



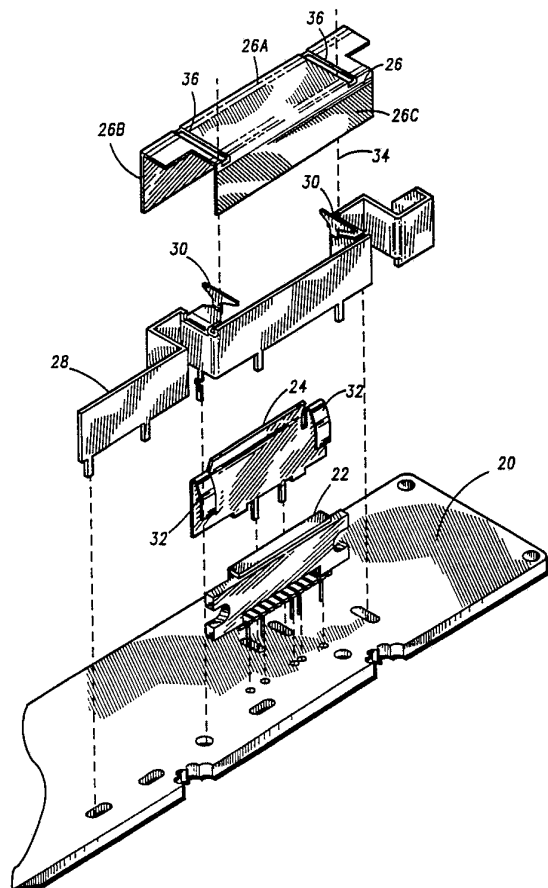
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁵ : H01L 23/02, 25/04, 23/26	A1	(11) International Publication Number: WO 91/17567 (43) International Publication Date: 14 November 1991 (14.11.91)
(21) International Application Number: PCT/US91/02636 (22) International Filing Date: 17 April 1991 (17.04.91) (30) Priority data: 516,843 30 April 1990 (30.04.90) US (71) Applicant: MOTOROLA, INC. [US/US]; 1303 East Algonquin Road, Schaumburg, IL 60196 (US). (72) Inventors: GALICH, Michael, G. ; 207 North Washington Ave., Park Ridge, IL 60068 (US). JOHNSON, Dale, G. ; 795 Interlaken Drive, Lake Zurich, IL 60047 (US). (74) Agents: PARMELEE, Steven, G. et al.; Motorola, Inc., Intellectual Property Dept., 1303 East Algonquin Road, Schaumburg, IL 60196 (US).		(81) Designated States: BR, CA. Published <i>With international search report.</i>

(54) Title: HEAT SINK ASSEMBLY

(57) Abstract

A heat sink/electromagnetic shield assembly for a circuit element (22) disposed upon a circuit board (20). A spring clip (24) containing at least one hooked projection (32) forming the spring is positioned in a confronting relationship with the circuit element (22). A U-shaped housing (26) is slidably positioned over the circuit element (22) and the spring clip (24) to enclose the circuit element (22) and to compress the hooked projection (32) which forms the spring. Compression of the hooked projection (32) causes the hooked projection (32) to exert a spring force to retain the housing (26) in position about the circuit element (22). The assembly may be constructed in line during construction of the electrical circuit (22) disposed upon the circuit board (20).



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	ES	Spain	MG	Madagascar
AU	Australia	FI	Finland	ML	Mali
BB	Barbados	FR	France	MN	Mongolia
BE	Belgium	GA	Gabon	MR	Mauritania
BF	Burkina Faso	GB	United Kingdom	MW	Malawi
BG	Bulgaria	GN	Guinea	NL	Netherlands
BJ	Benin	GR	Greece	NO	Norway
BR	Brazil	HU	Hungary	PL	Poland
CA	Canada	IT	Italy	RO	Romania
CF	Central African Republic	JP	Japan	SD	Sudan
CG	Congo	KP	Democratic People's Republic of Korea	SE	Sweden
CH	Switzerland	KR	Republic of Korea	SN	Senegal
CI	Côte d'Ivoire	LI	Liechtenstein	SU	Soviet Union
CM	Cameroon	LK	Sri Lanka	TD	Chad
CS	Czechoslovakia	LU	Luxembourg	TG	Togo
DE	Germany	MC	Monaco	US	United States of America
DK	Denmark				

5

HEAT SINK ASSEMBLY

10 Background of the Invention

The present invention relates generally to heat
dissipative apparatus for electrical circuitry, and, more
particularly, to a heat sink which may be assembled in-line
15 with an electrical circuit during assembly thereof.

A byproduct of normal operation of an electrical circuit
is thermal energy, i.e., heat. Thermal energy is generated as a
result of frictional effects of charge flow during operation of
the electrical circuit. Greater charge flows i.e., larger
20 currents, generate greater amounts of thermal energy. If not
dissipated, a buildup of thermal energy can cause abnormal
operation of the electrical circuit, and can even cause damage
to the component elements of the electrical circuit, as well as
component elements of other circuits positioned proximate to
25 the component elements.

Generation of thermal energy is particularly significant
in amplification elements such as, for example, a power
amplifier. Because an amplification element amplifies the
values of signals supplied thereto, signals output by the
30 amplification element are oftentimes many times the levels of
the signals supplied to the element. However, the efficiency of
a typical amplification element is only about 60%; therefore,
about 40% of any signal supplied to the amplification element
is not amplified, but, rather, is converted into thermal energy.

