A SECURITY HOUSING FOR A CIRCUIT

The present invention relates to the field of enclosures for electronic circuits and in particular to applications, for example payment card systems, where it is necessary to provide some physical security to prevent unauthorised access to a circuit and more particularly to the data contained within memory devices in the circuit. The present invention provides an improved housing overcoming problems associated with prior art housing and in particular provides a housing that allows for replacement and/or repair of an underlying circuit at a relatively low cost. This is achieved by provision of a single piece construction security housing having conductive patterns integrally provided thereon. In particular, a first embodiment of the invention provides a security housing for mounting in use on a circuit board to protect an associated circuit, comprising: a plurality of electrical contacts for making electrical contact with the circuit board, a cover, a plurality of side walls, where the plurality of side walls and cover define a space for accommodating the associated circuit, and at least one pattern of conductive tracks electrically connected to the electrical contacts and integrally formed with the plurality of side walls and the cover in a single piece construction.
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Title

A SECURITY HOUSING FOR A CIRCUIT

Field of the Invention

The present invention relates generally to the field of enclosures for electronic circuits and in particular to housings intended to prevent unauthorised access to electronic circuits and methods of manufacturing same.

Background to the Invention

In certain applications, for example payment card systems, it is necessary to provide some physical security to prevent unauthorised access to a circuit and more particularly to the data contained within memory devices in a circuit.

This is conventionally achieved by placement of the circuit to be protected within an enclosure. To enhance the mechanical security provided by these enclosures, detected interference with the enclosure triggers the protected circuit to perform one or more specific actions, including for example setting off an alarm and/or encrypting or erasing the data stored in circuit memory devices.

One method of detecting interference with an enclosure is sensing for any change in the ambient conditions within the enclosure, for example by means of a change in air pressure as exemplified by US 6,396,400 or by the detection of a change in the ambient light within an enclosure as exemplified by US 4,155,077.

Another method of detecting interference is to surround the circuit with one or more patterns of conductors. These conductors are arranged so that any person attempting to interfere with the enclosure will break one or more of the conductors. Appropriate sensing circuitry is provided to detect a break in a conductor.

One known example of such a technique is to deploy a flexible circuit foil with a pattern of tracks printed thereon. As an alternative to the flexible circuit foil, a wire mesh may be wrapped around the circuit to form an enclosure. To add mechanical strength to
the enclosure and to prevent bypassing of the conductors, the whole assembly may be encapsulated in a potting compound such as epoxy resin.

However, a weakness in this approach is that chemical substances may be used to remove the potting material, thus rendering the foil or mesh open to attack. In addition, potting material prevents both authorised as well as unauthorised access to the circuit, i.e. once a circuit is potted it can no longer be readily accessed for repair and maintenance purposes. This has the undesirable effect of increasing repair and replacement costs. Similarly, manufacturing yields are reduced since it is not feasible to re-work faulty circuits after encapsulation.

An alternative approach to encapsulation, as known from US 5,675,319, is to glue or otherwise fix the flexible circuit foil to an outer rigid cover. The outer rigid cover provides mechanical protection and because the flexible circuit foil is fixed to the cover, any attempt to remove the cover may result in the breakage of one or more of the conductors on the flexible foil. It is believed however that flexible foil circuits are relatively expensive and time consuming to assemble during manufacture.

EP 0,495,645 provides an alternative housing, which provides both detection and mechanical protection; in particular, it provides a housing formed by a top plate, a base plate and four upright side ceramic plates. Each of the ceramic plates has a serpentine pattern of conductors. The conductors on the side plates are interconnected with electrically conductive epoxy material and conductive tracks on an underlying circuit board. However, it is believed that the cost of ceramic and difficulties in assembly make this housing unsuitable for general use.

US 2002/0002683 (Benson et al) describes a system, method and apparatus for protecting circuit components from unauthorised access. The apparatus includes a cover member and a sensor. The cover member is composed of a number of layers and has side walls. The sensor includes at least one conduction path in at least one layer of the cover. At least one conduction path also runs within a layer of a substrate to be protected. The conduction path in the cover member and in the substrate are connected utilising vertical through holes and vias. The vias are provided internally within the structure of the side walls in the cover. The substrate and the cover together act as a security module for protection of a circuit on the substrate. To produce the
arrangement of Benson et al it is essential to use the multi-layer laminate approach described. While at the outset Benson states that a simpler construction assembly is desired the security module arrangement with its cover and substrate components that is described turns out to be quite a relatively complex structure with an equally complex manufacturing process which inter alia necessitates laminate structures for both the cover and the substrate. Furthermore the connection of the separate conduction paths of the cover and the substrate is achieved by an arrangement of vertical through holes and blind vias which further adds to the complexity of the device.

A skilled person will understand from the teaching of Benson et al that the construction described with the laminated structure with wholly internally held conduction paths will provide a degree of security for a circuit to be protected, but the complexity of the arrangement and especially the necessity to mate the cover and the substrate so as to provide the security module may be a task which is difficult to do within manufacturing tolerances. The skilled person would appreciate that a relatively high failure rate would be expected from Benson et al security modules assembled in a production environment.

Another disadvantage of the housing of Benson et al results from the fact that the tracks in the sidewalls are provided by means of through holes and blind vias. This restricts the configuration of the tracks to being vertical within the sidewalls, thus rendering the housing prone to chemical or mechanical attack at these points.

A further disadvantage of the housing of Benson et al is that the available cover height may be restricted due to the laminate nature of the housing and sidewalls.

In a different end-use application field EP 1 045 352 (Durigon) describes a tamper respondent enclosure. The enclosure is formed by a laminate that is folded over and adhered to itself to form the enclosure. The laminate has attached thereto a detection cable which runs through the enclosure and connects a monitor to the enclosure. The device is constructed so that removal of the detection cable from the enclosure is prevented. The document does describe stripping away an insulating layer (GORE-TEX® expanded PTFE) from the detection ribbon cable.
Summary of the Invention

The present invention provides an improved housing that allows for replacement and/or repair of an underlying circuit. The improved housing also provides for simple assembly in a manufacturing process at a relatively low cost. This is achieved by provision of a single piece construction security housing having conductive patterns integrally provided thereon.

In particular, a first embodiment of the invention provides a security housing for mounting (in use) on a circuit board to protect an associated circuit, comprising: a plurality of electrical contacts (on the housing) for making electrical contact with the circuit board, a cover, a plurality of side walls, where the plurality of side walls and cover define a space for accommodating the associated circuit, and at least one pattern of conductive tracks electrically connected to the electrical contacts and integrally formed with the plurality of side walls and the cover in a single piece construction.

In this respect the integral formation of the pattern of conductive tracks with the housing is achieved by the application of the tracks to the housing. In particular the housing forms the support substrate onto which the conductive tracks are set down. In this arrangement the tracks will not be pre-formed (for example carried on a substrate which is then bonded to a housing comprising a cover, and a plurality of side walls as described above).

Two methods of provision of the tracks in a form in which they are integral to the housing are desirable for use in the constructions and methods of the invention.

The first is to prepare the 3D structure of the walls and cover and to set down the tracks directly on the housing in a desired pattern. In this way the tracks are created *in-situ*. This may be achieved in many ways, for example by the etching/deposition processes described below. Laser techniques are desirable in this construction.

The second is to create a pre-form for the housing. This may be achieved *inter alia* by the laminate structure below where the housing is pressed out of a flat substrate to create the cover and walls (and where appropriate the flange). Again one can set down the tracks directly on the housing. In this way the tracks are created *in-situ*. This
may be achieved in many ways, for example by the etching/deposition processes described below.

