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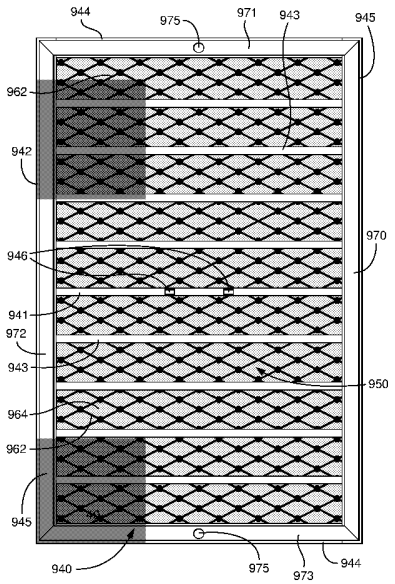
(54) Title: SCREEN ASSEMBLY AND SHALE SHAKER



(57) Abstract: A shale shaker comprising a screen assembly (940) , the screen assembly comprising a support (942) and at least one layer of screening material (950) , the screen support (942) having a periphery and an underside characterised in that a spacer (970-973) is arranged on the underside of the screen support (942) and wherein the shale shaker comprises fixing apparatus for fixing the periphery of the screen assembly (940) and a structural member underneath the screen assembly, the spacer (970-973) arranged between the screen support (940) and the structural member.

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SCREEN ASSEMBLY AND SHALE SHAKER

The present invention relates to a screen assembl for use in a shale shaker and a shale shaker.

In the drilling of a borehole in the construction of an oil or gas well, a drill bit is arranged on the end of a drill string and is rotated to bore the borehole. A drilling fluid known as "drilling mud" is pumped through the drill string to the drill bit to lubricate the drill bit. The drilling mud is also used to carry the cuttings produced by the drill bit and other solids to the surface through an annulus formed between the drill string and the borehole. The drilling mud contains expensive synthetic oil-based lubricants and it is normal therefore to recover and re-use the used drilling mud, but this requires the solids to be removed from the drilling mud. This is achieved by processing the drilling fluid. The first part of the process is to separate the solids from the solids laden drilling mud. This is at least partly achieved with a vibratory separator, such as those shale shakers disclosed in US 5,265,730, WO 96/33792 and WO 98/16328.

Shale shakers generally comprise an open bottomed basket having one open discharge end and a solid walled feed end. A number of rectangular screens are arranged in the basket, which are held in C-channel rails located on the basket walls, such as those disclosed in GB-A-2,176,424. The basket is arranged on springs above a receptor for receiving recovered drilling mud. A skip or ditch is provided beneath the open discharge end of the basket. A motor is fixed to the basket, which has a drive rotor provided with an offset clump weight. In use, the motor rotates the rotor and the offset clump weight, which causes the basket and the screens fixed thereto to shake. Solids laden mud is introduced at the feed end of the basket on to the screens. The shaking motion induces

the solids to move along the screens towards the open discharge end. Drilling mud passes through the screens. The recovered drilling mud is received in the receptor for further processing and the solids pass over the discharge end of the basket into the ditch or skip.

The screens are generally of one of two types: hook-strip; and pre-tensioned.

The hook-strip type of screen comprises several rectangular layers of mesh in a sandwich, usually comprising one or two layers of fine grade mesh and a supporting mesh having larger mesh holes and heavier gauge wire. The layers of mesh are joined at each side edge by a strip which is in the form of an elongate hook. In use, the elongate hook is hooked on to a tensioning device arranged along each side of a shale shaker. The shale shaker further comprises a crowned set of supporting members, which run along the length of the basket of the shaker, over which the layers of mesh are tensioned. An example of this type of screen is disclosed in GB-A-1,526,663. The supporting mesh may be provided with or replaced by a panel having apertures therein.

The pre-tensioned type of screen comprises several rectangular layers of mesh, usually comprising one or two layers of fine grade mesh and a supporting mesh having larger mesh holes and heavier gauge wire. The layers of mesh are pre-tensioned on a rigid support comprising a rectangular angle iron frame and adhered thereto. The screen is then inserted into C-channel rails arranged in a basket of a shale shaker. An example of this type of screen is disclosed in GB-A-1,578,948.

A further example of a known rigid support is disclosed in PCT Publication No. WO 01/76719, which discloses, amongst other things, a flat panel like portion having apertures therein and wing portions which are folded to form a support structure, which may be made

from a single sheet of material. This rigid support has been assigned the Trade Mark "UNIBODY" by the applicants.

US-A-4,575,421 discloses a screen assembly having a perforate rigid plate having two layers of mesh adhered thereto and two hook strips provided on either side to facilitate attachment in a shale shaker provided with a plurality of stringers over which the screen assembly is crowned. The rigid plate is rigid in terms of maintaining some tension in the screening material, but would nonetheless flex when held between the hook strips.

The layers of mesh in the screens wears out frequently and therefore needs to be easily replaceable. Shale shakers are generally in the order of 5ft wide and 10ft long. A screen of dimensions 4ft wide by 10ft long is difficult to handle, replace and transport. It is known to use two, three, four or more screens in a single shale shaker. A standard size of screen currently used is of the order of 4ft by 3ft.

US-A-4,582,597 discloses a vibratory separator having a basket and channels arranged on internal faces of the basket for receiving the two sides of a screen assembly. An inflatable hose is arranged in the channels. The screen assembly comprises screening mesh laid over and fixed to a frame. The screen assembly is slid into the channels in the vibratory separator. The hose is inflated using a pneumatic fluid to force the frame of the screen assembly to assume a crowned centre, in order to reduce whipping.

GB-A-2,176,424 discloses a vibratory separator having a basket and channels arranged on internal faces of the basket for receiving a screen assembly and a clamping device. The screen assembly comprises screening mesh laid over and fixed to a frame. The clamping device comprises a frame of similar dimensions to the frame of the screen assembly. The frame has an inflatable stocking thereon,

which is attached to pneumatic or hydraulic fluid supply means. When both the screen assembly and the clamping device are slid into the channels, the stocking is inflated to fix the screen assembly in the channels. There is also disclosed a clamping device having an intermediate frame member on which a tributary of the stocking is arranged. Support members are provided above and below the screen assembly so that, in use the tributary is inflated to clamp the screen assembly between the supports.

GB-A-2,176,425 discloses a vibratory separator having a basket and channels arranged on internal faces of the basket for receiving a screen assembly. The screen assembly comprises screening mesh laid over and fixed to a frame. The channels have an inflatable stocking therein for clamping the frame of the screen assembly in the channels. The screen assembly also has a stiffening rib along each of two intermediate parts of the screen assembly and the vibratory separator has a tributary of the stocking along each of two intermediate parts of the vibratory separator, such that in use, the tributaries are inflated to engage the stiffening ribs.

US-A-4,809,791 discloses a shaker having a screen. The screen is supported on flexible transverse arch-shaped beams attached to the sides of a frame. A ram is arranged in the shaker and is attached to the centre of the flexible transverse arch-shaped beam. The ram is extended to increase the tension in the screen.

It is important to achieve maximum screening area in a given space and to obviate the need for mechanisms for fixing screen assemblies to shakers which blind areas of the screening material and which will decrease the screen assembly's screening capacity.

The present invention also attempts to provide a panel for a screen, which will increase the life of

layers of screening material arranged thereon.

In accordance with the present invention, there is provided a screen assembly for a shale shaker, the screen assembly comprising a support and at least one layer of screening material, the support having a periphery and an underside characterised in that a spacer is arranged on the underside of the support.

Preferably, the support comprises two opposed sides and a support member extending between the sides, wherein the spacer is arranged underneath the support member. Advantageously, the spacer extends substantially the entire length of the support member. Alternatively, the spacer may be shorter or longer. Preferably, the support is generally rectangular.

Advantageously, the support comprises a frame. Preferably, the frame comprises support members made from tubing. Preferably square section or round section. The cross-member preferably, has a cross-member width and the generally flat side of the body has a body width and the body width is substantially equal to the cross-member width.

Alternatively, the support is of the type having a body member made of a single integral sheet-like material, said body member having a first portion and a second portion, said first portion having a plurality of rib supports bent or folded out from spaced apart openings, slots or cuts of said first portion, the second portion having at least one opening therethrough bent or folded over onto the first portion so that the underside of the second portion contacts top surfaces of the rib supports, the spacer arranged underside of the support.

Preferably, the spacer comprises a seal.

Advantageously, the support comprises a cross-member

within the periphery of the support, the spacer arranged on the cross-member. Preferably, the support comprises a plurality of cross-members.

Preferably, the spacer has a body defining generally a "D" shaped. Advantageously, the spacer is hollow. Alternatively, the spacer has a solid body. The spacer may rap around the support member and may form a lip. The spacer may be arranged in a recess in the support. The support member may have a series of openings therethrough, and may form a truss-like rib. Cutouts, which may be triangular openings in the rib may form the truss-like configuration. Preferably, the spacer is secured to the underside of the support by at least one of the following: glue; a friction fit between the spacer and the support.

Preferably, the screen assembly further comprises a seal on the periphery of the screen assembly for seal between an abutting screen or part of a shale shaker forming an interface. Preferably, on end faces of the ends of the screen assembly and/or side faces of the sides of the screen assembly.

Preferably, the spacer is a generally rectangular cross-section which is about 2cm (3/4") long and about 1cm (3/8") high. The spacer may be within one or two cm larger than these dimensions.

Preferably, the support has at least one hole for receiving an upwardly projecting member projecting upwardly from the mounting structure of the shale shaker. Advantageously, the spacer is arranged within the periphery of the support. Preferably, not only on the peripheral support members.

Advantageously, the screen assembly comprises a further layer of screening material.

Preferably, the spacer is arranged substantially around the entire periphery of the support.

The present invention also provides a shale shaker comprising a screen assembly of the invention, wherein the shaker comprises fixing apparatus for fixing the periphery of the screen assembly and a structural members underneath the screen assembly, characterised in that the spacer is arranged between the screen support and the structural member. Preferably, the structural members are arranged underneath the screen assembly and within the periphery thereof.

The present invention also provides a method for treating material with a shale shaker, the method comprising the steps of introducing material to be separated into the shale shaker of the invention, vibrating the screen assembly to separate the material. Preferably, the material is solids laden drilling mud.

The present invention also discloses, in at least certain embodiments and certain aspects, a screen assembly for mounting on mounting structure or deck of a vibratory separator or shale shaker, the screen assembly having a frame with a first frame end spaced apart from a second frame end by two opposed spaced-apart sides including a first side and a second side, the frame having a top and a bottom, the frame abutting the mounting structure or deck at a mounting-structure/frame interface, screening material on the frame, and seal apparatus on the frame for sealing the mounting-structure/frame interface.

