United States Patent [19]

Meyer

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[54] **COMMUNICATIONS CONNECTOR APPARATUS UTILIZING RADIANT ENERGY**

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[52] **U.S. Cl.**..... **200/51 R,** 200/51.09, 250/217 S

[51] **Int. Cl.**..... **H01r 13/70**

[58] **Field of Search**..... 250/217 S, 237 R, 277; 235/61.11 E; 200/51.09

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Attorney, Agent, or Firm—Robert M. Angus; Joseph A. Genovese

[57] **ABSTRACT**

Connector apparatus for a communications link includes first and second mateable housings defining an interface region therebetween. A plurality of radiation emitting devices are supported by one of the housings and a like plurality of radiation responsive devices are supported by the other housing so that upon application of an electrical signal to a radiation emitting device, the radiation emitting device emits radiation across said interface region to impinge a corresponding radiation responsive device. The level of radiation is representative of the level of the applied electrical signal, and the electrical characteristics of the receiving radiation responsive device are representative of the level of incident radiation.

14 Claims, 5 Drawing Figures

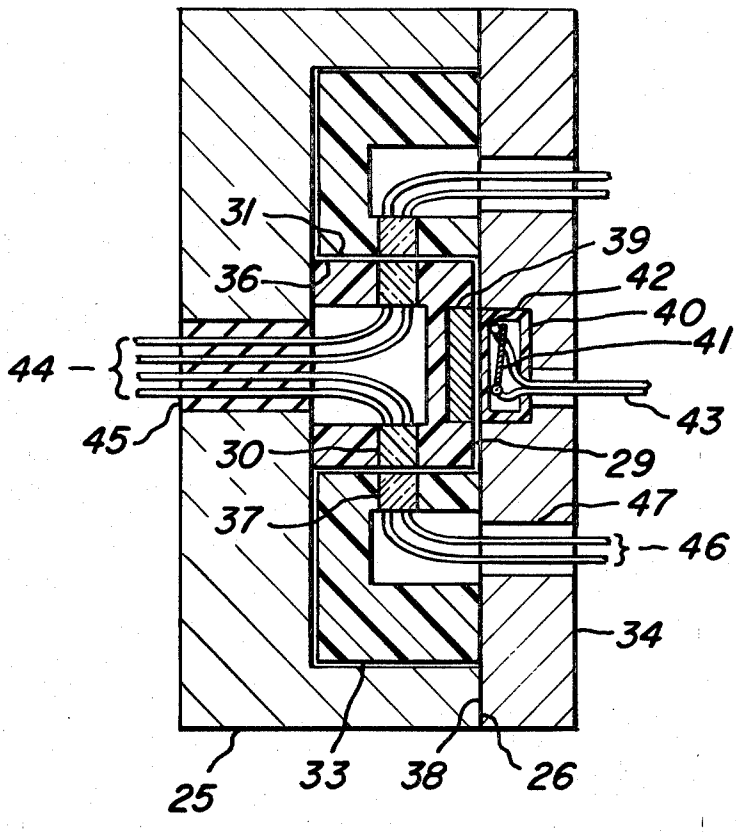


FIG. 1.

