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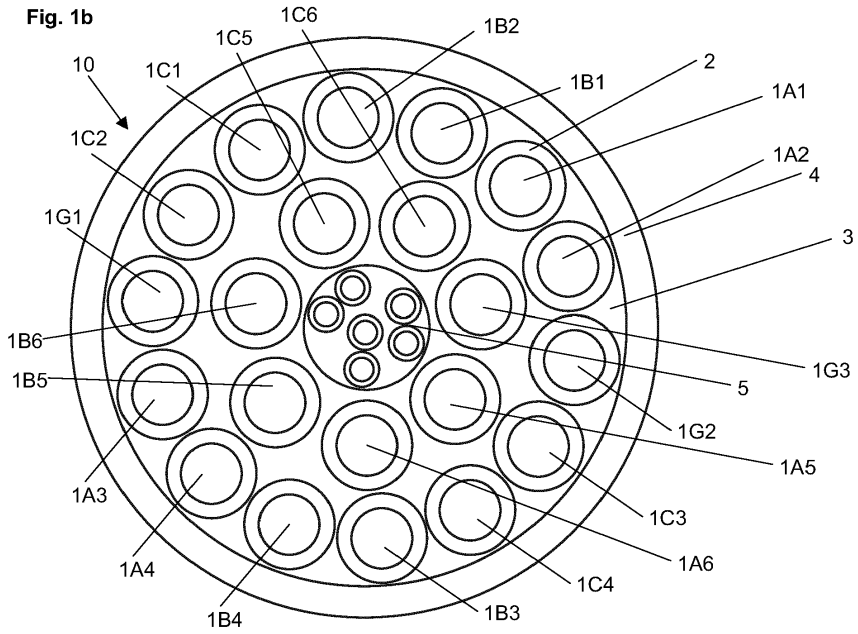
(54) **SHORE-TO-SHIP CABLE**

(57) The invention relates to a cable (10) for supplying shore-to-ship electrical power to ships (50) through several conductors (1) comprising:
- at least two first electrical phase conductors (1A1, 1A2, 1A3,...), each first electrical phase conductor (1A1, 1A2, 1A3,...) being enclosed in and electrically insulated by an insulation layer (2);
- at least two second electrical phase conductors (1B1, 1B2, 1B3,...), each second electrical phase conductor (1B1, 1B2, 1B3,...) being enclosed in and electrically insulated by an insulation layer (2);
- at least two third electrical phase conductors (1C1, 1C2, 1C3,...), each third electrical phase conductor (1C1, 1C2, 1C3,...) being enclosed in and electrically insulated by an insulation layer (2);
- at least one grounding conductor (1GA1, 1G2, 1G3,...), each grounding conductor (1G1, 1G2, 1G3,...) being enclosed in and electrically insulated by an insulation layer (2);
- an inner sheath (3), formed around and filling the space and gaps between the insulation layers (2);
- an outer sheath (4) enclosing said inner sheath (3) .

According to the invention, the first electrical phase conductors (1A1, 1A2, 1A3,...), the second electrical phase conductors (1B1, 1B2, 1B3,...) and the third electrical phase conductors (1C1, 1C2, 1C3,...) have nearly identical cross-sections.

Fig. 1b



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Description

[0001] The present invention relates to a cable suitable for supplying shore-to-ship electrical power to ships docked in ports.

[0002] When docked in ports, ships generate emissions by running their engines to create onboard electric power. This creates emissions that have a negative health and environmental impact on the local surroundings and on people working or staying on or around the ships.

[0003] To reduce emissions, electrical power can be provided to ships docked in ports through shore-to-ship power supply systems. Due to the size and power needs of the ships, such power supply systems rely on cables being able to carry large electric loads.

[0004] CN109585059A discloses a pressure-resistant, wear-resistant and low-temperature-resistant ship shore power cable. The cable comprises a main wire core, a ground wire core, a control wire core, a fibre combination unit and a filling core. The cable is very stiff and can only slightly be bent. Putting the cable in place when connecting a ship to the shore power is difficult and time-consuming, since the cable cannot be bent into a desired shape.

