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(19)(CA) **CANADIAN PATENT** (12)

(54) Electromagnetically Shielded Building

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ABSTRACT OF THE DISCLOSURE

All or a portion of the periphery of a building is constituted by an electromagnetic shielding structure to form an electromagnetically shielded space within the building. This is done by constructing the body of the building of ferrite- or mesh-containing concrete, or by constructing the external wall of the building of PC panels containing an imbedded mesh or of curtain walls consisting of an electromagnetic shielding material and fixed to the body of the building by anchor bolts through the intermediary of metal fasteners. Sets of communications equipment within the building communicate with one another by way of electric waves. Since the space within the building is electromagnetically shielded from the outside, any desired electric wave frequency band can be selected for the communication of information among the sets of communications equipment.

TITLE OF THE INVENTION

ELECTROMAGNETICALLY SHIELDED BUILDING

BACKGROUND OF THE INVENTION

This invention relates to a building having an electromagnetic shield structure well-suited for application to an information network system utilizing electromagnetic waves, and more particularly to an electromagnetically shielded building for enhancing the electromagnetic shielding performance of an external wall.

In many modern buildings, information generally is communicated between the interior and the outside of the building by making joint use of information communicating equipment such as multiple electronic exchanges and computers. With the increasing value of information, diversification of user needs and increasingly individual nature thereof, the amount of information involved in such communication is growing. Under these circumstances, how to transmit the necessary information rapidly and at low cost where large-scale buildings are involved has become of prime importance. In an effort to satisfy this need, data highway-type information networks utilizing optical fiber cables or coaxial cables have been studied and proposed.

However, with a data highway system utilizing optical fiber cables or coaxial cables, the cables must be stretched throughout all parts of the building to

reach the various pieces of communication equipment. Extra time is needed to complete the work and additional expenses are required to lay these cables.

If electromagnetic waves are used to transmit information within the building, laying cables is unnecessary but the radio waves are limited to a certain range owing to the emission of electrical noise waves from such a building. Another problem is that the communication system may malfunction due to electric waves from outside the building, television intermediate frequencies from inside the building, electric waves from wireless microphones, and the like.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an electromagnetic shielded building in which information can be communicated using electric waves of any frequency over a wide range of frequencies.

Another object of the present invention is to provide a method of electromagnetically shielding a building.

Still another object of the present invention is to provide an electromagnetic shielding structure of an external wall employing a curtain wall, in which an external wall using a curtain wall the structure whereof is similar to that of the conventional curtain wall is constructed in the form of a perfect electromagnetic shielding layer.

In accordance with a preferred embodiment of the invention, there is provided an electromagnetically shielded building comprising a building portion constituted by an electromagnetic shielding structure, all or a part of the interior of the building being formed as an electromagnetically shielded space, communications equipment for communications within the building, and an electromagnetic signal transmission medium in the shielded space arranged so that sets of the communications equipment communicate with each other within the building using electromagnetic waves transmitted through the transmission medium.

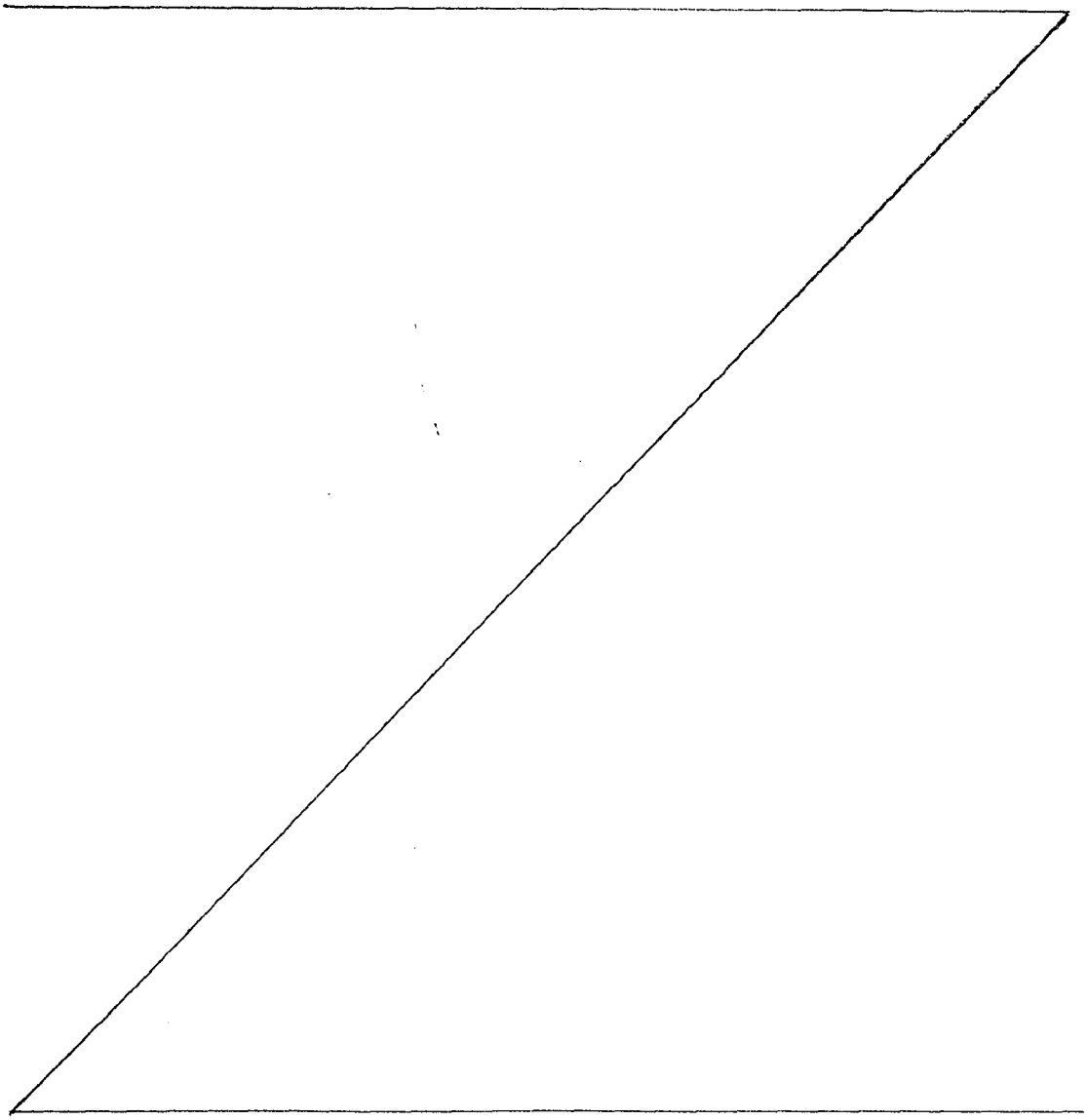
According to other embodiments of the invention, the outer peripheral of the electromagnetically shielded building is constituted by an electromagnetic shielding structure comprising ferrite-containing concrete, or mesh-containing concrete.

