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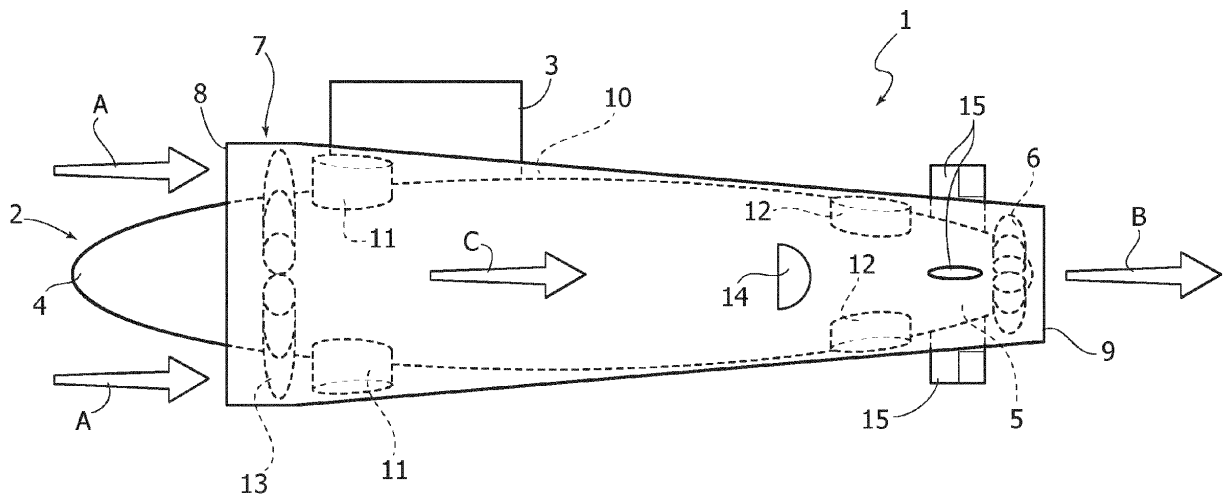
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(54) **Underwater vehicle**

(57) An underwater vehicle IS equipped with an external nozzle collector shield (7), or "ENS" ("External Nozzle Shield"), that surrounds a substantial portion of the hull (2), up to the rear propeller (6), so that water

flows inside the interspace (10) between the hull (2) and said external shield (7), starting from a front mouth (8) which is located at a position displaced rearwardly with respect to the bow (4) of the hull (2), and ending at an outlet mouth (9) located at the rear of the propeller (6).

FIG. 1



Description

Field of the invention

[0001] The present invention relates to the field of underwater vehicles, of the type including an elongated hull equipped with at least one propeller located at the stern of the vehicle. This definition comprises both vessels intended to transport personnel, such as those used for subaqueous explorations, and unmanned vehicles such as those used in oceanic studies.

General technical problem and prior art

[0002] Over the years, various solutions have been proposed in order to improve performance and efficiency of underwater vehicles, for example with aim of reducing the energy consumption necessary for propulsion, and/or increasing speed and manoeuvrability as well as noiselessness.

[0003] For instance, it has already been proposed that shrouding the propeller with an outer, circumferential covering, would result in its driving force becoming more efficient.

[0004] Furthermore, some of the proposed solutions (see, for example, U.S. Patents No. 2,969,759 and No. 4,395,965) involve an outer shell that forms an interspace between the hull and the shell in which water flows longitudinally from the bow to the stern of the vehicle. Water enters the interspace via lateral openings or pores within the shell. None of the known solutions, however, have been able to satisfactorily resolve the aforementioned technical issues.

[0005] An underwater vehicle of the type indicated in the preamble of claim 1 is known from US Patent No. 6,427,618 B1.

Object of the invention

[0006] The object of the present invention is to provide an underwater vehicle that produces minimal hydroacoustic disturbance through its movement and is characterized by an extremely high overall functional efficiency, so as to be able of overcoming the disadvantages of the known solutions.

[0007] A further object is that of providing an underwater vehicle which is adapted to the application of techniques for active control of noise emissions (which techniques, however, do not form part of the present invention and therefore are not disclosed in this document).

