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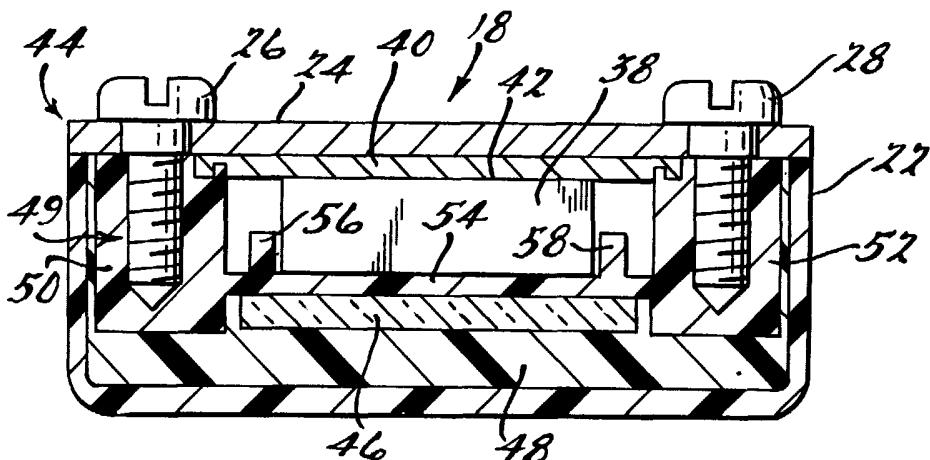
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[Continued on next page]

(54) Title: ELECTRICALLY ISOLATED MODULE



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(57) Abstract: A control module (18) includes a power device (38) and a thermal pad (40). The thermal (40) is disposed between an external tab (42) and a heat sink cover (24) of the module (18).



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ELECTRICALLY ISOLATED MODULE

BACKGROUND OF THE INVENTION

Technical Field

5 The present invention generally relates to electrically isolated control modules. More particularly, the invention relates to an electrically isolated control module having dual insulation layers between an internal line voltage and an external heat sink.

Discussion

10 Electronic devices operating on relatively high AC line voltages have existed for years. Power tools such as miter saws, belt sanders, and household appliances are but a few examples of these types of devices. The typical power tool has a voltage system providing the line voltage for the tool (based on a commercial AC source) and a tool housing enclosing the system.

15 Control modules (such as a speed controller) are often connected to the line voltage and are also disposed within the tool housing. Thus, in the case of a miter saw, the speed controller may control the rotational speed of the saw blade based on the line voltage and one or more switching signals. In order to avoid electric shock to individuals touching the outside of the tool housing,

20 such a controller is typically embedded into an internal enclosure and positioned far enough away from the tool housing to provide the desired amount of electrical isolation between the tool housing and the line voltage.

While the above-described approach to electrically isolating a control module is acceptable under some circumstances, certain difficulties remain.

25 For example, as the size of power tools and the amount of available airflow within the tool decreases, the flexibility in positioning the module within the tool also decreases. This fact is particularly troublesome considering the exacting requirements of modern day safety standards. For example, Underwriters Laboratories (UL) requires a minimum of 3700 volts of isolation

30 between the AC line voltage and any user-accessible (or user-graspable) housing of a tool or appliance. Design engineers are encountering considerable difficulty in meeting this requirement given the creepage and

clearance constraints dictated by these safety standards. It is therefore desirable to provide an electrically isolated module that is highly flexible with respect to module placement in relation to user-accessible housings.

SUMMARY OF THE INVENTION

5 The above and other objectives are provided by a power tool in accordance with the principles of the present invention. The tool has a voltage system providing a line voltage for the tool and a user-graspable tool housing enclosing the voltage system. A double insulated (DI) control module is connected to the line voltage and mechanically coupled to an interior tool
10 housing surface such that the metal tool housing itself functions as a heat sink for the control module. By mechanically coupling the control module to an interior tool housing surface, flexibility in the interior design of the tool as well as control module placement within the tool housing is significantly increased.

Further in accordance with the present invention, an electronic module
15 is provided. The module includes a power device and a thermal pad. The power device is connected to a line voltage, where the power device provides a first layer of electrical insulation between the line voltage and an external tab of the power device. The thermal pad is disposed between the external tab and a heat sink. The thermal pad provides a second layer of electrical
20 insulation between the external tab and the heat sink. Thus, the first and second layers combine to provide a predetermined minimum amount of electrical insulation between the line voltage and the heat sink.

In another aspect of the invention, a method for isolating a line voltage from a heat sink is provided. The method includes the steps of electrically
25 connecting a power device to the line voltage, and providing a first layer of electrical insulation between the line voltage and an external tab of the power device. The method further provides for positioning a thermal pad between the heat sink and tool housing such that the thermal pad provides a second layer of electrical insulation between the heat sink and tool housing. Isolation
30 is therefore provided by the combination of the first and second layers.

