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Training Manual
(TRAMAN)

Electronics Technician

Volume 3—Communications Systems

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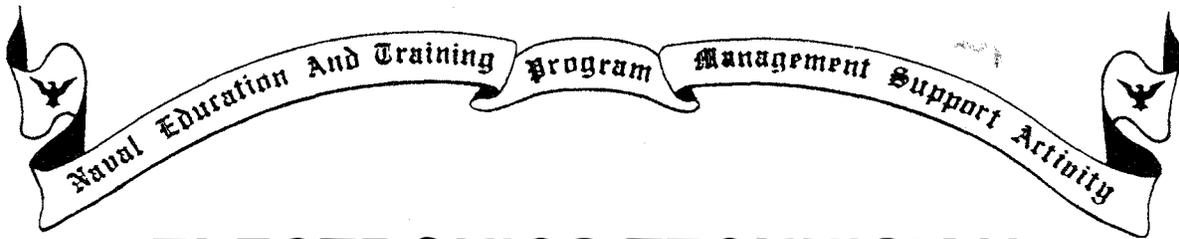


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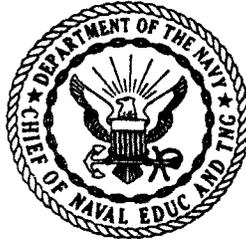
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ELECTRONICS TECHNICIAN

