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1 Navy Case No. 77914

2
3 STANDARDIZED MODULAR ANTENNA SYSTEM

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 payment of any royalties thereon
9 or therefor.

10
11 BACKGROUND OF THE INVENTION

12 (1) Field of the Invention

13 The present invention relates to a novel construction for
14 an antenna system used with submarines. More particularly, the
15 invention relates to a multifunction submarine mast antenna
16 system where each individual antenna within the system is
17 quickly and easily replaced by the same or a dissimilar antenna.

18 (2) Description of the Prior Art

19 Communications among submarine fleets are becoming
20 increasingly more sophisticated. As new communication
21 requirements have been added, new antenna systems have been
22 developed from scratch to accommodate the hardware associated
23 with emerging technologies. New antenna systems must be
24 integrated with existing equipment on board the submarine and
25 environmentally tested.

1 Replacing a single antenna element in a mast antenna system
2 is a tedious and time consuming task which requires great skill.
3 Even if installed correctly, a new component in a mast antenna
4 system may interact differently with the rest of the components
5 in the system and adversely affect overall performance.
6 Connector changes, wire movement, human error or any other
7 factor may also affect overall performance of the antenna
8 system. Repairing an improper replacement of parts to restore
9 proper performance is costly in terms of time and money. Thus,
10 some mast antenna systems are cumbersome and undesirable in that
11 they require extensive hardware design for even simple
12 modifications.

13 In some antenna systems, antenna modules of a fixed type
14 are used, however, one may only replace such modules with the
15 same type of module. For example, a UHF antenna may be replaced
16 only by another UHF antenna. This is not desirable when
17 different antennas are needed, when a change in the
18 configuration of the antenna system is desired, or when more
19 sophisticated antennas replace the need for existing ones.

20 In yet other antenna systems, once the antenna modules are
21 developed and installed, the inner mast structure must remain
22 fixed until a hardware redesign is performed. Such prior
23 antennas are replete with shortcomings that detract from their
24 usefulness for uses as herein contemplated.

SUMMARY OF THE INVENTION

It is a general purpose and object of the present invention to provide a mast antenna system that allows individual antennas in the system to be easily and economically changed or replaced by the same or dissimilar antennae, such as replacing a UHF antenna with a VHF, SHF or HF antenna.

It is another object of the present invention to provide a mast antenna system that allows advances in antenna technology to be easily incorporated into an existing antenna mast without high development costs.

It is still another object of the present invention to provide a mast antenna system that can be customized to meet operational requirements as needed or that allows individual antennas to be moved around inside the mast as desired.

Another object of the present invention is to provide a mast antenna system that uses fiber optic cables to transmit signals between an antenna and a radio room inside a submarine.

It is another object of the present invention to provide a mast antenna system where each antenna has uniform connectors that allow mating between both similar and dissimilar antenna types.

The objects are accomplished with the invention which is directed to a standardized modular antenna system which generally comprises a protective, RF transparent radome, an antenna support backbone, antennas, an electronic module associated with each antenna which contains equipment necessary

1 to operate the antenna, electronic interface connectors, and a
2 means to attach each antenna to the antenna support backbone.
3 Each antenna has uniform mating connectors allowing connection
4 between antennas. Each antenna also is shaped to allow a
5 predetermined number of cables to pass therethrough.
6

7 BRIEF DESCRIPTION OF THE DRAWINGS

8 A more complete understanding of the invention and many of
9 the attendant advantages thereto will be readily appreciated as
10 the same becomes better understood by reference to the following
11 detailed description when considered in conjunction with the
12 accompanying drawings wherein:

13 FIG. 1 is a perspective view of the components of the
14 present invention;

15 FIG. 2 is an antenna module of the present invention;

16 FIG. 3 is a front view of an electronic interface connector
17 of the present invention; and

18 FIG. 4 is a side view of an electronic interface connector
19 of the present invention.
20

21 DESCRIPTION OF THE PREFERRED EMBODIMENT

22 The Standardized Modular Antenna System (SMAS) incorporates
23 a Signal Distribution System (SDS). A desired SDS is capable of
24 handling RF signals from 5 kHz to 18 GHz and is easily
25 reconfigurable, expandable and reliable. A combination SDS
26 incorporates point-to-point cabling (PPC) and fiber optics. The

1 combination is capable of feeding conventional, low frequency
2 antennas using PPC while fiber optic cables, through use of
3 electro-optical converters, send signals to the higher frequency
4 antennas operating at more than 200 MHZ. An advantage of PPC is
5 the ability to incorporate any type of antenna or feed system in
6 the mast. Where possible, electronic componentry found in
7 present radio rooms and masts may be used in new designs, such
8 as the SMAS.

