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# EUROPEAN PATENT APPLICATION

21 Application number: 84106866.1

51 Int. Cl.<sup>4</sup>: H 01 B 7/14

22 Date of filing: 15.06.84

30 Priority: 21.07.83 US 516157

43 Date of publication of application:  
13.02.85 Bulletin 85/7

84 Designated Contracting States:  
DE FR GB NL

71 Applicant: **SHELL OIL COMPANY**  
One Shell Plaza P.O. Box 2463  
Houston Texas 77001(US)

72 Inventor: **Ayers, Ray R.**  
12431 Honeywood Trail  
Houston Texas 77077(US)

74 Representative: **Dreiss, Hosenthien & Fuhlendorf**  
Gerokstrasse 6  
D-7000 Stuttgart 1(DE)

54 **Faired umbilical cable.**

57 The present invention pertains to an underwater seismic cable which has at least one tensile cable (20) placed upstream in faired cross-sectional arrangement. Located downstream of the tensile cable (20) are placed other electrical, pneumatic and hydraulic cables (21) and hoses (22), with the electrical cable (20).

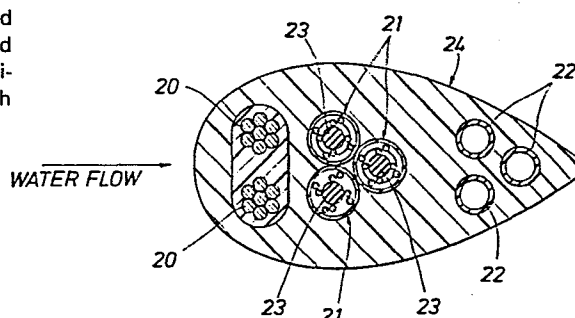


FIG. 2

# DREISS, HOSENTHIEN & FUHLENDORF

HANS LANGOSCH  
Dipl.-Ing. (1963-1981)  
UWE DREISS  
Dr. jur., Dipl.-Ing., M. Sc.  
HEINZ HOSENTHIEN  
Dr.-Ing., Dipl.-Ing.  
JÖRN FUHLENDORF  
Dipl.-Ing.

PATENTANWÄLTE  
Beim Europäischen Patentamt zugelassene Vertreter  
European Patent Attorneys

0132571

☐ für Besucher

DREISS, HOSENTHIEN & FUHLENDORF, D-7000 STUTTGART 1

## Applicant:

Shell Oil Company  
One Shell Plaza  
Houston, Texas 77001  
U.S.A.

Amtl. Akt. Z.  
Off. Ser. No.

Ihr Zeichen  
Your Ref.

Unser Zeichen  
Our Ref.  
0914 008

Datum  
Date  
21. Mai 1984

Title: FAIRED UMBILICAL CABLE

## Background of the Invention

In offshore seismic operations, an umbilical cable is required to pull a gun array, as well as to provide air, power and electrical conductors for shooting operations. Conventional practice in this art has been to use  
5 jacketed bundles which contain various air hoses, tension cables and electrical conductors or to use armored cables containing hoses and conductors. Such bundles do not last long because tow forces, wave forces and cable handling loads reduce the structural integrity of the  
10 umbilical cable to a point where conductors break and leak. The tension cables tend to abrade the electrical conductors, particularly when the bundle is reeled around a sheave or a drum under tension. More specifically, the tension cables tend to put point pressures on the electrical

conductors, causing breakage and insulation leakage. This problem has been recognized heretofore, and one solution has been to use a discrete wire rope tension cable as a "clothesline" from which to intermittently tie a round  
5 jacketed bundle of electrical cables and air hoses. Thus, the wire rope cable provides the tensile strength, and the electrical/air bundle adjacent to it is not significantly loaded in tension. This method has worked reasonably well as long as the bundle can be drawn up  
10 "accordian style" without reeling it up. But, as longer and longer cables are needed for towing gun subarrays further outboard of the tow vessel, the compacted clothesline bundle is too long and causes too much drag to be effective and practical. Another problem with this  
15 method is that very short-radius bends form in the bundle, and as the cycles of the bends increase, the bundle life is decreased.

