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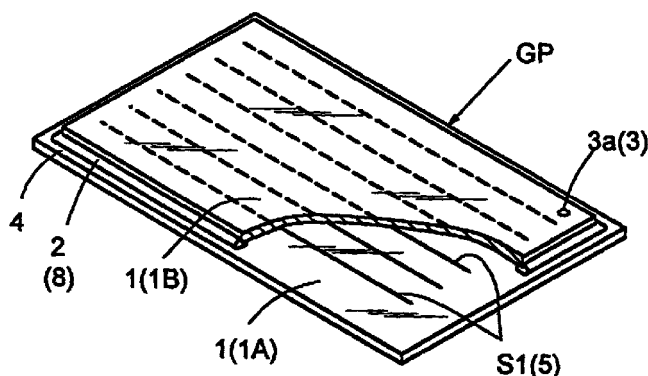
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(54) **GLASS PANEL**

(57) In a glass panel in which a spacer (S1) is interposed between a pair of first and second glass sheets (1A), (1B) and a sealing portion (2) is provided along the entire outer peripheral edges of the glass sheets (1A), (1B), and the space (V) between the first glass sheet (1A) and the second glass sheet (1B) is sealed under a pressure-reduced condition, the spacer (S1) capable of

obtaining a glass panel having superior heat insulating performance, greater resistance against breakage and transparency is disposed along the sheet surfaces of the first glass sheet (1A) and the second glass sheet (1B).

Fig.1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a glass panel wherein space between a pair of glass sheets is pressure-reduced to restrict convection of inner gas for reduction of thermal transmittance, hence improvement of thermal insulation performance.

[0002] More particularly, the invention relates to a glass panel wherein various spacers such as an elongate spacer or a spacer comprising a plurality of elements interconnected in spaced relationship via a wire member are interposed between a pair of glass sheets, and the glass sheets have entire outer peripheries thereof sealed for maintaining the space between them under a pressure-reduced condition.

BACKGROUND ART

[0003] With the above-described glass panel, the space between the glass sheets is maintained under pressure-reduced condition for enhancement of heat insulating and sound insulating performances. For this, the glass sheet are pressed against the spacers by the atmospheric pressure. If this pressing force is strong, there occurs stress concentration in the glass sheets at portions thereof contacting the spacers. Consequently, there may develop hertzian crack or conical crack or local crack called ring crack. With development of such local crack, the pressure-reduced condition of the space is impaired, leading to deterioration of the surface strength of the glass sheets or breakage of the glass sheets due to an external force such as a wind pressure, vibration etc.

[0004] Conventionally, for relieving such stress concentration to the glass sheets, there is known a construction in which a number of pillars as the spacers are distributed by a predetermined pitch over the glass sheet surfaces. However, the distributing operation and maintaining the set positions would be very troublesome.

[0005] Then, as a construction proposed for reducing the trouble of disposing the spacers, there is the Chinese patent published under No. CN1094475A. According to this, as shown in Fig. 68, elongate spacers S each comprised of a band-like element having a rectangular cross section are interposed between a first glass sheet 1A and a second glass sheet 1B.

[0006] However, this spacer S comes into contact, through the band-like side thereof, with the opposed glass sheets 1A, 1B, so that there exists a large contact area therebetween. Hence, heat transfer would readily occur between the spacers S and the glass sheets, leading to deterioration of the heat insulating performance of the glass panel.

[0007] Further, according to the above art, there exists significant resistance against ventilation between adja-

cent spaces V1 across the spacer S, so that the evacuating operation between the first glass sheet 1A and the second sheet glass 1B cannot be obtained efficiently.

[0008] Further, in order to reduce the distance between these glass sheets 1A, 1B, it is necessary to reduce the cross section of the spacer S. However, this will cause the spacer S to be readily twisted. If the spacer S is twisted to cause its corner portions thereof to come into point-contact with the opposed glass sheets 1A, 1B as illustrated in Fig. 69, such corner portions will give stress concentration to the glass sheets 1A, 1B. However, it is very troublesome to properly dispose a thin spacer S without any twisting thereof, so that there is a limit in improvement of production efficiency of the glass panel.

[0009] On the other hand, though not shown, there has been proposed a glass panel disclosed by e.g. Japanese laid-open patent gazette No. Hei. 6-200676 intended to enhance the insulating performance and also to reduce the ventilation resistance of the space V1.

[0010] This employs a spacer including a plurality of ball elements interconnected in an intermittent manner by a wire member. The use of the ball element having a reduced contact area with respect to the glass sheets allows reduction in contact heat resistance therebetween and the interconnection by means of a wire facilitate the disposing operation of the spacers.

[0011] However, as the surface of the ball element and the glass sheet are placed in point-contact, still local crack will readily develop in the surface of the glass sheet. In order to overcome this shortcoming, it is conceivable to dispose the ball elements more densely, so as to disperse the pressing reaction force to the glass sheets. However, this would result in deterioration in the transparency of the glass panel.

[0012] The present invention intends to provide a glass panel capable of solving the conventional problems, which allows easy manufacture, restricts stress concentration to the glass sheets by the spacers and which also provides superior heat insulating performance, transparency and so on.

DISCLOSURE OF THE INVENTION

[0013] According to the glass panel relating to the present invention, a spacer is interposed between a pair of first and second glass sheets and a sealing portion is provided along the entire outer peripheral edges of the glass sheets, and the space between the first glass sheet and the second glass sheet is sealed under a pressure-reduced condition.

[0014] With the glass panel according to the present invention, through ingenious modification of the shape of the spacer, the manufacture is facilitated, and the stress concentration to the glass sheets by the spacer is restricted and also the heat insulating performance and transparency are improved.

[0015] According to the glass panel relating to claim 1, as shown in Figs. 3 through 5, the spacer is comprised of a wire member having a rounded cross section and disposed along the surfaces of the opposed glass sheets.

[0016] As the cross section of the spacer is rounded according to this construction, even if the spacer is disposed in a twisted posture, for instance, no sharp edge will come into contact with the first and second glass sheets. Therefore, the supporting reaction force applied from the spacer to the first and second glass sheets may be dispersed, thus relieving local stress concentration to the glass sheets. Consequently, reduction in the strength of the first and second glass sheets is avoided, so that there is obtained a glass panel with which local crack or breakage will hardly occur.

[0017] Further, as described above, since the twisting of the spacer is permissible, the efficiency of the disposing operation of the space may be improved.

[0018] With this construction, it becomes possible to provide a glass panel at lower costs which is hardly breakable and which provides superior heat insulating and transparency performances.

[0019] According to a glass panel relating to claim 2, as shown in Fig. 3, the wire member has a circular or substantially circular cross section.

[0020] With this construction, in addition to the function/effect of the invention of claim 1, even if the spacer is disposed with a twisted posture between the first glass sheet and the second glass sheet, the distance between the first glass sheet and the second glass sheet may be maintained substantially constant because the diameter of the cross section comprises the height of the spacer.

[0021] Further, with this construction, the spacer comes into line or face contact with the first and second glass sheets. Hence, the load applied to the first sheet glass and so on may be dispersed, thereby to effectively prevent local crack or the like.

[0022] The glass panel relating to claim 3, as shown in Fig. 1, a plurality of wire members are disposed side by side in a spaced relationship so that the spaces between the wire members are communicated with each other.

[0023] With this construction, in addition to the functions/effects of the invention according to claim 1 or 2, as the spaces between the wire members are communicated with each other, when the gas or air is drawn from the spaces, this evacuating operation may be carried out in a reliable and smooth manner.

[0024] Further, with this construction, there is no necessity of providing a plurality of evacuating portions to be used for the evacuation. With at least one evacuating portion, the entire spaces may be evacuated.

[0025] In this manner, according to this construction, the glass panel having high heat insulating performance and so on may be formed efficiently and economically.

[0026] A glass panel relating to claim 4 is as shown in

Fig. 19 through Fig. 22.

[0027] Namely, the spacer includes a plurality of convex curved face portions on the side adjacent the glass sheet, and these convex curved face portions are provided in a spaced relationship along the length of the spacer. Further, when the convex curved portions are cut along a plane including two contact portions between the convex curved portions and the first and second glass sheets, each convex curved portion provides a cross-sectional peripheral edge having a curvature radius which varies for each cutting plane.

[0028] With this construction, as the plurality of convex curved face portions on the side adjacent the glass sheet are provided in a spaced relationship along the length of the spacer, the contact area between the first and second glass sheets and the convex curved portions may be rendered small

[0029] As a result, the heat conduction between the first and second glass sheets may be reduced, thus enhancing the heat insulating performance.

[0030] Further, between the convex curved face portions adjacent in the longitudinal direction of the spacer, there is formed a gap between the spacer and the first and second glass sheets, respectively. So that the ventilation resistance of the space too may be reduced.

[0031] Moreover, in this embodiment, the curvature radius of the cross-sectional peripheral edge of the convex curved face portion is caused to vary for each plane. Normally, when the spacer comes into contact with e.g. the first glass sheet, there occurs elastic deformation in both of them, so that they come into line or face contact with each other. Then, with the above construction, it is believed that the first and second glass sheets respectively come into substantially line contact with the convex curved face portion, so that this contact portion will be positioned within the plane where the maximum curvature radius is available. According to the glass panel having this construction, the contact condition between the spacer and e.g. the first glass sheet may be a line contact, not a point contact. Hence, it is possible to obtain a glass panel in which local crack such as hertzian crack will hardly occur.

[0032] As described above, the glass panel using the spacer having the above construction provides high heat insulating performance, low ventilation resistance of the space, non-impaired transparency and reduced possibility of crack of the interface with the glass.

[0033] A glass panel relating to claim 5 is as shown in Figs. 19 through 22.

[0034] Namely, the curvature radius is maximum in a section taken along the longitudinal direction of the spacer and the radius is minimum in a section taken normal to the longitudinal direction.

[0035] With this construction, the convex curved face portion may be formed like a narrow elongated spindle, so that the convex curved face portion interposed between the glass sheets may be less visible from the outside.

[0036] A glass panel according to claim 6, as shown in Figs. 23 and 24, is characterized in that the spacer is formed of a wire member coiled in the form of spiral.

[0037] With this spacer, the peripheral face of the wire comes into contact with the first and second glass sheets at a plurality of contact portions spaced apart along the extending direction of the spacer. Thus, the supporting reaction force applied from the spacer to the first and second glass sheets may be dispersed. Moreover, since the spacer is coiled in the form of spiral, gaps are formed between the first and second glass sheets and the wire member, thereby to reduce the ventilation resistance of the space.

[0038] As described above, according to this glass panel, by using the spiral spacer, the supporting reaction force applied to the first glass sheet or the like may be dispersed, so as to avoid crack or break of the first glass sheet or the like.

[0039] Further, as the contact area between the spacer and the glass sheets is small, the contact heat resistance therebetween may be large, thus enhancing the heat insulating performance.

[0040] Moreover, as the ventilation resistance of the space is small, the operation of drawing the gas from the space for pressure-reducing it may be conducted in an efficient manner.

[0041] In addition to the above, so as to allow the spacer as a whole to provide a desired heat resistance, the number of turns of the wire member per unit length may be varied. That is to say, if the number of turns of the wire member is reduced, the heat conduction between the first and second glass sheets may be restricted, so that the glass panel provides higher insulating performance.

[0042] A glass panel according to claim 7 may be as shown in Fig. 25. Namely, the configuration of the spacer employed here is such that the wire member is coiled in the form of spiral at limited portions thereof spaced apart by a predetermined distance therebetween.

[0043] With this construction, the ventilation resistance of the space may be further reduced. Moreover, by appropriately setting the distance between the adjacent turns of the spiral coil, a desired heat insulating performance may be readily assured.

[0044] A glass panel relating to claim 8 may be as shown in Fig. 26. Namely, the spacer may comprise a core member and a wire member wound in the form of spiral about the outer peripheral face of the core member.

[0045] With this construction, even if the wire member employed is readily deformable, the core member may effectively restrict such deformation. As a result, the handling of the spacer during the manufacture thereof may be facilitated, so that the glass panel may be manufactured efficiently.

[0046] Moreover, as the spacer includes a core member, the spacer may receive the first and second glass

sheets reliably, so as to prevent crack or break of the glass sheets effectively.

[0047] In addition, by appropriately varying the diameter and material of the wire member as well as the diameter and material of the core member, it is readily possible to set the heat resistance of the entire spacer at a desired value.

[0048] According to a glass panel relating to claim 9, as shown in Figs. 23 and 24, the spacer is preferably comprised of a wire member having a substantially circular cross section.

[0049] With this construction, the spacer comes into point contact with the first glass sheet or the like at a plurality of contact points spaced apart from each other, so that the total contact area between the spacer and the two glass sheets may be small. Further, depending on the diameter of the wire member, the contact condition when the wire member and the glass sheets come into contact with each other may be readily anticipated.

[0050] As a result, it becomes readily possible to anticipate the actual contact heat resistance between the spacer and the glass sheets, and the shape, material and so on of the wire member may be selected appropriately.

[0051] According to a glass panel relating to claim 10, as shown in Figs. 27 through 30, the spacer is comprised of a wire member having a plurality of knots spaced apart from each other with a predetermined distance therebetween.

[0052] If the spacer forms such knots, by appropriately selecting the manner of knotting, the spacer may form knots of any desired size, even if the spacer employs the same wire member, so that the distance between the first glass sheet and the second glass sheet may be set as desired.

[0053] Further, if the spacer forms such knots, the spacer and the two glass sheets will come into contact with each other only at the knots of the spacer. Hence, the contact area between the spacer and the two glass sheets may be significantly small. In this case, the contact heat resistance between the spacer and the glass sheets will be increased, thus enhancing the heat insulating performance.

[0054] Moreover, if the spacer and the glass sheets come into substantially point contact with each other, there is the risk of stress concentration at the portion where the glass sheets come into abutment against the knots. However, by freely setting the distance between the knots, it is readily possible to control the degree of flexion of the two glass sheets and/or the degree of stress concentration to be applied to the glass sheets from the knots. Thus, it is possible to effectively prevent crack or break of the glass panel.

[0055] In addition, with the above construction, only the knots come into contact with the first and second glass sheets, while the other portions of the spacer than the knots will remain apart from the glass sheets. Consequently, in spite of the presence of the spacer, the air

present in the space may easily move from one side of the spacer to the other side of the same. For this reason, even if a plurality of spacers are disposed side by side between the first glass sheet and the second glass sheet, the air present in the space may be readily evacuated.

[0056] According to a glass panel relating to claim 11, as shown in Figs. 27 through 30, the knot may be provided as a tight knot.

[0057] If the knot is provided as such tight knot, the knot is formed like a lump with reduced two-dimensional extension, so that it may be less conspicuous.

[0058] Further, in the case of such tight knot, this will be more resistance against deformation when pressed between the two glass sheets, so that it may provide its function as a spacer for a longer period of time.

[0059] According to a glass panel relating to claim 12, as shown in Figs. 31 through 33, the knot may be formed by twisting the wire member.

[0060] For instance, if the wire member is deformable by twisting and it may effectively retain such twisted shape, the knot may be formed simply by twisting the wire member. So that, the spacer may be manufactured efficiently.

[0061] According to a glass panel relating to claim 13, as shown in Figs. 34 through 36, the spacer is comprised of an elongated spacer including a plurality of wire members inter-twisted with each other.

[0062] If the spacer is formed by inter-twisting a plurality of wire members each other like the above construction, the first and second glass sheets and the spacer come into contact with each other at a plurality of contact portions spaced apart from each other. Hence, the supporting reaction force applied from the spacer to the two glass sheets due to the atmospheric pressure may be dispersed.

[0063] Further, between the contact portions adjacent in the longitudinal direction of the spacer, there are formed gaps between the spacer and the glass sheets. Hence, the ventilation resistance of the space may be reduced.

[0064] As described above, with the glass panel having this construction, the supporting reaction force applied to the glass panel may be dispersed so as to prevent crack or break of the glass panel.

[0065] Moreover, by reducing the contact area between the spacer and the glass sheets, the contact heat resistance may be increased for enhancing the heat insulating performance.

[0066] Also, as the ventilation resistance of the space is small, the operation for drawing gas from the space for pressure-reducing the same may be carried out efficiently, and also as the spacer is formed long, this may be fixed by being wound about e.g. the first glass sheet, so that the manufacture of the glass panel may be facilitated.

[0067] According to a glass panel relating to claim 14, as shown in Fig. 36, the spacer is formed by partially

inter-twisting a plurality of wire members at a plurality of predetermined positions thereof spaced apart from each other in the longitudinal direction.

[0068] With this construction, the ventilation resistance in the space may be further reduced. Also, by appropriately setting the distance between the inter-twisted portions, a desired heat insulating performance may be assured.

[0069] According to a glass panel relating to claim 15, as shown in Fig. 36, the spacer is comprised of a wire member having a substantially circular cross section.

[0070] With this construction, as shown in Figs. 34 and 35, the adjacent contact portions of the peripheral face of the wire member are formed straight along the longitudinal direction of the wire member. Further, the spacer comes into point contact with the glass sheets at a plurality of contact portions spaced apart from each other. As described above, since the contact area between the turns of the wire and the contact area between the spacer and the glass sheets may be reduced, the heat conduction across the first and second glass sheets may be reduced.

[0071] Further, the contact portions between the first and second glass sheets and the spacer are provided with a predetermined distance there between and these contact portions have a substantially fixed shape, depending on the diameter of the wire member. Hence, the actual contact heat resistance between the glass sheets and the spacers may be readily foreseen. Accordingly, the dimensions and material of the wire member may be appropriately designed in order to obtain a desired heat insulating effect.

[0072] A glass panel relating to claim 16, as shown in Figs. 37 and 38, is characterized in that the spacer comprises a braided cord.

[0073] Here the "braided cord" means a cord including a wire member braided in a predetermined shape. With such spacer comprising a braided cord, the first and second glass sheets and the spacer come into point contact with each other at a plurality of contact portions. Hence, the contact area between the two glass sheets and the spacer is very small, so that the contact heat resistance therebetween may be increased for enhancing the heat insulating performance of the glass panel.

[0074] On the other hand, if the two glass sheets and the spacer are placed in point contact with each other as described above, there is the risk of the two glass sheets being subjected to stress concentration due to the supporting reaction force from the spacer. However, if the cylindrical braided cord is employed, the distance between the adjacent contact portions is very small, so that the force applied to the two glass sheets may be appropriately dispersed. Moreover, since the spacer comprising a braided cord has a certain degree of elasticity, the stress concentration to the glass sheets may be relieved appropriately.

[0075] In addition, a braided cord, in general, has resistance against twisting and retains its straight shape

well. For this reason, when the braided cord is to be disposed between the first glass sheet and the second glass sheet, the trouble of correcting twist thereof may be eliminated.

[0076] A glass panel relating to claim 17, as shown in Figs. 37 and 38, is characterized in that the spacer comprises a braided cord including a core wire. This braided cord includes an inner portion formed of a single core wire and an outer portion formed of a cylindrical braided member for enclosing the inner portion.

[0077] In this case, if, for instance, the inner portion is formed of a material having a high tensile strength, the tensile strength of the entire braided cord may be increased. This reduces the risk of accidental cutting of the braided cord during the manufacture of the glass panel, so that the production efficiency of the glass panel may be improved.

[0078] On the other hand, if the outer portion is formed of e.g. carbon fiber having low thermal conductivity, thermal conduction between this braided cord and the two glass sheets may be restricted, so that a glass panel having high heat insulating performance may be obtained.

[0079] In this manner, if the inner portion and the outer portion are provided separately from each other, the respective portions may be formed of materials chosen for different purposes. Hence, the spacer may be conveniently designed for obtaining a glass panel having a desired performance.

[0080] A glass panel relating to claim 18, as shown in Fig. 39, is characterized in that the spacer comprises a plurality of the braided cords inter-braided or inter-knitted together.

[0081] If a plurality of braided cords are inter-braided with each other, the contact portions between the first and second glass sheets and the spacer are more dispersed. Namely, the distance between the contact portions adjacent along the longitudinal direction of the spacer is greater than that of the above-described construction relating to claim 17. Therefore, the communication of the air from one side to the other side of the spacer along the surface of the glass sheet may be facilitated. Consequently, even when a plurality of spacers are disposed side by side, the evacuation of the air present in the space may be carried out easily.

[0082] Incidentally, in the case of the present construction too, the spacer comes into contact with the two glass sheets intermittently. Thus, a good heat insulating performance may be obtained. Further, as the spacer comprising a braided cord has a certain degree of elasticity, stress concentration too may be relieved appropriately.

[0083] A glass panel relating to claim 19, as shown in Figs. 41 and 42, is characterized in that the spacer comprises a ribbon member formed of a knitted wire member.

[0084] In the case of the spacer of this construction formed by knitting, it is possible, for example, to knit a

single wire member at one portion after another, so as to obtain a two-dimensional extension. Alternatively, the wire member may be knitted in the shape of bar, so as to obtain a three-dimensional extension.

[0085] With such two-dimensional or three-dimensional knitted portion, the thickness thereof may be freely designed by controlling the degree of knitting. In case the distance of the spaces to be formed is predetermined, such knitted portion having a predetermined thickness may be readily formed by using a thin wire member which is sufficiently shorter than the distance. Further, such knitted portions may be provided intermittently along the longitudinal direction of the spacer.