It is to be understood that both the foregoing general description and the following detailed description are merely exemplary of the invention, and

are intended to provide an overview or framework for understanding the nature and character of the invention as it is claimed. The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute part of this specification. The drawings 5 illustrate various features and embodiments of the invention, and together with the description serve to explain the principles and operation of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The various advantages of the present invention will become apparent 10 to one skilled in the art by reading the following specification and sub joined claims and by referencing the following drawings, in which:

Figure 1 is a perspective view of a power tool with a user-accessible tool housing in accordance with the principles of the present invention;

15 Figure 2 is a perspective view of a power tool housing showing a representative control module location in accordance with the principles of the present invention;

Figure 3 is a perspective view of a power tool housing cavity showing a control module in accordance with the principles of the present invention;

20 Figure 4 is a perspective view of an electronic control module in accordance with the principles of the present invention;

Figure 5 is a plan view of the electronic control module shown in Figure 4;

Figure 6A is a section view of the control module taken along lines 6A- 25 6A shown in Figure 5;

Figure 6B is a section view of the control module taken along lines 6B- 6B shown in Figure 5;

Figure 6C is a section view of the control module taken along lines 6C- 6C shown in Figure 5;

30 Figure 6D is a section view of the control module taken along lines 6D- 6D shown in Figure 5; and

Figure 7 is a perspective view of an alternative embodiment of a control module mounted to an exterior of a power tool housing showing an external thermal pad.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

5 The following description of the preferred embodiment(s) is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

10 Turning now to Figure 1, a perspective view of an exemplary power tool 10 is shown. It should be noted that while the present invention will be primarily described with respect to power tools and appliances, the invention is not so limited. In fact, the principles described herein can improve the functionality of any electronic device in which electrical isolation is desired. Furthermore, the control module described below is only one type of electronic module that can benefit from the present invention. Thus, sensing 15 modules, power supply modules, display modules and other electronic modules can be improved using the principles described herein. Notwithstanding, the following discussion will demonstrate that power tool control modules have a number of aspects for which the present invention is uniquely suited. Turning to the present invention, it can be seen that the 20 power tool 10 has a power cord 12 for providing AC power to the tool 10, and a tool housing 14 that is accessible by a user 16. Tool housing 14 encloses a portion of the power cord 12 while the location of a control module 18 of the present invention is shown in phantom. It will be appreciated that the module 18 could be supported within the tool 10 at different locations within the tool. 25 The illustration of the control module 18 as being within the handle portion therefore represents one suitable internal area of the tool 10 where the control module 18 could be located. The housing 18 may be entirely of a metallic material or some portions thereof may be made from other materials such as plastic.

30 With additional reference to Figures 2 and 3, it is shown generally how the control module 18 connects to the power cord 12 and mechanically couples to an interior surface 20 of the tool housing 14 such that the tool

housing 14 functions as a heat sink for the electronic control module 18. While the discussion herein will primarily refer to the specific use of the heat sink as a tool housing 14, it will be appreciated that the heat sink is not limited to such an application. Nevertheless, by coupling the control module 18 directly to the 5 tool housing 14, significant space savings and flexibility in mounting the control module 18 are realized.

With continued reference to Figures 1-3, it is important to note that the power tool 10, being operated by a user 16, has various external surfaces that are accessible or touchable by the user 16 or which otherwise make user 16 10 contact. Furthermore, at least portions of the tool housing 14 are often made of a material that is electrically conductive, such as a metal alloy. Alternatively, an insulating material such as plastic comprises the tool housing 14 or the exterior surface of the tool housing 14. Thus, the AC source supplying power to the power cord 12 to which the control module 18 is 15 connected, must be electrically isolated from the tool housing 14 in order for a user 16 to avoid electrical shock.

Turning now to Figures 4 and 5, the electronic control module 18 is shown in greater detail. The control module 18 has a housing 22 forming a container with a heat sink cover 24 secured to the module housing 22 by 20 screws 26 and 28. The control module 18 is secured to a mounting surface, such as interior surface 20 of tool housing 14 as shown in Figure 3, by fastening members which extend through holes 30 and 32. Alternatively, the control module 18 may be secured to a mounting surface by an adhesive. The heat sink cover 24 and module housing 22 provide a gap 34 for a wiring 25 harness 36 to pass and be operatively coupled to the power cord 12. Furthermore, the module housing 22 encloses a circuit board, power device and thermal pad (to be described below).

With reference to Figures 6A-6D, the structure of the control module 18 will be explained in greater detail. Specifically, it can be seen that the control 30 module 18 includes a power device 38 and a thermal pad 40. The power device 38 is preferably an isolated-tab thyristor and is electrically connected to an AC voltage source. By selecting the power device 38 to be an isolated-tab

power device, an external tab 42 of the power device 38 is electrically isolated from the AC voltage source. Isolated-tab thyristors are commercially available and commonly provide a minimum breakdown voltage of 2700 volts. Thus, the power device 38 provides a first layer of electrical insulation between the line 5 voltage and the external tab 42.

