US 20030106346A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2003/0106346 A1

Matsumoto (43) Pub. Date: Jun. 12, 2003

(54) **DOUBLE KNITTED FABRIC**

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(21) Appl. No.: **10/203,920**

(22) PCT Filed: **Dec. 17, 2001**

(86) PCT No.: **PCT/JP01/11060**

(30) **Foreign Application Priority Data**

Dec. 18, 2000 (JP) ..... JP00/08966

**Publication Classification**

(51) **Int. Cl.**[7] ..... **D04B 21/00**

(52) **U.S. Cl.** ..... **66/195**

(57) **ABSTRACT**

The invention is aimed to provide a double knitted fabric wherein a stitch loop portion of a linking yarn is not jutted forth from the surface of the webs, and characteristic of touch, texture and so forth peculiar to a material of a web-forming yarn on the surface is not impaired, providing good decency, capable of decreasing density of the linking yarn and reducing weight, preventing rubbing sound, and also bringing out proper compressive strength, elasticity in the direction of thickness. To provide these features, in the double knitted fabric comprising of the front and rear webs (**1**), (**2**) and the linking yarn (**3**) linking both webs, the linking yarn (**3**) is knitted in two-needle stitch, or in combination with two-needle stitch and one-needle stitch, on at least one of the front and rear webs.