[0008] Still a further object of the invention is to provide an underwater vehicle having high passive safety features, where passive safety is intended as protection against damage caused by unintended collision with foreign bodies, and also having high active safety features, where active safety is intended as the provision of emergency tools for resurfacing of the vehicle following breakdown.

[0009] Still a further object is to achieve the aforementioned objects with extremely simple and relatively inexpensive means.

[0010] These and further objects are achieved according to the invention by providing an underwater vehicle having the features indicated in the appended claim 1.

[0011] This solution is further advantageous in terms of operability, as the frontal opening (mouth) of the tubular shield can be positioned in such a way so as not to compromise the functioning of detecting apparatus and/or devices located on the bow.

[0012] Thanks to the aforementioned characteristics, the vehicle according to this invention is capable of exploiting the mechanics of the ducted propeller to its maximum advantage. During subaqueous movement, the pressure exerted on the propeller by the water flowing through the interspace created by the tubular shield increases with the vehicle speed, dramatically reducing undesirable cavitation phenomena and thus increasing the velocity of rotation of the propeller, without any substantial limitations, apart from those imposed by the power of the engine driving the propeller.

[0013] The width of the interspace defined by the tubular shield is kept to a minimum, so that the thrust increase obtained by the higher rotational speed of the propeller is not jeopardised by an excessive increase of the cross section of the underwater vehicle.

[0014] In a preferred embodiment, the vehicle according to this invention is equipped with at least one additional auxiliary propeller which consists of an annular rotor rotatable around the hull and located within the interspace created by the outer tubular shield, more forwardly with respect to the rear propeller and preferably adjacent to the front mouth of the shield.

[0015] The hull is constructed according to standard techniques and materials with a metallic structure that is resistant to very high pressures, while the tubular shield comprises a light structure, ideally made of synthetic constituents such as fibre-reinforced composite materials. The external shield is not subjected to elevated pressures, as it is exposed to water on both its internal and external surfaces.

[0016] Still in the case of a particularly preferred embodiment, the shield is supported by several pillars projecting radially from the hull, at least some of which are hollow and house balloons which are inflatable (e.g. by gases generated by the explosion of pyrotechnic charges such as those used in motor-vehicle air-bags). The balloons can be deployed and used as emergency means to induce emersion of the vehicle in an emergency situation.

[0017] The pillars can be pressurised and fulfil multiple functions, such as the containment and protection of sensors and other devices, interconnecting cables, etc.

[0018] Still in the case of the preferred solution, the external shield's cross-section decreases towards the rear propeller, at least for the portion of the hull more closer to the rear propeller.

[0019] In addition, the rear propeller is preferably associated to a further, contra-rotating propeller and/or to a bladed stator.

[0020] Still in the case of the preferred embodiment, on the external shield there are distributed a number of movable lids that are adapted to provide a communication of the interspace between the hull and the shield with the environment external to the shield. These lids can be controlled in a differentiated manner, to provide the possibility of orienting the resulting vectorial thrust and to balance and/or reduce pressure within the interspace.

[0021] As already mentioned, the above features produce significant advantages in terms of hydrodynamics (dramatic reduction of the propeller cavitation factor, vis a vis a slight increase in drag due to the presence of the external shield) and in terms of hydroacoustics (noise reduction) as well as in terms of passive safety (the shield provides a non-pressurised deformable structure external to the reinforced hull) and active safety (inflatable balloons housed in the shield hollow pillars for emergency emersions).

[0022] A reduction of the vehicle's thermic trail is also obtained, as any discharges of fluids having a temperature higher than that of marine water can be dispersed within the interspace and mixed therein.

[0023] Further features and advantages of the invention will become apparent from the following description, with reference to the accompanying drawings, given purely by way of non-limiting example, in which:

figure 1 is a schematic representation of a lateral view of a preferred embodiment of an underwater vehicle according to this invention,
figure 2 is a front view of the vehicle of figure 1, and
figure 3 is a cross-sectional view of the vehicle of figure 1.

