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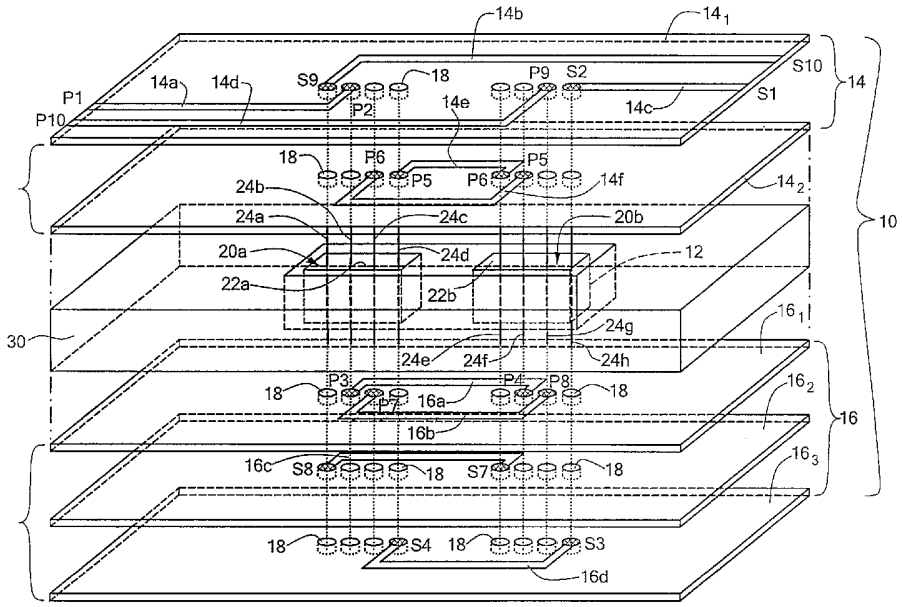

(57) Abstract: An electrical transformer is described having a core disposed between a pair of dielectrics, each having a plurality of electrically isolated electrical conductor segments disposed on each one of a plurality of electrically isolated levels. The core has an aperture therein which extends between the first and second dielectric with a dielectric body disposed in the aperture. The body has disposed therein a plurality of third electrically isolated electrical conductor segments with first ends electrically connected to the plurality of first electrically isolated electrical conductor segments and second ends are electrically connected to the plurality of second electrically isolated electrical conductor segments which are used as windings of the transformer.

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ELECTRICAL TRANSFORMER

TECHNICAL FIELD

This invention relates to electrical transformers, and more particularly to compact electrical transformers.

BACKGROUND

As is known in the art, electrical transformers have a wide variety of applications. The transformer includes a primary winging and an adjacent secondary winding. Changes in electrical current passing through the primary winding induce a corresponding change in a magnetic field around the primary winding. This changing magnetic field induces a corresponding change in current in the adjacent, magnetically coupled secondary winding.

As is also known in the art, it is desirable to reduce the size of the transformer.

SUMMARY

In accordance with the present invention, an electrical transformer is provided having a first dielectric. The first dielectric includes a plurality of first electrically isolated electrical conductor segments. A second dielectric is disposed over, and in registration with, the first dielectric, such second dielectric having a plurality of second electrically isolated electrical conductor segments disposed on the second dielectric. The transformer includes a core having an aperture therein, such aperture extending between the first and second dielectrics. A plurality of third electrically isolated electrical conductor segments is provided. First ends of the third electrically isolated electrical conductor segments are electrically connected to the plurality of first electrically isolated electrical conductor segments and second ends of the third electrically isolated electrical conductor segments are electrically connected to the plurality of second electrically isolated electrical conductor segments to provide a portion of a primary winding and a portion of a secondary winding for the transformer. The primary winding comprises first ones of the first electrically isolated electrical conductor segments, first ones of the second electrically isolated electrical conductor segments, and first ones of the third electrically isolated electrical conductor segments. The secondary winding comprises second ones of the first electrically isolated electrical conductor segments, second

ones of the second electrically isolated electrical conductor segments, and second ones of the third electrically isolated electrical conductor segments.

In one embodiment, the first and second dielectrics comprise multilevel printed circuit boards.

In one embodiment, the first and second multilevel printed circuit boards are disposed in a pair of overlaying planes and the plurality of third electrically isolated electrical conductor segments are disposed perpendicular to the overlaying planes.

In one embodiment, the primary and secondary winding provide loops around the core.

In one embodiment, the third electrically isolated electrical conductor segments are embedded within the core.

In one embodiment, the core comprises a toroidal shaped body and the dielectric body is disposed in a central region of the toroidal shaped body.

In accordance with another feature of the invention, an electrical transformer is provided having a first multilayer printed circuit board. The first multilevel printed circuit board includes a plurality of first electrically isolated electrical conductor segments disposed on each one of a plurality of electrically isolated levels of such first multilevel printed circuit board. A second multilayer printed circuit board is, disposed over, and in registration with, the first multilevel printed circuit board. The second multilevel printed circuit board has a plurality of second electrically isolated electrical conductor segments disposed on each one of a plurality of electrically isolated levels of such second multilevel printed circuit board. A pair of dielectric bodies is disposed between the first multilevel printed circuit board and the second multilevel printed circuit board. Each one of such bodies has disposed therein a plurality of third electrically isolated electrical conductor segments. First ends of the third electrically isolated electrical conductor segments are electrically connected to the plurality of first electrically isolated electrical conductor segments and second ends of the third electrically isolated electrical conductor segments are electrically connected to the plurality of second electrically isolated electrical conductor segments to provide a primary winding and a secondary winding for the transformer. The primary winding comprises a first ones of the first electrically isolated electrical conductor segments, first ones of the second electrically isolated electrical conductor segments, and first ones of the third electrically isolated electrical conductor segments. The secondary winding comprises second ones of the

first electrically isolated electrical conductor segments, second ones of the second electrically isolated electrical conductor segments, and second ones of the third electrically isolated electrical conductor segments.

