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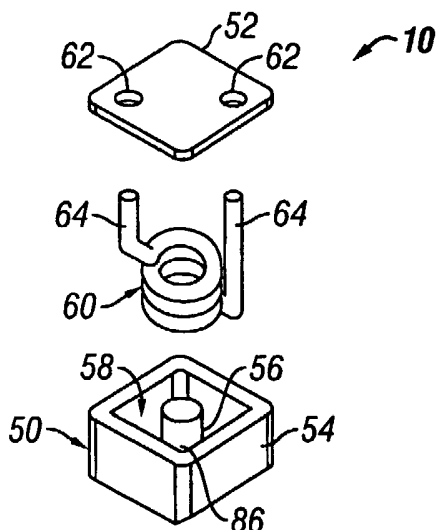
(43) International Publication Date
18 December 2003 (18.12.2003)

PCT

(10) International Publication Number
WO 03/105164 A1

- (51) International Patent Classification⁷: **H01F 27/02**, 27/29
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- (21) International Application Number: PCT/US02/37663
- (22) International Filing Date:
23 November 2002 (23.11.2002)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
10/163,259 4 June 2002 (04.06.2002) US
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- (81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.
- (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:**
— with international search report
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: SHIELDED INDUCTORS



(57) Abstract: An inductor (10) includes a core (14), a coil (12) disposed about the core, and a shield (40). The shield and the core are connected to each other so that a closed magnetic loop is formed. The core may be a single piece or made up of a pair of core segments (50, 52). The shield may include two halves or portions or may include a cover with a base. The core may be unitary with the shield at one or both ends thereof. In embodiments where the shield includes two portions, the portions may have substantially identical geometry and dimensions.

WO 03/105164 A1

SHIELDED INDUCTORS

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to electrical components, specifically inductors.

Description of the Related Art

[0002] The desirability for electrical components that are smaller in size but that have better electrical properties never fades. Often there are trade offs when it comes to designing such components. For example, when size is reduced, one or more of the electrical properties is adversely affected.

[0003] In the case of inductors, electromagnetic interference (EMI) is one of the properties that is desirably minimized or eliminated. EMI is an unwanted electromagnetic signal which may degrade the performance of an electronic device. To reduce EMI effects caused by inductors, shields are placed about the inductor. Shielded inductors thereby require more space than unshielded types. In addition, the shields require grounding.

BRIEF SUMMARY OF THE INVENTION

[0004] An inductor includes a core, a coil disposed about the core, and a shield. The shield and the core are connected to each other so that a closed magnetic loop is formed. The core may be a single piece or made up of a pair of core segments. The shield may include two halves or portions or may include a cover with a base. The core may be unitary with the shield at one or both ends thereof. In embodiments where the shield includes two portions, the portions may have substantially identical geometry and dimensions.

[0005] For a given energy storage capability, the inductor of the invention greatly improves upon conventional inductors. For example, the inductor of the invention is able to store the same amount of energy at a volume of about 10 times less than conventional toroidal inductors. In addition, with ratio of width to length of the inductor of the invention may be on the order of 1 to 1, while such ratio for conventional toroidal inductors is on the order of 2 to 1.

[0006] Other features and advantages of the present invention will become apparent to those skilled in the art from a consideration of the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

- [0007] FIG. 1 is a perspective view of a shielded inductor;
- [0008] FIG. 2 is an exploded perspective view of a shielded inductor;
- [0009] FIG. 3 is an exploded side view of a shielded inductor;
- [0010] FIG. 4 illustrates a closed magnetic loop of a shield and a core of an inductor;
- [0011] FIG. 5 is an exploded perspective view of a shielded inductor;
- [0012] FIGS. 6A and 6B are side views of the inductor of FIG. 5;
- [0013] FIG. 7 is an exploded perspective view of a shielded inductor;
- [0014] FIG. 7A is a perspective view of the inductor of FIG. 7;
- [0015] FIG. 8 is an exploded perspective view of a shielded inductor;
- [0016] FIG. 8A is a perspective view of the inductor of FIG. 8; and
- [0017] FIG. 9 illustrates dimensions of a shielded inductor.