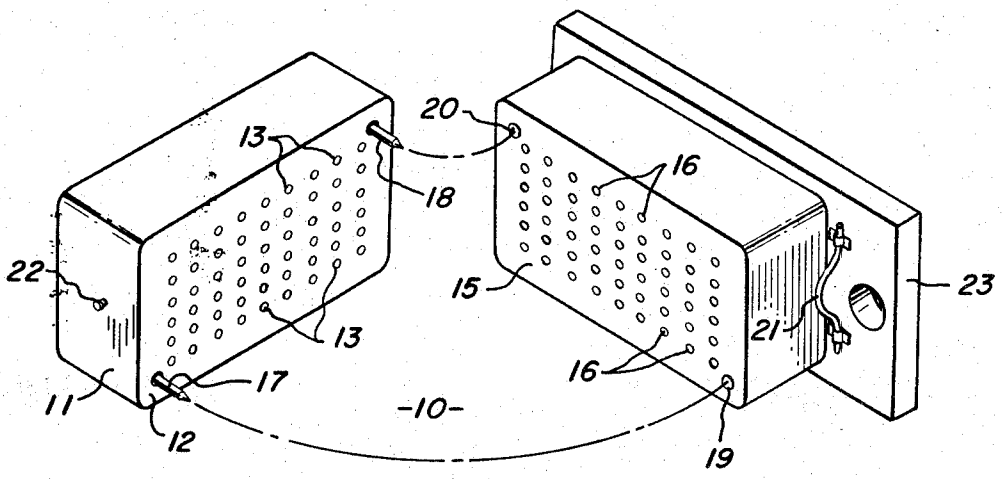

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FIG. 2.

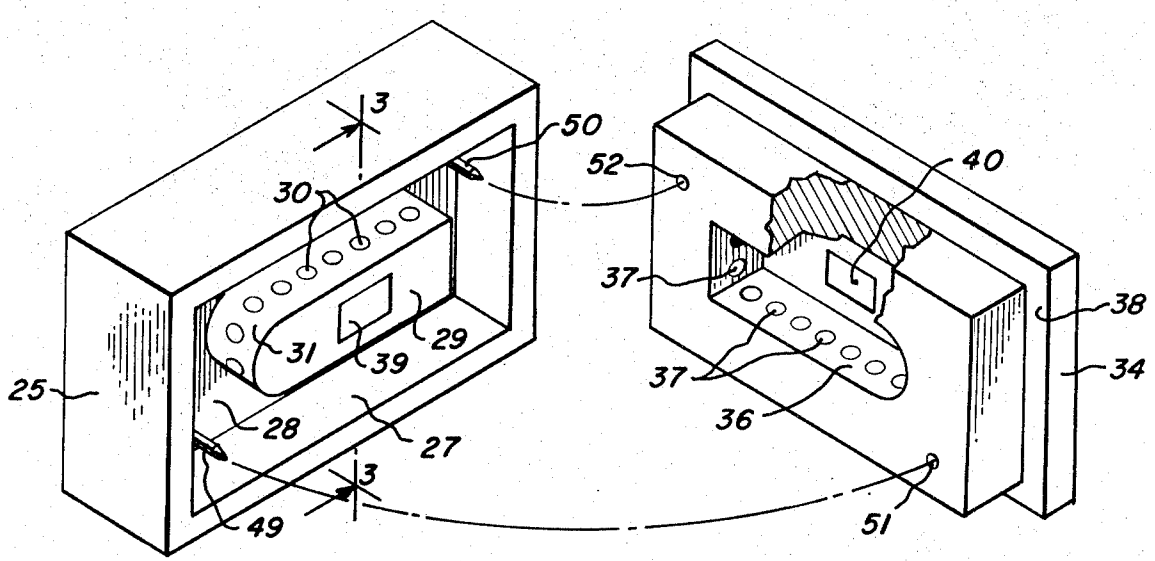

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FIG. 3.

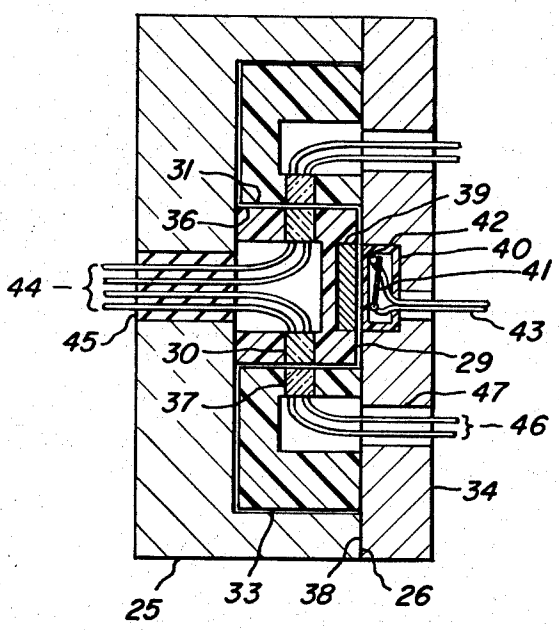


FIG. 4.

