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(54) **METHODS AND APPARATUS FOR IMPROVING WINDING BALANCE ON INDUCTIVE DEVICES**

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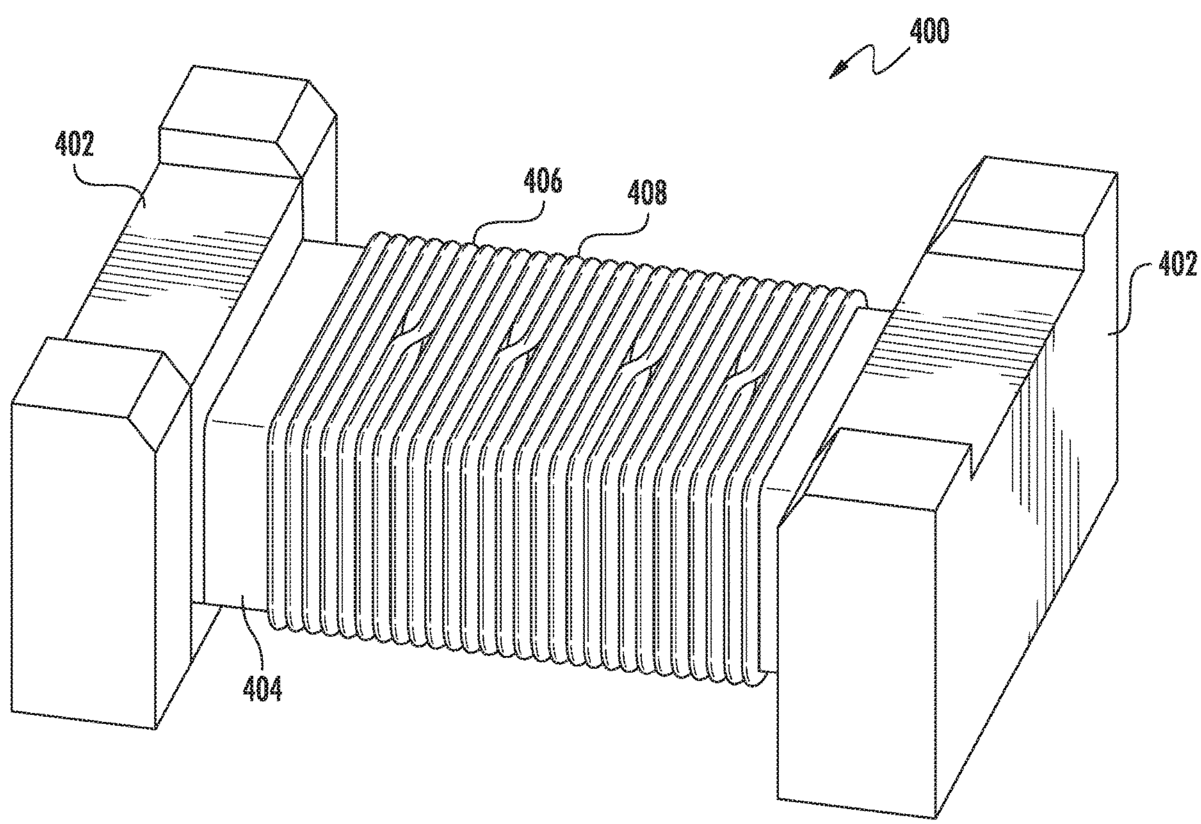
CPC ***H01F 17/045*** (2013.01)

(57) **ABSTRACT**

Improved balance winding of electronic components including common-mode chokes and methods for using and manufacturing the same. In one embodiment, the common-mode choke includes a core and a pair of windings. The first winding and the second winding are alternatingly wound around the core with each respective winding being flipped at least once over the traverse direction of the winding barrel of the core. In one variant, the number of flips is dependent upon the core geometry, number of windings, and/or the specification limits on electrical balance. In another variant, the windings are first twisted and/or braided prior to being wound onto the winding barrel of the core.