9 Referring to FIG. 1, the Standardized Modular Antenna
10 System (SMAS) utilizes existing radomes to protect sensitive
11 inner electronics. A radome 12 is a protective, RF-transparent
12 "shell" that surrounds antennas in outboard mast antenna
13 systems. A large, one-piece radome, like that of the AN/BRA-34,
14 is generally made from fiberglass (G10 type), chosen for its
15 strength and its transparency to electromagnetic signals. The
16 shape of radome 12 is limited only by the space within the sail
17 compartment for a particular mast and the environmental systems
18 it must withstand.

19 Generally the following are contained within radome 12 and
20 comprise the antenna system: antennas having a modular design
21 and being sized to a multiple of a given length to facilitate
22 interchangeability; an electronic module associated with each
23 antenna; standard or uniform connectors common to each different
24 antenna; electronic interface connectors; and an antenna support
25 or "backbone" to carry the antennas.

1 The antenna support is a "backbone" that provides
2 structural support for the antennas. The antenna support
3 backbone 14 may be made of fiberglass. An electronic module 16
4 is associated with each antenna 18 and comprises the essential
5 electronics needed for that particular antenna such as
6 preamplifiers, amplifiers, relays, mixers and electro-optic
7 devices. Each antenna 18 mates with an electronic module 16 to
8 form a single antenna module. The antennas 18 and electronic
9 modules 16 are fastened to the antenna support backbone 14 by
10 any suitable fastening means 20 allowing easy disconnection and
11 reconnection, such as by snap-on connector or screw attachment.
12 The fastening means 20 for securing the modules to the antenna
13 support backbone 14 are preferably non-metallic and are
14 standard, thereby allowing any particular module to be placed at
15 any location along the antenna support backbone 14.

16 In one embodiment, the fastening means 20 are installed at
17 regular intervals along the antenna support backbone 14, such as
18 at intervals of 6 inches. In this fashion, each antenna module
19 mates with the antenna support backbone 14 in a manner analogous
20 to that described herein for the plug-in prongs 34 and the prong
21 inputs 36. One antenna module may utilize more than one
22 fastening means 20 depending on the length of the antenna module
23 and the spacing interval between fastening means 20. The
24 spacing interval preferably allows fastening of the most antenna
25 modules possible. Thus, the preferred antenna module has a
26 length that is an integer of the spacing interval.

1 Each antenna 18 suitable for use in the assembly is
2 designed to pass a fixed number of cables therethrough. As in
3 FIG. 1 and FIG. 2, each antenna module contains the same number
4 and type of through cables with standard connectors 22 thereby
5 facilitating connection of each type of module with an
6 electronic interface connector 23 which has connector inputs
7 22a. Each electronic interface connector 23 provides a means to
8 connect connectors 22 from adjacent antenna modules,
9 particularly if connectors 22 from adjacent antenna modules are
10 both male. Each electronic interface connector 23 is a
11 component of the SDS, thereby coupling or carrying the signal or
12 DC power carried by the PPC.

13 As in FIG. 3 and FIG. 4, each electronic interface
14 connector 23 has plug-in prongs 34 that may be inserted into
15 prong inputs 36 in the antenna support backbone 14. Prong
16 inputs 36 may be spaced along the antenna support backbone 14
17 approximately every 10 centimeters, which allows any module to
18 be placed, or replaced, anywhere on the antenna support backbone
19 14 where there is sufficient space.

20 Alternatively, electronic interface connector 23 may be
21 secured to antenna support backbone 14 using fastening means 20.
22 Preferably, the electronic interface connector 23 and the
23 electronic modules 16 are fastened to antenna support backbone
24 14 using identical means such as plug-in prongs 36 or fastening
25 means 20, thereby simplifying overall design by standardizing
26 all connections with the antenna support backbone 14.

