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[54] **HIGH-VOLTAGE INDUCTIVE COIL**

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[52] **U.S. Cl.** **336/70;** 336/84; 336/223

[51] **Int. Cl.** **H01f 27/28**

[58] **Field of Search** 336/70, 69, 84, 206, 223

[56] **References Cited**

UNITED STATES PATENTS

2,728,879 12/1955 Erikson 336/84

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[57] **ABSTRACT**

A high-voltage output coil for use in an ignition system transformer. The frequency of the input energy is on the order of 10,000 Hertz and is square-wave in form. The coil has a wide strip first turn for preventing insulation burn-out caused by radio-frequency current flow.

12 Claims, 3 Drawing Figures

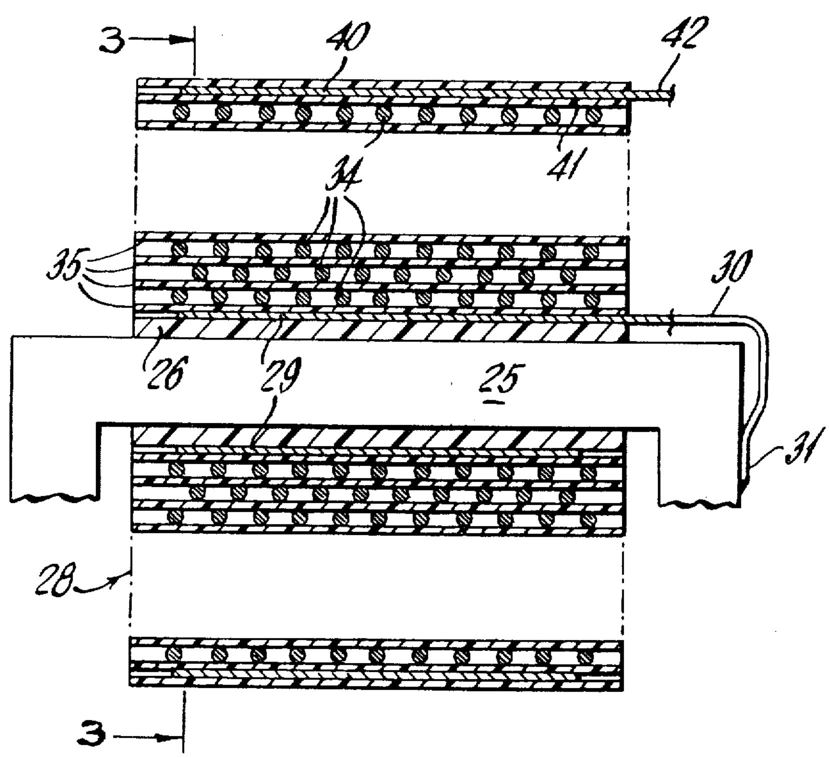


FIG. 1.
(PRIOR ART)

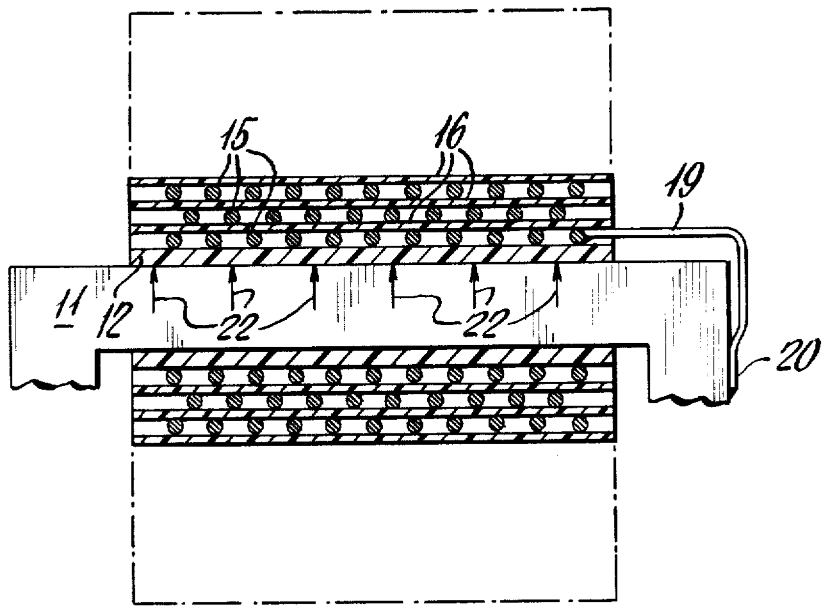


FIG. 2.

