(54) Title: SUBSTRUCTURE FOR OFFSHORE PLATFORM

(57) Abstract: The invention provides a substructure (111) to form part of a fixed offshore platform, the substructure having at least one foundation element (116) adapted to rest in or on the seabed (117), a structural component (112) configured to extend upwards from the foundation element (116), provision for at least one conductor (121) to extend downwardly from the structural component (112) into
the seabed (117), and provision for means (122) to apply tension to the conductor (121), so to increase the bearing (compressive) load of the foundation element (116) on the seabed (117) to resist any uplift (tensile) load arising from overturning moments which might otherwise tend to cause said foundation element (117) to lift off the seabed.
SUBSTRUCTURE FOR OFFSHORE PLATFORM

Technical Field of the Invention

The invention relates to a substructure for an offshore platform, and to a method of installation for such a substructure.

In particular, the invention relates to a substructure having pre-loaded foundations.

Background of the Invention

Fixed substructures, such as steel jackets or concrete gravity base structures, are used for platforms in the development of offshore oil and gas fields. These fixed substructures are set on the seabed to support working decks above the highest anticipated waves.

A fixed substructure is subject to static and environmental loads, which are transferred into the seabed by foundations. For jackets, these may be suction foundations known as “buckets” or “caissons”; or mudmats; or vertical or battered piles. Massive gravity base foundations may also be used.

Under static load conditions, the self-weight of a platform (i.e. substructure plus topsides) is supported by the seabed. The weight is distributed between supporting legs and their foundations (or across a gravity base foundation). When environmental forces - due to wind, waves or current - act on the platform, a lateral load component is introduced. This lateral load component changes the distribution of loads in the legs from their static load distribution. The lateral load is often enough to create a theoretical up-lift on one or more of the legs, i.e. to tend to overturn the platform. To counteract the up-lift force, two expedients are available. Either the foundations must have some tensile capacity; or extra weight must be added to the platform. In most circumstances, the addition of extra weight is undesirable.

This invention is intended to reduce or remove the need for any tensile capacity to resist up-lift, by adding extra bearing load in the static condition. This additional bearing load is created by applying tension to one or more well conductors.

In a typical surface well configuration, the conductor extends vertically down into the seabed below the platform. The conductor is grouted into the seabed. The fixity of the conductor in the seabed provides a significant load carrying capacity.

The additional load - required to stabilise the substructure against uplift - is a reaction on the substructure resulting from tensioning the well conductor.
A predetermined tensile load is applied to the well conductor. The load is resisted by the substructure, which in turn is supported by the foundations. In effect the tensile load applied to the conductor applies additional bearing load to the foundations. This extra bearing load in the static condition increases the lateral load carrying capacity – i.e. the lateral load which may be applied to the substructure before up-lift is experienced. The foundations are effectively pre-loaded with extra bearing pressure, to increase the capacity to resist uplift.

The invention may further require that the device to apply the tensile load should accommodate a significant relative vertical movement between the conductor and the substructure, while maintaining a near constant tensioning force. This will allow settlement and/or consolidation of the seabed to take place without an adverse affect on the ability of the foundations to support the platform. It will also allow readjustment of the tension in the conductor (or conductors) if required.

In relatively shallow waters - for instance in the southern North Sea - offshore oil or gas fields have been developed using fixed platforms having only six (or fewer) oil or gas wells. In the case of such platforms, it has been possible to use single leg substructures to support wellheads for the oil or gas wells. Single leg substructures are frequently known as "monotowers". This invention shows particular advantages when applied to monotowers.

One example of a monotower is shown in our UK Patent Specification No 2,290,334. This monotower has three feet. Other monotowers have been constructed with four feet. Typically, a pile is driven through each foot into the seabed to fix the monotower to the seabed. The piled foundations resist overturning moments arising from wind, wave and current forces.

In the past, monotowers have been installed using jack-up vessels. A typical jack-up vessel has a buoyant hull and three lattice legs. The vessel is floated to its intended location, and the lattice legs are jacked down and spudded-in to the seabed. The hull is then jacked vertically up the lattice legs to raise the hull clear of the highest waves anticipated in the intended area of operation. In its raised position, the hull forms a fixed deck. The hull carries a cantilever which is moveable outwardly from a transom on the hull. A drilling derrick is mounted on the cantilever. The outward movement (or outreach) of the drilling derrick is limited.