A pre-formed pattern of tracks may be set down on the laminate structure so that when the pressing action occurs the preformed pattern is also pressed into the desired end-use track pattern simultaneously with the walls and cover of the housing being created by the pressing action. Again the final desired pattern is thus created *in-situ*.

The present invention thus also relates to a security housing for mounting (in use) on a circuit board to protect a circuit associated with the circuit board, comprising:

- a plurality of electrical contacts (on the housing) for making electrical contact with the circuit board,
- a cover,
- a plurality of side walls, where the plurality of side walls and cover define a space for accommodating the associated circuit, and
- at least one pattern of conductive tracks electrically connected to the electrical contacts and formed *in situ* either on the already existing side walls and cover or simultaneously with the creation of the side walls and cover.

Desirably the pattern of conductive tracks are formed on inner surfaces of the cover and the side walls. In all embodiments of the invention the tracks are on the internal surface (face) of the housing – the underside thereof. They are not held internally (buried) within the cover or the walls.

The security housing may additionally comprise a flange having a mounting surface for mounting on the underlying circuit board. The side walls of the housing are interposed between the cover and the flange. Suitably, the flange extends outwardly from the housing.

Conveniently, the contacts may be provided on the mounting surface of the flange. Suitably, a portion of the at least one pattern of conductive track may be provided parallel and adjacent to a corner between adjoining side walls of the housing.

In one embodiment, the at least one conductive pattern comprises one or more loops which commence from a track on a side wall extend on to the mounting surface of the flange and return onto another track on the side wall. At least two contacts are provided with at least one continuous conductive pattern running from one contact to
the other. Preferably, two contacts are provided and a single continuous conductive pattern runs between them. The single continuous conductive pattern may commence at one of the two contacts and terminate at the second of the two contacts. The single continuous conductive pattern may also provide the one or more loops which extend from the sidewalls onto the mounting surface of the flange. In this way, the entire surface of the housing may be protected by the single conductive pattern.

For enhanced security, the mounting surface of the flange may have a guard track provided thereon. The guard track may be interposed between the at least one conductive pattern and the peripheral edge of the flange. In use, the guard track would be connected to a non-reference voltage.

Suitably, the inner surfaces of the cover and/or side walls are planar. The cover and flange are suitably aligned in a parallel configuration. The side walls are desirably inclined relative to the cover, suitably at a substantial angle for example at an angle of 20-70° and preferably at an angle of about 45°. In one construction the housing material is plastic for example a single molded piece of plastic. The housing is substantially rigid compared to flexible foil circuits.

A further embodiment of the invention provides (an assembly comprising) a circuit and housing arrangement in which a circuit is protected by a security housing as described herein.

In another embodiment, the present invention provides a method of manufacturing a security housing for protecting a circuit, comprising the steps of molding a housing comprising a cover and a plurality of side walls and using electromagnetic radiation to define a pattern of conductive tracks on surfaces of the cover and plurality of side walls.

The electromagnetic radiation may be used to ablate unwanted conductive material to define the pattern. Alternatively, the electromagnetic radiation may be used to break up non-conductive metal compounds into metal nuclei to define the pattern.

In a further embodiment, a security housing is provided for mounting (in use) on a circuit board (in an assembly comprising the housing and the circuit board) to protect an associated circuit, comprising:

- a plurality of electrical contacts for making electrical contact with the circuit board,
a cover,
a plurality of side walls, where the plurality of side walls and cover define a space for accommodating the associated circuit, and
at least one pattern of conductive tracks electrically connected to the electrical contacts and integrally formed with the plurality of side walls and the cover in a single piece construction,
wherein the security housing comprises a laminate structure comprising a metal substrate separated from the plurality of electrical contacts and the at least one pattern of conductive tracks by at least one layer of insulating material.

In this further embodiment (as with the earlier embodiments) a flange may be provided having a mounting surface for mounting on the underlying circuit board. Again it is desirable that the flange extends outwardly from the housing. The contacts may be provided on the mounting surface of the flange. The inner surfaces of the cover and/or side walls are suitably substantially planar. The side walls may be substantially inclined relative to the cover, suitably at an angle of 45° to 89°.

In this further embodiment, the at least one conductive pattern may comprise one or more loops which commence on a side wall extend on to the mounting surface of the flange and return onto the side wall. Suitably, the mounting surface of the flange may be provided with a guard track.

The invention, in a further embodiment includes a method of manufacturing a security housing for protecting a circuit, comprising the steps of providing a planar laminate structure comprising a metal substrate having at least one layer of insulating material formed thereon, the insulating material having a plurality of electrical contacts and at least one pattern of conductive tracks provided thereon, and forming the planar substrate into a housing comprising a cover and a plurality of side walls. In this method, the insulating material may be applied in sheet form to said metal substrate. The plurality of electrical contacts and conductive tracks may be formed using a PCB photo-resist and etching process.
Other advantages and features will become apparent from the detailed description which follows.

**Brief Description of the Drawings**

The present invention will now be explained in greater detail with reference to the accompanying drawings in which:

- FIG. 1 is a bottom view of a security housing according to the invention;
- FIG. 2 is a front view of the security housing of FIG. 1;
- FIG. 3 is a sectional view of the security housing of FIG. 1 in use;
- FIG. 4 is an exemplary pattern for use with the housing of FIG. 1;
- FIG. 5 is an exploded view of a corner portion of the housing of FIG. 1 with an exemplary track pattern for protecting the corner;
- FIG. 6 is an exploded view of a side portion of the housing of FIG. 1 with an exemplary contact pattern;
- FIG. 7 is an exploded view of a side portion of the housing of FIG. 1 with an alternative conductive pattern arrangement to that of FIG. 7;
- FIG. 8 is a process flow diagram for a first method of manufacture according to the invention;
- FIG. 9 is a process flow diagram for a second method of manufacture according to the invention,
- FIG. 10 is a bottom view of a security housing according to a further embodiment of the invention;
- FIG. 11 is a front view of the security housing of FIG. 10;
- FIG. 12 is a process flow diagram for a method of manufacture for the security housing of FIG. 10;
- FIG. 13 is a side view of a laminate structure provided at an intermediate step in the method of FIG. 12;
- FIG. 14 is an exploded view of a side (flange) portion of the housing of FIG. 1 with an alternative conductive pattern arrangement to that of FIG. 7 and FIG. 8;
FIG. 15 is an exemplary cross sectional view along a first axis (A-A') of FIG. 14; and
FIG. 16 is an exemplary cross sectional view along a second axis (B-B') of FIG. 14.

Detailed Description of the Drawings

The present invention, as illustrated by the exemplary embodiment of FIGs. 1-3, provides a security housing suitable for protecting a circuit 10. The housing 1 is a single piece construction comprising a cover 2, a flange 3 and a plurality of side walls 4,5,6,7. The side walls 4,5,6,7 are interposed between the flange 3 and the cover 2. The flange 3 extends outwardly around the edge of the housing 1. The flange 3 has a mounting surface 12 for mounting onto an underlying circuit board 14 associated with the circuit 10 to be protected.

In practice, the circuit 10 to be protected may comprise a group of components and tracks on the associated circuit board 14. Alternatively, the circuit 10 to be protected may comprise a separate circuit board mounted upon the associated circuit board 14.

To prevent interference with the circuit 10 through the associated circuit board 14, appropriate measures may be taken including the provision of one or more patterns of conductive tracks on one or more layers of the associated circuit board, so that any interference with the underlying circuit board may be detected. Suitably, the conductive tracks in the underlying circuit board are electrically connected to the conductive tracks of the housing (described below) to provide a complete electronic barrier to entry to the associated circuit.

