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Gilles

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[54] **SHIP HAVING SELF-SUPPORTING SPHERICAL TANKS PARTICULARLY FOR THE TRANSPORT OF FLUIDS AT LOW TEMPERATURES**

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[51] **Int. Cl.** **B63b 25/16**

[58] **Field of Search** ..... 114/72, 73, 74 R, 74 A; 220/9 LG, 9 A, 15; 287/96, 97; 64/10; 62/45, 55

[56] **References Cited**

UNITED STATES PATENTS

3,107,498	10/1963	Messer	220/9 LG X
3,380,611	4/1968	Brougham et al.	220/15 X
3,566,824	3/1971	Cuneo et al.	114/74 A
3,583,352	6/1971	Alleaume	114/74 A
3,759,209	9/1973	Iarossi et al.	114/74 A
3,770,158	11/1973	Alleaume	114/74 A X

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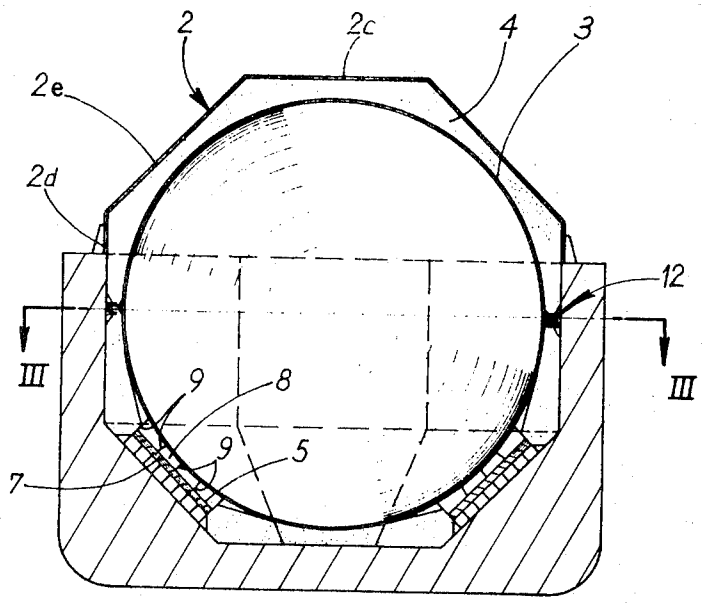
[57] **ABSTRACT**

A ship having self-supporting spherical tanks particularly adapted for the transport of fluids at low temperatures is constructed with connecting parts interposed between the tanks and the structure of the ship which permit contraction and expansion of the tanks and satisfactorily limit external heat exchange.

