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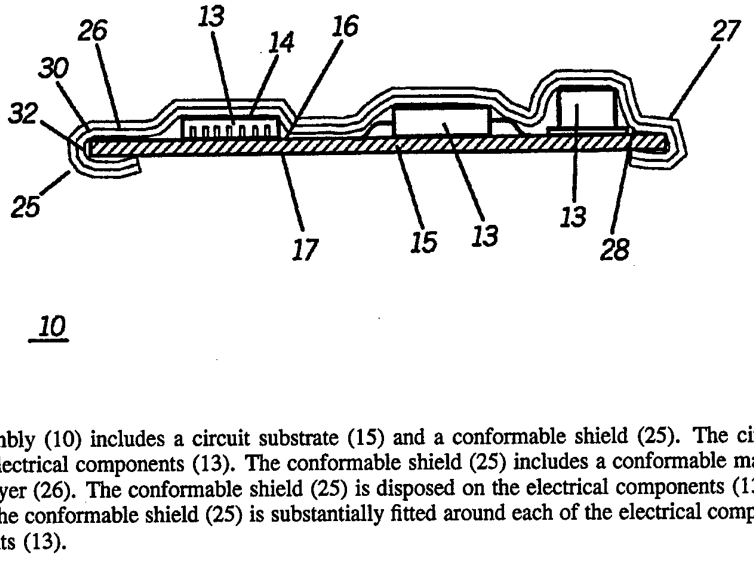

(57) Abstract

A shielded circuit assembly (10) includes a circuit substrate (15) and a conformable shield (25). The circuit substrate (15) houses electrical circuitry including electrical components (13). The conformable shield (25) includes a conformable material having a conductive layer (30) and an insulating layer (26). The conformable shield (25) is disposed on the electrical components (13) and on at least a portion of the circuit substrate (15). The conformable shield (25) is substantially fitted around each of the electrical components (13) to individually shield the electrical components (13).

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SHIELDED CIRCUIT ASSEMBLY AND METHOD FOR FORMING SAME

Technical Field

This invention relates in general to shields for electrical components, and more particular, to shields for electrical components on circuit substrates.

Background

Electronic products typically have electrical circuitry implemented on a circuit substrate, such as a printed circuit board. The performance of the circuitry may be adversely affected by factors such as electromagnetic interference (EMI), radio frequency interference (RFI), electrostatic discharge (ESD), and environmental elements. The sources of interference may be internal or external to the product. For example, many electrical components emit radio frequency (RF) signals which may adversely affect the operation of other portions of the circuitry. Moreover, these RF signals may cause interference for other electronic devices operating nearby.

Typically, a product designer incorporates shields, or other protective devices, to protect critical portions of the circuitry, or specific components. For example, to protect against EMI, a critical component is enclosed in EMI shield formed to substantially enclose the component and onto the circuit substrate. Components having a high EMI output are identified and electromagnetically isolated using EMI shields. Moreover, the shield components may be a part of a larger electrical module, such as power amplifier, which is preferably housed in EMI shielded enclosures to provide further protection.

Prior art shielding techniques include metal cans, metal foil claddings, wire mesh screens, and plastic enclosures or cases having metallized coatings. However, several problems associated with prior art shielding techniques need to be overcome. For example, a product may have many components requiring EMI shielding from other components within the product as well as from external sources. Depending on the number of the shields needed, significant weight and cost may be added to the product. Moreover, space must be allocated on the circuit board to accommodate the shields which reduces the space available for other components. Additionally, prior art shielding techniques typically do not facilitate shielding decisions made late in the product design cycle, which may be necessary after product testing. Consequently, major redesigns may be needed to add shields where the need was unanticipated.

The trend toward increasingly smaller products minimizes the space available on the circuit board for many of the shields typically used in the prior art. Cost, weight, and design convenience are also important factors in evaluating shielding options. These and other issues make prior art shielding techniques inadequate for some applications. Therefore, there exists a need for a new approach to EMI and other types of shielding.

Brief Description of the Drawings

FIG. 1 is a perspective view of a shielded circuit assembly, in accordance with the present invention.

FIG. 2 is a cross-sectional view of the shielded circuit assembly of FIG. 1.

FIG. 3 is an exploded perspective view of a thermo-conformable shield, in accordance with the present invention.

