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Oi

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(54) **CHOKE COIL**

(75) Inventor: **Takaaki Oi**, Takefu (JP)

(73) Assignee: **Murata Manufacturing Co., Ltd.**, Kyoto (JP)

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(52) **U.S. Cl.** **336/215**; 336/83; 336/212; 336/233; 336/192

(58) **Field of Search** 336/83, 192, 198, 336/212, 215, 233; 29/602.1; 313/440

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

JP 11-238636 8/1999

Primary Examiner—Anh Mai
(74) *Attorney, Agent, or Firm*—Keating & Bennett, LLP

(57) **ABSTRACT**

A choke coil includes a magnetic bobbin, windings, and a magnetic connecting member. The bobbin has a winding member. End flange portions are provided at both ends of the winding member, and a center flange portion is provided at the approximate center thereof. The center flange portion preferably has a substantially rectangular shape and is slightly smaller than the end flange portions, and has inclined portions at two adjoining corners. The connecting member connects the outer peripheral portions of the end flange portions. A gap is formed between the connecting member and the outer peripheral surface of the center flange portion.

16 Claims, 7 Drawing Sheets

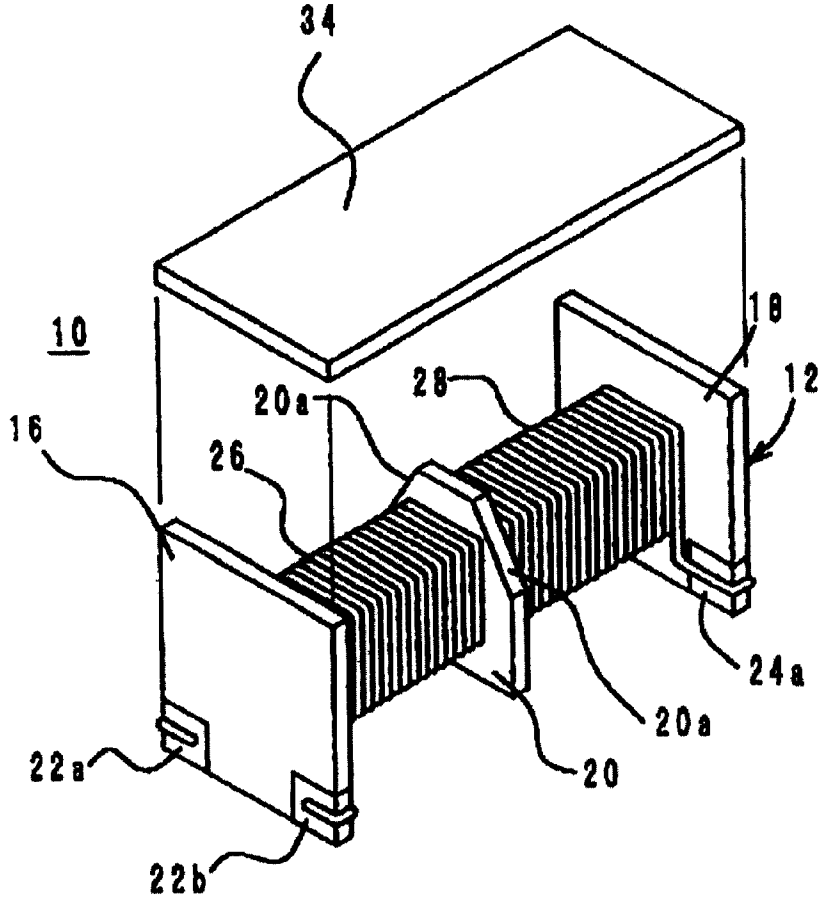


Fig.1

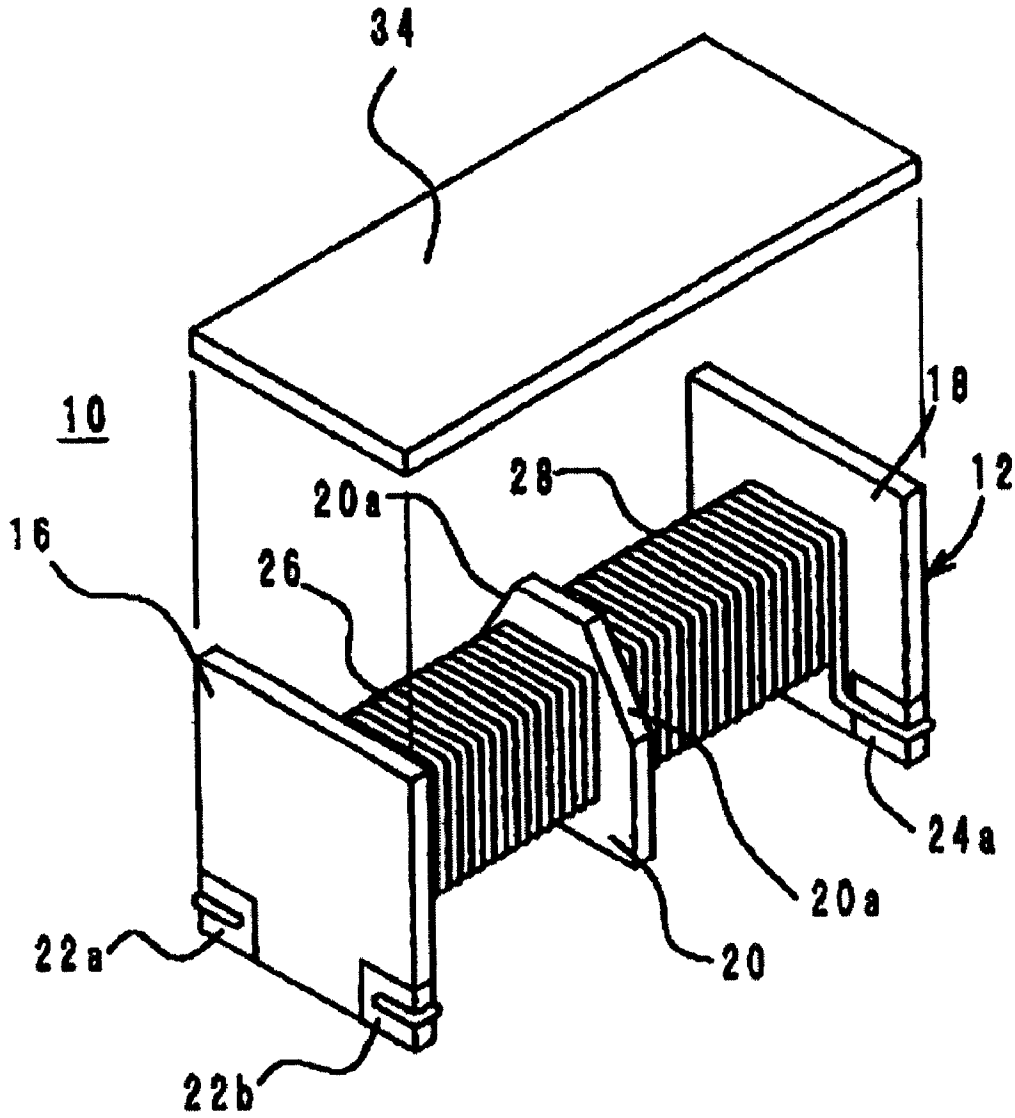


Fig.2

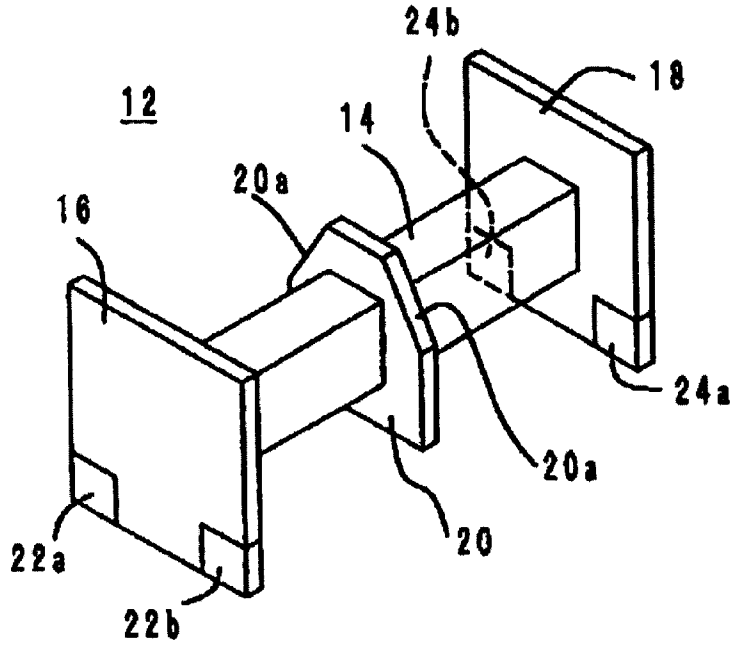

24b
18
12
14
20a
16
24a
20a
20
