

"SHEET-LIKE MINIATURIZED ELECTRONIC DEVICE"

This invention relates to a miniaturized electronic device having a thin sheet-like shape.

Recently, the thickness of miniaturized electronic devices, such as miniaturized electronic calculators and
5 timepieces, has been greatly reduced. However, there is a demand for even thinner, sheet-like portable electronic devices which would be no thicker than a credit card.

In the prior art miniaturized electronic calculators, however, various components such as certain
10 electronic parts, a wiring base, a display panel and a battery are accommodated in a casing. This imposes a lower limit on the height (i.e., the thickness) of the device, and so it has been impossible to obtain a sheet-like device as thin as a credit card.

15 The present invention has been created in light of the above situation, and its object is to provide a thin, sheet-like miniaturized electronic device, which has a uniform height or thickness dimension and is extremely flat.

20 To attain the above object, according to the invention there is provided a sheet-like miniaturized electronic device comprising:

an electronic component assembly including a thin insulating sheet having at least a hole, a predetermined
25 conductive pattern, and a semiconductor IC chip mounted on

said pattern in said hole;

first cover means having a predetermined surface area provided in close contact with one side of said electronic component assembly;

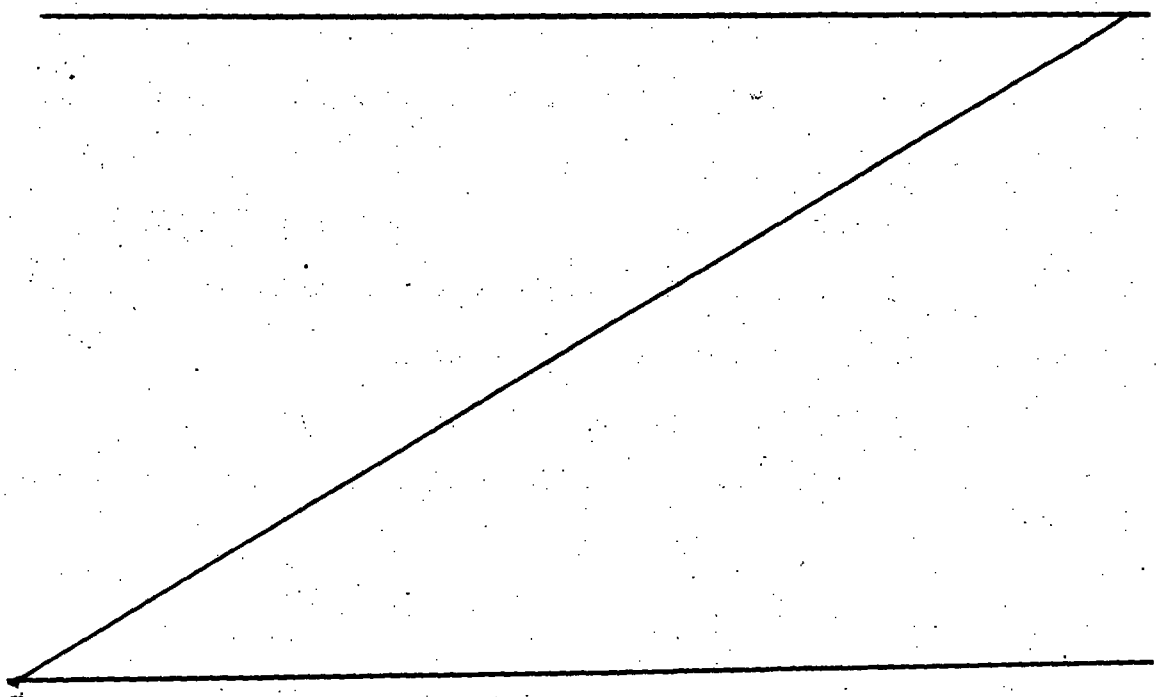
5 an adhesive layer consisting of an adhesive applied to the other side of said electronic component assembly; and

second cover means made of a metal sheet and having substantially the same surface area as said first
10 cover means.

The sheet-like miniaturized electronic device having the above construction according to the invention is assembled by laminating the upper cover on the upper side of the electronic component assembly in close contact
15 therewith, applying the adhesive layer to the underside of the electronic component assembly and laminating the lower cover on the underside of the adhesive layer in close contact therewith. The adhesive layer can thus accommodate fluctuations of the thickness of the electronic component
20 assembly and improve the flatness of the thin sheet-like miniaturized electronic device.