DETAILED DESCRIPTION OF THE INVENTION

[0018] Referring to FIGS. 1 and 2 in detail, an inductor 10 includes a coil 12 and a shielded core 14. The coil 12 may have a pair of terminals 16, and the shielded core 14 may include a first portion 18a and a second portion 18b.

[0019] As shown in FIG. 2, each portion 18 may include a housing 20 having an end wall 22 and a side wall 24. In the embodiment shown, the side wall 24 of each housing 20 may have a mating edge 26, which is also shown in FIG. 3. In addition, a pair of notches 28 may be formed in the side wall 24 for receiving a terminal 16 of the coil 12.

[0020] The housing of each portion 18 of the core 14 may also include a core segment 30, which is shown clearly in FIG. 3. The core segment 30 may be disposed on an inner surface 32 of the end wall 22. Each core segment 30 may have an end face 34. In a number of embodiments, a seat 36 may be defined within each portion 18, for example, the between the side wall 24 and the core segment 30 for receiving the coil 12.

[0021] With additional reference to FIG. 4, when the first and second portions 18a and 18b are engaged together with the coil 12 received by the seats 36, the mating edges 26 of the side walls 24 of the housings 20 mate with each other as shown by the dashed lines indicated at A to form a magnetically continuous shield 40. In addition, the end faces 34 of the core segments 30

contact each other as shown by the dashed line indicated at B to form a magnetically continuous core 42. Accordingly, a closed magnetic loop is formed by the shield 40 and the core 42, as indicated by magnetic flux lines C. When mounted in an electric circuit, the shield 40 does not require grounding.

[0022] As shown in FIG. 1, when the portions 18 are engaged, the notches 28 of the housing 20 of the first portion 18a respectively align with the notches 28 of the housing 20 of the second portion 18b to form a pair of apertures 44 in the shield 40 (only one of the apertures is shown in FIG. 1). Accordingly, with the coil 12 received by the seats 36 about the core 42, the terminals 16 may respectively project through the apertures 44 of the shield 40.

[0023] In a number of embodiments, for example, as shown in FIG. 5, a single notch 28 may be formed in the side wall 24 of each portion 18. Accordingly, when the portions 18 are secured as shown in FIGS. 6A and 6B, a pair of apertures 44 are formed in the shield 40 for respectively receiving the terminals 16 of the coil 12.

[0024] In other embodiments such as those shown in FIG. 7, the shielded core 14 may include a first portion such as a base 50 and a second portion such as cover 52. The base 50 may include a side wall 54 and a core 56, with a seat 58 for receiving a coil 60 defined between the side wall 54 and the core 56. The cover 52 may include a pair of apertures 64 for respectively receiving terminals 64 of the coil 60 when the coil is received in the seat 58. When the cover 52 is mated with the base 50 and the core 56 as shown in FIG. 7A, a closed magnetic loop is formed by the base 50, the cover 52, and the core 56, with the terminals 64 projecting through the apertures 64.

[0025] In still other embodiments, a single aperture may be utilized. For example, as shown in FIG. 8, the shielded core 14 may include a first portion such as a base 70 and a second portion such as cover 72. The base 70 may include a side wall 74 with a notch 76 formed therein. A core 78 is provided and may be disposed on either the base 70 or the cover 72; in the embodiment shown, the core 78 is attached to the cover 72. When the cover 72 is mated with the base 70 with a coil 80 received about the core 78 as shown in FIG. 8A, an aperture 82 is formed, and a closed magnetic loop is formed by the base 70, the cover 72, and the core 78, with terminals 84 of the coil 80 projecting through the aperture 82.