[0086] The spacer of this construction may be produced efficiently, without the trouble of e.g. combining a plurality of wire members. Further, the distance between the opposed glass sheets may be freely set and the evacuation of air from the space may be readily carried out. In addition, stress concentration to the two glass sheets may be relieved so as to prevent break of the glass panel. In this way, a glass panel having superior heat insulating performance may be obtained.

[0087] A glass panel relating to claim 20, as shown in Figs. 43 and 44, is characterized in that the spacer comprises a plurality of spacer bodies connected in a spaced apart relationship via a wire member. The spacer body is formed like a column and includes contact portions for contacting the glass sheets along the longitudinal direction.

[0088] With this construction, by interposing the column-like spacer bodies between the first and second glass sheets with aligning the longitudinal direction of the spacer bodies along the surfaces of the sheets, the space may be formed between these glass sheets. In the course of this, the two glass sheets will tend to flex by being pivoted about each spacer body. However, this spacer body is formed like a column and includes the contacting portions for the glass sheets along the longitudinal direction of the spacer body. Hence, the supporting reaction force applied from the spacer body to the two glass sheets may be dispersed along the longitudinal direction of the spacer body.

[0089] As described above, since the supporting reaction force may be dispersed without disposing the spacer bodies more densely than the conventional construction, the local crack or the like in the glass surface may be avoided and at the same time the transparency of the glass panel may be assured.

[0090] A glass panel relating to claim 21 is characterized in that the contact portions are adapted to come into line contact with the two glass sheets.

[0091] With this construction, the supporting reaction force applied from each spacer body to the two glass sheets may be dispersed linearly along its contact portions. In this case, even when the glass sheets receive e.g. wind pressure, flexion of the glass sheets may be minimized and the contacting length between the two glass sheets and the spacer body may be maintained

constant. As a result, the thermal conduction between the first and second glass sheets via the spacer body may be maintained constant. Further, as the contacting length is maintained constant, the vibration transmitting condition between the two glass sheets via the spacer body too may be maintained constant. Hence, with the glass panel having this construction, desired heat insulating and sound insulating performances may be obtained.

[0092] Further, as the cylindrical spacer bodies are interconnected in a spaced apart relationship via the wire member, there is another advantage that the transparency of the glass panel may be readily assured.

[0093] A glass panel relating to claim 22 is characterized in that the column-like spacer body includes a cylindrical outer peripheral face.

[0094] With this construction, even if the spacer body is rotated about its own axis, it may come into line contact with the glass sheets. In this manner, the contact condition between the spacer body and the glass sheets is stabilized. Hence, the glass panel may obtain greater resistance against breakage and may constantly provide heat insulating and sound insulating performances or the like.

[0095] A glass panel relating to claim 23, as shown in Figs. 45 though 50, is characterized by a column-like spacer body including a plurality of contact portions along the longitudinal direction thereof which come into point contact with the two glass sheets.

[0096] With this construction, the contact area between the spacer body and the glass sheets may be small, regardless of the size of the spacer body. Hence, the contact heat resistance therebetween may be increased, thus achieving good heat insulating performance.

[0097] A glass panel relating to claim 24 may employ a column-like spacer body as shown in Figs. 45 and 46. Namely, the cylindrical outer peripheral face of the spacer body includes a ridge portion of a predetermined height extending continuously along the peripheral direction relative to the axis of the spacer body; and a plurality of such ridge portions are provided along the longitudinal direction of the spacer body.

[0098] With the above construction, even if the spacer body is rotated about its own axis, the outer peripheral edges of the ridge portions may be kept in contact with the two glass sheets at a plurality of points in a stable manner. Hence, the attaching operation of the spacer body to the two glass sheets may be facilitated.

[0099] A glass panel relating to claim 25 is characterized in that the spacer includes a plurality of spacer bodies which are interconnected with each other at the radial centers thereof via a wire member.

[0100] With this construction, contact between the wire member and the glass sheets may be readily avoided. Hence, it is possible to prevent heat conduction through such contact between the wire member and the glass sheets.

[0101] A glass panel relating to claim 26 may employ a spacer shown in Figs. 51 and 52.

[0102] This construction employs a chain-like spacer formed by interconnecting a plurality of engaging pieces. The interconnection between the engaging pieces is effected by using an engaging portion provided at an end of each engaging piece.

[0103] In the case of this construction, the length of the engaging piece is set fixed. With this, the pitch of the engaging portions, i.e. the contacting pitch of the spacer relative to the first and second glass sheets may be determined. As a result, the supporting reaction force from the spacer to the glass sheets may be dispersed.

[0104] Further, the coefficient of thermal expansion of the engaging piece is different from that of the glass sheets. However, with the present construction using simple engagement of the engaging pieces with each other, any influence from change in the dimensions of the engaging pieces, and influence of mutual movement between the individual engaging pieces due to expansion/contraction of the glass may be effectively absorbed at the engaging portions. That is to say, through strengthening and weakening of the engaged condition of the engaging pieces, such dimensional change and mutual movement may be sufficiently allowed.

[0105] As described above, with this spacer, there occurs no disturbance in the arrangement of the spacer even when the temperature changes. Further, by restricting the relative displacement between the glass sheets and the engaging pieces, such inconvenience as scratching of the surfaces of the glass sheets may be avoided.

[0106] Moreover, when this spacer is held between the first glass sheet and the second glass sheet, it is possible to provide a gap between the glass sheets and the engaging piece e.g. at a position of the engaging portion of the adjacent engaging piece. Hence, when the space between the opposed glass sheets is evacuated, this evacuating operation may be effected by using one evacuating opening alone, so that the manufacture of the glass panel may be simplified.

[0107] As described above, with the spacer having this construction, the disposing operation of the spacer is easy and also the evacuating operation of the space between the first and second glass sheets may be facilitated. Further, the supporting reaction force applied to the glass sheets may be dispersed for preventing breakage of the glass sheets and dislocation, breakage or the like of the spacer associated with distortion of the glass sheets may be avoided.

[0108] According to a glass panel relating to claim 27, the spacer may be constructed as shown in Fig. 51.

[0109] That is to say, the engaging pieces are ring pieces which are interconnected like a chain to constitute a spacer. In this case, a portion of the ring piece functions as the engaging portion.

[0110] If a plurality of ring pieces are interconnected

like a chain as this construction, the individual ring pieces may freely change their postures relative to each other. Then, if this spacer is placed on the first glass sheet for instance, the respective ring pieces may be placed reliably on the surface of the first glass sheet. That is to say, there occurs no such inconvenience as a particular ring piece being afloat above the surface of the first glass sheet. As described above, with the spacer of the above construction, the spacer may be disposed with a stable posture between the first glass sheet and the second glass sheet.

[0111] According to a glass panel relating to claim 28, the spacer may be constructed as shown in Fig. 53.

[0112] That is, a ring-like second body capable of forming the engaging portion is provided at end of a first body, whereby the engaging piece is formed. And, the second bodies are engaged with each other like a chain to interconnect the adjacent engaging pieces, so as to constitute the spacer.

[0113] If the ring-like second bodies are formed at the opposite ends as the above construction, as described hereinbefore in connection with claim 27, the respective engaging pieces may be disposed with stable posture between the first and second glass sheets.

[0114] Further, if the engaging piece is formed by providing the ring-like second bodies at opposed end of e.g. a bar-like first body, in comparison with the spacer described in claim 27, a more linear arrangement of the spacer becomes possible.

[0115] In this case of the present construction, each engaging piece has a greater length. Hence, for forming a spacer of a predetermined length, the number of the engaging pieces needed therefor may be reduced. Consequently, the number of engaging portions, i.e. the number of flexing portions of the spacer is reduced, so as to assure the linearity, and the aesthetic appearance of the glass panel may be improved.

[0116] Further, with the space of this construction, with the reduction in the number of the required engaging pieces, the disposing operation of the spacer is easier.

[0117] According to a glass panel relating to claim 29, the spacer may be constructed as shown in Fig. 54.

[0118] That is to say, the engaging piece is formed by providing engaging portions in the form of hook-like portions at opposed ends of a bar-like body and the hook-like portions are engaged with each other for connecting adjacent engaging pieces together, thereby to constitute a spacer.

[0119] With this construction, in case the spacer is to be disposed on the surface of the first glass plate for instance, the spacer may be disposed while engaging and connecting the engaging pieces to each other. Hence, it becomes possible to construct a spacer having a desired length.

[0120] Further, with this construction, the individual engaging pieces remain separated from each other until the spacer is disposed. Therefore, in comparison with a

case in which the respective engaging pieces are interconnected in advance, the spacer may be transported in a compact manner.

[0121] In case the respective engaging pieces are interconnected in advance, there is the risk of the engaging portions being deformed due to certain external force applied during the transportation. In such case, there may occur the inconvenience that the spacer cannot be disposed straight. With the above construction, however, such risk of deformation of e.g. the engaging portions is less, and when the engaging pieces are to be interconnected with each other, they may be disposed more linearly. As a result, reliable contact may be assured between all of the engaging pieces and the first and second glass sheets, so that the supporting reaction force applied from the spacer to the two glass sheets may be dispersed.

[0122] Incidentally, even when a certain engaging piece is deformed, only this engaging piece may be disposed of; and there will occur no such inconvenience that deformation of any particular engaging piece leads to un-usability of the entire spacer.

[0123] Further, as the hook-like portion employed in this construction may be formed simply by bending the end of the bar-like body, the spacer may be formed and manufactured very simply.

[0124] According to a glass panel relating to claim 30, as shown in Fig. 55, the spacer includes a plurality first wire members arranged side by side in one direction in a spaced apart relationship along the surfaces of the first and second glass plates and a plurality of second wire members arranged side by side in a different direction in a spaced apart relationship along the surfaces of the first and second glass sheets.

[0125] When the plurality of first wire members and a plurality of second wire members are arranged in directions different from each other like the present construction, at the intersection points of the first and second glass sheets, the first and second wire members come into contact with either the first glass sheet or the second glass sheet. Hence, the spacer and the glass sheets come into contact with each other at a great number of points, so that the supporting reaction force applied from the spacer to the two glass sheets may be dispersed. Moreover, in the vicinity of the intersection point, the plurality of first wire members and the plurality of second wire members come into contact with the first glass sheet alone or the second glass sheet alone. Hence, the space is formed between the spacer and the two glass sheets, so that the inside of this space may be readily evacuated.

[0126] Further, with the present construction, in arranging the first wire members and the second wire members, these arranging operations may be readily done by e.g. putting together the first glass sheet to which the first wire members are attached and the second glass sheet to which the second wire members are attached.

[0127] In this manner, according to the glass panel of this construction, the spacer may be disposed without much trouble, the stress concentration to the glass sheets may be restricted, and the inside of the space may be easily evacuated.

[0128] According to a glass panel relating to claim 31, as shown in Fig. 55, the second wire members are placed over the first wire members in a grating pattern, thereby to constitute the spacer.

[0129] In the case of this construction too, like the spacer described hereinbefore of claim 30, there are achieved the functions and effects that the spacer may be disposed without much trouble, the stress concentration to the glass sheets may be restricted, and that the inside of the space may be easily evacuated.

[0130] A glass panel relating to claim 32 may employ a spacer shown in Figs. 56 and 57. This spacer is provided in the form of a grating wherein first and second wire members cross each other at a plurality of intersecting points, with the vertical relationship between the first wire member and the second wire member being reversed between adjacent ones of the intersecting points.

[0131] The spacer of the above construction is a spacer having the same construction as what is commonly called a mesh and can be handled as one assembly, so that the disposing operation thereof to the two glass sheets may be facilitated significantly.

[0132] Further, with the use of this spacer too, stress concentration to the glass sheets may be restricted and also the inside of the space may be readily pressure-reduced.

[0133] A glass panel relating to claim 33, as shown in Fig. 58, may employ a spacer in the form of a mesh. This mesh-like spacer includes a plurality of wire members disposed side by side along a direction in a spaced apart relationship along the surfaces of the glass sheets, with the adjacent wire members being intertwined together.

[0134] The mesh-like spacer having this construction too is very easy to handle.

[0135] Further, this spacer formed like a so-called fence net in which the adjacent wire members are engaged at a predetermined interval is expandable and retractable, so that this may be transported in a condition in which the spacer is retracted in the width direction.

[0136] Incidentally, as shown in Fig. 59, the adjacent wire members may be inter-twisted together. In this case, though its elasticity is lower, the spacer is self-supportive and the mesh is stably maintained, so that the spacer is easy to handle.

[0137] A glass panel relating to claim 34 may be constructed by using a spacer shown in Fig. 60. Namely, a plurality of first wire members are disposed side by side in a spaced relationship along the surface of the glass sheet and a plurality of second wire members are disposed so as to intersect the first wire members. In this,

at each intersection point between the first and second wire members, the intersecting first and second wire members are connected together.

[0138] In this construction, for example at the intersection point between the first wire member and the second wire member, these members are connected. And, for this connection, a further, i.e. third wire member is employed.

[0139] In the case of this construction too, the spacer is formed as one integral unit, so as to facilitate its handling.

[0140] Further, this spacer comes into contact with the two glass sheets mainly at the intersecting points and their vicinity. But, the connection portion at the intersecting point has a greater thickness than the wire member. Hence, the stress concentration to the glass sheets is restricted.

[0141] Moreover, at the intermediate portions between adjacent intersection points, there are formed gaps between the respective wire member and the glass sheets. Therefore, the inside of the space may be readily evacuated.

[0142] According to a glass panel relating to claim 35, as shown in Fig. 61, the spacer is constructed such that the intersecting wire members form a knot at each intersection point.

[0143] With this construction, mutual dislocation of the first and second wire members may be avoided. Hence, the mesh pattern may be stably maintained, thereby to further facilitate the handling of the spacer.

[0144] According to a glass panel relating to claim 36, as shown in Fig. 62, the spacer is constructed such that the intersecting wire members are bonded to each other at each intersection point.

[0145] With this construction too, the mesh pattern may be stably maintained, thereby to further facilitate the handling of the spacer.

[0146] According to a glass panel relating to claim 37, as shown in Figs. 64 through 67, the spacer is constructed such that the wire members are knitted into a planar knitted assembly.

[0147] With this construction, the spacer comprised of a planar knitted assembly has flexibility. Hence, this may be readily disposed in a stretched condition onto the surfaces of the wire members.

[0148] Further, the wire members may be knitted in various manners as shown in Figs. 64 and 65 or as shown in Figs. 66 and 67. As a result, it becomes possible to provide the glass panel with an ornamental design.

BRIEF DESCRIPTION OF THE DRAWINGS

[0149]

Fig. 1 is a partially cutaway perspective view showing a preferred glass panel relating to the present invention,

Fig. 2 is a section view showing the glass panel,
 Fig. 3 is a section view illustrating the disposing
 condition of a spacer,
 Fig. 4 and Fig. 5 are section views showing embod-
 iments of spacers having different cross-sectional 5
 shapes,
 Figs. 6 through 9 are descriptive views illustrating
 steps of forming a glass panel,
 Figs. 10 through 14 are descriptive views illustrating
 steps of forming a glass panel, 10
 Figs. 15 through 18 are descriptive views illustrating
 steps of forming a glass panel,
 Fig. 19 is a side view in partial section of a spacer
 relating to a second embodiment,
 Fig. 20 is a front view in partial section of the spacer 15
 relating to the second embodiment,
 Fig. 21 is a side view in partial section of a spacer
 relating to the second embodiment,
 Fig. 22 is a cross section of the spacer relating to
 the second embodiment, 20
 Fig. 23 is a side view in partial section of a spacer
 relating to a third embodiment,
 Fig. 24 is a front view in partial section of the spacer
 relating to the third embodiment,
 Fig. 25 is a side view in partial section of a spacer 25
 relating to the third embodiment,
 Fig. 26 is a side view in partial section of the spacer
 relating to the third embodiment,
 Fig. 27 is a plan view of a spacer relating to a fourth
 embodiment 30
 Fig. 28 is a side view of the spacer relating to the
 fourth embodiment,
 Fig. 29 is a plan view of the spacer relating to the
 fourth embodiment,
 Fig. 30 is a side view of the spacer relating to the 35
 fourth embodiment,
 Figs. 31 through 33 are descriptive views illustrating
 the steps of manufacturing the pacer relating to the
 fourth embodiment,
 Fig. 34 is a side view in partial section of a spacer 40
 relating to a fifth embodiment,
 Fig. 35 is a front view in partial section of the spacer
 relating to the fifth embodiment,
 Fig. 36 is a side view in partial section of the spacer
 relating to the fifth embodiment, 45
 Figs. 37 through 40 are descriptive views showing
 various kinds of spacers comprised of braided
 cords relating to a sixth embodiment,
 Figs. 41 and 42 are descriptive views showing vari-
 ous spacers comprised of braided cords relating to 50
 the sixth embodiment,
 Fig. 43 is a perspective view showing a spacer
 relating to a seventh embodiment,
 Fig. 44 is a cross sectional view showing a spacer
 body relating to the seventh embodiment, 55
 Fig. 45 is a perspective view showing a spacer body
 relating to the seventh embodiment,
 Fig. 46 is a vertical section showing a spacer body

relating to the seventh embodiment,
 Fig. 47 is a perspective view showing a spacer body
 relating to the seventh embodiment,
 Fig. 48 is a vertical section showing a spacer body
 relating to the seventh embodiment,
 Fig. 49 is a perspective view showing a spacer body
 relating to the seventh embodiment,
 Fig. 50 is a vertical section showing a spacer body
 relating to the seventh embodiment,
 Fig. 51 is a plan view showing an example of a
 spacer relating to an eighth embodiment,
 Fig. 52 is a vertical section of principal portions
 showing a disposing condition of the spacer relating
 to the eighth embodiment,
 Fig. 53 is a perspective view showing an example of
 the spacer relating to the eighth embodiment,
 Fig. 54 is a plan view showing an example of the
 spacer relating to the eighth embodiment,
 Fig. 55 is a partially cutaway perspective view
 showing an example of a glass panel relating to a
 ninth embodiment,
 Fig. 56 is a perspective view of principal portions
 showing an example of a further spacer relating to
 the ninth embodiment,
 Fig. 57 is a vertical section of principal portions of a
 glass panel using the spacer relating to the ninth
 embodiment,
 Figs. 58 through 64 are plan views showing other
 spacers relating to the ninth embodiment,
 Fig. 65 is a plan view showing an example of a
 glass panel using the spacers relating to the ninth
 embodiment,
 Fig. 66 is a descriptive view of principal portions
 showing an example of different knitting of the
 spacer relating to the ninth embodiment,
 Fig. 67 is a plan view showing an example of a
 glass panel using the spacer relating to the ninth
 embodiment,
 Fig. 68 is a partially cutaway perspective view
 showing a conventional glass panel, and
 Fig. 69 is a section view showing a disposing condi-
 tion of a conventional spacer.

BEST MODE OF EMBODYING THE INVENTION

[0150] Next, embodiments of the present invention will be described with reference to the drawings.

[first embodiment]

[0151] An embodiment of a glass panel GP relating to the present invention is shown in Fig. 1 and Fig. 2. The glass panel GP includes e.g. a pair of first glass sheet 1A and second glass sheet 1B. Between the first glass sheet 1A and the second glass sheet 1B, a number of spacers S1 are interposed. These spacers S1 are disposed in a spaced apart relationship along the sheet surfaces. A space V1 between the first glass sheet 1A

and the second glass sheet 1B is pressure-reduced and sealed. For instance, the first glass sheet 1A and the second glass sheet 1B each comprises a transparent float glass plate having a thickness of 3 mm. Along and between outer peripheral edges of the first glass sheet 1A and the second glass sheet 1B, there is provided a sealing portion. This sealing portion is a sealing portion 2 using a low melting glass such as solder glass or the like. By means of this sealing portion 2, the space V1 is maintained under the pressure-reduced condition.

[0152] The space V1 is pressure-reduced by such methods as manufacturing the glass panel under the vacuum environment or drawing air out of the glass panel after the manufacture of this panel, and so on. The pressure-reducing environment is preferably 1.0×10^{-2} Torr or lower, more preferably 1.0×10^{-4} Torr or lower.

[0153] However, in the case of the latter of drawing air after the manufacture of the glass panel it is necessary to provide either the first glass sheet 1A or second glass sheet 1B or the sealing portion 2 with an evacuating portion 3 for evacuating and sealing the space V1.

[0154] Incidentally, the outer peripheral edge of the first glass sheet 1A and the second glass sheet 1B is formed so that the first glass sheet 1A projects along the sheet surface. As the sealing material may be placed on this projecting portion 4 when the sealing portion 2 is formed, the outer peripheral portion of the space V1 may be sealed in an efficient and reliable manner.

[0155] The spacer S1 is formed of a wire member 5. This wire member 5 is disposed along the sheet surfaces of the first and second glass sheets 1A, 1B.

[0156] Incidentally, the spacer S1 is a thin wire of stainless steel (SUS304) and has a circular (or substantially circular) cross section having a diameter of 25 μm . And, these spacers S1 are disposed side by side with 30 mm pitch. Accordingly, as shown in Fig. 3, the spacer S1 comes into contact with the first and second glass sheets 1A, 1B at the radially outermost peripheral edge of its cross section. That is, the distance between the first glass sheet 1A and the second glass sheet 1B is determined by the diameter of the cross section of the spacer S1.