This invention can be more fully understood from

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the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a perspective view showing a sheet-like miniaturized electronic calculator embodying the invention;

Figs. 2(A) and 2(B) are exploded perspective views showing the sheet-like miniaturized electronic calculator shown in Fig. 1;

Fig. 3 is an enlarged fragmentary sectional view, taken along line A-A in Fig. 1;

Fig. 4 is an enlarged fragmentary sectional view, taken along line B-B in Fig. 1;

Fig. 5 is an enlarged fragmentary sectional view, taken along line C-C in Fig. 1;

Fig. 6 is an enlarged fragmentary sectional view, taken along line D-D in Fig. 1;

Fig. 7 is a fragmentary plan view showing switch springs of a switch contact sheet;

Fig. 8 is a fragmentary sectional view showing a switch being operated;

Figs. 9 and 10 are views for explaining the process of assembling the sheet-like miniaturized electronic device according to the invention;

Fig. 11 is a perspective view showing an eventual sheet-like miniaturized electronic calculator according to the invention; and

Fig. 12 is a partly fragmented sectional

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view showing a second embodiment of the invention.

An embodiment of the invention will now be described with reference to Figs. 1 through 11.

Fig. 1 is a perspective view of a sheet-like miniaturized electronic calculator, and Fig. 2 is an exploded perspective view of the same. The electronic calculator comprises an electronic component assembly 1, an upper cover 2 and a lower cover 3. The electronic component assembly 1 includes a wiring base 11, a semiconductor IC chip 12, electronic components 13, a display panel 14 and a solar battery 15. The upper cover 2 includes a upper protective sheet 18, a switch contact sheet 16, a spacer 17 and a frame 19, these parts being laminated together. The lower cover 3 includes a support sheet 20 and a lower protective sheet 21, these parts being laminated together. The electronic calculator further comprises an adhesive layer consisting of an insulating adhesive 22, which is shown in Figs. 3 through 6. The upper cover 2 is laminated on the upper side of the electronic component assembly 1 in close contact therewith, the adhesive layer 4 is provided on the underside of the electronic component assembly 1, and the lower cover 3 is laminated on the underside of the adhesive layer 4 in close contact therewith. The entire structure thus has a form just like a thin sheet.

The construction of the individual parts will now

be described with reference to Figs. 3 through 8.

Fig. 3 is a fragmentary sectional view, partly broken away, taken along line A-A in Fig. 1.

First, the electronic component assembly 1 will be described. The wiring base 11 is a rectangular sheet of an insulating material approximately 220 μ thick. It has a plurality of fixed switch contact pairs 23 formed on its upper side in a lattice-like array. It also has wiring patterns including the fixed switch contact pairs 23, as well as terminals 24 and 28 to be described later. These lead patterns are formed on the upper and lower sides of the wiring base 11. The wiring base 11 further has see-through mounting holes 11a. The semiconductor IC chip 12 and electronic components 13 such as chip capacitors and diodes are mounted in the mounting holes 11a such that they penetrate these holes. They are connected to the lead patterns formed on the wiring base 11. The display panel 14 is a liquid crystal display panel consisting of a liquid crystal packed in a film package. Its thickness is approximately 550 μ . The liquid crystal is sealed between upper and lower films, which respectively serve as upper and lower electrode bases and have film ends 14a (Fig. 2). The display panel 14 is disposed parallel to the wiring base 11 and in the same plane as the same. As shown in Fig. 3, the terminals 24 of the wiring base 11, formed on the

