(54) Title: HEARING AID CONNECTION SYSTEM

(57) Abstract: A cable (16-1, 16-2, 16-3) incorporates at least one flexible conductor (10a, 10b, 10c) and a non-conductive, elongated, strain relieving member (12) bound mechanically to the conductor. The strain relieving member is mechanically attached between two relatively movable components. The electrical conductor is in turn electrically attached to contacts on the components. Movement of the components relative to one another will be limited by the strain relieving member thereby protecting a somewhat longer electrical conductor extending therebetween. Alternately, a plurality of conductors can be integrally combined with the elongated strain relieving member, by braiding or twisting, to form a unitary cable which incorporates the strain relieving member. In this configuration, all of the conductors in the cable are mechanically protected by the strain relieving member.
Published:
— with international search report
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
HEARING AID CONNECTION SYSTEM

Field of the Invention:

The invention pertains to electrical units which incorporate a plurality of interconnected electrical components. More particularly, the invention pertains to electrical connection systems usable in deformable hearing aids.

Background of the Invention:

Historically, hearing aids have been manufactured with a substantially rigid, non-deformable, body which incorporated a battery, an audio input transducer, a microphone, audio processing circuitry and an audio output transducer, a receiver. Conventional hearing aids of the described type have become smaller and smaller such that they are now available to be almost completely inserted into a user’s ear canal.

Interconnecting wiring in such hearing aids is very delicate given the small size of such units. The conventional types of wire known as litz wire, or magnet wire, have been chosen to reduce transmission of vibrations, mechanical energy, through the hearing aid. The transmission of mechanical vibrations within a hearing aid adds to the likelihood that the unit will oscillate and become unstable.

Hearing aids which incorporate rigid plastic housings provide physical protection for the internal wiring. That wiring does not need to be able to survive tensile loading due to deformation of the hearing aid.

As an alternate to individual wires, flex-circuits or flexible cables have been used in smaller hearing aids such as completely in-the-canal aids. The results of using flex-circuits or flexible cable have not been very satisfactory.

It has been found that vibrations will be transmitted along the circuits causing instability of performance of the respective unit. In addition, flex-circuits or flexible cables are usually designed with very specific lengths and shapes. This, as a result, is not a practical approach for custom hearing aid applications where the varying ear canal shapes which are encountered make these parameters unpredictable.

More recent technologies have focused upon compliant or deformable hearing aids. For example, elastomeric hearing aids are known which have been
designed in the shape of a deformable plug. In such hearing aids, components move in different directions relative to one another. This imposes stresses on the connections.

Another approach has been illustrated in Geib US Patent 3,527,901. Geib illustrates a resilient hearing aid housing where individual looped wires extend between processing circuitry and an output audio transducer. The looped wiring is intended to tolerate deformation of the housing wherein the output transducer moves relative to the processing circuitry. There appears to be no stress protection for the wiring.

There continues to be a need for interconnection system solutions particularly usable in deformable or compressible hearing aids. Preferably, the solution will provide increased tensile strength while not significantly increasing the mass of the respective wires. The resultant wires or cables will preferably be flexible and limp. These characteristics are especially desirable with deformable or compressible hearing aids. Such cables or wires will preferably also resist the transmission of vibrations within the respective hearing aid. Preferably such cable will protect the electronic connections in the presence of relative motion of attached electronic components.

In addition, the wiring system must be very flexible to allow the hearing aid to move or change shape in accordance with the changes in the ear canal. Stiff strain members may protect the overall hearing aid from stretching or flexing in a manner that breaks conventional wiring systems. The disadvantage of this approach is a loss in the ability of a deformable hearing aid to easily change shape. Such strain relief systems reduce the advantage of compliant hearing aids by preventing changes in the shape of the hearing aid structure.
Summary of the Invention:

A non-vibration transmitting wiring system incorporates a light-weight, elongated, low-mass, small cross section non-conductive and high strength strain relieving member such as a non-stretchable thread or a wire in combination with very flexible electrical wires. This strain relief member does not transmit vibrations. This member in disclosed embodiments is twisted or braided into the respective multi-conductor cable assembly.