[0157] As the spacer S1 comprises a wire member, the spacer comes into contact with the first and second glass sheets 1A, 1B along the longitudinal direction of the spacer S1 over the entire or substantially entire length thereof. For this reason, the supporting reaction force of the spacer S1 is applied in a dispersed manner to the first glass sheet 1A and the second glass sheet 1B.

[0158] Incidentally, the cross sectional shape of the spacer S1 is not limited to the circular shape. For instance, as shown in Figs. 4 and 5, it may be an oval shape or a polygonal shape with rounded corners. In short, what is essential is that portions thereof which may come into contact with the first glass sheet 1A and the second glass sheet 1B be formed non-angular.

[0159] Next, a method of forming the glass panel under the atmospheric pressure environment will be described.

(first forming method)

[0160]

[1] As shown in Fig. 6, the wire member 5 is wound about the first glass sheet 1A spirally and temporarily fixed thereto. As the temporary fixing material, a tape or an adhesive agent is employed which may be readily eliminated in a heating step to be described later.

[2] As shown in Fig. 7, to the wire member 5 wound about the first glass sheet 1A, a fixing low melting glass 6 is applied in the form of dots. In the course of this, the fixing low melting glass 6 is applied by a height not exceeding the height of the wire member 5 so as to allow the wire member 5 to come into direct contact with the glass sheets 1. The applied positions are located on the inner side of the side edges of the first glass sheet 1A. As this fixing low melting glass 6, such glass having a melting point of 400 to 600°C is employed. With this, the wire member 5 is ready for final fixing.

[3] Next, as illustrated in Fig. 8, the first glass sheet 1A is heated by a heater 7 up to a temperature higher than the melting point of the low melting glass 6. After the fixing low melting glass 6 alone is melted, the glass is cooled to the normal temperature, so as to fix the wire member 5 by the fixing low melting glass 6.

[4] As illustrated in Fig. 9, the first glass sheet 1A is removed from the heater 7 and excess wire member 5 is eliminated therefrom.

[5] Over this one sheet glass, i.e. first glass sheet, the second glass sheet 1B is placed as illustrated in Fig. 10 and Fig. 11. Further, an outer peripheral sealing material 8 is placed on the projecting portion 4. As this outer peripheral sealing material 8, a low melting glass having a lower melting point than the fixing low melting glass 6 is employed. This outer peripheral sealing material 8 is applied as a fluid or placed as a solid object. In particular, in case the material is applied in the form of fluid, the second glass sheet 1B is placed over the first sheet after the outer peripheral sealing material 8 is sufficiently dried.

Incidentally, in the second glass sheet 1B, an evacuating opening 3a as the evacuating portion 3 is formed in advance.

[6] As illustrated in Fig. 12, these first and second

glass sheets 1A, 1B are heated by a second heater 7a. After the outer peripheral sealing material 8 is melted, the assembly is again cooled to the normal temperature. With this, the solidified outer peripheral sealing material 8 forms the sealing portion 2.

[7] As illustrated in Fig. 13 and Fig. 14, after the air in the space V1 is drawn out through the evacuating opening 3a by using a suction pump P, the evacuating portion is sealed. In this, as there are formed gaps between opposed ends of the spacers S1 and the sealing portion 2, the inter-spaces between the spacers S1 are communicated with each other. Hence, with air evacuation through one evacuating opening 3a, the entire space V1 may be evacuated.

(second forming method)

[0161] On the other hand, the glass panel relating to the present invention may be formed under a pressure-reduced condition as described next.

[1] As illustrated in Fig. 15, first, the wire member 5 is wound about the first glass sheet 1A in the spiral pattern and temporarily fixed thereto. For this temporal fixation, as described hereinbefore, a tape or an adhesive agent is employed so that it may be eliminated in the subsequent heating step.

[2] As illustrated in Figs. 16 and 17, the first glass sheet 1A with the outer peripheral sealing material 8 applied to its projecting portion 4 and the second glass sheet 1B are placed one over the other; and this assembly is charged into e.g. a vacuum oven 9. Then, the first glass sheet 1A and the second glass sheet 1B are heated under the pressure-reduced environment. The outer peripheral sealing material 8 is melted by the heating and the assembly is returned to the normal temperature. With this, the solidified outer peripheral sealing material 8 forms the sealing portion 2 and the space V1 is maintained under the pressure-reduced condition.

[3] Thereafter, the excessive portions of the wire member 5 projecting from the sealing portion 2 are eliminated, whereby a glass panel is completed as illustrated in Fig. 18.

[second embodiment]

[0162] A glass panel according to this second embodiment may employ a spacer S2 shown in Figs. 19 and 20.

[0163] Here, the spacer S2 is formed of a metal wire member having e.g. a circular cross section. The spacer S2 includes a plurality of convex curved face portions 10 spaced apart from each other along the longitudinal direction of the spacer. The spacer S2 is made of e.g.

stainless steel (SUS 304 or the like).

[0164] The convex curved face portions 10 are formed by means of etching. That is, convex and concave portions are formed on the surface of the wire member by melting the portions of the wire member between adjacent convex curved face portions 10 by means of etching. With this, between the convex curved face portions adjacent each other along the longitudinal direction of the spacer S2, there is formed a gap 11 between the spacer S2 and the first glass sheet 1A or the like.

[0165] For forming the spacer S2, it is preferred that a wire member having a diameter of 10 μm to 100 μm be employed.

[0166] Each convex curved face portion 10 has a curvature radius which varies along one cross section to another. In this case, the spacer S2 has a maximum first curvature radius R1 along the longitudinal direction of the spacer and a minimum second curvature radius R2 along the radial direction of the same. That is, there is supposed a cross section including two contact portions T1 where the convex curved face portion 10 comes into contact with the first glass sheet 1A and the second glass sheet 1B. Of respective cross sections, those closer to the plane including the first curvature radius R1 have progressively greater curvature radii. These curvature radii vary continuously between the plane including the first curvature radius R1 and the further plane including the second curvature radius R2.

[0167] Further, a glass panel relating to this second embodiment may be alternatively constructed as shown in Figs. 21 and 22.

[0168] That is, for forming the convex curved face portions 10, there may be employed alternative methods of e.g. intermittently plating the wire member 5 along the longitudinal direction or affixing e.g. a metal film or the like thereto by means of sputtering. Further, it is also possible to affix a metal film by thermal spraying or vapor depositing metal thereto. With these methods, there is formed the convex curved face portion 10 which as a longer length along the longitudinal direction of the wire member 5 than a length thereof along the radial direction of the wire member 5.

[0169] Incidentally, the wire member 5, as described hereinbefore, may be made of various kinds of stainless steel (SUS304 or the like).

[0170] Incidentally, in this second embodiment, the first curvature radius of the convex curved portion 10 may be rendered minimum and the second curvature radius of the same maybe rendered maximum. In this case too, it is preferred that the curvature radius continuously vary between the plane including the first curvature radius R1 and the further plane including the second curvature radius R2.

[0171] Further, in this second embodiment, by forming reduced diameter portions by partially extending those portions spaced apart from each other along the longitudinal direction of the wire member, the convex curved face portions 10 may be formed consequently.

[0172] Moreover, the shape and the disposing pitch of the convex curved face portion 10 may be appropriately set, depending on the distance between the opposed glass sheets required for obtaining a desired heat insulating performance.

[third embodiment]

[0173] A glass panel relating to a third embodiment is shown in Figs. 23 through 26.

[0174] A spacer S3 employed in this embodiment, as shown in Figs. 23 and 24, is a wire member 5 spirally coiled along the entire length thereof. As this wire member 5, a metal wire having a circular cross section may be employed. As the metal, eg. a stainless steel such as SUS 304 may be employed.

[0175] The diameter of the wire member 5 is preferably 10 μm to 100 μm , for instance. The maximum diameter d of the coiled wire member 5 is preferably 20 μm to 200 μm , for instance.

[0176] In the case of the present embodiment, the first glass sheet 1A and the second glass sheet 1B and the wire member 5 come into point contact with each other at contact portions T1. Between each adjacent pair of turns of the wire members 5 of the spacer S3 along the longitudinal direction, there is formed a gap 11.

[0177] The spacer S3 relating to this third embodiment may be alternatively constructed as shown in Fig. 25.

[0178] In this case, the spacer S3 is formed by partially coiling the wire member 5 in the spiral pattern at portions thereof spaced apart from each other with a predetermined distance therebetween. The wire member 5 is formed of a stainless steel such as SUS 304 having a circular cross section with a diameter of about 10 μm . The maximum diameter d of the spiral coiled portion 12 is about 40 μm . The rest of the construction is same as that shown in Fig. 23.

[0179] Further, the spacer S3 relating to this third embodiment may alternatively constructed as shown in Fig. 26.

[0180] In this case, the spacer S3 is formed by spirally winding a wire member 5 about the outer peripheral face of a column-like core member 13. The wire member 5 is formed of a stainless steel such as SUS 304 having a circular cross section with a diameter of about 10 μm . The core member 11 has a diameter of approximately 20 μm .

[0181] The rest of the construction is same as the first embodiment.

[0182] In addition to the above, the spacer S3 is not limited to those comprised of spirally coiled wire members having a circular cross section. It may comprise a spirally coiled wire member having a polygonal cross section. Or, it may be a spirally coiled hollow wire member.

[0183] Further, for obtaining a desired heat insulating performance of the glass panel, the diameter of the wire member 5 and the maximum diameter of the spacer S3

may be appropriately designed.

[fourth embodiment]

5 **[0184]** According to a glass panel relating to this fourth embodiment, as shown in Fig. 27 for example, there are formed a plurality of knots 14 with a predetermined distance therebetween. Each spacer S4 is formed of a wire member 5 having a circular cross section. This wire member 5 is made of e.g. stainless steel such as SUS 304. The diameter of the wire member is preferably 10 μm to 100 μm approximately.

10 **[0185]** Each knot 14 is formed by inserting a portion of the wire member 5 into each single loop formed by the same, as shown in Fig. 27. Alternatively, as shown in Fig. 29, a ring is formed by pinching a portion of the wire member 5 in the U-shaped form and then the U-shaped portion 14a is inserted into this ring. Especially, in the case of forming the knot 14 of Fig. 29, the knot 14 may be readily formed at any desired portion of the spacer S4.

15 **[0186]** In this fourth embodiment, the above construction in which the ring is formed by the spacer S4 and a further portion of the spacer S4 is inserted into this ring thereby to form the lump-like knot 14 will be referred to as "tight knot" hereinafter. With such knots 14, there is inevitably formed a single-overlapped portion of the spacer S4, so that the formed knot 14 may have a thickness at least two greater than the diameter of the spacer S4. Especially, in case the knot 14 of Fig. 29 is formed, by strongly pulling the U-shaped portion 14a, there will be formed more overlapping portion in the knot 14 than the conditions shown in Fig. 29 and 30 so as to be rendered into a lump-like shape. Hence, it becomes possible to form a knot 14 having a thickness 3 times or more greater than the diameter of the spacer S4.

20 **[0187]** As shown in Figs. 28 and 30, those portions of the knot 14 which portions are disposed in opposition to the first glass sheet 1A and the second glass sheet 1B become contact portions T1 for the point-contact with the sheet surfaces of the first and second glass sheet 1A, 1B. Between contact portions T1 adjacent each other in the longitudinal direction of the spacer S4, there is formed a gap 11.

25 **[0188]** With the use of spacer S4 having the knots 14 as is the case with this fourth embodiment, even when the same spacer S4 is employed, by appropriately selecting the knotting method, knots 14 of desired size may be formed. Hence, the distance between the first glass sheet 1A and the second glass sheet 1B may be freely designed.

30 **[0189]** Further, the spacer S4 and the two glass sheets come into contact with each other only through the knots 14. Thus, the contact area between the spacer S4 and the two glass sheets may be rendered very small. In this case, the contact heat resistance between the spacer S4 and the glass sheets is increased, whereby the heat insulating performance

may be enhanced.

[0190] Further, if the spacer S4 and the two glass sheets come into substantially point contact with each other as described above, there is the risk of stress concentration at those portions of the glass sheets coming into contact with the knots 14. However, in the case of the present invention, the distance between adjacent knots 14 may be freely set. Hence, it is easy to appropriately set the distance between adjacent knots 14 so as to achieve an appropriate amount of flexion of the glass sheets and to control the stress concentration applied from each knot 14 to the glass sheets at an appropriate value. Therefore, crack or breakage of the glass panel may be effectively prevented.

[0191] And, with the present construction, only the knots 14 come into contact with the two glass sheets, while the remaining portions of the spacer S4 may remain apart from the two glass sheets. Therefore, the air in the space V1 may freely move along the glass surfaces from one side to the other side of the spacer S4, in spite of the presence of this spacer S4. For this reason, even when a plurality of spacers S4 are disposed side by side in the space V1, the evacuating operation of the air from the space V1 may be readily carried out.

[0192] In addition, if the knot 14 is constructed as a tight knot, as this knot 14 is formed like a lump not having much two-dimensional extension, so that it may be less conspicuous from the outside. Further, such tight knot has greater resistance against deformation when being pressed between the first glass sheet 1A and the second glass sheet 1B, so that there is obtained another advantage that the spacer S4 can maintain its function for a longer period of time.

[0193] The glass panel relating to this fourth embodiment may alternatively be constructed as shown in Figs. 31 through 33.

[0194] That is, in this case the knot 14 is formed by twisting the spacer S4, i.e. the wire member. The wire member 5 may be made of stainless steel or the like, as is the case with the foregoing. In this case, it is required that the wire member 5 can be freely bent and can also maintain its twisted shape well. For, the function of the spacer S4 will be impaired if the twisted portion can easily restore its original non-twisted shape.

[0195] For forming such knot 14, a predetermined portion of the wire member 5 is hooked by a hook member 15 and then by turning the hook member 15 for a few turns, the knot 14 may be formed. Accordingly, the spacer S4 may be manufactured efficiently. In addition, there are also achieved other effects same as those of the first embodiment, i.e. the heat insulating performance of the glass panel GP due to the provision of the knots 14, prevention of crack or breakage and the greater ease of the evacuating operation for pressure reduction.

[fifth embodiment]

[0196] A glass panel relating to this fifth embodiment as shown in Figs. 34 and 35 employs a cord-like spacer S5 formed by intertwining two wire members 5.

[0197] Each wire member 5 is comprised of a wire of stainless steel such as SUS 304 having a circular cross section. The diameter of this wire member 5 is preferably about 10 μm to 100 μm for instance. The intertwined wire members 5 have a maximum diameter d of about 20 μm to 200 μm .

[0198] These two wire members 5 come into contact with the first glass sheet 1A and the second glass sheet 1B at a plurality of contact portions T1 distributed like dots. Further, the wire members 5 come into contact with each other at straight linear contact portions B along the longitudinal direction of the spacer S5. Between the spacer S5 and the two glass sheets, gaps 11 are formed.

[0199] The glass panel relating to this fifth embodiment may alternatively be constructed as shown in Fig. 36.

[0200] In this case, the spacer S5 is formed by partially intertwining the wire members 5 at longitudinal portions spaced apart from each other by a certain distance therebetween. The intertwined portion 16 has a maximum diameter d of about 20 μm to 200 μm for instance. Those portions of the two wire members 5 at the intertwined portion 16 in opposition to the first glass sheet 1A and the second glass sheet 1B form the contacting portions T1 for the point-contact with the surfaces of the first glass sheet 1A and second glass sheet 1B respectively.

[0201] Incidentally, the spacer S5 relating to this fifth embodiment may alternatively be formed by intertwining three or more wire members 5.

[0202] Further alternatively, the spacer S5 may be formed by a plurality of thin wire members 5 of a diameter of 4 μm or so.

[0203] Also, the wire member 5 to be employed is not limited that having a circular cross section. For instance, a wire member 5 having a polygonal cross section may be employed instead.

[sixth embodiment]

[0204] A glass panel relating to this sixth embodiment may be constructed as illustrated in Figs. 37 through 42.

[0205] In this case, a spacer S6 comprised of a braided cord K1 is employed.

[0206] In general, the braided cord K1 refers to a cord formed by assembling wire members 5. Here, however, a little narrower interpretation is applied. For instance, it shall not include a simple twisted cord formed simply by intertwining a plurality of wire members 5. That is, the braided cord K1 is understood herein to refer to such cord having a portion formed by knitting the wire member 5 into a predetermined pattern.

[0207] As the braided cord K1, as shown in Fig. 37 for instance, there is employed one having an inner portion 17 consisting of at least one core wire 5a and an outer portion 18 comprising a cylindrical knitted portion for enclosing the inner portion 17 therein.

[0208] In case the inner portion 17 is constructed from a plurality of core wires 5a, these core wires 7a may be simply bundled together along the longitudinal direction X1 or the respective core wires 5a may be loosely intertwined with each other. On the other hand, the outer portion 18 is to be formed by e.g. knitting the wire members 57a into a cylindrical member for wrapping the inner portion 17 therein.

[0209] Incidentally, for wrapping the inner portion 17, there may be employed such method as knitting outer wire members 5b forming the outer portion 17 onto the plurality of core wires 5a bundled together.

[0210] The braided cord K1 may be formed by using e.g. wire members 5 having a circular cross section. The wire member 5 may be made of e.g. stainless steel such as SUS 304. The diameter of the wire member 5 is preferably few μm to 20 μm .

[0211] The braided cord K1 may be formed entirely of wire members 5 of one same kind of material or may be formed of mixed assembly of wire members 5 of different kinds of material. For instance, if the inner portion 17 is formed of stainless steel having a high tensile strength or carbon fibers or the like, the tensile strength of the entire braided cord K1 may be increased. With this, the possibility of cutting of the braided cord K1 during the manufacture of the glass panel GP may be lowered, so that the manufacturing efficiency of the glass panel may be improved.

[0212] On the other hand, if the outer portion 18 is formed of e.g. carbon fibers of the like having low heat conductivity, heat conduction between this braided cord K1 and the two glass sheets may be restricted, whereby a glass panel GP having higher heat insulating performance may be obtained.

[0213] In the case of using as the spacer S6 the braided cord K1 consisting of the inner portion 17 and the outer portion 18, as the outer portion 18 is wound about the periphery of the inner portion 17, at least three wire members 5 are overlapped with each other. Hence, there may be readily obtained a spacer S6 having a thickness at least three times greater than that of the wire member 5 or the like.

[0214] As shown in Fig. 38, as the outer peripheral face of the braided cord K1 is constructed in the knitted form by the wire members 5, this braided cord K1 comes into contact with the first glass sheet 1A and the second glass sheet 1B at a plurality of points. These contact portions will be referred to as the contact portions T1. These contact portions T1 are formed intermittently along the longitudinal direction X1 of the spacer S6. And, between contact portions T1 adjacent each other along the longitudinal direction X1 of the spacer S6, there is formed a gap 11 between the spacer S6

and the opposed sheet glasses.

[0215] If the spacer S6 is constructed as a braided cord K1 as is the case with this construction, the spacer S6 and the two glass sheets come into contact with each other only at the contact portions T1, so that the contact area between the spacer S6 and the opposed glass sheets may be rendered extremely small. In this case, the contact heat resistance between the spacer S6 and the two glass sheets may be increased, whereby the heat insulating performance may be improved.

[0216] On the other hand, if the spacer S6 and the glass sheets come into substantially point contact with each other, there is the risk of stress concentration at those portions of the two glass sheets coming into contact with the contact portions T1. However, as the distance between adjacent contact portions T1 is very small, the force applied to the two glass sheets may be appropriately dispersed. Moreover, as the spacer S6 comprised of the braided cord K1 has a certain degree of elasticity, breakage of glass panel due to stress concentration to the glass sheets may be effectively prevented.

[0217] Furthermore, with the present construction, the spacer S6 comes into contact with the two glass sheets only at the contact portions T1, while the other portions thereof remain apart from the two glass sheets. Therefore, the air in the space V1 may be readily moved from one side to the other side of the spacer S6 along the surfaces of the glass sheets, in spite of the presence of the spacer S6. For this reason, even if a plurality of spacers S6 are disposed side by side in the space V1, the evacuating operation of the air present in the space V1 may be carried out easily.

[0218] In addition to the above, if the spacer S1 is comprised of the braided cord K1, the braided cord K1 has resistance against twisting and can maintain its straight shape well. Hence, there is obtained another advantage that an operation for correcting twisted condition may be eliminated when the braided cord K1 is disposed between the first glass sheet 1A and the second glass sheet 1B.

[0219] The glass panel relating to this sixth embodiment, as shown in Fig. 39, may employ a further spacer S6 formed by intertwining a plurality of braided cords K1. In this case, the distance between the adjacent contact portions T1 along the longitudinal direction X1 where the spacer S6 comes into contact with the two glass sheets becomes greater than the construction of the foregoing embodiments, and the distance between the glass sheet 1 and the spacer S6 between the contact portions T1 adjacent in the same direction becomes greater. Therefore, in the space V1, the communication of the air from one side to the other side of the spacer S6 along the surfaces of the glass sheets is facilitated. For this reason, even if a plurality of spacers S6 are disposed side by side in the space V1, the evacuating operation of the air present in the space V1 may be car-

ried out easily.

