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(54) A mineral fiber-insulated plate

(57) A method of producing a mineral fiber-insulating web comprises the steps of firstly producing a first non-wowen mineral fiber web. The first mineral fiber web contains mineral fibers arranged generally in the longitudinal direction of the mineral fiber web. Secondly, the first mineral fiber web is moved in the longitudinal direction of the web and folded parallel with the longitudinal direction and perpendicular to the transversal direction of the first mineral fiber web, so as to produce a second mineral fiber web comprising a central body and opposite surface layers sandwiching the central body, which central body contains mineral fibers arranged generally perpendicular to the longitudinal and transversal directions of the second mineral fiber web and which surface layers contain mineral fibers arranged generally in the transversal direction of the second mineral fiber web. Thirdly, a third non-wowen mineral fiber web being a mineral fiber web of a higher compactness as compared to the second mineral fiber web is produced and adjoin in facial contact with the second mineral fiber web for producing a fourth composite mineral fiber web which is thereupon cured. The method also optionally includes longitudinally compressing and/or transversally compressing the second mineral fiber web. The composite mineral fiber web may additionally be combined with additional mineral fiber webs or coverings for producing a composite mineral fiber web product which is cured in a single curing process.

Description

[0001] The present invention generally relates to the technical field of mineral fiber-insulating plates. Mineral fibers generally comprise fibers such as rockwool fibers, glass fibers, etc. More precisely, the present invention relates to novel mineral fiber-insulating plates. The mineral fiber-insulating plates according to the present invention exhibit advantageous characteristics as to mechanical performance, such as modulus of elasticity and strength, low weight and good thermal-insulating property.

[0002] Mineral fiber-insulating webs are normally hitherto produced as homogeneous webs, i.e. webs in which the mineral fibers of which the mineral fiber-insulating web is composed, are generally orientated in a single predominant orientation which is mostly determined by the orientation of the production line on which the mineral fiber-insulating web is produced and transmitted during the process of producing the mineral fiber-insulating web. The product made from a homogeneous mineral fiber-insulating web exhibits characteristics which are determined by the integrity of the mineral fiber-insulating web and which are predominantly determined by the binding of the mineral fibers within the mineral fiber-insulating plate produced from the mineral fiber-insulating web, and further predominantly determined by the area weight and density of the mineral fibers of the mineral fiber-insulating plate.

[0003] The advantageous characteristics of mineral fiber-insulating plates of a different structure has to some extent already been realized as techniques for the production of mineral fiber-insulating plates in which the mineral fibers are orientated in an overall orientation different from the orientation determined by the production line, has been devised, vide Published International Patent Application, International Application No. PCT/ DK91/ 00383, International Publication No. WO92/10602, US patent No. 4, 950, 355, Swedish patent No. 441,764, US patent No. 2,546,230 and US patent No. 3,493,452. Reference is made to the above patent applications and patents.

[0004] From the above published international patent application, International Publication No. WO92/ 10602, a method of producing an insulating mineral fiber plate composed of interconnected rod-shaped mineral fiber elements is known. The method includes cutting a continuous mineral fiber web in the longitudinal direction thereof in order to form lamellae, cutting the lamellae into desired lengths, turning the lamellae 90° about the longitudinal axis and bonding the lamellae together for forming the plate. The method also includes a step of curing the continuous mineral fiber web, or alternatively the plate composed of the individual lengths of lamellae bonded together for the formation of the plate.

[0005] From Swedish patent No. 441,764, a technique of producing mineral fiber boards or plates composed of rod-shaped elements is known, which technique is similar to the technique described in the above mentioned international patent application. Thus, according to the technique described in the above Swedish patent, a web of a mineral fiber material is cut into rod-shaped elements of a specific length which are thereupon turned and reassembled into a composite rod-shaped mineral fiber plate structure in which the rod-shaped elements are glued together by means of strands of bonding material which are introduced into through-going apertures of the composite rod-shaped mineral fiber plate structure in a separate production step.

[0006] From US patent No. 2,546,230, a technique of producing mineral fiber boards or plates composed of rod-shaped elements are known. Thus, the technique described in US patent No. 2,546,230 is very much similar to the techniques known from the above-mentioned international patent application and the above-mentioned Swedish patent and involves a separate step of bonding the rod-shaped lamellae together by means of an appropriate bonding agent.

[0007] From US patent No. 3,493,452, a method of producing a fibrous sheet structure including filaments or fibers of a polymeric material such as polyethylene trephtalate or polyhexamethyleaditamide is known. The method includes producing the polymeric material filaments or fibers by means of a carting machine from a supply of filaments or fibers constituted by a porous resilient batt of filaments or fibers, collecting the polymeric material filaments or fibers on a belt for the formation of a continuous web of polymeric material filaments or fibers, compressing the web, cutting the web into a series of parallel fiber strips including polymeric material filaments or fibers and turning the fiber strips 90° about the longitudinal axis and adjoining the strips together as the strips are caused to effect unification solely through the release of a compression effect which has been applied to the strips during the process of turning the strips. The web produced in accordance with the technique described in the above US patent is suitable for manufacturing fabrics such as carpets, blankets, bed spreads, bathrobes etc.

[0008] A particular advantage of the present invention relates to the novel mineral fiber-insulating plate according to the present invention which as compared to prior art mineral fiber-insulating plates contains less mineral fibers and is consequently less costly than the prior art mineral fiber-insulating plates, still exhibiting advantages as compared to the prior art mineral fiber-insulating plates relating to mechanical performance and thermal-insulating properties.

[0009] A particular feature of the present invention relates to the fact that the novel mineral fiber-insulating plate according to the present invention is produceable from less mineral fibers or less material as compared to the prior art mineral fiber-insulating plate still providing the same properties as the prior art mineral fiber-insulating plate regarding mechanical performance and thermal-insulating properties, thus, providing a more lightweight and more compact mineral fiber-insulating plate product as compared to the prior art mineral fiber-insulating plate product reducing transport, storage and handling costs.

[0010] The above above advantage and the above features together with numerous other advantages and features is obtained by means of a mineral fiber-insulating plate according to the present invention, which mineral fiber-insulating plate defines a longitudinal direction and comprises:

a central body containing mineral fibers,
a surface layer containing mineral fibers, the central body and the surface layer being adjoined in facial contact with one another,
the mineral fibers of the central body being arranged generally perpendicularly to the longitudinal direction and perpendicularly to the surface layer,
the mineral fibers of the surface layer being arranged generally in a direction parallel with the longitudinal direction,
the surface layer being of a higher compactness as compared to the central body, and
the mineral fibers of the central body and the mineral fibers of the surface layer being bonded together in an integral structure solely through cured bonding agents cured in a single curing process and initially present in uncured, non-woven mineral fiber webs from which the central body and the surface layer are produced.

[0011] The mineral fiber-insulating plate according to the present invention preferably comprises opposite surface layers of similar structure sandwiching the central body in the integral structure of the mineral fiber-insulating plate.
[0012] The present invention will now be further described with reference to the drawings, in which

Fig. 1 is a schematic and perspective view illustrating a first production step of producing a mineral fiber-insulating web from a mineral fiber forming melt,
Fig. 2 is a schematic and perspective view illustrating a production step of compacting a mineral fiber-insulating web,
Figs. 3, 4, 5 and 6 are schematic and perspective views illustrating four alternative techniques of folding a mineral fiber-insulating web parallel with the longitudinal direction of the mineral fiber-insulating web,
Fig. 7 is a schematic and perspective view illustrating a production step of separating a surface layer of the folded mineral fiber-insulating web produced in accordance with the techniques disclosed in Figs. 3-6, and a production step of compacting the surface layer,
Fig. 8 is a schematic and perspective view illustrating a production step of transversely compressing a mineral fiber-insulating web produced in the production step shown in Fig. 7,
Fig. 9 is a schematic and perspective view illustrating the production step of adjoining a surface layer, preferably a compacted surface layer to a mineral fiber-insulating web, or preferably a remaining part of a mineral fiber-insulating web produced in accordance with the techniques disclosed in Figs. 3-6, and from which a surface layer has been separated in accordance with the technique disclosed in Fig. 7,
Fig. 10 is a schematic and perspective view illustrating a production step of curing a mineral fiber-insulating web and a production step of separating the cured mineral fiber-insulating web into plate segments,
Fig. 11 is a schematic, sectional and perspective view illustrating the folded mineral fiber-insulating web produced in accordance with the techniques disclosed in Figs. 3-6,
Fig. 12 is a schematic and perspective view illustrating a first embodiment of a mineral fiber-insulating plate segment produced in accordance with the techniques disclosed in Figs. 1-10,
Fig. 13 is a schematic and perspective view illustrating a second embodiment of a mineral fiber-insulating plate segment produced in accordance with the techniques disclosed in Figs. 1-10,
Figs. 14 and 15 are diagrammatic views illustrating production parameters of an online production plant producing general building-insulating plates from a mineral fiber-insulating web produced in accordance with the teachings of the present invention, and
Figs. 16 and 17 are diagrammatic views similar to the views of Figs. 14 and 15, respectively, illustrating production parameters of an online production plant producing mineral fiber heat-insulating roofing plates from a mineral fiber-insulating web produced in accordance with the teachings of the present invention.

