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PIPE TENSIONER PAD

[001] This invention relates to a pipe tensioner pad for use in a pipe tensioner. The pipe tensioner pad comprises (a) a pipe contacting surface comprising an elastomer, and (b) a support mounting the pipe contacting surface, the support comprising a polyamide. This invention also relates to a pipe tensioner comprising the pipe tensioner pad, as well as a marine pipelay assembly comprising the pipe tensioner pad. In addition, this invention relates to a method of laying, recovering or spooling a marine pipeline using the pipe tensioner pad.

[002] Background

[003] Subsea marine pipelines are well known in the art for transporting fluids, for example hydrocarbons such as oil and gas. Such pipelines can be laid on a seabed or a sea floor for the passage of fluids between two sites, such as a production well or well head and an adjacent production platform. Such pipelines also need to be recovered from a sea bed after use.

[004] Three methods of laying a pipeline are employed and depend on the depth of the seabed. A first method, called J Lay, consists of constructing the pipeline on a vertical assembly line and laying it in a vertical position. This method is particularly suitable for laying underwater pipelines in very deep water (generally, a depth greater than 1500m). When the seabed is not very deep (generally, a depth of less than 1500m), in a second method called S Lay the pipeline is laid in a horizontal configuration. Subsea pipelines are generally laid from a pipe-laying vessel, sometimes termed a marine pipelay vessel. Where the pipeline has sufficient flexibility, a third method may be employed in which the pipeline can be formed 'on-shore' and located on a large storage drum or reel on the pipe-laying vessel for subsequent laying 'off-shore' directly from the reel. This is generally termed in the art 'reel-laying'. For this, the pipeline needs to be reeled or spooled both onto and later off from the reel, based on controlled movement, which can be provided by a suitable tensioning assembly.

[005] For laying, the pipe-laying vessel usually has a marine pipelay assembly thereon, such as a tower, for organising the pipeline from the vessel into the sea.

The marine pipelay assembly may control the direction, speed and/or other parameters of the pipeline during its laying operation, and the movement between the pipeline and vessel is generally controlled by one or more apparatus or devices intended to grip and/or apply tension to the pipeline during its passage through the marine pipelay assembly. Suitable devices or apparatus for this purpose are known as “tensioners”.

[006] An example of a tensioner is shown in FR2964441B1. Figure 1 from this earlier patent is reproduced as Figure 1 in this application. Referring to Figure 1, the tensioner (1A) comprises multiple continuous tracks (10A) which are adapted to engage the pipeline and support at least the weight of the pipeline. The tracks (10A) are each supported by a chassis (13A) which is mounted on a support structure (20A) by cylinders (26A). The cylinders (26A) provide relative movement of the tracks (10A) in order to provide clamping pressure between the tracks (10A) and the pipeline. This allows the pipeline to be held in place by friction between the tracks (10A) and the external surface of the pipeline. Each track (10A) comprises multiple pipe tensioner pads (16A) on its external, pipe contacting, surface. The friction is provided by the external, pipe contacting, surface of each pad being formed from a material having a relatively high coefficient of friction such as polyurethane. This pipe contacting surface is bonded to a rigid back plate, or support, in order to provide the pipe tensioner pad with the required mechanical strength. This back plate is conventionally made of steel.

[007] A pipelay tower can comprise more than six hundred of these pipe tensioner pads, meaning that their weight, mainly due to the weight of the steel back plate (or support), is an important consideration in relation to the stability of the pipe-laying vessel. The fact that the pipelay tower extends vertically, elevating this weight, means that vessel stability is a significant issue. Steel typically has a density of approximately 7.8g/cm^3 . The weight of the tensioner also represents a significant risk to personnel involved in handling and/or installing the tensioner. A way of reducing this risk, and increasing the stability of the pipe-laying vessel, is required.

[008] **Statement of invention**

[009] According to one aspect of the invention, there is provided a pipe tensioner pad for use in a pipe tensioner (also known as a pipe conveyor), the pipe tensioner pad comprising:

- (a) a pipe contacting surface comprising an elastomer, and
- 5 (b) a support mounting the pipe contacting surface, the support comprising a polyamide.

[0010] According to a second aspect of the invention, there is provided a method of making a pipe tensioner pad as defined herein, the method comprising the steps of

- 10 (a) providing a polyamide support, and
- (b) bonding the polyamide support to a pipe contacting surface.

[0011] According to a third aspect of the invention, there is provided a pipe tensioner comprising one or more pipe tensioner pads as defined above. In addition, the invention relates to a marine pipelay assembly, optionally a marine pipelay tower or a marine pipelay ramp, comprising one or more pipe tensioner pads as defined above.