9 Claims, 6 Drawing Figures



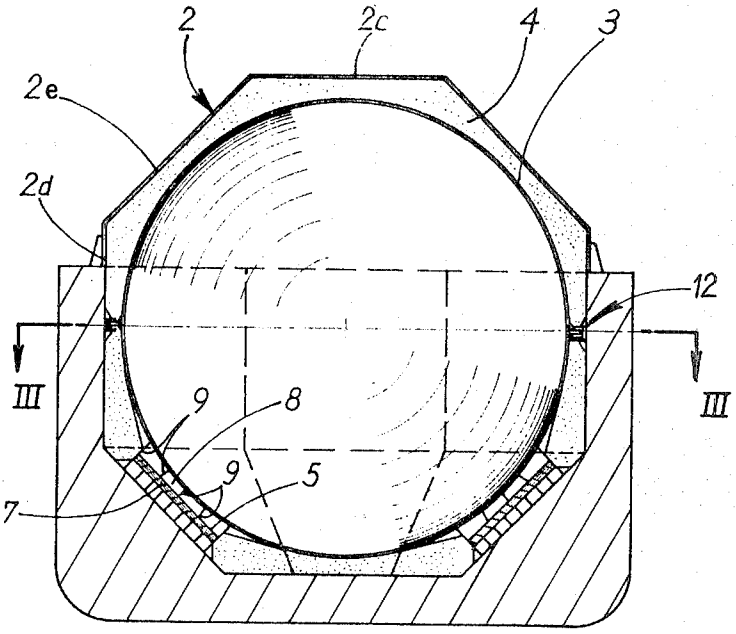


FIG.1

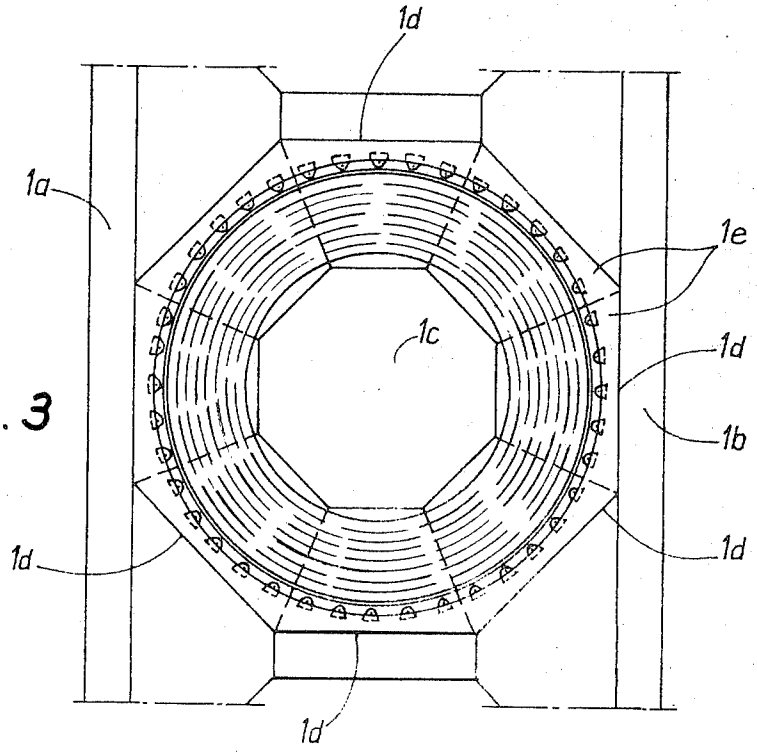


FIG. 3

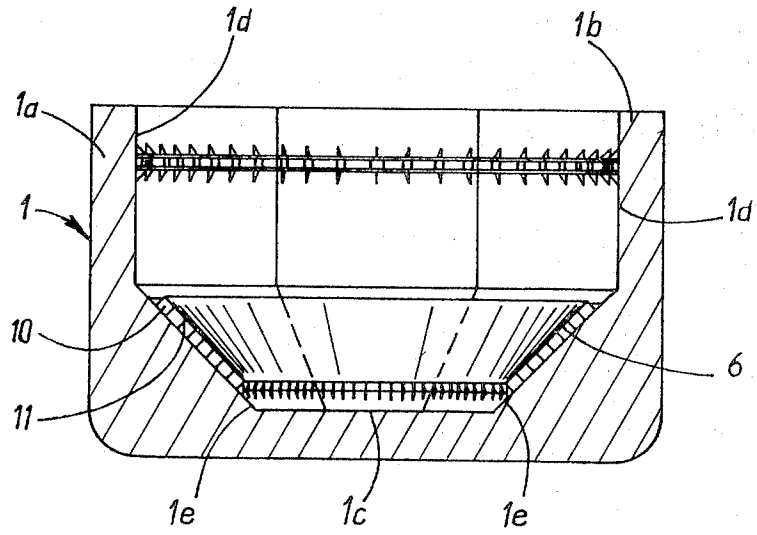


FIG. 2

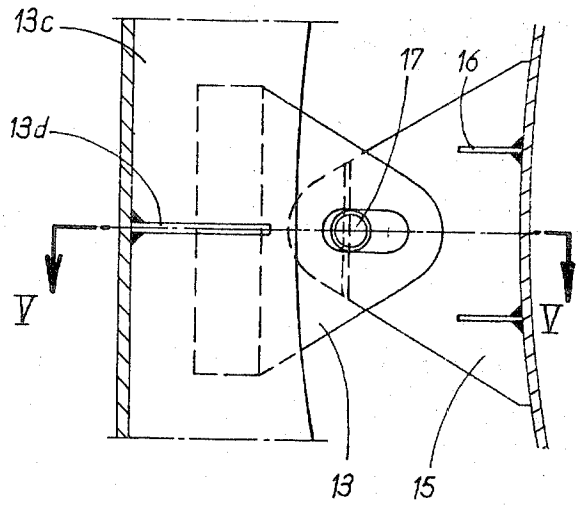


FIG. 4

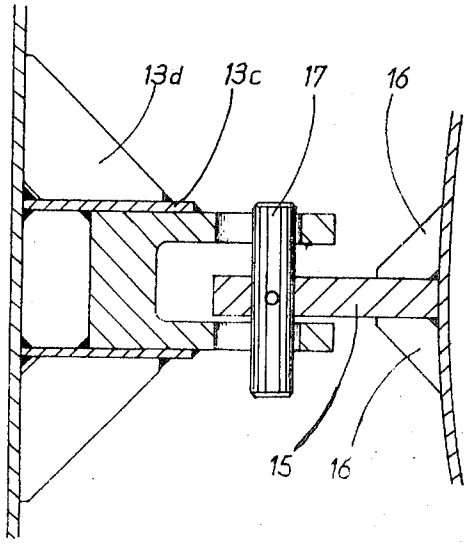


FIG. 6

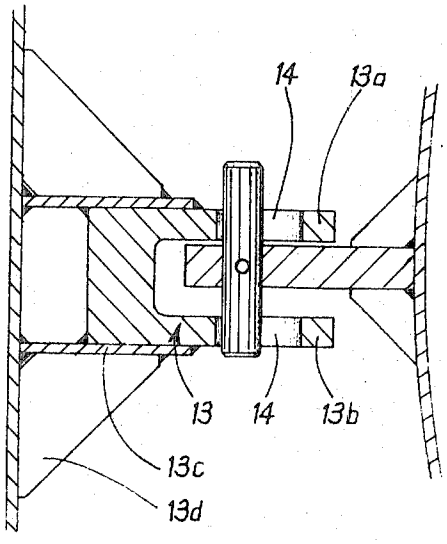


FIG. 5

SHIP HAVING SELF-SUPPORTING SPHERICAL TANKS PARTICULARLY FOR THE TRANSPORT OF FLUIDS AT LOW TEMPERATURES

BACKGROUND

It is known that gases found in nature constitute an important source of energy and a major development is providing means for transporting them in liquefied form at low temperatures. With respect to maritime transport, it has already been proposed to use ships comprising self-supporting cylindrical tanks capable of confining liquefied gases and storing such gases for long periods of time while limiting, in a satisfactory manner, external heat exchange. Nevertheless, it may be noted that the results obtained do not correspond to the optimum theoretical safety where the cylindrical tanks are used and such tanks could be advantageously replaced by a spherical form.

It is also known in the prior art to use ships adapted for the transport of liquid gases at low temperature in which the storage tanks consist of two water-tight barriers inserted between partitions of thermal insulation, the water-tight barriers being formed from welded unsupported metallic sheets. This technique of construction called "a membrane" is satisfactory but may, in certain cases, not have the benefits of a technique of construction using structures of self-supporting tanks, particularly for the transport of liquid ammonia and liquid ethylene.

