

PATENT SPECIFICATION

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(54) THERMALLY AND ACOUSTICALLY INSULATING GLASS SHEET STRUCTURE

(71) We, YOSHIDA KOGYO K.K., a corporation duly organized under the laws of Japan and existing at No. 1 Kanda Izumicho, Chiyoda-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a thermally and acoustically insulating structure of a type including three glass sheets arranged to define two air spaces therebetween. There are known various types of thermally and acoustically insulating structure for use in being installed in a window or door opening of a building. According to one conventional type of structure, there are three sheets of glass arranged to define two relatively wide air spaces therebetween, the air spaces containing air drying agents. The structure is designed to insulate incoming sounds of particularly high frequency range and provide a thermal insulating effect. Another known type of structure has at least one relatively small air space between two adjacent sheets which have the peripheral edges coated with adhesive thereby absorbing incoming sounds therein. A further different type of construction includes three sheets of glass defining air spaces of different widths therebetween to cut off heat radiation there-through. A four-glass structure has two pairs of outer and inner glass sheets, the inner glass sheets being kept spaced wide by spacer means and containing an air drying agent in the space, and the adjacent inner and outer sheets being kept spaced less wide and held so spaced by wrapping band. There are other similar types known which have two or more glass sheets spaced identically or differently. All known structures above cited have disadvantages. The first cited prior structure containing separate drying agents in the defined air spaces has no means for the two air spaces to communicate for circulating the air therebetween, thus making it necessary to install individual drying agents in the respective air

spaces. It is however necessary to provide a very narrow air space between the sheets so as to increase the insulating effect on sound of particularly low frequency range, and also to close the air space airtightly from the outside by means of sealant material. However, the above-cited structure and other structures, if the small air space is provided, are not capable of maintaining the air space in a dry condition because of structural limitations. Furthermore, in cases where a small air space is provided, the opposite glass sheets defining the space may become deformed under wind pressure upon the outer sheet, thus bringing the sheets closer relative to each other or eventually in contact with each other, which can unavoidably produce the effect of Newton's rings.

According to the invention there is provided a thermally and acoustically insulating structure comprising three sheets of glass arranged in parallel to define two air spaces of different widths therebetween and resiliently held by glazing members on the circumferential edges thereof, at least one of said air spaces having a spacer member circumferentially thereof containing air drying material therein; first and second ones of said sheets of glass being of a different thickness from each other and defining a relatively narrow or micro air space therebetween, said first and second sheets having the circumferential edges thereof opposite each other sealed by sealing material therebetween; the third sheet of glass defining with said second sheet an air space wider than said relatively narrow or micro air space, said second and third sheets having the circumferential edges thereof opposite each other sealed by sealing material therebetween; and one or more through-apertures provided in said second sheet of glass for providing communication between said relatively narrow or micro air space and said wider air space for air circulation therebetween.

The invention will be described by way of examples with reference to the accompanying drawings, wherein:

Figure 1 is a partly sectional view of a preferred embodiment of the invention;

Figure 2 is a partly sectional view of a modification of the structure of Figure 1, including means extending through the second one of two air spaces for preventing contact thereacross of two of the sheets of glass;

Figure 3 is a partly sectional plan view of Figure 2;

Figure 4 is a front view of an intermediate glass sheet having apertures at four corners through which dry air can flow between two air spaces;

Figure 5 is a graph of experimental data showing variations of acoustical transmission loss (dB) with frequency (H_z) when the structure of Figure 1 is installed with the first air space located on the side of the sound source;

Figure 6 is a graph of experimental data showing variations of the acoustical transmission loss (dB) with frequency (H_z) with the second air space located on the side of the sound source; and

Fig. 7 is a graph of comparative experimental data showing variations of dB with H_z with respect to two conventional structures and the preferred embodiment of the invention.