22a
22b

Fig.3

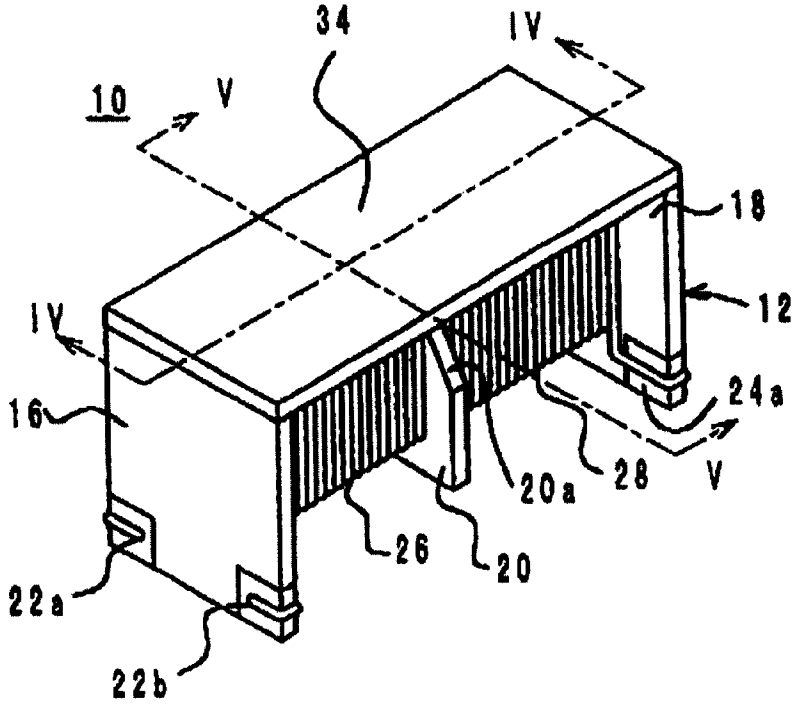

34
IV
10
V
18
12
IV
16
24a
28
V
20a
26
20
22a
22b

Fig.4

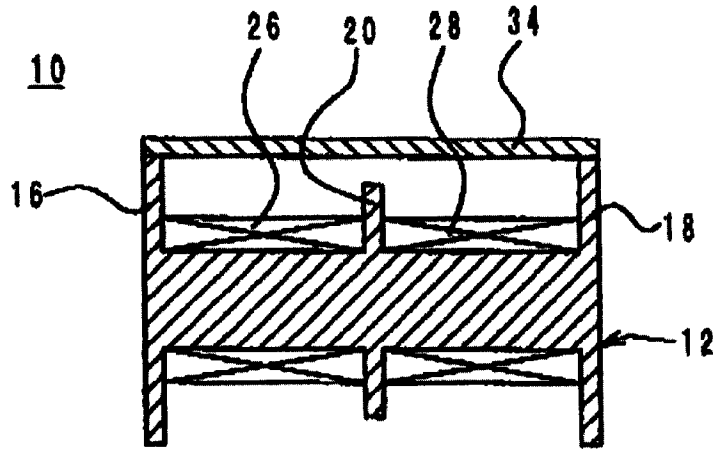


Fig.5

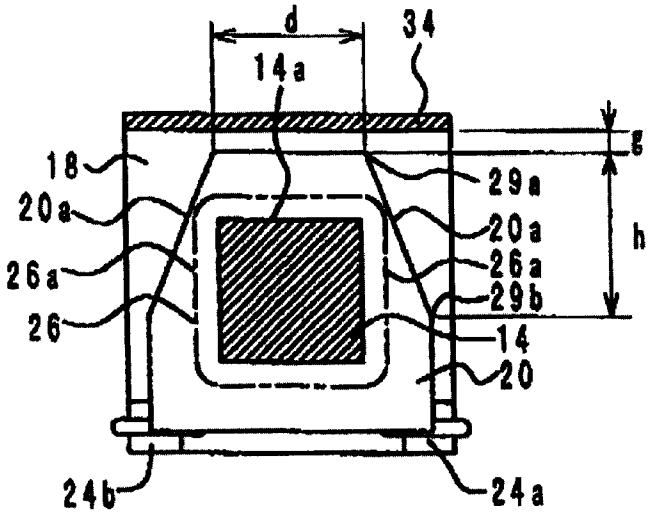


Fig.6

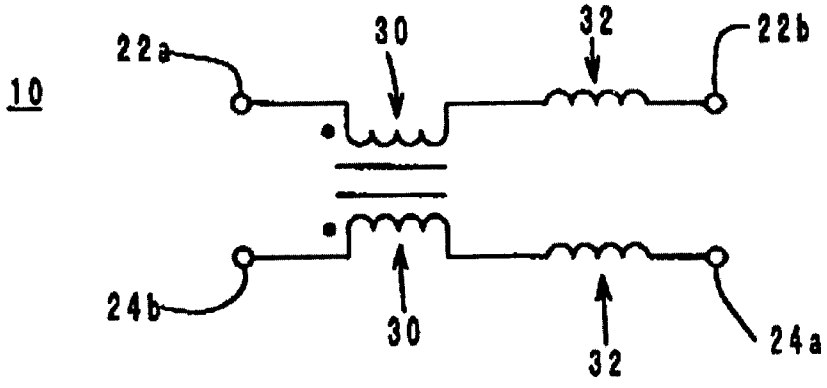


Fig.7

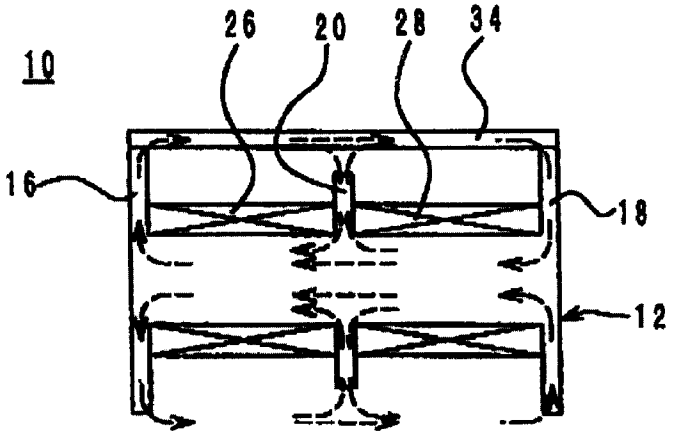


Fig.8

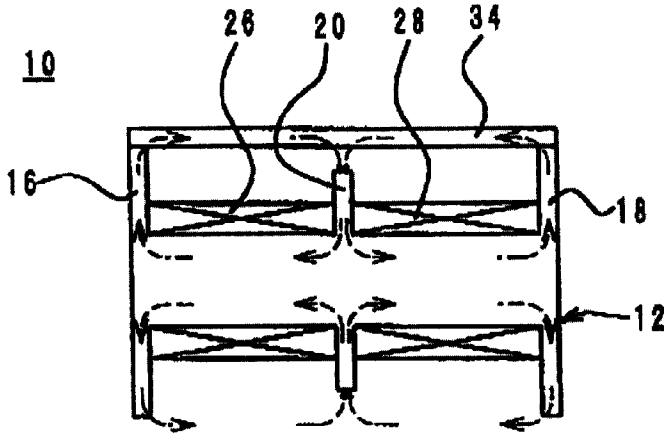


Fig.9

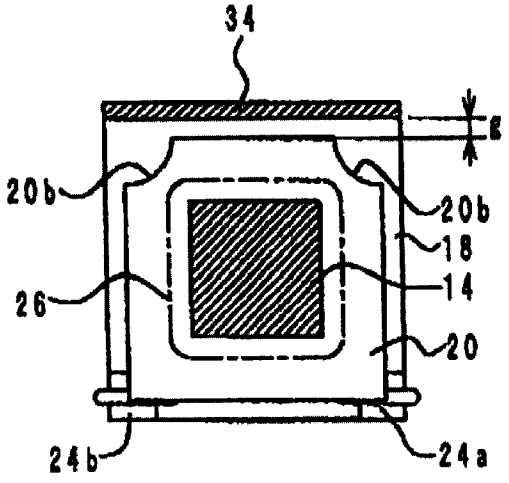


Fig.10

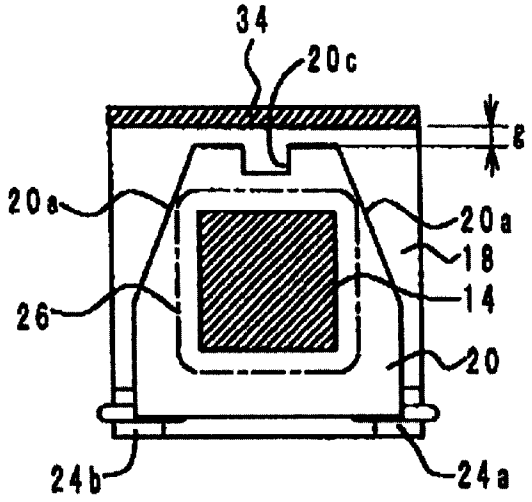


Fig.11