The mounting surface 12 of the flange 3 is substantially planar such that in use 12 the flange sits flush upon a corresponding planar surface of the associated circuit board 14. The cover 2 of the housing 1 is raised relative to the flange 3 and in conjunction with the side walls 4,5,6,7 of the housing and, in use, the underlying circuit board 14 provides an enclosed space 16 in which the components of the circuit 10 to be protected may be accommodated. For ease of manufacture, the inner surfaces of
the side walls, flange and cover should be substantially planar. Suitably, the flange 3 is disposed in a parallel alignment to the cover 2. Each of the side walls 4,5,6,7 are inclined relative to the flange. Suitably, the angle of incline between the flange and side walls is in the region of 20° to 70° for reasons which will become apparent from the exemplary methods of manufacture described below. Although, there is a trade-off between manufacturing complexity and the size of circuit that may be accommodated within the enclosed space 16, a preferred angle of incline is about 45°.

The housing 1 is suitably constructed out of an insulating material such as plastic. Alternatively, the housing may be constructed from a non-insulating material covered by a layer of insulating material. For example, the non-insulating material may be a pre-formed metal piece upon which a layer of insulating material has been molded (i.e. the pre-formed metal piece serves as the mold) for example by deposition or immersion. For reasons of manufacturing and/or use, which will become apparent from the exemplary methods described below, the housing material should be relatively rigid, i.e. the housing should retain its shape without support in contrast to flexible foil housings. Similarly, the housing should be somewhat resilient to applied pressure. This is important to negate the requirement for potting or other mechanical protection.

To facilitate the detection of interference by a third party with the housing at least one set of conductive tracks are provided on the inner surfaces of the cover 2 and side walls 4,5,6,7. For ease of illustration, the conductive tracks are not illustrated in FIG. 1. However, a section of an exemplary pattern of tracks 30 is shown in FIG. 4. This exemplary pattern of conductive tracks 20 is arranged in a serpentine fashion. The use of a serpentine pattern ensures that there are no vulnerable areas on the housing that may be attacked by mechanical means.

Each one of the conductive tracks 20 has a start point and an end point. These start and end points are defined, as shown in FIG. 6, by electrical contacts 22 provided on the mounting surface of the flange. In use these electrical contacts facilitate connections to the underlying circuit board. These connections ensure that a disruption in the continuity of the conductive tracks 20 may be detected by an appropriate detection circuit (not shown). Upon detection of a disruption, appropriate action taken to
protect the circuit using techniques known in the prior art, for example setting off an alarm and/or erasing the data stored in circuit memory devices.

As will be appreciated from the exemplary methods of manufacture described below, the housing 1 is a single piece pre-formed construction that does not require assembly of individual components. Similarly, the housing is less vulnerable to attack than prior art security housings since there are no mechanical joints or overlaps between individual components' sections of the housing.

To prevent undetected penetration of the housing by mechanical means, e.g. drilling, a combination of techniques may be used. Firstly, the width of the conductive tracks 20 is preferably narrower than the diameter of available drill bits, suitably in the range of 100 micron to 300 micron, preferably about 200 micron. Similarly, the spacing between adjacent tracks is designed to be less than the diameter of available drill bits. Suitably, this spacing is in the range 150-300 micron, preferably about 200 micron. Using these two restrictions ensures that any attempt to drill through the cover or side walls without breaking a track is defeated. Similarly, as described previously, the conductive tracks are laid out in a serpentine (snake-like) pattern to prevent a would-be attacker from identifying weaknesses potentially occurring from more conventional patterns.

The housing may have a number of locating features defined thereon to assist its placement on a circuit board during the assembly process. These features may include one or more lugs 18 intended to engage with corresponding apertures defined in the circuit board. The locating features may be configured to ensure that the housing may only be placed in one particular orientation, i.e. where the contacts 22 on the housing are placed on top of corresponding contacts on the circuit board. Alternatively, the contacts on the housing may be arranged to be symmetrical.

To operate as a security housing for a circuit, it is necessary to fix the housing 1 to the underlying circuit board 10 and to provide electrical connections between the contacts 22 of the housing and those of the underlying circuit board. These two requirements may be achieved simultaneously using a conductive material as both a fixative and as a conductor to adhere the security housing to the underlying circuit board. Suitable conductive materials include solder, conductive epoxy and z-axis tape
(for example EL-9032-3 available from Adhesives Research Inc. of Glen Rock, Pennsylvania, USA). To prevent accidental shorting by the conductive materials such as solder, the materials are selectively deposited on the circuit board and/or housing. In the case of solder, this may be achieved using solder ball technology. Using materials such as z-axis tape, this is not necessary as the material is anisotropically conductive, i.e. the material only conducts in one direction (vertically between housing and underlying circuit board and not horizontally between contacts).

Conventionally, detection circuits for detecting a break in a conductive track are quite simple. In brief, a reference (non-zero) voltage is applied at the start of a conductor track, As long as the track remains intact, the reference voltage will appear at the end of the track. A simple comparator may be used to detect this reference voltage and to trigger an alarm in the event of its absence or alteration.

A particularly vulnerable area in respect of prior art enclosures is at the corners of the housings where edges join. In flexible foil embodiments, this vulnerability may be mitigated using an overlap between adjoining surfaces. Nonetheless, the vulnerability is still present. In the present invention as the housing is a single piece construction, there is no gap or join present at the corner requiring protection by an overlap. Similarly, the housing has effectively the same strength in the corners as elsewhere. Additionally, it is possible to continue the conductive pattern from one side surface around a corner into an adjacent side wall, thus there is no vulnerable gap present at the corners. Although, the continuation of the conductive patterns from one side wall removes the potential of an attack at a corner, it adds to the complexity of manufacture of the housing. To simplify manufacturing and still mitigate against attack, an embodiment of the present invention, as shown in FIG. 5 (for ease of illustration, only the tracks adjoining the corner between side walls are shown; in practice the pattern will continue to effectively cover all vulnerable areas and in such a way that each track starts and ends at a contact), provides one or more tracks 27,28 of the conductive pattern 20 of tracks adjacent to the adjoining edge between side walls 4,7. The tracks are disposed in a substantially parallel configuration to the adjoining edge and are in close proximity to the edge (i.e. within the track spacing previously discussed), such that the space between the tracks on adjacent walls prevents an attack by drilling or other mechanical
means. The advantage of this approach is that protection is provided by the conductive pattern of tracks, which does not require a track to pass from one side wall to another side wall across an adjoining corner, which would increase the manufacturing time.

As the arrangement of narrow tracks closely spaced together provides an effective electronic barrier to entry through corners of the side walls, the only remaining area which may be vulnerable to attack is the flange. To protect the flange a number of special features may be used. In particular, the electrical contacts 22 for the start and end point of each of the conductive tracks may be separated from each other by a significant distance (to prevent bypassing the conductive pattern by shorting the contacts). Similarly, the start and end point of each conductive track may be separated by one or more end/start points for other conductive tracks.

Using contacts to prevent an attack by drilling sideways through the flange would normally necessitate that the distance between adjacent contacts should be less than that of the smallest drill bit normally available. Thus the separation between contacts on the mounting surface of the flange should be in the range 150-300 micron, preferably about 200 micron.

By locating the contacts a distance from the outer edge of the flange, space may be provided for a guard track 30. This guard track 30 which may conveniently be provided on the mounting surface of the flange adjacent to the outer edge provides a barrier which must be broken to get through to the electrical contacts 22 and/or conductive pattern 20. In use this guard track 30 is connected to a non-reference voltage (for example ground). If an attacker attempts to drill through the flange with a conventional conductive metal drill bit, the drill bit will initially make contact with the guard track. Mere disruption of the guard track will not trigger an alarm. However, continued drilling may cause the drill bit to make subsequent contact with the one or more electrical contacts and/or the conductive tracks, thus connecting the non-reference voltage of the guard track to the electrical contacts or conductive track, which is immediately detectable by the above described detector circuits.