The present invention has for an object the provision of a ship adapted to transport liquefied gases, and in particular ammonia and liquid ethylene, comprising self-supporting tanks in spherical form or the like and provided with connecting parts interposed between the tanks and the structure of the ship which permit contraction and expansion of the tanks and limit, in a satisfactory manner, heat exchange with the exterior.

BRIEF SUMMARY OF THE INVENTION

The present invention provides an industrial article of manufacture consisting of a ship adapted in particular for the transportation of liquefied gases at low temperatures, said ship comprising a hull structure in the interior of which is disposed at least one water-tight self-supporting tank, each tank being supported by or maintained in the hull structure being provided with a layer of thermal insulation all around the sides of the tank, characterized by the fact that, in the first place, the tank defines a volume of revolution whose axis is approximately perpendicular to the flotation level in the upright position of the ship and whose meridian is a curve without a sharp angle; that, in the second place, the tank rests on a supporting surface in the form of a sectional cradle positioned at its lower part, through an intermediate sectional bearing support having the same angle as the top of the cradle, a layer of appropriate material being interposed between the supporting surface of the sectional cradle and the sectional bearing support aforesaid; and that, in the third place, an assembly of connecting members is provided all around the tank in its median zone, the said connecting members permitting a parallel displacement in the vertical axis of the tank and radially.

