United States Patent

West

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[54] MICROINDUCTOR DEVICE

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[52] U.S. Cl. 336/200, 336/223

[51] Int. Cl. H01f 27/28

[58] Field of Search 336/200, 223, 225

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[57] ABSTRACT

A microinductor device comprising a ceramic body having opposing pairs of posts, each pair being separate from the other pairs, with a metallic path electrically uniting each of the separate pairs of posts, a printed circuit board having printed members electrically uniting neighboring posts of at least two post pairs, in order to provide a conductive path of the inductor type through a plurality of the pairs of posts, and a ferrite placed within the volume between pairs of posts.

7 Claims, 9 Drawing Figures

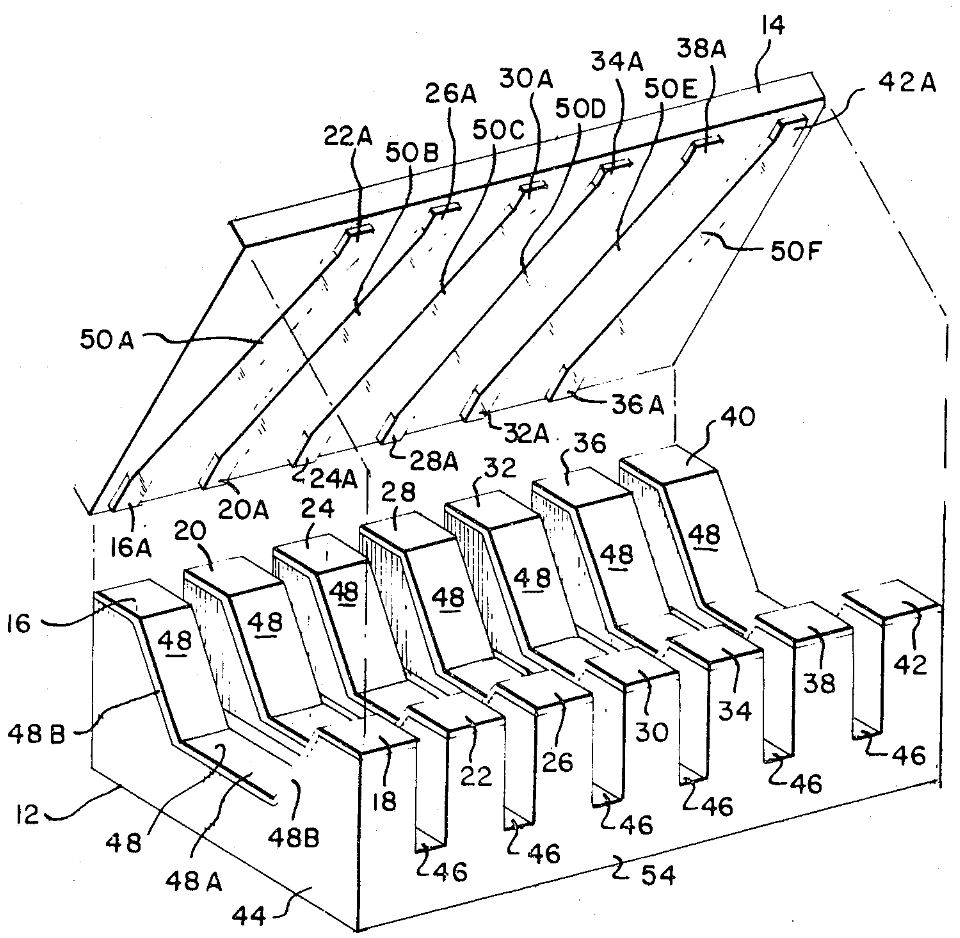


Fig. 1

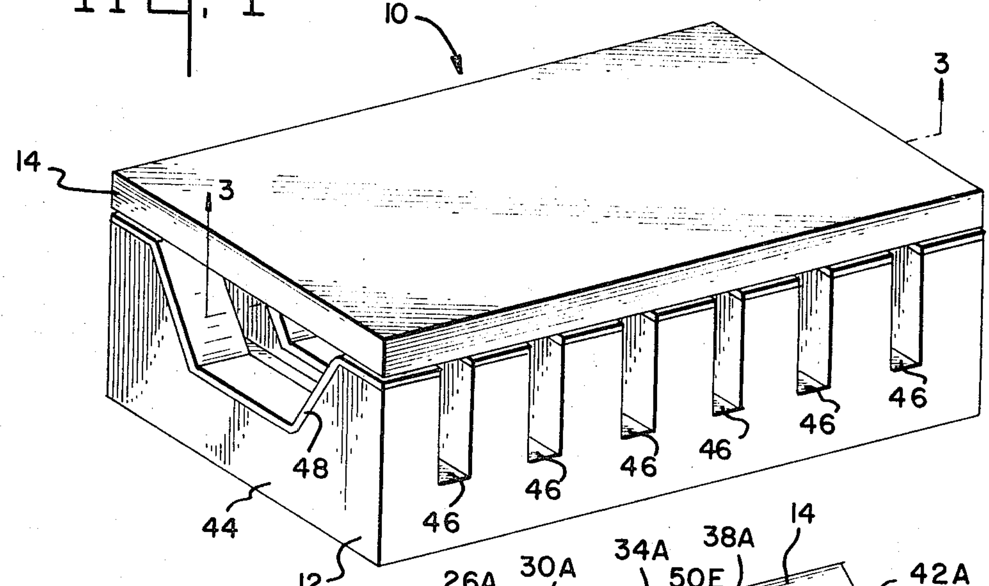
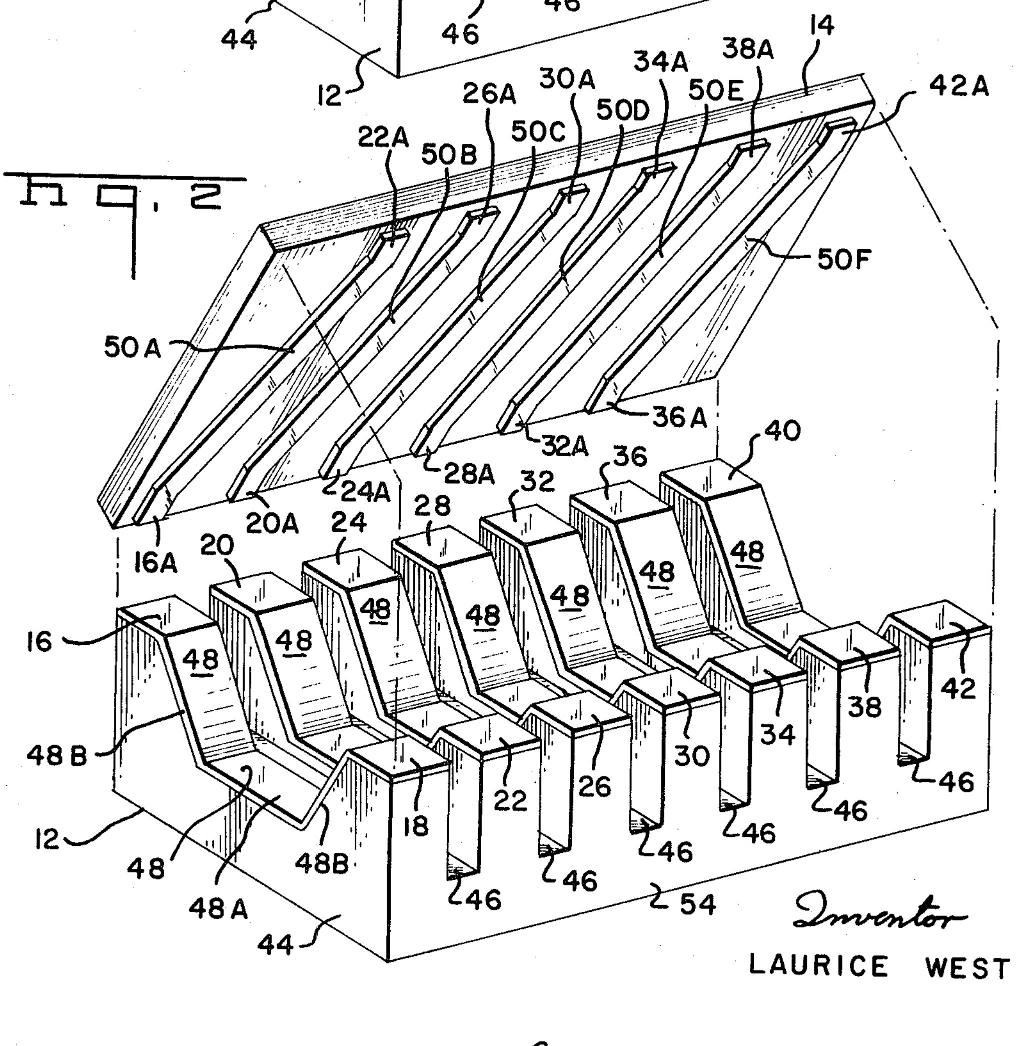