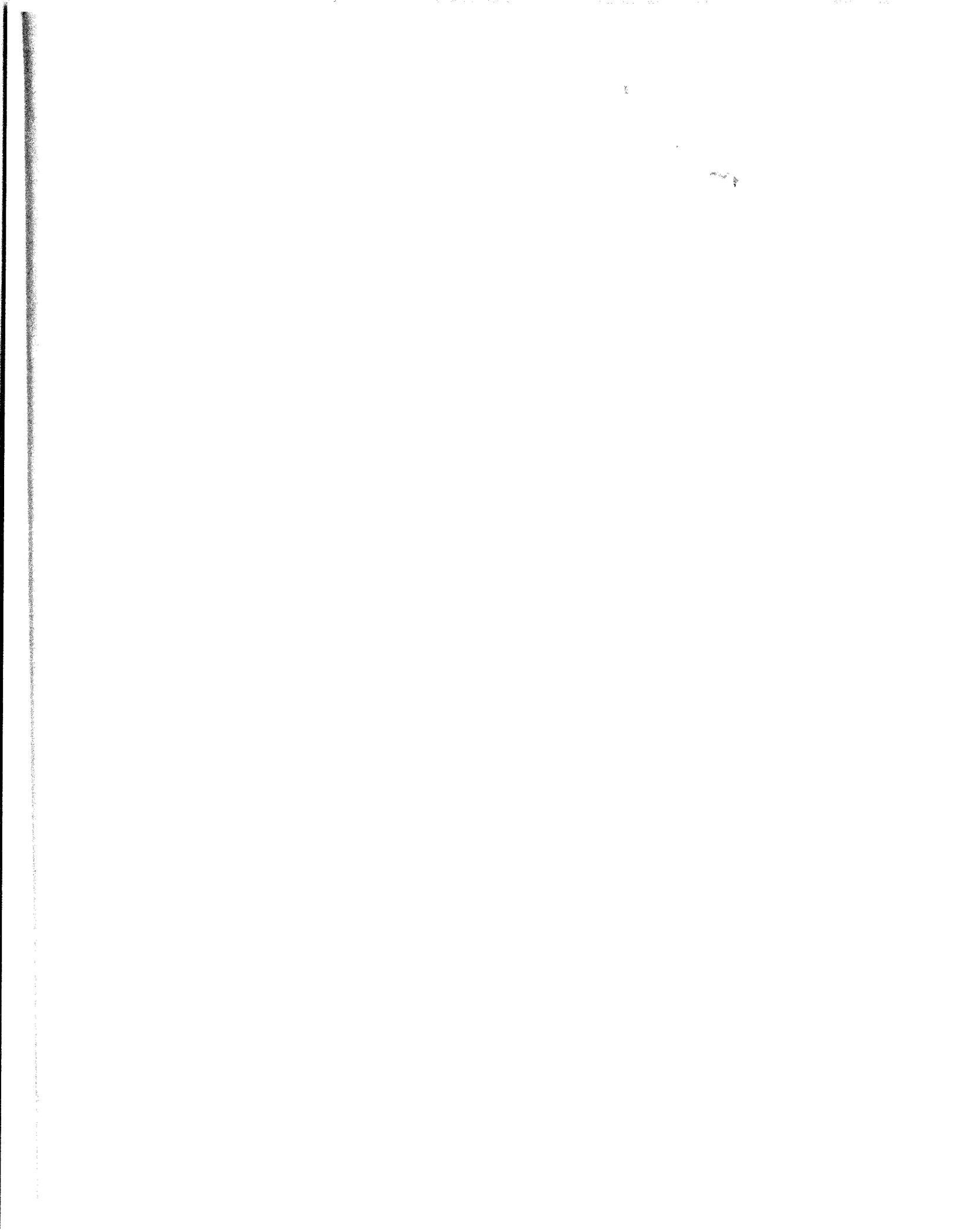
VOLUME 3 COMMUNICATIONS SYSTEMS

NAVEDTRA 12413



*1993 Edition Prepared by
ETC(SW/AW) James R. Branch*





PREFACE

This training manual (TRAMAN), *Electronics Technician, Volume 3, Communications Systems*, NAVEDTRA 12413, and its companion nonresident training course (NRTC), NAVEDTRA 82413, are part of a planned 9-part series of TRAMANs intended to provide Navy enlisted personnel with information pertinent to their assignments and necessary for advancement to the Electronics Technician Second Class rate. The nine volumes planned for the series are as follows: Volume 1, *Safety*; Volume 2, *Administration*; Volume 3, *Communications Systems*; Volume 4, *Radar Systems*; Volume 5, *Navigation Systems*; Volume 6, *Digital Data Systems*; Volume 7, *Antennas and Wave Propagation*; Volume 8, *System Concepts*; Volume 9, *Electro-Optics*.

Designed for individual study instead of formal classroom instruction, the TRAMANs provide subject matter that relates directly to the Occupational Standards for the Electronics Technician Second Class. The Navy Electricity and Electronics Training Series (NEETS) modules provide information that is basic to your understanding of the material presented in these volumes. To avoid repeating such basic information, these volumes refer you to the appropriate NEETS modules and EIMB handbook. You may also be directed to review or study additional references commonly found in ET workspaces or used by Electronics Technicians. You should study the referenced publications as thoroughly as you would if they were repeated as part of the ET2 TRAMAN. The NRTCs, printed under separate cover, consist of supporting questions designed to help you study the associated TRAMAN and referenced publications and to satisfy part of the requirements for advancement.

This training manual and the nonresident training course were prepared by the Naval Education and Training Program Management Support Activity for the Chief of Naval Education and Training.

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THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations as we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

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SUMMARY OF THE ELECTRONICS TECHNICIAN TRAINING SERIES

This series of training manuals was developed to replace the *Electronics Technician 3 & 2 TRAMAN*. The content is directed toward personnel working toward advancement to Electronics Technician Second Class.

The nine volumes in the series are based on major topic areas with which the ET2 should be familiar. Volume 1, *Safety*, provides an introduction to general safety as it relates to the ET rating. It also provides both general and specific information on electronic tag-out procedures, man-aloft procedures, hazardous materials (i.e., solvents, batteries, and vacuum tubes), and radiation hazards. Volume 2, *Administration*, discusses COSAL updates, 3-M documentation, supply paperwork, and other associated administrative topics. Volume 3, *Communications Systems*, provides a basic introduction to shipboard and shore-based communication systems. Systems covered include man-pac radios (i.e., PRC-104, PSC-3) in the hf, vhf, uhf, SATCOM, and shf ranges. Also provided is an introduction to the Communications Link Interoperability System (CLIPS). Volume 4, *Radar Systems*, is a basic introduction to air search, surface search, ground controlled approach, and carrier controlled approach radar systems. Volume 5, *Navigation Systems*, is a basic introduction to navigation systems, such as OMEGA, SATNAV, TACAN, and man-pac systems. Volume 6, *Digital Data Systems*, is a basic introduction to digital data systems and includes discussions about SNAP II, laptop computers, and desktop computers. Volume 7, *Antennas and Wave Propagation*, is an introduction to wave propagation, as it pertains to Electronics Technicians, and shipboard and shore-based antennas. Volume 8, *System Concepts*, discusses system interfaces, troubleshooting, sub-systems, dry air, cooling, and power systems. Volume 9, *Electro-Optics*, is an introduction to night vision equipment, lasers, thermal imaging, and fiber optics.

