

PATENT SPECIFICATION

(11)

1 457 006

1 457 006

- (21) Application No. 56454/73
- (22) Filed 5 Dec. 1973
- (23) Complete Specification filed 25 Nov. 1974
- (44) Complete Specification published 1 Dec. 1976
- (51) INT. CL.² B65D 87/18
- (52) Index at acceptance
E1T 6B4B 6D
- (72) Inventor CEDRIC LIVINGSTON LOW



(54) IMPROVED FLOATING ROOF

(71) We, MOTHERWELL BRIDGE ENGINEERING LIMITED, a British company of P.O. Box No. 4, Motherwell, ML1 3NP, Lanarkshire, Great Britain, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 This invention relates to floating roofs for covering liquid stored in bulk in storage tanks.

According to the present invention there is provided a floating roof for covering liquid stored in storage tanks wherein the roof floats on the stored liquid, said roof comprising an annular pontoon peripherally surrounding and supporting a substantially-flat diaphragm and a stiffening structure secured to the diaphragm, said stiffening structure being composed of a plurality of elongate stiffening elements, each said stiffening element being of lesser length than the radius of the diaphragm and extending radially with respect to the diaphragm.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings, in which:—

Fig. 1 is a view of a storage tank incorporating a floating roof according to the present invention; and

Figs. 2 to 11 are illustrative of alternative forms of floating roofs and of details thereof.

In Fig. 1 of the drawings a storage tank 10 for bulk storage of liquid is illustrated as comprising a generally cylindrical wall 11 formed by a plurality of metal plates welded together in a known manner and a floating roof 12 comprising an annular pontoon 13 peripherally surrounding a substantially flat diaphragm 14 to which is secured a stiffening structure composed of

rib-like or elongate stiffening elements 15 the alternative radial orientations of which on the diaphragm 14 will be described in detail hereinafter. At the centre of the diaphragm 14 there is a sump 16 and drain-pipe connected thereto to permit removal of liquid (such as rain water) from the upper surface of the roof. Although not illustrated, there is a liquid-tight seal of known construction between the pontoon 13 and the wall 11 and the diaphragm 14 is itself formed from a plurality of metal plates 17 which are welded together.

The rib elements 15 extend radially from the pontoon 13 towards the sump 16 but are of lesser length than the radius of the diaphragm and they may be attached to the pontoon 13 or may be spaced from the pontoon. Also, the elements 15 may be arranged in one or more annular bands and adjacent ends of the elements 15 in adjacent annular bands may terminate on a common radius or they may mutually overlap.

Fig. 2, for example, shows part of a floating roof suitable for medium size storage tanks (about 40-80 metres diameter), wherein there is a single annular band of elements 15 each of which is spaced at its outer end from the pontoon. On the other hand Fig. 3 shows an arrangement which is suitable for medium to small tanks wherein each of the elements 15 is attached to the pontoon 13.

Fig. 4 shows a still further arrangement of floating roof which is suitable for very large tanks, there being three annular bands of the elements 15, the bands being in overlapping relationship and the outer band having its rib elements spaced from the pontoon 13. The elements 15 in each annular band lie on radii of the diaphragm 14 which are intermediate the radii of the diaphragm on which the elements 15 of the other bands are located. Fig. 5 is a diagram-

matic cross-sectional view of a modification of the roof illustrated in Fig. 4, the modification comprising providing localised buoyancy for roof-attitude control by making the rib elements 15 hollow and arranging for the hollow rib elements to project through the diaphragm 14 into the liquid at parts 20. The hollow elements 15 may be filled with air or with any other suitable buoyant medium.

Fig. 6 illustrates a still further arrangement wherein the rib elements 15 are arranged in two annular bands, the bands being overlapping and the ends of the ribs in the outer band terminating short of the pontoon 13. Fig. 7 shows an arrangement similar to Fig. 6 but without overlapping of the bands and the cross-sectional view shown in Fig. 8 illustrates the relative disposition of the pontoon 13, the rib elements 15, the spacing between the pontoon 13 and the outer elements 15 and the central sump 16. A drainage pipe 21 leading from the sump 16 is also illustrated.

Figs. 9A, 9B and 9C are illustrative of the required flexibility of the diaphragm 14. In particular Fig. 9A illustrates the location of support legs 23 for the roof 12, these being fixedly connected to the rib elements 15 and extending downwardly towards the floor 22 of the tank. Fig. 9B illustrates the distortion occurring in the diaphragm 14 when with the tank empty, the leg 23A sinks into the tank floor due to localised subsidence. Fig. 9C illustrates the distortion occurring in the diaphragm 14 due to general irregularities in the tank floor 22. When two support legs 23 are used for each element 15 the preferred location is at the fifth points of the radius of the roof. Although not illustrated support legs are preferably provided to support the pontoon 13, and the diaphragm 14 intermediate the stiffening elements 15.