Referring first to Fig. 1, the thermally and acoustically insulating structure 1 embodying the present invention illustrated therein essentially includes three sheets of glass of non-uniform thickness. Fig. 1 indicates an embodiment of the invention in which the structure is installed in a building, with a relatively wide first air space located on the side of a sound or noise source. In Fig. 1, the structure generally designated by reference 1 comprises a 3mm (three millimetre) thick outer glass sheet 2, a 5 mm thick intermediate glass sheet 3 spaced substantially 6 mm distance away from the outer sheet 2 (the sheets 2 and 3 defining a first air space 5 of 6 mm width therebetween), and 3 mm thick inner glass sheet 4 spaced 0.2 mm to 0.5 mm (i.e., between 0.2 mm and 0.5 mm) away from the intermediate sheet 3 (the sheets 3 and 4 defining a second air space 6 of 0.2 mm to 0.5 mm width therebetween), the sheets 2, 3 and 4 being supported by a resilient member 8 such as rubber packing in a metallic frame 7 such that vibration of the sheets can be caused independently of one another when incoming sounds impact the sheets and pass through the sheets. As shown in detail in Fig. 1, the first air space 5 includes a spacer member 10 which contains a drying agent 9. More particularly, the spacer member 10 extends circumferentially of the first air space 5, and has an air channel 11 along the length of the inner face thereof, through which the drying agent 9 is exposed to act on the air in the air space 5. The gap between the spacer member 10 and the inner sides of the

opposite sheets 2 and 3 is circumferentially sealed with sealant material or like substances 12 so that the first air space 5 can be maintained air-tight from the atmosphere. As shown in Fig. 4, the intermediate sheet 3 has for example four apertures 13 at its four corners to allow the air in the first and second air spaces 5 and 6 to circulate therebetween. The arrangement, size and number of the apertures 13 are of arbitrary choice, and the essential consideration is the ease with which the air in the spaces 5 and 6 can be made to flow and circulate through the apertures 13 between the air spaces 5 and 6. The intermediate and outer sheets 3 and 4 defining the second air space 6 have their circumferential edges sealed with sealant 14 or similar material so that the space 6 can be maintained air-tight from the atmosphere. As shown in Figs. 1, 2 and 3, the sheets 3 and 4 each have a chamfer on the inner circumferential edge thereof sealed by adhesive sealant material therein. Provision of such cutout can make the second air space 6 better sealed in cooperation with the sealant 14 in the air space.

The drying agent 9 preferably contains synthetic zeolite, which has the property of being able to reduce moisture in the air to 0.1 p.p.m. (parts per million), and it is therefore possible to maintain the two air spaces 5 and 6 in a dry condition by circulating the air through the apertures 13 of the intermediate sheet 3 between the air spaces 5 and 6. The structure shown in Fig. 1 is preferably installed with the outer glass 2 on the side of any noise source. Fig. 2 indicates a modification of the structure in Fig. 1, in which the structure 1 is installed with the inner glass 4 or second air space 6 located on the side of a sound source. As already noted, the second air space 6, between the intermediate and inner sheets 3 and 4, is very narrow (0.2 mm to 0.5 mm) and therefore the possibility must be considered that the inner glass 4 may be subjected to strong wind pressure from the outside which may result in deforming the sheet 4 so that, as a consequence, the sheets 3 and 4 are brought in contact with each other at various points, with the accompanying effect of Newton's rings making various patterns on the sheets 3 and 4. The structure in Fig. 1 has no particular means to prevent such phenomenon, which will be described later, but even without such means it is possible to prevent the sheets 3 and 4 from coming into contact with a wind pressure of up to substantially one and a half times that which the sheet can resist without fracture, because there is dry air at atmospheric pressure air-tightly enclosed in the second and first air spaces.

