The Aspects Of Naval Communications

Efficient interchange of information is vital to the success of complex military missions; Navy has its own special problems and solutions

By J.A. Krcek
Electronics Division
Bureau of Ships

Complex modern military operations depend upon communications to a large extent for successful accomplishment of their mission. In units as mobile as ships, effective communications are even more vital. Multiple, widely dispersed portions of the fleet must act in cooperation and unison with each other, with Navy and Air Force air activity, and with carefully timed shore operations of the Marines and Army Ground Forces.

To meet these demands for reliable, efficient, and high capacity communications, the Navy makes use of all forms of communications facilities known and strives to apply each new technique and equipment to the ever-expanding demands for communications.

The Navy's communication problems are somewhat similar to those encountered by the other members of the armed services and by commercial communications organizations. In some important respects, however, they are very special to the Navy.

Highly Compacted Installations

A communications ship, varying in size from 7,000 to 15,000 tons, is extremely confining from a communications standpoint. It carries the equivalent of a large antenna field, a complete high and low power transmitting station, and the equivalent of a large receiving station. With a vast amount of other equipment vying for every cubic inch of space, highly compacted installations result.

Radio I is on deck 3, two levels below the quarter deck. The compartment measures roughly 50 feet square and houses the principal long and short range receiving equipment. The room is filled to capacity with receivers, roughly 80 in all, a few low power transmitters, and terminal equipment needed for teletype, facsimile, voice, and Morse operation. Fortunately, a part of the receiver output is piped to other sections of the ship, and an operator for each piece of equipment is not necessary in the close space. Virtually all receivers are either in full operation or in stand-by condition. Eighty sensitive receivers seeking signals are wide open and unfortunately are receptive to all other hash that may get on the air. Such difficulties make severe requirements for oscillator radiation, spurious response, and front-end selectivity in radio receiver design.

More Transmitters, Receivers

Two decks up and somewhat forward is Radio 2. This compartment, roughly 23 feet square, houses approximately 20 transmitters ranging in power from 15 watts to 2,000 watts and operating at frequencies from 175 kc. to 32 mc. Nine of these have ratings of 200 watts or higher. Most of these transmitters are in operation or in stand-by condition, ready to carry out communications, but also able, if permitted, to interfere with every receiver in the ship.

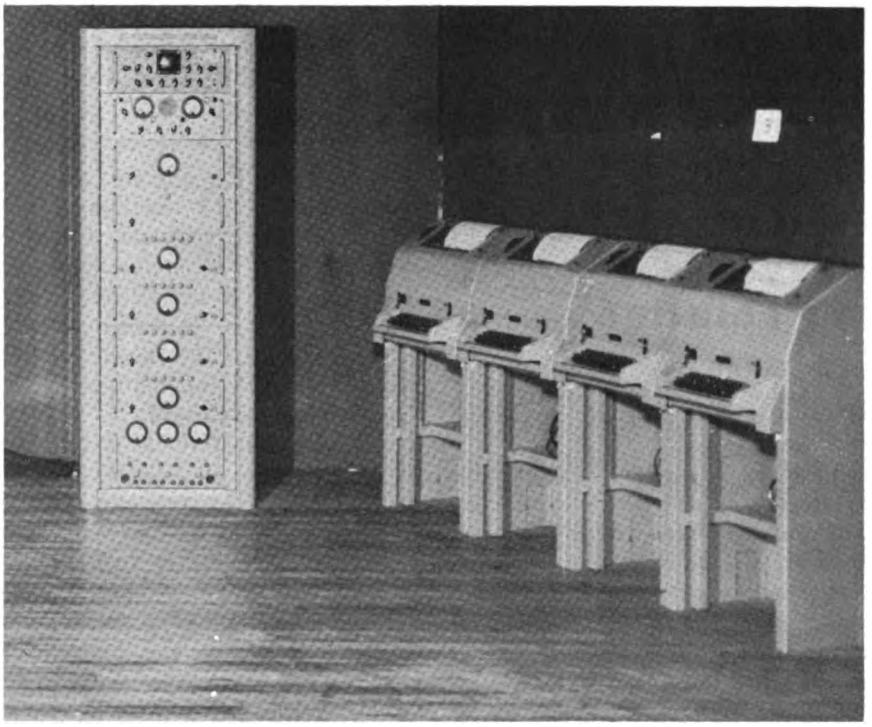
Radio 3 has 13 more transmitters and 3 receivers; the combat information center, 3 receivers; gunnery and air office, 3 receivers; flag bridge, 8 receivers and 4 transmitters; flag communications, 20 receivers and 8 transmitters; and the radar tower, 8 receivers and 4 transmitters. The total is 146 receivers and 59 transmitters.

Complex Antenna Field

The antenna field is mainly out in the open, or at least nearly out in the open. The transmitting antennas, amidship and aft, and receiving antennas, up forward, total 139. UHF antennas are up in the yardarms as high as possible, but not necessarily in the highest or best position on the ship. The various masts, bridge, stack, vents, and guns do not help intercoupling, radiation patterns, and the reception problem, but the ship needs these to operate. For purposes of comparison, an efficient shore receiving station will use approximately 400 acres for a 50 antenna installation.

High up on the ship's masts and in several other positions of prominence are radar antennas radiating kilowatts of power through the antenna field. If the radio receivers do not interfere with each other, the transmitters can disturb them. If the transmitters are of good quality and the frequency plan is correct, this interference is essentially eliminated, but then there is the radar to worry about. When the radar is cleaned up, there is possibility of interruption from shock caused by gunfire and interruptions arising from a disabled ship, antennas damaged or shot down, or power failures.