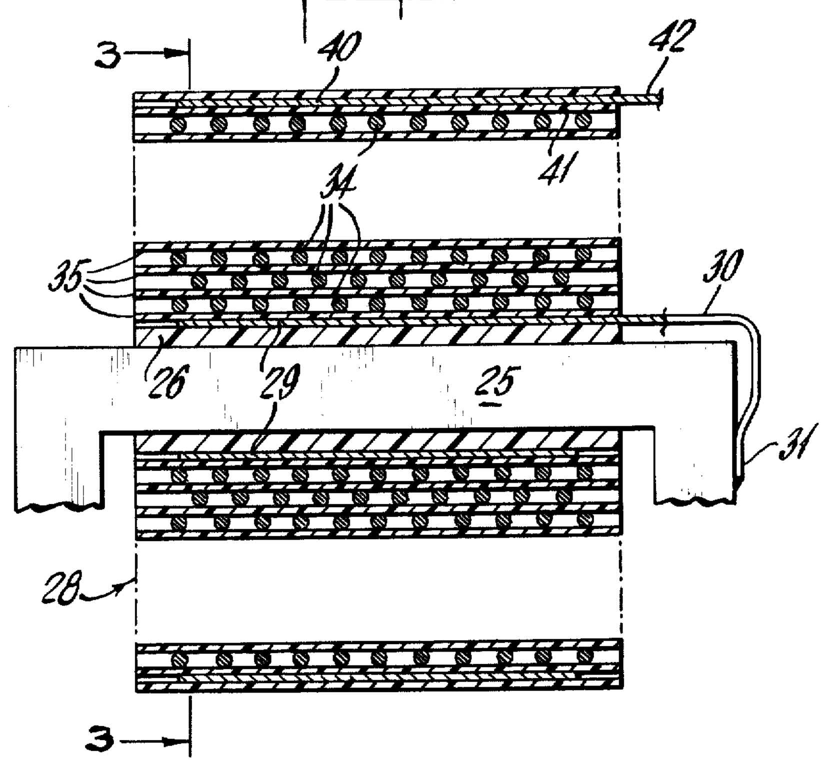
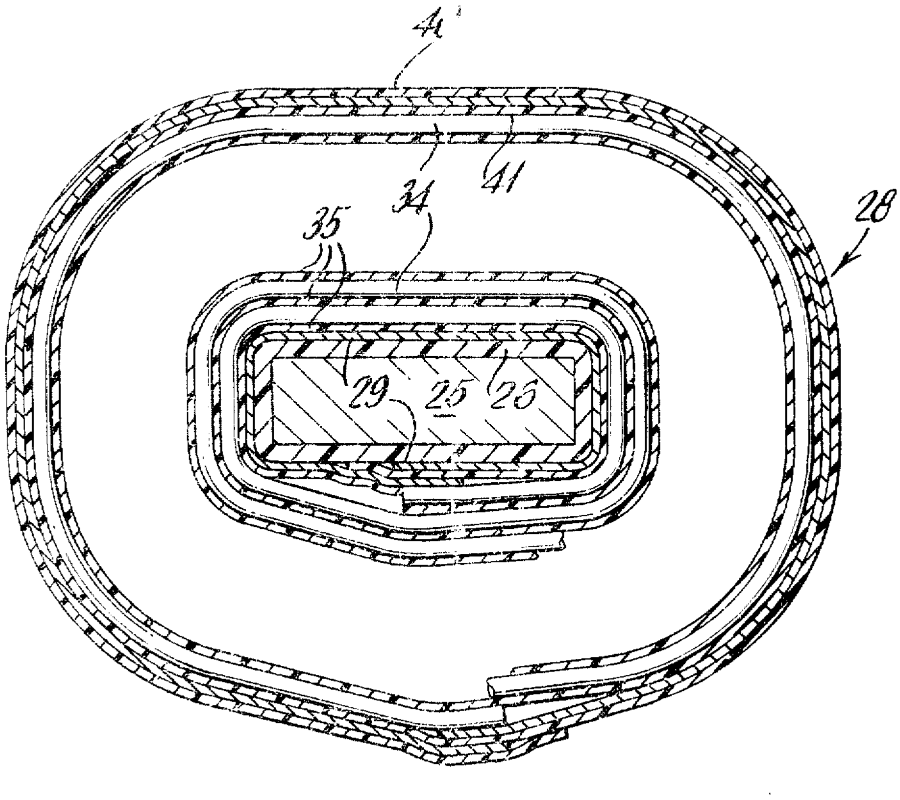


Fig. 3.



HIGH-VOLTAGE INDUCTIVE COIL

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention concerns inductive coil structure, in general. More specifically, it relates to an improvement for a high-voltage secondary winding of a transformer, e.g., a high-frequency, high-voltage transformer adapted to be used in ignition systems.

2. Description of the Prior Art

Heretofore, in the construction of a high-voltage, relatively low-current transformer of the type that was employed in an ignition system, there has been a difficulty that developed which resulted in burning out insulation. It caused short-circuiting of some inner turns of the transformer and consequent breakdown in its operation. It was particularly found to be true in ignition systems where the transformer is employed with a square-wave-type oscillator to develop a high-frequency spark output voltage.

The known type of winding structure employed an insulating sleeve designed to fit over a magnetic core and upon which a large number of turns would be wound. Thus, a large plurality of winding layers would be built up around the insulating sleeve, and the ends of such winding would be brought out for connection to an electrical output circuit. It was discovered that with such structure, when high-frequency square-wave signals were induced in the winding, there was a substantial build-up of radio-frequency energies that would cause breakdown or burn-out of the insulation between winding turns and layers of the windings.

It is an object of this invention to provide a first single turn of winding conductor that is made up of a wide conductive-material strip which extends over the entire width of the winding. It is a genuine first turn of the winding so that, thereafter, the multiple turns and plurality of layers of such turns are wound thereover.

SUMMARY OF THE INVENTION

Briefly, this invention concerns a high-voltage inductive coil. It comprises in combination a large plurality of windings including multiturn layers of an electrical conductor for developing a high-voltage output. The first turn of said windings comprises a unitary strip extending substantially over the entire width of said multiturn layers.

Again, briefly, the invention pertains to a transformer for use with an ignition system that employs a square-wave oscillator operating at a frequency on the order of 10,000 Hertz. The transformer employs a high-voltage output winding having means for avoiding insulation burn-out, which means and winding comprise a core tube for supporting said winding thereon, and the tube is adapted to receive a magnetic core therethrough. It also comprises a conductive-material strip having a beginning and an ending, and being at least as wide as said winding. The said strip is wound around said core tube with said ending overlapping said beginning. The output winding also comprises electrical insulation means for separating said overlapping portions of said strip. The said winding is wound over said strip with the inner end electrically connected to said strip ending so that said strip forms the first turn of said winding. The winding also comprises means for making an electrical circuit connection to the beginning of said strip.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects and benefits of the invention will be more fully set forth below in connection with the best mode contemplated by the inventors of carrying out the invention, and in connection with which there are illustrations provided in the drawings, wherein:

FIG. **1** is a schematic cross-sectional view illustrating the prior art; and

FIG. **2** is a schematic cross-sectional view illustrating transformer-winding structure according to the invention, and

FIG. **3** is a transverse cross-sectional view taken along the lines **3—3** of FIG. **2**, looking in the direction of the arrows.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In connection with ignition systems which employ high-frequency continuous-wave spark energy, and particularly where the energy is square-wave in form, difficulties have been encountered in the structure relating to the output winding of the transformer which delivers the spark signals to the distributor. The basic operating frequency, under load, of such ignition systems is on the order of 10,000 Hertz, and because the output wave form is essentially a square-wave, there are harmonics present which reach several megahertz.

It is to be understood that the term "Hertz" has been accepted as meaning — cycles per second — in connection with electromagnetic waves of all sorts. Consequently, the term "megahertz," of course, means millions of cycles per second. Such meanings will be attributed throughout this application unless a contrary meaning is clearly expressed.

In ignition systems for use with internal combustion engines, the foregoing radio-frequency harmonics have been found to be present on the whole engine and associated equipment. The ground return for such radio-frequency energy is through the frame of the total ignition system equipment and to the ground strap of the transformer which has the foregoing output winding thereon. However, it was found that the magnitude of the radio-frequency energies was sufficient that sparks could be drawn quite widely over the whole engine assembly. Furthermore, it was found that this radio-frequency energy included a path such that there would be current flow by capacitive action from the core laminations of the transformer to the winding layers of the transformer beginning with the first. Of course, the potential gradient would increase as the electrical distance from the ground potential became greater, and experience indicated that current flow was great enough near the far end of the first winding layer to destroy the insulation on the wires and cause short-circuited turns. Such short-circuited turns caused the ignition system to become inoperative.

Although it was found that the location where the foregoing burn-out of insulation occurred was only about 200–250 turns above ground out of a total number of 9,000 or so on the output winding of the transformer, and the potential of the fundamental frequency at that location was less than 1,000 volts peak above ground, it was discovered that the radio-frequency potentials reached much greater amplitudes than that, as indicated by the burn-outs. However, by employing this invention which pertains to the first turn of the winding, burn-outs may be prevented.

In order to fully understand the invention, reference may first be had to FIG. **1** which illustrates prior art. Thus, heretofore, a transformer output winding of the type applicable to this invention, was wound over a magnetic core **11.** However, the winding was first accomplished by winding on the outside of an insulating-material sleeve **12** that is adapted to fit over the core **11.** A plurality of layers of winding turns **15** would be wound over the sleeve **12** in a conventional manner.

It will be understood that the drawing is schematic and not to scale. Also, the spacing between individual turns **15** of the winding layers is greatly exaggerated, and actually individual winding turns **15** would be insulated from one another by having a conventional coating (not shown) on the wire filaments. However, individual layers of windings **15** are insulated from one another by layers of insulation **16,** as illustrated. It will be understood that the free end of the first turn of windings **15** is brought out for making an electrical connection. Of course, this may be done in any feasible manner, e.g., as indicated, by a wire **19** which is shown connected to electrical ground by having good metal-to-metal contact with the core **11** at a point **20** indicated.

As indicated previously, the prior art structure was subject to a build-up of radio-frequency energies between the winding turns **15** and the ground potential of the core **11** so that radio-frequency currents would flow through the insulating sleeve **12,** as indicated by the arrows **22** in FIG. **1.** It was found that these currents soon became destructive and caused burn-out of the transformer.

FIG. **2** illustrates a transformer coil structure according to this invention and in a similarly schematic manner as the showing of FIG. **1.** Thus, the spacing between individual turns of the winding is greatly exaggerated, and the drawing is generally not to scale.

In FIG. **2,** it will be observed that the transformer structure illustrated includes a magnetic core **25** that may be a conventional laminated magnetic material. Surrounding the core **25,** there is an insulating-material sleeve **26.** It takes the form of a so-called core tube which is adapted for being fitted closely over the core **25.** Such tube **26** may be constructed of any appropriate insulating material, e.g., a good insulating grade of fiber or paper board. Surrounding sleeve **26,** there is a conductive-material strip **29** that is made of any good conductor, e.g., copper. It has a width sufficient to extend substantially the entire width of a coil **28** that is wound thereover.

Strip **29** forms the first complete turn of the transformer winding **28,** and it has a beginning and an ending with sufficient length to complete at least a full turn around the sleeve **26** with some overlap. However, there is insulation provided between the overlapping ends so that the strip **29** is not merely a continuous shield, but acts as the first turn of the winding.

Connected to the beginning of strip **29,** by any feasible means, there is a conductor **30.** It is carried out through the sleeve or core-tube structure for making electrical connection to the inner end of the coil. Thus, as illustrated in FIG. **2,** the conductor **30** is grounded by having good electrical connection to core **25.** This is schematically indicated by a contact point **31** at the end of the conductor **30.** It will be appreciated that other arrangements for making desired electrical connection to the beginning end of the strip **29** might be used. Such other arrangements include the bringing of a narrow portion (not shown) of the strip through the insulating sleeve **26** so as to make good electrical contact with the surface of the core **25.** This would mean cutting a slit (not shown) in the sleeve **26** to permit the narrow portion (not shown) of the strip to extend through, and make intimate contact with the core **25** on the inside of the sleeve or core tube **26.** However, such an arrangement would be quite clear to anyone skilled in the art, and no specific illustration thereof has been made.

After the strip **29** has been wound around the sleeve **26** for a complete turn, it is continued far enough to have some overlap (not ilustrated). Also, some insulation is provided at the area of overlap. This creates a first turn of the transformer winding without any short-circuiting thereof.

Connected to the outside overlapping end of strip **29** is an end of an electrically conductive-material filament which is employed in winding additional turns, e.g., windings **34,** as illustrated. Successive winding layers of the filaments **34** are separated by insulating-material layers **35.** This insulation is conventional in form and substance. It may be made of an appropriate type of electrically insulating paper having the full width of the winding structure.

It may be noted that a transformer according to this invention, which is particularly for use in an ignition system, will be constructed with a total number of turns on the order of 9,000.

In addition to employing the wide first-turn radio-frequency current-shunting effect, described above, a transformer according to this invention may also make use of a similar last complete turn. For example, in FIG. **2,** there is a conductive strip **40** that has its inner end connected to the last of the filament turns **34.** There is an insulating layer, e.g., layer **41** that separates the overlap of strip **40** as it goes around far enough to make the full outer turn of the windings. At the outer, or free end of strip **40,** there is an electrical conductor **42** which is brought out in a conventional manner for making the electrical connection to the output circuit of the transformer. Use of a wide outer turn to obtain anticorona effects has been employed in the subject type of transformer construction as shown in U.S. Pat. No. 3,394,331 which is assigned to the same assignee as this invention. However, there was no concept relevant to a total transformer structure according to this invention.