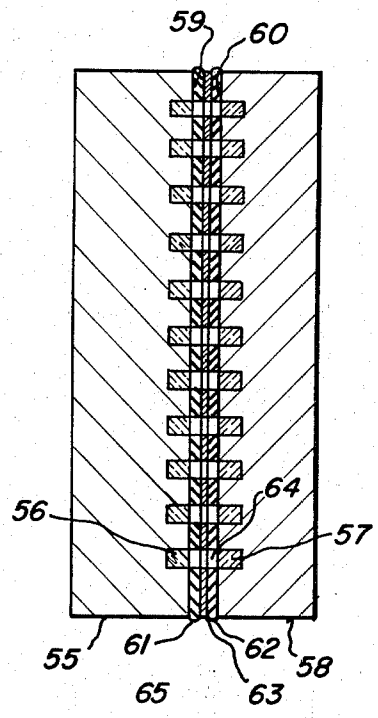
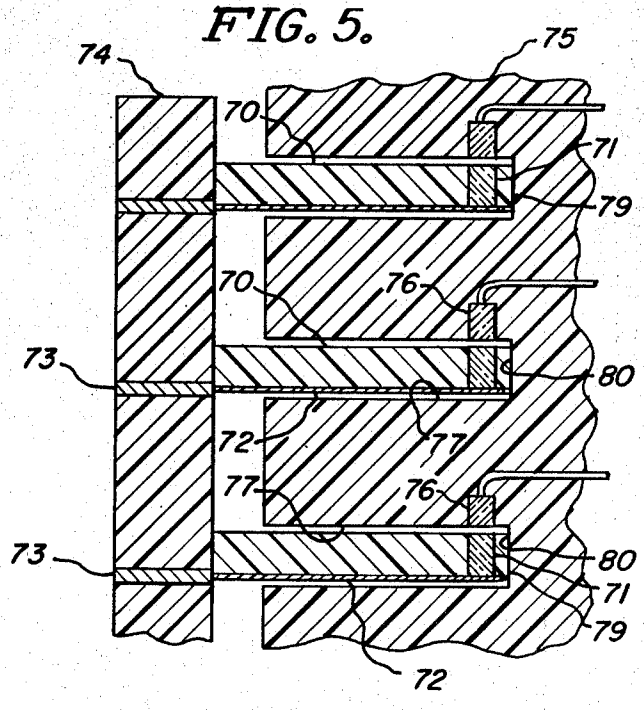


FIG. 5.



COMMUNICATIONS CONNECTOR APPARATUS UTILIZING RADIANT ENERGY

This invention relates to connectors for transmitting information, and particularly to connectors utilizing radiant energy to transmit information across an interface region.

Electrical transmission lines are well known communications links for transmitting electrical information between electrical devices at remote locations. Ordinarily, a transmission line comprises a multi-lead cable capable of carrying a plurality of channels of information. Heretofore, numerous problems have been associated with transmission lines by virtue of noise or other spurious electrical signals being imposed or induced on data signals carried by the lines. For example, natural phenomenon, such as thunderstorms and the like, often induce electrical noise onto transmission lines which can affect accurate reception of information and data signals. Further, electrical activity in one region may affect the "ground" or reference potential characteristics of electrical apparatus at one location to induce a voltage on transmission lines which is receivable and can impair the operation of electrical apparatus at another location.

Yet another problem associated with transmission lines resides in the connection of a transmission line to electrical apparatus. Heretofore, cumbersome mechanical apparatus have been utilized for connecting cables and the like to electrical apparatus. These mechanical connectors utilize numerous mateable contacts which require to be physically assembled in order to establish electrical connection. It is well known that such contacts oxidize and must be "wiped" to remove insulation oxidation from the contacts to establish good electrical connection between the contact pairs when assembled. While the force necessary to accomplish the "wiping" between any pair of electrical contacts is not significantly high, when the number of contact pairs is multiplied by several hundred or more, the force necessary to establish electrical connection between all of the contact pairs can become significantly high. Further, it has been difficult to maintain alignment of mateable contacts, as some contacts tend to bend and not properly mate with their intended mating contact.

It is an object of the present invention to provide connector apparatus for transmitting signals across an interface region which electrically isolates the opposite sides of the interface region from transmission of spurious electrical signals.

It is another object of the present invention to provide connector apparatus requiring minimal force to assemble.

It is yet another object of the present invention to provide connector apparatus for connecting a plurality of electrical data lines which provides positive alignment with minimal assemblage force.

In accordance with the present invention, connector apparatus is provided having first and second mateable housings defining an interface region therebetween. A plurality of radiation emitting devices are supported by the first housing and a plurality of radiation receiving devices supported by the second housing so that upon application of an electrical signal to the radiation emitting devices, each radiation emitting device emits radiation at a level representative of the level of the respective driving electrical signals and each radiation receiving device exhibits electrical characteristics representative of the level of incident radiation.

One feature of the present invention resides in the fact that the respective housings are mateable and require minimal force to assemble and disassemble.

Another feature of the present invention resides in the fact that the housings are electrically isolated so that electrical conditions affecting one of the housings are not transmitted to the other housing.

The above and other features of this invention will be more fully understood from the following detailed description and the accompanying drawings, in which:

FIG. 1 is a perspective assembly view of connector apparatus in accordance with the presently preferred embodiment of the present invention;

FIG. 2 is a perspective assembly view of connector apparatus in accordance with a modification of the present invention;

FIG. 3 is a section view of the apparatus illustrated in FIG. 2 taken at lines 3—3 in FIG. 2;

FIG. 4 is a section view of connector apparatus in accordance with yet another modification of the present invention; and

FIG. 5 is a section view of connector apparatus in accordance with yet another modification of the present invention.

With reference to the drawings, and particularly FIG. 1, illustrated is an electrical connector apparatus **10** in accordance with the presently preferred embodiment of the present invention. Connector **10** comprises a first housing **11** having a substantially planar surface **12.** A plurality of radiation emitting devices **13,** such as light emitting diodes (LED), are supported within housing **11** to emit radiation in a direction substantially normal to surface **12.** The light emitting diodes may be flush with surface **12** as shown in FIG. **1,** or may be recessed from surface **12** and provided with apertures so that the radiation is directed past surface **12.** A second housing **14** has a substantially planar surface **15** having a plurality of radiation response devices, such as light sensitive diodes **16** mounted flush with surface **15.** Alternatively, the sensors may be recessed from surface **15** and radiation from the LED's is transmitted through apertures associated with each of the sensors. Preferably, alignment means, such as pins **17** and **18** are provided on one of the housings, such as housing **11,** and are adapted to mate with other suitable alignment means, such as apertures **19** and **20,** on the other housing, such as housing **14.** The arrangement is such that when housing **11** is assembled to housing **14,** surfaces **12** and **15** are substantially contiguous to form an interface region therebetween and each light emitting diode **13** is positioned opposite a respective one of light sensors **16.** Hence, radiation from any of the light emitting diodes **13** will emit radiation to impinge the respective one of sensors **16.**

Preferably, suitable fastener means such as bracket **21** on housing **14** and mateable pin **22** on housing **11** are provided to fasten the housings **11** and **14** together. Also, one of the housings, such as housing **14,** may be provided with a suitable mounting bracket **23** for fixedly attaching housing **14** to electrical equipment (not shown).