In one embodiment, a high strength aramid-type fiber, or thread, such as KEVLAR-brand fiber, is twisted or braided with fine litz wires to create a multi-conductor cable. This cable is relatively light weight and limp enough such that it does not transmit vibrations throughout the respective hearing aid. The mechanical braiding or twisting locks the conductors and strain relief member together substantially blocking any relative movement therebetween.

Other organic fibers in the aromatic polyamide family can be used.

Strong inorganic fibers can also be used.

This invention protects the wires that extend between components. Thus, components can be located in more stress prone locations (that is, in locations where more changes in shape take place).

In accordance with the invention, the elongated strain relieving members absorb the mechanical loads between respective electrical units. Light weight flexible wires such as those normally used in hearing aids provide electrical paths between the components of the respective aid but do not provide mechanical stability relative thereto. The mechanical stability is provided by the elongated strain relieving member.

In one aspect of the invention, twisted, insulated, electrical conductors and an elongated plastic strain relieving member are optionally processed so as to form a single unitary electrical cable. One form of processing is to expose or to dip the cable into a solvent, such as alcohol, which softens the external non-conductive coverings of the various conductive wires. These in turn bond to one another, and to the elongated strain relieving element, thereby creating a unitary cable. As an alternate heat, UV or RF can be used to soften the non-conductive coverings, the insulating plastic, to produce
bonding between conductors. The individual wires can be coated with an adhesive, or, a UV curable plastic, which can be activated or cured after the conductors have been combined with the strain relieving member.

In yet another embodiment, the strain relief element can carry a bonding coating or adhesive. The coating or adhesive could be activated after the conductors have been combined with the strain relief member such as by ultraviolet, heat or radio frequency signals. When cured, a unitary cable structure results.

In a disclosed embodiment, the cable is subjected to five to forty twists per inch. Alternately, the wires and the elongated strain relieving member can be braided together.

The elongated strain relieving member is mechanically attached between the respective components thereby limiting movement therebetween. The conducting elements of the electrical cable can then be attached to respective contacts of the components.

The elongated strain relieving members can be attached to the respective components by adhesive, tying, trapping, or any other way that transfers the mechanical loads to the respective components. The electrical conductors themselves when attached can be longer than the length of the respective strain relieving member to permit relatively free motion between the respective components, subject to the length of the strain relieving member.

Benefits of the system of the present invention include the fact that the individual wires as well as the cables are protected from damage due to bending, and tensile forces when used in deformable or compressible hearing aids. The various disclosed cable embodiments do not contribute to vibration transmission within the respective hearing aid. Additionally, the cable subassemblies are very compatible with high quality, low defect manufacturing processes.

The invention provides wires with protection from relative movement of one component relative to another. The applied forces can be independent. The invention does not require judging from which way the force will be applied. It does not require the technician building the aid to make judgments as to which direction the components may be moving.
Numerous other advantages and feature of the present invention will become readily apparent from the following detailed description of the invention and the embodiments thereof, from the claims and from the accompanying drawings.

**Brief Description of the Drawings:**

Figs. 1A and 1B illustrate initial steps of producing a unitary cable in accordance with the present invention;

Fig. 2 illustrates an exemplary apparatus for practicing the method;

Fig. 3 illustrates another apparatus for practicing the method;

Fig. 4 illustrates yet another step in practicing the method;

Fig. 5A-5C illustrate alternate forms of cable in accordance with the present invention;

Figs. 6A, 6B are different views of a system in accordance with the present invention;

Fig. 7 is a block diagram of a hearing aid which embodies the present invention; and

Fig. 8 is a block diagram of another hearing aid which embodies the present invention.

**Detailed Description of the Preferred Embodiments:**

While this invention is susceptible of embodiment in many different forms, there are shown in the drawing and will be described herein in detail specific embodiments thereof with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the specific embodiments illustrated.