[0013] In Fig. 1, a first step of producing a mineral fiber-insulating web is disclosed. The first step involve the formation of mineral fibers from a mineral fiber forming melt which is produced in a furnace 30 and which is supplied from a spout 32 of the furnace 30 to a total of four rapidly rotating spinning-wheels 34 to which the mineral fiber forming melt is supplied as a mineral fiber forming melt stream 36. As the mineral fiber forming melt stream 36 is supplied to the spinning-wheels 34 in a radial direction relative thereto, a cooling gas stream is simultaneously supplied to the rapidly rotating spinning-wheels 34 in the axial direction thereof causing the formation of individual mineral fibers which are expelled or sprayed from the rapidly rotating spinning-wheels 34 as indicated by the reference numeral 38. The mineral fiber spray 38 is collected on a continuously operated first conveyer belt 42 forming a primary mineral fiber-insulating web 40. A heat-curable bonding agent is also added to the primary mineral fiber-insulating web 40 either directly to the primary mineral fiber-insulating web 40 or at the stage of expelling the mineral fibers from the spinning-wheels 34, i.e. at the stage of forming the individual mineral fibers. The first conveyer belt 42 is, as is evident from Fig. 1, composed of two conveyer belt sections. A first conveyer belt section which is sloping relative to the horizontal direction and relative to a second substantially horizontal conveyer belt section. The first section constitutes a collector section, whereas the second section constitutes a transport section by means of which the primary mineral fiber-insulating web 40 is transferred to a second and a third continuously operated conveyer belt designated the reference numeral 44 and 46, respectively, which are operated in synchronism with the first conveyer belt 42 sandwiching the primary mineral fiber-insulating web 40 between two adjacent surfaces of the second and third conveyer belts 44 and 46, respectively.

[0014] The second and third conveyer belts 44 and 46, respectively, communicate with a fourth conveyer belt 48 which constitutes a collector conveyer belt on which a secondary mineral fiber-insulating web 50 is collected as the second and third conveyer belts 44 and 46, respectively, are swung across the upper surface of the fourth conveyer belt 48 in the transversal direction relative to the fourth conveyer belt 48. The secondary mineral fiber-insulating web 50 is consequently produced by arranging the primary mineral fiber-insulating web 40 in overlapping relation generally in the transversal direction of the fourth conveyer belt 48.

[0015] By producing the secondary mineral fiber-insulating web 50 from the primary mineral fiber-insulating web 40 as disclosed in Fig. 1, a more homogeneous secondary mineral fiber-insulating web 50 is produced as compared to the less homogeneous primary mineral fiber-insulating web.

[0016] It is to be realized that the overall orientation of the mineral fibers of the primary mineral fiber-insulating web 40 is parallel with the longitudinal direction of the web 40 and the direction of transportation of the first conveyer belt 42. Contrary to the primary mineral fiber-insulating web 40 the overall orientation of the mineral fibers of the secondary mineral fiber-insulating web 50 is substantially perpendicular and transversal relative to the longitudinal direction of the secondary mineral fiber-insulating web 50 and the direction of transportation of the fourth conveyer belt 48.

[0017] In Fig. 2, a station for compacting and homogenizing an input mineral fiber-insulating web 50' is shown, which station serves the purpose of compacting and homogenizing the input mineral fiber-insulating web 50' for producing an output mineral fiber-insulating web 50", which output mineral fiber-insulating web 50" is more compact and more homogeneous as compared to the input mineral fiber-insulating web 50'. The input mineral fiber-insulating web 50' may constitute the secondary mineral fiber-insulating web 50 produced in the station shown in Fig. 1.

[0018] The compacting station comprises two sections. The first section comprises two conveyer belts 52" and 54", which are arranged at the upper side surface and the lower side surface, respectively, of the mineral fiber web 50'. The first section basically constitutes a section in which the mineral fiber web 50' input to the section is exposed to a height compression, causing a reduction of the overall height of the mineral fiber web and a compacting of the mineral fiber web. The conveyer belts 52" and 54" are consequently arranged in a manner, in which they slope from an input end at the left-hand side of Fig. 2, at which input end the mineral fiber web 50' is input to the first section, towards an output end, from which the height-compressed mineral fiber web is delivered to the second section of the compacting station.

[0019] The second section of the compacting station comprises three sets of rollers 56' and 58', 56" and 58", and 56''' and 58'''. The rollers 56', 56" and 56''' are arranged at the upper side surface of the mineral fiber web, whereas the rollers 58', 58" and 58''' are arranged at the lower side surface of the mineral fiber web. The second section of the compacting station provides a longitudinal compression of the mineral fiber web, which longitudinal compression produces a homogenization of the mineral fiber web, as the mineral fibers of the mineral fiber web are caused to be rearranged as compared to the initial structure into a more homogeneous structure. The three sets of rollers 56' and 58', 56" and 58", and 56''' and 58''' of the second section are rotated at the same rotational speed, which is, however, lower than the rotational speed of the conveyer belts 52" and 54" of the first section, causing the longitudinal compression of the mineral fiber web. The height-compressed and longitudinally compressed mineral fiber web is output from the compacting station shown in Fig. 2, designated the reference numeral 50".

[0020] It is to be realized that the combined height-and-longitudinal-compression compacting station shown in Fig. 2 may be modified by the omission of one of the two sections, i.e. the first section constituting the height-compression section, or alternatively the second section constituting the longitudinal-compression section. By the omission of one of the two sections of the compacting station shown in Fig. 2, a compacting section performing a single compacting or compression operation is provided, such as a height-compressing station or alternatively a longitudinally-compressing station. Although the height-compressing section has been described including conveyer belts, and the longitudinally-compressing section has been described including rollers, both sections may be implemented by means of belts or rollers. Also, the height-compressing section may be implemented by means of rollers, and the longitudinally-compressing section may be implemented by means of conveyer belts.

[0021] In Figs. 3, 4, 5 and 6, four alternative techniques of folding a mineral fiber-insulating web in the longitudinal direction of the mineral fiber-insulating web are disclosed. In Figs. 3, 4, 5 and 6, the mineral fiber-insulating web 50" may constitute the output mineral fiber-insulating web 50" shown in Fig. 2, or alternatively the mineral fiber-insulating web 50 produced in the station shown in Fig. 1.

[0022] In Fig. 3, the mineral fiber-insulating web 50" is brought into contact with a pressing roller 51, by means of which a continuous foil 99 of a thermoplastic material is applied to the upper side surface of the mineral fiber-insulating web 50". The continuous foil of the thermoplastic material is supplied from a roll 98. After the continuous foil 99 has been applied to the upper side surface of the mineral fiber-insulating web 50", the mineral fiber-insulating web 50" and the continuous foil 67 applied thereto are forced through a corrugated gate 60' which gate comprises two oppositely arranged, corrugated guide plates 64' and 66' and two oppositely arranged end walls, one of which is designated the reference numeral 62'. As will be readily understood, the foil 99 has to be of an elasticity allowing that the foil 99 and the mineral fiber-insulating web 50" are folded. The end walls of the corrugated gate 60' and the corrugations of the corrugated gate plates 64' and 66' taper from an input end of the corrugated gate 60' to an output end thereof. As the mineral fiber-insulating web 50" and the foil 99 applied thereto are forced through the corrugated gate 60', the mineral fiber-insulating web is folded in its longitudinal direction providing a corrugated and longitudinally folded mineral fiber-insulating web 50"'.

[0023] In Fig. 4, an alternative technique of producing the corrugated and longitudinally folded mineral fiber-insulating web 50"' from the plane mineral fiber-insulating web 50" is disclosed. The technique disclosed in Fig. 4 differs from the technique described above with reference to Fig. 3 in that a gate 60" is used, which gate 60" differs from the corrugated gate 60" shown in Fig. 3 in that the gate 60" comprises plane oppositely arranged walls one of which is designated the reference numeral 64" and curved end walls one of which is designated the reference numeral 62".

[0024] In Fig. 5, a further alternative technique of producing a longitudinally folded mineral fiber-insulating web 50"' from the plane mineral fiber-insulating web 50" is shown. The corrugated and longitudinally folded mineral fiber-insulating web 50"' is in accordance with the technique shown in Fig. 5 produced by means of a roller assembly 60"' comprising plane end walls 62"' serving the same purpose as the plane end walls 62' and curved end walls 62" shown in Figs. 3 and 4, respectively, viz. the purpose of guiding the outer edges of the plane mineral fiber-insulating web 50" to the corrugated and longitudinally folded configuration of the mineral fiber-insulating web 50"'. The roller assembly 60"' further comprises a total of eight sets of rollers, each set of rollers containing two rollers arranged at opposite sides of the mineral fiber-insulating web. In Fig. 5, two rollers are designated the reference numeral 68. The sets of rollers define a tapered configuration tapering from an input end of the roller assembly 60"' to an output end thereof from which output end the corrugated and longitudinally folded mineral fiber-insulating web 50"' is supplied. The tapered configuration serves the purpose of assisting the plane mineral fiber-insulating web 50" to corrugate and longitudinally fold into the configuration of the folded mineral fiber-insulating web 50"' shown in Fig. 5.

[0025] In Fig. 6, a further alternative technique of producing a longitudinally folded mineral fiber-insulating web 50"' is shown. According to the technique disclosed in Fig. 6, a station 60"" is employed, which station constitutes a combined height/longitudinally-compressing station and a transversally-folding station. Thus, the station 60"" comprises a total of six sets of rollers, three sets of which are constituted by the three sets of rollers 56', 58'; 56", 58"; and 56"', 58"' discussed above with reference to Fig. 2.