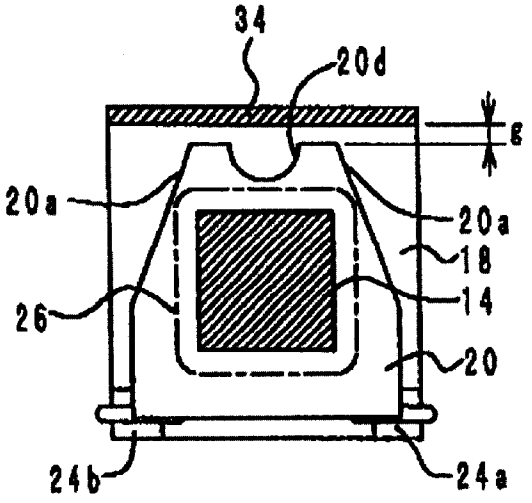


Fig.12

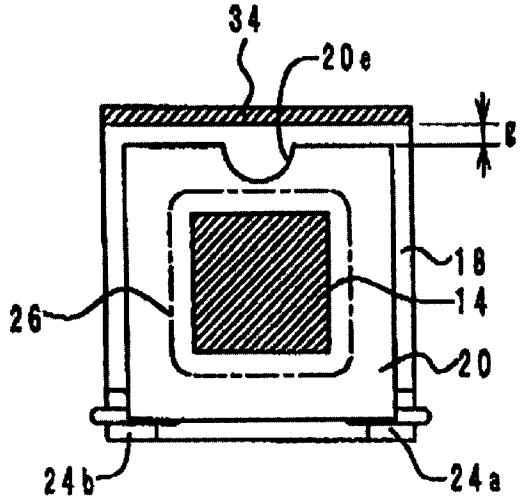


Fig.13

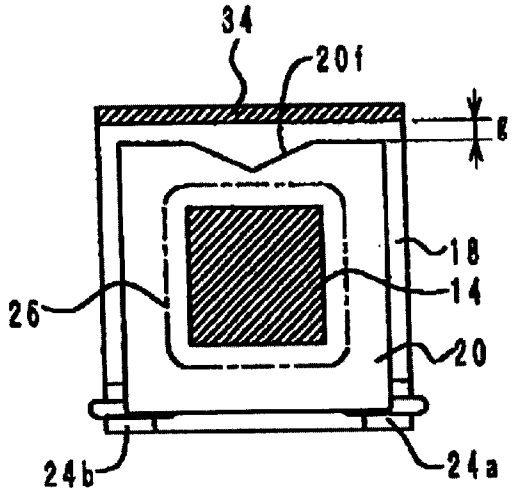


Fig.14
PRIOR ART

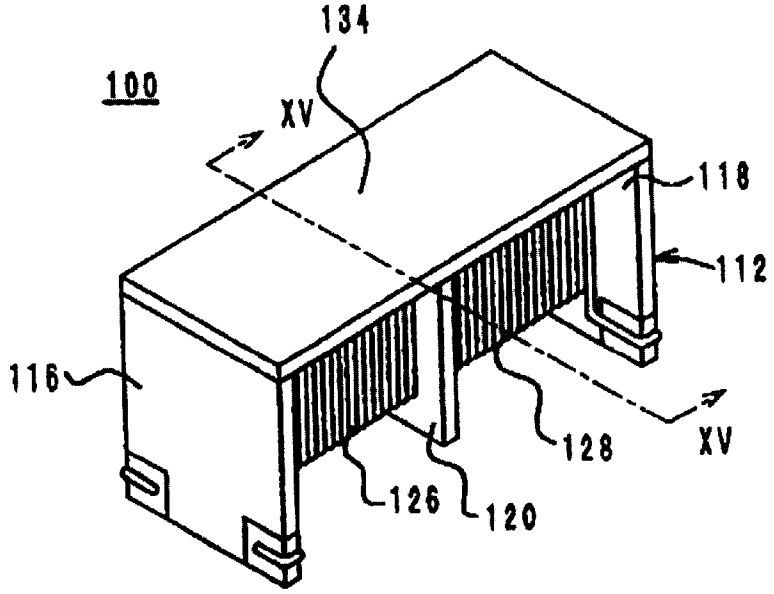
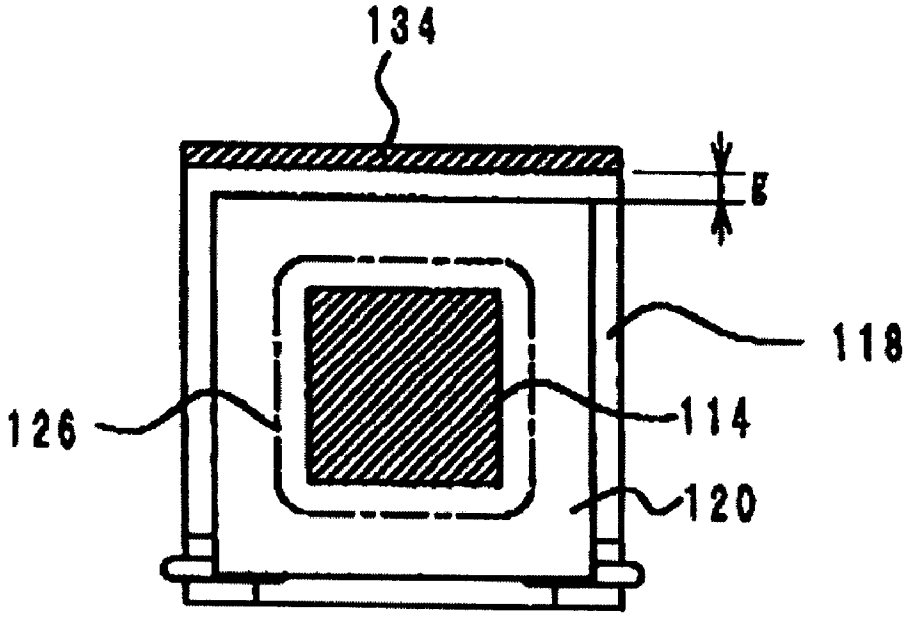


Fig.15
PRIOR ART



CHOKE COIL

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a choke coil, and more particularly, to a choke coil for use in eliminating noise produced from electronic devices and for preventing noise entering electronic devices.

