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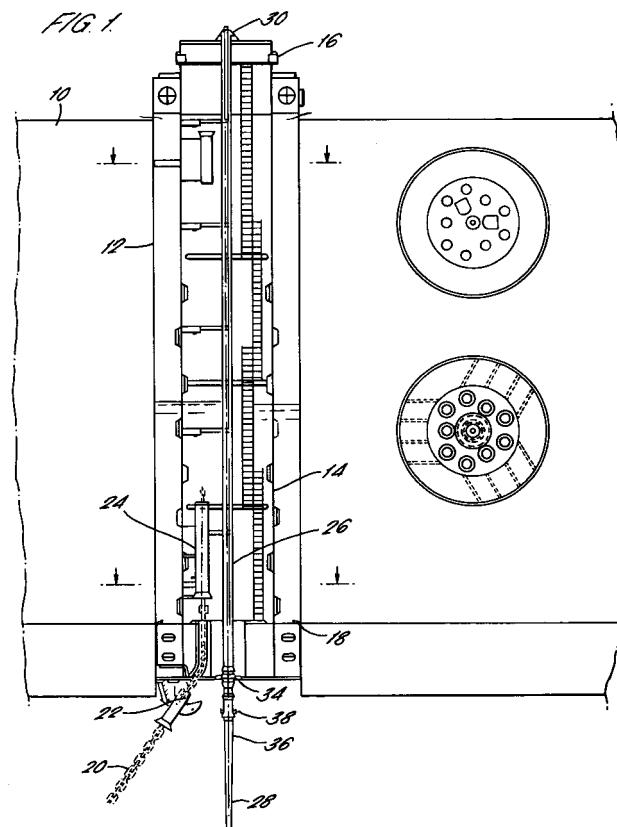
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### (54) Turret mooring apparatus for power plant

(57) A turret mooring system for a floating vessel which produces power from on-board power plant is described. The mooring apparatus comprises a turret structure (14) rotatably mounted on a floating vessel (10). At least one mooring line is securable to the turret (14). A riser pipe (26) extends through the turret (14)

and is securable to the vessel (10) for rotation therewith relative to the turret (14). An electrical cable (28) is connectable to the vessel (10) and extends into the riser pipe (26), wherein the cable (28) is operable to accommodate torsion created in use by rotation of the vessel (10) and riser pipe (26) relative to the turret (14).



## Description

**[0001]** The present invention relates to a turret mooring system for a floating vessel which produces power from on-board power plant.

**[0002]** It is known to generate power on-board floating barges located off-shore and to transfer the power to shore and into the electricity network. Normally, such barges are spread-moored in a manner which does not allow the barge to weathervane around the mooring in response to the action of wind, wave and current. Alternatively, such barges may be turret-moored wherein mooring lines are attached to a turret rotatably mounted to the barge. This system allows the vessel to weathervane around the turret and the mooring lines in response to wind, wave and current action.

**[0003]** If a barge is turret-moored in this way, an electrical swivel apparatus is required on top of the turret in order to transfer the power from the weathervaning barge to stationary subsea cabling. Usually, a large amount of power is being produced in these situations, in the order of 100 to 500MW, and thus a large electrical swivel is required.

**[0004]** The present invention provides a vessel mooring apparatus comprising a turret structure rotatably mountable to a vessel, at least one mooring line securable to the turret, a riser pipe extending through the turret and securable to the vessel for rotation therewith relative to the turret, and an electrical cable connectable to the vessel and extending into the riser pipe, wherein the cable is operable to accommodate torsion created in use by rotation of the vessel and riser pipe relative to the turret.

**[0005]** In this way, the invention avoids the need for an electrical swivel by allowing limited weathervaning of the vessel around a turret mooring system and using the torsion-absorbing capability of the subsea electrical cable to take up the torsion created by weathervaning of the vessel.