[0220] Further alternatively, as shown in Fig. 40, there may be employed a spacer S6 consisting solely of the outer portion 18 comprised of cylindrically knitted wire members 5. In this case too, a good heat insulating performance may be obtained and the evacuating operation of the space V1 may be carried out easily.

[0221] Incidentally, since the spacers S6 shown in Figs. 39 and 40 have a certain degree of elasticity, the stress concentration to the two glass sheets may be relieved appropriately.

[0222] In addition to the above, in this sixth embodiment, as shown in Figs. 41 and 42, the spacer S6 may be comprised of a ribbon member H1 formed of a knitted wire member 5.

[0223] In the case of the spacer of this construction formed by knitting, it is possible, for example, to knit a single wire member 5 at one portion after another, so as to obtain a two-dimensional extension. Alternatively, the wire member may be knitted in the shape of bar, so that it is possible to freely form the spacer S6 having such three-dimensional shape as the shape of bar. With such two-dimensional or three-dimensional knitted portion, the thickness thereof may be freely designed by controlling the degree of knitting. In case the distance of the space V1 to be formed is predetermined, such knitted portion having a predetermined thickness may be readily formed by using a thin wire member 5 which is sufficiently shorter than the distance.

[0224] Further, such knitted portions may be provided intermittently along the longitudinal direction X1 of the spacer S6, if desired. Hence, the gap between the two glass sheets and the spacer S6 may be formed reliably.

[0225] According to this construction, the spacer S6 may be produced efficiently, without the trouble of e.g. combining a plurality of wire members 5. Further, the distance of the space V1 between the opposed glass sheets may be freely set and the evacuation of air from the space may be readily carried out. In addition, stress concentration to the two glass sheets may be relieved so as to prevent break of the glass panel. In this way, a glass panel having superior heat insulating performance may be obtained.

[seventh embodiment]

[0226] A glass panel relating to this seventh embodiment may employ spacers S7 illustrated in Figs. 43 through 50.

[0227] The spacer S7 is comprised of a plurality of spacer bodies S7a interconnected with each other via a wire member 5. The wire member 5 may be made of various kinds of metal. As this metal, stainless steel such as SUS 304 or the like may be employed. The diameter of this wire member is preferably about 10 μm to 100 μm .

[0228] The spacer body S7a of this embodiment may be formed as shown in Figs. 43 and 44, for example.

Namely, the peripheral face of the wire member 5 is plated at a plurality of portions thereof spaced apart in the longitudinal direction so as to form large-diameter portions. And, these large-diameter portions are used as the spacer bodies S7a. Accordingly, the spacer bodies S7a adjacent each other in the longitudinal direction are connected at the radial centers thereof connected with each other via the wire member 5 which is smaller in diameter than the spacer bodies S7a.

[0229] Incidentally, the spacer bodies S7a may be formed also by causing metal films or the like to a plurality of longitudinally spaced-apart portions on the peripheral face of the wire member 5 by means of sputtering. Further, the metal films may be affixed to the wire member 5 by means of thermal spraying. Further alternatively, a plurality of longitudinally spaced-apart portions of a wire member having a diameter required for the spacer bodies S7a may be formed into small-diameter portions corresponding to the wire member 5 by means of etching.

[0230] The spacer body 7a, as shown in Figs. 43 and 44, may be formed as a cylindrical body having a cylindrical outer peripheral face 19 and having a diameter d2 of about 25 μm . In this case, the first glass sheet 1A, the second glass sheet 1B and the outer peripheral face 19 come into line contact with each other at the contact portions T1 along the longitudinal direction of the spacer body S7a.

[0231] The spacer S7 relating to this seventh embodiment may alternatively constructed by using a further spacer body S7a shown in Figs. 45 and 46.

[0232] In this case, the cylindrical outer peripheral face 19 of the spacer body S7a includes a ridge portion 20 extending continuously along the peripheral direction relative to the axis of the spacer body S7a; and a plurality of such ridge portions 29 are provided along the longitudinal direction of the spacer body S7a.

[0233] The ridge portion 20 is ring-shaped having a triangular cross section. The adjacent ridge portions 20 in the longitudinal direction are formed coaxially and integrally with each other. The projecting height of the respective ridge portions 20 relative to the outer peripheral face 19 is constant. Therefore, for one spacer body S7a, this spacer body S7a comes into point contact with the first glass sheet 1A and the second glass sheet 1B at a plurality of contact portions T1 along its longitudinal direction.

[0234] Incidentally, the ridge portion 20 may have a semi-circular cross section rather than the triangular cross section. Further, the respective ridge portions 20 may be formed in a spaced apart relationship in the longitudinal direction of the spacer body S7a.

[0235] The spacer S7 of the glass panel relating to this seventh embodiment may alternatively employ a further spacer body S7a shown in Figs. 47 and 48.

[0236] In the case of this spacer body S7a, a spiral ridge portion 20 is formed along the cylindrical outer peripheral face 19. The ridge portion 20 has a maximum

diameter d1 of about 25 μm .

[0237] This ridge portion 20 also has a substantially triangular cross section. The projecting height of the ridge portion 20 relative to the outer peripheral face 19 is constant. Hence, this ridge portion 20 too comes into point contact with the first or second glass sheet 1A, 1B at a plurality of contact portions T1 along the longitudinal direction of the spacer body S7a.

[0238] Incidentally, the spiral ridge portion 20 may have a semi-circular cross section. Also, by varying the pitch of the spiral, the distance between the adjacent contact portions T1 may be set appropriately.

[0239] The spacer S7 of the glass panel relating to this seventh embodiment may employ a column-like spacer body S7a shown in Figs. 49 and 50.

[0240] In this case, the spacer body S7a includes a number of projections 21 formed in a spaced apart relationship on a cylindrical outer peripheral face 19. Each projection 21 has a substantially conical shape and is formed integral with the spacer body S7a. This spacer body S7a has a maximum diameter d1 of about 25 μm . And, the projecting heights of the projections 21 relative to the outer peripheral face are substantially constant.

[0241] To the first glass sheet 1A and the second glass sheet 1B, the leading ends of the projections 21 come into point contact at a plurality of contact portions T1 in the longitudinal direction of the spacer body S7a.

[0242] Incidentally, the projection 21 may alternatively have a semi-circular cross section.

[eighth embodiment]

[0243] A glass panel relating the present invention employs spacers disclosed in the eighth embodiment. The spacers relating to this eighth embodiment are shown in Figs. 51 through 54.

[0244] The spacer relating to the present embodiment may be constructed as shown in Figs. 51 and 52 for example. The spacer S8 is formed by interconnecting a plurality of engaging elements 22. In this case, the engaging piece 22 is constructed as an oval ring element 22a for example. A portion of this ring element 22a functions as an engaging portion for interconnecting adjacent ring elements 22a. Hence, the adjacent ring elements 22a are connected like a chain.

[0245] Each ring element 22a is formed of a metal wire member or the like. The cross section of this wire member may be circular or substantially circular. The metal may be e.g. stainless steel such as SUS 304 or the like.

[0246] These spacers are disposed side by side by a pitch of e.g. 30 mm between the first glass sheet 1A and the second glass sheet 1B.

[0247] Fig. 52 shown a lateral section of the ring elements 22a interconnected with each other. As the spacer S8 is in the form of a chain, the adjacent ring elements 22a are disposed to intersect with each other. The respective ring elements 22a come into contact

respectively with the first glass sheet 1A and the second glass sheet 1B at one point, contact portion T1. That is, with the spacer S8 having this construction, the spacer S8 and the opposed glass sheets come into contact in an intermittent manner, so that the support reaction force applied from the spacer S8 to the glass sheets may be effectively dissipated. On other and, as shown in Fig. 52, the ring elements 22a interconnected with each other are superposed on each other. Therefore, the distance between the first glass sheet 1A and the second glass sheet 1B may be maintained at about twice greater than the diameter of the wire member constituting the ring element 22a. Moreover, between the first and second glass sheets 1A, 1B and the spacer S8, there are formed gaps 11, so that the evacuation resistance during the evacuation of the space V1 may be advantageously reduced.

[0248] The glass panel relating to the eighth embodiment may employ a spacer shown in Fig. 53.

[0249] In this case, the engaging element 22 includes a bar-like first body 25 and ring-like second bodies 26 provided at opposed ends of the first body 25. Adjacent engaging elements 22 are connected by engaging the second bodies 26 with each other.

[0250] When one engaging element 22 is considered, it is preferred that the second bodies 26 provided at opposed ends be formed in a common plane or in different planes having a predetermined angle therebetween. That is, as illustrated in Fig. 52, the engaging elements 22 are to be constructed such that the inter-engaged second bodies 26 are in abutment with each other and all of the second bodies 26 may come into reliable contact with the first glass sheet 1A and the second glass sheet 1B.

[0251] With the engaging element 22 having the above construction, the distance between adjacent contact portions T1 may be appropriately designed by controlling the length of the first body 25. For instance, the greater the length of the first body 25, the easier the forming and disposing operations of the spacer S3, and the greater the reduction in the heat conduction between the first glass sheet 1A and the second glass sheet 1B. However, if the first body 25 has too great distance, this results in decrease in the number of the contact portions T1, thus increasing the stress concentration to the two glass sheets at these contact portions A. Hence, with careful consideration of the above respective conditions, the length of the first body 25 should be set within an appropriate range.

[0252] The glass panel relating to the eighth embodiment may employ a spacer shown in Fig. 54.

[0253] In this case, the engaging element 22 is formed by providing hook-like portions 28 at opposed ends of a bar-like body 27. The hook-like portions 28 may be formed by e.g. bending the opposed ends of the bar-like body 27 by 180 degrees approximately. A portion of this hook-portion 28 functions as an engaging portion 23, so that the spacer S8 is formed by interconnecting adja-

cent hook portions 28.

[0254] As this construction can be formed simply by bending the opposed ends of the bar-like body 27, the forming and manufacturing operations of the engaging element 22 may be facilitated.

[0255] Further, when the spacer S8 is disposed on the surface of the first glass sheet 1A, this may be done by engaging and connecting the engaging elements 22 to each other and the spacer S8 may be formed with a desired length.

[0256] Moreover, the individual engaging elements 22 may be e.g. transported in a condition separated from each other until they are disposed on e.g. the first glass sheet 1A. Moreover, if the engaging elements 22 were interconnected in advance, there would exist the risk of the engaging portions 23 being deformed due to certain external force applied during the transportation. In such case, the spacer S8 could not be disposed straight or some engaging elements 22 would fail to contact evenly the two opposed glass sheets. With the present construction, however, there is less risk of the engaging portions 23 or the like being deformed and when the engaging elements 22 are connected with other, they may be disposed more linearly. As a result, all of the engaging elements 22 may be placed in reliable contact with the first glass sheet 1A and the second glass sheet 1B, thereby to effectively disperse the supporting reaction force applied from the spacer S8 to the two glass sheets.

[0257] Incidentally, even if a certain engaging element 22 becomes deformed, this engaging element 22 alone may be disposed of, and there will not occur such inconvenience that deformation of a particular engaging element 22 results in un-usability of the entire spacer S8.

[ninth embodiment]

[0258] In this ninth embodiment, as shown in Fig. 55, a spacer S9 is formed by placing a plurality of first wire members 5c and a plurality of second wire members 5d one above the other in different directions. The first wire members 5c are arranged in parallel and equidistantly with each other and so are the second wire members 5d.

[0259] Normally, the first wire members 5c and the second wire 5d differ only in the disposing directions thereof, but are formed of the same wire members 5 of same material. This wire member 5 is comprised of e.g. a metal wire having a circular or substantially circular cross section. The diameter thereof is preferably about 24 μm . The metal may be stainless steel such as SUS 304 or the like. The first wire members 5c and the second wire members 5d are bonded together at their intersection points 29.

[0260] The glass panel S9 using this spacer S9 is assembled by placing the first glass sheet 1A having the plurality of first wire members 5c wound about it on the second glass sheet 1B having the plurality of second

wire members 5d wound about it. The fixing of the first wire members 5c to the first glass sheet 1A and the fixing of the second wire members 5d to the second glass sheet 1B are effected by the same method described and illustrated herein before in Fig. 15.

[0261] The spacer relating to the ninth embodiment, as shown in Figs. 56 and 57, may be formed by interweaving a plurality of first wire members 5c and a plurality of second wire members 5d, just like a mesh for a sieve. Namely, at the adjacent intersections 29, the vertical relationship between the first and second wire members 5c, 5c intersecting each other are caused to differ from each other. The spacer S9 having this construction comes into contact with the two glass sheets only in the vicinities of the intersections 29. So that, the contact area between the spacer S9 and the glass sheets may be small and heat conduction between the first glass 1A and the second glass sheet 1B may be restricted, whereby a glass panel having a high heat insulation performance may be obtained.

[0262] On the other hand, however, as the space S9 comes into contact with the two glass sheets at a plurality of points, the supporting reaction force applied from the spacer S9 to the two opposed glass sheets may be dispersed, whereby a glass panel having resistance against cracking or the like may be obtained.

[0263] The spacer S9 relating to the ninth embodiment, as shown in Fig. 58, may be constructed in the form of a mesh with intertwining a plurality of wire members 5 disposed along one direction, just like a metal mesh for use as a fence. This may be formed by engaging the wire members 5 in the forms of coils with each other at respective adjacent portions thereof and then laterally displacing them away from each other.

[0264] Further, as shown in Fig. 59, at those intertwining portions of the wire members 5, these wire members 5 may be inter-twisted with each other. With this construction, as the adjacent wire members 5 are interconnected in a reliable manner, the spacer S9 may be formed as one unit for easy handling thereof.

[0265] In the spacer S9 relating to the ninth embodiment, as shown in Fig. 60, at the intersecting point 29, the first wire member 5c and the second wire member 5d may be tied each other at knots 30. In this, the knotting may be done by using a third wire member 5e, or by tying either one of the first and second wire members 5c, 5d to the other of the same. Also, the first wire members 5c and the second wire members 5d may be tied with each other as shown in Fig. 61.

[0266] Further, as shown in Fig. 62, at the intersecting point 29, the first wire member 5c and the second wire member 5d may be bonded together by using an adhesive.

[0267] In addition to the above, without causing the wire members 5 to be intersect each other, the adjacent wire members 5 may be joined together at predetermined pitch and then stretched out. In this case too, such spacer S9 as shown in Fig. 61 may be obtained.

[0268] The spacer S9 relating to this ninth embodiment may be alternatively constructed as illustrated in Fig. 63, in which by turning continuous wire members 5 back and forth with a predetermined distance between adjacent turns thereof. Incidentally, the wire member 5 arranged in one direction and the wire member 5 arranged in another direction may not be continuous with each other.

[0269] Further, the spacer S9 relating to the ninth embodiment, as shown in Figs. 64 and 65, may be provided in the form of a planar knitted assembly formed by knitting of wire members 5. Such spacer comprising a planar knitted assembly has flexibility, so that it may be readily disposed in a stretched out condition on the surfaces of the two glass sheets.

[0270] Further, the manner of knitting the wire members 5 may be freely selected. For instance, as illustrated in Figs. 66 and 67, the knitting may be done in a variety of manners with varying the knitting pattern. As the result, it becomes possible to provide the glass panel with an ornamental design. Accordingly, even if there is the risk of showing of the spacer S9 for deterioration of the aesthetic appearance, such deterioration of the aesthetic appearance may be avoided with provision of ornamental design to the spacer S9.

Industrial Applicability

[0271]

[1] The glass panel relating to the present invention may be used for a variety of applications. For instance, it may be used for buildings, vehicles (e.g. window pane of an automobile, window pane of a railway train, window pane of a ship), device components (a surface glass of a plasma display device, opening/closing door of a refrigerator, an opening/dosing door or a wall of a heat insulating device), etc.

[2] The first glass sheet 1A and the second glass sheet 1B are not limited to the glass sheets having 3 mm thickness described in the foregoing embodiments. They may be glass sheets of a different thickness. Further, the type of the glass may be freely selected. For instance, figured glass, frosted glass (glass provided with a function of light beam diffusion through a surface treatment thereof), wire glass, reinforced glass, or other glass sheets added with such functions as heat-absorbing function, ultraviolet absorbing function, heat-reflecting function and so on.

Also, the composition of the glass may be soda silica glass (soda lime silica glass), borosilicate glass, aluminosilicate glass, and other kinds of crystallized glass, etc.

[3] The lengths and widths of the first glass sheet

1A and the second glass sheet 1B need not necessarily different from each other, but may be same. Further, the overlapping manner of the two glass sheets may be such that the end edges thereof are overlapped in alignment with each other. Also, the glass panel may be formed by combination of first and second glass sheets 1A and 1B which differ in thickness thereof from each other.

[4] The spacer is not limited to those described in the foregoing embodiment made of stainless steel. For instance, it may be made of Inconel 718 alloy, or other kinds of metal, crystal glass ceramics and so on. In short, it should be any which is hardly deformable so as to prevent mutual contact between the two glass sheets when subjected to an external force.

[5] The diameter, disposing pitch and arrangement of the spacer are not limited to those in the foregoing embodiments. For instance, they may be appropriately selected, depending on e.g. the strength, thickness flexibility of the first glass sheet 1A and the degree of vacuum of the space, and so on.

[6] The spacers to be employed in the glass panel relating to the present invention may be formed hollow.

30 Claims

1. A glass panel in which a spacer (S1) is interposed between a pair of first and second glass sheets (1A), (1B) and a sealing portion (2) is provided along the entire outer peripheral edges of the glass sheets (1A), (1B), and the space (V) between the first glass sheet (1A) and the second glass sheet (1B) is sealed under a pressure-reduced condition; wherein the spacer (S1) is comprised of a wire member (5) having a rounded cross section and disposed along the surfaces of the opposed glass sheets (1A), (1B).
2. The glass panel according to claim 1, wherein the wire member (5) has a circular or substantially circular cross section.
3. The glass panel according to claim 1 or 2, wherein a plurality of said wire members (5) are disposed side by side in a spaced relationship so that the spaces between the wire members (5) are communicated with each other.
4. A glass panel in which an elongate spacer (S2) is interposed between a pair of first and second glass sheets (1A), (1B) having sheet surfaces thereof opposed to each other to form a space (V1) therebetween; and

said space (V1) is sealed along the outer peripheral edges of the first glass sheet (1A) and the second glass sheet (1B) so as to maintain the space (V1) under a pressure-reduced condition;

wherein the spacer (S2) includes a plurality of convex curved face portions (10) on the sides adjacent the first and second glass sheets (1A), (1B), and these convex curved face portions are provided in a spaced relationship along the length of the spacer (S2);

and, when the convex curved portions (10) are cut along a plane including two contact portions between the convex curved portions and the first and second glass sheets (1A), (1B), each convex curved portion (10) provides a cross-sectional peripheral edge having a curvature radius which varies for each cutting plane.

5. The glass panel according to claim 4, wherein the curvature radius is maximum in a section taken along the longitudinal direction of the spacer (S2) and the radius is minimum in a section taken normal to the longitudinal direction, and the curvature radius of an arbitrary cross section including said two contact portions varies continuously for different cross sections.

6. A glass panel in which an elongate spacer (S3) is interposed between a pair of first and second glass sheets (1A), (1B) having sheet surfaces thereof opposed to each other to form a space (V1) therebetween; and

said space (V1) is sealed along the outer peripheral edges of the first glass sheet (1A) and the second glass sheet (1B) so as to maintain the space (V1) under a pressure-reduced condition;

wherein the spacer (S3) is formed of a wire member (5) coiled in the form of spiral.

7. The glass panel according to claim 6, wherein the wire member (5) is coiled in the form of spiral at limited portions thereof spaced apart by a predetermined distance therebetween.

8. The glass panel according to claim 6 or 7, wherein the spacer comprises a core member (13) and the wire member (5) wound in the form of spiral about the outer peripheral face of the core member (13).

9. The glass panel according to any one of claims 6 through 8, wherein the wire member (5) has a substantially circular cross section.

10. A glass panel in which an elongate spacer (S4) is

interposed between a pair of first and second glass sheets (1A), (1B) having sheet surfaces thereof opposed to each other to form a space (V1) therebetween; and

said space (V1) is sealed along the outer peripheral edges of the first glass sheet (1A) and the second glass sheet (1B) so as to maintain the space (V1) under a pressure-reduced condition;

wherein the spacer (S4) is comprised of a wire member (5) having a plurality of knots (14) spaced apart from each other with a predetermined distance therebetween.

11. The glass panel according to claim 10, wherein the knot (14) is formed as a tight knot.

12. The glass panel according to claim 10, wherein the knot (14) is formed by twisting the wire member (5).

13. A glass panel in which an elongate spacer (S5) is interposed between a pair of first and second glass sheets (1A), (1B) having sheet surfaces thereof opposed to each other to form a space (V1) therebetween; and

said space (V1) is sealed along the outer peripheral edges of the first glass sheet (1A) and the second glass sheet (1B) so as to maintain the space (V1) under a pressure-reduced condition;

wherein the spacer (S5) comprises a plurality of wire members (5) inter-twisted with each other.

14. The glass panel according to claim 13, wherein the spacer (S5) is formed by partially inter-twisting the plurality of wire members (5) at a plurality of predetermined positions thereof spaced apart from each other in the longitudinal direction.

