Figure 31 shows the propulsion unit shown in figure 29 as seen from one side,

Figures 32 to 35 shows some alternative configurations of section X-X in figures 29 to 31,

Figure 36 shows a sixth embodiment of the propulsion unit,

Figure 37 the function principle of the propulsion unit shown in figure 36,

Figure 38 shows the propulsion unit shown in figure 36 as seen from one side,

Figures 39 to 42 shows some alternative configurations of section X-X in figures 36 to 38,

Figure 43 shows a seventh embodiment of the propulsion unit,

Figure 44 the function principle of the propulsion unit shown in figure 43,

Figure 45 shows the propulsion unit shown in figure 43 as seen from one side,

Figures 46 to ~~50~~ 49 shows some alternative configurations of section X-X in figures 43 to 45,

Figure ~~51~~ 50 shows an eight embodiment of the propulsion unit,

Figure ~~52~~ 51 the function principle of the propulsion unit shown in figure ~~51~~50,

Figure ~~53~~ 52 shows the propulsion unit shown in figure ~~51~~ 50 as seen from one side,

Figures ~~54~~ 53 to ~~56~~ 55 shows some alternative configurations of section X-X in figures ~~51~~ 50 to ~~53~~52,

Figure ~~57~~ 56 shows a ninth embodiment of the propulsion unit,

Figure ~~58~~ 57 the function principle of the propulsion unit shown in figure ~~57~~56,

Figure ~~59~~ 58 shows the propulsion unit shown in figure ~~57~~ 56 as seen from one side,

Figure ~~60~~ 59 shows a configuration of section X-X in figures ~~57~~ 56 to ~~59~~58,

Figure ~~61~~ 60 shows a tenth embodiment of the propulsion unit,

Figure ~~62~~ 61 shows a configuration of section X-X in figure ~~61~~60,

Figure ~~63~~ 62 shows an eleventh embodiment of the propulsion unit,

Figure ~~64~~ 63 the function principle of the propulsion unit shown in figure ~~63~~62,

Figure ~~65~~ 64 shows the propulsion unit shown in figure ~~63~~ 62 as seen from one side,

Figure ~~66~~ 65 shows a first configuration of section X-X in figures ~~64~~ 63 and ~~65~~64,

Figure ~~67~~ 66 shows a first configuration of section Y-Y in figures ~~64~~ 63 and ~~65~~64,

Figure ~~68~~ 67 shows a second configuration of section X-X in figures ~~64~~ 63 and ~~65~~64,

Figure ~~69~~ 68 shows a second configuration of section Y-Y in figures ~~64~~ 63 and

~~65~~64,

Figure ~~70~~ 69 shows a twelfth embodiment of the propulsion unit,

Figure ~~71~~ 70 the function principle of the propulsion unit shown in figure ~~70~~69,

Figure ~~72~~ 71 is another view of the propulsion unit shown in figure ~~70~~69, and

Figure ~~73~~ 72 shows a configuration of section Y-Y in figures ~~71~~ 70 and ~~72~~71.

**Detailed description of the invention**

In the following the ship's propulsion unit and some preferred embodiments and variants of the ship's propulsion unit will be described in greater detail.

The ship's propulsion unit (not marked with a reference numeral) such as a ship's azimuthing propulsion unit comprises a shell structure 1 arranged below a hull 2 of the ship (not marked with a reference numeral) and immersible at least partly in water (not marked with a reference numeral) so that the shell structure 1 is at least partly surrounded by water.

The propulsion unit comprises additionally an electric motor 3 for rotating a propeller 4 outside the shell structure 1. The electric motor 3 has a stator 5 and a rotor 6 for rotating in the stator 5. In the figures a propeller shaft 7 is connected to the rotor 6 for rotating with the rotor 6 as the rotor 6 rotates in the stator 5. In the figures the propeller shaft 7 is rotatable supported by means of bearing arrangements 8. In the figures the propeller 4 is attached to the propeller shaft 7.

The electric motor 3 is arranged in a motor housing section 9 of the shell structure 1 so that the stator 5 of the electric motor 3 is form-fitted into a cylindrical section 10 of the motor housing section 9 of the shell structure 1.

The cylindrical section 10 has a cylindrical outer surface 11.