CHAPTER 1

FUNDAMENTALS

INTRODUCTION

Communications in general, and especially in systems, covers a broad spectrum, from a simple single-channel voice circuit, to the fastest growing field of electronics—satellite communications. This training manual will provide you with knowledge applicable to questions and situations that arise on the job. Chapter 1 is a refresher course in basic communications systems and terminology. Chapters 2 and 3 will lead you through many of the systems and equipments in use today.

The Electronics Technician rating is extremely diverse. Many ETs never get the opportunity to work in the communications field. Those who do are often times locked into one particular system for many years. This assignment pattern sometimes causes ETs to feel overwhelmed or lost in their career. The massive amount of information ETs can be questioned on and are expected to know can be frustrating. But the goal **YOU** and every ET must have is to become as knowledgeable as possible, to be better prepared to handle all future challenges.

When you have completed this chapter, you should be able to discuss the basic principles of rf communications, the basic equipment used for rf communications, and the frequency spectrum allocated to rf communications.

RADIO COMMUNICATIONS

Navy ships, planes, and shore bases don't act independently of one another but operate as a team working together to accomplish a specific task. Radio equipment is used to coordinate the activities of the many fleet units by linking them with each other and with shore stations.

Radio can be defined as the transmission and reception of electronic impulses or signals through space by means of electromagnetic waves. Usually, the term is used in referring to the transmission of intelligence code and sound signals, although television and radar also depend on electromagnetic waves.

At one time, the term *radio communications* brought to mind telegraphy (CW), voice (AM), and

possibly teletype communications. Today's radio communications has become a highly sophisticated field of electronics. You, the technician, need to become familiar with the diverse systems in use today.

The primary means of communicating between ships and between ships and stations is known as *telecommunications*. Telecommunications refers to communications over a distance and includes any transmission, emission, or reception of signals, writing, images, and sounds. Intelligence produced by visual or oral means or by wire, radio, or other electromagnetic systems is also included. Electrical, visual, and sound telecommunications are all used by the Navy. In this volume we will discuss electrical types of telecommunications.

COMMUNICATIONS SYSTEMS

A communications system consists of two or more units, each having its own separate identity, arranged and interconnected to perform a circuit operation that cannot be performed by one of the individual units alone. Navy communications systems vary from simple to very complex, depending upon the circuit operations involved. Each system requires the integrated use of various types of equipment, so flexibility is of the utmost importance. This flexibility is provided through a complex arrangement of interconnections that allow the physically separated sets, groups, and units to be selectively switched (patched) into the different circuit configurations.

Most shipboard communication equipments do not operate independently. A particular piece of electronic gear may be designated "primary" and still be used in many different system operations. You need to understand **all** the associated equipment in a system to identify problems correctly and to make repairs promptly. Thorough knowledge of system operations will enable you to say with complete confidence, this communications suite is operational.

SAFETY

Hazards encountered in servicing electronic equipment and the precautions to be taken against

them are covered thoroughly in *Electronics Technician Volume 1, Safety*, NAVEDTRA 12411, and the *General Handbook* (NAVSHIPS 0967-000-0100) of the EIMB series.

Safety is everyone's responsibility. Observance of safety precautions will keep your equipment operating, help your career in the Navy, and possibly determine whether or not you survive. Always follow the appropriate safety precautions!

Note: Equipment that we cover in this and other chapters is intended to be merely representative of equipment that you may encounter on board your command. We will not attempt to include all the possible equipment or equipment configurations.

BASIC SYSTEM REQUIREMENTS

Radio equipment can be divided into three broad categories: transmitting equipment, receiving equipment, and terminal equipment. Transmitting equipment generates, amplifies, and modulates a transmitted signal. Receiving equipment receives a radio wave, then amplifies and demodulates it to extract the original intelligence. Terminal equipment is used primarily to convert the audio signals of encoded or data transmission into the original intelligence.

A basic radio communications system may consist of only a transmitter and a receiver, connected by the medium through which the electromagnetic waves travel (see figure 1-1). The transmitting equipment creates a radio-frequency (rf) carrier and modulates it