An alternative to the cable/bundle system is to use an  
20 umbilical cable with tension wires, conductors and air hoses cabled into a single "cable". The problem with this is that cyclically bending these cables around sheaves causes the wires to crush the conductors and hoses reducing cable life due to leakage.

25

Still another alternative is to build an armored cable with an outer-shell tension member, and hoses and electrical

conductors within. This is feasible from a strength standpoint and is reelable but has several problems: first, the umbilical cable is excessively heavy; second, the terminations are difficult to seal; and  
5 third, the cables are expensive to replace and have questionable reliability.

Still another serious problem with all of the above-mentioned umbilical cable designs is that they tend to  
10 have a large overall diameter as well as a poor cross-sectional shape, thus causing high drag forces. The problem with high drag has come about because of increasing requirements to tow guns in a wide array and at higher speeds as shown in Figure 1, and more  
15 particularly discussed hereinafter, as contrasted with narrower widths used previously.

An umbilical referred to as Flexpak <sup>(TM)</sup> is manufactured by Hydril Corporation (Bulletin 5086). The Flexpak <sup>(TM)</sup>  
20 umbilical tends to "cup" into flow inasmuch as it utilizes tensioning cables at both extremities and is not the equivalent of the present invention.

An umbilical with a faired shape referred to as Flexnose  
25 is manufactured by Fathom Oceanology Ltd. (brochures MSK 4, September 1976 and MSK 61, August 1976). The

Flexnose is a preformed clip-on or clip-together and is not equivalent to the integrally molded faired umbilical of the present invention.

5     Summary of the Invention

The primary purpose of the present invention is to provide an underwater cable which has a low drag coefficient when deployed outboard of a tow vessel. Another purpose of the present invention is to provide  
10     a reliable underwater cable which is capable of being turned around a sheave while under tension and of being wound upon a reel without damage to the cable. Preferably, the cable is an umbilical seismic cable.

15     In achieving the purposes of the present invention a cable suitable for underwater towing is provided in which conductors are covered by a continuously extruded jacket having a faired cross-section. Even more preferably, a cable is provided which includes electrical  
20     conductors, pneumatic hoses and a tension member arranged side-by-side inside a jacket, the tension member being axially stiffer than the adjacent hoses and conductors. Even further, a cable is provided which has relatively untensioned conductors twisted around a soft, flexible  
25     core member, with the jacketed assembly of conductors being arranged side-by-side with the tension member. Preferably, the cable is a seismic cable.

Brief Description of the Drawings

Figure 1 is a plan view of a wide subarray configuration.

5

Figures 2

and 3 are cross-sectional views of cable configurations.

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Figures 4

and 5 are cross-sectional views of various cable reel-ups.

Description of Preferred Embodiments

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As shown in Figure 1, a subarray 10 is towed with an umbilical seismic cable 11 at a position which is well outboard from vessel 12. While multiple floats are normally used, only one is shown here for purposes of illustration.

20

It is often desired for seismic studies to tow floats far outboard on either side of the tow vessel. The offset width 13 is directly affected by the fluid dynamic drag forces experienced by umbilical cable 11. Accordingly,

25

the solution of the present invention to the problems of getting greater offset width is to provide a specially-built faired cable design with a tension member or tension members

located at the forward or leading edge of the cross-section thereof. Two examples of this concept are shown in Figures 2 and 3. The faired cable construction is like an airplane wing shape with the purpose being to  
5 reduce drag. A round cable has a drag coefficient of about 1.2 to 1.3, depending upon its linear diameter. A flat cable with the same thickness has a drag coefficient of perhaps .13, an order of magnitude reduction in drag.

10

The tension members 20 and 30 in Figures 2 and 3 are at the forwardmost locations followed by the electrical cables 21 and 31 and air hoses 22 and 32. Tension members 20 and 30 are preferably anti-torsional steel  
15 wire rope so that when the umbilical cable is under load it doesn't tend to twist and is very torsionally stable. Next to the tension members are the electrical bundles 21 and 31. These bundles are purposely designed to be much more flexible in the axial direction than  
20 the tension members 20 and 30. It is preferable to use twisted pairs of insulated conductors which are twisted around each other and then layered around a circle. A soft insert 23 and 33, such as soft rubber, is inserted in the middle of the circle so that it acts much like a  
25 Chinese thumbpuller in that it has enough softness that when the cable is pulled, it will contract radially,

and then when tension is slacked off, it expands. The electrical conductors 21 and 31 are not tightly nestled. The twisted pairs of conductors in each layer are not placed too close together so that the electrical  
5 conductors can flex, resulting in an axially soft cable.