The shell structure 1 includes a support section 26 having a lower end (not marked with a reference numeral) connected to the motor housing section 9 of the shell structure 1 and an upper end (not marked with a reference numeral) connected to the hull 2 of the ship. The upper end of the support section 26 may be connected to the hull 2 of the ship by means of a turning arrangement (not shown in the drawings) for turning the propulsion unit with respect to the hull 2 of the ship.

The propulsion unit comprises a closed gas circulation cooling system 12 containing gas 13 such as air and comprising a gas circulation means 14 for circulating gas 13 through channels 23 in the electric motor 3. The channels 23 through the electric motor 3 are preferably, but not necessarily, formed by at least one of channels 23 in the rotor of the electric motor 3 and a channel 23 formed by

an air gap (not marked with a reference numeral) between the stator 5 and the rotor 6 of the electric motor 3. The gas circulation means can be in the form of a separate gas circulation means or arranged in connection with the propeller shaft as in the tenth embodiment of the propulsion unit shown in figures ~~61~~ 60 and ~~62~~61.

The propulsion unit comprises a closed liquid cooling system 15 having an inner space (not marked with a reference numeral) containing liquid 16 such as water.

The inner space of the closed liquid cooling system 15 is preferably, but not necessarily, partly limited by the shell structure 1 of the propulsion unit so that liquid 16 in the inner space of the closed liquid cooling system 15 is in direct contact with the shell structure 1 of the propulsion unit for exchanging thermal energy between liquid 16 in the closed liquid cooling system 15 and water surrounding the propulsion unit via the shell structure 1 of the propulsion unit.

The propulsion unit comprises a gas-liquid-heat exchanger 17 in fluid connection with the closed gas circulation cooling system 12 and in fluid connection with the closed liquid cooling system 15 for exchanging thermal energy between gas 13 circulating in the closed gas circulation cooling system 12 and liquid 16 in the closed liquid cooling system 15 without mixing gas 13 circulating in the closed gas circulation cooling system 12 with circulating liquid 16 in the closed liquid cooling system 15 or vice versa.

The closed gas circulation cooling system 12, the closed liquid cooling system 15, and the gas-liquid-heat exchanger 17 are all parts of the propulsion unit.

The support section 26 of the shell structure 1 may be provided with an opening 18 for allowing water surrounding the propulsion unit to flow through opening 18 in the shell structure 1, when the propulsion unit is at least partly immersed in water. Such opening 18 may be closed with covering parts 36 provided with apertures 37 for enabling water surrounding the propulsion unit to enter the opening 18 via the apertures 37 and correspondingly for enabling water in the opening 18 to exit the opening via the apertures 37. It is alternatively possible that such opening 18 may be closed with covering parts 36 so that apertures 37 for enabling water surrounding the propulsion unit to enter the opening 18 via the apertures 37 and correspondingly for enabling water in the opening 18 to exit the opening via the apertures 37 is formed.

The lower end of the support section 26 of the shell structure 1 may be connected to the motor housing section 9 of the shell structure 1 so that an opening 18 is formed in the support section 26 of the shell structure 1. Such opening 18 may be closed with covering parts 36 provided with apertures 37 for

enabling water surrounding the propulsion unit to enter the opening 18 via the apertures 37 and correspondingly for enabling water in the opening 18 to exit the opening via the apertures 37. It is alternatively possible that such opening 18 may be closed with covering parts 36 so that apertures 37 for enabling water surrounding the propulsion unit to enter the opening 18 via the apertures 37 and correspondingly for enabling water in the opening 18 to exit the opening via the apertures 37 is formed.

The lower end of the support section 26 of the shell structure 1 may connected to the motor housing section 9 of the shell structure 1 so that an opening 18 is formed between the support section 26 of the shell structure 1 and the motor housing section 9 of the shell structure 1 and so that a cylindrical part 19 of the cylindrical outer surface 11 of the cylindrical section 10 of the motor housing section 9 forms a part of an outermost surface (not marked with a reference numeral) of the propulsion unit, as is the case in the first embodiment of the propulsion unit shown in figures 1 to 13, in the second embodiment of the propulsion unit shown in figures 14 to 17, and in the third embodiment of the propulsion unit shown in figures 18 to 21. The outermost surface is at least partly in contact with water surrounding the propulsion unit, when the propulsion unit is at least partly immersed in water. Such opening 18 may be closed with covering parts 36 provided with apertures 37 for enabling water surrounding the propulsion unit to enter the opening 18 via the apertures 37 and correspondingly for enabling water in the opening 18 to exit the opening via the apertures 37. It is alternatively possible that such opening 18 may be closed with covering parts 36 so that apertures 37 for enabling water surrounding the propulsion unit to enter the opening 18 via the apertures 37 and correspondingly for enabling water in the opening 18 to exit the opening via the apertures 37 is formed.