[0012] According to a fourth aspect of the invention, there is provided a method of laying or recovering a marine pipeline from or to a pipe-laying vessel, the vessel comprising a marine pipelay assembly comprising one or more pipe tensioner pads as defined above, the method comprising the steps of:

- (a) providing the pipeline through the marine pipelay assembly,
- (b) contacting an outer surface of the pipeline with the pipe contacting surface of the pipe tensioner pad, and
- 25 (c) moving or holding the pipeline in the marine pipelay assembly to help lay or recover the pipeline.

[0013] According to a fifth aspect of the invention, there is provided a method of spooling a marine pipeline to or from a reel, the method comprising the steps of:

- 30 (a) providing the pipeline through a pipe tensioner comprising one or more pipe tensioner pads as defined above,
- (b) contacting an outer surface of the pipeline with the pipe contacting surface of the pipe tensioner pad, and
- 35 (c) moving the pipeline to or from the reel.

[0014] **Brief description of the drawings**

[0015] This invention will be further described by reference to the following Figures which are not intended to limit the scope of the invention claimed, in which:

Figure 1 shows a prior art tensioner,

Figure 2 shows a perspective view of a pipe tensioner pad according to an embodiment of the invention for use in a pipe tensioner, and

Figure 3 shows a vertical cross-section through line A-A of the pipe tensioner pad of Figure 2.

[0016] **Detailed description**

[0017] It has been surprisingly found by the inventors that replacing the steel in the support of a pipe tensioner pad with polyamide, an improved tensioner pad can be provided which is lighter but still has the required mechanical properties. The density of polyamide is generally about 1/7th that of steel, resulting in a significant reduction in the weight of the tensioner. In certain embodiments, the pipe tensioner pads of the invention can weight 10kg less than a prior art steel pad. Given that a tensioner can comprise more than 600 pipe tensioner pads, this can result in a 6 tonne weight saving.

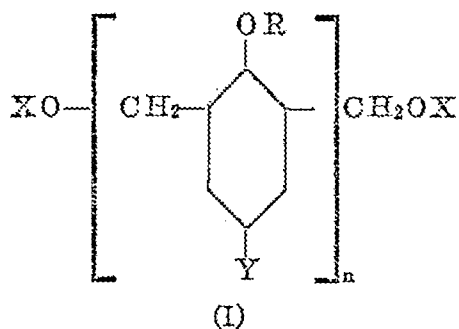
[0018] In relation to this invention, the term “polyamide” is used to refer to polymers and copolymers which include amide bonds in the polymer chain, in particular where the repeating units are linked by amide bonds. The polyamides of the invention may be obtained by polycondensation. In particular, the polyamide is selected from the group consisting of polyamide 6 (PA-6), polyamide 11 (PA-11), polyamide 12 (PA-12) and polyamide-based thermoplastic elastomers, as well as blends or copolymers of these polyamides. The polyamide may comprise one or more additives which are known in the art, such as carbon black for UV protection. In particular, the polyamide is polyamide 6, which has particularly good mechanical properties in the context of the invention (eg strength, brittleness, and temperature resistance (from -4°C up to 110°C)). More particularly the polyamide is a polyamide 6G (ie a cast polyamide), even more particularly a polyamide 6G-MO such as Sustamid® 6G MO produced by Röchling Sustaplast KG. Polyamide 6G-MO is cast polyamide 6 to

which molybdenum disulphide has been added. Polyamide 6G-MO is particularly useful for offshore applications due to its low water absorption. This can provide the polyamide pad with improved conservation of mechanical properties when it is contacted with water during use. In some embodiments, the majority of the support is formed from a polyamide, more particularly the support may be formed substantially entirely from a polyamide.

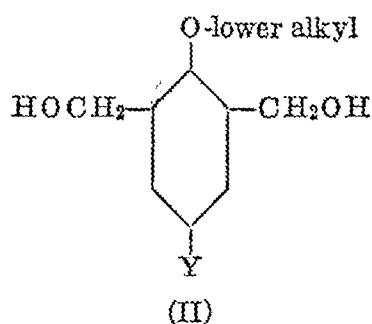
[0019] In particular, the elastomer is polyurethane or rubber. The polyurethane may be thermoplastic polyurethane (TPU). In particular, the elastomer may be rubber. In relation to the invention, the term "rubber" is used to refer to natural rubber (NR) or synthetic rubber. In particular, synthetic rubbers may be selected from ethylene propylene diene rubber (EPDM), chloroprene rubber (CR), styrene-butadiene rubber (SBR), isobutylene rubber (IIR), and chlorosulfonated polyethylene rubber (CSM). In particular, the rubber is a blend of natural rubber (NR) and styrene-butadiene rubber (SBR), known as NR-SBR, more particularly NR-SBR 86 (shore D). NR-SBR has been found to provide improved bonding with the polyamide support. The rubber may additionally comprise one or more additives selected from the group consisting of fillers, cross-linking agents, reinforcing agents, plasticizers, cross-linking assistants, activators, anti-scorching agents, and oxidation inhibitors. Additives selected from the group consisting of vulcanizing agents, vulcanization accelerators, and vulcanization assistants may be added to the rubber. More particularly, during use the coefficient of friction between the rubber and an outer surface of a pipeline may be between 0.036 and 0.6.