[0026] The station 60"" shown in Fig. 6 further comprises three sets of rollers, a first set of which is constituted by two rollers 152' and 154', a second set of which is constituted by two rollers 152" and 154", and third set of which is constituted by two rollers 152"' and 154"'. The rollers 152', 152" and 152"' are arranged at the upper side surface of the mineral fiber-insulating web 50" like the rollers 56', 56" and 56"'. The three rollers 154', 154" and 154"' are arranged at the lower side surface of the mineral fiber-insulating web 50" like the rollers 58', 58" and 58"'. The three sets of rollers 152', 154'; 152", 154"; and 152"', 154"' serve the same purpose as the belt assemblies 52", 54" discussed above with reference to Fig. 2, viz. the purpose of height compressing the mineral fiber-insulating web 50" input to the station 60"".

[0027] The three sets of height-compressing rollers 152', 154'; 152", 154"; and 152"', 154"' are like the above-described belt assemblies 52", 54" operated at a rotational speed identical to the velocity of the mineral fiber-insulating web 50" input to the height-compressing section of the station 60"". The three sets of rollers constituting the longitudinally-compressing section, i.e. the rollers 56', 58'; 56", 58"; and 56"', 58"', are operated at a reduced rotational speed determining the longitudinal compression ratio.

[0028] For generating the longitudinal folding of the mineral fiber-insulating web 50" input to the station 60"", shown in Fig. 6, four crankshaft assemblies designated the reference numerals 160', 160", 160"', and 160"" are provided. The crankshaft assemblies are of identical structures, and in the below description a single crankshaft assembly, the crankshaft assembly 160", is described, as the crankshaft assemblies 160', 160"' and 160"" are identical to the crankshaft assembly 160" and comprise elements identical to the elements of the crankshaft assembly 160", however, designated the same reference numerals added a single, a double and a triple mark, respectively.

[0029] The crankshaft assembly 160" includes a motor 162", which drives a gear assembly 164", from which an output shaft 166" extends. A total of six gearwheels 168" of identical configurations are mounted on the output shaft 166". Each of the gearwheels 168" meshes with a corresponding gearwheel 170". Each of the gearwheels 170" constitutes a drivewheel of a crankshaft lever system further comprising an idler wheel 172" and a crankshaft lever 174". The crankshaft levers 174" are arranged so as to be lifted from a retracted position to an elevated position between two adjacent rollers at the righ-hand, lower side of the mineral fiber-insulating web 50" input to the- station 60"" and are adapted to cooperate with crankshaft levers of the crankshaft lever system 160' positioned at the right-hand, upper side of the mineral fiber-insulating web 50" input to the station 60"".

[0030] Similarly, the crankshaft levers of the crankshaft lever systems 160"' and 160"", arranged at the left-hand, upper and lower side, respectively, of the mineral fiber-insulating web 50" input to the station 60"", are adapted to cooperated in a manner to be described below.

[0031] As is evident from Fig. 6, a first set of crankshaft levers 174', 174" 174"', 174"" of the crankshaft lever systems 160', 160", 160"' and 160"" are positioned between the first and second sets of rollers 152', 154' and 152", 154". Similarly, a second set of crankshaft levers are positioned between the second and third sets of rollers 152", 154" and 152"', 154"'.

[0032] The crankshaft levers of each of the total of six crankshaft lever sets are of identical widths. Within each of the crankshaft lever systems 160', 160", 160"' and 160"", the first crankshaft lever is the widest crankshaft lever, and the width of the crankshaft lever within each crankshaft lever system Is reduced from the first crankshaft lever to the sixth crankshaft lever positioned behind the sixth set of rollers 56"', 58"'.

[0033] By means of the motors of the crankshaft assemblies 160', 160", 160"' and 160"", the crankshaft levers of a specific crankshaft set are rotated in synchronism with the remaining three crankshaft levers of the crankshaft lever set in question. The crankshaft levers of all six sets of crankshaft levers are moreover operated in synchronism and in synchronism with the velocity of the mineral fiber-insulating web 50" input to the station 60"". The widest or first set of crankshaft levers is adapted to initiate the folding of the mineral fiber-insulating web 50", as the crankshaft levers 174" and 174"" of the crankshaft lever systems 160" and 160"", respectively, are raised from positions below the lower side surface of the mineral fiber-insulating web 50" and are brought into contact with the lower side surface of the mineral fiber-insulating web 50", and as the crankshaft levers 174' and 174"' of the crankshaft lever systems 160' and 160"', respectively, are simultaneously lowered from positions above the upper side surface of the mineral fiber-insulating web 50" and brought into contact with the upper side surface of the mineral fiber-insulating web 50".

[0034] Further rotation of the output shafts 166', 166", 166"' and 166"" causes the crankshaft levers of the first set of crankshaft levers to be moved towards the center of the mineral fiber-insulating web 50", producing a central fold of the mineral fiber-insulating web 50". As the crankshaft levers of the first set of crankshaft levers reach the central position, the crankshaft levers of the crankshaft lever systems 160' and 160"' are raised, whereas the crankshaft levers of the crankshaft lever systems 160" and 160"" are lowered and consequently brought out of contact with the upper and lower side surface, respectively, of the mineral fiber-insulating web 50".

[0035] As the mineral fiber-insulating web 50" is moved further through the station 60"", the next or second set of crankshaft levers generates a second and a third fold of the mineral fiber-insulating web 50", which second or third fold is positioned at opposite sides of the first fold, whereupon the third, the fourth, the fifth, and the sixth sets of crankshaft levers produce additional folds of the mineral fiber-insulating web, producing an overall, longitudinal folding of the mineral fiber-insulating web.

[0036] The width of the crankshaft levers of each set of crankshaft levers, the gear ratio of the gear assemblies 164', 164", 164"' and 164"", the gear ratio of the gearwheels 168 and 170, and the velocity of the mineral fiber-insulating web 50" input to the station 60"" are adapted to one another and further to the rotational speed of the height compression and the longitudinally-compressing sections of the station for producing the longitudinally-folded, and height- and longitudinally-compressed mineral fiber-insulating web 50"'.

[0037] The integration of the height-compressing section, the longitudinally-compressing section and the longitudinally-folding section into a single station, as described above with reference to Fig. 6, is, by no means, mandatory to the operation of the longitudinally-folding crankshaft systems described above with reference to Fig. 6. Thus, the height-compressing section, the longitudinally-compressing section and the longitudinally-folding section may be separated, however, the integration of all three functions reduces the overall size of the production plant. Furthermore, it is to be realized that the folding of the mineral fiber web as discussed above with reference to Figs. 4, 5 and 6 provides a transversal compacting and compression of the web, further providing a homogenization of the web as compared to the unfolded input web.

[0038] In Fig. 11, a vertical sectional view of the corrugated and longitudinally folded mineral fiber-insulated web 50"' is shown. The corrugated and longitudinally folded mineral fiber-insulating web 50"' comprises a central core or body 28 and two oppositely arranged surface layers 24 and 26, which surface layers 24 and 26 are separated from the central core or body 28 of the corrugated and longitudinally folded mineral fiber-insulating web 50"' along imaginary lines of separation 20 and 22, respectively. The surface layers 24 and 26 of the corrugated and longitudinally folded mineral fiber-insulating web 50"' are composed of segments of the folded mineral fiber-insulating web which segments contain mineral fibers which are orientated substantially transversally relative to the longitudinal direction of the corrugated and longitudinally folded mineral fiber-insulating web 50"'. The corrugated and longitudinally folded mineral fiber-insulating web 50"' is produced from the secondary mineral fiber-insulating web 50 by folding the secondary mineral fiber-insulating web 50, optionally after compacting the secondary mineral fiber-insulating web 50, as will be described below with reference to Fig. 8, and the overall orientation of the mineral fibers of the secondary mineral fiber-insulating web 50 is consequently maintained within the segments of the corrugated and longitudinally folded mineral fiber-insulating web

50''' which segments together constitute the surface layers 24 and 26.

[0039] The central core or body 28 of the corrugated and longitudinally folded mineral fiber-insulating web 50''' is composed of segments of the folded mineral fiber-insulating web 50''' which segments are folded perpendicular to the segments of the surface layers 24 and 26 of the mineral fiber-insulating web 50'''. The mineral fibers of the central core of body 28 of the corrugated and longitudinally folded mineral fiber-insulating web 50''' are consequently orientated substantially perpendicular to the longitudinal direction as well as the transversal direction of the corrugated and longitudinally folded mineral fiber-insulating web 50'''.

[0040] The corrugated and longitudinally folded mineral fiber-insulating web 50''' shown in Fig. 9 and produced in accordance with the techniques discussed above with reference to Figs. 3, 4, 5 and 6 is further processed in a station illustrated in Fig. 7, in which station the surface layer 24 is separated from the central core or body 28 of the corrugated and longitudinally folded mineral fiber-insulating web 50''' along the imaginary line of separation 20, shown in Fig. 9. The separation of the surface layer 24 from the remaining part of the mineral fiber-insulating web is accomplished by means of a cutting tool 72 as the remaining part of the mineral fiber-insulating web is supported and transported by means of a conveyer belt 70. The cutting tool 72 may be constituted by a stationary cutting tool or knife or alternatively be constituted by a transversely reciprocating cutting tool. The surface layer 24 separated from the mineral fiber-insulating web is derived from the path of travel of the remaining part of the mineral fiber-insulating web by means of a conveyer belt 74 and is transferred from the conveyer belt 74 to three sets of rollers comprising a first set of rollers 76' and 78', a second set of rollers 76'' and 78'', and a third set of rollers 76''' and 78''', which three set of rollers together constitute a compacting or compressing section similar to the second section of the corresponding station described above with reference to Fig. 2.