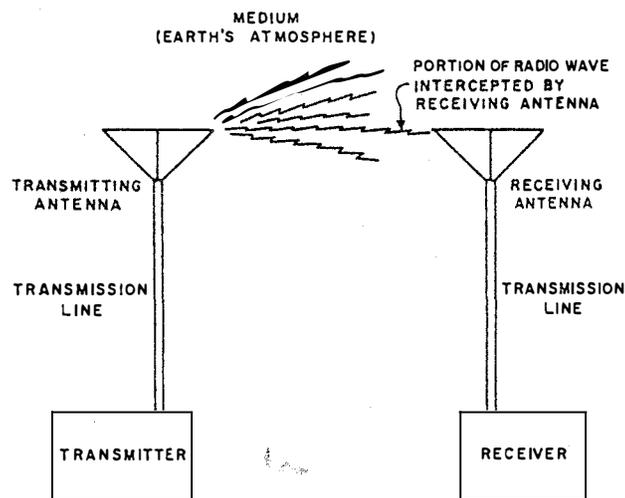


Figure 1-1.—Basic radio communication system.

with audio intelligence to produce an rf signal. This rf signal is amplified and fed to the transmitting antenna, which converts it to electromagnetic energy for propagation.

The receiving antenna converts the portion of the electromagnetic wave it receives into a flow of alternating rf currents. The receiver then converts these currents into the intelligence that was contained in the transmission.

Terminal equipment is used primarily where coded transmissions are employed, to convert the modulated signal into the original intelligence. Systems you will encounter in the fleet use terminal equipment, such as AN/UCC-1, AN/URA-17, and CV-2460.

THE FREQUENCY SPECTRUM

Figure 1-2 shows the overall electromagnetic frequency spectrum as defined by the International Telecommunications Union. Pay particular attention to the part used for communications. Rapid growth in the quantity and complexity of communications equipment and increased worldwide international requirements for radio frequencies have placed large demands upon the rf spectrum. These demands include military and civilian applications, such as communications, location and ranging, identification, standard time, industrial, medical, and other scientific uses.

The military has modified the frequency spectrum for its use as shown in table 1-1. A few general characteristics are described in the following paragraphs.

The extremely-low-frequency (elf), very-low-frequency (vlf), and low-frequency (lf) bands require high power and long antennas for efficient transmission (antenna length varies inversely with the frequency). Transmission of these frequencies is normally limited to shore stations.

The commercial broadcast band extends from about 550 kHz to 1700 kHz. This limits naval use to the upper and lower ends of the medium frequency (mf) band.

Long-range shipboard communications were conducted exclusively in the high-frequency (hf) band, so a large percentage of shipboard transmitters and receivers are designed to operate in this band. On board your command, you may find that satellite communications has pushed hf into a back-up role.

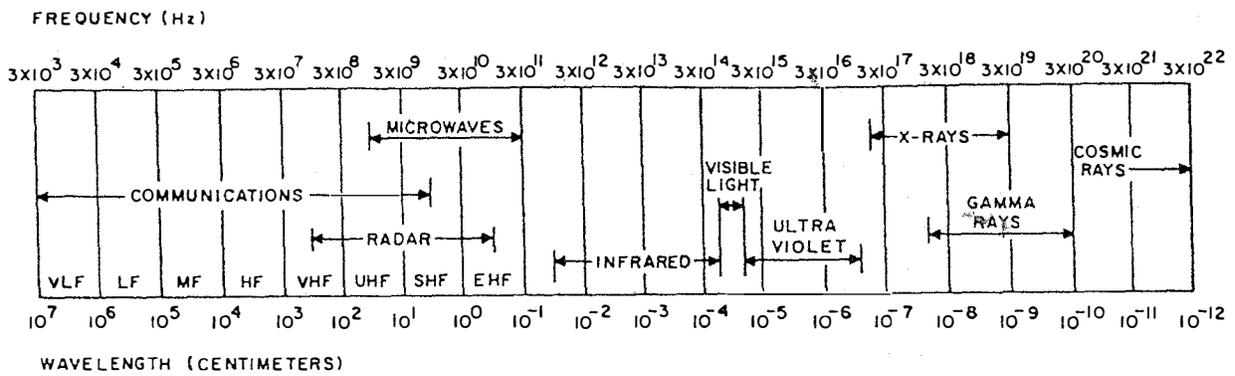


Figure 1-2.—Frequency spectrum.

Table 1-1.—Frequency Bands

FREQUENCY	DESCRIPTION
30-300 GHz	extremely-high-frequency
3-30 GHz	super-high-frequency
300 MHz-3 GHz	ultra-high-frequency
30-300 MHz	very-high-frequency
3-30 MHz	high-frequency
300 kHz-3 MHz	medium-frequency
30-300 kHz	low-frequency
3-30 kHz	very-low-frequency
300 Hz-3 kHz	voice frequency
up to 300 Hz	extremely-low-frequency

A significant portion of the very-high-frequency (vhf) band is assigned to the commercial television industry. Some naval uses of the vhf band are mobile communications, repeater operation, navigation, amphibious and special operations, short range line-of-sight (LOS) communications, and satellite communications.

