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ARRAY SYSTEM FOR SUPERCAVITATING HYDROFOILS

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT (1) THOMAS J. GIESEKE, (2) ROBERT KUKLINSKI, (3) ABRAHAM N. VARGHESE, and (4) JOHN R. GRANT, citizens of the United States of America, employees of the United States Government, resident of (1) Newport, County of Newport, State of Rhode Island, (2) Portsmouth, County of Newport, State of Rhode Island, (3) Wakefield, County of Washington, State of Rhode Island and (4) Jamestown, County of Newport, State of Rhode Island, have invented certain new and useful improvements entitled as set forth above of which the following is a specification.

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ARRAY SYSTEM FOR SUPERCAVITATING HYDROFOILS

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to a sonar system which utilizes a gaseous cavity to eliminate hydrodynamic noise associated with turbulent boundary layers and turbulent wakes. More specifically the present invention relates to a sonar system that can be utilized on a hydrofoil marine vessel.

(2) Description of the Prior Art

Marine operators would like to operate high-frequency sonar systems from high speed surface craft. These craft can operate at speeds exceeding 30 knots, but they produce bubbly wakes (high frequency noise source), have noisy propulsors, and have noisy appendages. Sonar systems towed in or operating near
their wakes are adversely affected by this generation of
their wakes are adversely affected by this generation of
background noise, thus limiting their effective detection range.
A similar problem exists for very fast transport ships.
Some futuristic concepts have been proposed which operate at
speeds up to and exceeding 100 knots. The ability of these
ships to maneuver at very high speeds is limited. Consequently,
the ability to detect obstacles at significant range increases
the ability of these craft to avoid collisions with marine
mammals, mines, and debris.

Sonar systems towed at very high speeds are affected by
several noise sources which may be controllable. The turbulent
flow of water over the streamlined fairing of an array generates
pressure fluctuations on the fairing. Both turbulent boundary
layers and turbulent wakes contribute to this type of structural
excitation. The pressure fluctuations can be experienced
directly on the array when the flow over the array is turbulent,
or indirectly as pressure fluctuations away from the sensor face
are transmitted through the structure to the array. Fluctuating
cavitation bubbles and collapsing vapor bubbles can also produce
large structural excitations. The best way to minimize these
types of hydrodynamic noise is to maintain laminar flow over the
array face and to physically isolate the array face from
portions of the structure experiencing large pressure
fluctuations.
The vessel propulsion system produces a large amount of noise. Components of this noise include blade tonals, cavitation bubbles, and entrained air which produce noise that can propagate through the environment to the array. Similarly, breaking bow waves, hull slapping, ship machinery noise, and other ship related noise sources can reach the array through the environment. Isolating the array from these sources by eliminating the direct acoustic path between the source and the array would greatly improve the array performance.

A mechanical path from the noise source through the array supporting structure can create another acoustic problem for the array. However, mechanical isolation techniques are advanced and can minimize these effects.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a sonar system having a forward looking sonar array which is isolated from own-ship and wake noise.

It is a further object of the present invention to provide a sonar system which minimizes hydrodynamic noise resulting from turbulent pressure fluctuations.

It is still another object of the present invention to provide a sonar system of the present invention in a high speed marine vessel.
The foregoing objects are attained by the sonar system of
the present invention.

In accordance with the present invention, a sonar system
broadly comprises a forward looking array which is embedded in a
cavitator. The cavitator generates a gaseous cavity that
minimizes hydrodynamic noise resulting from turbulent pressure
fluctuations.

As incorporated with a marine vessel, the present invention
broadly comprises a hull, a hydrofoil suspended beneath the hull
by a strut, and means for generating a laminar flow over said
hydrofoil and for creating a cavity. The laminar flow
generating and cavity creating means is located at a leading
edge area of the hydrofoil. The sonar array is embedded in the
laminar flow generating and cavity creating means.

Other details of the array system for supercavitating
hydrofoils of the present invention, as well as other objects
and advantages attendant thereto, are set forth in the following
detailed description and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of a marine vessel incorporating the
sonar system of the present invention;

FIG. 2 is a perspective view of a hydrofoil attached to the
marine vessel of FIG. 1;
FIG. 3 is a cross section of a strut which supports the
hydrofoil of FIG. 2; and

FIG. 4 is a cross section of the hydrofoil of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

A sonar array system for use on marine vessels having
supercavitating hydrofoils is provided by the present invention.
The sonar array system utilizes a gaseous cavity formed in the
wake of a cavitator instrumented with forward looking sonar
array elements.

FIGS. 1 and 2 illustrate the basic concept of the present
invention. As shown in FIG. 1, a marine vessel 1 has a hull 10
with front and rear hydrofoils 2 and 12 attached to the hull 10
by front and rear struts 4 and 14.