- 2 -

In order to prevent damage from occurring to the amplification element (as well as other component elements positioned proximate thereto), means for dissipating the generated thermal energy is oftentimes positioned in close physical proximity to the amplification element. More particularly, heat sinks comprised of thermally conductive materials are oftentimes positioned directly above the amplification element and a thermally conductive path is created between the element and the heat sink to permit thermal energy contained in, or generated during operation of, the amplification element to be conducted to the heat sink whereat the thermal energy is dissipated by convection.

Heat sinks for other electrical circuit component elements are similarly utilized. For example, heat sinks for several small circuit component elements are available which may merely be clipped or otherwise pressed into position upon the element in order to provide a convective surface whereat heat generated by or contained in the circuit element may be dissipated. For example, EG & G WAKEFIELD ENGINEERING of Wakefield, Massachusetts markets a series 298 "pressed top heat sink". This heat sink may be pressed onto a discrete transistor housing and consists of a convective surface and a connecting means comprised of a thermally conductive material to conduct thermal energy away from the transistor to be dissipated by the convective surface. However, no similar heat sink is available for dissipating heat contained in, or generated by, larger circuits.

Existing heat sink apparatus for amplification elements, and other large circuit component elements, comprise an assembly which is affixed to the amplification element. In order to create a thermally conductive path which permits conduction of thermal energy away from the amplification element, a substantial portion of the surface of the element must be maintained in physical abutment with a thermally

- 3 -

conductive material comprising a portion of the heat sink assembly to permit conduction of thermal energy thereaway. In order to maintain such physical abutment, these existing heat sink assemblies require threaded shaft members to
5 provide a clamping force for maintaining the thermally conductive material in the physical abutment with the surface of the element. The thermally conductive material provides a thermal conductive path to a convective surface formed by the heat sink assembly.

10 Such a heat sink assembly is not be assembled in-line during assembly of the electrical circuit, typically disposed upon a circuit board, of which the amplification element, or other circuit component element, forms a portion. Rather, the heat sink and the circuit component is assembled theretogether
15 during a subassembly process, and, only once assembled may the entire subassembly be assembled in-line during assembly of the electrical circuit.

The requirement of a separate subassembly process increases production costs significantly. What is needed,
20 therefore, is a heat sink assembly for a circuit element which may be constructed in-line during assembly of the electrical circuit.

Normal operation of an electrical circuit containing a high frequency oscillator causes generation of high frequency
25 electromagnetic signals. These electromagnetic signals are undesirable as the generated signals can interfere with normal functioning of other electrical circuits. In order to minimize the deleterious effects of such radio frequency electromagnetic signals, electromagnetic shielding materials
30 are oftentimes positioned to cover discrete circuit elements, or even entire electrical circuits. Such shielding materials not only prevent the transmission of the radio frequency electromagnetic signals generated by the electrical circuit over which the shielding material is positioned, but, further,

- 4 -

the shielding material shields the circuit elements and/or circuits to prevent transmission of the radio frequency electromagnetic signals generated by other electrical circuits thereto.

5 Existing electromagnetic shields are typically comprised of a metallic material to prevent the transmission of radio frequency electromagnetic signals. The shield is typically formed of a plate member suitable for positioning above a circuit component element (or entire circuit), and includes side
10 flange portions extending downwardly therefrom to cover side portions of the circuit component element. In order to function properly, the shield must be electrically coupled to the electrical circuit over which the shield is positioned.

Because many electrical devices are packaged in ever-
15 smaller housings, ever-smaller heat sink assemblies and electromagnetic shields are required. In many instances, the heat sink and the electromagnetic shield are combined in a single element. For example, portable transceivers, such as portable, cellular phones, are increasingly miniaturized to
20 permit the transceivers to be of ever-smaller dimensions. A heat sink which further functions as an electromagnetic shield permits increased miniaturization of the portable transceiver.

Summary of the Invention

25 It is accordingly an object of the present invention to provide a heat sink assembly which may be assembled in-line during assembly of the electrical circuit to which the heat sink assembly is to be attached.

30 It is a further object of the present invention to provide a heat sink assembly which further functions as an electromagnetic shield which may be assembled in-line during assembly of the electrical circuit to which the heat sink assembly is to be attached.

- 5 -

It is a still further object of the present invention to provide a heat sink and electromagnetic shield assembly for a portable transceiver which may be assembled in-line during assembly of the transceiver electrical circuits.

5 In accordance with the present invention, an assembly for dissipating thermal energy contained in an electrical circuit having at least one circuit element is disclosed. The assembly includes a convective surface for dissipating heat conducted and convected thereto, and is maintained in a desired position
10 relative to the circuit element by exerting a retentive spring force thereupon. Preferably, the convective surface is comprised of a metallic material, and is electrically connected to the electrical circuit over which the convective surface is positioned such that the convective surface further functions
15 as an electromagnetic shield.

Brief Description of the Drawings

The present invention will be better understood when
20 read in light of the accompanying drawings in which:

Fig. 1 is a perspective illustration, partially exploded, of the heat sink assembly of the present invention;

Fig. 2 is a perspective illustration of a spring clip forming a portion of the heat sink assembly of the present
25 invention;

Fig. 3 is a perspective illustration of a bracket forming a portion of the preferred embodiment of the heat sink assembly of the present invention;

Fig. 4 is a perspective illustration, similar to that of Fig.
30 2, but illustrating a spring clip of an alternate embodiment of the present invention;

Fig. 5 is a perspective illustration of the housing forming a portion of the present invention utilized with the spring clip of Fig. 4;

- 6 -

Fig. 6 is a flow diagram illustrating the method steps of the method of the preferred embodiment of the present invention for constructing the heat sink assembly; and

5 Fig. 7 is a cutaway, perspective illustration of a transceiver having a heat sink assembly constructed according to the teachings of the present invention included therewith.