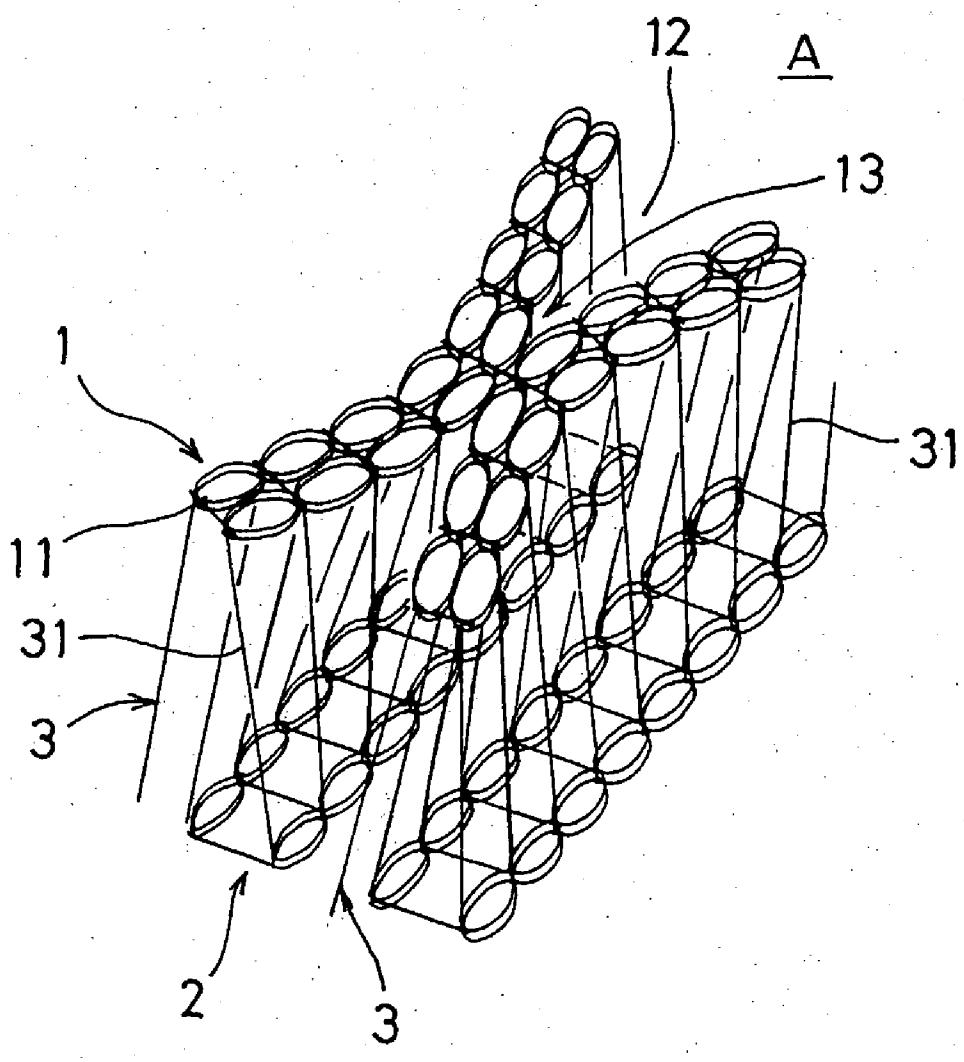


FIG. 1

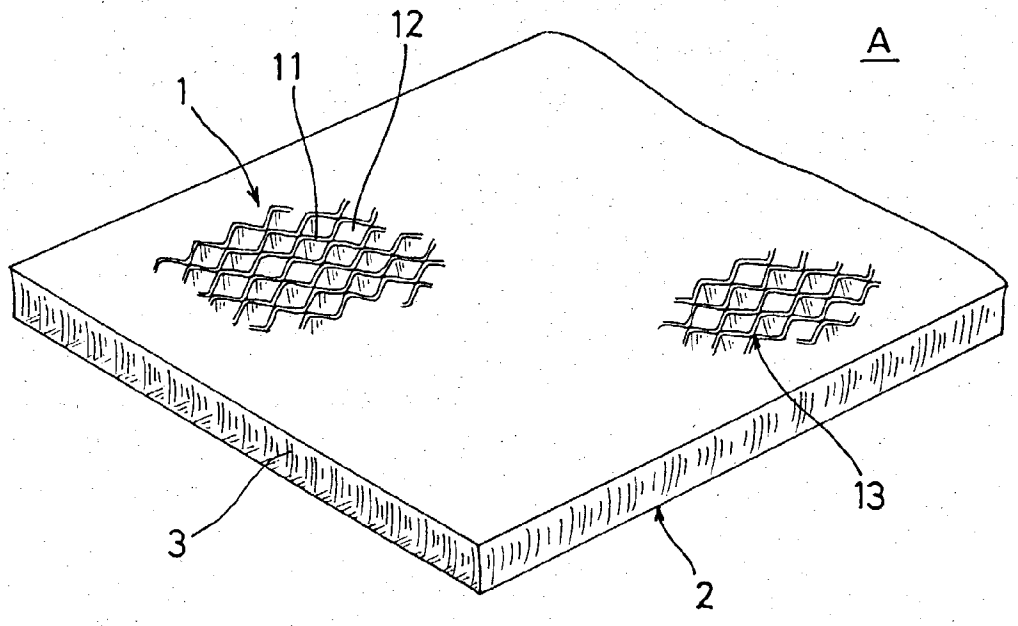



FIG. 2

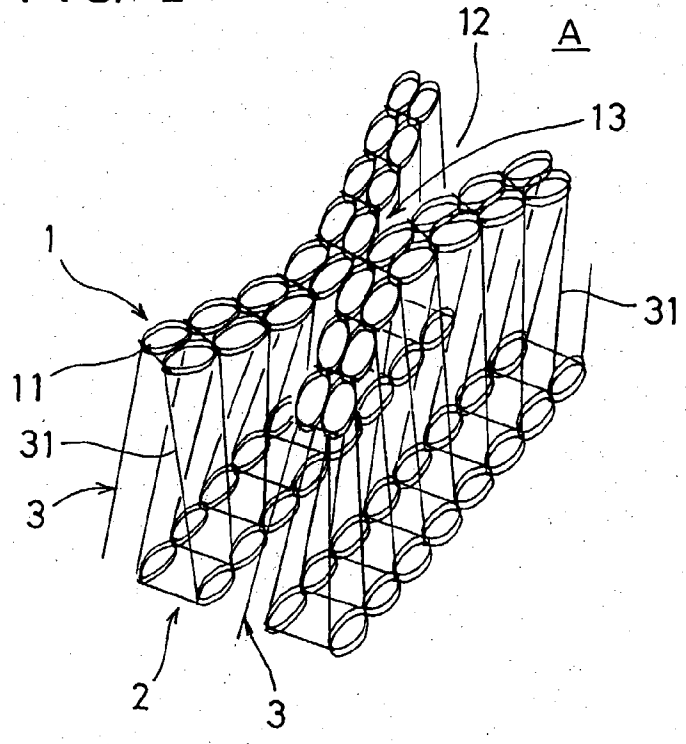


FIG. 3

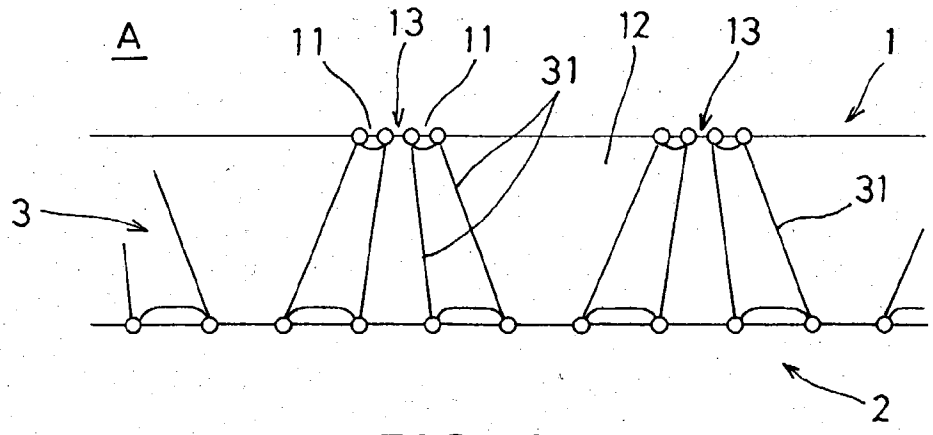



FIG. 4

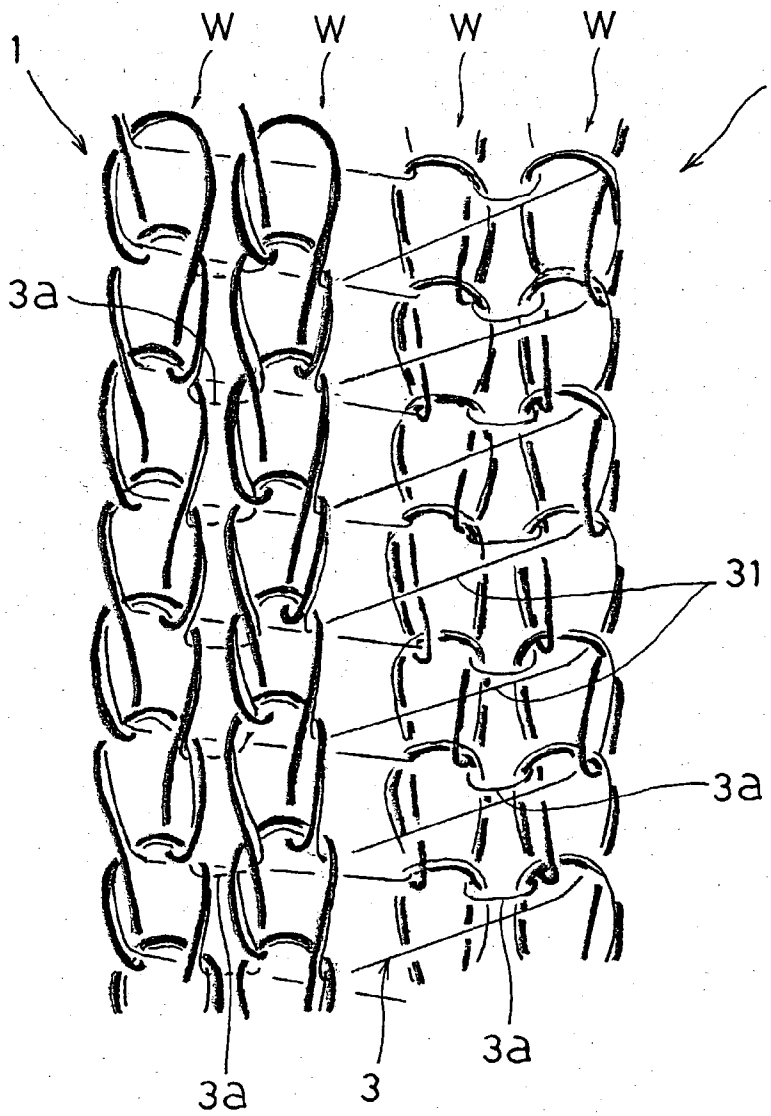


FIG. 5

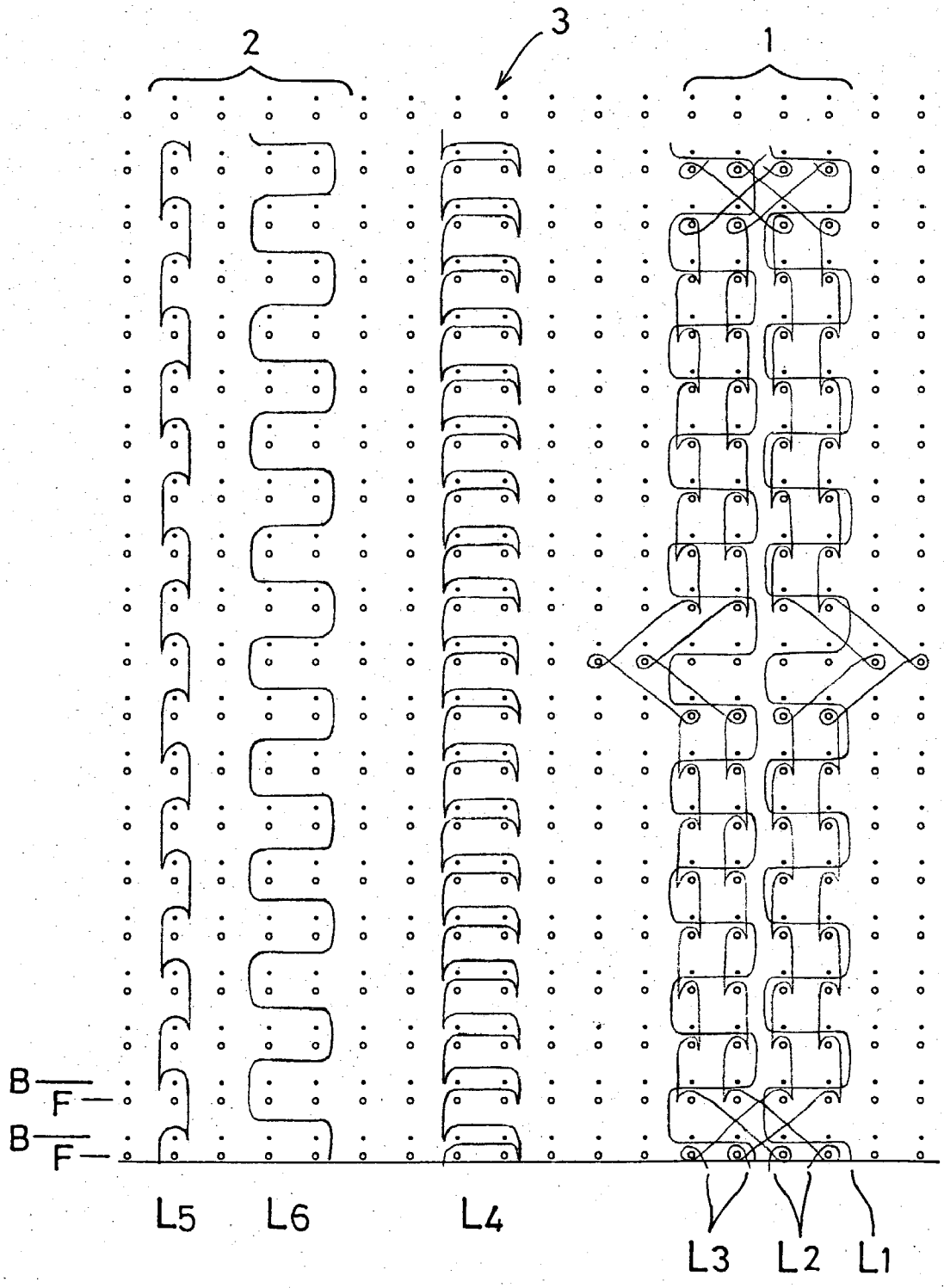


FIG. 6

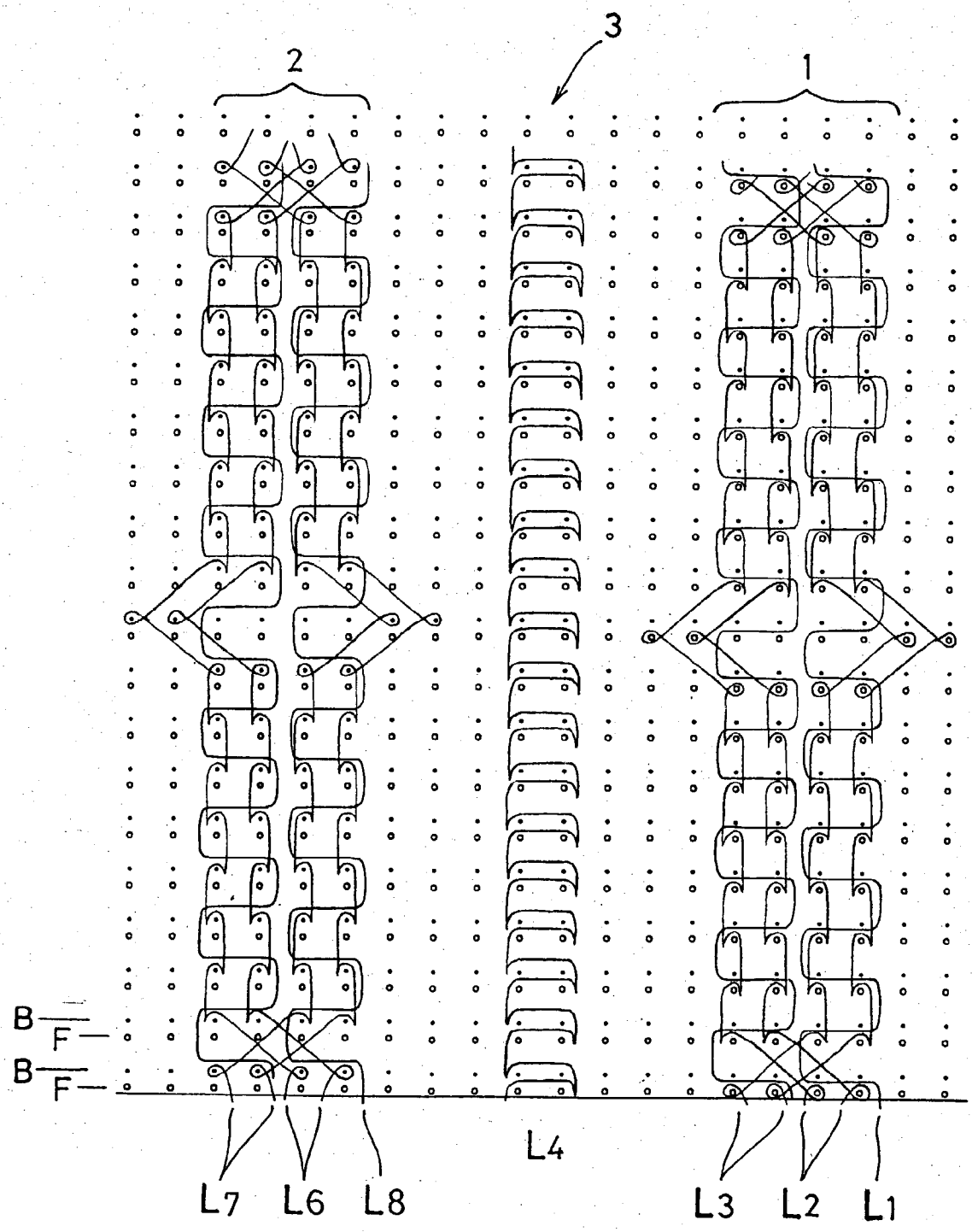


FIG. 7A

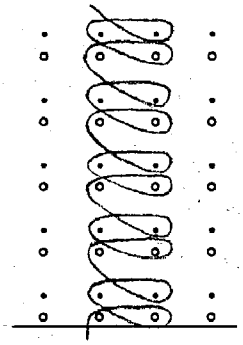



FIG. 7B

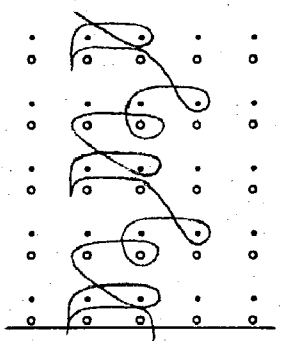



FIG. 7C

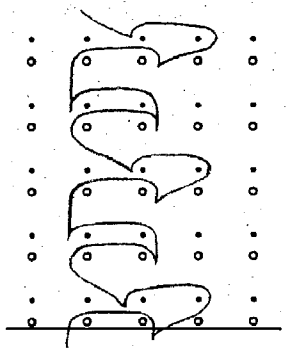



FIG. 7D

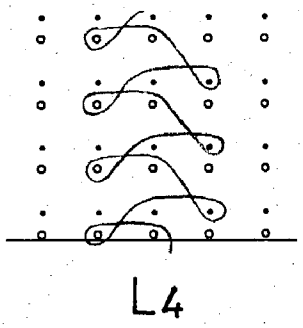



FIG. 7E

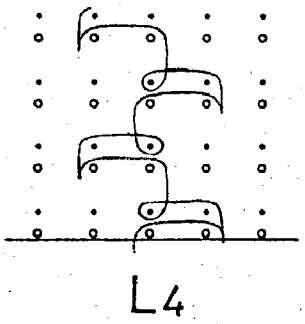



FIG. 7F

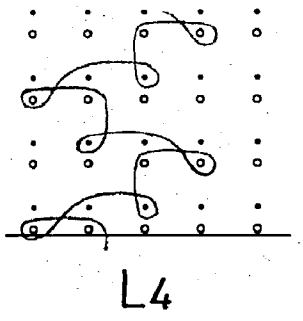



FIG. 7G

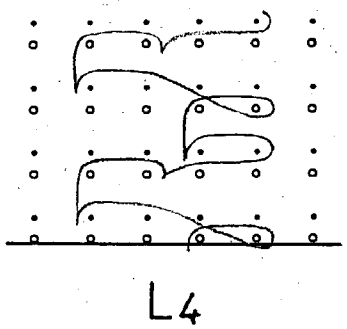



FIG. 7H

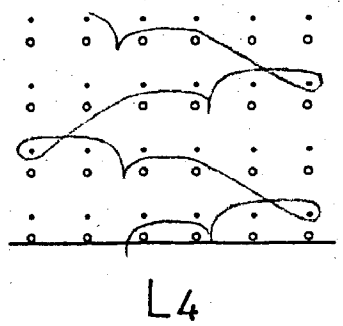


FIG. 8A

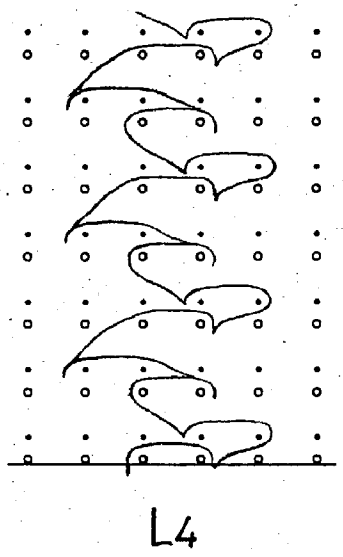



FIG. 8B

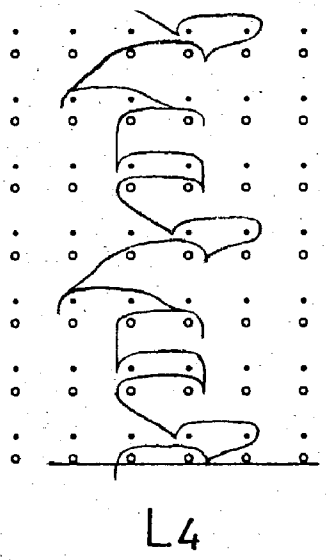



FIG. 8C

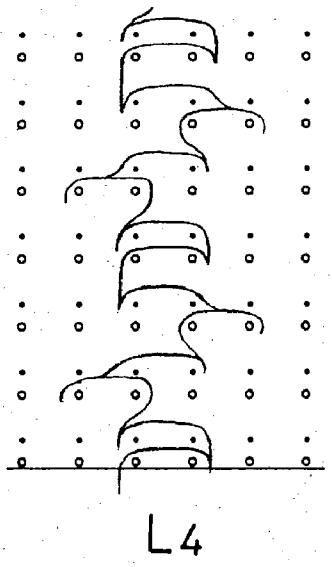



FIG. 8D

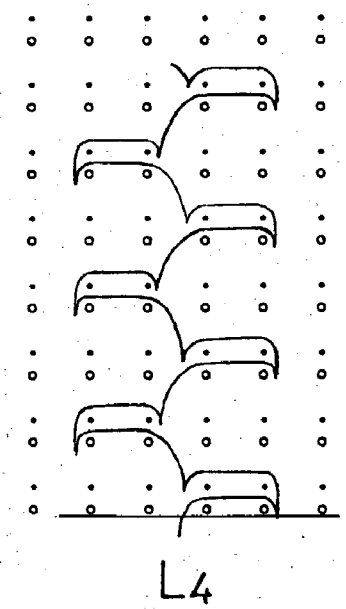



FIG. 8E

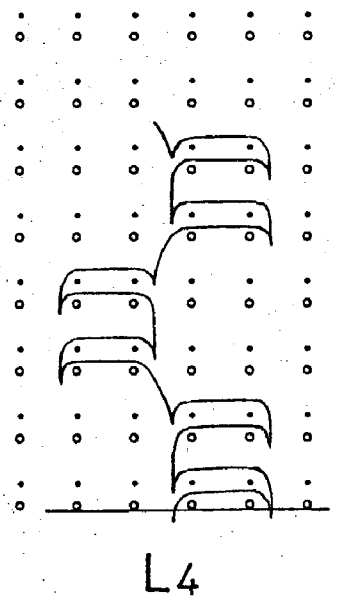



FIG. 8F

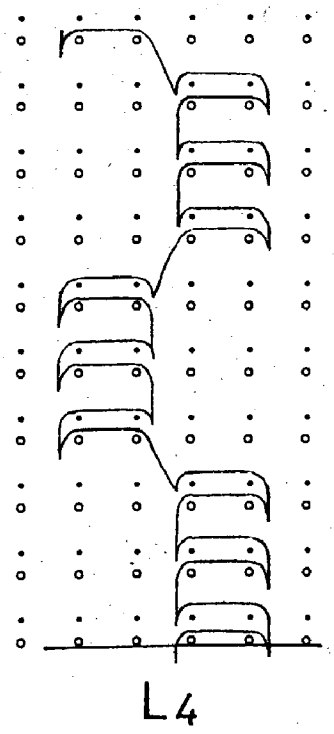


FIG. 9A

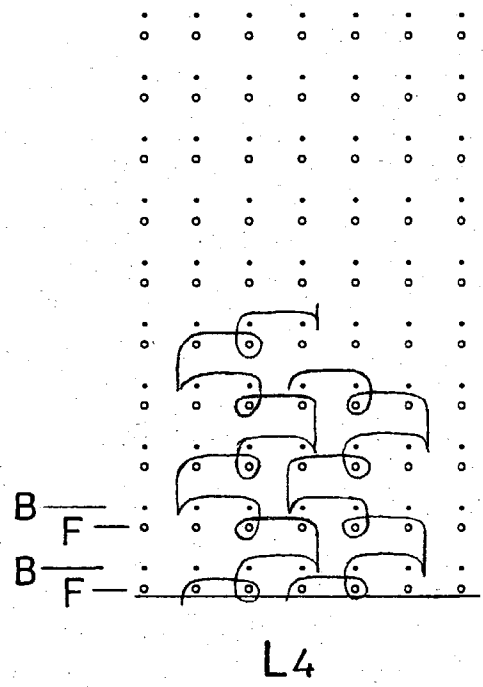



FIG. 9B

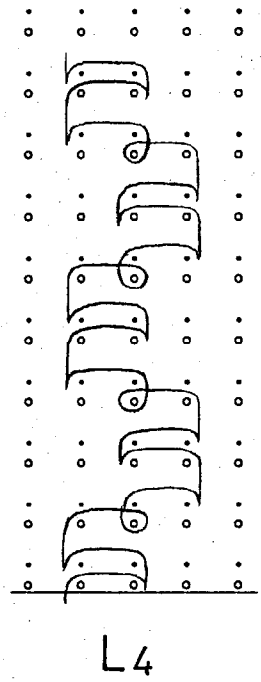



FIG. 9C

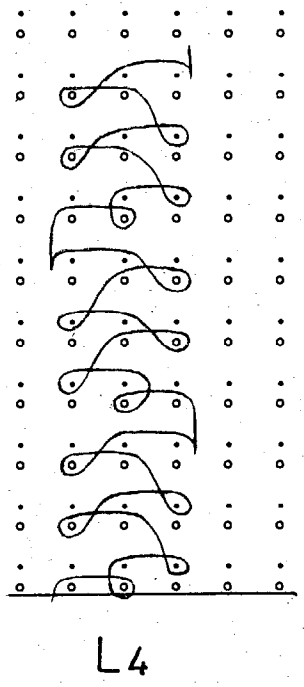
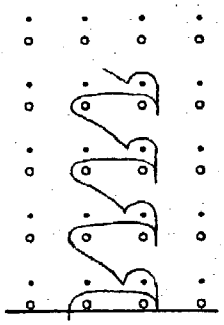
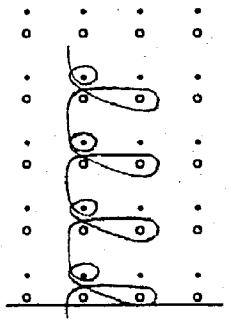


FIG. 10A



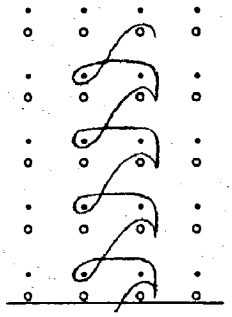
L4

FIG. 10B



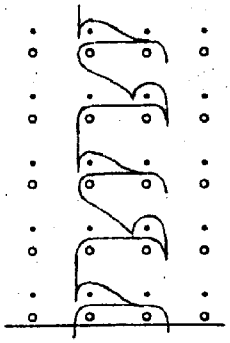
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FIG. 10C



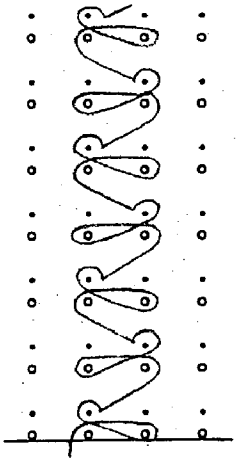
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FIG. 10D