**[0006]** The electrical cable may be suspended from hang-off means at the top of the riser pipe, or at the bottom of the riser pipe. The hang-off means may comprise a clamping device. This takes the vertical load of the cable.

**[0007]** In one embodiment, the top of the riser pipe is supported on the turret by a roller bearing, whereby the riser pipe is rotatable relative to the turret. This transfers the vertical load of the cable from the riser pipe to the turret.

**[0008]** Alternatively, the top of the riser pipe may be rigidly supported by a support frame mountable directly on the vessel.

**[0009]** The bottom of the riser pipe may be supported by a sliding bearing, to take the horizontal load of the cable.

**[0010]** Preferably the apparatus further comprises means to prevent or reduce bending of the electrical cable at the lower end of the riser pipe.

**[0011]** The invention also provides a vessel incorporating a mooring apparatus of the type described above. In this case, advantageously, means is provided which is operable to restore the original heading of the vessel when a maximum permissible rotation relative to the turret has been reached.

**[0012]** For example, the apparatus may be designed such that the weathervaning up to about 360° of rotation is permissible, after which point the vessel would be rotated back to its original heading either using thrust producing devices mounted on the vessel itself, or by some external means such as tugs.

**[0013]** The present invention will now be described in detail, with reference to the accompanying drawings in which:

Figure 1 shows a cross-section of a turret-mooring apparatus in accordance with one embodiment of the present invention;

Figures 2A-2D show alternative arrangements for supporting the riser pipe and electrical cable; and

Figure 3 shows an arrangement for supporting the bottom of the riser pipe.

**[0014]** A floating vessel 10, only part of which is shown, has a vertically extending aperture 12 through its hull in which a rotatable turret 14 is located, supported by upper and lower bearings 16, 18. A plurality of mooring lines, such as anchor chains 20, only one of which is shown for convenience, are attached to the turret 14 in a known manner, for example via a chain stopper 22 to a chain hawse pipe 24. In this way, the vessel 10 is able to rotate around the turret 14 and the anchor chains 20 in response to wave, wind and current action.

**[0015]** A riser pipe 26 passes up through the turret 14 and is connected to the vessel 10 such that it rotates with the vessel 10 relative to the turret 14 and anchor chains 20.

**[0016]** A subsea electrical cable 28 passes up inside the riser pipe 26 and is suspended from a hang-off 30, such as a clamping device at the top of the riser pipe 26. Alternatively, it may be suspended from a hang-off 45 located at the bottom of the riser pipe 26. In this case, the cable 28 still extends up above the hang-off 30 through the riser pipe 26 for connection to the power plant, while the hang-off 30 takes the vertical load of the cable 28.

**[0017]** The riser pipe 26 may be supported at the top by a roller bearing 32 to take the vertical load of cable 28. The bottom of the riser pipe 26 may be supported by a sliding bearing 34 to take the horizontal load of the cable 28.

**[0018]** Figures 2A-2D show in more detail alternative embodiments of an arrangement for supporting the turret 14, riser pipe 26 and cable 28.

**[0019]** In Figure 2A, the top of the cable 28 is attached

to a clamping device 30 which is itself attached to the vessel 10. The clamping device 30, cable 28 and riser pipe 26 are rotatably supported on the turret 14 by a bearing 32 and the turret rotatably supported on the vessel 10 by a bearing 16.

**[0020]** In Figure 2B the riser 26 and cable 28 and clamping device 30 are mounted on a support frame 42 secured to the part of the upper turret bearing 16 that is itself mounted on the vessel 10.

**[0021]** In Figure 2C the riser 26 and cable 28 and clamping device 30 are mounted on a support frame 44 secured directly to the deck of the vessel 10.

**[0022]** In Figure 2D the riser 26 and cable 28 and clamping device 30 are mounted on a cantilevered arm 46 secured to the deck of the vessel 10.

**[0023]** Thus, in each case the riser 26 and cable 28 and clamping device 30 are mounted so as to be rotatable with the vessel 10 and relative to the turret 14.