Although providing a significant number of contacts 22 on the mounting surface of the flange with associated tracks on the side walls and cover and corresponding contacts on the underlying circuit enhances the security of the housing by ensuring
there are no vulnerable gaps around the edge of the housing, the reliability of the assembly process may be less than desirable. The primary reason for this arises from the necessity of ensuring that proper electrical connections are provided between each contact on the flange and the corresponding contact on the underlying circuit board. The greater the number of contacts provided, the lower the overall reliability.

Prior art systems, such as that of Benson et al require a large number of interconnections between the housing and the circuit board. This makes the prior art housing more difficult to manufacture, which may lead to a lower yield in production.

A further embodiment of the invention significantly increases the reliability of the manufacturing process by reducing the number of contacts required. Referring to FIG.7, which illustrates a section of the mounting surface of the flange and an adjoining side wall, it will be seen that tracks 20 of the conductive pattern are disposed in a loop arrangement, whereby each track passing from a side wall 4 to the flange 12 is looped back onto a track on the surface of side wall 4. Any attempt to penetrate the housing 1 by drilling through the flange will cause a disruption in one or more of the loops (i.e. one of the conductive tracks), which may be detected as described above, and/or the connection of the guard track to one or more of the conductive tracks. It will be appreciated that in this embodiment, the necessity for a large number of contacts to the underlying circuit board is reduced. In practice, the number of contacts may be reduced to two, with a first contact providing a start point on a conductive track to which a reference voltage may be connected and an end point to which a detection circuit may be connected. To prevent access to the circuit by separating the surface of the flange from the surface of the underlying circuit board and adhesive may be used to fix the mounting surface of the flange to the surface of the underlying circuit board. To prevent shorting between the loops and the guard track, a non-conductive adhesive (e.g. a suitable epoxy) may be used. However, to provide an electrical connection between the contacts of the security housing and the underlying circuit board, a conductive adhesive is selectively used for fixing the surface areas with contacts to corresponding contacts on the underlying circuit board.

The adhesive qualities of the non-conductive adhesive should be selected to provide a greater adhesive force between the adhesive and tracks than the adherence
force between the tracks and the housing. In this way, any attempt to lift the surface of
the housing will cause tracks to break away from the housing, thus disrupting the
conductive pattern.

Although, the use of adhesive may perform the dual purpose of preventing
undetected non-authorised access to the housing and of fixing the housing to an
underlying circuit board, there may be circumstances where further additional fixing
means is required. An example of such a circumstance may be where the circuit is to
be exposed to severe vibration\shock for an extended period of time. In these
circumstances, mechanical fixing means may be provided, e.g. clips, or screw fixings.
The housing may be adapted to facilitate these additional mechanical fixing means, e.g.
by having screw holes drilled in the flange.

It will be appreciated that the most vulnerable places in a security housing will be
the contacts at either end of a protective conductive pattern, since if access is obtained
to both electrical contacts the protective conductive pattern may be bypassed with a
simple conductive bypass connection. Prior art housings, such as those described by
Benson et al in US2002/0002683, include a large number of contacts between the
housing and the circuit board to be protected and are thus vulnerable to such an attack.

Accordingly, it is beneficial if additional protective measures may be provided in
the region of the electrical contacts.

One additional protective measure is shown in the exemplary arrangement of
figure 14. This exemplary arrangement uses the looped tracks 104 described above to
prevent access to the one or more electrical contacts 100 positioned on the mounting
surface of the flange.

To prevent unwanted access to the contact 100, a conductive trace 104 is
effectively looped around the contact so as to substantially encircle it. Any attempt to
access the contact 100 is likely to break the conductive trace 104 looping the contact
thus triggering an alarm or other action as described previously. The conductive trace
104 looping the contact may start from the contact itself 100. To increase security the
trace emanating from the contact commences in a direction away from the flange outer
dege 105 towards the centre of the housing. Alternatively, the conductive loop may form
part of another conductive pattern to which the contact is not directly connected. The
use of a protective loop 104 around individual contacts 100 provides additional security. This security may be enhanced using the features described previously. For example, a guard track 102 may be placed adjacent to the outer edge 105 of the surface of the flange.

To ensure the looped track 104 is effective in protecting the individual contact 100, it will be appreciated that the looped track should be positioned as close as possible to the individual contact.

However limitations in the manufacturing technologies available limit the minimum effective distance between the protective loop and the contact. Moreover, if the contact 100 and protective loop 104 are too close, an accidental shorting between the contact and loop may occur during the subsequent assembly process.

A further enhancement shown in the cross sectional views of Figure 15 and Figure 16 overcomes this difficulty by providing the individual contacts on a plateau 106, i.e. a raised surface of the flange with respect to surrounding areas of the flange. Thus the separation distance between the looped track and the individual contact is provided by a combination of vertical and horizontal distances. Suitably, the plateau is 150 to 450 micron in height above the surrounding area, preferably about 300 microns. The conductive loop is suitably positioned on the area of the flange surrounding the plateau. The separation provided by the height of the plateau 106, means that the horizontal distance between the contact and the protective loop may be significantly reduced.

An added advantage of the plateau 106 is that because of the inherent nature of the additive manufacturing method described below, no conductive material may conventionally be formed on a vertical surface. Thus, what is normally a disadvantage provides a distinct advantage in the present case. Accordingly, it is beneficial if the plateau is raised sharply with respect to the surrounding surface i.e. to provide substantially vertical walls 110, 116, 118 rising from the surrounding flange surface 114 to the plateau surface (i.e. the contact 100).

To provide a connection between the contact and its corresponding protective pattern using the additive manufacturing method described below, one of the side walls 112 defining the plateau 106 is suitably inclined (not vertical) from the surrounding
flange area to the plateau surface. A suitable incline is in the range 20 to 70 degrees, preferably about 45 degrees. The use of an inclined surface for one of the side walls means the lasering process described below can establish a track from the contact to the surrounding flange area. Suitably this inclined surface faces inwardly away from the outer edge 105 of the flange towards the centre of the housing.

In addition, the use of raised surfaces on the flange for individual contacts also means connections with corresponding contacts on an underlying circuit board may, if required, be made by simple contact.

To ensure the raised surface 106 of the contact does not itself introduce a weakness into the integrity of the housing, a peripheral raised surface 108 may be provided adjacent to the outer edge of the flange. This peripheral raised surface ensures that in use there is no significant gap between the flange and the underlying circuit board through which the plateaus of the individual contacts may be attacked. The previously described guard track 102 may be provided on this further raised surface. As before, in the use the guard track 102 may be connected to a non reference voltage (for example ground).

In one embodiment, the present invention relies upon the use of a plastic housing having at least one pattern of conductive tracks formed on the inner surface thereof to provide an electronic barrier to entry through the housing. Two exemplary methods for manufacturing the housing will now be described, in which the two methods share a common first stage in a process which may be regarded as comprising two basic stages. The first stage of the process is the molding of the security housing and the second stage of the process uses electromagnetic radiation in the form of a laser to define a pattern of conductive tracks on the inner surfaces of the cover, flange and side walls.

The latter step of defining a pattern of conductive tracks may use a laser to either remove metal from unwanted areas or to provide metal in desired areas. The use of a laser to ablate metal, herein after referred to as the subtractive method, will now be described with reference to FIG 8. The method commences with the use of a suitable plastics, for example injection, molding process 40 to produce the desired shape for the security housing.
The resulting plastic housing is then plated with metal. As the plastic housing is to be plated with a metal, it is preferable that the plastics material selected for the housing is amenable to plating. Suitable plastics include Thermoplastic Liquid Crystal Polymer, commonly known as LCP, for example VECTRA E820i or VECTRA LP1156 as supplied by Ticona of Frankfurt am Main Germany.