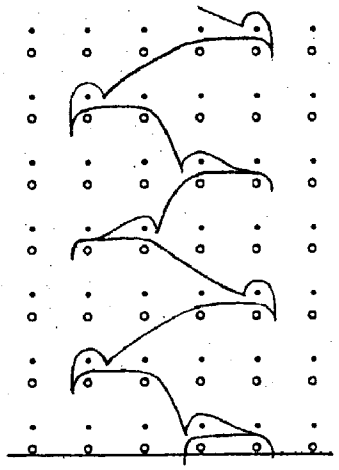
L4

FIG. 10E



L4

FIG. 10F



L4

FIG. 11A

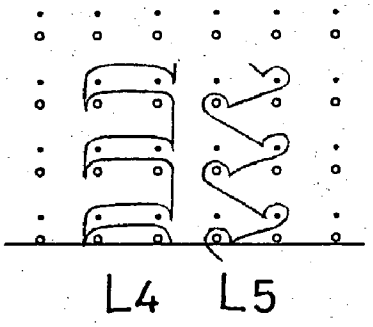



FIG. 11B

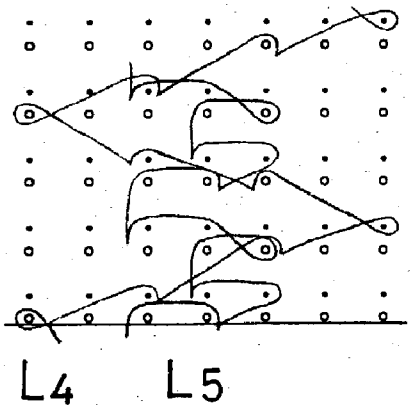



FIG. 11C

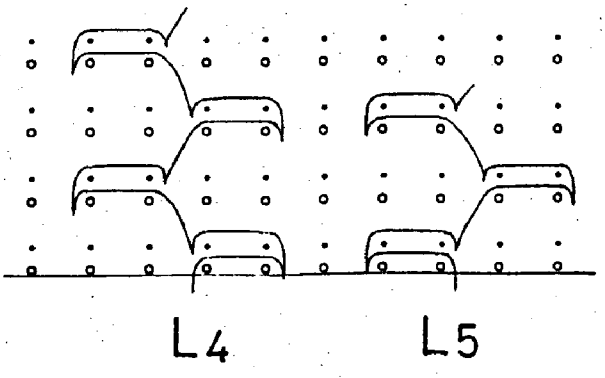


FIG. 12

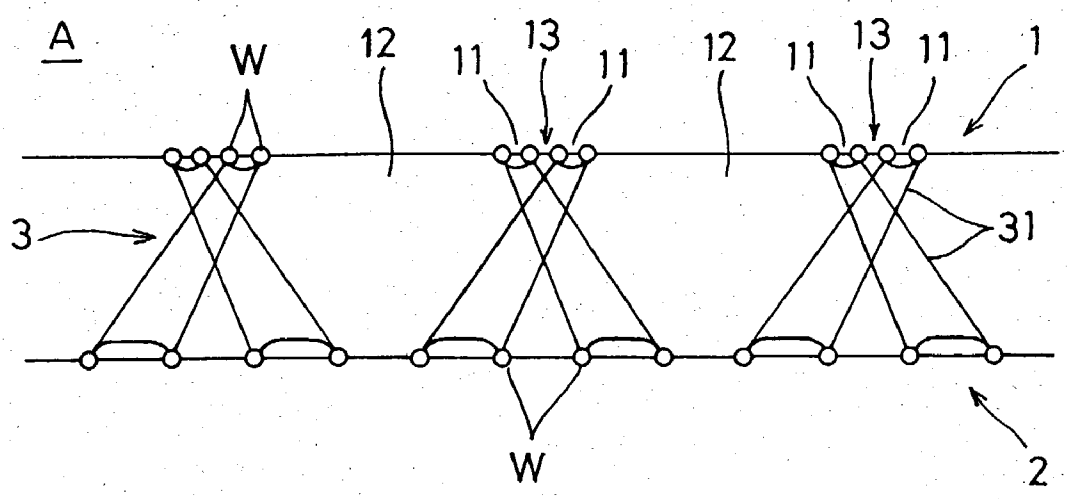



FIG. 13A

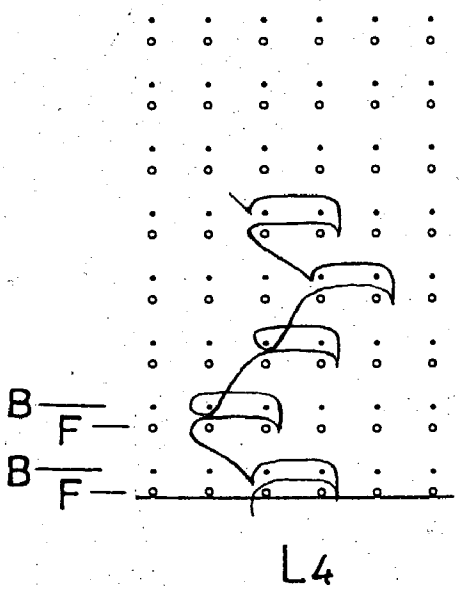



FIG. 13B

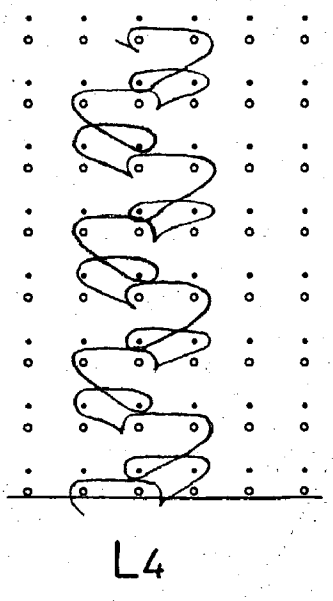


FIG. 14

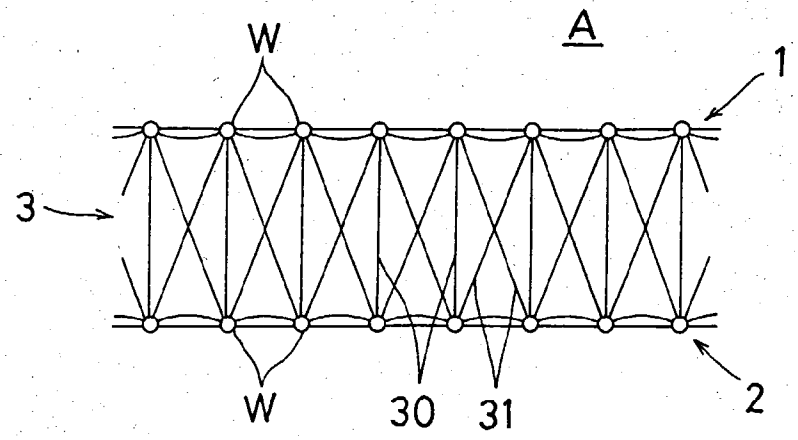



FIG. 15

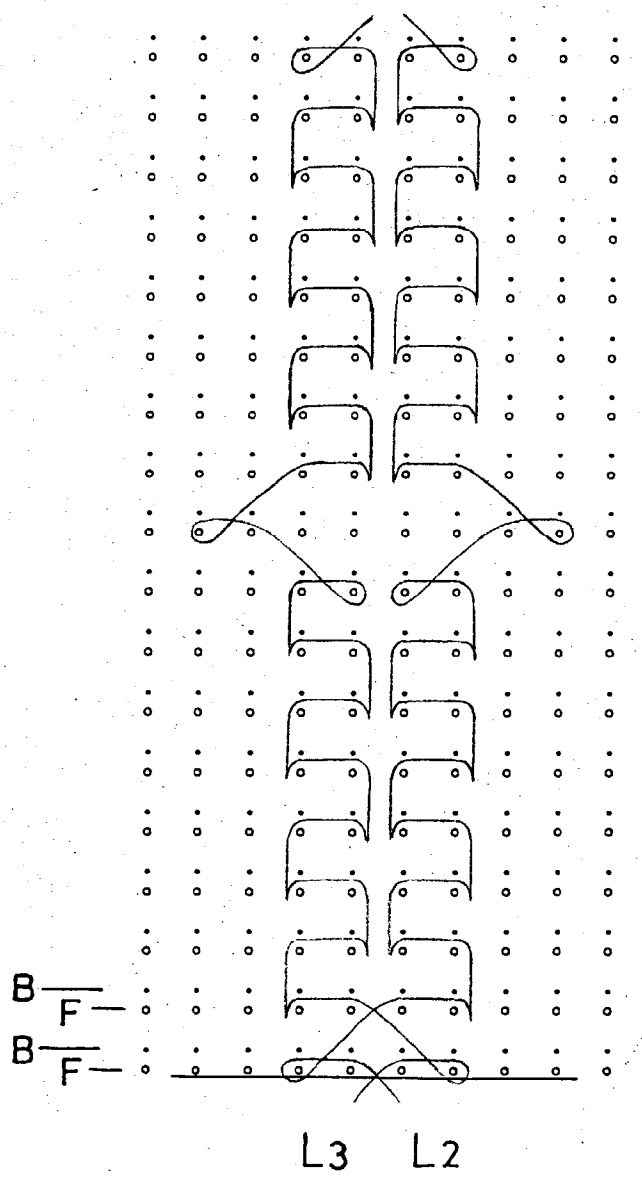


FIG. 16

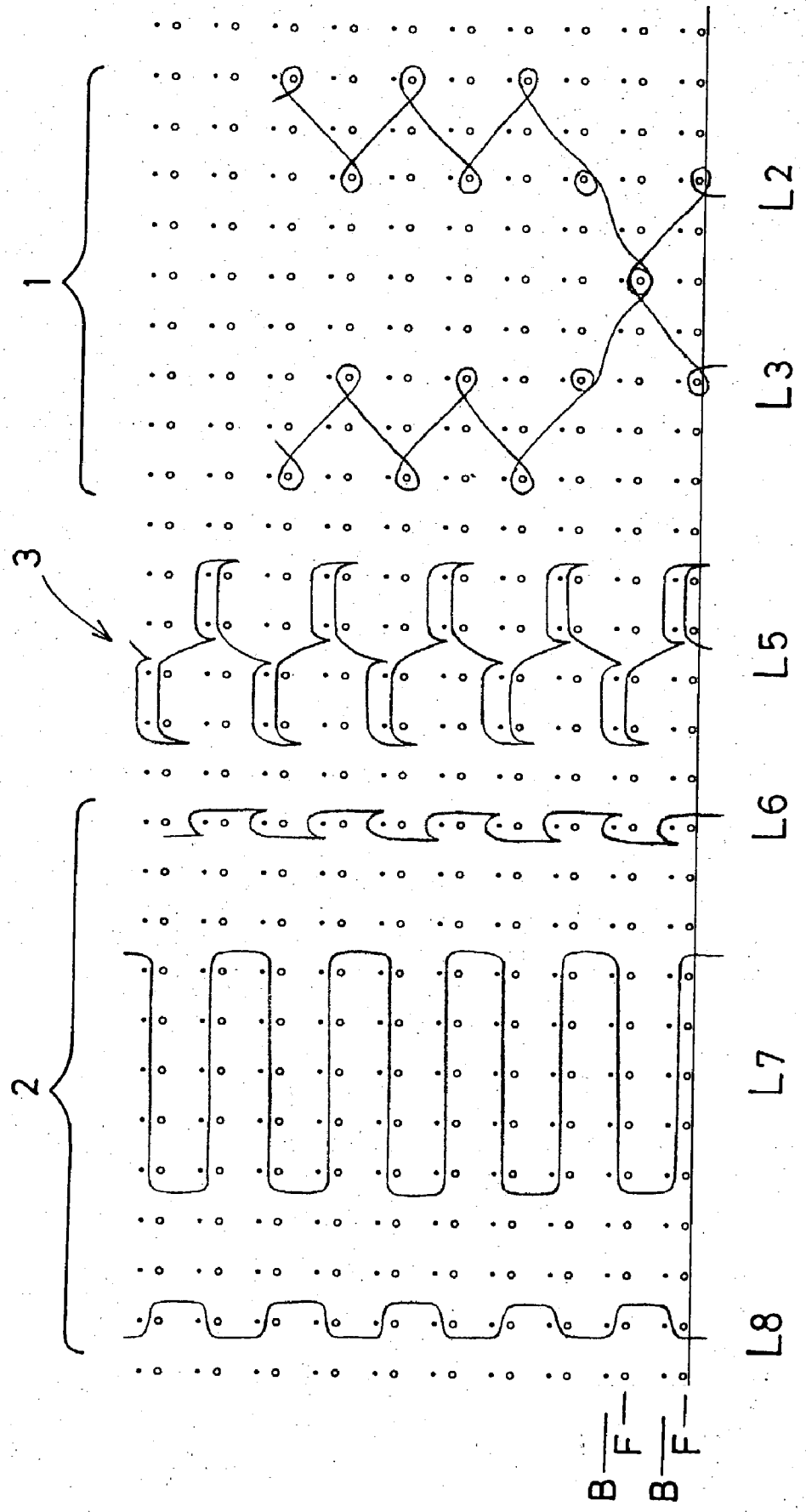


FIG. 17

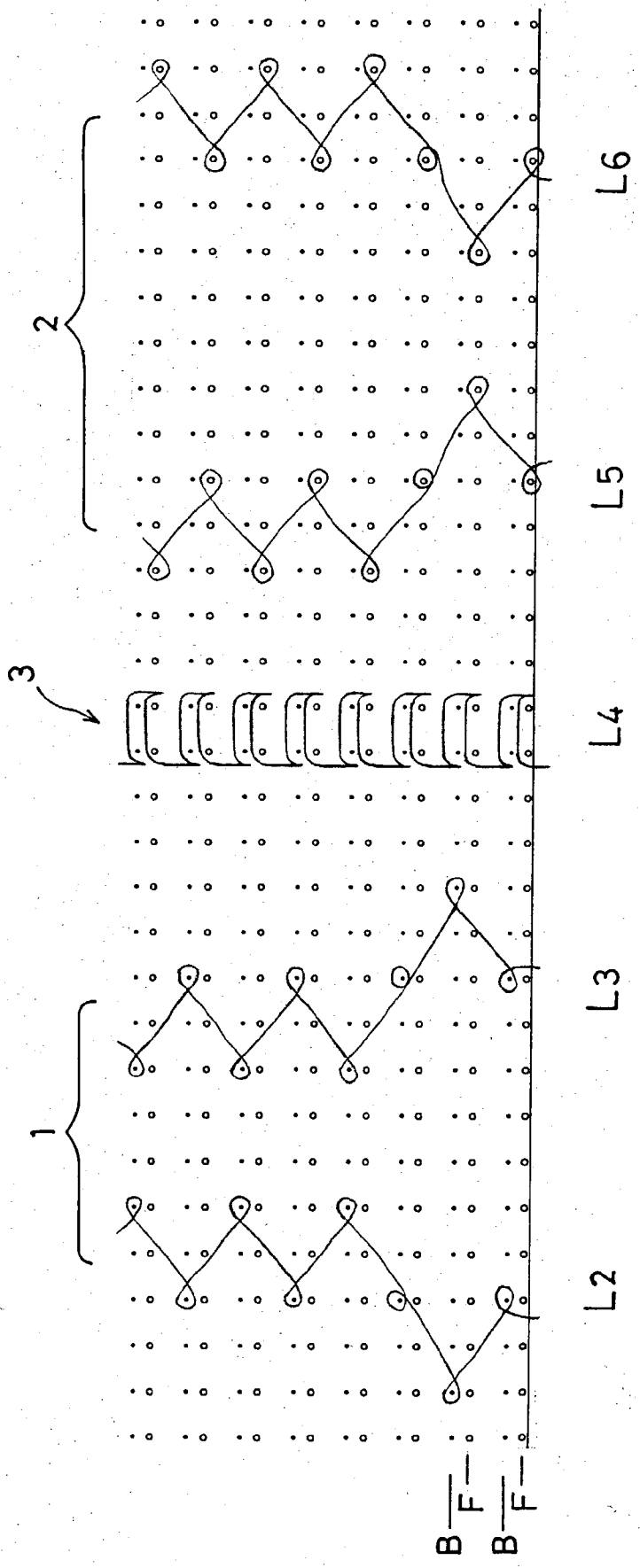


FIG. 18

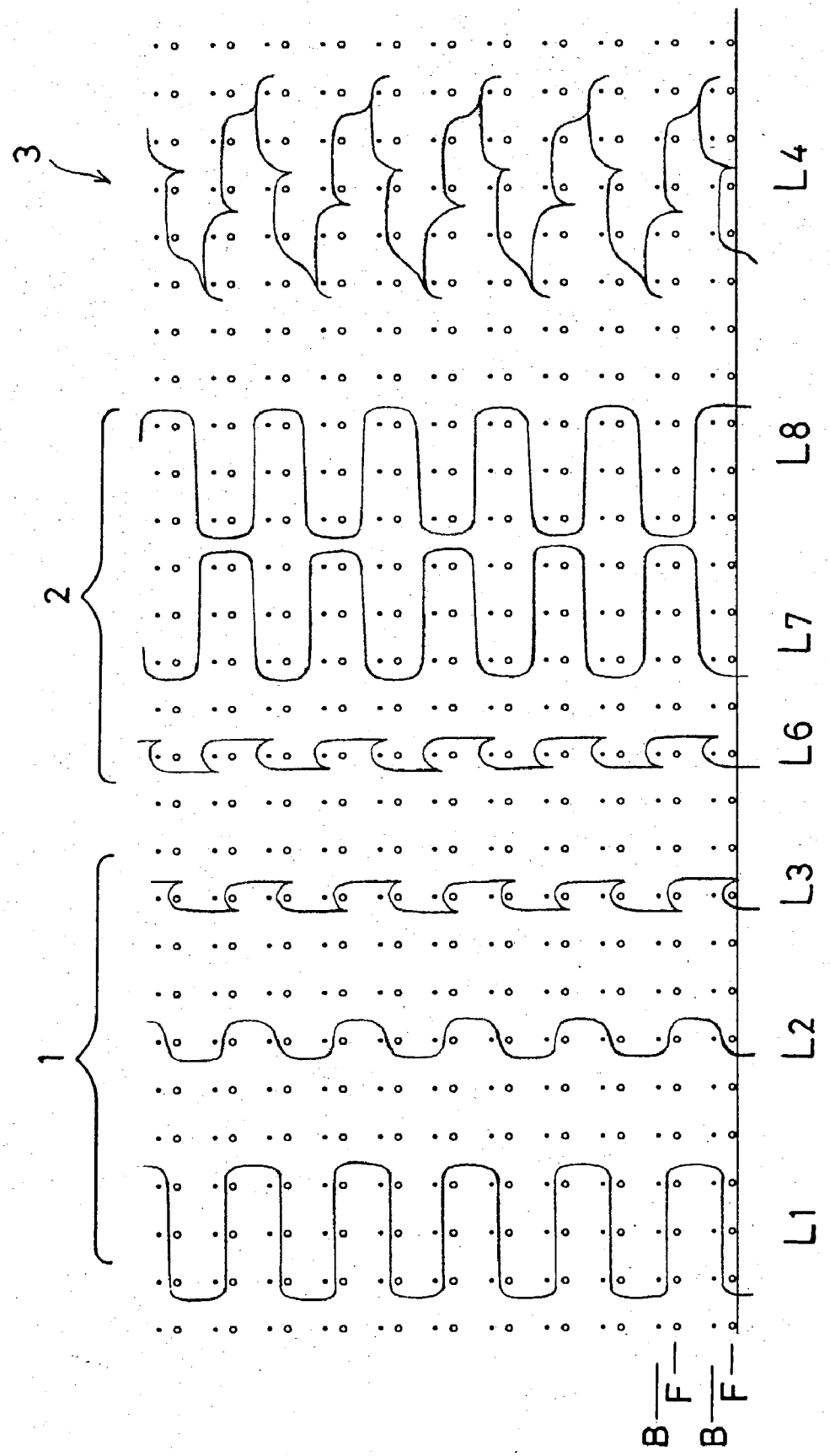


FIG. 19

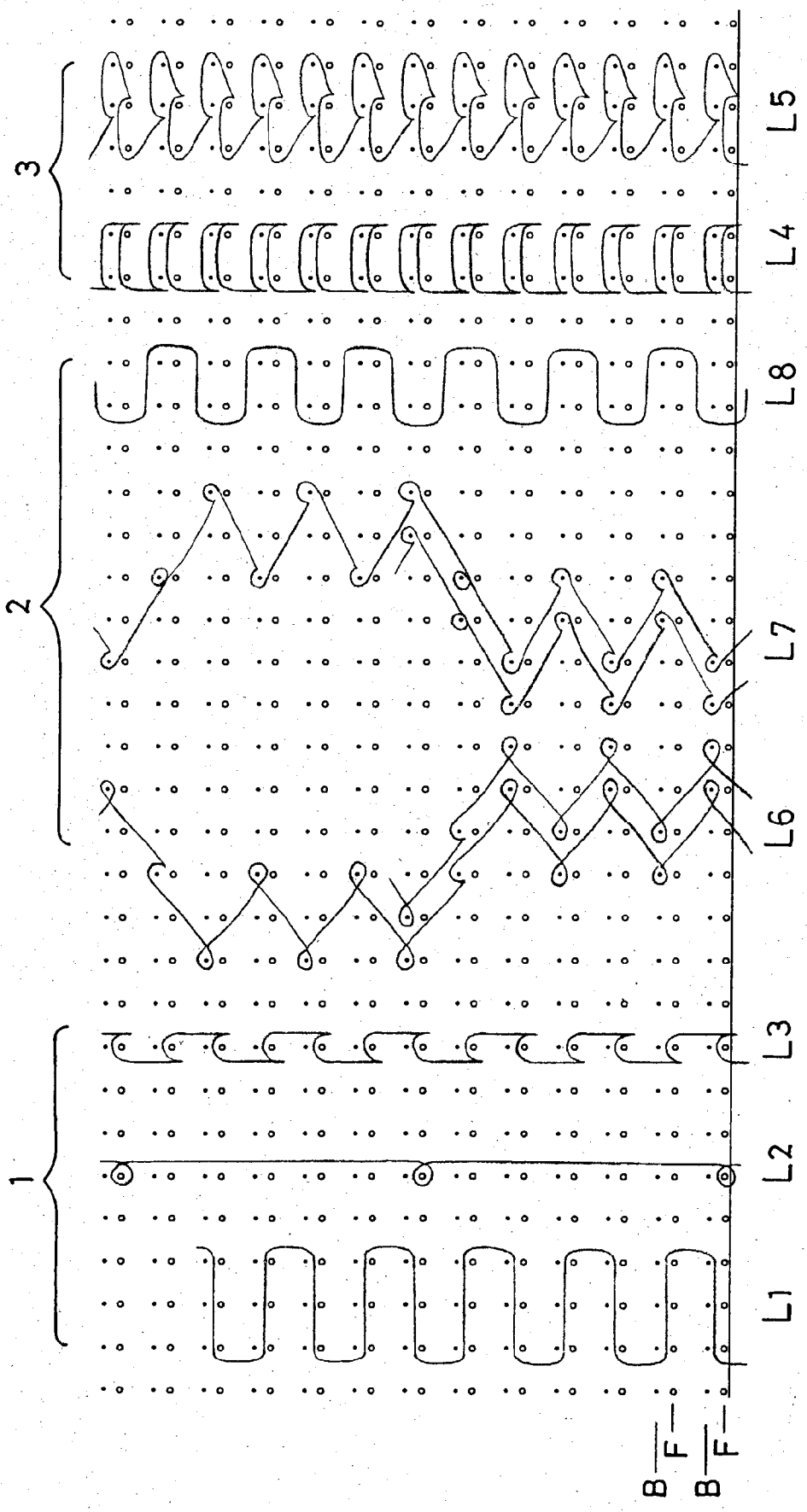


FIG. 20

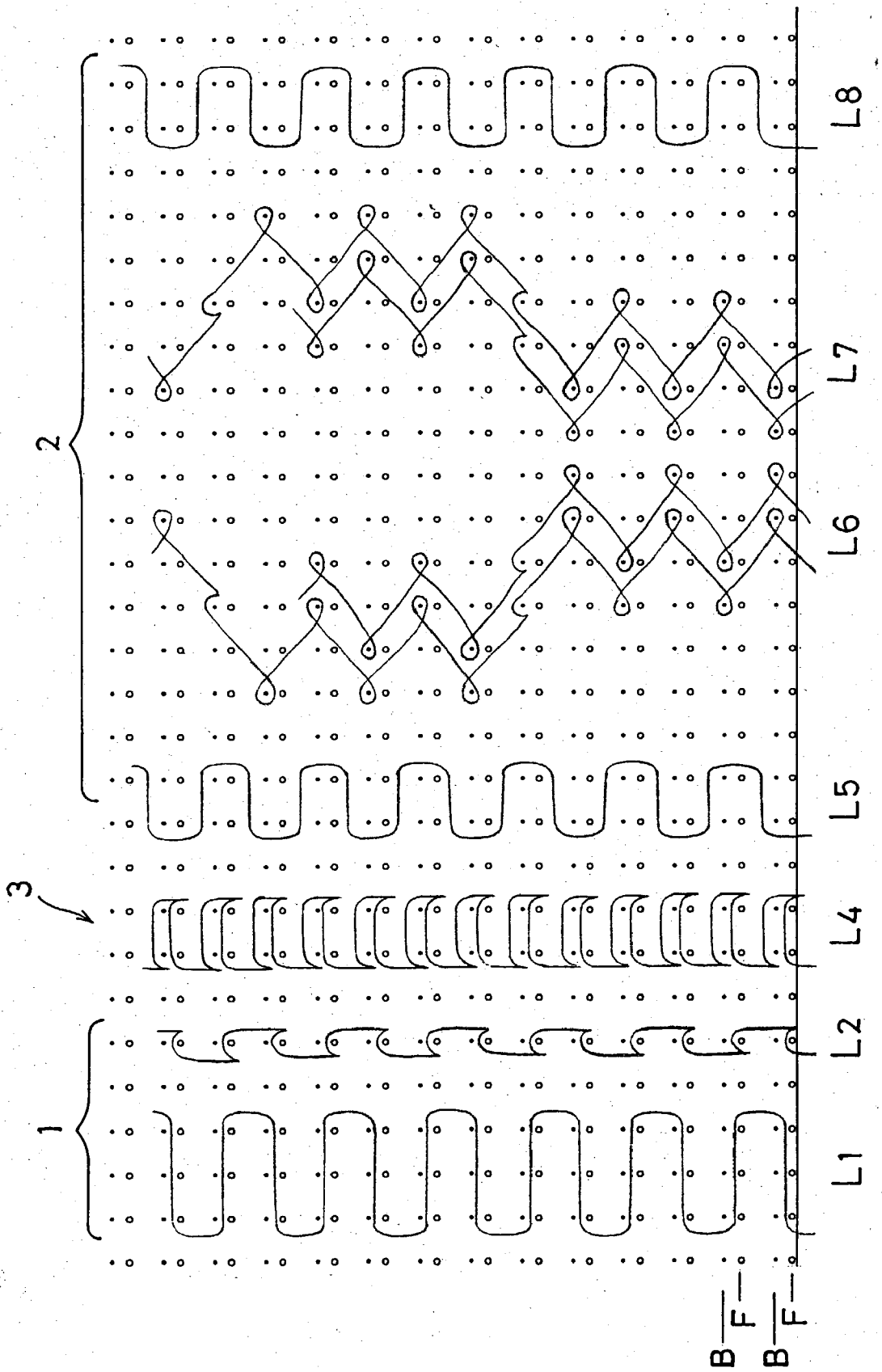


FIG. 21

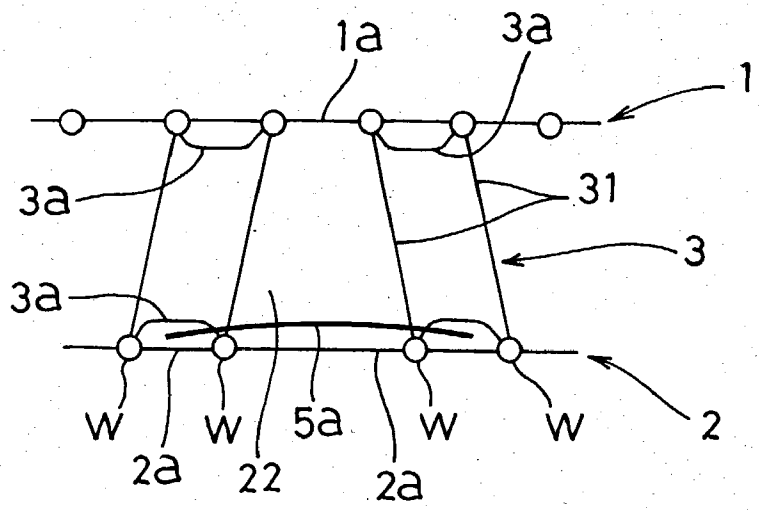



FIG. 22A

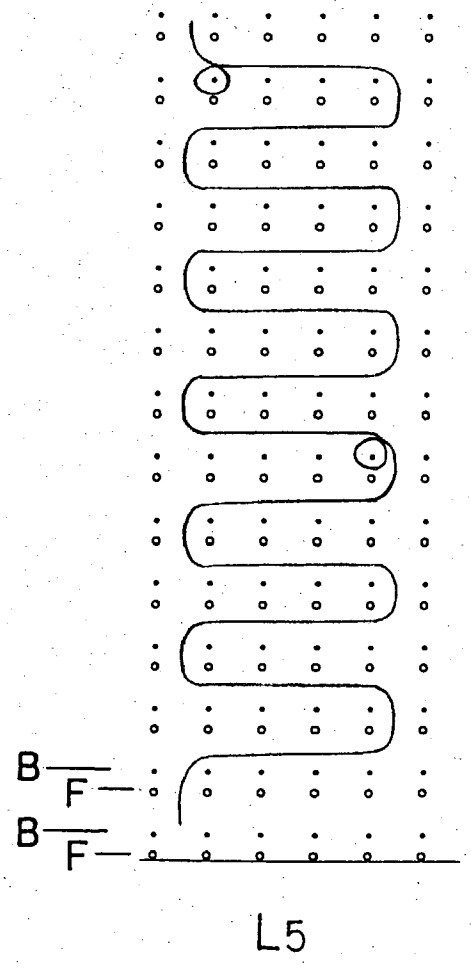



FIG. 22B

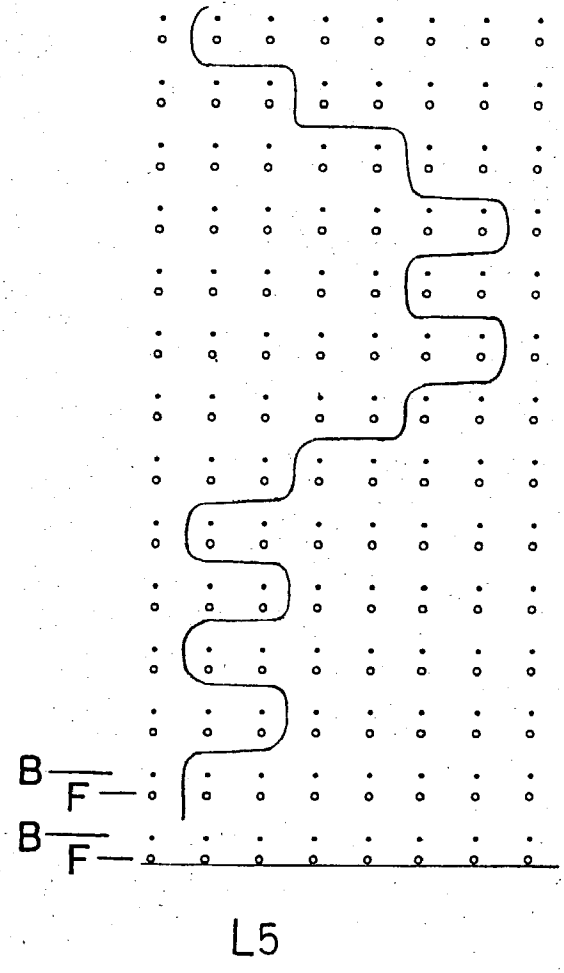


FIG. 23

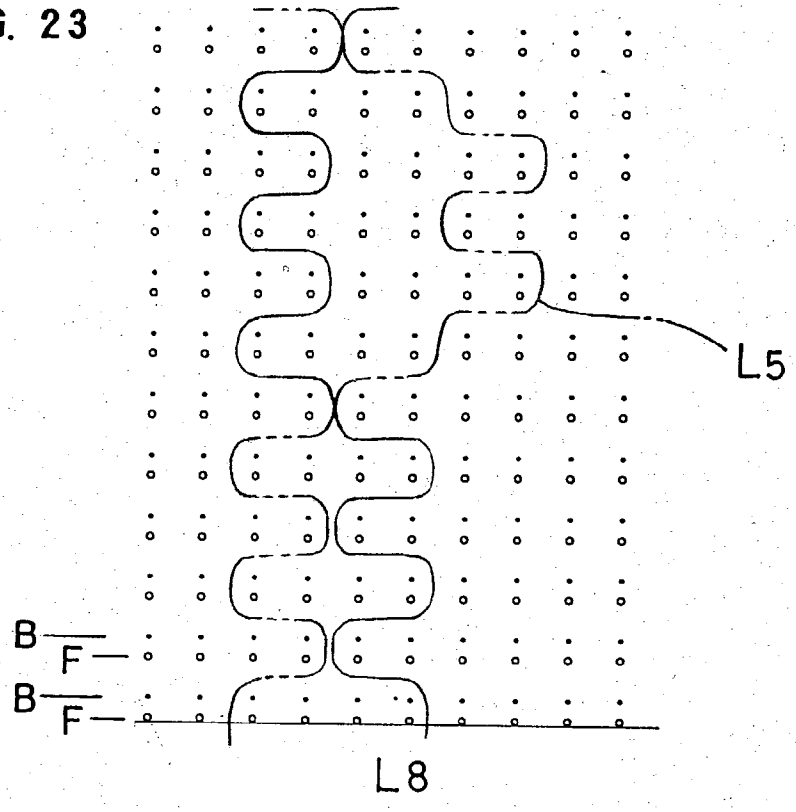



FIG. 24A

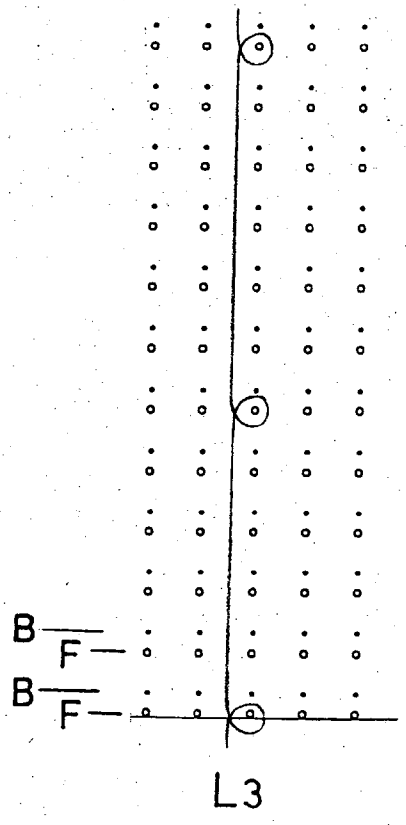



FIG. 24B

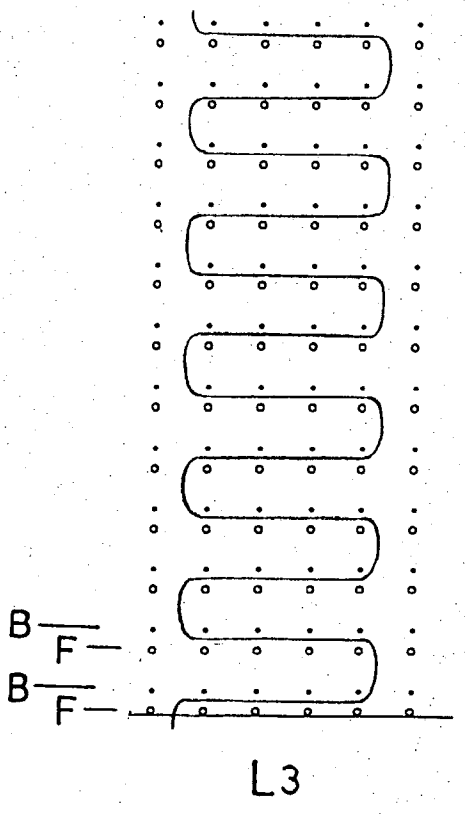


FIG. 25

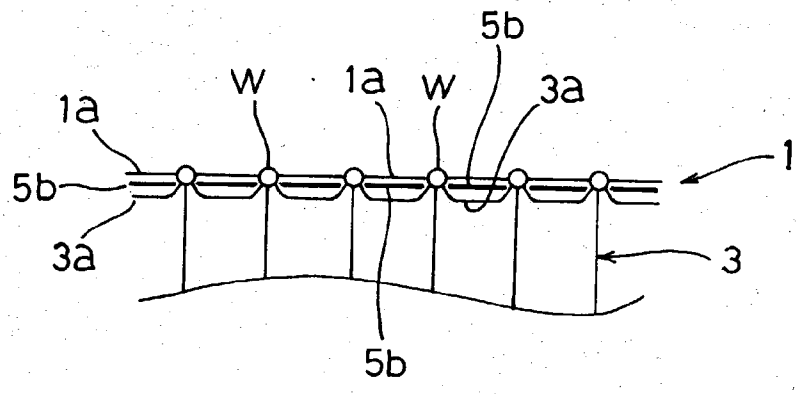



FIG. 26A

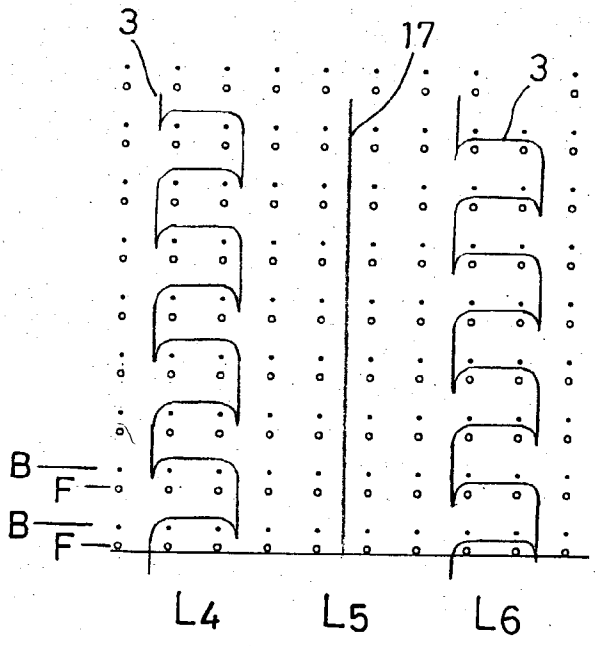



FIG. 26B

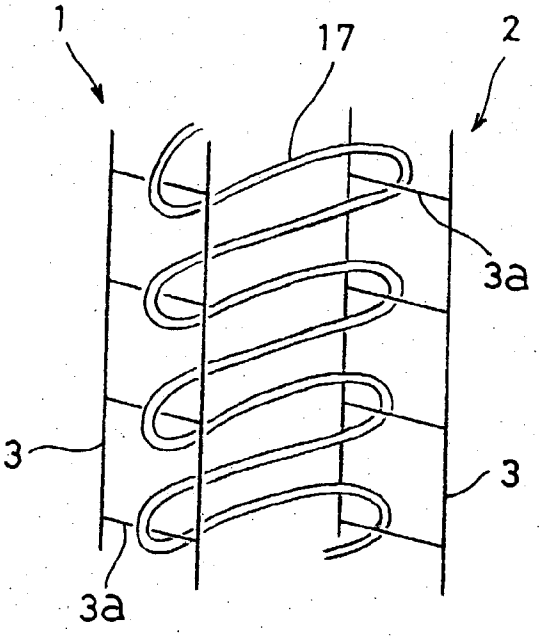


FIG. 27B

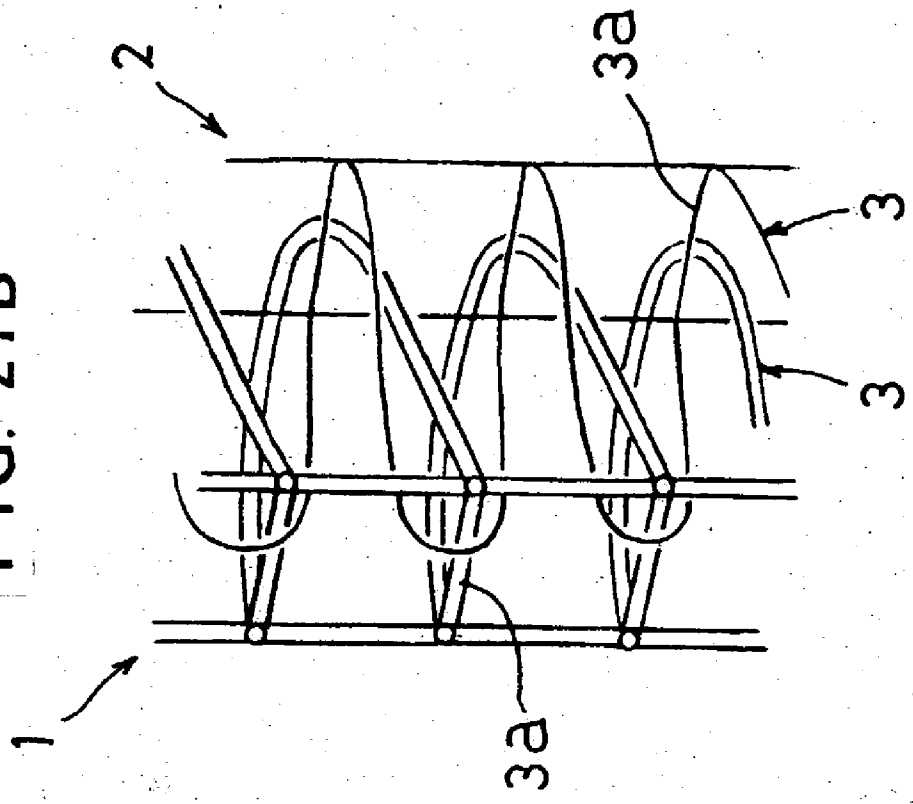



FIG. 27A

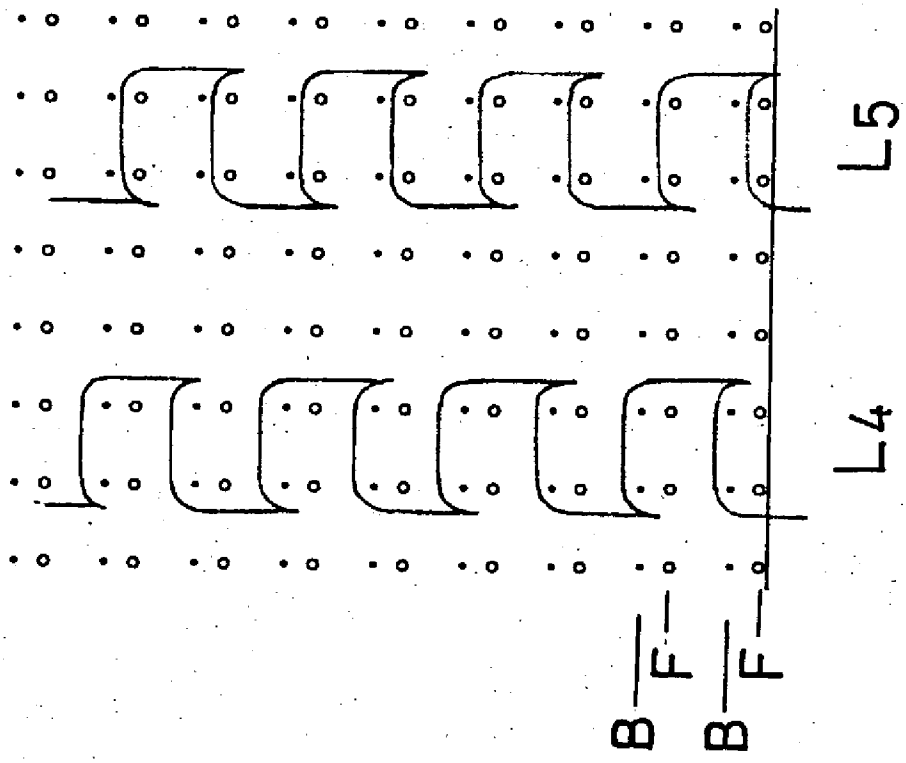