15. The glass panel according to claim 13 or 14, wherein the wire member (5) has a substantially circular cross section.

16. A glass panel in which an elongate spacer (S6) is interposed between a pair of first and second glass sheets (1A), (1B) having sheet surfaces thereof opposed to each other to form a space (V1) therebetween; and

said space (V1) is sealed along the outer peripheral edges of the first glass sheet (1A) and the second glass sheet (1B) so as to maintain the space (V1) under a pressure-reduced condition;

wherein said spacer (S6) comprises a braided

cord (K1).

17. The glass panel according to claim 16, wherein the braided cord (K1) includes an inner portion (17) comprised of at least one core wire (5a) and an outer portion (18) comprised of a cylindrical braided member for enclosing the inner portion (17). 5

18. The glass panel according to claim 16 or 17, wherein the spacer (S6) comprises a plurality of the braided cords (K1) inter-braided or inter-knitted together. 10

19. A glass panel in which an elongate spacer (S6) is interposed between a pair of first and second glass sheets (1A), (1B) having sheet surfaces thereof opposed to each other to form a space (V1) therebetween; and 15

said space (V1) is sealed along the outer peripheral edges of the first glass sheet (1A) and the second glass sheet (1B) so as to maintain the space (V1) under a pressure-reduced condition; 20
wherein the spacer (S6) comprises a ribbon member (H1) formed of a knitted wire member (5). 25

20. A glass panel in which a plurality of spacer bodies (S7a) are interposed between a pair of first and second glass sheets (1A), (1B) having sheet surfaces thereof opposed to each other to form a space (V1) therebetween, the spacer bodies (S7a) being interconnected in a spaced relationship via a wire member (5) having a diameter greater than the spacer bodies; and 30

said space (V1) is sealed along the outer peripheral edges of the first glass sheet (1A) and the second glass sheet (1B) so as to maintain the space (V1) under a pressure-reduced condition; 40
wherein the spacer body (S7a) is formed like a column and includes contact portions (T1) for contacting the glass sheet surfaces along the longitudinal direction. 45

21. The glass panel according to claim 20, wherein the contact portions (T1) are adapted to come into line contact with the two glass sheet surfaces. 50

22. The glass panel according to claim 21, wherein the column-like spacer body (S7a) includes a cylindrical outer peripheral face (19). 55

23. The glass panel according to claim 20, wherein the column-like spacer body (S7a) includes a plurality of contact portions (A) along the longitudinal direc-

tion thereof which come into point contact with the two glass sheet surfaces.

24. The glass panel according to claim 23, wherein the cylindrical outer peripheral face (19) of the spacer body (S7a) includes a ridge portion (20) of a predetermined height extending continuously along the peripheral direction relative to the axis of the spacer body; and a plurality of such ridge portions (20) are provided along the longitudinal direction of the spacer body.

25. The glass panel according to any one of claims 20 through 24, wherein said spacer bodies (S7a) are interconnected with each other at the radial centers thereof the wire member (5).

26. A glass panel in which a spacer (S8) is interposed between a pair of first and second glass sheets (1A), (1B) and a sealing portion (2) is provided along the entire outer peripheral edges of the glass sheets (1A), (1B), and the space (V) between the first glass sheet (1A) and the second glass sheet (1B) is sealed under a pressure-reduced condition; wherein a plurality of engaging pieces (22) having an engaging portion (23) at an end thereof are inter-connected to form said spacer (S8) along the sheet surfaces of the glass sheets.

27. The glass panel according to claim 26, wherein the engaging pieces (22) are ring pieces (22a) which comprise the engaging portions (23) interconnected like a chain to constitute said spacer (S8).

28. The glass panel according to claim 26, wherein a ring-like second body (26) capable of forming the engaging portion (23) is provided at end of a first body (25), whereby the engaging piece (22) is formed, and the second bodies (26) are engaged with each other like a chain to interconnect the adjacent engaging pieces (22), so as to constitute the spacer (S8).

29. The glass panel according to claim 26, wherein the engaging piece (22) is formed by providing engaging portions (28) in the form of hook-like portions at opposed ends of a bar-like body (27) and the hook-like portions (28) are engaged with each other for connecting adjacent engaging pieces (22) together, thereby to constitute the spacer (S8).

30. A glass panel in which a spacer (S9) is interposed between a pair of first and second glass sheets (1A), (1B) and a sealing portion (2) is provided along the entire outer peripheral edges of the glass sheets (1A), (1B), and the space (V) between the first glass sheet (1A) and the second glass sheet (1B) is sealed under a pressure-reduced condition;

wherein the spacer (S9) includes a plurality of first wire members (5c) arranged side by side in one direction in a spaced apart relationship along the surfaces of the first and second glass plates and a plurality of second wire members (5d) arranged side by side in a different direction in a spaced apart relationship along the surfaces of the first and second glass sheets.

31. The glass panel according to claim 30, wherein the second wire members (5d) are placed over the first wire members (5c) in a grating pattern, thereby to constitute the spacer (S9). 10
32. The glass panel according to claim 30, wherein said spacer (S9) is constructed in the form of grating pattern such that at each of a plurality of intersection points (29) of the plurality of first wire members (5c) and the plurality of second wire members (5d), the vertical relationship between the first wire member (5c) and the second wire member (5d) is reversed relative to the adjacent intersection point (29). 15 20
33. A glass panel in which a spacer (S9) is interposed between a pair of first and second glass sheets (1A), (1B) and a sealing portion (2) is provided along the entire outer peripheral edges of the glass sheets (1A), (1B), and the space (V) between the first glass sheet (1A) and the second glass sheet (1B) is sealed under a pressure-reduced condition; wherein the spacer (S9) is in the form of a mesh including a plurality of wire members (5) disposed side by side along a direction in a spaced apart relationship along the surfaces of the glass sheets, with the adjacent wire members (5) being intertwined together. 25 30 35
34. A glass panel in which a spacer (S9) is interposed between a pair of first and second glass sheets (1A), (1B) and a sealing portion (2) is provided along the entire outer peripheral edges of the glass sheets (1A), (1B), and the space (V) between the first glass sheet (1A) and the second glass sheet (1B) is sealed under a pressure-reduced condition; wherein said spacer (S9) is constructed such that a plurality of wire members (5) are disposed side by side in a spaced relationship along the surface of the glass sheet and a further plurality of wire members are disposed so as to intersect the wire members, and at each intersection point (29) said wire members are connected together. 40 45 50
35. The glass panel according to claim 34, wherein said connection is such that the intersecting wire members (5) form a knot of the wire members at each intersection point (29). 55

36. The glass panel according to claim 34, wherein said connection is such that the intersecting wire members (5) are bonded to each other at each intersection point (29).

37. A glass panel in which a spacer (S9) is interposed between a pair of first and second glass sheets (1A), (1B) and a sealing portion (2) is provided along the entire outer peripheral edges of the glass sheets (1A), (1B), and the space (V) between the first glass sheet (1A) and the second glass sheet (1B) is sealed under a pressure-reduced condition; wherein the spacer (S9) is constructed such that the wire members (5) are knitted into a planar knitted assembly.

Fig.1

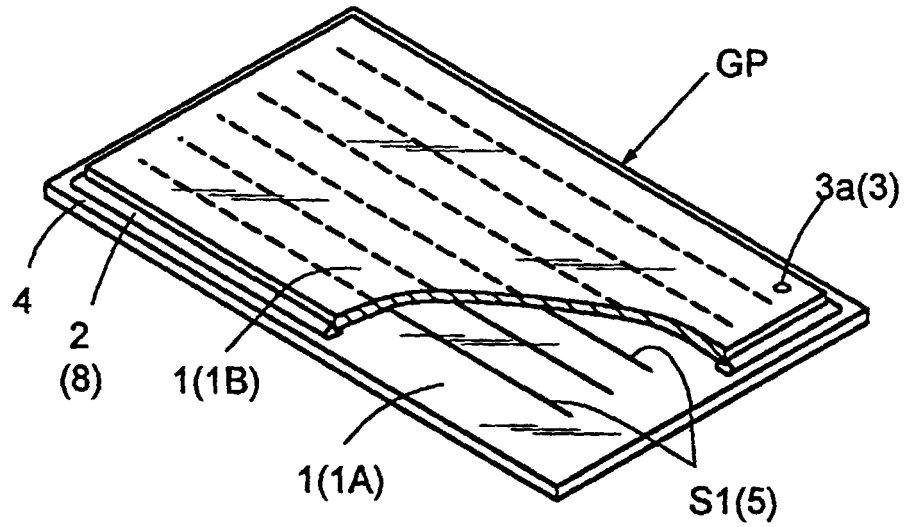


Fig.2

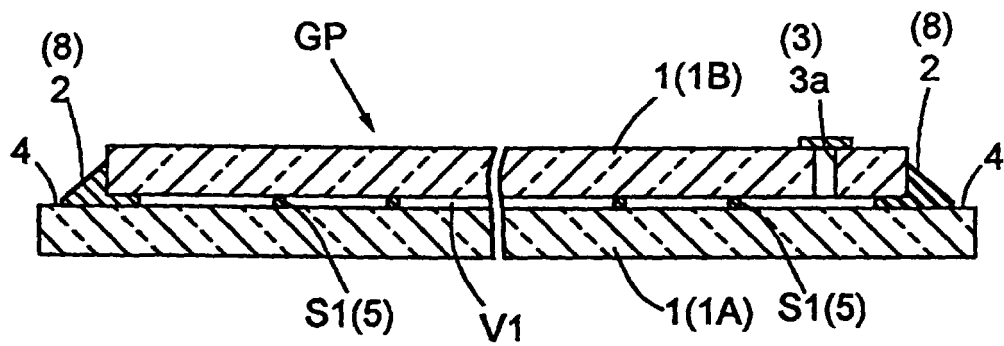


Fig.3

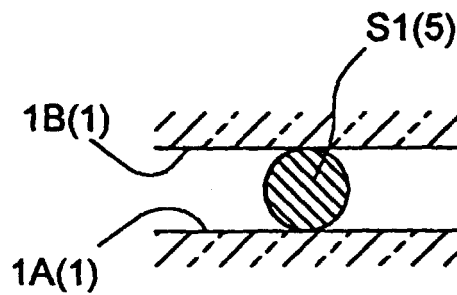


Fig.4

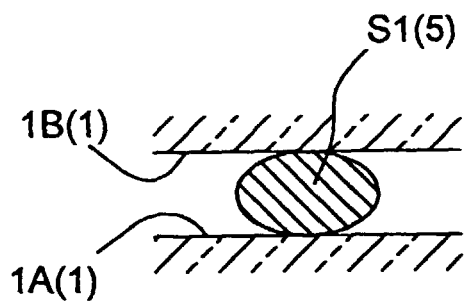


Fig.5

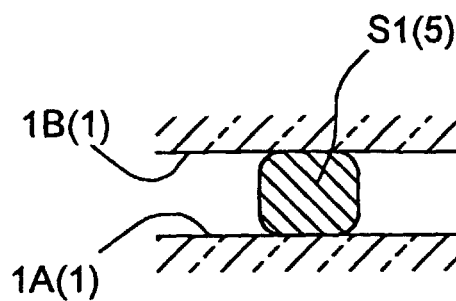


Fig.6

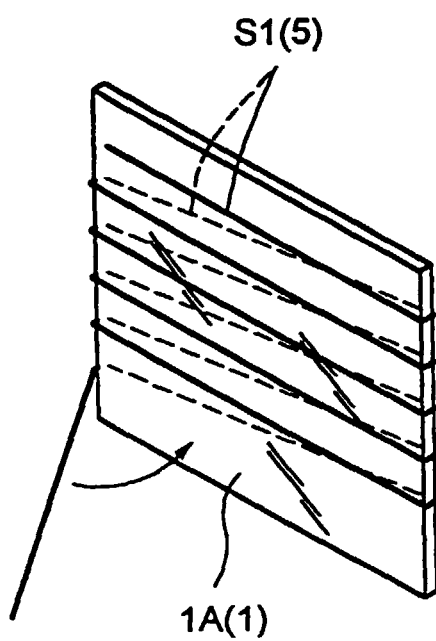
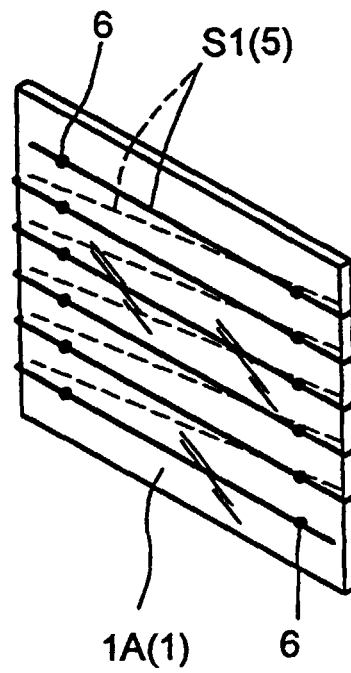


Fig.7



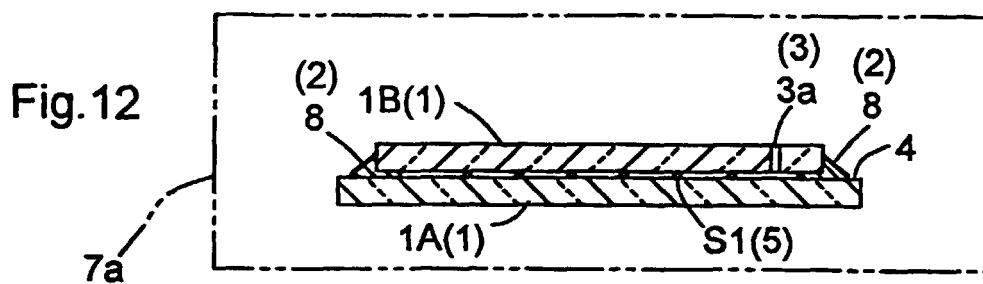
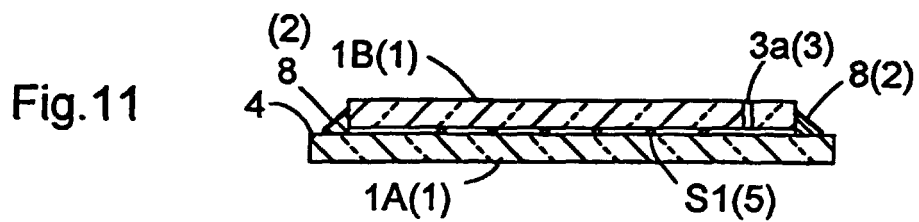
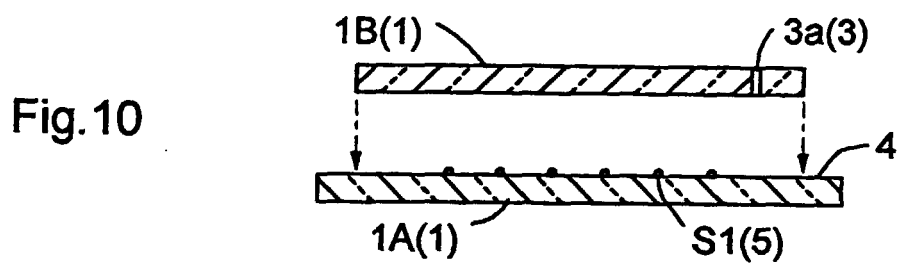
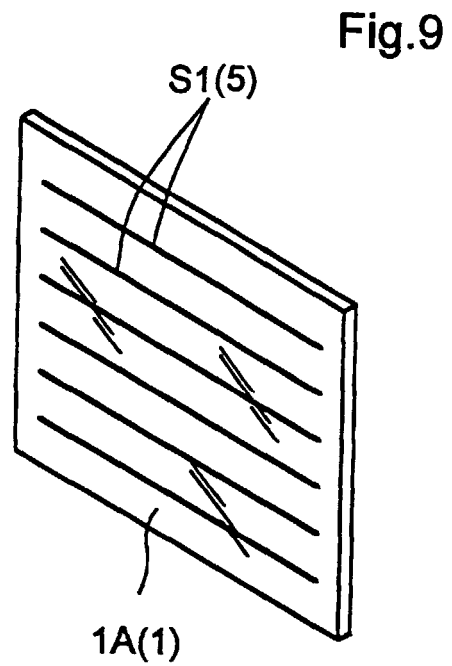
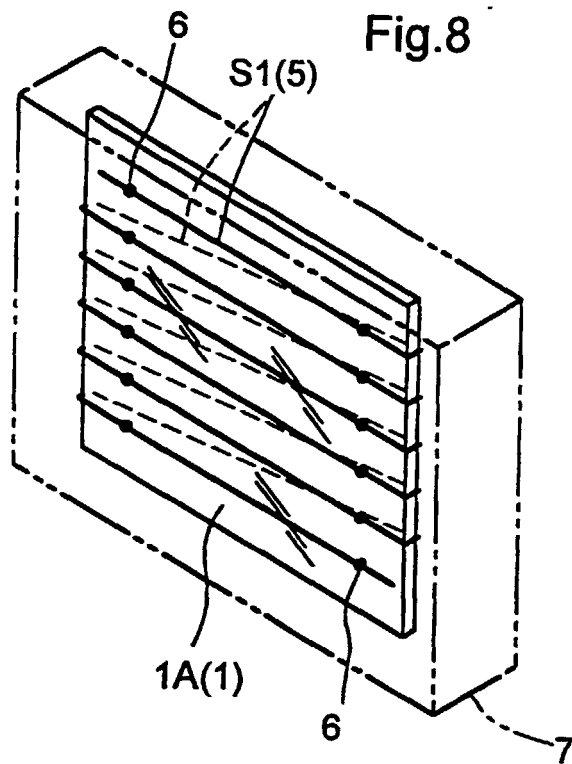