Fig. 2



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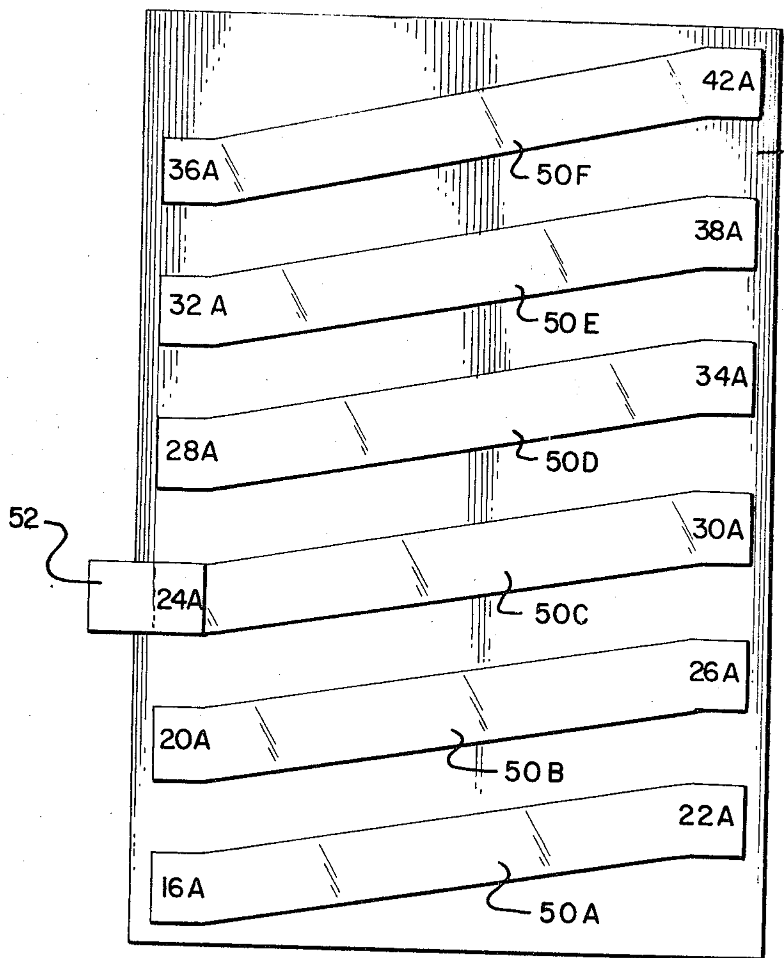