2. Description of the Related Art

This type of choke coil is disclosed in, for example, Japanese Unexamined Patent Application Publication No. 11-238636. FIG. **14** is a perspective view of an example of a choke coil. A choke coil **100** includes a magnetic bobbin **112**, windings **126** and **128**, and a magnetic connecting member **134**. The magnetic bobbin **112** has a winding member that has a quadrangular prism shape. End flange portions **116** and **118** are provided at both ends of the winding member, and a center flange portion **120** is provided at the center thereof. The center flange portion **120** has a square shape and is slightly smaller than the end flange portions **116** and **118** (see FIG. **15**).

The winding **126** is provided on the winding member between the end flange portion **116** and the center flange portion **120**, and the winding **128** is provided on the winding member between the end flange portion **118** and the center flange portion **120**. The plate-like magnetic connecting member **134** is placed on the outer peripheral surfaces of the end flange portions **116** and **118** so as to connect the outer peripheral portions thereof. On the other hand, a gap g is formed between the connecting member **134** and the outer peripheral surface of the center flange portion **120**, as shown in FIG. **15**.

In the above-described conventional choke coil **100**, however, when a large normal-mode current is passed therethrough, a magnetic saturation phenomenon occurs, inductance is decreased, and an ability to eliminate normal-mode noise is reduced. In order to solve these problems, conventionally, the magnetic saturation phenomenon is suppressed and the normal-mode noise eliminating ability is maintained by increasing the sizes of the end flange portions **116** and **118** so that the connecting member **134** is spaced away from the center flange portion **120**. However, this undesirably increases the height and overall size of the choke coil **100**.

SUMMARY OF THE INVENTION

In order to overcome the problems described above, preferred embodiments of the present invention provide a low-profile choke coil in which a magnetic saturation phenomenon is minimized.

According to a preferred embodiment of the present invention, a choke coil includes a magnetic bobbin having a winding member, end flange portions disposed at both ends of the winding member, and a center flange-portion disposed at an approximate center of the winding member, a magnetic connecting member connecting the end flange portions at both ends of the winding member, the magnetic connecting member being spaced from the center flange portion by a distance, a first winding wire wound between the end flange portion at one end of the winding member and the center flange portion, and a second winding wire wound between the end flange portion at the other end of the winding member and the center flange portion, wherein at least one of a recessed portion and an inclined portion is provided at an edge of the center flange portion on the side of the connecting member so as to increase the magnetic resistance between the center flange portion and the connecting member.

By providing a recessed portion or an inclined portion at the edge of the center flange portion on the side of the connecting member, the magnetic resistance between the center flange portion and the connecting member is significantly increased. This allows the choke coil to minimize the magnetic saturation even when a large normal-mode noise current is passed therethrough.

Additional features, elements, characteristics and advantages of the present invention will become apparent from the following description of preferred embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded perspective view of a choke coil according to a preferred embodiment of the present invention.

FIG. **2** is a perspective view of a magnetic bobbin used in the choke coil of FIG. **1**.

FIG. **3** is an external perspective view of the choke coil of FIG. **1**.

FIG. **4** is a cross-sectional view of the choke coil, taken along line IV—IV in FIG. **3**.

FIG. **5** is a cross-sectional view of the choke coil, taken along line V—V in FIG. **3**.

FIG. **6** is an electrical equivalent circuit diagram of the choke coil.

FIG. **7** is a magnetic circuit diagram showing elimination of common-mode noise by the choke coil.

FIG. **8** is a magnetic circuit diagram showing elimination of normal-mode noise by the choke coil.

FIG. **9** is a cross-sectional view showing another preferred embodiment of the present invention.

FIG. **10** is a cross-sectional view showing a further preferred embodiment of the present invention.

FIG. **11** is a cross-sectional view showing a further preferred embodiment of the present invention.

FIG. **12** is a cross-sectional view showing a further preferred embodiment of the present invention.

FIG. **13** is a cross-sectional view showing a further preferred embodiment of the present invention.

FIG. **14** is a perspective view of an example of a conventional choke coil.

FIG. **15** is a cross-sectional view of the conventional choke coil, taken along line XV—XV in FIG. **14**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

A choke coil according to a preferred embodiment of the present invention will be described below with reference to the attached drawings.

FIG. **1** is an exploded perspective view of a choke coil **10** of the present preferred embodiment. The choke coil **10** preferably includes a magnetic bobbin **12**, windings **26** and **28**, and a magnetic connecting member **34**. The magnetic bobbin **12** has a winding member **14** that preferably has a substantially quadrangular prism shape, as shown in FIG. **2**. Substantially rectangular end flange portions **16** and **18** are provided at both ends of the winding member **14**, and a center flange portion **20** is provided at an approximate center

of the winding member **14**. The center flange portion **20** preferably has a substantially rectangular shape and is preferably slightly smaller than the end flange portions **16** and **18**, and has inclined portions **20***a* provided at two adjacent corners thereof. The inclined portions **20***a* are arranged such that a width d of the upper end of the center flange portion **20** is decreased and a height h of the inclined portions **20***a* is increased while the windings **26** and **28** do not protrude from the center flange portion **20**, thereby increasing the magnetic resistance to a normal-mode noise current. Therefore, it is preferable that upper ends **29***a* of the inclined portions **20***a* be located inside of the side surfaces **26***a* of the winding **26** and that lower ends **29***b* of the inclined portions **20***a* be located below an upper surface **14***a* of the winding section **14** (see FIG. **5**).