Such cylindrical part 19 of the cylindrical outer surface 11 of the cylindrical section 10 of the motor housing section 9 may be provided with projecting heat-exchanging elements 20 for enhancing transfer of thermal energy between the electric motor 3 in the cylindrical section 10 of the motor housing section 9 and water surrounding the cylindrical part 19 of the cylindrical section 10 of the motor housing section 9, as is shown in figure 5.

In the propulsion unit, the closed liquid cooling system 15 may be in the form of a closed liquid tank 21 forming said inner space containing liquid 16, as is the case in the third embodiment of the propulsion unit shown in figures 18 to 21, in the ninth embodiment of the propulsion unit shown in figures ~~57~~ 56 to ~~60~~59, and in the tenth embodiment of the propulsion unit shown in figures ~~61~~ 60 and ~~62~~61. Closed liquid tank 21 means in this context that no liquid or other fluids such as

gases is during use of the closed liquid tank 21 for cooling purposes let in or let of from the closed liquid tank 21.

Such closed liquid tank 21 may be partly limited by the cylindrical outer surface 11 of the cylindrical section 10 of the motor housing section 9 so that liquid 16 in the closed liquid tank 21 is in direct contact with the cylindrical outer surface 11 of the cylindrical section 10 of the motor housing section 9 for exchanging thermal energy between the electrical motor arranged in the cylindrical section 10 of the motor housing section 9 and liquid 16 in the closed liquid tank 21 via the cylindrical section 10 of the motor housing section 9, as is the case in the ninth embodiment of the propulsion unit shown in figures ~~57~~ 56 to ~~60~~59, and in the tenth embodiment of the propulsion unit shown in figures ~~61~~ 60 and ~~62~~61.

Such closed liquid tank 21 may be partly limited by the support section 26 of the shell structure 1 of the propulsion unit so that liquid 16 in the closed liquid tank 21 is in direct contact with the support section 26 of the shell structure 1 of the propulsion unit for exchanging thermal energy between liquid 16 in the closed liquid tank 21 and water surrounding the support section 26 of the shell structure 1 of the propulsion unit via the shell structure 1 of the propulsion unit, as is the case in the third embodiment of the propulsion unit shown in figures 18 to 21, in the ninth embodiment of the propulsion unit shown in figures ~~57~~ 56 to ~~60~~59, and in the tenth embodiment of the propulsion unit shown in figures ~~61~~ 60 and ~~62~~61.

If the closed liquid cooling system 15 is in the form of a closed liquid tank 21 forming said inner space containing liquid 16, the gas-liquid-heat exchanger 17 may be formed by ducts 22 in fluid communication with the closed gas circulation cooling system 12 so that the ducts 22 extends through the closed liquid tank 21 for leading gas 13 circulating in the closed gas circulation cooling system 12 in said ducts 22 through the closed liquid tank 21 and for exchanging thermal energy between gas 13 flowing in said ducts 22 and liquid 16 in the closed liquid tank 21, as is the case in the third embodiment of the propulsion unit shown in figures 18 to 21, in the ninth embodiment of the propulsion unit shown in figures ~~57~~ 56 to ~~60~~59, and in the tenth embodiment of the propulsion unit shown in figures ~~61~~ 60 and ~~62~~61.

If the closed liquid cooling system 15 is in the form of a closed liquid tank 21 forming said inner space containing liquid 16, inner surface of the closed liquid tank 21 may be provided with projecting heat exchanging elements 32 projecting from the support section 26 of the shell structure 1 of the propulsion unit into the closed liquid tank for enhancing transfer of thermal energy between liquid 16 in the inner space of the closed liquid tank 21 and water surrounding the shell structure of the propulsion unit.

