

TITLE OF THE INVENTION

ELECTROMAGNETICALLY SHIELDED BUILDING

BACKGROUND OF THE INVENTION

The present invention relates to an electromagnetically shielded building, in which mobile communication can be carried out using wideband electric wave in indoor conditions, and it is possible to prevent radio interference or erroneous operation of electronic devices and systems inside the building caused by radio noise from outside and to create satisfactory electric wave environment for internal communication system.

In case radio communication is performed independently using electric wave in a building and if frequency range of the electric wave used is the same as that of external public electric wave, radio interference with external electric wave occurs in the communication system, thereby causing disturbance in public communication. However, if a building is constructed in an electromagnetically shielded structure to shield or cut off electric wave between inside and outside the building, frequency range can be freely selected for the communication system without worrying about the competition or interference with external public electric wave. For this purpose, it is necessary to completely cover the building with an electromagnetically shielding layer using conductive materials to prevent leakage of electric wave. With regard to an electromagnetically shielded building completely designed in

an electromagnetically² shielding structure, various proposals have already been filed.

When shielding of external radio noise is reviewed in terms of the prevention of erroneous operation as shown in Fig. 1, a shielding level of about 20 to 30 dB is needed in the frequency range of 100 kHz to 1 GHz. On the other hand, when prevention of information leakage is taken into account in terms of security, a higher shielding level, i.e. about 30 to 40 dB, is needed in the frequency range of 100 kHz to 3 GHz.

In the past, the electromagnetically shielded building has been considered as requiring higher electromagnetic shielding performance characteristics as described above, and construction cost for such a building has been accordingly higher. For example, a special type of electromagnetic shielding glass having an electromagnetic shielding layer comprising metal mesh, metal foil, etc. is used for windows of the building. The price for such electromagnetic shielding glass is by more than five times as costly as the ordinary type of glass.

However, it is not that a fixed shielding level is uniformly required for all types of buildings, which need electromagnetic shielding. The shielding level required varies according to the intended purpose or environmental conditions within the building or surrounding conditions of the building, and the specifications for construction are also diversified according to the shielding level. Among the buildings requiring electromagnetic shielding, the

shielding performance characteristics required for each purpose vary according to the types of buildings such as offices, hotels, sales stores and restaurants, schools and other educational institutions, hospitals and other welfare facilities, collective housings, cultural or other facilities for special events, factories, marketing and distribution facilities, etc.

For examples, in office buildings including computer centers in financial institutions, Government offices, public buildings, etc., it is necessary to reliably maintain the quality of information transmittance, to keep the constant number of channels, and to prevent erroneous operation of computers in order to eliminate radio disturbance. Also, it is necessary to perfectly prevent the leakage of secrecy in terms of security. In contrast, in collective housings, it will suffice if a certain quality of information transmittance can be maintained and an adequate number of channels can be kept so that privacy of the residents can be protected in terms of security.

In the buildings where computers are used, higher shielding level is required to exclude leakage of secret data, e.g. to prevent destruction of computer data caused by intrusion of external electric waves or to prevent leakage of data to outside. In such cases, higher shielding level must be provided for each electromagnetic shielding layer, and high confidentiality is required as a space using electric waves so that no gap occurs in the connecting or joining portions of the electromagnetic shielding layer.

On the other hand, various types of electronic systems and devices are now used in general buildings, and problems often arise such as erroneous operation of these electronic systems and devices or radio interference caused by various types of radio noise from outside. For example, in the regions lying along a highway, there are radio noises caused by high-output truck radio (the so-called "CB radio") not allowed by law. There are also radio noises caused by production equipment and facilities in adjacent factories or radio noises generated from pantographs of running electric trains in the regions along railroad. There are also electric waves of television and radio broadcasting.

These different types of radio noises cause erroneous operation of information systems such as general purpose computers, personal computers, etc., erroneous operation of smoke sensors, interphones, etc., erroneous operation of burglar alarm system, or radio interference to radio communication systems and devices. When such erroneous operation occurs late at night, false orders may be issued to guard personnel in remote control security system, or tranquility and sleeping may be disturbed in housing area, thereby causing serious problems such as disturbance of quiet daily life.

Because high shielding level nearly perfect is required for the protection of computer systems as in the former case described above, it is generally necessary to attain high shielding level as high as 30 dB by introducing high

5

quality electromagnetic shielding material and construction procedure. For this reason, construction costs are usually by 3 to 5% higher than those required for general construction. However, to maintain immunity to erroneous operation or radio interference of electronic systems and devices as the latter case, the problems can be solved by reducing radio noise down to the allowable level of each electronic system or device.

For example, of the radio noise as described above, which is likely to occur in normal surroundings, the maximum level at the generating source is about 140 dB, while it may be about 110 to 120 dB on wall surface of the building if attenuation due to distance is taken into account. On the other hand, the allowable level of radio noise on electronic systems and devices is 110 to 120 dB for a general-purpose computer and about 130 dB for a personal computer. Even in such cases, erroneous operation from unidentifiable cause may occur in actual situation. Naturally, the above values vary as time passes. Estimating from the circumstances, the problems of erroneous operation caused by radio interference can be solved by a shielding level of about 10 to 15 dB at the most. Therefore, if it is tried to achieve higher level of construction to attain the same shielding level as in the former case, the cost for construction will be much higher, and efficiency will be much lower in terms of cost-effectiveness.