[0020] In a further particular embodiment, the polyamide is a polyamide 6G-MO and the pipe contacting surface comprises NR-SBR 86 (shore D).

[0021] More particularly, the rubber pipe contacting surface is bonded to the polyamide support. The bond may be formed by an adhesive. In particular, the adhesive may comprise a cement or dispersion comprising (i) a compound selected from the group consisting of the dihydric phenols of the benzene and naphthalene series; and (ii) a phenolic dialkanol selected from the group consisting of (a) compounds having the structure (I)



where R and X independently are chosen from hydrogen and lower acyl, and where Y is chosen from alkyl, cycloalkyl, aryl, aralkyl, chloro, and nitro, and n is an integer in the range from one to three inclusive; (b) self-condensation polymers of those compounds of Formula I in which R and X are hydrogen and wherein Y is chosen from alkyl, cycloalkyl, aryl and aralkyl, and n is one; and (c) compounds having the structure (II)



where Y is the same as in structure (I). The term "lower" is used in this context to refer to alkyl groups containing not more than four carbon atoms. Optionally, the materials (I) and (II) may also have methyl groups in the 3- and 5-positions, numbering from the OR or O-lower alkyl group in the 1-position. In particular, the adhesive may be selected from the group consisting of (i) an adhesive comprising at least 5wt% butanone, 10-20wt% isobutyl methyl ketone and up to 1wt% of maleic anhydride, selenium, zinc oxide, 30-40wt% toluene and 5-10wt% xylene and (ii) an adhesive comprising up to 1wt% of N,N-(M-phenylene)dimaleimide, 20-30wt% toluene and 50-60wt% xylene.

[0022] In relation to the method of making the pipe tensioner pad, the bonding step may comprise applying an adhesive to at least part of either or both of the polyamide support and the pipe contacting surface. In particular, the adhesive is applied to at least part of the polyamide support and the pipe contacting surface is brought into contact with the adhesive coated part of the polyamide support. Alternative bonding

methods include oxidation, plasma discharge or flame bonding. When the pipe contacting surface comprises rubber the method may include, after step (b), the step of (c) heating the resulting pipe tensioner pad to vulcanise the rubber.

5 [0023] To assist vulcanisation, the rubber may comprise a curing agent. Suitable curing agents may be selected from the class consist of the self-condensation polymers defined in part (b) of the above definition of the adhesive, and monomers corresponding to those polymers.

10 [0024] In particular, after step (b) but prior to any vulcanisation step, the adhesive is allowed to dry. This is normally done at room temperature (ie around 23°C). Generally, the drying time is at least 30 minutes, more particularly around 40 minutes.

15 [0025] When the pipe contacting surface comprises rubber, it may be formed by any suitable known method such as compression moulding (for example, laying sheets of rubber into the mould) or injection moulding. The rubber may additionally comprise additives or processing agents known in the art. These can be selected from the group consisting of curing agents such as sulphur, accelerators, activators such as
20 zinc oxide, and vulcanisation catalysts such as stearic acid.

[0026] The polyamide support may be treated in order to increase the bonding between the polyamide support and the adhesive. For example, the polyamide support may undergo grit blasting or etching in order to increase the surface
25 roughness of the polyamide and therefore improve the adherence.

[0027] The adhesive may include one or more solvents. Solvents are added in order to provide an adhesive with the required viscosity. The one or more solvents may include one or more of the group consisting of xylene, toluene, ketone, methyl
30 proxitol acetate and other glycol ether esters, and mixtures thereof. The adhesive is optionally stirred to improve homogeneity before it is applied to the polyamide support.

[0028] In step (b) of the method, when the bonding step comprises applying an
35 adhesive the step of applying may in particular be by dipping spraying, brushing or

any suitable method known in the art. In particular, the adhesive may be applied to the polyamide support in order to provide an adhesive layer with an average thickness of less than 50 μ m, more particularly 10-20 μ m.