FIG. 4 is a graph comparing electro-magnetic interference emissions between an unshielded circuit assembly and an experimental shielded circuit.

FIG. 5 is a fragmentary view of a portable two-way radio incorporating the shielded circuit assembly, in accordance with the present invention.

Detailed Description of the Preferred Embodiment

The present invention provides for a shielded circuit assembly. Generally, shielding may be desirable for at least a portion of a circuit assembly to protect circuit assembly components from internally and externally sourced interfering elements. For example, the circuit assembly components can be shielded to provide protection from electro-magnetic interference, electro-static discharge, and environmental elements such as moisture, dust, and environmental contaminants. Additionally, by shielding a particular component, that component is protected from potential interference from other components of the circuit assembly. Moreover, other components are protected from interference sourced at the particular component. The shielded circuit assembly of the present invention includes a circuit substrate having electrical components disposed thereon, and a conformable shielding material disposed about the electrical components and at least a portion of the circuit substrate. The shielding material has a conductive layer and an insulating layer. The shielding material is formed to envelope and substantially conform to individual electrical components such that each electrical component is substantially enclosed. The present invention provides for a shielded circuit assembly which has significant cost, weight, and size advantages, in an easily manufactured, low design impact packaging scheme.

The present invention can be best understood with references to FIGs. 1-5. Referring to FIG. 1, a shielded circuit assembly 10 is shown in accordance with the present invention. The shielded circuit assembly 10 includes a circuit substrate 15, such as a printed circuit board, electrical or other circuit components 13 disposed on the circuit substrate 15, and a metallized plastic laminate 25, disposed so as to conform about the component 13 and at least a portion of the circuit substrate 15. The resulting structure is a substantially enclosed circuit assembly 10 which provides shielding to individual circuit components 13. The term "conformable" is used herein to describe materials which conform to or adapt to the shape of articles upon which they are disposed. The plastic laminate 25, typically has a low temperature softening point and is responsive to the application of thermal energy, optionally assisted by a vacuum process, to shrink around or conform to articles upon which it is disposed. Accordingly, the plastic laminate 25 and materials with similar properties are described herein as being ("thermo-conformable").

Referring to FIG. 2, a cross sectional view of the shielded circuit assembly 10 is shown. The circuit substrate 15 is a printed circuit board which houses electrical circuitry including electrical components 13. The printed circuit board 15 has first and second opposing surfaces 16, 17. The first surface 16 has electrical components 13 mounted thereon and the second surface 17 has an exposed ground plane disposed thereon. The circuit assembly 10 may be combined with other electrical modules and circuitry to implement a product or device. In the preferred embodiment, the circuit assembly 10 implements a major portion of a two-way portable radio, and includes communication circuitry for communicating over a radio frequency channel. The electrical components 13 include a power amplifier module 14 which is typically a source of significant electro-magnetic interference. Additionally, the power amplifier module 14 typically requires a heat dissipation path for dissipating excessive heat generated by this module. The circuit assembly 10 may also include electrical components 13 which are sensitive to electro-magnetic interference and which can be adversely affected by interference generated by the power amplifier module 14 among other sources. Accordingly, the thermo-conformable shielding material 25 is disposed over each component 13 such that each component 13 is substantially enclosed.

The thermo-conformable material 25 comprises three layers, a first or inner insulated layer 32, a shielding layer 30, and a second or outer insulating layer 26. The second insulating layer 26 is optional. A two layer shield may be simpler to construct and may be preferred in some applications. The inner and outer insulated layers 32, 26 are formed from thin plastic sheets, such as those suitable for use in shrink wrap applications. Preferably, a thin continuous sheet of thermo-conformable polymeric material is used. The shielding layer 30 is a thin conductive layer disposed between the inner and outer insulated layers 32, 26. Materials such as conductive plastics, conductive paints, metal films, metal meshes or screens, or metal plating, could be used for this layer. Magnetic organic/molecular based materials may also be used in the conductive layer 30. In the preferred embodiment the conductive layer 30 comprises polymeric material impregnated or coated with conductive material such as metal. The metal should be malleable, or one with a low softening point, so that the metal becomes pliable during the forming process. As such, both the metal and insulator will conform to the circuit assembly 10 including the electrical components 13. The properties of the metal may also be chosen for a proper thermal, grounding, and/or shielding requirements. In a primary application of the present invention, this conductive layer 30 provides electro-magnetic interference shielding when covering the electrical components 13 because the conductive layer 30 traps emissions from the components 13.

