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⑰ **Faired umbilical cable.**

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GB-A-1 580 089
GB-A-2 027 553
US-A-2 435 956
US-A-4 072 123

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Description

The invention refers to a seismic cable suitable for underwater towing having at least one tension member, electrically conducting elements and at least one air/hydraulic hose element and these elements being arranged side-by-side and spaced apart and surrounded by a continuously elongate, flexible jacket having a faired shape and at least one tension member being in the leading edge of the jacket.

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 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 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 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 "accordion 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 method is that the cycles of the bends increase, the bundle life is decreased.

An alternative to the cable/bundle system is to use an 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.

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 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 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 particularly discussed hereinafter, as contrasted with narrower widths used previously.

As streamlined conductor cable, however, is disclosed in US-A-2 435 956. This cable comprises a streamlined covering being either partly slit or divided into two complementary pieces. After having put the tow wire, conducting wires etc. into the covering this is held closed at least partly by wire staples. However such a design is extremely difficult to seal.

An umbilical referred to as Flexpak^(TM) is manufactured by Hydril Corporation (Bulletin 5086). The Flexpak^(TM) 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 is manufactured by Fathom Oceanology Ltd. (brochures MSK4, 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.

The object of the present invention is to provide a seismic cable suitable for underwater towing which has a low drag coefficient when deployed outboard of a tow vessel and which is reliable and capable of being turned around a sheave while under tension and of being wound upon a reel without damage to the cable.

In achieving the object of the present invention the seismic cable suitable for underwater towing of the above mentioned kind is characterized by a torsionally resistant torque-balanced tension member having cable strands arranged with alternating lay directions and lay angles to be resistant to twisting, by an electrical bundle as conducting elements and by a jacket which is in situ molded between and around and thereby locked to the tension member, electrical bundle and hose.

Other advantageous embodiments result from the features of the subclaims.

Brief Description of the Drawings

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

Figures 2 and 3 are cross-sectional views of cable configurations.

Figures 4 and 5 are cross-sectional views of various cable reel-ups.

Description of Preferred Embodiments

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. 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, 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 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 0.13, an order of magnitude reduction in drag.

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 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 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 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 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 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 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 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.

The two umbilical designs in Figures 2 and 3 behave somewhat similarly due to water flow around them, but they are 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.

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.

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.

Claims

1. A seismic cable (11) suitable for underwater towing having at least one tension member (20,30), electrically conducting elements (21,31) and at least one air/hydraulic hose element (22,32) and these elements being arranged side-by-side and spaced apart and surrounded by a

continuously elongate, flexible jacket (24,34) having a faired shape and the at least one tension member being in the leading edge of the jacket, characterized by a torsionally resistant torque-balanced tension member (20,30) having cable strands arranged with alternating lay directions and lay angles to be resistant to twisting, by an electrical bundle (21,31) as conducting elements and by a jacket (24,34) which is in situ molded between and around and thereby locked to the tension member, electrical bundle and hose.

2. The cable of claim 1 wherein the electrical bundle (21,31) comprises conductors twisted around a soft insert (23,33).

3. The cable of claim 2 wherein the soft insert (23,33) is functional to contract radially under tension and the twisted conductors have sufficient slack to flex with the tensionable insert.

4. The cable of one of the claims 1-3, characterized in that the tension member (20,30), electrical bundle (21,31) and hose (22,32) are generally round components.

5. The cable of one of the claims 1-4, characterized by at least two tension members (20,30) arranged side-by-side in the leading edge of the integrally molded jacket (24,34).

Patentansprüche

1. Seismisches Kabel (11) zum Unterwasser-schleppen, mit mindestens einem Zugelement (20,30), mit elektrischen Leiterelementen (21,31) und mit mindestens einem Luft/Hydraulik-Schlauchelement (22,32), wobei diese Elemente nebeneinander und im Abstand voneinander angeordnet und von einem kontinuierlich sich erstreckenden flexiblen Mantel (24,34) umgeben sind, der ein stromlinienförmiges Profil aufweist und bei dem das mindestens eine Zugelement im Vorderflankenbereich des Mantels angeordnet ist, gekennzeichnet durch ein torsionsbeständiges, Drehmoment entlastetes Zugelement (20,30), das Seilstränge aufweist, die in abwechselnden Schlagrichtungen und Schlagwinkeln verdrehfest angeordnet sind, durch ein elektrisches Leiterbündel (21,31) als Leiterelemente und durch einen Mantel (24,34), der innen und außen an Ort und Stelle geformt und dadurch mit dem Zugelement, dem elektrischen Leiterbündel und dem Schlauch verriegelt ist.

