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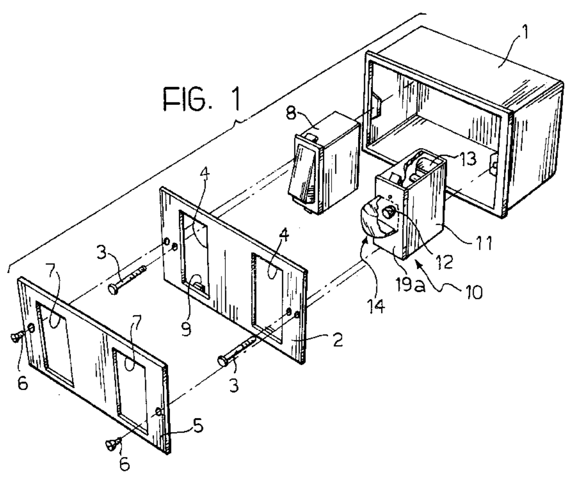
(54) **Infrared presence sensor.**

(57) A passive presence sensor (10) of the spatial type for rooms and the passenger compartments of motor vehicles includes a Fresnel lens (14) for focusing the monitoring radiation onto a respective pyroelectric sensitive element (12). The sensor (10) can be produced in the form of a module which can be fitted in a connection box (1 to 7) or the like of an electrical system and/or installed in motor vehicles as original equipment and is characterised by low energy consumption.

FIG. 1



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The present invention relates in general to infra-red presence sensors which can be used in anti-intrusion systems (anti-theft systems) for protecting spaces, particularly rooms in apartments and spaces in motor cars, or in other systems, for example, as presence detectors which can detect, for example, the entry of a person into a room and consequently switch on a device (e.g. a timed lighting device).

The specific object of the present invention is to provide an infra-red presence sensor which is very compact without its compactness adversely affecting its performance.

According to the present invention, this object is achieved by virtue of a sensor having the specific characteristics recited in the following claims.

One of the main advantages of the sensor according to the invention is that it can be produced in the form of a so-called "module", preferably a single module, which can be inserted in a connection box, a junction box, etc., or a similar element of a normal domestic electrical system. This is done in substantially the same way as with other modules such as switches, sockets, intensity regulators, etc.

From this point of view, the main advantage offered by the invention is that it enables the conduits (or ducts) of the electrical system which is usually already present in the premises to be protected against intrusion or in which the presence of people is to be detected to be used for the installation of an anti-theft system. This minimises or even completely eliminates the need to provide further pipes or to use wireless systems for the connections between the sensors and the central control unit of the system.

The need to provide additional connecting wires (usually external wires which are not particularly pleasing in appearance) often constitutes an obstacle to the installation of anti-theft systems in normal living areas, particularly when rooms in old houses with thick walls, possibly with good quality coverings, are involved. On the other hand, the use of wireless systems has the disadvantage that fairly sophisticated and expensive connections have to be provided - usually by hertzian waves - between the various sensors and the central control unit of the system, and each element of the system must have a respective supply, such as a battery, which has to be replaced periodically.

Another sector in which the sensor according to the invention can be used to particular advantage is the automotive sector.

According to a well-established choice, today, the fitting in motor vehicles of anti-theft systems for protecting spaces (that is, systems which can indicate intrusion into the passenger compartment regardless of whether operations on members of the vehicle itself are involved) is left to the "after market". In other words, it is the purchaser of the vehicle who has the system fitted in the motor vehicle by a reliable fitter.

This choice cannot be considered wholly satisfactory since the operations which the fitter can carry out, particularly as regards the positioning and fitting of the sensors and their connection to the central control unit of the system, are generally quite limited. Except for some particular cases (for example, in vehicles which are to be armour-plated, etc.) the fitter cannot generally carry out an extensive rearrangement of the passenger compartment with the removal and modification of parts thereof, particularly in view of the time which may be required for the operation.

For this reason, the choices of producers and fitters have up to now been limited, in practice, to ultrasound anti-intrusion sensors. These sensors and their systems have the disadvantage that, although their current consumption is low in absolute terms (3-4 milliamperes), it assumes a certain significance if one takes into account that the systems in question sometimes have to remain active for quite long periods of time, for example, when the vehicle is left in a car park and not used for several days.

The present invention therefore provides a sensor which can solve the problems expressed above, particularly as regards the possibility of providing an anti-intrusion system for protecting spaces as original equipment supplied by the builder of the vehicle.