**[0024]** Means to prevent excessive bending of the electrical cable 28 is preferably provided at the underside of the riser pipe 26. This may be in the form of a known device such as a bend stiffener or bend restrictor 36 as shown in Figure 3. The bend stiffener 36 itself may be supported from a hang-off 38 at the bottom of the riser pipe 26. The cable 28 is able to slide freely relative to the bend stiffener 36.

**[0025]** With all the arrangements described above, when the vessel 10 rotates around the turret 14 in response to wind, wave and current, the riser pipe 26 rotates with the vessel 10. The cable 28 accommodates the torsion this creates. Usually, the cable 28 is able to accommodate in the order of a few degrees per metre and thus the allowability angle to which the vessel 10 can rotate around the turret 14 depends upon the length of the subsea cable 28. Means are provided to return the vessel to its original heading when the maximum permissible amount of rotation has been achieved. This may involve thrust means of the vessel 10 itself, or thrust may be provided externally, for example by means of tugs (not shown).

**[0026]** In this way, the need for an electrical swivel is avoided, reducing cost and simplifying installation and maintenance procedures. It will be appreciated that variations and modifications to the precise details described can be made without departing from the scope of the invention as defined in the claims.

## Claims

1. A vessel mooring apparatus comprising a turret structure rotatably mountable to a vessel, at least one mooring line securable to the turret, a riser pipe extending through the turret and securable to the vessel for rotation therewith relative to the turret, and an electrical cable connectable to the vessel and extending into the riser pipe, wherein the cable is operable to accommodate torsion created in use

by rotation of the vessel and riser pipe relative to the turret.

2. A vessel mooring apparatus as claimed in claim 1, wherein the electrical cable is suspended from hang-off means at the top of the riser pipe.
3. A vessel mooring apparatus as claimed in claim 1, wherein the electrical cable is suspended from hang-off means at the bottom of the riser pipe.
4. A vessel mooring apparatus as claimed in claim 2 or claim 3, wherein the hang-off means comprises a clamping device.
5. A vessel mooring apparatus as claimed in any preceding claim, wherein the top of the riser pipe is supported on the turret by a roller bearing, whereby the riser pipe is rotatable relative to the turret.
6. A vessel mooring apparatus as claimed in any of claims 1-4, wherein the top of the riser pipe is rigidly supported by a support frame mountable directly on the vessel.
7. A vessel mooring apparatus as claimed in any preceding claim, wherein the bottom of the riser pipe is supported by a sliding bearing.
8. A vessel mooring apparatus as claimed in any preceding claim, further comprising means to prevent or reduce bending of the electrical cable at the lower end of the riser pipe.
9. A vessel incorporating a mooring apparatus as claimed in any preceding claim.
10. A vessel as claimed in claim 9, further comprising means operable to restore the original heading of the vessel when a maximum permissible rotation relative to the turret has been reached.