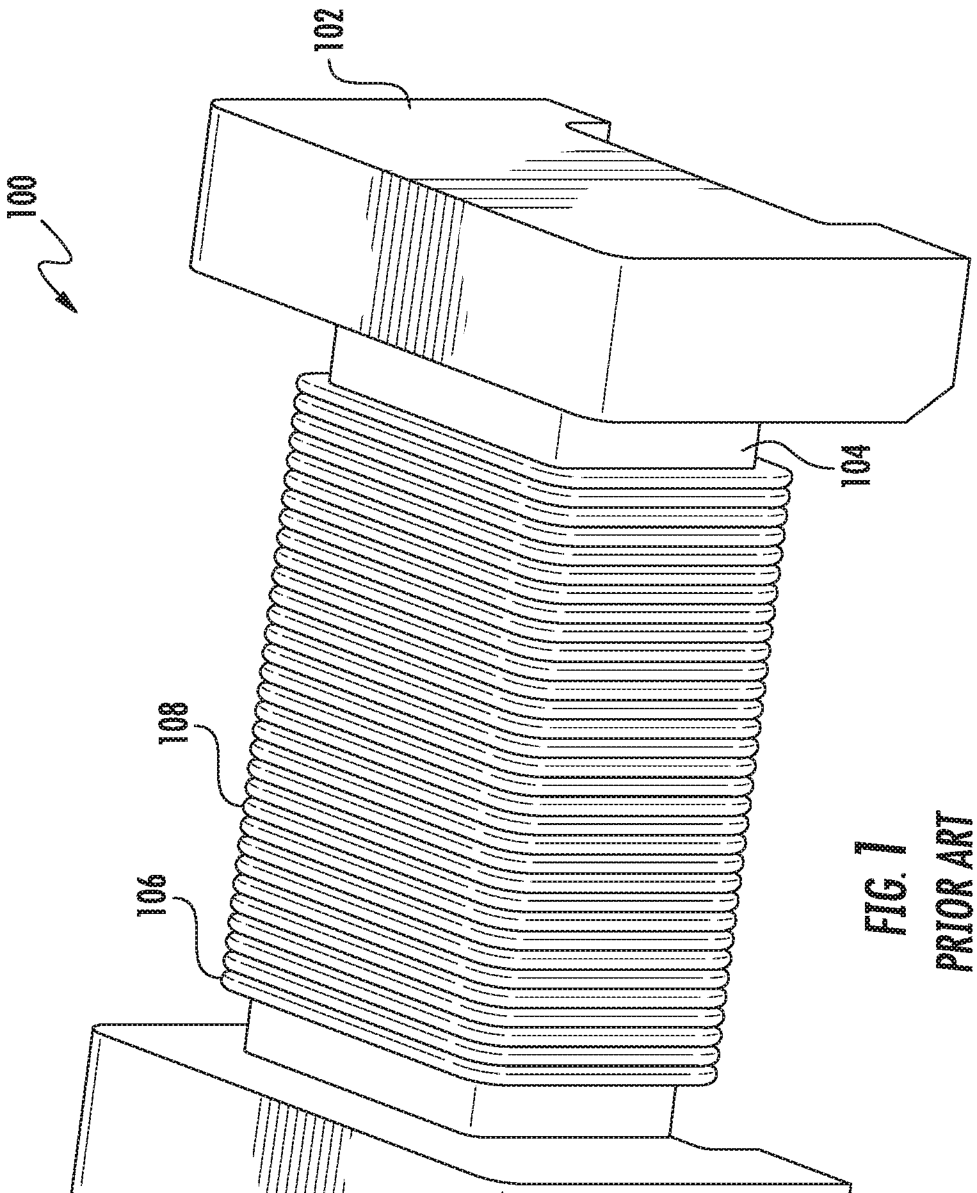


FIG. 1
PRIOR ART

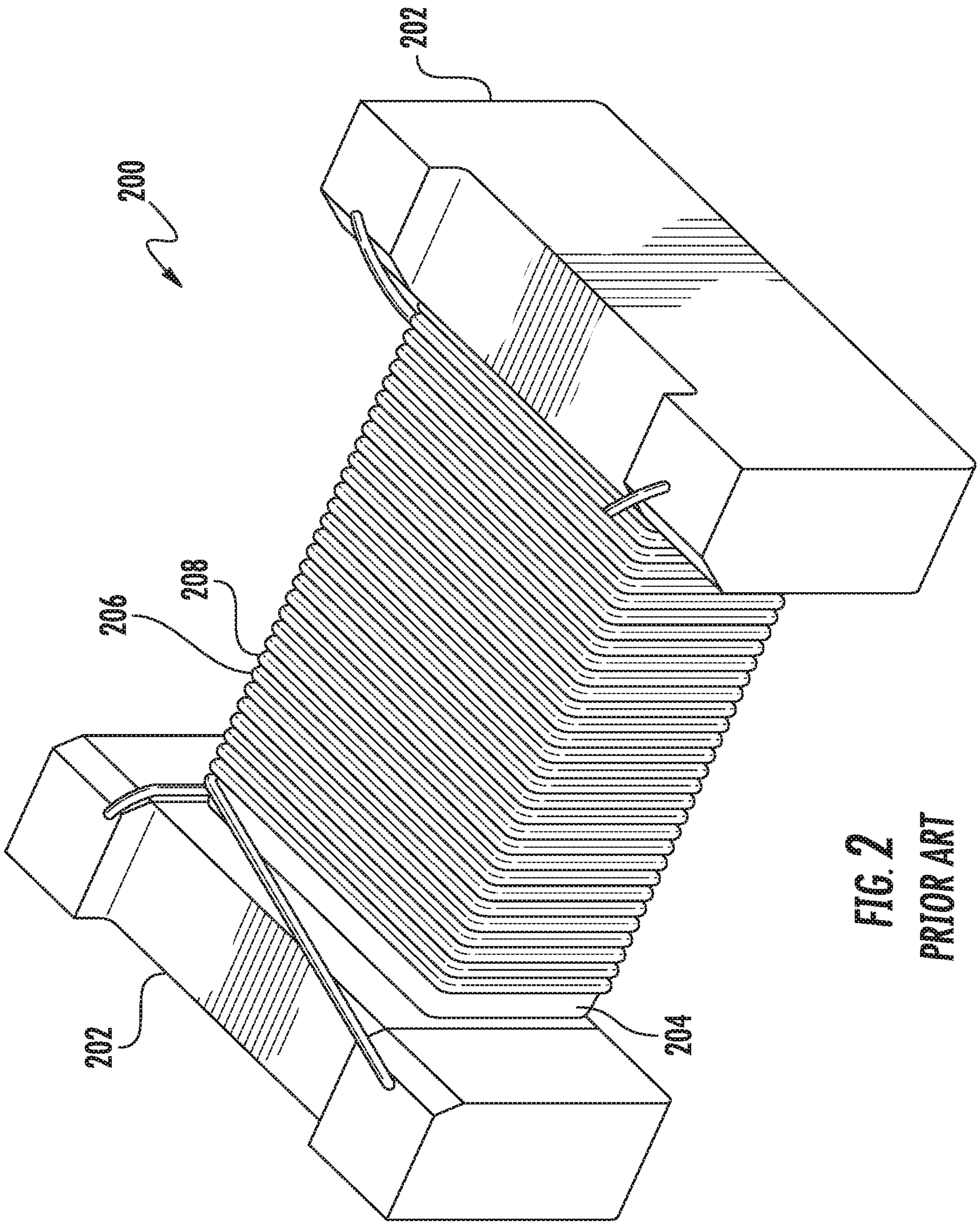


FIG. 2
PRIOR ART

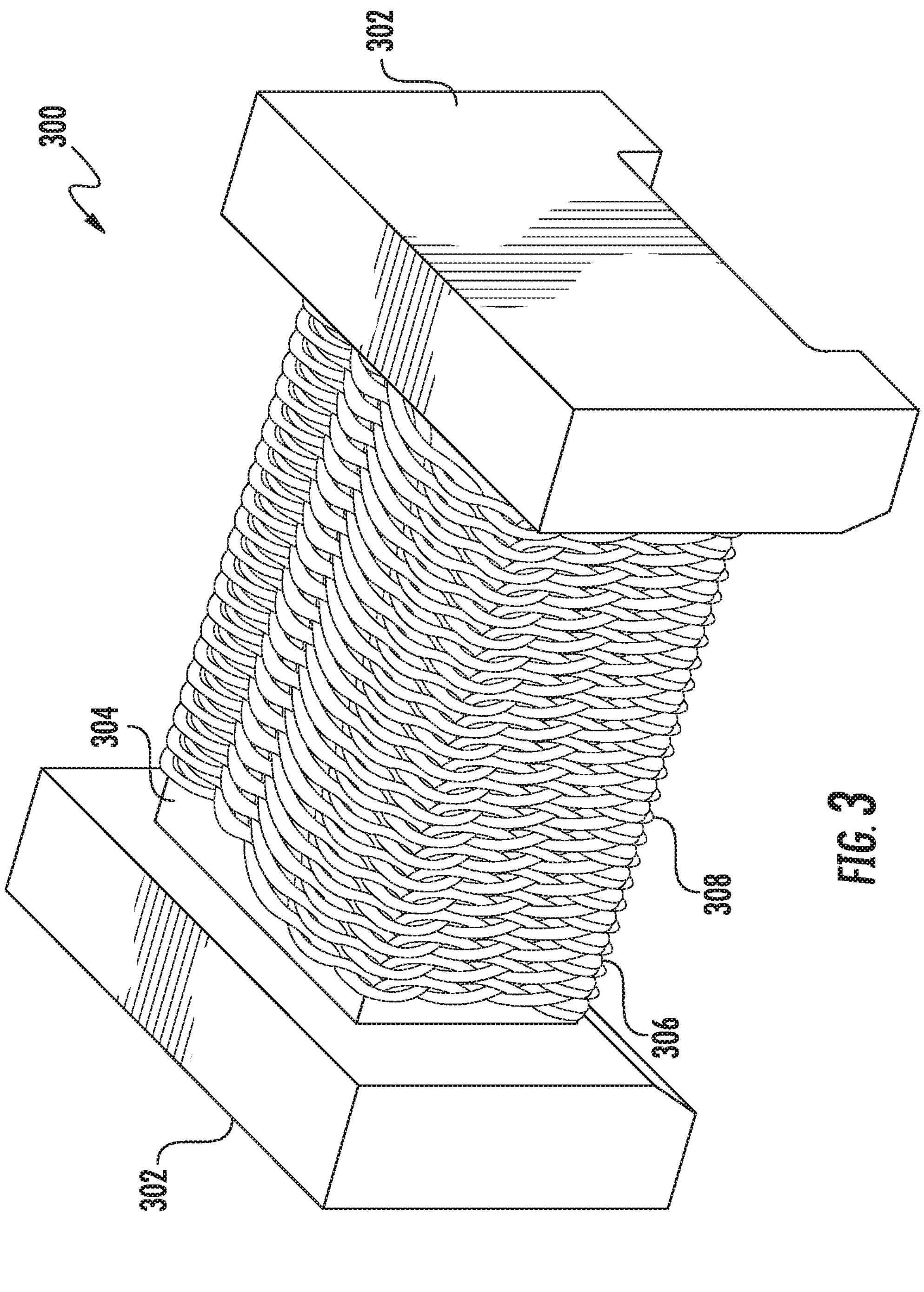


FIG. 3

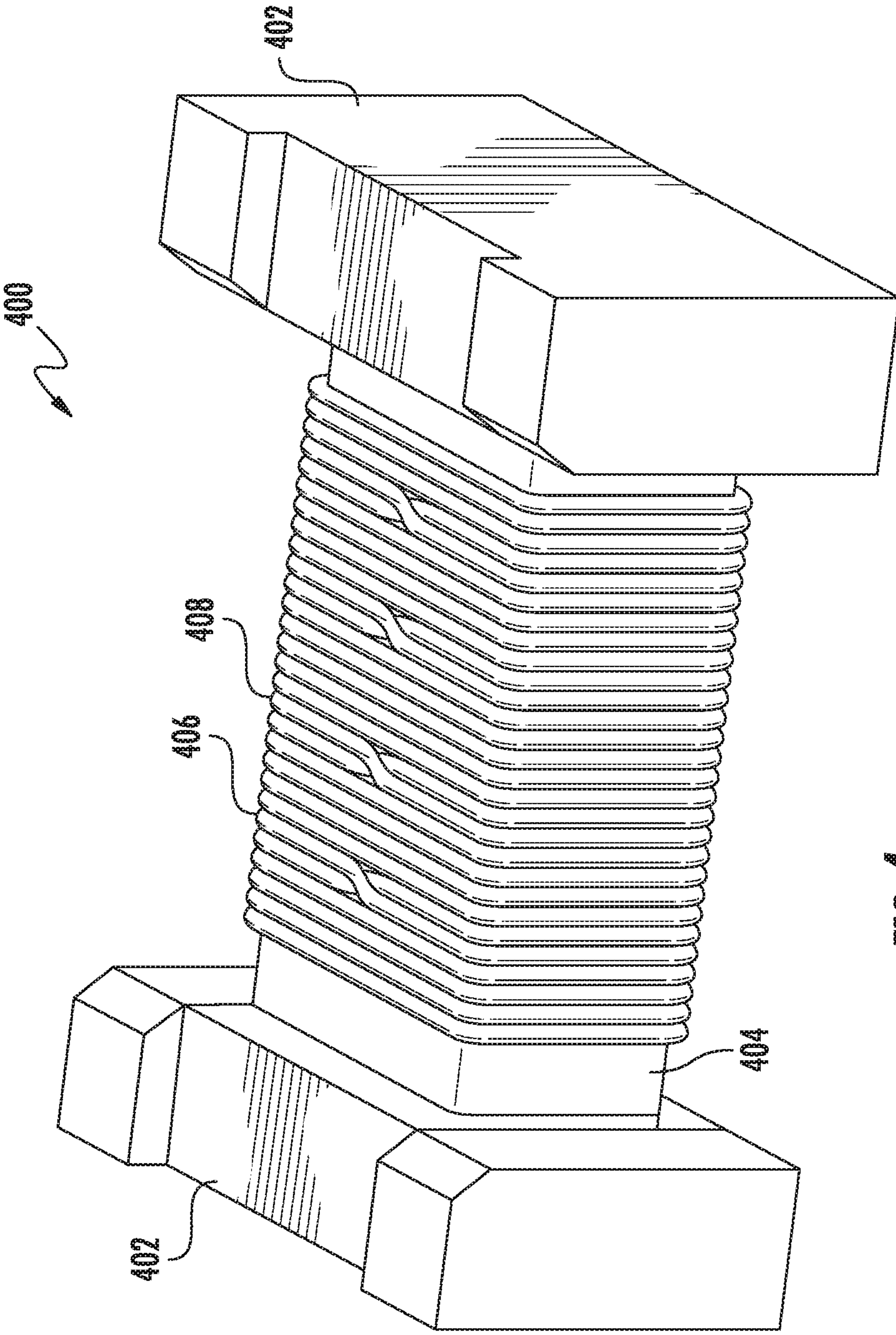


FIG. 4

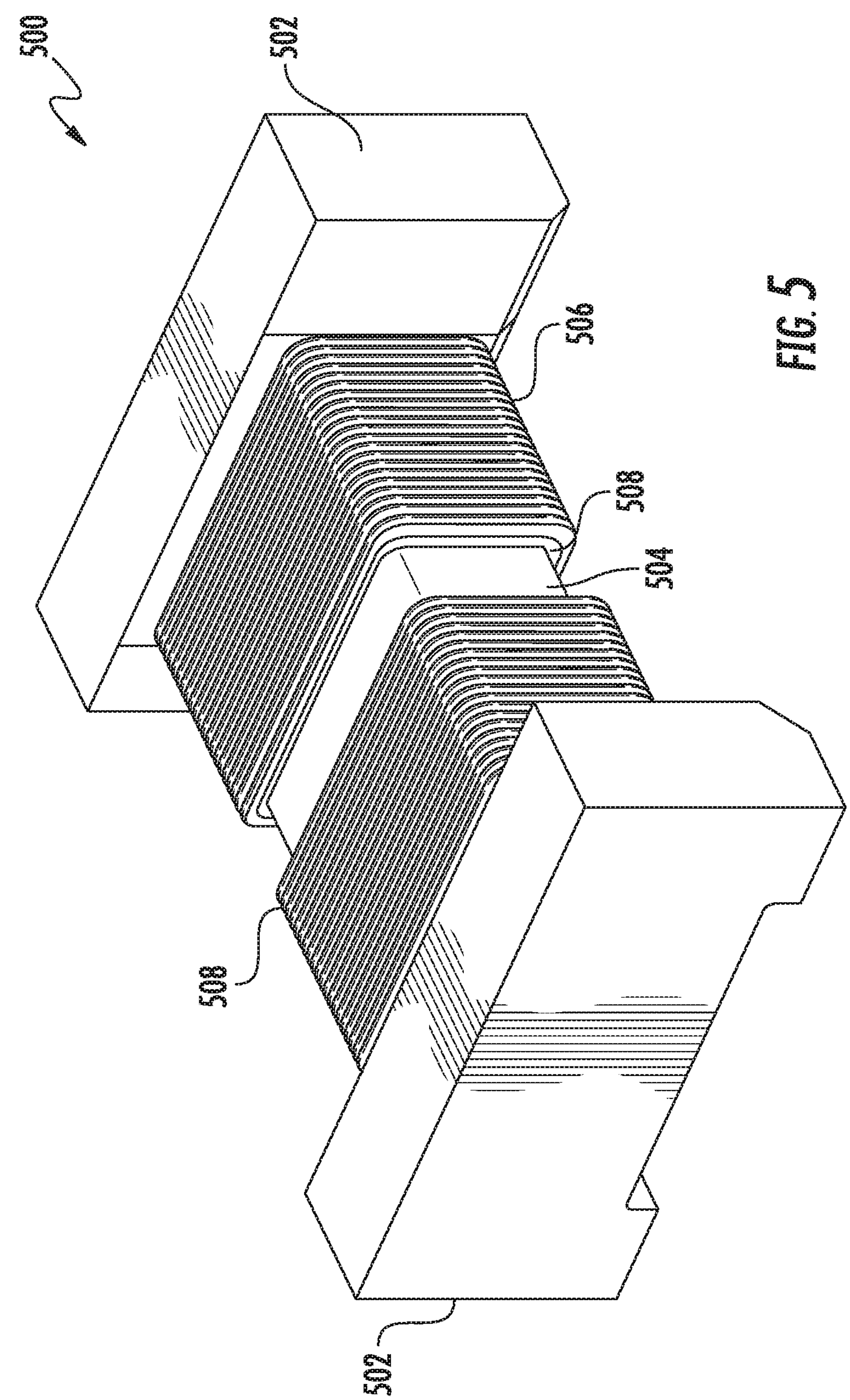


FIG. 5

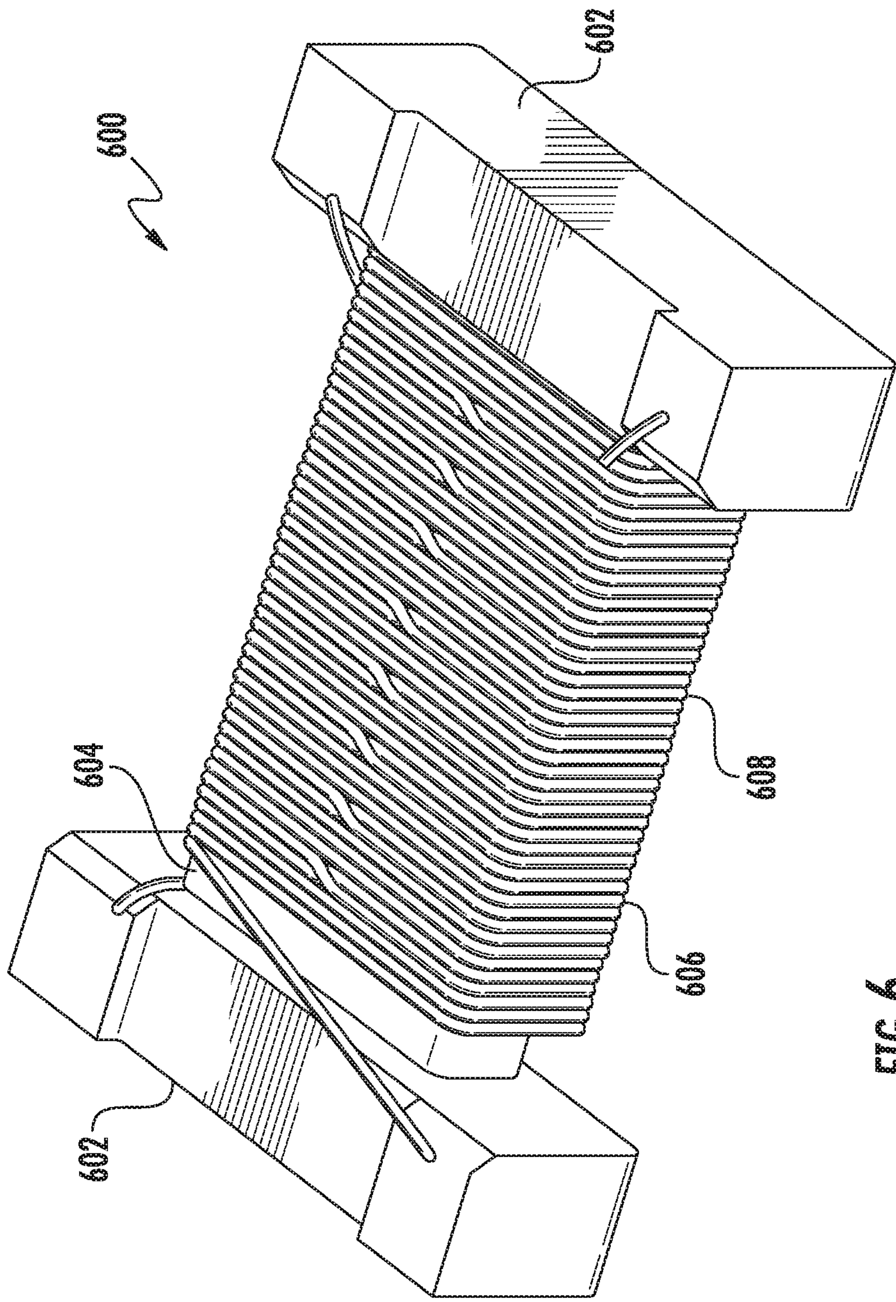


FIG. 6

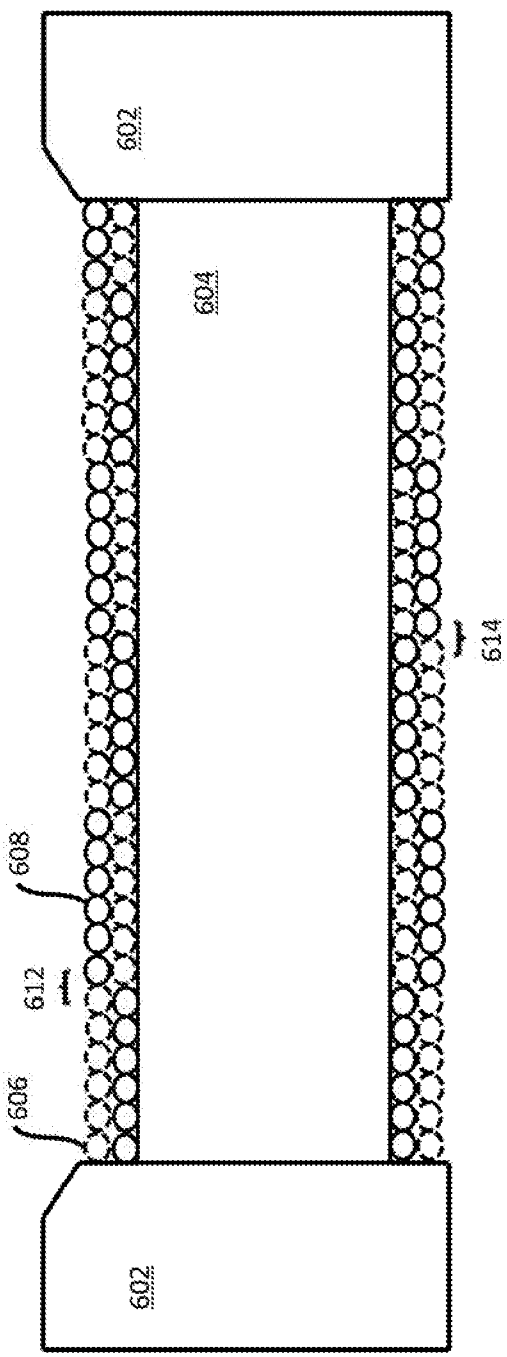


FIG. 6A

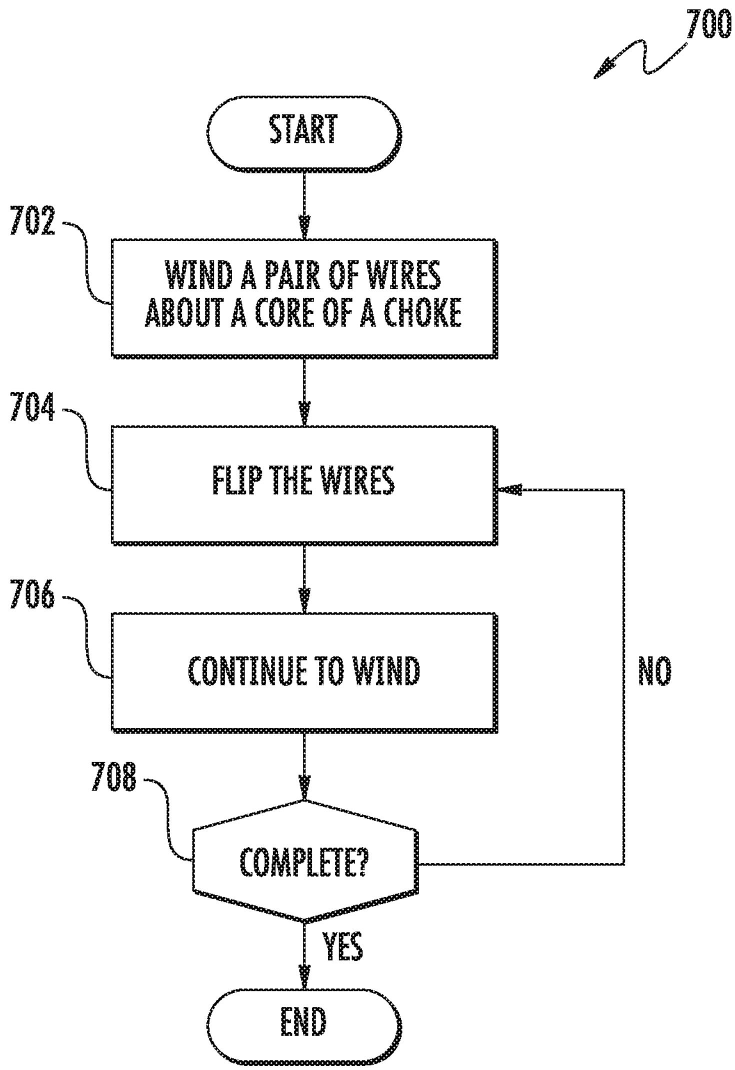

700
START
702
WIND A PAIR OF WIRES ABOUT A CORE OF A CHOKE
704
FLIP THE WIRES
706
CONTINUE TO WIND
NO
708
COMPLETE?
YES
END

FIG. 7

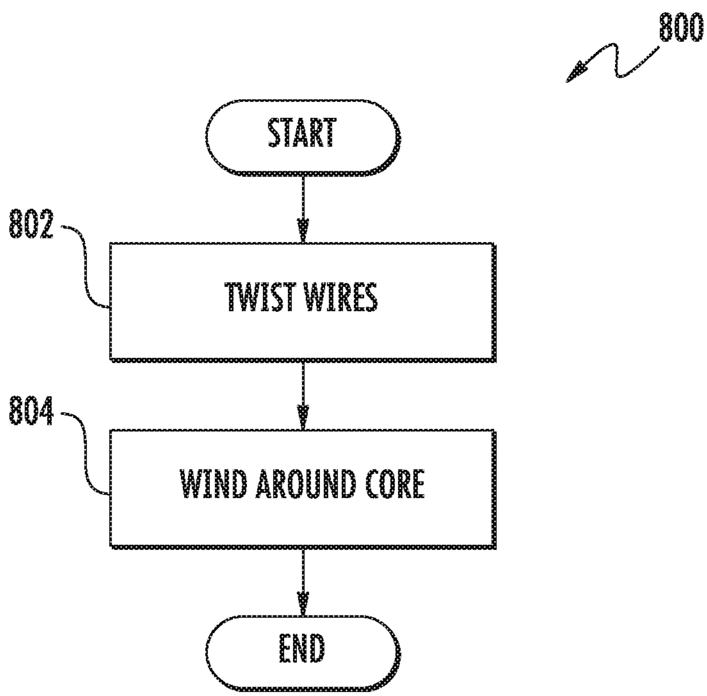


FIG. 8

METHODS AND APPARATUS FOR IMPROVING WINDING BALANCE ON INDUCTIVE DEVICES

PRIORITY

[0001] This application is a divisional of and claims the benefit of priority to co-owned U.S. patent application Ser. No. 14/550,739, which claims the benefit of priority to co-owned U.S. Provisional Patent Application Ser. No. 61/916,021 of the same title filed Dec. 13, 2013, the contents of which are incorporated herein by reference in its entirety.

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1. TECHNOLOGICAL FIELD

[0003] The present disclosure relates generally to conductors and circuit elements and more particularly in one exemplary aspect to apparatus for improving winding balance on electronic components, and methods of utilizing and manufacturing the same.

2. DESCRIPTION OF RELATED TECHNOLOGY