The invention will be described, purely by way of non-limiting example, with reference to the appended drawings, in which:

Figure 1 shows the mounting of a sensor according to the invention in a box of a normal electrical system,

Figure 2 shows the appearance of the sensor according to the invention in its mounted position,

Figure 3 shows schematically the structure of an anti-intrusion system which can be formed with the sensor according to the invention.

Figure 4 shows in greater detail the structure of one of the constituent elements of the device according to the invention,

Figure 5 is a section taken on the line V-V of Figure 4,

Figure 6 shows the structure of the passenger compartment of a motor vehicle fitted with an anti-intrusion sensor according to the invention, and

Figure 7 is a general perspective view showing in greater detail one of the elements indicated in Figure 6.

Figure 1 shows schematically the component parts of a box (a connection, junction or terminal box) of a normal domestic or industrial electrical system.

In this structure it is possible to distinguish the following elements:

– a casing (the actual box) 1 which is generally tank-shaped and is intended to be set in the structure of the wall with its open face facing outwardly,

– a cover 2 which is intended to be fitted to close the open face of the box 1 with the interposition of screws 3 and which has one or more holes 4 (which can usually be formed by the user from pre-punched blanks) for the mounting of respective modules, and

– a further front cover (or "screen") 5, usually made of polished or painted metal or good quality plastics material, which is intended to be fixed to the cover 2 by means of further screws , or by snap-engagement, and has holes 7 the number and positions of which correspond to those of the holes 4 in the cover 2.

A so-called "module", indicated 8, is intended to be mounted, in widely known manner, on the cover 2 in one of the holes 4. For this purpose, each hole has hook formations 9 which are intended to snap-engage corresponding hook formations on the body of the module 8.

The module 8 is connected to the electrical system by means of respective wires (not shown specifically) which extend through the box 1 and enter the conduits or ducts (pipes) which extend through the walls of the premises in which the electrical system is fitted.

This is all according to widely known criteria which do not need to be described herein.

The nature of the module 8 may vary widely; in fact it may be a switch, a regulator (a dimmer), an electrical or television socket, an indicator lamp, etc.

The sensor according to the invention, generally indicated 10, includes essentially a generally tank-shaped casing 11 which houses a monitoring circuit connected to an infra-red-sensitive element 12. The sensor is usually a so-called pyroelectric sensor which is sensitive, for example, to infra-red radiation in the range between 7 and 15 microns, with associated circuit elements 13, such as an amplifier and other members for pre-processing the signal generated by the sensitive element 12. A lens 14 is mounted on the front of the casing 11 which is intended to face the room in which the box is situated, the function of the lens being to focus the infra-red monitoring radiation coming from the room under surveillance towards the sensitive element 12.

The lens 14 has Fresnel-lens characteristics.

More precisely, the lens 14 is a kind of "double lens" constituted by a spherical surface, that is, a cap-shaped surface, preferably with double curvature (the first lens) which has (preferably on its internal surface), for example, three bands 15, 16, 17 of Fresnel-lens segments (the second lens) one above another and including, for example, six, five and three Fresnel-lens segments. This configuration ensures the coverage of the area under surveillance which is divided into three regions, that is, an upper region (the band of segments 15), a central region (the band of segments 16) and a lower region (the band of segments 17). The area under surveillance is thus fully protected particularly in the so-called "man-height" region. The sensor 10 according to the invention can in fact be mounted in a box situated at the normal height for a switch and hence typically within a band 80 to 120 cm. from the ground.

An important characteristic of the lens 14 is that it has a very marked arcuate shape.

For example, in the embodiment illustrated, it is spherical with a rectangular base, its configuration being comparable to a domed vault, and extends horizontally (in plan, when the sensor is in its normal position of use) through an angle of the order of 100-105° and vertically through an angle of the order of 45-60°.

These wide angles are intended to give the lens 14 as a whole a domed or arcuate vault-shaped structure so that it has good resistance to mechanical compression stresses which may be exerted thereon. The lens 14 is preferably injection-moulded from plastics material, for example, high-density polyethylene and is quite thin, preferably less than 1 mm thick. This is to avoid excessive absorption of the monitoring radiation. In this connection, it should be noted that the sensor 10 as a whole is a passive sensor. Moreover, as already stated, the lens 14 is intended (unlike a conventional anti-intrustion sensor which is usually mounted on the ceiling of the protected room) to be mounted in an easily accessible position and thus usually near another module such as a switch which is intended to be operated frequently even in the dark so that there is considerable exposure to pressures and knocks.