5 [0029] In the context of the invention, the term “upper” is used to mean the part of the pipe tensioner pad which is closest to the pipeline during use. Similarly, the term “lower” is used to mean the part of the pipe tensioner pad which is furthest from the pipeline during use. Similarly, in the context of the invention, the term “downward”, “downwardly” is used to mean the part of the pipe tensioner pad which is directed
10 towards the track of the pipe tensioner during use. The term “upward” is used to mean the opposite of the term downward, i.e. the part of the pipe tensioner pad which is directed towards the pipeline during use. In addition, in the context of the invention, during use, the pipe tensioner pad is about to engage or engages the pipeline. In this context, during use, the pipe tensioner pad faces the pipeline.

15 [0030] More particularly, the pipe contacting surface may comprise a valley which, in use, extends in a direction parallel to a longitudinal axis of the pipeline contacted by the surface. The longitudinal axis of the pipeline is that extending along the length of the pipeline. Even more particularly, the pipe contacting surface may comprise two
20 ridges, one on either side of the valley, the ridges extending in a direction parallel to the longitudinal axis of the pipeline contacted by the surface. In particular, the valley and/or the ridges may be shaped to accept the pipeline in use. Providing a pipe contacting surface with this profile assists in allowing it to deform under high squeeze loads without tearing.

25 [0031] In particular, the polyamide support may comprise an upper surface comprising a depression into which is mounted a pipe contacting insert comprising the pipe contacting surface. The depression may comprise a base and two opposing side walls, the side walls extending upwards from the base. More particularly, the
30 two side walls extend upwards (ie towards the pipe contacting surface) at an angle of 30-50 degrees from the base. The base is normally substantially horizontal. More particularly, the pipe contacting insert is a close fit within the depression in the support.

[0032] In particular, the polyamide support may be attachable to a track of a pipe tensioner. The support may comprise one or more apertures, each of which is shaped to accept a fastener, normally a screw, for attaching the support to the track. More particularly, the support may comprise two apertures which are spaced such that in use there is one on each side of longitudinal axis of the pipeline contacted by the surface. In particular, the support may comprise one or more ribs which are adjacent to the one or more apertures. The ribs normally extend from the lower end of the support towards the pipe contacting surface. When there are two apertures as describe above, the support may comprise four ribs which are positioned in pairs, the ribs in each pair on opposite sides of each aperture. The ribs can assist in increasing the mechanical strength of the support.

[0033] The support may also comprise a base at its lower end with a downwardly extending post at the centre of the base. More particularly, the post is a hollow tube. The post can assist in transferring forces from the support to the tensioner during use.

[0034] Figures 2 and 3 show a pipe tensioner pad 1 according to an embodiment of the invention for use in a pipe tensioner. Figure 2 is a perspective view of the pipe tensioner pad 1, and Figure 3 is a cross-sectional view of the pad 1 of Figure 2 along line A-A.

[0035] The pipe tensioner pad 1 comprises polyamide 6G-MO support 5 and rubber pipe contacting insert 10 (ie the shaded section) mounted on its upper surface.

[0036] The support 5 has a substantially rectangular base 15 at its lower end. The rectangular base measures 244mm x 70mm. As shown in Figure 2, extending upwards and substantially vertically from the two long sides of rectangular base 15 are side walls 20 (only one side wall 20 being visible in Figure 2). Each side wall 20 is substantially trapezoidal in shape, the trapezoid comprising base 25, sides 30 and top 35. The trapezoid narrows towards the upper surface of the pipe tensioner pad 1. The angle α made between the base 25 and the sides 30 of the trapezoid is around 67.5°.

[0037] Extending upwards and inwardly from the two shorter ends of rectangular base 15 are end walls 40. The end walls 40 abut the sides 30 of the trapezoid formed by each side wall 20. Thus, end walls 40 are generally at an angle of around 67.5° from the plane of base 15. End walls 40 are substantially rectangular in shape and, as shown in Figure 2, are each split into three substantially equal sections 45,50,55 which each extend from the base 15 to the upper end of pipe tensioner pad 1.

[0038] The two outermost sections, or ribs, 45,55 of each end wall 40 are planar and are at an angle of around 67.5° from the plane of base 15. Each rib 45,55 is 57.5mm wide. Each central section 50, between the two outermost sections 45,55, comprises a substantially horizontal section 60 which extends into the pipe tensioner pad 1. The horizontal section 60 of each end wall 40 is parallel to base 15. At its innermost end 60A, the horizontal section 60 meets vertical section 65. Vertical section 65 then extends upwards to the upper end of pipe tensioner pad 1. In this way, the horizontal section 60 and vertical section 65 of each end wall 40 form an L-shape. An aperture 70 is formed substantially in the middle of horizontal section 60 of each end wall 40, these apertures 70 extending through base 15 such that fastener such as a bolt can be used to fix the pipe tensioner pad 1 to a tensioner (not shown).