The next member in the cable aft of the tension member and the electrical bundles are air hoses 22 and 32. The air hose also is designed to be axially flexible. Some  
10 of the air hoses may be used for hydraulic hose as needed.

Tension members 20 and 30 can be coated with a soft coating to make them round and, where there is more than one  
15 cable, they can be circled together as shown in Figure 2 or placed side by side as shown in Figure 3. In addition, electrical bundles 21 and 31 can be jacketed with a soft coating material. The three elements, tension members, electrical bundles and air/hydraulic hoses, are passed  
20 through an injector mold having a faired shape and the outer plastic jacket 24 and 34 are molded. Nitrile rubber or polyurethane are preferred materials, both being durable and flexible.

25 The two umilical designs in Figure 2 and 3 behave somewhat similarly due to water flow around them, but they are

- 8 -

reeled up for storage in different ways as shown in Figures 4 and 5. The faired flat design can be rolled up like a single ribbon as shown in Figure 5, while the multiple tension cable umbilical shown in Figure 4 will automatically roll up with the nose toward the drum. It is wise to provide adequate reel width to avoid multiple layers of the cable of Figure 4 on the reel. It is important to design the air and electrical components of the cables to be extremely flexible in axial extension and compression so that reeling the cable on a drum will not cause excessive stresses. The faired umbilical design as shown in Figure 5 can be reeled under a much lower strain condition than the multiple tension cable umbilical design of Figure 4. This is because the bending axis, or pitch axis, of the electrical components 21 and 31 and air hose components 22 and 32 coincide with the bending axis of the tension member components 20 and 30. The tension members 20 and 30 are torque balanced so that the cable does not twist under varying axial load conditions. This is particularly important for the flat, faired design of Figure 5. In the design of Figure 4, the multiple paired cables can be combined with opposite lays to ensure structural symmetry and thus avoid undesirable twisting.

A further advantage of the cable of Figure 5 is that it can be rolled up on a ribbon reel, meaning that it can be rolled layer on top of layer, but it is not necessary to have it layer beside layer as in winding up the cable of Figure 4. Therefore, it is possible to have a very thin roll of large diameter as compared to a thicker reel of smaller diameter. There is another major advantage of this cable in the reaction of the tension member into the reel without having to load up any of the conductors. By comparison, with a round cable, the load in the tension member will squeeze the conductors in the process of feeding into the reel. This is effectively taken out of the design as shown in Figure 5 so it can be used with outrigger reels. The advantage is that the load is not fed through the electrical conductors, but the electrical conductors, air hose, and anything that is put in the cable, in effect, just go along for the ride and the tension member takes all the tension.

20

The present invention is useful not only as seismic cable as above described but also can be utilized in connection with other towed bodies, e.g., a submarine. In addition, by changing the orientation of the faired cross-section

of the cable from horizontal to vertical, or some orientation therebetween, it can be used to connect towed bodies which are directly or more directly behind and below the towing vessel.

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The foregoing description of the invention is merely intended to be explanatory thereof. Various changes in the details of the described apparatus may be made within the scope of the appended claims without departing from the spirit of the invention.