In spite of this difficult situation, the Navy communicates around the clock and over as many of the facilities as stay intact. Fortunately the problems have been of an evolutionary character; solutions were sought and, in most cases, found. Equipment and system stand-



TELEGRAPH MULTIPLEX SET AN/FGC-5 and associated teletype equipment.

ards have been established which seek to guarantee that each step or change is a forward one; as the amount of equipment is increased, the quality of equipment is correspondingly improved.

Improved Circuit Design

To permit this large number of receivers to operate adjacent to each other and close to high power transmitters, continuous stress has been placed on improvement of receiver front-end selectivity. When use of improved components and improved circuit design is insufficient, the needs for sensitivity are compromised to the degree needed to achieve desired selectivity. Spurious responses can play havoc in the typical shipboard communication installation. In each new receiver design, spurious response requirements are increased by dictating use of a special IF frequency or a particular circuit arrangement for deriving the desired heterodyne frequencies.

Physical size and weight of receivers must be minimized. By a reduction in size, operational requirements for more circuits and greater numbers of equipment can be met. Reduction in weight may seem like a costly luxury when ships, measured in many thousands of tons, are being dealt with. But even now weight and moment compensation, the factors which influence the stability of ships, must be carefully considered each time a piece of equipment is added to the ship's allowance. The lighter the equipment, the less is the problem of its placement.

As a higher degree of excellence is sought, many services such as long range teletype or facsimile deserve specially designed receivers, having precisely the desired electrical characteristics and the simplicity inherent in single purpose equipment. The optimized design makes the operation more automatic. Simplicity makes the operation more fool-proof.

Emission Reduced and Purified

Radio transmitter characteristics are carefully controlled to purify emission and reduce band width of emission. Accuracy of frequency setting and frequency stability requirements are increased each time equipment development is undertaken to reduce interference between channels and to permit closer spacing of channels. The ultimate, not yet reached, is to derive all transmitter frequencies and possibly even receiver oscillator frequencies from a single ship's frequency standard and a synthesizer or slave oscillator arrangement. By this method the relative accuracy of settings of the equipment would be extremely high and the possibility of mutual interference minimized.

In terminal equipment design, emphasis is placed on making the maximum possible use of signal energy in reception of radio signals. A shipboard receiving terminal is considerably handicapped; it must contend with less efficient antenna installation than on shore; it must contend with relatively high noise levels emanating from the numerous electrical and electromechanical elements that make up a modern fighting vessel; and as pointed out before, it must operate in presence of extremely strong fields of closely located high power transmitters.

Receiver facsimile and teletype converters, for example, must be precisely tailored, not only for the job of making best use of a weak signal but also for making best use of a weak signal in presence of a variety of interfering signals. This latter condition will sometimes dictate design that is not clearly understood unless there is awareness of all factors involved.

Antenna multicoupling techniques have been improved recently to permit multiple use of antennas by several transmitters and, in some instances, transmitter and receivers. Fundamentally the multicouplers consist of multiple tunable band pass filters which pass only a desired band of frequencies from a transmitter to an antenna. For receiving purposes they pass a certain band of frequencies from the antenna to the receiver.

In another form the multicoupler consists of combinations of fixed low-pass and high-pass filters. In such a combination there is provision for switching filters to provide proper frequency pass and rejection conditions for each piece of equipment using the single antenna. By means of these techniques, the number of antennas can be reduced by a factor of four or five that permits maximum use of optimum antenna locations. These units are not yet in general use, but when they are, they will tend to alleviate the antenna problem until the operating people increase requirements.

Antennas are being improved to provide greater constancy of impedance characteristics, more favorable radiation patterns, and simpler, more rugged structural characteristics. Greater efforts are being made to provide more efficient matching between transmitters and receivers, and the antennas. Since many transmitters in association with a given set of antennas must work on any frequency over the range of 175 kc. to 32 mc., the problem of antenna, multicoupler, and transmitter design becomes evident.

Single side-band systems are to be evaluated for possible application to shipboard communications. The advantages are less spectrum occupancy and higher efficiency. The disadvantages are equipment complexity and required precision. However, as demands for more communications develop, what today is considered to be an intolerable degree of complexity, tomorrow may be justified.

Single Side-Band Circuits

To increase the traffic handling capacity of radio circuits, multiplexing techniques are being resorted to which multiply many times the communications that can be handled by a single radio circuit. The multiplex apparatus AN/FGS-5 and the teletype printers are capable of copying over 300,000 words per day or assuming a four-man watch, the same amount of traffic 48 radio operators could handle on a Morse basis.

With availability of single side-band circuits, long range frequency-division carrier systems become practical and make possible the enlarging of circuit capacity beyond that which is possible with time division systems. Proper use of frequency-division carrier systems will permit transmission of up to 1,500 words per minute on a single radio circuit.

Requirements have arisen for use of television techniques, high speed facsimile, and data transmission involving communication speeds much higher than anything encountered before. To satisfy partially these new requirements, every element of a system must be scrutinized and evaluated so that it can be verified as the proper element and that it is employed to the maximum extent. Manual communications circuits must make way for automatics because skilled personnel are not available to man the circuits and because each circuit must be expanded in capacity to make way for the new requirements.

There is an increasing need to handle each communications system on a custom engineering basis so that no element is left to chance or that the fine features so carefully developed in each item or equipment are not compromised by improper installation. Advantage is taken of best location of equipment to minimize circuit losses and to render its use most efficient and convenient.

The Bureau of Ships feels that the Navy has a militarily efficient communications system operating under extremely difficult conditions. The conditions and requirements continually change, almost always in the direction of making the problems more severe; but by effectively using tools that are available and by making constant improvements, the Navy continually looks forward to meeting each new requirement as it arises.

A REPRESENTATIVE shipboard teletype installation.