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(54) IMPROVEMENTS RELATING TO STORAGE IN TANKS

(57) There is described a method of determining at least one geometrical characteristic of a structure, and related methods, apparatus, and a ship. In embodiments of the invention, the structure comprises a number of tank wall plates. In such embodiments, the number of tank wall plates is defined, and the geometrical characteristic, including the overall length and breadth of the structure is determined, based upon the number of tank wall plates.

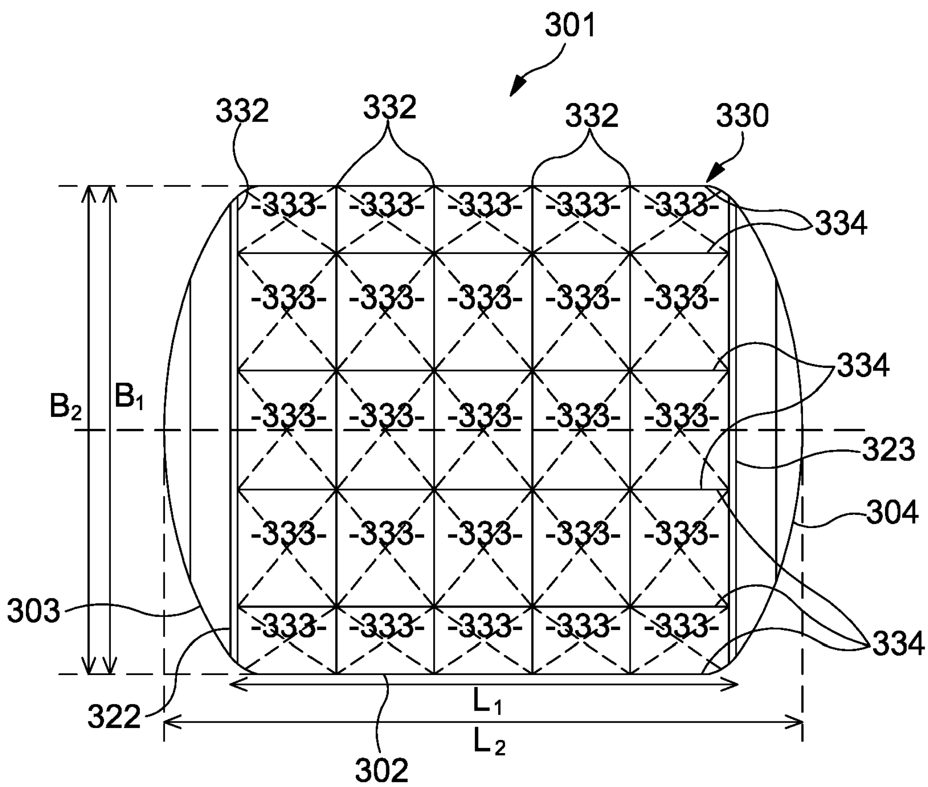

FIG. 10

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Description

Technical field

[0001] The present invention relates to structures comprising tanks, and in particular to a method of determining geometrical characteristics of a structure comprising tanks for containing oil or gas from offshore wells, and to related apparatus such as marine vessels, for example a floating production, storage, and offloading (FPSO) vessel.

Background

[0002] Large scale tanks are used for example in the oil and gas exploration and production industry for storing fluids. In the production of fluids from a subsurface well, a floating production, storage, and offloading (FPSO) vessel is sometimes employed. Such a vessel may then be used to store the fluids from the well, typically from several wells, for a period of time.

[0003] FPSO vessels are typically moored on site for substantial periods of time, such as weeks, months or years during which they are used to produce hydrocarbon fluids such as oil and gas from such wells. Accordingly, the FPSO vessels are normally provided with production equipment through which the fluids from the well are received onto the vessel. The produced fluids may then be stored on the vessel for a period of time until they are offloaded onto shuttle tankers which transport the fluids away from the FPSO vessel to a land facility for processing. The fluids are typically stored on the vessel in various tanks within the hull of the vessel.

[0004] Existing designs for FPSO vessels are typically based upon those of ocean going commodity tankers, e.g. crude oil tankers and the like, and some FPSO vessels are a result of conversions from earlier such tankers.

[0005] Accordingly, FPSO vessels are normally highly slender structures that are boat-like in shape and appearance. For example, the "Prelude" Floating LNG vessel currently under development has a hull length of 488 m and breadth of 74 m. The overall length of the hull divided by the overall breadth results in a slenderness ratio of about 6.6. Platforms with a circular hull section also exist as FPSO vessels, such as the FPSO "Piranema Sprit".

[0006] Clearly, substantial quantities of construction materials are typically required in order to construct FPSO vessels to provide the necessary storage capacity, etc. The FPSO vessels once constructed also need to be in compliance with industry standards and/or regulations. This places restrictions on how the FPSO vessels can be designed, and in turn on the consumption of materials, fabrication and project costs. Regulations may typically require that the tanks cannot exceed certain volume limits, such that an arrangement of multiple tanks may typically need to be provided for storing the fluid from the wells. Containing walls in the tanks normally need to be formed from steel plates, and typically each such wall may use at least three plates in the breadth dimension. Regulations also specify, for example, that personnel accommodation structures cannot be placed directly above the tanks used for the storage of the fluids from the well.

[0007] There is a need for FPSO solutions making more efficient use of space and materials whilst complying with constraints imposed from regulations and standards.

Summary of the invention

[0008] Various aspects of the invention are provided as set out in the claims appended hereto.

[0009] Any of the aspects of the invention may include the further features as described in relation to any other aspect, wherever described herein. Features described in one embodiment may be combined in other embodiments. For example, a selected feature from a first embodiment that is compatible with the arrangement in a second embodiment may be employed, e.g. as an additional, alternative or optional feature, e.g. inserted or exchanged for a similar or like feature, in the second embodiment to perform (in the second embodiment) in the same or corresponding manner as it does in the first embodiment.

[0010] Embodiments of the invention are advantageous in various ways as will be apparent from the specification throughout.

[0011] The term "ship" is used herein to refer to a ship complying with established offshore classification rules and standards, issued by a Recognized Classification Society, which is a member of the International Association of Classification Societies (IACS).