[0005] CN106856109A discloses a ship-shore connection cable which comprises a cable core which is externally wrapped by a chlorinated polyethylene inner sheath. The inner sheath is externally wrapped by an aramid yarn braided layer and a chlorinated polyethylene outer sheath. The cable is very stiff and can only slightly be bent, rendering the installation of the cable difficult and time-consuming. The halogenated materials in the cable are a health hazard in case of fire.

[0006] The problem of the present invention is to provide an improved cable that is suitable for supplying shore-to-ship electrical power to ships docked in ports. The cable shall be able to carry large currents of 1000A or more.

[0007] The cable shall be flexible with a bending radius below 300 mm to allow easy and fast installation and connection between shore and ship.

[0008] Further, the cable shall have a long service life.

[0009] The inventive solution shall withstand sprays of seawater and other media that are currently encountered in ports.

[0010] Additionally, the cable shall be made from materials that do not pose a threat to health in case of fire.

[0011] The problem is solved by a cable according to claim 1 and a shore-to-ship electrical power system according to claim 13. Further preferred embodiments of the invention are defined in dependent claims.

[0012] The cable, for supplying shore-to-ship electrical power to ships through several conductors comprises:

- at least two first electrical phase conductors, each first electrical phase conductor being enclosed in and electrically insulated by an insulation layer;
- at least two second electrical phase conductors, each second electrical phase conductor being enclosed in and electrically insulated by an insulation layer;
- at least two third electrical phase conductors, each third electrical phase conductor being enclosed in and electrically insulated by an insulation layer;
- at least one grounding conductor, each grounding conductor being enclosed in and electrically insulated by an insulation layer.
- an inner sheath (3), formed around and filling the space and gaps between the insulation layers (2);
- an outer sheath (4) enclosing said inner sheath (3).

[0013] According to the invention, the first electrical phase conductors, the second electrical phase conductors and the third electrical phase conductors have nearly identical cross-sections.

[0014] The cable allows for supplying high-energy three-phase electric power to a ship. A first phase of the three-phase electric power is passed through the at least two insulated first electrical phase conductors. The second phase of the three-phase electric power is passed through the at least two insulated second electrical phase conductors. The third phase of the three-phase electric power is passed through the at least two insulated third electrical phase conductors. At shore and on the ship, the first phase conductors are electrically connected together. The second phase conductors are at shore and on the ship electrically connected together. Equally, the third phase conductors are at shore and on the ship electrically connected together. The grounding conductor allows for a safe electrical connection. The cable is flexible with a low bending radius because of the nearly identical cross-sections of the conductors present in the cable. The cable is easily and quickly installed to connect a ship to electric power from shore.

[0015] In preferred embodiments, the conductors are formed from Copper or Aluminium or an alloy comprising Copper or Aluminium. The insulation layers are preferably made from a thermoplastic elastomer, a polyolefin polymer or a mixture comprising a thermoplastic elastomer or a polyolefin polymer.

[0016] In further preferred embodiments, an antifriction tape, preferably formed from Teflon, is wrapped around each of the insulation layers of the conductors. The antifriction tape reduces internal friction when moving or bending the cable, extending the service life of the cable.

[0017] In yet another preferred embodiment, the inner sheath consists of a plastic material, preferably a polyurethane material or a thermoplastic elastomeric material that protects the inner layers and conductors against mechanical and chemical impact. The outer sheath preferably consists of a plastic material, preferably a poly-

urethane material or a thermoplastic elastomeric material that protects the inner layers and conductors against mechanical and chemical impact. The cable can therefore withstand sprays of seawater and other media that are currently encountered in ports, giving the cable a long service life. Additionally, the cable no threat to health in case of fire is posed by the materials used for the cable.