With reference to FIGS. **2** and **3,** there is illustrated a modification of a connector apparatus in accordance with the present invention. The connector apparatus

illustrated in FIGS. 2 and 3 include a first housing 25 having a wall portion 26 enclosing a recessed portion 27 having an inner surface 28. A second housing 29 protrudes from surface 28 in recessed portion 27 and has a forward surface. As shown particularly in FIG. 3, the forward surface of housing 29 is preferably recessed in recessed portion 27 from surface 26. A plurality of radiation emitting devices 30, such as LED's, are supported within housing 29 and adapted to emit radiation in a direction substantially perpendicular to surface 31. As illustrated particularly in FIG. 2, surface 21 may be any desirable shape, and may be curved, or of any uniform or non-uniform shape. Preferably, and as shown in FIG. 2, surface 31 is a closed surface completely enclosing housing 29 so that light emitting diodes 30 are flush with surface 31 about the entire periphery of housing 29.

Housing 33 is mounted to housing 34 and includes a recessed portion 35 defining an inner surface 36. Radiation sensors 37 are mounted in housing 33 and adapted to receive radiation incident to surface 36. As shown in FIG. 2, the configuration of recess 35 is substantially identical to the configuration of housing 29 so that housing 29 may be assembled within recess 35 so that an interface region is defined between surfaces 31 and 36 of the housings 29 and 33, respectively. When so assembled, the light emitting diodes 30 are adjacent to respective light sensitive devices 37 so that radiation emitted by any one diode 30 is received by the respective sensor 37. Preferably, surface 28 of housing 25 will abut surface 38 of housing 34 when properly assembled, thereby accurately positioning the housings with respect to each other.

As shown particularly in FIG. 3, a magnet 39 is mounted in housing 29 so that upon assemblage of the housings, magnet 39 is adjacent switch 40. Switch 40 includes a movable contact 41 adapted to make electrical connection with stationary contact 42. Contact 41 is a magnetically operable reed contact so when the housings are assembled and magnet 39 is brought into close proximity with switch 40, contact 41 closes against contact 42 under the magnetic attraction from magnet 39, thereby making electrical connection between leads 43. Leads 43 may be connected to a disabling circuit (not shown) associated with the electrical equipment connected to sensors 37, so that when the housings are disassembled, switch 40 is open and the disabling circuit prevents operation of the equipment due to ambient radiation impinging sensors 37.

As shown in FIG. 3, LED's 30 are connected via leads 44 to equipment (not shown). Leads 44 extend through the back side of housing 25 through insulation 45. Likewise, leads 46, connected to sensors 37, extend through insulation 47 in the back side of housing 34 to equipment (not shown). It is understood, of course, that leads 44 together may form a cable, and that leads 46 may also form a cable for connection to the equipments.

As shown particularly in FIG. 2, the apparatus may include locating pins 49 and 50 extending from surface 28 of housing 25 and mateable with apertures 51 and 52 in housing 33. While the locating apparatus consisting of pins 49 and 50 and apertures 51 and 52 are illustrated in FIG. 2, it is to be understood that they may be eliminated and the housings may be self-aligning if housing 29 and recess 35 are of such shape as to be self-locating. Thus, for many geometrical shapes for housing 29 and recess 35, the locating pins and apertures may be eliminated and the close tolerances between the housings may be utilized for positioning the housings to assure alignment between the light emitting diodes and the sensors.