According to another preferred embodiment of the building, the outer peripheral walls of the building are an electromagnetic shielding structure, and electromagnetic curtain walls are fixed to the outer building walls by anchor bolts and metal fastener, affixing an electrically conductive annular ring to a side face of the curtain wall, and electrically integrating mutually adjacent curtain walls.

According to another preferred embodiment of the building, the signal transmission medium comprises a coaxial

cable laid so as to pass through each floor of the building, and leakage coaxial cables or antennas stretched along the ceiling of each floor and connected to the coaxial cable via branching devices.

In accordance with the invention, the body of a



building is constructed of concrete containing an electromagnetic shielding member. In another method, the external wall of a building is constructed of PC, precast concrete, panels having an imbedded mesh, the mesh in the PC panels is electrically connected to fixing members of the building body, and the PC panels of upper and lower floors are electrically connected and grounded. Alternatively, use is made of curtain walls constructed of electromagnetic shielding members and fixed to the body of a building by anchor bolts via metal fasteners. Electrically conductive cushions are affixed to the side faces of the curtain walls, and neighboring curtain walls are electrically integrated to form an electromagnetic shielding space. The communication system includes a coaxial cable laid so as to pass through the floors of the building, leakage coaxial cables stretched along the ceiling of each floor and connected via to the coaxial cable branching devices, and antennas. These cables and antennas are employed as a transmitting medium to permit communication within the building by utilizing electric waves.

In accordance with the above-described arrangements, the invention blocks electric waves at the body of the building by the formation of an electromagnetic shield. As a result, electric waves will not leak from the building even if information is communicated within the building using any desired frequency over a wide frequency band. In addition,

communication equipment within the building will not malfunction due to electric waves penetrating the building from outside. When the mesh is imbedded in the PC panels, the meshes are electrically connected to the fixing members of the building body and the PC panels of upper and lower floors are electrically interconnected and grounded, an electromagnetic shielding effect can be obtained at the external wall of the building through simple construction work.

If the curtain wall is adopted as the external wall, a curtain wall having an electromagnetic shielding function is used and the electrically conductive cushion is affixed to the side face of the curtain wall. Then, by securing the curtain wall to the body of the building by the anchor bolts via the metal fasteners, mutually adjacent curtain walls can be electrically integrated. By adopting this arrangement, the external wall can be assembled through the conventional method, i.e. by securing the curtain walls to the metal fasteners by the anchor bolts and then assembling the external wall, at the same time that the entirety of the external wall is furnished with the electromagnetic shielding property.

In the communication system, the leakage coaxial cables stretched along the ceiling of each floor serve as antennas and the antennas are interconnected by a coaxial cable via branching devices. As a result, electric wave signals emitted by the communication

equipment on each floor are transmitted by the antennas of the leakage coaxial cables and received by the communication equipment on other floors through the antennas of the leakage coaxial cables on these other floors.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a view for describing an embodiment of a building the body of which is electromagnetically shielded in accordance with the present invention;

Fig. 2 is a view illustrating an embodiment of the electromagnetic shielding of a building body in accordance with the present invention;

Fig. 3 is a view illustrating another embodiment of the electromagnetic shielding of a building body in accordance with the present invention;

Figs, 4A, 4B and 4C are views useful in describing the electromagnetic shielding of building openings in accordance with the present invention;

Figs. 5A and 5B are views for describing an embodiment of another electromagnetic shielding method according to the present invention; and

Fig. 6 is a view illustrating an embodiment of the electromagnetic shielding structure of an external wall using a curtain wall in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the invention will now be described with reference to the drawings.