Figs. 1-5C illustrate multi-conductor cables and methods of making same. With reference to Fig. 1A, B, one or more of insulated conductors 10a, b, c is combined with an insulating, low mass non-stretching strain relief member 12, such as a glass or aramid-type thread or fiber, so that they all extend generally parallel to one another. A preferred form of the thread or fiber is KEVLAR brand aramid fiber or its equivalent.

The insulated conductors, in accordance with the invention, are not movable relative to the strain relief member. The locking of the strain relief member to
the insulated wires can be accomplished by coating at least the strain relief member 12 with an activatable adhesive or other activatable bonding agent. Activation can be accomplished with a chemical, such as a solvent, or by heat, ultraviolet radiation or radio frequency radiation all without limitation. Other methods of forming unitary cable which incorporates an elongated strain relief member follow.

Fig. 2 illustrates an exemplary winding fixture 14 for the purpose of twisting conductors 10a, b, c and strain relief member 12 together to form a cable 16. It will be understood that the apparatus of Fig. 2 is schematic and exemplary only. The exact details of an apparatus to twist the wires with the strain relief member are not limitations of the present invention.

Fig. 3 illustrates an alternate apparatus 18 for twisting the wires 10a, b, c and the strain relief member 12 together to a specified number of twists per foot. The apparatus 18 includes reels 10a-1, 10b-1, 10c-1 of the respective conductors 10a, b, c. The reels are mounted on a rotating platform 18a.

The conductors 10a, b, c and strain relief member 12 (fed from reel 12a) are drawn through and twisted together in fixture 18b, as platform 18a rotates. Twisted cable 16' is wound onto take-up reel 18c. In cable 16', conductors 10a, b, c are twisted around thread or fiber 12.

The preferred number of twists per foot falls in a range generally on the order of 5 to 40 twists per inch. The result of the twisting process is a multi-conductor cable with an integral elongated strain relief member which, as described subsequently, can be used to protect connections with the conductors.

In Fig. 4 the twisted cable 16' from Fig. 3 is optionally dipped into or coated with a selected solvent, for example alcohol. In this step, once the solvent evaporates or is neutralized, the insulation of the conductors fuses together. The twisted composite 16' of conductors and strain relief member is, as a result, converted into a unitary mechanical structure. The strain relief member 12 is mechanically attached to the adjacent twisted wires 10a, b, c. No relative motion is possible between the member and the twisted wires. Bonding can alternately be achieved using heat or radiant energy, use as ultraviolet-type light or radio frequency signals.
Fig. 5A illustrates another form of a cable 16-1 in accordance with the present invention. In the cable of Fig. 5A, fine wires, for example litz wires 10a, b, c, are braided with a strain relief thread or fiber 12. After braiding, the composite 16-1 can be exposed to an appropriate solvent or activating radiation to fuse the insulation of the various conductors together to create a unitary structure.

Fig. 5B illustrates an alternate cable 16-2 wherein conductors 10a, b, c and strain relief element 12 are twisted together about a common central axis. These elements can be treated by heat, radiant energy or solvent to cause them to bond together to form a unitary structure.

Fig. 5C illustrates yet another cable 16-3 in accordance with the present invention. A plurality of insulated conductors 10a, b, c is wrapped around a central strain relieving thread or string 12, of the general type discussed above, and then wrapped with plastic 10d. The resulting composite 16-3 can then be exposed to a selected solvent or activating radiation to create a unitary structure.

It will be understood that other configurations of unitary cables and methods of making same are possible. All such variations come within the spirit and scope of the present invention.

Cables as described above can be constructed with various numbers of conductors as needed. In all instances, the elongated, non-conducting strain relieving thread or string will not be able to move relative to the conductors. Similarly, none of the conductors in the cable will be able to move relative to one another. As discussed below, the thread or string can be used as a strain relief between electrical components. Where the components are movable relative to one another, the strain relief member will protect the conductors and connections, for example solder joints, thereto.

Figs. 6A, 6B illustrate a two component electrical system 40. In the system 40, a unitary cable 42 of the type described above interconnects electrical components C1 and C2 which are movable relative to one another. It will be understood that cables of the type described above could be advantageously used in a variety of electrical/electronic systems where the electrical interconnections need to be protected from relative motion between components.
The cable 42 includes an integral, elongated strain relieving member or thread 42a. The member 42a is mechanically attached to each of the components C1,2 at respective joints 44a,b. Any type of mechanical attachment between the components C1,2 and the member 42 comes within the spirit and scope of the present invention. For example, ends 42a-1,-2 could be attached using adhesive or any type of mechanical clamp.

Once a secure mechanical bond has been established between member 42a and the components C1,2 the ability of the components to move, relative to one another such as motions M1,M2, M3, M4 is limited by the distance that the member 42a extends between the joints 44a,b.

The cable 42 also includes conductors 42b,c which are bonded to member 42a in the cable 42. The length of the conductors 42b,c is longer than is the length of the member 42a. As a result, when ends of the conductors 42b,c are electrically coupled, soldered for example, at terminals C1-1, 2 and C2-1, 2 to components C1,2 the electrical conductors are protected from mechanical shock and strain, particularly at the respective joints 46a,b,c,d by the elongated, non-stretchable strain relief member 42a.

Cables in accordance with the present invention, such as cable 42, can be manufactured in advance and combined with components C1,2 in accordance with cost-effective manufacturing practices. It will be understood that the conductors 42b,c could be implemented as individual, insulated wires or as preformed ribbon cable which can be used in automatic assembly machines.

Fig. 7 illustrates a hearing aid 50 which incorporates a cable 52 in accordance with the present invention. The aid 50 includes a preassembled electronic module 54a and an audio output transducer, receiver, 54b. The cable 52 interconnects the two modules. The modules are to be inserted into a flexible housing 50a.

Once the modules have been inserted into housing 50a, region 50b, the inner ear end 50a-1 will be deflected, relative to outer ear end 50a-2 when the aid is being inserted into or removed from a user’s ear canal. In addition, as the ear canal changes shape, due to jaw movement, the ends 50a-1,-2 move relative to one another.

The integrally formed cable 52 improves long term reliability and functionality of the aid 50 due to its structure and performance characteristics. Cable 52
includes an elongated strain relief member 52a, formed of one or more glass or aramid-type fibers, such as a KEVLAR brand fiber. As described above, the member 52a is bonded to insulated conductors 52b,c,d. Other materials, comparable to KEVLAR-brand fiber, including substantially non-stretching plastics, or fiberglass could also be used without departing from the spirit and scope of the present invention.

The conductors 52b,c,d are electrically coupled to the modules 54a,b by solder as will be understood by those of skill in the art at regions 56a,b. The member 52a is mechanically attached, for example by adhesive, to the components 54a,b as indicated in regions 52a-1,-2. It will be understood that other forms of connection, such as mechanical, could be used without departing from the spirit and scope of the present invention.

Any mechanical shocks due to movement of the ends 50a-1,-2 will be taken by the member 52a thereby protecting the connections 56a,b and the conductors 52b,c,d. In addition, once the member is mechanically attached to the components 54a,b it will protect the connections 56a,b during subsequent manufacturing steps prior to insertion into the housing 50a. Hence, the operation of the components 54a,b can more easily be evaluated in test fixtures as the assemblage need not be treated as gently as heretofore required for earlier, similar assemblages which did not include the unitary strain absorbing cable 52.

When the assemblage 52, 54a, b is being inserted into the housing 50a, the member 52a will continue to protect the connections 56a,b. This can be expected to reduce manufacturing reworks due to wiring failures.

Fig. 8 illustrates a system 60 which includes a plurality of cables 62a,b,c in accordance with the present invention. The cables interconnect components 64a,b,c,d. In each instance, each pair of components, such as 64a,b is mechanically interconnected with a respective elongated strain relieving member, such as member 62a-1, also 62b-1, and 62c-1. As described above, these members protect the respective electrical connections at each component such as connections 64a-1 and 64b-1, 64b-2, 64c-1, 64d-1.