DETAILED DESCRIPTION OF THE INVENTION

In a preferred method of accomplishing the invention, the tank consists of welded metallic plates; the volume limitation of the tank is a spherical volume; the thickness of the plates constituting the sides of the tank is variable according to the level in relation to a horizontal plane; the zone of maximum thickness of the side of the tank is situated in the part where the sectional bearing supports of the tank are disposed; the angles of the section of the cone of the supporting surface of the cradle and that of the bearing supports are open towards the top; the sectional support of the tank is a continuous surface connected to the tank by braces or struts disposed in diametrical planes, the said braces being separated from each other by cross members disposed along a conical surface whose tops intersect with the spherical tank; the half angle at the top of the supporting surface of the sectional cradle and the bearing supports is about 45°; the supporting surface of the sectional cradle is a continuous surface supported by the structure of the hull of the ship by way of the braces disposed in axial planes of the section of the cone, the said braces being separated by cross-members perpendicular to the supporting surface of the cradle; the intermediate layer disposed between the supporting surface of the cradle and the bearing supports consists of at least one thermal insulating material; the intermediate sectional layer is formed, in part, of a sheet of material known under the commercial trademark of "Klegecel," or of a sheet of plastic material such as polyvinylchloride or polyurethane, or the like, with a sheet of plywood interposed between the foregoing sheet and the bearing support; the intermediate layer may comprise interior reinforcement disposed preferably in an axial plane and constituted, for example, of pieces of hard wood; the assembly of points of attachment provided between the tank and the structure of the hull of the ship is disposed in the diametrical plane of the tank which is parallel to the upright plane of flotation of the ship; each point of attachment consists of a connecting device such as that described in French Pat. No. 1,364,070; each point of attachment also consists of an assembly of an arm radially fixed to the spherical tank, said arm carrying an axle or shaft which is perpendicular to the upright plane of flotation of the ship, and having a U-bracket, the two wings of which receive the ends of the aforesaid axle, the arm being disposed between the two wings of the U-bracket with a possibility of displacement parallel to the aforesaid axle, the U-bracket being rigidly connected to the hull structure of the ship, the median line of the U-bracket opening being radial and the axle or shaft of the arm having the possibility of a radial displacement in the said opening of the U-bracket; the U-bracket and the arms at the points of attachment are made of a material which is a poor conductor of heat such as, for example, stainless steel; the housing for the spherical tank defined by the hull structure of the ship has, in parallel sections to the upright flotation of the ship, the form of a regular octagon; the housing of the spherical tank defined by the structure of the ship's hull and the protective structure has in a diametrical plane of the tank perpendicularly to the plane of flotation in the upright position, the form of an octagon; the space between the tank, the hull structure and the protective super-structure is filled with a thermal insulating material such as, for example, "perlite."

It may be noted that the spherical tank of the ship transport may contract thermally in a completely free

matter which is a necessity when filling the tank with a liquefied natural gas; in fact, the points of attachment disposed in the diametrical plane of the tank which are parallel to the flotation plane permit radial contraction of the tank which is attributable in part to a displacement of the axle in the interior of the hollow portion between the two wings of the U-bracket and in part to the displacement of the clamp between the two wings of the U-bracket; moreover, the conical sectional form of the supporting surface of the sphere on the hull structure permits providing a continuous support of the sphere at the ambient temperature or at the temperature of the liquefied gas. Finally, the constitution of the layer or bed intermediately disposed between the supporting surface of the cradle and the bearing surface integral with spherical tank permits absorption of the residual construction deformation, adapting the deformation of the hull structure during the course of navigation, and limiting in a satisfactory manner thermal leakage at the support level.

The objects of the invention will be better understood by reference to the following description in conjunction with the drawings in which one embodiment of the invention is illustrated by way of an example without limiting the invention. In the drawings:

FIG. 1 represents, in transverse section, a ship according to the invention, the section passing through the center of the spherical tank of the ship;

FIG. 2 represents a sectional view of FIG. 1 without the spherical tank and the protective superstructure;

FIG. 3 represents a section taken along the line of III—III of FIG. 1;

FIG. 4 represents, in plan view, a detail of a point of attachment of the spherical tank in its diametrical plane parallel to the plane of flotation of the ship in its upright position, the various elements being disposed in the positions which they occupy at the ambient temperature;

FIG. 5 represents a section taken along the line V—V of FIG. 4;

FIG. 6 represents, in section, the various elements of FIG. 5 in the position which they occupy when the spherical tank is filled with a liquefied gas.