To install a monotower, a jack-up vessel is floated to the intended location, and the hull is jacked up so that the derrick is over the position of installation.

The monotower is transported upright on a Heavy Lift Vessel (HLV) or transport barge from the yard in which it was fabricated to its intended location. The HLV or barge is positioned next to the jack-up vessel so that the monotower is directly below the drilling derrick. The monotower is lifted from the HLV or barge using the drilling derrick. The HLV or barge is removed, and the drilling derrick lowers the monotower to set it on the seabed.
The drilling derrick is then used to install piles to secure the monotower to the seabed. The monotower is positioned on the seabed so that pile sleeves for two of the piles lie below the transom of the jack-up vessel. Piles are driven at these positions using the drilling derrick to support a pile driver. The cantilever is extended, and one additional pile is driven on the far side of the leg (for a three footed monotower) or two additional piles (for a four footed monotower).

The drilling derrick can then drill a well (or wells) through the leg of the monotower.

If a working deck were to be placed on top of the leg by the drilling derrick of the same jack-up vessel, the cantilever would have to be extended even further from the transom, to lift the deck from an HLV or barge located on the far side of the leg. The need to pile the feet nearest to the transom of the jack-up vessel, means that the jack-up vessel has to be set back from the centre of the base of the monotower. This limits the effective outreach of the drilling derrick to lift the deck. The HLV or barge carrying the deck cannot approach closely to the leg of the monotower (because of the outlying pile or piles).

For these reasons, the use of a drilling derrick to lift a working deck from an HLV or barge, and then to place it on top of a monotower, becomes problematical.

Disclosure of the Invention

The invention provides a substructure to form part of a fixed offshore platform, the substructure having at least one foundation element adapted to rest in or on the seabed, a structural component configured to extend upwards from the foundation element, provision for at least one conductor to extend downwardly from the structural component into the seabed, and provision for means to apply tension to the conductor, so to increase the bearing (compressive) load of the foundation element on the seabed to resist any uplift (tensile) load arising from overturning moments which might otherwise tend to cause that foundation element to lift off the seabed.

It is preferred that there is a single leg forming the structural component to extend vertically upward through the sea surface; a base at or near the lower end of the leg and configured to be set on the seabed so that at least three different regions of the base are spaced around the leg in a generally horizontal plane, and in which there is provision for the conductor to extend downwardly from the leg into the seabed.

It is further preferred that the leg is hollow and that the conductor may be located within the leg.

It is still further preferred that the leg is of cylindrical cross section and that the conductor may be concentric within the leg.
In one form the base is a cylinder of large diameter as compared with the largest lateral dimension of the leg, the axis of the cylinder is vertical, and the at least three different regions of the base are spaced arcuate portions of the cylinder.

In another form there are at least three discrete foundation elements.

In this last mentioned form, the foundation elements are suction or "bucket" or "caisson" foundations; or mudmats; or piles; or regions of a gravity base.

If the foundations are discrete, the provision for the conductor to extend downwardly from the structural component may lie within a horizontal planform defined by vertical axes passing through the foundation elements, so that compressive loads can be applied to or increased on all of the foundation elements.

The arrangement of the conductor relative to the foundation elements may be determined with respect to the weight distribution of topsides to be placed on the substructure, so that the greatest compressive load is applied to the foundation element or elements which carry least weight from the topsides.

It is preferred that the means to apply tension to the conductor is adapted to permit relative vertical movement between the conductor and the substructure, while maintaining the applied or increased compressive load on the at least one of the foundation elements. (The tension may be created by frictional force between the conductor and the seabed by bonding using grout or similar, or by the self-weight of the conductor, or by a combination of these effects.)

In one form the structural component is configured to extend from the seabed towards (but not through) the wave effected zone.

In another form the structural component is configured to extend from the seabed through the wave effected zone to above the sea surface.

In yet another form the structural component forms the upper part of a substructure having two or more parts, and in which there is provision for means to apply tension to the conductor.

The lowest part of the substructure may be a fixed subsea template; or another fixed substructure part; or a gravity base.

The invention includes a substructure as described above, in combination with a conductor which extends downwardly from the structural component, and with means to apply tension to that conductor.

The invention further includes a substructure in combination with a conductor, when the conductor is tensioned to apply or increase a compressive load on at least one of the foundation elements.