[0004] I-shaped cores are commonly used in the design of inductive devices including as, for example, inductors (e.g., using a single winding) and common-mode chokes (e.g., using two or more windings). In the case of common-mode chokes with two or more windings, electrical balance of the windings is becoming more paramount within certain common-mode choke applications.

[0005] FIG. **1** illustrates one such prior art common-mode choke **100**. The illustrated choke has flanges **102** disposed on opposite ends of a winding barrel of a core **104**, and two windings **106**, **108** that are disposed upon the winding barrel. The windings in the single layer choke **100** are wound such that the electrical balance can often be degraded as the signal traveling in a particular turn on one of the wires **106** will always be coupled in the same manner to the next turn of the other wire **108**. This small, uneven coupling can add up over the winding length of the winding barrel of core, resulting in an unacceptable imbalance in many modern day applications.

[0006] FIG. **2** illustrates an alternative prior art common-mode choke **200** having two or more layers of windings. Similar to that shown with respect to FIG. **1**, the illustrated choke has flanges **202** disposed on opposite ends of a winding barrel of a core **204**, with two windings **206**, **208** being disposed upon the winding barrel. The lower winding **206** is wound under the higher winding **208** causing the wire length of the lower winding **206** to be shorter than the upper winding **208** which results in degradation of electrical balance for the choke.