FIG. 28

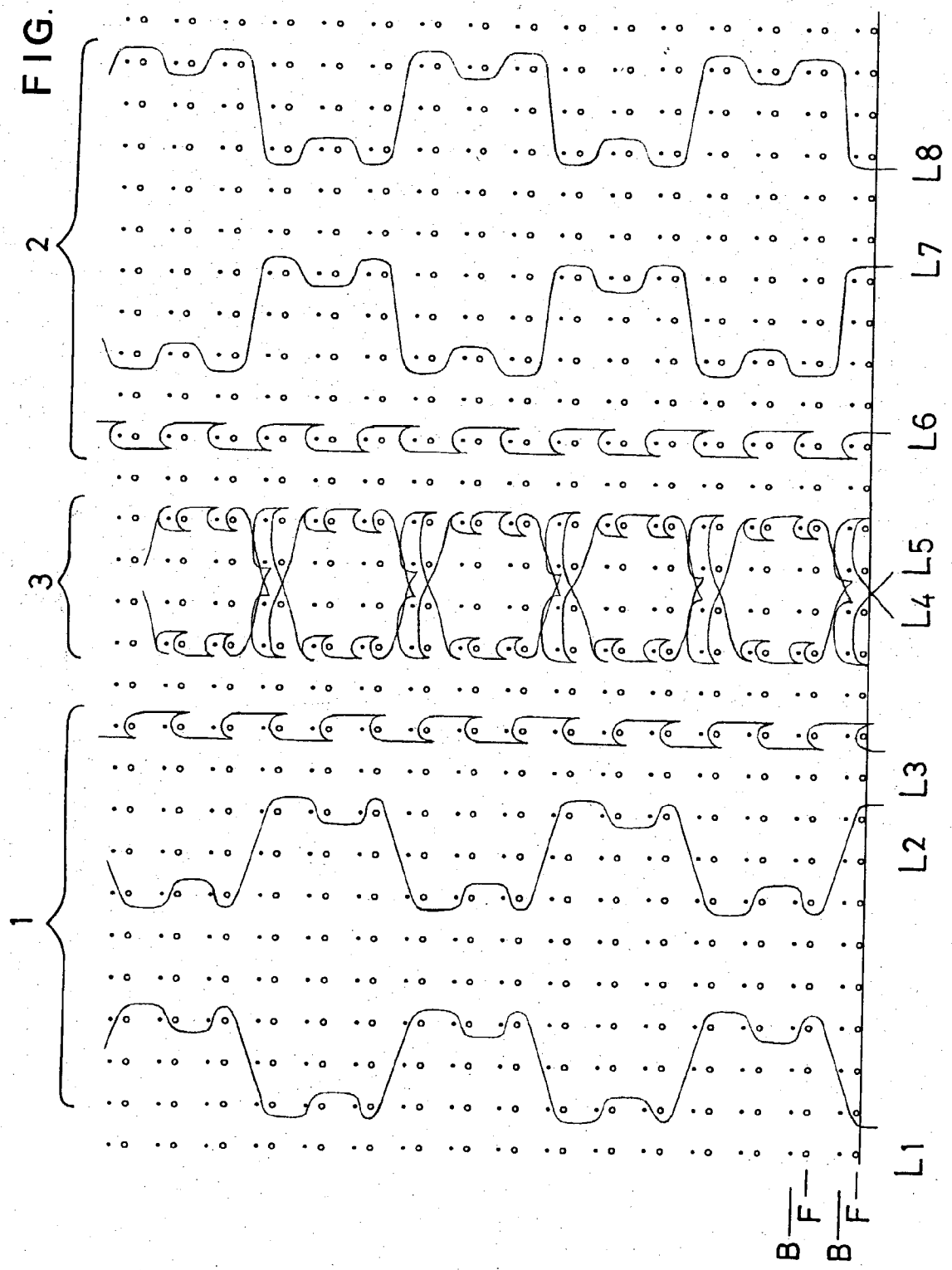


FIG. 29A

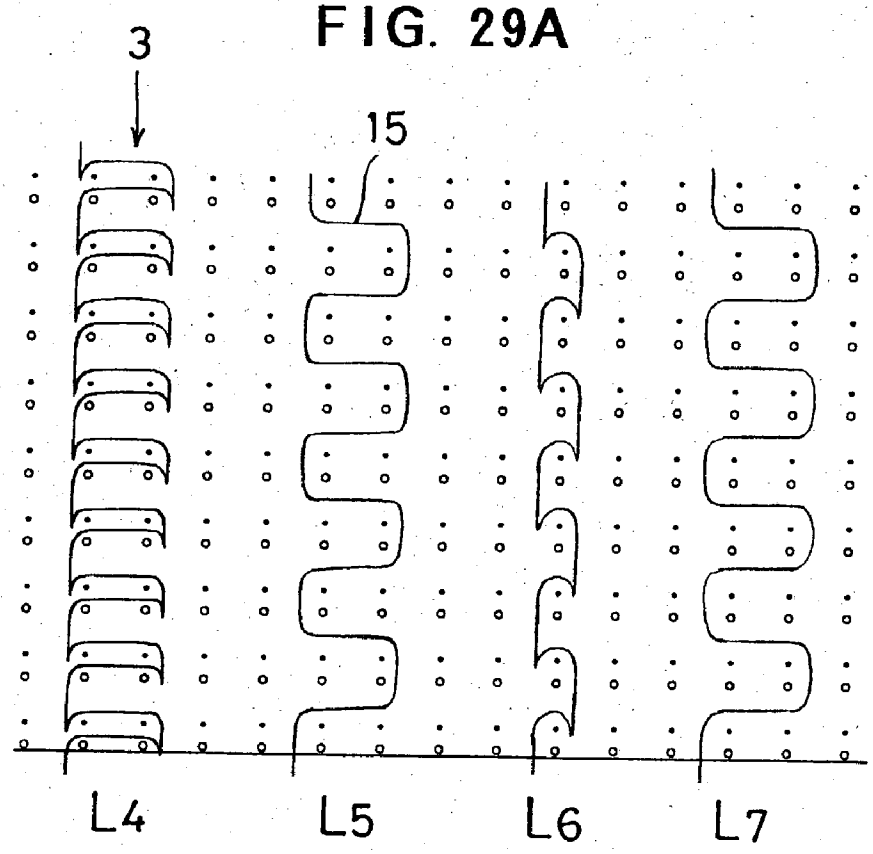



FIG. 29B

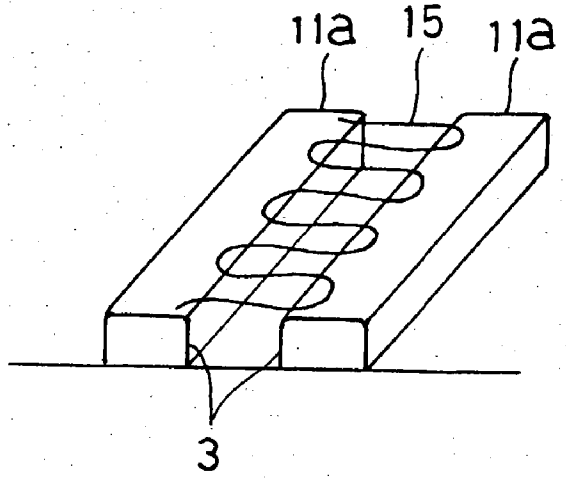


FIG. 30

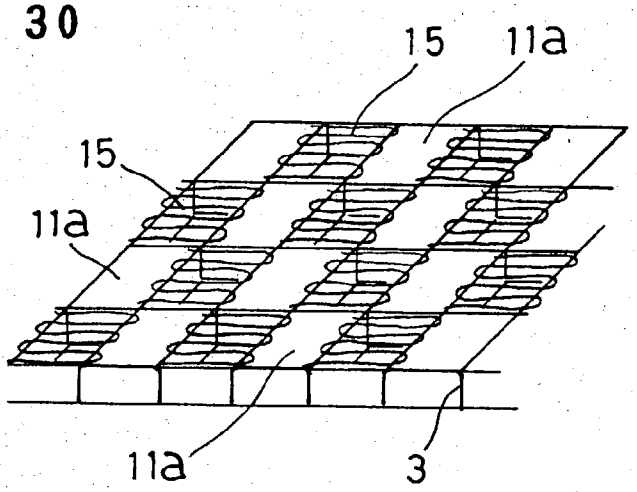



FIG. 31

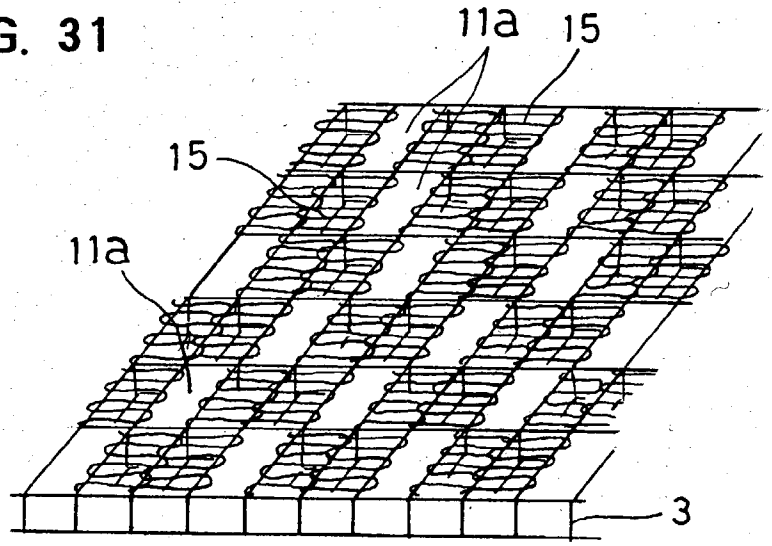
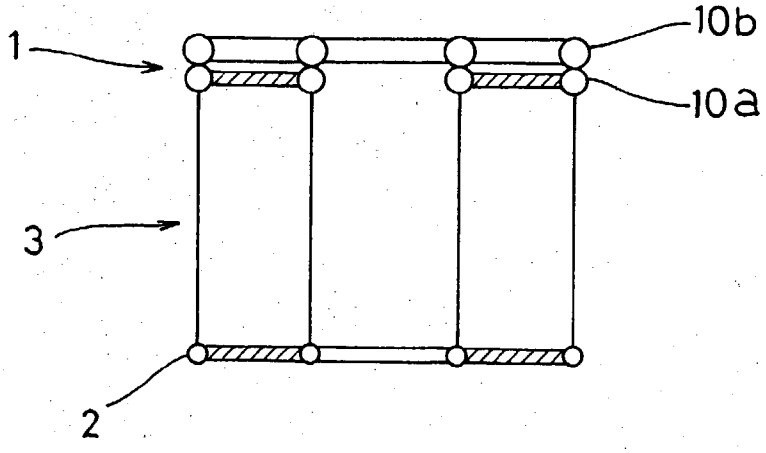



FIG. 32



# DOUBLE KNITTED FABRIC

## TECHNICAL FIELD

[0001] The present invention relates to a double knitted fabric made by warp knitting used for various applications such as afforestation, interior, bedclothes and accouterment, clothing, nursing, medical treatment, cushioning materials, industrial materials, and so forth.

## BACKGROUND ART

[0002] Conventionally, double knitted fabric made by warp knitting using a double Raschel machine has been comprised of front and rear webs and linking yarns connecting the front and rear webs. As double knitted fabrics, there are those with both front and rear webs made of flat structure, with one of the front and rear webs made of flat structure and the other made of a net structure, with both materials made of the net structure. The double knitted fabrics are used for various applications such as afforestation, interior, bedclothes and accouterment, clothing, nursing, medical treatment, cushioning materials, industrial materials, and so forth.