The invention also includes a method of stabilising a substructure of the kind described above, including the step of tensioning a conductor extending down from the structural component, so to preload at least one of the foundation elements.
In the case of a monotower substructure in which the leg and the base are set on the seabed using the drilling derrick of a jack-up vessel, the drilling derrick may be used to drill a well within or close to the leg, and the conductor may be tensioned to increase the bearing load on the seabed to be greater than any up-lift load arising from overturning moments which might otherwise cause any part of the substructure to lift off the seabed.

**Brief Description of the Drawings**

Five specific embodiments of the invention will now be described by way of example with reference to the accompanying drawings, in which:-

- Figure 1 is a side elevation of a jack-up vessel installing a monotower;
- Figure 2 is a plan (to an enlarged scale) showing an envelope for the outreach of a cantilever forming part of the jack-up vessel shown in Figure 1;
- Figure 3 is a side elevation of a first monotower substructure according to the invention;
- Figure 4 is a side elevation of a second monotower according to the invention;
- Figure 5 is a side elevation of a third monotower according to the invention;
- Figure 6 is a diagrammatic side view of a tripod substructure;
- Figure 7 is a plan of that tripod substructure;
- Figure 8 is a diagrammatic side view of a four legged substructure; and
- Figure 9 is a plan view of the substructure shown in Figure 8.

**Description of the Specific Embodiments**

The invention shows particular advantages when applied to monotowers installed by jack-up vessels.

An installation arrangement for a conventional monotower is shown in Figure 1. A jack-up vessel 10 has lattice legs 11 and a hull 12 which forms a fixed deck. A cantilever 14 outstanding from the hull 12 supports a drilling derrick 15. A monotower 16 has been installed on seabed 17 next to the jack-up vessel 10 using the derrick 15. Piles 18 (here shown undriven) are driven into the seabed to secure the monotower to the seabed.

Advantageously, the drilling derrick would be used to install a working deck on top of the monotower. However, a difficulty arises in that the position of the monotower makes it impossible for another HLV or barge - carrying the deck - to approach the jack-up vessel closely beneath the drilling derrick. The working envelope of the cantilever 14 is shown in Figure 2, in which the transom line of the jack-up vessel is designated 19, and the working envelope of the
drilling derrick on the cantilever is designated 21. Clearly the outreach required to lift a deck from a barge once the monower is installed would be beyond the limits of the envelope.

Figure 3 shows diagrammatically a monower substructure 30 exemplifying a first embodiment of the invention. The monower 30 has a hollow cylindrical leg 31, and a base formed of a skirted foundation 32. The skirted foundation 32 is a hollow cylinder of much larger diameter than the leg 31. The leg 31 and skirted foundation 32 are disposed about a common vertical axis. Bracing 33 connects the skirted foundation 32 to the leg 31. Conductors 34 extend down through the leg 31 into seabed 35.

Installation of this monower will now be described.

The monower 30 is set on the seabed by a jack-up vessel (not shown). After the monower has been set on the seabed, conductors 34 are drilled into the seabed. Following the invention, the conductors are then tensioned. The effect of tensioning the conductors is to draw the skirted foundation further down into the seabed. The tension is of such a magnitude that when an overturning moment is applied to the monower by environmental loads, the uplift force on the region of the cylinder nearest to the load is more than compensated for by the compressive load (created by tensioning the conductors) on that region. It will be understood that the overturning moment could be applied from any direction, so that the region where the uplift load is more than compensated for could be anywhere on the circumference of the cylinder. In the case of a discontinuous cylinder, the minimum number of spaced regions (constituting foundation elements) to support the monower would be three.

A working deck 36 (incorporating topsides) is installed on top of the leg 31. Because of the type of foundation (using tensioned conductors to react overturning moments), an HLV or transport barge can approach the monower closely. The deck 36 on the HLV or barge would be within the operating envelope of a drilling derrick supported on a cantilever. Thus the deck could be lifted from the HLV or barge by the drilling derrick, and placed on the top of the leg 31.

In this case the elimination of the pile on the far side of the monower from the jack-up vessel allows a close approach by the HLV or barge.

Figure 4 shows diagrammatically a monower substructure 40 exemplifying a second embodiment of the invention. The monower 40 has a hollow cylindrical leg 41, and a base comprising three feet 42, each formed of a downwardly extending cylinder. The axes of the leg 41 and the feet 42 are vertical. Bracing 43 connects the feet 42 to the leg 41. The feet are spaced apart in plan to form the apices of an equilateral triangle. The feet form individual regions of the base. Conductor 44 extends down through the leg 41 into seabed 45.