[0024] With reference to the drawings, figure 1 generally designates an underwater vehicle. The illustrated example is referred to the case of a vehicle intended for transporting personnel and used, for instance, to carry-out underwater surveys. As already indicated, it is readily apparent that this invention is equally applicable to unmanned vehicles, such as those that employ equipment for underwater surveys. Vehicle 1 comprises a hull 2 made of steel and constructed according to any known techniques in this field. Structural details of the hull 2 are not herewith described nor illustrated, because, as already stated, they can be made in any known manner, and because their deletion from the drawings render the same simpler and easier to understand.

[0025] The hull 2 has a thin and elongated shape, with a sail 3, a bow 4 and a stem 5. At the stem 5 a rear propeller 6 is provided for the vehicle propulsion, which is driven in rotation by an engine (not shown) of any known type. Details of the propeller 6 and its operating engine are not illustrated herein, as they can be made in any known manner, as readily apparent to those skilled

in the art.

[0026] According to this invention, around the hull 2 an external collecting nozzle shield 7 is provided, also called "ENS" ("External Nozzle Shield"), having a substantially tubular shape (a funnel-shape in the illustrated example) which extends for most of the length of the hull 2, starting from an inlet mouth 8, located at a position displaced rearwardly with respect to the bow 4, and ending at an outlet mouth 9, located at the rear of the propeller 6. Shield 7 defines an enveloping casing within which the rear propeller 6 is enclosed, and also provides an interspace 10 surrounding the hull 2 (at least partially in the circumferential direction and partially in the longitude direction), where the water flow is channelled towards the propeller 6. This water flow enters the shield 7 via the front mouth 8 (arrows A in figure 1) and travels along its entire length (arrow C) until it exits from the stem mouth 9, downstream of the propeller 6 (arrow B).

[0027] Shield 7 is not required to have a pressure resistant structure, as its surface is exposed to marine water both internally and externally. It is preferably made of a lightweight structure, for instance, of a synthetic material, such as fibre-reinforced composite material. The shield is supported by a number of front radial pillars 11 and rear radial pillars 12.

[0028] Preferably, at least some of pillars 11, 12 are hollow and house inflatable balloons, preferably balloons which are inflatable automatically by pyrotechnic charges, according to a technique used for motor-vehicle airbags. In this manner, the vehicle is thus provided with active safety features against breakdowns that would hinder an emersion. In case of emergency, the explosive charges can be triggered to cause inflation of the balloons and the vehicle ascent to the surface.

[0029] Preferably to the rear propeller 6 there is associated a further counter-rotating propeller and/or a bladed stator. Furthermore, according to a further preferred feature, the vehicle is provided with an additional auxiliary propeller 13 which consists of an annular rotor that revolves around the hull 2, positioned in the proximity of the front mouth 8 of shield 7.

[0030] In the case of the embodiment shown in the drawings purely by way of example, shield 7 has a truncated conical shape, but any other shape would be viable. However, the preferred shape is tapered towards the aft-most portion of the shield 7, close to the rear propeller 6.

[0031] According to a further preferred feature, movable lids 14 are provided circumferentially on shield 7, each movable between an opened and closed condition and adapted to be controlled in a differentiated manner to generate an orientable resulting vectorial thrust and/or to reduce and/or balance the pressure within interspace 10. Movable lids 14 can be placed, in variable number, in any position on shield 7.

[0032] In accordance with the conventional technique, the vehicle is equipped with hydroplanes at the stem 15.

[0033] In operation, activation of propeller 6 causes movement of the vehicle under water. Therefore, as a

result of both the movement of the vehicle and the suction effect of rear propeller 6 and front propeller 13 (if any), water is channelled longitudinally within interspace 10 from the front mouth 8 to rear propeller 6 and exit mouth 9 at the stem.

[0034] The operating principle is that of a ducted propeller, brought to a maximum in order to provide a virtual cycle, in which the more the vehicle advances and the higher is the increase in the pressure exerted on rear propeller 6 (or rear and front propellers 6 and 13), thus reducing cavitation phenomena dramatically. It is therefore possible to have the propellers rotating at much greater speeds than is commonly achieved in known vehicles, without risk of cavitation. Essentially, the only limit to the propellers speed is imposed by the power that the engine(s) of the underwater vehicle is/are able to supply.