The thermal pad 40 is disposed between the external tab 42 and the heat sink cover 24. The thermal pad 40 provides a second layer of electrical insulation between the external tab 42 and the heat sink cover 24. Thus, the power device 38 and thermal pad 40 combine to provide a predetermined 10 amount of electrical insulation between the AC source and the tool housing 14 (Figure 1). This double layer of insulation enables a user 16 to contact all external surfaces of the tool housing 14 without fear or risk of electrical shock. Additionally, this double layer of insulation meets TUV and UL requirements 15 with respect to insulation and control module 18 spacing requirements from a user contact surface.

With regard to the thermal pad 40 of Figure 6A and 6B, it will be appreciated that a connection mechanism 44 is coupled to the module housing 22. The connection mechanism is formed by screws 26 and 28 and a support component 49. The support component 49 is formed by a first post 20 50, a second post 52 and a bridge 54 extending between the posts 50 and 52. The connection mechanism 44 functions to compress the thermal pad 40 to a controlled minimum thickness of about 1.0 mm. One such thermal pad 40, for example, is available from Fuji Polymer Industries of Japan under the trade name Sarcon®. This material provides a minimum of approximately 2000 25 volts of electrical insulation and is compressed to a thickness of approximately 1.1 mm. This 1.1 mm thickness meets the mechanical UL requirement for isolation. Considerations in selecting the thermal pad 40 include strength of the material, softness, thermal conductivity, and electrical conductivity.

With reference to Figures 5-6D, it will be appreciated that a wiring 30 harness 36 couples the AC line voltage from the power cord 12 to the control module 18. The circuit board 46 is coupled to the power device 38 and to the wiring harness 36. The circuit board 46 contains conductors for coupling the

AC line voltage to the power device 38. As already mentioned, the control module 18 includes a module housing 22 coupled to the tool housing 14, where the module housing 22 encloses the circuit board 46, the power device 38 and the thermal pad 40. A potting compound 48 is disposed within the 5 module housing 22 to provide required further isolation, structural support, and environmental protection. Acceptable potting compounds are commercially available from a number of well known sources.

Continuing with reference to Figures 6A and 6B, a method of connection of the control module 18 will now be explained. The preferred 10 connection mechanism 44 includes the support member 49 having the first post 50, contacting a first edge of the circuit board 46, and the first screw 26, coupled to the first post 50. The second post 52 contacts a second edge of the circuit board 46, while the second screw 28 couples to the second post 52. It can also be seen that the bridge 54 includes wall portion 56 and portion 15 58 which cooperatively form a receptacle for nesting the power device 38 therein. The bridge 54 is also responsible for maintaining the required thickness of the thermal pad 40 between the external tab 42 and the heat sink cover 24, enhancing the mechanical support provided to the power device 38, and maintaining isolation between screws 26 and 28 and the AC line voltage. 20 The support member 49 is preferably made of plastic, and preferably formed as a single integral formed component.

Assembling the control module 18 of the present invention entails soldering the power device 38 to the circuit board 46 including bending an electrical lead of the power device 38 into a generally "L" shaped configuration 25 38a that extends into and through the circuit board 46 and into the potting compound 48 as shown in Figure 6D. The bridge 54 is disposed between the power device 38 and the circuit board 46. The thermal pad 40 is then applied to the heat sink cover 24, and the thermal pad 40 and heat sink cover 24 assembly is coupled to the circuit board 46 and associated bridge 54, via the 30 connection mechanism 44 shown in Figures 6A and 6B. Upon securing screws 26 and 28, the circuit board 46, connection mechanism 44, and

thermal pad 40 assembly is disposed within the module housing 22 and then potted with the potting compound 48.

Turning now to Figure 7, an alternative embodiment of a control module 60 in accordance with the present invention is shown. The control module 60 includes a thermal pad 62 interposed between a module heat sink cover 64 and a tool housing 66. The thermal pad 62 is preferably approximately 1.2 mm thick and provides the additional insulation necessary to surpass current DI standards for Europe and the United States. A wiring harness 68 extends through an aperture 70 defined by a housing surface 72 of a module housing 74. Screws 76 and 78 extend through holes 80 and 82, respectively, for attachment of the module housing 74 to the tool housing 66. Also, a creepage and clearance distance/path between the tool housing 66 and the heat sink cover 64, in accordance with arrow 65, needs to be provided of about 4 mm.

Through the configuration of Figure 7, the tool housing 66 is usable as a heat sink for the control module 60 without risk of electrical shock if user contact is made with tool housing 66. Unlike the embodiment of Figures 1-6D, the control module 60 of the Figure 7 embodiment does not possess a thermal pad 40 enclosed within the control module 18, as shown in Figures 6A-6D. Alternatively, control module 60 exemplifies an external thermal pad 62 approach to a dual insulation layer concept. It should also be noted that wiring harness 68 must meet applicable UL insulation requirements.