Description and drawings

[0012] There will now be described, by way of example only, embodiments of the invention with reference to the accompanying drawings, in which:

Figure 1 is a schematic representation of a prismatic 2x4 tank arrangement;

Figure 2 is a representation illustrating the relationship between orthogonal wall surfaces for a minimal surface area of plates in the tank arrangement of Figure 1;
Figure 3 is a schematic representation of a prismatic 5x5 tank arrangement and side ballast tanks;
Figure 4 is a schematic representation of a cube geometry;
Figure 5 is a schematic representation of a prism geometry;
Figure 6 is a schematic representation of a prismatic 2x4 tank arrangement;
Figure 7 is a representation illustrating the optimized relationship between weld edges in the tank arrangement of Figure 6;
Figure 8 is a schematic representation of a prismatic tank arrangement with side ballast tanks and an additional bottom tank;
Figure 9 is a schematic side plan view of an FPSO ship according to an embodiment of the invention;
Figure 10 is a representation of a hull for an FPSO ship according to an embodiment of the invention, including a tank arrangement for storing fluid from a well, optimized for minimal surface area; and
Figure 11 is a representation of a hull design for the FPSO ship of Figure 5.

Determining geometrical characteristics of tank arrangement

[0013] Turning firstly to Figure 1, a 2-dimensional matrix tank arrangement 10 is illustrated. Such an arrangement 10 may be used for storing fluid from a well, usually several wells, in the hull of an FPSO vessel. The tank arrangement 10 has a number of tanks formed by first, longitudinal plates 100 (first wall plates) and second, transverse plates 102 (second wall plates) which intersect and are arranged crossways with respect to the first plates 100. It will be appreciated that the first and second plates 100, 102 are spaced apart from each other in the respective length and breadth directions. The first plates 100 are arranged in parallel with one another. The second plates 102 are also arranged in parallel with one another. A series of storage tanks 103 for the fluid are thereby defined in the tank arrangement by the intersecting plates 100, 102. The tank arrangement further has parallel top and bottom plates 104, 105. The tank arrangement 10 has an overall Breadth *B,* Depth *D,* and Length *L* in orthogonal directions.

[0014] The surface plate area of any possible such tank arrangement 10, can be represented by the following equation:

$$A - xBD + yLD + 2LB \quad (Eq. 1)$$

where the two variables *x* and *y* are the number of transverse plates 102 (*BD*-plates) and longitudinal plates 100 (*LD*-plates), respectively. In other words, the overall surface area of the plates is equal to the sum of the surface areas of the transverse plates 102, the surface areas of the longitudinal plates 100, and the top and bottom plates 104, 105.

[0015] In the case of the FPSO vessel, there is only one layer of the tanks permitted. Tanks cannot be placed one above the other. Accordingly, the tank arrangement has only the top and bottom horizontal plates 104, 105 (parallel with *LB*-plane), and thus the number of plates is always 2 in Equation 1. As can be seen, Figure 1 provides an example of a 2 by 4 tank arrangement, where *x* is *5* and *y* is *3*.

[0016] The overall volume of all tanks, i.e. the tank arrangement as a whole, is given by:

$$V = LBD \quad (Eq. 2)$$

The optimum, i.e., the minimum area A can be represented by the following non-linear programming (NLP):

$$\min A = xBD + yLD + 2LB \quad (Eq. 3)$$

$$subject\ to\ (s.t.) \quad V = LBD$$

[0017] The partial derivatives of Equation 1 are:

$$\frac{\partial A}{\partial L} = yD + 2B \quad (Eq. 4a)$$

$$\frac{\partial A}{\partial B} = xD + 2L \quad (Eq.4b)$$

$$\frac{\partial A}{\partial D} = xB + yL \quad (Eq.4c)$$

[0018] If a local or global optimum exists it would be where the partial derivatives simultaneously equal zero, so this develops the following set of equations/relations:

$$D = \frac{2}{y}B \quad or \quad B = \frac{y}{2}D \quad (Eq.5a\ and\ 5b)$$

$$D = \frac{2}{x}L \quad or \quad L = \frac{x}{2}D \quad (Eq.6a\ and\ 6b)$$

$$B = \frac{y}{x}L \quad or \quad L = \frac{x}{y}B \quad (Eq.7a\ and\ 7b)$$

[0019] Multiplying Equation 5a with *L* and rearranging gives:

$$yLD = 2BL \quad (Eq.8)$$

[0020] Similarly, multiplying Equation 7a with *D* and rearranging gives:

$$xBD = yLD \quad (Eq.9)$$

[0021] Since the right hand side of Equation 8 is identical to the left hand side of Equation 9, the following is obtained:

$$xBD = yLD = 2LB \quad (Eq.10)$$

[0022] As can be seen, the expression of Equation 10 includes all parts of the right hand side of Equation 1. The three parts on the right hand side of Equation 1 are individually identical with one another, which for the 2 by 4 tank matrix arrangement is illustrated graphically by Figure 2 (this is same tank arrangement as in Figure 1, where *x* equals 5 and *y* equals 3).

[0023] The above only gives the relations between *L, Band D* at the optimum. An explicit solution is sought for *L, Band D* assuming that the tank configuration and cargo volume is given. Accordingly, *L, Band D* are expressed as functions of *x, y* and *V.*

[0024] One way to arrive at the explicit solution is to individually start with the three unique equalities inherent in Equation 10, which includes all 3 variables. Then we substitute with the appropriately selected equation from the set of Equations 5a to 7b to reduce the expression to only two variables. We can then use the volume equation (Equation 2) in various forms to remove a second variable and reducing the problem to the explicit solution given by the following:

$$L = \left(\frac{Vx^2}{2y}\right)^{(1/3)} \quad (Eq.11a)$$

$$B = \left(\frac{Vy^2}{2x}\right)^{(1/3)} \quad (Eq.11b)$$

$$D = \left(\frac{4V}{xy}\right)^{(1/3)} \quad (Eq.11c)$$

[0025] Although NLPs with 3 independent variables rarely can be solved explicitly and various algorithms and codes must frequently be used, this NLP is unique and explicit.