[0018] In further preferred embodiments, the cable further comprises at least one conductor pair, which is preferably centrally arranged within the cable, to transmit data or steering signals. Preferably, the cable comprises several conductor pairs, to transmit data or steering signals. The conductor pairs are preferably used to transmit data about the status of the cable or the shore-to-ship electric power supply system. This allows a monitoring of the cable or system status, such that upcoming failure of the cable or system can be predicted and hence avoided by power reduction or replacement of the cable.

[0019] Preferably, the cable further comprises a tube, which is preferably centrally arranged within the cable, through which a cooling fluid can circulate to cool the cable. The tube is preferably watertight. By circulating a cooling fluid through the tube, the cable can be cooled to guarantee an optimized working temperature and reduce failure.

[0020] In a particularly preferred embodiment, the cable has a minimum bending radius of less than 10 times its diameter. Preferably, the cable has a minimum bending radius of 300 millimetres. The cable is hence flexible enough, to be put in a working position to connect a ship to a shore-based power supply unit.

[0021] In yet another preferred embodiment, the cable further comprises a shielding layer and/or a reinforcing layer and/or an optical conductor. Preferably the cable comprises several grounding conductors.

[0022] The cable can preferably carry electric currents of 1000A or above.

[0023] In a preferred embodiment according to the invention, each individual conductor has an electric linear resistance of less than 1.4Ohms/km. The power loss and accompanying ohmic heating of the cable are thus reduced.

[0024] The grounding conductors have preferably the same cross-section as the first electrical phase conductors, the second electrical phase conductors and the third electrical phase conductors. This results in a lower overall bending radius of the cable and an improved stability towards repeated bending cycles.

[0025] With an inventive cable, an equally inventive system for supplying shore-to-ship electrical power to ships docked in ports can be realized. The system allows for a fast and easy connection of ships to shore-power even for large electric energy needs.

[0026] Preferably, the system comprises at least one support structure over which the cable is guided from the shore to the ship. The support structure facilitates the electrical connection and de-connection of a ship arriving at or leaving a port. Through the support structure, the cables are neatly guided, such that loading or unloading the ship can is not obstructed.

[0027] Particularly preferred, the system further comprising at least one power supply unit that is electrically connected to the cable based on the shore. The power supply unit may be an electric generator, a photovoltaic unit or a transformation station connected to a high-voltage power grid.

[0028] The present invention will be further described by way of example, with reference to the accompanying drawings, wherein:

Fig. 1a depicts a cross-sectional view of a first embodiment of an inventive cable 10;

Fig. 1b depicts the cable 10 from Fig. 1a with labelled first phase conductors (1A1, 1A2, 1A3,...), second phase conductors (1B1, 1B2, 1B3,...), third phase conductors (1C1, 1C2, 1C3,...) and grounding conductors (1G1, 1G2, 1G3,...);

Fig. 2 depicts a cross-sectional view of a second embodiment of an inventive cable 10; and

Fig. 3 schematically depicts an inventive cable 10 as part of an inventive shore-to-ship electrical power system to power a ship 50.

[0029] Fig. 1a shows a cross-sectional view of a first embodiment of an inventive cable 10. The cable comprises several conductors 1, each of which is enclosed in an electrically insulated by an insulation layer 2. An inner sheath 3 is formed around and fills the space and gaps between the insulation layers 2 of the conductors 1. An outer sheath 4 encompasses the inner sheath 3 and the other inner components of the cable 10.

[0030] In the center of the cable 10, the cable 10 comprises three conductor pairs 5. The conductor pairs 5 are formed from Copper or Aluminium stranded wires having a lower cross-section than the other conductors 1 in the cable. Each conductor of the conductor pairs 5 is electrically insulated.

[0031] Fig. 1b shows the cable 10 from Fig. 1a with labelled first phase conductors (1A1, 1A2, 1A3, ...), second phase conductors (1B1, 1B2, 1B3,...), third phase conductors (1C1, 1C2, 1C3,...) and grounding conductors (1G1, 1G2, 1G3,...). All conductors (1, 1A1, 1A2, 1A3,..., 1B1, 1B2, 1B3,... 1C1, 1C2, 1C3,...) are electrically insulated by an insulation layer 2 enclosing each conductor. The first phase conductors (1A1, 1A2, 1A3,...) are designed to carry a first phase of an electric three-phase power, the second phase conductors (1B1, 1B2, 1B3,...) are designed to carry a second phase of an electric three-phase power and the third phase conductors (1C1, 1C2, 1C3,...) are designed to carry a third phase of an electric three-phase power.