Figs. 10 and 11 are cross-sectional views of alternative forms which the rib stiffening elements 15 may take. The element 15 in Fig. 10 is trapezoidal in cross-section and is formed from metal plate approximately 6 millimetres thick. Conveniently the rib 15 has a base length of approximately 1 metre. The element 15 in Fig. 11 is semi-circular in cross-section and is formed from metal plate approximately 6 millimetres thick. Conveniently the rib 15 has a radius of approximately 50 centimetres.

The elements 15 may take forms other than those illustrated in Figs. 10 and 11 but conveniently they are shaped to allow stacking in a nesting fashion for ease of transport prior to on-site erection. Also, for the purpose of pressure testing hollow elements 15 after erection it is preferred that each element 15 be provided with a releasable gas-tight plug.

Although not illustrated in detail the diaphragm 14 is preferably attached to the pontoon 13 by means of a relatively thick flange of metal welded to the pontoon which provides a measure of rigidity to the pontoon 13. The flange may be in the form of a rolled section such as L or U shape. To obtain additional rigidity stiffening braces may be welded within the pontoon 13.

With the above-described roofs the actual number of rib elements must be chosen in accordance with the size and operational requirements of the particular case and to provide the required buoyancy under fault or emergency conditions, such as flooding or diaphragm puncture, the rib elements, when hollow are seal welded into position.

With the present invention it has become possible to construct tank roofs which are greatly in excess of 80 metres diameter and which remain fully wetted (thereby minimising corrosion) under all conditions permissible under American Petroleum Institute Specification No. 650. Furthermore, the roof, even when the rib elements are detached from the pontoon, is sufficiently flexible to accommodate accidental subsidence of the tank floor, when in the 'on-supports' condition.

In normal operation the radial layout of the rib elements provides an effective means of overcoming problems due to wind-induced waves in the diaphragm and when the rib elements are hollow the buoyancy thereby provided minimises loading effects caused by leakage of liquid and by flooding. Furthermore, if the hollow rib elements terminate short of the pontoon, flooding of the roof induces a directional drainage towards the centre of the diaphragm which houses the sump.

WHAT WE CLAIM IS:—

1. A floating roof for covering liquid stored in storage tanks wherein the roof floats on the stored liquid, said roof comprising an annular pontoon peripherally surrounding and supporting a substantially-flat diaphragm and a stiffening structure secured to the diaphragm, said stiffening structure being composed of a plurality of elongate stiffening elements, each said stiffening element being of lesser length than the radius of the diaphragm and extending radially with respect to the diaphragm.

2. A floating roof as claimed in claim 1, wherein the ends of the stiffening elements adjacent said pontoon are secured thereto.

3. A floating roof as claimed in claim 1, wherein the ends of the stiffening elements adjacent said pontoon terminate short of said pontoon.

4. A floating roof as claimed in any preceding claim, wherein said stiffening elements are arranged to form two annular bands of elements with the ele-



matic cross-sectional view of a modification of the roof illustrated in Fig. 4, the modification comprising providing localised buoyancy for roof-attitude control by making the rib elements 15 hollow and arranging for the hollow rib elements to project through the diaphragm 14 into the liquid at parts 20. The hollow elements 15 may be filled with air or with any other suitable buoyant medium.

Fig. 6 illustrates a still further arrangement wherein the rib elements 15 are arranged in two annular bands, the bands being overlapping and the ends of the ribs in the outer band terminating short of the pontoon 13. Fig. 7 shows an arrangement similar to Fig. 6 but without overlapping of the bands and the cross-sectional view shown in Fig. 8 illustrates the relative disposition of the pontoon 13, the rib elements 15, the spacing between the pontoon 13 and the outer elements 15 and the central sump 16. A drainage pipe 21 leading from the sump 16 is also illustrated.

Figs. 9A, 9B and 9C are illustrative of the required flexibility of the diaphragm 14. In particular Fig. 9A illustrates the location of support legs 23 for the roof 12, these being fixedly connected to the rib elements 15 and extending downwardly towards the floor 22 of the tank. Fig. 9B illustrates the distortion occurring in the diaphragm 14 when with the tank empty, the leg 23A sinks into the tank floor due to localised subsidence. Fig. 9C illustrates the distortion occurring in the diaphragm 14 due to general irregularities in the tank floor 22. When two support legs 23 are used for each element 15 the preferred location is at the fifth points of the radius of the roof. Although not illustrated support legs are preferably provided to support the pontoon 13, and the diaphragm 14 intermediate the stiffening elements 15.