An electronic control module 18 is therefore provided that offers a dual insulation arrangement between the power cord 12 and the tool housing 14 that also serves as a heat sink thereby allowing versatility in mounting the electronic control module 18 to the interior surface 20 and also eliminating the risk of electrical shock to a user 16 making contact with the tool housing 14. Additionally, the double insulated control module 18 provided meets or exceeds TUV and UL standards for its application within a tool housing 14.

Those skilled in the art can now appreciate from the foregoing description that the broad teachings of the present invention can be implemented in a variety of forms. Therefore, while this invention can be

described in connection with particular examples thereof, the true scope of the invention should not be so limited since other modifications will become apparent to the skilled practitioner upon a study of the drawings, specification and following claims.

CLAIMS

What is claimed is:

1. An electronic module adapted to be disposed within a housing of an
5 AC powered power tool and to make use of a portion of the housing as a heat
sink, the module comprising:

a power device having an external tab and being coupled to a line
voltage source, said power device providing a first layer of electrical insulation
between the line voltage source and the external tab of the power device; and

10 a thermal pad disposed between the external tab and the housing, the
thermal pad providing a second layer of electrical insulation between the
external tab and the housing;

15 said first and second layers combining to provide a predetermined
minimum amount of electrical insulation between the line voltage source and
the housing while enabling said housing to function as a heat sink to dissipate
heat developed by said power device.

2. The electronic module of claim 1 further comprising a bridge
support, said bridge support further comprising a first wall and a second wall
to form a receptacle to receive said power device therewithin.

20 3. The bridge support of claim 2 wherein said bridge support
further comprising a first post and a second post, said first post and said
second post being spaced apart from one another and used for securing said
power device within said module.

25 4. The electronic module of claim 1 further comprising a circuit
board, said circuit board being fixedly coupled to said power device.

5. The electronic module of claim 4, wherein said module
comprises a module housing, and a layer of potting compound disposed
within said module housing to support the circuit board on said layer within
said module housing.

30 6. The potting compound of claim 5 wherein said potting
compound is placed within said module housing to fill voids within said
module housing after said electronic module assembly is fully assembled.

7. An AC powered power tool having an electronic control module disposed within a tool housing of the power tool, the tool housing acting as a heat sink for the electronic control module, the power tool comprising:

5 a line voltage passing through said tool housing and connecting to the electronic control module which nests within the tool housing, said electronic control module comprising:

a power device, said power device connecting to said line voltage and providing a first layer of electrical insulation between said line voltage and a power tab of said power device; and

10 a thermal pad, wherein said thermal pad is disposed between said power tab and a control module cover, said thermal pad providing a second layer of electrical insulation between said power tab and said cover and providing a predetermined minimum amount of electrical insulation between said line voltage and said tool housing to prevent electrical shock to a user
15 contacting an external surface of said tool housing wherein said tool housing and said control module cover also act as heat sinks to dissipate heat developed by said power device.

8. The control module of claim 7 further comprising a connection mechanism comprising:

20 a first post on a first side of said power device;
a second post on a second side of said power device;
a bridge portion connecting said first post and said second post, said posts containing threads and securing a first screw and a second screw, respectively.

25 9. The control module of claim 8 wherein said bridge portion of said connection mechanism holds said power device and said thermal pad against said control module cover when said first screw and said second screw are tightened.

10. The thermal pad of claim 9 wherein said thermal pad is
30 compressed to a minimum thickness of 1 mm.

11. The power tool of claim 7 further comprising a power tool wall, said power tool wall further comprising an inside surface and an outside

surface, said power tool wall acting as a heat sink for said control module for heat radiated by said control module when said control module is attached to said inside surface of said power tool wall.

12. The power tool of claim 7 further comprising a circuit board, said 5 circuit board contacting said power device within said control module.

13. The power tool of claim 12 further comprising a potting compound, said potting compound providing a foundation to secure said circuit board within said control module.

14. An electrically isolated, double insulated electronic control 10 module for use in a power tool, the electronic control module comprising:

a module housing, said module housing having four walls, a bottom portion connected to said four walls at one end of said four walls, said four walls having an end opposite said bottom portion thereby defining an opening; a cover that covers said opening of said module housing;

15 a power device having a first side and a second side, said power device second side facing said cover, said power device first side situated on a first side of a bridge portion, said bridge portion further comprising:

20 a first wall and a second wall to form a receptacle to receive said power device therewithin, a first post and a second post, said first post and said second post each linking to said cover by a first fastener and a second fastener, respectively;

25 a thermal pad having a first side and a second side, said first side situated against said cover and said second side situated against said second side of said power device, said first fastener and said second fastener holding said bridge portion, said power device, and said thermal pad against said module housing cover; and

30 a circuit board having a first side and a second side, said first side of said circuit board situated against a second side of said bridge portion, and said second side of said circuit board situated against a layer of potting compound which rests upon said bottom portion of said module housing.

