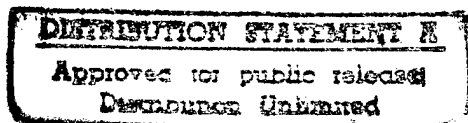


Serial No. 655,102
Filing Date 29 May 1996
Inventor Thomas R. Floyd
David M. Fedeli

NOTICE

The above identified patent application is available for licensing. Requests for information should be addressed to:



OFFICE OF NAVAL RESEARCH
DEPARTMENT OF THE NAVY
CODE OCCC3
ARLINGTON VA 22217-5660

19961127 039

2
3 SUPPORT BASE FOR SUBMARINE ANTENNA MAST

4
5 STATEMENT OF GOVERNMENT INTEREST

6 The invention described herein may be manufactured and used
7 by or for the government of the United States of America for
8 governmental purposes without the payment of any royalties
9 thereon or therefore.

10
11 BACKGROUND OF THE INVENTION

12 (1) Field of the Invention

13 The present invention relates to submarine antennas, and
14 deals more specifically with a cooling system provided in a
15 support base for such an antenna to allow cooling of heat
16 generating components in the antenna circuitry.

17 (2) Description of the Prior Art

18 Submarine antennas are used for communication and navigation
19 purposes, and typically several different types of antennas are
20 incorporated in a single mast which is affixed at its base to the
21 submarine. See, for example, U.S. Patent No. 4,030,100 issued to
22 Perrotti. Multi-purpose antennas provided in a single mast of
23 tear drop cross section are also shown in the prior art. See for

1 example, U.S. Patent Nos. 3,999,185 and 3,999,186 issued to
2 Polgar, Jr. et al. and Majkrzak et al., respectively.

3 Present day submarine antenna systems capable of high data
4 rates of production and processing require components which
5 typically generate considerable heat, particularly those antenna
6 systems capable of transmitting or receiving high frequency
7 electromagnetic energy. The electronic components are typically
8 located within the submarine such that the onboard electronics
9 can be water or forced air cooled within the submarine. However,
10 cabling necessary to transmit signals between the antenna and the
11 onboard electronics exhibit unacceptable losses in signal
12 strength. This situation has led to the need for locating at
13 least some of the electronics and other data converting and
14 amplification components in the antenna itself. The heat
15 generated by certain components of submarine antenna systems can
16 however limit use of the submarine's communication and navigation
17 systems if heat generated within the antenna cannot be
18 efficiently dissipated. The composite materials commonly used in
19 the construction of the antenna mast exhibit poor heat
20 conductivity and are adopted more for efficient size to strength
21 ratio than for heat transfer characteristics. Withdrawing heat
22 from the mast can therefor be difficult. Changing the material
23 of the mast itself is not practical due to the requirements for

1 the mast to be light in weight, small in cross sectional
2 configuration, and yet remain capable of withstanding the rigors
3 of wave action and the speed requirements of the submarine.

4 In order to avoid the operational limitations dictated by
5 the relatively slow process of natural cooling in such a
6 composite antenna, and to provide for more extended periods of
7 use for these submarine systems, especially when the antenna is
8 not immersed in sea water, but extends upwardly into the
9 atmosphere, some form of liquid or heat exchange system would
10 seem to be appropriate. See for example, U.S. Patent No.
11 4,851,856 to Altoz, wherein an electronically steerable microwave
12 antenna is cooled by pumping a cooling fluid between the
13 individual transmit/receive modules through elongated hoses from
14 a remote location or source of cooled fluid.

15 Altoz would suggest that fluid cooling lines or hoses must
16 be provided from an onboard source of cooled fluid to carry off
17 the excess heat generated in present day submarine antenna
18 systems having amplification and data converting components of
19 its antenna circuitry provided at the antenna itself. However,
20 such a cooling system would require that fluid connections be
21 provided through the pressure hull of the submarine, and could
22 conceivably lead as well to excessive noise being generated.
23 Noise is necessarily a situation that cannot be tolerated aboard

1 a tactical submarine as excessive noise will limit a submarine's
2 operational capability and interfere with the submarine's ability
3 to carry out its assigned mission.