[0026] The determination of *L, B* and *D* from Equations 11a to 11c is a true global optimum and there are no local optima. Moreover, it is the overall *L, B* and *D* combination that gives rise to the optimum and not the location of the internal plates. The internal plates can actually be moved, creating different individual tank sizes whilst remaining at the optimum in terms of the overall surface area *A* of plates used in the tank arrangement. For example, variants are possible where a particular tank row can have different breadth than other tank rows, as long as the overall breath is kept constant. The same is of course valid for the longitudinal plates.

[0027] Figure 3 gives an example of such a variant, where plates are positioned such the tank arrangement has central rows of tanks 110c for storing fluid from the well with a greater width than the side rows of tanks 110a, 110b for ballast. However, the overall *L, Band D* dimensions of the tank arrangement as a whole is optimal in terms of surface areas of the plates, in accordance with the theory as explained above.

[0028] By optimising for the surface area, i.e. minimising the surface area, for the number of plates and total volume capacity, the required steel plate material and cost can be minimised correspondingly.

[0029] By evaluating Equations 11a-11c, the Length *L*, Breadth *B* and Depth *D* can be determined, e.g. calculated or estimated, for an optimal tank arrangement. A volume *V* is provided initially, which may be a desired storage capacity volume for the tank arrangement for the FPSO vessel, and the number of plates *x* and *y* are determined, e.g. by a determination of the number of tanks required, and noting the maximum required tanks size requirement for compliance with regulations. Conversely, the overall volume capacity for a minimum of area *A* of plates (given *x* and *y*) can be determined for a certain available length *L,* breadth *B* or depth *D*.

[0030] The derivations above are provided on the basis of minimising surface area. With reference now to Figures 4 to 7, a further derivation is provided from considering the amount of welding or total weld length for welding the edges of the plates in the matrix tank arrangement.

[0031] In assessing the edges in an n by n matrix, consider the cube in Figure 4. It has a total of 12 edges. There are 4 edges in each of the three planes. The total length of edges for the cube is given by:

$$E = 4s + 4s + 4s = 12s \quad (Eq.12)$$

[0032] For a prism as shown in Figure 5, the sides(s) can be of different length in the three directions, denoted *l, b* and *d.* The total length of the edges in a rectangular prims is given by:

$$E = 4l + 4b + 4d \quad (Eq.13)$$

[0033] Now, with reference to Figure 6, consider that several cubes or rectangular prisms are put into a tank arrangement 50 with overall dimensions of *L, Band D* as illustrated. The tank arrangement comprises a 4x2 matrix of tanks 503 identical to the tank arrangement 10 of Figure 1, with an overall size of L, B and D.

[0034] The sum of all edges, understanding that several of the edges are shared between adjoining tanks is given by:

$$E = 2yL + 2xB + xyD \quad (Eq.14)$$

[0035] We want to minimize the total weld length *E* for a given volume *V*, therefore the NLP to be solved can be written as:

$$\min E = 2yL + 2xB + xyD \quad (Eq.15)$$

$$\text{s.t. } V = LBD$$

[0036] The partial derivatives of Equation 14 are:

$$\frac{\partial E}{\partial L} = 2y \quad (Eq.16a)$$

$$\frac{\partial E}{\partial B} = 2x \quad (Eq.16b)$$

$$\frac{\partial E}{\partial D} = xy \quad (Eq.16c)$$

[0037] An optimum can be where the partial derivatives are equal to zero. By rearranging and substituting using the above equations in a similar way that was done when developing the minimum plate area (as described with reference to Figures 1 and 2), the minimum edge length is where the following is true:

$$2yL = 2xB = xyD \;\; (Eq.17)$$

[0038] This relationship of Equation 17 is illustrated graphically in Figure 7 for the tank arrangement 50 in which x = 5 and y = 3.

[0039] By rearranging the equations above one can readily find the unique and explicit solution for the NLP above, as follows:

$$L = \left(\frac{Vx^2}{2y}\right)^{(1/3)} \quad (Eq.18a)$$

$$B = \left(\frac{Vy^2}{2x}\right)^{(1/3)} \quad (Eq.18b)$$

$$D = \left(\frac{4V}{xy}\right)^{(1/3)} \quad (Eq.18c)$$

[0040] Now we see that the derived Equations 18a-18c are the same set of equations as Equations 11a-11c as used for finding the minimum plate area. Equations 18a-18c gives the overall dimensions for the tank arrangement optimised for minimum weld length *E.* This indicates that the two optima i.e. minimum plate area and minimum edge length, coincide. Accordingly, the overall dimensions for the tank arrangement obtained through Equations 11a-11c or Equations 18a-18c are the same and are optimal for the weld length and the plate area.

[0041] In Figure 8, a tank arrangement 60 is illustrated. The tank arrangement 60 comprises ballast tanks 613a, 613b at the flanks, and cargo tanks 613c centrally, and is identical to that of Figure 3 except that the tank arrangement 60 includes an additional bottom tank 613d, in effect adding a tank layer in the depth dimension. Whilst the derivations above specify only two tank plates in the vertical (see the number 2 in third term of the right hand side of Equation 1), a similar derivation can be provided to give the optimum (area minimised) solution for the overall *L, Band D* for three tank plates in the vertical (depth dimension) as indicated in the arrangement 60 of Figure 8, or for a further number of such plates.

[0042] It will be appreciated that steps for determining the overall dimensions of the tank arrangement L, B, and D may be implemented by suitably configured apparatus such as a computer and/or computer program. Such a computer may thus comprise a processor configured to execute a computer program with instructions for calculating a geometrical characteristic such as the dimensions L, B, and D. The program could for example comprise machine readable instructions for implementing the Equations 11a-11c and/or Equations 18a-18c.

Results

[0043] In the following, results from performing the calculation of *L, Band D* according to Equations 11a-11c (or Equations 18a-18c) for the specified volume are shown. In particular, Table 1 shows a comparison between a non-optimised structure as may be typical of a prior art FPSO ship, and an optimised structure.