15. An electrically isolated, double insulated electronic control module for use in a power tool housing, the electronic control module comprising:

5 a module housing, said module housing having four walls, a bottom portion connected to said four walls at one end of said four walls, said four walls having an end opposite said bottom portion thereby defining an opening;

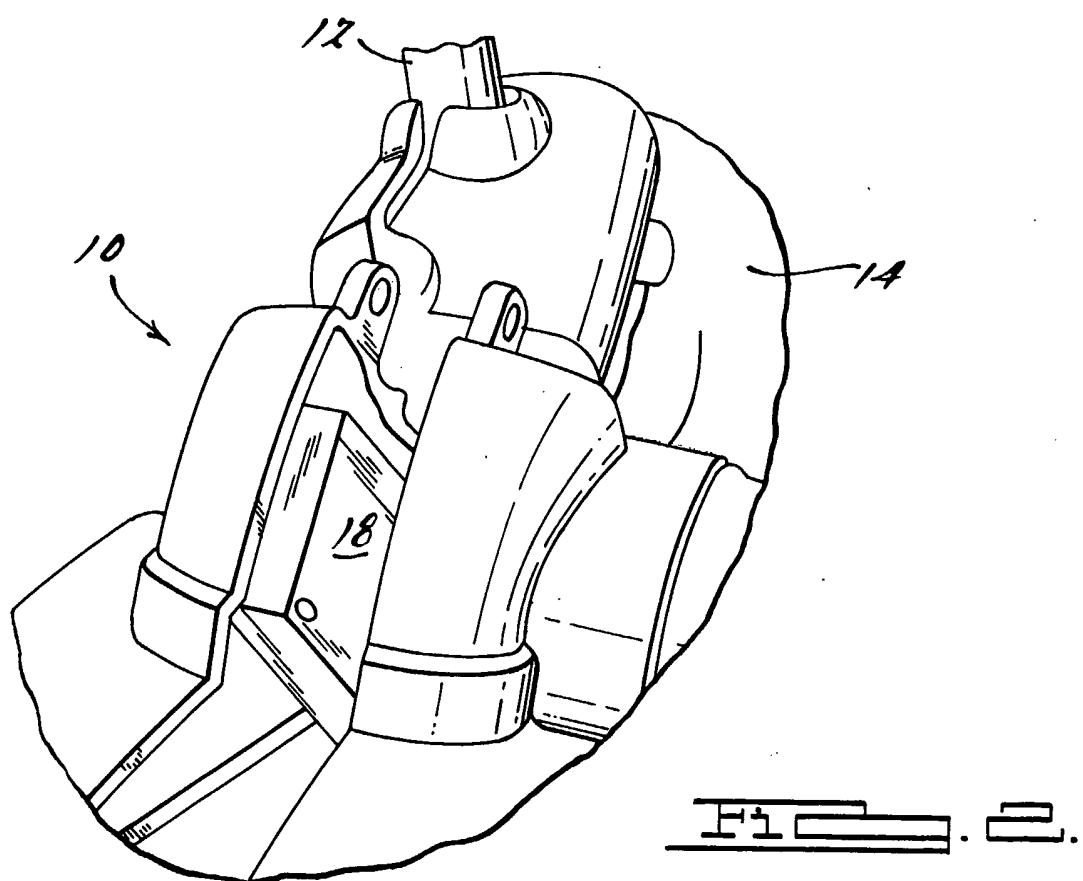
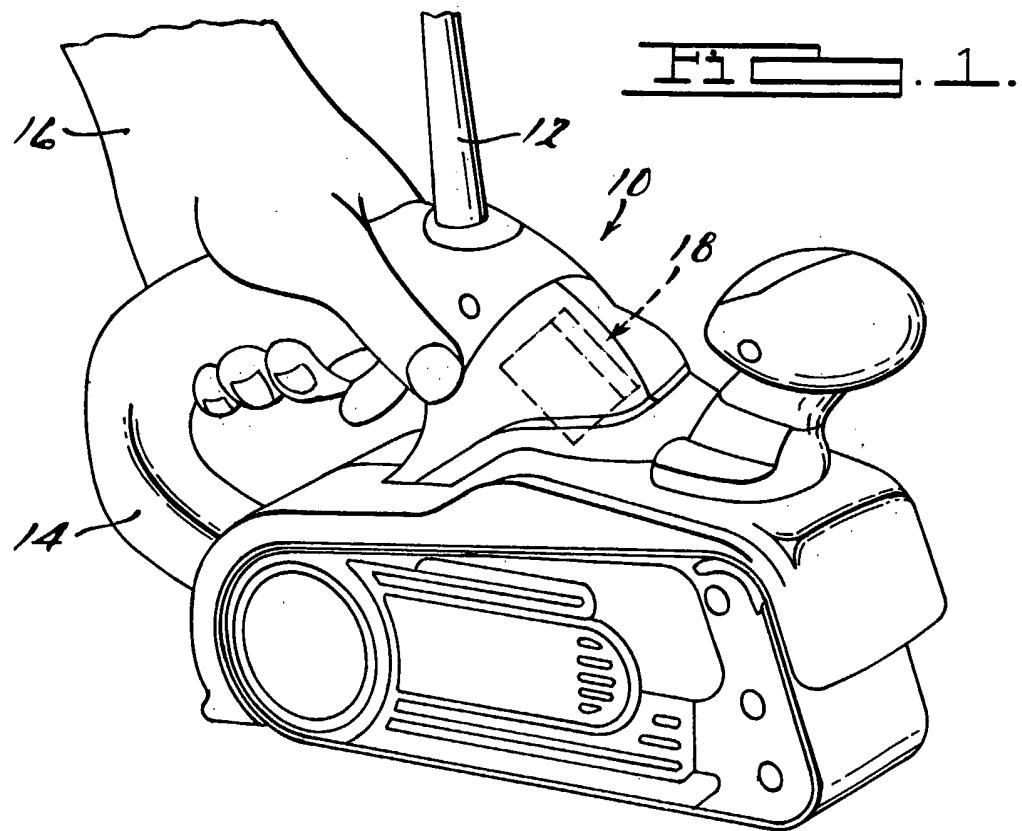
10 a cover that covers said opening of said module housing; a power device having a first side and a second side, said power device second side facing said cover, said power device first side situated on a first side of a bridge portion, said bridge portion further comprising:

15 a first wall and a second wall to form a receptacle to receive said power device therewithin, a first post and a second post, said first post and said second post each linking to said cover by a first fastener and a second fastener, respectively;

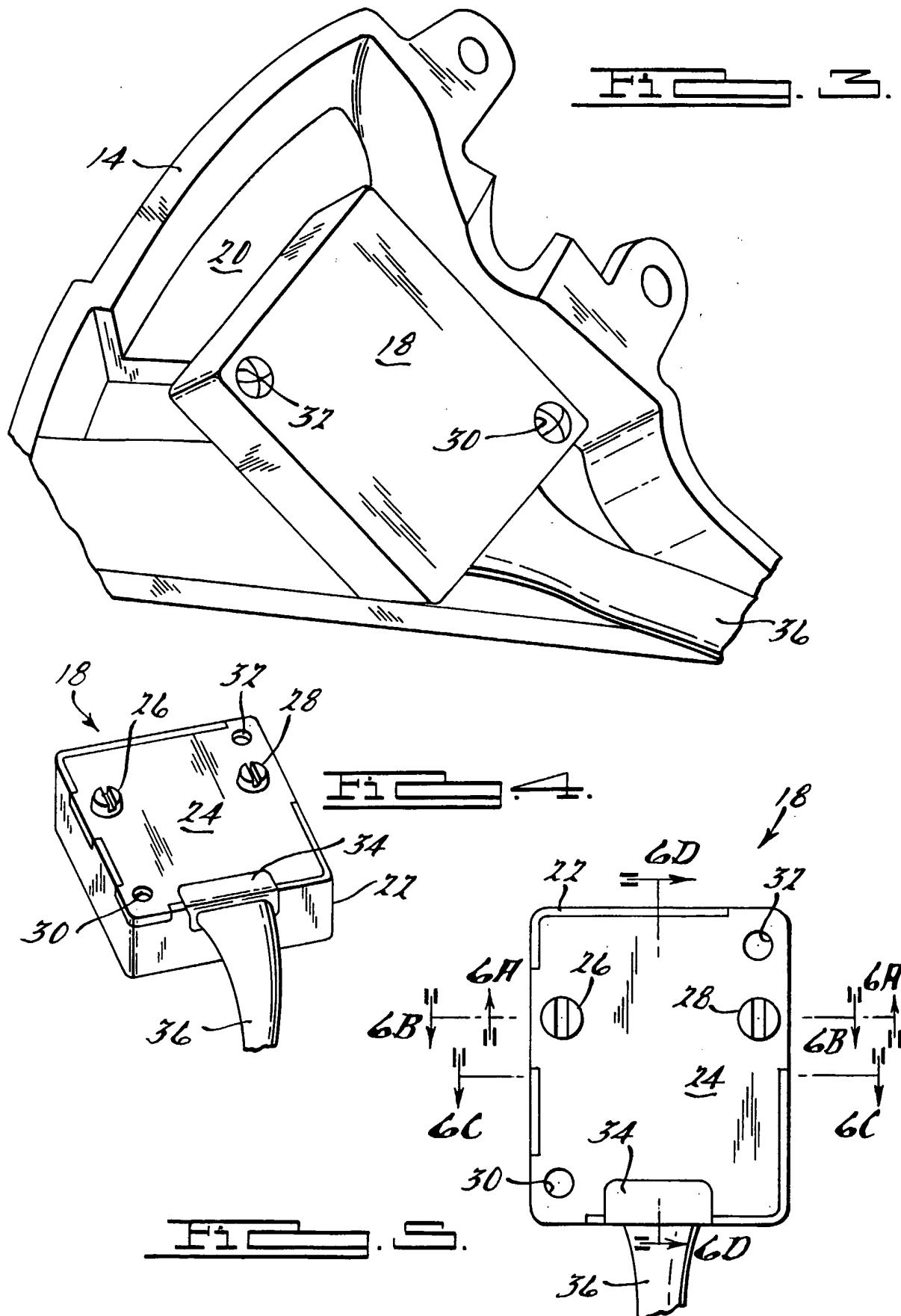
20 a thermal pad having a first side and a second side, said first side situated against said cover and said second side situated against the power tool housing, said first fastener and said second fastener holding said bridge portion and said power device against said module housing cover; and

25 a circuit board having a first side and a second side, said first side of said circuit board situated against a second side of said bridge portion, and said second side of said circuit board situated against a layer of potting compound which rests upon said bottom portion of said module housing.