underside thereof, are each connected to each terminal 25 formed on the underside of the upper electrode base of the display panel 14 through a flexible film 27 having a lead 26 consisting of a conductive adhesive. The terminals 24, 25 and leads 26 are bonded together by applying heat and pressure. The solar battery 15 (Fig. 4) has a stainless steel base and a thin film of amorphous silicon formed on the base, and is approximately 180 μ in thickness. It is disposed parallel to the wiring base 11 and in the same plane as the same. As shown in Fig. 4, the terminal 28 of the wiring base 11, formed on the underside thereof, is connected to terminal 29 formed on the upper side of the base of the solar battery 15 through a flexible film 31 having a lead 30 consisting of a conductive adhesive. The terminals 28 and 29 and lead 30 are bonded together by applying heat and pressure. The flexible film 31 is provided against the wiring base 11 such that it prevents the short-circuit of the lead 30 to the base of the solar battery 15. The lead 30 is led through a see-through hole 31a and electrically connected to the corresponding terminal 29 on the base of the solar battery 15. The components of the electronic component assembly 1 are arranged in a planar arrangement and electrically connected together. The semiconductor IC chip 12 effects processing with signals supplied from the fixed switch contacts 23 using power furnished from the solar battery 15 to produce

signals representing the results of processing for display on the display panel 14.

The upper cover 2 will now be described. The switch contact sheet 16 is a stainless steel sheet approximately 100 μ in thickness. It is rectangular in shape and corresponds in size to the frame 19. It has a plurality of switch contact springs 32, as shown in Fig. 7. These switch contact springs 32 are formed through an etching treatment. They are arranged in a lattice-like array and individually correspond to the respective fixed contact pairs 23 on the wiring base 11. The switch contact sheet 16 also has a display window 33 and a battery window 34, these windows also being formed through an etching treatment in positions corresponding to the display panel 14 and solar battery 15, respectively. It further has recesses 35 (Fig. 2) formed through an etching treatment on its underside in positions corresponding to the semiconductor IC chip 12 and electronic components 13. Each of the switch contact springs 32 has a movable contact 36 which can co-operate with a corresponding one of the fixed contacts 36 for coupling signals. The movable contact 36 is formed by coating a carbon paint on a central portion of the underside of the switch contact spring 32. The battery window 34 formed in the switch contact sheet 16 includes lead hole portions 34a, through which the leads of the flexible films 31 are

led (Fig. 4). The spacer 17 is a transparent polyester film approximately 50 μ in thickness, which serves to hold the switch contact sheet 16 and wiring base 11 apart. It is rectangular in shape and corresponds in size to the wiring base 11. It has switch contact holes 37 formed in a lattice-like arrangement such that they individually correspond in position to the respective fixed switch contacts 23 on the wiring base 11. It further has openings 38 formed in positions corresponding to the semiconductor IC chip 37 and electronic components 13 and is provided on each side thereof with a coating of a transparent insulating adhesive 43 with a thickness of approximately 25 μ . The frame 19 is formed from a stainless steel sheet approximately 400 μ thick. It is a rectangular frame surrounding the electronic component assembly 11 and having a partitioning projection 19a, by which the display panel 14 and solar battery 15 are spaced apart (Fig. 2). It further has contacts 39a and 39b provided at suitable positions. As shown in Figs. 5 and 6, the contacts 39a and 39b are formed by cutting corresponding portions of the spacer 17 and bending these portions upward and downward, respectively. The upper protective sheet 18 serves to protect the upper side of the switch contact sheet 16. It is made from a transparent polyester film approximately 50 μ thick. It is rectangular in shape and slightly larger than the switch

contact sheet 16. Its underside is provided with a non-transparent paint except for a see-through area 40 corresponding to the display panel 14 and a light-receiving area 41 corresponding to the solar battery 15. Its top is provided with an impression 42 of symbols for the respective switches. These symbols are provided in positions corresponding to the respective switch contact springs 32 of the switch contact sheet 16 (Fig. 2). The underside of the upper protective sheet 18 is provided with a coating of the transparent insulation adhesive 43 to a thickness of approximately 25 μ . The spacer 17 is disposed over the wiring base 11 of the electronic component assembly 1 and bonded thereto by the insulating adhesive 43 coated on its underside. The switch contact sheet 16 is disposed over the spacer 17 and bonded to the same by the insulating adhesive coated on its upper side. The upper protective sheet 18 is disposed over the switch contact sheet 16 and bonded to the same by the transparent insulating adhesive 43 coated on its underside. The frame 19 is disposed beneath the switch contact sheet 16 such that it surrounds the electronic component assembly 1 and spacer 17, and is bonded to the underside of the switch contact sheet 16 by the adhesive 43 coated on the underside thereof. As shown in Fig. 4, the switch contact springs 32 of the switch contact sheet 16 and corresponding switch holes 37 of the