Installation of this monower will now be described.

The monower 40 is set on the seabed by a jack-up vessel (not shown). After the monower has been set on the seabed, the conductor 44 is drilled into the seabed. Following
the invention, the conductor is then tensioned. The tension is of such a magnitude that when an overturning moment is applied to the monotower, the uplift force on the foot 42 nearest to the load is more than compensated for by the compressive load on that foot (created by tensioning the conductor). The overturning moment could be applied from any direction, so that the tension in the conductor could be applied on any of regions of the base formed by the three feet.

A working deck 46 is then installed in the manner described for the first embodiment.

Figure 5 shows an offshore platform with topsides 110 supported on a two-part monotower substructure 111. The substructure has a structural component 112 comprising a single water piercing tubular member. This component 112 forms the upper part of the substructure. The lower part of the substructure is formed of a central tubular member 114, bracing members 115, and three foundation elements 116. In this example the foundation elements are suction or "bucket" foundations.

However, the foundation elements of the lower part of the substructure might comprise mudmats (as shown in Figures 6 and 7), or piled foundations (as shown in Figures 8 and 9). In some circumstances, the whole base of the substructure could be plated. In other embodiments (not shown) the lower part of the substructure could be a subsea template or a gravity base.

The platform of Figure 5 is shown in an installed condition. The lower part of the substructure 111 (members 114 and 115 and elements 116) is set on seabed 117, and the upper part of the substructure (structural component 112) projects through sea surface 118 to support the topsides 110. The upper and lower parts of the substructure are fixedly connected at a structural joint 119. In some circumstances, the whole of the substructure could be subsea.

The platform has a wellhead 120 within the topsides 110. A conductor 121 extends vertically downward from the wellhead 120 through the structural component 112 into the seabed 117 beneath the platform. If the platform is installed on firm soil, the conductor is fixed in the seabed by friction. If the platform is installed on poor soil, the conductor may be held down by its own self-weight. A tensioning device 122 is disposed vertically between the wellhead 120 and the structural component 112. The tensioning device 122 is mounted on top of a floating ring 123. Beneath the floating ring 123 there is an adjustment chock 124.

When the platform has been installed, the tensioning device 122 is used to tension the conductor 121, and so to apply an additional compressive load in the structural component 112. This is reacted by larger bearing loads in the foundation elements 116. In this way the substructure is preloaded against uplift from lateral loads.

Figures 6 and 7 show a tripod substructure 130. This has two vertical legs 131 and one inclined leg 132, connected by bracing (shown diagrammatically in single lines). The legs and bracing comprise the structural component of a unitary substructure. At the bases of the legs there are mudmats 133, 134 and 135. The mudmats are horizontal, and constitute foundation
elements which rest on seabed 136 to support the substructure. The substructure is designed to support topsides (not shown). Three conductors 137 extend down from wellheads on the topsides into the seabed below the substructure.

Tensioning means (not shown) is used to tension the conductors 137, so to apply an additional compressive load in the structural component. This compressive load is reacted by larger bearing loads on the mudmats 133, 134 and 135. Thus the substructure is preloaded against uplift from lateral loads.

Figures 8 and 9 show a four-legged substructure 140. This has two vertical legs 141 and two inclined legs 142, connected by bracing (shown diagrammatically in single lines). The legs and bracing comprise the structural component of a unitary substructure. At the base of each of the four legs there are two vertical pile sleeves 143. Piles 144 extend down through the pile sleeves 143 into seabed 146 to fix the substructure to the seabed. The piles 144 constitute foundation elements. The substructure is designed to support topsides (not shown). Ten conductors 147 extend down from wellheads on the topsides into the seabed below the substructure.

Tensioning means (not shown) is used to tension at least some of the conductors 147, so to apply an additional compressive load in the structural component. This compressive load is reacted by larger bearing loads in the eight piles 144. Thus the substructure is preloaded against uplift from lateral loads.

The order of magnitude of conductor loads may be shown by way of numerical examples. (These numerical examples are not specifically related to any of the substructures illustrated in the Figures 3 to 9.)

If a jacket in 110m w.d. had a square base of 33m sides, the maximum up-lift force on any corner due to environmental loads might be 13,000kN. The total additional bearing load to counteract this force (if shared equally between four corners) would be 52,000kN. If ten conductors were to be tensioned, the tensile force required in each conductor would be 5,200kN. Alternatively, tensioning just two conductors up to 26,000kN could generate the required additional bearing load.