In order to facilitate the plating of the plastic material with metal, it is beneficial to chemically pre-treat 42 the plastic. It will be appreciated to those skilled in the art that a variety of techniques are available and the exact process selected will depend on a number of factors including the particular plastic material selected. Thus the following pre-treatment chemical steps should be treated as purely exemplary and in no way limiting. A first step in the chemical pre-treatment is the softening of the surface of the plastic to receive a chemical etch, for example by immersion of the housing in a solution of ENVISION MLB, available from Enthone, Inc., West Haven, Connecticut, USA, for 10 minutes at a temperature of 65°C. A next step is the etching of the surface of the plastic. This etching step is to provide microscopic holes in the surface of the plastic which serve as bonding sites for subsequent metal plating. A suitable etch for this process is immersion in a solution of Potassium Permanganate Etch (KMnO₄), also available from Enthone, Inc. for 20 minutes at a temperature of 80°C. After the etching stage, any trace of remaining etch may be removed by immersion in a KMnO₄ Neutraliser solution, for example for 5 minute at a temperature of 65°C. The plastic may then be processed in an activator to enhance activation and produce a change in the surface charge of the plastic. A suitable process for example would be immersion for three minutes at room temperature in a solution of ACTIVATOR 890 Predip (also available from Enthone, Inc.).

The plastic housing may then be immersed in an activator such as a stannous chloride colloidal solution, for example for five minutes at room temperature in a solution of ACTIVATOR 890 also available from Enthone, Inc., so as to provide catalytic sites on the surface of the plastic. Immersion in a further solution, for example for three minutes in a solution of ACCELERATOR 860 (also available from Enthone, Inc.), may be used to improve the initial deposition rate of the subsequent plating process and to promote dense fine grained deposits. This solution also removes excess stannous
chloride from the previous activation step. These initial steps prepare the plastic for
plating. The plating process commences with the electroless plating of the plastic
using a copper electroless plating solution. A suitable copper electroless plating solution
is Cu 872 (also available from Enthone, Inc.), as it produces a uniform fine grained
deposits which and have a low stress level to ensure adhesion. A suitable immersion
time is fifteen minutes at a temperature of 60°C.

As copper surfaces are not autocatalytic to nickel, it is necessary to use an
initiator solution, for example Initiator 892, also available from Enthone, Inc., for 1
minute at room temperature, to deposit a thin metallic film on the surface of the
copper. This thin metallic film promotes the formation of a dense adherent fine grained
deposit in the subsequent plating process.

The plastic housing may then be plated with nickel in an electroless nickel plating
process. A suitable electroless plating process is immersion in a solution of NI 418 also
available from Enthone, Inc., for 1 minute at room temperature. This exemplary solution
is a stable, medium phosphorous content Nickel that produces semi-bright deposits with
good wear properties.

After the nickel plating process, the housing may be plated 48 with a layer of
gold in a gold electroless plating process. A suitable electroless plating process is
immersion in a solution of Ormex Au, available from Schlotter of Geislingen, Germany
for five minutes at a temperature of 90°C.

It will be appreciated by those skilled in the art, that the process may include a
number of other conventional steps for example the use of a deionized water (DI) rinse
between each of the steps above. Similarly, it will be appreciated that several variations
are possible and the invention is not intended to be limited to the exact process steps
described. For example, the nickel and gold plating process steps and the associated
pre-treatment may be replaced by a tin plating process, as tin is autocatalytic to copper.

Once the plastic housing is plated with a metal (either copper, tin, nickel or
gold), a laser may be used to form a pattern of conductive tracks on the plastic by
removal (burning off) of unwanted metal. A suitable process for the removal of this
metal is the use of an infra red laser with a three dimensional scanning head to allow
structuring in three dimensions, for example of the types available from LPKF of
Garbsen, Germany. An infra red laser although having poorer line definition is preferred to the use of an ultra violet laser because of significantly reduced processing times. The plating processes described above will conventionally coat the entire plastic housing with a plating of metal, whilst the metal on the inside of the housing provides for the pattern of conductive tracks, the plating material on the outside need not be regarded as unwanted as it does not interfere the conductive pattern on the inside surfaces of the housing. Moreover, it may be used as a guard surface by connection to a non-reference voltage as described above.

An alternative process for making the housing as shown in FIG. 9, uses a plastics molding process and a process of laser direct structuring. However, in this process the laser is used to define areas where tracks are required rather than to remove material in areas where it is not wanted. This process uses an electrically non-conductive supporting material (i.e. a plastic), having electrically non-conductive metal compounds contained therein in a dispersed manner. Electromagnetic radiation (e.g. as produced by a laser) may be used to break up the non-conductive metal compounds into metal nuclei where tracks are required. These metal nuclei may then be used as a base for subsequent moralization steps. This process will now be described in greater detail. The process commences with a suitable material comprising an electrically non-conductive supporting material having electrically non-conductive metal compounds contained therein in a dispersed manner. An example of such a plastics material is Polybutyleneterephthalate PBT which has contains suitable electrically non-conductive metal compounds, available from LPKF Gmbh of Garbsen, Germany. This material is injection molded 60 using conventional plastics molding techniques into the shape of the required security housing. A laser having a suitable three-dimensional function as described above, is used to define 62 the pattern of the conductive tracks on the surfaces of the security housing, i.e. the laser is directed to areas where a conductive trace is required. This process, as described in US 6,319,564, breaks the non-conducting metallic bonds into conductive metal nuclei in these areas. These metal nuclei serve as a base for subsequent plating steps, whereas in the non-exposed areas no plating will occur.
The plating process starts with an initial step of removing 64 loosely bound ablation debris, arising from the laser process, from the surface of the housing. This step may be performed by immersion in an alkaline solution (e.g. 1-2 M NaOH for five minutes at 80°C). To thoroughly clean the surface, the housing may be immersed in a DI solution and subjected to ultrasonic vibration. The ultrasonic vibrations produce high intensity shock waves that penetrate right down to the surface porosity of the housing to ensure clean surface. Other methods of cleaning which may be used in addition to or in place of the ultrasonic vibration, would include the mechanical cleaning methods of water jet cleaning, air jet cleaning, vacuum cleaning or conventional wiping or brushing.

To improve the efficiency of the plating process, an initiator solution may be used as described above (Initiator 892, available from Enthone, Inc.). The next step is the plating 66 of the plastic with a seed layer of copper. The plating solution used for this should be suitable for activation by the metal nuclei freed in the plastic. In the case of the above mentioned PBT material, this means a Pd- activated solution. An exemplary seed plating solution is Cu 9060 available from Enthone. This step provides a seed copper layer in areas where the laser has freed nuclei (i.e. where metal tracks are required). This seed layer may be thickened using a further copper plating process 68, for example using Cu 872 solution, described above, for fifteen minutes at 60°C.

As described above, copper surfaces are not autocatalytic to nickel and thus an initiator solution, for example Initiator 892 for 1 minute at room temperature, may be used to deposit a thin metallic film on the surface of the copper. This thin metallic film promotes the formation of a dense adherent fine grained deposit in the subsequent nickel plating process 70.

The plastic housing may then be plated with nickel in an electroless nickel plating process 70 as described above in respect of the subtractive method.

After the nickel plating process, the housing may be plated with a layer of gold in a gold electroless plating process 72 as described above in respect of the earlier described subtractive process.