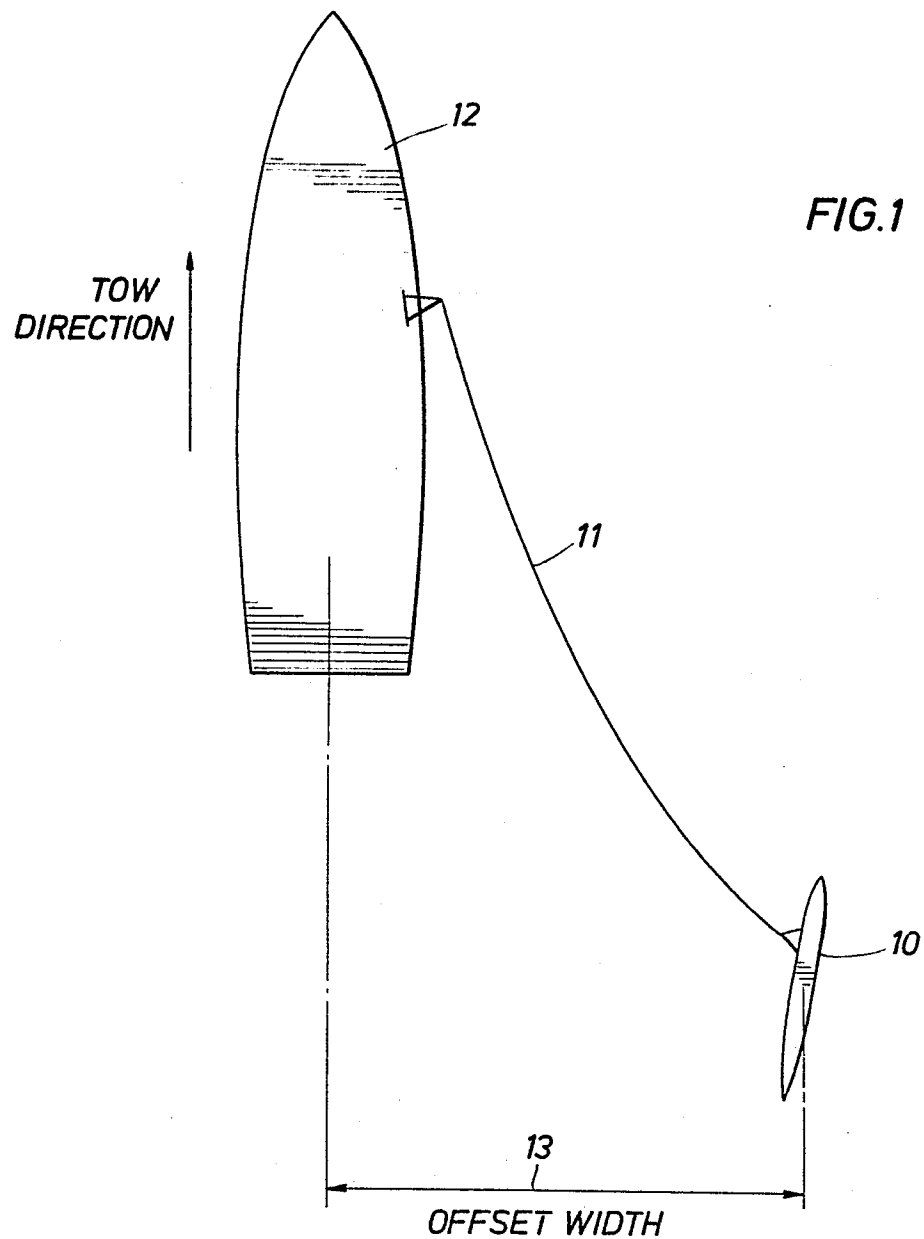
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Claims

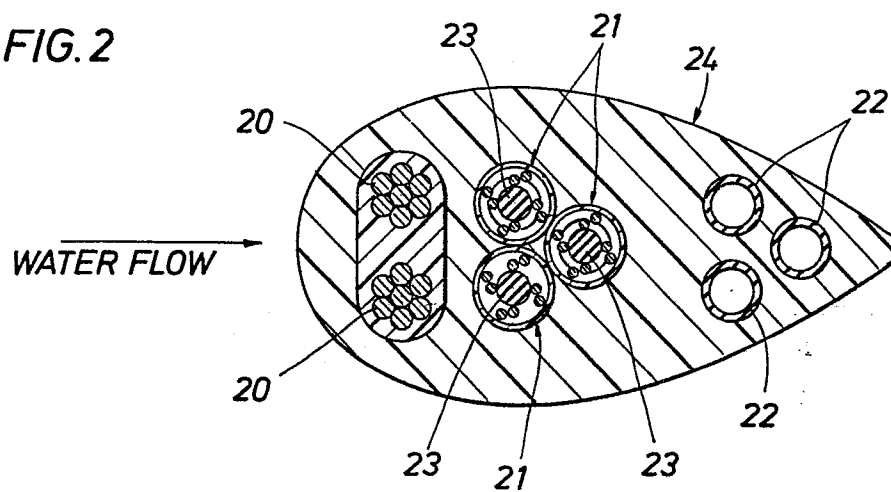
1. A cable suitable for underwater towing comprising conductors (21,31), a hose (22,32) and a tension member (20,30) arranged side-by-side inside a jacket (24,34), the tension member (20,30) being axially stiffer than the conductors (21,31) and the hose (22,32).
2. The cable of Claim 1 wherein the jacket (24,34) is integral and has a faired shape, and the tension member (20,30) is in a leading edge of the faired cross-section.
3. The cable of Claim 1 wherein the conductors (21,31) are twisted around a soft, flexible core member (23,33).
4. The cable of Claim 1 wherein the tension member (20,30) is an antitorsional wire rope.
5. The cable of Claim 1 wherein the conductors (21,31), hose (22,32), tension member (20,30) and integral jacket (24,34) are torque balanced.