In accordance with another feature of the invention, an electrical transformer structure is provided. The structure includes a first multilayer printed circuit board having a plurality of first electrically isolated electrical conductor segments disposed on each one of a plurality of electrically isolated levels of such first multilevel printed circuit board. The structure includes a second multilayer printed circuit board, disposed over, and in registration with, the first multilevel printed circuit board. The second multilevel printed circuit board has a plurality of second electrically isolated electrical conductor segments disposed on each one of a plurality of electrically isolated levels of such second multilevel printed circuit board. A dielectric spacer member is disposed between the first multilevel printed circuit board and the second multilevel printed circuit board. The spacer member has a plurality of apertures therethrough. The apertures in the spacer member pass between a top and a bottom surface of the spacer member. A plurality of toroidal shaped cores is provided. Each one of such cores is disposed in a corresponding one of the plurality of apertures of the dielectric spacer member. Each one of the cores has an aperture therein, the apertures of the cores being coaxial with the apertures in the dielectric spacer member. A plurality of dielectric bodies is provided. Each one of such dielectric bodies is disposed in a corresponding one of the apertures in the cores. A plurality of plurality of dielectric bodies has a corresponding one of the sets of third electrically isolated electrical conductor segments. First ends of the third electrically isolated electrical conductor segments are electrically connected to the plurality of first electrically isolated electrical conductor segments and second ends of the third electrically isolated electrical conductor segments are electrically connected to the plurality of second electrically isolated electrical conductor segments to provide a primary winding and a secondary winding for the transformer. The primary winding comprises first ones of the first electrically isolated electrical conductor segments, first ones of the second electrically isolated electrical conductor segments, and first ones of the third electrically isolated electrical conductor segments. The secondary winding comprises second ones of the first electrically isolated electrical conductor segments, second ones of the second electrically isolated electrical conductor segments, and second ones of the third electrically isolated electrical conductor segments.

The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

DESCRIPTION OF DRAWINGS

FIG. 1 is a an exploded view of an electrical transformer according to the invention;

FIG. 2 is an exploded view of a core and a pair of dielectric bodies having electrical conductor segments therein used in the transformer of FIG. 1;

FIG. 3 is an exploded view of the assembled core and a pair of dielectric bodies having electrical conductor segments therein of FIG. 2 and a dielectric spacer used in the transformer of FIG. 1;

FIG. 4 is a an exploded view of an electrical transformer according to another embodiment of the invention;

FIG. 5 is a top view of a dielectric body having electrical conductor segments therein used in the transformer of FIG. 4;

FIG. 6 is cross-sectional view of the dielectric body having electrical conductor segments therein of FIG. 5, such cross section being taken along line 6-6 in FIG. 5;

FIG. 7 is top view of a transformer according to another embodiment of the invention, such transformer having an array of the dielectric bodies having electrical conductor segments therein of FIG. 5, such top view showing only a partial routing of primary winding used in such transformer; and

FIG. 8 is a schematic diagram of primary and second winding segments connected to provide the transformer of FIG. 7.

DETAILED DESCRIPTION

Referring now to FIG. 1, an electrical transformer 10 is shown having a core 12, here, for example, a ferrite core, disposed between a pair of dielectrics 14, 16, here, for example, a pair of multilevel printed circuit boards 14, 16 as shown. The first multilayer printed circuit board 14 has a plurality of first electrically isolated electrical conductor segments 14a-14f disposed on each one of a plurality of electrically isolated levels, or dielectric boards 14_1 and 14_2 of such first multilevel printed circuit board 14. Thus, electrically isolated electrical conductor segments 14a-14d are on different electrically isolated regions of dielectric board

14_1 of board 14 and electrically isolated electrical conductor segments 14e and 14f are on different electrically isolated regions of dielectric board 14_2 of board 14.

The second multilayer printed circuit board 16 is disposed under, and is in registration with, the first multilevel printed circuit board 14. The second multilevel printed circuit board has a plurality of second electrically isolated electrical conductor segments 16a-16d disposed on each one of a plurality of electrically isolated levels of such second multilevel printed circuit board 16. Thus, electrically isolated electrical conductor segments 16a and 16b are on different electrically isolated regions of dielectric board 16_1 of board 16, electrically isolated electrical conductor segment 16c is on dielectric board 16_2 of board 16, and electrical conductor segment 16d is on dielectric board 16_3 of board 16. Each one of the boards has electrically conductive plated through holes, one portion of the plated through holes being indicated by the numerical designation 18 and the other portion being indicated by the designation S_2-S_9 and P_2-P_9.

It is noted that:

electrically conductive segment 14a has ends thereof connected between port P_1 and plated through hole P_2;

electrically conductive segment 14b has ends thereof connected between plated through hole S_9 and port S_{10};

electrically conductive segment 14c has ends thereof connected between plated through hole S_2 and port S_1;

electrically conductive segment 14d has ends thereof connected between plated through hole P_9 and port P_{10};

electrically conductive segment 14e has ends thereof connected between plated through hole S_5 and plated through hole P_5;

electrically conductive segment 14f has ends thereof connected between plated through hole P_6 and plated through hole P_5;

electrically conductive segment 16a has ends thereof connected between plated through hole P_3 and plated through hole P_4;

electrically conductive segment 16b has ends thereof connected between plated through hole P_7 and plated through hole P_8;

electrically conductive segment 16c has ends thereof connected between plated through hole S_8 and plated through hole S_7; and

electrically conductive segment 16d has ends thereof connected between plated through hole S_4 and plated through hole S_3.

The core 12, shown more clearly in FIG. 2, has a plurality of apertures 20a, 20b threrethough. When assembled, the apertures 20a, 20b extends between the first and second multilevel printed circuits boards 14, 16, as shown in FIG. 1. A pair of dielectric bodies, here for example, printed circuit boards 22a, 22b are disposed in the apertures 20a, 20b, respectively as shown. Each one of the dielectric bodies 22a, 22b has disposed therein a plurality of electrically isolated electrical conductor segments, 24a through 24h, as shown. Thus, here body 22a has electrical conductor segments 24a-24d thereon and body 22b has electrical conductor segments 24e-24h, thereon, as shown.

The core 12 with the dielectric bodies 22a, 22b with the electrical conductor segments 24a-24h are inserted into a dielectric spacer 30, as shown in FIGS. 1 and 3.

It is noted that the first and second multilevel printed circuit boards 14, 16 are disposed in a pair of overlaying planes and the plurality of electrically isolated electrical conductor segments 24a-24h are disposed perpendicular to the overlaying planes.