An essential step in both processes is the use of a electromagnetic source, i.e. a laser, to define the conductive pattern either by removal of unwanted material or by freeing conductive material (by breaking the bonds of non-conductive metallic
compounds). In both processes, a laser must be controlled to define the conductive pattern. To simplify the laser control, it is preferable that all of the surfaces are substantially planar, and that the angle between the cover/flange and side walls are not at 90° so that the laser may be directed from directly overhead.

In both of the alternative manufacturing processes, three dimensional features may be included in molding process. Thus for example, product marking may be provided on the surface of the housing.

The additive process causes a small dip in areas where the tracks are formed. This dip is not a significant issue when conductive glues are used to fix the housing to an underlying circuit board. However, when Z axis tape or solder is used, it may be beneficial if the effect of the dips could be negated. This is possible by providing three dimensional features, i.e. small raised areas in the surface of the flange, in the molding process in regions where the contacts will be defined. These small raised areas may or may not be removed after the laser definition process. Moreover, the raised areas may be used to increase the security of the housing when used as previously described with respect to the plateaus.

In certain circumstances, it would be advantageous if the security housing could withstand high temperatures for a period of time as might be experienced during reflow soldering. A further embodiment of the invention provides a security housing capable of withstanding higher temperatures.

As with the previously described embodiments, this further embodiment, as illustrated in figures 10 and 11, provides a security housing 1 suitable for protecting a circuit 10. The housing 1 is a single piece construction comprising a cover 2, a flange 3 and a plurality of side walls 4,5,6,7. The side walls 4,5,6,7 are interposed between the flange 3 and the cover 2. The flange 3 extends outwardly around the edge of the housing 1. The flange 3 has a mounting surface 12 for mounting onto an underlying circuit board associated with the circuit to be protected.

The housing of this further embodiment functions in the same way as the previously embodiments vis a vis the circuit to be protected, which as before may comprise a group of components and tracks on the associated circuit board or a separate circuit board mounted upon the associated circuit board. In either case,
appropriate measures, as described above, may be taken to prevent interference with the circuit. As before, the conductive tracks in the underlying circuit board are electrically connected to the conductive tracks of the housing to provide a complete electronic barrier to entry to the associated circuit.

The mounting surface 12 of the flange 3 is substantially planar such that in use the flange sits flush upon a corresponding planar surface of the associated circuit board. The cover 2 of the housing 1 is raised relative to the flange 3 and in conjunction with the side walls 4,5,6,7 of the housing and, in use, the underlying circuit board provides an enclosed space in which the components of the circuit to be protected may be accommodated. Suitably, the flange 3 is disposed in a substantially parallel alignment to the cover 2. Each of the side walls 4,5,6,7 are inclined relative to the flange. Because of the method of manufacture (described below), a greater range of angle of incline between the flange and side walls may be obtained than the previously described embodiments. In particular, an angle of incline of about 89° is achievable.

Thus more circuit space is available within the housing compared to the previous embodiments.

In this embodiment, the housing 1 is suitably constructed as a metal substrate covered by a layer of insulating material. Suitable materials for the metal substrate would include copper, copper alloy, stainless steel, nickel silver or aluminium. The thickness of the metal substrate is typically, but not limited to, the range of 0.2–0.5mm. The insulating material is selected to be flexible so as to be usable in the housing forming process described below. Suitable insulating materials would include for example Polyimide and certain epoxy resins.

As with the previously described embodiments, the housing material is relatively rigid, i.e. the housing retains its shape without support. Similarly, the housing is somewhat resilient to applied pressure, thus negating the requirement for potting or other mechanical protection.

As with the previously described embodiments, at least one set of conductive tracks are provided on the inner surface of the cover 2, flange and side walls 4,5,6,7 to facilitate detection of third party interference with the housing, i.e. the conductive tracks are on the surface of the insulating material. Suitably, the conductive pattern is as
previously described in respect of the previous embodiments, for example, the serpentine arrangement of Figure 4, such that each one of the conductive tracks has a start point and an end point defined by electrical contacts provided on the mounting surface of the flange. In use these electrical contacts facilitate connections to the underlying circuit board. As with the previous embodiments, these contacts may be provided on raised surfaces (plateaus).

As will be appreciated from the exemplary method of manufacture described below, the housing 1 is a single piece pre-formed construction that does not require assembly of individual components. Similarly, the housing is less vulnerable to attack than prior art security housings since there are no mechanical joints or overlaps between individual components of the housing. Moreover because the housing is fabricated with a metal substrate, electromagnetic radiation from the housing is reduced i.e. the metal layer acts as an EMC shield. Additionally, a metal substrate housing is stronger than the previously described plastic embodiments, which provides enhanced resistance against projectiles fired at the housing.

To prevent undetected penetration of the housing by mechanical means, e.g. drilling, a combination of techniques as described with reference to the previous embodiments may be used, e.g. a guard track around the perimeter of the flange. An added advantage of the present embodiment, as will be appreciated from the exemplary method of manufacture described below, is that a multi-layer arrangement of tracks may be provided, with each layer having one or more patterns of conductive tracks. Connections between layers may be made using conventional PCB layer interconnect methods. Moreover, for specialised applications the multi layer process may be used to provide a very secure housing in which the protective patterns are substantially unique, i.e. each housing has an individual pattern. By substantially unique is meant that the ratio between the total number of housings and housings sharing a common protective pattern is extremely high.

This may be achieved using one or more initial layers having common protective conductive patterns provided thereon. By common, it is meant that the conductive patterns provided thereon are used in more than one housing. Suitably, these initial layers are sufficient in themselves to provide effective security to the housing.
After the initial layers, one or more custom layers are provided. These custom layers are intended to add a degree of uniqueness to each individual housing. As the custom layers are not the primary protection in the housing but instead are for primarily introducing an element of uniqueness, the track widths and separation are not as critical as for the initial layers. As the track widths and track separation are not as critical they may be fabricated using techniques such as laser etching, whereas the initial layers may be fabricated using conventional low cost PCB (e.g. photo-resist) techniques. Alternatively, the custom layers may comprise a series of pseudo random patterns, which may be provided using conventional PCB techniques, e.g. photo resist techniques. The pseudo random patterns may comprise a plurality of combinations of different paths which may be selected to define an overall pattern. An individual pattern is obtainable by the appropriate removal of sections of the conductive pattern, e.g. by laser means.

Another possibility for providing somewhat unique housings is to have a plurality of multiple layers, wherein the pattern(s) of each layer is designed so as to function in a plurality of different orientations. For example, for a four sided square housing, the pattern and contacts may be designed to provide four different orientations. Suitably, each orientation has the same positions for interconnect with an overlying/underlying layer.

A degree of uniqueness (randomness) may then be introduced into each individual housing by altering the orientation of one or more of the layers. Thus for a four sided square housing with four layers, two hundred and fifty six different housing configurations are possible.

The number of permutations may be increased where several housings are made simultaneously and subsequently singulated from each other.

For example, if housings using four layers are produced together in an 8 x 8 arrangement, the patterns for each of the individual sections (corresponding to each individual housing) of each layer of the four layer structure may be designed to be different. Thus using four standard photo-resist patterns (one for each layer) 16,384 housings, each having a different overall conductive pattern, may be constructed, i.e. each layer has four possible orientations with 64 different patterns. It will be appreciated
to those skilled in the art that further steps are available to increase the number of possible combinations available without requiring an increase in the number of layers.

As described previously, the housing may have a number of locating features defined thereon to assist its placement on a circuit board during the assembly process. However, unlike the previously described plastics molding process, lugs are not a practical proposition in the method of forming used since the part is press formed rather than injection moulded. Instead, the locating features may include suitable edge profiling of the flange to engage with cooperating features on an underlying circuit board or holes drilled in the flange through which the flange may be fixed by screws. The locating features may be configured to ensure that the housing may only be placed in one particular orientation, i.e. where the contacts 22 on the housing are placed on top of corresponding contacts on the circuit board. Alternatively, the contacts on the housing may be arranged to be symmetrical.

