

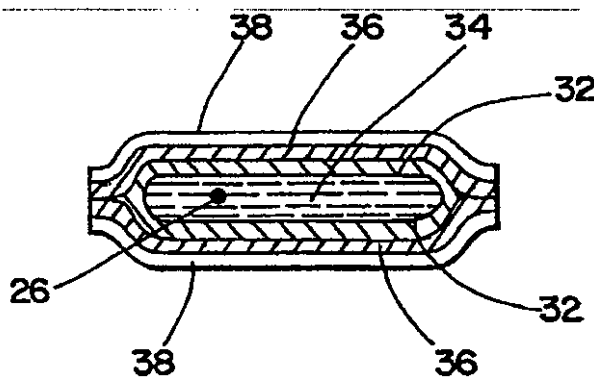
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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : H01Q 1/00	A1	(11) International Publication Number: WO 99/44257 (43) International Publication Date: 2 September 1999 (02.09.99)
(21) International Application Number: PCT/US99/03949 (22) International Filing Date: 24 February 1999 (24.02.99) (30) Priority Data: 09/031,223 26 February 1998 (26.02.98) US (71) Applicant: ERICSSON, INC. [US/US]; 7001 Development Drive, P.O. Box 13969, Research Triangle Park, NC 27709 (US). (72) Inventors: HAYES, Gerard, James; 207 Abercrombie Road, Wake Forest, NC 27587 (US). MacDONALD, James, D., Jr.; 134 Parkcrest Drive, Apex, NC 27502 (US). SPALL, John, Michael; 113 Houndschase Run, Cary, NC 27513-3028 (US). (74) Agents: BODDIE, Needham, J., II et al.; Myers, Bigel, Sibley, & Sajovec, P.A., P.O. Box 37428, Raleigh, NC 27627 (US).		(81) Designated States: AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> 5000+100 图

(54) Title: FLEXIBLE DIVERSITY ANTENNA**(57) Abstract**

Flexible diversity antennas having gain and bandwidth capabilities suitable for use within small communications devices such as radiotelephones are provided. A core of flexible material has an electrical conductor embedded therewithin in a meandering pattern and is surrounded by a first layer of flexible dielectric material. At one end of the antenna, the first layer of dielectric material is surrounded by flexible conductive material. The flexible conductive material is surrounded by a second layer of flexible dielectric material. The portion of the antenna surrounded by conductive material serves as a tuning element, and the portion of the antenna not surrounded by conductive material serves as a radiating element. A flexible signal feed is integral with the antenna and extends outwardly from the flexible core.



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FLEXIBLE DIVERSITY ANTENNA

Field of the Invention

The present invention relates generally to antennas, and more particularly to antennas used within communication devices.

5

Background of the Invention

Antennas for personal communication devices, such as radiotelephones, may not function adequately when in close proximity to a user during operation, or
10 when a user is moving during operation of a device. Close proximity to objects or movement of a user during operation of a radiotelephone may result in degraded signal quality or fluctuations in signal strength, known as multipath fading. Diversity antennas have been
15 designed to work in conjunction with a radiotelephone's primary antenna to improve signal reception.

Many of the popular hand-held radiotelephones are undergoing miniaturization. Indeed, many of the contemporary models are only 11-12 centimeters in
20 length. Unfortunately, as radiotelephones decrease in size, the amount of internal space therewithin may be reduced correspondingly. A reduced amount of internal space may make it difficult for existing types of

diversity antennas to achieve the bandwidth and gain requirements necessary for radiotelephone operation, because their size may be correspondingly reduced.

One type of diversity antenna is referred to as a Planar Inverted F Antenna (PIFA). A PIFA derives its name from its resemblance to the letter "F" and typically includes various layers of rigid materials formed together to provide a radiating element having a conductive path therein. The various layers and components of a PIFA are typically mounted directly on a molded plastic or sheet metal support structure. Because of their rigidity, PIFAs are somewhat difficult to bend and form into a final shape for placement within the small confines of radiotelephones. In addition, PIFAs may be susceptible to damage when devices within which they are installed are subjected to impact forces. Impact forces may cause the various layers of a PIFA to crack, which may hinder operation or even cause failure.

Various stamping, bending and etching steps may be required to manufacture a PIFA because of their generally non-planar configuration. Consequently, manufacturing and assembly is typically performed in a batch-type process which may be somewhat expensive. In addition, PIFAs typically utilize a shielded signal feed, such as a coaxial cable, to connect the PIFA with the RF circuitry within a radiotelephone. During assembly of a radiotelephone, the shielded signal feed between the RF circuitry and the PIFA typically involves manual installation, which may increase the

cost of radiotelephone manufacturing.

Summary of the Invention

5 It is, therefore, an object of the present invention to provide PIFAs that can easily conform within the internal confines of small communications devices such as radiotelephones.

10 It is another object of the present invention to provide small PIFAs that can have sufficient gain and bandwidth capabilities for use within radiotelephones.

15 It is also an object of the present invention to provide PIFAs that can be less vulnerable to damage caused by impact forces to the devices within which they are installed.

It yet another object of the present invention to simplify radiotelephone assembly and thereby reduce radiotelephone manufacturing costs.

20 These and other objects of the present invention are provided by flexible diversity antennas that can have gain and bandwidth capabilities suitable for use within small communications devices such as radiotelephones. A core of flexible material, such as silicone, has an electrical conductor embedded
25 therewithin and is surrounded by a first layer of flexible dielectric material. At one end of the antenna, the first layer of dielectric material is surrounded by conductive material, such as copper or nickel fabric. The conductive material is flexible and
30 replaces rigid metallic elements typically utilized in

PIFAs.

The conductive material is preferably surrounded by a second layer of flexible dielectric material. The portion of the antenna surrounded by conductive material serves as a tuning element, and the portion of the antenna not surrounded by conductive material serves as a radiating element. Preferably, the electrical conductor within the core extends between the radiating and tuning elements along a meandering path.

A flexible signal feed is integral with the antenna and extends outwardly from the flexible core. The signal feed is electrically connected to the electrical conductor embedded within the flexible core. The signal feed is surrounded by a layer of flexible material, preferably the same material as the flexible core. This flexible material is surrounded by a layer of dielectric material. Surrounding this layer of dielectric material is a layer of conductive material which serves to shield the signal feed. This layer of conductive material may be surrounded by another layer of dielectric material.

Operations for fabricating a flexible diversity antenna having a predetermined impedance, include: forming a planar antenna element having an electrical conductor embedded within an elastomeric core, a first layer of dielectric material surrounding the elastomeric core, portions of the first layer of dielectric material surrounded with conductive material, and a second layer of dielectric material

surrounding the conductive material; and then folding the planar antenna element into a shape for assembly within an electronic device, such as a radiotelephone. The elastomeric core and material utilized to laminate the various layers of material around the core are
5 cured prior to folding the planar antenna element into a shape for assembly within an electronic device. During curing operations, texturing of the surface of the second layer of dielectric material may be
10 performed.

Diversity antennas according to the present invention can be manufactured in a planar configuration, which is conducive to high volume automated production. Furthermore, repeatable impedance characteristics are obtainable through the selection of
15 materials and the control of thickness of the various layers of materials. Because flexible dielectric and conductive materials are utilized, the antennas can then be formed into various shapes so as to fit into
20 small areas during radiotelephone assembly.

In contrast with known diversity antennas, the present invention is capable of achieving sufficient gain and bandwidth for radiotelephone operation for a given size and location. Using this
25 invention, the antenna designer has a greater degree of design flexibility than with known diversity antennas. Furthermore, conductive material can be selectively added to create a controlled impedance stripline transmission medium on sections of the antenna.

30 The relatively rigid antenna assemblies in

previous PIFAs generally do not lend themselves to being folded easily to conform with small spaces within communications devices. By contrast, diversity antennas according to the present invention have a flexible configuration that allows the antenna to conform to the small space constraints of current radiotelephones and other communication devices. The flexible configuration of the present invention can also reduce the possibility of damage from impact forces. Furthermore, the present invention incorporates an integral, flexible signal feed which eliminates the need for a separate coaxial cable to connect the antenna with signal circuitry within a device. Accordingly, assembly costs of communications devices, such as radiotelephones, can be reduced.

Brief Description of the Drawings

Fig. 1 illustrates a typical PIFA used within radiotelephones.

Fig. 2 is a plan view of a flexible PIFA according to aspects of the present invention.

Fig. 3 is a perspective view of the PIFA illustrated in Fig. 2 with the tuning portion in a folded configuration.

Fig. 4 is a sectional view of the PIFA illustrated in Fig. 2 taken along lines 4-4.

Fig. 5 is a sectional view of the PIFA illustrated in Fig. 2 taken along lines 5-5.

Fig. 6 is a sectional view of the PIFA illustrated in Fig. 2 taken along lines 6-6.

Figs. 7A-7B schematically illustrate operations for fabricating flexible diversity antennas according to aspects of the present.

5 Detailed Description of the Invention

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may,
10 however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those
15 skilled in the art. Like numbers refer to like elements throughout.

As is known to those skilled in the art, an antenna is a device for transmitting and/or receiving electrical signals. A transmitting antenna typically
20 includes a feed assembly that induces or illuminates an aperture or reflecting surface to radiate an electromagnetic field. A receiving antenna typically includes an aperture or surface focusing an incident radiation field to a collecting feed, producing an
25 electronic signal proportional to the incident radiation. The amount of power radiated from or received by an antenna depends on its aperture area and is described in terms of gain. Radiation patterns for antennas are often plotted using polar coordinates.
30 Voltage Standing Wave Ratio (VSWR) relates to the

impedance match of an antenna feed point with the feed line or transmission line. To radiate RF energy with minimum loss, or to pass along received RF energy to the receiver with minimum loss, the impedance of the antenna should be matched to the impedance of the transmission line or feeder.

Radiotelephones typically employ a primary antenna which is electrically connected to a transceiver operably associated with a signal processing circuit positioned on an internally disposed printed circuit board. In order to maximize power transfer between the antenna and the transceiver, the transceiver and the antenna are preferably interconnected such that the respective impedances are substantially "matched," i.e., electrically tuned to filter out or compensate for undesired antenna impedance components to provide a 50 Ohm (or desired) impedance value at the circuit feed.

As is well known to those skilled in the art, a diversity antenna may be utilized in conjunction with a primary antenna within a radiotelephone to prevent calls from being dropped due to fluctuations in signal strength. Signal strength may vary as a result of a user moving between cells in a cellular telephone network, a user walking between buildings, interference from stationary objects, and the like. Diversity antennas are designed to pick up signals that the main antenna is unable to pick up through spatial, pattern, and bandwidth or gain diversity.

A type of diversity antenna well known in the

art is the Planar Inverted F Antenna (PIFA) and is illustrated in Fig. 1. The illustrated PIFA 10 includes a radiating element 12 maintained in spaced apart relationship with a ground plane 14. The radiating element is also grounded to the ground plane 14 as indicated by 16. A hot RF connection 17 extends from underlying circuitry through the ground plane 14 to the radiating element 12 at 18. A PIFA is tuned to desired frequencies by adjusting the following parameters which can affect gain and bandwidth: varying the length L of the radiating element 12; varying the gap H between the radiating element 12 and the ground plane 14; and varying the distance D between the ground and hot RF connections. Other parameters known to those skilled in the art may be adjusted to tune the PIFA, and will not be discussed further.

Referring now to Fig. 2, a planar diversity antenna 20 in accordance with a preferred embodiment of the present invention is illustrated. The antenna 20 has an "F" shape and includes a tuning portion 22 and an adjacent radiating portion 24, as indicated. The antenna 20 is preferably manufactured in a planar configuration as illustrated in Fig. 2. Prior to assembly within a communications device, the flexible antenna is folded to conform with the internal space of the device.

Fig. 3 illustrates the antenna 20 with its tuning portion 22 folded under the radiating element 24 so that the antenna has the proper configuration for assembly within a particular communications device.

Fig. 3 also illustrates the shielded flexible signal feed 28 in a substantially transverse orientation with respect to the radiating element 24 so as to be in proper orientation for connection with signal circuitry within a communications device. A flexible diversity antenna according to the present invention can be formed into various shapes as required to facilitate installation within various internal spaces of devices such as radiotelephones.

Referring back to Fig. 2, a continuous electrical conductor 26 extends between the tuning element 22 and radiating element 24 and serves as an antenna element for sending and receiving electronic signals. In the illustrated embodiment, the electrical conductor 26 extends from a tuning element end portion 22a to an opposite radiating element end portion 24a in a meandering pattern.

A flexible, shielded RF or microwave signal feed 28 is integrally connected to the radiating element 24 of the antenna 20, as illustrated. The shielded signal feed 28 has a similar construction to that of the radiating element 22, which is described in detail below. An electrical conductor 30 is contained within the flexible signal feed 28 and has opposite end portions 30a and 30b. The electrical conductor 30 is electrically connected at end portion 30a with the electrical conductor 26 of the radiating element 24 at location 29, as illustrated. Opposite end portion 30b is preferably configured for assembly to a circuit board via conventional connection techniques including

soldering, displacement connectors, conductive elastomers, metal compression contacts, and the like.

5 The flexible signal feed 28 can be configured in various orientations to facilitate assembly within radiotelephones and other electronic devices.

Conventional diversity antennas generally require a shielded signal feed from the main circuit board in a radiotelephone. Coaxial cables are often used for this purpose. However, coaxial cables are relatively costly and require manual assembly. The present invention is
10 advantageous because a shielded signal feed 28 is provided as an integral part of the antenna 20.

Referring now to Fig. 4, a cross-sectional view of the radiating element 24 of the antenna 20 of Fig. 2 taken along lines 4-4 is illustrated. The
15 electrical conductor 26 is embedded within a flexible core 34. The flexible core is preferably formed from an elastomeric material such as silicone. Preferably, the flexible core is also formed from a dielectric material having a dielectric constant between about 1.8 and 2.2.
20 A first layer of flexible dielectric material 32 surrounds the elastomeric core 34 as illustrated. Preferably, the first layer of dielectric material has a dielectric constant between about 1.8 and 2.2. The
25 first layer of dielectric material may be formed from non-metalized, woven or knit fabrics. Polyester or liquid crystal polymer (LCP) cloth capable of withstanding processing temperatures up to 120°C is an exemplary dielectric material for use as the first
30 layer of dielectric material 32.