Fig. 7

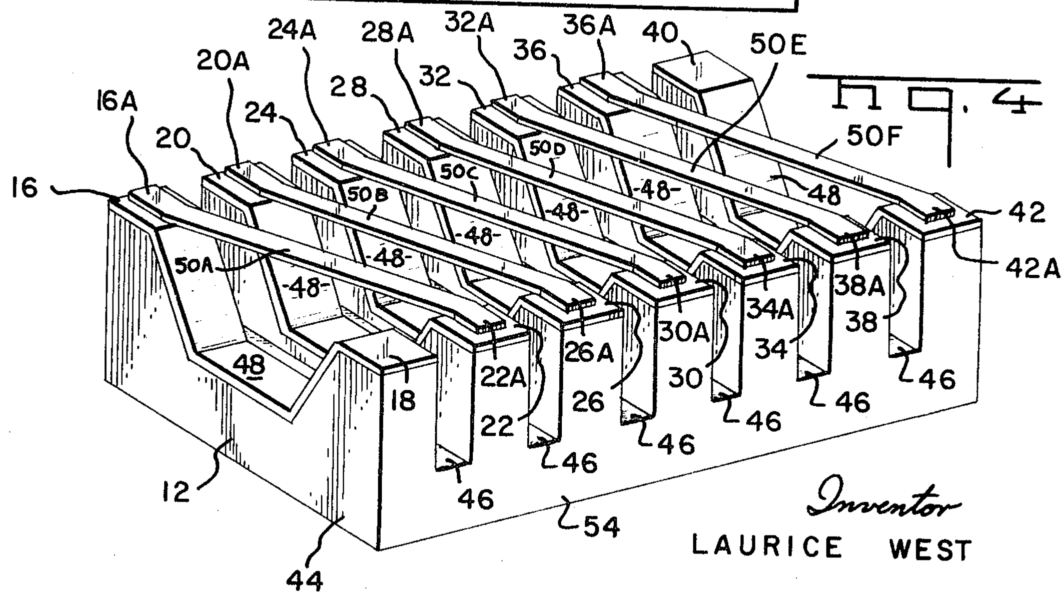

Fig. 4

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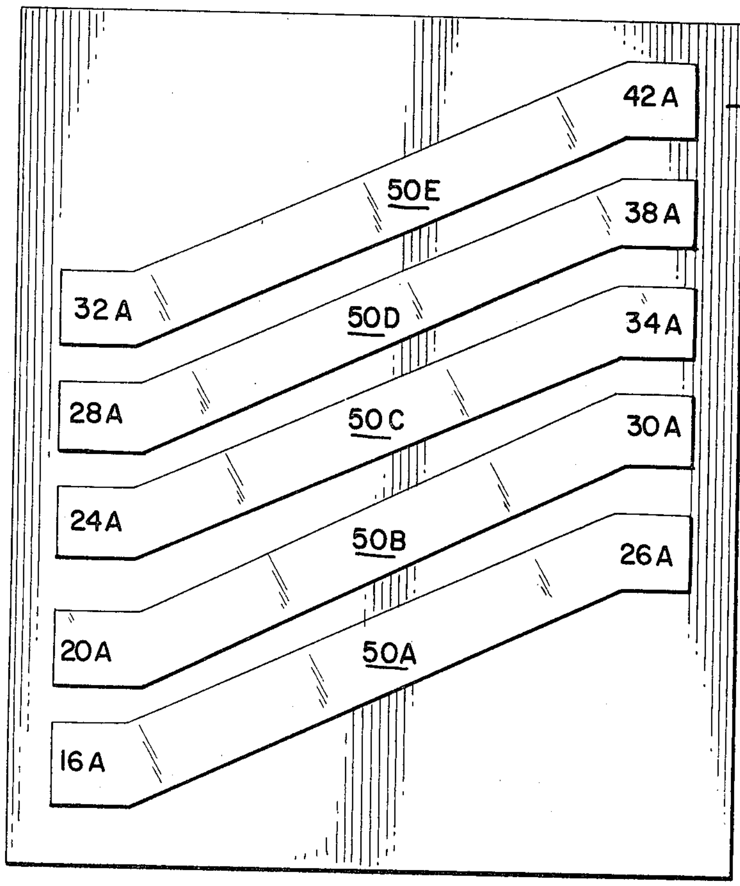