If we consider high utilization of frequency in

personal handyphone system (PHS) or in mobile communication applied in radio Local Area Network (LAN) from the viewpoint of keeping communication line, the shielding level as high as 30 dB is not required in the frequency range of 1 to 3 GHz. PHS or radio LAN can be achieved at a shielding level lower than the level required for the purpose of security or for prevention of erroneous operation as emphasized in the electromagnetically shielded buildings in the past. Moreover, effective utilization of electric wave can be accomplished at much lower shielding level than the above cases. In future, if there may be the need to widen the frequency band width used, it can be easily anticipated that the frequency range of 3 GHz or higher would be included for such use.

As described above, if buildings are to be designed as the electromagnetically shielded buildings to cope with every possible conditions, the construction cost for such buildings may be much costlier in case attention is focused on high utilization of frequency for PHS or radio LAN in the frequency range of 1 to 3 GHz or in case it is aimed to prevent radio interference or to exclude erroneous operation of electronic systems and devices.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an electromagnetically shielded building suitable for mobile communication in wide range using electric wave and designed in simplified electromagnetic shielding structure depending

upon performance characteristics needed in high utilization of frequency. It is another object of the present invention to provide an electromagnetically shielded building, which can be built through simplified construction procedure by effectively utilizing common building materials and by which it is possible to reduce radio noise, to accomplish immunity to radio interference and to prevent radio interference and erroneous operation of electronic systems and devices in the building and to avoid radio interference in upper and lower floors.

To attain the above objects, the electromagnetically shielded building according to the present invention has an electromagnetically shielded space comprising an outer peripheral electromagnetic shielding layer provided on outer wall surface and a horizontal electromagnetic shielding layer provided on upper and lower floor surfaces for the purpose of preventing radio interference or erroneous operation of electronic systems and devices caused by radio noises from outside and of creating satisfactory radio environment suitable for internal communication system, whereby said outer peripheral electromagnetic shielding layer is made of building materials using glass and metal plates having electromagnetic shielding characteristics, and said horizontal electromagnetic shielding layer is made of floor structural materials having electric wave attenuating characteristics.

The glass having electromagnetic shielding

characteristics is a type of ⁸ glass having metallic film or wired glass, and the glass having metallic film is high-performance heat reflecting glass.

The building material using the metal plate is an aluminum spandrel. The outer peripheral electromagnetic shielding layer is transverse serial window comprising high-performance heat reflecting glass and aluminum spandrel or a full-face high-performance heat reflecting glass curtain wall or full-face aluminum spandrel. Or, it is provided on outer peripheral walls or on walls in a well or a stairwell and comprises wired glass or full-face aluminum spandrel.

In the outer peripheral electromagnetic shielding layer, a blind or a shade having blades each comprising conductive material and magnetic material attached on front and rear sides respectively is used to cover inner side of a window opening. When the window opening has sliding doors made of metal frames, a conductive material for blocking a gap on sliding portion of the window frame is arranged.

The above floor structural material is built with metal structural material, which also serves as a formwork.

The electromagnetically shielded building comprises an outer peripheral electromagnetic shielding layer provided on outer peripheral wall surface and a horizontal electromagnetic shielding layer provided on upper and lower floor surfaces, thereby forming an electromagnetically shielded space. Thus, radio interference or erroneous operation of electronic systems and devices caused by radio

noises from outside can be prevented, and satisfactory radio environment suitable for internal communication system can be created. The outer peripheral electromagnetic shielding layer has its electromagnetic shielding materials arranged along polarization direction of electric wave used in the internal communication system, and the horizontal electromagnetic shielding layer is built with floor structural materials having electric wave attenuating characteristics.

Said electric wave used is in the range of 1 to 3 GHz and in longitudinal polarization direction. By arranging the electromagnetic shielding material in longitudinal stripes with spacing of 5 cm or shorter, a shielding space having shielding performance characteristics of 10 dB or more can be provided. Said electromagnetic shielding material is a metallic longitudinal type blind used for window and is an electric wave absorber arranged on wall surfaces in the room.

Still other objects and advantages of the invention will in part be obvious and will in part be apparent from the specification.