Referring now to Fig. 5, a cross-sectional view of the tuning element 22 of the antenna 20 of Fig. 2 taken along lines 5-5 is illustrated. A layer of flexible conductive material 36 surrounds the first layer of dielectric material 32. Preferably the conductive material 36 is metalized fabric. Preferred metalized fabrics are those with high strength and high temperature processing capability. Exemplary metalized fabrics include, but are not limited to, polyester or liquid crystal polymer (LCP) woven fabric having fibers coated with copper, followed by a nickel outer layer; nickel and copper fabrics formed of metallic fibers or metallic felt structures; carbon fiber fabrics formed of fiber or felt structures. Alternatively, portions of the first layer of dielectric material 32 may be metalized with conductive material on the outer surface.

Preferably, the metalized fabric 36 is laminated to the first layer of dielectric material 32 with an elastomeric material such as silicone. The silicone fills the voids in the metalized fabric to enhance bending characteristics. As is known to those skilled in the art, silicone provides consistent flexibility with high elongation over various temperatures, particularly low temperatures. The conductive material 36 may then be surrounded as illustrated with a second layer of flexible dielectric material 38. The second layer of dielectric material 38 may be formed from non-metalized polymers formed as films, or as woven or knit fabrics. Polyetherimide

(PEI) films, or cloth made of polyester or liquid crystal polymer (LCP) capable of withstanding processing temperatures up to 120°C is an exemplary dielectric material for use as the second layer of dielectric material 38.

The thickness of the first and second layers of dielectric material 32, 38 can be varied during manufacturing of the antenna 20 to produce a controlled characteristic impedance for the electrical conductor.

The characteristic impedance (Z_0) of the RF transmission line is calculated from the geometry and the dielectric constant of the materials (conductor width and dielectric thickness) comprising the line. As the geometry changes from a stripline to microstrip transmission line, the thickness of the layers is adjusted for the desired impedance. Stiffer dielectric materials may also be added to both the first and second layers of dielectric material 32, 38 to control the flexibility of the antenna 20 or to tailor the dielectric constant of the antenna. Films of polyetherimide (PEI) may be used where high strength and good flexibility are required. As is known to those skilled in the art, PEI closely matches the dielectric constant of silicone elastomer and bonds well to both silicone and various outer coating materials. Bonding of the first and second dielectric layers 32, 38 may require the use of heat activated bonding films. Preferably, fluorinated ethylene propylene (FEP) bonding film is utilized with TFE dielectric materials

and silicone film is utilized with PEI dielectric materials.

5 The antenna 20 may undergo curing operations to cure the silicone or other elastomeric material used in the core 34 and to laminate the various layers of material together surrounding the core. Curing operations are typically performed according to the recommendations of the manufacturer of the bonding system used. For example: FEP films may bond at
10 temperatures greater than or equal to 235°C; silicone elastomer heat cured adhesives may bond at temperatures greater than or equal to 120°C; or pressure cured silicone elastomer adhesives may be given an accelerated bond at temperatures greater than or equal
15 to 90°C. As is normal in adhesive bonding of thin sheets of materials, pressure may be applied through rigid backing plates. The interface between the backing plate and the material to be bonded may be filled with a compliant elastomer pad. The compliance of the
20 elastomer pad aids in producing a void-free adhesive interface. Features or surface texture on the elastomer pad may be used to create fold lines or bend relief points to aid final assembly of the antenna.

 The second layer of dielectric material 38
25 may contain surface texturing to evenly distribute bending stresses throughout the cross section of the antenna 20. Texturing may be formed via pressure pads used in the curing process. Pressure may be applied during curing to ensure that the silicone fills the
30 voids between the fibers in the conductive material 36.

Referring now to Fig. 6, a cross-sectional view of the transition region between the radiating portion 24 and the tuning portion 22 of the antenna 20 of Fig. 2 taken along lines 6-6 is illustrated. In the illustrated embodiment, the second dielectric layer 38 terminates just beyond the termination point of the conductive material 36. However, the second dielectric layer 38 may extend further over the first layer of dielectric material 32. Extending the second dielectric layer 38 over the first layer of dielectric material 32 may be used to produce a more even thickness transition (to aid the bonding process), or to produce a greater stiffness at the transition (to aid bending of the final assembly). A similar configuration may exist in the transition region between the signal feed 28 and the radiating element 24.

A stiffer outer layer of material (not shown) may be utilized to form an environmentally suitable outer surface for the antenna 20. Various materials may be utilized as an outer surface including, but not limited to, FEP. An outer layer of material may be desirable to protect against abrasion and other causes of wear.

Operations for fabricating a flexible diversity antenna according to the present invention are illustrated schematically in Figs. 7A and 7B. A planar antenna is formed (Block 100) and then folded for assembly within an electronic device (Block 200). Operations for forming a planar antenna include embedding an electrical conductor within an elastomeric

core (Block 102), preferably in a meandering configuration. The elastomeric core is then surrounded by a first layer of dielectric material (Block 104). One or more portions of the first layer of dielectric material is surrounded with conductive material to tune the antenna to a predetermined impedance (Block 106). A shielded signal feed is integrally formed with the antenna and extends outwardly therefrom (Block 108). The elastomeric core and materials for bonding the dielectric and conductive layers to the core are cured using curing techniques known to those skilled in the art, including, but not limited to, air curing, thermal curing, infrared curing, microwave curing, and the like (Block 110). Surface texturing may be created in the second layer of dielectric material during curing operations (Block 112).

The foregoing is illustrative of the present invention and is not to be construed as limiting thereof. Although a few exemplary embodiments of this invention have been described, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention as defined in the claims. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents but also equivalent structures. Therefore, it is to be

understood that the foregoing is illustrative of the present invention and is not to be construed as limited to the specific embodiments disclosed, and that modifications to the disclosed embodiments, as well as
5 other embodiments, are intended to be included within the scope of the appended claims. The invention is defined by the following claims, with equivalents of the claims to be included therein.

THAT WHICH IS CLAIMED IS:

1. An antenna, comprising:
a flexible core surrounded by a first layer
of flexible dielectric material and having opposite end
5 portions;
a layer of flexible conductive material
surrounding said first layer of flexible dielectric
material at one of said end portions; and
an electrical conductor embedded within said
10 flexible core and extending between said end portions.
2. An antenna according to Claim 1 wherein
said layer of flexible conductive material is
surrounded by a second layer of flexible dielectric
material.
3. An antenna according to Claim 1 wherein
said electrical conductor has a meandering
configuration through said elastomeric core.
4. An antenna according to Claim 1 wherein
said flexible core comprises silicone.
5. An antenna according to Claim 1 wherein
said flexible conductive material comprises metalized
fabric.
6. An antenna according to Claim 5 wherein

said metalized fabric is laminated to said first layer of flexible dielectric material with a silicone elastomer.