Preferably, the conductive layer 30 is electrically grounded, such as by grounding to the circuit substrate 15, to provide shielding to prevent radio frequency emissions from entering or leaving protected areas. The inner insulated layer 32 ordinarily makes contact with the electrical component 13 and helps protect the electrical components 13 and other portions of the circuitry on the circuit substrate 15 from electrical shorts. The outer insulated layer 26 is optional and serves to protect the conductive layer 30. Excisions 35 in the insulating layer may be selectively made to expose the metallic or conductive layer 30 for electrical grounding and/or to provide a thermally conductive path. This arrangement is particularly attractive where flip-chip technology is employed for electrical components 13 on the circuit assembly 10. In such cases, it is necessary to provide electrical ground connections at locations other than at the point of direct attachment of the electrical component 13 to the circuit substrate 15.

Preferably, the circuit substrate 15 has an exposed ground plane such that the conductive layer 30 can be electrically coupled, thereby electrically grounding the conductive layer 30. By exposing portions of the conductive layer 30, electrical ground connections can be made directly between the conductive layer 30 and an electrical component 13 mounted on the circuit assembly 10. The thermo-conformable material 25 envelopes the top 16 and sides of the printed circuit board 15 and is electrically coupled to the ground plane on the second surface of the printed circuit board, thereby electrically grounding the thermo-conformable enclosure to form a shield. The thermo-conformable shield can be attached and grounded directly to the printed circuit board by conventional fasteners such as lead crimping, spring clips, conductive or non-conductive adhesives, and the like. If the conductive layer 30 is being used for electrical grounding or as a heat dissipation path, the use of conductive adhesive may be the preferred attachment methodology.

In constructing the shielded circuit assembly 10, the circuit substrate 15 is populated with electrical components 13 and electrical circuitry to form a functional electrical module. The circuit substrate 15 is then encased with the thermo-conformable material 25 such that the electrical components 13 and at least a portion of the circuit substrate 15 is covered by the thermo-conformable material 25. The thermo-conformable material 25 can be applied to the circuit substrate 15 by vacuum forming the thermo-conformable material 25 onto the circuit substrate 15, and by applying thermal energy to the thermo-conformable material 25 such that the thermo-conformable material 25 reaches its softening point and conforms to the circuit substrate 15 and electrical components 13. Preferably, the thermo-conformable material 25 is metallized before it is vacuum formed over the circuit substrate 15. Alternatively, the thermo-conformable material 25 may be constructed by first applying a thermo-conformable film over the circuit substrate 15, then metallizing the thermo-conformable film while on the circuit substrate 15. Commonly available shrink or blister packaging technology can be used as a starting point for developing a manufacturing process.

In one experiment to form an electro-magnetic interference (EMI) shield, a circuit assembly 10 having electrical components 13 disposed thereon was encased in a commonly available shrink wrap film material which was vacuum formed over the circuit assembly 10. The excess material was removed and the board was prepared for the application of a conductive layer 30 comprising gold leaf. The assembly was sprayed with adhesive and gold leaf applied such that a conductive layer 30 of approximately of 5 microns thick was created. The gold leaf was allowed to make electrical contact with the ground plane of the circuit assembly 10. Testing was conducted to determine EMI emissions from the shielded circuit assembly 10 and comparisons were made with EMI emission from an unshielded circuit assembly 10. The results are presented in FIG. 4. From the graph 400 presented it is clear that the EMI emissions from the thermo-conformable EMI shielded circuit assembly 10, represented by line 410, is significantly less that from an unshielded circuit assembly, represented by line 420. The results shown in the graph of FIG. 4 is but one example done in experimentation and results will differ depending on choices of materials and construction methodologies.