Fig. 5

Fig. 6

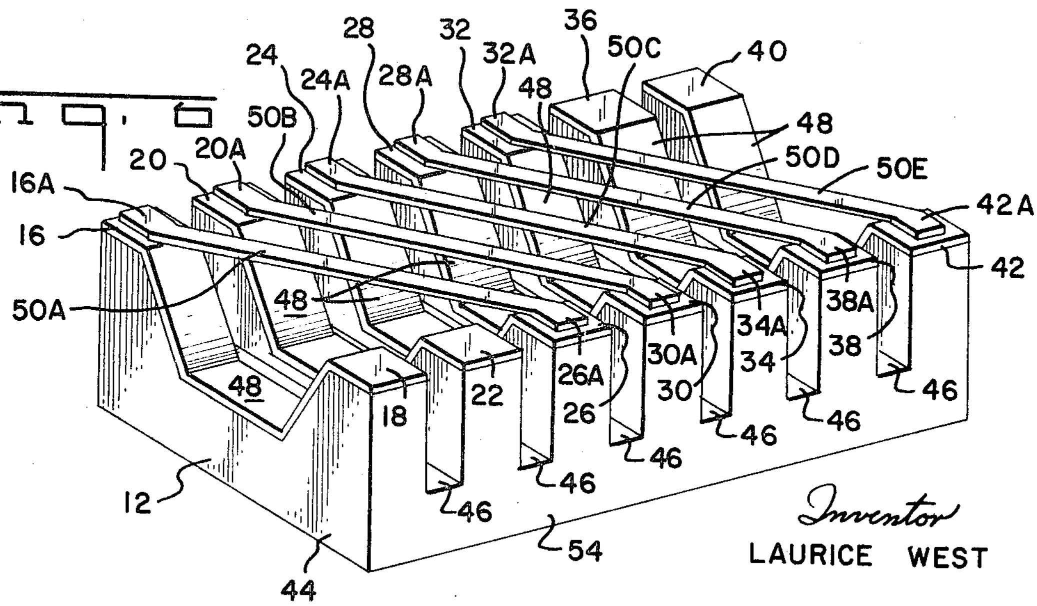

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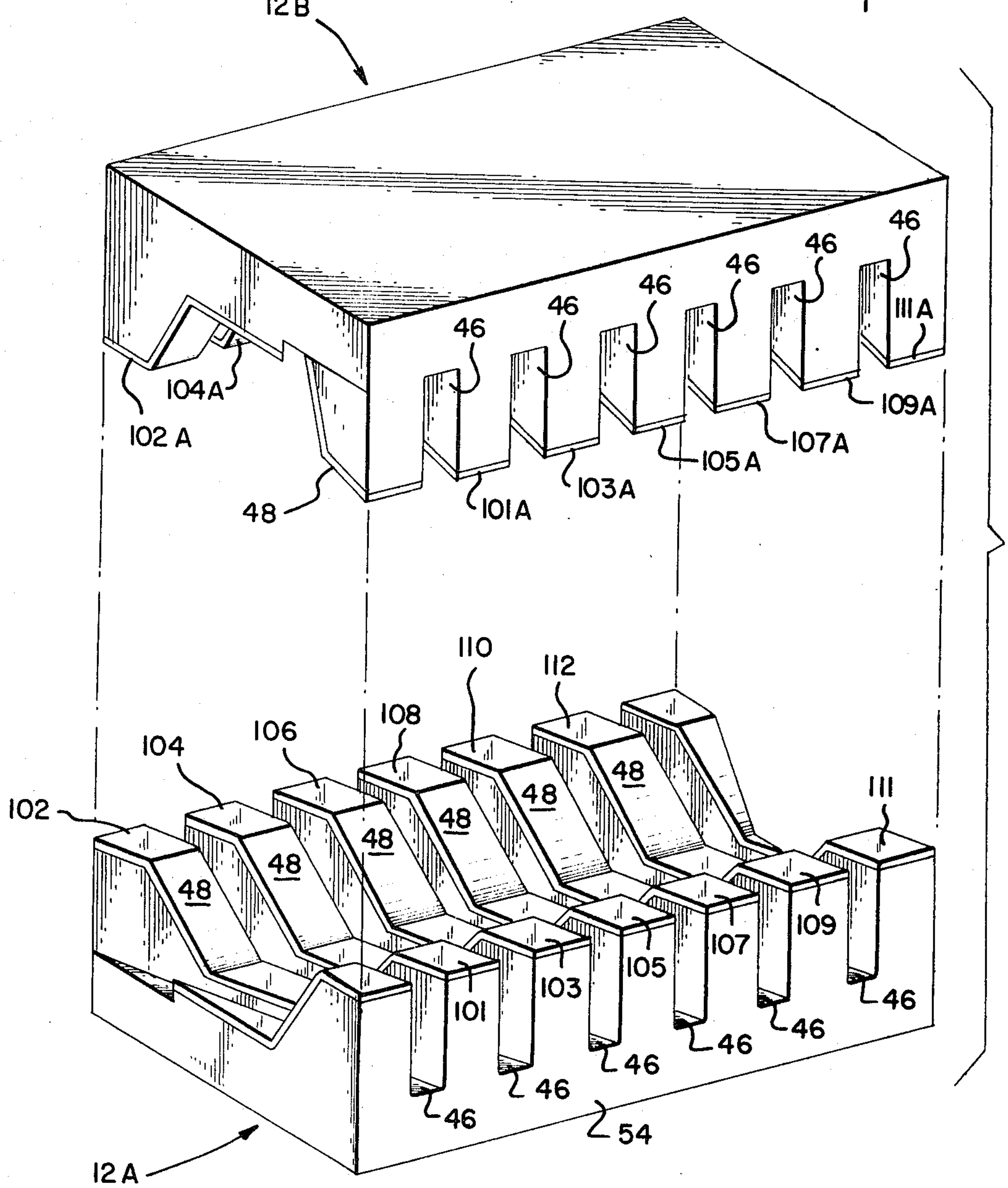
Fig. 7



