage output transformer for a television receiver, and can be tuned by the novel method developed in accordance with the present invention.

As shown in FIG. **4**, the primary winding **51** of the transformer **10** is adapted to be electrically connected by electrical conductors **53** and **54** across an electric power source, such as the horizontal sweep circuit drive means for a television receiver and the like (not shown in detail). A tuning capacitor **55** and a primary load **56** (shown in block), such **51**, the deflection yoke for a television receiver and the like, are each electrically connected in parallel with the primary winding **51** across the conductors **53** and **54**. And, the high-voltage winding **52** of the transformer **10** is electrically connected by another electric conductor **57** to a secondary load **58** (shown in block), such as the high-voltage rectifier and the anode of a television receiver picture tube and the like. As shown in shadow in FIG. **4**, the circuit also has stray capacitance C_{52} from the high-voltage winding **52** to the primary winding **51**, primary winding leakage capacitance C_{51}, and high-voltage leakage capacitance to ground C_{52g}.

For simplicity in understanding, the circuit can be reduced to the equivalent circuit shown in FIG. **5**, wherein the tuning capacitor **55** is redesignated as equivalent primary winding capacitance C_1; the stray and leakage capacitances C_{51}, C_{52} C_{52g} can be lumped together and redesignated as equivalent high-voltage winding capacitance C_2; and the inductances of the primary winding **51** high-voltage winding **52** and primary load are respectively designated as L_p, L_h, L_y.

While several factors are involved in tuning a high-voltage transformer, the coefficient of coupling k is one of the most important. This coefficient of coupling k is dependent upon the physical placement of the transformer primary winding with respect to the transformer high-voltage winding. It has been known heretofore that the best or "ideal" value of the coefficient of coupling k for such transformers could only be obtained if the primary and high-voltage windings could be axially spaced apart from one another. However, prior to the invention described in the aforenoted copending, commonly assigned application it was thought that such axial spacing of the primary and high-voltage windings was impossible because of mechanical and electrical difficulties. Now, as shown in FIGS. **1–3**, it has been found possible to construct a high-voltage transformer, such as the slot-wound transformer **10**, wherein the primary **51** and high-voltage **52** windings can be axially spaced apart from one another. Furthermore, this novel slot-wound transformer construction permits the coefficient of coupling k to be made both ideal and also constant, since its value can be determined and fixed by the shape of the novel slotted coil-form means, such as the coil-form means **20** shown in FIGS. **1–3**.

Because the aforenoted unique structure of the slotted coil-form means, such as the slotted coil-form means **20**, permits the coefficient of coupling k to be made both ideal and constant, and since the primary load **56** is also usually fixed in value, tuning of a slot-wound transformer, such as the transformer **10**, can be achieved by adjusting one or more of the only three variables which remain. As shown in FIG. **5**, these three remaining variables are: C_1, which can be varied by changing the value of the tuning capacitor **55**; C_2, which can be varied by changing the number of turns of the high-voltage windings **52**; and L_p, which can be varied by changing the number of turns in the primary winding **51**. The transformer is a random-wound type. Therefore, changing the number of turns in the primary **51** and high-voltage **52** windings is very simple, while the capacitor **55** may be made of a variable type for ease of adjustment.

In accordance with the present invention, it has been found that the transformer **10** can be tuned by a method comprising the following steps:

a. First, constructing a preliminary transformer having the general configuration of the transformer **10** shown in FIGS. **1–3** of the drawing, omitting the illustrated auxiliary windings **50**, and providing the approximate required number of turns for the primary **51** and high-voltage **52** windings wound around and axially spaced apart from one another on the novel slotted coil-form means **20**;

b. Next, electrically connecting the primary winding **51** of the preliminary transformer to a primary load **56**, such as the deflection yoke of a television receiver picture tube and the like;

c. Then, electrically connecting a tuning capacitor **55** in parallel with the primary winding **51**;

d. Next, electrically connecting the high-voltage winding **52** of the preliminary transformer to a secondary load **58**, such as the high-voltage rectifier and the anode of a television receiver picture tube;

e. Electrically connecting means, such as an oscilloscope **59** as schematically shown in FIG. **4**, across the primary winding **51** of the preliminary transformer and energizing and evaluating the preliminary transformer in terms of the shape of the primary winding voltage pulse *p* with regards to its amplitude *a*, width *w* and harmonic relationship *m*. (FIG. **6** illustrates a typical desired pulse shape as seen on the oscilloscope **59**); and

f. Now, assuming that the observed shape of the pulse *p* across the primary winding **51** is as desired except for the harmonic tuning relationship *m*, correcting this exception by adjusting the value of the tuning capacitor **55** (FIG. **4**) to thus modify C_1 and, hence C_1/C_2 (FIG. **5**) and thereby obtain the desired harmonic tuning relationship *m* of the primary winding voltage pulse *p* (FIG. **6**).

Hopefully, the foregoing steps will be sufficient to produce the desired tuning of an improved transformer, such as the transformer **10**.