As shown in Fig. 1, a building in accordance with the invention includes a body 1, pipe shafts 2-1 through 2-n for electrical equipment (each electrical equipment pipe shaft being referred to as an EPS hereinafter), a coaxial cable 3, branching devices 4, leakage coaxial cables 5, and a grounding plate 6. Figs. 2, 3 and 4, numeral 7 denotes a mesh-containing concrete, 8 a mesh, 9 ferrite-containing concrete, 10 ferrite, 11 a doorway, 12 a revolving door, and 13 a window.

In the building shown in Fig. 1, the body 1 is electromagnetically shielded, as indicated by the dashed line in Fig. 1, in such a manner that electric waves from communications equipment within the building will not leak from the building. The leakage coaxial cables 5 are stretched along each ceiling and are connected to the coaxial cable 3 via the branching devices 4. By using electric waves transmitted through these cables, communication is possible among communications equipment installed on each floor without requiring that cables be laid to interconnect the equipment. In particular, if the entirety of the building body 1 is furnished with an electromagnetic shielding capability, the transmission and reception of electric waves between upper and lower floors will be blocked by the body 1. For this reason, the leakage coaxial cables 5 are provided to perform a relay function on each floor. A community television cable ordinarily used in buildings can be employed as the coaxial cable 3, which

is passed through the EPSs 2-1 through 2-n. Though not shown, a community antenna is connected to the head end of the coaxial cable 3, and television receivers or the like are connected to the coaxial cable 3 via the branching devices 4. Accordingly, a signal received from the community antenna is distributed by the branching devices 4 via the head end and coaxial cable 3.

In accordance with the invention, the emission of electrical noise to the exterior of the building is eliminated by electromagnetically shielding the body 1. Therefore, merely stretching the leakage coaxial cables 5 along the ceiling of each floor as antennas and connecting them to the branching devices 4 makes it possible to freely use even electric waves in a frequency band subjected to restrictions in accordance with law, thus enabling these electric waves to be used for the communication of information within the building. The invention thus makes it possible to employ electric waves of any economical, convenient easy-to-use frequency band.

A specific method of electromagnetically shielding the body of a building is shown in Fig. 2, in which the body 1 is constructed of concrete 7 having an imbedded mesh 8. An alternative is shown in Fig. 3, in which the body 1 is constructed of concrete 9 in which ferrite 10 has been mixed. In a case where the body is constructed of the mesh-containing concrete 7, a method

using PC panels for the external wall, a method using PC panels for the external wall for, or a method using a mesh form can be employed. Generally, in an ordinary building body, electric waves are attenuated by 5 - 20 dB. However, if the aforementioned ferrite-containing concrete or mesh-containing concrete is used to construct the body, as set forth above, noise removal in a building having such a body can be raised to 60 dB. This makes it possible to avoid emission of electrical noise from the building and to prevent the communication system within the building from being adversely affected by electric waves from outside the building.

Even if the body of a building has an electromagnetic shielding structure, the building has openings in its body, such as a doorway 11 and window 13, as shown in Fig. 4A, and electric waves pass through these openings. Accordingly, it is necessary that these openings also be electromagnetically shielded. To this end, a revolving door method can be employed, as shown in Fig. 4B, or a double-door can be employed, as shown in Fig. 4C. In the latter method, the linear propagation property of high-frequency electric waves is utilized to attenuate the energy of the electric waves during their transit from the first door to the second door, or an interlocked arrangement is adopted in which one of the two doors is always kept closed. At a window opening, it will suffice if the

glass contains electrically conductive mesh or makes use of an electrically conductive tape that also conserves energy. Adopting the above-described expedients prevents electric waves from passing in and out of the building through the doorways and windows to provide the overall building with an electromagnetically shielded structure.

Another example of an opening in the body of a building is a duct. A duct can be electromagnetically shielded by using a metal mesh in the duct filter. As for portions where gaps are formed, electromagnetic shielding can be provided by using an electrically conductive rubber packing or electrically conductive brushes. These portions can be electromagnetically shielded by any appropriate method.

Figs. 5A, 5B are views for describing an embodiment of another method of electromagnetically shielding a building, in which 21 represents a PC (precast concrete) panel, 22 a conductor, 23 a fastener, 24 a slab and 25 a mesh.

In Figs. 5A, 5B,, the mesh 25 having the conductor 22 led out therefrom it imbedded in the PC panel 21, which is attached to the slab 24 by a fastener 23. When the PC panel 21 is attached to the slab 24, the conductor 22 is connected to the fastener 23, and the meshes 25 in PC panels 21 of the upper and lower floors are electrically interconnected via the fasteners 23. By grounding the mesh 25 in the PC panel 21 on the

lowermost floor, all of the meshes 25 in the PC panels 21 covering the building are grounded to improve the electromagnetic shielding performance of the building.