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spacer 17 overlap. The movable contacts 36 on the switch contact springs 32 are found over the corresponding fixed contacts 23 of the wiring base 11 via the respective switch holes 37. The symbols of the impression 42 on the upper protective sheet 18 are found over the corresponding switch contact springs 32. Each switch contact spring 32 of the switch contact sheet 16 is normally held in its horizontal state by its own spring force as shown in Fig. 4, with the movable contact 36 and fixed contact 23 being spaced apart. When a portion of the impression 42 on the upper protective sheet 18 corresponding to a given switch contact spring 32 of the switch contact sheet 16, is pushed down with a finger, as shown in Fig. 8, the switch contact spring 32 is flexed downward against its spring force into the switch hole 37 in the spacer 17, whereby the movable contact 36 is brought into contact with the fixed contact pair 11.

As shown in Fig. 3, the see-through area 40 of the upper protective sheet 18 and the display window 33 of the switch contact sheet 16 overlap. An upper portion of the display panel 14 is situated in the display window 33, and its display surface faces the transparent see-through area 40. The display on the display panel 14 can thus be read out through the see-through area 40. The top of the display panel 14 is bonded to the upper protective sheet 18 by the

transparent insulating adhesive 43.

As shown in Fig. 4, the light-receiving area 41 of the upper protective sheet 18 and the battery window 34 of the switch contact sheet 16 overlap. The solar battery 15 is set in the battery window 34, and its light-receiving element faces the transparent light-receiving area 41. The solar battery 15 can thus receive external light through the light-receiving area 41. Its top is bonded to the upper protective sheet 18 by the transparent insulating adhesive 43.

Fig. 3 shows the recesses 35 in the switch contact sheet 16 and openings 38 in the spacer 17. The upper portions of the semiconductor IC chip 12 and electronic components 13 mounted in the wiring base 11 are set in the recesses 35 and openings 38, respectively. Meanwhile, they are insulated from the switch contact sheet 16 by the insulating adhesive 43. The upper cover 2 is thus laminated over the upper surface of the electronic component assembly 1 in close contact therewith. In the present embodiment, the frame 19 is provided as part of the upper cover 2, and it surrounds and holds the electronic component assembly 1.

The adhesive layer 4 will now be described. Its insulating adhesive 22 consists of acrylic resin or an epoxy resin-based insulating adhesive of mixed two-liquid type. The insulating adhesive 22 is provided to fill a space defined between the protective sheet 18 of

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the upper cover 2 and the protective sheet 21 of the lower cover 3. Thus, it entirely covers the underside of the wiring base 11 of the electronic component assembly 1 and also the underside of the semiconductor IC chip 12 and electronic components 13 projecting from the underside of the wiring base 11. Further, it covers the underside of the display panel 14 and solar battery 15. Furthermore, it surrounds the outer side surfaces of the frame 19 in the upper cover 2. The individual components of the electronic component assembly 1 thus have their underside secured in position by the insulating adhesive 22. In addition, the irregularities of the height of the components projecting from the underside of the wiring base 11 of the electronic component assembly 1, are made up for by the insulating adhesive 22. Where a case structure is used in lieu of the adhesive layer 4 on the underside of the electronic component assembly 1, a complicated structure will be necessary for securing the electronic component assembly 1 in position. Also, in this case, it is difficult to compensate for the irregularities of the height of the individual components. In particular, it is difficult to make up for errors, if any, in the mounting dimensions or thickness of the components of the electronic component assembly 1. The adhesive layer 4 in the present embodiment, in contrast, has fluidity, so that it can reliably secure the components

of the electronic component assembly 1 in correct positions while taking up the irregularities of the component's thickness dimension. In particular, it is possible to absorb errors that may be introduced in the mounting dimensions or thickness of the components at the time of assembly. Further, since the insulating adhesive 22 secures the outer side surfaces of the frame 19 positioned between the protective sheets 18 and 21, the mechanical strength of the sheet-like miniaturized electronic calculator can be increased. Moreover, the junctions between adjacent laminated parts on the sides of the calculator can be covered by the adhesive 22 to obtain an improved appearance.