2. Kabel nach Anspruch 1, dadurch gekennzeichnet, daß das elektrische Leiterbündel (21,31) Leiter aufweist, die um eine weiche Einlage (23,33) verdreht sind.

3. Kabel nach Anspruch 2, dadurch gekenn-

zeichnet, daß die weiche Einlage (23,33) sich unter Zugspannung radial zusammenziehen kann und daß die verdrehten Leiter genügend Spiel haben, mit der spannbaren Einlage flexibel nachzugeben.

4. Kabel nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß das Zugelement (20,30), das elektrische Leiterbündel (21,31) und der Schlauch (22,32) im wesentlichen runde Bauteile sind.

5. Kabel nach einem der Ansprüche 1 bis 4, gekennzeichnet durch mindestens zwei Zugelemente (20,30), die nebeneinander im Vorderflankenbereich des einstückig geformten Mantels (24,34) angeordnet sind.

Revendications

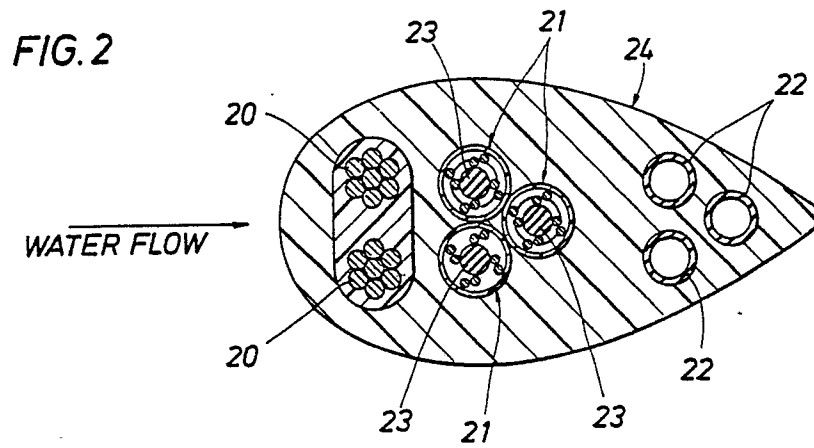
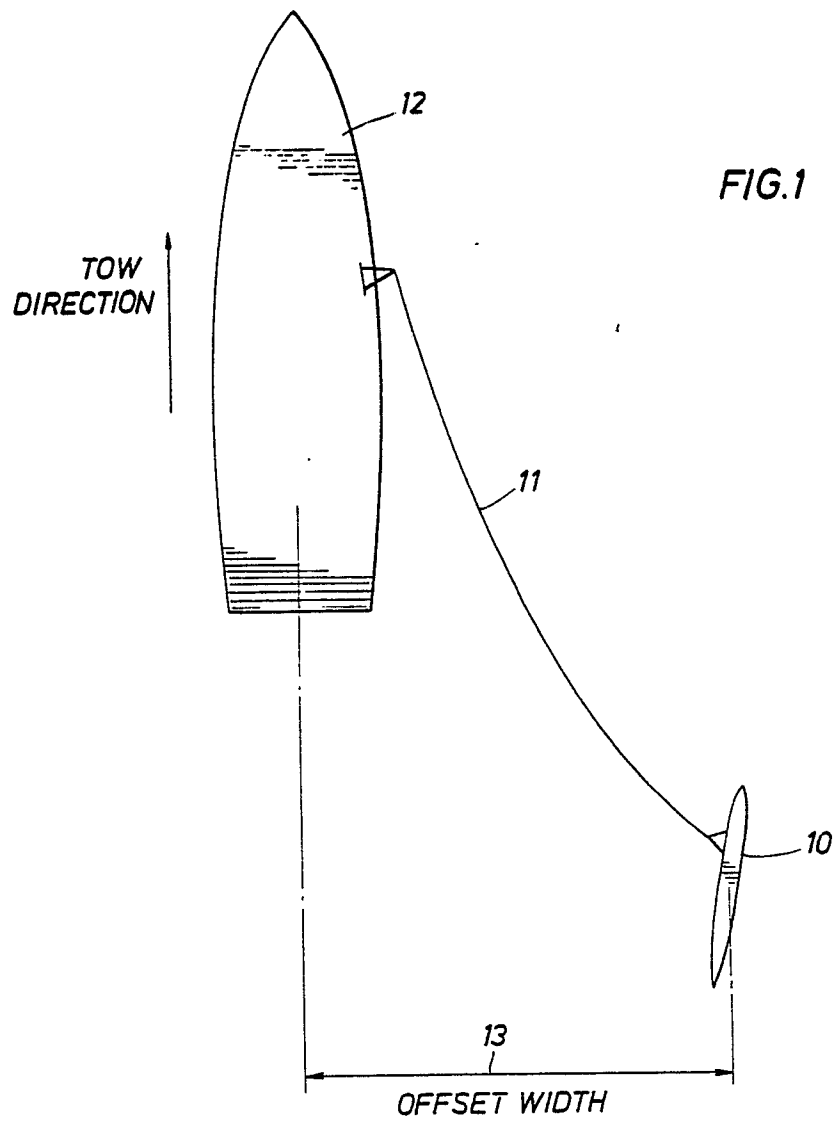
1. Câble sismique (11) approprié au remorquage sous l'eau ayant au moins un élément de traction (20,30), des éléments électriquement conducteurs (21, 31) et au moins un élément de tuyau pneumatique/hydraulique (22,32), ces éléments étant arrangés côte à côte et espacés et entourés par une enveloppe continue allongée souple (24,34) ayant une section droite carénée et ledit élément de traction étant dans le bord d'attaque de l'enveloppe, caractérisé par un élément de traction à couple équilibré résistant à la torsion (20,30) ayant des torons de câble disposés avec des directions et des inclinaisons alternées pour résister à la torsion, par un faisceau électrique (21,31) servant d'éléments conducteurs et par une enveloppe (24,34) qui est moulée in situ entre l'élément, le faisceau électrique et le tuyau et autour d'eux et ainsi fermée sur eux.

