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(54) Articulated fluid loading arm

(57) A fluid loading arm particularly for loading cryogenic and/or corrosive fluids has an articulated product tube (12) for carrying the fluid and an articulated support structure (13) extending alongside the tube and connected thereto, the tube and the structure respectively each having an inboard section (17, 23) connected by a swivel joint (19, 25) to an outboard section (18, 24) for movement about horizontal axes. A further swivel joint supports the loading arm on a riser pipe (29) for movement about a vertical axis.

FIG_1

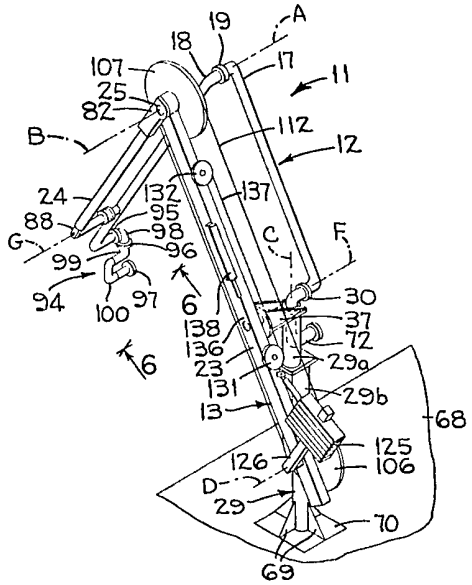

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FIG_1

