WO 2005/044657 discloses a device for cleaning under-water surfaces, such as ships' hulls. The device comprises a rotary disc having nozzles for discharging pressurized liquid against the surface to be cleaned. The nozzles are mounted obliquely in relation to the rotational axis of the rotary disc and are arranged to be supplied with pressurized liquid through a hollow spindle that is concentric with the rotational axis.

The state of the art also includes remotely operated vehicles (commonly referred to as an ROV) for carrying hull cleaning devices. One example is disclosed by KR 2008/0093536 A, describing an underwater robot for cleaning and inspecting a ship hull. The robot comprises wheels for rolling on the submerged hull, vertical/horizontal thrusters to induce movement in the vertical and horizontal directions, and a water jet spraying device. The robot wheels are driven by motor, whereby the robot is driven along the ship hull. The robot is remotely controlled from a console (above water), via an umbilical cable.

Another example of an ROV-carried hull cleaning device is disclosed by US 4 462 328, describing a carriage with wheels for travelling along the ship hull and having a plurality of cleaning nozzles and a reactor nozzle aligned to produce a reactive force which opposed the force component of the cleaning nozzles which tends to urge the carriage away from the hull of a ship.

It is an object of this invention to provide cleaning device and vehicle which is more efficient and simpler to operate that those of the prior art.

Summary of the invention

The invention is set forth and characterized in the main claims, while the dependent claims describe other characteristics of the invention.

According to an embodiment, there is~~It is thus~~ provided a device for cleaning of surfaces submerged in water, comprising a disk member rotatably supported by a spindle and configured for rotation about a rotational axis by drive means; said disk member having a first side which is facing said surface when the device is in use, and a second side facing away from the surface, and where the disk member further comprises a plurality of nozzles for discharging liquid under pressure against the surface to be cleaned; said nozzles being fluidly connected to a liquid reservoir via a first conduit in the disk member and a second conduit in the spindle, characterized in that the disk member comprises a plurality of through holes, spaced at regular intervals and arranged symmetrically with respect to the rotational axis.

In one embodiment, a plurality of ridges is arranged at regular intervals on the first side and extending radially. Preferably, successive ridges alternating extend to a respective one of said through holes and between adjacent through holes. The height

of each ridge is in one embodiment decreasing radially, from a maximum height near the disk central portion, to a minimum height in a disk peripheral portion.

In one embodiment, the first side comprises a concave portion, symmetrically with the rotational axis. The through holes are preferably circular and have in one embodiment bores that are substantially parallel with the disk rotational axis. In another embodiment, the bores are slant with respect to the disk rotational axis. In a further embodiment, each through hole further comprises a vane rotatably supported in the hole and arranged radially in the disk member.

The nozzles are arranged at regular intervals around the disk member periphery and arranged for discharging liquid in a radial direction and towards the surface to be cleaned.

The second conduit in the spindle is preferably concentric with the rotational axis, and the disk member is rotatably supported in a housing, thus defining a cavity between the second side and the housing interior. The housing comprises at least one liquid discharge opening.

In a preferred embodiment, the drive means is configured for rotating the disk member at a speed in the range 200 rpm to 800 rpm, and, when the device is in operation, liquid is supplied to the nozzles at a pressure in the range of 50 bar to 450 bar.

According to another embodiment, there is~~It is also~~ provided a cleaning apparatus, characterized by a plurality of cleaning devices as described herein~~according to the invention~~, each cleaning device being connected to a central unit comprising at least one liquid intake opening and a liquid return opening; each liquid intake opening being fluidly connected to a respective liquid discharge opening; and the liquid return opening being fluidly connected to a liquid reservoir. The cleaning devices are preferably connected via hinge means to respective side faces of the central unit, and the central unit further comprises a pump means which is fluidly connected to the at least one liquid intake openings and to the liquid return opening.

Each of the cleaning devices preferably comprises rotatable support means arranged and configured for supporting each of the cleaning devices a distance from the surface to be cleaned. In one embodiment, the distance is approximately 12 millimetres.

According to an aspect of the invention, there is provided a remotely operated underwater vehicle for carrying cleaning devices for cleaning of surfaces submerged in water, the ~~It is also provided an~~ underwater vehicle~~,~~ having a roll axis (x), a pitch axis (y), and a yaw axis (z), all of said axes intersecting the vehicle's centre of gravity; the vehicle comprising a first side, a second side, propulsion means, at least one pair of trimming means, a first buoyancy means attached to the first side and a second buoyancy means attached to the second side, wherein the elements of each pair of trimming means are arranged on opposite sides of the centre of gravity (CG) and ~~propulsion means and buoyancy means, characterized by at least one pair of trimming means, where the elements of each pair are arranged on opposite sides of the centre of gravity;~~ each said trimming means comprising a

movable mass and a displacement region into which the mass can move, whereby the trimming means' individual centre of gravity is automatically shifted due to gravity and inertia when the vehicle is accelerating or changes its orientation in the water. The first buoyancy means provides more buoyancy than the second buoyancy means such that the centre of buoyancy is located above the centre of gravity (CG) irrespective of the orientation and attitude of the underwater vehicle.

In one embodiment, the trimming means of the first pair are arranged in a plane which is parallel with the vehicle's y-z plane, and a distance away from the centre of gravity; and the trimming means of the second pair are arranged in the x-y plane and along the x axis.

In one embodiment, first buoyancy means are arranged on a first external side of the vehicle and second buoyancy means are arranged on a second external side of the vehicle, on the opposite side of side first side.

In one embodiment, each of the trimming means comprise closed and mutually isolated compartments, each such compartment being partly filled with a substance having a specific gravity greater than one. The substance may comprise a liquid, such as mercury, or a powder.

In a preferred embodiment, each trimming means comprise a sealed and isolated compartment. In one embodiment, the first trimming means comprise tubular elements, each element extending substantially the width of the vehicle.

In one embodiment, each first trimming means comprises two slanted regions interconnected by a level central region. In one embodiment, the displacement region is in the slanted region.

The first trimming means are in one embodiment arranged in region of the second buoyancy means, and the second trimming means are arranged on opposite sides of the centre of gravity and concentric with the x axis.

The underwater vehicle is preferably a neutrally buoyant ROV and is configured for carrying and operating at least one cleaning device according to the invention, or a cleaning apparatus according to the invention.

The skilled person will understand that movable weights constitute an equivalent variant of the trim tanks described above. That each, the liquid or powder filled trim tanks may be replaced by astable and movable trim weights that are configured to move a predetermined distance.

Brief description of the drawings

These and other characteristics of the invention will be clear from the following description of a preferential form of embodiment, given as a non-restrictive example, with reference to the attached drawings wherein: