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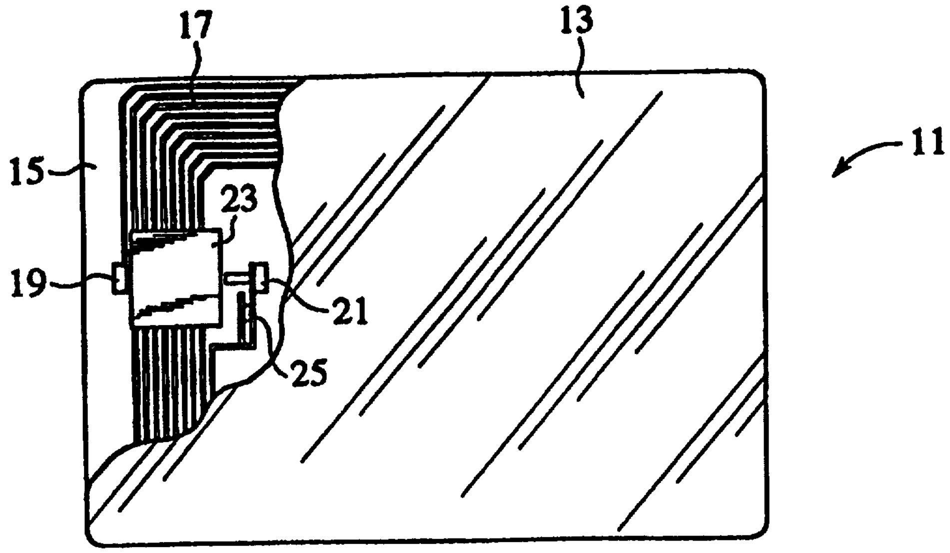
(54) Title: SMART CARD FORMED WITH TWO JOINED SHEETS



(57) Abstract

A method for forming smart cards (11) in which upper (13) and lower (15) layers of semi-rigid polymeric sheets are placed into die halves for injection molding of flowable material of the same type. An antenna pattern (17) defined on a very thin, very flexible copper foil by photolithography is deposited on one of the layers, with an electronic module (23) containing an integrated circuit placed over the antenna pattern. The flowable polymeric material surrounds the module and unites the upper and lower layers for good strength and flexing properties. The module may be completely sealed in the card and communicate only with the antenna, or the module may be partially sealed in the card, with metal contacts (19, 21) projecting through one layer of the card for selective communication via antenna or contacts.

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Description

Smart Card Formed with Two Joined Sheets

Technical Field

The invention relates to smart cards, and in particular, to a method of forming a smart card of the type having an internal antenna or coil.

Background Art

Smart cards are wallet size plastic cards, resembling credit cards, but containing one or more integrated circuit chips. Typically, at least one of the chips can perform arithmetic functions, while other chips, or portions of a single chip, perform memory functions. With this capability, a typical card may be used as a debit card for telephone or transportation purposes or as a substitute for cash transactions, such as in restaurants and hotels. The cards may also serve as keys for entry to hotel rooms, automobiles and other locked areas since the chip or chips may have logic circuits which contain a code for opening and securing locks. The number of uses for smart cards is rapidly increasing, including uses in security applications, such as cryptography and digital fingerprint storage.

The size of a card is frequently governed by dimensions set forth by the International Standards Organization (ISO). For example, ISO standard 7816 specifies dimensions which are very similar to the familiar wallet-size bank or credit cards which merely carry embossing and a magnetic stripe. Meeting the standard is difficult because the maximum permissible thickness is approximately 0.035 inches.

In U.S. Pat. No. 5,365,655 to R. Rose, a three layer card is disclosed in which the middle layer defines a nest for a chip. A thin metallic structure is interposed between two layers, for forming electrically conductive traces. The nest is filled with resin, within a mold, to secure the chip within the nest.

In U.S. Pat. No. 5,283,423 to J. Venambre, et al., a card is disclosed which features a bulk layer with a nest for seating a chip plus printed circuit and a cover foil layer which closes the nest. The foil acts as a circuit support and is glued in place with a hard polyurethane resin. Various hardnesses for the resin are disclosed.

In U.S. Pat. No. 5,134,773 LeMaire et al. disclose a two layer card structure in which each layer defines one-half of a nest. A metal strip seats a chip or electronic module and is adhered to one of the layers and the module is adhered in place with resin.

For small chips and electronic modules the properties of the resin bonding card layers are not important, so long as the resin acts as a good adhesive. However, for larger chips and modules, the amount of bonding material between layers increases and contributes substantially to the construction of the card. On the one hand, if the resin is soft, the card loses internal strength and is subject to breaking. On the other hand, if the resin is too hard, the card becomes brittle and may crack upon flexing. Even for small chips or modules, the resin or bonding material may contribute to the mechanical response of the card to bending and flexing.

An object of the invention was to devise a card construction, particularly a card with an antenna or coil, which would yield a robust smart card, with good properties for bending and flexing, whether small or large electronic modules were employed.

Disclosure of Invention

The above object was achieved with a smart card formed of first and second sheets or layers of the same polymeric material, without any rigid or semi-rigid intervening circuit card or chip layer or antenna support layer. The sheets are cut to card dimensions, with one or both of the sheets forming a nest for a chip encapsulation module. A circuit pattern, particularly an antenna or coil is applied directly to one of the sheets and the circuit pattern is brought into contact with the electronic module. The two sheets are placed in mold halves without any intervening rigid or semi-rigid printed circuit layer and the nest, as well as the interstices of the sheets are filled with a flowable form of the same polymeric material as the sheets. Upon cooling, the card is made of a uniform composition, except for the electronic module and the circuit pattern, giving good strength and flexibility.

Brief Description of the Drawings

Fig. 1 is a top view of a contactless smart card of the present invention, of the type having an internal chip and antenna loop.

Fig. 2 is a top view of an alternate embodiment of a smart card of the present invention, namely a hybrid card having a partially exposed chip for electrical contact and an internal antenna loop for contactless operation.

Fig. 3A is a top view of a lower layer of the smart card of Fig. 1 or 2 with all turns of the antenna loop in a single plane.

Figs. 3B and 3D are top views of alternate embodiments of a lower layer for the smart cards shown in Figs. 1 and 2, with stacked turns of the antenna loop.

Fig. 3C is a sectional view taken along lines 3C-3C in Fig. 3B.

Fig. 4 is a diagrammatic side view of a method for forming a loop antenna on one of the layers of Figs. 1 and 2.

Fig. 5 is a side plan view of process equipment for making loop antennas.

Fig. 6 is a side plan view of an alternate process for making loop antennas.

Fig. 7 is a perspective plan view of two mold halves for pressing together two opposed card layers, .pa with a chip mounted to one of the layers, in accord with the present invention.

Best Mode for Carrying Out the Invention

With reference to Fig. 1, a data card 11 is shown having an upper layer 13. Below this upper layer is a lower layer 15 which is coextensive with the upper layer 13 and made of the same material, preferably a polymer and specifically ABS, an acronym for a copolymer of acrylonitrile, butadiene and styrene. The two layers may have informational or decorative artwork affixed to non-mating major surfaces. The mating major surfaces are free of such artwork. One of the layers bears a loop antenna 17 on a mating surface, as well as contact pads 19 and 21 for making direct contact with electronic components such as electronic module 23, which contains an integrated circuit chip, and miniature capacitor 25. The chip in electronic module 23 picks up power through the antenna, from external electromagnetic signals at radio frequencies, so that an internal source of power is not needed.

Electronic module 23 is encapsulated using well known encapsulation materials, such as epoxy. Prior to encapsulation the chip is adhered onto a lead frame and wire leads are soldered from chip contact regions to contact pads of the lead frame. In the case of the hybrid embodiment described below, the contact pads may be enlarged and specially shaped to interface with card reader/writer equipment. In the present embodiment, the chip is not exposed, so the contact pads are of convenient size for connection to the antenna and any other components.

An alternative encapsulation process is by transfer molding. In a transfer molding process, a chip is mounted to a lead frame having different traces which make contact with the antenna loop. Bonding wires are joined to appropriate traces leading to the antenna loop. The metal traces of the lead frame are supported by a very thin polyimide film and the metal is backed by transfer molding compound which is also used to fill any opening in a card where the module has been mounted. It is important that any encapsulation method yield very thin structures suitable for mounting on one of the card layers. No intervening circuit board is used for either the electronic module nor the antenna.

With reference to Fig. 2, a data card 31 is shown having an electronic module 33 which contains an integrated circuit chip and projects through the upper layer 35 allowing a user to directly make contact with pads 37 for communication of signals and power. A loop antenna 39 which may have all turns in a single plane or may have stacked turns, is also available for electromagnetic wave communication with electronic module 33. In other words, some communication may be by means of loop antenna 39, while other communication, such as programming, may be through contacts or pads 37, thus creating two modes of communication with the electronic module. In any event, the card 31 is constructed of upper layer 35 and lower layer 41, with the loop antenna deposited on one of the layers and the electronic module residing in a cutout region in the upper layer 35. To properly locate the electronic module in the lower layer, a slight indentation may be made or a module outline printed on the layer.

With reference to Fig. 3A, a mating surface of lower layer 15 is seen to carry loop antenna 17 over a target scribe line 53 where a chip may be placed. The antenna is a helical metal pattern in a single plane deposited in a manner passing over the scribe line, with the scribe line serving to locate the position of the chip. In Fig. 3, the dimensions of the lower layer 15 may be seen and the areawise dimensions of the lower layer are equal to those of the upper layer. Dimension "A" defines the length of the card and is 85.6 millimeters. Dimension "B" defines the width of the card and is 54.05 millimeters. Dimension "C" defines the inside edge of the antenna loop and is 15.18 millimeters from the edge of the card. The dimension "D" defines the center line for the scribe line 53. That dimension is 23.83 millimeters. The thickness of each of the upper and lower layers is 0.010 inches. The thickness of the injected bonding layer, described below, is 0.013 inches. Outer spiral turns of the antenna are close to at least three edges of the card and sometimes all from rectangular edges.

With reference to Fig. 3B, a coil having many turns is wound on a mandrel, forming a coil with stacked turns, then removed and adhered to lower layer 40 which will be covered by an upper layer. The coil 38 is thicker than coil 17 in Fig. 3A because the multiple turns are stacked, besides being wrapped helically. The thickness of the coil may approximate that of the electronic module 42, but not exceeding this thickness by very much. The stacked helical windings will allow for several hundred turns of very fine copper wire, having a thickness of approximately 5 mils, for example. This leads to higher inductance than available from the coil shown in Fig. 3A which has relatively few turns. For low frequencies, high inductance coils are needed. In Fig. 3A, the coil is seen to be circular, having a diameter on the order of about 1.5 inches.

In Fig. 3C representative stacked coil windings are shown. The drawing is intended to symbolize several hundred turns of very fine copper wire which would be stacked one layer upon another. Not shown in the drawing is insulative material, such as a polymer coating, surrounding each turn, so that the turns do not short out against each other. The spacing between turns is at least partially occupied by this insulative material, which is conventional in the coil making art.

In Fig. 3D, a coil 48, similar to coil 38, is shown adhered to the lower layer 50. The generally rectangular coil 48 has the electronic module 52 mounted within the coil. Once again, the coil 48 has from 70-250 turns of very fine copper wire, with stacked turns. This makes the coil a relatively high inductance coil suitable for picking low frequencies. Coils having few turns, as shown in Fig. 3A, are more suitable for high frequencies. In both Figs. 3B and 3C, ends of the coil are brought into contact with the electronic module.

Fig. 4 shows a lamination process for placing antenna material on the lower layer for later etching an antenna loop. A roll of semi-rigid ABS material 61 is placed above a roll of thin, flexible double-sided adhesive film 63. The ABS material has somewhat more flexibility as common credit cards, but two layers of the material, when joined, have the same flexibility as a common credit card. The ABS material from roll 61 forms the lower layer of the laminate card. A very thin, very flexible, foil of copper, similar in thickness and flexibility to household aluminum foil, is spooled from roll 65 in a manner such that the double-sided adhesive film from roll 63 joins the copper foil from roll 65 to the ABS material from roll 61. The laminate from the three rolls is joined together, like a sandwich, through pinch rollers 67 and 68, with the adhesive film from roll 63 holding the foil from roll 65 to the ABS material from roll 61. The single layer is spooled on takeup roll 69 and forms one of the mating layers of the card, carrying the antenna pattern.

Once spooled, the material is taken to another location, shown in Fig. 5, illustrating a coil etching processing station. Material is spooled from roll 69 to the turning idler 71 and to cleaning station 73 where the surface of the copper foil is washed and particulate debris is removed. The material advances to a spray station 75 where a thin layer of photoresist is applied, defining an antenna pattern, typically a spiral pattern of at least five turns, and then baked on in a planar oven 77. The resist is exposed to actinic radiation in exposure station 79 so that the desired antenna loop pattern now exists as a latent image on the photoresist. The latent image is developed in a developer station 81 and then excess photoresist material is etched away at an etchant spray station 83. Excess etchant is removed at a cleaning station 85 and the material is further cleaned at a washing station 87, after passing by turning idlers 91 and 93. A foil layer, per se, no longer exists, only spiral turns of an antenna defined in copper. The antenna loops are now fully processed on the laminate from roll 69 and the last step is cutting the rolled material to A4 or 8.5 inch x 11 inch sheet size which occurs at shear 95. The sheared sheets are then placed in a stack 97 for placement of the electronic module on the sheet. A single A4 sheet contains several card bottom layers and antenna loops. The A4 sheets can be further cast to isolate card layers.

Fig. 6 shows an alternative method of forming antenna loops, but is not preferred if manufacturing speed is critical. Very fine copper wire 101 from a reel 103 is guided through a capillary 105. The lower layer 15 may be robotically moved below the capillary 105 until a loop pattern is formed. The lower layer is treated with adhesive to hold the fine copper wire in place. Upon forming the antenna loop, the wire is cut and the next position for antenna placement is advanced below the capillary 105. This loop formation method has the advantage that coil turns can be stacked one atop another, yielding a more sensitive antenna than the etched antenna.

Fig. 7 shows die halves 167 and 169 receiving lower layers 171 and upper layers 173 of either embodiment for joinder under pressure. The lower layers are seen to be carrying the electronic chip modules 172. The upper and lower layers are made of ABS material. When the die halves 167 and 169 are joined together, liquid ABS material is injected under pressure to fill the space between the upper and lower card layers. The ABS material is of the same composition as the upper and lower layers and so the card has a uniform consistency, without any tendency for shearing between different layers because of dissimilar material. After molding, the cards are removed from the mold and edges are etched or polished to the desired smoothness. The cards are now ready for use. By avoiding use of a circuit board layer between upper and lower layers, the uniform composition of the card provides superior strength, good flexibility and durability, while meeting ISO standards for size.

Claims

1. A method of forming smart data cards comprising,

forming first and second sheets of a flexible, semi-rigid polymeric material, the sheets having thicknesses which, when summed, is less than or equal to the thickness of a standard wallet size card, with about the same flexibility, the first sheet having a deposited contact region for seating an electronic module containing an integrated circuit chip,

forming a conductive antenna on the first sheet and bringing said electrical module into electrical contact with the antenna,

mounting said electronic module on the first sheet,

bringing the first and second sheets together in a mold,

injecting a flowable, hardenable bonding compound of said polymeric material into the mold, some portions of the flowable polymeric material residing between the two sheets, and

hardening the flowable material.

2. The method of claim 1 wherein said antenna is formed by photolithography.

3. The method of claim 1 wherein said antenna is formed by deposition of a wire directly onto the first sheet.

4. The method of claim 1 wherein said antenna is formed by stacking helically wound turns and then adhering the antenna to the first sheet.

5. The method of claim 1 wherein said antenna is formed by laminating a very thin, flexible conductive foil antenna pattern to the first sheet.

6. The method of claim 1 wherein the first and second sheets have an areawise size sufficient for defining the area of four cards.

7. The method of claim 7 wherein the areawise size of each sheet defines the area of eight cards.

8. The method of claim 1 wherein said chip has no portions exposed outside of the card.

9. The method of claim 1 wherein said chip has contact portions exposed outside of the card.

10. A smart card comprising,

a first polymeric semi-rigid layer having opposed major surfaces, with an antenna pattern deposited on one of the surfaces and an electronic module supported over a portion of the antenna pattern, the electronic module containing an integrated circuit chip,

a second semi-rigid layer having opposed major surfaces, the layer having identical areawise dimensions and composition to the first layer, a major surface of the second layer joined to the surface of said first layer having said antenna pattern.

11. The smart card of claim 10 wherein a sealant joins the first and second layers, the sealant being of the same composition as the first and second layers.

12. The smart card of claim 10 wherein said antenna pattern comprises spiral turns in a plane.

13. The smart card of claim 10 wherein said antenna pattern comprises stacked spiral turns.

14. The smart card of claim 10 wherein the card has rectangular edges and said spiral turns are close to at least two of the rectangular edges.

15. The smart card of claim 10 wherein the electronic module has contact pads exposed though the second layer.

16. The smart card of claim 10 wherein the electronic module is completely sealed between said opposed layers, without exposed contact pads.

17. A wallet size smart card comprising,

an electronic module disposed over a portion of a spiral antenna pattern, the spiral antenna pattern laminated between two polymeric layers of the same composition having exposed outer surfaces and inner surfaces joined by a sealing material of the same composition as the polymeric layers.

18. The smart card of claim 17 wherein said antenna pattern comprises spiral turns in a plane.

19. The smart card of claim 17 wherein said antenna pattern comprises stacked spiral turns.

20. The smart card of claim 17 wherein the electronic module has contact pads exposed though the second layer.

21. The smart card of claim 17 wherein the electronic module is completely sealed between said opposed layers, without exposed contact pads.

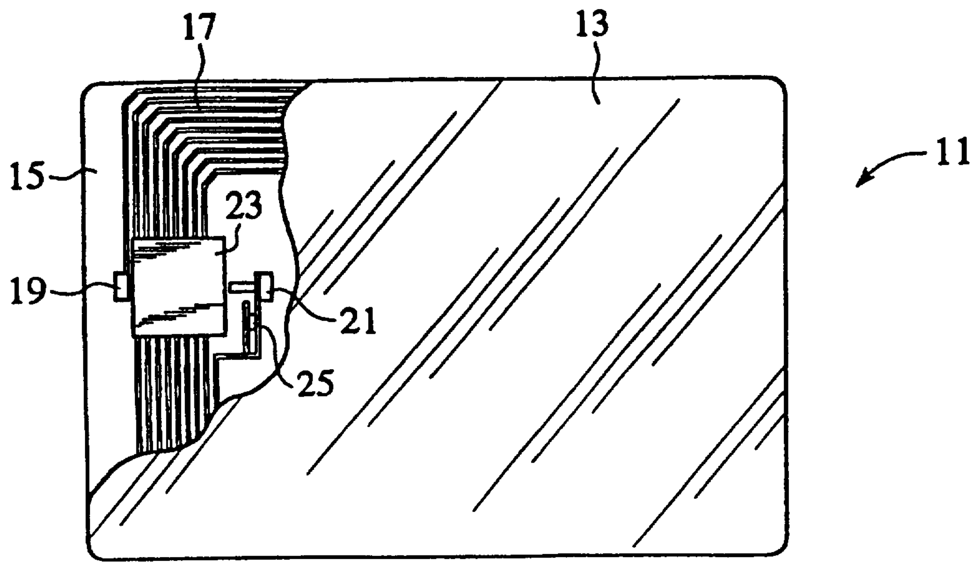

FIG. 1

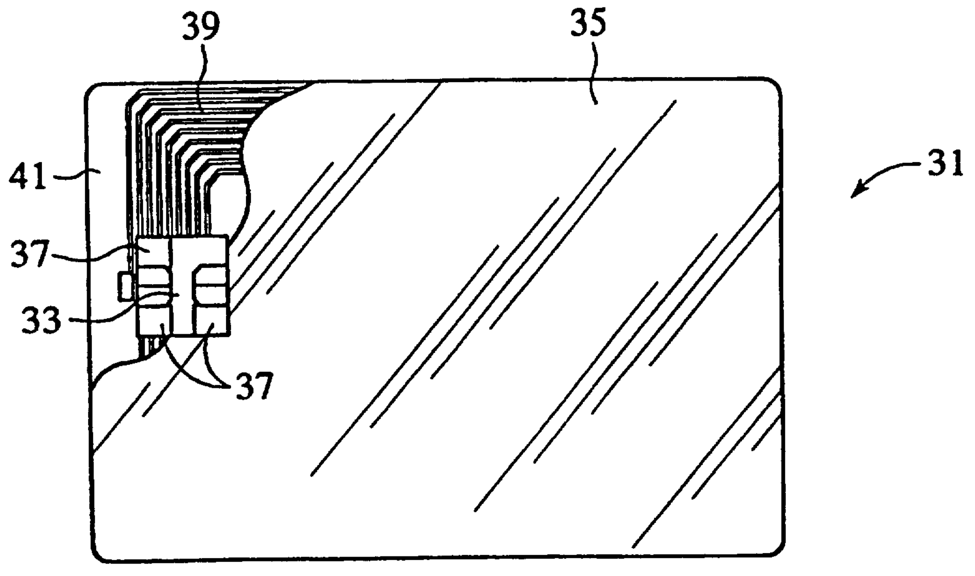

FIG. 2

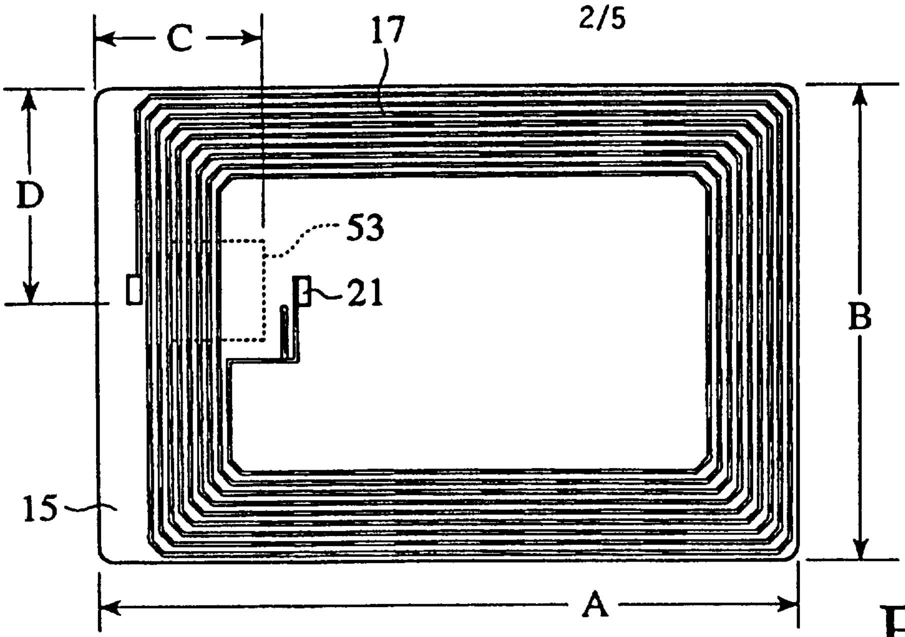

FIG. 3A

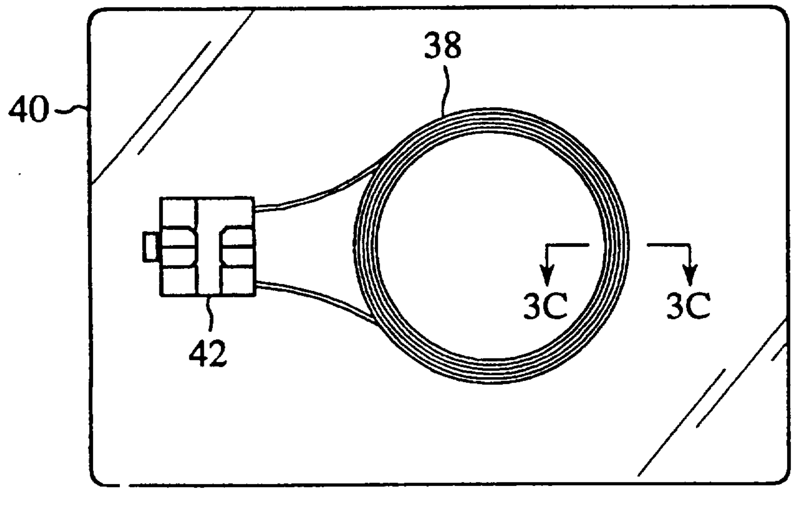

FIG. 3B

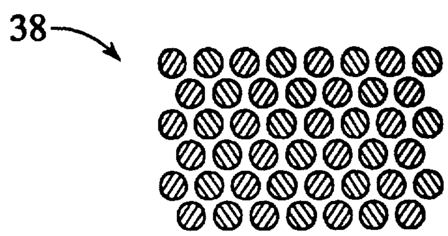

FIG. 3C

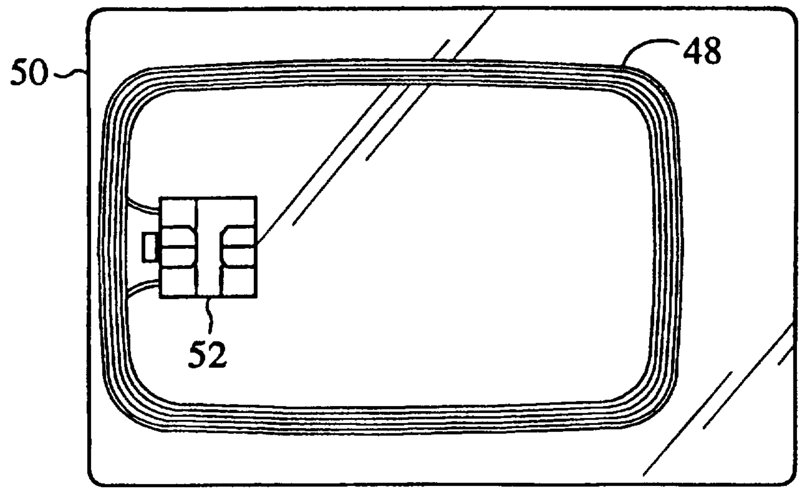

FIG. 3D

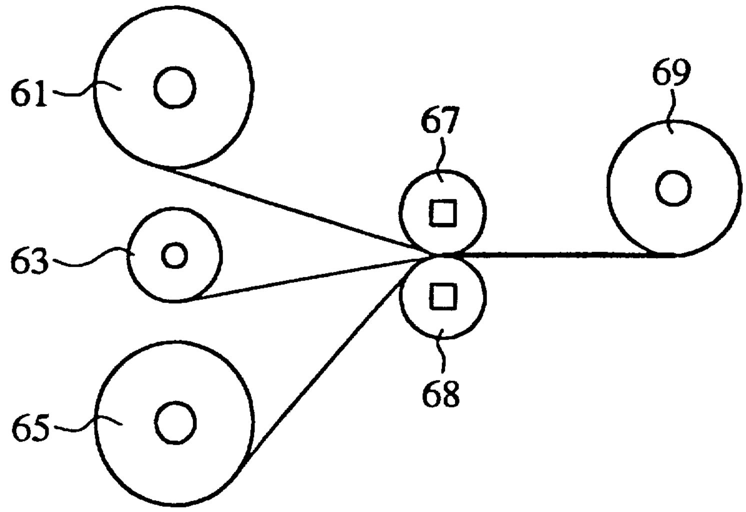

FIG. 4

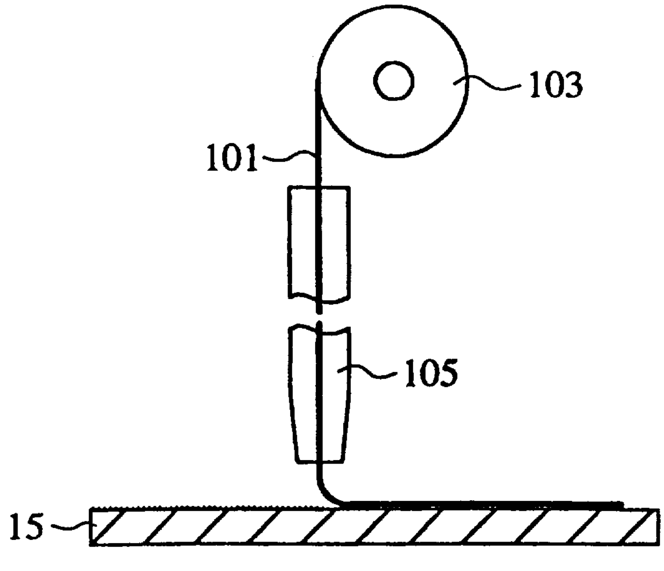

FIG. 6

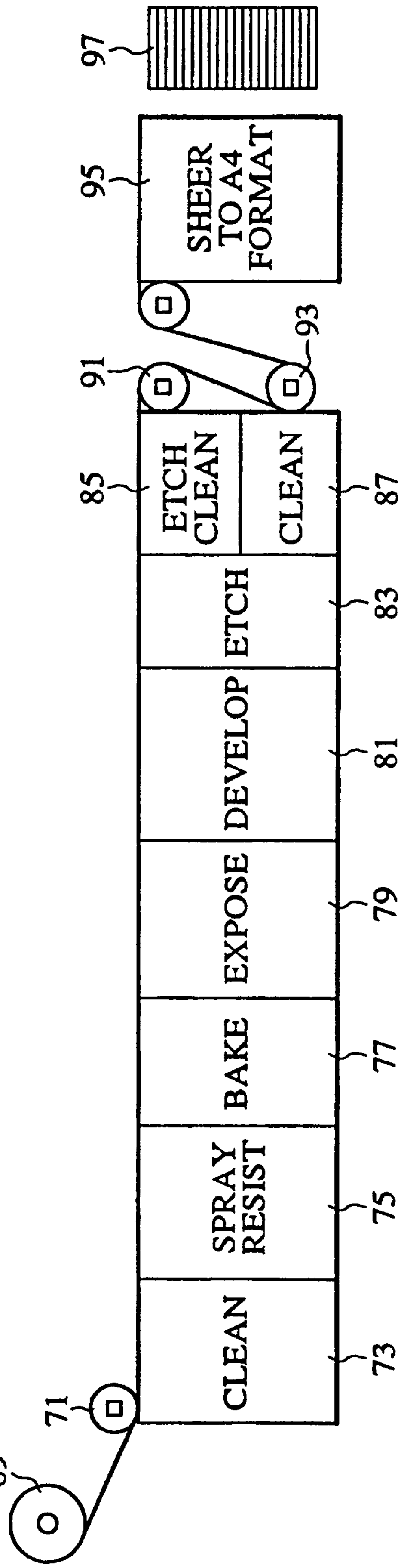
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FIG. 5