4
5 SUMMARY OF THE INVENTION

6 Accordingly, it is the chief object of the present invention
7 to provide an effective heat exchange capability entirely within
8 the confines of the antenna mast structure.

9 It is another object of the heat exchanger of the present
10 invention to provide adequate support to the mast structure. A
11 further object is that the heat exchanger provide a passageway or
12 conduit from the submarine to electronics components within the
13 mast structure. A still further object is that the heat
14 exchanger maintain the watertight integrity of the mast.

15 These and other objects are accomplished by locating a heat
16 exchanger at the support base of the mast, between the mast
17 structure and the faired mast, and taking advantage of the cool
18 sea water at this location adjacent the submarine itself in order
19 to cool the cooling fluid contained in a uniquely shaped
20 reservoir built into this support base for the antenna.

21 More specifically, the support base has an outer wall of
22 tear drop cross section that cooperates with an inner partition
23 assembly to define a convoluted or serpentine shaped series of

1 interconnected spiral loops. The warmed coolant fluid from the
2 antenna mast enters this reservoir at the outboard end of the
3 support base for the mast, and cool fluid leaves the reservoir at
4 a point near the inboard end of the support base. The support
5 base provides a structural surface for attaching the mast which
6 can support axial and bending loads from the mast. A conduit is
7 provided through the heat exchanger reservoir for passage of
8 electronic cables. An o-ring connection between the mast and the
9 support base provides a watertight connection. The connection of
10 the support base to the faired mast of the submarine maintains
11 the watertightness of the existing mast structure to faired mast
12 connection.

13
14 BRIEF DESCRIPTION OF THE DRAWINGS

15 A more complete understanding of the invention and many of
16 the attendant advantages thereto will be readily appreciated as
17 the same becomes better understood by reference to the following
18 detailed description when considered in conjunction with the
19 accompanying drawings wherein corresponding reference characters
20 indicate corresponding parts throughout the several views of the
21 drawings and wherein:

1 the mast structure 10, and in accordance with the present
2 invention, this cooling fluid is fed to and from a heat exchanger
3 16 within the mast support 12 through inlet and outlet ports
4 associated with the heat exchanger all as described in greater
5 detail hereinafter.

6 The mast support or base 12 may be fabricated in selected
7 lengths to handle various heat loads depending upon the cooling
8 requirements of the submarine systems which the heat exchanger
9 will service. Lower cooling needs dictate a shorter length heat
10 exchanger 16 while higher cooling loads require a somewhat longer
11 heat exchanger 16. The materials for heat exchanger 16 are
12 selected based upon their capability for conducting heat.
13 Beryllium, copper or other heat conductive metals are the
14 presently preferred materials for fabricating the mast support
15 12.

16 Referring now additionally to FIG. 2 and FIG. 3, an internal
17 fluid passageway is provided in the heat exchanger 16 through
18 which cooling fluid can be circulated to the mast, and more
19 particularly to the components therein which require cooling.
20 Preferably, and as best shown in FIG. 2, this internal fluid
21 passageway is more particularly defined by an internal partition
22 means 20 that is spaced inwardly of the outer wall portion 22 of
23 heat exchanger 16. This internal partition means 20 further

1 includes axially-spaced and inclined convoluted walls 24 that
2 cooperate with one another to define serpentine shaped passageway
3 18 that is advantageously defined on one side by the outer wall
4 22 of the mast support 12, and on the other side by the partition
5 wall 20. An opening (not shown) is provided in partition wall 20
6 such that passageway 18 is in fluid communication with reservoir
7 26. Reservoir 26 is defined by the interior surface of partition
8 wall 20 and serves to contain the cooling fluid. The reservoir
9 26 and passageway 18 define an efficient heat exchanger capable
10 of cooling the fluid that has been heated by the components
11 within the mast 10. Because it is intended that heat from the
12 cooling fluid be carried through outer wall 22 into the
13 surrounding medium, partition means 20 is preferably fabricated
14 from a stainless steel or other material of equivalent low heat
15 conductivity. In this way, undesirable heat transfer through
16 partition wall 20 to the fluid in reservoir 26 is minimized.