The present invention, in certain aspects, discloses methods for mounting a screen assembly to a screen mounting structure of a vibratory separator to facilitate sealing of an interface between the screen assembly and

the screen mounting structure, the method including locating the screen assembly on the screen mounting structure so that all cross-members of a support supporting screening material of the screen assembly are all either generally transverse to or all generally parallel to the a direction of material flow from one side of the screen assembly to the other, or at least two exterior sides of the support are independent along their entire lengths without connection between an exterior side and a cross-member that extends across the support parallel to the side (i.e., there may be one or more transverse cross-members extending between two longitudinal cross-members, but such transverse cross-members do not connect with the exterior sides of the support), and forcing first and second sides of the support down with crowning apparatus to effect crowning of the screen assembly, third and fourth sides (the sides which have no connection to the transverse cross-members) which are at right angles to the first and second sides rigid yet sufficiently flexible so that with the screen assembly in a crowned configuration the third side and the fourth side each along substantially all of the length thereof sealingly contact a surface of the screen mounting structure, In certain embodiments of the present invention a screen assembly is disclosed in which a honeycomb structure serves as a support member for screen mesh material.

Such screen assemblies which have relatively less material than certain prior art screen assemblies, yet which are sufficiently strong and stable for effective use; Such screen assemblies with one or more spring members in a support for screening material.

For a better understanding of the present invention, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1A is an underneath view of a support for a screen assembly in accordance with the present invention; Figure 1B is a view in cross-section taken along line 1B-1B of Figure 1A;

Figure 2 is an underneath view of part of support for a screen assembly in accordance with the present invention;

Figures 3A, 3B, and 3C are views in cross-section of alternative parts of a support for a screen assembly in accordance with the present invention;

Figures 4A and 4B are side views in cross-section of seals and seal holders for use in a screen assembly in accordance with the present invention;

Figures 5A to 5D are side cross-section views of seal structures in accordance with the present invention.

Figure 6A is a top view of a screen assembly in accordance with the present invention; Figure 6B is an underneath view of the screen assembly shown in Figure 6A;

Figure 6C is an end view and Figure 6D is a side view of the screen assembly shown in Figure 6A;

Figure 7 is a perspective view of a shale shaker in accordance with the present invention;

Figure 8 is a view in cross-section of a seal member arranged on a frame member forming part of a screen assembly in accordance with the present invention;

Figure 9A is a top view of a frame for a screen assembly in accordance with the present invention; Figure 9B is a view in cross-section taken along line 9B-9B of Figure 9A; Figure 9C is a view in cross-section taken

along line 9C-9C of Figure 9A;

Figure 10A is a top view of a frame for a screen assembly in accordance with the present invention; Figure 10B is a side view of the screen assembly shown in Figure 10A; Figure 10C is an end view of the screen assembly shown in Figure 10A; Figure 10D is a view in cross-section taken along line 10D-10D of Figure 10A; Figure 10E is a view in cross-section taken along line 10E-10E of Figure 10A; Figure 10F is a side view in cross-section of a cross-member of the screen assembly shown in Figure 10A;

Figure 11A is a top view of a frame for a screen assembly in accordance with the present invention; Figure 11B is a side view of a cross-member of the screen assembly shown in Figure 11A; Figure 11C is a side view of an alternative cross-member for the screen assembly shown in Figure 11A;

Figure 12 is a view in cross-section of a member for a screen assembly in accordance with the present invention;

Figure 13A is a side view of a prior art shale shaker; Figure 13B is a top view of the shale shaker shown in Figure 13A; Figure 13C is a side view in cross-section of the shaker shown in Figure 13A; Figure 13D is a view of part of the shale shaker shown in Figure 13C; Figure 13E is a view of a part of the shale shaker shown in Figure 39A; and

Figure 14 is a view in cross-section of part of a support having a space maintainer for a screen assembly in accordance with the present invention.

Referring to Figures 1A and 1B, there is shown a support for use in a screen assembly 300 in accordance with the present invention which has two end members 301,

302 spaced apart by two side members 303, 304. Two optional spaced-apart cross-members 305, 306 extend between the two end members 301, 302 and two optional spaced-apart cross-members 307, 308 extend between the cross-members 305, 306. The end members, side members, and/or cross-members may be solid or they may be hollow. As shown in Figure 1B a side member 303 is a hollow tubular member as is commonly used in supports for screen assemblies for vibratory separators and shale shakers. One, two, three or more layers of screening material (not shown) may be provided to form a screen combination (not shown). The layer of screening material may be glued or sewn together. The screen combination may further comprise a supporting mesh (not shown). The supporting mesh may be glued, epoxied, sewn or otherwise attached to the screen combination. The screen combination or supporting mesh may be adhered, epoxied, sewn or otherwise attached to the support to form a complete screen assembly. A perforate plate may also be used to support the screen combination and/or supporting mesh and may be bonded thereto. The perforate plate may be bonded to the support or simply placed over the support and fixed to the support in a fixing mechanism in a shale shaker, such as a pneumatic bladder, such as the one sold by the applicants under the trade name "PNEUMO-SEAL", thus forming a screen assembly in the shale shaker.

As shown in Figure 1A seal members 311 - 314 are affixed to underneath surfaces of the end members 301, 302 and the side members 303, 304 to seal an interface between a screen assembly with a support 300 and a deck or mounting surface of a vibratory separator or shale shaker. Optionally, either the seal members 311, 312 or the seal members 313, 314 are deleted. Any suitable seal

members, including any seal disclosed herein in accordance with the present invention, may be used for the seals 311 - 314; and, as shown in Figure 27B, in one aspect the seal 314 is "D" shaped with a hollow interior 315 which facilitates flexing of the seal to enhance sealing against a shaker deck or other screen mount or support. In one aspect the seals are made of nitrile material.

As shown in Figure 2 a screen support 310 (or any support in accordance with the present invention) may have exterior seals around its periphery like the seals 316, 317 shown on an end member 301 and a side member 303 (shown partially; seals extend completely around support). As with the bottom seals 311 - 314, any pair of two of the peripheral seals may be deleted. The seals 316, 317 may be solid or hollow with any shape shown or referred to herein.

Figure 3A shows a seal 320 (similar to the seal 260 described above) secured to a screen assembly support part 321. Optionally, the seal 320 has a void space 322 which enhances seal/screen deck contact and, also optionally, a corrugated surface 324 for contacting a surface for sealing. Any seal structure in accordance with the present invention may be made of any suitable plastic, metal, rubber, composite, fiberglass, alloy or seal material.

Figure 3B shows a seal 330 (similar to the seal 280 described above) secured to a screen assembly support 332. The seal 330 has a lip 334 for abutting a surface to be sealed against. A wall 335 connects the lip 334 to a base part 336 of the seal 330. Optionally a void space 337 extends throughout the length of the seal 330 to enhance flexibility. Any seal or seal member in

accordance with the present invention may have a void space like the void space 337 of a cross-sectional shape similar to or different than that of the void space 337 (e.g., oval, circular, square).

Figure 3C shows a seal 340 on a support part 342. The seal 340 has a hemispherically-shaped head 344 projecting from a base 346.

A seal like the seals 311 to 314 on the screen support 300 helps inhibit unscreened fluids from flowing beneath a screen assembly and a shaker deck (or other mount or screen assembly support). The seals also prevent a metal screen support from directly contacting a metal screen mounting structure, reducing metal-to-metal wear. Any suitable fasteners, connectors and/or adhesives or glues may be used to secure a seal in accordance with the present invention to a frame or screen support. In one particular aspect LOCTITE (trademark) adhesives are used to adhere the seals to a screen support.

Figure 4A shows a seal holder 240 in accordance with the present invention which has a lower part 241a, an upright part 241b, and a top part 241c projecting downwardly. A seal 242 has a body 243 releasably and removably disposed in an interior space of the seal holder 240. Optionally, the body 243 is hollow as shown (or it may be solid). A lip 244 is connected to or formed integrally of a projecting part 245. The projecting part 246 is connected to or formed integrally of the body 243. The seal holder 240 can be used in a vibratory separator or shale shaker. Preferably the shape of the interior space of the seal holder 240 and of the body 243 of the seal 242 are substantially the same. The lip 244 is optional. Preferably the seal 242 is

flexible to enhance its sealing effect against the end of a screen assembly. The top part 241c of the seal holder 240 projects into a recess 246 formed between the lip 244 and the body 243 of the seal 242. This assists in maintaining the seal 242 in a desired position with respect to the end of a screen assembly. Such seal holders may be suitable for the one or both ends of the screen to seal between abutting screens and for abutting a surface in the shale shaker. The seals shown in Figure 1A to 3C are used in conjunction with the seal holders shown in Figures 4A and 4B.

Figure 4B shows a seal holder 247 in accordance with the present invention which has a lower part 247a, an upright part 247b, and an inclined part 247c projecting upwardly. A seal 248 has a body 248a releasably and removably disposed in an interior area of the seal holder 247. Optionally, the body 248a is hollow as shown (or it may be solid). A lip 249 is connected to or formed integrally of a projecting part 248b. The projecting part 248b is connected to or formed integrally of the body 248a. The seal holder 247 can be used in a vibratory separator or shale shaker as the seal holder 22. Preferably the shape of the interior space of the seal holder 247 and of the major portion of the body 248a of the seal 247 are substantially the same. The lip 249 is optional. Preferably the seal 282 is flexible to enhance its sealing effect against the end of a screen assembly. The inclined part 247c of the seal holder 247 projects into a recess 248c formed between a lower part 248d of the lip 249 and the body 248a of the seal 248. This assists in maintaining the seal 248 in a desired position with respect to the end of a screen assembly. In one aspect the lip 249 is flexible with respect to the

projecting part 248b and can move backwardly (to the left in Figure 30B) to accommodate a screen assembly end and/or to enhance sealing contact therewith.

It is within the scope of this invention for a screen assembly with a seal structure in accordance with the present invention (as is the case for any of the screen assemblies disclosed herein) to be any known screen assembly that abuts an end, side, or surface of a vibratory separator or shaker; and for the screening material to be any known screening material of one or more layers, with or without support, with or without layers connected together, which are generally flat or undulating.

Figure 5A shows a seal 250 removably mounted in a seal holder 251 with a screen assembly 252 (shown schematically) having an end 253 sealingly contacting the seal 250. The seal 250 has a lip 254 that abuts an exterior surface 255 of the seal holder 251. The screen assembly 252 has screening material 256. The seal 250 is of a length substantially equal to or slightly larger than a length of the end 253. The seal holder 251 is secured to, connected to, or formed integrally of a side wall 257 of a basket or other screen supporting structure of a separator or shaker.

Figure 5B shows a seal 260 removably mounted to a seal holder 261 with a screen assembly 262 (shown schematically) having an end 263 sealingly contacting the seal 260. The seal 260 has a recesses 264 that receive portions 265 of the seal holder 261. The screen assembly 262 has screening material 266. The seal 260 is of a length substantially equal to or slightly larger than a length of the end 263. The seal holder 261 is secured to, connected to, or formed integrally of a side

wall 267 of a basket or other screen supporting structure of a separator or shaker. Optionally, the seal 260 has a void space 268 which enhances seal/screen assembly contact and, also optionally, a corrugated surface 260a for contacting the screen end 263. Optionally a member 269 may be permanently or removably positioned within the seal holder 261 to serve as a space maintainer, shock absorber, cushion, and/or seal and may be made of any suitable plastic, metal, composite, fiberglass, alloy or seal material.