In the case of system 60, the use of multiple cables 62 facilitates electrical assembly and testing prior to installation into a hearing aid. The existence of
these benefits is independent of the type of housing of the respective hearing aid into which the system 60 is inserted.

   It will be understood that while Figs. 7, 8 illustrate the use of the present unitary cables in hearing aids, such illustrations are exemplary only. Cables in accordance with the present invention can be used in a variety of electrical units without departing from the spirit and scope of the present invention. The manufacturing and testing benefits discussed above are also independent of the type of units with which the cables are to be used.

   From the foregoing, it will be observed that numerous variations and modifications may be effected without departing from the spirit and scope of the invention. It is to be understood that no limitation with respect to the specific apparatus illustrated herein is intended or should be inferred. It is, of course, intended to cover by the appended claims all such modifications as fall within the scope of the claims.
What is Claimed:

1. A wiring system for coupling first and second electrical units, movable relative to one another, comprising:
   at least one elongated, flexible, non-conductive, strain relieving member and at least one elongated, flexible electrical conductor wherein the conductor is at least intermittently locked axially to the strain relieving member by one of winding and braiding and wherein the combined member and conductor extend between the units and are respectively mechanically and electrically coupled therebetween such that relative movement of the units is limited by the member thereby protecting the electrical coupling between the units.

2. A system as in claim 1 which includes a plurality of elongated wires combined by one of winding and braiding with the strain relieving member.

3. A system as in claim 2 wherein the conductors are insulated from one another and the insulation is, at least intermittently, bonded together.

4. A system as in claim 3 wherein the conductors and the strain relieving member are bonded together.

5. A system as in claim 1 wherein the strain relieving member comprises one of non-stretching polymer, glass fiber, and aramid-type fiber.

6. A system as in claim 1 wherein the member is selected from a class which includes an aromatic polyamide fiber, and a non-stretching inorganic fiber.

7. A system as in claim 2 wherein the conductors are combined with at least a second strain relieving member wherein the strain relieving member extends between a first pair of conductor ends and the second member extends between a second pair of conductor ends.

8. A system as in claim 7 wherein a first electrical unit is attached to one end of the strain relieving member, a second electrical unit is attached to another end of the member and to one end of the second member and, a third electrical unit is attached to another end of the second member.

9. A system as in claim 8 wherein at least one conductor is coupled between each pair of electrical units.
10. A system as in claim 8 wherein one unit comprises an amplifier, the second comprises a microphone and the third comprises a receiver.

11. A hearing aid comprising:
   a housing;
   at least two spaced apart electrical components carried by the housing wherein the at least two components are interconnected with at least one elongated strain relieving member wherein the member is mechanically attached to each of the at least two components; and,
   at least one wire coupled to the strain relieving member and electrically connected to each of the components whereby movement of the components, relative to one another, is limited by the member thereby isolating the electrical conductor from relative movement induced forces.

12. A hearing aid as in claim 11 wherein a plurality of litz wires are axially joined with the strain relieving member, wherein at least two members of the plurality are electrically connected between the components.

13. A hearing aid as in claim 11 wherein the effective distance between the components, as limited by the strain relieving member, is less than conductor length.

14. A hearing aid as in claim 12 wherein the effective distance between the components, as limited by the strain relieving member, is less than conductor length.

15. A hearing aid as in claim 11 wherein the housing is deformable.

16. A hearing aid as in claim 12 wherein the housing is deformable.

17. A hearing aid as in claim 13 wherein the housing is deformable.

18. A hearing aid as in claim 14 wherein the housing is deformable.

19. A hearing aid as in claim 14 wherein one of the components comprises a microphone, another comprises signal processing circuitry and a third comprises an audio output transducer wherein one elongated strain relieving member extends between the microphone and the circuitry and a second elongated strain relieving member extends between the circuitry and the output transducer.
20. A hearing aid as in claim 18 wherein one of the components comprises a microphone, another comprises signal processing circuitry and a third comprises an audio output transducer wherein one elongated strain relieving member extends between the microphone and the circuitry and a second elongated strain relieving member extends between the circuitry and the output transducer.