Figs. 10 and 11 are cross-sectional views of alternative forms which the rib stiffening elements 15 may take. The element 15 in Fig. 10 is trapezoidal in cross-section and is formed from metal plate approximately 6 millimetres thick. Conveniently the rib 15 has a base length of approximately 1 metre. The element 15 in Fig. 11 is semi-circular in cross-section and is formed from metal plate approximately 6 millimetres thick. Conveniently the rib 15 has a radius of approximately 50 centimetres.

The elements 15 may take forms other than those illustrated in Figs. 10 and 11 but conveniently they are shaped to allow stacking in a nesting fashion for ease of transport prior to on-site erection. Also, for the purpose of pressure testing hollow elements 15 after erection it is preferred that each element 15 be provided with a releasable gas-tight plug.

Although not illustrated in detail the diaphragm 14 is preferably attached to the pontoon 13 by means of a relatively thick flange of metal welded to the pontoon which provides a measure of rigidity to the pontoon 13. The flange may be in the form of a rolled section such as L or U shape. To obtain additional rigidity stiffening braces may be welded within the pontoon 13.

With the above-described roofs the actual number of rib elements must be chosen in accordance with the size and operational requirements of the particular case and to provide the required buoyancy under fault or emergency conditions, such as flooding or diaphragm puncture, the rib elements, when hollow are seal welded into position.

With the present invention it has become possible to construct tank roofs which are greatly in excess of 80 metres diameter and which remain fully wetted (thereby minimising corrosion) under all conditions permissible under American Petroleum Institute Specification No. 650. Furthermore, the roof, even when the rib elements are detached from the pontoon, is sufficiently flexible to accommodate accidental subsidence of the tank floor, when in the 'on-supports' condition.

In normal operation the radial layout of the rib elements provides an effective means of overcoming problems due to wind-induced waves in the diaphragm and when the rib elements are hollow the buoyancy thereby provided minimises loading effects caused by leakage of liquid and by flooding. Furthermore, if the hollow rib elements terminate short of the pontoon, flooding of the roof induces a directional drainage towards the centre of the diaphragm which houses the sump.

WHAT WE CLAIM IS:—

1. A floating roof for covering liquid stored in storage tanks wherein the roof floats on the stored liquid, said roof comprising an annular pontoon peripherally surrounding and supporting a substantially-flat diaphragm and a stiffening structure secured to the diaphragm, said stiffening structure being composed of a plurality of elongate stiffening elements, each said stiffening element being of lesser length than the radius of the diaphragm and extending radially with respect to the diaphragm.

2. A floating roof as claimed in claim 1, wherein the ends of the stiffening elements adjacent said pontoon are secured thereto.

3. A floating roof as claimed in claim 1, wherein the ends of the stiffening elements adjacent said pontoon terminate short of said pontoon.

4. A floating roof as claimed in any preceding claim, wherein said stiffening elements are arranged to form two annular bands of elements with the ele-

ments in one of said bands lying on radii of the diaphragm which are intermediate the radii of the diaphragm on which the elements of the other of said bands are located.

5 5. A floating roof as claimed in claim 4, wherein the adjacent ends of the elements of said bands lie on a common radius of the diaphragm.

6. A floating roof as claimed in claim 4, wherein said bands overlap.

7. A floating roof as claimed in any preceding claim, wherein said stiffening elements are formed as buoyancy chambers.

8. A floating roof as claimed in claim 7, wherein said buoyancy chambers are air-filled.

9. A floating roof as claimed in claim 7 or claim 8, wherein each buoyancy chamber is trapezoidal in cross-section.

10. A floating roof as claimed in claim 7 or claim 8, wherein each buoyancy cham-

ber is semi-circular in cross-section.

11. A floating roof as claimed in claim 7 or claim 8, wherein the buoyancy chambers project through the diaphragm.

12. A floating roof substantially as hereinbefore described with reference to any one of Figs. 2, 3, 4, 5, 6, 7 and 8 of the accompanying drawings.

13. A liquid storage tank incorporating a floating roof as claimed in any preceding claim.

14. A liquid storage tank substantially as hereinbefore described with reference to Fig. 1 of the accompanying drawings.

FITZPATRICKS,
Chartered Patent Agents,
14-18 Cadogan Street,
Glasgow, G2 6QW.

— and —
Warwick House,
Warwick Court,
London, WC1R 5DJ.

Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1976.
Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.



* C L M S *