While the invention has been described above in considerable detail and in accordance with the applicable statutes, this is not in any way to be taken as limiting the invention but merely as being descriptive thereof.

We claim:

1. High-voltage AC inductive coil, comprising in combination

a large plurality of winding turns beginning at the inside of said coil and including multi-turn layers of an electrical conductor for developing a high-voltage output,

the first turn of said winding turns comprising a unitary strip having a beginning and an ending and extending laterally substantially the entire width of said multiturn layers, said ending overlapping said beginning and being insulated at said area of overlap, and means for connecting a lead conductor to said beginning of the first turn.

2. An inductive coil according to claim 1, further comprising

first electrically insulating sleeve means for supporting said windings and being adapted to receive a magnetic core therein.

3. An inductive coil according to claim 2, further comprising

second insulating means located between each of said layers, and

third insulating means for separating each turn of said conductor from the others.

4. An inductive coil according to claim 3, further comprising

electrically conductive means for connecting said lead conductor of said first turn to ground.

5. An inductive coil according to claim 4, wherein

said conductive means is connected to said magnetic core.

6. An inductive coil according to claim 3, further comprising

at least a last turn of said winding turns comprising a unitary strip having a beginning and an ending and extending laterally substantially the entire width of said multiturn layers, said ending overlapping said beginning and being insulated at said area of overlap, and

means for connecting a lead conductor to the outside end of said coil.

7. An inductive coil according to claim 4, further comprising

at least a last turn of said winding turns comprising a unitary strip having a beginning and ending and extending laterally substantially the entire width of said multiturn layers, said ending overlapping said beginning and being insulated at said area of overlap, and

means for connecting a lead conductor to the outside end of said coil.

8. An inductive coil according to claim 5, further comprising

at least a last turn of said winding turns comprising a unitary strip having a beginning and and ending and extending laterally substantially the entire width of said multiturn layers, said ending overlapping said beginning and being insulated at said area of overlap, and

means for connecting a lead to the outside end of said coil.

9. High-voltage AC inductive coil adapted for use in a secondary winding of a transformer for use in an ignition system including a continuous square-wave-type oscillator, comprising in combination

a large plurality of winding turns beginning at the inside of said coil and including multiturn layers of an electrical conductor for developing a high-voltage output,

at least the first complete turn of said winding turns comprising a unitary strip having a beginning and an ending and extending laterally substantially the entire width of said multiturn layers, said ending overlapping said beginning and being insulated at said area of overlap,

means for connecting a lead conductor to said beginning of the first turn,

an electrically insulating sleeve for having said windings wound thereon and adapted to receive a magnetic core therein,

an insulating-material layer located between each of said winding layers,

insulating means for separating each of said turns from the others,

at least a last complete turn of said winding turns comprising a unitary strip having a beginning and an ending and extending laterally substantially the entire width of said multiturn layers and said ending overlapping said beginning and being insulated at said area of overlap, and

means for connecting a lead to the outside end of said coil,

an electrically conductive lead connector for making an electrical connection between said beginning of said first turn and ground,

said ground including said magnetic core.

10. In a transformer for use with an ignition system, employing a square-wave oscillator operating a frequency on the order of 10,000 Hertz, a high voltage AC output winding having means for avoiding insulation burnout, comprising

a core tube for supporting said winding thereon and adapted to receive a magnetic core therethrough,

a conductive-material strip forming the inside first turn of said winding and having a beginning and an ending and being at least as wide as said winding,

said strip being wound around said core tube with said ending overlapping said beginning,

electrical insulating means for separating said overlapping portions of said strip,

the remainder of said winding being wound as multiturn layers in continuation of said first turn and lying over said strip with the inner end thereof being electrically connected to said strip ending so that said strip forms the first turn of said winding, and

means for making an electrical circuit connection to the beginning of said strip.

11. The invention according to claim 10, wherein

said means for making an electrical circuit connection comprises a circuit connection to said magnetic core.

12. The invention according to claim 11, wherein said means for avoiding insulation burn-out also comprises

a second conductive-material strip forming at least the last turn of said winding and having a beginning and an ending and being at least as wide as said winding,

said second strip being wound around the outside of said winding with said beginning electrically connected to the outside end of said winding,

said second strip being more than one full turn of said winding and

electrical insulating means for separating said overlapping portions of said second strip.

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