[0007] Accordingly, despite the variety of prior art techniques for winding, for example, common-mode chokes, there is a salient need for winding configurations that are both low in cost to manufacture and offer improved electrical balance over prior art devices. Ideally such a solution would not only offer very low manufacturing cost and improved electrical balance for the device, but also provide a high level of consistency and reliability of performance by limiting opportunities for errors or other imperfections during manufacture of the windings.

SUMMARY

[0008] The present disclosure satisfies the aforementioned needs by providing an improved balance winding for, inter alia, common-mode chokes and methods of using and manufacturing the same.

[0009] In a first aspect, an inductive device is disclosed. In one embodiment, the inductive device comprises a common-mode choke having a core that includes a winding barrel with two (2) flanges disposed at opposing ends of the winding barrel; a first winding; and a second winding. The first winding and the second winding are wound about the winding barrel of the core such that in a first portion of the winding barrel, the first winding is wound a first distance from the core and the second winding is wound a second distance from the core with the first distance being shorter than the second distance and at a second portion of the winding barrel, the first winding and the second winding are flipped such that the second winding is wound the first distance from the core and the first winding is wound the second distance from the core.

[0010] In a variant, the core comprises an I-shaped core.

[0011] In another variant, the first winding and the second winding are flipped a plurality of times along a traversing direction of the winding barrel.

[0012] In yet another variant, the number of times that the first and second windings are flipped is selected such that the common-mode choke has increased balance at a higher frequency than a common-mode choke that does not have the plurality of flips.

[0013] In yet another variant, the number of times chosen is an odd number.

[0014] In yet another variant, the winding barrel has a plurality of sides and the flips of the first and second windings occur on at least two sides of the winding barrel.

[0015] In yet another variant, the two sides includes at least two opposing sides of the winding barrel.

[0016] In yet another variant, the winding barrel comprises a cylindrical winding barrel and at least two of the plurality of flips of the first and second windings occurs on at least two distinct points along the circumference of the winding barrel.

[0017] In yet another variant, the first winding and the second winding collectively comprises a twisted winding characterized as having a plurality of flips over a given turn.

[0018] In yet another variant, the twisted winding is secured to a plurality of distinct terminations, each of the distinct terminations occurring on the flanges of the core.