If, however, following completion of all the aforedescribed steps *a–f*, exceptions still exist between the observed shape of the primary voltage wave pulse *p* and the desired shape thereof, certain additional steps can be performed in accordance with the method of the present invention to achieve the desired tuning of an improved transformer, such as the transformer **10**. For example, if, upon evaluation of the shape of the primary voltage wave pulse *p* after completion of all of the aforedescribed steps *a–f*, both the amplitude *a* and the harmonic relationship *m* are as desired but the retrace time or pulse width *w* is not as desired, this latter deficiency may then be corrected in accordance with the method of the present invention by performing an additional step *g* of adjusting the number of turns in the high-voltage winding **52** (FIG. **4**) to achieve the desired width or retrace time *w* of the pulse *p*. An increase of turns in the high-voltage winding **52** will increase the pulse width *w*, and vice versa. Repetition of the aforenoted step *f* may also be required after completion of this additional step *g* since a change in the number of turns in the high-voltage winding **52** will also cause a change in the equivalent high-voltage winding capacitance C_2 (FIG. **5**) and, hence, a change in the ratio of C_1/C_2.

Or, if, after completion of all of the aforedescribed steps *a–f*, it is impossible to obtain the desired harmonic relationship *m* of the pulse *p* through adjustment of the tuning capacitor **55** alone, this deficiency may then be corrected in accordance with the method of the present invention by performing an additional step *h* of adjusting the number of turns in the primary winding **51**. And, repetition of steps *f* and *g* may also be required after completion of this additional step *h*.

Or, if, after completion of the aforedescribed steps *a–f* and/or step *g* and/or step *h*, the observed amplitude *a* of the voltage pulse *p* is not as desired, it may be corrected to the desired level, in accordance with the method of the present invention, by performing yet another additional step *i* of adjusting the number of turns in the high-voltage winding **52**. And, repetition of one or all of the aforedescribed steps *f*, and/or *g*, and/or *h* may also be required after completion of this additional step *i*.

Once the desired tuning of the preliminary transformer has been obtained in accordance with the aforedescribed method of the present invention, the preliminary transformer is then deenergized and the auxiliary winding **50** is then added and construction of the transformer **10** is completed.

Thus, it should be apparent from the foregoing description that the present invention provides a novel method for tuning a novel slot-wound transformer, such as the transformer **10**, which can be accomplished by adjusting only three variables, the tuning capacitor **55**, the number of turns in the primary winding **51** and the number of turns in the high-voltage winding **52** and, hence, is greatly simplified over the complex methods that have previously been required to tune the conventional layer-wound transformers which have heretofore been employed.

It should be apparent that while there has been described what, at present, is considered to be the preferred embodiment of this invention in accordance with the Patent Statutes, changes may be made in the disclosed method without actually departing from the true spirit and scope of this invention.

I claim:

1. A method of tuning a high-voltage transformer for television receivers and the like wherein the primary and high-voltage windings are wound around and axially spaced from one another in a plurality of axially spaced circumferential slots provided on the exterior of hollow, electrically insulative coil-form means, the interior of which surrounds a portion of the transformer core means, said method comprising the steps of:

a. constructing a preliminary transformer with approximately the required number of turns of primary and high-voltage windings wound around and axially spaced apart from one another on the slotted coil-form means;

b. electrically connecting the primary winding to a primary load, such as the deflection yoke for a television receiver picture tube and the like;

c. electrically connecting a tuning capacitor in parallel with the primary winding;

d. electrically connecting the high-voltage winding to a secondary load, such as the high-voltage rectifier and the anode of a television receiver picture tube or the like;

e. electrically energizing and evaluating the preliminary transformer in terms of the shape of the primary winding voltage pulse;

f. adjusting the value of the tuning capacitor to thereby obtain as closely as possible the desired harmonic tuning of the primary winding voltage pulse; and

g. adjusting the inductive value of the primary or the high-voltage windings by adding or removing turns thereof from ones of said axially spaced circumferential slots of said coil form means to thereby obtain the desired harmonic tuning of the primary winding voltage pulse.

2. The method of claim **1**, wherein the number of turns in the high-voltage winding is varied to thereby obtain the desired width of the primary winding voltage pulse.

3. The method of claim **1**, wherein the number of turns in the primary winding is varied to thereby obtain the desired harmonic tuning of the primary winding voltage pulse.

4. The method of claim **1**, wherein the number of turns in the high voltage winding is varied to thereby obtain the desired amplitude of the primary winding voltage pulse.

5. A method of tuning a high-voltage transformer for television receivers and the like wherein the primary and high-voltage windings are wound around and axially spaced from one another in a plurality of axially spaced circumferential slots provided on the exterior of hollow, electrically insulative coil-form means, the interior of which surrounds a portion of the transformer core means, said method comprising the steps of:

a. constructing a preliminary transformer with approximately the required number of turns of primary and high-voltage windings wound around and axially spaced apart from one another on a slotted coil-form means;

b. electrically connecting the primary winding to a primary load, such as the deflection yoke for a television receiver picture tube and the like;

c. electrically connecting a tuning capacitor in parallel with the primary winding;

d. electrically connecting the high-voltage winding to a secondary load, such as the high-voltage rectifier and the anode of a television receiver picture tube and the like;

e. electrically energizing and evaluating the preliminary transformer in terms of the shape of the primary winding voltage pulse;

f. adjusting the value of the tuning capacitor to thereby obtain the desired harmonic tuning of the primary winding voltage pulse;

g. adjusting the number of turns in the high-voltage winding to thereby obtain the desired width of the primary winding voltage pulse; and

h. adjusting the number of turns in the primary winding to thereby obtain the desired harmonic tuning of the primary winding voltage pulse.

6. The method of claim 5, further comprising the additional step of: adjusting the number of turns in the high-voltage winding to thereby obtain the desired amplitude of the primary winding voltage pulse.

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