Fig.13

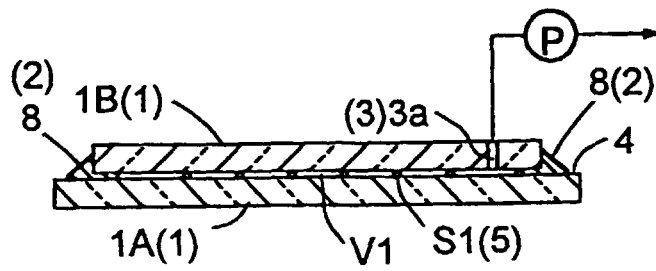


Fig.14

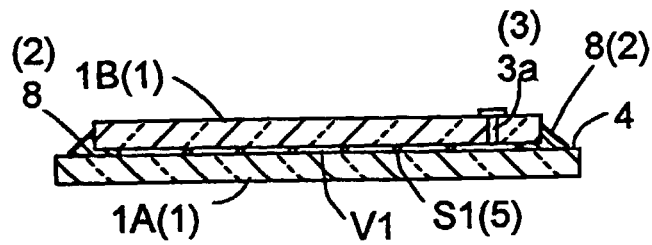


Fig.15

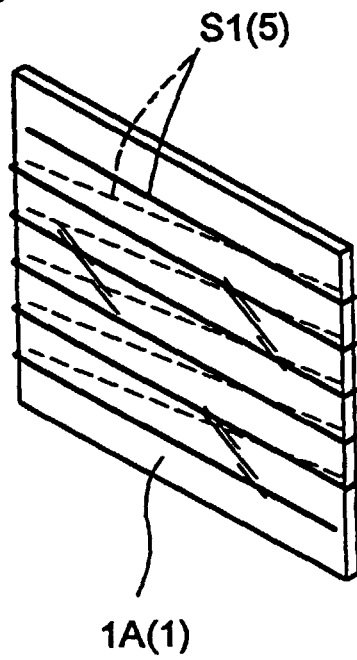


Fig.16

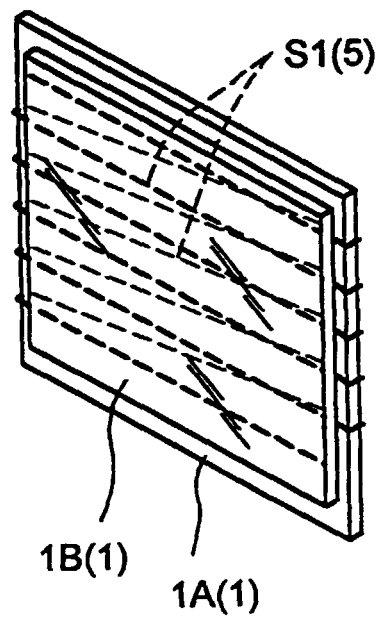


Fig.17

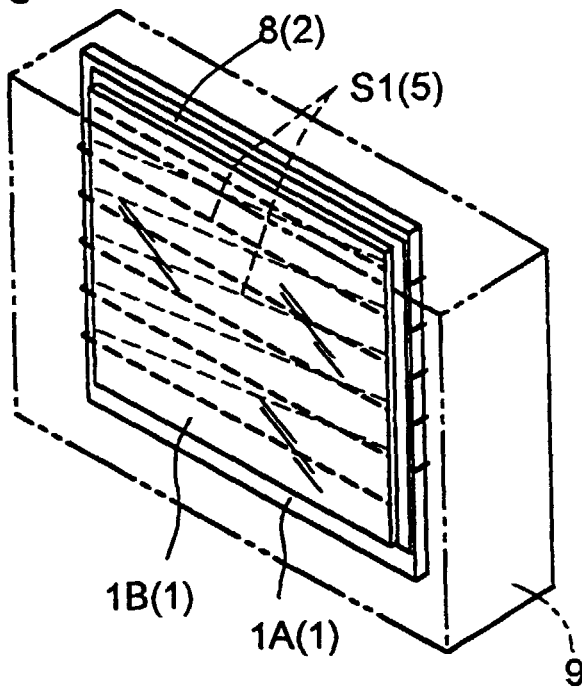


Fig.18

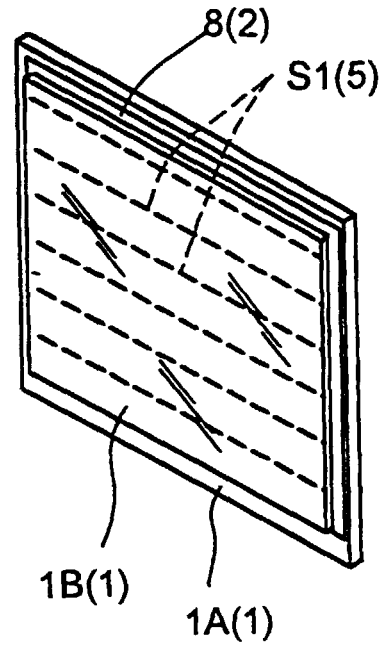


Fig.19

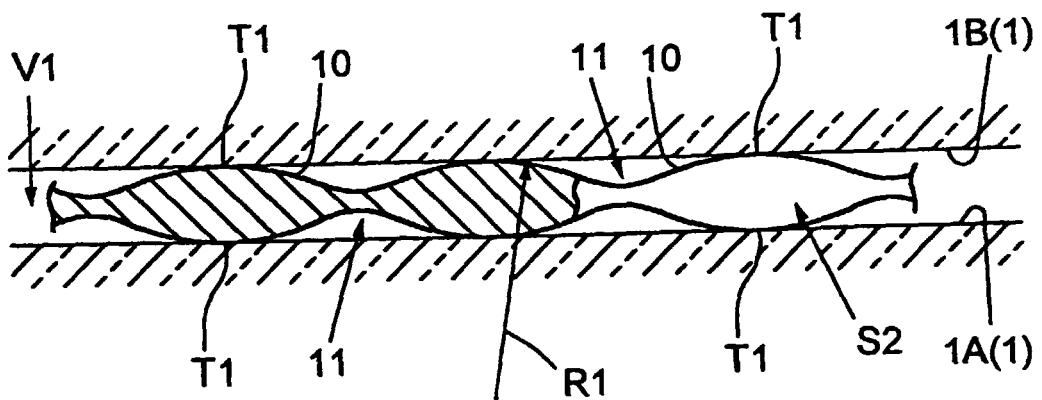


Fig.20

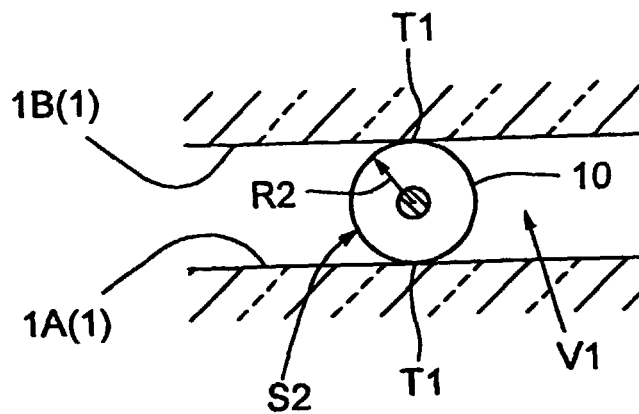


Fig.21

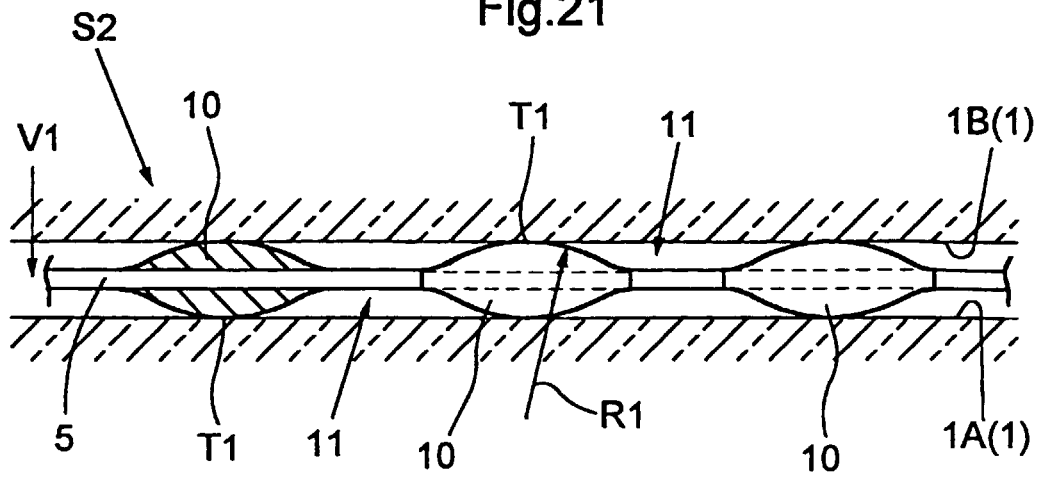


Fig.22

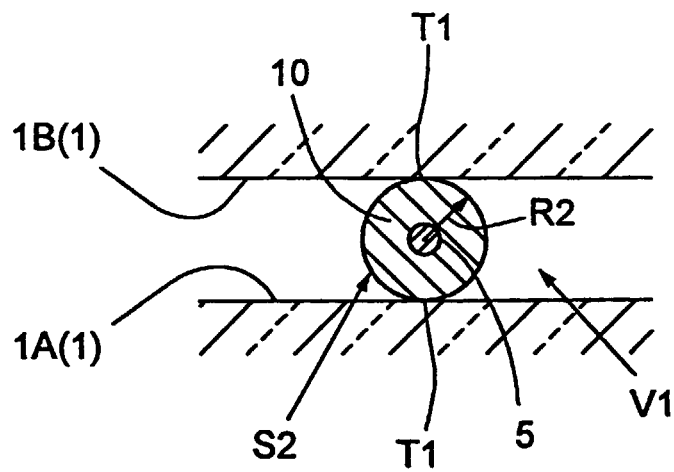
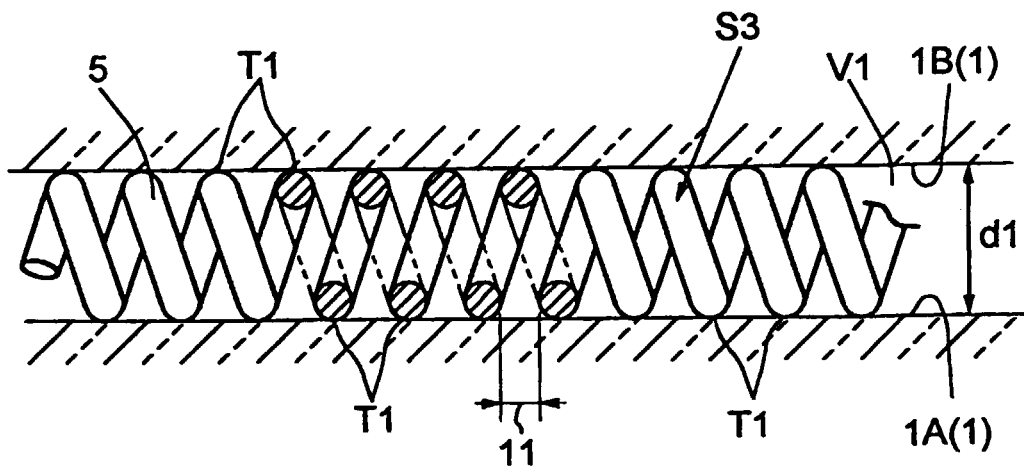


Fig.23



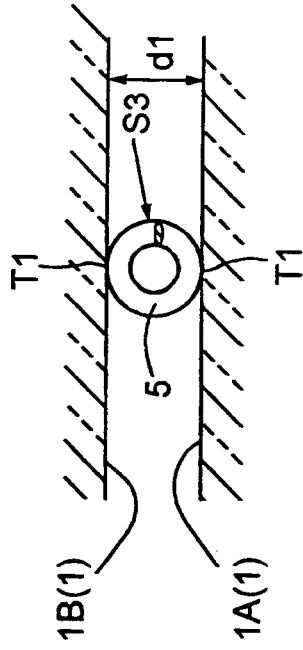


Fig. 24

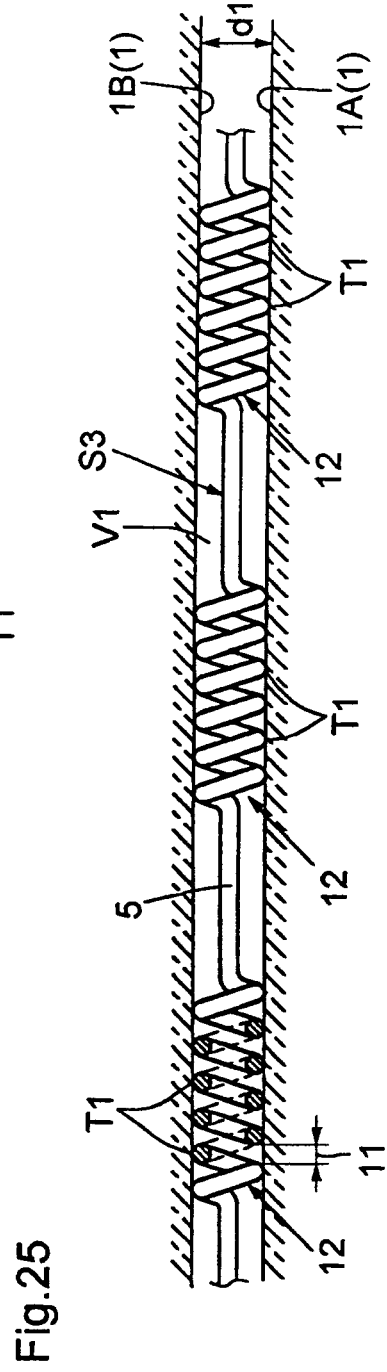


Fig. 25

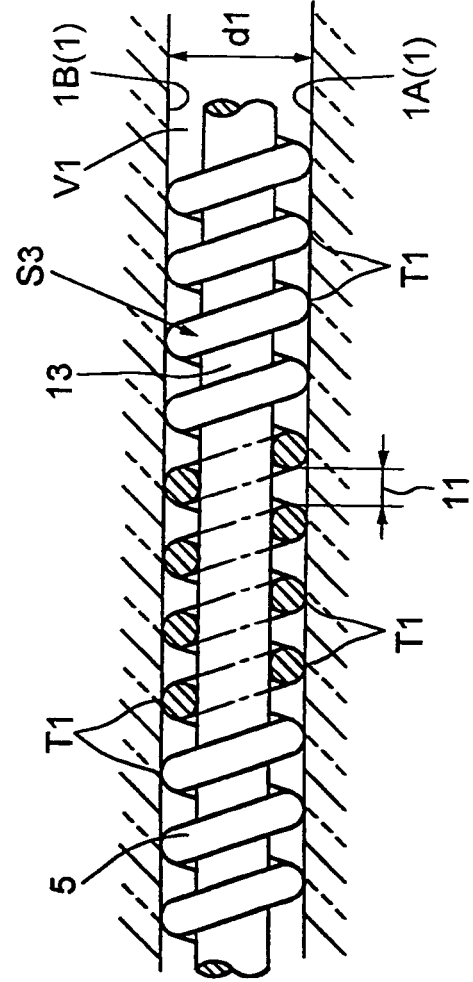


Fig. 26

Fig.27

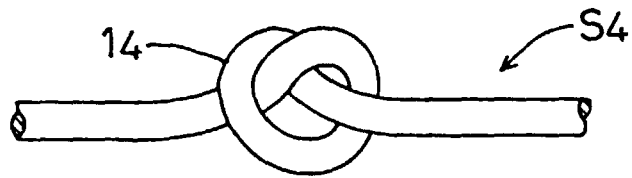


Fig.28

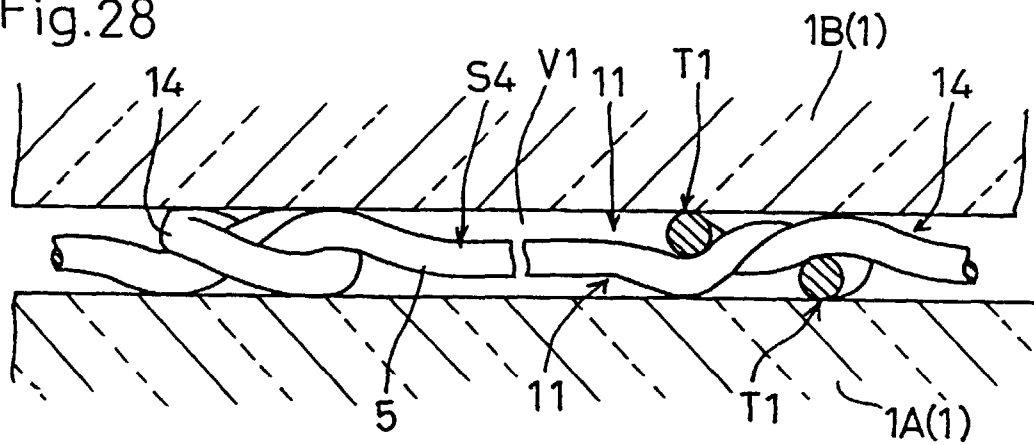


Fig.29

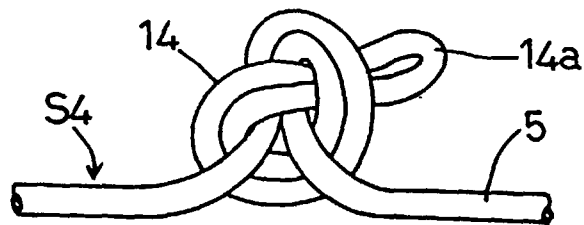


Fig.30

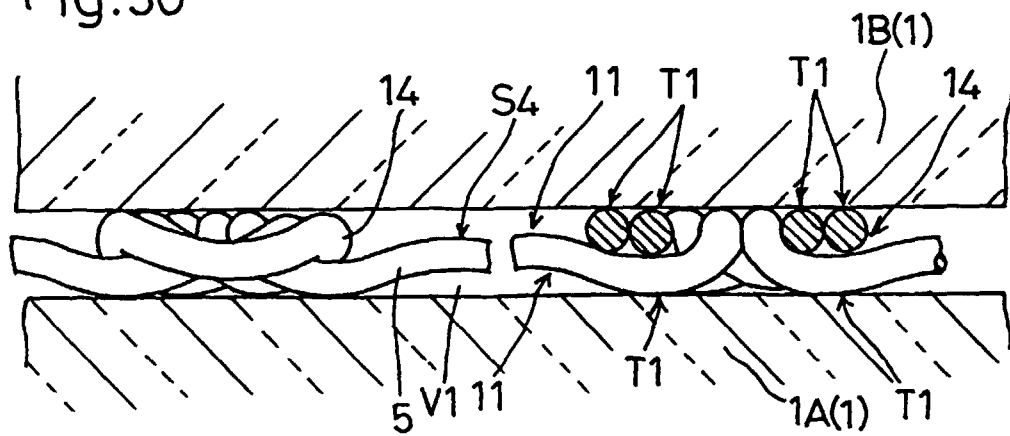


Fig.31

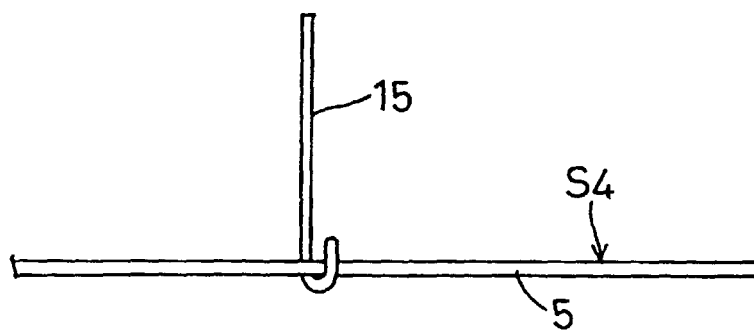


Fig.32

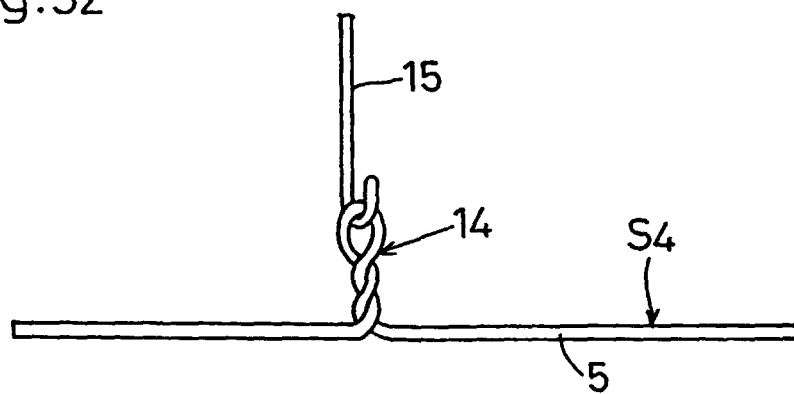
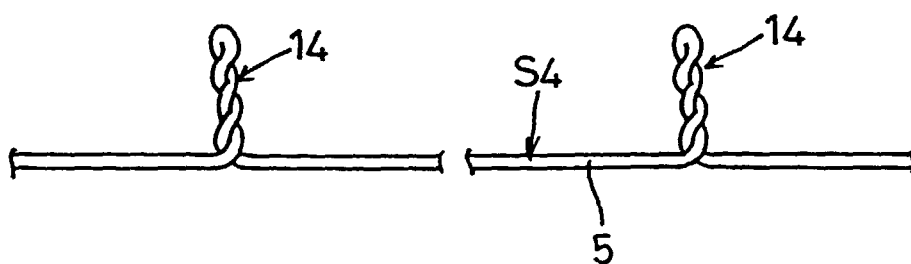


