PRELOADING DEVICE

Field of the invention

This invention relates to a device intended for the application of a preload between two members.

Background to the invention

A specific example of the invention will be described in the context of a device for the application of a preload between two members which are specifically inner and outer members constituted by a subsea wellhead and a conductor housing. One example of the state of the art in relation to such devices is provided by our patents No. GB-2393990 and US-7025145. In those patents there is an explanation of the need for the application of a preload between a wellhead and the conductor housing, i.e. for the reduction of fatigue damage.

Summary of the invention

According to the invention a device for the application of a preload between two members, comprising an activating member, a datum member, a locking member and means for securing the datum member relative to one of said two members, the activating member being moveable in an activating direction relative to the datum member, the activating member and the datum member including engagement zones which engage the locking member so as to cause in response to movement of the activating member in the activating direction a lateral movement of the locking member, said lateral movement having a component parallel to the activating direction which is substantially smaller than the movement of the activating member, further comprising a support member which is positioned to be moved laterally in response to movement of the activating member and to support the locking member against the engagement zone of the datum member.

The locking member and the support member may be laterally expansible rings. The said component is preferably in a direction opposite to the said activating direction.

One of the activating and datum members may carry a ratchet comprising a multiplicity of serrations which have a regular pitch in the activating direction and the other of the activating and datum members may carry at least one latch which allows the activating movement and can engage the ratchet to inhibit movement reverse to the activating direction, the latch providing a respective multiplicity of discrete locking positions spaced in the activating direction. The activating member may carry the ratchet and the datum member may carry the latch or latches.

The means for securing may comprises a plurality of engagement dogs carried by the datum member and wherein each dog may be arranged for advancement through a window in the activating member.

The activating member and the datum member are preferably annular, the activating member being disposed within the datum member. The activating member may be adapted for upward pulling.

The invention also provides a subsea assembly comprising a wellhead, a conductor housing and a device for the application of a preload between the wellhead and the conductor housing, the device comprising an activating member (1), a datum member (2), a laterally expansible locking ring (3) for engaging the conductor housing, and means (9) for securing the datum member relative the wellhead, the activating member being moveable in an activating direction relative to the datum member, the activating member and the datum member including engagement zones (6, 18) which engage the locking member (3) so as to cause in response to movement of the activating member in the activating direction a lateral movement of the locking member, said lateral movement having a component opposite to the activating direction which is substantially smaller than the movement of the activating member, ***characterised by*** a laterally expansible support ring (16) which is positioned to be moved laterally in response to movement of the activating member and to support the locking member (3) against the engagement zone (18) of the datum member (2).

One example of the present invention will be described with reference to the accompanying drawing.

Brief description of the drawing

The single Figure 1 illustrates one embodiment of a mechanism for pre-loading a conductor housing relative to a subsea wellhead.

Detailed description

The mechanism shown in Figure 1 is primarily intended for the application of a pre-load to a conductor housing (not shown) relative to a subsea wellhead (not shown) which is disposed at least partly within the conductor housing. Such wellhead and housing have generally cylindrical forms and are in use disposed normally disposed upright, their principal axes being vertical.

As is mentioned in GB-2393990 and US-7025145, it is desirable to apply a preload between the conductor housing and the wellhead in order to reduce the susceptibility of the assembly of conductor housing and wellhead to fatigue damage due to repetitive bending forces to which the assembly is subjected.

Three important components of the mechanism shown in Figure 1 are an activating member 1, in this example having an annular form, a support housing 2, which also in this example has an annular form, and a locking member 3, which is this example is a laterally expansible ring such as a split ring. As will be described below, the support housing 2 acts as a datum member which is secured to one of the members (in this example the wellhead housing) between which the pre-load is to be applied. The activating member or ring 1 is moved relative to the support housing 2, in this example in an upward axial direction, and the locking ring 3 is slidingly moved by virtue of the engagement zones on the activating member 1 and the support housing 2 laterally obliquely, i.e. both radially and vertically. The locking member or ring 3 slidingly engages the other of the two members (i.e. the conductor housing) between which the pre-load is to be applied and the vertical component of the movement of the locking member 3

stresses the said other member, which preferably has a slot (and more particularly an annular slot) for reception of the locking member 3.

More particularly the wellhead is disposed inside the activating member 1 and the support housing 2 may be landed on the conductor housing. Neither the conductor housing nor the wellhead are shown in the drawing; the relationship between the mechanism shown in Figure 1, the conductor housing and the wellhead generally corresponds to that shown for the tensioning mechanism described in patent No. GB2393900.

At its upper end the activating ring 1 has an external profile 4 which is adapted for engagement by a suitable tool which can thereby pull up the activating ring. The profile in this example comprises annular serrations.

