The Trend in Shipboard Antennas

The quality of communications aboard ship is determined to a great extent by antennas. The Navy has struggled with the shipboard antenna problem for years and has attained some degree of success, although persons who have never been face to face with the problem can scarcely appreciate its magnitude.

This article merely indicates the trend in shipboard antennas and describes a recent Navy application in the USS *Northampton* (ECLC-1) to improve the situation.

The accompanying figures illustrate rather clearly the antenna trend aboard ship. Figure 1 shows the USS *Marblehead* (CL-12) in 1924; figure 2, the same ship in 1942. Figure 3 is an illustration of the *Northampton,* commissioned in 1953.

The *Marblehead* as shown in figure 1 is typical of vessels in 1924. It gives a ready picture of how antenna efficiency was then obtained. Most vessels carried two tall, well-spaced masts. The height of the masts was limited by the clearance requirements of the Brooklyn Bridge. In many cases, the use of housable topmasts meant that masts could be even higher.

In 1924 antennas consisted of large flattops or cages carried on spreaders or yardarms. The spreaders were seldom less than 19 feet in length, often longer. Each flattop or cage consisted of at least six wires, so that antennas had very high effective capacitance or, in modern parlance, a high degree of top loading.

Lead-ins

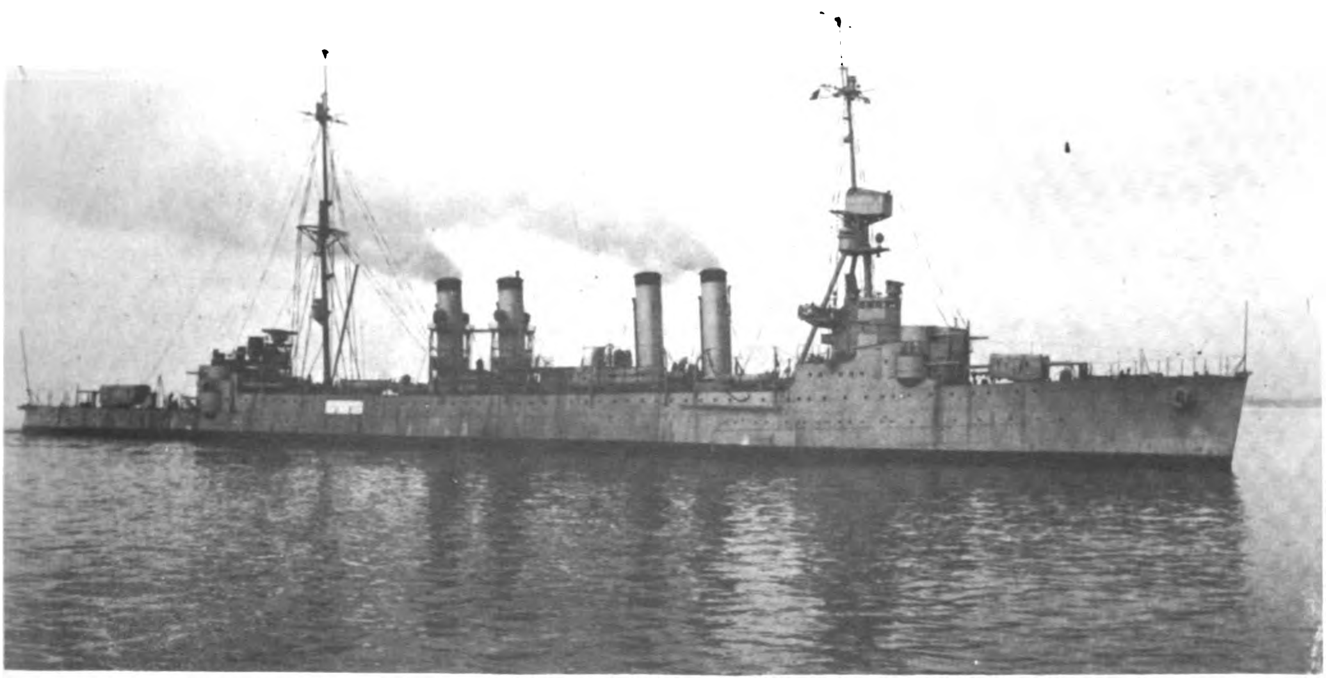
Lead-ins were kept well in the clear to minimize their capacitance. Although no record of accurate measurements can be found, the antennas must have had heights that were quite effective. When it was necessary to carry the antenna lead-in through or between decks, trunks of very large diameter were used.