If a three footed monotorower in 32m w.d. had a base dimension of 23m, the maximum up-lift force on any one foot due to environmental loads might be 2,400kN. The total additional bearing load to counteract this force would be 7,200kN. If six conductors were to be tensioned, the tensile force required in each conductor would be 1,200kN. Alternatively, tensioning just one conductor up to 7,200kN could generate the required additional bearing load.
Advantages of the Invention

Advantages lie in preloading a conductor to reduce or eliminate tensile (uplift) loads on the foundations of an offshore platform. This can eliminate the need for piles, and, in the case of a monotower, can allow the close approach of a cargo barge to a jack-up vessel, so that its drilling rig can be used to lift and place a deck.
Claims

1/ A substructure to form part of a fixed offshore platform, the substructure having at least one foundation element adapted to rest in or on the seabed, a structural component configured to extend upwards from the foundation element, provision for at least one conductor to extend downwardly from the structural component into the seabed, and provision for means to apply tension to the conductor, so to increase the bearing (compressive) load of the foundation element on the seabed to resist any uplift (tensile) load arising from overturning moments which might otherwise tend to cause that foundation element to lift off the seabed.

2/ A substructure as claimed in claim 1, and comprising a single leg forming the structural component to extend vertically upward through the sea surface; a base at or near the lower end of the leg and configured to be set on the seabed so that at least three different regions of the base are spaced around the leg in a generally horizontal plane, and in which there is provision for the conductor to extend downwardly from the leg into the seabed.

3/ A substructure as claimed in claim 2, in which the leg is hollow and the conductor may be located within the leg.

4/ A substructure as claimed in claim 3, in which the leg is of cylindrical cross section and the conductor may be concentric within the leg.

5/ A substructure as claimed in any one of claims 2 to 4, in which the base is a cylinder of large diameter as compared with the largest lateral dimension of the leg, the axis of the cylinder is vertical, and the at least three different regions of the base are spaced arcuate portions of the cylinder.

6/ A substructure as claimed in any one of claims 1 to 4, in which there are at least three discrete foundation elements.

7/ A substructure as claimed in claim 6, in which the foundation elements are suction or “bucket” or “caisson” foundations.

8/ A substructure as claimed in claim 6, in which the foundation elements are mudmats.

9/ A substructure as claimed in claim 6, in which the foundation elements are piles.
10/ A substructure as claimed in claim 6, in which the foundation elements are regions of a gravity base.

11/ A substructure as claimed in any one of claims 6 to 10, in which the provision for the conductor to extend downwardly from the structural component lies within a horizontal planform defined by vertical axes passing through the foundation elements, so that compressive loads can be applied to or increased on all of the foundation elements.

12/ A substructure as claimed in any one of claims 6 to 11, in which the arrangement of the conductor relative to the foundation elements is determined with respect to the weight distribution of topsides to be placed on the substructure, so that the greatest compressive load is applied to the foundation element or elements which carry least weight from the topsides.

13/ A substructure as claimed in any one of the preceding claims, in which the means to apply tension to the conductor is adapted to permit relative vertical movement between the conductor and the substructure, while maintaining the applied or increased compressive load on the at least one of the foundation elements.

14/ A substructure as claimed in any one of the preceding claims, in which the structural component is configured to extend from the seabed towards (but not through) the wave effected zone.

15/ A substructure as claimed in any one of claims 1 to 13, in which the structural component is configured to extend from the seabed through the wave effected zone to above the sea surface.

16/ A substructure as claimed in any one of claims 1 to 13, in which the structural component forms the upper part of a substructure having two or more parts, and in which there is provision for means to apply tension to the conductor.

17/ A substructure as claimed in claim 16, in which the lowest part of the substructure is a fixed subsea template.

18/ A substructure as claimed in claim 16, in which the lowest part of the substructure is another fixed substructure part.
19/ A substructure as claimed in claim 16, in which the lowest part of the substructure is a gravity base.

20/ A substructure as claimed in any one of the preceding claims, in combination with a conductor which extends downwardly from the structural component, and with means to apply tension to that conductor.

21/ A substructure as claimed in claim 20, when the conductor is tensioned to apply or increase a compressive load on at least one of the foundation elements.