17 Inlet and outlet ports are provided in the mast support
18 structure as indicated generally at 28 and 30, respectively, so
19 as to provide a convenient means for fluidly connecting heat
20 exchanger 16 to the various lines (not shown) that circulate the
21 cooling fluid to and from the components requiring heat
22 extraction. Preferably, and as shown in FIG. 2, the reservoir
23 inlet and outlet ports 28 and 30 are located adjacent the upper

1 section 32 of the mast support 12 and the base 34, respectively,
2 to ensure that the warm cooling fluid returned to the reservoir
3 is not located adjacent the cooled fluid leaving the reservoir.

4 As so constructed and arranged, the serpentine passageway 18
5 can be more particularly described as comprising a convoluted
6 series of interconnected spiral loops, each of distorted shape,
7 so as to fit within the confines of the faired tear drop shaped
8 mast support 12. This faired tear dropped shape is shown in FIG.
9 3. The cross section shows a relatively large radius of
10 curvature at the leading edge and a smaller radius of curvature
11 at the trailing edge, and with relatively straight sides provided
12 tangent to these leading end trailing edge radii in order to
13 assure minimum drag of the mast 10 and support 12 as they travel
14 through the sea. The tear drop shape also assures a relatively
15 large heat exchange area for the cooling fluid. Thus, the
16 relatively low temperature of sea water surrounding the mast 10
17 generally can be used to take away the heat absorbed by the
18 cooling fluid through the heat conductive metal outer wall
19 portion 22 of the heat exchanger 16.

20 With reference to FIG. 3, the tear drop shaped mast cross
21 section is further characterized by an axially extending conduit
22 36 which is located generally at the center of the leading edge
23 radius of the mast support 12. This conduit provides a path for

1 cables or conductive leads that interconnect the circuitry
2 contained in the antenna mast 10 with the onboard equipment
3 within the submarine (not shown).

4 In summary, the mast support or base 12 provides a
5 convenient attachment point for the mast antenna system 10.
6 Since under normal operating conditions, the faired mast 14 is
7 always submerged, attachment of the heat exchanger 16 of base 12
8 at this location provides maximum cooling for the components in
9 the mast system. Although these heat generating components may
10 be located well above the sea surface, they are nevertheless
11 cooled efficiently by the unique mast base 12 with its associated
12 heat exchanger 16.

13 The mast support or base 12 not only affords a structure
14 that serves as a heat exchanger, but such structure also affords
15 electrical connections, through conduit 36, to provide power,
16 radio frequency signals, and other signals to and from the
17 electronic components required in the mast antenna 10. Conduit
18 36 provides a dry path to and from the electronics within the
19 mast 10. This conduit may be brazed or welded to the tank base
20 34 and to the upper section 32 of the mast support 12.

21 As shown clearly on FIG. 2, upper section 32 is fitted to
22 the composite mast structure 10. This upper section 32 performs
23 a variety of functions including that which allows the mast

1 antenna structure 10 to be attached to the support 12. Screws 38
2 are provided in the mast 10 so as to be received into the boss 40
3 defined by this upper section 32. An O-ring 42 may also be
4 provided to maintain water tight integrity for the interior of
5 the mast structure 10. The mast structure 10 rests on a flat
6 surface 44 just above the outer wall 22 of the heat exchange
7 portion 16 of the mast support 12. This configuration allows the
8 weight of the mast 10 and also hydro-static pressure forces to be
9 transferred to the outer wall 22 of the support 12 instead of
10 being transmitted to the mounting screws 38. The upper section
11 32 is long enough so that the walls 22 take all the bending
12 loads. Finally, the upper section 32 also serves as a structural
13 support for the internal mast components themselves. This allows
14 ready access for disassembly and assembly of the mast structure
15 10 by removing the support 12 from the mast 10. Inlet and outlet
16 coolant ports 28 and 30 pass through upper section 32 as shown.