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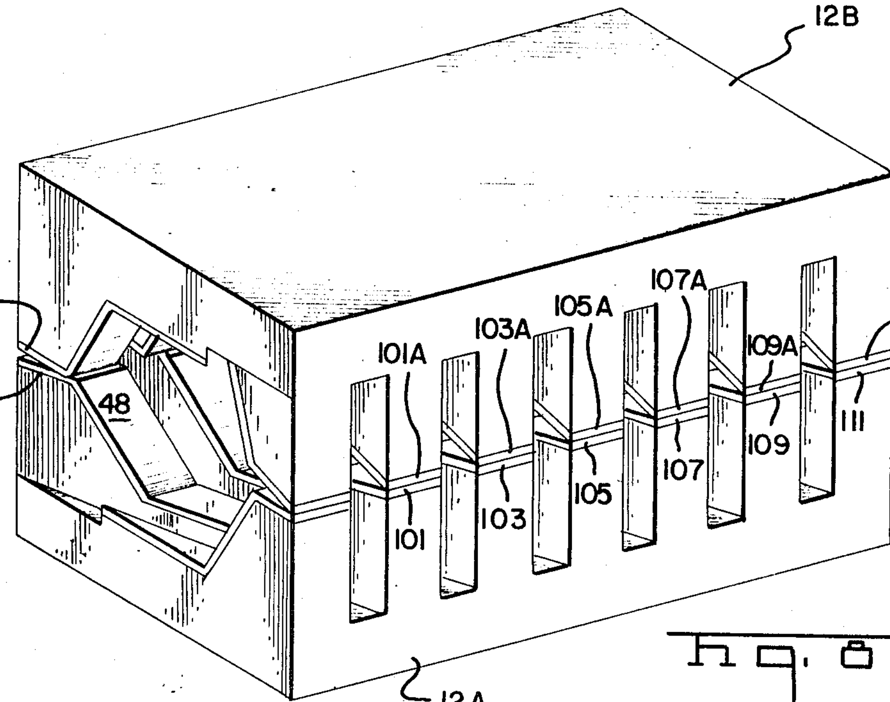

Fig. 8

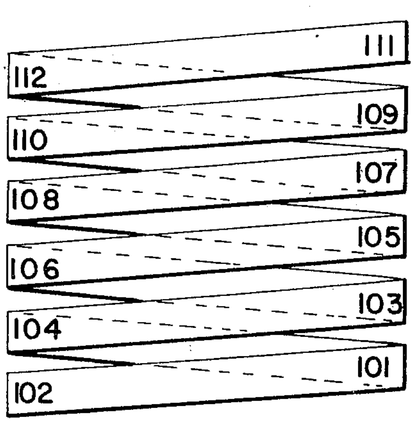

Fig. 9

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MICROINDUCTOR DEVICE

This invention relates to a microinductor device and has as its objective the provision of a simply constructed microinductor device that has eluded the art for many years.

Microelectronic apparatus in which circuit components are formed directly on an underlying substrate are mounted thereon as discrete components, and interconnected by printed circuitry, is widely known and used in the art. Where discrete microcomponents are utilized, they may be combined with circuit components such as resistors or capacitors which are formed or "printed" directly on a substrate or all the components may be discrete.

Common types of such discrete microcomponents are capacitors, resistors, transistors, and large-scale integrated devices. All of these components are commercially available, can be manufactured within specific tolerances, and are quite economical.

However, microinductors are still unavailable in the art. There are small-sized inductors which can be obtained, but they are of a relatively large size. Also, such so-called small-sized inductors are exceedingly cumbersome in relation to the other microcomponents and are not compatible with small printed circuits and other microelectronic devices.

The microelectronic engineer, faced with the need for a microinductor, must custom make such an inductor, and is generally limited to a small range of inductance, due to the delicate technique of winding fine wire around a core.

While it is known to provide spiral or concentric inductors, deposited on circuit boards for use with microcircuits, such inductors are extremely lossy and generally have poor characteristics. There thus remains a component gap in the area of discrete microelectronic components, and a specific need for a good microinductor compatible with present microelectronic modules and fabrication techniques.

It is therefore a primary object of the invention to provide a microinductor compatible with existing microelectronic components and circuits.

Still another object of the present invention is to provide microinductors having a wide range of inductance and which are convenient to fabricate, inexpensive, and compatible with existing microelectronic components.