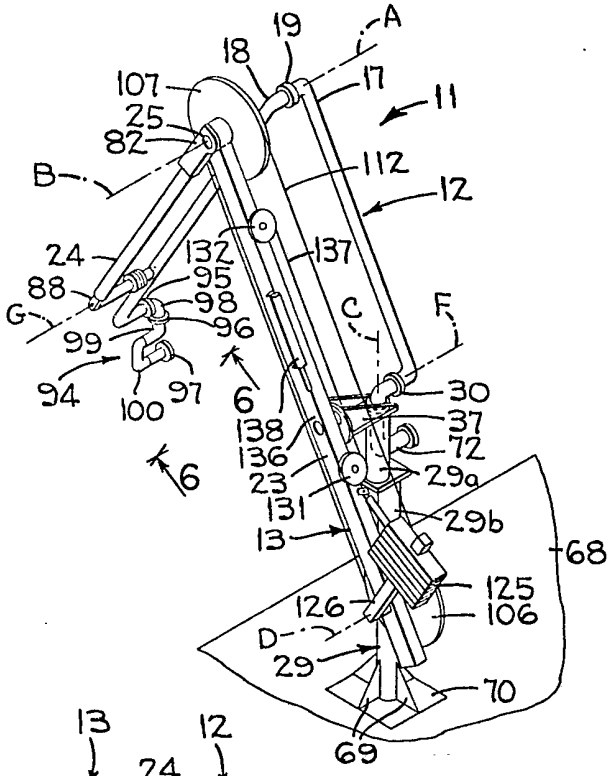


FIG_6

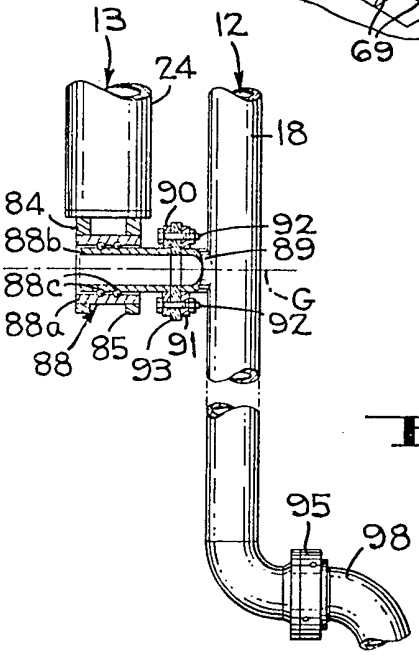


FIG_7

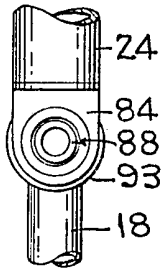
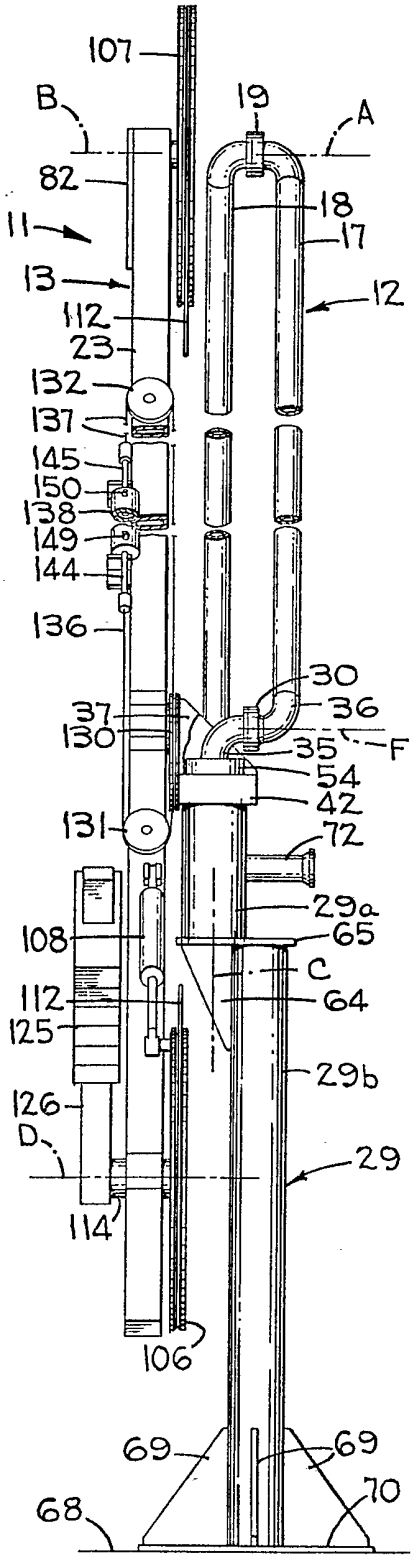
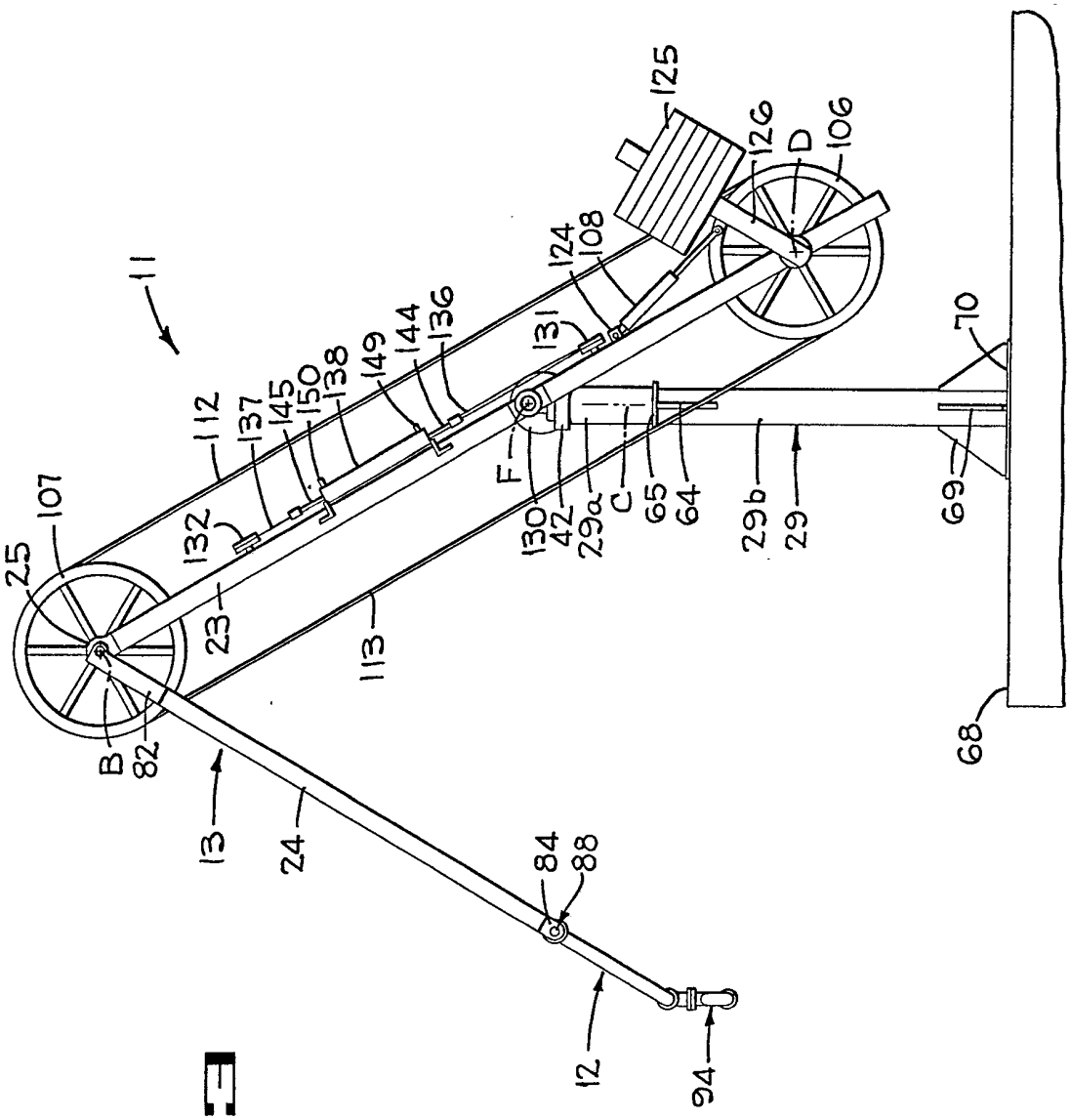


FIG_2

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125
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D
106
124
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131
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144
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137
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107
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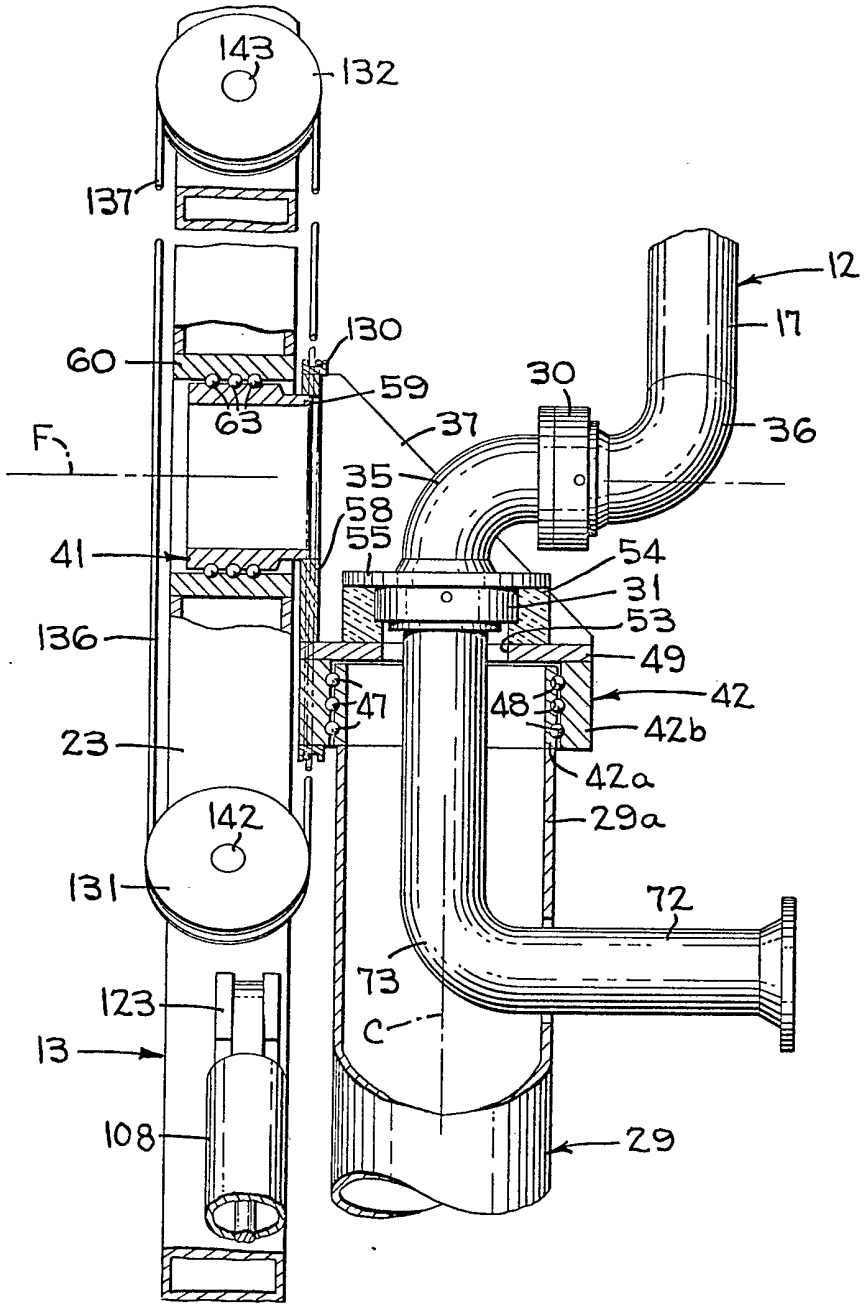
132
23
113
F
130
42
29a
C
65
64
29b
29
70
69
68
B
82
13
24
84
88
12
94