In accordance with the present invention, a cavitator 16 is
attached to the leading edge 18 of the front hydrofoil 2 and/or
the strut 4. Sonar arrays 3 are also positioned on the leading
glede 18 of the front hydrofoil 2 and strut 4. The cavitators 16
cause a cavitation induced vapor bubble 6 to form in the wake of
each cavitator 16. Sonar array 3 is positioned to be in liquid
portion in front of the vapor bubble 6. Each cavitator 16 may
be a simple flat plate arranged normal to the flow of water over
the hydrofoil 2. Alternatively, each cavitator 16 may be shaped
like a disc, a cone, or a hemisphere, or have a streamlined
shape. Each cavitator 16 may be axisymmetric or largely two
dimensional. Each cavitator 16 preferably is arranged to
maintain a laminar flow over the entire surface of the hydrofoil
2 and/or the surfaces of the strut 4 until the flow separates at
the base of the respective hydrofoil and/or strut.

The sonar array 3 may be formed by a plurality of sonar
array elements incorporated or embedded into a front surface of
the cavitator 16. A communication means (not shown) can
transfer received acoustic signals from arrays 3 up through
strut 4 to sonar equipment aboard vessel 1. Care must be taken
to guarantee that the flow over the array face is laminar. If
the flow becomes turbulent prior to separation, significant edge
noise may be generated at the separation point of the array. In
a preferred embodiment of the present invention, the sonar array
elements are forward looking sonar array elements. The sonar
array elements are embedded with sufficient density and number
to enable forward looking acoustic beams.

In accordance with the present invention, the hydrofoil 2
and the strut 4 are each provided with a ventilation system 5.
Each ventilation system 5 has one or more discharge nozzles 20
for discharging a gas or vapor in a quantity sufficient to
create a gaseous cavity. For example, as shown in FIG. 4, one
or more nozzles 20 may be incorporated into an upper surface 26
of the hydrofoil 2. Further, as shown in FIG. 3, one or more
nozzles 20 may be incorporated into each of two opposed strut
surfaces 28 and 30. The ventilation system 5 further includes a
source of gas or vapor (not shown) and suitable ducting (not
shown) for delivering the gas or vapor from the source to each
of the nozzles 20. This cavity envelops the supporting
structure and all equipment downstream of each cavitator 16. By
maintaining laminar flow over each sonar array 3 and eliminating
all turbulent boundary layers and attached wakes, the
hydrodynamic excitation is eliminated. A baffling effect is
also realized by creating a vapor shield between each sonar
array 3 and any acoustic sources aft of the array such as a ship
propulsor.

The marine vessel 1 is preferably a high speed surface
ship. The sonar system operation relies at least in part upon
the ship speed to enable generation of the gaseous cavity. A
ventilation system can also be used to enhance or form this
cavity.

The support strut 4 is preferably a cavitating support
strut. As shown in FIG. 3, the strut 4 may be streamlined to
minimize drag and noise production. The shielding effects of
the gas bubble and mechanical isolation reduce the impact of the
strut generated noise. The support strut 4 contains ventilation
ducting (not shown) and the signal and communication means (not
shown) to each array 3. If desired, the strut 4 may be
extendable to increase the stand-off between each array 3 and
the hull 10 and to enable complete retraction of the system into
the marine vessel 1. Any suitable means known in the art may be
used to extend and/or retract the strut 4.

As can be seen from the FIGS 1-4, to enable the formation
of a suitable size cavity 6, gas is pumped through the nozzles
20 in the strut 4 to the area just aft of each cavitator 16.
Gas injection increases the size of the gaseous sheet for a
given size cavitator. Significant ventilation rates may be
required to generate large cavities at modest ship speeds.
Preferably, each cavity 6 is inflated to envelop the entire
support strut 4 and hydrofoil 2. The gas bubble which is formed
aft of each cavitator 16, as a result of the injected air,
eliminates contact of turbulent flow with the structure
containing the sonar array 3.

With the gaseous sheet created and mechanical isolation
incorporated, the direct paths between the ship noise sources
and each array 3 are reduced, especially sources aft of the
array system. The noise produced by the cavity and each
cavitator are minimal because the flow separating from each
cavitator is laminar (no fluctuating edge forces) and the cavity
closes as large gas bubbles.

The sonar array system of the present invention minimizes
the effects of hydrodynamically excited noise and reduces the
acoustic and structural path between significant own ship noise
sources. This enables very high speed ship operations with low
array noise.

If desired, the ship hull 10 can be partially wetted, using
the hydrofoil lift to reduce the displaced volume of the vessel.
Further, the pressure side of the hydrofoil can be fully
instrumented to provide increased array area.

It is apparent that there has been provided in accordance
with the present invention an array system for supercavitating
hydrofoils which fully satisfies the objects, means, and
advantages set forth hereinbefore. While the present invention
has been described in the context of specific embodiments
thereof, other alternatives, modifications, and variations will
become apparent to those skilled in the art having read the
foregoing description. Accordingly, it is intended to embrace
those alternatives, modifications, and variations as fall within
the broad scope of the appended claims.
ARRAY SYSTEM FOR SUPERCAVITATING HYDROFOILS

ABSTRACT OF THE DISCLOSURE

A sonar system includes a forward looking array which is embedded in a cavitator for generating a gaseous cavity which minimizes hydrodynamic noise resulting from turbulent pressure fluctuations. A marine vessel incorporating the sonar system includes a hull, a hydrofoil suspended beneath the hull by a strut, and a cavitator for generating a laminar flow over the hydrofoil and for creating a cavity for eliminating turbulent flow contact. The cavitator is located at a leading edge area of the hydrofoil. The sonar array is embedded into the cavitator.