It is a further object of the invention to provide a microinductor device which is relatively simple in construction, and which is still extremely versatile and therefore capable of being used in a wide variety of designs.

The foregoing as well as other objects of the invention are achieved by providing a microinductor device that includes a ceramic body having opposing rows of posts that are separated from each other except that each of the opposing posts in a pair are electrically united by a metallic path. A printed circuit board is positioned on the ceramic body in such a way that the printed members of the board achieve electrical connections by each pair of posts to a neighboring pair of posts, thereby providing a classical inductive path, and a ferrite is placed within the volume between pairs of posts.

Other objects and many of the attendant advantages of the invention will become more readily apparent by reference to the accompanying drawings wherein:

FIG. 1 is a three-dimensional view showing a microinductor device embodying the present invention;

FIG. 2 is a view similar to FIG. 1, but showing the printed circuit board in exploded relationship to the ceramic base;

FIG. 3 is a sectional view taken along the lines 3—3 of FIG. 1 (with conductor direction reversed);

FIG. 4 is a view similar to FIG. 1, but showing the relationship of the circuitry of the printed circuit board to the circuitry of the ceramic base, the nonconductive portion of the printed circuit board having been removed for the sake of clarity;

FIG. 5 is a plan view of a modified printed circuit board for use with the ceramic base of FIGS. 1 and 2;

FIG. 6 is a view similar to FIG. 4 but showing the use of the printed circuit board of FIG. 5;

FIG. 7 is an exploded three-dimensional view showing an alternative embodiment involving the use of a pair of ceramic bases;

FIG. 8 is a view similar to FIG. 7 but wherein the two bases of FIG. 7 have been brought together; and

FIG. 9 is a diagrammatic view illustrating the helical winding generated by the embodiment of FIGS. 7 and 8.

Referring now in greater detail to the various figures of the drawing wherein like reference characters refer to like parts, there is generally shown at 10 in FIG. 1, a three-dimensional view showing a first embodiment of the present invention with certain details of FIG. 1 being in full view in FIG. 2.

It can be seen that the microinductor device 10 comprises ceramic body 12 and printed circuit board 14. The ceramic body 12 is of conventional materials, such as glass or plastic, like Bakelite, and of a low dielectric constant so as to exhibit low loss at normal operating frequencies. It will be seen that the microinductor of the present invention possesses great mutual coupling (little capacitance, higher self-resonant frequency).

As shown in FIG. 2 the ceramic body 12 possesses a series of opposing pairs of posts. The first pair of posts is identified as posts 16 and 18. The second pair is identified as posts 20 and 22. The third pair of posts is identified as 24 and 26. The next pair of posts is identified as 28 and 30. The following pair of posts is identified as 32 and 34. There are then post pairs 36 and 38, and 40 and 42. Obviously there is no theoretical limit to the number of posts.

In a preferred embodiment of the invention, the width 44 of ceramic body 12 was about 0.050 inch and the length of the ceramic body was about one-half inch, although these dimensions are purely for the sake of giving a specific embodiment.

It is to be noted that each pair of posts is separated from a neighboring pair of posts by a slot 46. Furthermore, each pair of posts is electrically united by a metallic coating 48 which may also take the form of strips. The metallic coating is applied by techniques that are conventional in the art such as vacuum deposition.

The other side of the printed circuit board 14 is shown in FIG. 2 as having a series of printed members 50 in order to electrically unite neighboring pairs of posts and thereby achieve a typical path of the inductor type.

It can be seen from FIG. 2 that printed member 50–A possesses a tab 16–A that contacts post 16 and also possesses at its opposite end a tab 22–A that contacts post 22 of the post pair 20–22. Similarly printed member 50–B unites posts 20 and 26, printed member 50–C unites posts 24 and 30, printed member 50–D unites posts 28 and 34, printed member 50–E unites posts 32 and 38, and printed member 50–F unites posts 36 and 42. Reference is also made to FIG. 3 which shows the foregoing and to FIG. 4 which illustrates the contact achieved between the printed members 50 and the posts of ceramic body 12. Also, FIG. 3 illustrates the use of a tab 52 to provide further connections to any one or all of the printed members 50.