Conventionally, EMI shielding is provided by enclosing critical components and/or the entire circuit assembly within a metal can which requires that space be reserved on the circuit assembly to accommodate the cans. The use of the thermo-conformable enclosure for EMI shielding significantly reduces the number of parts required by eliminating the need for metal cans as shields. Furthermore, the additional space required on the circuit substrate to accommodate the shielding is relative small. This shielding approach is particularly useful when addressing product miniaturization and manufacturing cost reduction. FIG. 5 is a portable two-way radio 50 incorporating the shielded circuit assembly 10. The radio 50 includes a radio housing 52 which protects the circuit assembly 10. The radio 50 houses well known communications circuitry for communicating over a radio frequency channel.

A shielded circuit assembly 10 made in accordance with the present invention offers significant benefits. These benefits include simple design and construction, low cost, and compact design. The thermo-conformable shield 25 provides EMI protection without a significant increase in the size of the circuit assembly 10. Additionally this shielding technique can be used on circuit assemblies which were not originally designed for EMI shielding. Moreover, design cycle time and design costs can be saved by eliminating the need to accommodate conventional metal can shields. The elimination of metal can shields also reduces the part count and overall product weight. A thermo-conformable shield can be constructed to provide additional features. For example, the shielding material 25 may be chosen to provide electrostatic discharge protection, electromagnetic pulse protection, and also to provide a thermal path for heat dissipation. Moreover, by fully encasing the circuit assembly 10 or portions thereof, an effective moisture seal can be created for the assembly components 13. An additional benefit is the prevention of electrical shorts among electrical components 13 of the circuit assembly 10 or between external components 13 and components 13 of the circuit assembly 10.

Claims

1. A shielded circuit assembly, comprising:

a circuit substrate having an electrical circuitry comprising a plurality of electrical components; and

a shield, comprising:

a conformable material having a conductive layer and a first insulating layer, the conformable material being disposed on the plurality of electrical components and on at least a portion of the circuit substrate;

the conformable material being substantially fitted around each of the plurality of electrical components to individually shield each of the plurality of electrical components.

2. A shielded circuit assembly as defined in claim 1, wherein the first insulating layer comprises a continuous sheet of thermo-conformable polymeric material.

3. A shielded circuit assembly as defined in claim 1, wherein the conductive layer comprises polymeric material impregnated with metal.

4. A shielded circuit assembly as defined in claim 1, wherein:

the conformable material has a second insulating layer; and

the conductive layer is disposed between the first and second insulating layers.

5. A shielded circuit assembly as defined in claim 4, wherein the second insulating layer has excisions to expose portions of the conductive layer.

6. A shielded circuit assembly, comprising:
a circuit substrate having a plurality of electrical components; and
an electromagnetic interference shield, comprising:
a thermo-conformable film laminate having a conductive layer, and a first insulating layer disposed on the plurality of electrical components and on at least a portion of the circuit substrate;
the thermo-conformable film laminate being form fitted around each of the plurality of electrical components to individually shield each of the plurality of electrical components.

7. A method of forming a shielded circuit assembly, comprising the steps of:
providing a circuit substrate having a plurality of electrical components;
encasing the circuit substrate with a thermo-conformable material;
vacuum forming the thermo-conformable material onto the circuit substrate;
applying thermal energy to the thermo-conformable material having a softening point such that the thermo-conformable material reaches the softening point and conforms to the circuit substrate and the electrical components; and
metallizing the thermo-conformable material.

8. The method of claim 7, wherein the step of metallizing the thermo-conformable material is performed before the step of vacuum forming.