FIG-3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63
37
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F
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41
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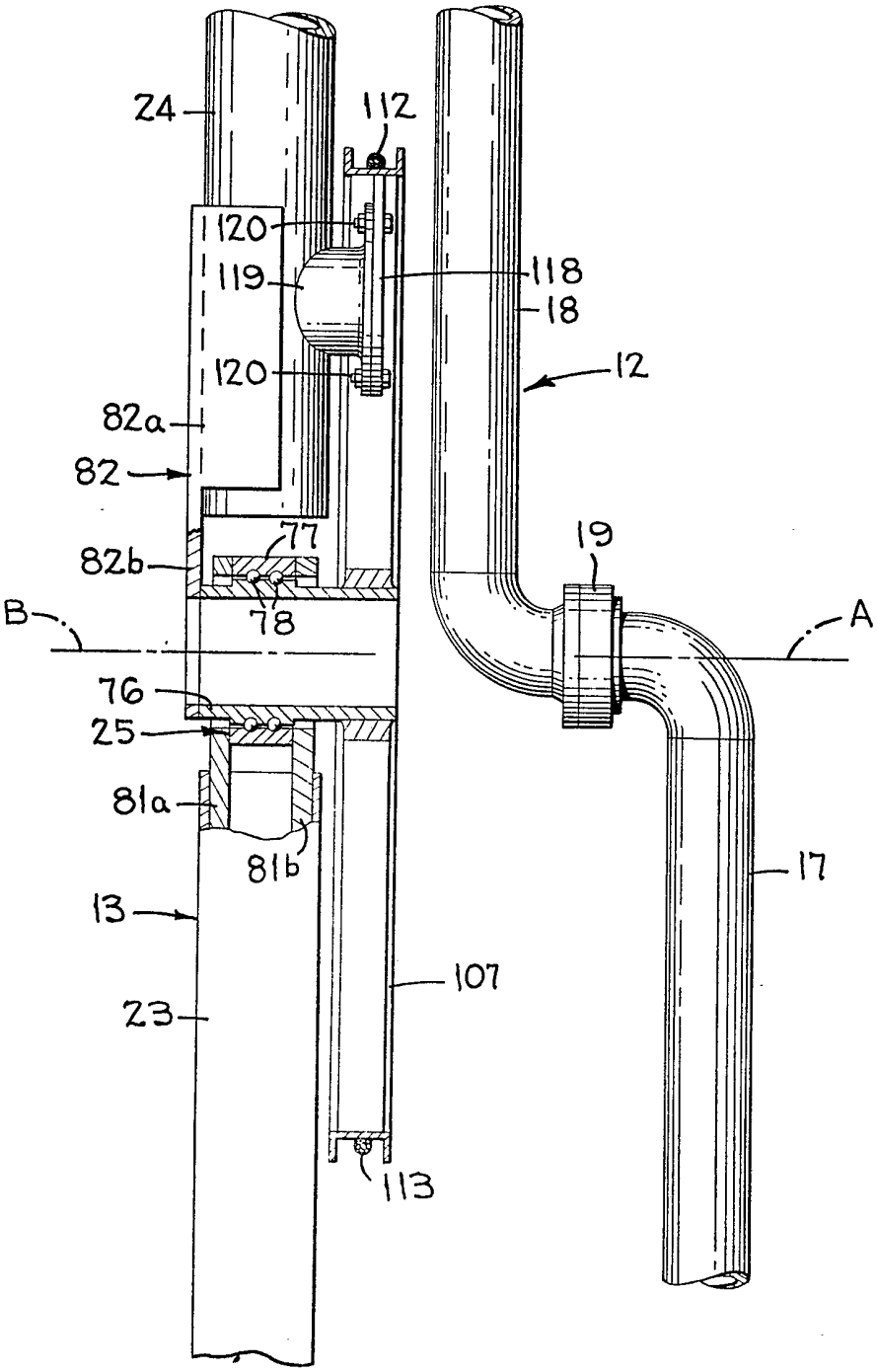
31
53
136
49
47
48
42
42b
23
42a
142
29a
131
72
73
123
C
13
108
29