Fig.33



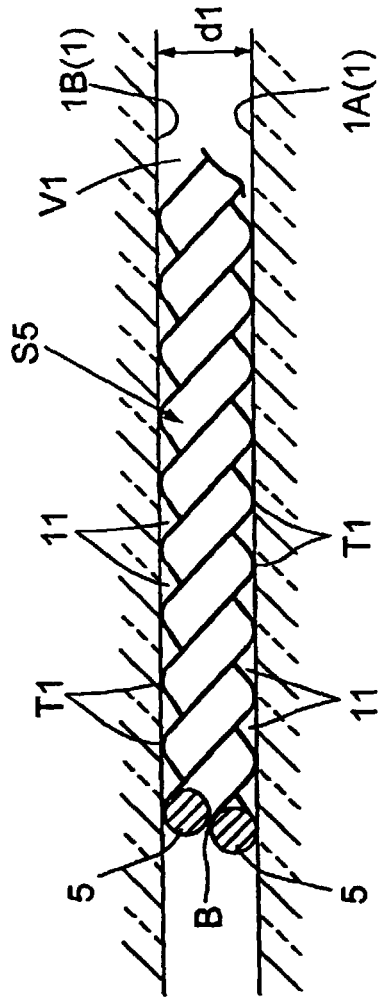


Fig. 34

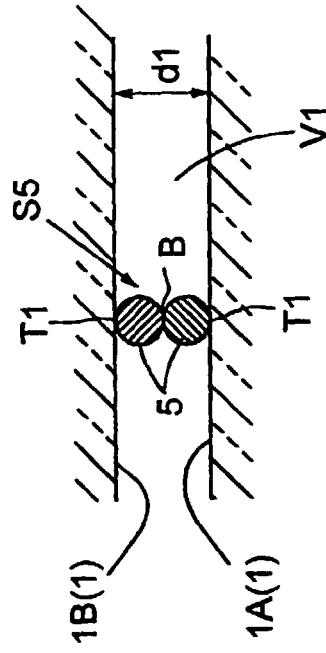


Fig. 35

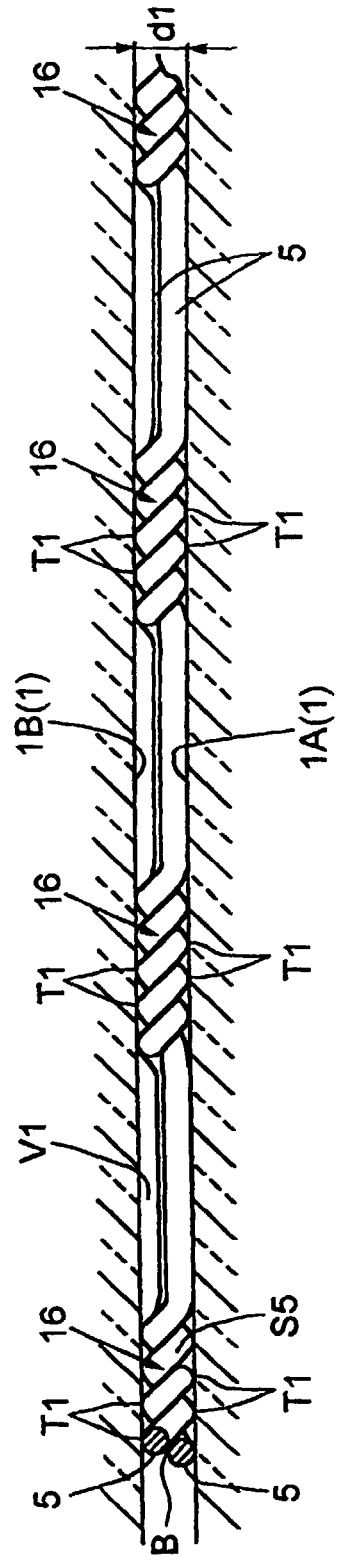


Fig. 36

Fig.37

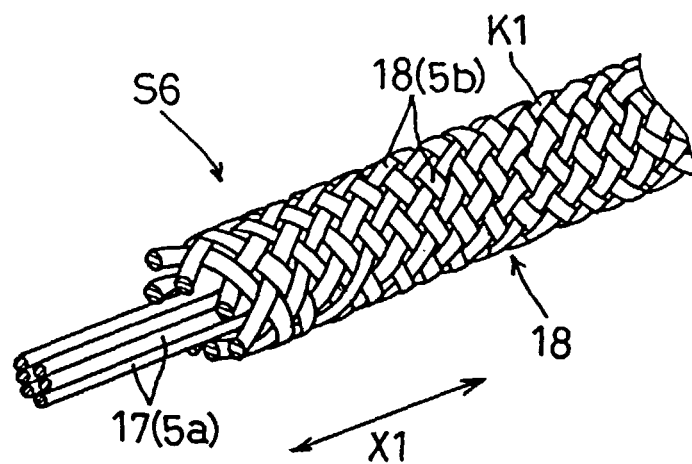


Fig.38

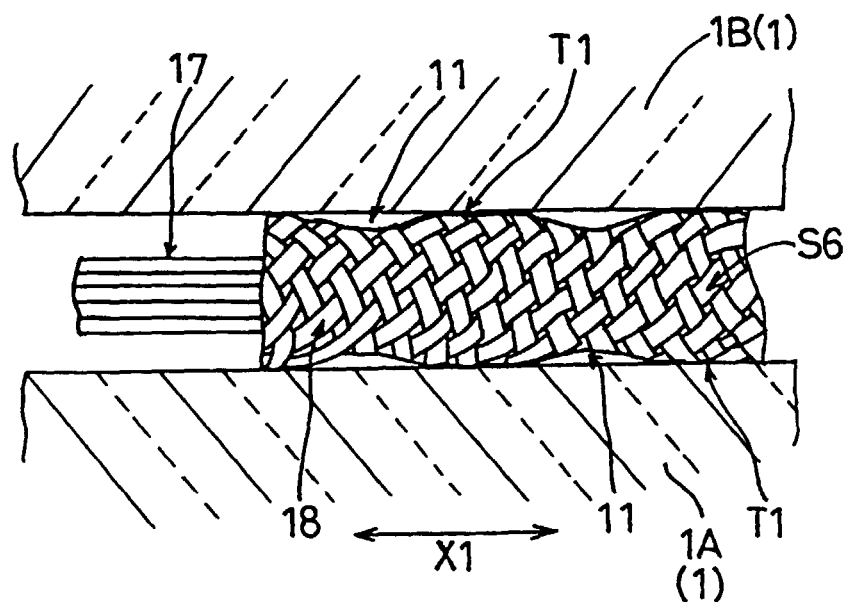


Fig.39

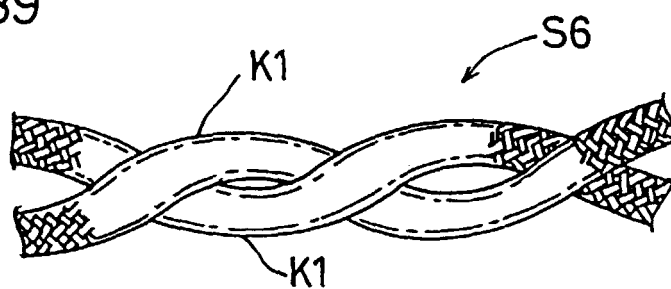


Fig.40

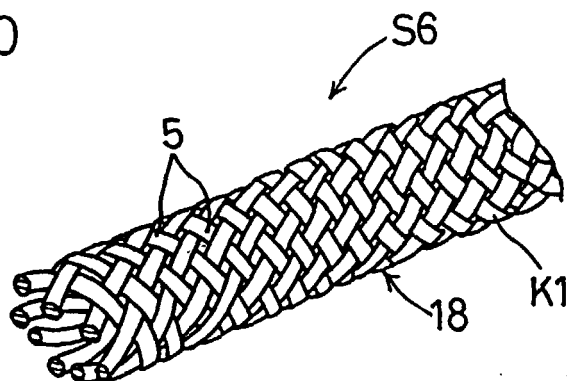


Fig.41

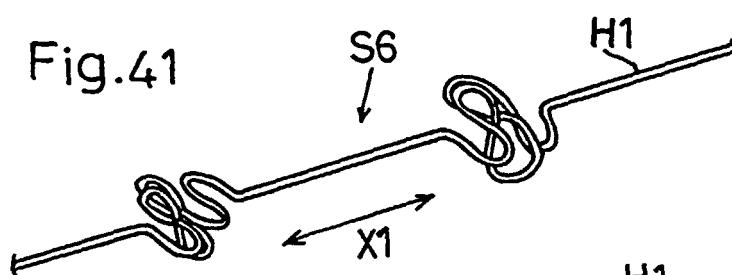


Fig.42

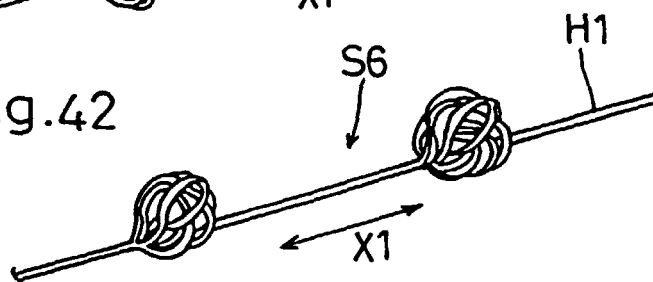


Fig.43

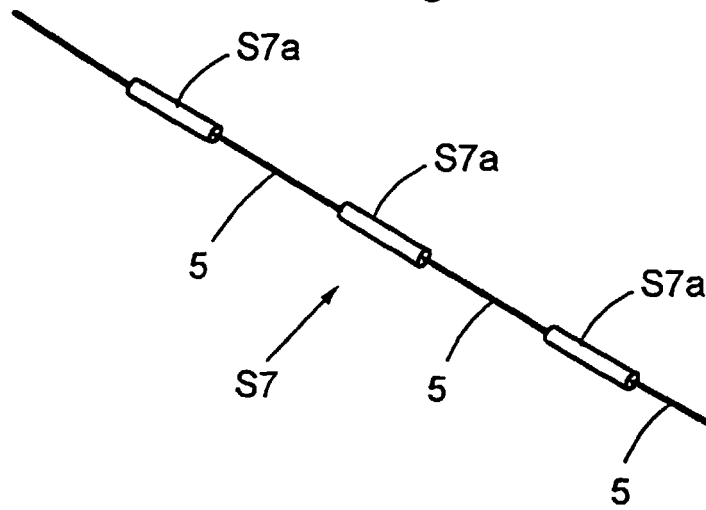


Fig.44

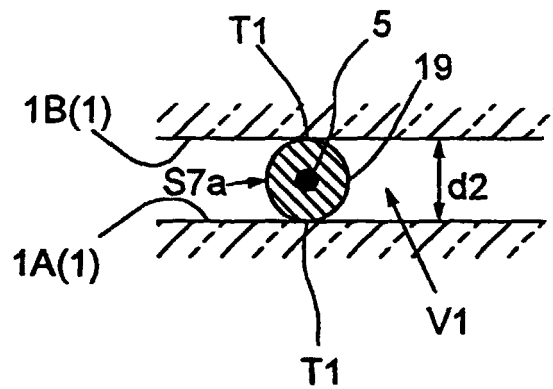


Fig.45

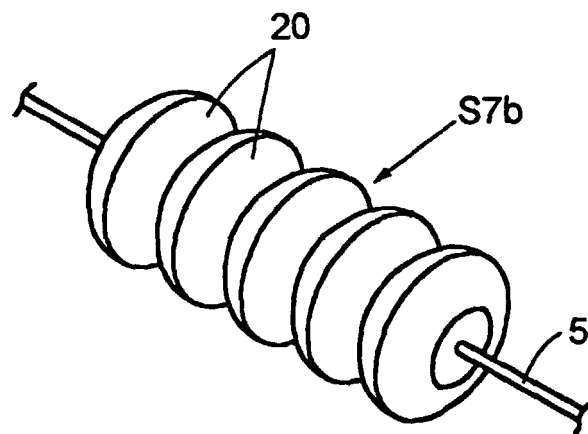


Fig.46

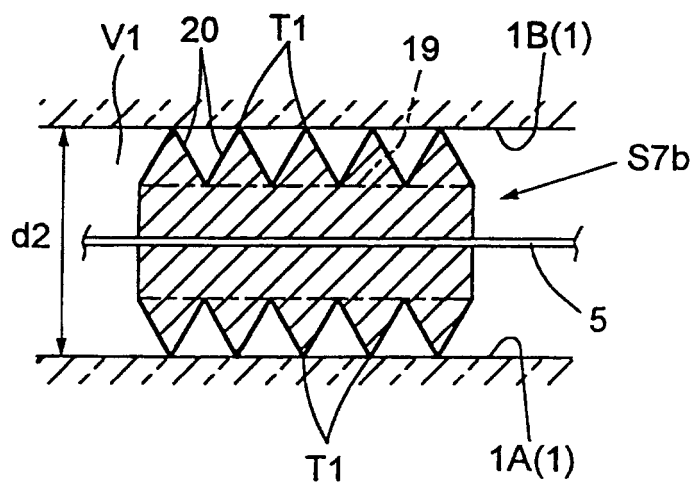


Fig.47

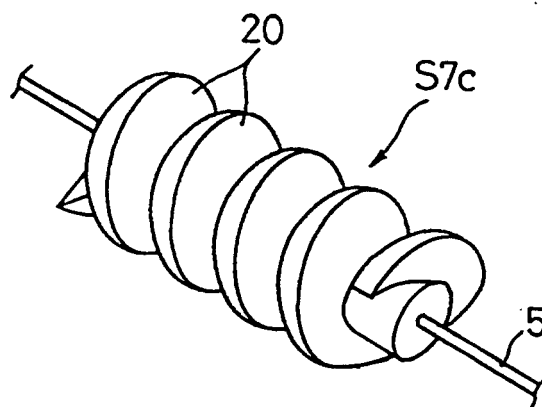


Fig.48

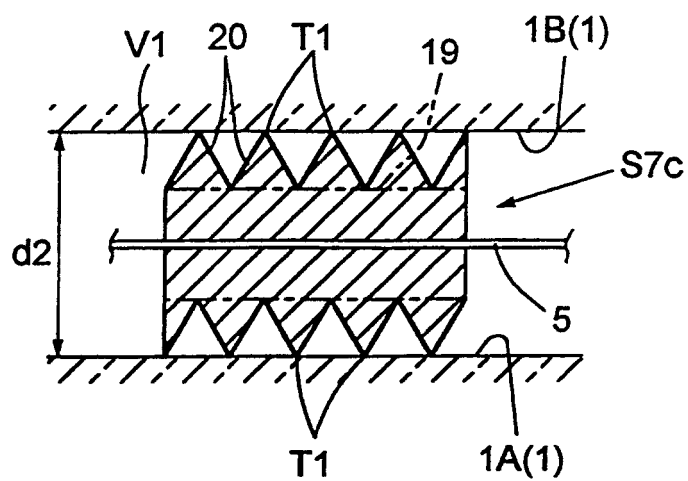


Fig.49

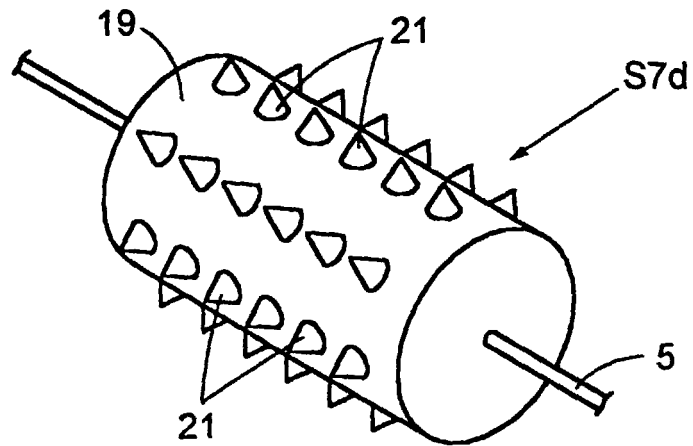


Fig.50

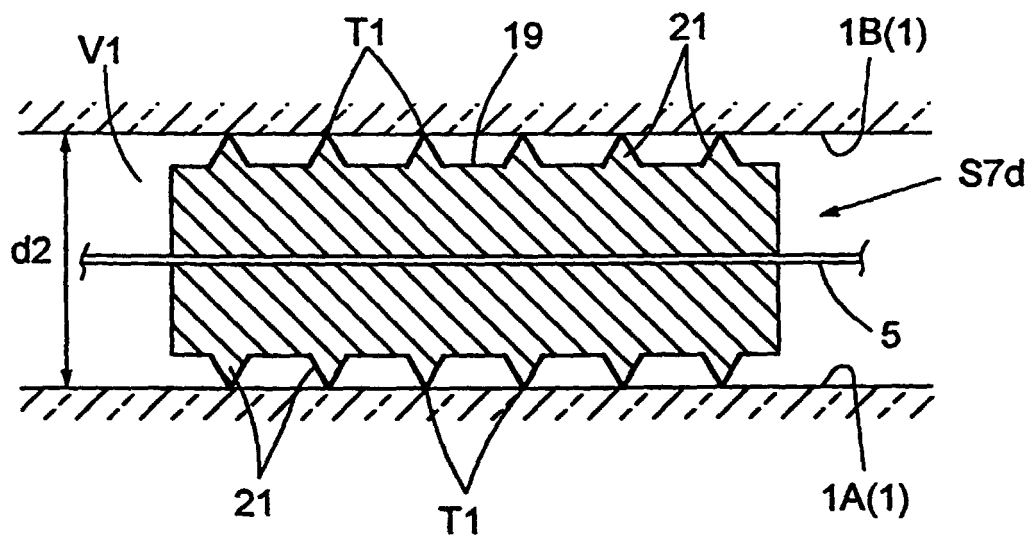


Fig.51

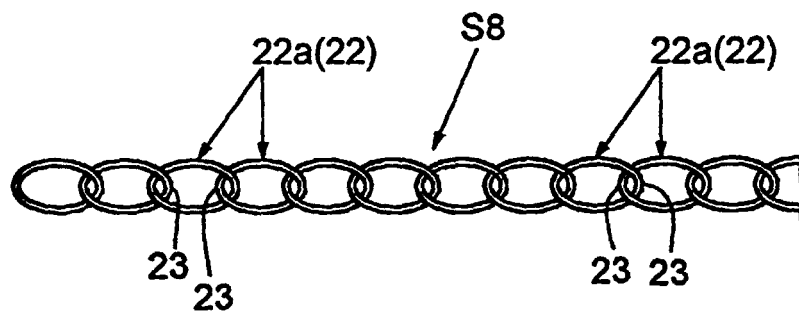


Fig.52

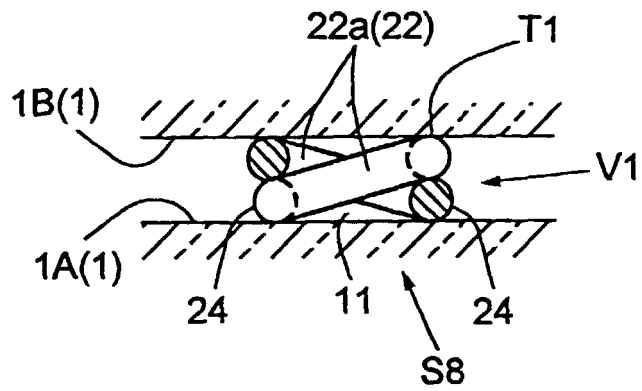


Fig.53

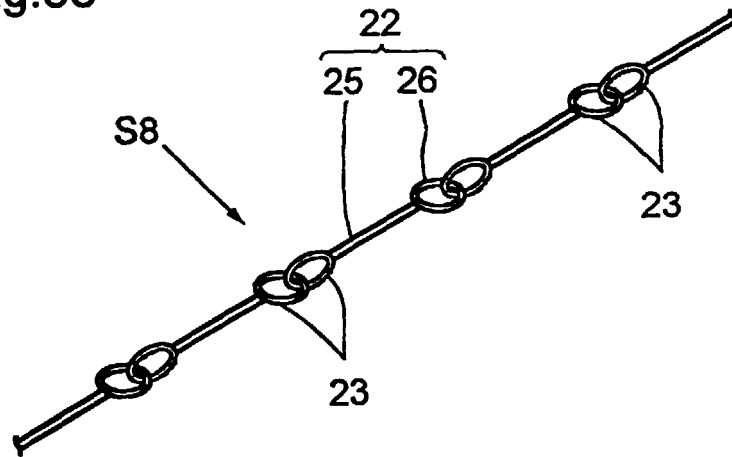


Fig.54

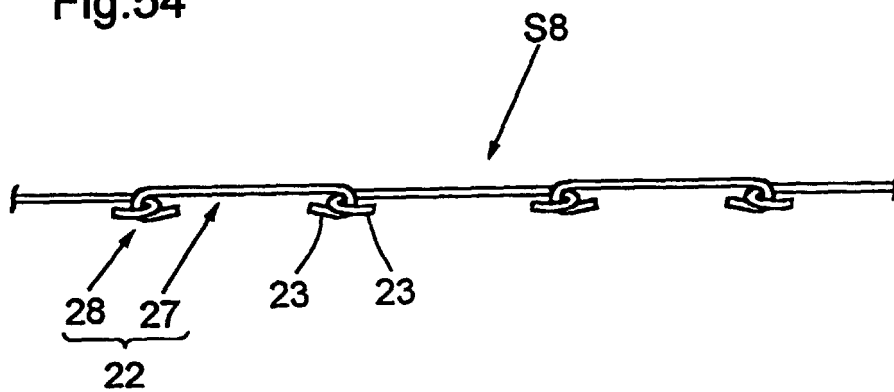


Fig.55

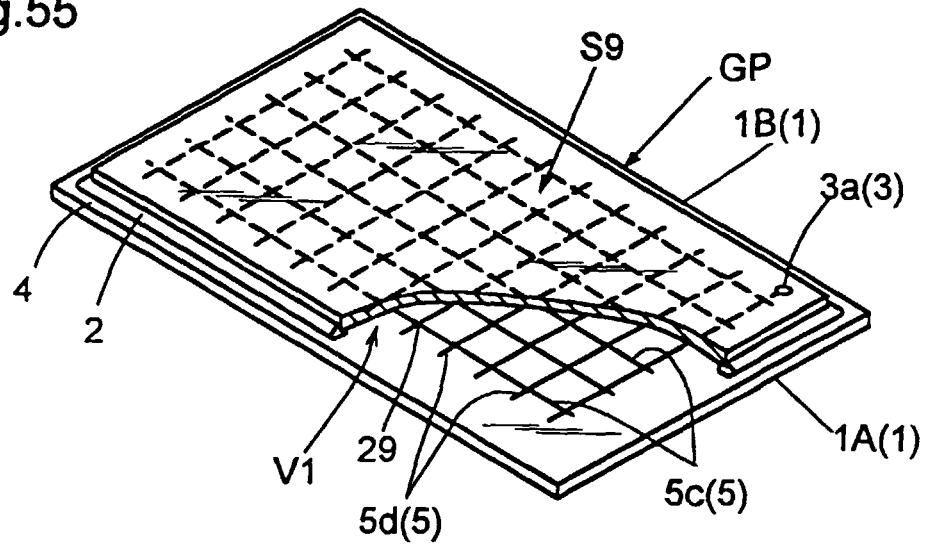


Fig.56

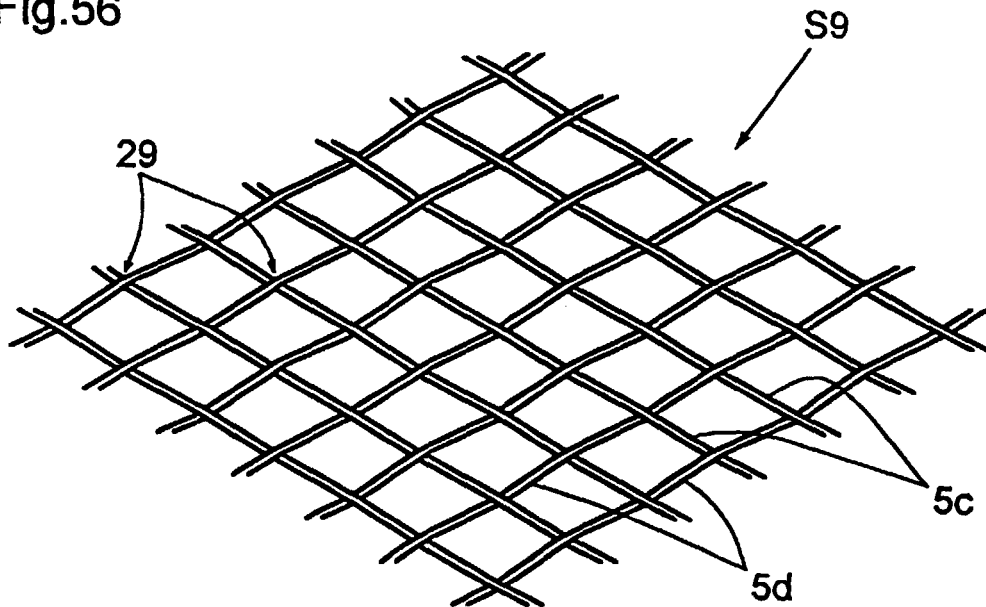


Fig.57

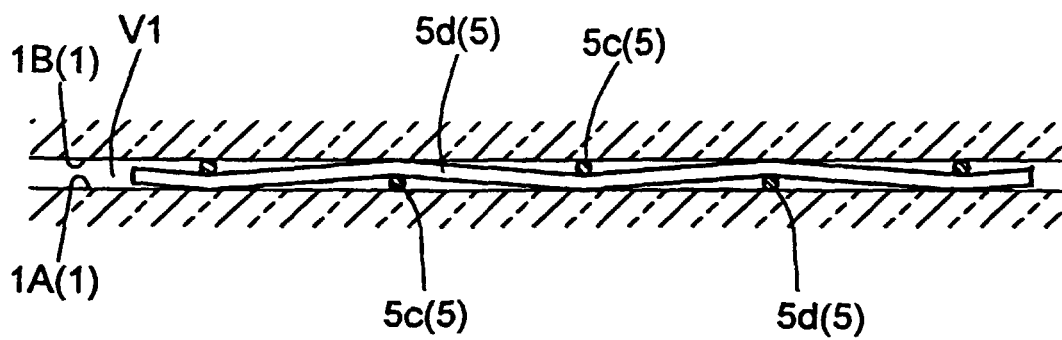


Fig.58

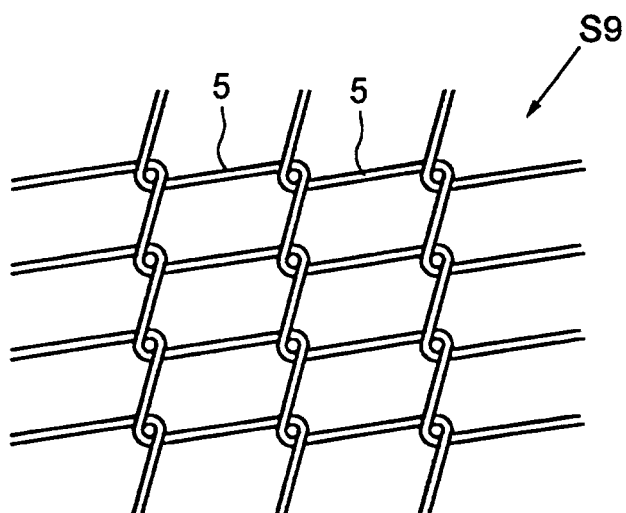


Fig.59

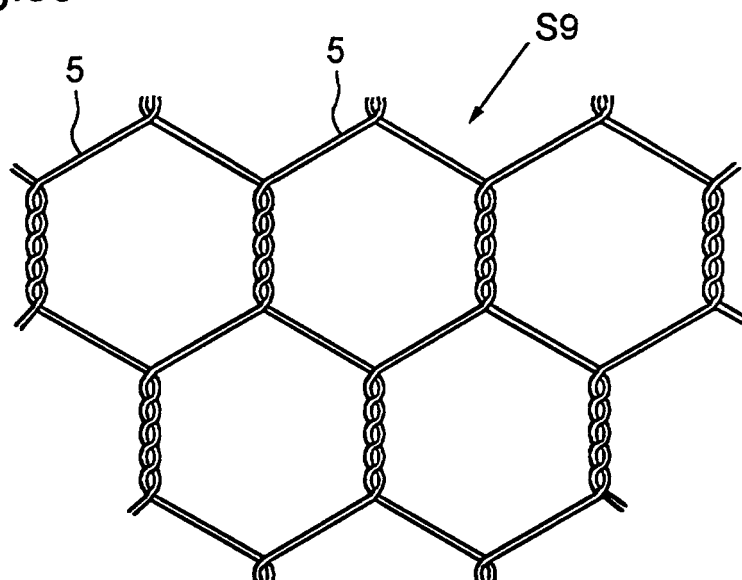


Fig.60

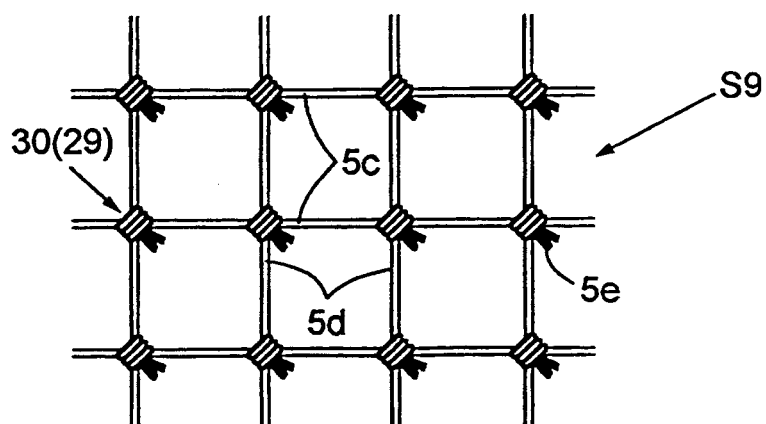