At its lower end the activating member 1 is formed as an enlarged ring 5 of which the upper part 6 of its outer surface is an engagement zone which tapers inwardly at a selected (small) acute angle relative to the upward (activating) direction. Over most of its height between the profile 4 and the lower ring 5 the activating member carries, and is preferably integrally formed as, a ratchet 7, in this example consisting of a multiplicity of annular serrations evenly spaced in the activating (vertical) direction.

At circumferentially spaced intervals the activating ring 1 has windows 8, which are generally upright oblongs. These windows allow access through the activating ring for locking means, in this example constituted by locking dogs 9, to engage a suitable profile (particularly a plurality of axially spaced annular grooves not shown) on the outside of the 'inner' member (i.e. the body of the wellhead).

The locking dogs 9 are mounted on the support housing 1. The dogs 9 can be moved into engagement with the inner member by means of a screw drive. In this example the screw drive comprises for each dog 9 a pair of screws 10, 11 which are disposed in radially oriented threaded bores 12 and 13 respectively in the support housing 2. These screws may be operated by any suitable means, for example by a suitable tool of an ROV.

Each locking dog in this example is held captive relative to the support housing. In particular the upper screw 10 of the respective pair has a circumferential slot 14 into which extends a flange 15 carried on an extension from the outer side of the respective locking dog 9.

Adjacent the enlarged lower end of the activating ring 1 is a support ring 16, which has an inner surface slidingly abutting the tapered surface of the activating ring and an upper surface slidingly abutting the lower face of the locking ring 3. The locking ring has an upper surface which has an oblique outer part 17 slidingly abutting an oblique engagement zone provided by a surface 18 of the support housing 2. The various engagement zones (and particularly the surfaces 6 and 18) have angles relative to the actuating direction of the activating member 1 such that there is a substantial mechanical advantage between the movement of the activating member 1 in the (vertical) activating direction and the vertical movement of the locking member 3, i.e. the upward movement of the activating ring is much greater than the vertical component (in this example downwards) of movement of the locking ring 3. A small movement of the locking ring is sufficient (having regard to the modulus of elasticity of the conductor housing) to produce a sufficient stress on the conductor housing.

Thus upward movement of the activating ring forces the locking ring outwardly. The oblique engagement zone 18 of the datum member (the support housing 2) forces the locking member to have a vertical component of movement., which is in the opposite direction to the movement of the activating member. The support ring 16 acts as a reaction member. It supports the locking ring against the engagement zone 18 of the datum member. It has to accommodate the vertical component of movement of the locking ring 3 and but in doing so it is caused to move laterally by virtue of its engagement with the inclined engagement zone 6 of the activating member. The support ring 16 has a tapered surface 19 which engages, and is preferably at the same angle as, the engagement surface 6 of the activating member.

The combination of the locking ring, the activating member, the support housing (i.e. a datum member) and the support ring allows operation without excessive loading of the locking ring. Moreover, bending or twisting of the locking ring 3 may be avoided by

virtue of the support of the locking ring 3 by the support ring 16. In these respects the combination is in itself a potential improvement over the device shown in GB-2393990.

The applied preload is set by latching the activating member relative to the support housing 2. For this purpose the mechanism preferably has at least two serrate latches 20 and 20a, each of which is mounted in the support housing. Each latch in this example is in the form of a set of evenly spaced serrations which can engage the serrations of the linear ratchet 7. Each latch has spigots each received in a respective bore 21, 21a in the support housing 2 and each latch may be loaded by a spring (not shown) which urges the latch inwards. The latches may be provided at circumferentially spaced intervals and may be discrete or be formed on a respective ring.

Thus the activating ring 1 may be moved in the activating direction, this movement being allowed by the latches, until a desired end position is reached, whereupon at least one of the latches (or sets of latches) engages the ratchet and inhibits substantial reverse movement of the activating member 1.

The multiple latch is designed to work in the general manner as a customary ratchet and latch system in that it provides one-directional travel of one component past another.

In an ordinary ratchet and latch system one component (the latch) may be sprung so that it engages discrete positions of the profile of a second component (the ratchet). Movement in the reverse direction is prevented by the locking engagement of the two profiles. The backlash of the system is determined by the pitch of the discrete locking positions of the engagement profile between the two components (the ratchet and the latch). In the conventional system it is possible for the moving part of the system to come to rest within an infinitesimally small distance from which it can engage with a discrete locking position of the fixed component. From this position there is nothing to prevent a reversal of travel up to the previous discrete locking position witch is approximately one pitch away from the resting position.

It is advantageous to minimise the backlash of the system such that reverse movement is prevented as efficiently as possible. One method for doing this would be to

reduce the pitch of the discrete locking positions. However this typically has the unfavourable effect of reducing the perpendicular travel of engaging the ratchet latch, which can present other problems such as (i) reducing the engagement force e.g. in a split ring application; (ii) making the system more expensive to produce and more difficult to inspect; and (iii) making the system more prone to fouling owing to foreign objects obstructing the operation of the ratchet and latch.