[0041] In Fig. 8, a transversally-compressing station is shown, which is designated the reference numeral 80 in its entirety. In the station 80, the central core or body 28 or alternatively the corrugated and longitudinally folded mineral fiber-insulating web 50''', produced in one of the stations described above with reference to Figs. 3, 4, 5 and 6, Is brought into contact with two conveyer belts 85 and 86, which define a constriction in which the mineral fiber-insulating web is caused to be transversally compressed and into contact with a total of four surface-agitating rollers 89a, 89b, 89c and 89d which together with similar rollers, not shown in the drawing, arranged opposite to the rollers 89a, 89b, 89c and 89d serve the purpose of assisting in providing a transversal compression of the central core or body 28. The conveyer belts 85 and 86 are journal led on rollers 81, 83 and 82, 84, respectively.

[0042] From the transversally-compressing station 80, a transversally compressed and compacted central core or body 28' is supplied. As the central core or body 28 is transmitted through the transversally-compressing station 80 and transformed into the transversally compressed central core or body 28', the core or body is supported on rollers constituted by an input roller 87 and an output roller 88.

[0043] Although the central core or body 28 input to the transversally-compressing station 80 is preferably constituted by the above-described central core or body separated from the mineral fiber-insulating web 50'', as described above with reference to Fig, 7, the mineral fiber-insulating web 50'' may alternatively be processed in the station 80 shown in Fig. 8.

[0044] Provided the central core or body 28 or the mineral fiber-insulating web 50''' to be transversally compressed within the station 80 is provided with a top surface layer, such as the foil 99 described above with reference to Fig. 3, the foil has to be of a structure compatible with the transversal compression of the web and foil assembly. Thus, the foil applied to the upper side surface of the mineral fiber-insulating web 50'', as shown in Fig. 3, has to be compressable and adaptable to the reduced width of the transversally compressed central core or body 28' or the transversally compressed mineral fiber-insulating web output from the transversally-compressing station 80.

[0045] As the compacting of the separate surface layer 24 has been accomplished, as described above with reference to Fig. 7, the compacted surface layer 24 is returned to the remaining part of the mineral fiber-insulating web or the central core or body, which has preferably been transversally compressed as described above with reference to Fig. 8, and adjoined in facial contact with the upper surface of the central core or body 28, as shown in Fig. 9.

[0046] In Fig. 9, a set of rollers comprising a roller 79' and a roller 79'', arranged at the upper and lower side surface of the surface layer 24, respectively, constitutes a set of rollers by means of which a surface foil 99' supplied from a roll 98' is applied to the upper side surface of the compacted surface layer 24. From the rollers 79' and 79'', the surface layer 24 which constitutes an integral mineral fiber-insulating web of higher compactness as compared to the central core or body 28, is shifted towards the upper side surface of the central core or body 28 by means of two rollers 77' and 77''. The roller 77'' is positioned below the surface layer 24 and constitutes a turning roller, whereas the roller 77', which is positioned above the upper side surface of the surface layer 24, serves the purpose of pressing the compacted surface layer 24 into facial contact with the upper side surface of the central core or body 28, which is supported and transported by means of the conveyer belt 70 also shown in Fig. 7. After the compacted surface layer 24 has been arranged in facial contact with the upper side surface of the central core or body 28, a mineral fiber-insulating web assembly is provided, which assembly is designated the reference numeral 90 in its entirety.

[0047] In Fig. 9, a further foil 99'' is shown in dotted line. This foil is supplied from a roll 98''. The foil 99'' may constitute a continuous foil or alternatively a mesh foil, i.e. a foil similar to the surface foil 99' described above. It is, however, to be emphasized that the foils 99, 99' and 99" constitute optional features which may be omitted, provided an integral mineral fiber web structure is to be produced. Alternatively, one or more of the above-listed foils, or all foils, may be provided in various embodiments of the mineral fiber-insulating web produced in accordance with the teachings of the present invention.

[0048] It is to be realized that the compacted surface layer 24 which is separated from the mineral fiber-insulating web 50''' as shown in Fig. 7, may alternatively be provided from a separate production line, as one of the production stations shown in Fig. 3, 4, 5 and 6 may communicate directly with the production station shown in Fig. 9, optionally through the production station shown in Fig. 8, thus, eliminating the production station shown in Fig. 7. Preferably, the production station shown in Fig. 7 is adapted to separate two surface layers from the central core or body 28 for producing two separated surface layers separated from opposite side surfaces of the central core or body 28, which surface layers are processed in accordance with the technique described above with reference to Fig. 7 for the formation of two high compactness surface layers which, in accordance with the technique described above with reference to Fig. 9, are adjoined with the central core or body 28 at opposite side surfaces thereof, producing a sandwiching of the central core or body 28, which has preferably been transversally compressed as described above with reference to Fig. 8, between two opposite surface layers similar to the surface layer 24 shown in Fig. 9.

[0049] In Fig. 10, the mineral fiber-insulating web assembly 90 is moved through a curing station constituting a curing oven or curing furnace comprising oppositely arranged curing oven sections 92 and 94, which generate heat for heating the mineral fiber-insulating web assembly 50 to an elevated temperature so as to cause the heat-curable bonding agent of the mineral fiber-insulating web assembly to cure and cause the mineral fibers of the central core or the body of the assembly and the mineral fibers of the compacted surface layer or surface layers to be bonded together so as to form an integral bonded mineral fiber-insulating web which is cut into plate-like segments by means of a knife 96. Provided the foil 99 and optionally the continuous foils 99' and 99" are provided, the thermoplastic material of the foils 99, 99' and 99" is also melted, providing an additional bonding of the mineral fibers of the mineral fiber-insulating web. In Fig. 10, a single plate-like segment 10" is shown comprising a central core 12 and a top layer 14. The top layer 14 is made from the compacted surface layer 24, whereas the core 12 is made from the central core or body 28 of the corrugated and longitudinally folded mineral fiber-insulating web 50''' shown in Fig. 9.

[0050] In Fig. 12, a fragmentary and perspective view of a first embodiment of a plate segment of a mineral fiber-insulating web according to the present invention is shown, designated the reference numeral 10 in its entirety. The plate segment 10 comprises the central core 12 and the top layer 14 and further a bottom layer 16 made from a surface layer of the mineral fiber-insulating web 50". The reference numeral 18 designates a segment of the core 12 of the plate segment 10 which segment 18 is made from the central core or body 28 of the corrugated and longitudinally folded mineral fiber-insulating web 50''', which central core or body has preferably been transversally compressed as described above with reference to Fig. 8.

[0051] In Fig. 13, a fragmentary and perspective view of a second embodiment of a plate segment of a mineral fiber-insulating web according to the present invention is shown, designated the reference numeral 10' in its entirety. Like the plate segment 10, described above with reference to Fig. 12, the plate segment 10' comprises the central core 12, the top layer 14 and the bottom layer 16. Moreover, a top surface covering 15 is provided, which is constituted by the foil 99' described above with reference to Fig. 9. The top surface covering 15 may constitute a web of a plastics material, a woven or non-woven plastic foil, or alternatively a covering made from a non-plastics material, such as a paper material serving design and architectural purposes exclusively. The top surface layer 15 may alternatively be applied to the mineral fiber-insulating web after the curing of the heat-curable bonding agent, i.e. after the exposure of the mineral fiber-insulating web 90 to heat generated by the oven sections 92 and 94 shown in Fig. 10.

<u>Example 1</u>

[0052] A heat-insulating plate of a structure similar to the plate shown in Fig. 12, made from a mineral fiber-insulating web produced in accordance with the method as described above with reference to Figs. 1-10, is produced in accordance with the specifications listed below:

[0053] The method comprises steps similar to the steps described above with reference to Figs. 1, 2, 6, 7, 8, 9 and 10. The production output of the plant is 5000 kg/h. The area weight of the primary web produced in the station disclosed in Fig. 1 is 0.4 kg/m^2, and the width of the primary web is 3600 mm. The density of the central core or body 28 is 20 kg/m^3. The rates of longitudinal compression produced in two separate stations similar to the station disclosed in Fig. 2 are 1:1 and 1:2, respectively, and the rate of transversal compression produced in the station disclosed Fig. 8 is 1:2. The final plate comprises a single surface layer of an area weight of 1 kg/m^2. The rate of longitudinal compression of the surface layer is 1:2. The thickness of the surface layer 10.00 mm, and the density of the surface layer is 100 kg/m^3. The width of the mineral fiber-insulating web produced in Fig. 1 is 1800 mm.