The lower cover 3 will now be described. The support sheet 20, as shown in Figs. 4 and 5, is made from a stainless steel sheet approximately 100 μ thick. It is rectangular in shape and the same size as the frame 19 of the upper cover 2. The lower protective sheet 21 is made from a transparent polyester film approximately 25 μ thick. It is rectangular in shape and is slightly greater in size than the support sheet 20. A transparent insulating adhesive 43 is coated on its upper side to a thickness of approximately 25 μ . The support sheet 20 is secured to the underside of the adhesive layer 4. It is provided on its upper side and at portions thereof facing the components of the electronic component assembly 1 with

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an insulating adhesive 43 so that it is insulated from the components. The lower protective sheet 21 is secured to the underside of the support sheet 20 via the adhesive 43. The lower cover 3 can be disposed
5 parallel to the upper cover 2 and, if necessary, precisely spaced apart therefrom, because the adhesive 22, to which the support sheet 20 is secured, has fluidity. In addition, its distance 2 from the upper cover 2, i.e., the thickness of the calculator, can be
10 adjusted during manufacture. The support sheet 20 supports the adhesive layer 4 from the underside thereof. The lower protective sheet 21 protects the underside of the support sheet 20. Its underside, i.e., its outer side, may be provided with a decorative
15 impression.

In the sheet-like miniaturized electronic calculator as described above, the switch contact sheet 16, frame 19 and support sheet 20 are made from metal sheets such as stainless steel sheets. Thus, the calculator
20 has high mechanical strength and is very rugged. The thickness of this calculator is approximately 800 μ .

The sheet-like miniaturized electronic calculator as described above is further provided with electrostatic shielding means. To be more specific, the
25 upwardly bent contact 39a of the frame 19, as shown in Fig. 5, is in contact with the underside of the switch contact sheet 16, while the downwardly bent

contact 39b, as shown in Fig. 6, is in contact with the upper side of the support sheet 20. With this arrangement, the switch contact sheet 16, made of a stainless steel sheet, which is disposed over the stainless steel frame 19, and the support sheet 20, also made from a stainless steel sheet which is disposed beneath the frame 19, can be held at the same electric potential as the frame 19. Thus, it is possible to eliminate the effects of external static electricity on the semiconductor IC ship 12 mounted in the wiring base 11, etc.

Now, the method of manufacture of the sheet-like miniaturized electronic calculator having the above construction will be described. The electronic component assembly 1, as is seen from Fig. 2, is assembled by mounting the semiconductor IC ship 12 and electronic components 13 in the wiring base 11 with the surface (upper surface) thereof as a reference surface, and then connecting the display panel 14 and solar battery 15 to the wiring base 11 with the flexible films 27 and 31. The upper cover 2 is assembled by securing the frame 19 to the underside of the switch contact sheet 16 via the adhesive 43 by the application of heat and pressure and then securing the upper protective sheet 18 to the upper side of the switch contact sheet 16 via the adhesive 43, again by the application of heat and pressure. The electronic component assembly 1 and the

lamination of the frame 19 and switch contact sheet 16 are then set on the upper and lower sides of the spacer 17, respectively, and the three are secured together, via the adhesive 43 provided on both sides of the spacer 17, by the application of heat and pressure. At this time, the surface of the upper protective sheet 18 is made a reference surface. When the three parts noted above have been secured, a semi-assembly consisting of the upper cover 2 and electronic component assembly 1 is obtained. This semi-assembly is flat on the side of the upper cover 2 and has a complicated configuration on the side of the electronic component assembly 1 in which the components project (see Figs. 9 and 10). The semi-assembly is then held inverted, i.e., with the side of the upper cover 2 directed downwards and the side of the electronic component assembly 1 directed upwards. Then, the top and four sides, i.e., the periphery, of the inverted semi-assembly is covered with the adhesive 22. The adhesive 22 at this time has fluidity, so that it can readily fill the spaces defined by the complicated configuration of the projecting components of the electronic component assembly 1 and cover all these components. The adhesive layer 4 formed in this way thus accommodates the irregularities of the height or thickness of the individual components of the electronic component assembly 1. Meanwhile, the lower cover 3 is prepared

by securing together the support sheet 20 and lower protective sheet 21 via the adhesive 43 by the application of heat and pressure. The lower cover 3 thus prepared is placed on the adhesive 22 provided on the semi-assembly noted above, and it is then secured to the adhesive 22 by the application of pressure.