[0039] The upper edge 75 of each end wall 40 connects to each side wall 20 via two triangular wedges 80,85. At their widest point, the wedges 80,85 are 65mm wide. The wedges 80,85 extend lengthways in a direction which, in use, is parallel to the longitudinal axis of the pipeline. This longitudinal axis is indicated by line X-X in Figure 2. The wedges 80,85 have a cross-section which is a right-angled triangle. The side of each wedge 80,85 which is the hypotenuse of this triangle abuts the rubber pipe contacting insert 10. The wedges 80,85 can withstand a lot of the stress from compressing the rubber pipe contacting insert 10 against the pipeline at up to 120Tonne/m³. The wedges 80,85 form a depression 90 in the polyamide support 5 into which is mounted the rubber pipe contacting insert 10. The adhesive (not shown) is provided at at least part of the interface between the depression 90 and the rubber pipe contacting insert 10.

[0040] As shown in Figure 3, extending downwards from the centre of base 15 is central post 120. Central post 120 is in the form of a solid cylinder. It has an upper

end 125 where it meets base 15 and a lowermost end 130. Central post 120 is shaped to mate with an aperture on the tensioner (not shown) to which the pipe tensioner pad 1 is fitted in use. This connection helps the central post 120 transfer shear loading forces (in use) from the axial tension of the pipeline to the structure of the tensioner.

[0041] The rubber pipe contacting insert 10 has a lower surface 195 which is substantially the same shape as depression 90 such that the rubber pipe contacting insert 10 is a close fit within the depression 90. In addition, the rubber pipe contacting insert 10 has an upper pipe contacting surface 95. The rubber pipe contacting insert 10 is at least 66mm thick.

[0042] The upper pipe contacting surface 95 extends upwardly from the support 5 and is contoured in order to assist in tensioning the contacted pipeline during use. The contours comprise a central channel 100 which is shaped to accept the pipeline during use and which, in use, is parallel to the longitudinal axis (X-X in Figure 2) of the pipeline. Adjacent to this central channel 100, one on each side, and parallel to the central channel 100, are ridges 105,110. These ridges 105,110 extend further in an upward direction than central channel 100 such that channel 100 forms a valley between these two ridges 105,110. The ridges 105,110 are configured to initiate the deformation of the rubber under high squeeze loads. In addition, the rubber pipe contacting insert 10 comprises side walls 120 which are coplanar with side walls 20 of polyamide support 5.

[0043] The method of making the pipe tensioner pad 1 comprises providing a polyamide support 5 and a rubber pipe contacting insert 10. An adhesive (not shown) is applied to the surfaces which form depression 90 in the polyamide support 5. The lower surface 195 of the rubber pipe contacting insert 10 is then fitted into the depression 90 such that the rubber pipe contacting insert 10 contacts the adhesive on the surfaces which form depression 90. In this way, the polyamide support 5 is bonded to the rubber pipe contacting insert 10.

[0044] The bond between the rubber pipe contacting insert 10 and the polyamide support 5 has been tested in lap shear and 90 degree peel tests and has proven to be similar to the bond between rubber and steel in known tensioner pads. The

results of this testing are shown in Table 1 below. The polyamide is Sustamid 6G MO and the rubber is the NR-SBR 86 (shore D)

	90° peel test (ISO813 2010)	Lap shear (ISO 1827 2007)
Steel/Rubber	17,65N/mm	7.58MPa
Polyamide/Rubber	19.44N/mm	4.77MPa

Table 1

CLAIMS

1. A pipe tensioner pad for use in a pipe tensioner, the pipe tensioner pad comprising:

- 5 (a) a pipe contacting surface comprising an elastomer, and
 (b) a support mounting the pipe contacting surface, the support comprising a polyamide.

10 2. A pipe tensioner pad as claimed in claim 1, wherein the polyamide is polyamide 6.

3. A pipe tensioner pad as claimed in claim 2, wherein the polyamide is polyamide 6G.

15 4. A pipe tensioner pad as claimed in claim 3, wherein the polyamide is polyamide 6G-MO.

20 5. A pipe tensioner pad as claimed in any one of the preceding claims wherein the elastomer is polyurethane or rubber.

6. A pipe tensioner pad as claimed in any one of the preceding claims, wherein the pipe contacting surface comprises a valley which, in use, extends in a direction parallel to a longitudinal axis of the pipeline contacted by the surface.