1 Connectors 22 connect each adjacent antenna 18 via an
2 electronic interface connector 23. Preferred RF connectors 22
3 are "easy on/easy off" and must have high reliability. Suitable
4 RF connectors include SMA and Type-N design, and suitable fiber
5 optic connectors include the polarization-preserving ST design.
6 It is preferred that fiber optic cable is not carried through
7 each antenna so as to minimize insertion losses. For example, a
8 system of five antenna modules requires one electronic interface
9 connector 23 between each module, for a total of four electronic
10 interface connectors 23. If each electronic interface connector
11 23 had an insertion loss of 1 dB, there would be a 10 dB total
12 insertion loss. Thus, the preferred placement of fiber optic
13 cables is through a channel or slot in the antenna support
14 backbone 14.

15 A fiber optic cable runs from the base of the mast to each
16 of the antenna modules that require a fiber optic connection.
17 Insertion losses are limited to a maximum of 1 dB per
18 polarization-preserving ST connector. Preferred connection for
19 the fiber optic cable must preserve the polarization of the
20 light wave to keep insertion losses to a minimum.

21 Fiber optic cables are particularly useful in transmitting
22 RF signals between the radio room inside the submarine and an
23 antenna. Use of fiber optic cables allows random placement of
24 antenna modules inside the mast as well as extending the usable
25 frequency range to at least 18 Ghz (SHF). As technology
26 advances to create higher frequency electro-optic converters,

1 new antennas (i.e. greater than 40 GHz) may be used by simply
2 utilizing newly developed electro-optic converters in the
3 antenna modules.

4 Two RF paths are provided through each antenna 18 and
5 electronic module 16. RF cables are secured between each module
6 using N-type connectors. The two RF cables allow any antenna to
7 be placed anywhere within the mast and have direct access to an
8 RF path to the radio room. More RF lines are desirable, but the
9 number is limited by the size of the hull penetration. High
10 power RF cable, such as RG-217 type cable, passing through each
11 module should handle up to 1000 watts of power while a "medium"
12 power cable, such as RG-142, may carry up to 400 watts.

13 Cables 24 in the radome 12, including RF and DC types, are
14 passed through the approximate center of each antenna 18 and
15 electronic module 16. Such placement simplifies replacement and
16 maintenance of the modules.

17 Three "high" current/voltage DC wires are used to provide
18 enough DC power to the high power RF amplifiers 26 in the mast.
19 Each antenna 18 and electronic module 16 is assigned its own DC
20 power line as needed. As an example, in installing an SHF power
21 amplifier, approximately 10 amps of current is needed. Seven
22 "medium" power DC lines are provided with the connectors being
23 specified at approximately 7.0 amps. A ground path to seawater
24 is provided through each connector. This supplies a return path
25 for the DC power for each module.

1 The SDS design requires that RF power amplifiers 26 be
2 placed inside the mast. The number and type of amplifiers 26 is
3 determined by the communication link and the required antennas.
4 HF and VHF power amplifiers 26 can be located inboard because of
5 the DC power requirements, low transmission line losses, size
6 and Electro-Magnetic Interference (EMI) considerations. Higher
7 frequency RF amplifiers (i.e. >200 MHZ) are located within the
8 mast to reduce the transmission line loss. As an example, a UHF
9 amplifier may be located within the mast, such as a 100 watt
10 amplifier operating across the 225-400 MHZ frequency band with
11 35-dB of gain. The DC requirements may include 28 volts and up
12 to 10 amps of current.

13 Amplifiers 26 within the mast radome generate heat that
14 must be dissipated. The amplifiers 26 may be placed on cooling
15 plates 28 located at fixed areas within the SMAS. Where there
16 are cooling plates there are no modules. A desirable cooling
17 system has a dissipation capacity of 600 watts of power. The
18 preferred UHF amplifier will fit within the area having the
19 cooling plates.

20 As for a JTIDS/IFF/Cellular Phone Power Amplifier, the
21 requirements are driven by IFF. The specification for IFF is
22 1000 watts peak power transmitted with a 5% duty cycle at the
23 transmitter. Allowing for transmission line loss from a
24 transmitter in a radio room to the antenna in the mast, the
25 actual power received at the antenna is approximately 100 watts
26 peak.