As described above to successfully operate as a security housing for a circuit, it is necessary to fix the housing 1 to the underlying circuit board 10 and to provide electrical connections between the contacts 22 of the housing and those of the underlying circuit board. In this further embodiment a number of different methods may be used to provide electrical connections between the contacts of the housing and the underlying circuit board, including for example but not limited to one of the following:

1. Constructing the contacts of the housing proud of the surrounding flange surface. The use of proud contacts facilitates direct connection by surface contact to a contact on the underlying circuit board, or with the assistance of a conductive medium for example conductive epoxy. The contacts may be made proud by indenting the surface around them during the manufacturing process described below.

2. The Pads on the trace are open to the solder mask (i.e. all other areas are covered with a solder mask) and plated with Ni and gold flash these in turn can be connected to pads on the PCB using conductive epoxy.

3. Using intermediate conductive pieces positioned between the contacts of the housing and corresponding contacts on the underlying circuit to ensure a proper connection. Exemplary intermediate conductive pieces would include small metal pieces or surface mount links of a suitable size (e.g. a zero ohm link 0402 package or
smaller). The intermediate conductive pieces may be placed on (e.g. by a pick and place machine) and fixed to either the housing or the circuit board prior to mounting the housing on the circuit board.

3. By using spring contacts rather than PCB pads (which may for example be picked and placed) as the contacts on the underlying circuit board.

The housing is suitably fixed to the underlying circuit board using a non conductive adhesive, for example epoxy adhesive Loctite 3425 A&B available from the Henkel Corporation (formerly Loctite Corporation) CT, US. As previously described, the adhesive may be applied using a continuous bead or with dots.

As described above in respect of the previous embodiments, the use of the adhesive to fix the housing to an underlying circuit prevents mechanical attacks on the circuit, i.e. if the housing is lifted from the circuit board the traces on the housing are damaged and the alarm is triggered. To ensure this happens, the adhesive qualities of the adhesive should be selected to provide a greater adhesive force between the adhesive and tracks than the adherence force between the tracks and the housing. In this way, any attempt to lift the surface of the housing will cause tracks to break away from the housing, thus disrupting the conductive pattern.

A particularly vulnerable area in respect of the prior art housings is the corners of the housing where edges were joined. The previously described embodiments used a number of different features to protect the corners. In the case of the present embodiment, the corners may be protected by traces in practically the same way as any other part of the housing since the tracks (as will be appreciated from the method of manufacture described below) are formed prior to shaping the housing. Thus the corners may readily be protected without the necessity for special design features.

In respect of the flange area, the special features described above may readily be applied to the present embodiment. Moreover, whilst a large number of contacts may be provided for connecting between housing and underlying circuit, as described above the reliability of the assembly process may be less than desirable. To overcome this, the looping features of FIG. 7 (previously described) may readily be applied to the present embodiment.
This further embodiment has a number of additional advantages, in particular, copper substrates have the same or very similar Co-efficient of thermal expansion to PCB materials, which improves the reliability of the housing in use with temperature cycling. Another advantage is that the metal substrate may, in use be grounded or raised to another potential to form part of the security strategy. For example, if the substrate was grounded and the conductive tracks at a raised potential, an alarm could be triggered if the conductive trace was shorted to the metal housing e.g. by a metal drill bit. Another advantage of the metal substrate is that in use it reduces the risk of third parties intercepting and analysing/decoding signals radiating from the protected circuit.

An exemplary method of manufacture will now be described for this embodiment with reference to Figure 12. The method will be described with reference to the production of a single housing, however in practise a number of housing may be manufactured simultaneously and subsequently singulated from each other.

The first step in the method is the provision 80 of a laminated structure comprising a metal substrate, at least one layer of conductive tracks and at least one layer of insulating material separating the metal substrate from the conductive tracks. Suitable materials for the metal substrate include Copper or an alloy thereof, stainless steel, nickel silver or aluminium.

The substrate is of a suitable thickness to allow for pressing. The exact thickness of the substrate will depend on the substrate material, but is suitably in the range of 0.2 –0.5mm.

The metal substrate forms the base layer 92 of the laminate structure, as shown in Figure 13, upon which insulation and conductive trace layers 94, 96 are formed using techniques which are commonplace in the field of printed circuit board (PCB) manufacture.

In particular, the insulative layer 94 is laminated onto the metal substrate. This layer 94 provides an insulation barrier on the metal substrate. The insulative layer ideally has the following properties; good adhesion to the substrate, able to withstand typical reflow temperatures (for example a peak of 260°C for a short period of time), suitable for having a solder mask layer printed onto it, and suitable for plating on using
conventional PCB plating techniques or on which a metal (e.g. copper) foil may be laminated. Significantly, the insulative layer 94 must be reasonably flexible after lamination i.e. suitable to be formed or deep drawn as a subsequent operation. An exemplary insulative material would be Polyimide. Further exemplary materials are described in EP 0 598 914 in the name of Mitsui Toatsu Chemicals Inc. Japan.

The layer comprising at least one pattern of conductive traces 96 is provided on top of the insulative layer, suitably using conventional PCB manufacturing techniques. Thus, for example, the insulative layer may be plated with copper and then etched using a suitable photo resist process to form the conductive traces. Alternatively, the circuit traces may be pre-etched on the insulative layer prior to lamination on the metal substrate as in a conventional flex foil process.

An advantage using PCB manufacturing techniques is that a multi-layer arrangement of interconnected conductive traces may be provided to increase the security of the housing.

In any event, the pattern of conductive traces provided on the housing is as described above for the previous embodiments, the pattern is preferably somewhat random as a regular pattern is a known weakness in security housings. Typical track widths and spaces are 150um, but may vary depending on the secure application. Moreover, it will be appreciated that when designing the pattern of conductive traces, which is in a 2D form, careful consideration must be given to the fact that it will be subsequently shaped and stretched i.e. tracks lengthened and angled to suit the finished product by the subsequent pressing/deep drawing process described below. However, this is similar to a development drawing in engineering.

The laminated sheet comprising metal substrate, insulating material and conductive traces is then deep drawn or pressed 82 using a specific die tool into a 3D shape to form the housing, as described for example in EP 0 598 914. If the contacts are required to be formed proud to facilitate contacts as described above, by forming the indent in the metal at the same time as pressing. It will be appreciated that pressing is performed such that the layer of conductive traces is on the inside of the housing.
The resulting housing may then be affixed to a circuit board as described above.

It will be apparent to persons skilled in the art that the present invention has been described with reference to exemplary embodiments and that modifications can be made thereto without departing from the spirit and scope of the invention. Accordingly, it is not intended to limit the invention in any way except as may be deemed necessary in the light of the appended claims.

The words "comprises/comprising" and the words "having/including" when used herein with reference to the present invention are used to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.
Claims

1. A security housing for mounting on a circuit board to protect an associated circuit, comprising:
   a plurality of electrical contacts for making electrical contact with the circuit board,
   a cover,
   a plurality of side walls, where the plurality of side walls and cover define a space for accommodating the associated circuit, and
   at least one pattern of conductive tracks electrically connected to the electrical contacts and integrally formed with the plurality of side walls and the cover in a single piece construction.

2. A security housing according to claim 1 wherein the pattern of conductive tracks are formed on inner surfaces of the cover and the side walls.

3. A security housing according to claim 1 or claim 2, further comprising a flange having a mounting surface for mounting on the underlying circuit board.