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FIG. 1

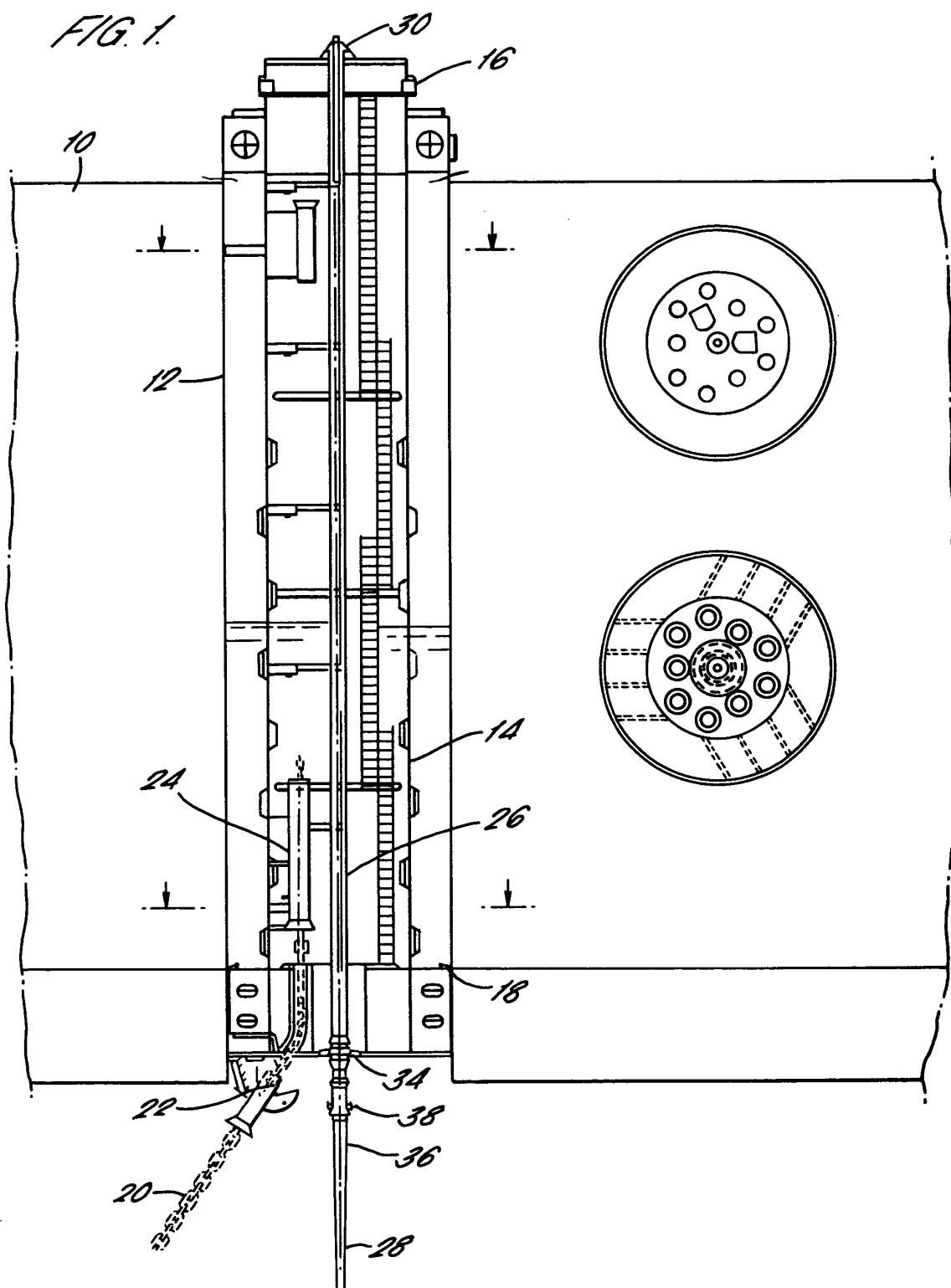


FIG. 2A.