FIG_4

FIG_5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118
18
120
12
82a
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82b
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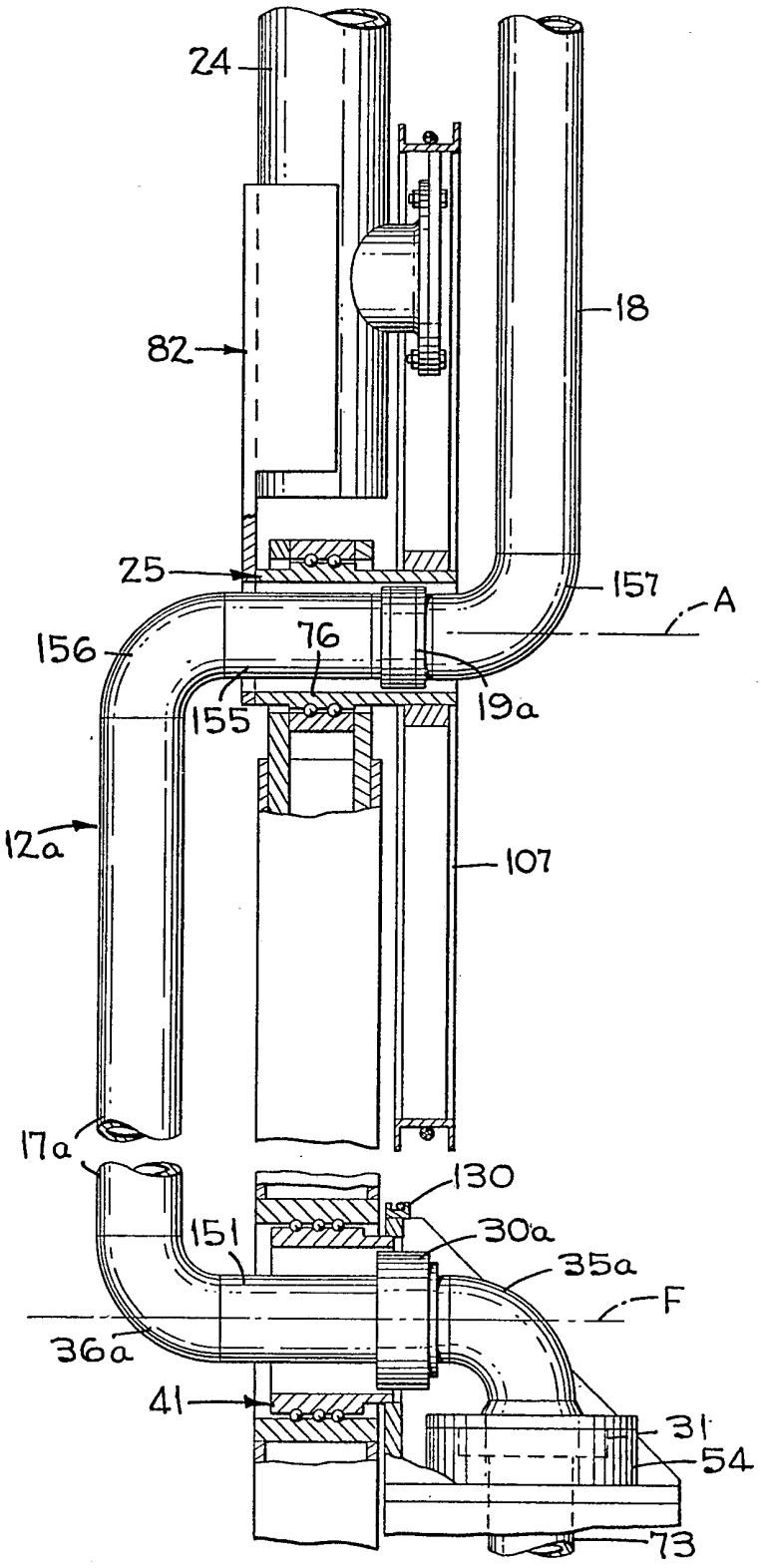
B
A
76
25
81a
81b
17
13
107
23
113