6. A cable suitable for underwater towing comprising untensioned conductors (21,31) twisted around a soft, flexible core member (23,33), the conductors (21,31) being arranged side-by-side with a single tension member (20,30) and hose (22,32).
7. The cable of Claim 6 including a ribbon reel containing the wound cable, the tension member (20,30) bearing all of the winding stress.
8. The cable of Claim 7 including a faired cross-sectional jacket (24,34) covering the tension member (20,30) and conductors (21,31).
9. A cable suitable for underwater towing comprising conductors (21,31) covered by a jacket (24,34) having an integrally faired cross-section.
10. The cable of Claim 9 wherein the length to thickness of the cable (11) ranges from about 2/1 to about 5/1.
11. The cable of Claim 9 wherein a leading edge of the cable (11) is stiffer than the remaining part of the cable (11).

12. A cable suitable for underwater towing comprising conductors (21,31) and a tension member (20,30) arranged side-by-side inside a jacket (24,34), the tension member (20,30) being axially stiffer than the conductors (21,31).
13. The cable of Claim 12 wherein the jacket (24,34) is integral and has a faired shape, and the tension member (20,30) is in a leading edge of the faired cross-section.
14. The cable of Claim 12 wherein the conductors (21, 31), tension member (20,30) and integral jacket (24,34) are torque balanced.



**FIG.2**



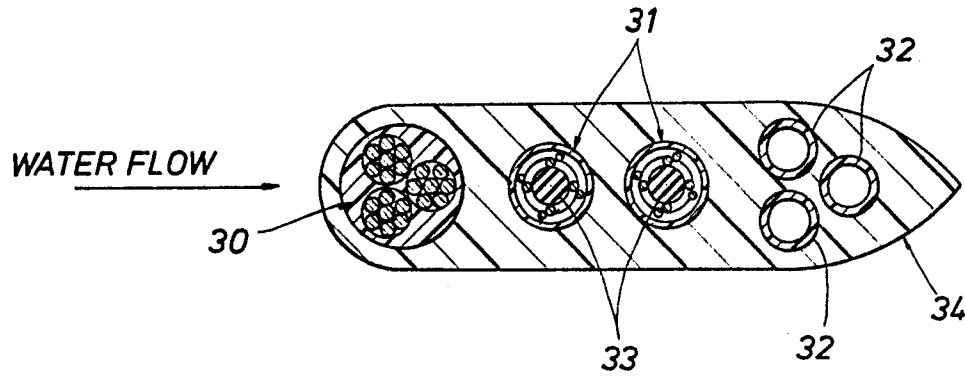


FIG. 3

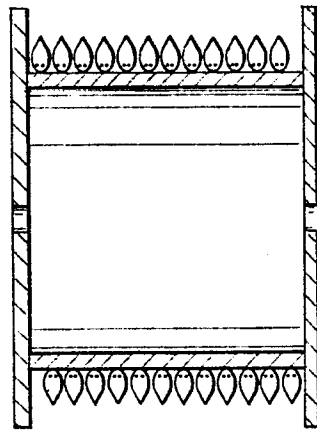


FIG. 4

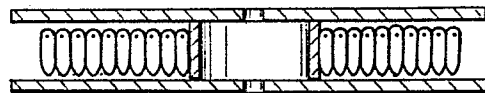


FIG. 5