Description of the Preferred Embodiments

10 Referring first to the perspective illustration of Fig. 1, there is shown the heat sink assembly of the present invention positioned upon circuit board 20. The heat sink assembly is positioned about circuit element 22, shown in hatch, which comprises a portion of an electrical circuit disposed upon
15 circuit board 20. The heat sink assembly of the present invention includes spring clip 24, U-shaped housing 26, and preferably, bracket member 28. Bracket member 28 is mounted upon circuit board 20 and has a face surface portion for positioning against a face surface of circuit element 22 to
20 support circuit element 22 thereagainst. Circuit element 24, shown in hatch in the Figure, is rectangular in shape, similar to the shape of a power amplifier, and bracket member 28 contains folds to permit supportive engagement of a face surface of bracket member 28 against a corresponding face
25 surface of circuit element 22. It is to be noted, of course, that bracket member 28 may be alternately shaped to provide a face surface to abut against a differently-shaped circuit element 22 to permit supportive engagement thereagainst. Bracket member 28 further includes upwardly projecting tab members
30 30 formed integral with the bracket member.

Spring clip 24 is positioned such that a face surface thereof abuts against a face surface of circuit element 22. Preferably, and as illustrated, the face surface of spring clip 24 abuts against a face surface of circuit element 22 opposite

- 7 -

that of the face surface of circuit element 22 abutting against the face surface of bracket member 28. Spring clip 24 includes at least one, and preferably two, hooked projections 32 formed integral with the clip 24. Spring clip 24, and hooked
5 projections 32 projecting therefrom, are comprised of a flexible material such as, for example, a spring-temper, copper-berillium alloy. Compressive forces applied to hooked projections 32 bias the projections, thereby creating a spring force. Spring clip 24, similar to bracket member 28, is further
10 preferably mounted upon circuit board 20.

U-shaped housing 26, positioned in the exploded view of Fig. 1 above the circuit board 20, may be positioned to cover circuit element 22 by translating housing 26 in the vertical direction illustrated by arrows 34 to thereby position the
15 housing 26 about circuit element 22 about three sides thereof. U-shaped housing 26 contains at least one surface comprised of a thermally conductive material, such as aluminum or copper, to form a convective surface. In the preferred embodiment, housing 26 is integrally formed of aluminum, and
20 includes convective surface 26a having side flanges 26b and 26c projecting downwardly from opposing sides of surface 26a. Convective surface 26a further contains slotted openings 36 formed to correspond in position with fastening tabs 30 projecting upwardly from bracket member 28. When housing 26
25 is suitably positioned to enclose circuit element 22 about three sides thereof, fastening tabs 30 extend through slotted openings 36 of housing 26. Once suitably positioned to extend through slotted openings 36, torsional and/or bending forces may be applied to fastening tabs 30 to deflect tabs 30 out of
30 their respective vertical projections to prevent dislocation of housing 26.

When face surfaces of spring clip 24 and bracket member 28 abut against face surfaces of circuit element 22, circuit element 22 is sandwiched therebetween. By positioning

- 8 -

housing 26 such that convective surface 26a rests directly above circuit element 22, the circuit element 22 (as well as spring clip 24 and a portion of bracket member 28) is surrounded by housing 26. Thermal energy contained in, or generated by, circuit element 22 is conducted through clip 24 and bracket 28 to convective surface 26a and flange portions 26b and 26c of housing 26. The thermal energy is dissipated by the surfaces of flanges 26b and c, as well as the convective surface 26a formed integrally therewith, by convection and radiation.

Turning now to Fig. 2, spring clip 24 forming a portion of the assembly of the present invention is shown in greater detail. Clip 24 is preferably comprised of a flexible, thermally conductive material, such as, as previously mentioned, a spring-temper, copper-berillium alloy. Spring clip 24 is of dimensions to form a face surface 37 which may be positioned in a confronting relationship with a thermal energy-containing circuit element. Hooked projections 32 are formed integral with clip 24, and may be constructed by a conventional progressive die process. Surfaces 33 of projections 32 abut against circuit element 22 to form a conductive path to conduct thermal energy thereaway.

Projecting from an end of spring clip 24 opposite that of hooked projections 32 are one or more foot members 38. Foot members 38 are formed integral with clip 24 and project downwardly to engage with circuit board 20 to permit mounting thereupon. In the preferred embodiment of the present invention, foot members 38 of clip 24 are affixed to a ground plane of an electrical circuit disposed upon circuit board 20 to permit electrical connection therewith. Foot members 38 may be affixed to circuit board 20 by any conventional means, such as, for example, by a reverse flow weld material. Application of a compressive force in the

- 9 -

direction illustrated by arrows 40 compresses the hooked projections 32 to generate a compressive spring force thereby.

Fig. 3 illustrates the bracket member 28 forming a portion of the preferred embodiment of the heat sink assembly of the present invention. Bracket member 28 is comprised of an elongated strip of thermally conductive material, such as, for example, a preplated cold-rolled steel or other thermally conductive material. Bracket member 28 contains folds to form at least one face surface 42 which may be positioned in a confronting relationship with a circuit element such as circuit element 22 of Fig. 1. Face surface 42 formed of a portion of bracket member 28 is of dimensions to form a conductive path to facilitate conduction of thermal energy contained in, or generated by, circuit element 22 thereaway. Projecting upwardly from a top side of bracket member 28 are fastening tabs 30. As mentioned previously, fastening tabs 30 may be inserted through slotted openings 36 formed to extend through convective surface 26a of housing 26. Similar to foot members 38 of spring clip 24, foot members 44 formed integral with bracket member 28 and projecting downwardly therefrom at a side of bracket member 28 opposing that of fastening tabs 30, engage with circuit board 20 to permit mounting engagement thereto. Again, foot members 44 preferably engage with a ground plane of the electrical circuit disposed upon circuit board 20 to maintain bracket member 28 in electrical connection therewith.