FIG_8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54
73

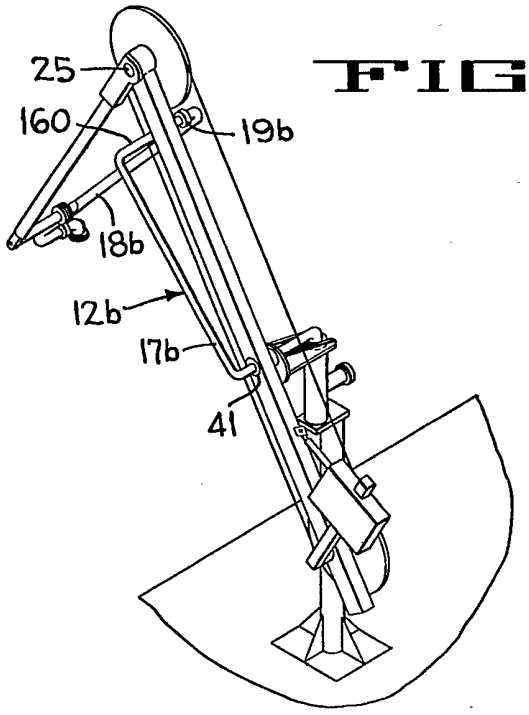


FIG_9

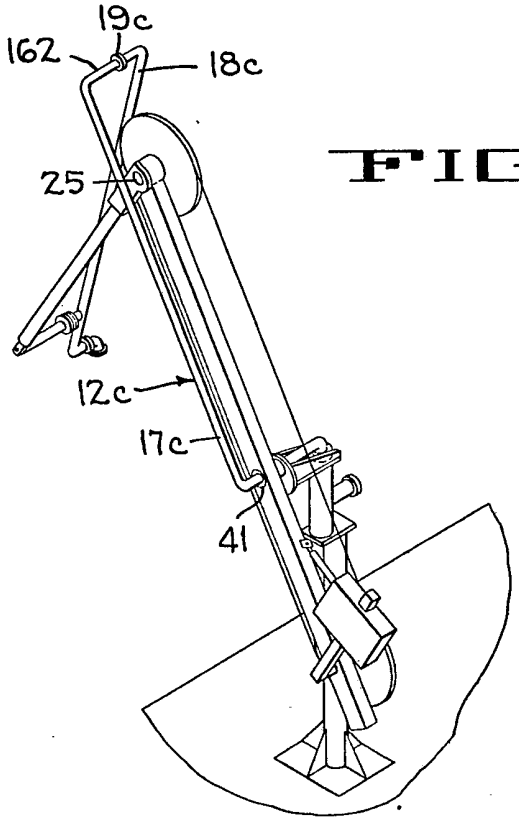
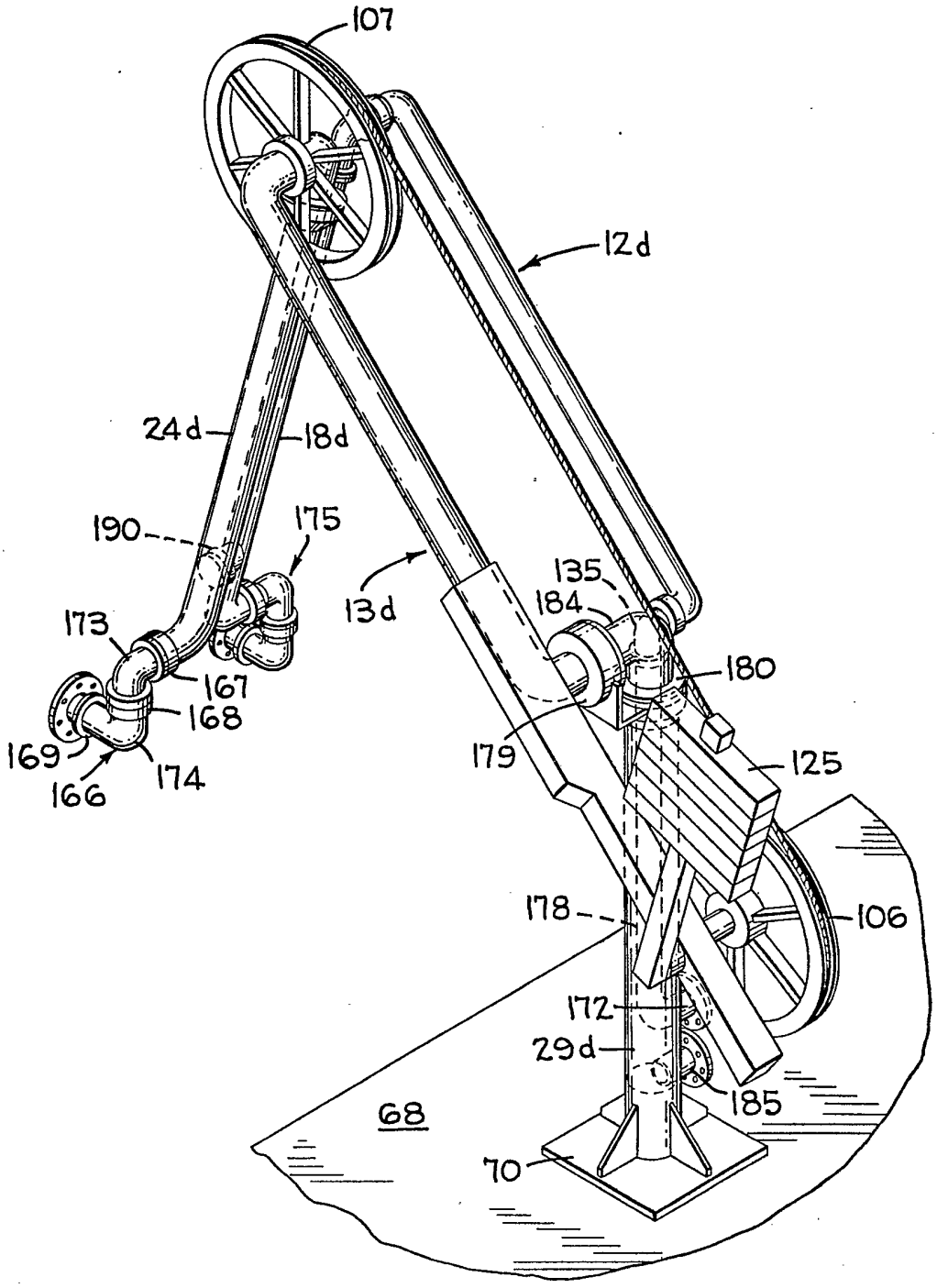


FIG_10

FIG_11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178
106
172
29d
185
68
70

SPECIFICATION

Articulated fluid loading arm

This invention relates to fluid loading arms, and more particularly to an articulated loading arm for cryogenic and/or corrosive fluids.

Fluid loading arms constructed of articulated pipe are extensively used in the petroleum industry for transferring oil or other fluids between a jetty, wharf or other loading station and a marine tanker moored alongside. Such an arm generally comprises an inboard boom or limb supported on a vertical riser pipe by pipe swivel joints to facilitate pivotal movement about horizontal and vertical axes, and an outboard boom or limb connected by a pipe swivel joint to the inboard limb so as to be pivotal relative thereto about a horizontal axis. The outer end of the outboard limb is adapted to be connected to a pipe manifold on a tanker located within reach of the loading arm.

Some fluids being transferred through loading arms have special characteristics, such as a corrosive nature, which makes it necessary for the product tube to be fabricated from stainless steel or other relatively difficult-to-work material. If the product tube of the arm is to be self-supporting it must be constructed from thick-walled, heavy pipe and joint elements that are very costly when manufactured from corrosion-resistant materials. If a relatively light weight, corrosion-resistant product tube is used and supported by a beam or truss assembly of common steel or other less expensive composition, serious problems can result from differential thermal expansion and contraction of the product tube and its support arise when arms of this design are employed in transfer of cryogenic fluids.