[0003] The double knitting fabrics are constructed by passing the linking yarns connecting the front and rear webs on to corresponding knitting needle to form stitches on both webs. Normally, the linking yarns are knitted in one-needle stitch on the front and rear webs, and the double knitted fabrics are constructed by passing two linking yarns in and out between both webs to form a single stitch. The linking yarn does not necessarily play a part sufficiently as a constituent yarn on the webs, bringing about less role in stability and strength, etc.

[0004] To make up for these problems, the double knitted fabrics have very high density of the linking yarns, resulting in large and heavy weight per unit area ($g/m^2$). Furthermore, a great deal of relatively thin yarns must be used to lighten weight per unit area, also leading to production of expensive fabrics If thin yarns are used as a linking yarn, its elastic force is weak; therefore the double knitted fabric is liable to be crushed in the direction of thickness, thus sufficient compressive strength may not be kept. Moreover, because of being knitted in one-needle stitch, the linking yarns are difficult to be fixed securely on the front and rear webs; accordingly the linking yarns move or slip on the webs, being defective in structural stability and also leading to possible cause of rubbing sound.

[0005] Besides, because the linking yarns are knitted In one-needle stitch, a loop portion of the stitch of the linking yarn is liable to be jutted forth from the surface of the webs. Especially, if the linking yarn is made up of a monofilament yarn, the loop portion is liable to be jutted forth. Moreover, there are also problems that, since the jutted portion of the linking yarn may not be enveloped and covered by a web-forming yarn, touch and texture on the surface of the webs is detracted; and therefore it is hard to be exhibited feature of quality of the web knitting yarn itself.

[0006] Furthermore, when the double knitted fabrics are used for bedclothes and accouterment or chair and so forth as a cushioning material, relatively thick monofilament yarns may be used as a linking yarn to assure compressive strength. Accordingly, there is also a problem that rubbing sound produced by the yarns going in and out at the stitches gives users an unpleasant feeling.

[0007] When the front and rear webs are knitted by a net structure, that is, when the adjoining wales or two or more rows of wales are joined by chain stitch yarns, inlayed yarns or the other web yarns, two or more guide bars are required as chain stitch or inlay yarn for jointing the wales. Therefore, as the number of guide bars increases, not only mechanical cost increases, but more difficult technical skill is also required, thus reducing efficiency of a knitting machine and also efficiency of the knitting operations.

[0008] Furthermore, from the viewpoint of knitting technology, even if the inserting yarn or other knitting yarn is got in on the back side of the web-forming yarn such as chain stitch yarn and so forth, there are not any yarns to hold those yarns at a portion of the linking yarns between the front and rear webs; therefore, the inlay yarns are liable to be displaced inwardly between the front and rear webs, the effect of insertion is not obtained adequately, the knitting (warp) inlay yarns and so forth may not be got effectively into the front and rear webs. Besides, the double knitted fabrics by the linking yarns knitted in one-needle stitch have its limit in the knitting construction, that is, small width of selection of the construction and small width of selection of pattern or functionality.

[0009] In view of the aforementioned problems or difficulties, this invention has been accomplished and provides a double knitted fabric by warp knitting to solve the aforementioned problems, wherein the linking yarns are knitted in two-needle stitch.

## DISCLOSURE OF THE INVENTION

[0010] The present invention brings a solution to the aforementioned problems and provides a double knitted fabric by warp knitting, comprising of front and rear webs and linking yarns connecting the front and rear webs, characterized in that the linking yarns are knitted in two-needle stitch on at least one of the front and rear webs.

[0011] According to the double knitted fabrics, the linking yarns perform larger part in stability or strength of the webs due to two-needle stitch. Thereby, since it is possible to form the linking yarns by, for example,"one-in and one-out", density of the linking yarns becomes smaller as much, allowing weight per unit area to be smaller and lighter despite of the double knitted stitch. That is, since only one of the linking yarns passing between both webs goes in and out from two-needle stitch, density of the linking yarn, especially density of the linking yarn between the front and rear webs, is substantially half the density of one-needle stitch; thus weight is reduced and void volume is also improved. In despite of double knitted fabrics, its production may be done inexpensively.

[0012] Moreover, since weight per unit area and density of the linking yarns may be made smaller, twice as thick linking yarns may be used if the same weight per unit area is employed as conventional one. Therefore, it is possible to use thicker yarns than conventional linking yarns. Thereby, since strength against bending moment may be improved greatly, compressive strength in thickness and elasticity may be enhanced while maintaining weight reduction and growing stronger against crushing. Furthermore, since the linking

yarns passing between both the front and rear webs go in and out at separate stitch when being knitted in two-needle stitch mentioned above, rubbing sound produced mutually by yarns is suppressed even if monofilament yarns and so forth are used for the linking yarns. Especially, when a multifilament yarn made of such as polyester and nylon or a spun yarn made of such as cotton are used for a knitting yarn of the webs, rubbing sound may be prevented more effectively. In case of a thin yarn with the same weight per unit area as conventional one, it is possible to use a plurality of yarns in parallel for the linking yarns and thus keep similar compressive strength as described above.

[0013] Furthermore, since the linking yarns in two-needle stitch as described above are knitted (looping) by two adjoining wales in the webs, the linking yarns are hard to be jutted from the surface of the webs, touch and texture brought about by the web-forming yarns is not detracted and it is easy to be characteristic of a material of the web-forming yarn itself, thus making good appearance and keeping good quality. In addition, since the stitch portion of the linking yarn plays a role in constituting a part of the webs due to two-needle stitch, not only strength of the webs is raised, but also the linking yarns are securely fixed to the webs due to two-needle stitch and stability of three-dimensional structure is also increased.

[0014] Accordingly, by means of a combination of two-needle stitch construction of the linking yarns and the web-forming yarn construction of the webs, variations of the knitting construction of the webs are increased, allowing appearance, design, touch, texture, functionality, and so forth to be diversified.

[0015] Besides, if the front and rear webs are knitted by a mesh construction, or if, for example, adjoining two rows of wales or three or more rows of wales are formed or temporarily joined according to other knitting constructions, two-needle stitch of the linking yarns may be employed; it is not necessary to add special guide bars just as being knitted by means of the chain stitch or inlay yarns, requiring less number of guide bars, whereby efficiency of the knitting machine and knitting operations may be raised.

[0016] The second embodiment of the present invention provides the second double knitted fabrics and characterized in that the linking yarns are knitted by the knitting construction in which two-needle stitch and one-needle stitch are combined on at least one of the front and rear webs.

[0017] When this double knitted fabric has the linking yarns knitted in two-needle stitch, density of the linking yarns may be decreased and weight per unit area becomes smaller and lighter in weight, similar to those described above. Besides, this double knitted fabric is economical three-dimensional structure. Furthermore, a thick yarn may be used for the linking yarn knitted in two-needle stitch; thereby compressive strength and elasticity in the direction of thickness may be improved. Moreover, as well as easy characteristics of a material of the web-forming yarn, a wide variety of selection of constructions may be made by means of a combination of two-needle stitch and one-needle stitch on the front and rear webs as compared with one-needle stitch only, bringing forth novel knitting construction.

[0018] In the double knitted fabrics mentioned above, the web-forming yarn of at least a part of the front and rear webs may be knitted in two-needle stitch. In this arrangement, the knitting construction of the front and rear webs are varied to form the double knitted fabrics of more diversified constructions, allowing stability of the webs to be increased. Two-needle stitch may further be selected for both web-forming yarn and linking yarn on the front and rear webs. The double knitted fabrics may also be knitted with different front and rear gauges, and diversifiable constructions and designs may be selected, allowing much more weight reduction and also bringing forth economical configuration.

[0019] In the double knitted fabrics mentioned above, at least one of the front and rear webs is knitted by a mesh construction in which the mesh is defined by the web elements in appearance of the braids comprising of one or a plurality of wales of stitch rows; two-needle stitch is knitted so that the linking yarns join the adjoining stitch rows at any points on the web elements.

[0020] In this case, since the linking yarns may securely and firmly be knitted and held on the webs by means of two-needle stitch in which at least one web is in the form of a mesh, characteristic feature is constituted similarly as described above, structure of the webs in the form of the braids forming the mesh may also be stabilized, as well as the joining strength of the webs in the form of the braids may be raised. Furthermore, three-dimensional structural stabilization and rubbing sound preventive effects may also be heightened.

[0021] For example, if the webs in the form of the braids forming the mesh comprise of two wales or more of stitch rows, the linking yarns may be knitted in two-needle stitch so as to join the adjoining stitch rows within the web elements in the form of the braids. In this arrangement, as compared with conventional case where the wales are knitted by web-forming yarns, less number of guide bars is required, and efficiency of the knitting machine and knitting operations may be raised. Besides, since the linking yarns knitted in two-needle stitch are not jutted forth on the surface of the webs, good touch and decent webs in the form of a mesh may be constituted.

[0022] Besides, the linking yarns may be knitted in two-needle stitch so that both webs in the form of a mesh are mutually joined at a joint of adjoining web elements. Thereby, the joint between the webs may be reinforced and further firmly joined.

[0023] On at least one of the front or rear webs of the double knitted fabrics, a width-wise inlay yarn or a knitting-direction-wise inlay yarn may be inlayed between the web-forming yarn and a traverse-wise running portion, which is between adjoining stitches and of the linking yarns knitted in two-needle stitch.

[0024] In this arrangement, the width-wise inlay yarn or the knitting-direction-wise inlay yarn is stably held on the inside of the web-forming yarn on the webs in itself, allowing the effect of inlaying the inlay yarn to exhibit fully. The inlay yarn may also be used as a lock yarn or a power yarn depending on its insertion form. Furthermore, since the inlay yarn is covered by the web-forming yarn located outside of the inlay yarn even if the inlay yarn is made of a functional material such as low hardwearing properties, low weathering resistance, the inlay yarn may be prevented from directly being in contact with ambient atmosphere, being

applied to atmospheric pressure, or coming into contact directly with the skin of a human being, and so forth, thus properly exhibiting function inherent in a material of the inlay yarn and properly maintaining durability.

[0025] When a yarn made of a material of poor hardwearing properties or touch or a material of poor dyeing properties or color development properties is inlayed as a width-wise or a knitting-direction-wise inlay yarn to be inlayed between the traverse-wise running portion of the linking yarn and the web-forming yarn, and when a yarn of good hardwearing properties or good touch or a material of good dyeing properties or color development properties are used as a web-forming yarn located outside of the inlay yarn, it is possible to improve hardwearing properties and touch or dyeing properties and color development properties on the surface of the mesh fabric and also to properly hold the function to be performed by the inlay yarn.

[0026] Furthermore, when the linking yarn is knitted in two-needle stitch on both front and rear webs, the knitting-direction-wise inlay yarn may alternately be passed through the front and the back sides and inserted between the traverse-wise running portion of the linking yarn and the web-forming yarn on the front and rear webs, respectively. Thereby, it is possible to facilitate knitting in two-needle stitch of the linking yarn, and also possible to easily make the front and rear webs come close to each other by pulling the inlay yarn after knitting.

[0027] In the double knitted fabrics mentioned above, the linking yarn knitted in two-needle stitch on at least one of the front and rear webs shifts right and left from opposite wale by one wale or more, at a required course position. between the front and rear webs and is obliquely passed; thereby, this obliquely passed portion is inclined to the direction of thickness and knitted so as to be in the form of substantially X-shaped, substantially V-shaped or inversed V-shaped, substantially U-shaped or inversed U-shaped, and so forth in section.

[0028] Accordingly, when pressure is applied vertically to the front and rear surfaces, a vertical force may be escaped laterally. Besides, elasticity of the webs itself assist cushioning effect to increase compressive strength or durability, as well as preventing the transverse-wise shifting portion of the linking yarn in itself from buckling.

[0029] Besides, in the double knitted fabrics, by alternately knitting the linking yarn linking the front and rear webs by two guide bars, and by knitting the linking yarn so as to alternately provide two kinds of passing form, that is, substantially vertical passing against the surface of the webs and passing at inclined angle, between the front and rear webs, three-dimensional structure in the knitting direction and in the direction of thickness may further be stabilized, and elasticity in the direction of thickness may also be raised.

[0030] In the double knitted fabrics, by knitting the linking yarn using two kinds or more of yarns with different material or properties, unevenness or compressive strength of the surface of the double knitted fabrics may be modulated. Besides, by knitting the linking yarn with different length of the transverse-wise shifting portion of the linking yarn between the front and rear webs, unevenness or compressive strength may also be modulated on the surface of the double knitted fabrics. In these cases, double knitted fabrics with much more peculiar appearance and special touch may be obtained in addition to the features described above.

[0031] Especially, after knitting the linking yarns in two-needle stitch so that there exists a mesh partially or all over the surface, the linking yarns may be slipped or elongated by means of extension action during heat setting, and mesh shape or the height of the linking yarns are varied, so that a pattern by means of fabric design or uneven pattern may be made on the surface of the double knitted fabrics.

[0032] Furthermore, the double knitted fabrics are knitted so that the web-forming yarn from at least one of the front and rear webs is jutted forth out of the external surface of the fabrics, as well as the web-forming yarn jutted out of the external surface is raised and sheared. Thereby, raised surface made up of the web-forming yarn only may be processed, thus value added high quality double knitted fabrics are obtained.

[0033] In the double knitted fabrics, at least one of the front and rear webs is marquisette-like knitted in two-needle stitch by the linking yarn. In this arrangement, the double knitted fabrics with much more peculiar appearance and special touch may be obtained in addition to the features described above.

[0034] Especially, in the double knitted fabrics mentioned above, it is preferably that at least one of the front and rear webs is knitted in marquisette-like knitting construction by means of the stitch rows of the chain stitch yarn extending In the knitting direction and the width-wise inlayed inlay yarn into the wales of one or several rows laterally at every plural number of courses with respect to the stitch row: and the linking yarns linking the front and rear webs are shifted in the opposite direction with each other and knitted in two-needle stitch, on each of the front and rear webs at a course portion corresponding to the width-wise portion of the inlay yarn, by two guide bars.

[0035] Thereby, width-wise inlay yarn is held by two-needle stitch of the linking yarn on the marguisette-like webs to prevent from slipping at the lateral portion, the quadrangular mesh opening in the marquisette-like knitting construction is stabilized due to the holding action between the wales worked by the linking yarn. Furthermore, high-tenacity yarns such as conductive material, carbon or aramid may be used as inlay yarn in the marquisette-like knitting construction. Even when such high quality yarns are used, the double knitted fabrics may be knitted inexpensively. The chain stitch yarn may also be knitted in two-needle stitch on the front and rear webs, whereby much more effect of structure stability will be produced.

[0036] In the double knitted fabrics mentioned above, a base layer including the web-forming yarn on the webs and an outermost layer of the knitting yarns comprising ornamental surface or functional surface, and so forth may be laid and knitted on top of at least one of the front and rear webs. Thereby, appearance, design or touch and texture may be obtained according to purpose or usage of the double knitted fabrics, or double knitted fabrics having desired functions are available. As the knitting yarns used for the outermost layer of the webs mentioned above, at least one kind of flexible yarns such as multifilament yarns, spun yarns, natural yarns, or at least one kind of yarns such as

elastic yarns, fusing yarns, functional yarns, and so forth, or these yarns may be mixed and used. When flexible yarns are used, the surface of the mesh fabrics will assume soft appearance.

[0037] When one kind of elastic yarns, polytrimethylene terephthalate yarn, is used for the front and rear webs and the linking yarn, various double knitted fabrics superior in soft, elasticity and cushioning properties, for example, double knitted fabric in which the front and rear webs are made of plain stitch construction, or double knitted fabric in which at least one of the front and rear webs is made of mesh structure, may be obtained.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0038] **FIG. 1** is a general perspective view showing an embodiment of a double knitted fabric by warp knitting according to the present invention.

[0039] **FIG. 2** is a general partial enlarged perspective view taken from **FIG. 1**.

[0040] **FIG. 3** is a general partial enlarged sectional view taken from **FIG. 2**

[0041] **FIG. 4** is an enlarged explanatory view of two-needle stitch structure of a linking yarn.

[0042] **FIG. 5** is a lapping diagram of each guide bar showing an example of knitting construction taken from **FIG. 4**.

[0043] **FIG. 6** is a lapping diagram of each guide bar showing an example of knitting construction of other embodiment of the double knitted fabric by warp knitting according to the present invention.

[0044] **FIGS. 7A** to **7**H are a lapping diagram of the linking yarn guide bar showing another two-needle stitch knitting construction of the linking yarn, respectively.

[0045] **FIGS. 8A** to **8**F are a lapping diagram of the linking yarn guide bar showing still another two-needle stitch knitting construction of the linking yarn, respectively.

[0046] **FIGS. 9A** to **9**C are a lapping diagram of the linking yarn guide bar showing still another two-needle stitch knitting construction of the linking yarn, respectively.

[0047] **FIGS. 10A** to **10**F are a lapping diagram of the linking yarn guide bar showing construction in which one-needle stitch and two-needle stitch are combined using a single guide bar, respectively.

[0048] **FIGS. 11A** to **11**C are a lapping diagram of the linking yarn guide bar showing construction in which one-needle stitch and two-needle stitch or two-needle stitch and two-needle stitch are combined using two guide bars, respectively.

[0049] **FIG. 12** is a general partial enlarged sectional view showing still another embodiment of the double knitted fabric according to the present invention.

[0050] **FIGS. 13A** to **13**B are a lapping diagram of the linking yarn guide bar showing construction in which the linking yarns passed between the front and rear webs are changed, respectively.

[0051] **FIG. 14** is a general partial enlarged sectional view showing the linking yarns passed taken from **FIGS. 13***a*to **13**B.

[0052] **FIG. 15** is a lapping diagram of a guide bar for the webs showing the construction in which the webs are knitted in two-needle stitch.

[0053] **FIG. 16** is a lapping diagram of each guide bar showing the knitting construction of still another embodiment of the double knitted fabrics according to the present invention.

[0054] **FIG. 17** is a lapping diagram of each guide bar showing the knitting construction of still another embodiment of the double knitted fabrics according to the present invention.

[0055] **FIG. 18** is a lapping diagram of each guide bar showing the knitting construction of still another embodiment of the double knitted fabrics according to the present invention.

[0056] **FIG. 19** is a lapping diagram of each guide bar showing the knitting construction of still another embodiment of the double knitted fabrics according to the present invention.

[0057] **FIG. 20** is a lapping diagram of each guide bar showing the knitting construction of still another embodiment of the double knitted fabrics according to the present invention.

[0058] **FIG. 21** is a general partial enlarged sectional view of the double knitted fabrics taken from **FIG. 20**.

[0059] **FIGS. 22A** to **22**B are a lapping diagram showing another example of construction of a guide bar for inlay yarn inlayed between a web-forming yarn and the linking yarn on the webs on the mesh construction side.

[0060] **FIG. 23** is a lapping diagram of a guide bar showing another knitting construction of the inlay yarn on the webs.

[0061] **FIGS. 24A** to **24**B are a lapping diagram showing an example of construction of a guide bar for inlay yarn inlayed between the web-forming yarn and the linking yarn on the webs on the plane knitting construction side.

[0062] **FIG. 25** is a general partial enlarged sectional view of the double knitted fabrics taken from **FIGS. 24A** to **24**B.

[0063] **FIGS. 26A** to **26**B are a lapping diagram of a guide bar for linking yarn showing still another embodiment of the double knitted fabrics according to the present invention and a general partial enlarged explanatory view.

[0064] **FIGS. 27A** to **27**B are a lapping diagram of a guide bar for linking yarn showing still another embodiment of the double knitted fabrics according to the present invention and a general partial enlarged explanatory view.

[0065] **FIG. 28** is a lapping diagram of each guide bar showing the knitting construction of still another embodiment of the double knitted fabrics according to the present invention.

[0066] **FIGS. 29A** to **29**B are a lapping diagram of partial guide bar showing still another embodiment of the double knitted fabrics according to the present invention and a general partial enlarged explanatory view.

[0067] **FIG. 30** is a general partial perspective view showing still another embodiment of the double knitted fabrics according to the present invention.

[0068] **FIG. 31** is a general partial perspective view showing still another embodiment of the double knitted fabrics according to the present invention.

[0069] **FIG. 32** is a general partial enlarged sectional view showing still another embodiment of the double knitted fabrics according to the present invention.

## BEST MODE FOR CARRYING OUT THE INVENTION

[0070] Referring now to the drawings, the embodiments of the present invention will be described.

[0071] **FIG. 1** is a general perspective view showing an embodiment of a double knitted fabric by warp knitting according to the present invention. **FIG. 2** is a general partial enlarged perspective view taken from **FIG. 1**. **FIG. 3** is a general partial enlarged sectional view taken from **FIG. 2**. **FIG. 4** is an enlarged explanatory view of two-needle stitch structure of a linking yarn. **FIG. 5** is a lapping diagram of guide bars showing an example of knitting construction taken from **FIG. 4**.

[0072] In the drawings, the reference numerals **(1)** and **(2)** designate the front and rear webs: the reference numeral **(3)** designates a linking yarn for linking together the webs **(1)**, **(2)** with certain gap there between. In this embodiment of double knitted fabrics (A), one of the front and rear webs, for example, the web **(1)** on the front side is knitted by a mesh construction, and the other rear web **(2)** is knitted by a flat knitting construction. The reference numeral **(11)** designates an element of the web **(1)** on the front side, which is formed of wales (w) of a double-stitch or coupled-pair stitch row: the reference numeral **(13)** designates a joint with which the web elements **(11)**, **(11)** are jointed.

