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PULSE TRANSFORMER

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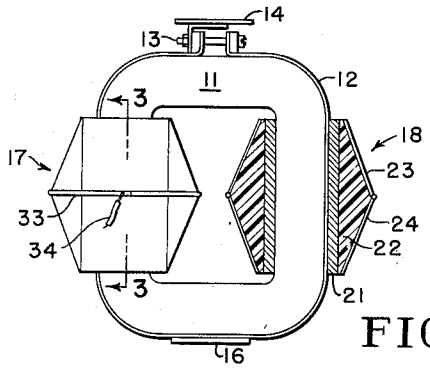


FIG. 1

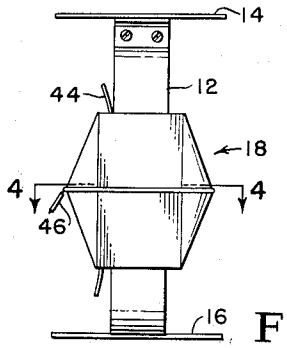


FIG. 2

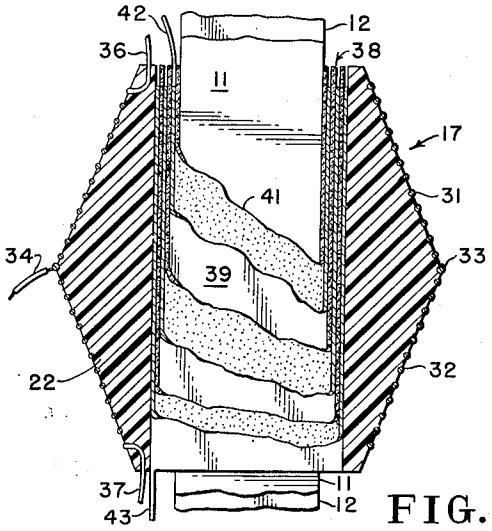


FIG. 3

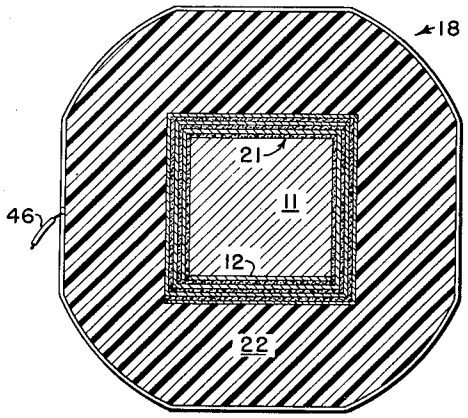


FIG. 4

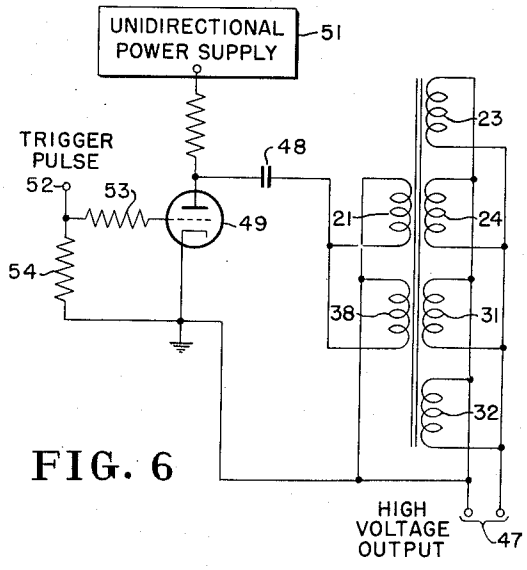


FIG. 6

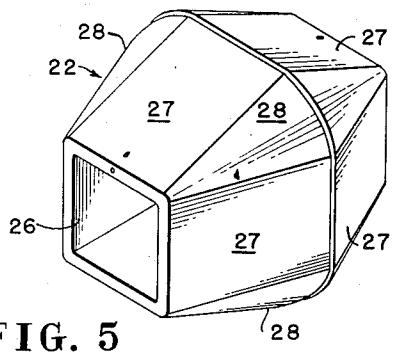


FIG. 5

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PULSE TRANSFORMER

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7 Claims. (Cl. 336—220)

The present invention relates generally to an improvement in transformers and more specifically to a small light weight transformer particularly adapted as a pulse transformer.