[0026] In a number of embodiments, the dimensions of the inductor 10 are minimized while still maintaining desirable electrical characteristics. As an example, with reference to FIG. 9, an overall height H of the shield core 40 may be less than about 10 mm, with the side wall 24 of

each housing having a height h of less than about 5 mm. In addition, the shielded core **40** may have a length L of less than about 10 mm and a width W of less than about 10 mm. Accordingly, in embodiments where the dimensions are approximately equal, a ratio of width W to length L is on the order of 1 to 1. In other embodiments, the width-to-length ratio is less than about 1.5 to 1.

[0027] As another example, one of the electrical properties for inductors is energy storage, which is determined by the equation $E = \frac{1}{2}LI^2$, where L is inductance and I is current DC. A desirable characteristic of inductors is volume versus energy storage. If each of the dimensions (i.e., height H , length L , and width L) of the inductor **10** is about 6.8 mm, then a volume of the shield core **40** is about 310 mm³. At these dimensions, the inductor **10** may have an inductance of about 400 nH (nanohenrys) at a frequency of about 100 kHz and a current of about 20 amperes DC, and an energy storage of 80 μJ (microjoules). For comparison purposes, a conventional toroidal inductor capable of storing the same amount of energy would need to have a length of about 20 mm, a width of about 20 mm, and a height of about 8 mm, thereby having a volume of about 3,200 mm³. Accordingly, the inductor **10** with a columnar core **42** and closed magnetic loop of the present invention reduces the volume by over 10 times for the same energy storage capability.

[0028] In a number of embodiments, such as that shown in FIGS. 1, 2, and 3, the first and second portions **18a** and **18b** of the shielded core **14** have substantially identical geometry and substantially equal dimensions. Accordingly, during manufacturing, only a single die, mold, or cast (depending upon the manufacturing process) needs to be made to produce the portions **18** of the shielded core **14** with, e.g. powder iron, thereby reducing costs. In addition, the core segment **30** and the housing **20**, specifically, the end wall **22**, of each portion **18** may be of unitary construction, thereby eliminating manufacturing processes dedicated to producing a separate core and attaching such core to a shield. In other words, an end **86** (see FIGS. 3, 7, and 8) of the core **78** or core segment **30** may be unitary with the shield **14**.

[0029] With regard to manufacturing, to fabricate the inductor **10**, the coil **12** may be positioned in the seat **36** of the housing **20** of one of the portions **18** with the terminals aligned with the notch or notches **28**. The other portion may then be positioned thereon, with the mating edges **26** and the end faces **34** respectively contacting. The portions **18a** and **18b** may be secured together at the mating edges **26** of the side walls **24** with, for example, adhesive such as epoxy. Although the coil **12** may be wound about the core, the coil **12** may be prefabricated, e.g., with an automatic winder, to reduce manufacturing costs.

[0030] Those skilled in the art will understand that the preceding exemplary embodiments of the present invention provide the foundation for numerous alternatives and modifications thereto. These other modifications are also within the scope of the present invention. Accordingly, the present invention is not limited to that precisely as shown and described in the present invention.

CLAIMS

What is claimed is:

1. An inductor comprising:
a coil including a pair of terminals; and
a shielded core including a first portion and a second portion;
each of the portions including:
a housing having an end wall and a side wall, the side wall having a mating edge
and a pair of notches;
a core segment disposed on an inner surface of the end wall and having an end
face; and
a seat defined between the housing and the core segment for receiving the coil;
wherein when the first and second portions are engaged together with the coil received by
the seats:
the mating edges of the side walls of the housings mate with each other to form a
magnetically continuous shield;
the end faces of the core segments contact each other to form a magnetically continuous
core, such that a closed magnetic loop is formed by the shield and the core;
the notches of the housing of the first portion respectively align with the notches of the
housing of the second portion to form a pair of apertures in the shield; and
the coil is received by the seats about the core with the terminals respectively projecting
through the apertures of the shield.
2. An inductor as claimed in claim 1 wherein a ratio of a width to a length of the shield
is less than about 1.5 to 1.
3. An inductor as claimed in claim 1 wherein the side wall of each of the housings has a
height of less than about 5 mm, such that a height of the shield is less than about 10 mm.
4. An inductor as claimed in claim 3 wherein the shield has a length of less than about
10 mm and a width of less than about 10 mm.
5. An inductor as claimed in claim 4 wherein the inductor has an inductance of about
400 nH at a frequency of about 100 kHz.
6. An inductor as claimed in claim 1 wherein the first and second portions of the
shielded core have substantially identical geometry.