In the propulsion unit, the closed liquid cooling system 15 may be in the form of a closed liquid circulation cooling system 24 containing liquid 16 and forming said inner space containing liquid 16 and provided with liquid circulation means 25 for circulating liquid 16 in the inner space of the closed liquid circulation cooling system 24, as is the case in the first embodiment of the propulsion unit shown in figures 1 to 13, in the second embodiment of the propulsion unit shown in figures 14 to 17, in the fourth embodiment of the propulsion unit shown in figures 22 to 28, in the fifth embodiment of the propulsion unit shown in figures 29 to 35, in the sixth embodiment of the propulsion unit shown in figures 36 to 42, in the seventh embodiment of the propulsion unit shown in figures 43 and ~~50~~49, in the eleventh embodiment of the propulsion unit shown in figures ~~36~~ 62 to ~~69~~68, and in the twelfth embodiment of the propulsion unit shown in figures ~~70~~ 69 to ~~73~~72.

The closed liquid circulation cooling system 24 may be partly formed by a tube section 33 having an outer surface 34 that is in direct contact with water surrounding the propulsion unit for exchanging thermal energy between liquid 16 circulating in the closed liquid circulation cooling system 24 and water surrounding the propulsion unit via the tube section 33 of the closed liquid circulation cooling system 24, as is the case in the eleventh embodiment of the propulsion unit shown in figures ~~36~~ 62 to ~~69~~68, and in the twelfth embodiment of the propulsion unit shown in figures ~~70~~ 69 to ~~73~~72. The tube section 33 may include a part in the form of a coiled tube.

If the closed liquid circulation cooling system 24 is partly formed by a tube section 33, the tube section 33 may be a part of a liquid-liquid-heat exchanger 38 that is in fluid communication with the closed liquid cooling system 15 so that liquid circulating in the inner space of the closed liquid cooling system 15 circulates through the tube section 33 of the liquid-liquid-heat exchanger 38 for exchanging thermal energy between liquid flowing through the tube section 33 of the liquid-liquid-heat exchanger 38 and water in contact with the tube section 33 of the liquid-liquid-heat exchanger 38 and surrounding the shell structure 1 of the propulsion unit.

The inner space of such closed liquid circulation cooling system 24 may be partly limited by the support section 26 of the shell structure 1 of the propulsion unit so that liquid 16 flowing in the inner space of the closed liquid circulation cooling system 24 is in direct contact with the support section 26 of the shell structure 1 for exchanging thermal energy between liquid 16 flowing in the inner space of the closed liquid circulation cooling system 24 and water surrounding the support section 26 of the shell structure 1 via the support section

26 of the shell structure 1.

The inner space of such closed liquid circulation cooling system 24 may additionally be partly limited by a part 31 of the cylindrical outer surface 11 of the cylindrical section 10 of the motor housing section 9 so that liquid 16 flowing in the inner space of the closed liquid circulation cooling system 24 is in direct contact with said part 31 of the cylindrical outer surface 11 of the cylindrical section 10 of the motor housing section 9 for exchanging thermal energy between the electric motor 3 arranged in the cylindrical section 10 of the motor housing section 9 and liquid 16 flowing in the inner space of the closed liquid circulation cooling system 24 via said part 31 of the cylindrical section 10 of the motor housing section 9 between the electric motor 3 and liquid 16 circulating in the inner space of the closed liquid circulation cooling system 24, as is the case in the fourth embodiment of the propulsion unit shown in figures 22 to 28, in the fifth embodiment of the propulsion unit shown in figures 29 to 35, in the sixth embodiment of the propulsion unit shown in figures 36 to 42, in the seventh embodiment of the propulsion unit shown in figures 43 to ~~50~~49, and in the eight embodiment of the propulsion unit shown in figures ~~51~~ 50 to ~~56~~55.

Said part 31 of the cylindrical outer surface 11 of the cylindrical section 10 of the motor housing section 9 in contact with liquid 16 in the inner space of the closed liquid circulation cooling system 24 may be provided with partition elements 27 for creating several individual flows of liquid 16 along said part 31 of the cylindrical outer surface 11 of the cylindrical section 10 of the motor housing section 9, as is shown in figures 26, 33, 40, and 47.