Also, about 1924, the rigging in many vessels was completely broken up by insulators. In this manner the spacing between the antennas and the nearest grounded members of the vessels was increased further and the effective height was thus improved.

The *Marblehead* in 1942 (figure 2) is typical of vessels of that time. In 1942—

- The mainmast had disappeared, or at best, only a small stub mast remained.
- The spacing between the foremast or citadel and the main stub or other antenna support had been reduced.
- The height of the mainmast had been reduced by probably half.

Figure 1. USS Marblehead (CL-12), a typical cruiser of 1924, showing arrangement of masts and antennas to obtain maximum antenna efficiency.



• The number of necessary antennas had increased considerably.

• An 18-inch trunk for the main transmitter antenna was a problem. Even 9-inch trunks, although more common, were difficult to obtain.

Because of these conditions in 1942, practically all antennas consisted of a single wire supported among a maze of other antennas, superstructure, stacks, and grounded rigging. Effective height was rapidly decreasing.

In addition to the progressive decrease in the height of masts and other antenna-supporting structures in naval vessels, the superstructure was being continually raised. The raising of the superstructure caused a still further reduction in effective height of the antennas because the major part of the capacitance is between the antennas and the superstructure rather than between the antennas and the water.

Some of the trends have stopped. Today, designing the topside of a naval vessel is a cooperative task of the naval architect and the electronics engineer.

Work to solve the antenna problem started at the Naval Electronics Laboratory in San Diego in 1944 as the result of World War II experience. Until 1944, individual antennas had been designed and engineered in strict accordance with the operational requirements of their own associated equipments without too much regard for interaction.

The approach to the antenna system study was to test and measure antennas on operating ships. This slow, time-consuming procedure has been replaced by the testing of ship models and the use of scaled frequencies. A model range built about 1944 at the Naval Electronics Laboratory for that purpose is in constant use today.

Valid results are obtained from models if both ship size and wavelengths are scaled to the same value. The work can also be done for ships still in the preliminary design stage.

The antenna model range method was used by the Naval Research Laboratory and the Naval Electronics Laboratory in the command ship *Northampton*. Since many of the same antenna types and principles will undoubtedly be used for some time, her communications and antenna arrangements are of interest.

The *Northampton*, which is basically a heavy cruiser, was designed as a task force flagship.

The antenna arrangement on the *Northampton* is different from that of any other ship of the Navy. Because of the ship's command function, good communications were given top priority. Therefore, many compromises had to be worked out.

For example, blocking the line of fire of the forward guns was accepted so that antenna structures could be erected.