The moulding of the lens 14 from plastics material also has the advantage that it enables the lens to be pigmented (for example, in black), for example, to provide it with colouring coordinated with that of the screen 5 for aesthetic purposes with a minimal addition of pigment (1-2‰) and thus without adversely affecting its attenuation characteristics.

As has been seen, an important characteristic of the lens 14 is that it is constituted, in practice, by a surface with double curvature, for example, a spherical surface, on which the Fresnel-lens segments are arranged in the adjacent bands 15, 16 and 17.

From this point of view, the lens 14 may be compared to a kind of double lens, in the sense that it includes a spherical surface whose centre of curvature corresponds at least approximately to the position of the pyroelectric sensor 12 whilst the various Fresnel-lens segments (see, for example, the segments of the upper band 15 to which Figure 5 relates in greater detail) are formed so as to focus the infra-red radiation which reaches the sensor 10 precisely onto the spatial position occupied by the pyroelectric sensitive element 12; in other words, the sensitive element 12 is positioned at the focus of the various segments 15, 16 and 17.

The distribution of the Fresnel-lens segments in the three bands 15, 16 and 17 one above another is intended primarily to achieve protection or surveillance in three different spatial regions.

In particular, the segments of the upper band 15 are intended to cause the infra-red radiation coming from the upper portion of the area under surveillance to converge on the pyroelectric sensor 12 and the segments of the central band 16 are intended to focus the radiation coming from the central-lower region of the area under surveillance. Finally, the segments 17 of the lower band are intended to cause the radiation coming from the lower part of the area under surveillance and, in particular, from the portion of the area situated directly below the sensor 10 to converge on the sensor 12. This characteristic, together with the general dome or cap-shaped conformation of the lens 14 with double curvature enables the sensor to detect in a very reliable manner any attempts to approach it in order to try to mask, neutralise, or circumvent it.

Again, as regards the spatial distribution of the bands 15, 16 and 17, it can be seen that, at least in the currently-preferred embodiment, the depth of the upper band 15 corresponds approximately to half the height of the lens 14 as a whole whilst the depths of the other two bands (the central band 16 and the lower band 17) are about half the lower portion, that is, one quarter of the overall height of the surface of the lens.

As regards the number of bands and the number and distribution of the segments in each band, the solution described, which has three bands with six, five and three segments respectively, has also been found advantageous in that a certain angular staggering of the serpents in the various bands can be achieved. In practice, this means that in each band the regions with maximum sensitivity to the incident radiation are offset from those of the adjacent bands so that the overall effect is that the sensitivity curves of the various bands overlap. This is beneficial in preventing the sensor as a whole from having regions of low sensitivity at certain angular positions.

The use of a smaller number of segments in the lower bands and, in particular, in the lowest band 17 enables each serpent to have a larger surface which improves the picking-up of the infra-red radiation in the lower regions which are angularly more remote from the central axis of the pyroelectric sensor.

Another important characteristic of the lens 14 (see in particular the views of Figures 4 and 5) is that, as well as its optically active portion (that is, the portion including the three bands of Fresnel-lens segments 15, 16 and 17), it has a base or skirt portion 19 which is generally prismatic (with a rectangular cross-section in the embodiment shown) which enables the lens 14 to be mounted in a position such that, with the face 19a of the casing 11 which holds the circuits associated with the pyroelectric sensor 12, it defines a chamber which is substantially closed to the exterior, for housing the element 12. This arrangement has the advantage of insulating the pyroelectricelement 12 from phenomena such as, for example, draughts which could disturb its operation, for example, causing the pyroelectricelement to generate alarm signals in conditions in which the emission of such a signal is actually unjustified (so-called false alarms).

An important characteristic of the sensor according to the invention, which is connected with the fact that it is a passive infra-red sensor and does not need auxiliary elements (such as a generator, as is the case with microwave sensors), is that the casing 11, including the lens 14 disposed on its front face, can be formed so as to have dimensions which fully correspond to those of a normal module.

Thus, as is clear from the drawings, the sensor 10 can assume the characteristics of a so-called single module which is intended to occupy a single mounting position in the box 1.

In particular, with the use of the technical solution described, the lens 14 can be formed so that the radius of its spherical surface is of the order of 14 mm and the dimensions of its base (the sides of the prismatic skirt portion 19) are 16 x 20 mm so that the lens 14 (and the sensor 10 as a whole) can be fitted in a casing 11 for electrical modules conforming to the European standard (maximum width 25 mm).

This is unlike more or less similar devices (for example thermostats for heating systems, etc.) whose mounting in connection boxes or the like has already been proposed but which clearly need to occupy a good portion, if not the whole, of the box.

These characteristics enable the potential uses of the sensor according to the invention to be developed considerably, particularly as regards the possibility, shown by way of example in Figures 2 and 3, of forming a complete anti-intrusion system including a central control unit 20 (possibly with push-buttons 20a for shutting down parts of the system and/or a receiver 20b, typically an infra-red receiver, for receiving activation and de-activation signals) and one or more sensors 10 mounted in various connection boxes, by inserting the connecting wires 21 through the conduits or ducts (pipes) 22 of the electrical system which is normally already present in the premises protected.

In the diagram of Figure 3, other modules, generally indicated 8, (switches, sockets, etc.) are mounted in combination with various sensors 10 in corresponding boxes of the electrical system.

Figure 2 and the left-hand portion of Figure 3 also show how - precisely because of the small size of the sensor itself - the sensor 10 can be combined, in at least one of the boxes, with a more complex processing member, for example, the central control unit 20 which controls the operation of the system formed by the various sensors 10 and may be capable of being activated and deactivated selectively by remote control (20b) so that certain sensors 10 can be made inoperative (partial shutting-down), for example, in order to retain protection only in certain rooms whilst others continue to be used (for example, during the night).

Still for the same prospective use, a solution is also possible in which a microwave sensor is associated with a sensor 10 within the same connection box in order to provide the system with better protection against attempted masking or obstruction.

Naturally, one might also consider making the geometry of the lens 14 different from that described above.

In particular, as regards the arrangement of the Fresnel-lens serpents, it is possible to adopt either the arrangement with several bands one above another, of which the bands of Fresnel-lens segments 15, 16 and 17 of Figure 4 are an example, or a different arrangement, for example, including two identical bands, one above the other, or three bands of different lengths, one above another in a cross-shaped arrangement.

In Figure 6, the passenger compartment of a vehicle such as a motor car, not shown as a whole, is indicated W.

The front seats S_1 and the rear seats S_2 of the car are visible, however, and are shown schematically.

A so-called ceiling light 100 is fitted in the passenger compartment in a central position on the front edge of the roof above the upper edge of the windscreen P.

This element, which is shown in greater detail in Figure 7 includes, in known manner, devices such as, for example, a clock 102 and one or more switches 103, 104 disposed in positions in which they are easily visible and/or accessible to the people in the passenger compartment.

A sensor 10 substantially similar to that described above is mounted in the ceiling light 100 and is intended to act as an anti-intrusion (anti-theft) sensor of the type for protecting a space.

In this case also, the sensor 10 is constituted by a box-shaped body 11 which can be fitted or engaged in the ceiling light 100 so that it can be fitted in the vehicle as original equipment. This solution enables the sensor 10 to be connected to the central control unit of the anti-theft system, which usually also includes other sensors (sensitive to events such as an attempt to open the doors, an attempt to start the engine, etc.) and can be activated/deactivated remotely by signals transmitted to the central control unit by a remote control.

Amongst other things, the positioning of the sensor 10 in the ceiling light 100 enables it to be connected to the central control unit by making direct use of the conduits which are usually already provided in the passenger compartment for the wires of the vehicle's electrical system. This is not usually true of current anti-theft systems for which the fitter, who operates on the finished vehicle, usually has to provide wires and conduits specifically for connecting the sensors to the central control unit.

In this example of application, the lens is also characterised by two important factors, that is:

– the presence of a distribution of Fresnel-lens serpents which is specifically adapted to the shape of the area under surveillance, and
– the very marked and distinct arcuate ("rounded") shape of the surface of the lens with double curvature.

The field covered by the sensor 10 in the passenger compartment W is shown schematically in Figure 6 and has a central or middle region of coverage A (the band of segments 16) which includes essentially the upper portions of the front seats S_1 and a good portion of the rear seats S_2, an upper region of coverage B (the band 15) which includes the upper portions of the rear seats S_2 and the rear window, and a lower region of coverage C (the band 17) which includes the sitting surfaces of the front seats S_1 and members such as the gear lever, etc.