The ultra-high-frequency (uhf) band is used extensively by the Navy for LOS and satellite communications. Mobile communications, radar (over 400 MHz), and special operations are some other uses.

The super-high-frequency (shf) band is the work-horse of microwave communications. LOS communications, terrestrial, and satellite relay links, radar, and special operations are some other uses.

Experimental use of the extremely-high-frequency (ehf) band is ending. The Fleet Satellite (FLTSAT) Ehf Package (FEP) is attached to two modified uhf FLTSATs. The FEP is currently providing ehf communications capability to Army, Navy, and Air Force ground, airborne, and oceangoing

terminals. We will discuss the FEP and its purpose in chapter 3.

Infrared devices and lasers use even higher frequency ranges. Information on equipment using these frequencies can be found in *Electro-Optics*, volume 9, of this training series.

RADIO EMISSIONS

The emission class of an rf transmitter is determined by the type of modulation used. The international designation system for AM and FM emissions is shown in table 1-2. It designates the rf emission by type, mode, and supplemental characteristics.

We will now discuss the basic equipment required for communications.

TRANSMITTERS

For rf communications to take place, a signal has to be generated. Generating the signal is the job of the transmitter. The following paragraphs will very briefly discuss basic transmitters and transmitter fundamentals.

TRANSMITTER FUNDAMENTALS

Equipment used for generating, amplifying, and transmitting a rf carrier is collectively called a radio transmitter. Transmitters may be simple, low-power units, for sending voice messages a short distance or highly sophisticated, using thousands of watts of power for sending many channels of data (voice, teletype, telemetry, t.v., etc.) over long distances.

Basic transmitters are identified by their method of modulation: continuous wave (CW), amplitude modulation (AM), frequency modulation (FM), or single-sideband (ssb). We will first describe the types of modulation. We will then describe briefly the basic transmitters themselves.

MODULATION

Modulation is the process of varying some characteristic of a periodic wave with an external signal. The voice frequencies (about 110-3,000 Hz) are contained in the audio frequency spectrum, 10-20,000 Hz. In naval communications the terms *voice communications* and *audio communications* are sometimes used interchangeably. The audio signal is impressed upon the rf carrier because it is impractical to transmit

Table 1-2.—Types of Radio Emissions

AM	FM	MODULATION
A0	F0	No modulation intended to carry intelligence.
A1	F1	On-off or mark-space keying without the use of a modulating tone.
A2	F2	On-off or mark-space keying of a modulating audio frequency, or of the modulated emission.
A3	F3	Voice-frequency modulating, including simplex AFTS RATT.
A3A		Single-sideband, reduced carrier (SSB).
A3B		Two independent sidebands (ISB).
A3H		Single-sideband, full carrier (compatible SSB).
A3J		Single-sideband, suppressed carrier (SSSC).
A4	F4	Facsimile, with modulation of main carrier directly or by a frequency-modulated subcarrier.
A4A		Facsimile using single-sideband, reduced carrier.
A5	F5	Television.
A5C		Television, vestigial sideband.
	F6	Four-frequency duplex telegraphy (RFCS RATT).
A7		Multichannel voice-frequency telegraphy (AFTS MUX).
A7A		Multichannel voice-frequency telegraphy (AFTS MUX) using single-sideband, reduced carrier.
A7B		Multichannel voice-frequency telegraphy (AFTS MUX) using two independent sidebands.
A7J		Multichannel voice-frequency telegraphy (AFTS MUX) using single-sideband, suppressed carrier.
A9	F9	Cases not covered by above (e.g., a combination of telephony and telegraphy).
A9B		Combinations using two independent sidebands.

frequencies in the audio range due to their excessive wavelength.

Three characteristics of the carrier wave may be varied, or modulated, at an external signal rate: amplitude, frequency, and phase. The following paragraphs discuss each type of modulation.

Amplitude Modulation (AM)

Amplitude modulation is the process of combining audio frequency and radio frequency signals so that the *amplitude* of the radio frequency waves varies at an audio frequency rate.

Frequency Modulation (FM)

Frequency modulation is a process in which the *frequency* of the carrier wave is made to vary. An FM signal should remain constant in amplitude and change only in frequency.