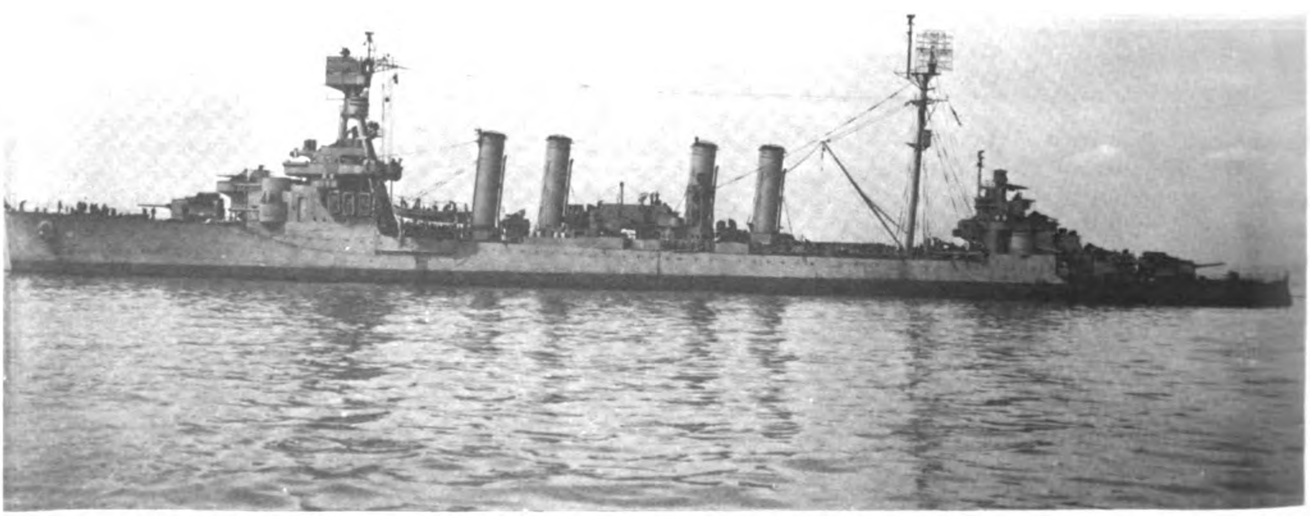
Patterns

Also, the originally proposed smokestack was found to cause interference to radiation patterns, principally between 3 and 8 megacycles. The severity and extent of interference depended on the stack height. To correct the condition a 25-percent reduction in stack height was first recommended, but later it was decided to use the stack as the broad base of a sleeve antenna.

The effect of the forward and after towers was also determined, and optimum antenna locations were selected as far from the tower effects as possible.

The forward sleeve antennas are all receiving antennas, and the

Figure 2. Later view of the Marblehead showing the changes that took place in antenna arrangements between 1924 and 1942.



after antennas are all transmitting antennas. Thus, transmitting and receiving functions are somewhat separated.

The sleeve antenna, which is the predominant type of antenna in the *Northampton*, was selected because of its particular characteristics. The sleeve antenna has a lower portion called the sleeve, which is electrically connected to, and is an integral part of, the ground plane or deck of the ship. The upper portion, called the upper radiator, is insulated from the lower portion.

Feed Point

The terminal of the upper section and the top of the sleeve provide two terminals, called the feed point. A section of transmission line is run inside the sleeve. The outer conductor of this line is connected to the top of the sleeve, whereas the inner conductor is connected to the terminal of the upper radiator.

The impedance-versus-frequency characteristics of the antenna, as measured at the feed point, may be designed to operate over a wide range by changing the diameters of the upper and lower sections, as well as the ratios of the length of the upper section to the length of the lower section.

Of the infinite number of impedance characteristics that may thus be obtained, there are some which, when transformed by a short section of line of impedance greater than 50 ohms, will give an impedance relative to 50 ohms that will produce a standing wave ratio not poorer than 3-to-1 over a 3-to-1 frequency range. Under these conditions, the losses of the output circuit and the transmission line become of negligible importance.

Beyond the 3-to-1 frequency range, the mismatch rises rapidly as the impedance of the antenna varies more widely and the transformer section ceases to provide compensation. The factor of antenna system radiation efficiency is therefore greatly improved within the 3-to-1 frequency range of the antenna by the use of the sleeve type of construction.

The sleeve antenna also has the desirable characteristics of maintaining one lobe of its pattern along the surface of the water.

Figure 3. USS Northampton (ECLC-1), a cruiser commissioned in 1953. The antenna arrangements on the Northampton are as nearly ideal as developments to 1953 indicated would give the best communication efficiency.

Besides the sleeve antenna, another comparatively new device is used on the *Northampton* to improve communications. The *Northampton* carries the first extensive use of antenna multicouplers aboard ship in the naval service.

Broadband antenna characteristics, like those of the sleeve antenna, are also a fundamental requirement for the use of the multicoupler. The numbers of transmitters and receivers influence the extent to which multicouplers are used.

The *Northampton* has 60 transmitters and 114 receivers. Obviously, to rig an antenna for each transmitter and receiver is impossible. Hence, the reliance on the multicoupler.

By the use of multicouplers, about four transmitters can be operated on a single antenna, and as many as 14 receivers. Losses are not too great, although in some instances as much as a 6-decibel loss must be accepted through the multicoupler on certain frequencies. Multicouplers have been generally satisfactory, and the Navy will continue to extend their use.

In recent designs, more efficient operation is possible by the use of remote automatic antenna tuners. By the use of these tuners, on the *Northampton*, the Navy can in general maintain a standing wave ratio of 3-to-1 or better. The Navy gets about 80 percent efficiency in the midfrequency band with the tuners, as compared with about 5 percent without them.

Better antenna systems will greatly increase the Navy's ability to handle more information with continuous coverage over longer ranges. Nevertheless, many other factors besides antennas affect good communications. It is most important that anyone thinking in terms of naval communications recognize the many serious obstacles that must be overcome.

The Navy is making progress. Our communications are improved in quality, and the distances over which communications can travel and still remain intelligible are increasing.