Figure 5C shows a seal 270 removably mounted in a seal holder 271 with a screen assembly 272 (shown schematically) having an end 273 sealingly contacting the seal 270. The seal 270 has a lip 274 that abuts a surface 275 of a seal holder 279. The seal holder 279 is removably or permanently positioned within a seal holder 271. The screen assembly 272 has screening material 276. The seal 270 is of a length substantially equal to or slightly larger than a length of the end 273. The seal holder 271 is secured to, connected to, or formed integrally of a side wall 277 of a basket or other screen supporting structure of a separator or shaker. The seal holder 279 may be made of any material mentioned above for the member 269. Optionally the seal holder 279 may have a corrugated outer surface 279a to facilitate its movement within the seal holder 271. A recess 279b receives a lip 274 of the seal 270. A wall 275 connects the lip 274 to an outer part 278 of the seal 270. Optionally, the seal 270 has an inner void space 270a.

Figure 5D shows a seal 280 removably mounted in a seal holder 281 with a screen assembly 282 (shown schematically) having an end 283 sealingly contacting the seal 280. The seal 280 has a lip 284 that abuts an

exterior surface 285 of the seal holder 281. The screen assembly 282 has screening material 286. The seal 280 is of a length substantially equal to or slightly larger than a length of the end 283. The seal holder 281 is secured to, connected to, or formed integrally of a side wall 287 of a basket or other screen supporting structure of a separator or shaker. A recess 281b receives a lip 288 of the seal 280. A wall 289 connects the lip 281b to an outer part 281c of the seal 280. A rigid member 280d extends throughout the length of the seal 280 to provide strength and rigidity. .

Any seal or seal member according in any embodiment of the present invention may have a rigid member like the rigid member 280d of a cross-sectional shape similar to or different than that of the rigid member 80d (e.g., oval, circular, square).

The seal holders of Figures 5A - 5D have a length corresponding to the length of the seals mounted therein or thereto (e.g. slightly shorter, slightly larger or similar to that of the seals). The seal preferably has a length equal to the length of the end member of the support for the screen assembly, or at least over a portion of the length of the end member which requires a sealing to be effected.

Figures 6A - 6F show a screen assembly 940 in accordance with the present invention which has a tubular frame 942 with end members 944 and interconnected side members 945. A screening material layer or combination of layers 950 is secured to the tubular frame 942, e.g. with glue, adhesive, epoxy, and/or fasteners. An optional cross-member 941 (of a plurality of optional spaced-apart cross-members 943 that extend between and have ends connected to the sides 945) has two optional

notches 946, either of which is for receiving a portion of an upstanding member of a shale shaker deck. As shown in Figure 6B, the frame 942 is surrounded with seal members 970 - 973 which are secured to the frame 942 with any suitable glue, adhesive, epoxy, and/or fasteners. In one aspect the seal members 970 - 973 are hollow with a general "D" shape with the flat part of the "D" adhered to the frame 942, in one particular aspect, with LOCTITE (trademark) brand commercially available adhesives, e.g. LOCTITE (trademark), TAK PAK (trademark) adhesives, PRISM (trademark) adhesives, or SUPER BONDER (trademark) adhesives; and, in one particular aspect, the seal members 970 - 973 are made of Nitrile material (which can withstand the heat and chemical composition of drilling materials pumped from a wellbore).

As shown in Figures 6A to 6D, optionally the seal members 971, 973 have holes 975 corresponding to and aligned with holes 974 in the frame 942 (holes 974 shown in dotted lines in Figures 6A, 6C, 6D). The holes 974, 975 are sized, configured and located for receiving an upwardly projecting member projecting upwardly from a screen mounting structure or deck of a shaker or vibratory separator. Optionally, one of the holes 974 is deleted.

Figure 7 shows a shale shaker 990 with a plurality of spaced-apart upwardly projecting members 902 projecting up from a deck 992. It is to be understood, although not shown, that as desired, upstanding members 902 may be provided spaced-apart on both sides or around the entire periphery of the deck 992 (or of any vibratory separator or shaker deck). Optionally, holes 993 may be deleted or they may be provided and sized for receiving downwardly projecting members of a screen assembly. In

one particular aspect the upstanding members 902 are sized and located for receipt within holes like the holes 974, 975 of the screen assembly 940, Figures 6A to 6D. Optionally, only one upstanding member 902 is provided for each screen assembly.

Thus it is seen, e.g. as shown in Figures 6A to 7, that the present invention provides a screen assembly for releasable mounting to a mounting structure of a vibratory separator or shale shaker, the mounting structure with a body over which a screen assembly is positionable, part of material to be treated flowable through the body, at least one upwardly projecting member projecting upwardly from the body, the at least one upwardly projecting member sized and configured so it is receivable in a corresponding hole in the screen assembly, the at least one projecting member having a projecting member cross-sectional area, the screen assembly having a support (e.g. a frame); screening material on the support (e.g. one, two, three or more layers); the support two spaced-apart ends, the two spaced-apart ends spaced-apart by two spaced-apart sides, each of the two spaced-apart sides connected to each of the two spaced-apart ends, optionally one or a plurality of spaced-apart cross-members extending between the two spaced-apart sides from one side to the other side, at least part of the support being a tubular member with a top and a bottom, a portion of the screening material over the tubular member; at least one hole in the bottom of the tubular member, the at least one hole sized, configured, and located for receiving the at least one upwardly projecting member of the body of the mounting structure, the at least one hole having a hole cross-sectional area greater than the projecting member cross-

sectional area.

Thus it is also seen, e.g. as shown in Figures 6A to 7, that the present invention provides a shale shaker system for separating components of drilling fluid with solids entrained therein, the shale shaker system having a base; a screen mounting basket on the base; vibrating apparatus connected to the screen mounting basket for vibrating the screen mounting basket; the screen mounting basket having mounting structure for at least one screen assembly mounted on the mounting structure, the mounting structure having a body over which the at least one screen assembly is positionable, part of the drilling fluid to be treated by the shale shaker flowable through the at least one screen assembly and through the body; at least one screen assembly mounted on the mounting structure; the at least one screen assembly releasably mounted to the mounting structure of a shale shaker; the mounting structure having at least one upwardly projecting member projecting upwardly from the body, the at least one upwardly projecting member sized and configured so it is receivable in a corresponding hole in the screen assembly; the at least one projecting member having a projecting member cross-sectional area; the at least one screen assembly including a support; screening material on the support; the support being a frame with two spaced-apart ends, the two spaced-apart ends spaced-apart by two spaced-apart sides, each of the two spaced-apart sides connected to each of the two spaced-apart ends, the frame optionally having one or a plurality of spaced-apart cross-members extending between the two spaced-apart sides from one side to the other side, at least part of the frame being a tubular member with a top and a bottom, a portion of the screening material on top

of the tubular member; and at least one hole in the bottom of the tubular member, the at least one hole sized, configured, and located for receiving said at least one upwardly projecting member of the body of the mounting structure, the at least one hole having a hole cross-sectional area greater than the projecting member cross-sectional area.

Figure 8 shows a seal member 980 in accordance with the present invention which may be used in place of or in combination with any seal or seal member disclosed herein for sealing a support/mounting-structure interface. The seal member 980 has a corrugated structure (as viewed in cross-section in Figure 8) and, in accordance with the present invention, such a seal member may have any desired member of ridges and valleys. In one aspect, the seal member 980 is made of a single sealing material; but, as shown, the seal member has multiple layers 981 - 983. In one aspect these layers are of differing flexibilities with the layer 981 most flexible, the layer 982 less flexible, and the layer 983 least flexible. Optionally, any one or two layers are deleted. Adhesive, glue, or epoxy 985 - 987 secures the seal member 980 to a frame member 984.

Figures 13A - 13E illustrate a prior art shale shaker SH which has a four screen assembly mounting structures M each of which has two crossbars C. Cross-members of screen assemblies (e.g. see the screen support in Figure 1A) mounted on the mounting structures M are often located and positioned to abut the crossbars C. Use of peripheral seals around the bottom of a screen assembly support or frame (e.g. see the seal members 311 - 314, Figure 1A) can effectively raise a screen assembly with respect to a mounting structure or deck; e.g. in one

particular aspect a three-eights inch gap is created between parts of a mounting structure or deck and the bottom of a support or frame. With such a gap present a screen assembly can flex repeatedly in use resulting in damage to the screen assembly and a shortened screen assembly useful life. In the prior art, to remedy this situation, pieces of resilient material called "crown rubbers" (see crown rubber R, Figure 13E) are placed on the crossbars C which fill the gap and maintain contact with the bottom of the screen assembly, e.g. with cross-members as in Figure 1A. The crown rubbers R are made of urethane or nitrile.

Problems have arisen related to the use of the crown rubbers. Over time the crown rubbers wear and need to be replaced. If they are not replaced regularly, a gap can be formed between the crown rubbers and the bottom of a screen assembly. This gap allows the screen assembly to flex inordinately resulting in damage to the screen assembly and shortened screen assembly life.

In accordance with the present invention, a screen assembly is provided which has screening material (any known in the prior art, any described herein, any number of layers either connected together or not) secured over a screen assembly support or frame with space maintenance apparatus on the bottom of the screen assembly to fill the gap between the bottom of the screen assembly and the top of screen assembly mounting structure to maintain the screen assembly in contact with the mounting structure and to inhibit or prevent inordinate flexing of the screen assembly.

Figures 9A to 9B show a screen assembly support 400 in accordance with the present invention which has two ends 401, 402 spaced apart by two sides 403, 404. The

screen assembly 400 as shown is upside down with its bottom shown in Figure 35A. Two spaced-apart cross-members 405, 406 extend between the two ends 401, 402 and two optional spaced-apart cross-members 407, 408 extend between the cross-members 405, 406. (It is within the scope of this invention to use one, two, three, four or more of the cross-members 405 and/or cross-members 407). The ends, sides, and/or cross-members may be solid or they may be hollow. As shown in Figure 9C hollow tubular members are used for the support 400 (as is common in supports for screen assemblies for vibratory separators and shale shakers).

As shown in Figure 9B space maintainers 411, 412 are affixed to bottom surfaces of the cross-members 405, 406 to contact a mounting structure or deck and to maintain contact between a screen assembly with a support 400 and a deck or mounting surface of a vibratory separator or shale shaker. As shown in Figure 9C, the space maintainer 411 is hollow and is like the previously described seal members 311 to 314. Any seal members disclosed herein may be used for the space maintainers 411, 412 (and as may be any space maintainer disclosed herein). In one aspect the space maintainers 411, 412 are made of nitrile material. To reduce flexing of a screen assembly, in one aspect, e.g. as shown in Figure 9C, the base 414 of a space maintainer is as wide as a part to which it is secured A hollow space 412 allows a curved part 413 to flex to maintain contact with a mounting structure.

The space maintainers 411, 412 (and any space maintainer in accordance with the present invention) may be secured to the bottom of a frame or support as are any seals or seal members described herein and/or with

screws, staples, brads, rivets and/or releasably cooperating hook/loop fastener material. In one aspect the space maintainers are secured to the bottom of cross-members of the frame or support with glue or adhesive.