21. A method of making an electrical cable comprising:
   providing at least one elongated, substantially non-stretchable, non-conductive; flexible strain relief member;
   providing at least one elongated, flexible electrical conductor;
   coupling the strain relief member to the conductor by one of winding and braiding thereby precluding relative motion therebetween wherein the strain relief member extends coextensively with the conductor for a substantial portion of the length of one of the strain relief member and the conductor.

22. A method as in claim 21 which includes providing a plurality of conductors.

23. A method as in claim 22 wherein the coupling step comprises fusing at least insulators for the conductors at least to one another.

24. A method as in claim 22 which includes exposing the conductors to one of ultraviolet-type radiant energy, radio frequency-type radiant energy, heat, and a selected solvent.

25. A method as in claim 23 wherein at least the conductors are fused together after the coupling step to form a unitary cable.

26. A method as in claim 24 wherein at least the conductors are fused together after the coupling step to form a unitary cable.

27. A method of making an electrical cable comprising:
   providing a plurality of insulated conductors;
   providing an elongated, substantially unstretchable, non-conductive strain relief member;
   winding the conductors and the strain relief member together so as to substantially block relative axial movement therebetween; and
bonding at least the insulated conductors together forming a unitary cable.

28. A method as in claim 27 wherein the combining step comprises twisting the conductors and the strain relief member together with twists/inch in a range on the order of five to forty twists per inch.

29. A method as in claim 27 wherein the combining step comprises mechanically attaching conductors to the strain relief member.

30. A method as in claim 27 wherein the combining step comprises wrapping the conductors and the strain relief member with a flexible member.

31. A method as in claim 27 in which the bonding step includes exposing at least the conductors to one of a solvent, heat, ultra-violet type radiant energy, and radio frequency energy.

32. A method as in claim 31 which includes providing a selected alcohol as the solvent.

33. A method of wiring comprising:
   providing a unitary cable having at least one elongated conductor axially mechanically bonded to an elongated strain relief member;
   providing at least two components which are to be electrically coupled and mechanically attached to one another;
   mechanically attaching first and second ends of the strain relief member to respective first and second components whereby relative movement therebetween is limited by the strain relief member, and, electrically connecting the components together by coupling them to respective ends of the conductor wherein the conductor has a physical, end-to-end, length greater than the length of the strain relief member between the components.

34. A method as in claim 33 which includes providing a plurality of insulated litz wires bonded to the strain relief member by one of twisting and braiding.

35. A method as in claim 34 which includes electrically coupling the components via the plurality of conductors.
36. A method as in claim 33 which includes moving the components relative to one another while protecting the conductor and the electrical connections with the components by the shorter length of the strain relief element.

37. A method as in claim 33 which includes twisting the conductor and the strain relief member together to form the unitary cable.

38. A method of manufacturing a hearing aid comprising:
   providing at least two electrical components for installation into the hearing aid;
   mechanically connecting the components together with a flexible, elongated, non-stretchable strain relief member;
   electrically connecting the components to one another whereby the member, not the electrical connection, absorbs mechanical stresses due to moving the components relative to one another;
   providing a housing for the aid; and
   inserting the interconnected components into the housing.

39. A method as in claim 38 which includes one of twisting and braiding the member with a plurality of litz wires, and, wherein the electrically connecting step includes connecting the conductors to terminals on the components.

40. A method as in claim 38 which includes:
   electrically testing the interconnected components before inserting them into the housing.

41. A method as in claim 38 wherein the mechanically connecting step includes applying adhesive to at least one of the components, embedding an end of the member in the adhesive and curing same.

42. A method as in claim 38 wherein the mechanically connecting step includes mechanically clamping an end of the member to one of the components.