The invention accordingly comprises the features of construction, combinations of elements, and arrangement of parts which will be exemplified in the construction hereinafter set forth, and the scope of the invention will be indicated in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram for explaining shielding levels required for various purposes;

Fig. 2 shows an arrangement of an embodiment of an electromagnetically shielded building according to the present invention;

Fig. 3 is a diagram showing measured values of electromagnetic shielding characteristics in the range of 1 to 3 GHz of a longitudinal type blind;

Fig. 4 represents drawings for explaining effects to improve electric wave propagation characteristics in the electromagnetically shielded building according to the present invention;

Fig. 5 represents drawings of an embodiment of a building having an arrangement to reduce radio noise according to the present invention;

Fig. 6 represents a plan view of a standard floor and a longitudinal sectional view of a building having an arrangement for reducing radio noise shown in Fig. 5;

Fig. 7 is a diagram for explaining relationship between noise level and shielding level;

Fig. 8 shows examples of backing materials at a connecting portion of metal plates;

Fig. 9 is a drawing of an example of floor structure on each floor using a metal structural material, which also serves as a formwork;

Fig. 10 shows examples of a glass mounting sector;

Fig. 11 represents an example of electromagnetic shielding glass using films;

Fig. 12 shows an example of shielding for a gap between a sash frame and a window frame of a sliding door in a window opening;

Fig. 13 is a partial cross-sectional view of a window frame of the sliding door shown in Fig. 12;

Fig. 14 represents examples of a blind used to build an electromagnetic shielding layer of a window opening; and

Fig. 15 shows an example of an indoor electromagnetic environment model in a building having an arrangement to reduce radio noise according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Description will be given on an embodiment of an electromagnetically shielded building according to the present invention referring to Fig. 2. In Fig. 2, reference numeral 1 represents a frame body of a building, 2 represents a floor, 3 a ceiling, 4 a window, 5 a blind, 6 represents glass, 7 represents an electromagnetic wave reflecting film, 9 an electric wave absorber, 10 a partition, 11 a parent antenna, 12 a daughter antenna, 13 a terminal, 14 a partition wall, and 15 represents an electromagnetic wave transmitting partition wall. In the frame body 1, ferrite-containing concrete or concrete with wire mesh is used together with slabs of the floor 2 or the ceiling 3 to provide electromagnetic shielding characteristics. Metal curtain walls may be used for the outer wall to provide electromagnetic shielding characteristics. In the window 4, the electromagnetic

12
wave reflecting film 7 is attached on the glass 6, or high-performance heat reflecting glass is used, or the metallic longitudinal type (longitudinal stripes) blind 5 or a curtain are arranged on inner side to provide electromagnetic shielding characteristics.

By the above arrangement, a shield zone (cell 1) and a shield zone 2 (cell 2) each constitute a space for communication unit respectively. The electric wave absorber 9 is attached on inner side of the wall or the floor and is used to absorb electric wave and to prevent generation of non-transmitting zones caused by reflection of electric wave in the room. The partition 10 is made of building materials primarily comprising a component for transmitting electromagnetic wave such as alumina hydroxide and is used to prevent interruption of electric wave. The parent antenna 11 is used to perform communication with the daughter antenna 12 connected to the terminal 13. The partition wall 14 is used to divide the shield zone 1 (cell 1), which constitutes a space for communication unit, and the electromagnetic wave transmitting partition 15 is arranged on a part of it to match the positions of the parent antenna 11 and the daughter antenna 12. Naturally, partition wall 14 may be designed totally as the electromagnetic wave transmitting partition.

As described above, an electromagnetic wave transmitting room can be designed if the electromagnetic wave transmitting material is used for the partition wall in

the same manner as the partition 10. However, it is needless to say that the electromagnetic wave absorbing material may be used as the partition 10 depending upon the arrangement of antennas or conditions of electric wave in the room. An electromagnetic wave absorbing partition or an interior electromagnetic absorbing panel are used to improve delay dispersion characteristics. By the above arrangement, it is possible to provide a shielded space, where delay dispersion characteristics are improved and high-speed radio equipment can be used.

By the way, transverse polarized waves in the frequency range of 500 kHz to 1 GHz are generally used in television and radio broadcasting. On the other hand, longitudinal polarized waves in the frequency range of 1 to 3 GHz are used in PHS (personal handyphone system) or radio LAN. Moreover, in case PHS in the frequency range of 1 to 3 GHz is adopted in the buildings, the shielding level is relatively lower to longitudinal polarization plane, and it may be much lower than the values of 20 to 30 dB required conventionally in the frequency range of 100 kHz to 1 GHz as already described. Even on such a shielding level, the same frequency can be used, for example, between the shield zone 1 (cell 1) and the shield zone 2 (cell 2) in PHS and radio LAN, and electric wave can be effectively utilized.

Fig. 3 is a diagram showing the measured values of electromagnetic shielding characteristics in the range of 1 to 3 GHz or a longitudinal type blind.

In some cases, electric wave can be effectively

utilized even when no shielding level of 30 dB as in the past is not available to longitudinal polarization plane in the frequency range of 1 to 3 GHz, e.g. even when the shielding level is about 10 to 20 dB. In such case, according to the experiment performed by the present inventors, it was found that effective utilization of electric wave can be achievable even when the electromagnetic shielding materials are arranged in longitudinal stripes with a given spacing. It was confirmed that, in case a longitudinal type metallic blind was used as the blind 5, for example, the above shielding level could be attained even with the spacing of about 4 to 5 cm each. Fig. 3 shows measure values in the frequency range of 1 to 3 GHz, and the shielding level of about 13 dB is attained. The spacing varies according to wavelength of the frequency in question and is not limited to the value of about 4 to 5 cm.