Electrodes **22***a* and **22***b* are provided at two corners of the end flange portion **16** so as to extend over both sides of the end flange portion **16**. Electrodes **24***a* and **24***b* are provided at two corners of the end flange portion **18** so as to extend over both sides of the end flange portion **18**. The electrode **22***a* and the electrode **24***b* are opposed to each other, and the electrode **22***b* and the electrode **24***a* are opposed to each other. The bobbin **12** is preferably made of a ferrite material, such as Ni-Zn or Mg-Zn, having a strong insulating ability, a magnetic resin containing the ferrite material, or other suitable material.

As shown in FIG. **1**, the winding **26** is provided on the winding member **14** between the end flange portion **16** and the center flange portion **20**. The two ends of the winding **26**. are connected to the electrodes **22***a* and **22***b*, respectively. The winding **28** is provided on the winding member **14** between the end flange portion **18** and the center flange portion **20**. The two ends of the winding **28** are connected to the electrodes **24***a* and **24***b* respectively. The winding **26** is arranged, for example, so as to be left-handed from the electrode **22***a* to the electrode **22***b*, as viewed from the side of the end flange portion **16**. In this case, the winding **28** is arranged so as to be right-handed from the electrode **24***b* toward the electrode **24***a*, as viewed from the side of the end flange portion **18**.

Furthermore, the magnetic connecting member **34** that is preferably shaped like a plate is placed on the outer peripheral surfaces of the end flange portions **16** and **18** so as to connect the outer peripheral portions thereof, as shown in FIGS. **3** to **5**. On the other hand, a gap g is provided between the connecting member **34** and the outer peripheral surface of the center flange portion **20**.

FIG. **6** is an electrical equivalent circuit diagram of the choke coil **10** with the above-described structure. In FIG. **6**, reference numeral **30** denotes an inductance with respect to a common-mode current, and reference numeral **32** denotes an inductance with respect a normal-mode current.

Since the winding **26** and the winding **28** are separated at the center flange portion **20** in the choke coil **10**, magnetic fluxes generated by the windings **26** and **28** will not overlap. For this reason, magnetic fluxes generated by a normal-mode current will not cancel each other, and an inductance can also be obtained for the normal mode current. Therefore, the choke coil **10** can remove not only common-mode noise but also normal-mode noise. Furthermore, since the windings **26** and **28** are separated, a high voltage-resistance can be obtained therebetween.

Elimination of the common mode noise and the normal mode noise by the choke coil **10** will be described in more detail.

When the choke coil **10** is used, for example, a signal source is connected to the electrodes **22***a* and **24***b*, and a load is connected to the electrodes **22***b* and **24***a*. A forward current is passed through the winding **26** and a reverse current is passed through the winding **28**. When a common-mode noise current is applied, in-phase noise currents are passed through the windings **26** and **28**. Magnetic fluxes are generated around the windings **26** and **28** by the noise currents. Since the magnetic fluxes cancel each other at the center flange portion **20**, a magnetic flux which surrounds both the windings **26** and **28** can be obtained as a whole, as shown by the arrows in FIG. **7**.

In this case, since the connecting member **34** connects the outer peripheral portion of the end flange portion **16** and the outer peripheral portion of the end flange portion **18**, a closed magnetic circuit is defined by the bobbin **12** and the connecting member **34**, the magnetic resistance to the magnetic flux generated by the common-mode noise current is minimized. Therefore, the inductance against the common-mode noise current is greatly increased. This makes it possible to increase the impedance against the common-mode noise current, and to thereby effectively eliminate the common-mode noise.

Magnetic fluxes generated by a normal-mode current do not cancel each other inside the bobbin **12**, but are generated around the individual windings **26** and **28**, as shown by the arrows in FIG. **8**. That is, the magnetic fluxes flow out of the end flange portions **16** and **18** provided at both ends of the bobbin **12** and enter the center flange portion **20** along respective circulatory paths. In a section where the connecting member **34** defines a magnetic circuit, magnetic fluxes flow through the connecting member **34**. Inductances are generated in the windings **26** and **28** by the magnetic fluxes, thereby eliminating the normal-mode noise.

In this case, since the center flange portion **20** has the inclined portions **20***a* on the side of the connecting member **34**, as shown in FIG. **5**, the effective dimension of the gap g increases and the magnetic resistance between the center flange portion **20** and the connecting member **34** increases. This allows the magnetic resistance to the normal-mode current to be increased without having to move the connecting member **34** away from the center flange portion **20**. As a result, magnetic saturation is not prone to occur even when the choke coil is used in a place where large current passes, and the normal-mode noise is effectively eliminated.