FIG.1

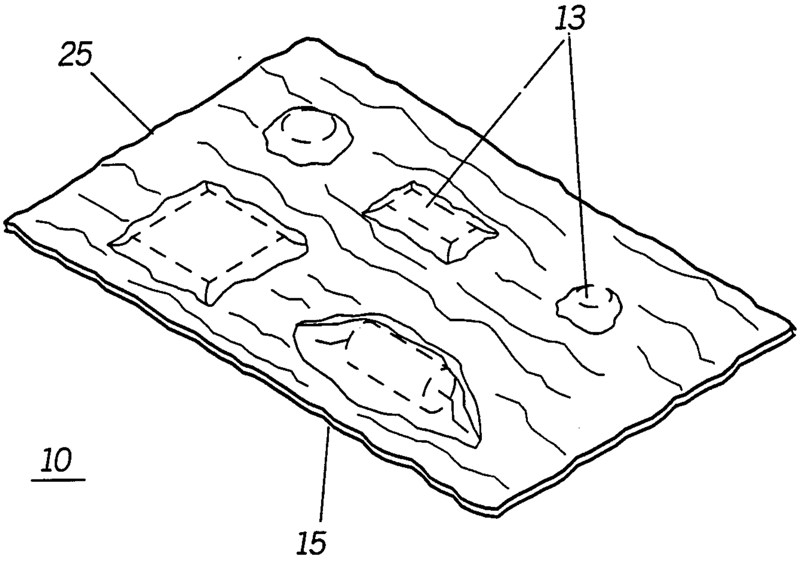


FIG.2

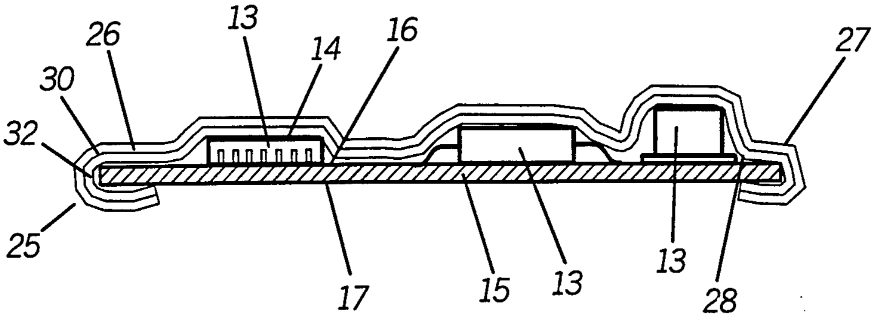


FIG.3

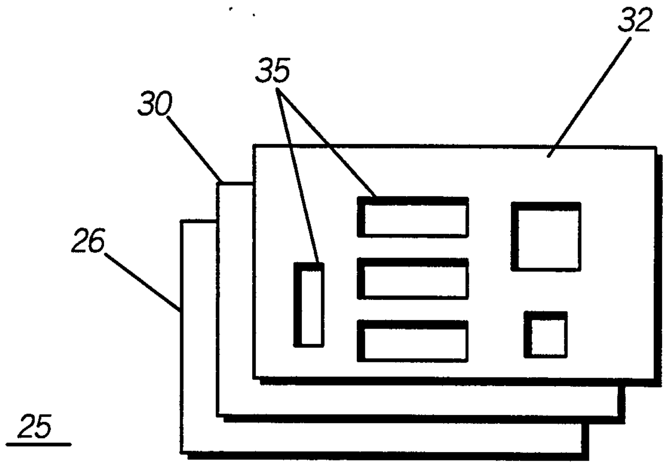


FIG.5

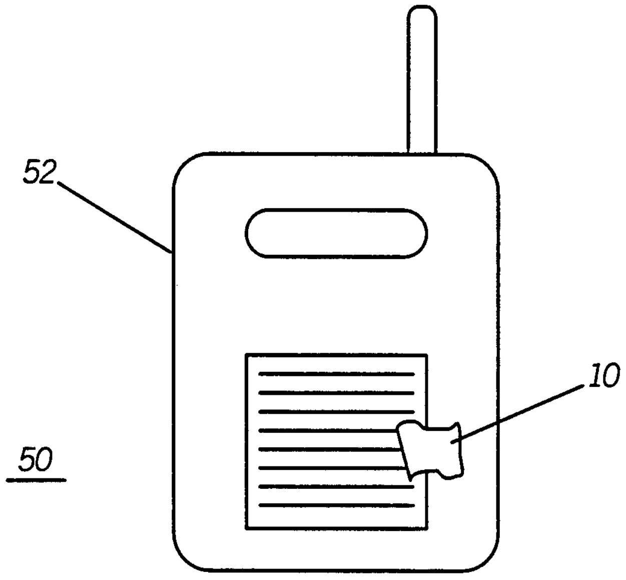
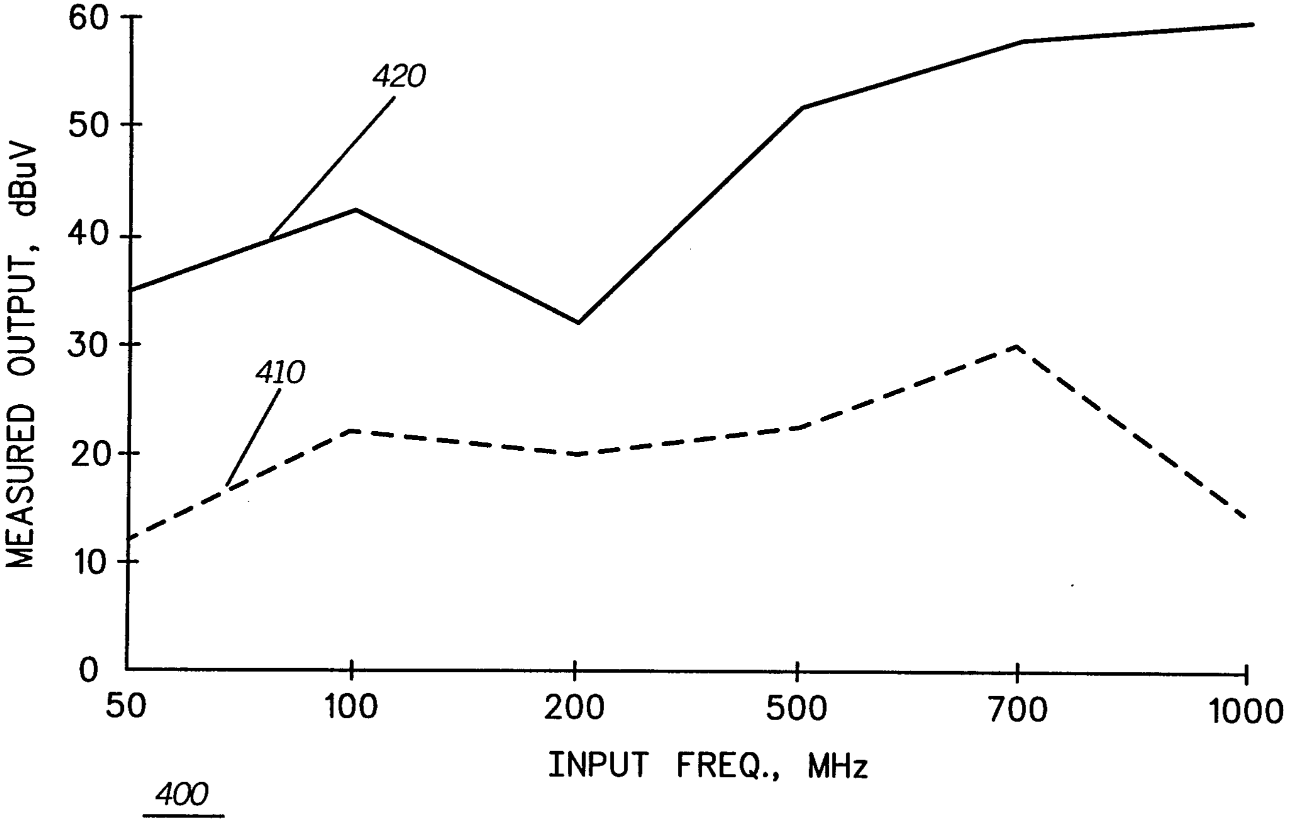


FIG.4


60
50
40
30
20
10
0
MEASURED OUTPUT, dBuV
50
100
200
500
700
1000
INPUT FREQ., MHz
420
410
400

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/04186

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04B 1/10
US CL :455/300
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. : 455/300,301,89,90; 361/816,818; 174/35MS

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

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none

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE, A, 4041-071 (BRISAC ET AL) 27 June 1991, fig. 1.	1-8
Y	US, A, 3,756,399 (COSIER ET AL) 04 September 1973, figure 4, col. 2, lines 1-49.	1-8
A	US, A, 4,890,199 (BEUTLER) 26 December 1989, figure 1, col. 1, lines 8-24.	1-8
A,P	US, A, 5,318,855 (GLOVATSKY ET AL) 07 June 1994, col. 1, lines 19-23, col. 1, line 67 - col. 2, line 5, col. 2, lines 8-21, col. 4, lines 35-40.	1-8
A,P	US, A, 5,394,304 (JONES) 28 February, 1995, figure 3, col. 2, lines 16-35.	1-8

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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