Said part 31 of the cylindrical section 10 of the cylindrical outer surface 11 of the motor housing section 9 in contact with liquid 16 in the closed liquid cooling system 15 may be provided with projecting heat-exchanging elements for enhancing transfer of thermal energy between the electric motor 3 in the motor housing section 9 and liquid 16 in the closed liquid cooling system 15, as is shown in figures 25, 32, 39, and 46.

If the closed liquid cooling system 15 is in the form of a closed liquid circulation cooling system 24, the closed liquid circulation cooling system 24 may be provided with a first liquid tank 28, having a first inner space (not marked with a reference numeral) that forms a part 31 of the inner space of the closed liquid circulation cooling system 24, as is the case in the fifth embodiment of the propulsion unit shown in figures 29 to 35, in the sixth embodiment of the propulsion unit shown in figures 36 to 42, and in the eight embodiment of the propulsion unit shown in figures ~~51~~ 50 to ~~56~~55.

Such first liquid tank 28 is in fluid communication with the closed liquid

circulation cooling system 24 such that liquid 16 flowing in the closed liquid circulation cooling system 24 flows through the first inner space of the first liquid tank 28. The first inner space of the first liquid tank 28 is partly limited by said part 31 of the cylindrical outer surface 11 of the cylindrical section 10 of the motor housing section 9 so that liquid 16 in a first inner space of the first liquid tank 28 is in direct contact with the cylindrical outer surface 11 of the cylindrical section 10 of the motor housing section 9 for exchanging thermal energy between the electric motor 3 arranged in the motor housing section 9 and liquid 16 flowing in the first inner space of the first liquid tank 28 via said part 31 of the cylindrical outer surface 11 of the cylindrical section 10 of the motor housing section 9.

If the closed liquid circulation cooling system 24 is provided with a first liquid tank 28, the first liquid tank 28 may be additionally partly limited by the support section 26 of the shell structure 1 so that liquid 16 in the first inner space of the first liquid tank 28 is additionally in direct contact with the support section 26 of the shell structure 1 for exchanging thermal energy between liquid 16 flowing in the first inner space of the first liquid tank 28 of the closed liquid circulation cooling system 24 and water surrounding the support section 26 of the shell structure 1 via the support section 26 of the shell structure 1, as is the case in the fifth embodiment of the propulsion unit shown in figures 29 to 35, in the sixth embodiment of the propulsion unit shown in figures 36 to 42, and in the eight embodiment of the propulsion unit shown in figures ~~51~~ 50 to ~~56~~55.

If the closed liquid circulation cooling system 24 is provided with a first liquid tank 28, the first liquid tank 28 being provided with baffles 29 for guiding liquid 16 through the first liquid tank 28 to prolong the residence time of liquid 16 in the first liquid tank 28 and/or for serving as heat exchanging elements between liquid 16 flowing through the first liquid tank 28 and the support section 26 of the shell structure 1, as is the case in the fifth embodiment of the propulsion unit shown in figures 29 to 35, and in the sixth embodiment of the propulsion unit shown in figures 36 to 42.

If the closed liquid circulation cooling system 24 is provided with a first liquid tank 28, the gas-liquid-heat exchanger 17 can be formed by ducts 22 in fluid communication with the closed gas circulation cooling system 12, wherein the ducts 22 extends through the first liquid tank 28 for leading gas 13 circulating in the closed gas circulation cooling system 12 in said ducts 22 through the first liquid tank 28 and for exchanging thermal energy between gas 13 flowing in said ducts 22 through the first liquid tank 28 and liquid 16 in the first liquid tank 28, as in the eight embodiment of the propulsion unit shown in figures ~~51~~ 50 to ~~56~~55.

If the closed liquid cooling system 15 is in the form of a closed liquid

circulation cooling system 24, the closed liquid circulation cooling system 24 may be provided with a second liquid tank 30 having a second inner space (not marked with a reference numeral) that forms a part of the inner space of the closed liquid circulation cooling system 24, as is the case in the first embodiment of the propulsion unit shown in figures 1 to 13, in the fifth embodiment of the propulsion unit shown in figures 29 to 35, and in the seventh embodiment of the propulsion unit shown in figures 43 to ~~50~~49.