In addition to the above embodiments, it is of course possible to provide an external wall with an electromagnetic shielding structure in accordance with the invention. For example, if a curtain wall is used as the external wall, the prior-art structure is such that cushion (an annular ring) is attached to the side face of a conventional curtain wall, a curtain wall edge portion is placed on the cushion, and this is fastened by securing anchor bolts to fasteners fixed to the building body side. Therefore, mutually adjacent curtain walls will not be electrically integrated merely by constructing an external wall of curtain walls using electromagnetic shielding members, and electric waves will leak from the gaps between the curtain walls. Thus, the overall external wall will have a very poor electromagnetic shielding effect. An example of an electromagnetic shielding structure capable of solving this problem will now be described.

Fig. 6 is a view showing an embodiment of an electromagnetic shielding structure of an external wall using a curtain wall for a building in accordance with the invention. Numerals 31, 39 denote PC curtain walls, 32, 34 anchor bolts, 33 a faster, 34 an annular ring, 35 a back-up member, 36 a caulking material, 37 the beam of a steel frame, and 38 a crossover

connecting wire.

Fig. 6 shows a transverse section of the connection between an upper-side PC curtain wall 31 and a lower-side curtain wall 39. In the external wall structure using the PC curtains walls shown in Fig. 6, the fastener 33 is secured to the steel frame beam 37, and the PC curtain walls 31, 39 are fixed to the fastener 33 by anchor bolts 32, 40. By securing the PC curtain walls 31, 39 to the fastener 33 with the annular ring 34 affixed to the side face of the PC curtain walls 31, 39, the gap between the panels is closed by the annular ring wound on the side face, as illustrated. A gap near the surface of the external wall is filled with the back-up member 35 and with the caulking material 36 disposed on the back-up member.

In the electromagnetic shielding structure of an external wall using a curtain wall in accordance with the invention, electromagnetic shielding members are used in the PC curtain walls 31, 39, the main body is made an electromagnetic shielding layer, and an electrically conductive cushion is used as the annular ring 34. In a case where the PC curtain wall has the annular ring 34 affixed to the side face with an electrical insulator layer interposed therebetween, the annular ring 34 and anchor bolt 32 are connected using the crossover wire 38, thereby electrically integrating the electromagnetic shielding layers on the main bodies of the PC curtain walls 31, 39 at the anchor bolts 32,

40 and fastener 33. The annular ring 34 is electrically integrated with the anchor bolt 32 by the crossover wire 38. An electrically integrated structure is obtained by using an electromagnetic shielding member as the back-up member 35.

Since the annular ring is wound on the side face of the PC curtain walls, a gap at the joint of the left and right PC curtain walls is closed by an annular ring, back-up member and caulking material, just as shown in Fig. 6, in order to obtain an electrically integrated structure.

By thus providing the periphery of a building with an electromagnetic shielding structure as set forth above, the communication of information utilizing electric waves can be carried out freely within the building.

In the system using the branch devices shown in Fig. 1, the branch devices connected to the community coaxial cable possess reverse-connection loss in order to reduce interference among one another. More specifically, owing to reverse-connection loss, signals flow between the head end and each set of equipment, but signals do not readily flow between one set of equipment and another. Ordinarily, reverse-connection loss is set in accordance with the FM or television frequency band of 80 MHz or greater for community use and is effective for high frequencies of 10 MHz or more.

In a case where a frequency band of the coaxial cable other than the FM or television frequency band is adopted for the communication line, there will be a frequency band in which reverse-connection loss is effective, i.e. a high-frequency band of 10 MHz or more, and a frequency band in which reverse-connection loss is not effective, i.e. a low-frequency band of several MHz or less.

Accordingly, if the high-frequency band is used, it is necessary that the head end be provided with a repeater and that the transmission of information between communication controllers be carried out through the repeater. In other words, assume that a signal transmitted by a communication controller is an up-signal and that a signal received thereby is a down-signal. By using the repeater to switch the up-signal for the down-signal instead of up- and down-carrier frequencies, a single transmission line will enable communication between communication controllers.

If the low-frequency band is used, on the other hand, the repeater is unnecessary. However, a base band FSK (frequency shift keying) system is employed for signal transmission between communication controllers so that FM and television broadcasts will not be adversely affected. More specifically, when information is transmitted via a television community axial cable by "1", "0" pulses, the pulse signal

contains high-frequency components, as a result of which FM and television broadcasts are adversely affected. With the base band FSK system, however, a frequency shift (FS) takes place in a frequency band of several MHz or less in accordance with the "1", "0" information, so that there are no high-frequency components detrimental to FM and television broadcasts.

The present invention is not limited to the above-described embodiments but can be modified in various ways. For example, instead of leading out a conductor from a mesh imbedded in a PC panel, the mesh and an imbedded bolt used for connection to the fastener can be electrically connected beforehand at the factory.