[0032] Fig. 2 shows a cross-sectional view of a second

embodiment of an inventive cable 10. The cable comprises three first phase conductors (1A1, 1A2, 1A), three second phase conductors (1B1, 1B2, 1B3), three third phase conductors (1C1, 1C2, 1C3) and a grounding conductor (1G1) each of which is enclosed in an electrically insulated by an insulation layer 2. An inner sheath 3 is formed around and fills the space and gaps between the insulation layers 2 of the conductors. An outer sheath 4 encompasses the inner sheath 3 and the other inner components of the cable 10. The cable 10 comprises a tube 6 which is arranged at the center of the cable 10. The tube 6 is hollow, allowing fluids to be passed through the tube.

[0033] Fig. 3 shows schematically an inventive cable 10 as part of an inventive shore-to-ship electrical power system to power a ship 50. The ship 50 is docked in a port. On shore 40, a cable 10 is electrically connected to a power supply unit 30. The cable 10 is guided over a support structure 20 before being electrically connected to the ship 50. With the support structure 20, the cable 10 is precisely and in a controlled manner guided to the ship.

List of reference signs

[0034]

1	conductor
1A1, 1A2, 1A3...	first electrical phase conductors
1B1, 1B2, 1B3...	second electrical phase conductors
1C1, 1C2, 1C3...	third electrical phase conductors
1G1, 1G2, 1G3...	grounding conductors
2	insulation layer
3	inner sheath
4	outer sheath
5	conductor pairs
6	tube
10	cable
20	support structure
30	power supply unit
40	shore
50	ship

Claims

1. A cable (10) for supplying shore-to-ship electrical power to ships (50) through several conductors (1) comprising:

- at least two first electrical phase conductors (1A1, 1A2, 1A3,...), each first electrical phase conductor (1A1, 1A2, 1A3,...) being enclosed in and electrically insulated by an insulation layer (2);
- at least two second electrical phase conductors (1B1, 1B2, 1B3,...), each second electrical phase conductor (1B1, 1B2, 1B3,...) being enclosed in and electrically insulated by an insulation layer (2);
- at least two third electrical phase conductors (1C1, 1C2, 1C3,...), each third electrical phase conductor (1C1, 1C2, 1C3,...) being enclosed in and electrically insulated by an insulation layer (2);
- at least one grounding conductor (1GA1, 1G2, 1G3,...), each grounding conductor (1G1, 1G2, 1G3,...) being enclosed in and electrically insulated by an insulation layer (2);
- an inner sheath (3), formed around and filling the space and gaps between the insulation layers (2);
- an outer sheath (4) enclosing said inner sheath (3) ;

characterized in that;

the first electrical phase conductors (1A1, 1A2, 1A3,...), the second electrical phase conductors (1B1, 1B2, 1B3,...) and the third electrical phase conductors (1C1, 1C2, 1C3, ...) have nearly identical cross-sections.

2. A cable (10) according to claim 1, wherein the conductors (1, 1A1, 1A2, 1A3..., 1B1, 1B2, 1B3..., 1C1, 1C2, 1C3..., 1G1, 1G2, 1G3) are formed from Copper or Aluminium or an alloy comprising Copper or Aluminium and/or the insulation layers (2) are made from a thermoplastic elastomer, a polyolefin polymer or a mixture comprising a thermoplastic elastomer or a polyolefin polymer.

3. A cable (10) according to claim 1 or 2, wherein an antifriction tape, preferably formed from Teflon, is wrapped around each of the insulation layers (2) of the conductors (1, 1A1, 1A2, 1A3..., 1B1, 1B2, 1B3..., 1C1, 1C2, 1C3..., 1G1, 1G2, 1G3).