[0035] As already stated, the width of interspace 10 - primarily determined by the distance between shield 7 and hull 2 - must be made as minimal as possible, so that the increased thrust is not thwarted by the wider cross section of the vehicle.

[0036] The high drag, slow rotating front propeller 13 can be actuated independently or jointly with the main rear propeller 6.

[0037] As previously indicated, inflatable balloons housed within the supporting pillars 11, 12 provide an active safety feature in the event of vehicle breakdown preventing its resurface.

[0038] The main rear propeller 6 is completely surrounded by the outer shield 7. The shield follows the contour of the vehicle and may present a cross-section tapering in proximity of the main rear propeller 6. This causes a higher pressure flow of water onto the propeller itself, which increases its thrust. As already mentioned, thrust can be augmented further by the installation of additional devices, such as an auxiliary counter-rotating propeller and a bladed stator located downstream of rear propeller 6.

[0039] As readily apparent from the foregoing description, thanks to the above indicated features, the vehicle has several advantages over the known vehicles, both in terms of hydrodynamics (reduction of the cavitation factor) and hydroacoustics (noise reduction) and also from the standpoint of active and passive safety. The interspace 10 can also be utilised to mix any discharges of hot fluids with marine water in order to reduce the vehicle thermic trail.

[0040] Naturally, while the principle of the invention remains the same, the details of construction and the embodiments may widely vary with respect to what has been disclosed purely by way of example, without departing from the scope of the present invention.

Claims

1. Underwater vehicle, comprising:

- an elongated hull (2) provided at its stem with at least one propeller (6), which is ducted within a circumferential casing,
 - an outer tubular shield (7) at least partially surrounding the hull (2) and forming an interspace (10) between the shield (7) and the hull (2),
 - wherein said shield (7) extends throughout at least a substantial portion of the length of the hull (2), starting from a front mouth (8) and ending at the stem, where it defines said casing within which the propeller (6) is ducted,
 so that the entire flow of water which is directed to the propeller (6) is guided within said interspace (10) defined by said outer shield (7), starting from said front mouth (8) to an outlet mouth (9) located at the rear of the propeller (6),
characterized in that said front mouth (8) is located at a position displaced rearwardly with respect to the bow (4) of said elongated hull (2).

2. Underwater vehicle according to claim 1, **characterized in that** it is provided with an auxiliary propeller (13) constituted by an annular rotor rotating around the hull (2) and located within the interspace (10) defined between by the outer shield (7), ahead of the propeller (6).
3. Underwater vehicle according to claim 2, **characterized in that** said auxiliary propeller (13) is located in proximity of the front mouth (8) of the shield (7).
4. Underwater vehicle according to claim 1, **characterized in that** the hull (2) is constructed with a structure resistant to high pressures, whereas the outer shield (7) is constituted by a lightweight structure, preferably made of a synthetic material, particularly a fibre-reinforced composite material.
5. Underwater vehicle according to claim 1, **characterized in that** the shield (7) is supported by a plurality of pillars (11, 12) projecting radially from the hull (2).
6. Underwater vehicle according to claim 5, **characterized in that** at least some of said pillars (11, 12) are hollow and contain inflatable balloons which can be used as emergency devices to cause an emersion of the vehicle.
7. Underwater vehicle according to claim 1, **characterized in that** the shield (7) has a cross-section tapering towards the rear propeller (6), at least throughout a portion of the shield (7) which is more proximate to the rear propeller (6).
8. Underwater vehicle according to claim 1, **characterized in that** the rear propeller (6) is provided with a counter-rotating auxiliary propeller and/or a stator with vanes.

9. Underwater vehicle according to claim 1, **characterized in that** on said shield (7) there are distributed movable lids (14) adapted to provide a communication between the interspace (10) and the environment outside the shield (7), said lids (14) being adapted to be controlled in a differentiated manner, in order to obtain a resulting vectorial thrust which can be oriented in order to equalize and/or reduce the pressure inside the interspace (10).