1 If used, an SHF power amplifier should have at least 600
2 watts output and should be mounted on a cooling plate.

3 In passing optical signals to and from the submarine via
4 fiber optic cables, a connector is needed that can join at least
5 14 single-mode fiber optic cables while preserving the
6 polarization within the fiber optic cables.

7 The SMAS mast, based on anticipated Navy communications
8 requirements, requires 14 fiber optic channels, three 10-amp DC
9 lines, seven 5-amp DC lines and two RF coaxial lines to enter
10 the radome from outside the sail while preserving the
11 polarization of the optical signals. These lines pass through a
12 baseplate connector and must be accommodated by a hull
13 penetrator insert (HPI).

14 The baseplate 30 is connected to the antenna support
15 backbone 14. Antenna modules are replaced by separating the
16 baseplate 30 from the radome 12 and pulling the antenna support
17 backbone 14 and attached modules from the radome, thereby
18 allowing easy access to the modules. Once the antenna modules
19 have been reconfigured as desired, the antenna support backbone
20 14 is reinserted into the radome.

21 It is expected that problems with Electro-Magnetic
22 Interference (EMI) occur when a single communications mast is
23 expected to operate over a wide number of frequency bands
24 simultaneously. EMI may originate from one or more transmitting
25 antennas while attempting to receive on another communication
26 link on another frequency. The use of fiber optics alleviates

some problems, however shielding of electric components remains the best way to reduce EMI.

In operation, a controller 32 in the submarine controls the antennas used in the SMAS mast. The controller 32 switches in or out the desired antenna using relays built into each electronic module located between each antenna module. If a new antenna is added to the SMAS, a new PC card only need be placed in the onboard controller. The invention described herein creates the ability to add communication capability to a submarine without having to redesign an entire system. In order to add communication capability to the SMAS, one need only develop the antenna module and controller card and "plug" each into its respective location.

In light of the above, it is therefore understood that _____ the invention may be practiced otherwise than as specifically described.

1 Navy Case No. 77914

2
3 STANDARDIZED MODULAR ANTENNA SYSTEM

4 ABSTRACT OF THE DISCLOSURE

5 For use in a submarine, an easily reconfigurable mast
6 antenna system disposed within an RF transparent radome is
7 disclosed where modularly, interchangeably designed antenna of
8 the system are detachably attached to each other via an
9 electronic interface connector and to a carrier backbone. RF,
10 DC and fiber optic cables transmit signals to antennas operating
11 in the range of 5 kHz to 18 GHz.