As described above, surrounding outer walls, ceilings, floors, and openings of the electromagnetically shielded space are totally covered with the electromagnetic shielding material in case of a conventional type electromagnetically shielded building, while effective utilization of electric wave can be accomplished on a shielding level much lower than the conventional level of 30 dB to longitudinal polarization plane in the frequency range of 1 to 3 GHz. Under this condition, conductive material may be arranged by the longitudinal type metallic blind in the same direction as the electric field

polarization direction of the electromagnetic wave. As a result, it is possible to arrange the electromagnetic shielding material in longitudinal direction with a given spacing to the longitudinal polarization plane by arranging wired glass in longitudinal stripes and also to simplify the electromagnetically shielded structure.

For example, in case of a window, it is possible as shown in Fig. 2 to arrange a metallic curtain in longitudinal stripes or a curtain woven with conductive fibers in longitudinal stripes, to attach an electromagnetic wave reflecting film on glass, or to use glass with metal wires woven in longitudinal stripes. Also, shielding characteristics of the same level (about 20 dB) can be attained by the use of high-performance heat reflecting glass. In other words, if conductive material is arranged by aligning it in the same direction as the electric field polarization direction of electromagnetic wave, a spacing corresponding to the wavelength of the frequency in question can be maintained. It is needless to say that the spacing may be turned to zero, i.e. it may be turned to a plane.

In PHS in the frequency range of 1 to 3 GHz, effective utilization of electric wave can be achieved even at a shielding level much lower than the conventional level of 30 dB in longitudinal polarization plane. Thus, a shielded space can be provided by arranging the electromagnetic shielding material in longitudinal stripe, and the renewal of the space can be accomplished in simple manner and at low cost. For the complete renewal of the

shielded space, it is necessary to replace window glass and sash, and further to guarantee the shielding characteristics of about 30 to 40 dB in the electromagnetically shielded space by providing interior electromagnetic shielding structure. If simple renewal of the space is acceptable, it will suffice to attach the electromagnetic wave reflecting film, to adopt high-performance heat reflecting glass, to mount the longitudinal type metallic blind and to take necessary steps for electrical connection.

Fig. 4 represents drawings for explaining the effect to improve electric wave propagation characteristics in the electromagnetically shielded building of the present invention. First, in a conventional type electromagnetically shielded building with its inner side covered with a metallic surface 21 as shown in Fig. 4A, electric wave from the parent antenna 22 is reflected by the metallic surface 21, and non-transmitting zones are generated near the metallic surface 21. To eliminate the non-transmitting zones, an electric wave absorber 24 is attached on the metallic surface 21 as shown in Fig. 4B. Therefore, the electric wave absorber 24 may be arranged at least at a position where electric wave from the parent antenna 22 is directed in vertical direction. The electric wave absorber 9 as shown in Fig. 2 is arranged for this purpose. Because polarization plane is deviated when electric wave is reflected, such phenomenon must be taken into account when the electric wave absorber is to be

provided.

Next, description will be given on an embodiment, by which it is possible to reduce radio noise and to prevent radio interference or erroneous operation caused by radio noise from outside in radio equipment, electronic systems and devices, etc. in the building. In the electro-magnetically shielded buildings shown in Fig. 5 and Fig. 6, electromagnetic shielded characteristics of a certain degree are provided, and radio noise can be reduced by effectively combining the building materials commonly in use. At the same time, to prevent radio interference in upper and lower floors, building materials having electromagnetic shielding characteristics are used on walls and floors of a well.

In Fig. 5A, transverse windows having high-performance heat reflecting glass 31 and an aluminum spandrel 32 are used on front and right walls. A full-face glass curtain wall 33 using high-performance heat reflecting glass is adopted on the left wall as shown in Fig. 5B, and a full-face aluminum spandrel 35 is used for the rear wall. The high-performance heat reflecting glass has thin metallic film (metal film coating) formed by vacuum deposition of metal by sputtering, and this is used as a radio noise shielding film, which attenuates radio noise to about 1/5 (about 15 dB). In the high-performance heat reflecting glass, visible light transmittance varies according to film thickness or mixing ratio of the materials. In general, the thicker the film is, the lower the visible light

transmittance is, and the more the radio noise shielding characteristics are improved. For this reason, it is necessary to select film thickness or mixing ratio of the materials by taking special care on the shielding characteristics required, lighting condition of the building, heat from outside (air-conditioning efficiency), conditions for designing, etc. If the distance from the adjacent building is very short and light quantity from windows is not much, wired glass may be used instead of the high-performance heat reflecting glass or the aluminum spandrel as the outer wall if there is no special problem in designing.

In case it is desired not only to reduce radio noise from outside and to prevent erroneous operation, but also to exclude radio interference from upper and lower floors and to establish a communication cell on each floor, radio interference may not be prevented if there is a well (or a stairwell) even when electric wave is shielded on upper and lower floors. Therefore, if there is a well, it is necessary to shield the walls even when the well is inside the building. In the plan view of a standard floor shown in Fig. 6A, an area A is used for the purpose other than elevators EL, toilets WC, dressing rooms, and other office rooms, and there is no need to take special care on lighting. Thus, full-face aluminum spandrels 35 and 36 are used in this area for both the outer walls and the walls of the well. On the other hand, wired glass 37 is used on the other walls of the well because light quantity is lower

than the outer walls. In this case, the pitch of the mesh is selected according to frequency of the electric wave to be shielded and the shielding level, and it is preferably in size of 10 mm x 10 mm or smaller. Of course, high-performance heat reflecting glass may be used instead of the wired glass 37.