FIG. 4 illustrates yet another modification of the present invention wherein a radiation and magnetic shield is positioned between the sensors and the light emitters across the interface between the assembled housings. Thus, as illustrated in FIG. 4, housing 55 contains a plurality of radiation emitters, such as light emitting diodes 56, adapted to emit radiation which in turn is received by sensors 57 in housing 58. A laminated washer structure is sandwiched between surfaces 59 of housing 55 and 60 of housing 58. The washer structure comprises a first resilient layer 61, a second resilient layer 62, and a metallic layer 63, sandwiched between the layers 61 and 62. A plurality of apertures 64 extend through layers 61, 62 and 63 so as to establish a radiation path between each light emitter 56 and each sensor 57. When housings 55 and 58 are assembled with the laminate washer structure between surfaces 59 and 60, resilient layers 61 and 62 are slightly deformed under pressure between the housings so as to establish a fluid seal between the housings, thereby preventing moisture from entering the region between the sensors and radiation emitting devices. Plate 63, which may be connected to ground 65, provided electromagnetic and electrical shielding between the light emitting diodes and the sensors. Thus, the respective housings of the connector apparatus are electrically shielded from each other to further prevent spurious or erratic signals from being transmitted from electrical equipment connected to the light emitting diodes to the electrical equipment connected to the sensors. While the laminated shield structure is illustrated in FIG. 4 as being substantially planar, it is understood that the laminate structure may be of any desirable shape to conform to the interface region between two housings. Thus, the laminate structure may occupy the the interface region between the radiation emitters in one housing and the sensors in the other housing of any modification of this invention.

FIG. 5 illustrates yet another modification of the present invention wherein one set of the connector pairs comprises a plurality of the circuit cards which may be received in slots of a housing forming the other set of the connector pair. Thus, a plurality of circuit cards 70 each containing a radiation emitting device, such as LED 71, is electrically connected via conductor 72 to connectors 73 on board 74. Board 74, which may be mounted at right angles to cards 70, supports the cards. Housing 75, which may, for example, comprise a portion of the housing for electrical equipment connected to sensors 76, includes a plurality of slotted recesses 77 forming receptacles for receiving individual cards 70. Leads 78 connect each sensor 76 to the electrical equipment housed by housing 75. Cards 70 are assembled within the receptacles 77 so that end surface 79 of the cards are contiguous to surface 80 within each receptacle. When so positioned, the light emitting diodes 71 are adjacent to individual light sensitive devices 76, and the region between the upper surface of the cards 70 and the internal surface of the receptacles 77 form a bounding interface region between the light emitting diodes and the sensors across which radiation is emitted onto the surface of the sensors.

In operation of the optical connectors in accordance with the present invention, the light emitting diodes or other radiation emitting devices are energized by an electrical signal so as to emit radiation, such as light, at a level representative of the intensity or level of the applied electrical signal. The radiation emitted by the radiation emitters is directed across the interface region between the coupler housings to impinge on an individual radiation sensor. The electrical characteristics of the radiation sensor are dependent upon the incident radiation impinging the particular sensor. For example, if the sensor is a signal generating device, such as a photo cell, the sensor generates electric signals having a level representative of the intensity of incident radiation. On the other hand, if the sensor is a photo diode, phototransistor, photo resistor, or the like, the conductive characteristics of the sensor are altered in accordance with incident radiation; the characteristics of each sensor being sensed by external circuitry associated with the receiving device. Preferably, suitable amplifiers (not shown) are associated with the sensors to amplify the signals received from the sensors.

The present invention thus provides connector apparatus for a communications link capable of transmitting electrical signals between electronic equipment whereby extraneous electrical conditions occurring at one or the other of the electrical equipment does not affect the characteristics of electrical signals transmitted between the equipments. One feature of the invention resides in the fact that minimal assemblage force is required to assemble the housings together. Thus, if locating pins and apertures are used, as shown in FIGS. 1–3, only the force necessary to assemble the pins is required to assemble the housings. Contact "wiping" is not necessary, as information is transmitted across the interface region by radiant energy, rather than direct electrical connection as in the case of mechanical connectors.