According to the present invention there is provided an articulated loading arm for mounting on a vertical riser, said arm comprising a product tube through which a fluid to be loaded can flow, the tube having an inboard limb, an outboard limb and swivel means pivotally connecting said outboard limb to said inboard limb, a support structure having an inboard section, an outboard section and pivot means connecting said outboard section to said inboard section, joint means for pivotally connecting an inboard end of said product tube and an inboard end of said support structure to said vertical riser, and means connecting an outboard portion of said product tube to an outboard portion of said support structure to support said outboard portion of said product tube.

The present invention also provides a dual articulated loading arm for mounting on a vertical riser having therein dual flow paths, said arm having one self supporting portion and one supported portion, said arm comprising a product tube through which a fluid to be loaded can flow, the tube having an inboard limb, an outboard limb and swivel means for pivotally connecting said outboard limb to said inboard limb, a support structure through which said fluid or another fluid can flow, said structure having an inboard section, an outboard section and pivot means for connecting said outboard section to said inboard section, joint means for pivotally connecting an inboard end of said product tube and an inboard end of said support structure on said vertical riser to permit the inboard end of said product tube to communicate with one said flow path and the inboard end of said support structure to communicate with the other said flow path, and means connecting an outboard portion of said product tube to an outboard portion of said support structure to support said outboard portion of said product tube.

The invention will now be particularly described with reference to the accompanying drawings in which:—

Figure 1 is a diagrammatic isometric view of one embodiment of a fluid loading arm according to the present invention;

Figure 2 is an enlarged rear elevation of the loading arm of Fig. 1;

Figure 3 is an enlarged side elevation of the loading arm of Fig. 1;

Figure 4 is an enlarged fragmentary rear elevation of the loading arm of Fig. 1, partly in section;

Figure 5 is an enlarged fragmentary rear elevation, partly in section;

Figure 6 is an enlarged fragmentary elevation, partly in section, of the loading arm of Fig. 1, taken in the direction of the arrows 6–6;

Figure 7 is a side elevation of a portion of the loading arm elements shown in Fig. 6;

Figure 8 is another embodiment of loading arm in accordance with the invention;

Figures 9 and 10 are diagrammatic isometric views of further embodiments of a loading arm according to the present invention, and

Figure 11 is an isometric view of still another embodiment of a loading arm according to the present invention.

First Embodiment—Figs. 1–7

One embodiment of fluid loading arm 11 in accordance with the present invention comprises an articulated product tube 12 (Fig. 1) mounted in a parallel arrangement with an articulated support structure 13. The product tube 12 (Figs. 1, 2) includes an inboard limb 17 pivotally connected to an outboard limb 18 by a swivel joint 19 oriented about a horizontal axis A. The parallel mounted support structure 13 includes an inboard section 23 pivotally connected to an outboard section 24 by a swivel joint 25 oriented about a horizontal axis B that is parallel to or coaxial with the axis A. The inner end of the inboard limb 17 is coupled to a vertical riser 29 (Figs.

1–4) by a pair of swivel joints 30, 31 (Figs. 2, 4) and a pair of elbows 35, 36 for pivotal movement about a vertical axis C and a horizontal axis E, the axis F being parallel to the axes A and B. The inner end of the inboard support section 23 is coupled to the vertical riser 29 by a bracket 37 and a pair of swivel joints 41, 42 for pivotal movement about the same vertical axis C and horizontal axis F.

The swivel joint 42 (Fig. 4) comprises an inner annular male element 42*a* fixed to the upper portion 29*a* of the riser 29, an outer annular female element 42*b* surrounding and coaxial with the riser portion 29*a*, and a plurality of balls or other suitable rollable bearing elements 47 in raceways 48 that rotatably interconnect the male and female elements 42*a*, 42*b*. An annular support plate 49, having a central bore 53, is welded or otherwise connected to the top of the female joint element 42*b*, and an insulating sleeve 54, which is secured to the plate 49 and an upper annular plate 55, provides thermal insulation and support for the swivel joint 31 which also is welded or otherwise connected to the plate 55.

The bracket 37 and a plate 58 (Fig. 4), which are welded or otherwise connected together and to the plate 49, provide a support for the inner element 59 of the swivel joint 41. The outer element 60 of the joint 41 is welded or otherwise connected to the inboard section 23 of the suport structure 13, and the inner and outer joint elements 59 and 60 are rotatably interconnected by a plurality of rollable bearing elements 63 in the conventional manner. The upper portion 29*a* of the riser 29 is secured to a lower riser portion 29*b* (Fig. 2) by a bracket comprising a gusset 64 and a plate 65. The riser 29 is secured in a vertical attitude to a dock or wharf 68 (Figs. 1–3), such as by a plurality of gussets 69 and a base plate 70. An inlet pipe 72 (Figs. 1, 2, 4), coupled to the lower end of the swivel joint 31 by suitable piping 73 (Fig. 4), conducts fluid to or from the inner end of the product tube.

The swivel joint 25 (Fig. 5) comprises an annular inner element 76 and an annular outer element 77 rotatably interconnected by a bearing system such as a plurality of balls or other suitable rollable bearing elements 78. A pair of plates 81*a*, 81*b* are welded or otherwise connected to the outer element 77 and the outer end of the inboard section 23 of the support structure 13. A connecting bracket 82 (Fig. 5), having a generally U-shaped outer portion 82*a* and a flat inner portion 82*b* is welded or otherwise fixed to the inner end of the support structure's outboard section 24 and one end of the inner bearing element 76 to support the outboard section 24.

The outer end of the support structure's outboard section 24 is pivotally secured to the outboard limb 18 of the product tube 12 by a swivel joint or other rotatable bearing 88 oriented on a horizontal axis G parallel to the axes A, B and F. The bearing or joint 88 comprises an outer or female element 88*a*, an inner or male element 88*b*, and balls or other rollable bearing elements 88*c*. The outer or female element 88*a* of the bearing 88 is fixed to the outboard section 24 by a pair of brackets 84, 85, and the inner or male element 88*b* of the bearing is secured to the outboard limb 18 by a pipe section 89 welded or otherwise fixed to the limb 18.