[0073] The linking yarns **(3)** mentioned above are passed alternately between the front and rear webs **(1)**, **(2)** and are knitted by two-needle stitch constructions on at least one of the front and rear webs; for example on both webs **(1)**, **(2)** as shown in the drawings, at whole or part of the area or at any selected areas on each of the webs **(1)**, **(2)**. Especially, yarns are guided through every second yarn-guide position on guide bars for the linking yarns **(3)**; that is, "one-in and one-out". The reference numeral **(31)** designates pass-between or hung-across portions of the linking yarn.

[0074] In the illustrative embodiment, a double Raschel machine is used which has two rows of needle beds arranged substantially parallel; as in knitting construction shown in **FIG. 5** for example, the front and rear webs **(1)**, **(2)** are knitted basically by the chain stitch yarn and the inlay yarn, as arranged as distanced by a certain gap; and the double knitted fabrics (A) is formed of such webs **(1)**, **(2)** and the linking yarn **(3)** linking between them.

[0075] The front web **(1)** is knitted in following manner on the front side of the double Raschel machine: There are used chain stitch guide bars **(L2)**, **(L3)**, which guide web-forming yarns alternately two by two, and the inlay yarn guide bar **(L1)** that guides the inlay yarn on every second rows of stitches. Inlay yarns are inlayed in a width-wise swaying manner into two rows of wales knitted by the chain stitch, so that the web elements **(11)** each appearing like a braid are knitted by two rows of wales defining the mesh opening **(12)**. The chain stitch guide bars **(L2)**, **(L3)** are swayed and shifted rightward and leftward alternately at every required number of courses corresponding to the mesh opening **(12)**, thus alternately jointing the braid-like web elements **(11)** adjoining on the right and left sides; and then are returned to their original position. In this way, the webs are fabricated in such mesh constructions that form substantially rhombic or hexagonal openings of two-dimensional shape, or that form combination of such rhombic openings and hexagonal openings.

[0076] The rear web **(2)** is knitted in following manner on the back side of the double Raschel machine: the chain stitch guide bar **(L5)** and the inlay yarn guide bar **(L6)** are used as to form a flat construction, each of which guide bars **(L5)** **(L6)** guide a yarn at their every yarn-guiding positions; that is, what is called "yarns-fully-guided" or "full-set".

[0077] The linking yarn **(3)** is passed between the front and rear webs **(1)**, **(2)** in following manner. Linking yarn guide bars **(L4)** are used where yarns are guided at every second guide bars **(L4)**; that is "one-in and one-out". As schematically illustrated in **FIG. 4**, two-needle stitch knitting is made on each webs **(1)**, **(2)**, in a manner that each two-needle stitch is formed across two adjoining rows of wales (w). In particular, on the front web **(1)**, each of the two-needle stitches is formed within a coupled pair of wales, that is, the web element **(11)** appearing like a braid. In this way, adjoining two stitch rows or wales are bound together by the linking yarns **(3)**, as to further stabilize the web elements **(11)**. By such binding, moreover, the inlay yarn may be omitted in some occasion. When monofilament yarns are used as the linking yarns **(3)**, strength of the binding is further heightened.

[0078] On the rear webs **(2)** in flat construction, the two-needle stitches are formed on two wales (w) that correspond to wales of the web elements **(11)** in appearance of braids on the front web **(1)**. The reference numeral **(3*a*)** in **FIG. 4** designates a traverse-wise running portion between adjoining stitches, of the linking yarns **(3)**.

[0079] After such knitting, heat setting treatment is performed while being properly strained, and synthetic resin processing and so forth is made as occasion demands; consequently, as shown in FIGS. **1** to **3**, the double knitted fabric (A) is completed with the front side in the form of a net and the rear side formed by the flat construction.

[0080] In the double knitted fabrics (A) according to the embodiment, since the linking yarns **(3)** are guided on every second yarn-guiding position on the guide bars and knitted in two-needle stitch as aforementioned, per area density of the linking yarns **(3)** at the pass-between portions is reduced by half as compared with conventional one having the linking yarns knitted in one-needle stitch; consequently weight per unit area is reduced, irrespective of being a double knitted fabric.

[0081] In other words, to and from a pair of stitches of the double-needle stitch, only a single transverse-wise shifting portion of the linking yarns **(3)** is passed between the front and rear webs, basically; See **FIG. 4**. For this reason, per area density of the pass-between portions of the linking yarns **(3)** is reduced by half, so that entire double knitted

fabrics is reduced in weight and content of void is also heightened. By the two-needle stitch knitting, the number of yarns of the linking yarns may be reduced to a half, a third, a quarter, and so on, for example, on basis of the "yarns-fully-guided" or "fullset"; thus, weight per unit area is reduced. Conversely speaking, in case of the same weight per unit area, substantially twofold or more thick linking yarns may theoretically be used. Accordingly, bending moment is greatly improved and compressive strength will also be improved. Besides, even if relatively thick monofilament yarns are used for the linking yarns, rubbing sound between the monofilament yarns is hard to be produced. Furthermore, by the two-needle stitch knitting of the linking yarns, the linking yarns securely be incorporated on the webs and stabilized; and thus, stability of three-dimensional structure is greatly improved to prevent from collapsing and so forth.

[0082] If thin monofilament yarns are used as such linking yarns, when two to three thin monofilament yarns are paralleled in bundle and guided by the linking yarn guide bar (L4), similar compressive strength as thick yarns is obtained; and knitting loop portion of the linking yarns are difficult to be jutted forth on the surface as compared with thick yarns.

[0083] As aforementioned, within the front and rear webs (1), (2), the linking yarns (3) in two-needle stitch are knitted at back of the chain-stitch yarn, that is, at inward between the front and rear webs (1), (2), as shown in explanatory view of **FIG. 4**. Thus, the linking yarns are difficult to be Jutted from the surface of the webs; touch and texture brought about by the web-forming yarn is not detracted. Furthermore, mixing up of the linking yarns and web-forming yarns became difficult to be given arise; thus, the touch of the web-forming yarns is sufficiently exhibited on surfaces of the fabrics. The more the linking yarns are knitted in two-needle stitch, the more conspicuous such effects are.

[0084] Two-needle stitches of the linking yarns (3) maybe formed not only within each of braid-shaped web elements (11) defining the mesh openings (12) on the net-shaped webs (1), but also at between the two web elements (11) as to join the two web elements (11), (11) by shifting the linking yarn guide bar (L4) rightward and leftward alternately at every required number of courses. In otherwise, the two-needle stitches of the linking yarns (3) may be formed only at joints (13) between the two adjoining web elements (11), In either case, joining strength of the joints (13) mentioned above may further be heightened.

[0085] Meanwhile, for the knitting, two guide bars may be used in guiding the linking yarns (3), so as to alternately join each web element (11) with web elements (11) adjoining right and left at every required number of courses. For example, from the knitting construction in **FIG. 5**, it is modified as using two linking yarn guide bars; the linking yarns are arranged alternately on the two guide bars, as to be guided at every second guiding positions on each guide bar; and the guide bars are shifted rightward and leftward alternately at every required number of courses corresponding to the mesh openings, so as to join adjoining web elements (11), (11) by two-needle stitches. Thereby, the joints (13) between the web elements (11), (11) is reinforced to be further secure the binding. Meanwhile, by such knitting construction, it is not necessary to have two chain stitch guide bars be width-wise swayed at every required number of courses to form the mesh openings.

[0086] In other words, when to bind together two adjoining rows of wales or three or more rows of wales or to bind adjoining web elements at every required number of courses, it is not necessary to use an additional special guide bar; just as using a two-piece guide bar for the chain stitch yarns; thus, requiring less number of guide bars, whereby efficiency of the knitting machine and knitting operations may be raised.

[0087] In the embodiment described above, the web elements (11) defining the mesh opening (12) maybe modified as each web element is formed of three or more rows of wales, in mesh construction on the front web (1); the size and shape of the mesh opening (12) may be set as one's discretion, as to facilitate various mesh constructions. Although each of the web elements (11) may also be formed of a single row of wales as to seek for design or functional effect, it is desirable that the each web element (11) is formed of two or more rows of wales.

[0088] In the embodiment described above, the linking yarns (3) are knitted in two-needle stitch on front web (1) in the mesh construction and on rear web (2) in the flat construction; however, the rear webs (2) may also be knitted in mesh construction in the same manner as the front webs (1), as shown in **FIG. 6**.

[0089] In such knitting, the two-needle stitches of the linking yarns (3) may be formed at any part on one or both of the front and rear webs (1), (2); for example, at within each of the web elements defining the mesh and/or at the joint between adjoining web elements.

[0090] In such knitting construction, the mesh openings on the front and rear webs (1), (2) are not necessarily be formed at corresponding position with the same shape on the front and rear sides; rather, the position of the mesh openings may be shifted in the knitting direction on the front and rear sides, and different shape or size of the mesh openings may also be employed. The double knitted fabrics (A), the front and rear webs (1), (2) of which are made of corresponding mesh construction, may preferably be used for a fishing net. In this case, its joining strength and durability is enhanced by forming the two-needle stitches of the linking yarns at the joints between the web elements in the form of braids as mentioned above.

[0091] In either embodiment described above, various two-needle stitch knitting construction may be formed by the linking yarns (3), in accordance with the knitting construction of the front and rear webs (1), (2).

[0092] For example, with regards to the linking yarn guide bar (L4) in knitting diagrams in **FIGS. 5 and 6**, any knitting construction other than those shown in FIGS. **5** or **6** may be employed as shown in **FIGS. 7A** to **7H**, **FIGS. 8A** to **8F**, **FIGS. 9A** to **9C**.

[0093] Since two-needle stitch knitting shown in **FIG. 9A** has different wale position on every course for both front and rear sides, the mesh opening becomes smaller when the front and rear sides are formed by the mesh construction. When, as shown in **FIG. 9B**, the wale position of the two-needle stitch is varied on arbitrary number of courses, larger mesh

openings than those in **FIG. 9A** is formed. According to the two-needle stitch knitting in **FIG. 9**C, the positions of the mesh openings may be staggered between the front and rear webs.

[**0094**] With regards to the linking yarn guide bar (**L4**) mentioned above, the two-needle stitches of the linking yarns (**3**) are not necessarily be on both front and rear webs (**1**), (**2**); that is, the two-needle stitches of the linking yarns (**3**) may be formed only on either front or rear web, like the knitting construction formed by the linking yarn guide bar (**L4**) as shown in **FIGS. 10A** to **10**F.

[**0095**] In either case, weight per unit area is reduced as mentioned above, and elasticity and compressive strength are also raised. Besides, the joining strength between the wales is enhanced on the web where the linking yarns (**3**) are knitted in two-needle stitch; by either of embodiments, low-cost production is achievable, and improvements. In appearance, design, touch, texture, and so forth are achievable.

[**0096**] With regards to the two-needle stitch knitting construction formed of the linking yarns (**3**) mentioned above, when one or both front and rear webs (**1**), (**2**) are knitted in two-needle stitches, it is not necessary to be knitted in two-needle stitches for all courses on the front and rear webs; but the knitting construction may be formed by a combination of two-needle stitch and one-needle stitch.

[**0097**] Although a one-piece guide bar is used for knitting of the linking yarns (**3**) in **FIGS. 7A** to **7**H, **FIGS. 8A** to **8**F, **FIGS. 9A** to **9**C, **FIGS. 10A** to **10**F, a two-piece guide bar may also be used for knitting the linking yarns (**3**) as in **FIGS. 11A** to **11**C; thereby the linking yarns of both guide bars may be fabricated by different knitting construction.

[**0098**] For example, by knitting in two-needle stitch using one guide bar (**L4**) and knitting in one-needle stitch using the other guide bar (**L5**) to form like the construction as shown in **FIG. 11**A, two-needle stitch wale and one-needle stitch wale are formed alternately in the direction of course. By making use of this construction, two-needle stitch wale may be set at any position. Furthermore, when two kinds of yarns are alternately guided by "one-in and three-out" using the linking yarn guide bars (**L4**), (**L5**) in the construction shown in **FIG. 11**C, weight per unit area of the linking yarns is reduced to a half or less, in any cases where the front and rear webs are formed by the knitting construction such as flat, mesh, honeycomb, two-wale marquisette, and so forth; thus weight of the double knitted fabrics is greatly reduced. In case of the construction described above, when the linking yarns of two linking yarn guide bars (**L4**), (**L5**) are intersected, three-dimensional structures on the front and rear sides may also be stabilized.

[**0099**] Furthermore, when two kinds of yarns are used for the linking yarn guide bars (**L4**), (**L5**) mentioned above, various function or ornamental effect may be imparted by adopting followings for example; a monofilament yarn for one linking yarn guide bar (**L4**) and a multifilament yarn for the other linking yarn guide bar (**L5**); or an elastic yarn for one linking yarn guide bar (**L4**) and an inelastic yarn for the other linking yarn guide bar (**L5**); or materials of different function and color for both linking yarn guide bars (**L4**), (**L5**).

[**0100**] The rubbing sound produced by monofilaments fractioned with each other is suppressed more effectively by following; as linking yarns, at least one kind of yarn among multifilament yarn, spun yarn, elastic yarn, fusing yarn or the like is used together with a monofilament yarn; and two-needle stitch construction is adopted to alternately knit these yarns at every required number of courses.

[**0101**] When the two-needle stitch construction mentioned above is adopted properly, portions where the linking yarns are not knitted are made on every other course of wales in the knitting direction on the front and rear sides; as to bring out a feeling of material of the knitting yarn on the front and rear sides or as to vary limitations on the number of linking yarns to be knitted. Thereby, the two-needle stitch construction brings out touch and texture that may not be accomplished by conventional double knitted fabrics. Besides, double knitted fabrics hard to be crushed is accomplished by enhancing compressive strength irrespective of lightweight.

[**0102**] In this case, by increasing diameter of the linking yarn, it is possible to further enhance compressive strength or to raise the reinforcing effect due to the intersecting structure of the linking yarns, that is, the effect of preventing the pass-between portions of the linking yarns from collapsing due to inclination. Accordingly, the double knitted fabrics may preferably be used for applications such as industrial materials and cushioning materials, etc.

[**0103**] When touch or functionality of material on the front and rear webs are desired rather than compressive strength, relatively thin yarns are used as a linking yarn. Meanwhile, if primary object is to link the front and rear webs and secondary object is to produce the effect of three-dimensional structure, relatively thick yarn is used as a linking yarn; and, moreover, as web-forming yarns for front and rear webs, cotton, acetate, superfine multi-nylon/ester, high bulky nylon/ester, polytrimethylene terephthalate, polyurethane, other elastic yarn, and so forth may be used; the same yarn may be used for both front and rear sides, different yarns may be used on the front and rear-sides, or such yarn may be mixed as used on every several wales. The yarns mentioned above may also be used for the linking yarn as occasion demands.

[**0104**] In the two-needle stitch construction of the linking yarn in **FIGS. 8E and 8F**, the linking yarns are laterally moved and knitted between two adjoining wales on every two or three courses, thus bringing out a feeling of material, unevenness or slip resistance effect on the front and rear sides of the double knitted fabrics. The double knitted fabrics made of the two-needle stitch construction may preferably be used for uses such as clothing, sporting goods, nursing articles, medical articles, supports or shoes, slippers, insoles, wheelchair seats. In addition, the double knitted fabrics are suited for interior materials such as floor slip resistance, partition or curtain: the double knitted fabrics may also be used for other various industrial materials or filters, and so forth.

[**0105**] In the two-needle stitch construction in **FIGS. 10D** or **10**F, the linking yarns may be guided and knitted in the linking yarn guide bar (**L4**), as "one-in and one-out", or "one-in and three-out"; and then when its width is properly expanded and heat setting is made, more lightweight double knitted fabrics is obtained. Smaller density of the linking yarn facilitates resin or concrete and so forth to get into the fabrics; thus, the double knitted fabrics are preferably used as a reinforcing material.

[0106] In addition to those mentioned above, various knitting construction may be adopted by making use of well-known two-needle stitch constructions that use the one-piece or two-piece guide bar.

[0107] Irrespective of using either the one-piece or two-piece guide bar in knitting the linking yarns (3), the linking yarns (3) may be passed between the front and rear webs (1), (2) in a manner shown schematically in **FIG. 12**; that is, the linking yarns (3) are shifted right and left from the opposite wale by one wale or more so as to be passed obliquely between the front and rear webs (1), (2). Thereby, this obliquely passed portion (31) is inclined either rightward or leftward or both rightward and leftward, to the direction (thick-wise direction) vertical to the surface of the webs, and is knitted so as to be substantially X-shaped, substantially V-shaped or inversed V-shaped, substantially U-shaped or inversed U-shaped, or substantially in parallelogram and so forth, as viewed in cross section.

[0108] **FIGS. 13A and 13B** illustrate the knitting constructions of the linking yarn guide bar (L4) when a part or all of the linking yarns (3) are passed as X-shaped as viewed in cross section: the linking yarns (3) are guided and knitted as "one-in and one-out", "one-in and two-out" or "one-in and three-out", respectively.

[0109] As shown in **FIG. 14**, the knitting construction in **FIG. 13A** provides two kinds of passing form—one is substantially vertical or close to vertical passing against the surface of the webs, and the other is passing at inclined angle, between the front and rear webs (1), (2). The reference numeral (30) designates vertical or substantially vertical passed portion against the surface of the webs. The reference numeral (31) designates inclined passed portion. These passed portions (30), (31) are not necessarily in the form of a straight line as schematically shown in the drawings even in case of a monofilament yarn: there are also many cases where the passed portions are curved as bowed or arced on actual fabrics. When the linking yarns (3) are knitted in two-needle stitch with high tension, the passed portions (30), (31) of the linking yarns (3) mentioned above are curved slowly.

[0110] In this way, when the linking yarns (3) are passed obliquely at all or a part of any course position, either of following shape is formed; substantially trapezoidal or inversely trapezoidal shape, substantially parallelogram, substantially triangular or inversely triangular shape, rectangular shape, or combination thereof, as viewed in cross section; such shape being formed by combination of obliquely pass-between portion (31), substantially vertical pass-between portion (30), portion knitted in two-needle stitch in the webs, and so forth. Thereby, the amount of linking yarns is decreased to reduce its weight, as well as stability of the three-dimensional structure may be heightened.

[0111] That is, because of the structure with obliquely pass-between portions against the webs, load vertical to the webs is alleviated by converting through obliquely pass-between portions (31) into horizontal direction; thus, three-dimensional structure may be maintained properly without buckling or excessively crooking the linking yarns (3).

[0112] Besides, the web-forming yarns on one or the other of the front or rear webs (1), (2) may also be knitted in two-needle stitch construction. For example, in the knitting construction in FIGS. **5** or **6**, the chain stitch guide bars (L2), (L3), which guide two kinds of web-forming yarns alternately as "one-in and three-out", as shown in **FIG. 15**, may be used to form two-needle stitch construction, instead of the chain stitch guide bars (L2), (L3) and the inlay yarn guide bar (L1) used to be knitted on one web. In this case, the inlay yarn guide bar (L1) may be omitted; and less number of chain stitch yarns may also be guided in the guide bar.

[0113] When the chain stitch guide bars (L2), (L3) are used to form the mesh structure, the chain stitch guide bars are traverse-wise shifted by two needles rightward and leftward alternately in the opposite direction to each other at every required number of courses; so as to alternately join the web elements with right and left adjoining ones that are knitted by the web-forming yarns on both guide bars (L2), (L3).

[0114] In such manner of knitting, the two-needle stitch construction of the web-forming yarns mentioned above may be in combination with the two-needle stitch construction of the linking yarns (3). Thereby, the web structure will become further strong and stable, the knitting construction of the front and rear webs (1), (2) will be varied, thus resulting in the double knitted fabrics with further diverse structure and properties.

[0115] The present invention allows variations of the front and rear webs and properties of the mesh fabrics to be diversified, by combining the two-needle stitch construction formed by the linking yarns (3) mentioned above with various construction of the front and rear web, further in combination with materials or properties of the web-forming yarn and linking yarn, or in combination with the inlaying technology.

[0116] Modified embodiments for such variations are described hereinafter.

[0117] The knitting construction in **FIG. 16** shows one of the modified embodiments. In the shown knitting construction, one of the front and rear sides, for example, the front web (1) is formed by the mesh structure having a fine mesh using the guide bars (L2), (L3); and the other web (2) is formed by the flat or even structure using the chain stitch guide bar (L6) and the inlay yarn guide bar (L7) that are "yarns-fully-guided" or "full-set". By such knitting construction, a loop of the wale formed by the chain stitch guide bar (L6) is pulled by the inlay yarn, turning rightward and leftward in the form of a zigzag. This is the cause of stretch of the mesh fabric, which impairs dimensional stability in the knitting and widthwise direction. However, as shown in the knitting diagram of **FIG. 16**, when an additional inlay yarn guide bar (L8) is further employed and further inlay yarn extending in the knitting direction within the same wale is introduced as inlayed in the knitting, elongation in the knitting direction is stopped to prevent widthwise mesh fabric from contracting. In particular, looping of the knitting-direction-wise: inlay yarn once at every required number of courses, e.g. once at every eight courses (not shown), is effective for preventing the knitting-direction-wise inlay yarn in the knitting direction from slipping.

[0118] The double knitted fabrics of such knitting construction, which have high dimensional stability in the knitting and widthwise directions; are suitably used for:

sheet, futon cover, bedcover, cloth for covering car seat/chair; and various applications requiring dimensional stability such as civil engineering or industrial materials.