Fig.61

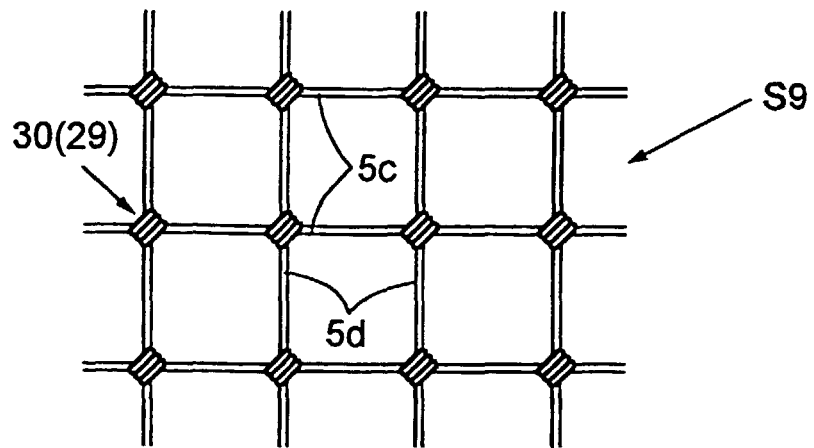


Fig.62

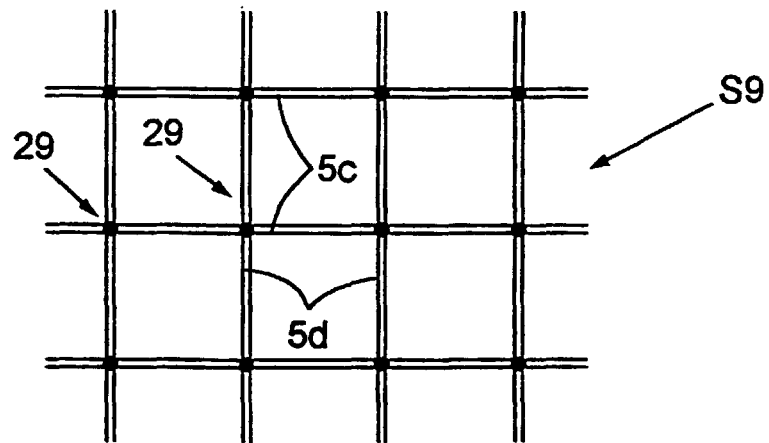


Fig.63

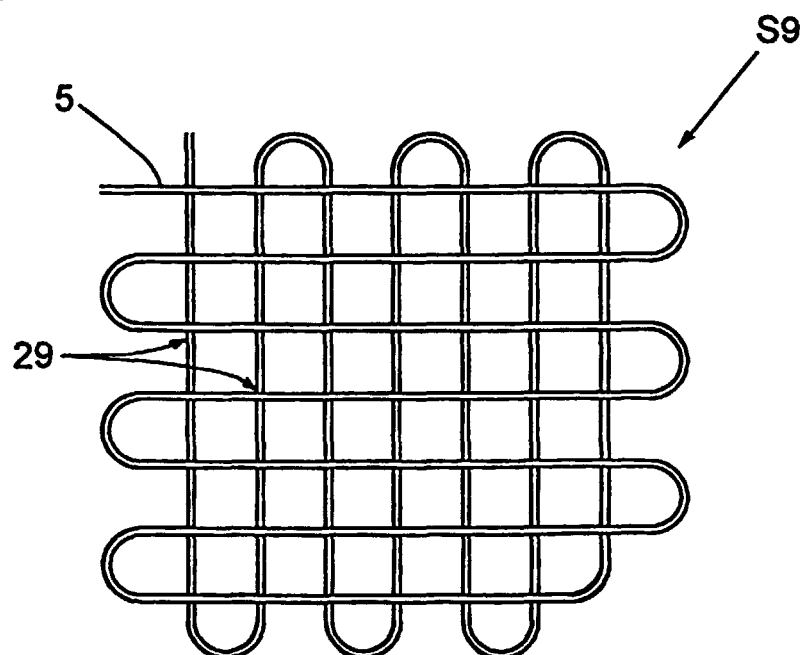


Fig.64

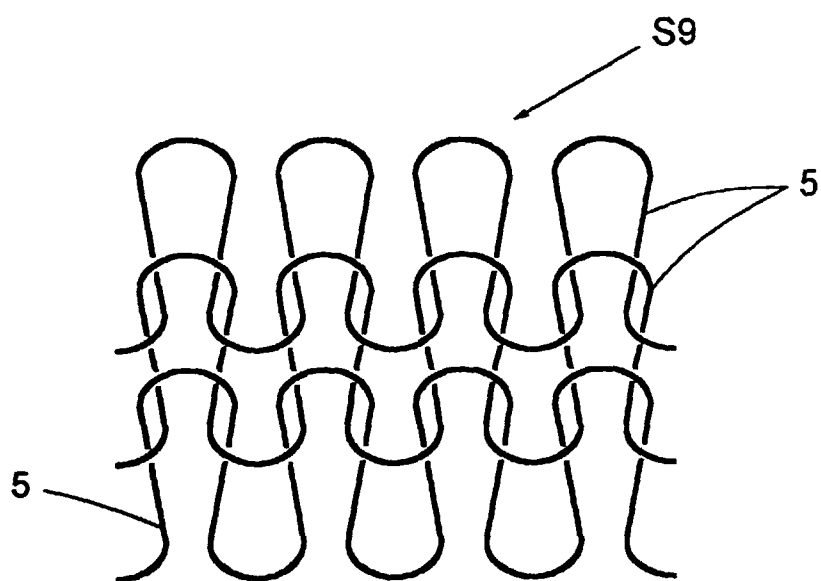


Fig.65

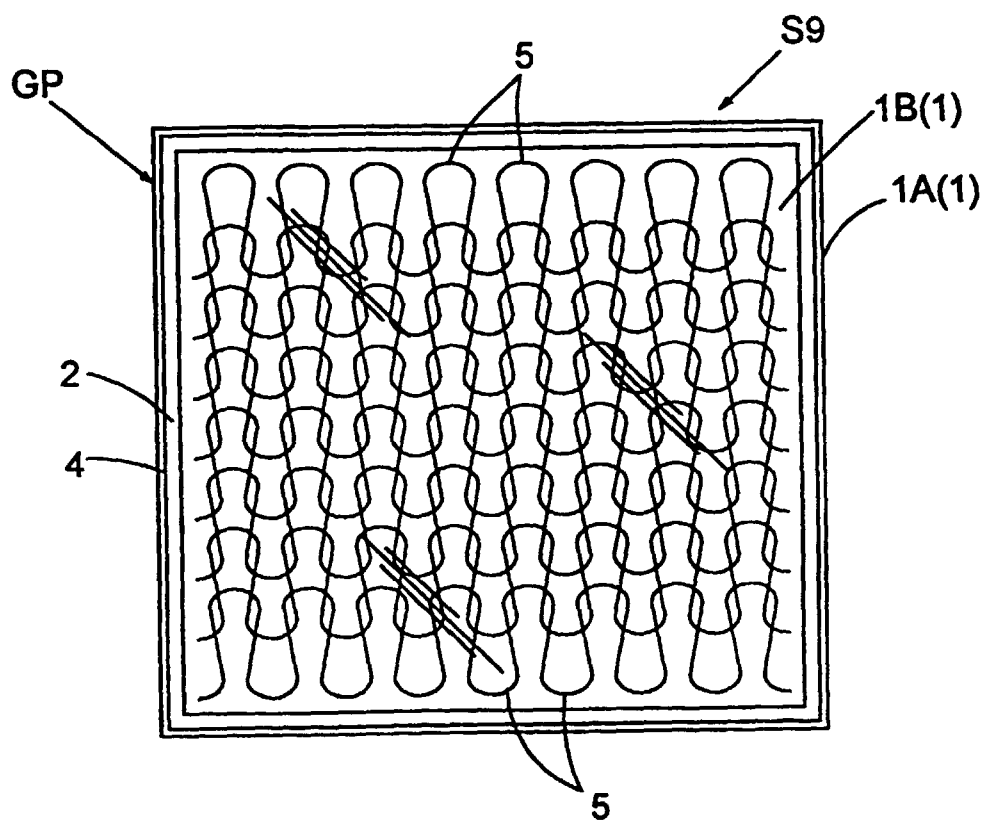


Fig.66

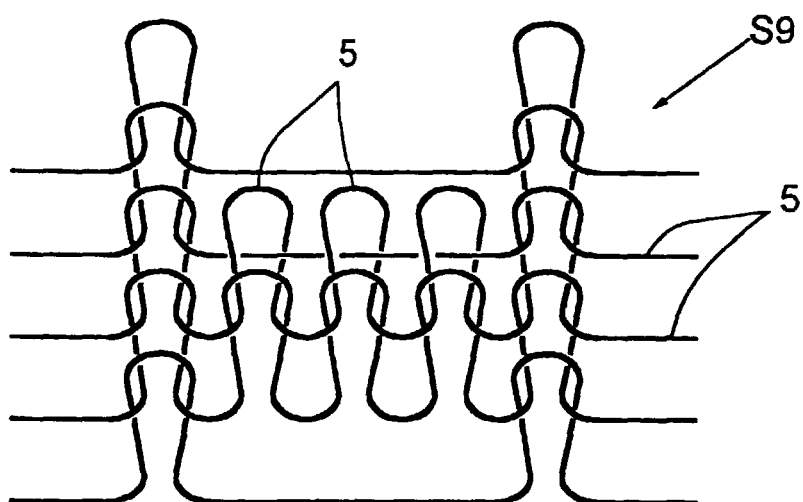


Fig.67

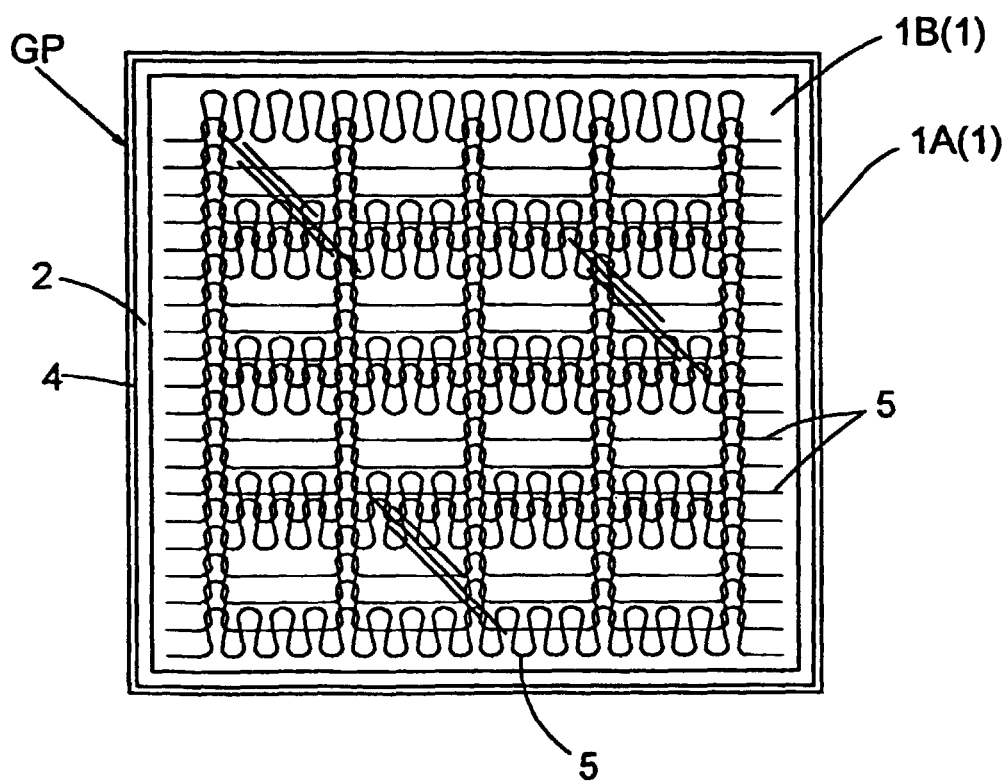


Fig.68

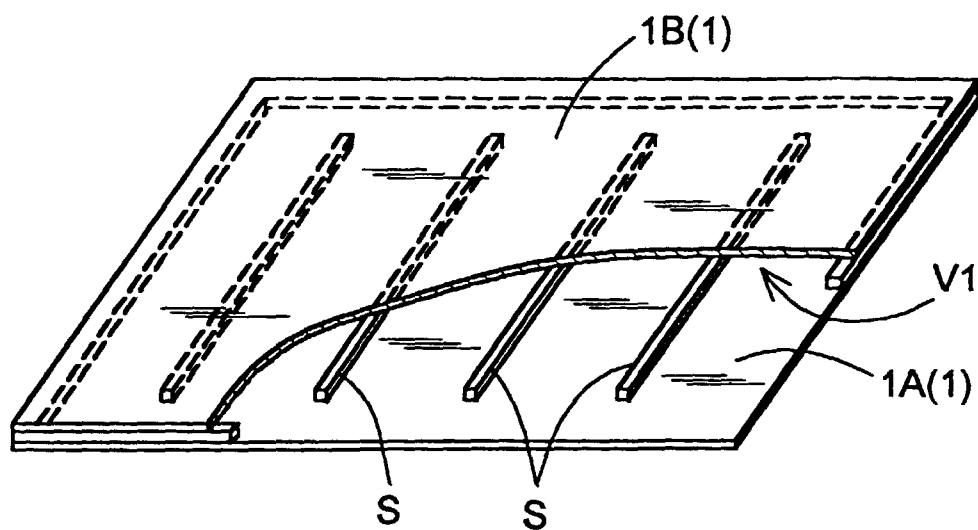
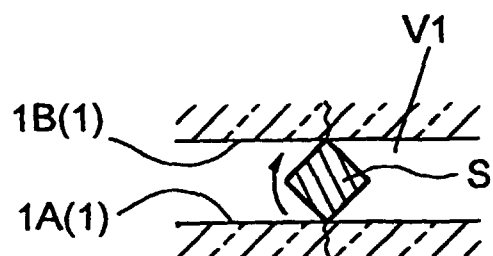


Fig.69



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP99/01339

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl ⁶ C03C27/06		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) Int.Cl ⁶ C03C27/06		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1926-1996 Toroku Jitsuyo Shinan Koho 1994-1999 Kokai Jitsuyo Shinan Koho 1971-1999 Jitsuyo Shinan Toroku Koho 1996-1999		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	JP, 10-297944, A (Central Glass Co., Ltd.), 10 November, 1998 (10. 11. 98) (Family: none)	1-3, 33-37
EX	JP, 11-092181, A (Yuugen Kaisha Kobayashi Garasu Kenzai), 6 April, 1999 (06. 04. 99) (Family: none)	1-3, 33-37
X A	JP, 09-124347, A (Affinity K.K.), 13 May, 1997 (13. 05. 97) (Family: none)	1-3 4-29
X	JP, 50-156525, A (Masashi Misumi), 17 December, 1975 (17. 12. 75) (Family: none)	1-3, 30-37
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
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