[0054] The production parameters used are listed in tables A and B below:

Table A

Total thickness mm	A m/min x 10	B m/min	C m/min	D m/min	E m/min	F m/min
50	11.57	51.44	51.44	51.44	15.72	25.72
75	11.57	40.26	40.26	40.26	20.13	20.13
100	11.57	33.07	33.07	33.07	16.53	16.53
125	11.57	28.06	28.06	28.06	14.03	14.03
150	11.57	24.37	24.37	24.37	12.18	12.18
175	11.57	21.53	21.53	21.53	10.77	10.77
200	11.57	19.29	19.29	19.29	9.65	9.65
225	11.57	17.47	17.47	17.47	8.74	8.74
250	11.57	15.96	15.96	15.96	7.98	7.98
275	11.57	14.70	14.70	14.70	7.35	7.35

A = Velocity of belt 42 of spinning chamber
B = Velocity of belt 48
C = Velocity of belt 70 after first longitudinal compression (Fig. 2)
D = Velocity of belt 70 after transversal compression (Fig. 8)
E = Velocity of belt 70 after second longitudinal compression (Fig. 2)
F = Velocity of belt 70 before curing oven (Fig. 5)

Table B

Total thickness mm	G kg/m^2	H kg/m^2	I kg/m^2	J kg/m^2	K kg/m^2	L kg/m^2
50	0.45	0.45	0.90	0.40	0.80	1.80
75	0.58	0.58	1.15	0.65	1.30	2.30
100	0.70	0.70	1.40	0.90	1.80	2.80
125	0.83	0.83	1.65	1.15	2.30	3.30
150	0.95	0.95	1.90	1.40	2.80	3.80
175	1.08	1.08	2.15	1.65	3.30	4.30
200	1.20	1.20	2.40	1.90	3.80	4.80
225	1.33	1.33	2.65	2.15	4.30	5.30
250	1.45	1.45	2.90	2.40	4.80	5.80
275	1.58	1.58	3.15	2.65	5.30	6.30

G = Area weight of mineral fiber-insulating web on belt 42
H = Area weight of mineral fiber-insulating web after first longitudinal compression (Fig. 2)
I = Area weight of mineral fiber-insulating web after transversal compression (Fig. 8)
J = Area weight of mineral fiber-insulating web before second longitudinal compression (Fig. 2)
K = Area weight of mineral fiber-insulating web aber second longitudinal compression (Fig. 2)
L = Area weight of mineral fiber-insulating web before curing oven

[0055] In Fig. 14, a diagramme is shown, illustrating the correspondence between the parameters listed in Table A. The reference signs used in Fig. 14 refer to the parameters listed in Table A.

[0056] In Fig. 15, a diagramme is shown, illustrating the correspondence between the parameters listed in Table B. The reference signs used in Fig. 15 refer to the parameters listed in Table B.

Example 2

[0057] A composite roofing plate of a structure similar to the plate shown in Fig. 12, made from a mineral fiber-insulating web produced in accordance with the method as described above with reference to Figs. 1-10, is produced in accordance with the specifications listed below:

[0058] The method comprises steps similar to the steps described above with reference to Figs. 1, 2, 6, 7, 8, 9 and 10. The production output of the plant is 5000 kg/h. The area weight of the primary web produced in the station disclosed in Fig. 1 is 0.6 kg/m^2, and the width of the primary web is 3600 mm. The density of the central core or body 28 is 110 kg/m^3. The rates of longitudinal compression produced in two separate stations similar to the station disclosed in Fig. 2 are 1:3 and 1:2, respectively, and the rate of transversal compression produced in the station disclosed in Fig. 8 is 1:2. The final plate comprises a single surface layer of an area weight of 3.57 kg/m^2. The rate of longitudinal compression of the surface layer is 1:2. The thickness of the surface layer is 17.00 mm, and the density of the surface layer is 210 kg/m^3. The width of mineral fiber-insulating web produced in Fig. 1 is 1800 mm.

[0059] The production parameters used are listed in tables C and D below:

Table C

Total thickness mm	A m/min x 10	B m/min	C m/min	D m/min	E m/min	F m/min
50	7.72	38.58	12.86	12.86	6.43	6.43
75	11.57	27.92	9.31	9.31	4.65	4.65
100	11.57	21.87	7.29	7.29	3.65	3.65
125	11.57	17.98	5.99	5.99	3.00	3.00
150	11.57	15.26	5.09	5.09	2.54	2.54
175	11.57	13.26	4.42	4.42	2.21	2.21
200	11.57	11.72	3.91	3.91	1.95	1.95
225	11.57	10.50	3.50	3.50	1.75	1.75
250	11.57	9.51	3.17	3.17	1.59	1.59
275	11.57	8.69	2.90	2.90	1.45	1.45

A = Velocity of belt 42 of spinning chamber
B = Velocity of belt 48
C = Velocity of belt 70 after first longitudinal compression (Fig. 2)
D = Velocity of belt 70 after transversal compression (Fig. 8)
E = Velocity of belt 70 after second longitudinal compression (Fig. 2)
F = Velocity of belt 70 before curing oven (Fig. 5)

Table D

Total thickness mm	G kg/m^2	H kg/m^2	I kg/m^2	J kg/m^2	K kg/m^2	L kg/m^2
50	0.60	1.80	3.60	1.82	3.63	7.20
75	0.83	2.49	4.98	3.19	6.38	9.95
100	1.06	3.18	6.35	4.57	9.13	12.70
125	1.29	3.86	7.73	5.94	11.88	15.45
150	1.52	4.55	9.10	7.32	14.63	18.20
175	1.75	5.24	10.48	8.69	17.38	20.95
200	1.98	5.93	11.85	10.07	20.13	23.70
225	2.20	6.61	13.23	11.44	22.88	26.45
250	2.43	7.30	14.60	12.82	25.63	29.20
275	2.66	7.99	15.98	14.19	28.38	31.95

G = Area weight of mineral fiber-insulating web on belt 42
H = Area weight of mineral fiber-insulating web after first longitudinal compression (Fig. 2)
I = Area weight of mineral fiber-insulating web after transversal compression (Fig. 8)
J = Area weight of mineral fiber-insulating web before second longitudinal compression (Fig. 2)
K = Area weight of mineral fiber-insulating web aber second longitudinal compression (Fig. 2)
L = Area weight of mineral fiber-insulating web before curing oven

[0060] In Fig. 16, a diagramme similar to the diagramme of Fig. 14 is shown, illustrating the correspondance between the parameters listed above in table C.

[0061] In Fig. 17, a diagramme similar to the diagramme of Fig. 15 is shown, illustrating the correspondance between the parameters listed above in table D.

Example 3

[0062] The importance of exposing the mineral fiber-insulating web to a longitudinal and transversal compression is illustrated in the data in table E given below:

Table E

		Conventional mineral fiber-insulating plates	Mineral fiber-insulating plates according to the present invention, not being exposed to longitudinal/transversal compression	Mineral fiber-insulating plates according to the present invention being exposed to longitudinal/-transversal compression
Heat-insulating plate of a density of 30 kg/m³	Pressure strength:	2 kPa	7 kPa	9 kPa
	Modulus of elasticity:	15 kPa	125 kPa	150 kPa
Roofing plate of a density of 150 kg/m³	Pressure strength:	70 kPa	180 kPa	210 kPa
	Modulus of elasticity:	600 kPa	3300 kPa	4000 kPa

[0063] The mineral fiber-insulating plates according to the present invention clearly demonstrate increased pressure strength and modulus of elasticity as compared to a conventional heat-insulating plate. The mechanical performance of the mineral fiber-insulating plates according to the present invention, is, however, further increased by exposing the mineral-insulating web, from which the insulating plates are produces, to longitudinal and transversal compression as discussed above with reference to Fig. 2 and Fig. 8.

Claims

1. A mineral fiber-insulating plate (10, 10', 10") defining a plane and comprising:

a central body (12) containing mineral fibers,
a surface layer (14, 16) containing mineral fibers, said central body (12) and said surface layer (14, 16) being adjoined in facial contact with one another,
said mineral fibers of said central body (12) being arranged generally perpendicularly to said plane and said surface layer,
said mineral fibers of said surface layer (14, 16) being arranged generally in a direction parallel with said plane,
said surface layer (14, 16) being of a higher compactness as compared to said central body (12),
CHARACTERIZED in that
said mineral fibers of said central body (12) and said mineral fibers of said surface layer (14, 16) being bonded together in an integral structure solely through cured bonding agents cured in a single curing process and initially present in uncured, non-woven mineral fiber webs from which said central body (12) and said surface layer (14, 16) are produced.

2. The mineral fiber-insulating plate according to claim 1, comprising opposite surface layers (14, 16) of similar structure, sandwiching said central body (12) in said integral structure.