7. An inductor as claimed in claim 1 wherein the core segment and the housing of each portion are of unitary construction.
8. An inductor comprising:
a core;
a coil disposed about the core; and
a shield connected to core to form a closed magnetic loop.
9. An inductor as claimed in claim 8 wherein the core has a pair of ends at least one of which being unitary with the shield.
10. An inductor as claimed in claim 8 wherein the core includes at least one core segment that is unitary with the shield.
11. An inductor as claimed in claim 8 wherein the core includes two core segments and the shield includes two housings;
the core segments being unitary with the housings, respectively.
12. An inductor as claimed in claim 11 wherein each of the core segments has an end face and each of the housings has a mating edge;
the end faces contacting each other and the mating edges contacting each other when the housings are engaged to form the shield.
13. An inductor as claimed in claim 11 wherein the housings have substantially identical geometry.
14. An inductor as claimed in claim 11 wherein the housings have substantially identical dimensions.
15. An inductor as claimed in claim 11 wherein each of the housings has a pair of notches;
the notches of one of the housings aligning with the notches of the other housing when the housings are secured together to form a pair of apertures through which terminals of the coil are receivable.
16. An inductor as claimed in claim 8 wherein the core has a pair of terminals, the shield including a pair of apertures through which the terminals are receivable.

17. An inductor as claimed in claim 8 wherein the shield has a height of less than about 10 mm, a length of less than about 8 mm, and a width of less than about 8 mm.

18. A method of manufacturing an inductor, the method comprising:
providing a plurality of housings each including:
an end wall and a side wall with a mating edge and a pair of notches;
a core segment disposed on an inner surface of the end wall and having an end face; and
a seat defined between the housing and the core segment;
positioning a coil with a pair of terminals in the seat of one of the housings with the terminals positioned at the notches; and
securing another one of the housings to the housing with the coil such that the mating edges of the side walls and the end faces of the core segments are respectively in magnetic contact, thereby forming a closed magnetic loop.