Figures 10A to 10E illustrate a screen assembly support 420 like the screen assembly 400, Figure 9A, and like numerals indicate like parts Seal members 401a, 402a, 403a and 404a are like the seal members 311 - 314, Figure 1A and may be as wide as the seal members 311 - 314 but as shown are as wide as the support part to which they are secured. Figure 10F illustrates an alternate embodiment for the cross-member 406 (and also for the cross-member 405) in which a space maintainer 460 (like the space maintainer 411 in materials and cross-sectional dimensions or like any space maintainer disclosed herein) has ends 461, 462 which terminate a distance d from seals 401a, 402a, respectively, so that the space maintainer 460 does not inhibit sealing of the seals 401a, 402a. Such length and spacing may be used with any space maintainer in accordance with the present invention.

Figures 11A and 11B illustrate a screen assembly support 430 in accordance with the present invention which is like the support 400, Figure 9A and like numerals indicate like parts. Although it is within the present invention to provide a space maintainer for each cross-member of a screen assembly support, it is also within the present invention to provide only one cross-member with a space maintainer. It is also within the present invention to provide a space maintainer which is as long as a cross-member or which is shorter (e.g. in certain aspects between four and thirty inches long) than a cross-member. It is also within the scope of the present invention to provide a cross-member with two,

three, four or more spaced-apart space maintainers. Space maintainers in accordance with the present invention may be made of urethane (e.g. 80 to 90 durometer hardness) or of nitrile rubber material.

As shown in Figures 11A and 11B, a space maintainer 439 (e.g. like the space maintainers 411, 412, Figure 9A except in length relative to the side 403) is secured to a bottom of the cross-member 406. In certain aspects the space maintainer 439 is between 10cm and 76cm (four and thirty inches) long. It is within the scope of the present invention to provide a similar space maintainer on the cross-member 405. As shown in Figure 11C it is within the scope of the present invention to provide a plurality of spaced-apart space maintainers 436 - 438 (e.g. like any space maintainer discussed herein) on a cross-member 435 (e.g. like any cross-member discussed herein) of a screen assembly.

159. Although they are not equivalent to space maintainers as in Figures 9A - 11C, a space maintainer 440 in accordance with the present invention may be secured to a bottom of a screen assembly support cross-member 441 by friction fit and/or with a suitable glue or adhesive, e.g. "Super Glue."

The screen support may be of the type disclosed in PCT Publication Number WO 01/76719 (which discloses, *inter alia* a "UNIBODY" screen support) and provided with space maintainers as disclosed herein on the cross-members or ribs. Further, space maintainers as disclosed herein may be arranged on the truss-like cross-members and folded leaves disclosed in PCT Publication Number WO 2004/035231

The seals for sealing between screens may be any suitable seal may be used [and, in one aspect, a seal as

disclosed in U.S. Patent 6,443,310 B1 issued Sept. 3, 2003; in WO 2004/069429; or in WO 2004/035232; or in WO 2004/035233 -both said patent and all said applications incorporated fully herein for all purposes].

It has been recognized that in some vibratory separators employing screening assemblies employing supports (or frames) made of relatively rigid material (e.g., hollow tubular mild steel with a square cross-section and a side measuring about 3/4" with a wall thickness of about 1/8") that an effective seal between an edge or side of the support and part of a bed, basket or mounting structure of the vibratory separator is not achieved. In some aspects, two spaced-apart sides of a screen assembly are secured in place by edge mounting structure, wedge structures, or inflated bladders which push down on or wedge in the two spaced-apart sides. With a relatively rigid screen support, such mounting can result in insufficient flexing of the support so that sides of the support (not the sides contacted by the wedges or bladders) are not effectively sealed against the bed, etc., (or against a seal member on a bed, etc.) resulting in unsealed areas between the bed and the support through which pieces of drilled cuttings or other solids (which would normally move over and off the top of the screen assembly) can move, i.e., move through the open unsealed area (rather than as intended off the top of the screen for collection) and fall into a sump or reservoir (which is intended ideally to receive only filtered drilling fluid) from which they can be recycled back down into the wellbore negatively affecting drilling efficiency. One specific vibratory separator in which this problem may be encountered depending on the screen assemblies used is disclosed in U.S. Patent 5,641,070

issued June 24, 1997, incorporated fully herein for all purposes.

In one aspect this ineffective sealing problem is addressed in accordance with the present invention by modifying a typical rigid prior art support for a screen assembly by removing cross-members that extend in one of two general directions between one or the other pair of two spaced-apart sides thereof, so that the remaining cross-members are all positioned so that they lie generally in the direction of material flow on the screen assembly when it is in use on a vibratory separator or are all transverse to such flow direction; i.e., cross-members are present in certain of the methods in accordance with the present invention in only one direction, not both; and, in certain aspects, there are two, three, four, five, six or more of such cross-members which, in one aspect, are equally spaced-apart across the screen assembly and from the sides thereof. It is to be understood that the structure shown in these figures may be modified so that there are any desired number of cross-members and, in one particular aspect, two or five such cross-members equally spaced-apart across the support.

It is also desirable that as the solids, etc. move on top of the screens that, as viewed from above, the solids are uniformly and evenly distributed across the width of the screen assemblies. With a screen assembly with a prior art support as shown in Figure 12 with cross-members transverse to the length of the screen and cross-members connecting between a screen side and a cross-member (cross-members that in use would be generally parallel to the direction of material flow on the tops of the screen assemblies in Figure 24), "dead zones" develop on top of

the screen assemblies above the transverse cross-members and solids do not move in these dead zones or do not move as readily in these dead zones, creating a relatively larger mass of solids that moves along areas of the tops of the screen assemblies not above these cross-members resulting in a non-uniform flow of solids on the tops of the screens. When there are transverse cross-members extending from one side of the support to the other, these dead zones can also extend from one side of the screen assembly to the other. Undesirable masses of solids in these dead zones, masses with more liquid in them than in material in adjacent areas on top of the screen assembly, may not have as much fluid removed from them if the dead zones were not present. By removing transverse cross-members and using a support, e.g. as in Figures 13A and 23A or 25A or 26, the occurrence and/or size of these dead zones is reduced and greater processing efficiency is achieved. The relatively large masses of material moving on the top of a screen assembly with the prior art support can increase wear of the screen mesh and contribute to a shorter useful screen assembly life. If a screen assembly with the prior art support has these undesirable relatively large masses of solids moving on top of it, and the screen assembly is ineffectively sealed to the shaker's basket, deck, or bed for supporting screen assemblies, the problem with solids moving through an unsealed area into the sump is exacerbated.

The present invention, therefore, in at least some, but not necessarily all embodiments, provides a method for treating material with a vibratory separator, the method including introducing material to be treated to a vibratory separator, the vibratory separator as any

described herein in accordance with the present invention. Such a method may have one or some (in any possible combination) of the following: wherein the vibratory separator is a shale shaker and the material is drilling fluid with drilled material therein; and/or wherein the frame has at least one hole for receiving an upwardly projecting member projecting upwardly from the mounting structure of the vibratory separator, the method further including installing the at least one screen assembly so that the upwardly projecting member is received in the at least one hole.

CLAIMS:

1. A screen assembly for a shale shaker, the screen assembly comprising a support (942) and at least one layer of screening material (950), the support (942) having a periphery and an underside characterised in that a spacer (970-973) is arranged on said underside of said support (942).

2. A screen assembly as claimed in Claim 1, wherein said support (942) comprises two opposed sides (945) and a support member (943,944) extending between said sides, wherein said spacer (971,973) is arranged underneath said support member (943,944).

3. A screen assembly as claimed in Claim 2, wherein said spacer (971,973) extends substantially the entire length of the support member (943,944).

4. A screen assembly as claimed in Claim 2 or 3, wherein said support (942) is generally rectangular.

5. A screen assembly as claimed in any preceding claim, wherein said support (942) comprises a frame.

6. A screen assembly as claimed in Claim 5, wherein said frame comprises support members made from tubing.

7. A screen assembly as claimed in any preceding claim, wherein said spacer (413) comprises a seal.

8. A screen assembly as claimed in any preceding claim, wherein said support (400) comprises a cross-member (411) within the periphery of the support (400), said spacer (413) arranged on said cross-member (411).

9. A screen assembly as claimed in any preceding claim, wherein the spacer (413) has a body defining generally a "D" shaped.

10. A screen assembly as claimed in any preceding claim, wherein the spacer (413) is hollow.

11. A screen assembly as claimed in any preceding claim,

wherein the spacer (440) has a solid body.

12. A screen assembly as claimed in any preceding claim, wherein the spacer (440) is secured to the underside of the support (400) by at least one of the following: glue; a friction fit between the spacer and the support.

13. A screen assembly as claimed in any preceding claim, further comprising a seal (245) on the periphery of the screen assembly for seal between an abutting screen or part of a shale shaker forming an interface.

14. A screen assembly as claimed in any preceding claim, wherein the spacer (440) is a generally rectangular cross-section which is about 2cm (3/4") long and about 1cm (3/8") high.

15. A screen assembly as claimed in any preceding claim, wherein the support (942) has at least one hole (975) for receiving an upwardly projecting member projecting upwardly from the mounting structure of the shale shaker.

16. A screen assembly as claimed in any preceding claim, wherein the spacer (440) is arranged within the periphery of the support.

17. A screen assembly as claimed in any preceding claim, wherein said screen assembly comprises a further layer of screening material.

18. A screen assembly as claimed in any preceding claim, wherein said spacer (970-973) is arranged substantially around the entire periphery of the support (942).

19. A shale shaker comprising a screen assembly as claimed in any preceding claim, wherein said shaker comprises fixing apparatus for fixing the periphery of said screen assembly and a structural members underneath said screen assembly, characterised in that said spacer is arranged between the screen support and the structural

member.

20. A method for treating material with a shale shaker, the method comprising the steps of introducing material to be separated into the shale shaker as claimed in Claim 19, vibrating said screen assembly to separate said material.