When assembled, first ends, here the upper ends in FIG. 1, of the electrically isolated electrical conductor segments 24a-24h are electrically connected to the electrically isolated electrical conductor segments 14a-14f and second ends, here the lower ends of the electrically isolated electrical conductor segments 24a-24h are electrically connected to the electrically isolated electrical conductor segments 16a-16h through the electrically plated through holes S_2-S_9 and P_2-P_9. More particularly, when assembled:

the upper ends of electrical conductor segments 24a-24h are electrically connected to plated through holes S_9, P_2, P_6, S_5, S_6, P_5, P_9 and S_2, respectively; and

the lower ends of electrical conductor segments 24a-24h are electrically connected to plated through holes S_8, P_3, P_7, S_4, S_7, P_4, P_8 and S_3, respectively

With such connections, a primary winding of the transformer 10 comprises port P_1, electrical conductor segments 14a, 24b, 16a, 24f, 14f, 24c, 16b, 24h, 14d and port P_{10} and a secondary winding comprises port S_1, electrical conductor segments 14c, 24h, 16d, 24d, 14e, 24e, 16d, 24a, 14b and port S_{10}.

It is noted that the primary and secondary winding provide loops around the portion 12a (FIG. 3) of the core 12. Further, it is noted that the electrically isolated electrical conductor segments 24a-24h are embedded within the core 12.

Referring now to FIG. 4, another embodiment is shown. Here, the transformer 10' has the pair of multilevel printed circuit boards, 14 and 16, as described above in connection with FIGS. 1, 2 and 3. Here, however, adjacent portions of a pair of toroidal shaped cores 12a, 12b provide the core. The pair of toroidal shaped cores 12a, 12b are disposed within a pair of apertures provided through the dielectric spacer 30', as shown. A pair of circular shaped dielectric bodies 22'a, 22'b having the electrically conductive segments 24a-24b are disposed within a corresponding one of the central, apertured, regions of the toroidal shaped bodies 12a, 12b as shown.

When assembled, first ends, here the upper ends in FIG. 4, of the electrically isolated electrical conductor segments 24a-24h are electrically connected to the electrically isolated electrical conductor segments 14a-14f and second ends, here the lower ends of the electrically isolated electrical conductor segments 24a-24h are electrically connected to the electrically isolated electrical conductor segments 16a-16h through the electrically plated through holes S_2-S_9 and P_2-P_9. More particularly, when assembled:

the upper ends of electrical conductor segments 24a-24h are electrically connected to plated through holes S_9, P_2, P_6, S_5, S_6, P_5, P_9 and S_2, respectively; and

the lower ends of electrical conductor segments 24a-24h are electrically connected to plated through holes S_8, P_3, P_7, S_4, S_7, P_4, P_8 and S_3, respectively

With such connections, a primary winding of the transformer 10 comprises port P_1, electrical conductor segments 14a, 24b, 16a, 24f, 14f, 24c, 16b, 24g, 14d and port P_{10} and a secondary winding comprises port S_1, electrical conductor segments 14c, 24h, 16d, 24d, 14e, 24e, 16d, 24a, 14b and port S_{10}.

Thus, here the primary and secondary winding provide loops around the portion 12a (FIG. 3) of the adjacent portions 12a' and 12b' of the cores 12a and 12b. Further, it is noted that the electrically isolated electrical conductor segments 24a-24h are embedded within the cores 12a and 12b, as shown. It is noted that segments 24b, 24c, 24f and 24g provide the vertical portions of the primary loop and segments 24h, 24d, 24e and 24a provide the vertical portions of the secondary loop.

It should be understood that the number of conductive segments through the dielectric bodies 22a, 22b or 22a', 22b' might be larger than the four segments shown with the number of conductive segments of the printed circuit boards being correspondingly increased. Thus, referring now to FIGS. 5 and 6, a modified exemplary one of the dielectric bodies 22'a and

22'b, here body 22"a is shown. Here, the body 22"a has eight conductive segments $24'S_1$-$24'S_4$ and $24P_1$-$24P_4$. The conductive segments $24'S_1$-$24'S_4$ provide the vertical portions of the secondary loop and the conductive segments $24'P_1$-$24'P_4$ provide the vertical portions of the primary loop. The eight conductive segments $24'S_1$-$24'S_4$ and $24P_1$-$24P_4$ have upper and lower conductive tabs 38 for making electrical connection to the plated through holes of the multilevel printed circuit boards 14, 16. Here, there is an electrically conductive shield 40 disposed between the segments $24'S_1$-$24'S_4$ and the segments $24P_1$-$24P_4$. The electrically conductive shield 40 has tabs 42 for connection to a ground plane, not shown, of the multilevel printed circuit boards, 14, and 16 and a vertical cutout that prevents the shield from introducing a shorted turn in the transformer. Here, the electrical conductor segments $24'S_1$-$24'S_4$ and $24P_1$-$24P_4$ and the shield 40 are copper and are embedded within an epoxy filler 44.

As noted above, the body 22"a is disposed within the central region of the toroidal shaped core 12a.

Referring now to FIG. 7, an electrical transformer 10" is shown here with the upper multilayer printed circuit board 14 illustrated with only the electrical conductive segments used to interconnect transformer segments to be described in connection with FIG. 8. Here, the dielectric spacer member 30" has a plurality of, here 20, apertures therethrough. The apertures in the spacer member 30" pass between a top and a bottom surface of the spacer member. A plurality of toroidal shaped cores 12", as shown in FIG. 4 is provided. Each one of such cores 12" is disposed in a corresponding one of the plurality of apertures of the dielectric spacer member 30". Each one of the cores 12" has an aperture therein, the apertures of the cores 12" being coaxial with the apertures in the dielectric spacer member 30". A plurality of dielectric bodies, here the body 22" as described above in connection with FIGS. 5 and 6 is provided. Each one of such dielectric bodies 22" is disposed in a corresponding one of the apertures in the cores 12".

Thus, a plurality of plurality of dielectric bodies 22" has a corresponding one of the vertical electrically isolated electrical conductor segments $24S_1$-$24S_4$ and $24P_1$ - $24P_4$, as described above in connection with FIGS. 5 and 6. The ends or tabs 38 of the electrical conductor segments are electrically connected to electrically isolated electrical conductor segments of the upper and lower multilevel printed circuits boards. Here, however, the boards 14, 16 are modified to provide not only primary and secondary windings, or loops

around each one of the toroidal shaped cores, i.e., to provide a transformer segment 10', as shown in FIG. 8, but the conductor segments on the multilevel printed circuit boards are used to electrically interconnect each one of the transformer segments 10' as shown in FIG. 8, and thereby provide a larger transformer assembly10".