Table 1:

	Non-optimised	Optimised
L (m)	211.2	97.3
B (m)	43.7	97.3
D (m)	33.2	32.4
A (m^2)	69260	56760
V (Sm^3)	306698	306698
x	6	6
y	6	6
l (m)- individual	42.2	19.5
b (m) - individual	14.6	19.5
d (m)- individual	33.2	32.4
BD (m^2)	1452	3153
LD (m^2)	7012	3153
LB (m^2)	9238	9460
Slenderness ratio (L/B)	4.83	1

[0044] The individual tanks within the arrangement in this example are of equal size, having a length *l,* breadth *b,* and depth *d* as indicated in Table 1 (whilst in contrast capital letters are used to denote the overall quantities, as explained in the theory section above).

[0045] Table 1 indicates that the structure where the tank arrangement is optimised has a significantly smaller overall tank plate area than the non-optimised arrangement for the same overall volume and number of plates or tanks. Accordingly, a given wall material, e.g. steel plate of given thickness, can likewise be much less than in the non-optimised structure.

[0046] It can be seen from Table 1 that the optimised design reduces *A* by about 18%. It can at the same time be noted that the foot print area (*LB*) of the tank arrangement overall is in fact greater than that of the non-optimised structure.

[0047] The overall breadth *B* and overall length *L* of the optimised tank arrangement are equal, such that the slenderness ratio (*L* divided by *B*) is 1. In contrast, the slenderness ratio of the non-optimised arrangement is 4.83.

[0048] While it can be noted that the tank arrangement optimised as set out in Table 1 and embodied in the hull 301 of Figure 5 (described below) has equal length and breadth, this is not necessarily the case more generally. For different numbers of plates *x, y,* the overall Length L_1 of the tank arrangement may be substantially different to the Breadth B_1.

[0049] Table 2 below indicates the slenderness ratios (L/B) of the tank arrangement only for any combination of *x* and *y* in the range *x* = 5,..., 12 and *y* = 5,..., 7 resulting from different values of *x* and *y*.

Table 2:

Tank section slenderness			
	y		
x	5	6	7
5	1.00	0.83	0.71
6	1.20	1.00	0.86
7	1.40	1.17	1.00
8	1.60	1.33	1.14
9	1.80	1.50	1.29
10	2.00	1.67	1.43
11	2.20	1.83	1.57
12	2.40	2.00	1.71

[0050] Table 3 illustrates various solutions for *L, Band D* obtained from the Equations 11a-11c for a given, predefined overall volume, for different *xy* tank matrices, varying only *x.* The solutions in Table 3 are for a matrix tank arrangement such as that illustrated in Figure 3 including ballast tanks 113a, 113b (on the flank rows 110a, 110b), and cargo tanks 113c for storing e.g. oil or gas from the wells (on the central rows 110c).

Table 3:

		Tank matrix w/ cargo tanks and ballast tanks half the cargo tank width					
Parameter	**Units**	**5x5**	**5x6**	**5x7**	**5x8**	**5x9**	**5x10**
L	m	124.71	138.21	151.08	163.42	175.31	186.81
B	m	124.71	118.47	113.31	108.95	105.19	101.90
D	m	41.57	39.49	37.77	36.32	35.06	33.97
A	m^2	93318	98238	102710	106823	110641	114212
V	Sm^3	646548	646548	646548	646548	646548	646548
x		6	7	8	9	10	11
y		6	6	6	6	6	6
L (single cargo tank)	m	24.94	23.03	21.58	20.43	19.48	18.68
B (single cargo tank)	m	31.18	29.62	28.33	27.24	26.30	25.47
D (single cargo tank)	m	41.57	39.49	37.77	36.32	35.06	33.97
BD	m^2	5184	4678	4280	3956	3688	3461
LD	m^2	5184	5458	5706	5935	6147	6345
LB	m^2	15553	16373	17118	17804	18440	19035
Slenderness *L*/*B* (Tank section)		1.00	1.17	1.33	1.50	1.67	1.83

FPSO ship

[0051] Turning now to Figure 9, an example FPSO ship 200 is illustrated having a tank arrangement 230 which is optimised as described above for storing fluid from at least one well in a hull 201 of the ship 200. The tank arrangement comprises multiple tanks 233 having walls 232 for containing fluid in the tanks (without leakage). The tank arrangement 230 is arranged in a storage section 202 of the hull 201 between end sections 203, 204. First and second cofferdams 222, 223 separate the tank arrangement from the first and second end sections 203, 204 respectively. The end sections 203, 204 are configured to allow for example personnel accommodation modules 240, 241 to be arranged thereupon, or other equipment that may not be suitable to be placed above the tank arrangement, e.g. due to regulations or other constraints. The end sections are not designated areas for storage of produced well fluids. The distance between the end sections 203, 204 is determined by the length of the tank arrangement. In this case, the ship 200 has dual bows. Accordingly, the end sections 203, 204 both comprise bow sections. In other variants however, the first end section 203 may be a bow section, and the second end section 204 may be stern section.

[0052] In general, the end sections can typically include cranes, offloading stations, offloading reels, lifeboats, life rafts and/or marine evacuation systems, muster areas, laydown areas, mooring systems, mooring winches, a flare tower, machinery rooms, living quarter and/or temporary refuge, helideck, HPU rooms, emergency generators, essential generator, firewater pump system, and can also have process systems.

[0053] The ship 200 further includes topside production equipment in order to facilitate performing operations in the well and/or processing the fluid arriving on board the ship from the well, e.g. through production pipes. The production equipment 250 in this example includes processing equipment including processing tanks 251 for use in processing the fluid from the well prior to being directed into the storage tanks 233 within the tank arrangement 230. Such processing may for example include separating the produced fluid into respective components such as oil, water and/or gas. The ship may also include a utilities structure 252 including power and/or drive machinery for operating equipment. The utilities structure 252 and the processing tanks 251 are arranged above the storage section of the hull.

[0054] Turning now to Figure 10, there is shown a section of a hull 301 of an FPSO ship. The hull 301 has a matrix tank arrangement 330 which is optimised for minimum surface area of the plates making up the containing walls of the tanks 333 in the tank arrangement 330, such as described above. The tank arrangement is provided within a storage section 302 of the hull, between end sections 303, 304.

[0055] The tank arrangement has intersecting containing walls 332, 333 which extend the length and breadth of the arrangement, and define orthogonal rows of tanks 333 in a 5 x 5 matrix (with *x, y* equal to 6). For the particular volume in question, the optimised tank arrangement 320 will therefore adhere to the dimensions described in Table 1 (and Table 3 for the 5x5 matrix).

[0056] The overall length L_2 of the hull 301 is somewhat longer than the length L_1 of the tank arrangement due to the presence of end sections 302, 304 which are not used for storage of fluids, in the same way as described in relation to the vessel 200 above. The tank arrangement 320 spans the distance L1 from a first cofferdam 322 to a second cofferdam 323, the cofferdams 322, 323 separating respective end sections of the hull from the tank arrangement.

[0057] The tank arrangement spans the full breadth B_1 of the hull. Accordingly, the breadth B_1 of the tank arrangement and the breadth B_2 of the hull are substantially the same. The hull 301 has dual bows. Accordingly, the first and second end sections 303, 304 in this example comprise bows.

[0058] Figure 11 provides a modelled 3-D representation illustrating an example shape of the hull 301.

[0059] The end sections 303, 304 of the hull 301 will typically add less than 20% to the length of the tank arrangement. Thus the slenderness overall of the hull of the FPSO ship will also remain low, compared with traditional designs for the expected plate numbers necessary for providing necessary volume of storage of fluids. The slenderness ratio of the hull (L_2 divided by B_2) in Figure 5 is 1.4, but the slenderness ratio of the tank arrangement (L_1 divided by B_1) is 1.

[0060] In particular, the slenderness ratio of any of the tank arrangement, hull or of the ship as a whole is generally below 3.8, more specifically below 2, and typically in the range of 1 to 2. In particular, the slenderness ratio of the hull is typically in the range of 1.3 to 3, such as for example 1.4 to 2.5 or 1.5 to 2.0.

Advantages

[0061] Embodiments of the invention are advantageous in various ways. By determining the overall dimensions for a tank arrangement as set out above, an optimum tank arrangement and vessel design can be obtained. The optimisation can allow quantities of materials for construction of the tank arrangement to be reduced, and the amount and time required for welding to be reduced as difficult edge weld lengths are at a minimum (at the same point as the minimum plate area). Thus, there can be savings in both materials and fabrication costs. An orthogonal tank arrangement formed from intersecting planar orthogonal plates can be particularly convenient and cost effective, as plates, e.g. of steel, can be obtained at low cost, ready for construction of the tanks. Orthogonal prismatic designs can be well suited to ship hulls.

[0062] Incorporation of storage sections with tank arrangements based on the optimisation technique above, can give further advantages in vessels such as FPSO ships, particularly due to the designs generally being much less slender and of lesser weight, such as:

a) reduced use of hull steel;
b) reduced mooring forces;
c) better fatigue qualities;
d) better stability (e.g. in high winds);
e) reduced hull motions (e.g. in high winds);
f) larger footprint laterally, facilitating placement of equipment topside; and

g) more advantageous footprint laterally for layout of topside.

[0063] Ship hulls can be efficient in providing a large amount of cargo storage such as well fluids in the tank arrangement whilst accommodating supporting equipment in the hull end sections.

[0064] Various modifications and improvements may be made without departing from the scope of the invention described herein.

Claims

1. A method of determining at least one geometrical characteristic of a structure, the structure comprising a number of tanks or tank components, the method comprising the steps of:

   (a) defining the number of tank or tank components; and
   (b) determining the geometrical characteristic based upon said number.

2. A method as claimed in claim 1, wherein the structure has a desired overall volume, and step b includes using the desired overall volume to determine the geometrical characteristic.

3. A method as claimed in claim 1 or 2, which further comprises defining a first number of tanks or tank components in a first horizontal direction, and defining a second number of tanks or tank components in a second horizontal direction, wherein the geometrical characteristic is determined based upon said first and second numbers.

4. A method as claimed in claim 3, wherein the first and second horizontal directions are orthogonal to one another.

5. A method as claimed in claim 3 or 4, wherein the tank components are spaced apart from each other in the first and second directions respectively.

6. A method as claimed in any of claims 3 to 5, wherein the geometrical characteristic comprises at least one lateral dimension of the structure, and the tank components are tank wall elements, wherein the lateral dimension is determined based on scaling the first number of tank wall elements with the second number of tank wall elements.

7. A method as claimed in any of claims 3 to 5, wherein the geometrical characteristic comprises at least one lateral dimension of the structure, and the tank components are tank wall elements, wherein the lateral dimension is determined based on scaling the square of first number of tank wall elements with the second number of tank wall elements.

8. A method as claimed in claim 6 or 7, wherein the wall elements are wall plates.

9. A method as claimed in any preceding claim, performed for restricting, minimising or optimising an amount of construction material required to construct the structure, and/or for restricting, minimising or optimising a weld length.

10. A method as claimed in any preceding claim, wherein the determined geometrical characteristic comprises any one or more of an overall breadth, length and depth of the structure.

11. A method as claimed in any preceding claim, wherein the geometrical characteristic comprises any one or more of: a surface area of the structure, a lateral footprint of the structure, and a dimension thereof.

12. A method as claimed in any preceding claim, wherein the tank components are any of wall elements, wall portions or wall sections.

13. A method as claimed in claim 12, wherein the wall elements or sections are intersecting wall elements or sections.

14. A method as claimed in claim 13, wherein the intersecting wall sections are orthogonal to one another.

15. A method as claimed in any preceding claim, wherein the geometrical characteristic is determined by calculating the characteristic in dependence upon said number.

16. A method as claimed in any preceding claim, wherein the geometrical characteristic is determined by evaluating any of Equations 11a to 11c or Equations 18a to 18c as hereinbefore described.

17. A method of providing a structure comprising tanks, the method comprising the steps of:

(a) determining at least one geometrical characteristic of the structure based upon a predefined number of the tank or tank components and a desired volume of the structure; and
(b) using the determined geometrical characteristic to provide the structure.

18. A method as claimed in claim 14, wherein providing the structure comprises making the structure.

19. A method as claimed in any preceding claim, wherein the structure comprises tanks for storing fluid from at least one well.

20. A method as claimed in any preceding claim, wherein the structure is configured to be provided on a floating production storage and offloading vessel.