As described above, when the high-performance heat reflecting glass 31, the aluminum spandrel 32, the full-face glass curtain wall 33, the full-face aluminum spandrels 35 and 36, the wired glass 37, etc. are used as the outer walls and the walls of the well, it is possible to attenuate radio noise entering through the walls and to prevent erroneous operation of smoke sensors, interphones, or other electronic systems and devices and to exclude radio interference of radio communication equipment. On the other hand, for the toproof of the building and the floor of the lowermost floor, electromagnetic shielding layers 38 and 39 are provided, which comprise metal meshes, metal foils, or fibers, sheets, nonwoven fabrics, etc. using electromagnetic shielding materials as shown in the longitudinal sectional view of Fig. 6B. In the example shown in the longitudinal sectional view of Fig. 6B, the first floor (ground floor) is used as passage, lobby and entrance and is designed as an area 34 not used as office rooms but communicated with a well, and upper floors from the second floor are designed as the area used for office rooms. For this reason, the electromagnetic shielding layer 39 is provided on the floor of the second floor

because the upper floors above the second floor are used as the area for office rooms.

For the floor surfaces on each floor, shielding level of a certain degree can be achieved depending upon concrete thickness of floor slabs. Because electric wave for internal communication can be used with relatively low output, the shielding level as desired for upper and lower floors can be achieved depending upon concrete thickness and structure of floor slabs. On the other hand, in a building having relatively narrower floor area, output of electric wave for internal communication can be lowered, while, if floor area increases and communication area per floor is widened, output of communication wave may be increased. In such case, concrete thickness and structure of floor slabs may be sufficient without any change or an electromagnetic shielding layer may be specifically needed for the prevention of radio interference on upper and lower floors. In case sufficient attenuation of electric wave cannot be attained on upper and lower floors by concrete slabs alone, a metallic structural material, also serving a formwork, such as a metal deck plate (F deck plate) may be used to prevent radio interference of radio communication equipment on upper and lower floors and to completely utilize the usable channels.

Fig. 7 is a diagram for explaining the relationship between the noise level and the shielding level.

Radio noise coming from illegal and high output truck radio (CB radio) as already described, radio noise caused

by production equipment in adjacent factories, or radio noise generated from pantographs of electric trains are at the level of about 140 dB at the highest at the generating sources. In contrast, the allowable level of general-purpose computers, personal computers, and other electronic systems and devices is about 110 to 130 dB. Supposing that the attenuation due to distance from the generating source is about 20 to 30 dB, it is attenuated nearly to the allowable level. Even though erroneous operation or radio interference occurs rarely, erroneous operation or radio interference can be prevented at the shielding level to attenuate radio noise to about 1/5 or at the shielding level of about 15 dB as shown in Fig. 7. Therefore, even when metal mesh or film is not attached or even when the electromagnetic shielding glass (with the shielding level of about 30 dB) with metal film formed on it is not used, the shielding level of about 15 dB can be attained with the high-performance heat reflecting glass depending upon film thickness or mixing ratio of the materials. In case of wired glass, it is generally considered that the shielding level is 1/20 or less in comparison with wavelength of the electric wave to be shielded and that it is 5 mm x 5 mm or less in the frequency of up to 3 GHz, and this is based on the assumption that the shielding level is about 30 dB. However, if the shielding level of one-half of the above, i.e. about 15 dB, can be attained, that is, if the level of radio noise is attenuated to about 1/5, the size may be 10 mm x 10 mm or less at the same frequency. It is needless

to say that higher shielding level can be attained with aluminum spandrel, steel panel, metal deck plate, etc. As described above, by selecting and combining the building materials used in the past depending upon surrounding radio noise environment and by adding more elaborate procedure when necessary, it is possible to attain the adequate shielding level in order to prevent radio interference and erroneous operation of the electronic systems and devices caused by radio noise from outside and to create satisfactory electric wave conditions for internal radio systems without causing mutual radio interference in upper and lower floors.

Next, description will be given on concrete construction examples of walls and floors. Fig. 8 shows examples of backing materials at connections of metal plate; Fig. 9 represents an example of floor structure of each floor using a metal structural material, also serving as a formwork; Fig. 10 represents construction examples of glass mounting sector; and Fig. 11 shows an example of electromagnetic shielding glass using film. In the figures, reference numeral 31-2 represents a metallic film, 31-3 represents a sash frame, 31-4 a sealing member, 31-5 and 31-6 each represents a backup member, 31-7 represents a setting block, 31-8 an electromagnetic shielding sheet, 31-9 a pressor rim, 41 a cement plate, 42 a metal plate, 43 a C-shaped channel plate, 44 a aluminum spandrel, 45 a modified C-shaped channel plate, 46 a metal panel, 47 a floor slab concrete, and 48 represents a metal structural material, also serving as a formwork.