In the generation and transmission of fast electrical pulses very exacting requirements are imposed upon the component circuit elements and conventional transformers are normally unsatisfactory in this respect. A pulse transformer should have a low impedance and a very small time constant in order to produce a pulse having a very short rise time and to transmit fast pulses without undue distortion. In order to minimize the transformer time constant it is necessary that the transformer have a low leakage inductance and a small distributed capacitance.

The present invention provides a pulse transformer having a small leakage inductance and distributed capacitance so that the transformer time constant is minimized, the rise time of the output pulse is short and the transformer impedance is small. Further, the pulse transformer of the present invention is very compact and light weight so as to be particularly adaptable for use in circumstances where weight and space are of importance. The above advantages of the invention are provided by the accomplishment of the following objects.

It is an object of the present invention to provide an improved pulse transformer having single layer helically wound secondary windings minimizing the transformer distributed capacitance.

It is another object of the present invention to provide an improved pulse transformer having the secondary winding separated a minimum distance from the primary winding consistent with insulation requirements to minimize the leakage inductance.

It is a further object of the present invention to provide an improved pulse transformer having a plurality of secondary windings disposed at an angle to the primary winding for reducing the size, weight and leakage inductance of the transformer.

It is a still further object of the present invention to provide an improved pulse transformer having a conical coil frame about which is wound a helical secondary winding.

Numerous other advantages and possible objects of the invention will become apparent from the following description of the invention taken together with the attached drawings illustrating a preferred embodiment thereof and wherein:

Figure 1 is a side elevation of the complete pulse transformer with one winding unit in schematic section;

Figure 2 is an end elevation of the transformer;

Figure 3 is a sectional view taken at 3—3 of Figure 1 and showing one winding unit with the primary winding thereof broken away;

Figure 4 is a sectional view taken at 4—4 of Figure 2 and showing a single winding unit;

Figure 5 is a projected view of a coil frame; and

Figure 6 is a wiring diagram of a pulse circuit including the pulse transformer of the present invention.

Considering now the structure of the illustrated embodiment of the invention and referring to the above-noted drawings, there will be seen to be provided a core 11 formed of material having good magnetic properties, such as hypersil or the like. Core 11 has a square cross section and is formed in a closed loop with straight sides. Mounting of the transformer may be facilitated by providing a core bracket 12 disposed about the outer edge of core 11 and having upstanding ends disposed adjacent each other at the top of core 11 and secured together by bolts 13, a top mounting plate 14 being attached to the core bracket 12 by bolts 13 through the upstanding ends thereof. An additional mounting plate 16 may be secured to the outside of core bracket 12 at the bottom of core 11 so that the core and attached elements may be firmly mounted in any desired position. A pair of like winding units 17 and 18 are disposed one about each of the upstanding sides of core 11 and, as shown generally in Fig. 1, the winding unit 18 for example includes a primary winding 21 wound about a portion of core 11, a coil frame 22 disposed about primary winding 21 and included portion of core 11, and a pair of secondary windings 23 and 24 wound upon coil frame 22.

With regard to the composition of a single winding unit 17, the coil frame 22, as shown in Fig. 5, is formed of an insulating material such as a plastic and has a square axial aperture 26 therethrough. Coil frame 22 has the external configuration of two truncated cones joined at their base, in other words the maximum diameter of coil frame 22 is found at the center thereof and the frame tapers symmetrically therefrom to end diameters only slightly larger than the width of axial aperture 26. While the cones of coil frame 22 may have a circular cross section, it is preferable to form flat surfaces 27 upon the outer surface of frame 22 which are projections of the sides of axial frame aperture 26. These flat surfaces 27 are joined by curved surfaces 28 so that in cross section coil frame 22 resembles a modified square with the corners rounded. Flat surfaces 27 are longitudinally inclined with respect to the respectively adjacent sides of axial frame aperture 26; however, each transverse section of frame 22 finds the external flat surface parallel with the adjacent aperture side.