21. A method as claimed in any preceding claim, wherein the structure comprises any one of: a marine vessel; a ship; a floating, production, storage and offloading ship; and a hull for any of the aforementioned vessel or ships.

22. Apparatus for performing the method of any of preceding claim.

23. A structure comprising tanks, the structure having at least one geometrical characteristic determined using the method of any of claims 1 to 21.

24. A ship comprising a hull for storing production fluid from at least one well, the hull having an overall length and an overall breadth, wherein the overall length is equal to or up to 3 times greater than the overall breadth.

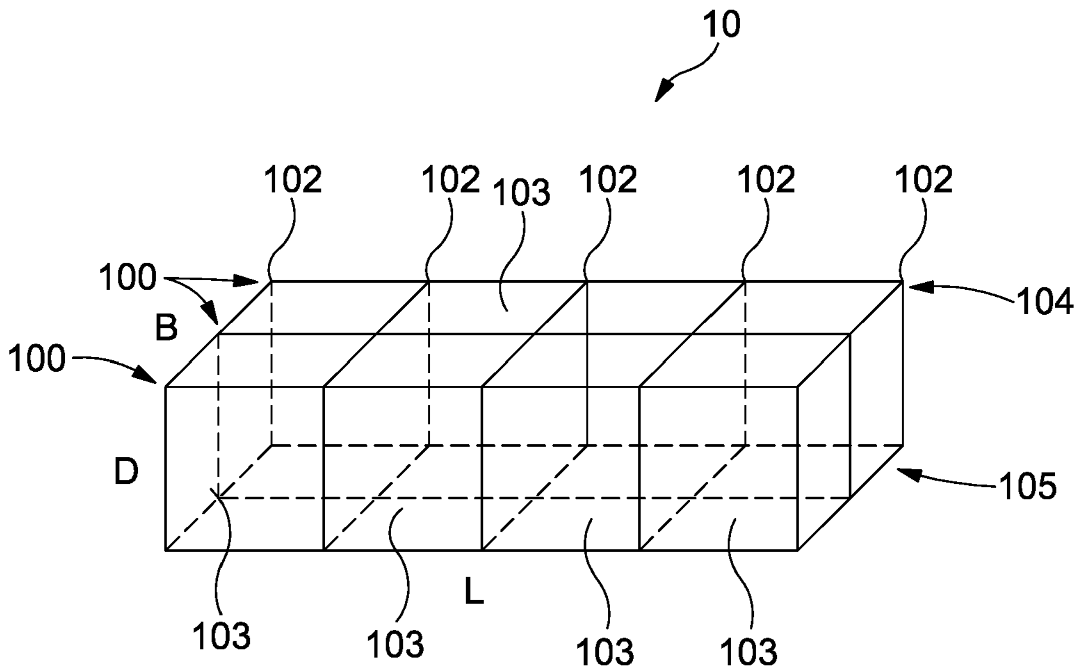
25. A ship as claimed in claim 24, wherein said overall length is in the range of 1.4 to 2 times greater than said overall breadth.

26. A ship comprising an arrangement of tanks in a hull of the ship, for storing production fluid from at least one well, the arrangement of tanks having an overall length and an overall breadth, wherein the overall length is equal to or up to 3 times greater than the overall breadth.

27. A ship as claimed in claim 26, wherein said overall length is in the range of 1.4 to 2 times greater than said overall breadth.

28. A ship as claimed in any of claims 20 to 27 being a floating production storage and offloading, FPSO, ship.

29. A method of storing fluid produced from a well using the ship as claimed in any of claims 20 to 28.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103
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FIG. 1

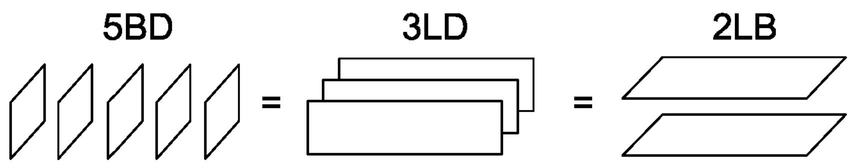
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FIG. 2

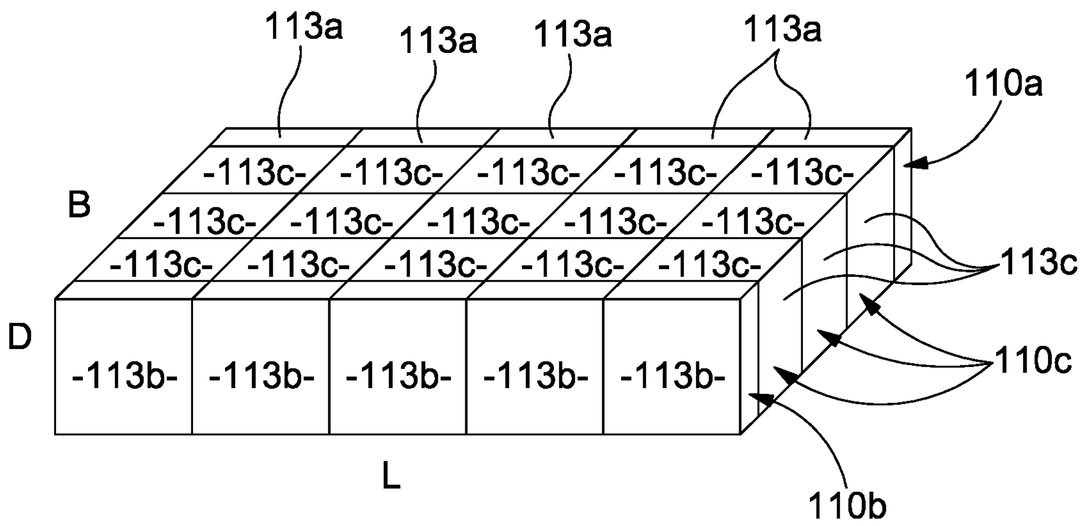
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FIG. 3