A number of embodiments of the invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. Accordingly, other embodiments are within the scope of the following claims.

WHAT IS CLAIMED IS:

1. An electrical transformer, comprising:

a first dielectric having a plurality of first electrically isolated electrical conductor segments disposed on the dielectric;

a second dielectric, disposed over, and in registration with, the first dielectric, such second dielectric having a plurality of second electrically isolated electrical conductor segments disposed on the second dielectric;

a core having an aperture therein, such aperture extending between the first and second dielectrics;

a plurality of third electrically isolated electrical conductor segments; and

wherein first ends of the third electrically isolated electrical conductor segments are electrically connected to the plurality of first electrically isolated electrical conductor segments and second ends of the third electrically isolated electrical conductor segments are electrically connected to the plurality of second electrically isolated electrical conductor segments to provide a portion of a primary winding and a portion of a secondary winding for the transformer;

wherein such primary winding comprises first ones of the first electrically isolated electrical conductor segments, first ones of the second electrically isolated electrical conductor segments, and first ones of the third electrically isolated electrical conductor segments; and

wherein such secondary winding comprises second ones of the first electrically isolated electrical conductor segments, second ones of the second electrically isolated electrical conductor segments, and second ones of the third electrically isolated electrical conductor segments.

2. The electrical transformer recited in claim 1 wherein the first and second dielectrics are disposed in a pair of overlaying planes and wherein the plurality of third electrically isolated electrical conductor segments are disposed perpendicular to the overlaying planes.

3. The electrical transformer recited in claim 2 wherein the primary and secondary winding provide loops around the core.

4. The electrical transformer recited in claim 3 wherein the third electrically isolated electrical conductor segments are disposed within the core.

5. The electrical transformer recited in claim 4 wherein the core comprises a toroidal shaped body and wherein core is disposed in a central region of the toroidal shaped body.

6. An electrical transformer, comprising:

a first dielectric having a plurality of first electrically isolated electrical conductor segments disposed on each one of a plurality of electrically isolated levels of such first dielectric;

a second dielectric, disposed over, and in registration with, the first dielectric, such second dielectric having a plurality of second electrically isolated electrical conductor segments disposed on each one of a plurality of electrically isolated levels of such second dielectric;

a plurality of third electrically isolated conductor segments;

a plurality of fourth electrically isolated conductor segments;

wherein the plurality of third and fourth conductors segments are disposed between the first dielectric and the second dielectric; and

wherein first ends of the third electrically isolated electrical conductor segments and first ends of the fourth electrically isolated electrical conductor segments are electrically connected to the plurality of first electrically isolated electrical conductor segments and second ends of the third electrically isolated electrical conductor segments and the fourth electrically isolated electrical conductor segments are electrically connected to the plurality of second electrically isolated electrical conductor segments to provide a primary winding and a secondary winding for the transformer;

wherein such primary winding comprises first ones of the first electrically isolated electrical conductor segments, first ones of the second electrically isolated electrical conductor segments, and first ones of the third and fourth electrically isolated electrical conductor segments; and

wherein such secondary winding comprises second ones of the first electrically isolated electrical conductor segments, second ones of the second electrically isolated electrical conductor segments, and second ones of the third and fourth electrically isolated electrical conductor segments.

7. The electrical transformer recited in claim 6 wherein the first and second dielectrics are disposed in a pair of overlaying planes and wherein the plurality of third and fourth electrically isolated electrical conductor segments are disposed perpendicular to the overlaying planes.

8. The electrical transformer recited in claim 7 including a core is disposed between the first and second dielectrics and wherein the primary and secondary winding provide loops around the core.

9. The electrical transformer recited in claim 8 wherein the third and fourth electrically isolated electrical conductor segments are embedded within the core.10. The electrical transformer recited in claim 9 wherein the core comprises a pair of adjacent, toroidal shaped bodies and each one of the third and fourth electrically isolated conductive segments is disposed in a central region of a corresponding one of the pair of toroidal shaped bodies.

10. An electrical transformer, comprising:

a first multilayer printed circuit board having a plurality of first electrically isolated electrical conductor segments disposed on each one of a plurality of electrically isolated levels of such first multilevel printed circuit board;

a second multilayer printed circuit board, disposed over, and in registration with, the first multilevel printed circuit board, such second multilevel printed circuit board having a plurality of second electrically isolated electrical conductor segments disposed on each one of a plurality of electrically isolated levels of such second multilevel printed circuit board;

a core having an aperture therein, such aperture extending between the first and second multilevel printed circuits boards;

a dielectric body disposed in the aperture, such body having disposed therein a plurality of third electrically isolated electrical conductor segments; and

wherein first ends of the third electrically isolated electrical conductor segments are electrically connected to the plurality of first electrically isolated electrical conductor segments and second ends of the third electrically isolated electrical conductor segments are electrically connected to the plurality of second electrically isolated electrical conductor segments to provide a portion of a primary winding and a portion of a secondary winding for the transformer;

wherein such primary winding comprises first ones of the first electrically isolated electrical conductor segments, first ones of the second electrically isolated electrical conductor segments, and first ones of the third electrically isolated electrical conductor segments; and

wherein such secondary winding comprises second ones of the first electrically isolated electrical conductor segments, second ones of the second electrically isolated electrical conductor segments, and second ones of the third electrically isolated electrical conductor segments.

11. The electrical transformer recited in claim 10 wherein the first and second multilevel printed circuit boards are disposed in a pair of overlaying planes and wherein the plurality of third electrically isolated electrical conductor segments are disposed perpendicular to the overlaying planes.

12. The electrical transformer recited in claim 11 wherein the primary and secondary winding provide loops around the core.

13. The electrical transformer recited in claim 12 wherein the third electrically isolated electrical conductor segments are embedded within the core.

14. The electrical transformer recited in claim 13 wherein the core material comprises a toroidal shaped body and wherein dielectric body is disposed in a central region of the toroidal shaped body.