17 In operation, coolant fluid flows from the inlet port 28,
18 through distorted spiral passageway 18, to the base 34 of the
19 heat exchanger 16 and into reservoir 26. The stainless steel
20 inner wall 20 acts as a heat insulator between passageway 18 and
21 reservoir 26 because stainless steel does not conduct heat
22 readily. The coolant in the internal reservoir 26 can thus be
23 held at a proper temperature to serve as the source of cooling

1 fluid for electronic components within mast 10. Using this
2 cooling fluid to maintain electronic components at reduced
3 temperatures allows for reduced power to be expended during
4 operational situations when the mast is raised completely out of
5 the water or when the submarine is dock side.

6 The heat exchanger 16 is designed to be easily assembled,
7 such as by welding or brazing of the various metal components
8 including the conduit 36 fitted to the base 34 as shown. The
9 base 34 is welded to the outer wall 22, and the partition wall
10 20, with inclined walls 24 attached, is connected to the upper
11 section 32 with inlet cooling port 28 welded to the partition
12 wall 20. Outlet port 30 is welded to the upper section 32.
13 Upper section 32 with its tank partition wall 20 and inclined
14 wall 24 is then lowered into the outer wall 22 where a final weld
15 46 completes the construction of the support 12.

16 The mast support 12 described above supports the mast 10,
17 which has internal cooling fluid lines conventionally provided
18 therein to carry cooling fluid to and from the various heat
19 generating components inside the mast 10. A conventional pump
20 (not shown) may be provided in the mast to provide the desired
21 flow of cooling fluid between the mast 10 and the ports 28 and 30
22 at the mast support 12.

1 Navy Case No. 77339

2
3 SUPPORT BASE FOR SUBMARINE ANTENNA MAST

4
5 ABSTRACT OF THE DISCLOSURE

6 A support base fabricated with a heat exchanger for use in
7 supporting an antenna mast which contains heat generating
8 electronic components. The base is attached to the faired mast
9 of a submarine and the mast structure is attached to the support
10 base. A cooling fluid is circulated through passageways within
11 the mast adjacent to the electronic components to remove excess
12 heat. The passageways are connected to the heat exchanger within
13 the base. The heat exchanger consists of heat conductive
14 exterior outer walls and an internal partition spaced inwardly
15 from the outer wall forming a reservoir on the interior of the
16 partition. The heated cooling fluid circulates through a
17 serpentine passageway formed between the outer wall and the inner
18 partition. Heat is dissipated through the outer wall into the
19 surrounding medium. The passageway opens into the reservoir
20 where the cooled fluid is returned to the electronic components.
21 A watertight conduit is placed within the support for the passage
22 of wiring to the electronic components. The seal between the
23 mast and the support is also made watertight.