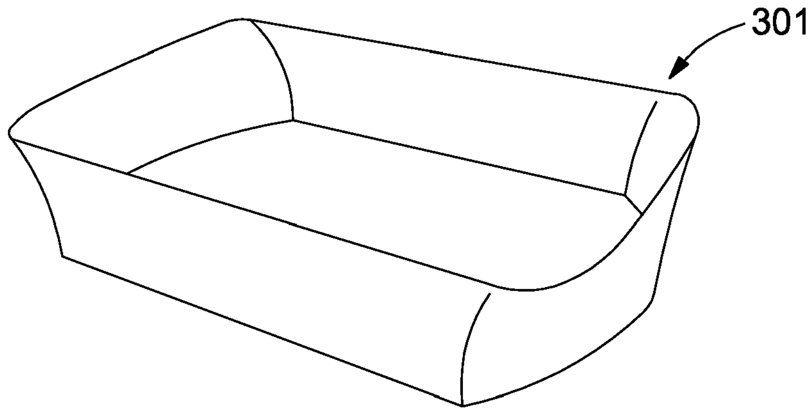
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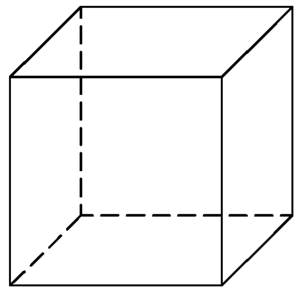
FIG. 11



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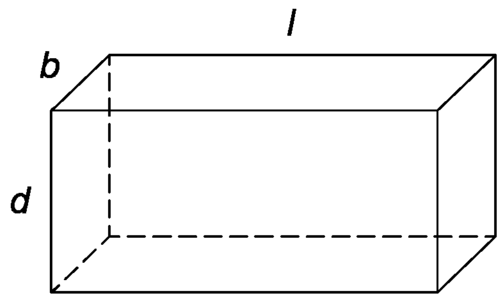


FIG. 5

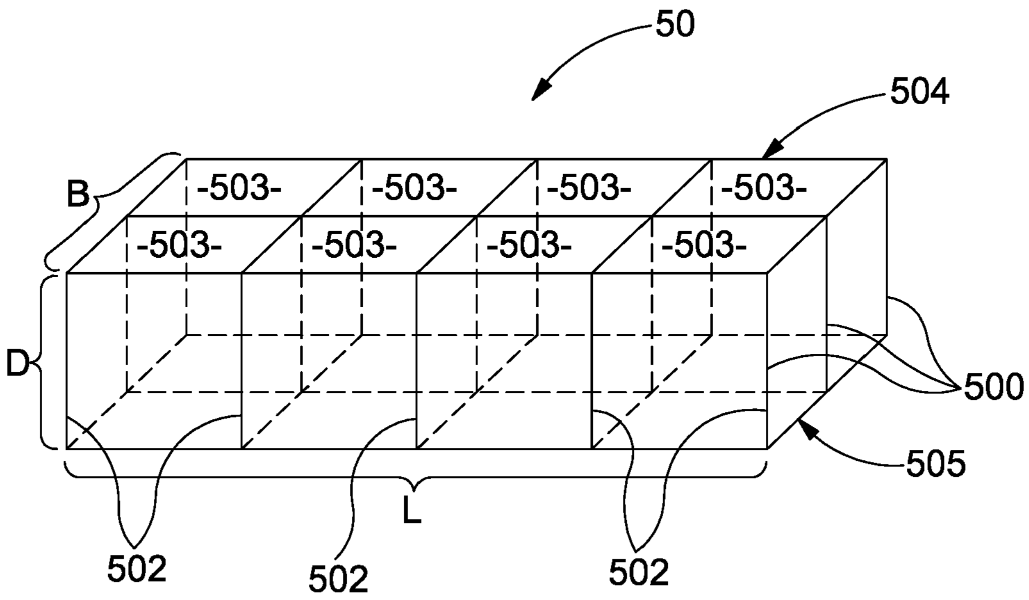
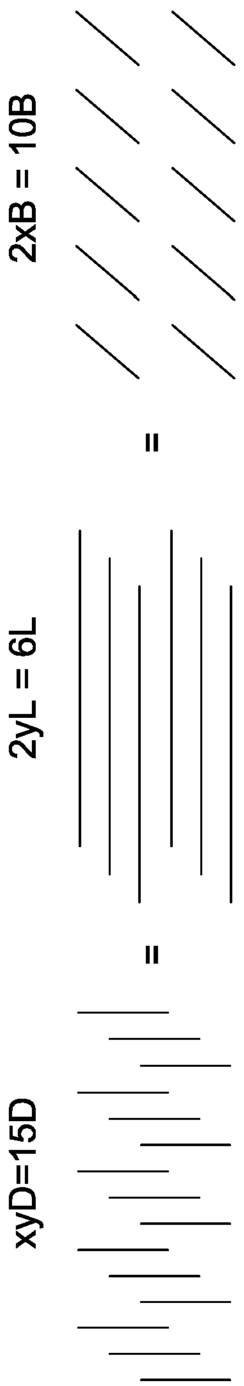


FIG. 6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2yL = 6L
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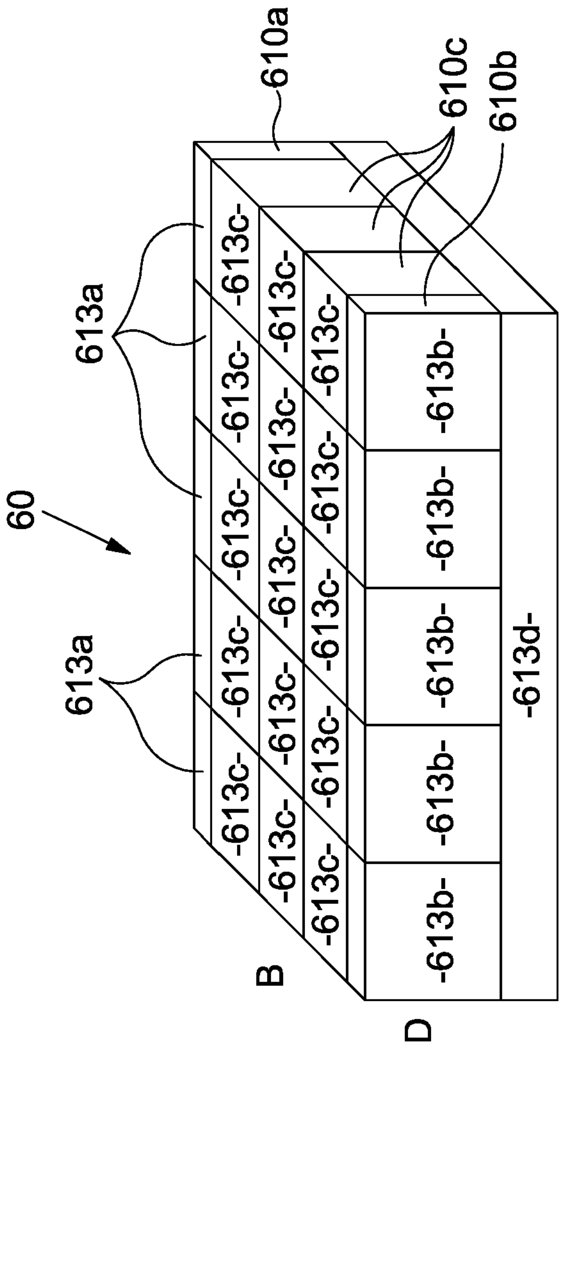
2xB = 10B