22/ A method of stabilising a substructure of the kind claimed in any one of the preceding claims 1 to 19, including the step of tensioning a conductor extending down from the structural component, so to preload at least one of the foundation elements.

23/ A method of installing a monotower substructure of the kind claimed in any one of the preceding claims 1 to 19, in which the leg and the base are set on the seabed using the drilling derrick of a jack-up vessel, the drilling derrick is used to drill a well within or close to the leg, and the conductor is tensioned to increase the bearing load on the seabed to be greater than any up-lift load arising from overturning moments which might otherwise cause any part of the substructure to lift off the seabed.
AMENDED CLAIMS
[received by the International Bureau on 7 May 2001 (07.05.01);
original claims 1, 20, 22 and 23 amended; remaining claims unchanged (2 pages)]

1/ A substructure to form part of a fixed offshore platform, the substructure having at least one foundation element adapted to rest in or on the seabed, a structural component configured to extend upwards from the foundation element, provision for at least one well conductor to extend downwardly from the structural component into the seabed, and provision for means to apply tension to the conductor, so to increase the bearing (compressive) load of the foundation element on the seabed to resist any uplift (tensile) load arising from overturning moments which might otherwise tend to cause that foundation element to lift off the seabed.

2/ A substructure as claimed in claim 1, and comprising a single leg forming the structural component to extend vertically upward through the sea surface; a base at or near the lower end of the leg and configured to be set on the seabed so that at least three different regions of the base are spaced around the leg in a generally horizontal plane, and in which there is provision for the conductor to extend downwardly from the leg into the seabed.

3/ A substructure as claimed in claim 2, in which the leg is hollow and the conductor may be located within the leg.

4/ A substructure as claimed in claim 3, in which the leg is of cylindrical cross section and the conductor may be concentric within the leg.

5/ A substructure as claimed in any one of claims 2 to 4, in which the base is a cylinder of large diameter as compared with the largest lateral dimension of the leg, the axis of the cylinder is vertical, and the at least three different regions of the base are spaced arcuate portions of the cylinder.

6/ A substructure as claimed in any one of claims 1 to 4, in which there are at least three discrete foundation elements.

7/ A substructure as claimed in claim 6, in which the foundation elements are suction or "bucket" or "caisson" foundations.

8/ A substructure as claimed in claim 6, in which the foundation elements are mudmats.

9/ A substructure as claimed in claim 6, in which the foundation elements are piles.

AMENDED SHEET (ARTICLE 19)
19/ A substructure as claimed in claim 16, in which the lowest part of the substructure is a gravity base.

20/ A substructure as claimed in any one of the preceding claims, in combination with a well conductor which extends downwardly from the structural component, and with means to apply tension to that conductor.

21/ A substructure as claimed in claim 20, when the conductor is tensioned to apply or increase a compressive load on at least one of the foundation elements.

22/ A method of stabilising a substructure of the kind claimed in any one of the preceding claims 1 to 19, including the step of tensioning a well conductor extending down from the structural component, so to preload at least one of the foundation elements.

23/ A method of installing a monotower substructure of the kind claimed in any one of the preceding claims 1 to 19, in which the leg and the base are set on the seabed using the drilling derrick of a jack-up vessel, the drilling derrick is used to drill a well within or close to the leg, and a well conductor is tensioned to increase the bearing load on the seabed to be greater than any up-lift load arising from overturning moments which might otherwise cause any part of the substructure to lift off the seabed.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E02B17/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched: (classification system followed by classification symbols)
IPC 7 E02B E02D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US 4 704 051 A (ELLINGVAG NILS A) 3 November 1987 (1987-11-03) column 1, line 66</td>
<td>1,6, 9, 14, 15,19-22</td>
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<td>A</td>
<td>US 4 968 180 A (DANGUY DES DESERTS LOIC M J ET AL) 6 November 1990 (1990-11-06) column 2, line 62</td>
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<td>--line 63 column 3, line 23 - line 42 column 7, line 23 - line 24 figures 1-3,5,9</td>
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Further documents are listed in the continuation of box C.

 PATENT FAMILY MEMBERS ARE LISTED IN ANNEX.

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Date of the actual completion of the international search
5 April 2001

Date of mailing of the international search report
17/04/2001

Name and mailing address of the ISA
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel (+31-70) 340-2040, Tx. 31 651 epo nl Fax (+31-70) 340-3016

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Movadat, R
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