19. A method as claimed in claim 18 wherein the core segment and the end wall of each housing are unitary.

20. A method as claimed in claim 18 wherein each of the housings have substantially identical geometry.

1/4

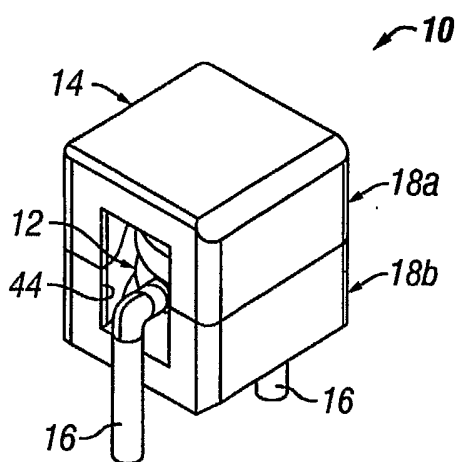


FIG. 1

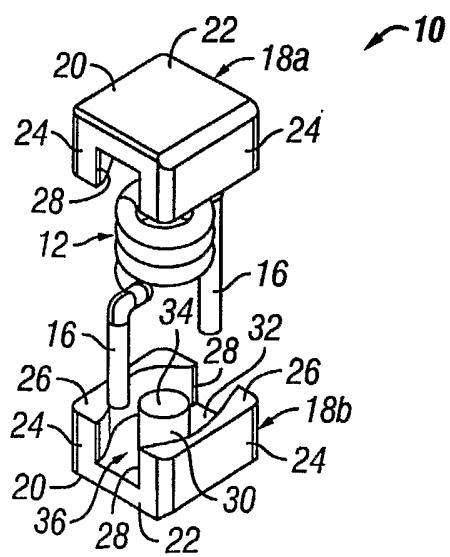


FIG. 2

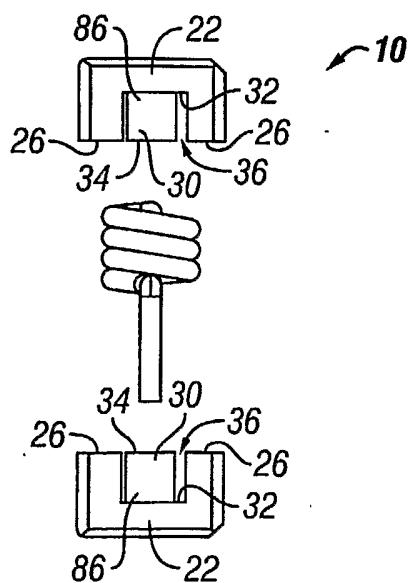


FIG. 3

2/4

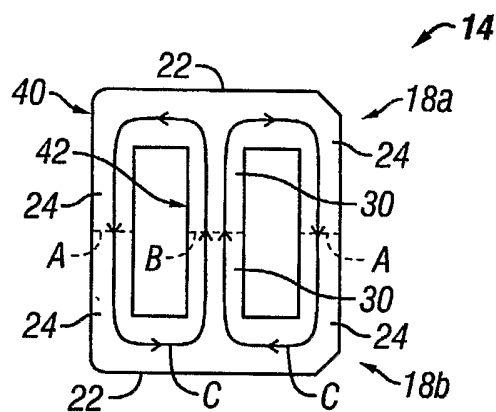


FIG. 4

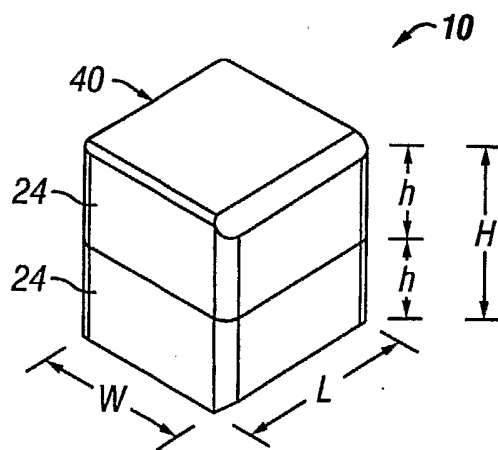


FIG. 9

3/4

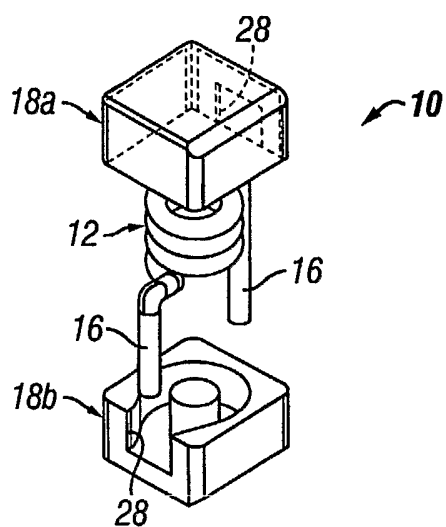


FIG. 5

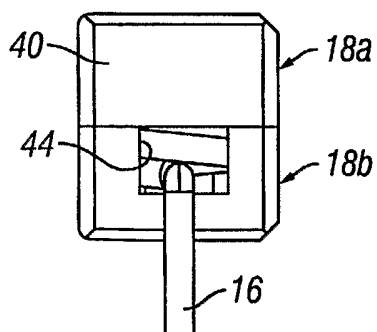


FIG. 6A

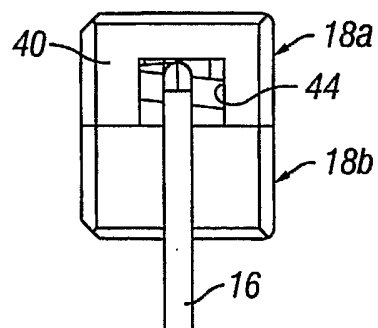
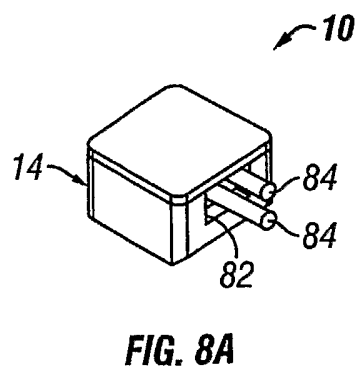
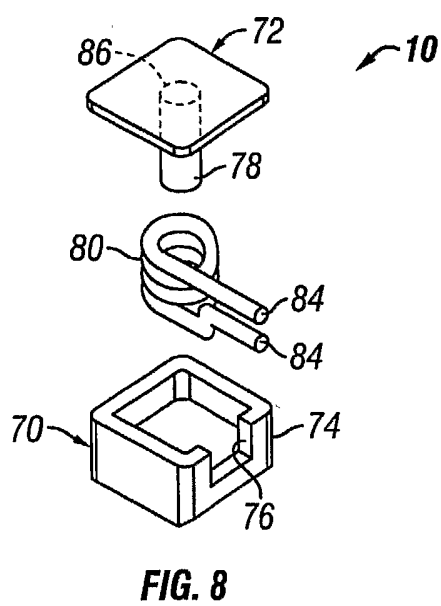
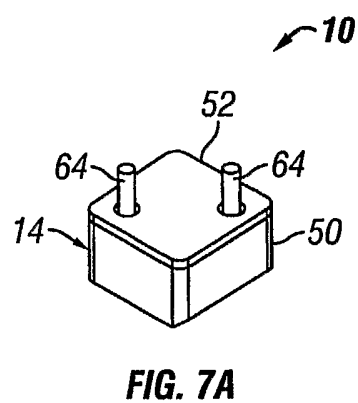
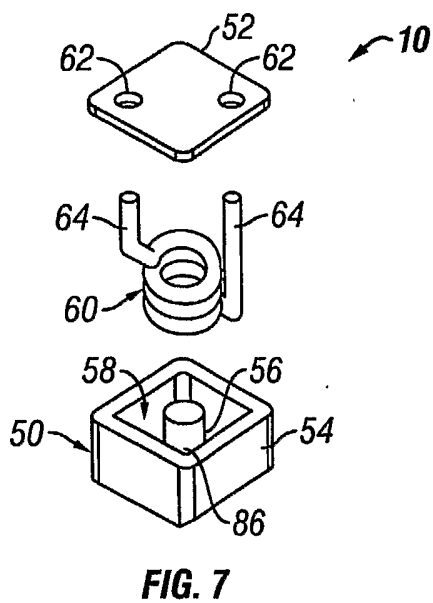


FIG. 6B

4/4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US02/37663

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :H01F 27/02, 27/29

US CL :336/83, 192, 212, 220, 221, 212

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)

U.S. : 336/83, 192, 212, 220, 221, 212

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST: USPAT, JPO, DERWENT, PGPUB, EPO

search terms: coil inductor, shield, terminal, core

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,912,609 A (USUI et al) 15 June 1999 (15.06.1999), entire document.	1-20
Y	US 5,814,986 A (GOSKOWICZ et al) 29 September 1998 (29.09.1998), entire document.	1-20

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Further documents are listed in the continuation of Box C.

☐

See patent family annex.

* Special categories of cited documents:		"I"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"B"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
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Date of the actual completion of the international search

04 FEBRUARY 2003

Date of mailing of the international search report

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