Further, in the above-described embodiments, the annular ring and anchor bolt are connected solely on the lower side of the curtain wall. However, a similar connection can be made on the upper side as well. In addition, if the annular ring is affixed to the side face of the PC panel without an intervening insulating layer, the crosswire between the annular ring and anchor bolt can be deleted.

In accordance with the invention, the body of a building is electromagnetically shielded and communication using electric waves of any frequency is carried out inside the building. This enables communication using a wide frequency band and permits communication lines to be increased without limitation. Since the laying of communication cables is

unnecessary, building construction is facilitated and construction costs can be reduced. Since an electromagnetic shielding effect is obtained thanks to the mesh imbedded in the PC panels, work on-site is simplified, the term of construction is shortened and expenses are reduced.

The entire external wall surface using curtain walls can be constructed as an electromagnetic shielding layer since an electrically conductive cushion is used as the annular ring wound on the side face of the curtain wall. If an insulating layer is interposed between the electrically conductive cushion and the electromagnetic shielding layer of the curtain wall, the electromagnetic shielding effect of the external wall can still be assured by connecting the electrically conductive cushion and the anchor bolt with the crossover connection wire. Moreover, by connecting the electrically conductive cushion and anchor bolt in advance before construction of the external wall, the latter can be constructed, and the electromagnetic shielding effect can be obtained simultaneously, merely by securing the PC curtain wall to the fastener by means of the anchor bolts, just as in the prior art.

In the communication system, a coaxial cable ordinarily laid in a building is utilized. Leakage coaxial cables and antennas need only be provided on the ceiling of each floor and connected to the

aforementioned coaxial cable via branch devices. This reduces the expenses required for the communication medium and eliminates some of the labor involved in construction work. If wireless transceivers are used, communication within the building becomes possible. This makes it unnecessary to modify the partitions and equipment arrangements on each floor as well as the wiring of communication lines when tenants change. The overall result is a very flexible system.

WHAT IS CLAIMED IS:

1. An electromagnetically shielded building comprising:

a building portion constituted by an electromagnetic shielding structure, all or a part of the interior of the building being formed as an electromagnetically shielded space;

communications equipment for communications within said building; and

an electromagnetic signal transmission medium in said shielded space arranged so that sets of said communications equipment communicate with each other within said building using electromagnetic waves transmitted through said transmission medium.

2. An electromagnetically shielded building according to claim 1, wherein the outer peripheral portion of said building is constituted by an electromagnetic shielding structure comprising ferrite-containing concrete.

3. An electromagnetically shielded building according to claim 1, wherein the outer peripheral portion of said building is constituted by an electromagnetic shielding structure comprising mesh-containing concrete.

4. An electromagnetically shielded building according to claim 1, wherein the outer peripheral portion of said

building is constituted by an electromagnetic shielding structure comprising an external wall of PC panels having an imbedded electrically conductive mesh electrically connected to fixed electrically conductive members of said body and grounding PC panels.

5. An electromagnetically shielded building according to claim 4, wherein the electromagnetic shielding of said building is by a mesh-containing concrete in the outer peripheral portion of said building and said electrically conductive mesh in said PC panels are connected to the mesh in said mesh-containing concrete.

6. An electromagnetically shielded building according to claim 1, wherein the outer peripheral walls of said building are an electromagnetic shielding structure and electromagnetic shielding curtain walls are fixed to said outer building walls by anchor bolts and metal fastener, affixing an electrically conductive annular ring to a side face of said curtain wall, and electrically integrating mutually adjacent curtain walls.

7. An electromagnetically shielded building according to claim 6, wherein said electrically conductive annular ring and said anchor bolts are electrically connected.

8. An electromagnetically shielded building according to claim 6, wherein a gap between mutually adjacent curtain walls is filled by a back-up member comprising an electromagnetic shielding material, and a caulking material disposed on said back-up member.

9. An electromagnetically shielded building according to claim 1, wherein said signal transmission medium comprises:

a coaxial cable laid so as to pass through each floor of the building, and

leakage coaxial cables or antennas stretched along the ceiling of each floor and connected to said coaxial cable via branching devices.