The inner bearing element 88b and the pipe section 89 have opposed flanges 90,91 interconnected by a plurality of circumferentially spaced bolts 92, and an insulating gasket 93 mounted between the flanges 90,91, provides a thermal barrier which reduces the transfer of heat between the support structure 13 and the product tube 12. The pipe 89 is connected to the outboard limb 18 at a point which causes the outboard limb to be substantially balanced about the axis G when the swivel joint 19 (Fig. 1) is dismantled and the outboard limb 18 is disconnected from the inboard limb 17. This facilitates repair and/or replacement of the swivel joint 19. In the usual manner, the product tube 12 carries at its outer end a triple pipe swivel joint assembly 94 (Fig. 1) comprising first, second and third swivel joints 95, 96 and 97, respectively, interconnected by a plurality of pipe elbows 98, 99 and 100.

The support structure 13 (Figs. 1–3) includes a pantograph assembly comprising an inboard sheave 106, an outboard sheave 107, a hydraulic ram 108 and a pair of cables 112,113. The sheave 106 is rotatably mounted on the lower end of the inboard section 23, coaxially with a horixontal axis D, by an axle 114 (Fig. 2) which extends transversely through the section 23. The sheave 107 (Fig. 5) is mounted on the inner element 76 of the swivel joint 25 at the outer end of the inboard section, and is fixed to the inner portion of the outboard section 24 by a bracket 118 and a bracket 119 that are welded or otherwise fixed to the sheave 107 and the section 24 respectively. The bracket 118 and the brace 119 are connected together by a plurality of bolts 120 to facilitate disconnecting the bracket from the brace during repair of the support structure 13. The cables 112 and 113 (Figs. 1–3) are trained about the sheaves 106,107 with the inboard ends of these cables secured to the inboard sheave 106 and the outer ends of these cables secured to the outboard sheave 107. The hydraulic ram 108 (Fig. 3), connected between the sheave 106 and an ear 124 which is welded or otherwise connected to the inboard section 23, rotates the inboard sheave 106 about the axis D to pivot the sheave 107 and the outboard section 24 about the axis B for raising and lowering the outboard section

24 of the support structure 13 and the outboard limb 18 of the product tube 12.

As illustrated in Fig. 3, the articulated support structure 13 includes a counterweight 125 designed to neutralize the majority of the weight of the support structure 13 and of the articulated product tube 12 about the axis D. The counterweight 125 is connected to a beam 126 which is secured to the sheave 106 by the axle 114 (Fig. 2), thereby rotating about the axis D along with the sheave 106.

The inboard section 23 of the support structure 13 is pivoted relative to the riser about the horizontal axis F (Figs. 1–4) by means of a sheave and cable assembly comprising a plurality of sheaves 130–132, a pair of cables 136,137, and a hydraulic ram 138. The sheave 130 is welded or otherwise fixed to the bracket 37 (Fig. 2) and does not rotate, and the sheave 131 is rotatably mounted on a shaft 142 that is fixed to the inboard section 23. One end of the cable 136 (Fig. 2) is trained around and secured to the sheave 130, the other end is secured to a piston rod 144 which is connected to a piston (not shown) inside the cylinder of the ram 138, and the mid-portion of the cable is trained around the sheave 131. The sheave 132 is rotatably mounted on a shaft 143 that is fixed to the inboard section 23 of the support structure. One end of the cable 137 is trained around and secured to the sheave 130, and the other end is trained around the sheave 132 and is secured to a piston rod 145 (Fig. 2) which is also connected to the piston inside the hydraulic ram 138.

Thus, conducting fluid under pressure through an inlet/outlet vent 149 to the lower portion of the ram 138 while venting fluid from the upper portion of the ram through the inlet/outlet 150 causes the ram piston to move downward and the inboard section 23 (Fig. 3) to pivot counterclockwise about the axis F, thereby lowering the outboard end of the section 23. In a similar manner, conducting fluid under pressure through the inlet/outlet 150 to the upper portion of the ram 138 while venting fluid from the lower portion of the ram causes the ram piston to move downward, thereby elevating the outer end of the inboard section 23.

Second Embodiment

A second embodiment of articulated fluid loading arm according to this invention is partially illustrated in Fig. 8, and includes means for mounting a horizontal portion of the product tube inside, but spaced from, the hollow swivel joints 25 and 41. The vertical riser conduit 73 and the outboard limb 18 of the second embodiment are the same as in the first embodiment of Figs. 1–7. In this second embodiment, a swivel joint 30*a* is mounted inside, spaced from, and coaxial with the swivel joint 41. An elbow 35a interconnects the swivel joint 30*a* and the swivel joint 31. A short length of tubing 151 interconnects the swivel joint 30*a* and the elbow 36*a* of the inboard limb 17*a* of the product tube 12*a*. A swivel joint 19*a*, coaxial with the swivel joint 25, is located inside and spaced from, but not connected to, the joint 25. A short length of tubing 155 and an elbow 156 interconnect the outer end of the inboard limb 17*a* and the swivel joint 19*a*, and an elbow 157 interconnects the swivel joint 19*a* and the inner end of the outboard limb 18. Other portions of the second embodiment are the same as the embodiment of Figs. 1–7. Contraction and expansion of the length of the limb 17*a* may cause the swivel joint 19*a* to move closer to the inner element 76 of the swivel joint 25, but proper spacing prevents their interference.

Third Embodiment

A third embodiment of articulated fluid loading arm according to this invention is shown in Fig. 9. This embodiment includes means for mounting a horizontal portion of the product tube 12*b* through hollow swivel joint 41 as shown in Fig. 8, but has a product tube 12*b* with an inboard limb 17*b* and an outboard limb 18*b* each of which is somewhat shorter than the corresponding limbs of the product tube 12*a* of Fig. 8. The limbs 17*b*,18*b* are interconnected by a short length of tubing 160 and a swivel joint 19*b*, positioned a suitable distance below the swivel joint 25. The inner and outer ends of the product tube 12*a* are supported in the manner disclosed in Figs. 1–7.