There are wound upon each of the cones of the coil frame 22 a helical winding and these windings 31 and 32 are wound oppositely in a single layer upon the outer surface of coil frame 22. The individual turns of each of the helical windings may be separated slightly to improve the insulating properties of the winding, and as an aid to winding the coils upon the frame there may be provided a small helical groove about each of the cones of the coil frame. At the maximum diameter of the coil frame, i. e., a juncture of the two cones thereof, there is disposed a corona ring 33 formed of heavy metal wire or the like extending about the coil frame and having the adjacent end of each of the helical windings 31 and 32 electrically connected thereto. A conductor 34 is attached to corona ring 33 and provides the high voltage terminal of the transformer. The opposite ends of helical windings 31 and 32 are disposed a short distance from the ends of coil frame 22 and may be led through a small aperture disposed at each end of coil frame 22 and extending from the outer surface thereof to the end surface thereof. These coil ends 36 and 37 disposed at the ends of coil frame 22 comprise a low voltage terminal of the winding unit 17 and for most applications may be electrically grounded. Within coil frame 22 and about core 11 extending through the axial aperture coil frame 22, there is disposed a strip winding 38. This strip winding 38 is composed of alternate layers of strip electrical conductor

39 and strip electrical insulator 41 with insulator 41 having the same width as the coil frame length and conductor 39 preferably having a slightly lesser width, as shown. The winding 38 is wound about core 11 and extends from core 11 to the sides of the axial aperture 26 through coil frame 22. A conductor or lug 42 is connected to the end of the strip winding conductor 39 adjacent coil 11 and a second conductor or lug 43 is connected to the outer end of this winding conductor with the latter being adapted as a ground connection in the manner of the coil ends 36 and 37. Strip winding 38 has the insulating layer 41 disposed immediately about core 11 so that the inner end of strip conductor 39 is maintained out of electrical contact with core 11 whereby conductor 42 may be energized above ground level.

It will be appreciated from the foregoing description of winding unit 17 that the single layer helical windings 31 and 32 constitute secondary windings analogous to windings 23 and 24 of winding unit 18, while strip winding 38 constitutes the primary winding analogous to winding 21 of winding unit 18. Secondary windings 31 and 32 are disposed upon coil frame 22 with successive turns thereof displaced an increasing distance from primary winding 38 along the coil frame 22 from the outer ends thereof to corona ring 33 disposed at the maximum diameter of frame 22. Thus the insulation disposed between the secondary windings 31 and 32 and the primary winding 38 increases from a minimum amount at the low voltage ends 36 and 37 to a maximum amount at the high voltage end 34. A transformer designed in accordance with these principles for any particular job thus has exactly the right amount of insulation between the primary and secondary windings to prevent electrical breakdown at all points thereof and yet these windings are disposed as closely to each other as possible. By increasing the separation of the primary and secondary windings from the low voltage to high voltage ends, the insulating properties are preserved while the spacing is minimized. With a minimum separation of primary and secondary windings the leakage inductance of each winding unit of a transformer is minimized. The use of single layer secondary windings with a small potential difference between adjacent turns thereof minimizes the distributed capacitance as does the use of wire wound rather than strip wound secondary windings.

With regard to the electrical connections of the invention, certain variations thereof are possible in accordance with the particular application to which the invention is to be placed. Typical connections might include the connection of primary winding lug 43 to secondary winding coil ends 36 and 37 and a grounding of this connection. A similar connection of like elements would be made in the winding unit 18 and the primary winding lug 42 of winding unit 17 would be connected to a similar lug 44 on winding unit 18, while the high voltage connector 34 of winding unit 17 would be connected to a similar conductor 46 on winding unit 18. With these connections the winding units 17 and 18 are electrically connected in parallel, which thereby provides a further reduction in leakage inductance to approximately one-fourth the inductance of the same four secondary windings connected in series. A typical application of the invention might be in a pulsed circuit, as illustrated in Fig. 6, wherein the high voltage conductors 34 and 46 of the secondary windings of units 17 and 18 are connected to one pole of an output terminal 47, the other pole thereof being connected to secondary coil ends 36 and 37 and grounded. The primary windings 21 and 38 have their low voltage ends connected to the grounded pole of output terminal 47 and their high voltage ends 42 and 44 connected through a capacitor 48 to the anode of the gaseous discharge tube 49. A unidirectional power supply 51 is connected through a resistor to the anode of tube 49 and there is applied to an input terminal 52 a trigger pulse. Input terminal 52 is connected to the control grid of discharge tube 49 through a resistor 53 and is grounded through a resistor 54. In operation of the above-described circuit, an input trigger pulse at terminal 52 triggers discharge tube 49 which thereby conducts and causes a current flow in the primary windings 21 and 38 of the transformer. There is thus induced in the secondary windings of winding units 17 and 18 a current flow which produces a voltage pulse at output terminal 47. By virtue of the above-described and illustrated structure of the invention, the time constant of the transformer is minimized and therefore the rise time of the output pulse may be made very short. Further, the impedance of the transformer is very low inasmuch as impedance is a function of inductance and capacitance, both of which, as stated above, are minimized in the transformer in the present invention. Aside from the noted electrical advantages of the invention, there is further provided a great saving in weight and size, inasmuch as the particular structure of the invention is very compact and utilizes a minimum of materials.