15. An electrical transformer, comprising:

a first multilayer printed circuit board having a plurality of first electrically isolated electrical conductor segments disposed on each one of a plurality of electrically isolated levels of such first multilevel printed circuit board;

a second multilayer printed circuit board, disposed over, and in registration with, the first multilevel printed circuit board, such second multilevel printed circuit board having a plurality of second electrically isolated electrical conductor segments disposed on each one of a plurality of electrically isolated levels of such second multilevel printed circuit board;

a pair of dielectric bodies disposed between the first multilevel printed circuit board and the second multilevel printed circuit board, each one of such bodies having disposed therein a plurality of third electrically isolated electrical conductor segments; and

wherein first ends of the third electrically isolated electrical conductor segments are electrically connected to the plurality of first electrically isolated electrical conductor segments and second ends of the third electrically isolated electrical conductor segments are electrically connected to the plurality of second electrically isolated electrical conductor segments to provide a primary winding and a secondary winding for the transformer;

wherein such primary winding comprises first ones of the first electrically isolated electrical conductor segments, first ones of the second electrically isolated electrical conductor segments, and first ones of the third electrically isolated electrical conductor segments; and

wherein such secondary winding comprises second ones of the first electrically isolated electrical conductor segments, second ones of the second electrically isolated electrical conductor segments, and second ones of the third electrically isolated electrical conductor segments.

16. The electrical transformer recited in claim 15 wherein the first and second multilevel printed circuit boards are disposed in a pair of overlaying planes and wherein the plurality of third electrically isolated electrical conductor segments are disposed perpendicular to the overlaying planes.

17. The electrical transformer recited in claim 16 including a core material disposed between the first and second multilevel printed circuit boards and wherein the primary and secondary winding provide loops around the core material.

18. The electrical transformer recited in claim 17 wherein the third electrically isolated electrical conductor segments are embedded within the core material.

19. The electrical transformer recited in claim 18 wherein the core material comprises a pair of adjacent, toroidal shaped bodies and each one of the a pair of dielectric bodies is disposed in a central region of a corresponding one of the pair of toroidal shaped bodies.

20. An electrical transformer structure, comprising:

a first multilayer printed circuit board having a plurality of first electrically isolated electrical conductor segments disposed on each one of a plurality of electrically isolated levels of such first multilevel printed circuit board;

a second multilayer printed circuit board, disposed over, and in registration with, the first multilevel printed circuit board, such second multilevel printed circuit board having a plurality of second electrically isolated electrical conductor segments disposed on each one of a plurality of electrically isolated levels of such second multilevel printed circuit board;

a dielectric spacer member disposed between the first multilevel printed circuit board and the second multilevel printed circuit board, such spacer member having a plurality of apertures therethrough, such apertures passing between a top and a bottom surface of the spacer member;

a plurality of toroidal shaped cores, each one of such cores being disposed in a corresponding one of the plurality of apertures of the dielectric spacer member, each one of the cores having an aperture therein, the apertures of the cores being coaxial with the apertures in the dielectric spacer member;

a plurality of dielectric bodies, each one of such dielectric bodies being disposed in a corresponding one of the apertures in the cores;

a plurality of plurality of dielectric bodies having a corresponding one of the sets of third electrically isolated electrical conductor segments;

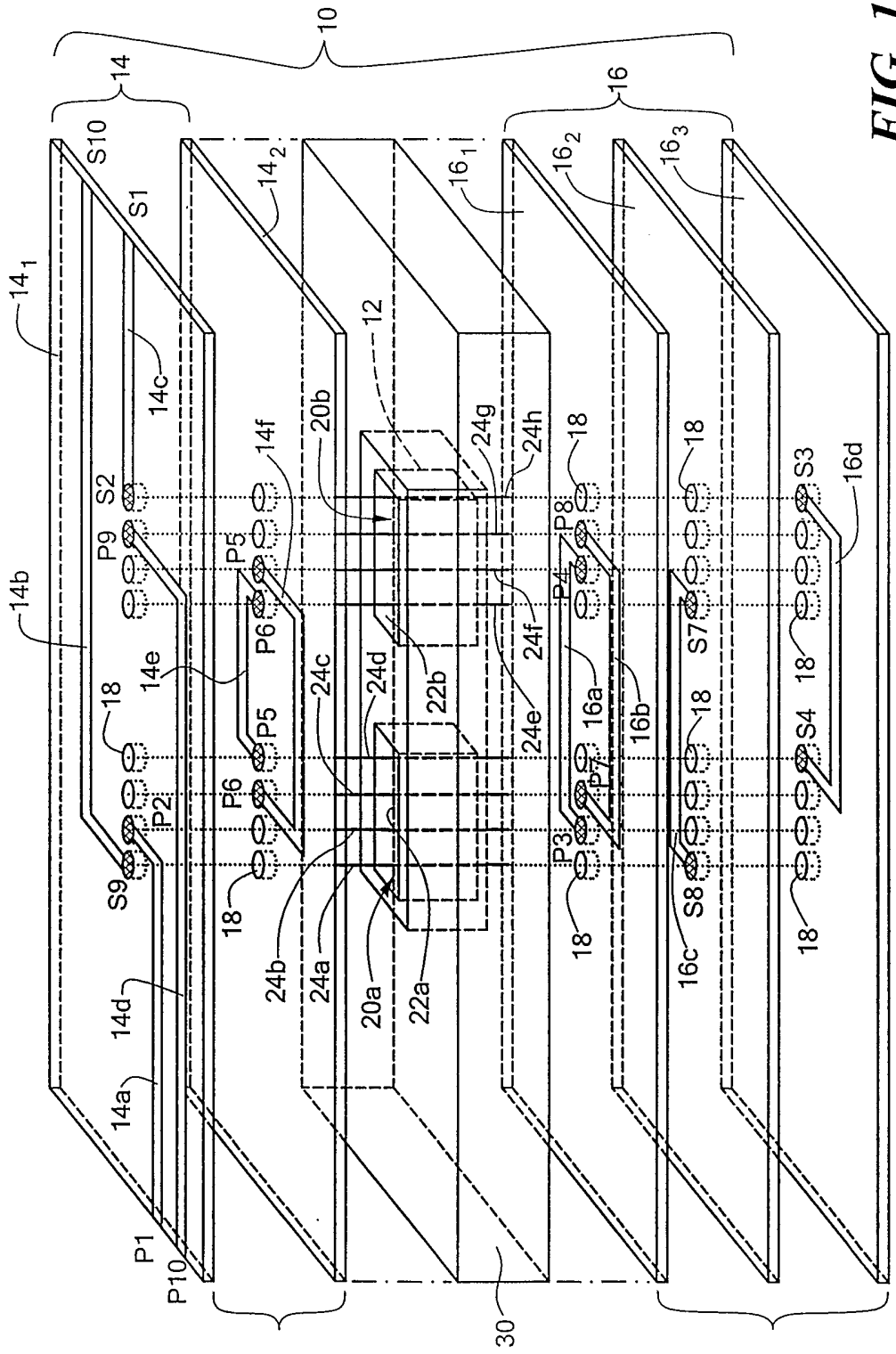
wherein first ends of the third electrically isolated electrical conductor segments are electrically connected to the plurality of first electrically isolated electrical conductor segments and second ends of the third electrically isolated electrical conductor segments are electrically connected to the plurality of second electrically isolated electrical conductor segments to provide a primary winding and a secondary winding for the transformer;