While the present invention has been described in connection with the use of discrete elements, it is obvious that the sensors and emitters may be fabricated utilizing etching techniques. For example, a photo voltaic detector array for receiving radiation may be fabricated by forming a layer of P-type silicon onto the surface of a crystal of highly conductive N-type silicon. Utilizing well known masking and etching techniques, neutral areas between the sensors may be formed by etching through the P layer and deeply into the N layer to provide electrical isolation of the P layer. Leads for the respective layers may be formed by deep etching into the layers and depositing leads into the layers for conductivity. Likewise, photo detectors may be formed in arrays of N on P and PIN structures for photo diode and/or photo voltaic arrays. Similarly, the light emitting diodes may similarly be formed through deposition techniques. Hence, high density of photo cells and light emitting diodes may be achieved utilizing either discrete elements or the selected etching techniques just described.

This invention is not to be limited by the embodiments shown in the drawings and described in the description, which are given by way of example and not of limitation, but only in accordance with the scope of the appended claims.

What is claimed is:

1. In a communication link between first and second electrical devices, the improvement comprising: connector apparatus connecting portions of said link together, said connector apparatus including first and second housings each having an interface surface, said interface surfaces together defining an interface region therebetween when said housings are assembled together; a plurality of radiation emitting devices mounted to said first housing and adapted to emit radiation across said interface region, each of said radiation emitting devices being capable of emitting radiation at a level representative of the level of an applied electric signal; first conductor means for electrically connecting each of said radiation emitting devices to said first electrical device to apply individual electric signals to respective ones of said radiation emitting devices; a plurality of radiation responsive devices mounted to said second housing, each of said radiation responsive devices exhibiting electrical characteristics representative of the level of incident radiation; second conductor means for electrically connecting each of said radiation responsive devices to said second electrical device; and attachment means for assembling said first and second housings so that individual ones of said radiation responsive devices receive radiation emitted by respective ones of said radiation emitting devices, whereby the electrical characteristics of each of said radiation responsive devices are representative of the level of electric signals applied to the respective radiation emitting device.

2. Apparatus according to claim **1**, further including positioning means for positioning said first and second housings relative to each other.

3. Apparatus according to claim **1**, wherein one of said first and second housings includes a cavity portion so sized with respect to the other of said first and second housings that at least a portion of said other housing is fitted in said cavity portion upon assembly of said housings.

4. Apparatus according to claim **3**, wherein the interface surfaces of said first and second housings are defined by at least a portion of the bounding wall of said cavity portion and at least a portion of the bounding wall of said other housing.

5. Apparatus according to claim **4**, wherein the said cavity portion includes a plurality of slots in said one housing, and said other housing includes a plurality of members adapted to be simultaneously positioned in respective ones of said slots.

6. Apparatus according to claim **4**, further including switch means associated with at least one of said housings for selectively establishing electrical connection for the respective electrical device connected thereto when said housings are assembled.

7. Apparatus according to claim **6**, wherein said switch means includes a magnetically operable switch supported by one of said housings and a magnet supported by the other of said housings.

8. Apparatus according to claim **1**, further including switch means associated with at least one of said housings for selectively establishing electrical connection for the respective electrical device connected thereto when said housings are assembled.

9. Apparatus according to claim **8**, wherein said switch means includes a magnetically operable switch supported by one of said housings and a magnet supported by the other of said housings.

10. Apparatus according to claim **9**, further including disable means operable by said switch means for dis-

abling said second electrical device so as not to respond to said radiation responsive devices when said housings are disassembled.

11. Apparatus according to claim **8,** further including disable means operable by said switch means for disabling said second electrical device so as not to respond to said radiation responsive devices when said housings are disassembled.

12. Apparatus according to claim **1,** further including electrical shielding means in said interface region, said shield means including electrically conductive means connected to a reference potential, and means providing a radiation path through said conductive means.

13. Apparatus according to claim **12,** wherein said shield means further includes seal means providing a fluid seal between the interface surfaces of said first and second housings.

14. Apparatus according to claim **1,** further including seal means providing a fluid seal between the interface surfaces of said first and second housings.

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