Although the present invention has been described in connection with a single preferred embodiment thereof, it will be appreciated by those skilled in the art that numerous modifications and variations are possible within the spirit and scope of the invention and thus it is not intended to limit the invention except by the terms of the following claims.

What is claimed is:

1. An improved pulse transformer comprising a conical coil frame formed of insulating material and having an axial aperture therethrough, a magnetically permeable core, a primary winding formed of a few turns of strip electrical conductor and sheet insulation wound radially about said core, said primary winding and core being disposed within said coil frame aperture, and a single layer secondary winding formed of electrical conductor helically wound about said coil frame along said core and adapted to have the end thereof closest to said core connected to one end of said primary winding.

2. An improved pulse transformer comprising an insulating coil frame, said frame having the shape of a pair of truncated cones with the bases joined and having an axial aperture therethrough, an elongated magnetically permeable core, a primary winding wound about said core and including alternate layers of sheet electrical conductor and insulation, said core and primary winding being disposed in engagement with said frame through the aperture therein, and a pair of single layer secondary windings wound about the outside said coil frame on opposite conical surfaces thereof and adapted for connection together at the cone bases.

3. An improved pulse transformer comprising a magnetically permeable core formed in a closed loop, a pair of separated primary windings wound about said core with each including alternate layers of sheet conductor and insulation, a pair of electrically nonconducting coil frames each having an axial aperture therethrough and being tapered from the center radially inward at the ends, said coil frames each being disposed with said core and a primary winding through the aperture therein, and a pair of single layer secondary windings wound about each of said coil frames, the two windings on each of said coil frames being connected together at the frame center and to the center connection of the other two coils to form a high voltage transformer terminal.

4. An improved high voltage pulse transformer comprising an insulated coil frame having an outer configuration of two truncated cones joined at their bases and having an axial aperture therethrough, a core formed of material having good magnetic permeability disposed through said coil frame aperture, a primary winding about said core within said coil frame and including a few insulated turns of sheet conductor having substantially the same width as said coil frame length, said winding being adapted for connection to an external pulsed circuit, and a pair of secondary windings disposed one about each conical portion of said coil frame and electrically

connected at the maximum diameter thereof to form a high voltage secondary winding terminal, said secondary windings having a small thickness radially of said coil frame and the ends of said secondary windings at the minimum diameters of said coil frame being connected together to form a low voltage secondary winding terminal.

5. A pulse transformer comprising a laminated core forming a closed magnetic circuit and having a rectangular cross section, a first winding including a few insulated turns of sheet conductor about said core, a solid coil frame formed of insulating material having an axial aperture therethrough disposed about said core and first winding, said coil frame having an external configuration of two frustrums joined at their bases, and a pair of thin second windings having a large number of turns wound circumferentially about said coil frame with one on each frustrum thereof, said second windings being electrically connected at the ends adjacent the maximum coil frame diameter and electrically connected together at the ends adjacent the minimum coil frame diameters, said connections forming the transformer secondary winding terminals.

6. A pulse transformer as claimed in claim 5 further defined by said axial coil frame aperture having a rectangular cross section, said core also having a rectangular cross section whereby said coil frame engages said first winding about said core, and said coil frame having external planar surfaces aligned with the core sides and connected by curved surfaces whereby said first and second windings are separated an increasing distance from low to high voltage ends of said second winding and the winding separation is minimized consistent with required insulation therebetween.

7. A pulse transformer comprising a magnetically permeable core shaped as a closed loop and having a rectangular cross section, a pair of separated insulating coil frames having axial apertures therethrough and disposed about said core, said frames being disposed on opposite sides of said core loop with said core through the apertures therein, each of said coil frames having an external configuration of two frustrums joined at their bases and having flat sides lying upon projections of the core sides, a pair of strip windings disposed one within each coil frame and wound about the core therethrough, and two pairs of single layer windings with each winding being separately disposed about a conical portion of a coil frame, and the coil ends disposed at the maximum diameter of the coil frames being adapted for connection together to form a high voltage transformer terminal.

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