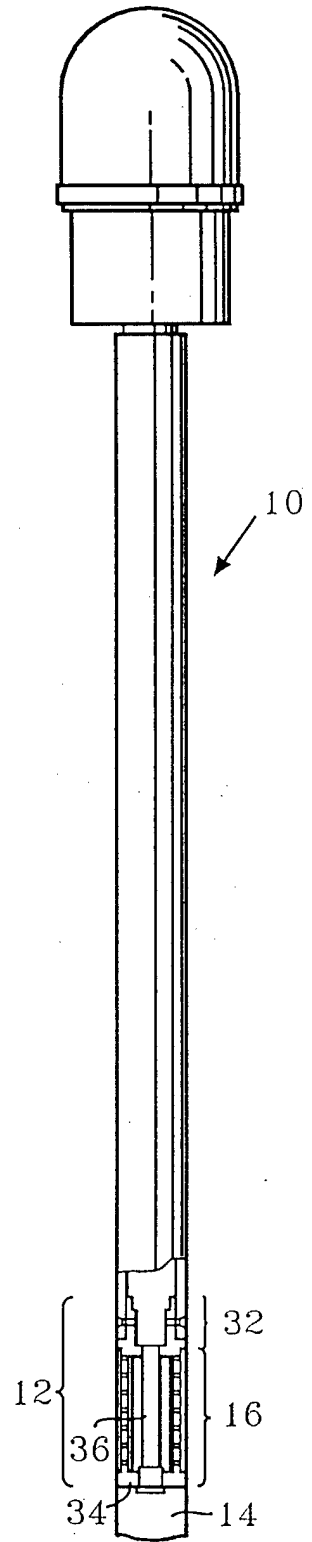


FIG. 1

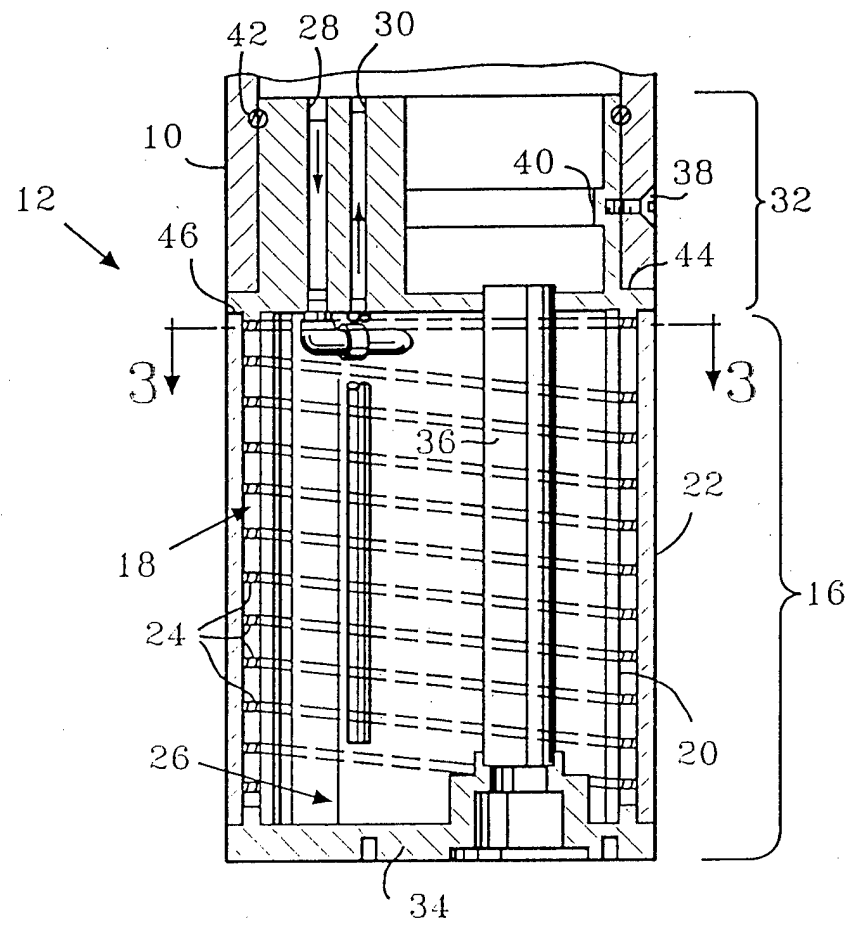


FIG. 2

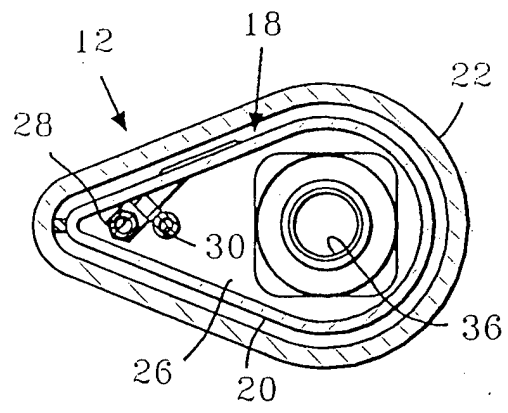


FIG. 3