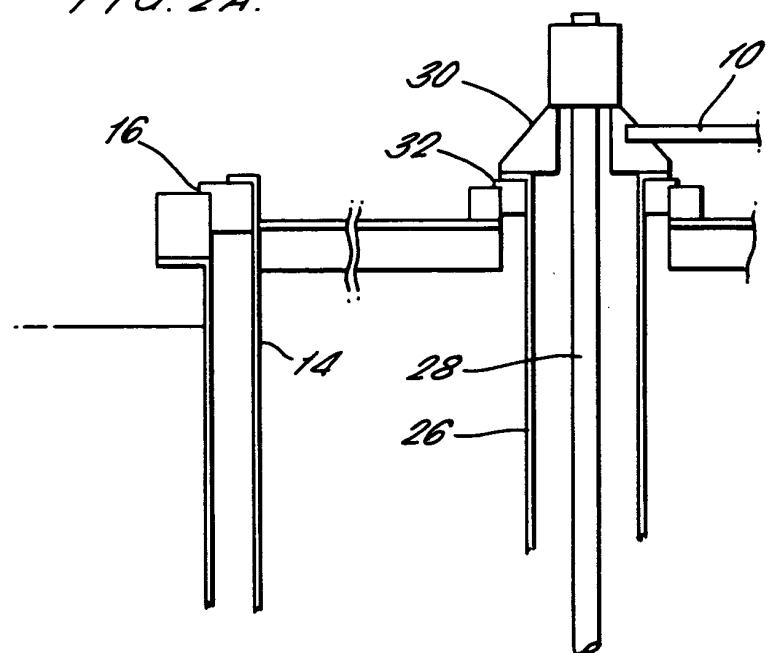


FIG. 2B.

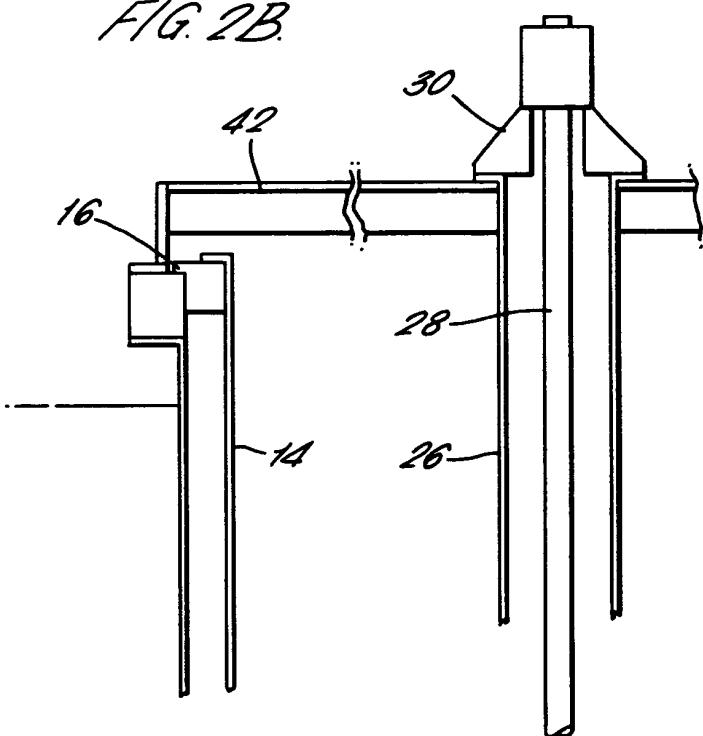


FIG. 2C.