The modification of the structure shown in Fig. 2 includes means to eliminate the effect of Newton's rings. Referring to Fig. 2,

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the structure generally designated by 1 has a similar construction to that in Fig. 1, except that there is provided a Newton's ring preventive means 15 in the second air space 6, in the form of a plurality of tapes or wires 15 (two parallel wires for example being shown) extending vertically in the second air space 6 and having both ends thereof secured to the peripheral edges of the opposite sheets 3 and 4 by means of adhesive sealant material. Each tape or wire 15 is preferably metallic wire such as piano wire or a strip of synthetic resin such as polyester, and has thickness or diameter smaller than the width of the air space 6 such that it can extend tautly across without contact with the inner surfaces of the opposite sheets 3 and 4. As shown, preferably two parallel tapes or wires are provided for the convenience of the appearance, but its number and arrangement are not limited to the embodiment shown. The sealant material used to seal the spaces tight between the adjacent sheets is preferably flexible butyl rubber which can maintain the spaces 5 and 6 perfectly air tight from the atmosphere. This airtightness of the spaces can prevent the glass from breakage or crack due to difference in temperature inside and outside.

In the preferred embodiments illustrated heretofore, the thicknesses of the sheets and the widths of the two air spaces have been given specific values, but those values should be understood to be non-limitative and may be varied properly depending on the surroundings in which the structure is installed. In other words, those values should have a range respectively which allows the structure to

provide a good acoustical insulating effect on particularly low-frequency range sounds or noises thereby having an average stably high transmission loss in the low frequency range of 125 to 500 Hz.

Fig. 5 indicates experimental data showing variations of the acoustical transmission loss (dB) with frequency (Hz), with the first air space located on the side of a sound source, and Fig. 6 indicates experimental data with the second air space on the side of the sound source. The experiment was carried out under the following conditions. The structure embodying the invention with an area of glass of 570 mm × 1170 mm (equal to 0.667 m² where "mm" is millimetres and "m" is metres) is installed in an opening (an area of 4 m²) of a test room (247 m³), and is fixed by means of clay to light weight concrete block. The sound supply room has a size of 109 m³ which produce sounds of 1/3 oct. (one third octave) range, and the structure was subjected to tests with the first and second air spaces on the source side. The test room had an ambient temperature and relative humidity of 12°C and 70%.

The table below presents values of the transmission loss (dB) varying with frequency of 100 to 5,000 Hz with regard to two embodiments of the invention and two conventional structures which have been obtained from the experiments, and those values are plotted in Fig. 7. Fig. 7 indicates the comparative graphical data in which the embodiments of the invention are each installed with the first air space on the side of the noise source.

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Frequency (Hz)	Acoustical transmission loss (dB)			
	3—6(*)—5—0.5(*)—3 (mm) (1)	3—0.5(*)—5—6(*)—3 (mm) (2)	Single glass 10 mm (3)	6—6(*)—6 (mm) (4)
100	—	23	19	—
125	23	27	21	27
160	24	23	23	24
200	24	23	25	20
250	24	24	26	24
315	25	24	28	27
400	26	26	29	24
500	28	28	30	27
630	31	31	30	30
800	33	32	29	33
1,000	35	34	29	34
1,250	37	36	27	34
1,600	37	37	28	32
2,000	36	37	33	25
2,500	39	39	37	29
3,150	40	39	39	30
4,000	41	39	42	34
5,000	42	41	—	—

Remarks:

*: air space (1) and (2): inventions, (3) and (4): conventional

5 The embodiments of invention have an average transmission loss of 27 dB in the frequency range of 125 to 500 Hz while the single sheet has an average value 26 dB and two sheets structure (6 mm—6 mm—6 mm) has an average 24 dB. In the frequency range of 315 to 5,000 Hz, the embodiments of invention have an average 35 dB as opposed to 32 dB and 30 dB, respectively. As shown in the table, the invention is superior to the 6—6—6 (mm) structure in respect of the thermal insulation, and is superior to the single sheet in respect of the sound insulation.