Referring to the drawings, it will be seen that the hull structure 1 of the ship is surmounted by a protective superstructure 2 which covers the upper part of spherical tank 3. The diameter of tank 3 is slightly less than the width of beam between the two sides 1*a* and 1*b* of the ship. For a tank diameter of 36.5 meters a minimum space of 0.7 meter is required between the tank 3 and the hull structure. The housing provided in the ship for each spherical tank 3 is defined, in the first place, by a base or bottom 1*c* parallel to the plane of the flotation of the ship in the upright position, the said base 1*c*, in plan view, forming a regular octagon; secondly, by the lateral walls 1d perpendicular to the plane of flotation of the ship in its upright position, the lateral walls surrounding the tank 3 so as to define a housing which is perpendicular to the plane of upright flotation of the ship, in the form of a regular octagon, the sides 1*a* and 1*b* of the ship constituting two opposing sides of said regular octagon; and thirdly, by the intermediate oblique sides connecting the bottom 1*c* to the various sides perpendicular to the plane of flotation of the ship in its upright position, these sides having an inclination of 45° to said plane of flotation. The protective superstructure 2 consists, first, of a side 2d disposed in the prolongation of the side 1*a;* secondly, of an octagonal horizontal upper plate 2*c;* and thirdly, of an oblique side 2*e* connecting the side 2*d* and the plate 2*c*. The space between the spherical tank 3, on the one hand, and the housing 1*c*, 1*a*, 1*d*, 2*d* and 2*e*, 2*c*, on the other hand, is filled with a special insulation material, for example, a material known as "perlite."

The tank consists of steel plates containing 9 percent of nickel, the thickness of the plates varies according to the level with respect to the plane of flotation of the ship in the upright position; the variation occurs by successive spherical rings from at least 10 millimeter thickness in the upper part to at least 16 millimeter thickness in the lower part, with two maxima, one of 22 mm. situated at a level at the center of the sphere and the other of 34 mm. located at the level of the median zone of the oblique sides 1*e*. In the zone where the thickness is equal to 34 millimeter, the sphere is supported exteriorally by sectional bearing supports 5 and opposing sectional supports 6 of a cradle; the support 5 and the surface 6 are at an angle of about 45° from the vertical; they are separated by layer 7 formed of a sheet of thermal insulating material known by the commercial name of "Klegecel" and by a layer of plated metal forming a slippery surface and disposed in contact with the points of support 5. The points of support 5 are separated from the sphere 3 by intermediate braces 8 disposed in diametrical planes of the sphere 3; the braces 8 are separated from each other by cross-pieces 9 having conical surfaces, whose tops are in contact with sphere 3. The bearing surface 6 is separated from the sides 1*e* of the housing of the tank 3 by means of braces 10 disposed in diametrical planes of hull 1, said braces being separated by cross-members 11, perpendicular to the sides 1*e*.

In the diametrical plane of the spherical tank 3 which is parallel to the flotation level of the upright hull is disposed an assembly of points of attachment 12 spaced regularly every 10° around tank 3. Each point of attachment 12 consists of a U-bracket 13 formed of two parallel wings 13*a*, 13*b* on the interior of which is an oblong slot 14 whose median line is a straight line passing approximately through the center of sphere 3. U-bracket 13 made of unoxidizable steel is connected to hull 1 by angle brackets and radial members 13*c*, 13*d* respectively. Arm 15 cooperating with U-bracket 13 is connected to the side of spherical tank 3 and disposed approximately in a diametrical plane parallel to the plane of flotation of the ship in its upright position. The connection of arm 15 made of unoxidizable steel is reinforced by bracket 16. Arm 15 carries an axle 17 affixed thereto approximately perpendicularly to the plane of flotation of the ship in its upright position. The axle 17 has its two extremities engaged in the interior of slots 14 of the two wings 13*a*, 13*b* of U-bracket 13. It is made of steel containing 9 percent nickel. The axle 17 which may have to be displaced radially in the interior of oblong slots 14 and the bracket 15 has a permissible displacement between the two wings 13*a*, 13*b* of bracket 13 parallel to axle 17.