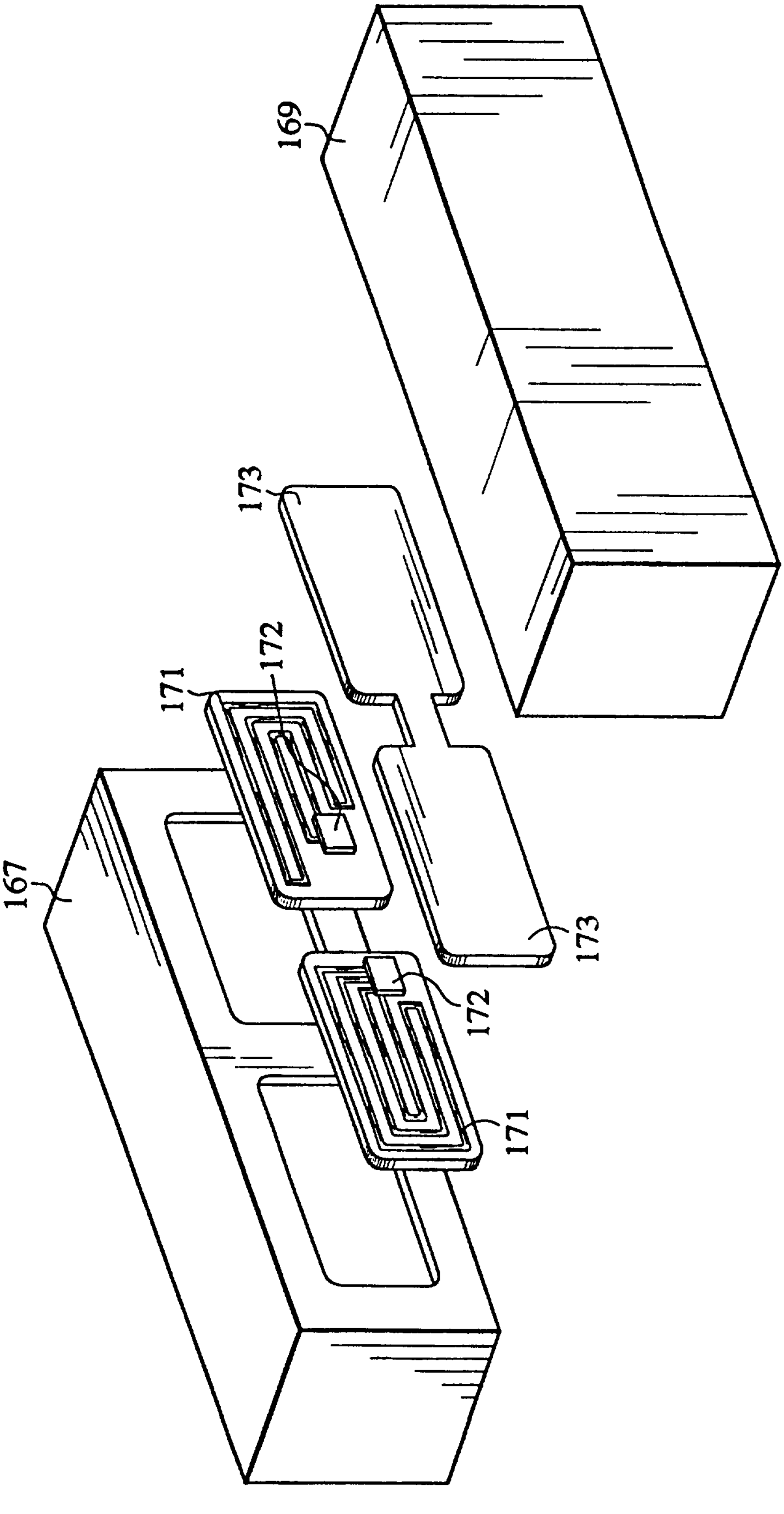

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/07561

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :G06K 19/06
US CL :235/492
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. : 235/492

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

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

APS (search terms: smart card antenna) MAYA (search terms: entire summary of the invention and abstract)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P ----- Y,P	US 5,598,032 A (FIDALGO) 28 JANUARY 1997 (28/01/97), see entire document, especially column 4, lines 16-65.	10,12,14,15 ------ 1-9, 11,13, 16-21
Y,P	US 5,581,445 A (HOREJS, JR. ET AL) 03 DECEMBER 1996 (03/12/96), see especially figures 12-17 and column 6, lines 4-12.	1-9, 11, 17-21
Y,P	US 5,519,201 A (TEMPLETON, JR. ET AL) 21 MAY 1996 (21/05/96), see entire document, especially column 6, lines 16-42.	1-9, 11, 17-21
Y	US 5,476,629 A (YABE ET AL) 19 DECEMBER 1995 (19/12/95), see especially figure 2.	6-7
Y	US 5,399,847 A (DROZ) 21 MARCH 1995 (12/03/95), see	1-9

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

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