[0019] In yet another variant, the first winding and the second winding collectively comprise multiple layers of windings about the winding barrel of the core.

[0020] In yet another variant, a length of the first winding is substantially equal to a length of the second winding.

[0021] In yet another variant, the winding barrel includes at least a portion of the winding barrel that is substantially free from the first winding and the second winding.

[0022] In a second embodiment of the common-mode choke, the first winding and the second winding are wound about the winding barrel of the core, the wound first and second windings includes one or more flips.

[0023] In a variant, the one or more flips includes a plurality of flips, the plurality of flips occurring no more than once per a given turn of the first and second winding.

[0024] In another variant, the one or more flips includes a plurality of flips, the plurality of flips occurring a plurality of times over a given turn of the first and second winding.

[0025] In yet another variant, a length of the first winding is substantially equal to a length of the second winding.

[0026] In yet another variant, the winding barrel includes at least a portion of the winding barrel that is substantially free from the first winding and the second winding.

[0027] In yet another variant, the first winding and the second winding collectively comprises a twisted pair winding.

[0028] In yet another variant, the first winding and the second winding collectively comprise multiple layers of windings about the winding barrel of the core.

[0029] In yet another variant, the first winding and the second winding are alternatingly wound around the core with the winding being flipped at least once which changes the wire order in the traverse direction.

[0030] In yet another variant, the winding is flipped an odd number of times.

[0031] In yet another variant, the number of flips is dependent on the core geometry, wires, and/or the specification limits on electrical balance.

[0032] In yet another variant, the number of flips limit the phase of the unbalanced signal from becoming too large to be effectively canceled.

[0033] In a second aspect, methods of manufacturing the aforementioned inductive devices are disclosed. In one embodiment, the method includes obtaining a core having a winding barrel; obtaining a first conductive wire and a second conductive wire; winding the first conductive wire and the second conductive wire about the winding barrel of the core; flipping the first conductive wire and the second conductive wire one or more times as the first and second conductive wires are wound about the winding barrel; and securing respective ends of the first and second conductive wires to the core.

[0034] In a third aspect, a technique for reducing electrical imbalance in the aforementioned inductive devices is disclosed.

[0035] In a fourth aspect, methods of using the aforementioned inductive devices are disclosed.

[0036] In another aspect of the present disclosure, a common-mode choke is disclosed. In one embodiment, the common-mode choke includes: a core comprising a winding barrel with two flanges disposed at opposing ends of the winding barrel; a first winding; and a second winding; wherein at least the first winding and the second winding are twisted about each other to produce a twisted winding; and wherein the twisted winding is wound around the winding barrel.

[0037] In another aspect of the present disclosure, an inductive device is disclosed. In one embodiment, the inductive device includes: a magnetically permeable core, the magnetically permeable core comprising a first flange, a second flange, and a central element disposed between and connecting the first and second flanges; and a braided winding wound around the central element, the braided winding comprising a first winding and a second winding braided together.

[0038] In another aspect of the present disclosure, a common-mode choke is disclosed. In one embodiment, the common-mode choke includes: a core element comprising a winding barrel with two flanges disposed at opposing ends of the winding barrel; a first twisted winding comprising a first pair of windings twisted about each other; and a second twisted winding comprising a second pair of windings twisted about each other; wherein the first and second twisted windings are alternatingly wound about a first portion of the winding barrel in a given order; and wherein the first and second twisted windings are wound about second portion of the winding barrel in another order that is opposite of the given order.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039] The features, objectives, and advantages of the disclosure will become more apparent from the detailed description set forth below taken in conjunction with the drawings, wherein:

[0040] FIG. **1** is a perspective view of a prior art common-mode choke having a single-layer bifilar winding.

[0041] FIG. **2** is a perspective view of the underside of a prior art common-mode choke having a multiple-layer bifilar winding.

[0042] FIG. **3** is a perspective view of a first exemplary embodiment of a common-mode choke having twisted wire in accordance with the principles of the present disclosure.

[0043] FIG. **4** is a perspective view of a second exemplary embodiment of a common-mode choke in accordance with the principles of the present disclosure.

[0044] FIG. **5** is a perspective view of a third exemplary embodiment of a common-mode choke having multiple layers in accordance with the principles of the present disclosure.

[0045] FIG. **6** is a perspective view of a fourth exemplary embodiment of a common mode choke having multiple layers with multiple wire flips in accordance with the principles of the present disclosure.

[0046] FIG. **6**A is a front elevational view of, for example, the fourth exemplary embodiment of a common mode choke of FIG. **6**, in accordance with the principles of the present disclosure.

[0047] FIG. **7** is a process flow diagram illustrating a first exemplary embodiment of a method for manufacturing the common-mode choke illustrated in FIGS. **4**-**6**.

[0048] FIG. **8** is a process flow diagram illustrating a second exemplary embodiment of a method for manufacturing the common-mode choke illustrated in FIG. **3**.

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DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0050] Reference is now made to the drawings, wherein like numerals refer to like parts throughout.

[0051] As used herein, the terms "electrical component" and "electronic component" are used interchangeably and refer to components adapted to provide some electrical and/or signal conditioning function, including without limitation inductive reactors ("choke coils"), transformers, filters, transistors, gapped core toroids, inductors (coupled or otherwise), capacitors, resistors, operational amplifiers, and diodes, whether discrete components or integrated circuits, whether alone or in combination.

[0052] As used herein, the term "magnetically permeable" refers to any number of materials commonly used for forming inductive cores or similar components, including without limitation various formulations made from ferrite.

[0053] As used herein, the terms "top", "bottom", "side", "up", "down" and the like merely connote a relative position or geometry of one component to another, and in no way connote an absolute frame of reference or any required orientation. For example, a "top" portion of a component may actually reside below a "bottom" portion when the component is mounted to another device (e.g., to the underside of a PCB).

Overview

[0054] The present disclosure provides, inter alia, improved electrical balance for the windings of electronic components such as common-mode chokes that utilize I-shaped cores. In one embodiment, the electrical balance is a measure of the ratios between the common-mode signals coming from one end of the winding to the differential-mode signals coming out the other end of the winding. In order to improve upon the electrical balance, modifications of the winding process are performed. These modifications can produce a more favorable electrical balance as the small uneven coupling present within prior art winding techniques can add up over the winding length of the core resulting in an unacceptable imbalance in many modern applications.

[0055] One such modification is to twist the two (or more) windings prior to winding them onto the winding barrel of the core. Such a winding technique will cause the electrical coupling of the signal from one turn of a winding to the next turn of the other winding to be continuously changed, and hence, accumulated uneven coupling can be minimized or avoided altogether.

[0056] In an alternative configuration, the winding technique involves the flipping of the order of the wire pairs every predetermined number of turns. This enables the uneven coupling to reverse direction periodically therefore nullifying the accumulated uneven coupling effects. The number of flips may be dependent on core geometry, geometry and number of wires, as well as the specification limits on electrical balance. For example, common-mode chokes requiring more balance at high frequencies often necessitate more flips in order to limit the size of unbalanced sections of windings. These smaller sections will limit the phase of the unbalanced signal from becoming too large to be effectively cancelled. Since this technique often involves flipping the wire in order to counterbalance the unbalance accumulated in the preceding section, an odd number of flips may be optimal. However, an even number of flips may be utilized as well in certain applications. Furthermore, these windings may be comprised of twisted pair windings or alternatively, weaved windings as well.

[0057] These windings may be made from single or multiple layers. For single-layer windings, flipping will change the wire order in the traverse direction while in, for example, two-layer winding configurations the flipping changes the wire in the vertical direction (i.e. orthogonal to the traverse direction).