As readily understood from the foregoing description, embodiments of the present invention have numerous merits and advantages in respect of both thermal and acoustical insulation, in that the dry air in the two air spaces can circulate and flow through apertures in the intermediate sheet between the spaces, thereby cutting off the thermal energy passing through glass in the first air space and thus eliminating formation of dew or condensation on the glass surfaces due to the differential temperatures inside and outside, and furthermore thereby having an increased transmission

loss by absorbing the sound in the second air space. The effect of Newton's rings due to the contact of the closely spaced sheets which is caused by deformation of glass under strong wind pressure can be eliminated by maintaining the air in the second air space in an always dry state thereby making the outer sheet highly resistant to the wind pressure thereon, and preferably by interposing piano wires to extend across the second air space. The formation of dew or condensation on the inner surface of the glass sheets can be eliminated down to an ambient temperature of -49°C , when the structure shown in Fig. 1 has the arrangement of 3 mm thick intermediate sheet, whilst it can be eliminated down to -65°C when the arrangement includes 5 mm thick outer sheet—6 mm wide air space—5 mm thick intermediate sheet.

Although the invention has been described by way of the several preferred embodiments thereof, it should be understood that various changes and modifications may be made without departing from the scope of the invention as defined in the claims.

WHAT WE CLAIM IS:—

1. A thermally and acoustically insulating structure comprising three sheets of glass arranged in parallel to define two air spaces of different widths therebetween and resiliently held by glazing members on the circumferential edges thereof containing air drying material therein; first and second ones of said sheets of glass being of a different thickness from each other and defining a relatively narrow or micro air space therebetween, said first and second sheets having the circumferential edges thereof opposite each other sealed by sealing material therebetween; the third sheet of glass defining with said second sheet an air space wider than said relatively narrow or micro air space, said second and third sheets having the circumferential edges thereof opposite each other sealed by sealing material therebetween; and one or more through-apertures provided in said second sheet of glass for providing communication between said relatively narrow or micro air space and said wider air space for air circulation therebetween.

2. A structure as claimed in claim 1 wherein: said through-apertures comprise a plurality of apertures provided at four corners of said second sheet and exposed in said relatively narrow or micro air space and wider air space.

3. A structure as claimed in claim 1 or 2 wherein there is provided means extending across said relatively narrow or micro air space for preventing said first sheet from such deformation upon receipt of external wind pressure as to result in contact with said second sheet (thereby eliminating the effect of Newton's rings due to light incident on said first sheet being refracting through portions in contact of said first and second sheets).

4. A structure as claimed in claim 3 wherein said last-mentioned means comprises a plurality of parallel-spaced strips of material extending tautly across said relatively narrow or micro air space each having both ends secured to the circumferential edges of said first and second sheets and having a diameter or thickness substantially smaller than the width of said micro air space arranged so that said strip is normally not in contact with the inner surfaces of said first and second sheets opposite said strip.

5. A structure as claimed in claim 4 wherein said parallel-spaced strips comprise piano wire strips.

6. A structure as claimed in claim 4 wherein said parallel-spaced strips comprise polyester strips.

7. A structure as claimed in any preceding claim wherein the thicknesses of said three sheets of glass are:—the first sheet 3 mm thick; the second sheet 5 mm thick; and the third sheet 3 mm thick.

8. A structure as claimed in any preceding claim wherein said relatively narrow or micro air space defined by said first and second sheets is substantially in the range of 0.2 mm to 0.5 mm and said wider air space defined by said second and third sheets is substantially 6 mm wide.

9. A structure as claimed in any preceding claim wherein each of said first and second sheets has a chamfer on the inner side circumferential edge thereof opposite said relatively narrow or micro air space filled with sealing material therein.

10. A structure substantially as described with reference to and as illustrated in Figs. 1 and 4 of the accompanying drawings.

11. A structure substantially as described with reference to and as illustrated in Figs. 2, 3 and 4 of the accompanying drawings.

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11. A structure substantially as described with reference to and as illustrated in Figs. 2, 3 and 4 of the accompanying drawings.

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