Because both spring clip 24 and bracket member 28 are comprised of metallic materials, positioning of U-shaped housing 26 thereabout electrically connects the housing 26 to clip 24 and bracket 28, and, hence, to the ground plane of the electrical circuit disposed upon circuit board 20. By enclosing circuit element 22 about three sides thereof by surface 26a, and flanges 26b and 26c, respectively, and by creating an electrical connection between housing 26 and the electrical

- 10 -

circuit disposed upon circuit board 20, housing 26 further functions as a radio frequency electromagnetic shield. More particularly, inner sides of surface 26a and flanges 26b and 26c prevent transmission of electromagnetic energy generated by the electrical circuit and/or circuit element positioned therebeneath, and outer sides of surface 26a and flanges 26b and 26c prevent transmission of electromagnetic energy generated elsewhere to the electrical circuit and/or circuit element.

Turning now to the perspective illustration of Fig. 4, there is shown a further embodiment of a portion of the assembly of the present invention. Spring clip 124 of Fig. 4 differs from spring clip 24 of Fig. 2 in that, in addition to hooked projections 132, spring clip 124 further includes snap members 132A. The snap members 132A are cut about three sides thereof from the face surface of clip 124. Bending forces applied to the projections 132 cause rotation of the projections 132 out of the plane of the face surface 137 of the body of clip member 124. Similar to surfaces 33 of projections 32 of spring clip 24, surfaces 133, shown in hatch, abut against a circuit element, such as circuit element 22, to form a conductive path to conduct thermal energy thereaway.

Fig. 5 illustrates U-shaped housing 126 which may be utilized in conjunction with the spring clip 124 of Fig. 4. Housing 126 of Fig. 5 differs from housing 26 illustrated in Fig. 1 only in that housing 126, in addition to slotted openings 136, further includes slotted openings 137 formed to extend through side flanges 126b and/or 126c extending downwardly from side portions of convective surface 126a. Slotted openings 137 are formed to correspond in position with the snap members 132A of spring clip 124. When housing 126 is positioned to enclose circuit element 22, sliding of housing 126 into position causes compression of snap members 132A. The spring force exerted by snap members 132A, once snaps 132A are aligned with

- 11 -

openings 137, cause the snaps 132A to project through slotted openings 137 to thereby maintain the housing 126 in position about circuit element 22. Hooked projections 132 function similar to hooked projections 32 as described hereinabove.

5 The heat sink assembly of the present invention is advantageous for the reason that the assembly may be assembled in-line during assembly of the electrical circuit upon circuit board 20. The assembly need not be assembled as the subassembly process necessitated to assemble existing
10 heat sink assemblies. Each component portion of the assembly may be affixed to or mounted upon circuit board 20 in a single direction, similar to the positioning required to position any circuit component element disposed upon the circuit board 20.

 Therefore, in the preferred embodiment of the present
15 invention, a method for constructing a heat sink assembly upon circuit board 20 comprises the steps illustrated in the flow diagram of Fig. 6. The method may be carried out during an assembly line-like, automated process. Preferably, circuit board 20 is prebored to permit installation (i.e., mounting) of
20 the assembly component portions by an automated process. First, and illustrated by block 602, bracket member 28 is mounted upon circuit board 20 by insertion of foot members 44 through pre-formed bores extending into circuit board 20. Next, and illustrated by block 604, circuit element 22 is
25 disposed upon circuit board 20 to form a portion of the electrical circuit thereby. Alternately, circuit element 22 may be already disposed upon circuit board 20 prior to installation of the assembly of the present invention. It is important to note, however, that each component portion of the assembly of
30 the present invention is mounted upon circuit board 20 in the same manner that circuit element 22, or any other circuit element is positioned upon circuit board 20. Next, illustrated by block 606, spring clip 24 is mounted upon circuit board 20 by inserting foot members 38 through appropriately positioned

- 12 -

bores extending into circuit board 20. Foot members 38 of
spring clip 24, as well as foot members 44 of bracket member
28, are preferably electrically connected to a ground plane of a
circuit disposed upon circuit board 20, and may be electrically
5 coupled to the ground plane by reflow solder techniques
connecting the foot members 38 and 44 to the ground plane.
Once spring clip 24, and, in the preferred embodiment, also
bracket member 28, have been mounted upon circuit board 20,
U-shaped housing 26 may be lowered into position to enclose
10 circuit element 22 by sliding the flange portions of housing 26
over the clip 24 and bracket 28, as illustrated by block 608, to
compress the hooked projections which, in turn, exert a spring
force. Such spring force maintains the housing 26 in position
to enclose circuit element 22. More particularly, the spring
15 forces exerted by hooked projections 132 are transmitted to
flange portions 26b and/or 26c formed integral with
convective surface 26a to maintain the housing 26 in position
thereby.