FIG. 1

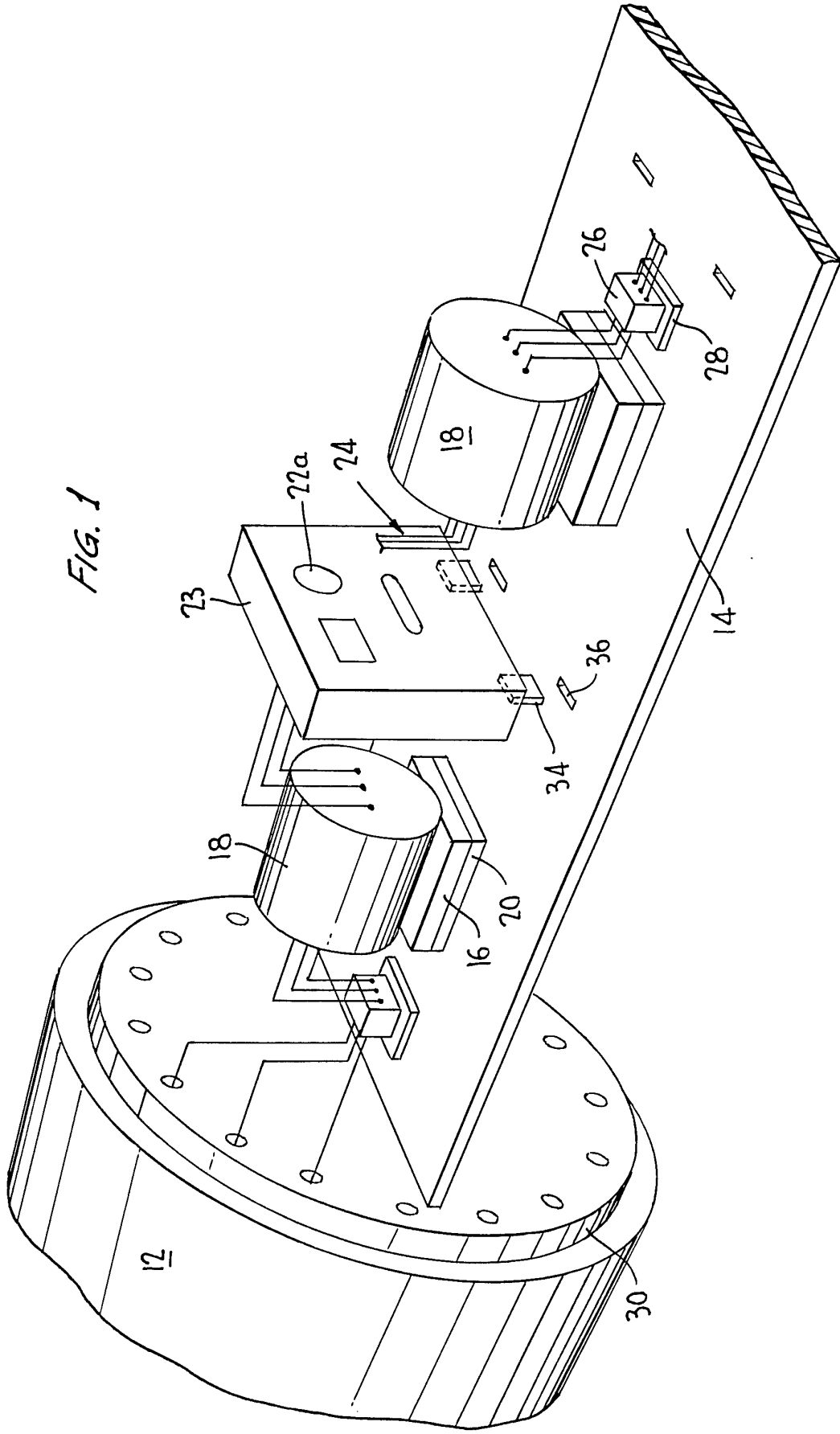


FIG. 2

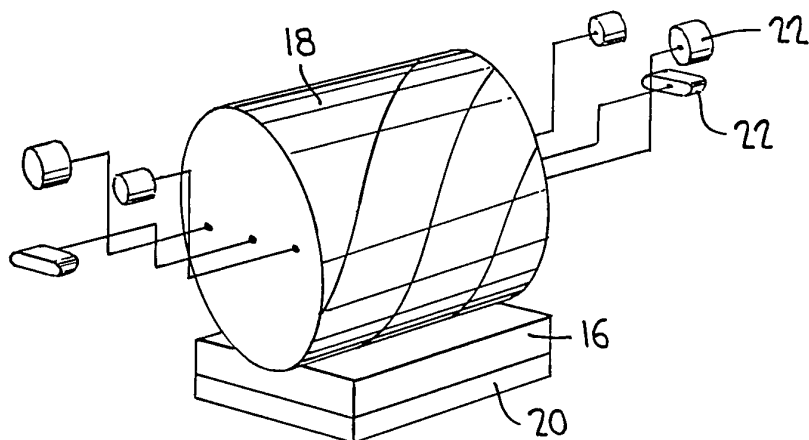


FIG. 3

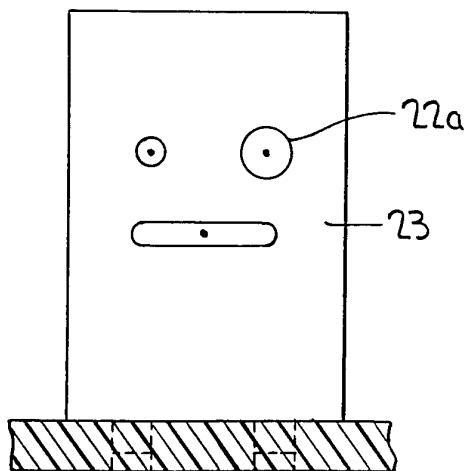


FIG. 4