4. A cable (10) according to claim 1, 2 or 3, wherein the inner sheath (3) consists of a plastic material, preferably a polyurethane material or a thermoplastic elastomeric material that protects the inner layers and conductors (1) against mechanical and chemical impact and/or the outer sheath (4) consists of a plastic material, preferably a polyurethane material or a thermoplastic elastomeric material that protects the inner layers and conductors (1) against mechanical and chemical impact.

5. A cable (10) according to one of the claims 1 - 4, wherein the cable (10) further comprises at least one conductor pair (5), which is preferably centrally arranged within the cable (10), to transmit data or steering signals.

6. A cable (10) according to one of the claims 1 - 4, wherein the cable (10) further comprises a tube (6),

which is preferably centrally arranged within the cable (10), through which a cooling fluid can circulate to cool the cable.

7. A cable (10) according to claim 6, wherein the tube (6) is watertight.

8. A cable (10) according to one of the claims 1 - 7, wherein the cable (10) has a minimum bending radius of less than 10 times its diameter.

9. A cable (10) according to one of the claims 1 - 8, wherein the cable (10) has a minimum bending radius of 300 millimetres.

10. A cable (10) according to one of the claims 1 - 9, wherein the cable (10) further comprises a shielding layer and/or a reinforcing layer and/or an optical conductor and/or several grounding conductors (1G1, 1G2, 1G3, ...) .

11. A cable (10) according to one of the claims 1 - 10, wherein the cable (10) can carry electric currents of 1000A or above.

12. A cable (10) according to claim 11, wherein each individual conductor (1, 1A1, 1A2, 1A3..., 1B1, 1B2, 1B3..., 1C1, 1C2, 1C3..., 1G1, 1G2, 1G3) has an electric linear resistance of less than 1.40hms/km and/or the grounding conductors (1G1, 1G2, 1G3, ...) have the same cross-section as the first electrical phase conductors (1A1, 1A2, 1A3,...), the second electrical phase conductors (1B1, 1B2, 1B3,...) and the third electrical phase conductors (1C1, 1C2, 1C3,...).

13. A system for supplying shore-to-ship electrical power to ships (50) docked in ports comprising a cable (10) according to one of the claims 1 - 12.

14. A system according to claim 13, further comprising at least one support structure (20) over which the cable (10) is guided from the shore (40) to the ship (50).

15. A system according to claim 13 or 14, further comprising at least one power supply unit (30) that is electrically connected to the cable (10) and based on the shore (40).