7. An antenna according to Claim 1 wherein said first and second layers of flexible dielectric material have a dielectric constant of between about 1.8 and 2.2.

8. An antenna according to Claim 1 wherein said flexible core is formed from material having a dielectric constant of between about 1.8 and 2.2.

9. An antenna according to Claim 1 wherein said first and second layers of flexible dielectric material comprise polyetherimide film.

10. An antenna according to Claim 1 further comprising an integral, flexible signal feed extending outwardly from said flexible core, said signal feed electrically connected to said electrical conductor
5 embedded within said elastomeric core.

11. An antenna according to Claim 10 further comprising:

a layer of flexible material surrounding said signal feed;

5 a first layer of flexible dielectric material surrounding said layer of flexible material;

a layer of flexible conductive material surrounding said first layer of flexible dielectric

material; and

10 a second layer of flexible dielectric
material surrounding said layer of flexible conductive
material.

12. A flexible diversity antenna,
comprising:

5 an elastomeric core surrounded by a first
layer of dielectric material and having opposite end
portions, said first layer of dielectric material
having selected portions metalized with conductive
material; and

10 an electrical conductor embedded within said
elastomeric core and extending between said opposite
end portions.

13. A flexible diversity antenna according
to Claim 12 further comprising a second layer of
dielectric material surrounding said metalized portions
of said first layer of dielectric material.

14. A flexible diversity antenna according
to Claim 12 wherein said electrical conductor has a
meandering configuration through said elastomeric core.

15. A flexible diversity antenna according
to Claim 12 wherein said elastomeric core is formed of
silicone.

16. A flexible diversity antenna according
to Claim 12 further comprising a signal feed extending

outwardly from said flexible core, said signal feed
electrically connected to said electrical conductor
5 embedded within said elastomeric core.

17. A flexible diversity antenna according
to Claim 12 further comprising:

a layer of elastomeric material surrounding
said signal feed;

5 a first layer of dielectric material
surrounding said layer of elastomeric material;

conductive material surrounding said first
layer of dielectric material; and

a second layer of dielectric material
10 surrounding said conductive material.

18. A radiotelephone comprising:

a radiotelephone housing;

a circuit board disposed in said housing;

a flexible diversity antenna disposed in said
5 housing, said flexible diversity antenna comprising:

an elastomeric core surrounded by a
first layer of dielectric material and having
opposite end portions;

a layer of conductive material
10 surrounding one of said end portions; and

an electrical conductor embedded within
said elastomeric core and extending between
said end portions; and

a signal feed extending outwardly from said
15 diversity antenna and electrically connecting said
electrical conductor embedded within said elastomeric

core with said circuit board.

19. A radiotelephone according to Claim 18 wherein said layer of conductive material is surrounded by a second layer of dielectric material.

20. A radiotelephone according to Claim 18 wherein said electrical conductor has a meandering configuration through said elastomeric core.

21. A radiotelephone according to Claim 18 wherein said elastomeric core comprises silicone.

22. A radiotelephone according to Claim 18 wherein said conductive layer comprises metalized fabric.

23. A radiotelephone according to Claim 22 wherein said metalized fabric is laminated to said first layer of dielectric material with a silicone elastomer.

24. A radiotelephone according to Claim 18, further comprising:

a layer of elastomeric material surrounding said signal feed;

5 a first layer of dielectric material surrounding said layer of elastomeric material; conductive material surrounding said first layer of dielectric material; and

a second layer of dielectric material

-23-

10 surrounding said conductive material.

25. A method of fabricating a flexible diversity antenna having a predetermined impedance, the method comprising the steps of:

5 forming a planar antenna having an electrical conductor embedded within an elastomeric core, a first layer of dielectric material surrounding the elastomeric core, portions of the first layer of dielectric material surrounded with conductive material, and a second layer of dielectric material
10 surrounding the conductive material; and

folding the planar antenna into a shape for assembly within an electronic device.

26. A method according to Claim 25 wherein said step of forming a planar antenna comprises embedding the electrical conductor in a meandering configuration through the elastomeric core.

27. A method according to Claim 25 wherein said step of forming a planar antenna comprises forming an integral shielded signal feed extending outwardly from the elastomeric core, wherein the signal feed is electrically connected to the electrical conductor embedded within the elastomeric core.

28. A method according to Claim 25 further comprising the step of curing the elastomeric core prior to said step of folding the planar antenna into a shape for assembly within an electronic device.

29. A method according to Claim 25 wherein said step of forming a planar antenna comprises forming the elastomeric core from silicone elastomer.

30. A method according to Claim 25 wherein the conductive material is metalized fabric.

31. A method according to Claim 25 wherein the metalized fabric is laminated to the first layer of dielectric material with a silicone elastomer.

32. A method according to Claim 28 wherein said step of curing the elastomeric core comprises forming surface texturing in the second layer of dielectric material.

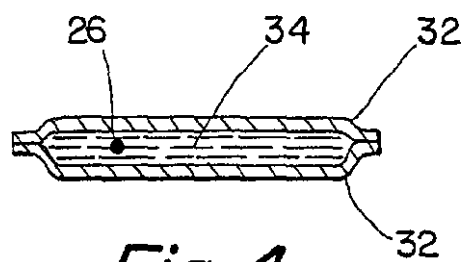
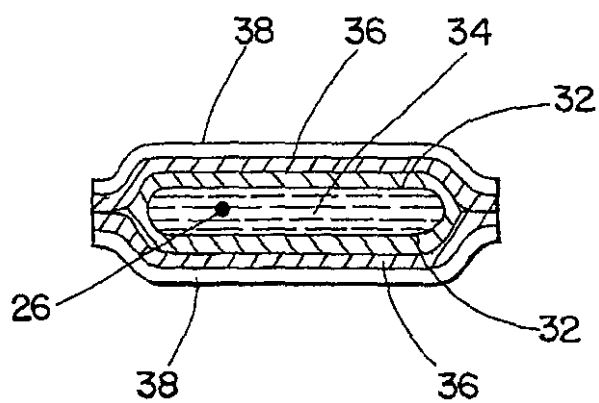
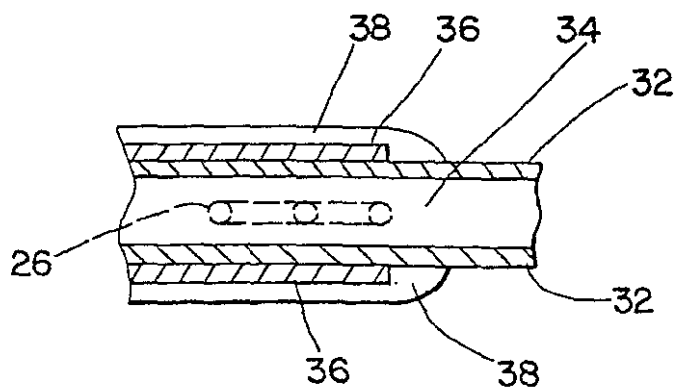
*Fig. 4**Fig. 5**Fig. 6*