wherein such primary winding comprises first ones of the first electrically isolated electrical conductor segments, first ones of the second electrically isolated electrical conductor segments, and first ones of the third electrically isolated electrical conductor segments; and

wherein such secondary winding comprises second ones of the first electrically isolated electrical conductor segments, second ones of the second electrically isolated electrical conductor segments, and second ones of the third electrically isolated electrical conductor segments.

21. The electrical transformer recited in claim 20 wherein the first and second multilevel printed circuit boards are disposed in a pair of overlaying planes and wherein the plurality of third electrically isolated electrical conductor segments are disposed perpendicular to the overlaying planes.

22. The electrical transformer recited in claim 21 including wherein the primary and secondary winding provide loops around the cores.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P10
S1
S2
S3
S4
S7
S8
S9
S10

FIG. 1

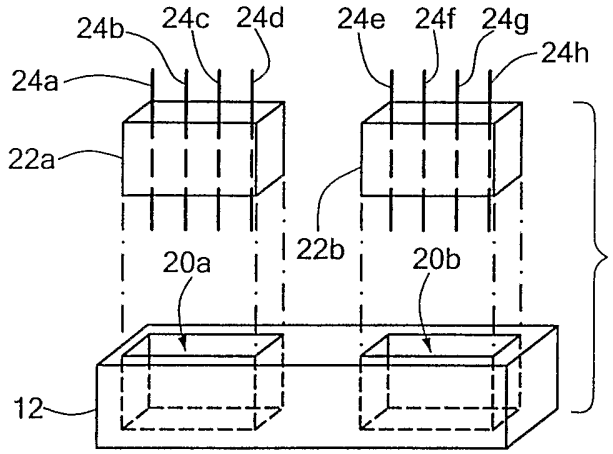

FIG. 2

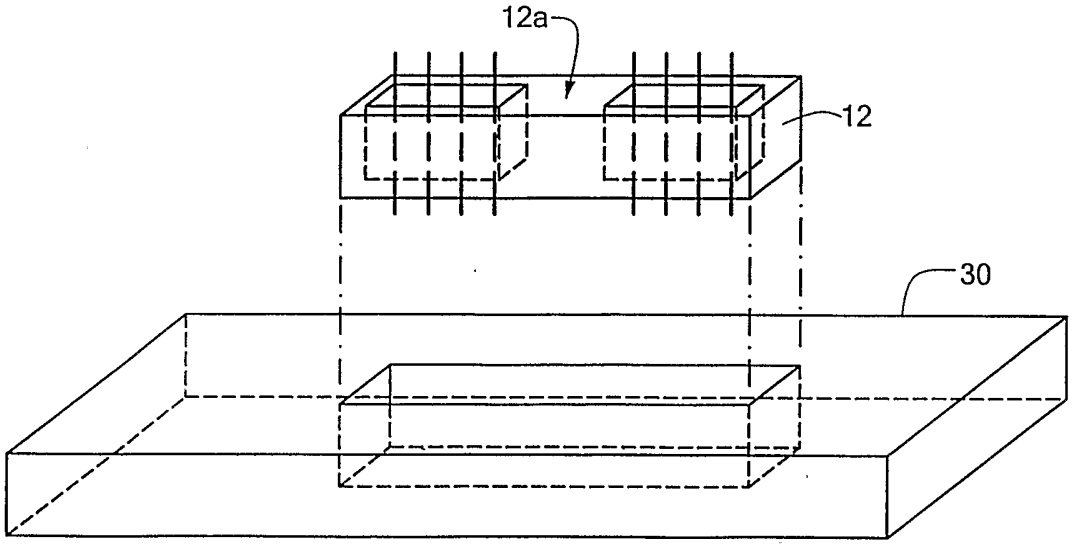

FIG. 3

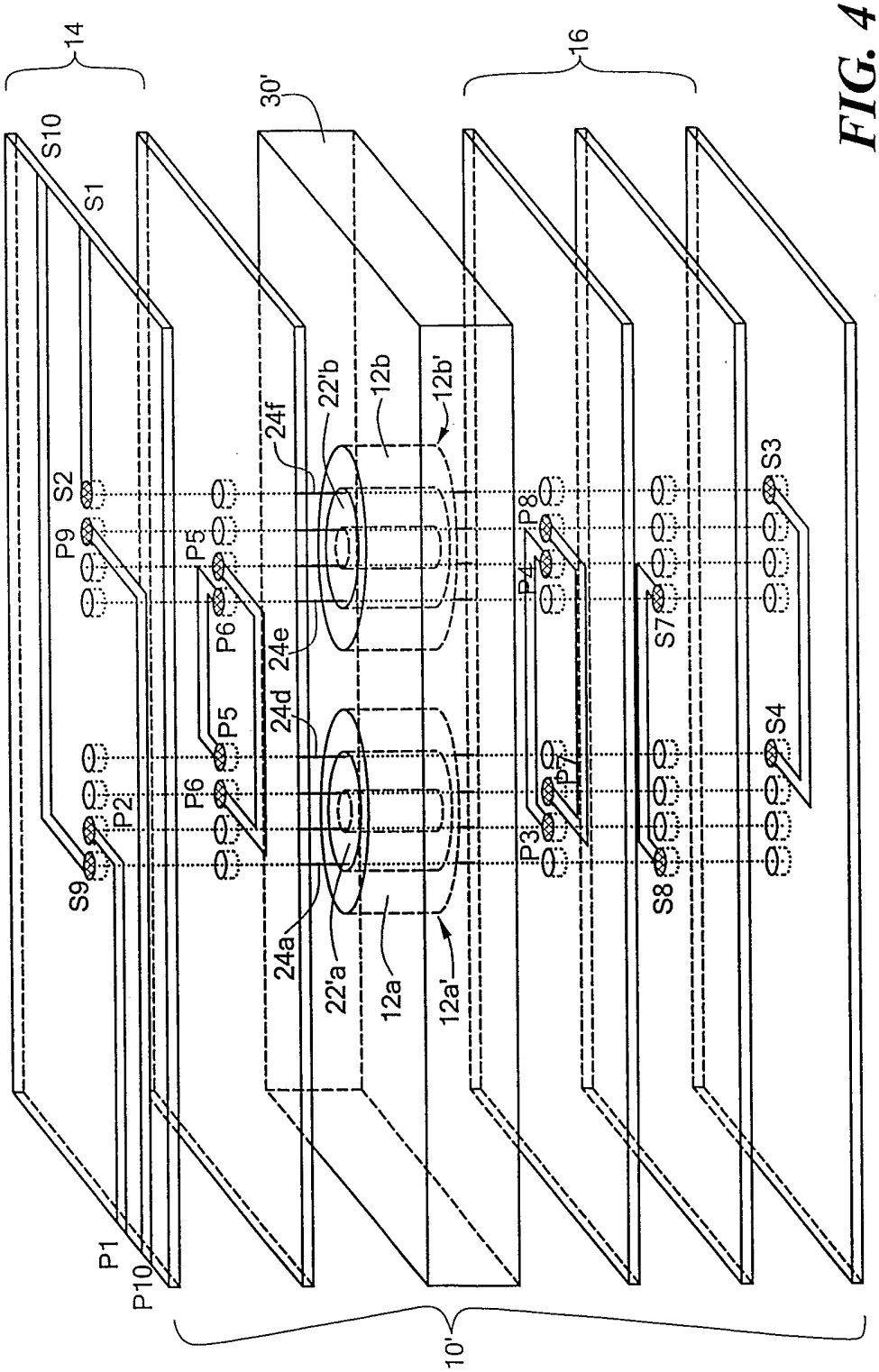
14
16
30'
10'
S10
S1
S2
S3
S4
S7
S8
S9
P1
P10
P2
P3
P4
P5
P6
P7
P8
P9
24a
24d
24e
24f
22'a
22'b
12a
12a'
12b
12b'

FIG. 4

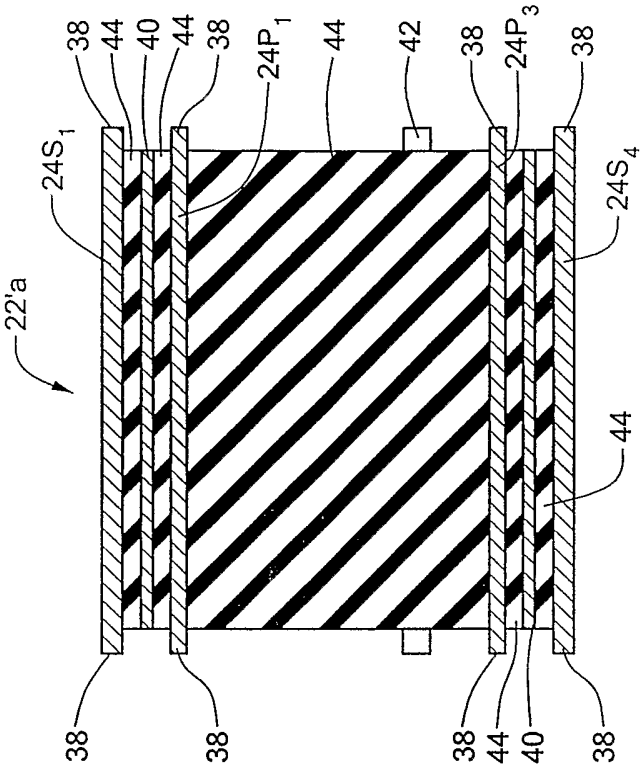
38
44
40
44
38
24P1
44
42
38
24P3
38
24S1
24S4
22'a
44
38
38
38
44
40
38

FIG. 6

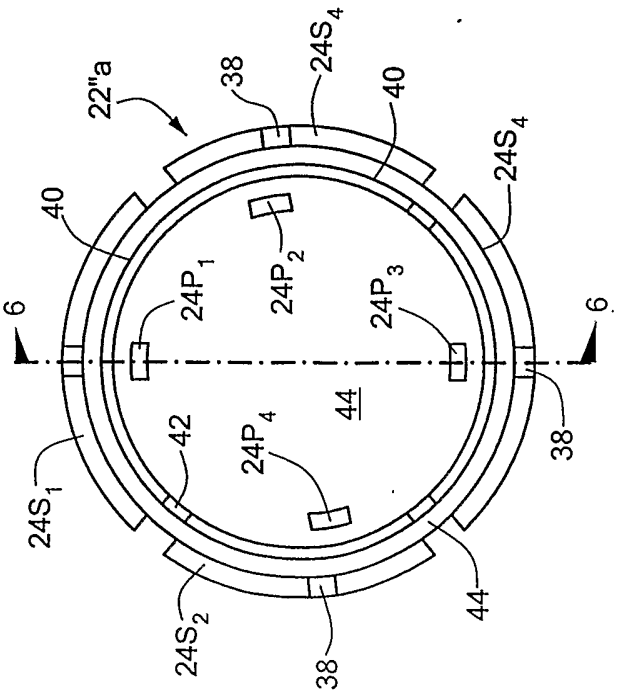
22"a
38
24S4
40
24S4
40
24P1
24P2
24P3
6
6
44
42
24P4
24S1
24S2
38
38
44