The present invention is not limited to the above preferred embodiments, and various modifications are possible without departing from the scope of the invention. In particular, the shapes of the inclined portions and recessed portions provided in the center flange portion **20** may be determined arbitrarily. For example, as shown in FIG. **9**, arc-shaped inclined portions **20***b* may be provided at two corners of the center flange portion **20**.

As shown in FIGS. **10** and **11**, respectively, inclined portions **20***a* may be provided at two corners of the center flange portion **20**, and a substantially rectangular recessed portion **20***c* or a semicircular recessed portion **20***d* may be provided at the center of one side of the center flange portion **20** on the side of the connecting member **34**. This makes the magnetic resistance to a normal-mode noise current, which exists between the center flange portion **20** and the connecting member **34** shown in FIGS. **10** and **11**, higher than that in FIG. **5**.

Alternatively, a substantially semicircular recessed portion **20***e* or a substantially triangular recessed portion **20***f* may be provided at the center of one side of the center flange portion **20** on the side of the connecting member **34**, as shown in FIG. **12** or FIG. **13**. The shape of the center flange

portion **20** is not limited to those in the above preferred embodiments as long as the center flange portion **20** has a sufficient size to separate the windings **26** and **28** and has a desired magnetic resistance.

The connecting member **34** need not always be plate-like, but may be, for example, substantially cylindrical. In this case, the connecting member **34** is mounted so as to cover the entire windings **26** and **28**. In this way, the shape of the connecting member **34** may be arbitrarily changed as long as the connecting member **34** can connect the end flange portions **16** and **18**.

As described above, according to preferred embodiments of the present invention, since a gap is provided between the center flange portion of the winding member and the connecting member, and the center flange portion has a recessed portion or an inclined portion, it is possible to adjust the magnetic resistance to the magnetic flux generated by a large normal-mode current without having to move the connecting member away from the center flange portion, and to thereby prevent magnetic saturation. This also prevents the choke coil from being increased in size. In a case in which only a saturation characteristic equivalent to that of the conventional art is necessary, it is possible to reduce the gap between the center flange portion and the connecting member to achieve a lower-profile choke coil.

While the present invention has been described with reference to what are presently considered to be the preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments. On the contrary, the invention is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

What is claimed is:

1. A choke coil comprising:

a magnetic bobbin having a winding member, end flange portions disposed at both ends of said winding member, and a center flange portion disposed at an approximate center of said winding member;

a magnetic connecting member connecting said end flange portions at both ends of said winding member, said magnetic connecting member being spaced from said center flange portion;

a first winding wire wound between said end flange portion at one end of said winding member and said center flange portion; and

a second winding wire wound between said end flange portion at the other end of said winding member and said center flange portion; wherein

at least one of a recessed portion and an inclined portion is provided at an edge of said center flange portion on the side of said connecting member so as to increase the magnetic resistance between said center flange portion and said connecting member.

2. A choke coil according to claim **1**, wherein the winding member preferably has a substantially quadrangular prism shape.

3. A choke coil according to claim **1**, wherein the end flange portions are substantially rectangular.

4. A choke coil according to claim **1**, wherein the center flange portion has a substantially rectangular shape.

5. A choke coil according to claim **1**, wherein the center flange portion is smaller than the end flange portions.

6. A choke coil according to claim **1**, wherein the first and second winding wires do not protrude from the center flange portion.

7. A choke coil according to claim **1**, wherein upper ends of the inclined portions are located inside of the side surfaces of the first winding and lower ends of the inclined portions are located below an upper surface of the winding member.

8. A choke coil according to claim **1**, wherein electrodes are provided at two corners of each of the end flange portions so as to extend over both sides of the respective one of the end flange portions.

9. A choke coil according to claim **1**, wherein the bobbin is made of a ferrite material and a magnetic resin containing the ferrite material.

10. A choke coil according to claim **8**, wherein the first winding wire is arranged to be left-handed from a first one of the electrodes to a second one of the electrodes, and the second winding wire is arranged to be right-handed from a third one of the electrodes toward a fourth one of the electrodes.

11. A choke coil according to claim **1**, wherein the magnetic connecting member is disposed on the outer peripheral surfaces of the end flange portions so as to connect the outer peripheral portions thereof.

12. A choke coil according to claim **1**, wherein a gap g is provided between the magnetic connecting member and the outer peripheral surface of the center flange portion.

13. A choke coil according to claim **1**, wherein arc-shaped inclined portions are provided at two corners of the center flange portion.

14. A choke coil according to claim **1**, wherein inclined portions are provided at two corners of the center flange portion and one of a substantially rectangular recessed portion and a semicircular recessed portion **20***d* is provided at the center of one side of the center flange portion on the side of the magnetic connecting member.

15. A choke coil according to claim **1**, wherein one of a substantially semicircular recessed portion and a substantially triangular recessed portion is provided at the center of one side of the center flange portion on the side of the magnetic connecting member.

16. A choke coil according to claim **1**, wherein the magnetic connecting member is arranged to cover the entire first winding wire and the entire second winding wire.

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