Thermal energy contained in, or generated by, circuit
20 element 22 is conducted away from the circuit element through
surface 42 of bracket 28 to the U-shaped housing 26 to be
dissipated thereat by convection and radiation. Additionally,
thermal energy is conducted away from the circuit element
through surfaces 33 of spring clip 24 to the U-shaped housing
25 26 to be dissipated thereat by convection and radiation.
Thermal energy may also be convected directly to the housing
26 to be dissipated thereat. Additionally, because hooked
projections 32 of spring clip 24 electrically connect housing
26 and the ground plane of the electrical circuit disposed upon
30 circuit board 20 (through foot members 38), the housing 26
further functions as an electromagnetic shield for absorbing
radio frequency electromagnetic energy transmitted by circuit
element 22, or radio frequency electromagnetic energy
transmitted to circuit element 22 from other circuits.

- 13 -

Turning now to Fig. 7, there is shown a portable transceiver 702 having transmit/receive circuitry disposed upon circuit boards 704 and housed within housing 706. The assembly of the present invention is advantageously utilized to provide a heat sink and shield for a circuit element, such as a power amplifier disposed upon circuit board 704. Because the assembly of the present invention may be assembled during assembly of the transmit/receive circuitry disposed upon circuit board 704, significant assembly cost savings are permitted. Additionally, because the assembly functions as both a heat sink and an electromagnetic shield, space requirements for the heat sink/shield are minimized. Bracket member 28 further absorbs drop, vibrational, and thermal bending forces which would otherwise be transmitted directly to the circuit element 22, such as the power amplifier.

While the present invention has been described in connection with the preferred embodiments of the various figures, it is to be understood that other similar embodiments may be used and modifications and additions may be made to the described embodiments for performing the same function of the present invention without deviating therefrom. Therefore, the present invention should not be limited to any single embodiment, but rather construed in breadth and scope in accordance with the recitation of the appended claims.

25

Claims

What is claimed is:

5 1. An assembly for dissipating thermal energy contained in an electrical circuit disposed upon an electrical circuit board, and having at least one circuit element, said assembly comprising:

10 means forming a housing having at least one convective, face surface for dissipating heat conducted and convected thereto;

15 means separable from the housing formed by the means for dissipating heat for positioning said housing in a position proximate to the circuit element of the electrical circuit, said means for positioning having at least one foot member integrally formed therewith to affix the means for positioning to the electrical circuit board thereby, and said means for positioning further having means for exerting a retentive spring force forming at least one spring element wherein said at least one spring element protrudes from a surface of the
20 means for positioning and engages with the housing to retain thereby the housing in said position proximate to the circuit element; and

25 means forming a bracket having a face surface thereof positioned in a confronting relationship with a corresponding face surface of the circuit element for supporting the circuit element of the electrical circuit thereagainst, said means for supporting having at least one foot member integrally formed therewith to affix the means for supporting to the electrical circuit board thereby.

30

2. The assembly of claim 1 wherein said means for positioning further provides a thermal conductive path for conducting thermal energy away from the circuit element and to the convective surface to be dissipated thereat.

- 15 -

3. The assembly of claim 2 wherein said means for
dissipating heat, said means for positioning, and said means
for supporting are comprised of electrically conductive
5 materials.

4. The assembly of claim 3 wherein said means for
dissipating heat, said means for positioning, and said means
for supporting are electrically connected theretogether.
10

5. The assembly of claim 4 further comprising means for
electrically connecting the convective surface formed by the
means for dissipating heat and the electrical circuit such that
said convective surface forms a shielding surface thereby.
15

6. The assembly of claim 5 wherein said means for
electrically connecting is comprised of the at least one foot
member formed integral with the means for positioning.

7. The assembly of claim 6 wherein said convective
surface formed by the means for dissipating heat further
comprises downwardly extending flange portions wherein the
flange portions and the convective surface together form a
housing of a U-shaped cross section.
20

8. The assembly of claim 7 wherein the at least one
spring element formed of the means for positioning comprises
at least one hooked projection for springingly engaging with
the flange portions of the housing wherein compression of said
hooked projection provides the retentive spring force for
30 retaining the housing in said position proximate to the circuit
element.

- 16 -

9. The assembly of claim 8 wherein said bracket is comprised of a thermally conductive material for conducting thermal energy away from the circuit element of the electrical circuit supported thereagainst.