2. Câble de la revendication 1 dans lequel le faisceau électrique (21,31) comprend des conducteurs torsadés autour d'une pièce rapportée molle (23,33).

3. Câble de la revendication 2, dans lequel la pièce rapportée (23,33) est fonctionnelle pour se contracter en sens radial sous tension et les conducteurs torsadés ont suffisamment de jeu pour fléchir avec la pièce rapportée supportant la tension.

4. Câble selon l'une des revendications 1 à 3 caractérisé en ce que l'élément de tension (20,30), le faisceau électrique (21,31) et le tuyau (22,32) sont des constituants ronds dans l'ensemble.

5. Câble selon l'une des revendications 1 à 4, caractérisé par au moins deux éléments de traction (20,30) disposés côte à côte dans le bord d'attaque de l'enveloppe moulée en totalité en une pièce.



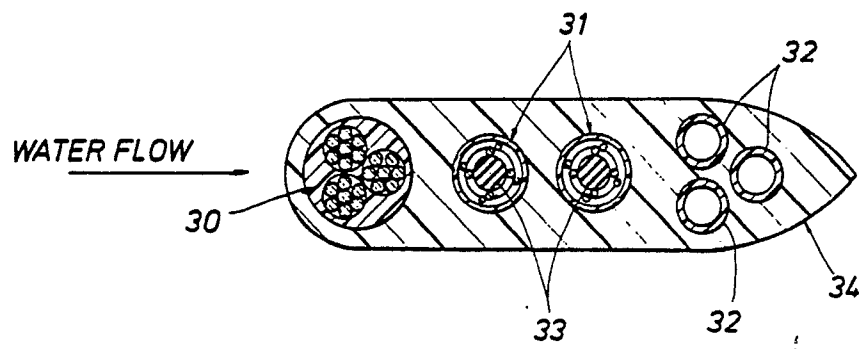


FIG. 3

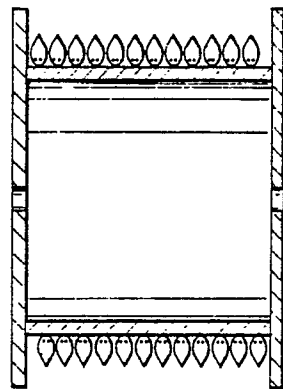


FIG. 4

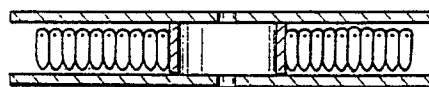


FIG. 5