Fig. 7A

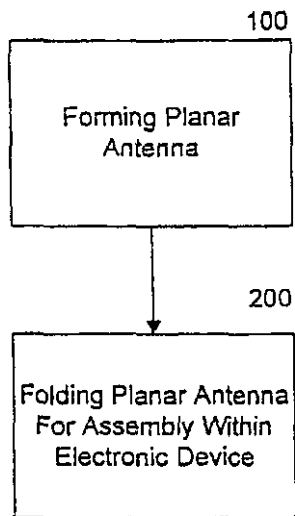
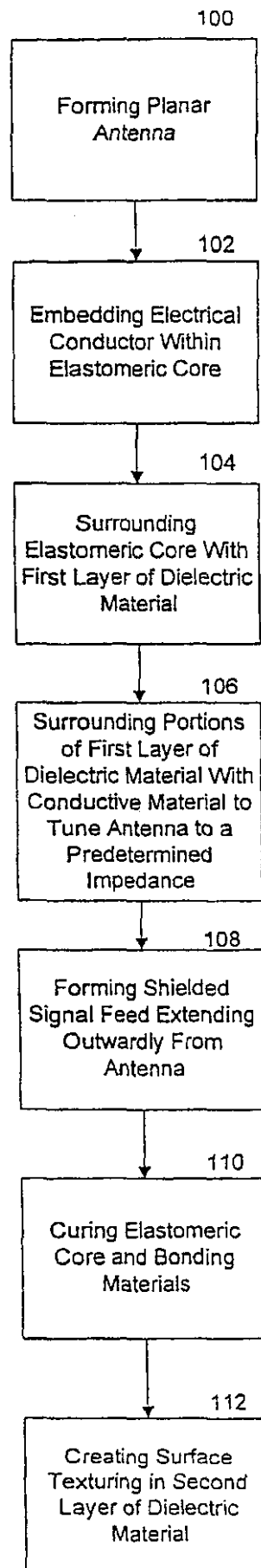


Fig. 7B



[12] 发明专利申请公开说明书

[21] 申请号 99803356.1

[43] 公开日 2001 年 4 月 18 日

[11] 公开号 CN 1292158A

[22] 申请日 1999.2.24 [21] 申请号 99803356.1

[30] 优先权

[32] 1998.2.26 [33] US [31] 09/031,223

[86] 国际申请 PCT/US99/03949 1999.2.24

[87] 国际公布 WO99/44257 英 1999.9.2

[85] 进入国家阶段日期 2000.8.25

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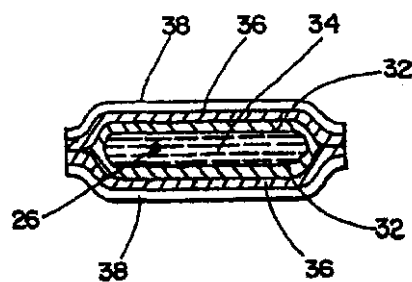
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权利要求书 4 页 说明书 8 页 附图页数 3 页

[54] 发明名称 柔性分集天线

[57] 摘要

提供一种柔性分集天线,该天线具有适用于在小型通信设备例如 无线电话机中使用的增益和带宽性能。柔性材料的一个核心具有镶嵌 在其中以弯曲图形的电导体,该核心由第一层柔性电介质材料包围。在该天线的一端,第一层电介质材料被柔性导电材料所包围。该柔性 导电材料被第二层柔性电介质材料所包围。该天线被导电材料所包围 的部分起调谐元件的作用,而该天线没有被导电材料所包围的部分起 辐射元件的作用。一个柔性信号馈源与该天线成一体并且从柔性核心 向外延伸。



ISSN 1008-4274

权 利 要 求 书

1. 一种天线, 包括:
一个柔性核心, 由第一层柔性电介质材料包围并具有相反的端部;
- 5 一层柔性导电材料, 在所述端部之一包围所述第一层柔性电介质材料; 和
一个电导体, 镶嵌在所述柔性核心内并在所述端部之间伸展。
2. 按照权利要求 1 的一种天线,
其中所述柔性导电材料层由第二层柔性电介质材料包围。
- 10 3. 按照权利要求 1 的一种天线,
其中所述电导体具有贯穿所述弹性核心的弯曲设计。
4. 按照权利要求 1 的一种天线,
其中所述柔性核心包括硅树脂。
5. 按照权利要求 1 的一种天线, 其中所述
- 15 柔性导电材料包括镀金属织物。
6. 按照权利要求 5 的一种天线,
其中所述镀金属织物被碾压在具有硅树脂弹性体的所述第一层柔性电介质材料上。
7. 按照权利要求 1 的一种天线,
- 20 其中所述第一和第二层柔性电介质材料具有大约 1.8 到 2.2 之间的介电常数。
8. 按照权利要求 1 的一种天线,
所述柔性核心由具有大约 1.8 到 2.2 之间的介电常数的材料形成。
- 25 9. 按照权利要求 1 的一种天线,
其中所述第一和第二层柔性电介质材料包括聚醚酰亚胺薄膜。
10. 按照权利要求 1 的一种天线,
进一步包括一个一体的柔性信号馈源从所述柔性核心向外延伸, 所述信号馈源与镶嵌在所述弹性核心内的所述电导体电连接。
- 30 11. 按照权利要求 10 的一种天线, 进一步包括:
一层柔性材料包围着所述信号馈源;
一个第一层柔性电介质材料包围着所述柔性材料层;



一个柔性导电材料层包围着所述第一层柔性电介质材料； 和
一个第二层柔性电介质材料包围着所述柔性导电材料层。

12. 一种柔性分集天线， 包括：

5 一个弹性核心， 由第一层电介质材料包围并具有相反端部， 所述
第一层电介质材料具有镀有导电材料的所选择部分； 和
一个电导体， 镶嵌在所述弹性核心内并在所述相反端部之间延
伸。

13. 按照权利要求 12 的一种柔性分集天线， 进一步包括一个第
二层电介质材料， 包围着所述第一层电介质材料的所述镀金属部分。

10 14. 按照权利要求 12 的一种柔性分集天线， 其中所述电导体具
有贯穿所述弹性核心的弯曲设计。

15. 按照权利要求 12 的一种柔性分集天线， 其中所述弹性核心
由硅树脂形成。

16. 按照权利要求 12 的一种柔性分集天线， 进一步包括一个信
15 号馈源， 从所述柔性核心向外延伸， 所述信号馈源与镶嵌在所述弹性
核心内的所述电导体电连接。