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Fig. 1

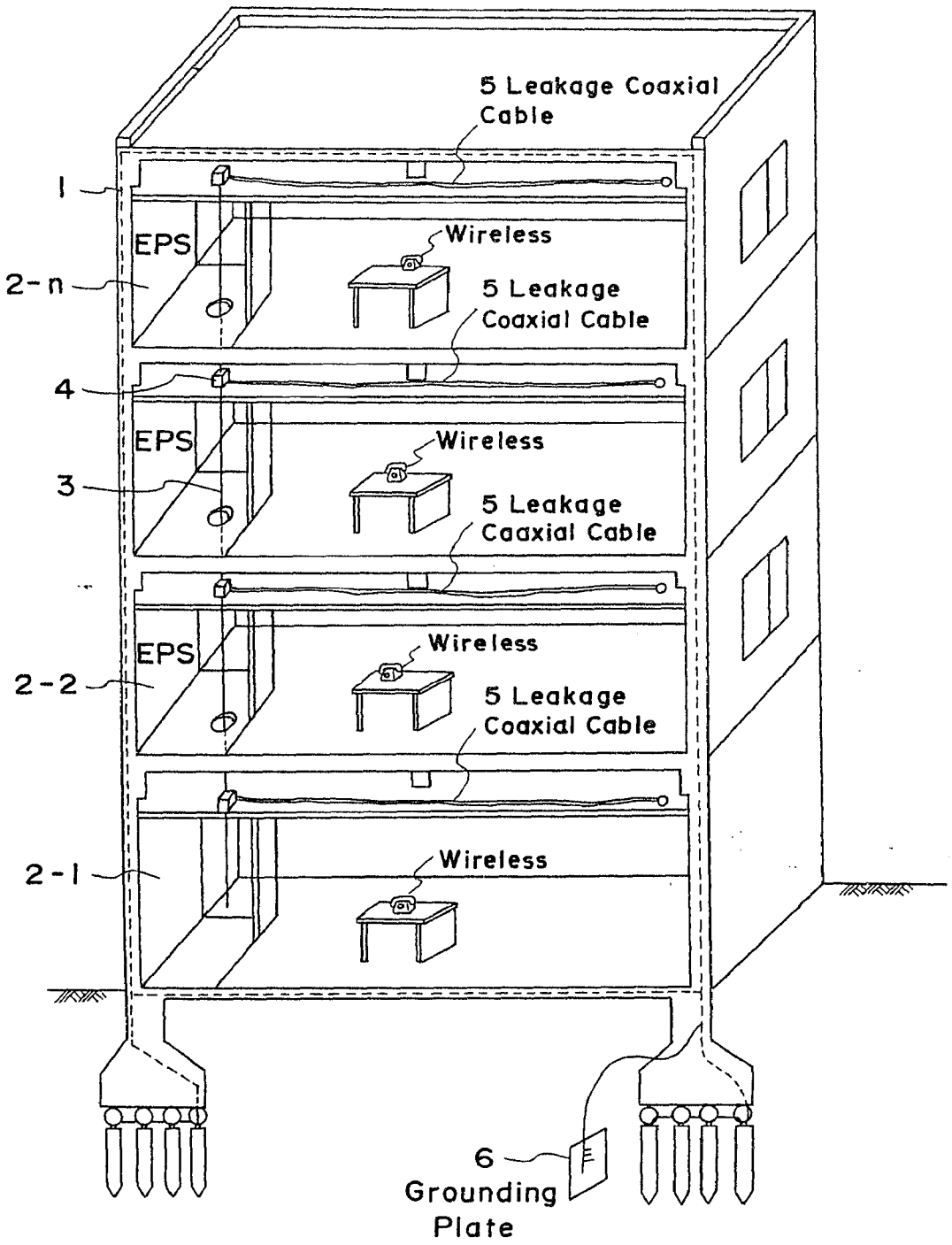

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Fig. 2

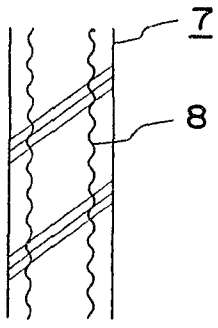

Fig. 3

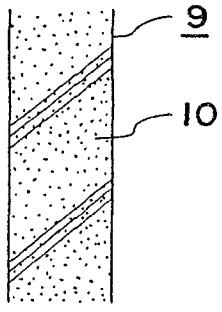

Fig. 4A