Fourth Embodiment

A fourth embodiment of articulated fluid loading arm according to the present invention, illustrated in Fig. 10, also includes means for mounting a horizontal portion of the product tube 12*c* through the hollow swivel joint 41 is shown in Fig. 8, and longer inboard and outboard limbs 17*c*,18*c* to position an interconnecting length of tubing 162 and swivel joint 19*c* above the swivel joint 25. The inner and outer end of the product tube 12*c* are supported as shown in Figs. 1–7.

Fifth Embodiment

The embodiment of articulated fluid loading arm according to this invention that is illustrated in Fig. 11 is similar to that of Figs. 1–7, except that the support structure 13*d* is constructed of pipe or other fluid conducting elements, thereby providing two separate flow conduits between dock 68 and the tanker (not shown). The outboard section 24*d* of the support product structure 13*d* carries at its outer end a triple pipe swivel joint assembly 166 comprising first, second and third pipe swivel joints 167, 168, 169 interconnected

by a pair of pipe elbows 173, 174, and the outer end of the product limb 18d terminates in a similar triple swivel assembly 175. The limb 18*d* is pivotally connected at 190 to the support-product section 24*d* in the same manner shown in Figs. 1–7. The inboard end of the product tube is mounted for support on a riser 29*d* in the manner shown in Figs. 1–7. The inboard end of the support structure is connected to the hollow riser 29*d* by a pair of swivel joints 179,180 interconnected by a pipe elbow 184. A pipe elbow 135 at the inboard end of the product tube extends through the side wall of the elbow 184 and is welded to the elbow 184 to provide a fluid tight seal in the side wall of the elbow 184. A vertical pipe 178 connected between the lower end of the pipe elbow 135 and an inlet pipe 172 to convey fluid to the product tube 12*d*. Another inlet pipe 185 welded to the riser 29*d* conveys fluid into the space between the inner wall of the riser 29*d* and the outer wall of the vertical pipe 178. Thus, fluid can flow from the inlet pipe 172, through the vertical pipe 178 and through the product tube 12*d* to the swivel joint assembly 175, and a separate fluid can flow from the inlet pipe 185, through the space between the riser 29*d* and the pipe 178, through the support structure 13*d* to the swivel joint assembly 166. The means for raising and lowering the loading arm of Fig. 11 (only partly shown) is similar to the means shown in Figs. 1–7.

The present invention provides an articulated support structure mounted on a riser and connected at both ends to corresponding ends of an articulated product tube to provide support for the product tube. This allows the use of lightweight material in the product tube and reduces the cost of construction.

CLAIMS

1. An articulated loading arm for mounting on a vertical riser, said arm comprising a product tube through which a fluid to be loaded can flow, the tube having an inboard limb, an outboard limb and swivel means pivotally connecting said outboard limb to said inboard limb, a support structure having an inboard section, an outboard section and pivot means connecting said outboard section to said inboard section, joint means for pivotally connecting an inboard end of said product tube and an inboard end of said support structure to said vertical riser, and means connecting an outboard portion of said product tube to an outboard portion of said support structure to support said outboard portion of said product tube.

2. An articulated loading arm according to claim 1 including power means for raising and lowering said product tube and said support structure.

3. An articulated loading arm according to claim 1 or claim 2 wherein said product tube and said support structure are independent of each other except that the product tube and the support structure are connected together at an inboard end and at an outboard end.

4. An articulated loading arm according to any preceding claim wherein said joint means permit the inboard end of said product tube and the inboard end of said support structure to move about both a vertical axis and a horizontal axis.

5. An articulated loading arm according to any preceding claim wherein said product tube and said support structure are mounted in a mutually parallel arrangement.

6. An articulated loading arm according to any preceding claim wherein said pivot means includes a hollow swivel joint, said swivel means is mounted inside said hollow swivel joint.

7. An articulated loading arm according to claim 6 wherein said product tube passes through said pivot means without contact therewith, and wherein said inboard limb is substantially parallel to said inboard section and said outboard limb is substantially parallel to said outboard section.

8. An articulated loading arm comprising a product tube through which a fluid to be loaded can flow, the tube having an inboard limb, an outboard limb, swivel means pivotally connecting said outboard limb to said inboard limb and a first joint means pivotally connecting said riser to an inboard end of said inboard limb; a support structure having an inboard section, an outboard section, pivot means connecting said outboard section to said inboard section and a second joint means pivotally connecting said riser to said inboard section, and means for connecting an outboard end of said support structure to an outboard portion of said product tube to support said product tube.

9. An articulated loading arm according to claim 8 wherein said product tube and said support structure pivot about a common vertical axis extending through said riser.

10. An articulated loading arm according to claim 8 or claim 9 wherein said product tube and said support structure are mounted in a substantially parallel arrangement, the tube and the structure being independent of each other except that the tube and the structure are connected together at an inboard end and at an outboard end.

11. An articulated loading arm according to claim 8 or claim 9 wherein said inboard limb of said product tube is substantially parallel to said inboard section of said support structure, said outboard limb of said product tube is substantially parallel to said outboard section and an articulated portion between said inboard limb and said outboard limb of said product tube extends through a vertical plane containing said support structure with-

out contact with said structure.

12. A dual articulated loading arm for mounting on a vertical riser having therein dual flow paths, said arm having one self supporting portion and one supported portion, said arm comprising a product tube through which a fluid to be loaded can flow, the tube having an inboard limb, an outboard limb and swivel means for pivotally connecting said outboard limb to said inboard limb, a support structure through which said fluid or another fluid can flow, said structure having an inboard section, an outboard section and pivot means for connecting said outboard section to said inboard section, joint means for pivotally connecting an inboard end of said product tube and an inboard end of said support structure on said vertical riser to permit the inboard end of said product tube to communicate with one said flow path and the inboard end of said support structure to communicate with the other said flow path, and means connecting an outboard portion of said product tube to an outboard portion of said support structure to support said outboard portion of said product tube.

13. An articulated fluid loading arm substantially as hereinbefore described with reference to any one of the embodiments illustrated in the accompanying drawings.

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