Fig. 1

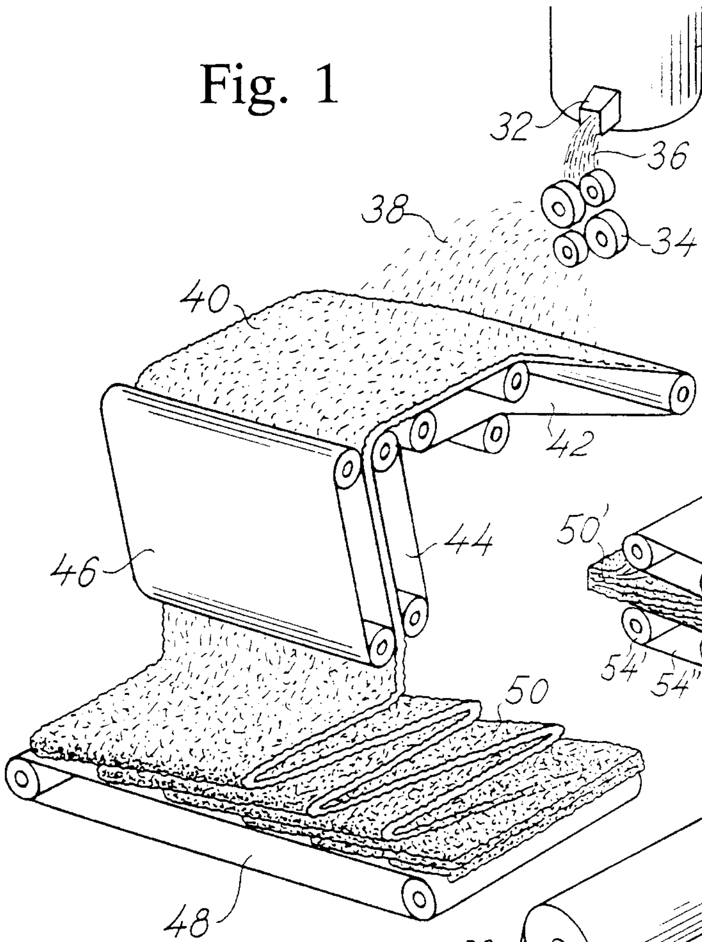

Fig. 2

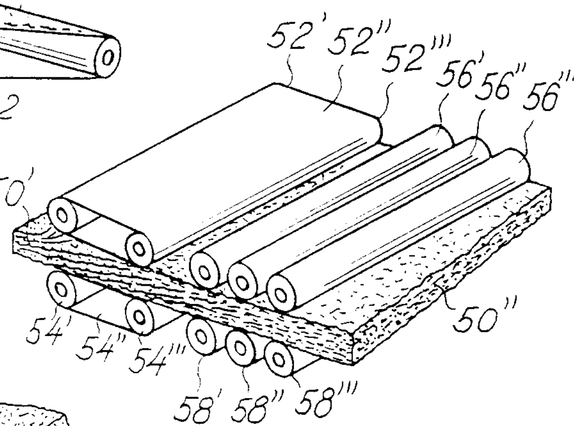

Fig. 3

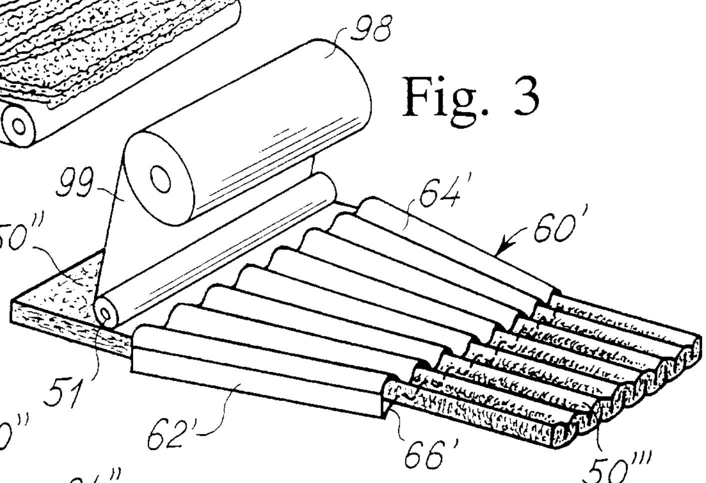

Fig. 4

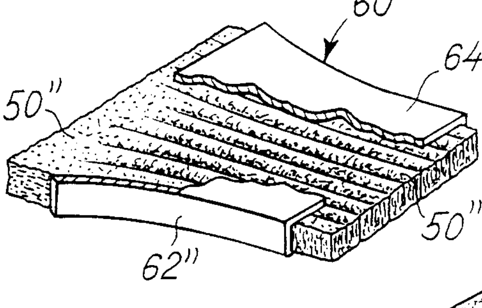

Fig. 5

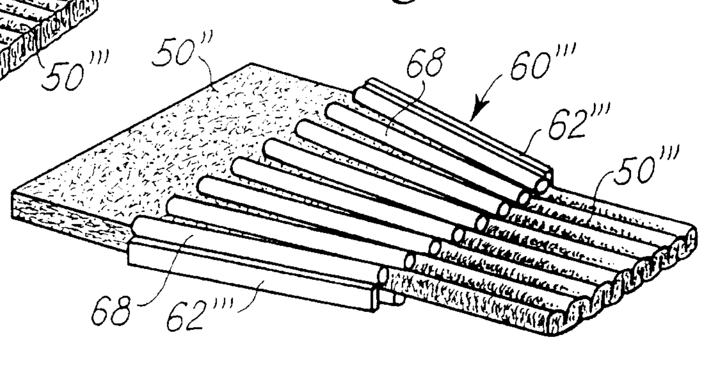

Fig. 6

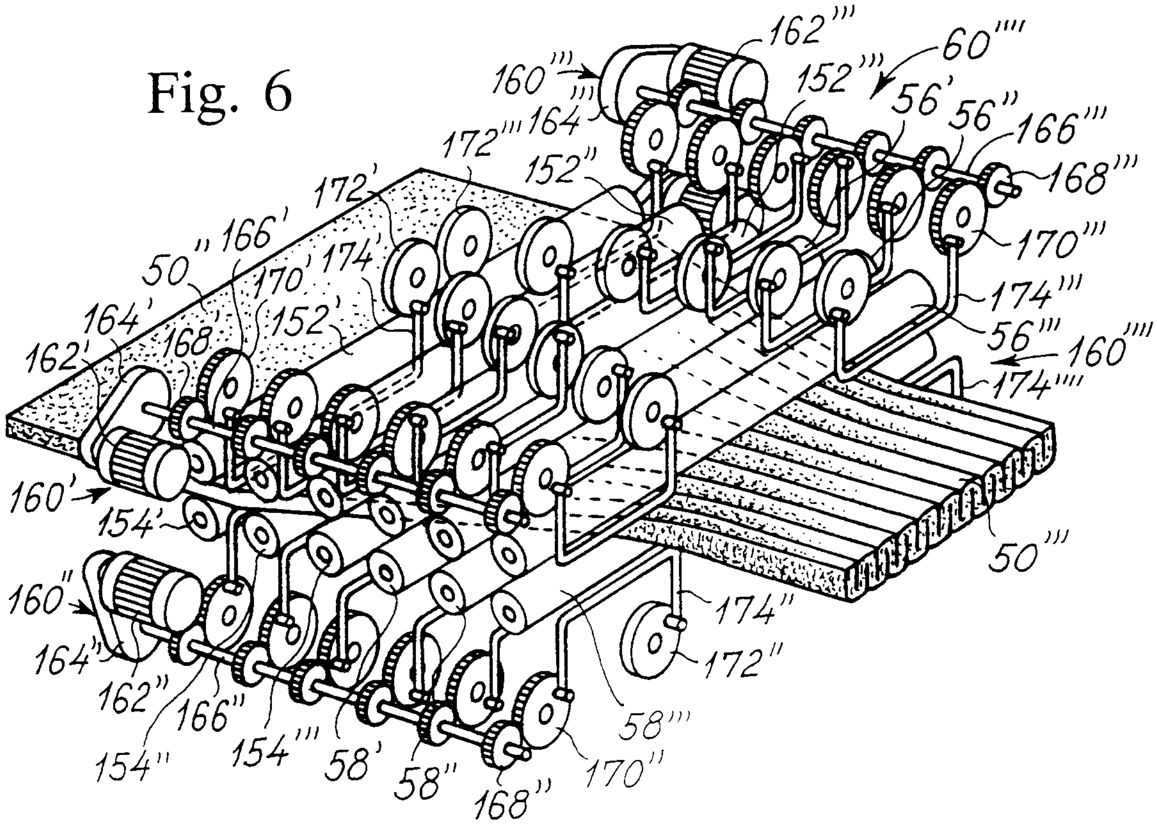
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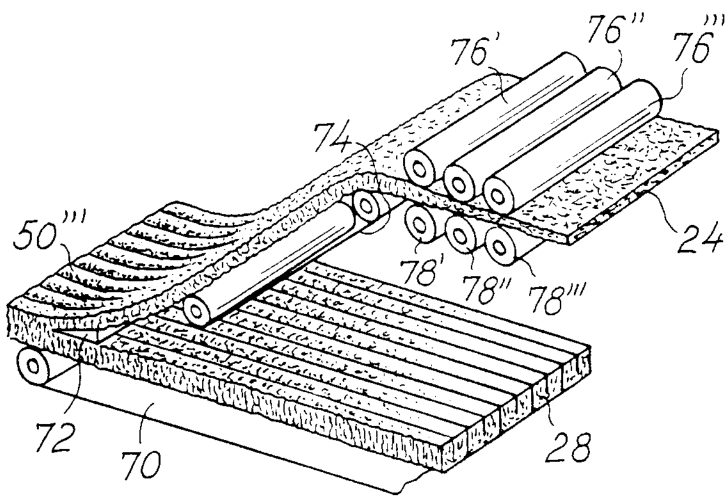
Fig. 7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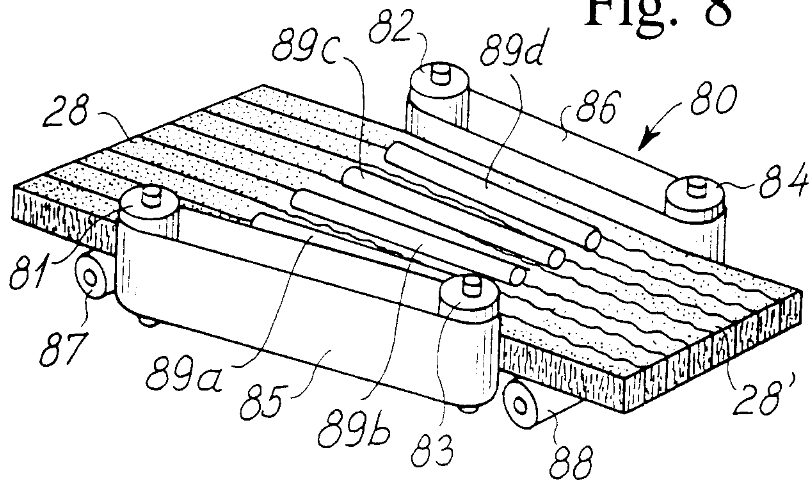
28