4. A security housing according to claim 3, wherein the contacts are provided on the mounting surface of the flange.

5. A security housing according to any one of claims 1 to 4, wherein the inner surfaces of the cover and/or side walls are planar.

6. A security housing according to any preceding claim, wherein the side walls are substantially inclined relative to the cover, suitably at an angle of from about 20° to about 70°.

7. A security housing according to claim 6, wherein the angle is about 45°.
8. A security housing according to any preceding claim, wherein the housing material is plastic.

9. A security housing according to any one of claims 1 to 5, wherein the security housing comprises a laminate structure comprising a metal substrate separated from the plurality of electrical contacts and the at least one pattern of conductive tracks by at least one layer of insulating material.

10. A security housing according to claim 9, wherein the side walls are substantially inclined relative to the cover, suitably at an angle of from about 45° to about 89°.

11. A security housing according to any preceding claim, wherein the at least one conductive pattern comprises one or more loops which commence on a side wall extend on to the mounting surface of the flange and return onto the side wall.

12. A security housing according to any preceding claim, wherein at least one of the electrical contacts is substantially encircled by a portion of the at least one pattern of conductive tracks.

13. A security housing according to claim 12, wherein the at least one pattern of conductive tracks commences at the at least one electrical contact.

14. A security housing according to any preceding claim, wherein at least one of the plurality of electrical contacts is provided on a plateau raised relative to the surrounding surface of the flange.

15. A security housing according to claim 14, wherein the plateau is in the range from about 150 to about 450 micron above the surrounding surface of the flange.
16. A security housing according to claim 15, wherein the plateau is about 300 microns above the surrounding surface of the flange.

17. A security housing according to any one of claims 14 to 16, wherein at least one wall extends from the surface of the flange to the plateau and said wall is substantially vertical.

18. A security housing according to any one of claims 14 to 17, wherein a conductive trace extending from the contact is provided on an inclined wall extending from the surface of the flange to the plateau.

19. A security housing according to any preceding claim, wherein the mounting surface of the flange is provided with a guard track.

20. A security housing according to claim 19, wherein the guard track extends around the perimeter of the mounting surface of the flange.

21. A security housing according to claim 19 or claim 20, wherein the guard track is provided on a guard track plateau raised relative to the surrounding surface of the flange.

22. A security housing according to claim 21, wherein the guard track plateau is in the range from about 150 to about 450 micron above the surrounding surface of the flange.

23. A security housing according to claim 22, wherein the guard track plateau is about 300 microns above the surrounding surface of the flange.

24. A security housing according to any one of claims 20 to 22, wherein at least one wall extends from the mounting surface of the flange to the guard plateau and said
wall is substantially vertical.

25. A security housing according to any one of claims 20 to 23, wherein at least one of the walls extending from the mounting surface of the flange to the guard plateau is inclined wall is at an angle in the range of from about 20 to about 70 degrees, preferably at about 45 degrees.

26. A method of manufacturing a security housing for protecting a circuit, comprising the steps of: molding a housing comprising a cover and a plurality of side walls and using electromagnetic radiation to define a pattern of conductive tracks on surfaces of the cover and plurality of side walls.

27. A method of manufacturing a security housing according to claim 26 wherein the pattern of conductive tracks are formed on inner surfaces of the cover and the side walls.

28. A method of manufacturing a security housing according to claim 27, wherein the electromagnetic radiation is used to ablate unwanted conductive material to define the pattern.

29. A method of manufacturing a security housing according to claim 27, wherein the electromagnetic radiation is used to break up non-conductive metal compounds into metal nuclei to define the pattern.

30. A method of manufacturing a security housing for protecting a circuit, according to any one of claims 27 to 29, wherein the molded housing comprises a flange having a mounting surface for mounting onto an associated circuit board.

31. A method of manufacturing a security housing for protecting a circuit according to any one of claims 27 to 30, wherein the electromagnetic radiation is used to define
at least two electrical contacts for the pattern of conductive tracks on the mounting surface of the flange.

32. A method of manufacturing a security housing for protecting a circuit according to any one of claims 27 to 31, wherein the electromagnetic radiation is used to define one or more loops as part of the conductive tracks which commence on a side wall extend on to the mounting surface of the flange and return onto the side wall.

33. A method of manufacturing a security housing for protecting a circuit according to claim 26, wherein the electromagnetic radiation is used to define an electrical contact which is substantially encircled by a portion of the at least one pattern of conductive tracks.

34. A method of manufacturing a security housing for protecting a circuit according to claim 33, wherein the at least one pattern of conductive tracks commences at the at least one electrical contact.

35. A method of manufacturing a security housing for protecting a circuit according to claim 33 wherein the step of molding defines at least one plateau area on the flange and the step of using electromagnetic radiation defines a contact on the plateau.

36. A method of manufacturing a security housing for protecting a circuit according to claim 33 wherein the step of using electromagnetic radiation defines a guard track on the mounting surface of the flange.

37. A method of manufacturing a security housing for protecting a circuit according to claim 36, wherein the guard track is adjacent to and extends substantially around the perimeter of the mounting surface of the flange.
38. A method of manufacturing a security housing for protecting a circuit according to any one of claims 27 to 35 wherein the step of molding defines a guard track plateau area adjacent to the periphery of the flange and raised relative to the surrounding surface of the flange and where the step of using electromagnetic radiation defines a guard track on the guard track plateau.

39. A method of manufacturing a security housing for protecting a circuit, comprising the steps of providing a planar laminate structure comprising a metal substrate having at least one layer of insulating material formed thereon, the insulating material having a plurality of electrical contacts and at least one pattern of conductive tracks provided thereon, and forming the planar substrate into a housing comprising a cover and a plurality of side walls.

40. The method of claim 39, wherein said insulating material is applied in sheet form to said metal substrate.

41. The method of claim 39 or 40, wherein said plurality of electrical contacts and conductive tracks are formed using a PCB photo-resist and etching process.

42. A method of assembling a circuit board comprising the steps of: providing a circuit board having a circuit to be protected; fixing a security housing as claimed in anyone of claims 1 to 25 on the circuit board so as to cover the circuit to be protected.

43. A method of assembling a circuit board as claimed in claim 42, wherein the step of fixing the security housing comprises the step of applying conductive adhesive to provide a layer of conductive adhesive between corresponding electrical contacts on the circuit board and the security housing.
44. A method of assembling a circuit board as claimed in claim 42 or claim 43, wherein the step of fixing the security housing comprises the step of applying non-conductive adhesive to provide a layer of adhesive between opposing surfaces of the circuit board and the security housing.

45. An assembly comprising a security housing according to any one of claims 1 to 25 attached to a circuit board.
Mold Plastic Housing

Pre Treatment of Surface of Plastic

Copper Plating

Nickel Plating

Gold Plating

Laser Ablation

FIG. 8
Mold Plastic Housing

Define Pattern using Laser

Clean Housing

Seed Plating

Copper Plating

Nickel Plating

Gold Plating

FIG. 9
Form laminated structure comprising a metal substrate and at least one insulating layer and at least one layer of conductive traces.

Press/Form the laminated structure into a housing.

FIG. 12

FIG. 13
**INTERNATIONAL SEARCH REPORT**

A. CLASSIFICATION OF SUBJECT MATTER

<table>
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<tr>
<th>IPC</th>
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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)

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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 practical, search terms used)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

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*#* document member of the same patent family

Date of the actual completion of the International search

2 August 2004

Date of mailing of the International search report

09/08/2004

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentisken 2
NL – 2280 HV Rijswijk
Tel. (+31-70) 340–2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340–3016

Authorized officer

De la Cruz Valera, D
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