25 7. A pipe tensioner pad as claimed in claim 6, wherein the pipe contacting surface comprises two ridges, one on either side of the valley, the ridges extending in a direction parallel to the longitudinal axis of the pipeline contacted by the surface.

30 8. A pipe tensioner pad as claimed in any one of the preceding claims, wherein the support is attachable to a track of a pipe tensioner.

9. A pipe tensioner pad as claimed in any one of the preceding claims, wherein the pad comprises an adhesive between the pipe contacting surface and the support.

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10. A pipe tensioner comprising one or more pipe tensioner pads as claimed in any one of the preceding claims.

5 11. A marine pipelay assembly comprising one or more pipe tensioner pads as claimed in any one of claims 1-9.

12. A marine pipelay assembly as claimed in claim 11, wherein the marine pipelay assembly is a marine pipelay tower or a marine pipelay ramp.

10 13. A method of making a pipe tensioner pad as claimed in any one of claims 1-9, the method comprising the steps of:

- (a) providing a polyamide support, and
- (b) bonding the polyamide support to a pipe contacting surface.

15 14. A method as claimed in claim 13, wherein step (b) comprises applying an adhesive to at least part of either or both of the polyamide support and the pipe contacting surface.

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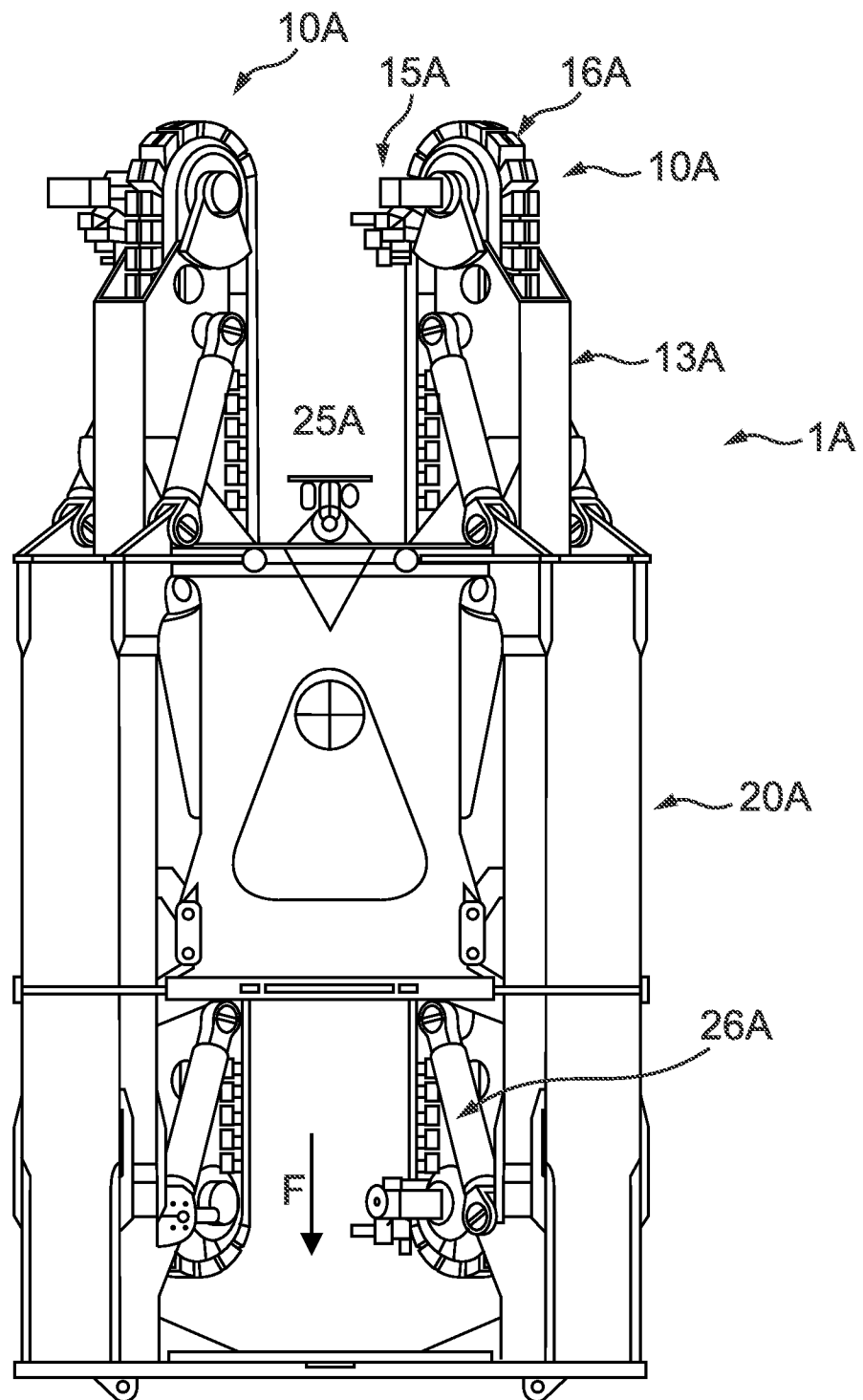