At this time, the lower cover 3 is forced down to a position parallel with the upper cover 2, and the total height of the final product is 800 μ . As the lower cover 3 is forced down, the adhesive 22 is forced out from the periphery of the final product. Thus, the lower cover 3 can be forced down to a position corresponding to a preset height. It is thus possible to precisely dispose the upper and lower covers 2 and 3 parallel to each other and to precisely set the distance between them to a designated value. The adhesive 22 flows out freely from between the protective sheets 18 and 21 of the respective upper and lower covers 2 and 3. After the adhesive has been solidified, the protective sheets 18, 21 and the adhesive 22 that are found between these sheets are cut to the final shape along the dashed lines shown in Fig. 10 and 11. The protective sheets 18 and 21 are cut slightly greater than the final size. With the product obtained in the above way, the periphery of the switch contact sheet 16, frame 19 and support sheet 20, all made from stainless steel sheets, are covered by the adhesive 22

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found between the protective sheets 18 and 21. The adhesive 22, together with the protective sheets 18 and 21 which are made of resin, provides a feel or resin to the periphery of the sheet-like miniaturized electronic calculator.

A second embodiment of the invention will now be described with reference to Fig. 12.

In this embodiment, as in the preceding first embodiment, the invention is applied to sheet-like miniaturized electronic calculators. In Fig. 12

like reference numerals to those in Figs. 2 and 3 designate like parts.

In the second embodiment of Fig. 12, an adhesive layer 22 of an adhesive layer 4 is provided between an electronic component assembly 1 and a lower cover 3 and covers the outer four sides of the frame 19 between a switch contact sheet 16 of an upper cover 2 and a support sheet 20 of a lower cover 3. In this instance, the mechanical strength of the edges of the calculator is improved.

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The constituents of the electronic component assembly 1 are not limited to those described above; for instance, a sheet-like manganese battery may be used instead of
5 the solar battery.

Further, the invention is not limited to sheet-like miniaturized electronic calculators and is applicable to other miniaturized electronic devices such as minuatized electronic timepieces as well.



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CLAIMS:

1. A sheet-like miniaturized electronic device comprising:

an electronic component assembly including a thin insulating sheet having at least a hole, a pre-determined conductive pattern, and a semiconductor IC chip mounted on said pattern in said hole;

first cover means having a predetermined surface area provided in close contact with one side of said electronic component assembly;

an adhesive layer consisting of an adhesive applied to the other side of said electronic component assembly; and

second cover means made of a metal sheet and having substantially the same surface area as said first cover means.

2. The sheet-like miniaturized electronic device according to claim 1, wherein another metal sheet is disposed between said first cover means and said electronic component assembly.

3. The sheet-like miniaturized electronic device according to claim 2, wherein the surface area of said electronic component assembly is smaller than that of the first metal sheet, and a metal frame is disposed between said first cover means and the second metal sheet to accommodate said electronic component assembly.

4. The sheet-like miniaturized electronic device according to claim 2, wherein at least one of the first and second metal sheets has a recess, formed by an etching process, to accommodate said semiconductor IC chip.



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5. The sheet-like miniaturized electronic device according to claim 4, wherein said metal frame and the first and second metal sheets are electrically interconnected by contacts formed on one of said metal frame and the first and second metal sheets.

6. The sheet-like miniaturized electronic device according to claim 1, wherein said electronic component assembly further includes a liquid crystal display.

7. The sheet-like miniaturized electronic device according to claim 6, wherein said electronic component assembly further includes a solar battery.

8. The sheet-like miniaturized electronic device according to claim 7, wherein said electronic component assembly further includes discrete electronic parts.

9. The sheet-like miniaturized electronic device according to claim 1, wherein said predetermined conductive pattern includes switch contacts, and said first cover means has an operating section externally operable to supply signals to said switch contacts.

10. The sheet-like miniaturized electronic device according to claim 9, wherein a steel switch contact sheet having switch contact spring portions formed by an etching process is disposed between said first cover means and said electronic component assembly, each of said spring portions having a movable contact to contact the associated switch contact.

11. A sheet-like miniaturized electronic device, substantially as hereinbefore described with reference to the accompanying drawings.