Fig. 8



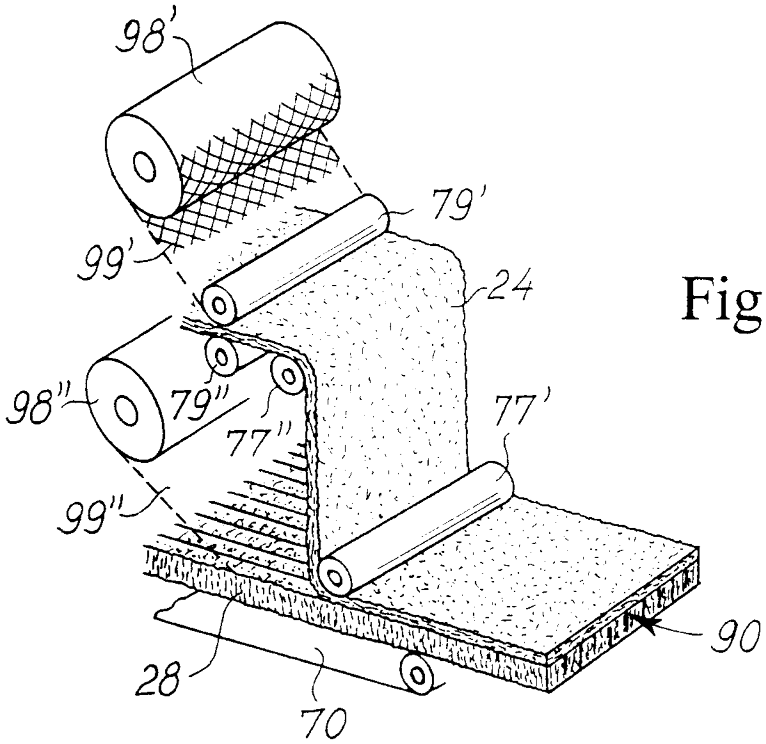


Fig. 9

Fig. 10

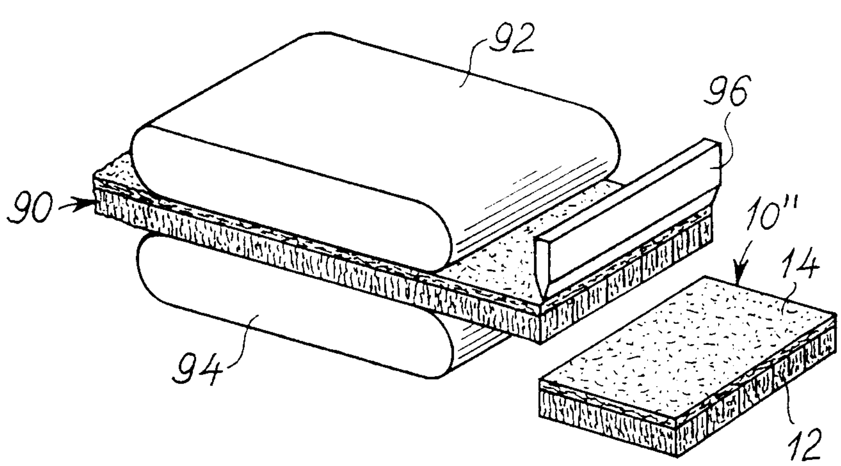


Fig. 11

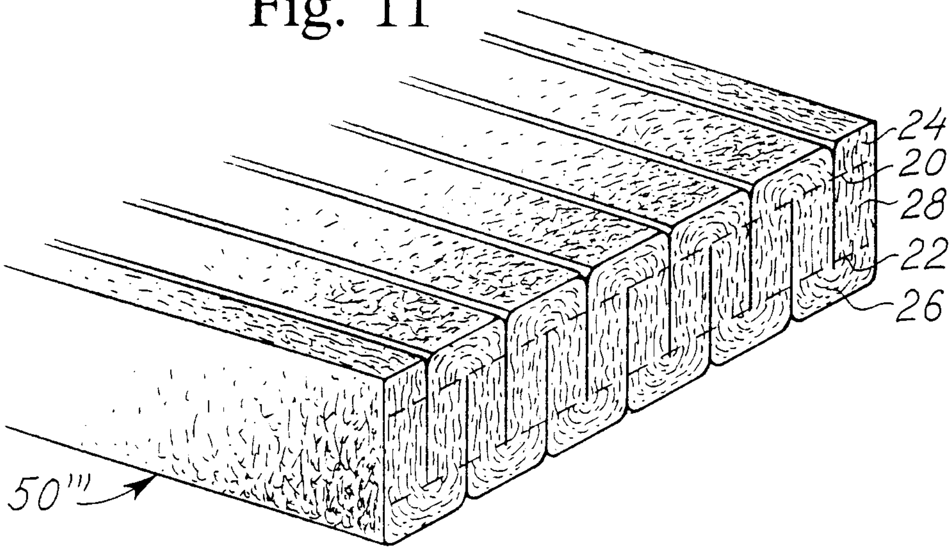


Fig. 12

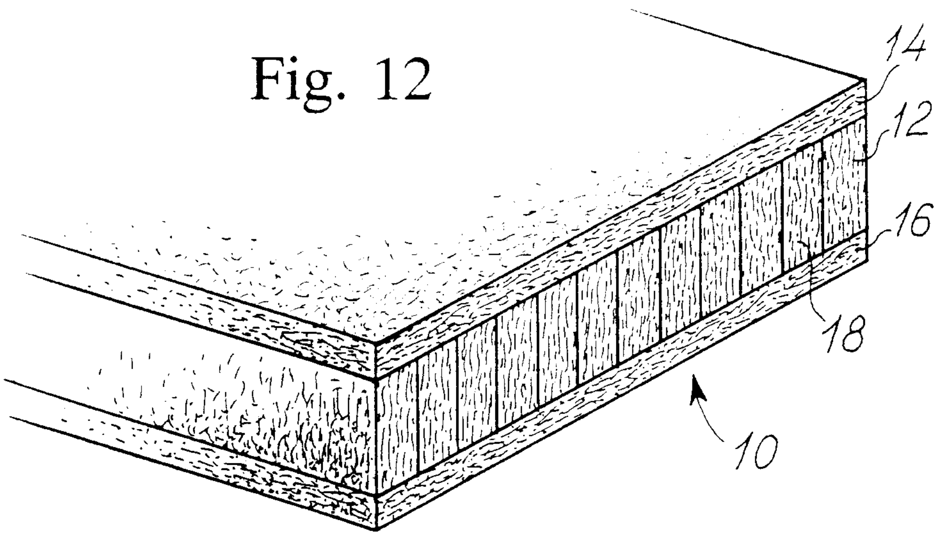


Fig. 13

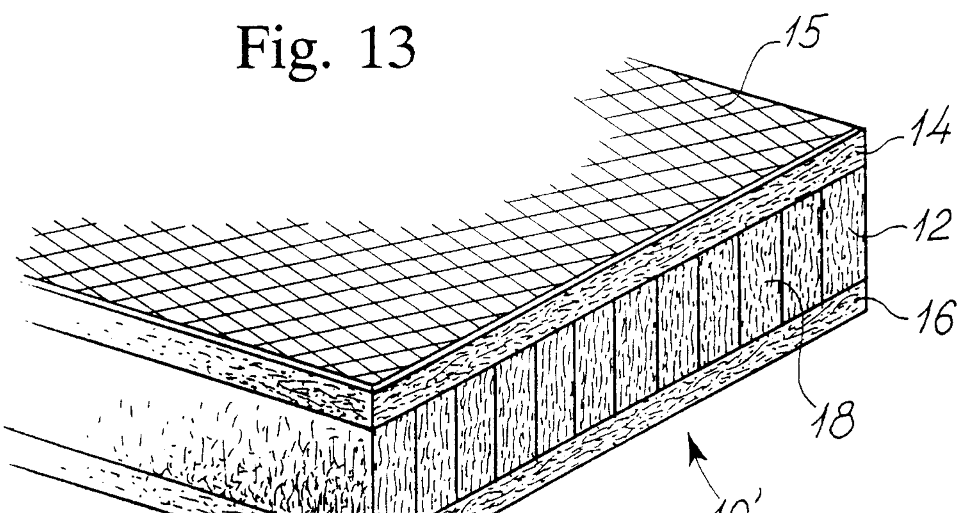
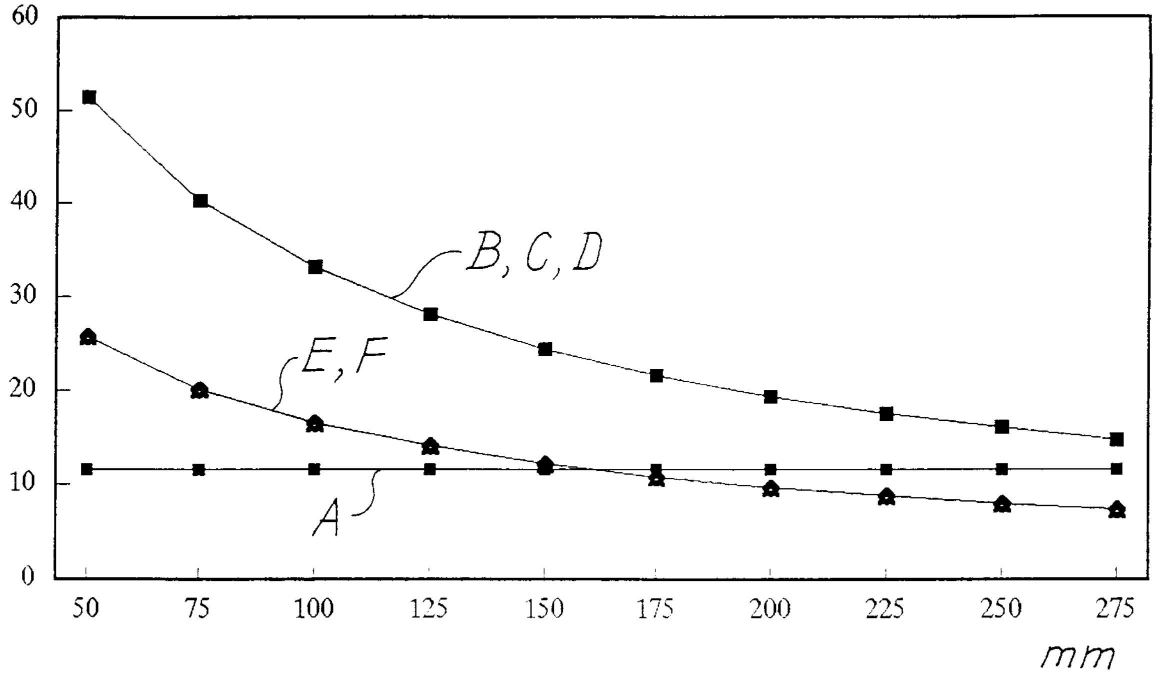