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2/4



3/4

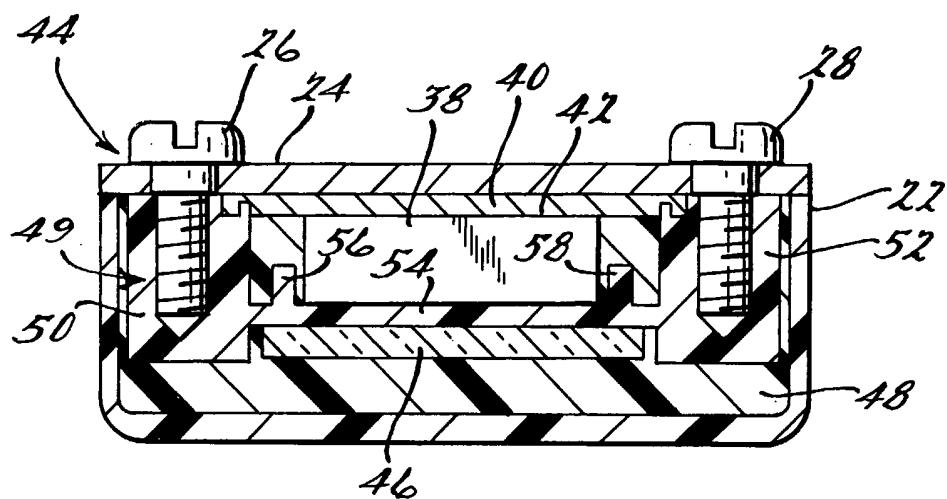


Fig. B.

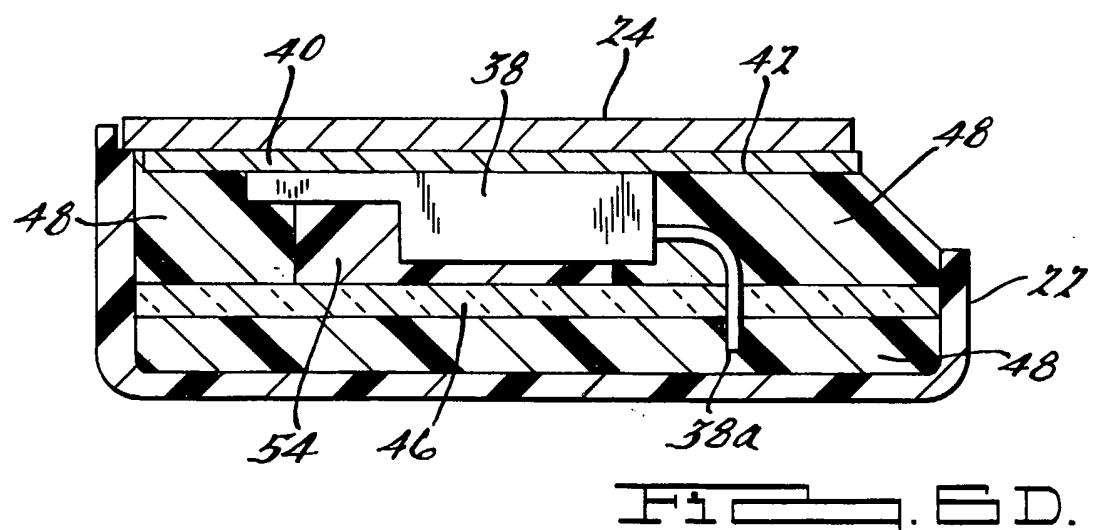


Fig. D.