43. A method of assembling a multiple component electrical unit comprising:
   providing a plurality of electrical components;
   providing a plurality of cables each having an elongated strain absorbing member, attached axially to a plurality of coextensive electrical conductors;
mechanically connecting ends of the members to respective electrical components thereby limiting the relative movement between interconnected components;
electrically coupling ends of the conductors to respective components; and
moving the components and testing the interconnected components.
Fig. 7

VENT

AUDIO OUTPUT
# INTERNATIONAL SEARCH REPORT

**A. CLASSIFICATION OF SUBJECT MATTER**

- IPC(7) : H01B 11/02
- US CL : 174/116

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)


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

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

East Text Search

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
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<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tr>
<td>X</td>
<td>US 3,433,890 A (GABRIEL et al.) 18 March 1969 (18.03.1969), see all Figures.</td>
<td>1, 2, 6, 7</td>
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<td>3, 4, 5</td>
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<td>Y</td>
<td>US 5,359,150 A (IKEUCHI) 25 October 1994 (25.10.1994), Figure 6.</td>
<td>3, 4, 23-32</td>
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<td>X</td>
<td>US 5,808,239 A (OLSSON) 15 September 1998 (15.09.1998), Figure 2 &amp; the Abstract.</td>
<td>43</td>
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<td>X</td>
<td>US 4,326,094 A (HUNN) 20 April 1982 (20.04.1982), Figs 1, 2 &amp; 4-6.</td>
<td>21, 22</td>
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* Further documents are listed in the continuation of Box C. Yes

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<tr>
<td>&quot;A&quot;</td>
<td>document defining the general state of the art which is not considered to be of particular relevance</td>
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<tr>
<td>&quot;E&quot;</td>
<td>earlier document published on or after the international filing date</td>
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<tr>
<td>&quot;L&quot;</td>
<td>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)</td>
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<tr>
<td>&quot;O&quot;</td>
<td>document referring to an oral disclosure, use, exhibition or other means</td>
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<tr>
<td>&quot;P&quot;</td>
<td>document published prior to the international filing date but later than the priority date claimed</td>
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"I" | 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 when the document is taken alone |

"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 |

| See patent family annex. |

Date of the actual completion of the international search: 30 OCTOBER 2001

Date of mailing of the international search report: 14 DEC 2001*

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Form PCT/ISA/210 (second sheet) (July 1998)*
<table>
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<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tr>
<td>A</td>
<td>US 5,920,635 A (LENZ) 06 July 1999 (06.7.1999), Figures 3 and 4.</td>
<td>11, 38</td>
</tr>
</tbody>
</table>

Form PCT/ISA/210 (continuation of second sheet) (July 1998)∗
INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/20590

Box I  Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  
   [ ] Claims Nos.:  
   because they relate to subject matter not required to be searched by this Authority, namely:

2.  
   [ ] Claims Nos.:  
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3.  
   [ ] Claims Nos.:  
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 64(a).

Box II  Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

   Please See Extra Sheet.

1.  
   [X] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2.  
   [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3.  
   [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4.  
   [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet(1)) (July 1998)
BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I, claims 1-10 and 43, drawn to a wiring system and a method of assembling a multiple component unit.
Group II, claims 11-20, drawn to a hearing aid.
Group III, claims 21-32, drawn to a method of making an electrical cable.
Group IV, claims 33-37, drawn to a method of wiring.

The inventions listed as Groups I, II, III, IV and V do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:
Group I is directed to a wiring system wherein a non-conductive member is used with at least one electrical conductor as a strain relieving member. Group II is directed to a hearing aid with housing and spaced apart electrical components, etc. Group III is directed to a method of making an electrical cable in which fusing, ultraviolet-type radiant energy, radio frequency-type radiant energy, heat or a selected solvent is used in making the cable. Group IV is directed to a method wiring wherein two electrical components are connected together by a plurality of litz wires. Group V is directed to a method of manufacturing a hearing aid in which an electrical testing the interconnected components before inserting them into the housing is required. Accordingly, the listed Groups do not relate to a single inventive concept.