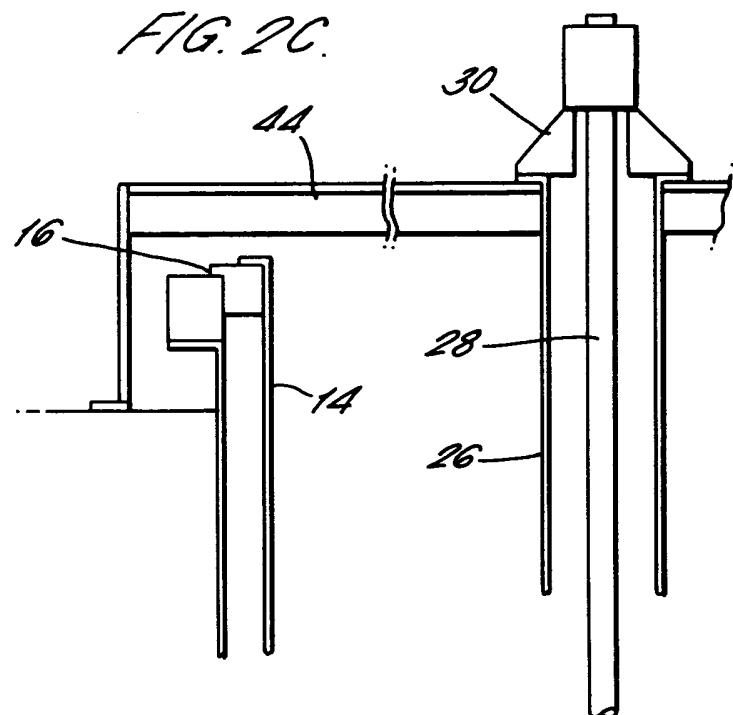
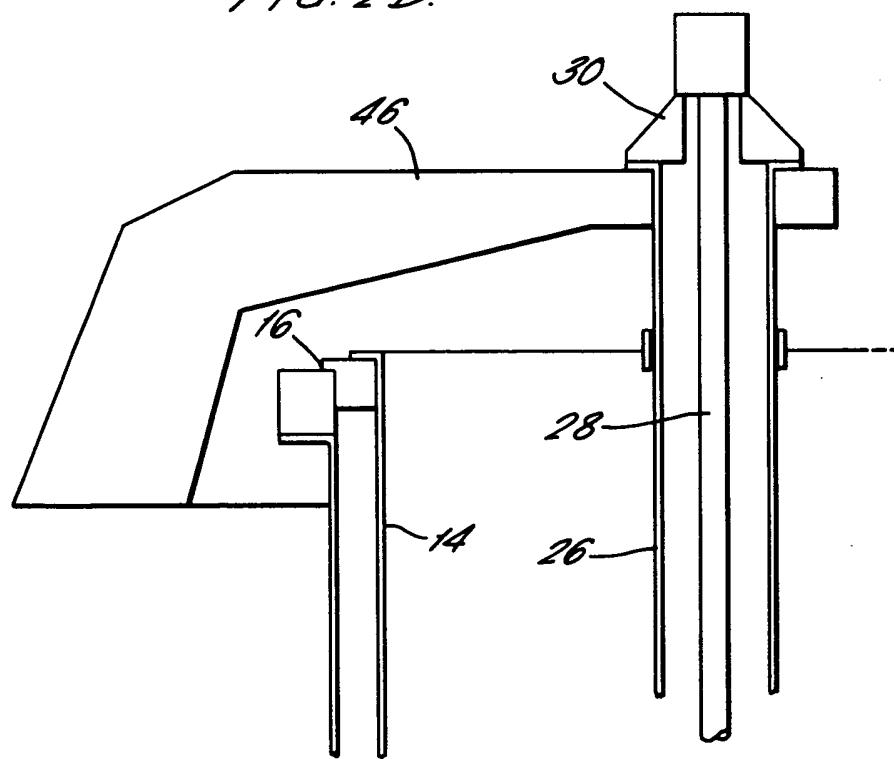
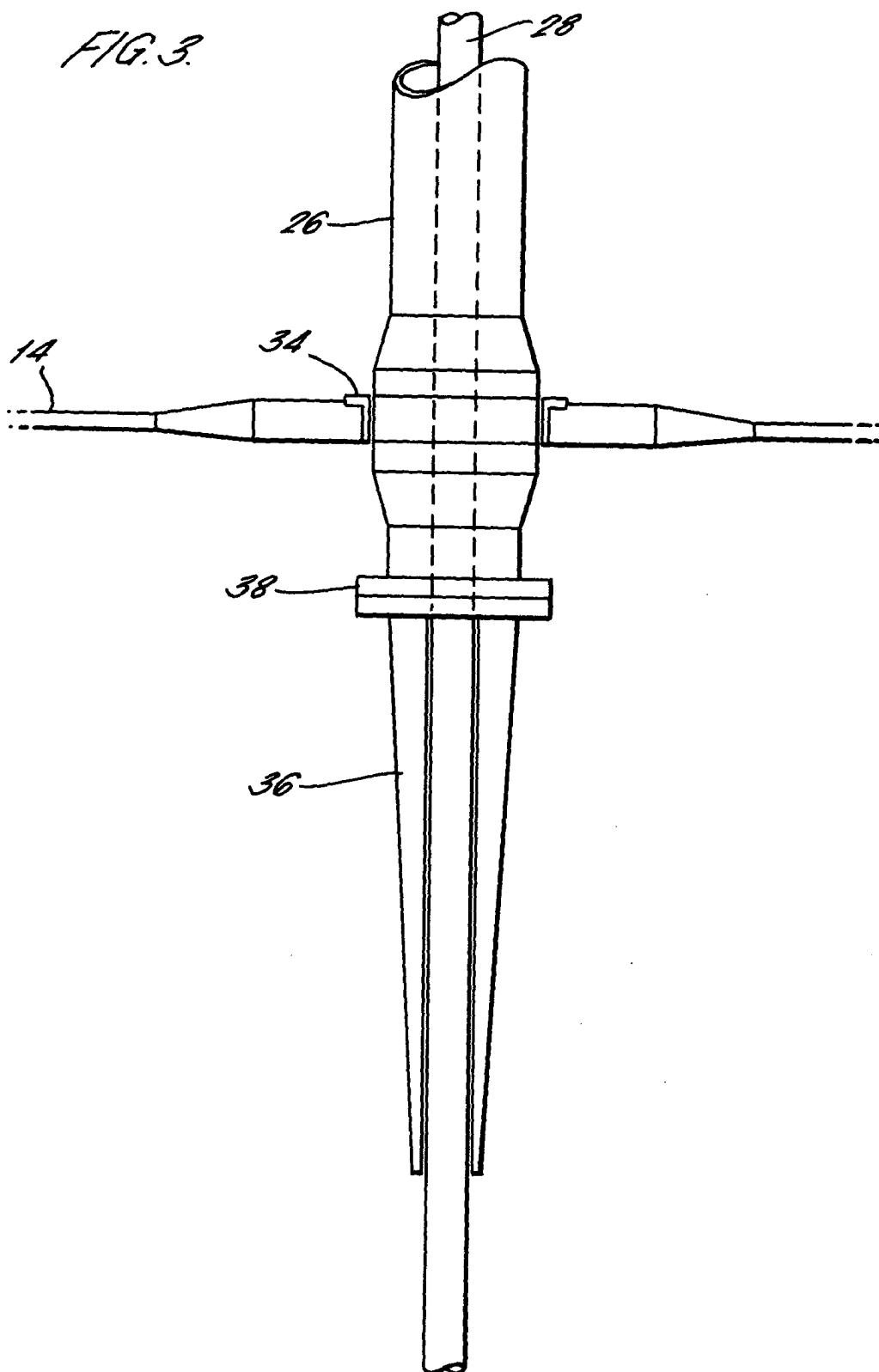


FIG. 2D.







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Application Number  
EP 03 25 7846

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Y	US 4 420 276 A (ROBERTS ROY G) 13 December 1983 (1983-12-13) * column 5, line 20 - line 42 * * column 6, line 53 - column 7, line 6; figures 1,2,6 *	3-5,7,8	
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Y	US 5 913 279 A (BRAUD JEAN ET AL) 22 June 1999 (1999-06-22) * abstract; figure 1 *	3	
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Y	US 4 406 333 A (ADAMS JOHNIE R) 27 September 1983 (1983-09-27) * abstract; figure 2 *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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<p>The present search report has been drawn up for all claims</p>			
Place of search	Date of completion of the search	Examiner	
MUNICH	24 March 2004	Moya, E	
CATEGORY OF CITED DOCUMENTS		<p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons</p> <p>&amp; : member of the same patent family, corresponding document</p>	
<p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p>			

ANNEX TO THE EUROPEAN SEARCH REPORT  
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