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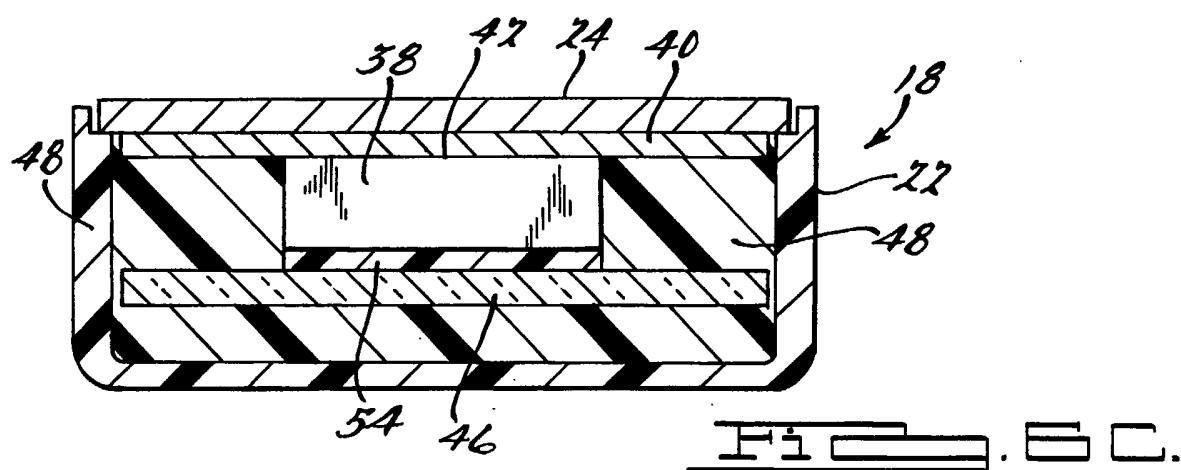
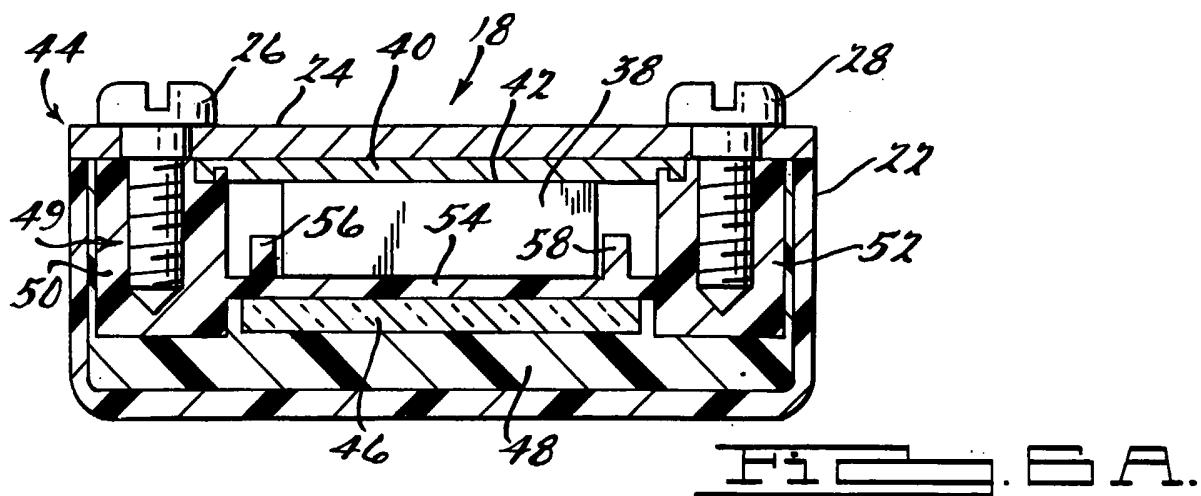
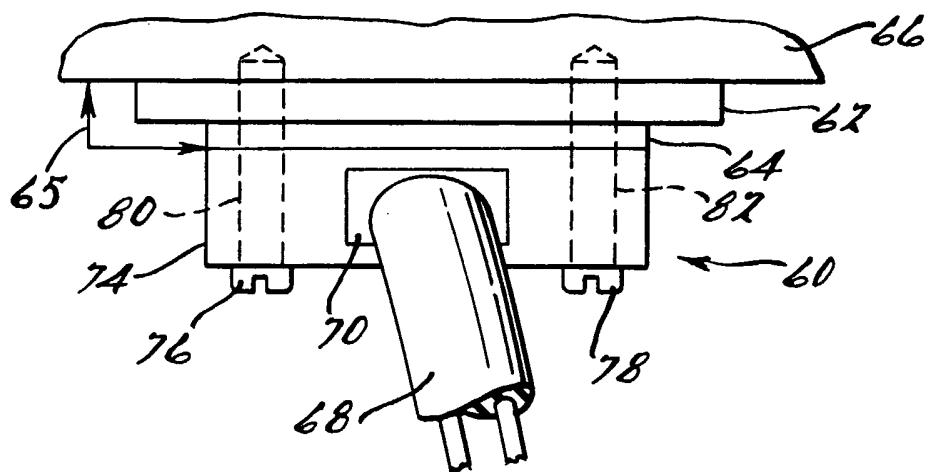


FIG. 7.



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US02/25547

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :H05K 7/20

US CL :Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : NONE

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

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

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,909,358 A (BRADT) 01 JUNE 1999 (01.06.1999), cols.3-5	1 and 4
X	US 5,926,373 A (STEVENS) 20 JULY 1999 (20.07.1999), cols.3-7	1 & 4-6
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A		2,3,7-15

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

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"A"	document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search

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Paralegal Specialist

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US CL :

165/80.3,185 ; 174/16.3,52.2,52.4 ; 257/707,713 ; 361/600,679,704,707,708,715,717,718,722 ; 310/50,91 ;
173/49,216