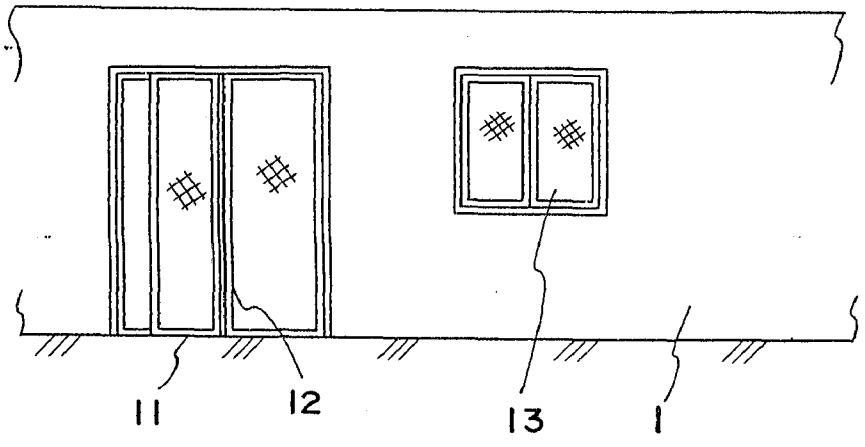

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Fig. 4B

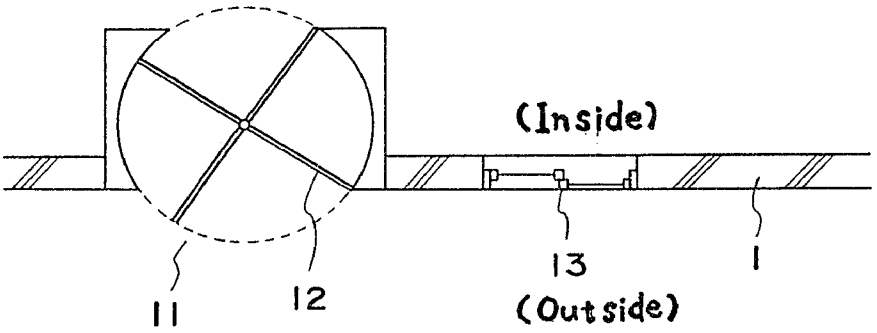

Fig. 4C

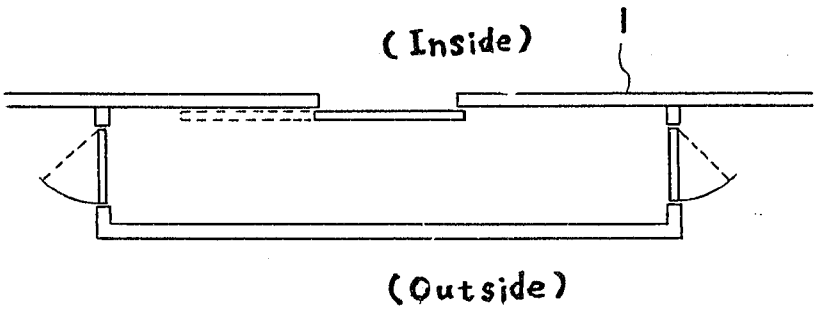

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Fig. 5A

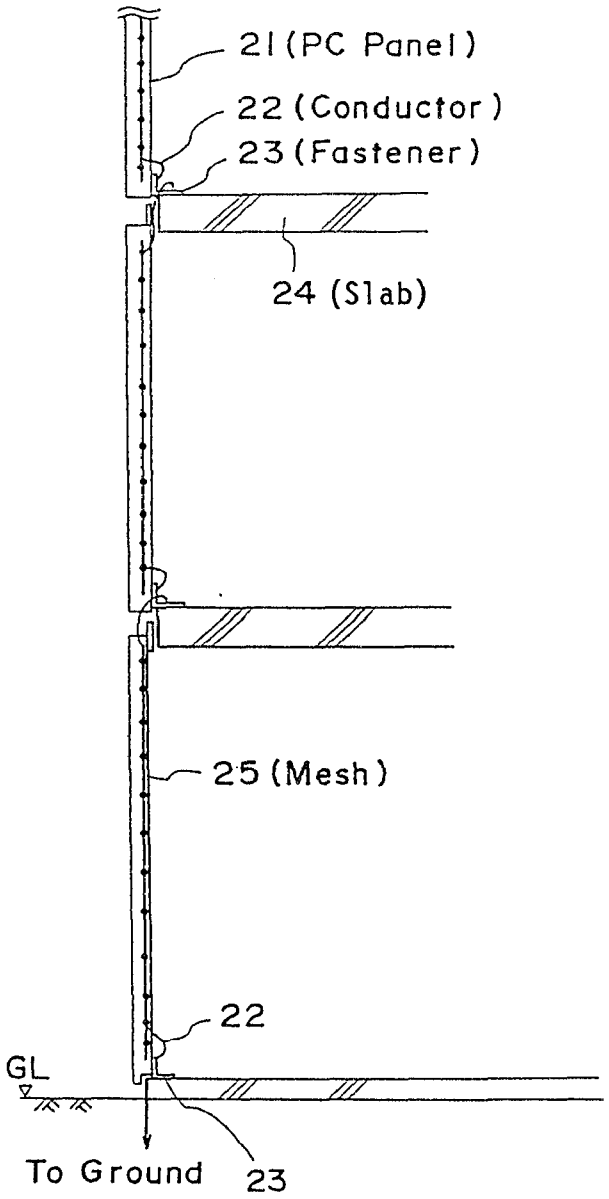