For the connection of outer peripheral wall using aluminum spandrel, metal panel, or other metal plate, for example, the metal plate (aluminum plate) 42 and the C-shaped channel plate 43 are used as backing materials on the cement plate 41 as shown in Fig. 8A. In so doing, even when a gap for connection is provided to absorb expansion or shrinkage of the metal plate due to temperature change, it is possible to prevent decrease of shielding characteristics by covering the gap with the metal plate 42. In case the metal panel 46 as shown in Fig. 8B is used, a special hardware such as a modified C-shaped channel plate 45 may be connected. By designing the connection in this manner, even when a surplus gap occurs to joining portion of the aluminum spandrel 44 of the metal panel 46 by taking expansion or shrinkage due to temperature change into account, it is possible to prevent direct intrusion of radio noise and to attenuate radio noise to some extent because the gap is blocked by the backing materials such as the metal plate 42 or the modified C-shaped channel plate 45. As the backing materials, C-shaped channel or plate made of conductive steel, aluminum, or stainless steel are used.

In case sufficient electric wave attenuation level (shielding level) cannot be attained by concrete slabs alone in floor structure of each floor, a metal structural material 48, also serving as a formwork, such as a metal deck plate (F deck plate) is used for floor structure of each floor as shown in Fig. 9, and concrete slabs 47 are placed on it. In this case, a gap is generated between

the metal structural material and formwork 48 serving as the electromagnetic shielding layer and the aluminum spandrel 44 on wall, but sufficient attenuation characteristics can be achieved by the use of the metal structural material/formwork 48 to the electric wave used for internal communication because it is at the end. This is attributable to the fact that the radio systems (such as PHS, radio LAN) used indoors have been turned to lower output in recent years. In case the characteristics of sufficient level as described above cannot be obtained, it is needless to say that adequate connecting procedure between the shielding layers may be selected and adopted for the abutted portion as already proposed.

On the mounting sector of the high-performance heat reflecting glass, the setting block 31-7 and the high-performance heat reflecting glass 31 are set on the sash frame 31-3 as shown in Fig. 10A and are fixed by the backup members 31-5 and 31-6 and the sealing member 31-4. In this case, the gap between the sash frame 31-3 and the metal film 31-2 is blocked using the electromagnetic shielding material as the backup member 31-6 on the side where the metal film 31-2 is present.

Or, as shown in Fig. 10B, the electromagnetic shielding sheet 31-8 may be placed on the setting block 31-7 and the high-performance heat reflecting glass 31 may be set, and this may be fixed by the backup member 31-5 and the sealing member 31-4. As the electromagnetic shielding sheet 31-8, nonwoven fabric, metal foil, tape, etc. using

electromagnetic shielding material may be used. Naturally, in case where radio noise can be reduced to the allowable level by conventional construction procedure using the high-performance heat reflecting glass 31 depending upon the surrounding conditions, there is no need to use the backup member 31-6 or the electromagnetic shielding sheet 31-8 using such electromagnetic shielding material.

Instead of the arrangement to use electromagnetic shielding material as the backup member 31-6 on the side where the metal film 31-2 is present as shown in Fig. 10A, the pressor rim 31-9 using conductive material may be used as shown in Fig. 10C. The pressor rim 31-9 is used to electrically connect the metal film 31-2 with the sash frame 31-3, and it may be a conductive gasket.

As the metal film 31-2, the one in composite film construction, combining a sunlight reflecting film 41-2a with a conductive film 41-2b as shown in Fig. 11, may be used. In this case, if the sunlight reflecting film 41-2a is used on outer side and the conductive film 41-2b is used on inner side, ultraviolet ray is shut off, and durability of the entire film can be improved. Durability is extensively improved and cost is reduced compared with the case where only the conductive film 41-2b is used.

Next, description will be given on an example of shielding for a gap between sash frame and window frame having sliding doors at window opening as shown in Fig. 12 and Fig. 13.

In the window opening, metal sash 65 such as aluminum

sash is fixed on an opening 55 as shown in Fig. 12, and a metal frame 64 having rectangular cross-section is mounted on the sash 65. A gap between outer periphery of the sash frame 65 and the outer wall 54 is sealed by a sealing member 66 and a backup member 67. On the sash frame 65, a pair of upper rail 65a and a lower rail 65b are integrally formed, and two sliding doors 63 and 63 are incorporated. The sliding door 63 comprises a metal window frame 63a, a wheel 63b mounted on lower portion of the window frame 63a, a guide groove 63c arranged on upper portion of the window frame 63a, and a window glass 63d engaged in the window frame 63a and having electromagnetic shielding characteristics. The wheel 63b of the sliding door 63 and the guide groove 63c are arranged between the rails 65a and 65b of the sash frame 65 to make the sliding doors 63 slidable.

In the window opening as described above, a gap is generated between the upper portion of the window frame 63a and the upper rail 65a and between the lower portion of the window frame 63a and the lower rail 65b. Also, in case the sliding doors 63 are closed as shown in Fig. 13, a gap is generated on the portion where two window frames 63a are overlapped. Conductive members 59 to 61 each comprises a conductive gasket or a conductive brush, and these are helpful in blocking the gaps and in preventing electric wave leakage, thus excluding decrease of electromagnetic shielding characteristics on this portion.