17. 按照权利要求 12 的一种柔性分集天线， 进一步包括：

一个弹性材料层包围着所述信号馈源；

第一层电介质材料包围着所述弹性材料层；

20 导电材料包围着所述第一层电介质材料； 和
第二层电介质材料包围着所述所述导电材料。

18. 一种无线电话机包括：

一个无线电话机外壳；

一个电路板部署在所述外壳中；

25 一个柔性分集天线部署在所述外壳中， 所述柔性分集天线包括：

一个弹性核心， 由第一层电介质材料包围并具有相反端部；

一个导电材料层包围着所述端部之一； 和

一个导电体镶嵌在所述弹性核心内并在所述端部间延伸； 和

30 一个信号馈源从所述分集天线向外延伸并且将镶嵌在所述弹性
核心内的所述电导体与所述电路板电连接。

19. 按照权利要求 18 的一种无线电话机， 其中所述导电材料层
被第二层电介质材料包围。

20. 按照权利要求 18 的一种无线电话机, 其中所述电导体具有贯穿所述弹性核心的弯曲设计。

21. 按照权利要求 18 的一种无线电话机, 其中所述弹性核心包括硅树脂。

5 22. 按照权利要求 18 的一种无线电话机, 其中所述导电层包括镀金属织物。

23. 按照权利要求 22 的一种无线电话机, 其中所述镀金属织物被碾压在具有硅树脂弹性体的所述第一层电介质材料上。

24. 按照权利要求 18 的一种无线电话机, 进一步包括:

10 一个弹性材料层包围着所述信号馈源;
一个第一层电介质材料包围着所述弹性材料层;
导电材料包围着所述第一层电介质材料; 和
一个第二层电介质材料包围着所述导电材料。

25. 一种制造具有预定阻抗柔性分集天线的方法, 该方法包括步
15 骤:

形成一个平面天线, 具有一个镶嵌在弹性核心内的电导体, 一个第一层电介质材料包围着弹性核心, 第一层电介质材料的一部分由导电材料包围和一个第二层电介质材料包围着导电材料; 和

将平面天线折叠成用于组装在电子设备内的形状。

20 26. 按照权利要求 25 的一种方法, 其中所述形成平面天线的步骤包括镶嵌弯曲形状的电导体贯穿全部弹性核心中。

27. 按照权利要求 25 的一种方法, 其中所述形成平面天线的步骤包括形成一个一体屏蔽信号馈源从弹性核心向外延伸, 其中信号馈源与镶嵌在弹性核心内的电导体电连接。

25 28. 按照权利要求 25 的一种方法, 进一步包括在将平面天线折叠成用于在电子设备内组装的形状的所述步骤之前将弹性核心固化的步骤。

29. 按照权利要求 25 的一种方法, 其中所述形成平面天线的步骤包括由硅树脂弹性体形成弹性核心。

30 30. 按照权利要求 25 的一种方法, 其中导电材料是镀金属织物。

31. 按照权利要求 25 的一种方法, 其中镀金属织物被碾压在具有硅树脂弹性体的第一层电介质材料上。

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32. 按照权利要求 28 的一种方法，其中固化弹性核心的所述步骤包括在第二层电介质材料上形成表面刻纹。

说明书

柔性分集天线

发明领域

5 本发明总的涉及天线，更具体地涉及在通信设备中使用的天线。

发明背景

用于个人通信设备例如无线电话的天线当在工作期间靠近用户时或当用户在设备工作期间移动时可能不能充分地发挥作用。在无线电话机工作期间靠近物体或用户移动可以产生信号质量退化或信号强度波动，称为多径衰落。已经设计出结合无线电话机主要天线工作的分集天线以改善信号接收。

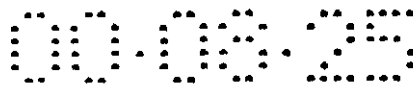
许多流行的手持无线电话机正在小型化。实际上许多现代机型只有 11 到 12 厘米长。不幸的是，由于无线电话机尺寸减小，其内部空间也相应地减小。内部空间的减少使现有类型分集天线实现无线电话机工作所需要的带宽和增益要求更困难，因为它的尺寸可相应地减小。

一种类型分集天线称为平面反向 F 天线 (PIFA)。PIFA 因其类似字母 F 而得名，并且特别包括形成在一起的几层刚性材料以提供具有其中的导电路径的辐射元件。PIFA 的各层和元件一般直接安装在模制塑料或片状金属支撑结构上。因为其刚性，将 PIFA 弯曲和形成用于安置在无线电话机小型区域内的最终形状有些困难。另外，当它们所安装在内的设备受到冲击力时 PIFA 易于损坏。冲击力可以使 PIFA 各层断裂，从而可能阻碍工作甚至产生故障。

因为通常为非平面设计，为制造 PIFA 可能需要冲压、弯曲和蚀刻等各种步骤。因此，制造和组装一般在稍微高成本的分批式处理中进行。另外，PIFA 一般使用屏蔽信号馈源，例如同轴电缆，将 PIFA 与无线电话机内的 RF 电路连接。在组装无线电话机期间，RF 电路与 PIFA 之间的屏蔽信号馈源一般涉及人工安装，这增加了无线电话机的制造成本。

30 发明概述

因此，本发明的目的是提供可以容易地与小型通信设备例如无线电话机内部区域相适应的 PIFA。



本发明的另一个目的是提供可以具有用于无线电话机内使用的足够增益和带宽性能的 PIFA。

本发明的又一个目的是提供对内部安装了 PIFA 的设备由冲击力产生的损害不敏感的 PIFA。

5 本发明的另一个目的是简化无线电话机组装并由此降低无线电话机制造成本。

10 本发明的这些和其它目的是由柔性分集天线提供的，该天线可以具有适合于在小型通信设备例如无线电话机中使用的增益和带宽性能。柔性材料例如硅树脂的核心具有镶嵌在其内部的电导体，并由柔性电介质材料的第一层包围。在该天线的一端，电介质材料的第一层被导电材料例如铜或镍织物所包围。导电材料是柔性的并替代通常使用在 PIFA 中的刚性材料元件。

15 导电材料最好被柔性电介质材料的第二层包围。被导电材料包围的天线部分起调谐元件的作用，而没有被导电材料包围的天线部分起辐射元件的作用。最好，在核心内的电导体在辐射元件和调谐元件之间沿蜿蜒路径伸展。

20 柔性信号馈源与该天线合并为一体并从柔性核心向外延伸。该信号馈源与镶嵌在柔性核心内的电导体电连接。该信号馈源被一层柔性材料包围，最好是与柔性核心相同的材料。该柔性材料被电介质材料层包围。包围电介质材料层的是一层导电材料，该导电材料起屏蔽信号馈源的作用。该导电材料层可以被另一个电介质材料层包围。

25 为制造具有预定阻抗的柔性分集天线的工作包括：形成具有镶嵌在弹性核心内的电导体，包围弹性核心的第一电介质材料层，用导电材料包围电介质材料第一层一部分和一个包围导电材料的第二电介质材料层的平面天线元件；和然后将平面天线元件折叠成用于组装在电子设备例如无线电话机中的形状。在将平面天线元件折叠成用于组装在电子设备内的形状之前，弹性核心和用来围绕核心分层叠放的各个材料层被弯曲。在弯曲操作期间，可以实现第二层电介质材料表面的构造。

30 按照本发明的分集天线可以在平面结构中制造，这可以有助于大量自动化生产。另外，通过选择材料并控制各个材料层的厚度可获得重复的阻抗特性。因为利用了柔性电介质和导电材料，该天线可以形