It will be understood that this spatial coverage affords complete protection of the space in the passenger compartment even as regards attempts to steal objects in the passenger compartment without full entry to the passenger compartment.

The very arcuate shape of the lens 14 is intended to give it a generally dome-shaped configuration and consequently resistance to mechanical compression stresses exerted on the lens 14. As already stated above, the lens is usually made of fairly thin plastics material in order to prevent eccessive attenuation of the radiation used for the monitoring; the sensor 10 is in fact a passive sensor.

In the application according to the invention it is therefore essential to prevent any, even involuntary, handling of the lens 14 from leading to damage thereto.

Given its passive sensor characteristics, the sensor 10 according to the invention is characterised by an extremely low level of energy consumption so that the anti-intrusion system as a whole (including the central control unit to which the sensor 10 is connected) has consumption characteristics considerably lower than those of the ultrasound or microwave anti-intrusion systems currently used with which, however, the sensor according to the invention can easily be combined.

Naturally, the principle of the invention remaining the same, the details of construction and forms of embodiment may be varied widely with respect to those described and illustrated, without thereby departing from the scope of the present invention.

Claims

1. A presence sensor (10), characterised in that it includes, in combination:

– an infra-red-sensitive element (12),
– a lens (14) for focusing the monitoring radiation onto the sensitive element (12), the lens (14) having Fresnel-lens characteristics and including a cap-shaped surface on which there is at least one Fresnel-lens segment (15 to 17).

2. A sensor according to Claim 1, characterised in that the cap-shaped surface of the lens (14) has double curvature.

3. A sensor according to Claim 1, characterised in that it includes a casing (11) with dimensions such that the sensor (10) as a whole is configured as a module, preferably a single module, which can be inserted in a box (1 to 7) or the like of an electrical system.

4. A sensor according to any one of Claims 1 to 3, characterised in that the at least one Fresnel-lens segment (15 to 17) is on the inner face of the cap-shaped surface.

5. A sensor according to Claim 1, characterised in that a plurality of Fresnel-lens segments (15 to 17) are formed on the cap-shaped surface of the lens (14).

6. A sensor according to Claim 5, characterised in that the Fresnel-lens segments are arranged in several adjacent bands (15 to 17).

7. A sensor according to Claim 6, characterised in that the adjacent bands (15 to 17) include angularly staggered Fresnel-lens segments.

8. A sensor according to Claim 6 or Claim 7, characterised in that the number of Fresnel-lens segments in the bands (15 to 17) varies generally from band to band.

9. A sensor according to any one of Claims 6 to 8, characterised in that it has three adjacent bands (15 to 17) of Fresnel-lens segments.

10. A sensor according to Claim 9, characterised in that the lens (14′) includes a central band (16) of Fresnel-lens segments and two further bands (15 and 17) of Fresnel-lens segments, above (15) and below (17) the central band (16), respectively.

11. A sensor according to Claim 6 or Claim 10, characterised in that the adjacent bands (15 to 17) are of equal size.

12. A sensor according to Claim 10, characterised in that the upper band (15) of Fresnel-lens segments occupies about half the cap-shaped surface of the lens (14).

13. A sensor according to Claim 10 or Claim 12, characterised in that each of the central band (16) and the lower band (17) occupies about one quarter of the cap-shaped surface of the lens (14).

14. A sensor according to any one of the preceding claims, characterised in that the cap-shaped surface of the lens (14) is substantially spherical.

15. A sensor according to Claim 1 or Claim 14, characterised in that the lens (14) extends horizontally through an angle of the order of 90-105°.

16. A sensor according to any one of Claims 1, 14 or 15, characterised in that the lens (14) extends vertically through an angle of the order of 45-60°.

17. A sensor according to any one of the preceding claims, characterised in that the shape of the cap-shaped surface is generally comparable to that of a domed vault.

18. A sensor according to any one of the preceding claims, characterised in that the lens (14) is defined by a body with a skirt portion (19) which surrounds the infra-red sensitive element (12) so as to insulate it from the exterior.

19. A sensor according to any one of the preceding claims, characterised in that the lens (14) is moulded, preferably by injection-moulding, from a plastics material.

20. A sensor according to Claim 1 or Claim 19, characterised in that the lens (14) is made of a plastics material such as, for example, high-density polyethylene.