Fig. 1
PRIOR ART

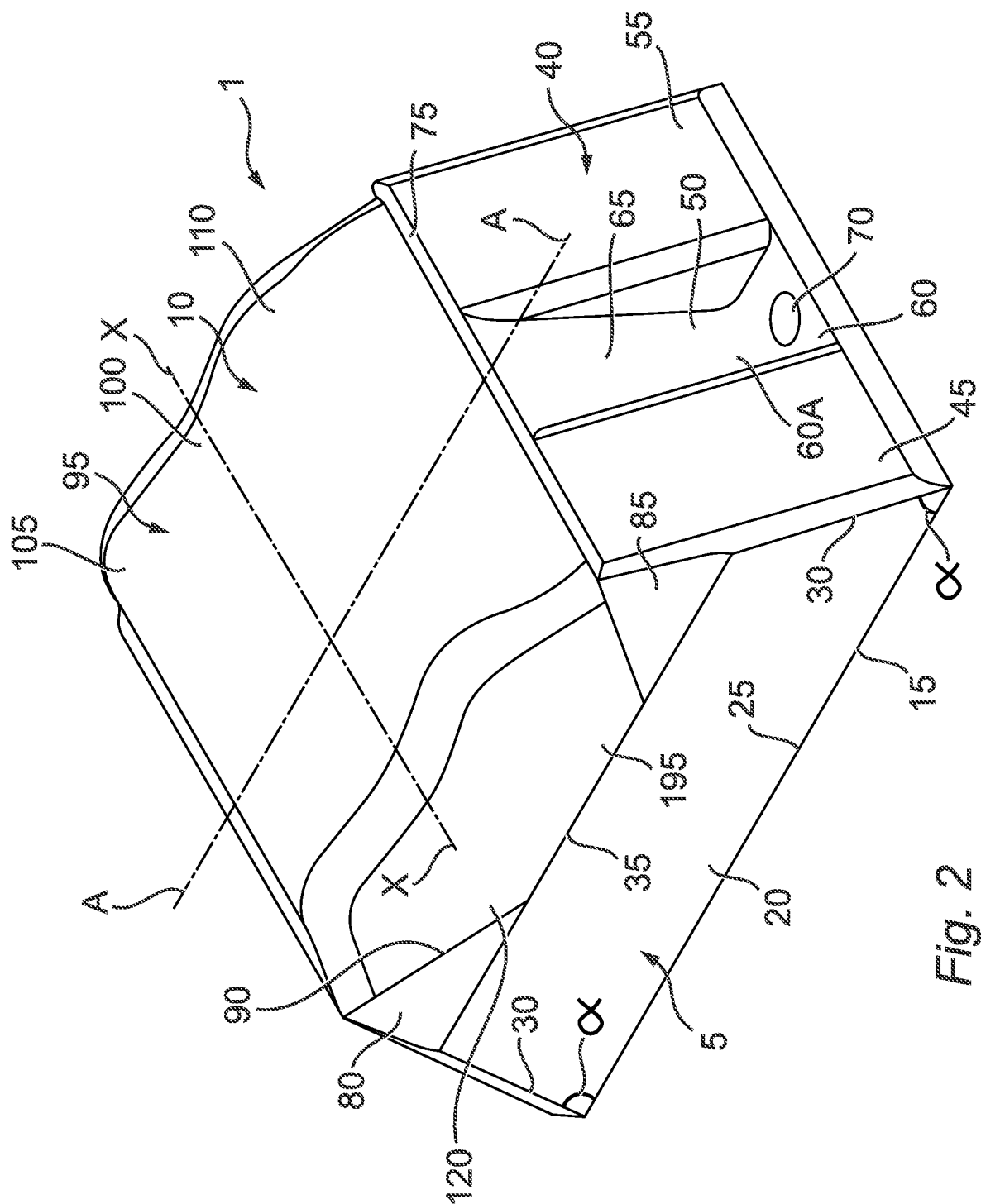


Fig. 2

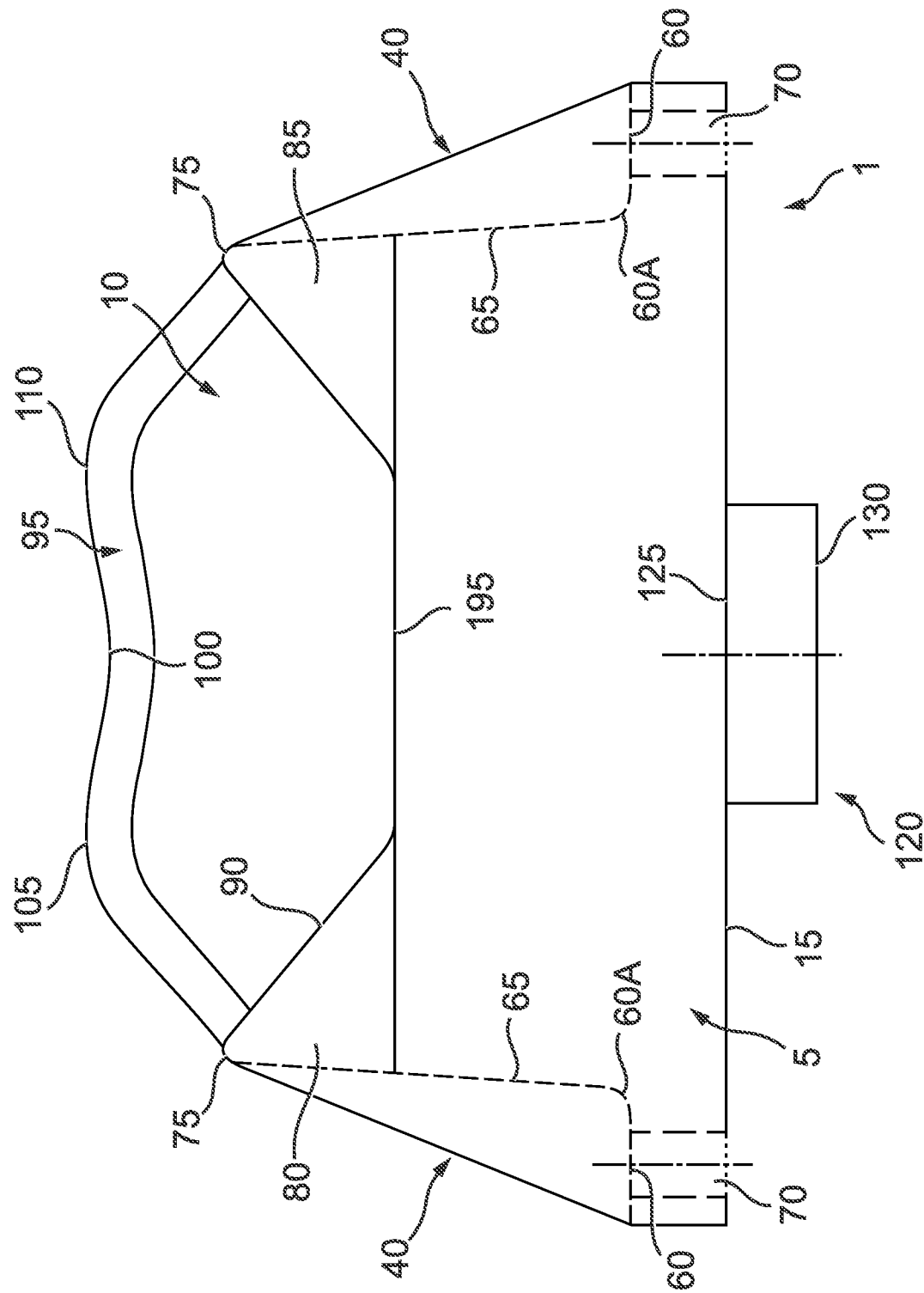


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2016/001986

A. CLASSIFICATION OF SUBJECT MATTER

INV. F16L1/23 B66D3/00 E21B19/22
ADD.

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)

F16L B66D E21B

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 618 840 A (COURRET BERNARD FRANCOIS MAURI) 9 November 1971 (1971-11-09) column 1, lines 7-9; figures 1-5 column 2, lines 9-26 -----	1,5,8, 13,14
X	US 3 754 474 A (PALYNCHUK A) 28 August 1973 (1973-08-28) column 1, lines 4-16; figures 1-4 column 2, line 31 - column 3, line 26 -----	1-12
X	US 6 189 609 B1 (SHAABAN KHALED M [US] ET AL) 20 February 2001 (2001-02-20) column 1, lines 5-7; figures 1-3 column 4, lines 51-68 column 5, lines 5-58 -----	1-11



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

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Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2016/001986

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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