FIG. 5

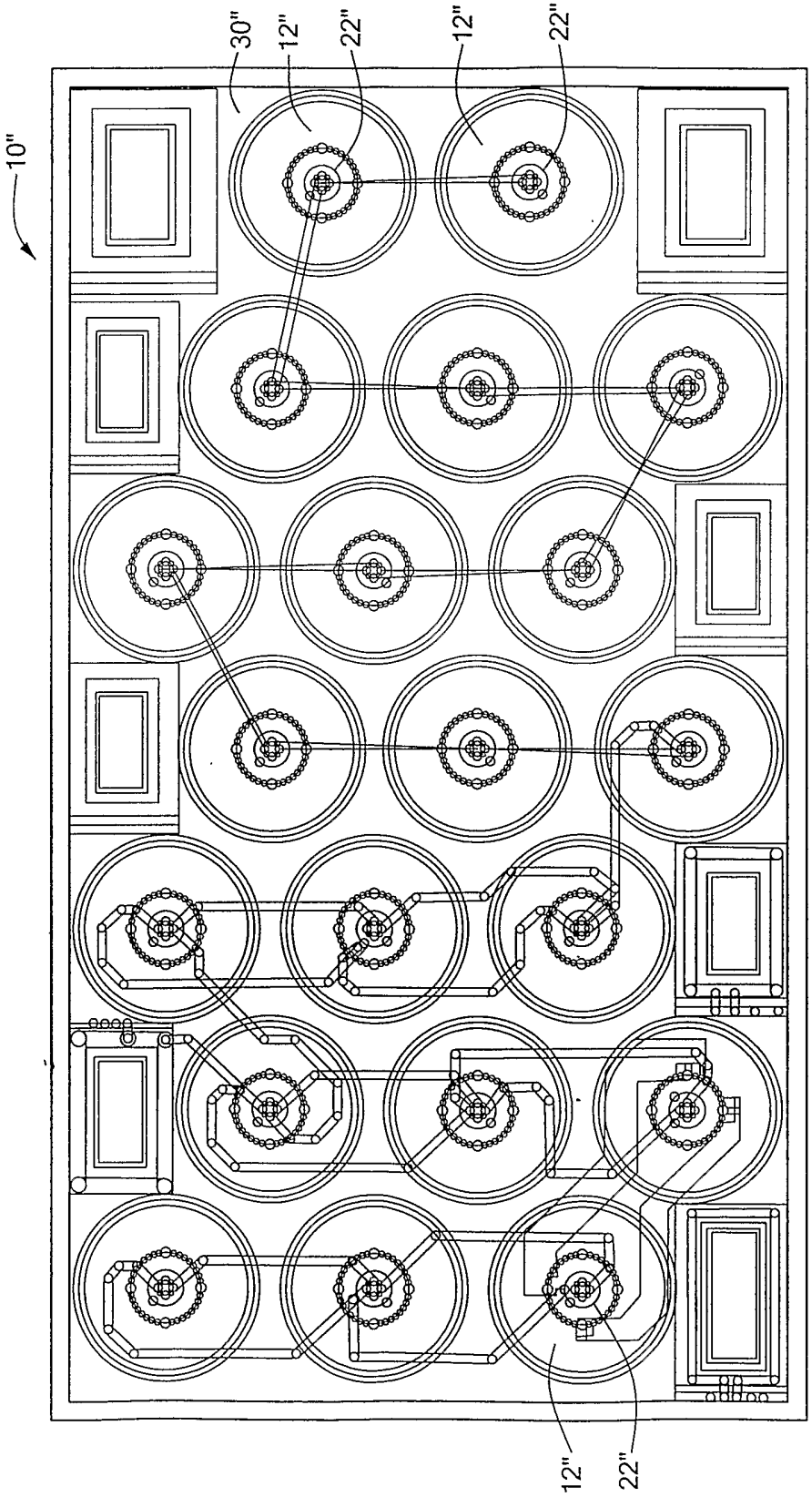

FIG. 7

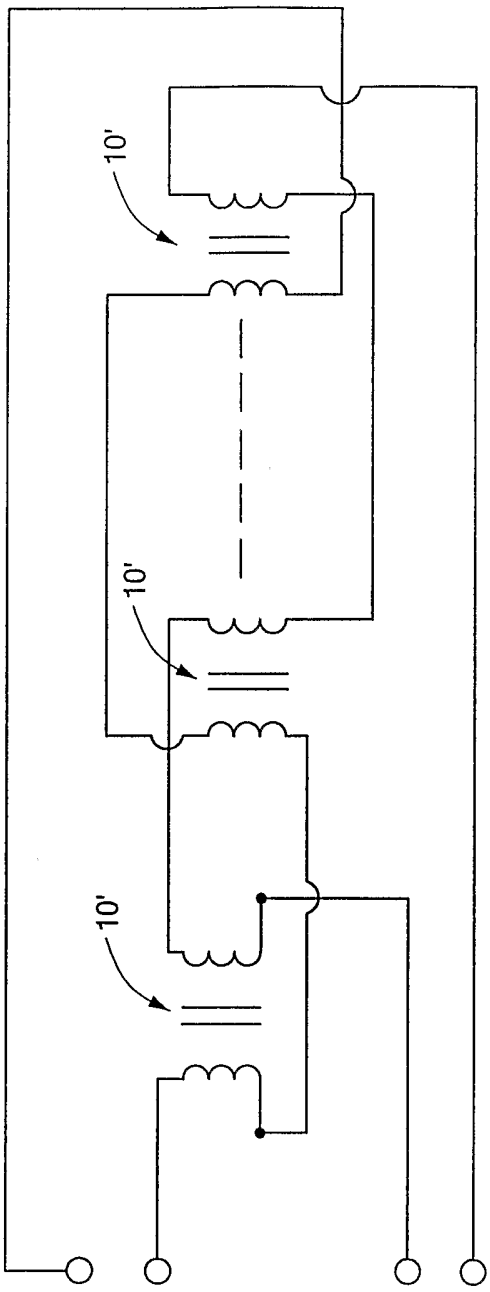

FIG. 8

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2004/002465

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01F17/00 H01F17/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	EP 0 756 298 A (AUTOSPLICE SYSTEMS INC) 29 January 1997 (1997-01-29) column 4, lines 13-30; claim 12; figures 7,15,17,25	1-9 10-22
X Y	EP 1 085 536 A (MANNESMANN VDO AG) 21 March 2001 (2001-03-21) paragraphs '0004!, '0016!; claims 1,3	1-4,6-9 10-22
X	EP 0 851 439 A (CITIZEN ELECTRONICS) 1 July 1998 (1998-07-01) abstract; claim 1 column 11, lines 10-14; figure 9	1-4,6-8
Y	US 2003/011458 A1 (KULINETS JOSEPH M ET AL) 16 January 2003 (2003-01-16) paragraphs '0081! - '0086!; claim 1; figures 21-24	10-22

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
24 June 2004	02/07/2004

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INTERNATIONAL SEARCH REPORT

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PCT/US2004/002465

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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