[0058] Furthermore, methods for manufacturing and using these aforementioned chip choke assemblies are also disclosed.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0059] It will be recognized that while the following discussion is cast in terms of an exemplary common-mode choke having an I-shaped magnetically permeable core, it would be readily apparent to one of ordinary skill given the present disclosure that same principles apply for a common-mode choke with different magnetically permeable core shapes including, e.g. a C-shaped magnetically permeable core, a square shaped magnetically permeable core, and a rectangular shaped magnetically permeable core.

[0060] Furthermore, while the magnetically permeable cores are primarily discussed herein as being formed from a ferrite material, other common core materials can be readily substituted if desired (such as e.g., laminated silicon steel, etc.) to achieve the desired electrical performance characteristics of the chip choke assembly.

Twisted Windings—

[0061] Referring now to FIG. **3**, a first exemplary embodiment of a common-mode choke **300** in accordance with the principles of the present disclosure is shown and described in detail. The common-mode choke **300** comprises an I-shaped core with flanges **302** disposed on opposite sides of the winding barrel of core **304**. The core **304** is wound, in the illustrated embodiment, with two (2) windings **306**, **308**. These two (2) windings **306**, **308** are twisted about each other prior to their distribution onto the core and wound around the winding barrel of core **304**. This technique causes the electrical coupling of a present signal from one turn of a winding to the next turn of the other winding to be continuously changed, and hence, accumulated uneven coupling can be avoided. In other words, this technique minimizes the cumulated undesired electrical coupling within the turns of the common mode choke by randomly changing the areas of coupling so that the net effect can be much more electrically balanced. The ends of this twisted pair windings **306**, **308** are subsequently secured to four (4) distinct terminations which are resident on opposite corners of each flange **302**.

[0062] In an alternative embodiment, more than two (2) wires may be twisted and wound around the core. For example, a woven strand of multiple wires, such as that described in U.S. Pat. No. 8,405,481 entitled "Woven Wire, Inductive Devices, and Methods of Manufacturing" issued Mar. 26, 2013, which is incorporated herein by reference in its entirety, could be readily added to the core **304**.

Flipped Windings—

[0063] Referring now to FIG. **4**, a second exemplary embodiment of a common-mode choke **400** in accordance with the principles of the present disclosure is shown and described in detail. Similar to the embodiment illustrated above with respect to FIG. **3**, the common-mode choke **400** comprises an I-shaped core with flanges **402** disposed on opposite sides of core **404**. The winding barrel of core **404** is wound, in the illustrated embodiment, with two (2) windings **406**, **408**. The windings **406**, **408** are wound about the core alternating between one wire **406** and the other **408**

with the order of the wire pairs **406**, **408** being flipped every few turns about core **404**. The flipping of the wire changes the wire order in the traverse direction. This allows the uneven coupling generated by a portion of the windings to reverse direction after every few turns and therefore, nullify the accumulated uneven coupling effects. The number of flips required is dependent upon, for example, the core geometry, the number and size of the wires utilized, and the specification limits on electrical balance. For instance, common-mode chokes that require more balance at higher frequencies need more flips in order to limit the size of the unbalanced sections. This is because the resultant smaller sections will limit the phase of unbalanced signal from becoming too large to be effectively cancelled. As illustrated in FIG. **4**, the windings of the wired pair **406**, **408** are flipped four (4) times.

[0064] However, in an alternative variant, the number of flips is odd (i.e., three (3) flips, five (5) flips, etc.). Using an odd number of flips is particularly useful where the number of turns for each section is the same between flips which would counterbalance the unbalance that has accumulated in the preceding section. Furthermore, while illustrated as having the wire flips occurring in multiple locations on the top portion of the core **404**, the location of the wire flips can be readily varied depending upon the electrical requirements for the choke. For instance, flips can occur on the top, bottom, and sides, or even variations thereof on the winding barrel of the core, or anywhere around the circumference of a cylindrical winding barrel.

[0065] In a further variant, a pair of the twisted (or braided) windings (such as that illustrated with respect to FIG. **3**) is alternatingly wound about the winding barrel of core **404**. Each pair of the twisted windings is subsequently flipped periodically about the core **404**, similar to that described above with respect to FIG. **4**.

Multiple Layer Windings—

[0066] Referring now to FIGS. **5**-**6**A, wire flipping as discussed above with respect to FIG. **4** is illustrated with multiple layers of windings of a common-mode choke. As shown in FIG. **5**, a first exemplary embodiment of a multiple layer common-mode choke **500** is shown. The choke **500** includes flanges **502** on either side of the winding barrel of core **504**. The illustrated choke **500** has two wires **506**, **508**. On a first portion of the core **504**, the first wire **508** is wound adjacent to the core **504**. The second wire **506** is wound on top of the first wire **508**. In a second portion of the core **504**, the second wire **506** is wound adjacent to the core **504** while the first wire **508** is wound on top of the second wire **506**. In between the first portion and the second portion the wires **506**, **508** are flipped. Flipping the wires **506**, **508** in the multiple layer winding reverses the wires in the vertical direction thereby providing better electrical balance. This improved electrical balance is a result of, inter alia, the lengths of the wires **506**, **508** being made equal whereas without the flip the inner wire would be shorter than the outer wire.

[0067] Referring now to FIGS. **6** and **6**A, an alternative embodiment for a multiple layer common mode choke is shown and described in detail. Specifically, the embodiment of FIG. **6** illustrates multiple wire flips (e.g., flip **612** and flip **614** in FIG. **6**A) as compared with the embodiment of FIG. **5**. Like the other embodiments illustrated in FIGS. **3**-**5**, the choke **600** includes flanges **602** on opposite ends of the winding barrel of core **604**. In a first portion of the core **604**, a first wire **606** (indicated by dashed circle **606** in FIG. **6**A) is a first distance from the core **604** and a second wire **608** (indicated by circle **608** in FIG. **6**B) is a second distance from the core **604** where the second distance is longer than the first distance. The positions of the first wire **606** and the second wire **608** switch in a second portion of the winding barrel of core **604** that is adjacent to the first portion via the flipping of the wires **606**, **608**. In this flipped position, the second wire **608** is now at a first distance from the core **604** while the first wire **606** is at the second distance from the core. The first and second wires **606**, **608** alternate distances from the core **604** along the entire length of the winding barrel of core **604**. As illustrated in FIG. **6**, the first and second wires **606**, **608** flip eight (8) times; however, it is of course envisaged that the number of wire flips can vary depending on the particular electrical design constraints, For example, variables such as wire diameter, thickness of the wire coating, dielectric constant of the dielectric itself, and most importantly, the desired balance level, which also varies as a function of frequency are factors to consider in determining the number of wire flips within a given design.

[0068] For example, in an alternative variant (and similar to the discussion with respect to the embodiments illustrated in FIGS. **3** and **4**), the number of flips is odd (i.e., three (3) flips, five (5) flips, etc.). Using an odd number of flips is particularly useful where the number of turns for each section is the same between flips which would counterbalance the unbalance that has accumulated in the preceding section. Furthermore, while illustrated as having the wire flips (e.g., wire flip **612** in FIG. **6**A) occurring in multiple locations on the top portion of the core **604**, the location of the wire flips can be readily varied depending upon the electrical requirements for the choke. For instance, flips can occur on the top, bottom (e.g., wire flip **614** in FIG. **6**A), and sides, or even variations thereof on the winding barrel of the core, or anywhere around the circumference of a cylindrical winding barrel.