[0119] The knitting construction in **FIG. 17** represents the double knitted fabrics having fine mesh structures on the front and rear webs (**1**), (**2**) and having the linking yarns (**3**) knitted in two-needle stitch. In such double knitted fabrics, yarns of less elongation such as cotton yarn, spun yarn, multifilament yarn or multifilament thread, and so forth are alternately guided at interval of two guiding position ("two-in and two-out") on the front and rear web-forming guide bars (L**2**), (L**3**) and (L**5**), (L**6**). Stitches are formed while being shifted transverse-wise among three needles on every course. The web-forming yarns are shifted transverse-wise rightward and leftward alternately in the opposite direction to each other over several wales at every required number of courses. In this way, the webs are knitted as mesh structure so that the yarns of both guide bars are connected alternately. Mean while, on the linking yarn guide bar (L**4**), a stretch yarn or an elastic yarn such as rubber, polytrimethylene terephthalate, polyurethane, and so forth are guided as the linking yarns (**3**). The linking yarns (**3**) are knitted into two-needle stitches, on at least one of the front and rear webs, for example, on both webs, so as to connect adjoining two wales. Accordingly, the double knitted fabrics has stretch properties in the knitting and widthwise directions due to the stretch properties of the linking yarns, and also has cushioning properties as the double knitted fabrics per se. The double knitted fabrics may preferably be used especially for support, underwear, sportswear, cushion cover, shipping cover, etc.

[0120] When the elastic yarn is used for the web-forming yarn mentioned above and the monofilament yarn without stretch properties is used for the linking yarn, the double knitted fabrics become to have physical properties—certain elongation and no elongation beyond certain limit, due to restraint on elongation of linking yarn made of monofilament yarn mentioned above. Such double knitted fabrics are preferably be used for covering the chair, and so forth.

[0121] **FIG. 18** shows a knitting construction, in which both the front and rear webs (**1**), (**2**) have flat structure, and the linking yarns (**3**) are knitted into two-needle stitches. In the knitting construction, on the guide bars (L**3**), (L**6**) for respectively knitting the front and rear webs, multifilament yarn, spun yarn, monofilament yarn, and so forth are guided as chain knitting yarns in a manner as "yarns-fully-guided" or "full-set". Meanwhile, on the guide bars (L**1**), (L**7**) and (L**8**) for inlay yarns, multifilament yarns or monofilament yarns are guided as traverse-wise inlay yarns in a manner as "yarns-fully-guided" or "full-set" or as "one-in and one-out". Meanwhile, onto a front side guide bar (L**2**), same yarns as described above are guided as knitting-direction-wise inlay yarns in a manner of "yarns-fully-guided" or "full-set"; and on the linking yarn guide bar (L**4**), the same yarns as described above are guided in a manner as "one-in and one-out".

[0122] In such knitting construction, on the front web, dimensional stability in the knitting and widthwise direction is enhanced, and structural stability as double knitted fabrics is improved, because of the two-needle stitches of the linking yarn (**3**) and because of the traverse-wise and knitting-direction-wise inlay yarns on the guide bars (L**1**) (L**2**). Widthwise elongation of the fabrics is prevented by the two-needle stitches and knitting-direction-wise of the fabrics is prevented by the knitting-direction-wise inlay yarns; such effects being on a large scale; and thus, bringing out mesh fabric products with higher dimensional stability in the knitting and widthwise directions.

[0123] When the elastic yarn or the stretch yarn such as polytrimethylene terephthalate is used for the linking yarn (**3**) for knitting in two-needle stitch using the linking yarn guide bar (L**4**) mentioned above, not only knitting work is facilitated to be done, but lasting quality of cushioning effect is also heightened; because such two-needle stitches are inter knitted firmly within the webs, properties of good touch, lightweight and thin stuff as well as more effective cushioning properties are obtained. Further, when the multifilament yarn of the elastic yarn mentioned above or processed yarns of such multifilament yarn is employed for at least one of the front and rear webs (**1**), (**2**), double knitted fabrics with good touch may be formed.

[0124] **FIG. 19** illustrates a knitting construction of the double knitted fabrics in which one of the front and rear webs (**1**), (**2**) has an unpatterned flat structure and the other has a mesh structure.

[0125] In the knitting construction, the guide bars (L**1**), (L**2**), (L**3**) knitting one of the front and rear webs (**1**) form the flat structure; the guide bars (L**6**), (L**7**), (L**8**) knitting other web (**2**) form the mesh structure. In this case, the guide bars (L**1**), (L**2**), (L**3**) guide web-forming yarns such as inlay yarn or chain stitch yarn in a manner as "yarns-fully-guided"; the guide bars (L**6**), (L**7**) guide the web-forming yarn as "two-in and two-out" and the guide bar (L**8**) as "one-in and one-out"; the linking yarn guide bars (L**4**), (L**5**) guide the yarns "one-in and one-out", respectively.

[0126] And, when a polyester multifilament yarn is used for the guide bars (L**1**), (L**2**), (L**3**) mentioned above, a kind of "solid" mesh fabric with stretch properties suppressed is obtained; when the elastic or stretch yarn such as rubber yarn, polyurethane yarn, polytrimethylene terephthalate yarn, wooly thread is used for the guide bar (L**2**), a mesh fabric with stretch properties in the knitting direction is obtained. When the elastic yarn is used for all guide bars (L**1**), (L**2**), (L**3**) or for the guide bars (L**1**), (L**2**), a web with stretch properties in the knitting and widthwise directions is obtained. Furthermore, when a natural fiber yarn such as cotton is used for the guide bars (L**3**), (L**6**), (L**7**), the double knitted fabrics with good touch on the surface of the front and rear webs are obtained. Of course, the natural fiber yarn may also be used for the guide bars (L**1**), (L**2**), (L**8**).

[0127] According to the knitting construction mentioned above, the yarns knitted by the guide bars (L**3**), (L**6**), (L**7**) may be put out on the surface of the double knitted fabric web and may effectively be laid close to human body when used for clothing and so forth; thus, effects of such as moisture absorption, antibacterial, deodorization, negative ion, far infrared rays are ready to be produced by making the use of fibers having functionalities such as moisture absorption, chitosan, catechin, far infrared rays, negative ion, instead of natural fiber mentioned above.

[0128] In any case, when primary object is to reduce weight, one of the linking yarn guide bars (L**4**), (L**5**) in **FIG. 19** is omitted, and, for example, the linking yarn guide bar

(L4) only is used when the linking yarn (3) is knitted. Besides, when primary object is to make the web of flat structure as to be kind of "solid", as shown in **FIG. 19**, two kinds of linking yarn guide bars (L4), (L5) are used to link adjoining two-needle stitch linking yarns. The linking yarn is knitted in two-needle stitch at the corresponding wale position on the front and rear webs by the linking yarn guide bar (L4); another linking yarn is knitted in two-needle stitch by the linking yarn guide bar (L5) at a position staggered by one wale between the front and rear webs; thus, the linking yarns are passed in the form of substantially X in section and intersected at an opening portion on the mesh-structure web (2) to form a truss structure.

[0129] In otherwise, in the knitting construction as shown in **FIG. 18**, when the linking yarn guide bar (L4) forms two-needle stitch construction as shown in **FIG. 10**F and the linking yarns are knitted on every other course on the flat structure side, stretching properties are liable to be provided in the knitting structure. Since there are the linking yarns on every other course, number of loops of the linking yarns become a half, in combination with natural fiber, thus the linking yarn becomes more inconspicuous.

[0130] The double knitted fabrics knitted in such a manner may preferably be used for various uses such as sports, support, medical or nursing, outer clothing, bedclothes & accouterment, cloth for covering the chair, interior, car seat upholstery, safety belt, cushion, civil engineering or construction for afforestation stability and so forth, industrial materials, concrete reinforcing materials.

[0131] Furthermore, the present invention adopts the inlaying technique for at least one of the front or rear webs (1), (2); a width-wise inlay yarn or a knitting-direction-wise inlay yarn may be inlayed between; the traverse-wise running portion, of the linking yarns (3), connecting adjoining two-needle stitches; and the web-forming yarn, such as yarn forming stitches of the web; and inlay yarn. **FIG. 20** shows one example.

[0132] In the knitting construction illustrated in **FIG. 20**, the inlaying technique mentioned above is adopted for the double knitted fabrics in which one of the front and rear webs (1), (2) is formed by a unpatterned flat structure and the other by the mesh structure; the width-wise inlay yarn is inlayed and held between the web-forming yarn and the linking yarn (3) on the mesh structure web.

[0133] In the knitting construction, the flat structure is on the side of the guide bars (L1), (L2) and the mesh structure is on the other side of the guide bars (L6), (L7), (L8). In this case, the guide bars (L1), (L2) guide the inlay yarns and the chain stitch yarns as "yarns-fully-guided"; the guide bars (L6), (L7) guide the yarns forming the stitch as "two-in and two-out"; the guide bar (L8) guides the inlay yarns for knitting-width-wise inlaying over two wales, as "one-in and one-out"; and the linking yarn guide bar (L4) guides the linking yarns (3) as "one-in and one-out". And, the guide bar (L5), which is disposed between the guide bars (L6), (L7) on the side of the mesh structure web (2) mentioned above and the linking yarn guide bar (L4), guides inlay yarns (5*a*) for knitting-width-wise inlaying over two wales on every course, for example, as "one-in and one-out".

[0134] Hence, as shown schematically in **FIG. 21**, the inlay yarn (5*a*) of the guide bar (L5) is inlayed, without being knitted in a stitch loop, on back of the web-forming yarn (2*a*) such as the stitch forming yarn of the guide bars (L6), (L7) and the inlay yarn of the guide bar (L8); that is, the inlay yarn (5*a*) being between the web-forming yarn (2*a*) and the traverse-wise running portion (3*a*) of the linking yarn (3); and the inlay yarn (5*a*) being held by the traverse-wise running portion (3*a*) of the linking yarn (3) so as not to be got inwardly deep between the front and rear webs (1), (2). In other words, the inlay yarn may be held inside more stably than the web-forming yarn of the web itself, and the effect of inlaying the inlay yarn may be produced adequately.

[0135] For example, when the inlay yarn is knitted as "one-in and one-out", the inlay yarn is held under the condition of being inlayed on the opening side of the hollow (22); thus being good in air conductibility and also bringing on a feeling of three-dimensional structure even at the hollow (22) mentioned above. Besides, the inlay yarn (5*a*) inserted into the opening side of the hollow mentioned above may prevent dust or dirt from getting inwardly in the hollow (22) of the mesh structure. a good filtering effect.

[0136] With regards to the inlay yarn of the guide bar (L5) mentioned above, like structures as illustrated in **FIGS. 22A** or **22**B other than those mentioned above, it is possible to inlay and knit in accordance with various structures, by enlarging the knitting width or properly shifting and inlaying into adjoining wales, and so forth. Such way of inlaying may be set freely according to design or function and application, etc. Especially, as an example shown in **FIG. 22**A, it is preferably to prevent the inlay yarn inlayed between the web-forming yarn and the transverse-wise shifting portion of the linking yarn from easily being pulled out by, for example, looping the inlay yarn at every required number of courses such as at every six courses.

[0137] According to the structure shown in **FIG. 22**A, the inlay yarns are inlayed into the hollows of the mesh structure; therefore, when the elastic yarns are used as inlay yarn, the double knitted fabrics having stretch properties are brought out and may be used for extensive applications such as sports good, support, clothing, cloth for covering the chair.

[0138] Besides, when silvered flat yarns and other optical reflection yarns, luminescent yarns are used as inlay yarn (5*a*) on the guide bar (L5) getting into the hollow of the mesh structure mentioned above, it is possible to make ray of reflected light from the direction of a certain angle only visible. Furthermore, the optical reflection yarns or luminescent yarns mentioned above may be used for the linking yarns (3) knitted in two-needle stitch to bring on a luminous net fence.

[0139] Since the webs varying colors such as cross-stitch pattern may be formed on the surface depending on a combination of the inlay yarns on the guide bars (L5), (L8), not only shape of the opening portions but its color may also be varied to extend the ornamental effect all the more. For example, when the guide bar (L5) and the guide bar (L8) guide the inlay yarns of different color alternately one by one on every four wales in the structure shown in **FIGS. 22B and 23**, respectively, each inlay yarn of different color will come out of the opening portions.

[0140] In this way, various color effects, design, color variation may be brought out using the inlaying technique

mentioned above. For example, when the inlay yarns are inlayed at arbitrary points between the web-forming yarns and the traverse-wise running portions of the linking yarns, as well as the inlay yarns are interknitted with the web-forming yarns at required points, color effect of several colors and a feeling of plural materials may also be brought out.

[0141] Furthermore, the guide bar (L3) may be added between the guide bar (L2) of the web-forming yarn in the chain stitch and the linking yarn guide bar (L4) as to form the structure in **FIGS. 24A** or **24B**, on the side of the flat structure web (1) of the knitting construction in **FIG. 20** as well; then, similarly as described above, the inlay yarn (5*b*) of the guide bar (L3) is inlayed between the web-forming yarn (1*a*) and the traverse-wise running portions (3*a*) of the linking yarn (3) (**FIG. 25**).

[0142] And, for example as shown in **FIG. 24A**, when the inlay yarn of the guide bar (L3) is inlayed in the knitting direction and knitted so as to be looped at every required number of courses, inelastic yarns may be used for the inlay yarns to stop elongating in the knitting direction, or elastic yarns may be used to have the stretch properties in the knitting direction. Besides, when the inlay yarns of the guide bar (L3) are inlayed traverse-wise as shown in **FIG. 24B**, the webs (1) maybe stabilized much more. Moreover, since the inlay yarns (5*b*) are held between the web-forming yarn (1*a*) and the traverse-wise running portions (3*a*) of the linking yarn (3) and do not come forth outside as shown in **FIG. 25**, no problem arises on ornamental design or decency on the surface of the mesh fabric even if materials inferior in dyeing or coloring properties, such as aramid fiber yarn, carbon yarn, are used, as long as the web-forming yarns are superior in dyeing and coloring properties.

[0143] **FIG. 20** shows a case where one of the front and rear webs is the flat structure and the other the mesh structure; otherwise, it is also possible to form various knitting constructions by forming both the front and rear webs by corresponding mesh structure on each front and rear sides, or by forming both webs by the flat structure, etc. In these cases, in the same manner as mentioned above, not only the linking yarn may be knitted in two-needle stitch, but also the width-wise inlay yarn or knitting-direction inlay yarn may be inlayed, on at least one of the webs, between the web-forming yarn and the transverse-wise shifting portion of the linking yarn.

[0144] Besides, the linking yarns mentioned above are knitted in two-needle stitch on the front and rear webs, as the structure shown in **FIG. 26A, a** set of three guide bars (L4), (L5), (L6) are used; the linking yarns are guided by two guide bars (L4), (L6) on both sides; the inlay yarns (17) in the knitting direction are guided by the intermediate guide bar (L5); and two-needle stitches are knitted on each of the front and rear opposite sides to the position of the guide bars (L4), (L6). The inlay yarns (17) in the knitting direction are knitted by the intermediate guide bar (L5). Thus, as shown in **FIG. 26B**, the inlay yarn (17) described above may alternately be hooked around the traverse-wise running portions (3*a*) of each linking yarns (3) on the front and rear sides and inlayed there. Such structure facilitate the linking yarns (3) to be knitted in two-needle stitch; and, both front and rear webs (1). (2) to be taken close to each other by pulling the inlay yarns (17) mentioned above after knitting.

[0145] Furthermore, like the inlay yarns of the guide bar (L5) mentioned above and the inlay yarn of the guide bar (L3) and so forth, it is possible to carry out the following embodiments by making the use of the inlaying technique to inlay the width-wise inlay yarns or the knitting-direction inlay yarns between the traverse-wise running portions of the linking yarns and the web-forming yarns.

[0146] For example, as the inlay yarns between the traverse-wise running portions of the linking yarns and the web-forming yarns, functional material yarns having various functions may be used such as; having deodorization, anti-bacterial, moisture/water absorption, generation of heat, static electricity prevention, nonflammability, anti-electromagnetic wave, negative ion, conduction; then, the double knitted fabrics having these functions maybe formed easily and inexpensively. In this case, since functional material yarns are held close to the webs, its function may be exhibited properly. Moreover, since these functional material yarns may be disposed on the inside than the web-forming yarn of the web in itself, the double knitted fabrics may be prevented from directly coming in direct contact with the outside air or receiving external pressure; even if the functional material is inferior in hardwearing and weathering properties, and so forth. When the double knitted fabrics are used for applications coming into contact with human body, the functional material yarns do not come into contact with the body, accordingly bringing no problems such as damage from chemicals or dirt. Especially, when outside of the inlay yarn of the functional material is covered by the web-forming yarns of the web itself and the inlay yarns of the flat structure, and so forth, the effect mentioned above is produced more significantly; and durability of the functional material becomes good.

[0147] Besides, even if the materials inferior in hardwearing properties or touch are used, such as a case of using the stretch yarn, elastic yarn, high shrinkable yarn, and so forth, as an inlay yarn between the transverse-wise shifting portion of the linking yarns and the web-forming yarns or as an inlay yarn in the knitting direction; the touch on the surface of the mesh fabrics may also be improved and the function of the inlay yarns made of the functional material may be kept properly; when using yarns made of material with good touch, soft and flexible yarns, such as a natural fiber or a multifilament yarn, as a chain stitch yarn located outside of these materials or a proper web-forming yarn such as an inlay yarn.

[0148] Furthermore, even if the materials inferior in tinting, that is, dyeing and coloring properties such as monofilament yarn, conductive yarn, carbon yarn, aramid fiber yarn, phenolic fiber yarn are used as the inlay yarn, dyeing or coloring properties on the surface of the mesh fabric will be improved; as long as the materials superior in dyeing and coloring properties such as polyester or nylon are used as a web-forming yarn outside of these materials. Namely, without impairing dyeing properties and so forth, functional effect will be produced using the yarns made of functional materials.

[0149] Moreover, when the stretch yarn and the elastic yarn are disposed as an inlay yarn located inside mentioned above, or when non-stretch yarn such as polyester multifilament yarn are disposed as web-forming yarn located outside, or when being fabricated with its disposition opposite to

those mentioned above, the double knitted fabric in which stretch and non-stretch properties coexist may be obtained. This double knitted fabric may preferably be used as clothing, cloth for covering the chair, interior materials, bedclothes and accouterment materials.

[0150] Besides, when the stretch yarn such as polytrimethylene terephthalate yarn is inlayed between the transverse-wise shifting portion of the linking yarn knitted in two-needle stitch and the web-forming yarn on the front and rear webs of the double knitted fabrics as width-wise inlay yarn by making the use of the inlaying technique mentioned above, heat setting due to expanding will be carried out easily after knitting.

[0151] That is, since the width-wise inlay yarn on the front and rear webs of normal double knitted fabrics are inlayed into the base knitting structure of the webs relatively firmly, it is hard to be slipped in spite of the inlay yarn, accordingly tentering will not be done easily by expanding operation. However, the inlay yarns inlayed between the web-forming yarns and the traverse-wise running portions of the linking yarns are easy to be slipped because of getting into the back of the webs, and tentering is also easy to be carried out by expanding operation. Especially, in a case where both the front and rear webs are formed by the mesh structure or the net structure such as substantially rhomb or substantially hexagon, while being overfed and inlayed at the mesh openings, when expanding operation is carried out after knitting, its fabric width becomes larger than the knitting width, and the double knitted fabrics with larger fabric width may be produced economically efficiently. This also brings out the fabrics with good stretch properties.

[0152] Furthermore, if there occurs operating inconvenience that an opening at the mesh opening on the front and rear webs is too large to be sewn by a sewing machine, the opening shall be blocked by the inlay yarn mentioned above to avoid such inconvenience.

[0153] The inside inlay yarn described above may be supported by the linking yarn from back to face or, in otherwise, may only be passed around the linking yarn depending on insertion form; thus, the position inlayed by the inlay yarn may be set appropriately by combining these cases properly. For example, the hollow in which the inlay yarn is inlayed and the hollow in which the inlay yarn is not inlayed may be combined by one s discretion.

[0154] Furthermore, by making the use of two-needle stitch technology, the linking yarns mentioned above may be knitted in two-needle stitch on one of the front and rear webs, and on the other side the linking yarns maybe in an inlayed structure.

[0155] For example, as shown in **FIG. 27A, a** set of two guide bars (L4), (L5) are used as linking yarn guide bar; linking yarns (3) are guided on guide bars (L4), (L5) in a manner that linking yarns (3) on first guide bar (L4) are passed through needles on front side of the first guide bar (L4) while linking yarns (3) on second guide bar (L5) are passed through needles on rear side of the second guide bar (L5); and knitting being made in two-needle stitch on the front and rear webs (1), (2), respectively. Thereby, as shown schematically in **FIG. 27**B, the linking yarns (3) of both guide bars (L4), (L5) maybe passed, in their inlayed structure, round the traverse-wise running portions (3*a*) knitted in two-needle stitch of the other linking yarns, mutually on other side. This results in double knitted fabrics in which two-needle stitch and insertion structure coexist.

[0156] Besides, by making the use of the two-needle stitch structure of the linking yarns (3) mentioned above, the mesh fabrics may be knitted according to the marquisette-like or in the form of tulle on at least one of the front and rear webs. The mesh fabrics may also be knitted by making the use of the inlaying technique.

[0157] For example, while guiding each yarn through the inlay yarn guide bar (L6) and the linking yarn guide bar (L4) as "one-in and one-out" in the knitting construction as shown in **FIG. 5**, knitting operation is repeated by shifting the linking yarn guide bar (L4) to adjoining wale at every required number of courses and returning to its original wale: thereby, for example, quadrangular mesh may be formed on the rear web (2) in FIGS. **1** to **3** to fabricate the marquisette-like fabrics. Accordingly, two stitch rows may be joined strongly and hard to come untied, and the linking yarns are difficult to come from the surface of the webs, thus bringing out proper touch and decency on the surface of the mesh fabrics.

[0158] Besides, it is also possible to form the knitting construction as shown in **FIG. 28**, as the marquisette-like double knitted fabrics mentioned above.