The described mechanism reduces the backlash of the system while maintaining the original pitch of the discrete locking positions. The two latches 19 and 20 in the specific example are positionally out of phase relative to the ratchet. In other words the spacing in the activating direction between a latch tooth on the upper latch and a latch tooth on the lower latch is not an integral multiple of the spacing of the teeth on the ratchet. In the specific example of two distinct latches the phase difference may be 180^0, i.e. the spacing or pitch is $Y = Z*p + p/2$ where p is the pitch of the discrete locking positions and Z is any integer.

More generally the latches 20 and 20a (and others) can be identical in design or they may differ; what is important is their positions relative to each other and relative to the ratchet. Any number of latches or sets of latches can be used and the greater the number of latches or sets thereof the smaller the system's backlash. However each subsequent latch provides a diminishing backlash reduction over the previous one,

A general formula for determining the pitch of the latches relative to the pitch of the discrete locking positions is as follows:

$$Y = (Z * p) + (p / n)$$

where Y is the pitch of the latches, p is the pitch of the discrete locking positions, Z is any integer, and n is the number of distinct latches (spaced in the activating direction) employed. In the preferred example, when the top latch is fully engaged in a discrete locking position, the lower latch is exactly halfway between two discrete locking positions. If the top latch had failed to engage, the ratchet could travel in the reverse direction until the lower latch engaged. In this dual latch example the ratchet would be locked after travelling ½ a tooth pitch rather than a whole tooth pitch under a single latch system. If

three latches were employed the maximum backlash would be 1/3 the pitch, for four latches it would be ¼, for five latches it would be 1/5, etc.

In the described embodiment the ratchet is carried by the activating member and the latches are carried by the support housing, but a converse arrangement is feasible.

Claims

1. A device for the application of a preload between two members, comprising an activating member (1), a datum member (2), a locking member (3), and means (9) for securing the datum member relative to one of said two members, the activating member being moveable in an activating direction relative to the datum member, the activating member and the datum member including engagement zones (6, 18) which engage the locking member (3) so as to cause in response to movement of the activating member in the activating direction a lateral movement of the locking member, said lateral movement having a component, parallel to the activating direction, which is substantially smaller than the movement of the activating member, ***characterised by*** a support member (16) which is positioned to be moved laterally in response to movement of the activating member and to support the locking member (3) against the engagement zone (18) of the datum member (2).

2. A device according to claim 1, in which the locking member (3) and the support member (16) are laterally expansible rings.

3. A device according to claim 1 or 2, in which the said component is in a direction opposite to the said activating direction.

4. A device according to any of claims 1 to 3 in which one of the activating and datum members (1, 2) carries a ratchet (7) comprising a multiplicity of serrations which have a regular pitch in the activating direction and the other of the activating and datum members (1, 2) carries at least one latch (20) which allows the activating movement and can engage the ratchet to inhibit movement reverse to the activating direction, the latch providing a respective multiplicity of discrete locking positions spaced in the activating direction.

5. A device according to claim 4, in which the activating member (1) carries the ratchet (7)) and the datum member (2) caries the latch or latches (20, 20a).

6. A device according to any of claims 1 to 5, in which the means for securing comprises a plurality of engagement dogs (9) carried by the datum member (2) and

wherein each dog is arranged for advancement through a window (8) in the activating member (1).

7. A device according to any of claims 1 to 6, in which the activating member (1) and the datum member (2) are annular, the activating member being disposed within the datum member.

8. A device according to any of claims 1 to 7, in which the activating member (1) is adapted for upward pulling.

9. A subsea assembly comprising a wellhead, a conductor housing and a device for the application of a preload between the wellhead and the conductor housing, the device comprising an activating member (1), a datum member (2), a laterally expansible locking ring (3) for engaging the conductor housing, and means (9) for securing the datum member relative the wellhead, the activating member being moveable in an activating direction relative to the datum member, the activating member and the datum member including engagement zones (6, 18) which engage the locking member (3) so as to cause in response to movement of the activating member in the activating direction a lateral movement of the locking member, said lateral movement having a component, opposite to the activating direction, which is substantially smaller than the movement of the activating member, ***characterised by*** a laterally expansible support ring (16) which is positioned to be moved laterally in response to movement of the activating member and to support the locking ring (3) against the engagement zone (18) of the datum member (2).

10. A subsea assembly according to claim 9, in which the means for securing comprises a plurality of engagement dogs (9) carried by the datum member (2) and wherein each dog is arranged for advancement through a window (8) in the activating member (1).