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Fig. 5B

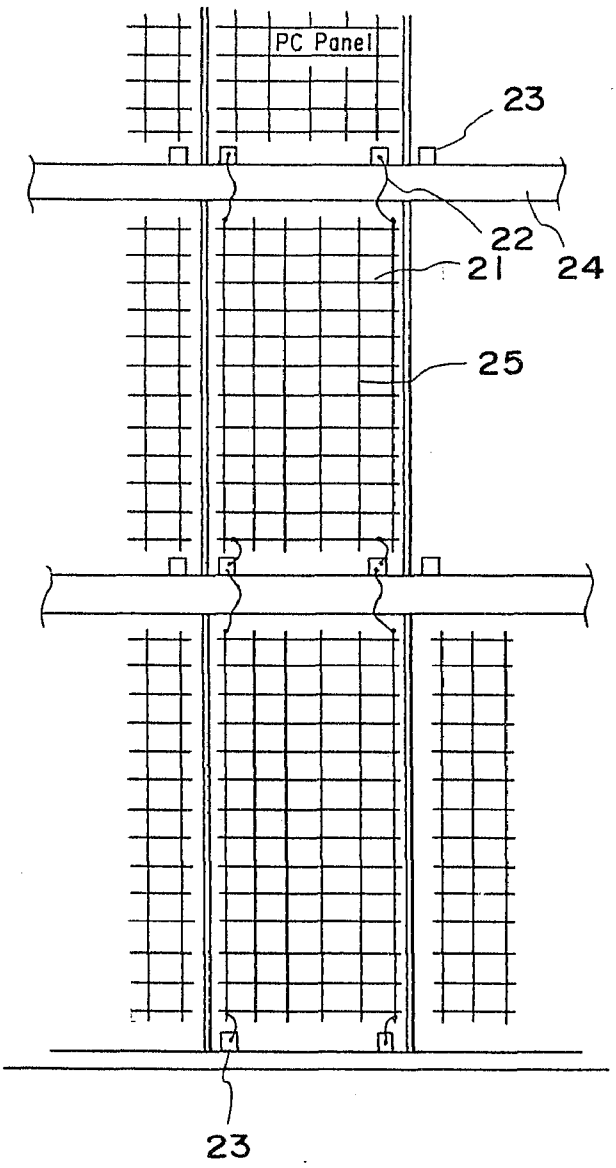

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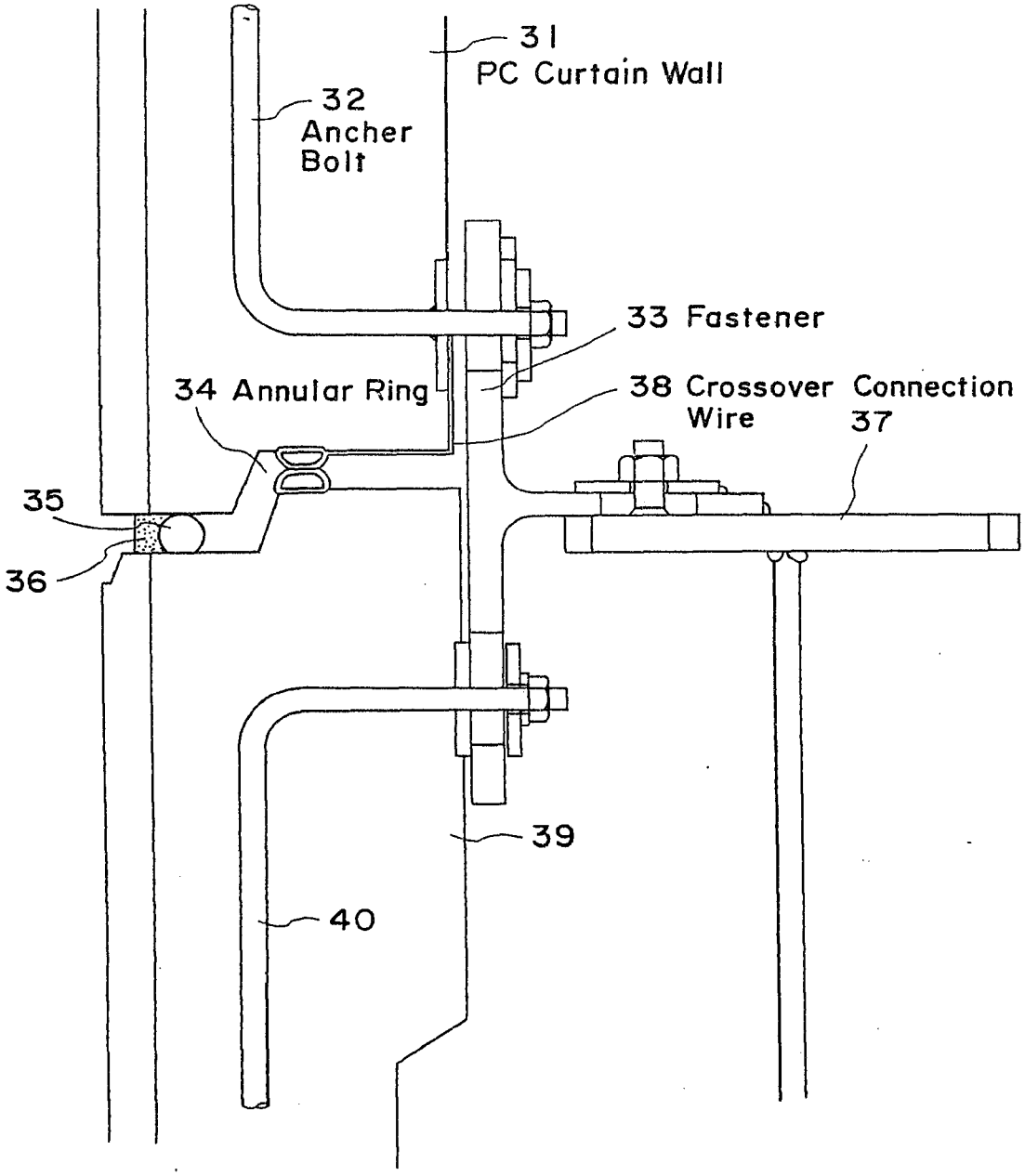
Fig. 6



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