Such second liquid tank 30 is in fluid communication with the closed liquid circulation cooling system 24 such that liquid 16 flowing in the closed liquid circulation cooling system 24 flows through the second inner space of the second liquid tank 30. The second liquid tank 30 being partly limited by the support section 26 of the shell structure 1 so that liquid 16 in the second inner space (not marked with a reference numeral) of the second liquid tank 30 is in direct contact with the support section 26 of the shell structure 1 for exchanging thermal energy between liquid 16 flowing in the second inner space of the second liquid tank 30 and water surrounding the support section 26 of the shell structure 1 via the support section 26 of the shell structure 1.

If the closed liquid circulation cooling system 24 is provided with a second liquid tank 30, the second inner space of the second liquid tank 30 may be provided with baffles 29 for guiding liquid 16 through the second inner space of the second liquid tank 30 to prolong the residence time of liquid 16 in the second inner space of the second liquid tank 30 and/or for serving as heat exchanging elements between liquid 16 flowing through the second inner space of the second liquid tank 30 and the support section 26 of the shell structure 1, as is the case in the fifth embodiment of the propulsion unit shown in figures 29 to 35, and in the seventh embodiment of the propulsion unit shown in figures 43 to ~~50~~49.

If the closed liquid circulation cooling system 24 is provided with a second liquid tank 30, the gas-liquid-heat exchanger 17 can be formed by ducts 22 in fluid communication with the closed gas circulation cooling system 12, wherein the ducts 22 extends through the second liquid tank 30 for leading gas 13 circulating in the closed gas circulation cooling system 12 in said ducts 22 through the second liquid tank 30 and for exchanging thermal energy between gas 13 flowing in said ducts 22 through the second liquid tank 30 and liquid 16 in the second liquid tank 30 as in the second embodiment of the propulsion unit shown in figures 14 to 17.

In the propulsion unit the lower end of the support section 26 of the shell structure 1 may be connected to the motor housing section 9 of the shell structure 1 so that the cylindrical outer surface 11 of the cylindrical section 10 of the motor

housing section 9 of the shell structure 1 of the propulsion unit partly forms the outermost surface of the propulsion unit, as is shown in the figures. In such case the part 31 of the cylindrical outer surface 11 of the cylindrical section 10 of the motor housing section 9 forming the outermost surface of the propulsion unit may be provided with projecting heat-exchanging elements 20 for enhancing transfer of thermal energy between the electric motor 3 in the motor housing section 9 and water surrounding the part 31 of the cylindrical outer surface 11 of the cylindrical section 10 of the motor housing section 9 forming the outermost surface of the propulsion unit.

The gas-liquid-heat exchanger 17 can be a separate heat exchanger in fluid connection with the closed gas circulation cooling system 12 and in fluid connection with the closed liquid cooling system 15 as is the case in the first embodiment of the propulsion unit shown in figures 1 to 13, in the fourth embodiment of the propulsion unit shown in figures 22 to 28, in the fifth embodiment of the propulsion unit shown in figures 29 to 35, in the sixth embodiment of the propulsion unit shown in figures 36 to 42, and in the seventh embodiment of the propulsion unit shown in figures 43 to ~~50~~49.

The cylindrical section 10 of the motor housing section 9 is preferably, but not necessarily, of a single-layer construction, as is illustrated in the figures. It is however obvious for a person skilled in the art that the cylindrical outer surface 11 of the cylindrical section 10 of the motor housing section 9 can for example additionally be painted.

The closed liquid cooling system 15 is preferably, but not necessarily, arranged at least partly enclosed by the shell structure 1 of the propulsion unit. The closed liquid cooling system 15 is more preferably, but not necessarily, arranged fully enclosed by the shell structure 1 of the propulsion unit, as is illustrated in the figures.

The closed gas circulation cooling system 12 is preferably, but not necessarily, arranged at least partly enclosed by the shell structure 1 of the propulsion unit. The closed gas circulation cooling system 12 is more preferably, but not necessarily, arranged fully enclosed by the shell structure 1 of the propulsion unit, as is illustrated in the figures.

The gas-liquid-heat exchanger 17 is preferably, but not necessarily, arranged at least partly enclosed by the shell structure 1 of the propulsion unit. The gas-liquid-heat exchanger 17 is more preferably, but not necessarily, arranged fully enclosed by the shell structure 1 of the propulsion unit, as is illustrated in the figures.

The closed liquid cooling system 15 is preferably, but not necessarily,