5

10. The assembly of claim 9 further comprising a means for fastening the bracket to the convective surface.

1 / 4

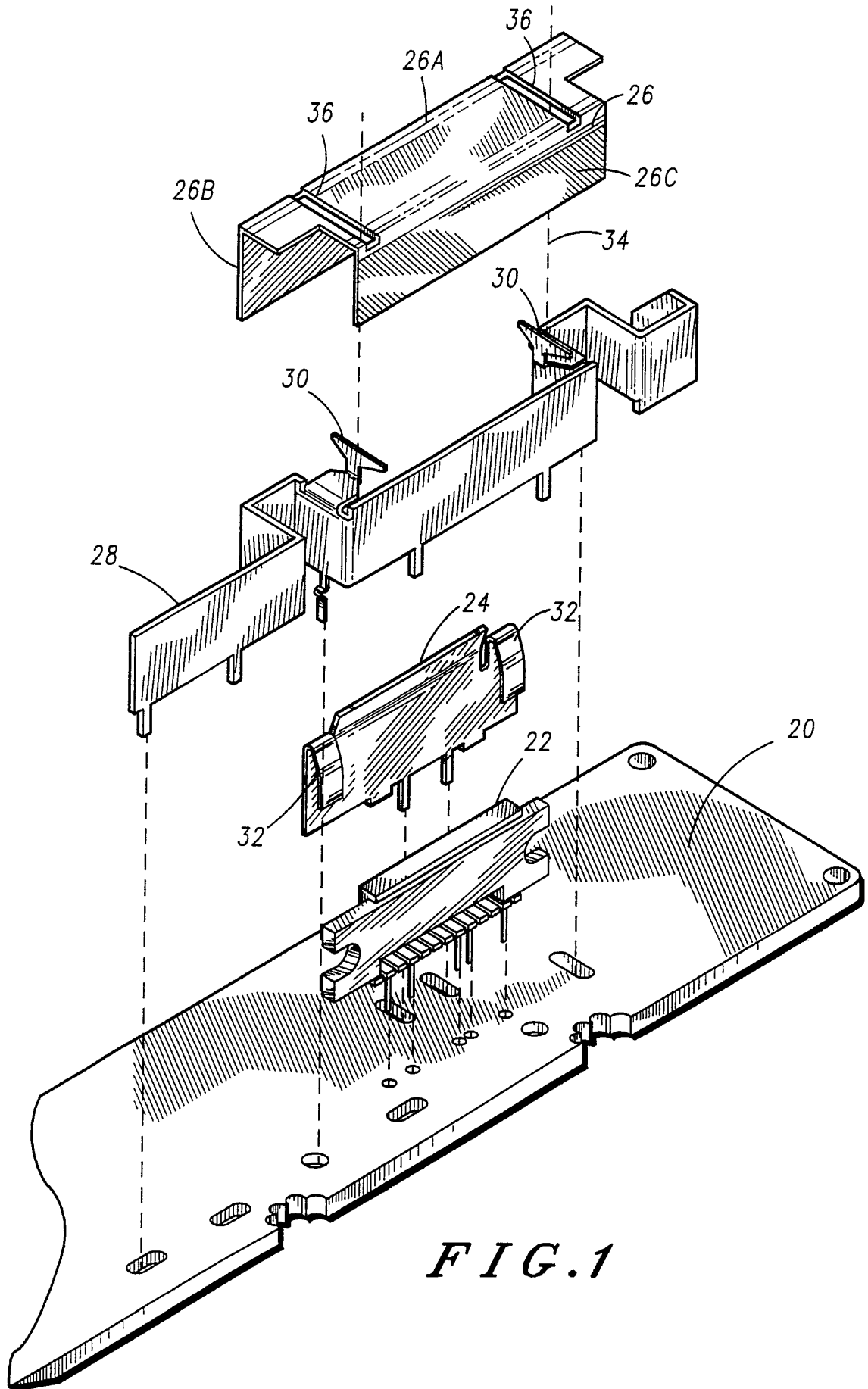


FIG. 1

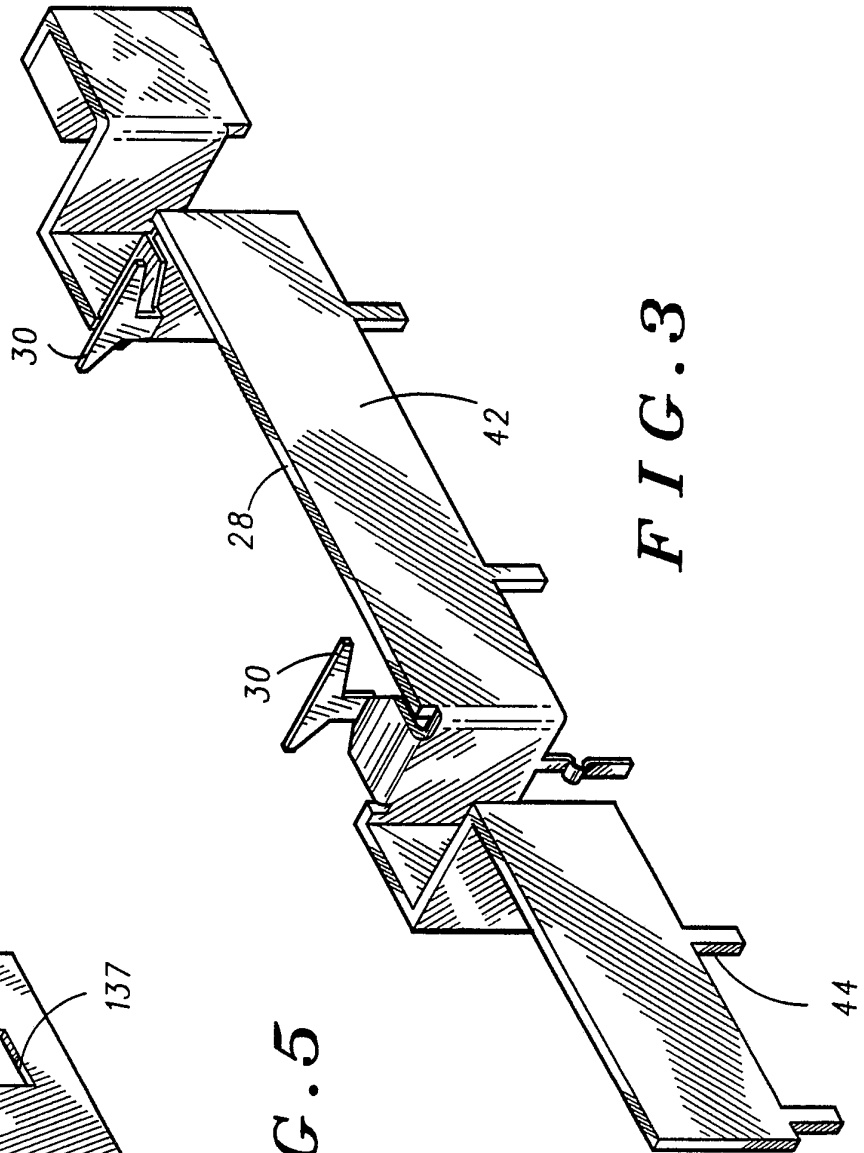


FIG. 3

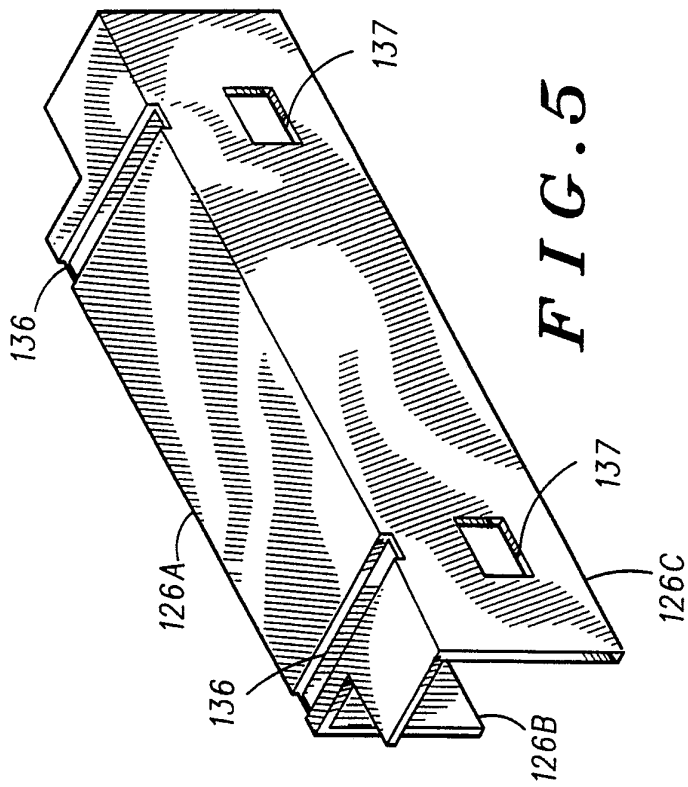


FIG. 5

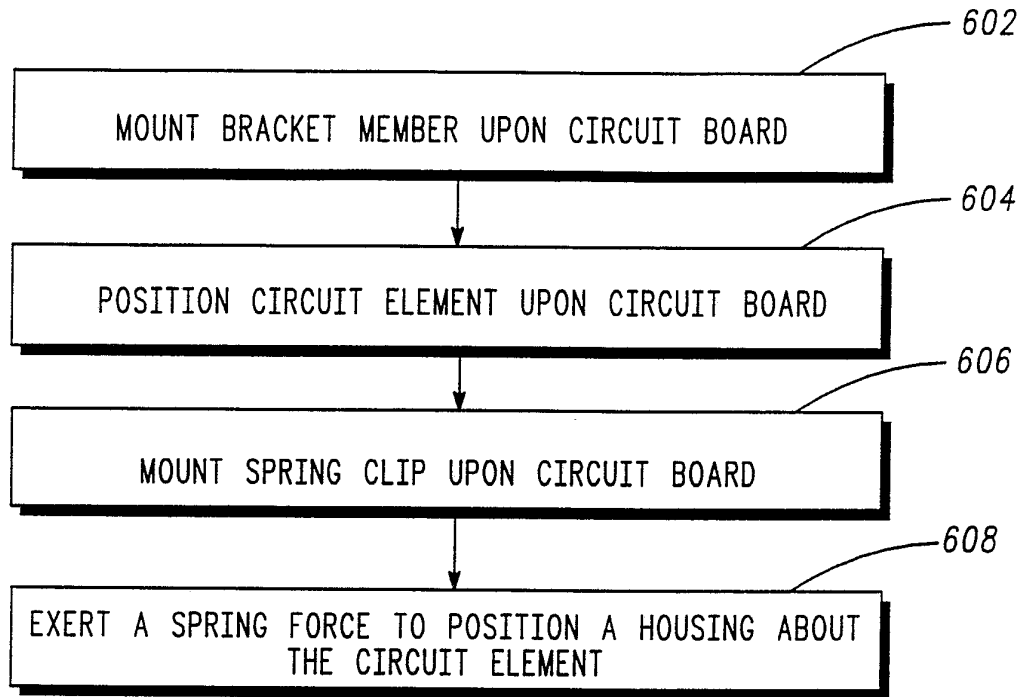


FIG. 6

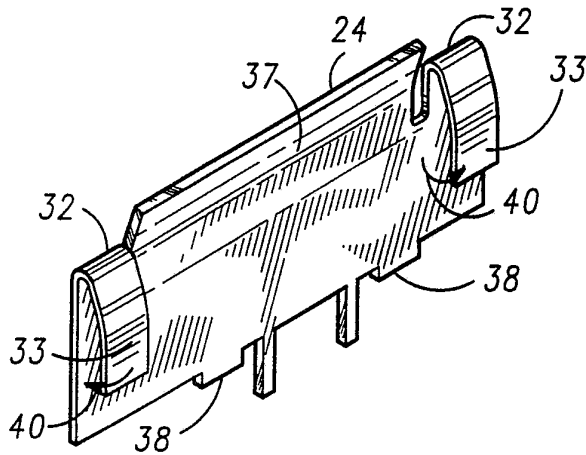


FIG. 2

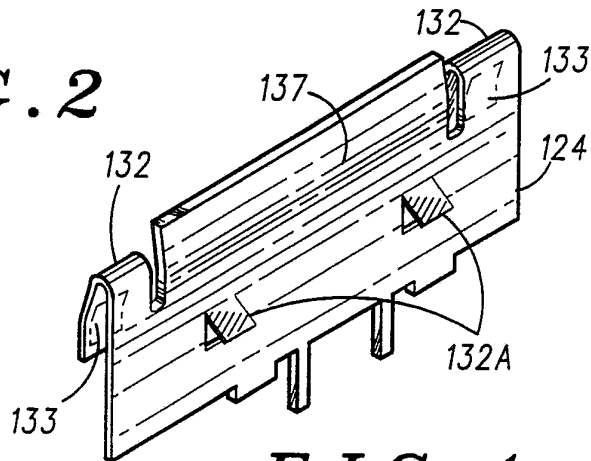
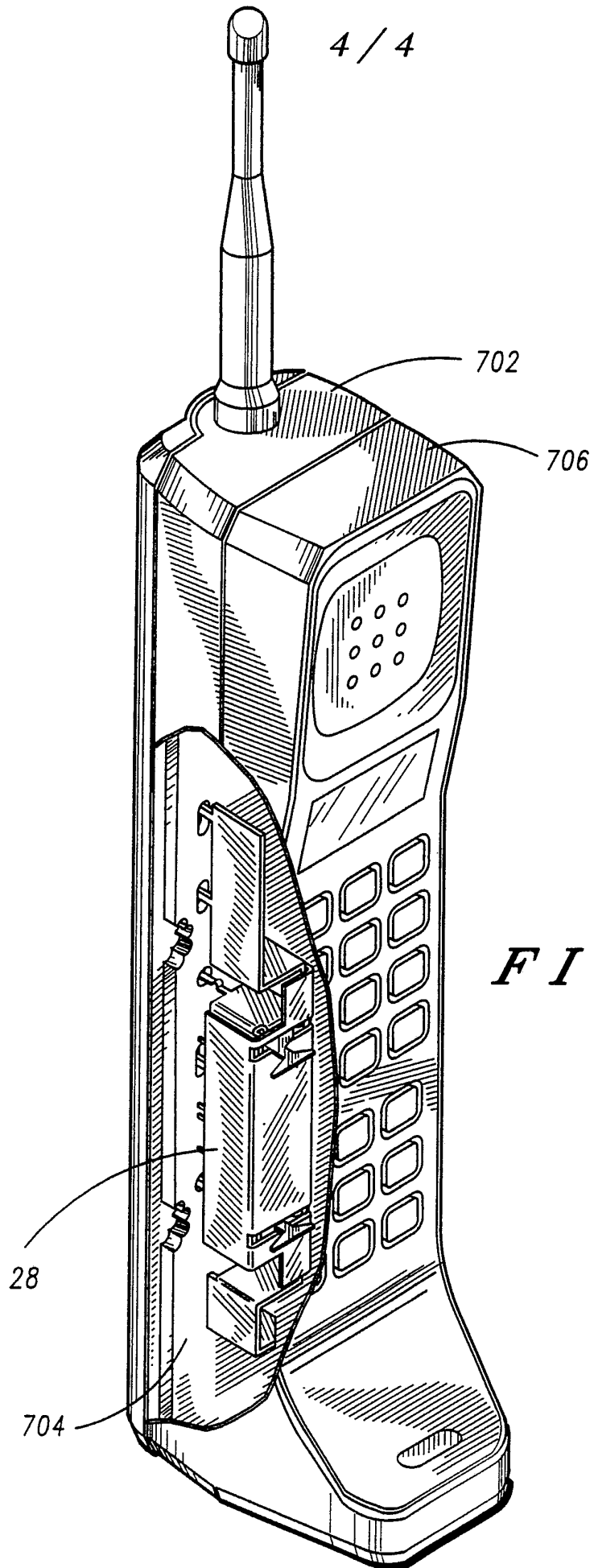


FIG. 4



INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US91/02636

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶				
According to International Patent Classification (IPC) or to both National Classification and IPC IPC(5): H01L 23/02; H01L 25/04; H01L 23/26 US CL.: 357/81,84; 174/16.3,52.5; 361/381,386,389				
II. FIELDS SEARCHED				