Next, description will be given on examples where a

blind is used in the electromagnetic shielding layer of the window opening. A blind 71 comprises blades each having a conductor such as conductive material or conductive paint on one side and a magnetic material such as ferrite on the other side. In a blind box 75 on inner side of the window opening, a blind suspender 76 is mounted, and the blind 71 is suspended using steel cord for moving up and down the blind itself. A conductive gasket 73 is mounted on its lower end and on the lower wall, and it is integrally and electrically connected with the electromagnetic shielding layer 74 on inner side of the wall. A conductive material is used in a connecting bellows 77, and it is used to electrically connect the blind box 75, for example, to a deck plate (metal) of slab. An electric wave absorber 72 is arranged on both sides of the blinds when these are aligned in transverse direction, i.e. when these are provided on a vertical portion 78 of the window opening between the blinds 71, and it prevents the leakage of electric wave from gaps at left and right ends and at lower end of the blind.

For the electric waves commonly in use, frequency range is assigned according to the intended purpose. These electric waves are divided to longitudinal polarized wave and transverse polarized wave in relation to polarization direction of electric field. Transverse polarized wave is used in the frequency range of 500 kHz to 1 GHz for general television and radio broadcasting, while, for PHS (personal handyphone system) or radio LAN, longitudinal polarized wave

in frequency range of 1 to 3 GHz is used. When electromagnetic shielding is performed with metal blind, which is a conductive material, it is possible to attain a certain shielding level for PHS and radio LAN using longitudinal polarized wave, but shielding effect cannot be effectively obtained for transverse polarized wave. However, by the blind 71 of the present invention as described above, front and rear sides of the blade are made of a conductive material and a magnetic material respectively to match the electric wave where electric field and magnetic field perpendicular to each other are spatially and simultaneously present and propagate, and a certain shielding level can be attained regardless of whether polarization direction of the electric field of electric wave is longitudinal polarized wave or transverse polarized wave, and it is possible to suppress the decrease of the shielding level at the window opening. This is because electric wave having transverse polarization direction in electric field is longitudinal polarized wave in magnetic field, and electric wave can be shielded by the magnetic material arranged in longitudinal direction.

Next, description will be given on an example of an indoor electromagnetic environmental model in a building to reduce radio noise according to the present invention shown in Fig. 15. In the model shown in the figure, a high-performance heat reflecting glass 81 and an aluminum spandrel 82 are used for outer wall, a wired glass 83 is used for the wall of the well, and a steel panel 84 is used

for the partition wall. Further, electromagnetic shielding materials 85 and 86 by deck plate are used for ceiling and floor. In this way, building materials commonly in use are effectively utilized on six surfaces of the room space of the model shown in the figure, and although high shielding level is not attained, radio noise coming from outside can be attenuated to at least about $1/5$, i.e. to about 15 dB. As a result, it is possible to prevent erroneous operation of smoke sensors, interphones, electronic systems and devices such as general-purpose computers, personal computers, etc. caused by radio noise and also to extensively reduce radio interference of radio communication system on upper and lower floors.

The present invention is not limited to the above embodiments, and various changes and modifications can be made without departing from the scope and the spirit of the invention. For example, in the above embodiments, transverse windows comprising high-performance heat reflecting glass and aluminum spandrel are used on the front side, while curtain wall of full-face high-performance heat reflecting glass may be used or various combinations of glass having metallic film, metal panel and wired glass may be used for the outer peripheral wall. The numerical values given above are shown as general examples, and level of radio noise, allowable level, shielding level, etc. vary according to environmental conditions. Further, the glass having metallic film will suffice, and it is not limited to high-performance heat reflecting glass. To prevent radio

interference on upper and lower floors, electromagnetic shielding material may be used for the ceiling.

In the above embodiments, description has been given on a case where longitudinal polarized wave is used as communication medium, while the present invention can be applied in a case where transverse polarized wave is used as communication medium if consideration is given to the arrangement of the electromagnetic shielding material, e.g. the metallic blind is designed in transverse type in a direction aligned with the polarization plane or metal wires in transverse stripes are arranged. In the above embodiments, the electromagnetic shielding materials are used with a spacing of 5 cm or less in longitudinal stripes, while the spacing may be turned to zero, and it may be in planar shape.

As it is evident from the above description, it is possible according to the present invention to reduce radio noise from outside and to effectively utilize internal radio system. Moreover, radio interference on upper and lower floors can be prevented by reducing electric wave using wall of a well and floor structural materials, and it is possible to establish the upper and the lower floors as separate communication cells and completely utilize the usable channels. Because it is possible to select the materials from the building materials commonly used in the past, construction cost and working cost can be reduced and erroneous operation of fire alarms, interphones, etc. can be prevented.