Methods of Manufacture

[0069] Exemplary methods of manufacture and use of the common-core choke according to the principles of the present disclosure are now described in detail.

[0070] Referring to FIG. **7**, an exemplary method for manufacturing **700** the aforementioned common-mode choke is described in detail. The method may be performed by an automated winding machine or alternatively, may be wound by hand. In one embodiment, the core is an I-shaped core of the type illustrated in, for example, FIGS. **3**-**6**. The core thus has an axial portion (i.e., winding barrel) and two (2) flanges disposed on both ends of the axial portion. As discussed previously herein, it will be readily apparent to those skilled in the art without departing from the present disclosure that another shape may be used as required for the final desired shape and properties of the common-mode choke assembly. In one embodiment, the windings used are magnet wire windings with two (2) such windings being wound around the axial portion of the core. In an alternative embodiment, more than two (2) windings are utilized. While the use of the "I" shaped core and square shaped winding barrel are exemplary, other shapes and winding barrel geometries may be formed to get the desired magnetic flux and electrical properties without deviating from the principles of the present disclosure.

[0071] At step **702**, a pair of wires is wound about a core that is to form the common-mode choke. In a multiple layer variant, the pair of wires is wound vertically about the core such that a first wire of the pair is wound adjacent the core while the second wire of the pair is wound adjacent the first wire.

[0072] At step **704**, after a predetermined number of windings about the core, the wires are flipped. For example, in the multiple layer variant discussed previously herein, the flipping changes the orientation of the wires in a vertical direction with respect to the winding barrel of the core. Alternatively, in a single layer variant, the flipping of the windings causes the wires to be changed in the horizontal direction (i.e. the traversal direction of the windings) with respect to the core.

[0073] At step **706**, the pair of wires is continued to be wound with the predetermined orientation governed by step **704**.

[0074] At step **708**, if the number of flips is sufficient to limit the size of unbalanced sections with respect to specification limits on electrical balance, the method **700** ends. Otherwise, the method continues at step **706** where the windings are once again flipped.

[0075] Referring now to FIG. **8**, an exemplary method for manufacturing **800** an exemplary common-mode choke as illustrated in, for example, FIG. **3** is described in detail.

[0076] At step **802**, two (2) or more windings are twisted or braided together. In one embodiment, the method of braiding can be done as described in co-owned and co-pending U.S. Pat. No. 8,405,481 entitled "Woven Wire, Inductive Devices, and Methods of Manufacturing" issued Mar. 26, 2013, which was previously incorporated herein by reference in its entirety.

[0077] At step **804**, the windings are wound onto the length of the winding barrel of a core thereby forming a common-mode choke. In an alternative variant, multiple twisted pairs from step **802** are used as the individual windings of method **800** of FIG. **8**.

[0078] It will be recognized that while certain aspects of the disclosure are described in terms of specific design examples, these descriptions are only illustrative of the broader methods, and may be modified as required by the particular design. Certain steps may be rendered unnecessary or optional under certain circumstances. Additionally, certain steps or functionality may be added to the disclosed embodiments, or the order of performance of two or more steps permuted. All such variations are considered to be encompassed within the disclosure and claims herein.

[0079] While the above detailed description has shown, described, and pointed out novel features of the disclosure as applied to various embodiments, it will be understood that various omissions, substitutions, and changes in the form and details of the device or process illustrated may be made by those skilled in the art. The foregoing description is of the best mode presently contemplated. This description is in no way meant to be limiting, but rather should be taken as illustrative of the general principles of the disclosure, the scope of which should be determined with reference to the claims.

1.-**20**. (canceled)

21. A common-mode choke, comprising:
- a core comprising a winding barrel with two flanges disposed at opposing ends of the winding barrel;
- a first winding; and
- a second winding;
- wherein at least the first winding and the second winding are twisted about each other to produce a twisted winding; and
- wherein the twisted winding is wound around the winding barrel.

22. The common-mode choke of claim **21**, wherein ends of the first winding are secured to respective first terminations resident on each of the two flanges, and ends of the second winding are secured to respective second terminations resident on each of the two flanges.

23. The common-mode choke of claim **22**, wherein the respective first and second terminations are each disposed on respective ones of a plurality of corners of the two flanges.

24. The common-mode choke of claim **22**, wherein:
- the two flanges are each approximately rectangular in shape;
- the two approximately rectangular shaped flanges are disposed in a common angular orientation relative to a central axis of the winding barrel; and
- the first termination and second termination on each of the two flanges are disposed on a common side of the respective flange such that the common-mode choke can be surface mounted to a substrate with each of the first and second terminations disposed away from the substrate.

25. The common-mode choke of claim **21**, wherein the twisted winding wound around the winding barrel comprises at least one additional winding is twisted with the first and second windings.

26. The common-mode choke of claim **21**, wherein the twisted winding is associated with an electrical coupling that is more balanced as compared to a winding that is not twisted.

27. The common-mode choke of claim **21**, wherein the core comprises an I-shaped magnetically permeable core.

28. An inductive device, comprising:
- a magnetically permeable core, the magnetically permeable core comprising a first flange, a second flange, and a central element disposed between and connecting the first and second flanges; and
- a braided winding wound around the central element, the braided winding comprising a first winding and a second winding braided together.

29. The inductive device of claim **28**, wherein each end of the first and second windings of the braided winding is secured to a respective termination on the first and second flanges, the respective termination being one of four corresponding terminations.

30. The inductive device of claim **28**, wherein the braided winding comprises at least a third winding braided with the first and second windings.

31. The inductive device of claim **30**, wherein the first, second and third windings are comprised of a primary sub-group and a secondary sub-group; and
- wherein at least said primary and secondary sub-groups are at least partly braided such that at least a portion of the braided windings reside on at least three distinct levels relative to the central element.

32. The inductive device of claim **30**, wherein the first, second and third windings are braided together over a given length;

wherein the first, second and third are comprised of a plurality of braided portions and a plurality of braided portions; and

wherein at least one of the non-braided portions resides between two adjacent braided portions

33. The inductive device of claim **28**, wherein the braided winding is associated with an electrical coupling that is more uniform as compared to a non-braided winding made from the first winding and the second winding.

34. A common-mode choke, comprising:

a core element comprising a winding barrel with two flanges disposed at opposing ends of the winding barrel;

a first twisted winding comprising a first pair of windings twisted about each other; and

a second twisted winding comprising a second pair of windings twisted about each other;

wherein the first and second twisted windings are alternatingly wound about a first portion of the winding barrel in a given order; and

wherein the first and second twisted windings are wound about second portion of the winding barrel in another order that is opposite of the given order.

35. The common-mode choke of claim **34**, wherein the first and second twisted windings are disposed in a single layer around the winding barrel.

36. The common-mode choke of claim **34**, wherein the first and second portions of the winding barrel are adjacent to each other, and the other order is caused by a flip of the given order of the winding of the first and second twisted windings.

37. The common-mode choke of claim **36**, wherein the first and second twisted windings are alternatingly wound about a third portion of the winding barrel in the given order, the third portion and the second of the winding barrel being adjacent to each other.

38. The common-mode choke of claim **34**, wherein, based on a plurality of flips of the first and second twisted windings, the first and second twisted windings are wound in the given order along a first plurality of portions of the winding barrel and the other order along a second plurality of portions of the winding barrel, each of the first and second plurality of portions alternating along the winding barrel.

39. The common-mode choke of claim **34**, wherein the twisted winding is associated with an electrical coupling that is more balanced as compared to a winding that is not twisted.

40. The common-mode choke of claim **34**, wherein at least one of the first and second twisted windings comprises at least another winding twisted with the corresponding first and second pair of windings.

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