Fig. 1a

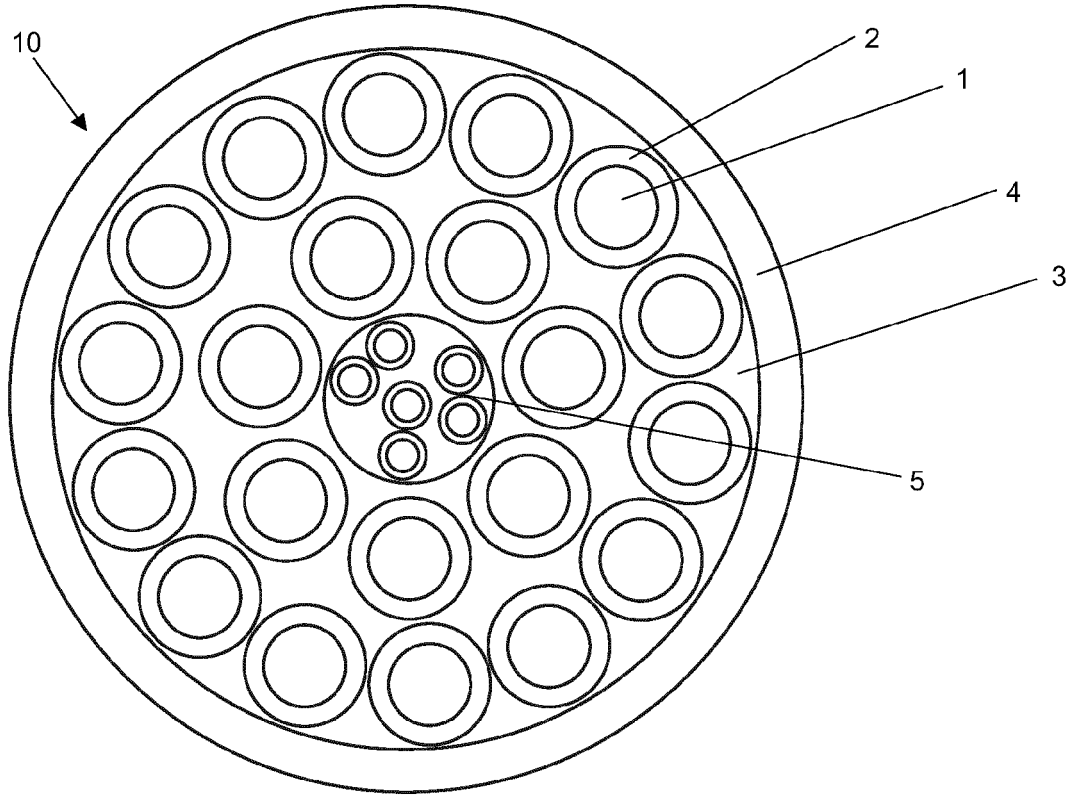

10
2
1
4
3
5

Fig. 1b

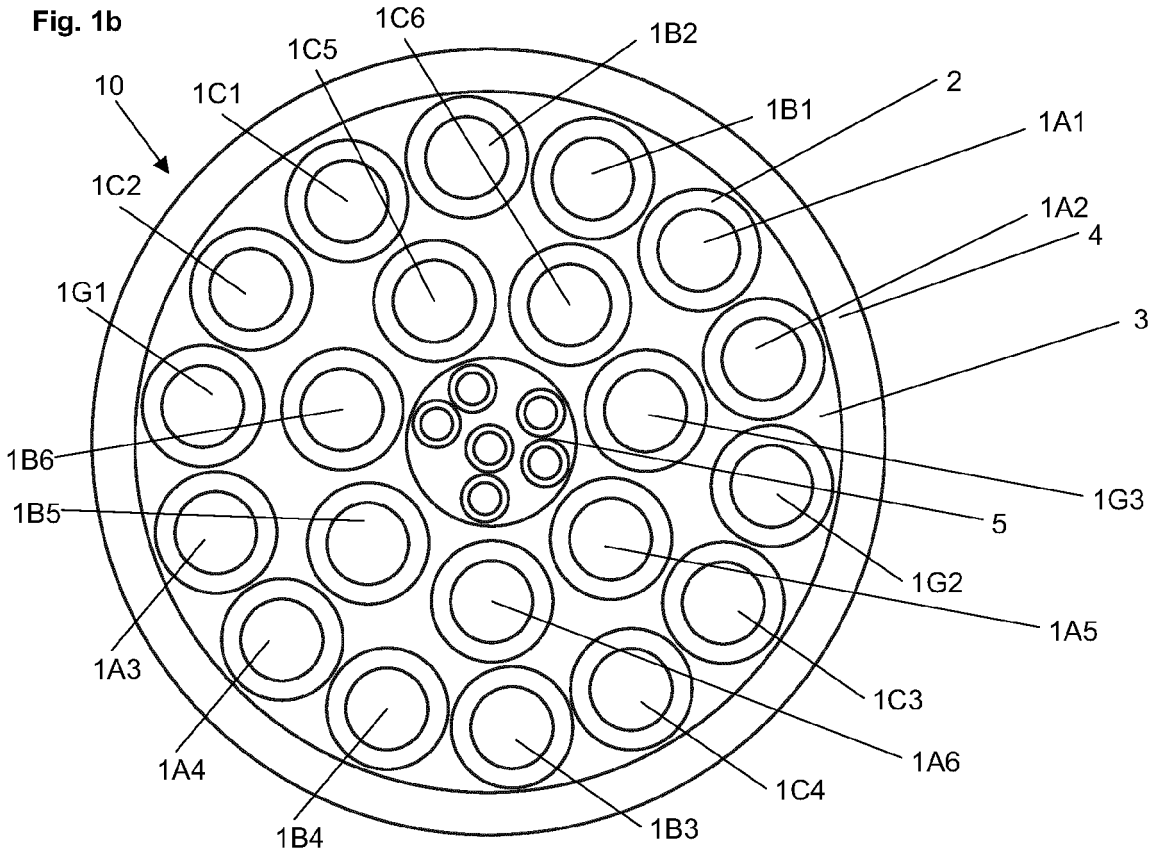

1C6
1C5
1B2
10
1C1
1B1
2
1A1
1C2
1A2
4
1G1
3
1B6
1G3
1B5
5
1G2
1A5
1A3
1C3