FIG. 7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-613b-
-613d-
B
D
L

FIG. 8

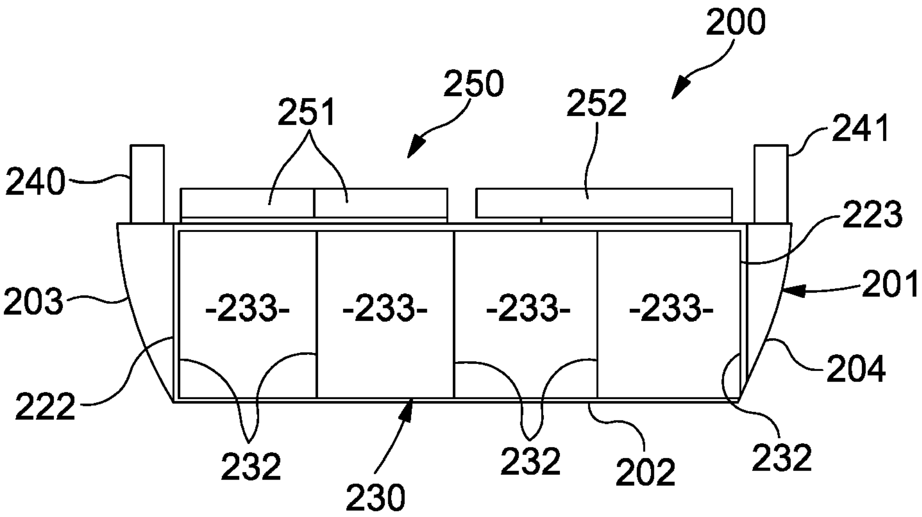
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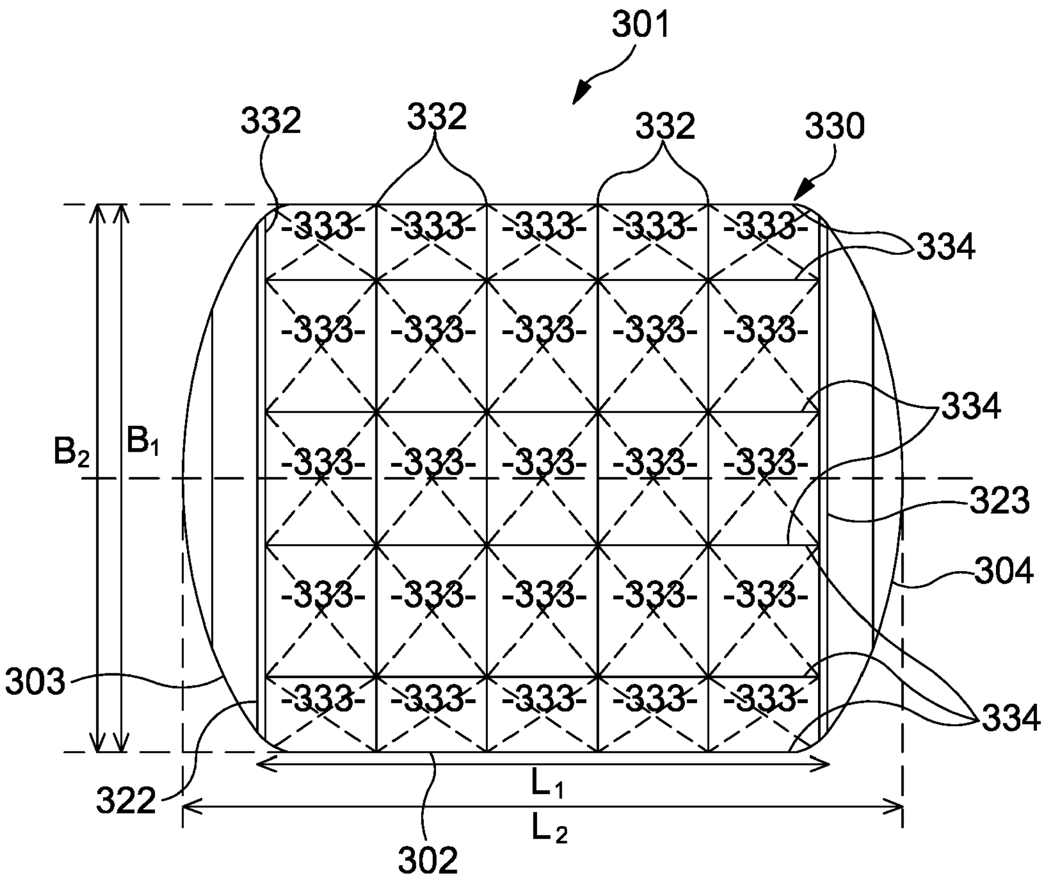
FIG. 9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B2
B1
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334
322
L1
L2
302

FIG. 10

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EUROPEAN SEARCH REPORT

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	14 October 2015	Brumer, Alexandre

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EUROPEAN SEARCH REPORT

Application Number
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			TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
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