21. A method in accordance with claim 18, wherein the material is solids laden drilling mud.

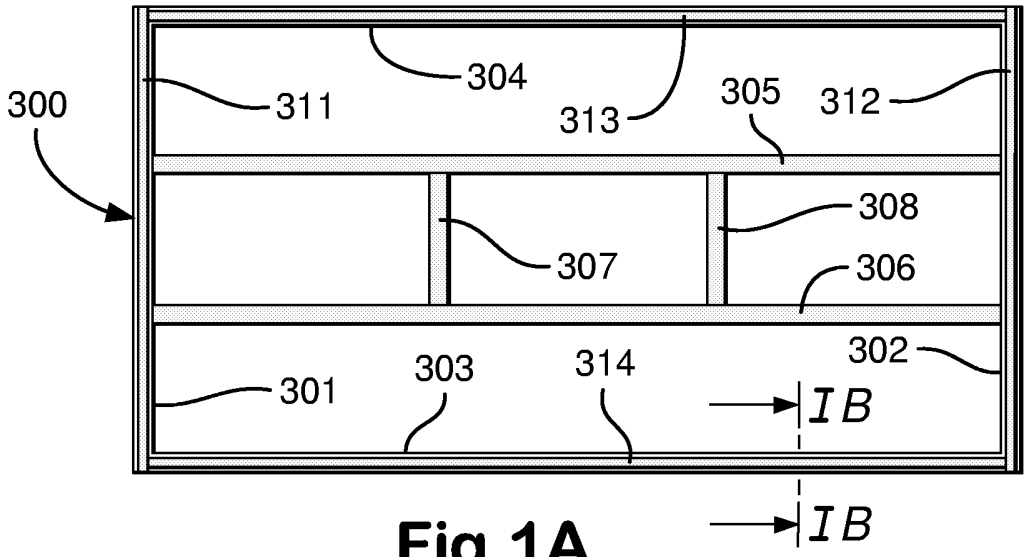

Fig.1A

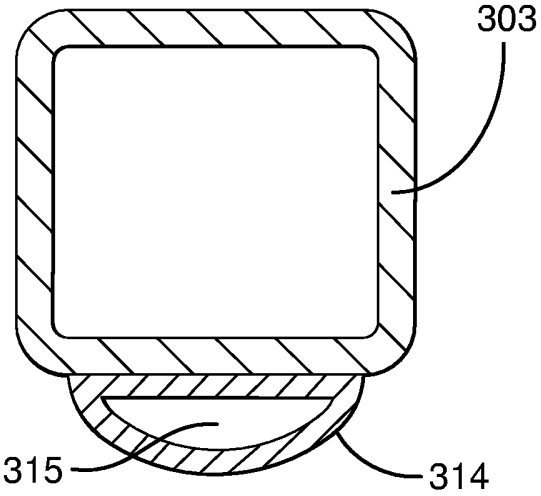

Fig.1B

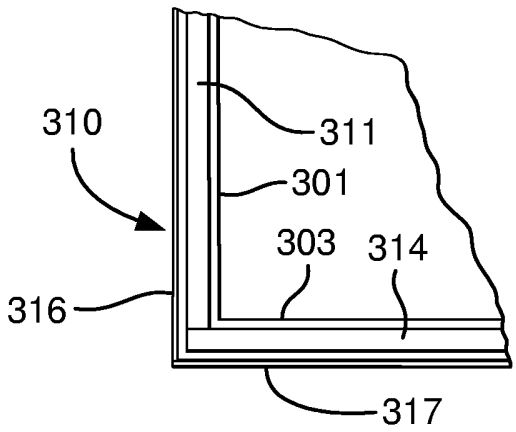

Fig.2

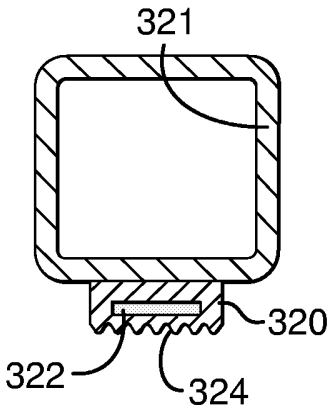

Fig.3A

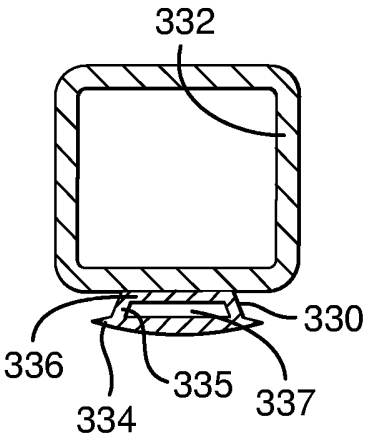

Fig.3B

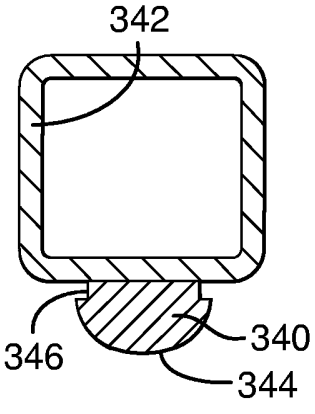

Fig.3C

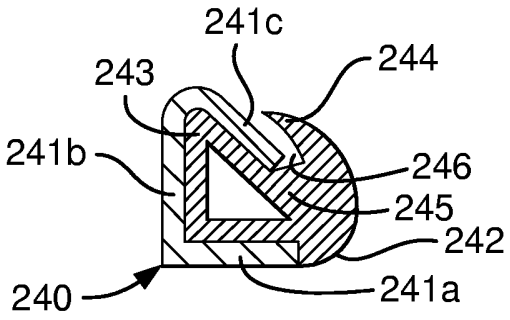

Fig.4A

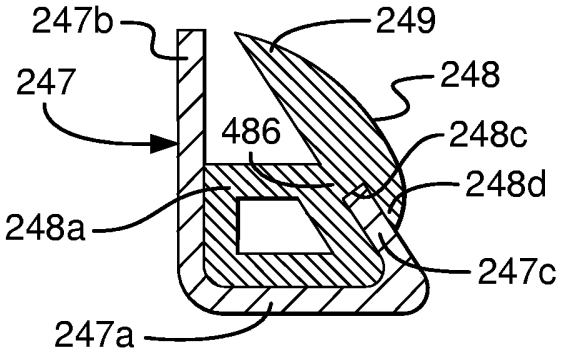

Fig.4B

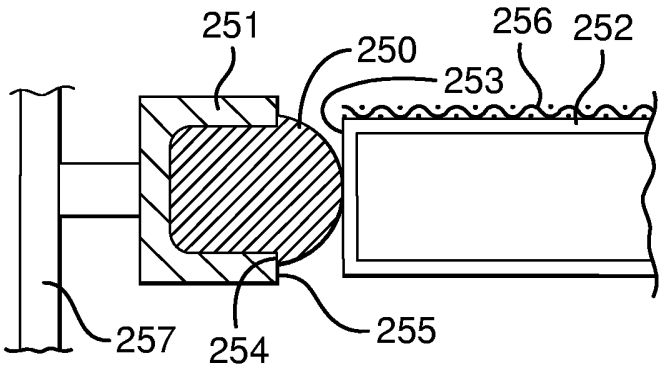

Fig.5A

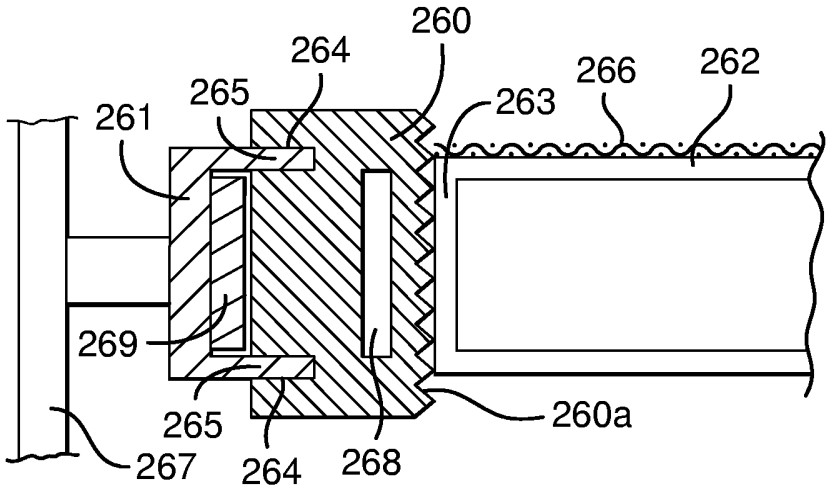

Fig.5B

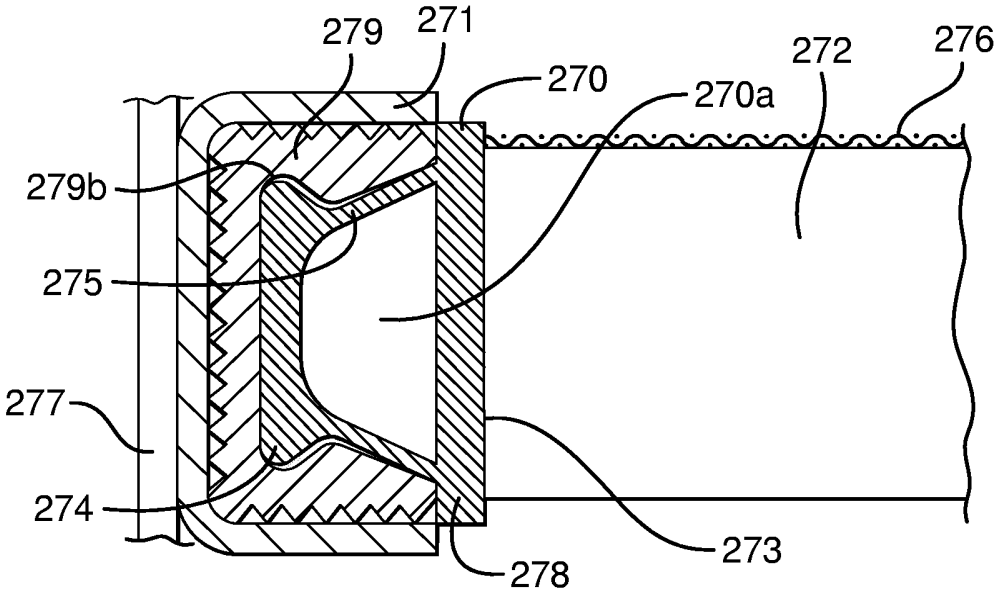
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Fig.5C

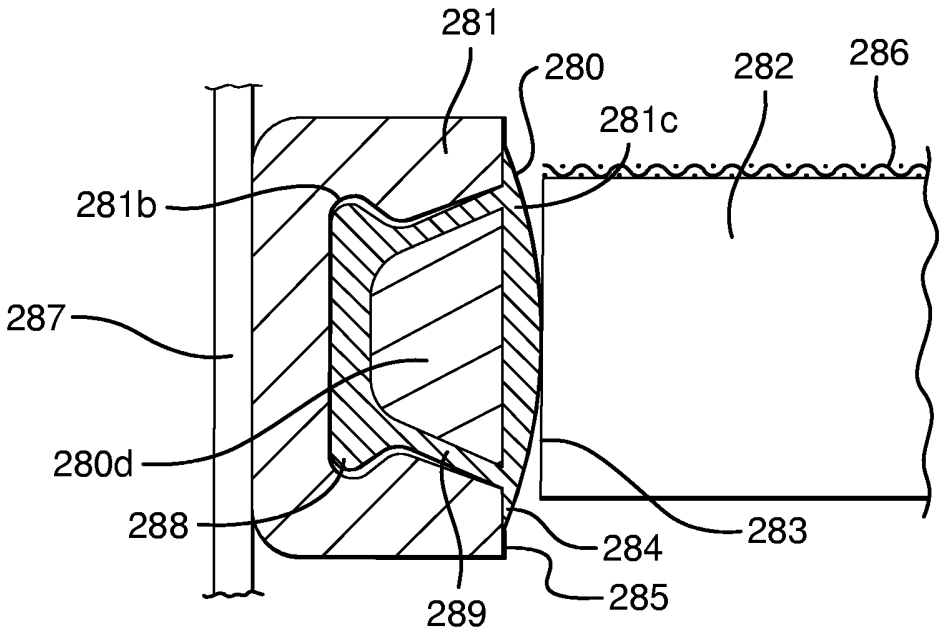
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Fig.5D