Further, compared with the shielding characteristics of 40 dB required in the past, the shielding level is decreased extensively (to less than one-half), and a simplified shielding structure can be adopted. Further, the electric wave used is in the range of 1 to 3 GHz, polarization direction is longitudinal, and electromagnetic shielding materials are used with a spacing of 5 cm or less in longitudinal stripes, and it is possible to reduce the quantity of the electromagnetic shielding material used and to simplify the construction procedure, and to reduce the cost. Moreover, it is possible to effectively utilize radio system for frequency range of 1 to 3 GHz in longitudinal polarization direction as adopted for PHS. Because longitudinal metallic blind can be used for window, it is possible to easily adapt for windows. By arranging electric wave absorber on inner wall surface in the room, reflection of electric wave by wall surface can be prevented, and non-transmitting zone in the room can be eliminated. Thus, it is possible to reduce cost and to provide an electromagnetically shielded building suitable for communication in wider range.



WHAT WE CLAIM ARE:

1. An electromagnetically shielded building, having an electromagnetically shielded space comprising an outer peripheral electromagnetic shielding layer provided on outer peripheral wall and a horizontal electromagnetic shielding layer provided on upper and lower floor surfaces for the purpose of preventing radio interference or erroneous operation of electronic systems and devices caused by radio noises from outside and of creating satisfactory radio environment suitable for internal communication system, whereby:

said outer peripheral electromagnetic shielding layer is made of building materials using glass and metal plates having electromagnetic shielding characteristics; and

said horizontal electromagnetic shielding layer is made of floor structural materials having electric wave reducing characteristics.

2. An electromagnetically shielded building according to Claim 1, wherein the glass having the electromagnetic shielding characteristics is a type of glass having metallic film or wired glass.

3. An electromagnetically shielded building according to Claim 2, wherein said glass having metallic film is high-performance heat reflecting glass.

4. An electromagnetically shielded building according to Claim 3, wherein said outer peripheral electromagnetic shielding layer is designed in such manner that an electromagnetic shielding sheet is placed on a setting block



and the high-performance heat reflecting glass is engaged in a sash frame.

5. An electromagnetically shielded building according to Claim 3, wherein said outer peripheral electromagnetic shielding layer uses nonwoven fabric comprising an electromagnetic shielding material as an electromagnetic shielding sheet.

6. An electromagnetically shielded building according to Claim 3, wherein said outer peripheral electromagnetic shielding layer comprises a backup member using an electromagnetic material and arranged between the surface having metallic film of the high-performance heat reflecting glass and the sash frame.

7. An electromagnetically shielded building according to Claim 1, wherein the building material using the metal plate is an aluminum spandrel.

8. An electromagnetically shielded building according to Claim 1, wherein said outer peripheral electromagnetic shielding layer is transverse windows comprising high-performance heat reflecting glass and aluminum spandrel or a full-face high-performance heat reflecting glass curtain wall or a full-face aluminum spandrel.

9. An electromagnetically shielded building according to Claim 1, wherein said outer peripheral electromagnetic shielding layer is provided on an outer peripheral wall and on a wall of a well.

10. An electromagnetically shielded building according to Claim 9, wherein a wired glass or a full-face



aluminum spandrel is used for the wall of the well.

11. An electromagnetically shielded building according to Claim 1, wherein a metal plate is used as a backing material on a connection of said metal plate in said outer peripheral electromagnetic shielding layer, and a C-shaped channel steel is mounted on the metal plate, and the metal plate is fixed.

12. An electromagnetically shielded building according to Claim 1, wherein inner side of a window opening is covered with a blind comprising blades each having a conductive material and a magnetic material on front and rear sides respectively in said outer peripheral electromagnetic shielding layer.

13. An electromagnetically shielded building according to Claim 1, wherein sliding doors using metal frames are arranged on a window opening on said outer peripheral electromagnetic shielding layer, and a conductive member is arranged for blocking a gap formed on sliding portions of the window frame.

14. An electromagnetically shielded building according to Claim 1, wherein said floor structural material comprises a metal structural material also serving as a formwork.

15. An electromagnetically shielded building, having an electromagnetically shielded space comprising an outer peripheral electromagnetic shielding layer provided on outer peripheral wall and a horizontal electromagnetic shielding layer provided on upper and lower floor surfaces for the



purpose of preventing radio interference or erroneous operation of electronic systems and devices caused by radio noises from outside and of creating satisfactory radio environment suitable for internal communication system, whereby:

said outer peripheral electromagnetic shielding layer comprises an electromagnetic shielding material arranged to align with polarization direction of electric wave used in an internal communication system; and

said horizontal electromagnetic shielding layer comprises a floor structural material having electric wave reducing characteristics.

16. An electromagnetically shielded building according to Claim 15, wherein said electric wave used is in a range of 1 to 3 GHz.

17. An electromagnetically shielded building according to Claim 15, wherein said electric wave used is in longitudinal polarization direction, and said electromagnetic shielding material is designed in longitudinal stripes and the spacing is limited to 5 cm or less to create a shielded space having electromagnetic shielding characteristics of 10 dB or more.

18. An electromagnetically shielded building according to Claim 15, wherein said electromagnetic shielding material is a longitudinal type metallic blind used for window.

19. An electromagnetically shielded building according to Claim 15, wherein said electromagnetic



36

shielding material is an electric wave absorber arranged on wall surface in a room.