1A6
1A4
1C4
1B4
1B3

Fig. 2

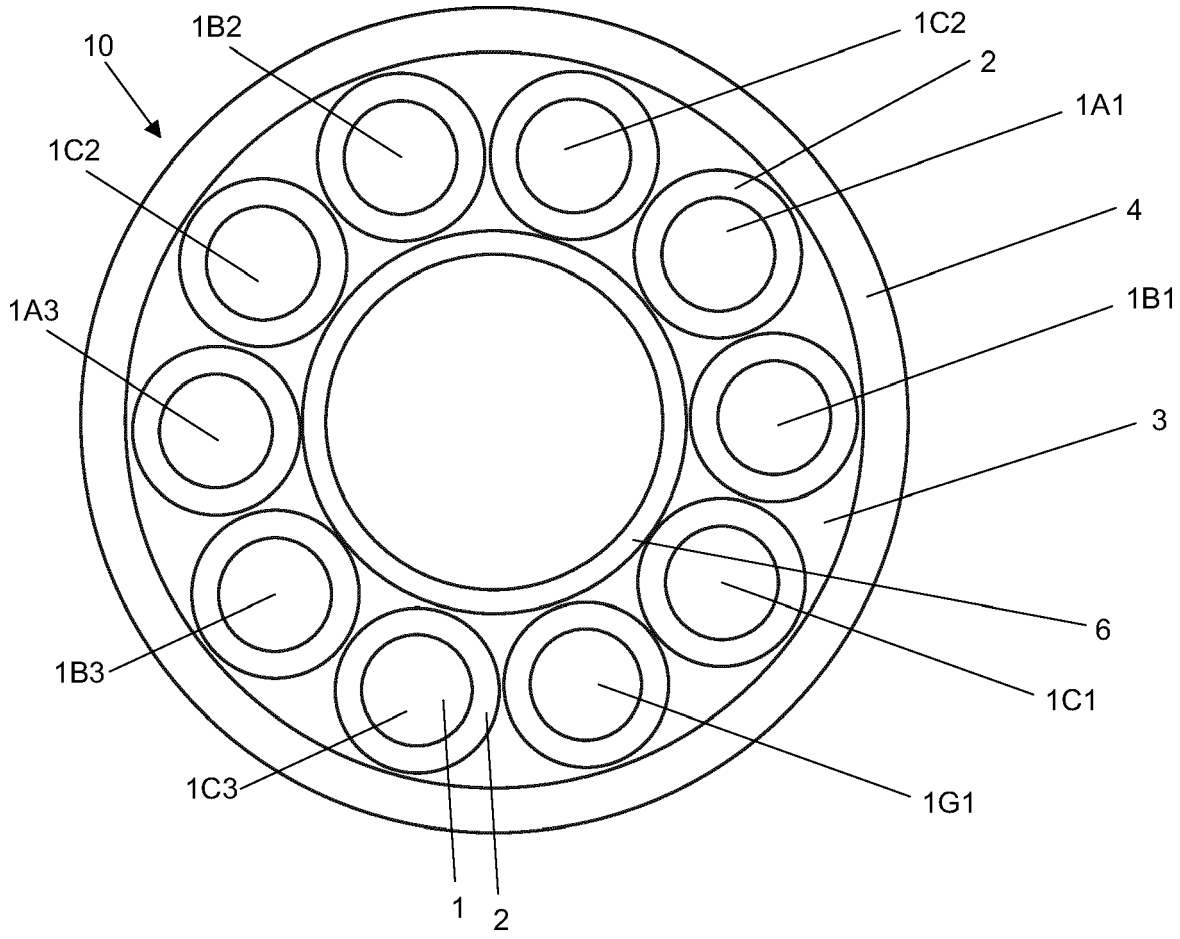
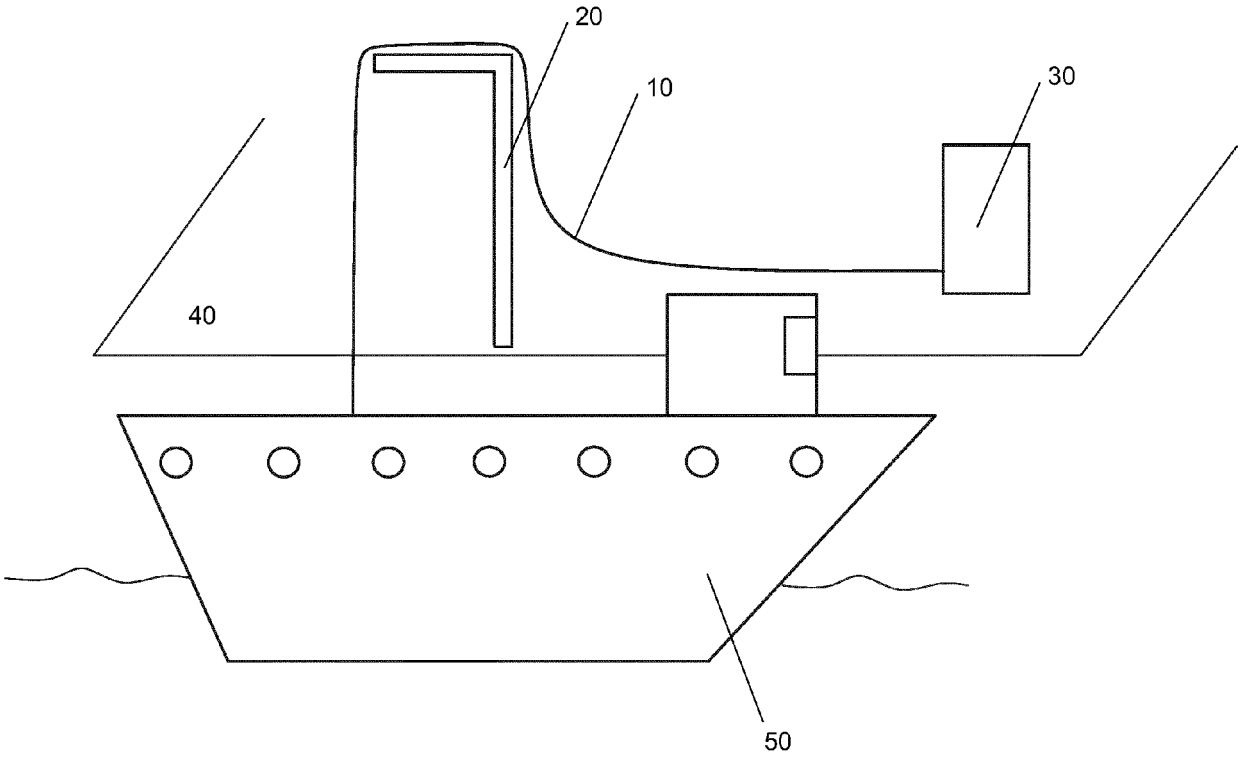


Fig. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 20 17 3810

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	3 September 2020	Alberti, Michele

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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