21. A sensor according to Claim 1, characterised in that the cap-shaped surface of the lens (14) is less than 1 mm thick.

22. A sensor according to Claim 1 or any one of Claims 19 to 21, characterised in that the lens (14) is pigmented.

23. A sensor according to any one of the preceding claims, as an element of a presence-detection system in a room, the system including connecting wires (21) which extend through the conduits (22) of the electrical system of the room in which the system is fitted.

24. A sensor according to Claim 23 which is com-

bined in its box (1 to 7) or the like with a control unit (20) of the presence-detection system, possibly with remote control (20b).

25. A sensor according to Claim 1, characterised in that it is incorporated in a lamp or a similar accessory (100) which is fitted in a portion of the passenger compartment (A) of a vehicle.

26. A sensor according to any one of the preceding claims, characterised in that it is combined with an ultrasound or microwave sensor.

The whole substantially as described and illustrated and for the purposes specified.

FIG. 1

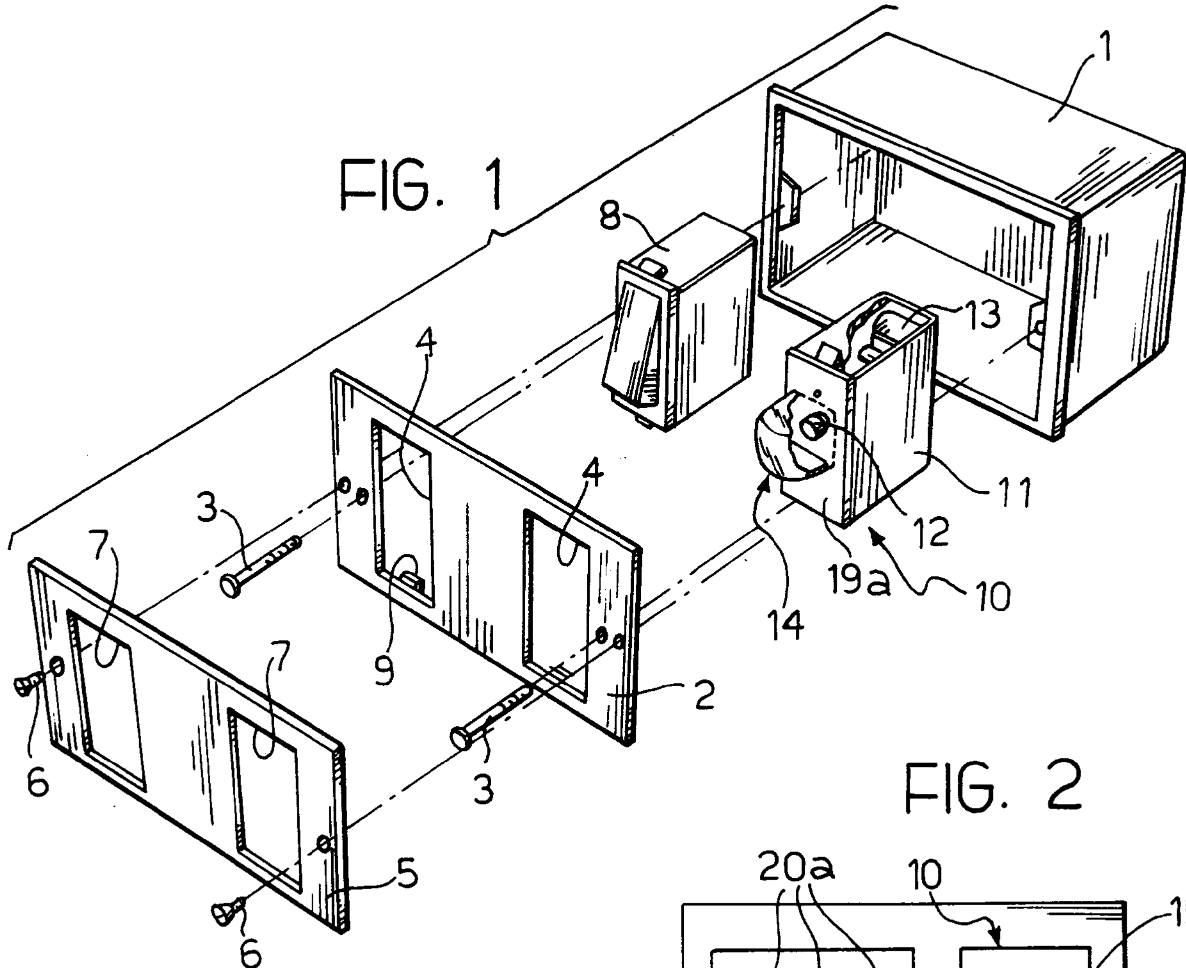

FIG. 2

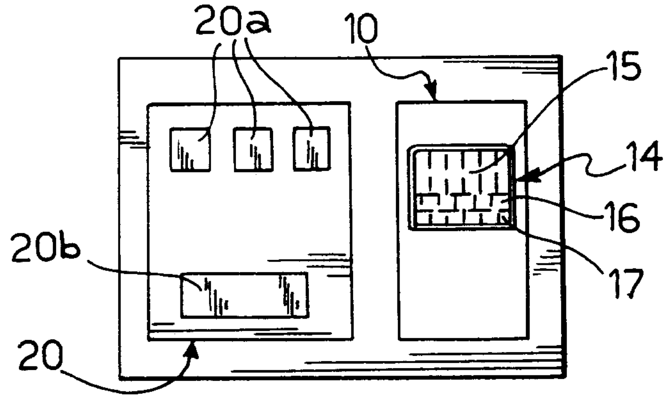

FIG. 3

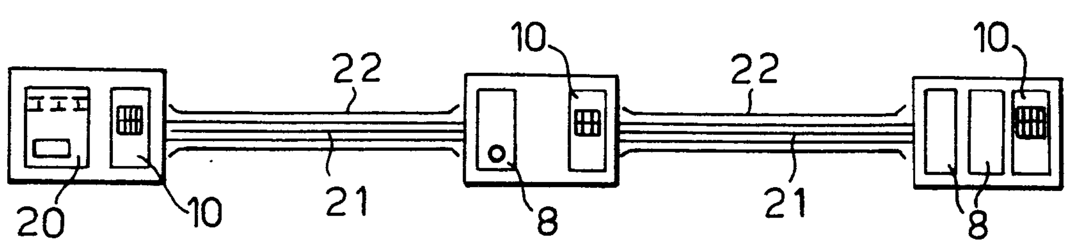

FIG. 4

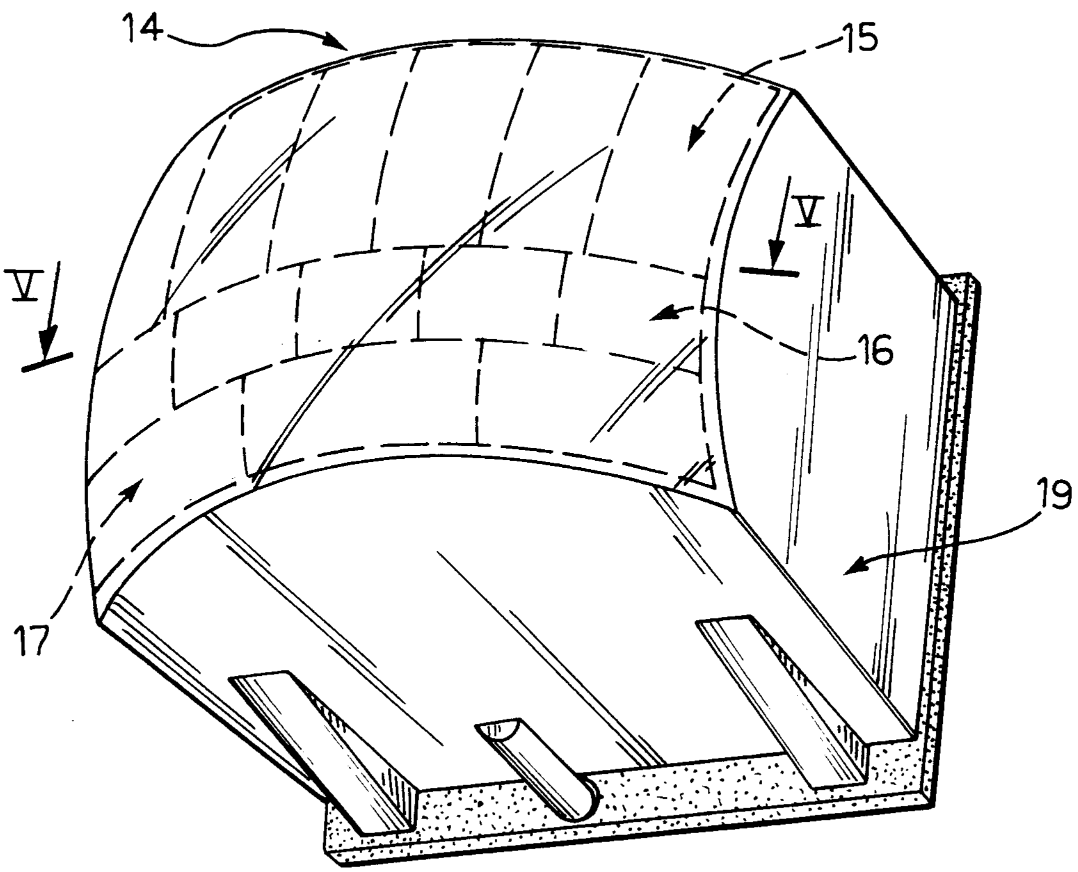

FIG. 5

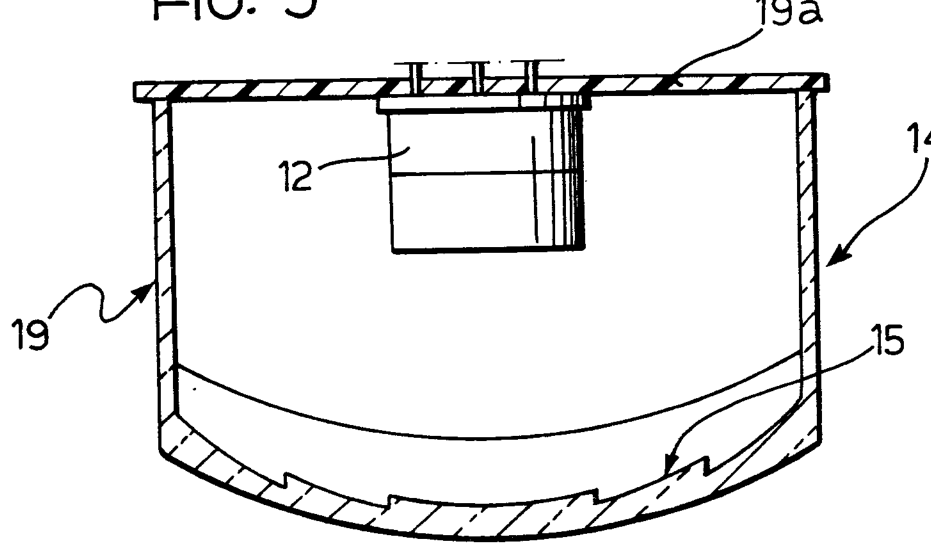

FIG. 6

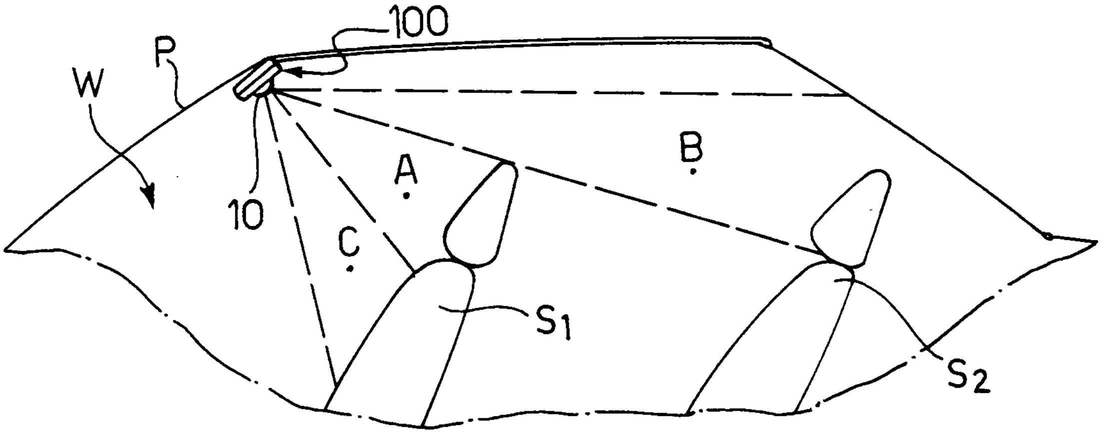

FIG. 7