It may be noted in accomplishing the invention, the connection of the spherical tank 3 permits thermal contraction of the tank without difficulty. Contraction is produced at the moment when the tank is filled with a liquefied gas. In fact, the form of the conical section of the aforesaid supports between the support 5 and the supporting surface 6 of the cradle permits a continu-

ously maintained support despite variation of temperature and construction of the sphere. Moreover, the points of attachment **12** permit a radial displacement of the sides of the tank **3** with respect to walls **1d** of the housing by reason of displacement of axles **17** in the slots **14** and while equally permitting a displacement in the height of bracket **15** between the wings **13***a*, **13***b* of bracket **13** due to the effect of the diminution of radius of spherical tank **3**.

It may be noted, furthermore, that the thermal insulation of the tank **3** is perfectly assured in part due to the presence of the layer of insulating material **4** which surrounds the sphere and in part due to the small thermal loss in the connecting zones and in the support zones; in this regard, the composition of the layer **7** interposed between the support **5** and the supporting surface **6** of the cradle has an importance which is not negligible. The presence in this layer of a plastic sheet permits absorption of residual deformities in construction and adapts itself to the deformations in the structure of the ship's hull during navigation. It is desirable to provide that the points of attachment **12** do not permit the passage of the flow of thermal loss through the limited zones of contact of axles **17** with wings **13***a*, **13***b* and contact of axles **17** with bracket **15**; these zones being very reduced because the contacts are generated along the axles **17**. Furthermore, the thermal flow is equally limited by reason of the poor thermal conductivity of wings **13***a* and **13***b* and brackets **15**.

It will be understood that the practice of the invention herein described is subject to various modifications without departing from the invention; in particular, one may utilize as points of the attachment of the spherical tank in its equatorial plane connections of a known type of such as those described in French Pat. No. 1,364,070, said connections permitting a free thermal contraction of the spherical tank when it becomes cold.

I claim:

1. A ship adapted in particular for the transport of liquefied gases at a low temperature, the ship comprising a hull structure in the interior of which is disposed at least one self-supporting water-tight tank, each tank being supported by and maintained in the hull structure by a supporting surface comprising a sectional cradle having planar sides all sloping upwardly and outwardly at an angle to the sides of the hull, a bed of thermal insulation being provided all around the sides of the tank, said tank defining a volume of revolution whose vertical axis is approximately perpendicular to the flotation plane of the ship and whose meridian is a curve without a sharp angle, the lower portion of said tank resting on said supporting surface of said sectional cradle, and means securing said tank to the interior of said hull comprising points of attachment around the tank in its median zone, the said points of attachment permitting parallel and radial displacement of the tank with respect to the vertical axis of the tank.

2. A ship as claimed in claim **1** wherein the volume defined by the tank is a spherical volume.

3. A ship as claimed in claim **1** wherein the thickness of sides of the tank is variable according to the level with respect to a horizontal plane.

4. A ship as claimed in claim **1** wherein the planar sides of the sectional cradle are supported by the structure of the hull of the ship by means of supporting members disposed perpendicular to said sides of the cradle.

5. A ship as claimed in claim **1** wherein an intermediate layer is interposed between the supporting surface of the cradle and the tank comprising at least one thermal insulating material.

6. A ship as claimed in claim **5** wherein said layer is formed in part of a plastic sheet material.

7. A ship as claimed in claim **1** wherein each said point of attachment consists of an assembly of an arm connected to the spherical tank, the said arm carrying a fixed shaft which is perpendicular to the plane of the flotation of the ship, and by a U-bracket with two wings each comprising an oblong opening to receive an end portion of said shaft, the arm being disposed in the space between the two wings of the U-bracket to permit parallel and radial displacement of said shaft and the U-bracket being rigidly fixed to the interior of the ship's hull.

8. A ship as claimed in claim **7** wherein the U-brackets and the arms of the points of attachment are made of a material which is a poor conductor of heat.

9. A ship as claimed in claim **1** wherein said supporting surface comprises conical members whose tops are in contact with said tank.

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