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FIG. 1

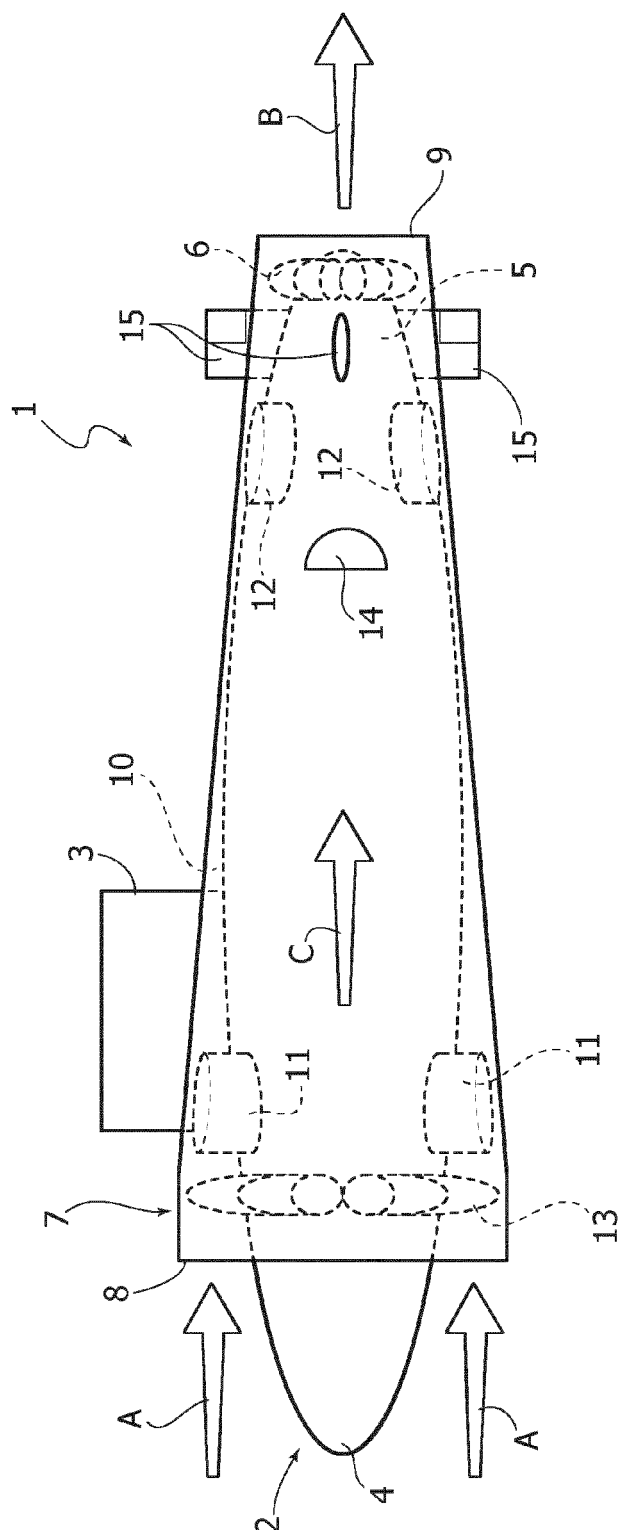


FIG. 2

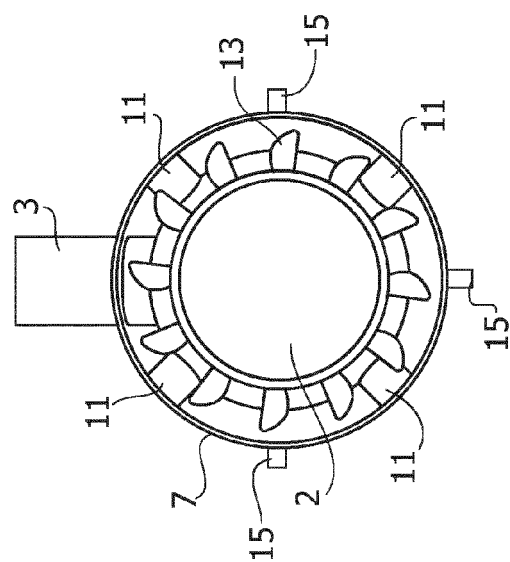
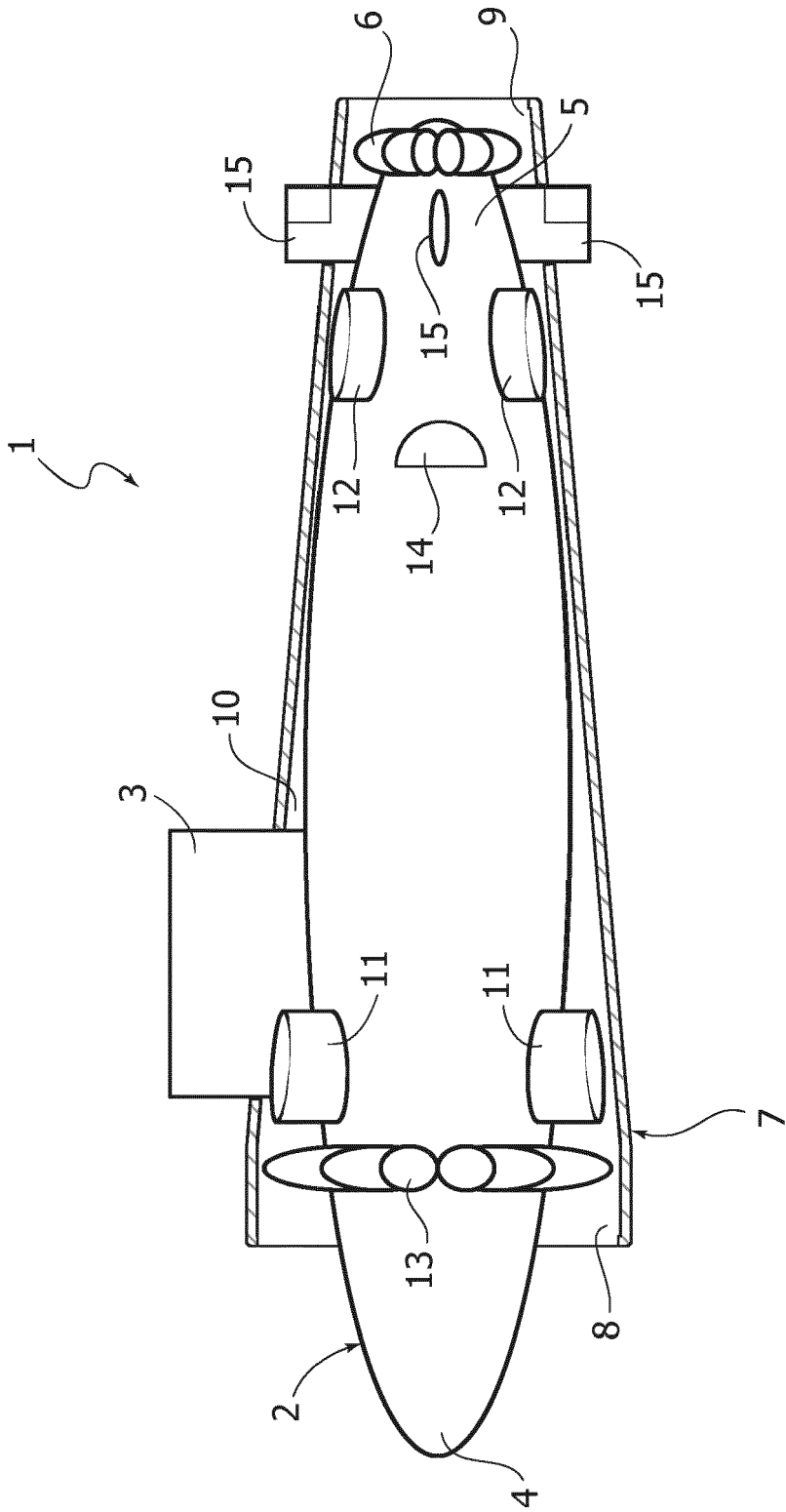


FIG. 3





EUROPEAN SEARCH REPORT

Application Number
EP 13 16 9748

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			B63G B63H
Place of search		Date of completion of the search	Examiner
The Hague		30 July 2013	Martínez, Felipe
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 13 16 9748

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The members are as contained in the European Patent Office EDP file on
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30-07-2013

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