的功率数量取决于孔径面积并用增益描述。天线的辐射方向图通常使用极坐标标示。电压驻波比 (VSWR) 与天线馈源点与馈线或传输线的阻抗匹配有关。为以最小损耗辐射 RF 能量, 或以最小损耗将所接收的 RF 能量传递给接收机, 天线的阻抗应当与传输线或馈源阻抗相匹配。

5 无线电通常使用一个主天线, 该主天线由连接到与位于内置印刷电路板上的信号处理电路有效联合的收发信机。为使天线与收发信机之间传输的功率最大, 收发信机和天线最好相互连接得使各自阻抗基本上“匹配”, 即电调谐滤除或补偿不希望的天线阻抗分量以在电路馈源处提供 50 欧姆 (或所希望的) 阻抗值。

10 如同本领域技术人员所知, 分集天线可以与无线电中的主天线结合使用以防止由于信号强度波动引起的通话掉线。因为用户在蜂窝电话网络中的小区之间移动、用户在建筑物之间漫步、来自静止物体的干扰等, 信号强度可能改变。分集天线设计得通过空间、方向图、带宽或增益分集来采集主天线不能采集的信号。

15 本领域所知的一种分集天线是平面反 F 天线 (PIFA) 并在图 1 中说明。所说明的 PIFA10 包括与接地板 14 保持空间分离关系的辐射元件 12。该辐射元件也如同 16 所示在接地板 14 接地。通电的 RF 连接 17 从下面电路穿过接地板 14 在 18 处伸展到辐射元件 12。通过调节可以影响增益和带宽的下列参数将 PIFA 调谐到所希望的频率上: 改变辐射元件 12 的长度; 改变辐射元件 12 与接地板 14 之间的间隙 H; 和改变接地与通电的 RF 连接之间的距离 D。也可以调节本领域技术人员所知的其它参数来调谐 PIFA, 不再进一步讨论。

20 现在参照图 2, 说明按照本发明优选实施例的平面分集天线 20。该天线 20 具有 F 型形状并包括调谐部分 22 和邻接辐射部分 24, 如图所示。该天线 20 最好如同图 2 所示制造成平面设计。在通信设备内组装前, 柔性天线被折叠以符合设备的内部空间。

30 图 3 说明具有折叠在辐射元件 24 之下的调谐部分 22 的天线 20, 以便该天线具有在特定通信设备内组装的适当设计。图 3 也说明基本上与辐射元件 24 横切方向的屏蔽柔性信号馈源 28, 以便是在与通信设备内信号电路连接的适当方向上。由于需要有利于在例如无线电的设备的各种内部空间中安装, 按照本发明的柔性分集天线可以形成

各种形状。

参照图 2, 一条连续电导体 26 在调谐元件 22 与辐射元件 24 之间延伸并起发送和接收电子信号的天线元件作用。在所示的实施例中, 电导体 26 从调谐元件端部 22a 以弯曲形状延伸到对面的辐射元件端部 24a。

柔性屏蔽 RF 或微波信号馈源 28 整体连接到天线 20 的辐射元件 24, 如图所示。屏蔽信号馈源 28 具有与辐射元件 22 类似的结构, 将在下面详细描述。电导体 30 被包含在柔性信号馈源 28 内并具有相反端部 30a 和 30b。电导体 30 在端部 30a 与辐射元件 24 的电导体 26 在位置 29 电连接, 如图所示。相反端部 30b 最好设计得通过常规连接技术包括焊接、移置连接件、导电弹性体、金属加压触点等组装到电路板上。

柔性信号馈源 28 可以设计成各种方向有利于在无线电话和其它电子设备内组装。常规分集天线一般需要来自无线电话中主电路板的屏蔽信号馈源。为此目的通常使用同轴电缆。可是, 同轴电缆相对较贵而且需要人工组装。因为屏蔽信号馈源 28 作为天线 20 的一体部件安装, 本发明是先进的。

现在参照图 4, 说明图 2 中天线 20 辐射元件 24 沿线 4-4 的横截面图。电导体 26 被包围在柔性核心 34 内。柔性核心最好由例如硅树脂的弹性材料形成。最好, 柔性核心也由具有 1.8 到 2.2 之间介电常数的电介质材料形成。柔性电介质材料 32 第一层包围弹性核心 34 如图所示。最好, 介电材料第一层具有 1.8 到 2.2 之间的介电常数。柔性电介质材料第一层可以由非金属、织物或针织织物形成。能够经受 120°C 处理温度的聚酯或液晶聚合物 (LCP) 织物是用于第一电介质层 32 的示范电介质材料。

现在参照图 5, 说明图 2 中天线 20 调谐元件 22 沿线 5-5 的横截面图。一层柔性导电材料 36 包围着第一层电介质材料 32。导电材料 36 最好是镀金属织物。镀金属织物最好是具有高强度和高温处理能力的材料。示范性镀金属织物包括但不限于具有镀铜纤维的聚酯或液晶聚合物 (LCP) 纺织物, 随后是镍外层; 由镀金属纤维或含金属毡垫结构形成的镍和铜织物; 由纤维或毡垫结构形成的碳纤维织物。另一

个方式，第一层电介质材料 32 部分可以在外表面镀以金属的导电材料。

最好，镀金属织物 36 碾压在具有弹性材料例如硅树脂的第一层电介质材料 32 上。硅树脂填充镀金属织物的空隙以增强弯折特性。

- 5 如同本领域技术人员所知，硅树脂提供在各种温度下具有高延伸性的稳定的柔性，特别是在低温下。然后导电材料 36 可以如图所示由第二层柔性电介质材料 38 包围。第二层电介质材料 38 可以由非金属聚合物形成薄膜、或织物或针织织物。可以经受 120°处理温度的聚酰亚胺 (PEI) 薄膜、聚酯或液晶聚合物 (LCP) 制造的织物是用于第二层电介质材料 38 的示范性电介质材料。

- 10 在制造天线 20 期间第一和第二层电介质材料 32、38 的厚度可以改变以产生电导体的受控特性阻抗。RF 传输线的特性阻抗 (Z_0) 是根据构成该线材料 (导体宽度和电介质厚度) 的几何尺寸和介电常数计算出的。由于从带线到微带传输线几何尺寸改变，为所希望的阻抗需调节层的厚度。较刚性的电介质材料也可以加入到第一和第二层电介质材料 32、38 中，以控制天线 20 的柔性或修改天线的介电常数。在需要高强度和良好柔性的场合可以使用聚酰亚胺 (PEI) 薄膜。如同本领域技术人员所知，PEI 接近匹配硅树脂弹性体的介电常数并与硅树脂和各种外层镀膜材料良好粘接。第一和第二电介质层 32、38 的粘接可能需要使用热激活后的黏合薄膜。最好，对 TFE 电介质材料使用氟代乙烯丙烯 (FEP) 粘接薄膜，而对 PEI 电介质材料使用硅树脂薄膜。