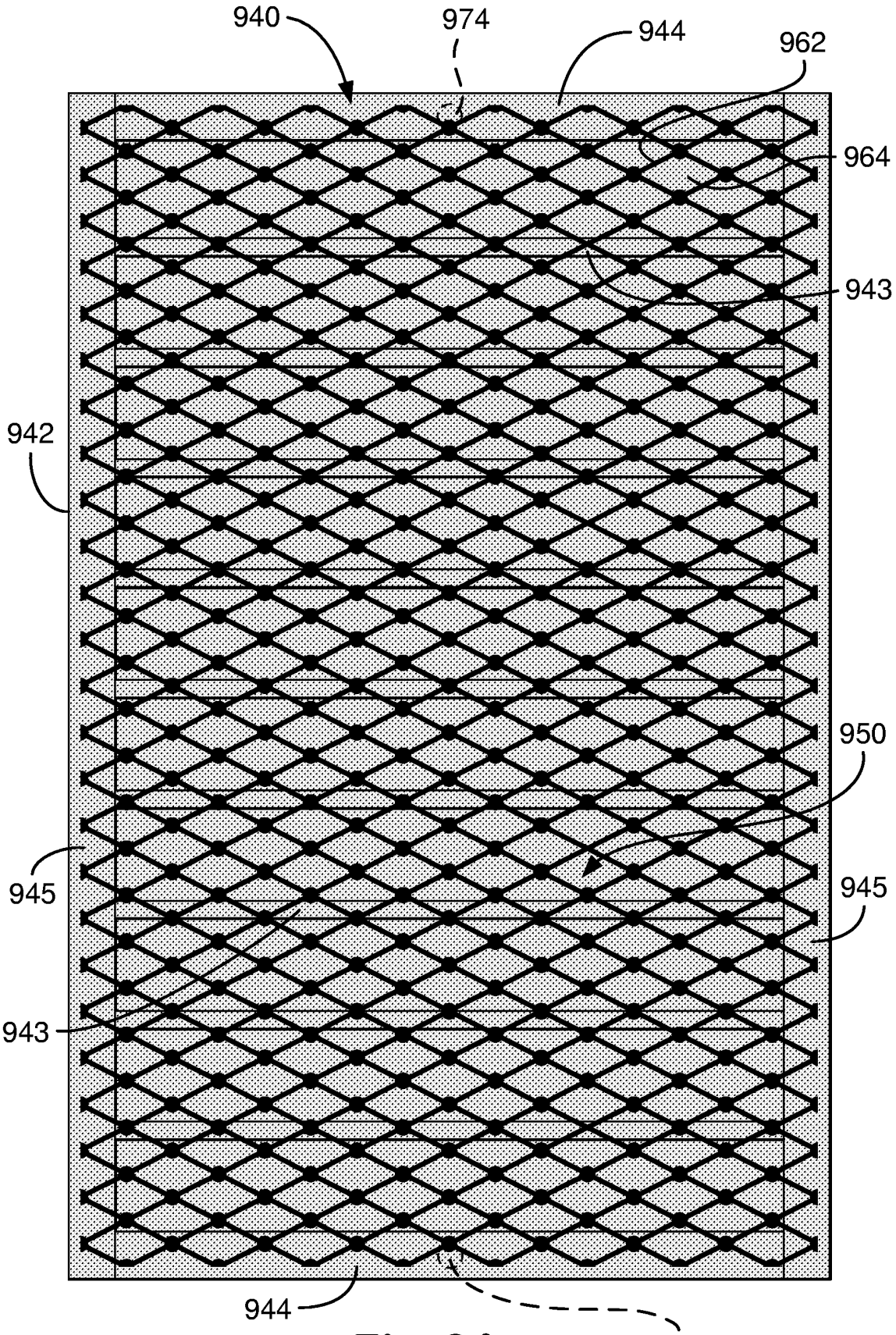

Fig.6A

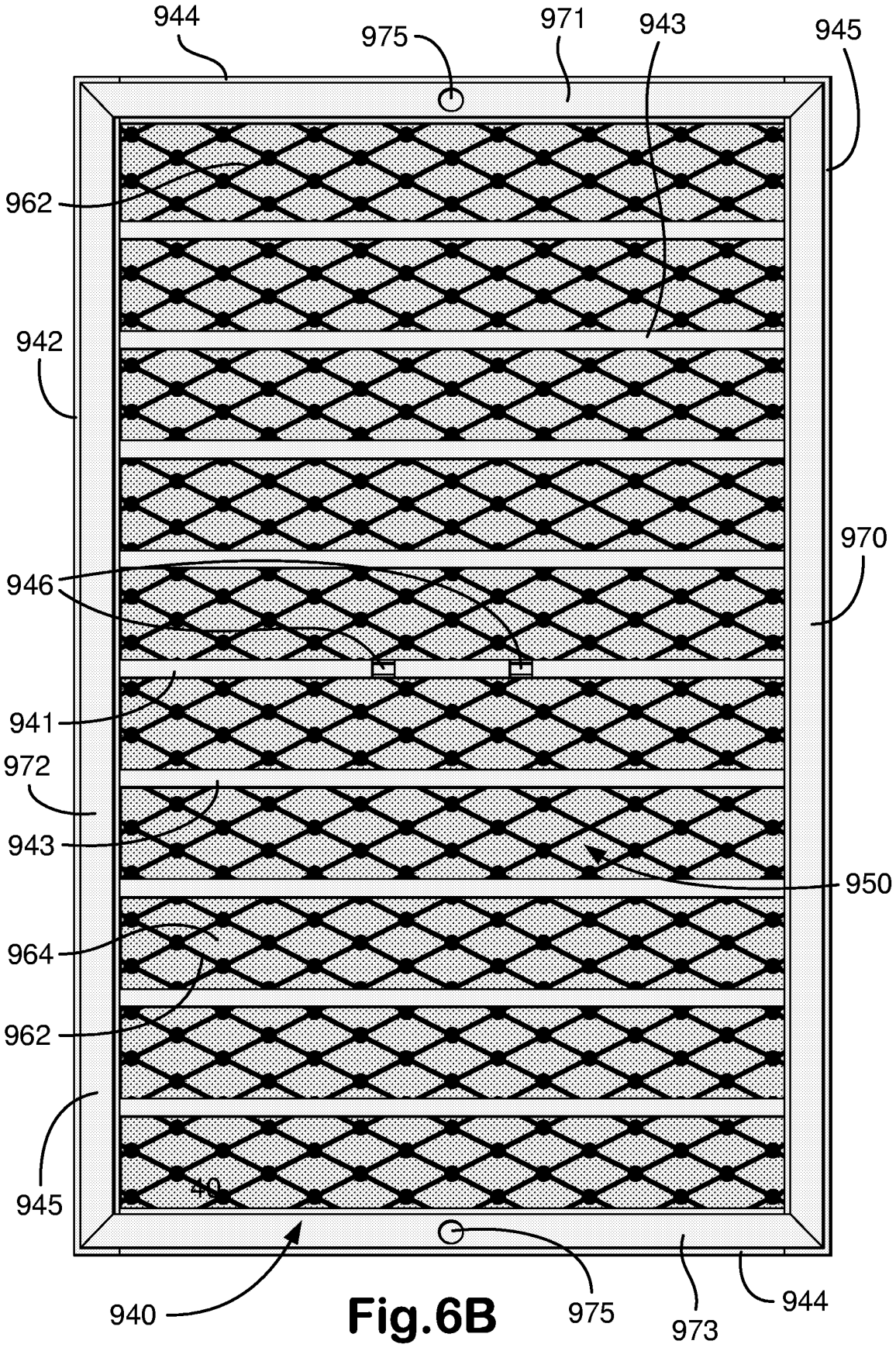
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Fig.6B