[0159] In this embodiment, the chain stitch yarn guide bar (L3) or (L6) and the inlay yarn guide bars (L1). (L2), or (L7), (L8) are used as "yarns-fully-guided" at each guide bars. On at least one of the front and rear webs, for example, on both webs (1), (2), the inlay yarn guide bars (L1), (L2), (L7), (L8) are width-wise shifted by one or several rows of wales for inlaying the inlaying yarns alternately rightward and leftward on every plural courses, into the chain stitch wales extending in the knitting direction; so as to form the quadrangular mesh marquisette-like knitting construction. Especially, in this case, on both the front and rear webs (1), (2), either the inlay yarn guide bar (L1) or (L7) and (L2) or (L8) are shifted for inlaying in the opposite direction to each other at every required number of courses, allowing two kinds of inlay yarns to be inlayed in the form of cross.

[0160] Hence, the inlay yarns adjoining in the front and rear webs (1), (2) may securely be in contact with each other.

[0161] Besides, in the knitting construction mentioned above, as shown in **FIG. 28**, two kinds of linking yarns (3) linking the front and rear webs (1), (2) are guided by two guide bars (L4), (L5); at the course corresponding to the width-wise inlaying of the inlay yarns, the linking yarns may be shifted in the opposite direction with each other and passed obliquely between the front and rear webs (1), (2); then knitted In two-needle stitch on the front and rear webs (1), (2), respectively. By knitting in this manner, the linking yarns will form the marquisette-like construction not only on at least one of the front and rear webs but also inside the intermediate layer.

[0162] Hence, being width-wise inlayed into the marquisette-like webs, the inlay yarns are held by the two-needle-stitch of the linking yarns to prevent width-wise inlayed portion from slipping, allowing quadrangular openings on the marquisette-like knitting construction to be stabilized by means of holding action of the linking yarns. Moreover, yarn of conductive material or high strength yarn such as carbon

or aramid may be used as an inlay yarn on the marquisette-like knitting construction; even if such yarns are used, economical efficiency is ensured.

[0163] The inlay yarns out of the web-forming yarns on the front and rear webs may be width-wise inlayed so as to be intersected at the required course position, as shifting of the inlay yarn guide bars (L1), (L2) or (L7), (L8). In such a case, for example, problem for ornamental tinting is solved; when fiber yarns easy to be dyed such as nylon or polyester are used for the inlay yarn guide bars (L1), (L8); and fiber yarns hard to be dyed such as carbon, aramid or conductive fibers are used for the inlay yarn guide bars (L2), (L7). As for yarns inferior of resistance to light, hardwearing properties, and so forth, such yarn are used for one of the inlay yarn guide bars (L2), (7) in the knitting, as to be inlayed inside of the webs. In this case, if the inlay yarns on the inlay yarn guide bars (L2), (L7) are inlayed on the rear side of the web-forming yarn, as in the inlaying technique of the guide bar (L5) of **FIG. 20**, it is more effectively carried out.

[0164] Furthermore, when the conductive material yarns are used for the inlay yarn guide bars (L2), (L7), all inlay yarn guide bars (L2), (L7) are width-wise shifted by two needle or more, that is, two wales or more, like the knitting construction in **FIG. 28**, to securely join and bring contact with adjoining inlay yarns. In this case, the yarns of the other inlay yarn guide bars (L1), (L8) shall be knitted so as to be intersected against the inlay yarn guide bars (L2), (L7), thus heightening the effect of the yarn of the inlay yarn guide bars (L2), (L7). When the conductive material is further used for the linking yarns of two linking yarn guide bars (L4), (L5), it becomes much more effective.

[0165] The double knitted fabrics may be used for electromagnetic wave shield, for example, curtain, shielding apron, shielding material for building, shielding material for electric appliance, conductive gasket having cushioning properties, and so forth. Besides, the double knitted fabrics for accessories materials or thin-width tapes may be formed.

[0166] The double knitted fabrics may be constructed by plane and mesh structure, or marquisette-like construction, as well as vertically-striped and checkered or zigzag pattern.

[0167] For example, in the structure shown in **FIG. 29**A, inlaying technique of inlaying width-wise inlaying yarn (15) between the web-forming yarn and the traverse-wise running portions (3*a*) of the linking yarns (3) is adopted by using the guide bar (L5) between the linking yarn guide bar (L4) and the web-forming guide bars (L6), (L7); thus, the ridge-shaped web elements (11*a*) in the knitting direction, which are made up of the stitch rows of two wales or more jointed by the two-needle stitch of the linking yarns (3), on at least one of the webs (2), are linked by width-wise inlay yarn (15) on the guide bar (L5) at required intervals, so as to form vertically-striped knitting construction.

[0168] Besides, as against the web elements (11*a*) knitted in two-needle stitch of the linking yarns (3), the linking portions width-wise knitted by the inlay yarns (15) may be arranged to form the checkered pattern as shown in **FIG. 30** or the zigzag pattern in **FIG. 31**.

[0169] In addition, when two or more kinds of yarns of different materials and characteristics are used for the linking yarns (3) to form the double knitted fabrics (A) of each embodiment described above. the surface of the double knitted fabrics (A) may be made uneven or compressive strength may be controlled. Moreover, when different length of the pass-between portions of the linking yarns is used between the front and rear webs, the surface of the double knitted fabrics may also be made uneven or compressive strength may be controlled. In these cases, the double knitted fabrics having unique appearance and touch may be obtained, in addition to the features described above. Furthermore, it is also possible to comprise one of the front and rear webs (for example, rear web), only by the two-needle stitch construction of the linking yarns, depending on the uses and so forth.

[0170] Besides, after knitting the linking yarns (3) in two-needle stitch so that there exists a mesh opening (12) partially or all over the surface, the linking yarns (3) may be slipped or elongated by means of expanding action during heat setting, and mesh shape or the height of the linking yarns (3) are varied, so that a pattern by means of fabric design or uneven pattern may be made on the surface of the double knitted fabrics (A).

[0171] Furthermore, with regards to the web-forming yarns forming the stitches such as chain stitch yarns on one of the front and rear webs (1) or (2), a plurality of web-forming yarns may be arranged, so that the knitting loop portions of the linking yarns (3) hardly come out of the surface; that is, the knitting loops of the web-forming yarns are laid on top of the knitting loops of the linking yarns. In this case, tension of the chain stitch yarns is raised, the knitting loops of the linking yarns will be prevented from being jutted forth much more effectively.

[0172] Furthermore, the double knitted fabrics (A) mentioned above may be knitted so that the web-forming yarns are jutted forth out of the surface of the mesh fabrics; then, when the web-forming yarns are further raised or sheared, raised surface made up of the web-forming yarns only may be obtained; thus high quality double knitted fabrics are obtained.

[0173] Furthermore, with respect to at least one of the front and rear webs (1), (2) of the double knitted fabrics (A), as shown in **FIG. 32**, knitting may be made In such a manner that the base layer of the web (10*a*) is overlaid with the outermost layer (10*b*) that is formed by the knitting yarns forming ornamental surface or functional surface. Thereby, various functional yarns or those yarns with flexible and a feeling of soft may be used for the outermost layer (10*b*); then these yarns come out of the surface, allowing the functionality of the yarns to be exhibited adequately.

[0174] In the case described above, for example, yarns such as polyester multifilament yarn, having strong tension enough to form the double knitted fabrics, may be used as web-forming yarn at the base layer (10*a*) to firmly tighten two stitches knitted in two-needle stitch of the linking yarns; then, the linking yarns are firmly knitted into the webs to be integrated into one piece; thus allowing stability and the effect of preventing the linking yarns from jetting forth to be heightened. On the other hand, when a cotton yarn or a functional material yarn is used for the outermost layer (10*b*) formed as ornamental surface or functional surface and knitted softly in the knitting construction in which these yarns are liable to be jutted forth out of the outermost layer, good feeling may be obtained on the surface of the mesh fabrics.

[0175] In any cases of the embodiments described above, the amount of supply of the chain stitch yarns or inlay yarns, the number of courses corresponding to a mesh or knitting construction may be varied, at every course by one's discretion, with respect to at least one of the front and rear webs. In such arrangement, the fabric that is partially different in elasticity or tentering, in other words, in the cushioning effect or mesh fabric's resiliency may be fabricated.

[0176] In the double knitted fabrics (A) of each embodiment mentioned above, constituent yarns for the front and rear webs (1), (2), that is, the web-forming yarns such as chain knitting yarns or inlay yarns, are not particularly limited, whereas the types of yarn may be selected appropriately according to the applications, various types of natural fiber yarns such as wool or cotton, cuprammonium rayon, or synthetic fiber yarns such as nylon yarns, polyester yarns, polypropylene yarns, or carbon fiber yarns, other various multifilament yarns, or processed yarns or paralleled yarns thereof, synthetic fiber yarns such as synthetic fiber spun yarns may be used. Further, union fiber yarns may also be used.

[0177] Particularly, when at least the outermost side on the front web (1) the web-forming yarns comprises flexible and good touch multi-fiber yarns such as synthetic fiber and process yarn thereof, spun yarn of natural fiber, multifilament yarn, flexibility of the surface of the web (1) may be increased, the linking yarns (3) made up of the monofilament yarns may be prevented from jutting forth, as well as extreme soft touch and texture may also be obtained.

[0178] In this case, because of retaining compressive strength and proper cushioning properties, the double knitted fabrics may preferably be used for various applications requiring a feeling of soft, for example, nursing and medical supplies, bedclothes and accouterment, cushioning material, mat material, or spacers for sports and clothing.

[0179] Besides, there may be used, as web-forming yarn on at least one of the front and rear webs (1), (2), for example, on the front web (1)—water absorbable yarns coated with high water absorbable resin by means of coating, or dipping; functional yarns provided with special functions by being adhered with or kneaded with metal such as iron, mineral, antibacterial agent, mildewproofing agent, or some other chemicals, or fungi; functional yarns having at least one kind of functions such as high water absorbable hygroscopicity, antibacterial properties, mildew resistance, deodorizing properties, antistatic function; accordingly, desired function maybe used depending on applications. For example, water absorbable hygroscopic material may be used on the rear side, and good touch material such as cotton may be used on the front side.

[0180] It is also possible to use heat contractive yarn, heat fusible yarn or elastic yarn for a part or the entire portion of constituent yarn and/or the linking yarns (3) for at least one of the front and rear webs (1), (2). Accordingly, due to contraction or fusing of the mesh fabrics, for example, the stitch knitted by the stitch forming yarn of the web (1) contracts or fuses, thus shape retainability and dimensional stability becomes much more good. Furthermore, different kinds of yarns having different processing effect on properties such as rigidity or flexibility, color, material, texture, or dyeing, etc. may be used for the constituent yarns of the front and rear webs (1), (2), thus a net structure with different appearance and properties on the front and rear sides may be obtained.

[0181] In addition, when polytrimethylene terephthalate yarns are used for constituent yarns and linking yarns (3) on the front and rear webs (1), (2), various double knitted fabrics superior in soft, elasticity, cushioning properties, for example, double knitted fabrics in which the front and rear webs are made of plain stitch construction, or double knitted fabric in which at least one of the front and rear webs is made of mesh structure, maybe obtained. This double knitted fabrics may preferably be used especially for a thin width tape or a string and so forth for dress and its ornaments as having soft and elasticity.

[0182] Moreover, if a monofilament yarn of synthetic fiber is used as a linking yarn (3) mentioned above, it may be used as a single yarn, as well as a plurality of paralleled yarns. An elastic yarn, a multifilament yarn, a spun yarn, and a combination thereof may be selected to be a linking yarn (3), according to desired object.

[0183] The thickness or material of these lines of yarn are determined considering its strength, tensile strength and elasticity required for its usage. For example, as regards cushioning materials, mat materials, or industrial materials such as seat cushioning materials for various vehicles; when it is to be knitted with 18 to 6 gauge (the number of needles/inch) by double Raschel machine; yarns of 20 to 10000 deniers, preferably of 20 to 2000 deniers are suitably used for the front and rear webs; and yarns of 20 to 10000 deniers, preferably of 30 to 5000 deniers are suitably used for linking yarn. Naturally, yarns thinner than yarns mentioned above may be used with finer gauge such as 28-22 gauges. While when it is desired to increase the physical strength, yarns thicker than yarns mentioned above may be used with 4.5-3 gauges, or yarns of different sectional shape having desired function may be used. It is also possible to use yarns of different thickness for the front and rear webs; strength of the webs may further be raised, and stability and cushioning properties of three-dimensional structure may also be enhanced.

[0184] The thickness of the double knitted fabrics (A) of the present invention or the size of mesh opening (12) of at least one of the mesh structure web (1) varies depending on the application thereof. When it is used as various cushioning materials, or mat materials, the fabric of the thickness of 0.1 to 100 mm, the diameter of the mesh opening (12) of 1 to 100 mm are generally used. Of course, an embodiment outside these ranges is possible. For example, when it is used for clothing such as spacer, medical or nursing purposes, the smaller dimension may be employed.

[0185] The double knitted fabrics (A) mentioned above may preferably be used for various purposes, for example, as shown below by utilizing the structural properties described above.

[0186] It is used for cloths or clothing related items such as sashes, bands, bandages, tapes, supports, protectors, caps, bags, attaché cases, rucksacks, spacers for clothing, shoulder pads, and outer wears; foot wears such as slippers, shoes, insole, sandals or the like; cushioning materials or core materials such as carpets, entrance mats, anti-friction mats, helmets or the like. In addition, it is used as core materials

or surface materials for bed items or furniture such as mats for beds, pillows, sheets, covers, blankets, sofas, chair coverings; as seat materials or seat cover for motor vehicles, soft cushions, air-permeable interior material, saddle cover for auto bicycles or bicycles; as curtains or partitions for acoustical insulation, air ventilation or hiding; light blocking nets, anti-dazzle nets, anti-insect nets, electromagnet or static electricity preventing nets, or conductive nets, or cushioning materials for transportation. It is also used as industrial materials such as base materials for non-woven cloths, washing nets, anti-slippage materials, various filters or spacers; reinforcing material for resin and foamed concrete, reinforcing material for various boards such as lightweight boards and the other industrial reinforcing materials or core materials. Besides, it is used as various cushioning materials for sports and industrial purposes. In addition, it may also be used as protective materials or water retaining material for civil engineering, bank protection, or afforestation, nets for agricultural use, draining material, stabilizing sheet material for civil engineering, air-permeable safety net, and so on.

[0187] Besides, the double knitted fabrics (A) of the present invention may be used in combination with other materials. Especially, in case of the double knitted fabrics where at least one of the front and rear webs forms the mesh structure and the linking yarns are passed in the form of substantially V-shaped or inversed V-shaped or substantially X-shaped, foams, its recycled materials, plated materials such as woven fabric, mesh fabric, nonwoven fabric, mesh-shaped material, film-shaped material, sheet-shaped material, polyurethane foam may be laid on top of at least one of the front and rear webs and used as composite material. In this case, the double knitted fabrics may be contact with other materials face to face, therefore compressive strength or shape retainability may be enhanced as joining strength of composite materials.

[0188] For example, since nonwoven fabric has flexibility but is deficient in compressive strength, it is liable to be permanently compressed or deformed by fatigue. However, when nonwoven fabric is laid on top of the double knitted fabrics, it combines compressive strength and elasticity provided by the double knitted fabrics with cushioning and flexible properties of nonwoven fabric itself.

## Industrial Applicability

[0189] As is described thus far, the double knitted fabrics of the present invention may preferably be used for various applications such as afforestation, construction/civil engineering, interior, bedclothes and accouterment, clothing, medical treatment and nursing, industrial materials, and so forth by making the use of structural properties described above, that is, by holding touch and texture of a material of a web-forming yarn due to prevention of a linking yarn, knitted in two-needle stitch on at least one of the front and rear webs, from jutting forth, by preventing rubbing sound from producing, by keeping compressive strength, elastic force in the direction of thickness or cushioning properties, and by making the use of lightweight, void retention, variations of mesh or web in the knitting construction on the front and rear side, independently or in combination with other materials.

**1**. A double knitted fabric made by warp knitting comprising of front and rear webs and linking yarns connecting the front and rear webs, wherein the linking yarns are knitted in two-needle stitch on at least one of the front and rear webs.

**2**. The double knitted fabric according to claim 1, wherein yarns constituting at least a part of the front and rear webs are knitted in two-needle stitch.

**3**. A double knitted fabric made by warp knitting comprising of front and rear webs and linking yarns connecting the front and rear webs, wherein the linking yarns are knitted by a knitting construction in which two-needle stitch and one-needle stitch are combined, on at least one of the front and rear webs.

**4**. The double knitted fabric according to claim 3, wherein yarns constituting at least a part of the front and rear webs are knitted in two-needle stitch.

**5**. The double knitted fabric according to any one of claims **1** through **4**, wherein at least one of the front and rear webs is knitted by a mesh construction in which mesh openings are defined by web elements, in appearance of braids, comprising of one or a plurality of wales of stitch rows; the linking yarns being in two-needle stitch at any points on web elements.

**6**. The double knitted fabric according to claim 5, wherein the web elements in appearance of the braids defining the mesh openings comprises of two wales or more of stitch rows; and the linking yarns being in two-needle stitch within respective web element so as to join the adjoining stitch rows within the web element.

**7**. The double knitted fabric according to claim 5, wherein the linking yarns being in two-needle stitch at joints of adjoining web elements so as to join the adjoining two of the web elements.

**8**. The double knitted fabric according to anyone of claims **1** through **4**, wherein on at least one of the front or rear webs, a width-wise inlay yarn or a knitting-direction-wise inlay yarn is inlayed between a web-forming yarn and a traverse-wise running portion of the linking yarn; said traverse-wise running portion being between adjoining stitches in two-needle stitch of the linking yarn.

**9**. The double knitted fabric according to claim 5, wherein on at least one of the front or rear webs, a width-wise inlay yarn or a knitting-direction-wise inlay yarn is inlayed between a web-forming yarn and a traverse-wise running portion of the linking yarn; said traverse-wise running portion being between adjoining stitches in two-needle stitch of the linking yarn.

**10**. The double knitted fabric according to claim 8, wherein a yarn made of a material of poor hardwearing properties or touch or a material of poor dyeing properties or color development properties is inlayed as a width-wise or a knitting-direction-wise inlay yarn to be inlayed between the web-forming yarn and the traverse-wise running portion of the linking yarn; and a yarn of good hardwearing properties or good touch or a material of good dyeing properties or color development properties is used as the web-forming yarn located outside of such inlayed yarn.

**11**. The double knitted fabric according to claim 9, wherein a yarn made of a material of poor hardwearing properties or touch or a material of poor dyeing properties or color development properties is inlayed as a width-wise or a knitting-direction-wise inlay yarn to be inlayed between the web-forming yarn and the traverse-wise running portion

of the linking yarn; and a yarn of good hardwearing properties or good touch or a material of good dyeing properties or color development properties is used as the web-forming yarn located outside of such inlayed yarn.

**12**. The double knitted fabric according to claim 8, wherein the linking yarns being knitted in two-needle stitch on both of the front and rear webs; the knitting-direction-wise inlay yarn is inlayed between the web-forming yarn and the traverse-wise running portion of the linking yarn on each of the front and rear webs, so as to be passed between the front and rear webs.

**13**. The double knitted fabric according to claim 9, wherein the linking yarns being knitted in two-needle stitch on both of the front and rear webs; the knitting-direction-wise inlay yarn is inlayed between the web-forming yarn and the traverse-wise running portion of the linking yarn on each of the front and rear webs, so as to be passed between the front and rear webs.

**14**. The double knitted fabric according to anyone of claims **1** through **15**, wherein the linking yarn knitted in two-needle stitch on at least one of the front and rear webs shifts right and left from opposite wale by one wale or more, at a required course position, when passing between the front and rear webs so as to be obliquely passed; thereby, such obliquely passed portions are inclined from thickness-wise direction so as to be substantially X-shaped, substantially V-shaped or inversed V-shaped, substantially U-shaped or inversed U-shaped, and so forth, as viewed in cross section, after knitting.

**15**. The double knitted fabric according to anyone of claims **1** through **13**, wherein the linking yarns linking the front and rear webs are alternately knitted by two guide bars, between the front and rear webs, so as to provide two kinds of passing; one of the passing being substantially vertical to surfaces of the webs, and the other of the passing being with an inclined angle.

**16**. The double knitted fabric according to anyone of claims **1** through **15**, wherein two kinds or more of yarns with different material or properties are used as the linking yarns, so that compressive strength is undulated or unevenness is provided on surfaces of the front and rear webs.

**17**. The double knitted fabric according to anyone of claims **1** through **16**, wherein the linking yarn is knitted with different length of pass-between portion of the linking yarn between the front and rear webs, so that compressive strength is undulated or unevenness is provided on surfaces of the front and rear webs.

**18**. The double knitted fabric according to anyone of claims **1** through **17**, wherein web-forming yarns of at least one of the front and rear webs is jutted forth out of external surface of the webs; and the web-forming yarn jutted out of the external surface is raised and sheared.

**19**. The double knitted fabric according to anyone of claims **1** through **18**, wherein at least one of the front and rear webs is knitted as marquisette tone by two-needle stitches of the linking yarns.

**20**. The double knitted fabric according to anyone of claims **19**, wherein at least one of the front and rear webs is knitted in marquisette-tone knitting construction formed of stitch rows of chain stitch yarns extending in knitting direction, as well as of width-wise inlay yarns that are inlayed into said stitch rows as shifted by wales of one or several rows laterally at every plural number of courses; and

the linking yarns linking the front and rear webs are knitted by two guide bars and shifted in opposite direction with each other by the two guide bars, as to be knitted in two-needle stitch on each of the front and rear webs, at a course portion substantially corresponding to the traverse-wise running portion of the inlay yarn.

**21**. The double knitted fabric according to anyone of claims **1** through **19**, wherein, with respect to at least one of the front and rear webs, abase layer formed of web-forming yarn is overlaid with an outermost layer formed of knitting yarns forming ornamental surface or functional surface or the like.

**22**. The double knitted fabric according to claim 21, wherein at least one kind of yarns such as multifilament yarns, elastic yarns, spun yarns, natural yarns is used as a knitting yarn to form the outermost layer of at least one of the front and rear webs.

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