- 25 天线 20 可以进行固化处理以固化用于核心 34 的硅树脂或其它弹性材料，并将包围核心的各层材料碾压在一起。固化处理一般按照所使用粘和系统制造商的建议进行。例如：FEP 薄膜在高于或等于 235°C 的温度下粘和；硅树脂弹性体热固化黏合剂在高于或等于 120°C 的温度下可以粘和；或可以给加压固化硅树脂弹性体黏合剂在温度高于或等于 90°C 上的加速粘合。如同普通的粘和薄片材料的黏合剂，通过刚性支撑板施加压力。在要粘和的材料与支撑板之间表面可以填充适当弹性垫片。弹性垫片的柔顺性有助于产生无缝隙的粘和表面。弹性垫片的特性或表面质地可以用于产生折叠线或减弯点，有助于天线的最终组装。

第二层电介质材料 38 可以包含表面刻纹，将弯折应力均匀分散在天线 20 的整个横截面上。刻纹可以通过固化处理中使用的压力垫片形成。在固化期间施加压力以保证硅树脂填充导电材料 36 内纤维之间的缝隙。

- 5 现在参照图 6，说明图 2 的天线 20 辐射部分 24 与调谐部分 22 之间过渡区沿线 6-6 的横截面。在所示的实施例中，第二电介质层 38 刚刚在导电材料 36 终止点之外终止。可是，第二电介质层 38 可以进一步伸展到第一层电介质材料 32 上。在第一层电介质材料 32 上延伸第二电介质层 38 可以用于产生更均匀的厚度过渡（有助于粘和处理），或在过渡部分产生更大刚性（有助于最后组装弯曲）。类似设计可以存在于信号馈源 28 与辐射元件 24 之间的过渡区上。

较刚性的材料外层（未示出）可以用于形成天线 20 的环境适应性外表面。可以用于外层的各种材料包括，但不限于，FEP。希望材料外层可以防止磨损或其它磨损原因。

- 15 在图 7A 和 7B 中示意性说明了按照本发明的制造柔性分集天线的工作。形成平面天线（方框 100），而然后折叠用于在电子设备中组装（方框 200）。形成平面天线的工作包括在弹性核心中镶嵌电导体（方框 102），最好用弯曲设计。弹性核心然后由第一层电介质材料包围（方框 104）。第一层电介质材料的一部分或几部分由导电材料包围以将天线调谐到预定阻抗（方框 106）。屏蔽信号馈源与天线一体形成并从天线向外伸展（方框 108）。弹性核心和用于将电介质与导电层粘和到核心的材料被固化，使用本领域技术人员所知的固化技术，包括但不限于晾晒、热固化、红外线固化、微波固化等（方框 110）。在固化处理期间可以在第二层电介质材料上产生表面刻纹（方框 112）。

- 25 上述内容是对本发明的说明而不能理解为对本发明的限制。尽管已经描述了本发明的几个示范性实施例，本领域技术人员容易理解在示范性实施例中可以进行许多修改而不实质性地脱离本发明的新颖教导和优点。因此，所有这些修改都包括在由权利要求书所限定的本发明的保护范围内。在权利要求书中，装置加功能的句型往往概括了在此描述的实现列举功能的结构，不仅包括结构上等同而且包括等同结构。因此，应当理解上述内容对本发明是说明性的而不能被认为是

限制于所公开的特定实施例，并且对所公开实施例的修改以及其它实施例往往被包括在附属的权利要求书范围内。本发明由下列权利要求书所限定，在此也包括权利要求的等同物。

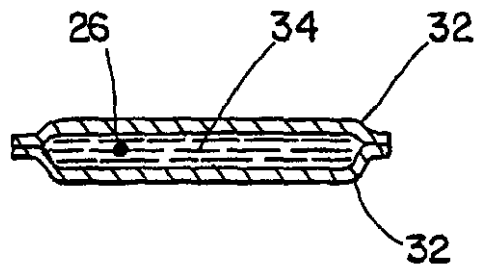


图 4

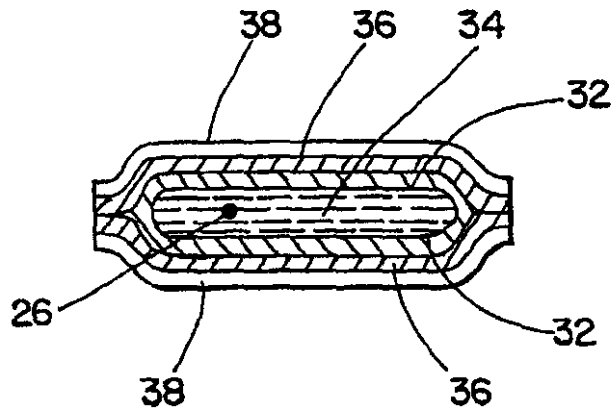


图 5

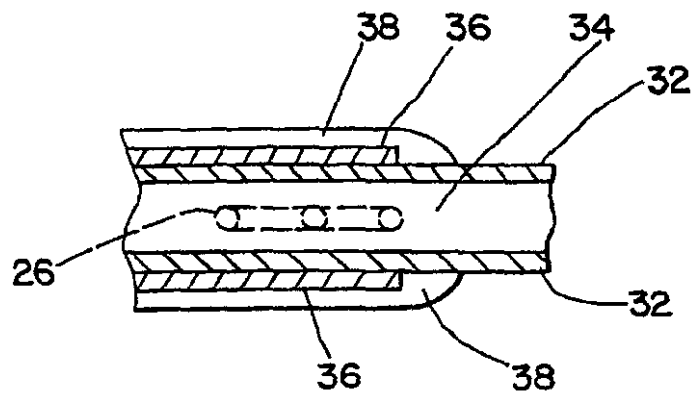


图 6

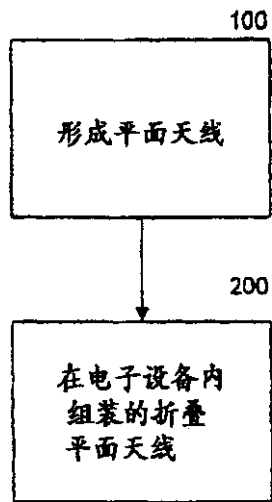


图 7A

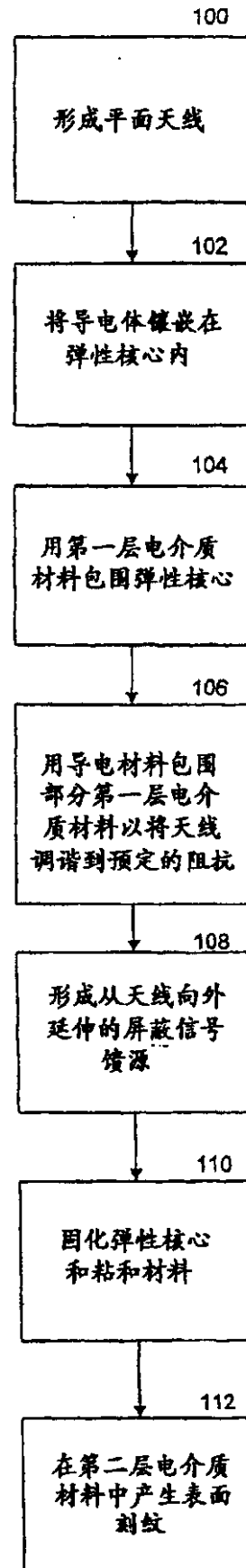


图 7B