Minimum Documentation Searched ⁷				
Classification System	Classification Symbols			
US	357/81,84 174/16.3,52.5	361/381,386,389		
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸				
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹				
Category [*]	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³		
A	US, A, 4,521,828 (FANNING) 04 June 1985	1-10		
A	US, A, 4,481,525 (CALABRO) 06 November 1984	1-10		
A	US, A, 4,707,726 (TINDER) 17 November 1987	1-10		
A	US, A, 4,599,680 (GIBSON et al.) 08 July 1986	1-10		
A	US, A, 4,605,058 (WILENS) 12 August 1986	1-10		
A	US, A, 4,872,089 (OCKEN) 03 October 1989	1-10		
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;"> [*] Special categories of cited documents: ¹⁰ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed </td> <td style="width: 50%; border: none;"> "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 "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family </td> </tr> </table>			[*] Special categories of cited documents: ¹⁰ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"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 "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family
[*] Special categories of cited documents: ¹⁰ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"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 "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family			
IV. CERTIFICATION				
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report			
25 JULY 1991	21 AUG 1991			
International Searching Authority	Signature of Authorized Official			
ISA/US	NGUYEN NGOC HO INTERNATIONAL DIVISION By CARL WHITEHEAD JR <i>Nguyen Ngoc Ho</i>			