Instead of having the printed members 50 of the printed circuit board so disposed as to connect to a terminal of the next immediately occurring pair of posts, the printed members may jump to a further pair of posts as illustrated in FIGS. 5 and 6. Clearly, other patterns of printed members of circuits board 14 will occur to those skilled in the art including overlaps and special designs in order to achieve unique effects in combining the various pairs of posts to produce an inductor-type path.

It can be seen that the ceramic body 12 includes a central horizontal area 48–A connected by inclined areas 48–B (FIG. 2) with the inclined areas 48–B merging into relatively horizontal posts. The inclined areas and the flat area create a volume that may receive a ferrite in order to achieve a higher value of inductance. In some cases the ferrite may be partially or wholly slidable away from the volume defined by the inclined and flat areas, and in this way, a variable inductor is achieved.

It is to be further noted that the slots **46** are essentially perpendicular to the long side **54**. However, in some cases it may be desired to incline the slots **54** as will be discussed in connection with the device of FIGS. **7**, **8**, and **9**.

With reference to FIG. **7** it will be seen that two ceramic bodies **12–A** and **12–B** are provided. Each ceramic body **12–A** or **12–B** is essentially of the construction of ceramic body **12** of FIG. **2** except the slots **46** are somewhat inclined with respect to long side **54** as best seen in FIG. **9**.

The ceramic bodies **12–A** and **12–B** are identically constructed and include conductive paths **48** that electrically unite post pairs **101** and **102** or post pairs **103** and **104** or post pairs **105** and **106** or post pairs **107** and **108** or post pairs **109** and **110** or post pairs **111** and **112**.

The ceramic bodies **12–A** and **12–B** will have the orientation of FIGS. **7**, and **8**, and **9** in order to produce a continuous closed group helical-type winding. In such an orientation post pairs **101** and **102** of ceramic body **12–A** of FIG. **7** are electrically united with posts pairs **103** and **104** by a connection achieved between posts **101** and **104** through a conductive path provided by ceramic body **12–B**. This repeats itself again and again in order to provide the physical equivalent of a helical wire.

It should be apparent that the microinductor devices produced by the present invention can be trimmed to value simply by limiting the number of turns utilized. The microinductor can be enlarged by placing two or more microinductor devices in series and connecting them with common or separate printed circuit boards. The microinductor devices of the present invention can be soldered in place on the printed circuit board and held thereto by auxiliary devices if necessary. The microinductor devices can then be adjusted at value by coupling terminal leads to post positions corresponding to the number of turns desired. Furthermore, the principle of the present invention is also applicable to the formation of transformer configurations to achieve various windings.

It can be seen that the microinductor devices of the present invention are produced by readily reproducable techniques to achieve a unique overall process that is simple, inexpensive, flexible, and reliable. The method of manufacture lends itself to production of inductors having a wide range of inductance as well as transformers having any desired turns ratio. Even with the device of FIGS. **7**, **8**, and **9**, a ferrite can be used in order to adjust the inductance.

In the fabrication of a microcircuit the engineer designs a printed circuit board in a conventional manner, providing conductive paths and terminal locations as desired. He then simply incorporates a metallization pattern on the board where the microinductor device is to be attached. The ceramic body or bodies are then selected in order to correspond to the inductance or transformer desired. The engineer then positions the ceramic bodies in relation to the metallization pattern and solders it. The ceramic body may be premetallized or the engineer may metallize it prior to attachment to the board.

From the foregoing it will be seen that at least one insulating body with post pairs must be provided and a second body is provided to make the inductive path, with the second body being either a printed circuit board or a second insulating body of a construction similar to the first insulating body.

Without further elaboration, the foregoing will so fully illustrate my invention, that others may, by applying current or future knowledge, adapt the same for use under various conditions of service.

What is claimed as the invention is:

1. A microinductor device comprising an insulating body having opposing pairs of posts that are separated from each other except that the post pairs are electrically united, a second body having a conductive path that electrically unites other posts in an inductive path.

2. The device of claim **1** wherein said insulating body opposing pairs of posts are electrically united but insulated from other pairs of posts, and said insulating body is ceramic.

3. The device of claim **2** wherein said second body is a printed circuit board having printed members that electrically unite one pair of posts to another pair of posts.

4. The device of claim **3** wherein immediately neighboring posts pairs are electrically united.

5. The device of claim **3** wherein the printed members unite post pairs that are remote from the immediate neighboring post pairs.

6. The device of claim **2** wherein said second body is of a construction essentially the same as said first body.

7. The invention of claim **2** including slots insulating said post pairs from other post pairs.

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