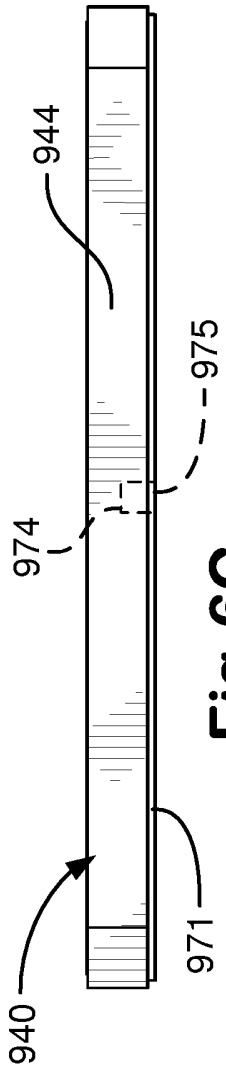

Fig.6C

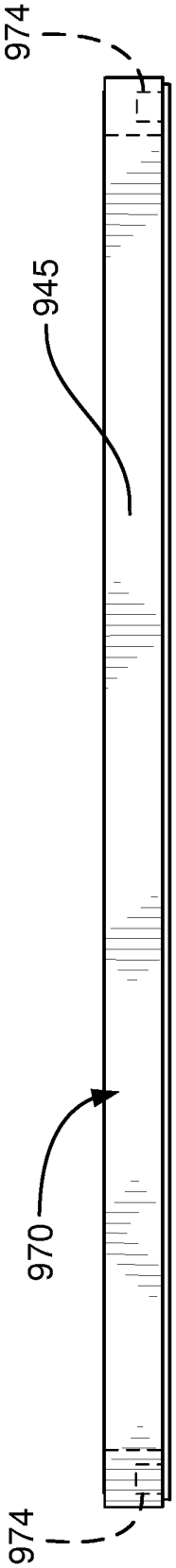

Fig.6D

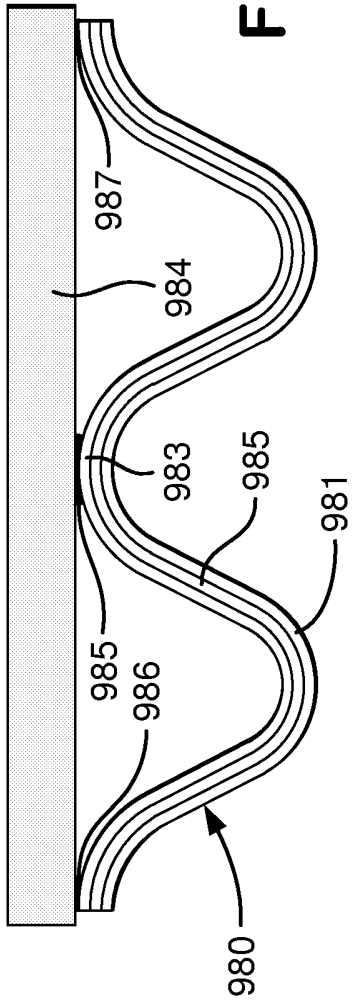

Fig.8

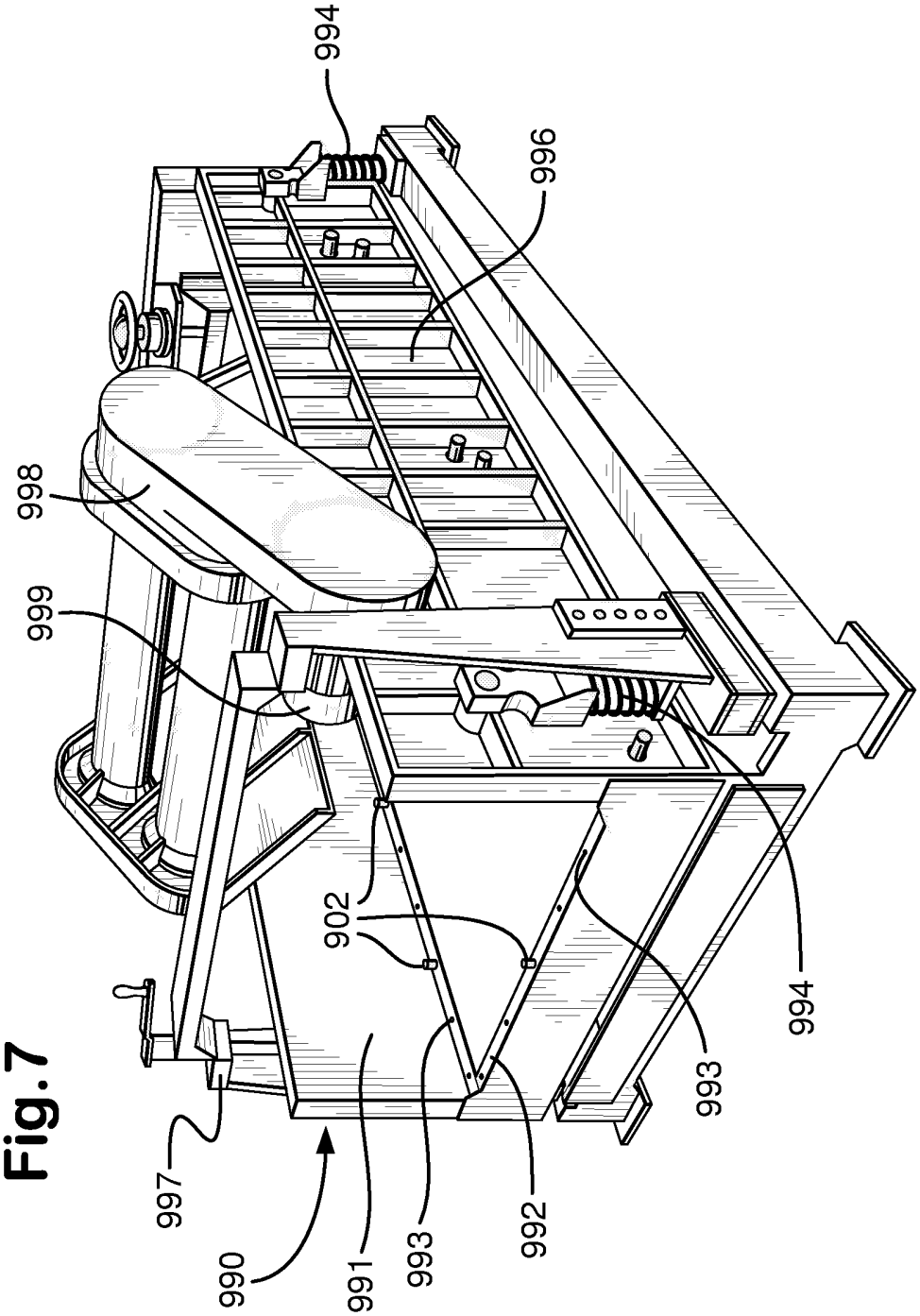

Fig.7

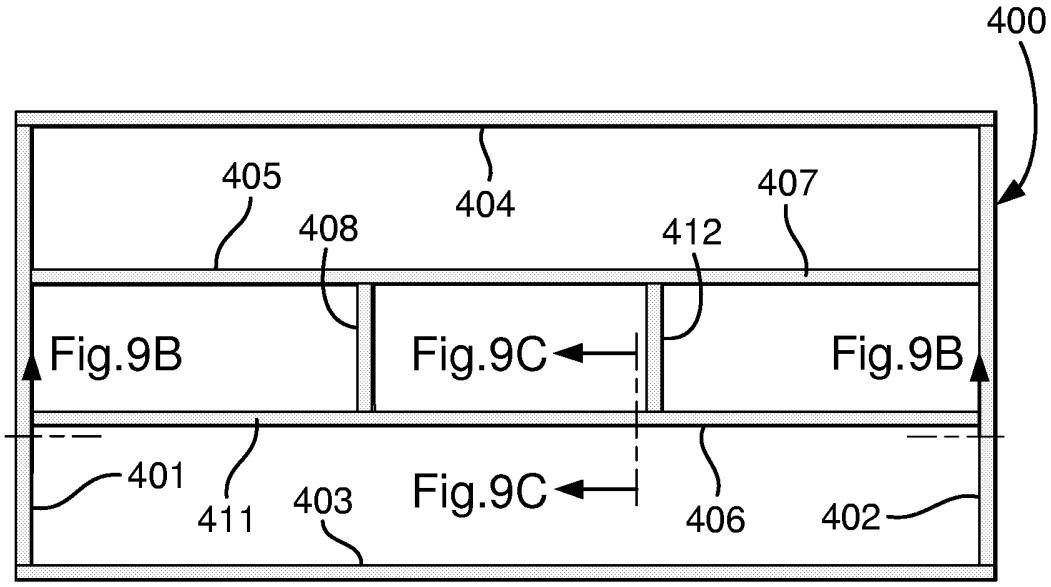

Fig.9A

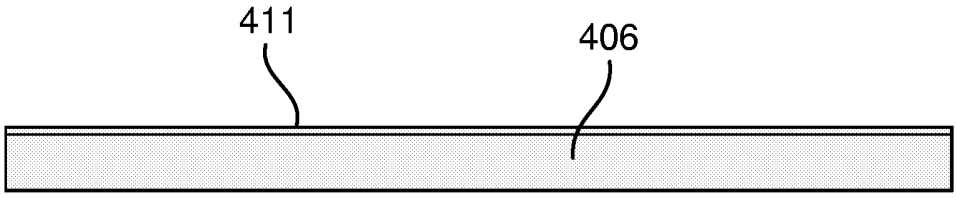

Fig.9B

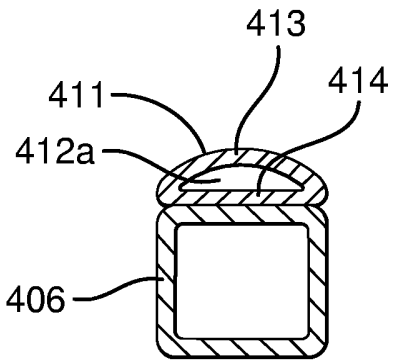

Fig.9C

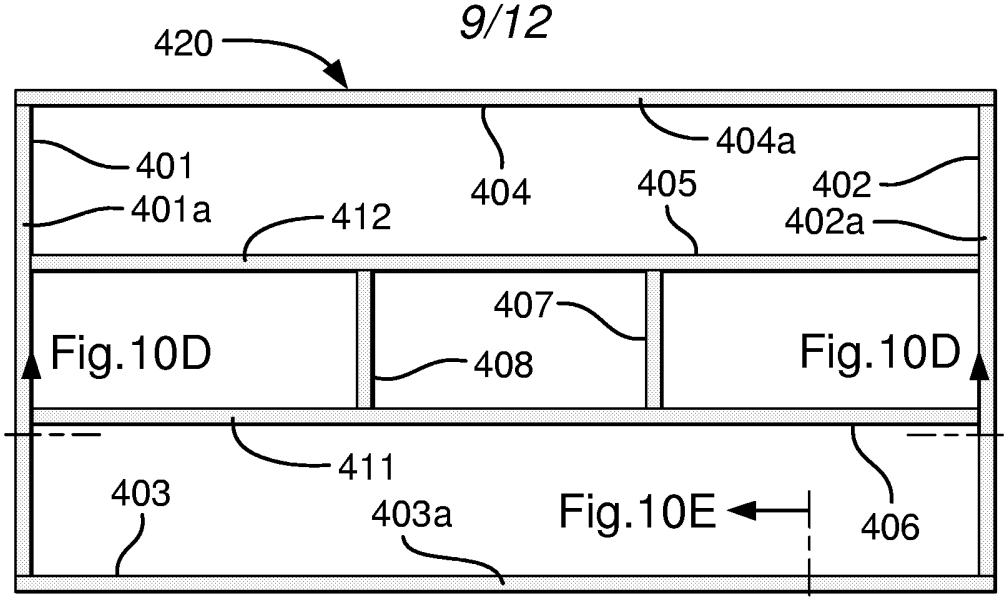

Fig.10A

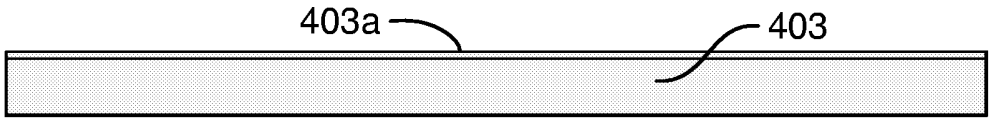

Fig.10B

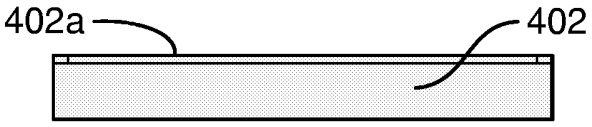

Fig.10C

Fig.10D

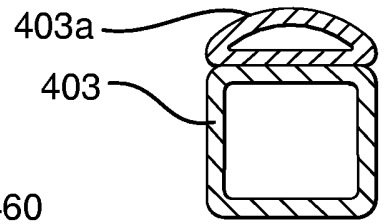

Fig.10E

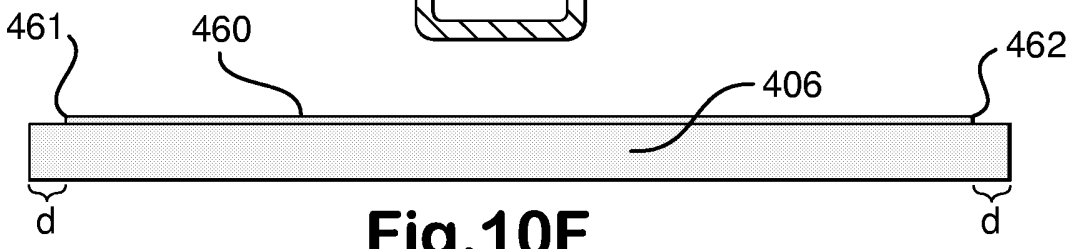

Fig.10F

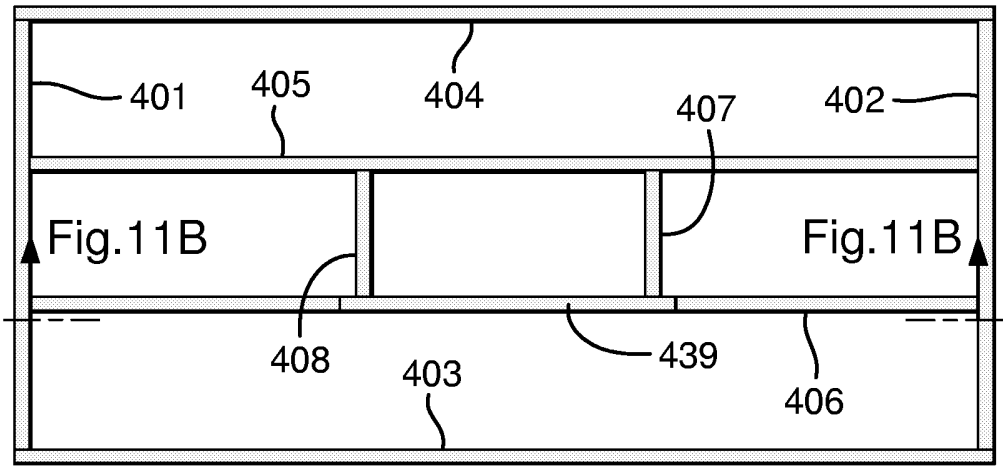

Fig.11A

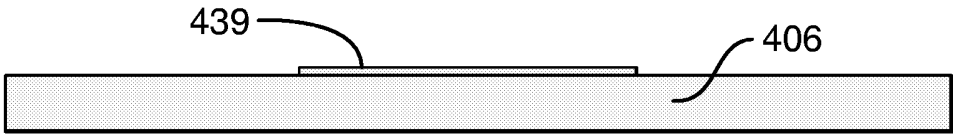

Fig.11B

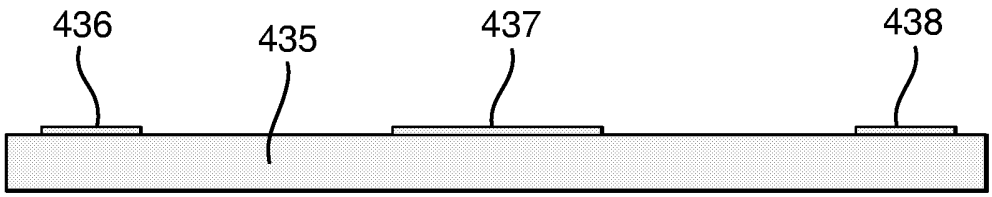

Fig.11C

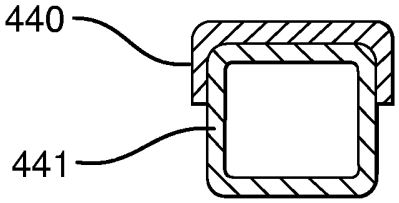

Fig.12

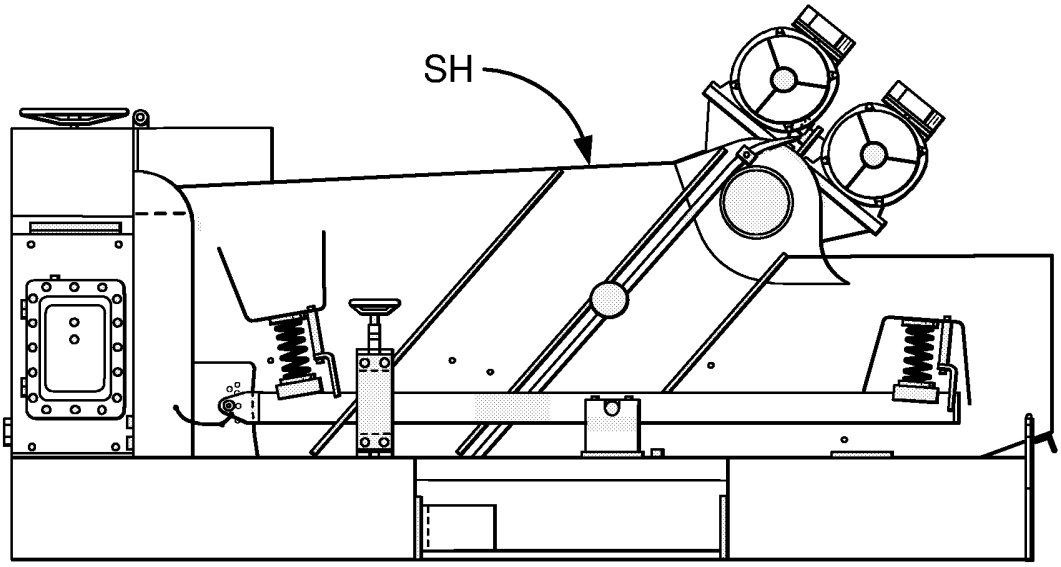

Fig.13A Prior Art

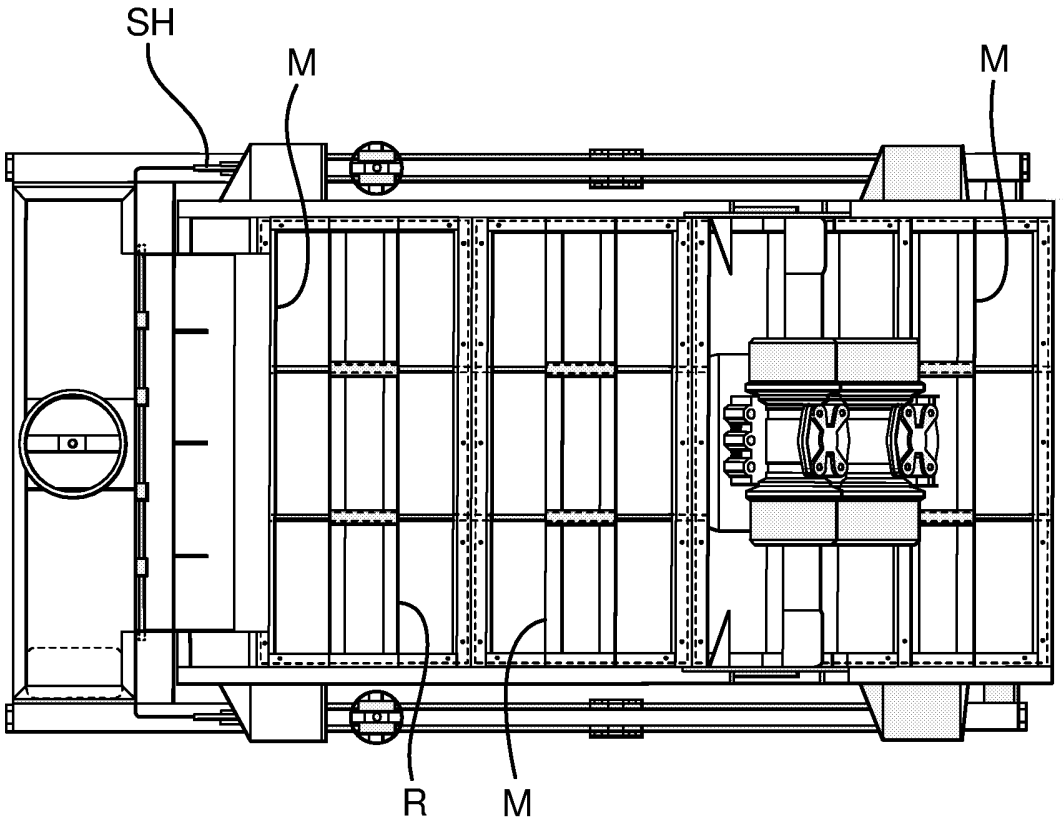

Fig.13B Prior Art

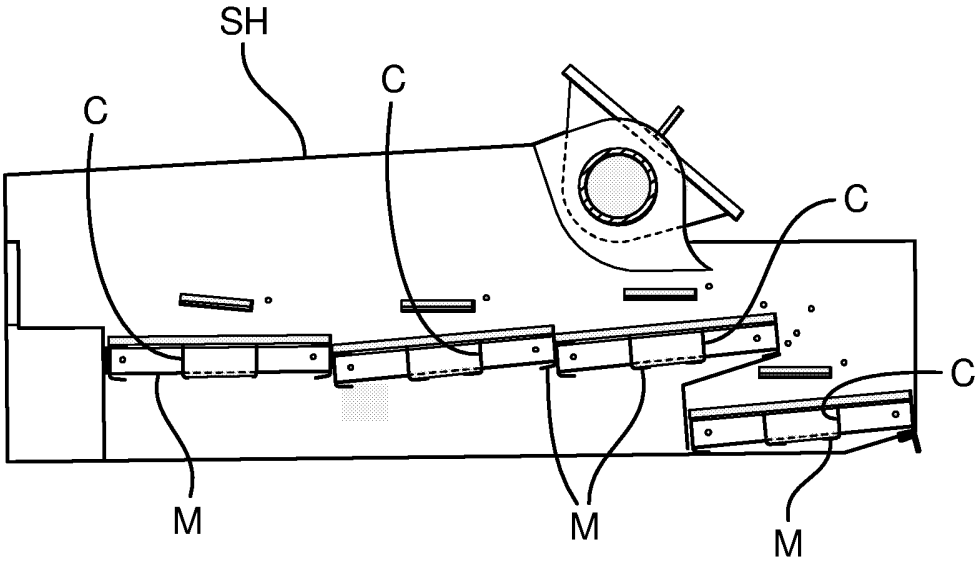

Fig.13C Prior Art

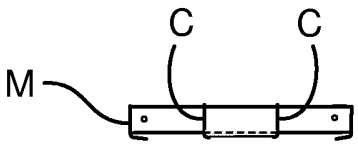

Fig.13D Prior Art

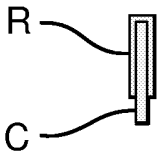

Fig.13E Prior Art

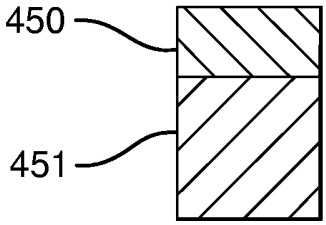

Fig.14

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB2005/050133

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B07B1/46 B01D33/03

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B07B B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2002/056667 A1 (BALTZER TERRY L ET AL) 16 May 2002 (2002-05-16) figures 12,15-23	1-21
X	US 5 332 101 A (BAKULA ET AL) 26 July 1994 (1994-07-26) figures 13-15	1-5,7, 10,12, 16-21
X	EP 0 470 422 A (CONN-WELD INDUSTRIES, INC) 12 February 1992 (1992-02-12) figures 1-3	1-5,7,8, 11,12, 14,16-21
X	US 5 392 925 A (SEYFFERT ET AL) 28 February 1995 (1995-02-28) figures 25,26	1,5-8, 10-14, 16-21

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 October 2005	18/10/2005

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	de Biasio, A

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB2005/050133

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2004/035232 A (VARCO I/P, INC; LUCAS, BRIAN, RONALD; SEYFFERT, KENNETH, WAYNE; MCCLUN) 29 April 2004 (2004-04-29) cited in the application figures 4-11	1-21

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INTERNATIONAL SEARCH REPORT

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PCT/GB2005/050133

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