Fig. 14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30
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275
mm

Fig. 15

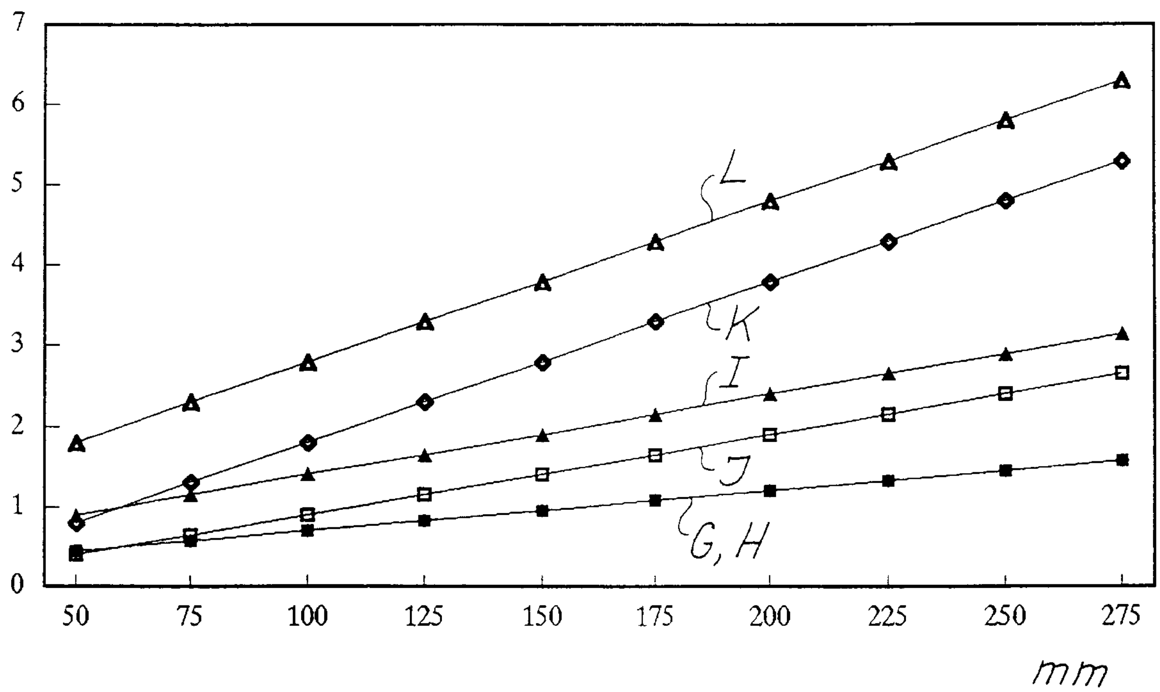
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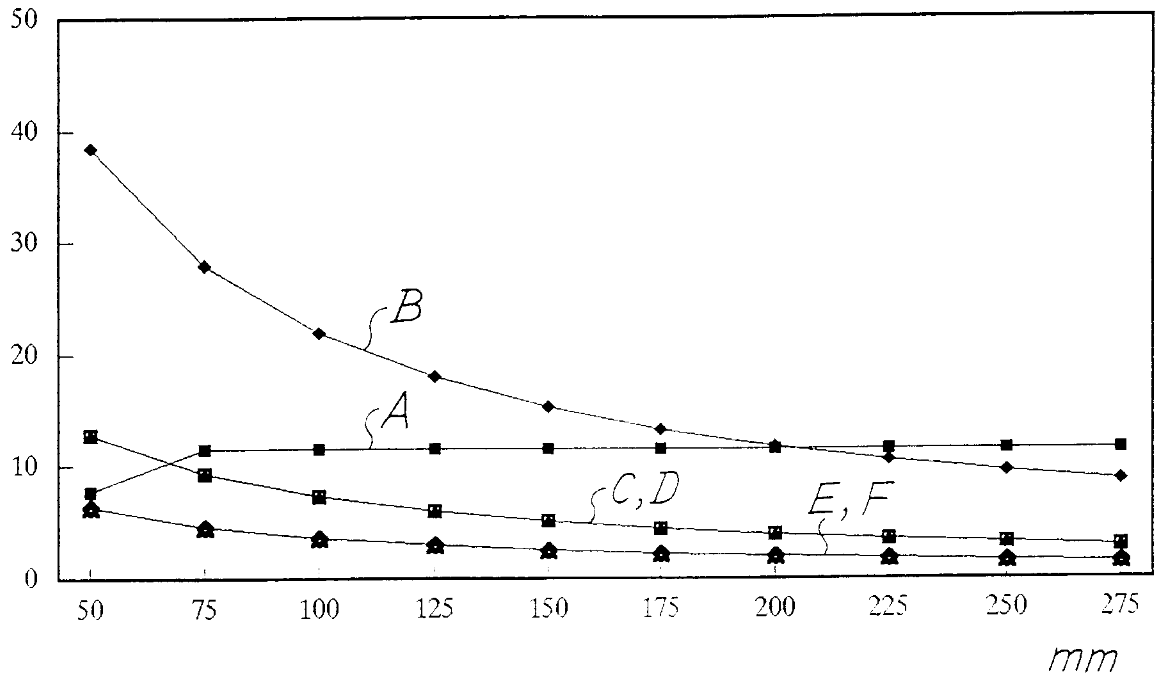
Fig. 16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B
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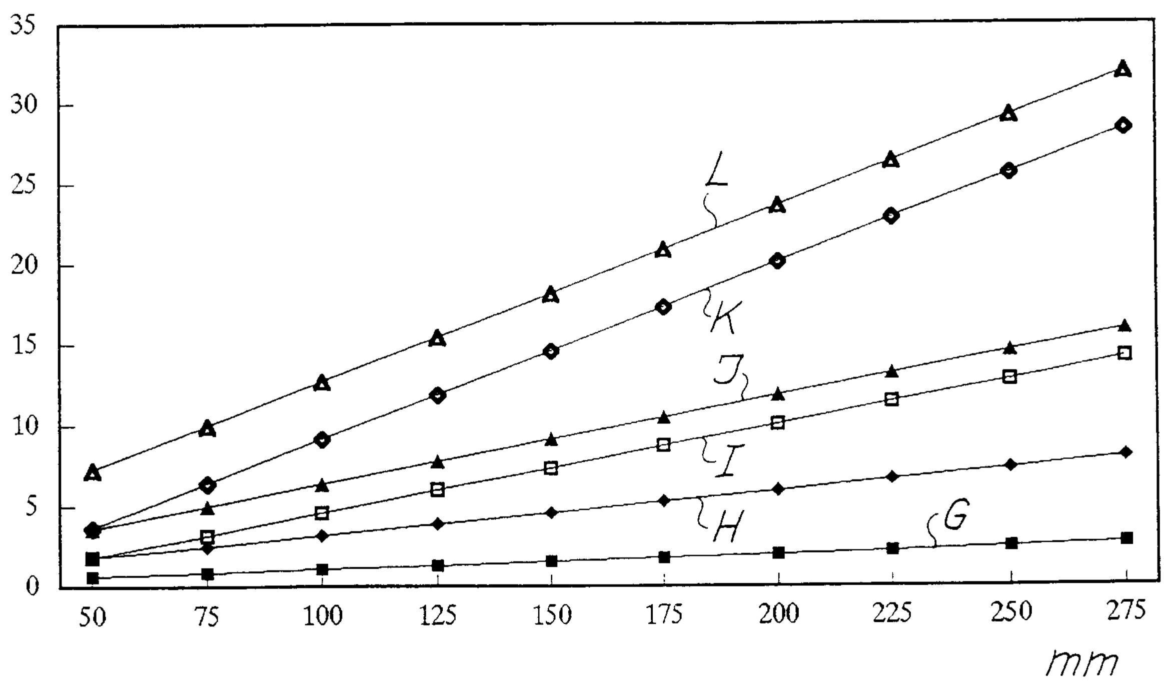
C,D
E,F

Fig. 17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