Frequency-Shift Keying (FSK)

Frequency-shift keying is considered a form of FM. It is a digital mode of transmission commonly used in radioteletype applications. In FSK the carrier is present all the time. In a keyed condition, the carrier frequency changes by a predetermined amount called the *mark frequency*. The unkeyed state is called a space.

Phase-Shift Keying (PSK)

Phase-shift keying is similar to FSK except that the phase, not the frequency, is shifted. The primary advantage of PSK is that it can be accomplished in an amplifier stage.

Pulse Modulation

Pulse modulation is accomplished by varying the characteristics of a series of pulses. This can be done by varying the amplitude, duration, frequency, or position of the pulses. It can also be done through coding. Pulse modulation is especially suited for use with communications systems incorporating time-division multiplexing.

BASIC TRANSMITTERS

Remember, transmitters are generally divided according to their type of modulation. In the discussion below, we describe very briefly how each type operates to help you differentiate between them.

CW Transmitter

A basic CW transmitter is shown in figure 1-3. CW is one of the oldest and least complicated forms of communications. Two advantages of CW are a *narrow bandwidth*, which requires less power out, and *clarity*, even under high noise conditions. The major disadvantage of a CW transmitter is that it must be turned on and off at specific intervals to produce Morse code keying (dots and dashes). This method is

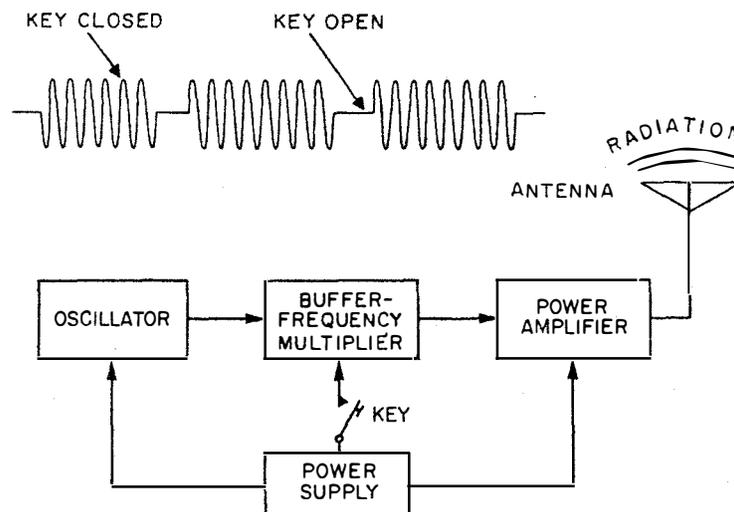


Figure 1-3.—Continuous-wave transmitter.

very slow by modern day standards. A better method of transmitting is AM.

AM Transmitter

Figure 1-4, a block diagram of an AM transmitter, shows you what a simple AM transmitter looks like. The microphone converts the audio frequency input to electrical energy. The driver and modulator amplify the audio signal to the level required to modulate the carrier fully. The signal is then applied to the power amplifier (pa). The pa combines the rf carrier and the modulating signal to produce the AM signal for transmission.

FM Transmitter

A block diagram of an FM transmitter is shown in figure 1-5. The transmitter oscillator is maintained at a constant frequency by a quartz crystal. This steady signal is passed through an amplifier, which increases the amplitude of the rf subcarrier. The audio signal is applied to this carrier phase-shift network. Here, the frequency of the carrier shifts according to audio signal variations. The FM output of the phase-shift network is fed into a series of frequency multipliers that increase the signal to the desired frequency. The signal is then amplified in the power amplifier and coupled to the antenna.

Two important things to remember are (1) the amount of variation from the carrier frequency depends on the magnitude of the modulating signal and (2) the rate of variations in carrier frequency depends on the frequency of the modulating signal.

The FM transmitter is better than an AM transmitter for communications purposes because FM is less affected by static and other types of interference. An even better transmitter is the single-sideband transmitter, or ssb. Let's look at some of the advantages of ssb transmitters.

SINGLE-SIDEBAND TRANSMITTER

In ssb communications, the carrier is suppressed (eliminated) and the sideband frequencies produced by the carrier are reduced to a minimum. This means no carrier is present in the transmitted signal. It is removed after the signal is modulated and reinserted at the receiver during demodulation. Since there is no carrier, all the energy is concentrated in the sideband(s).

We can make ssb even more efficient by removing one of the sidebands. By filtering out one of the sidebands before it reaches the power amplifier, all the transmitter energy is concentrated into one sideband instead of being split between the carrier and two sidebands. This allows us to use less power for

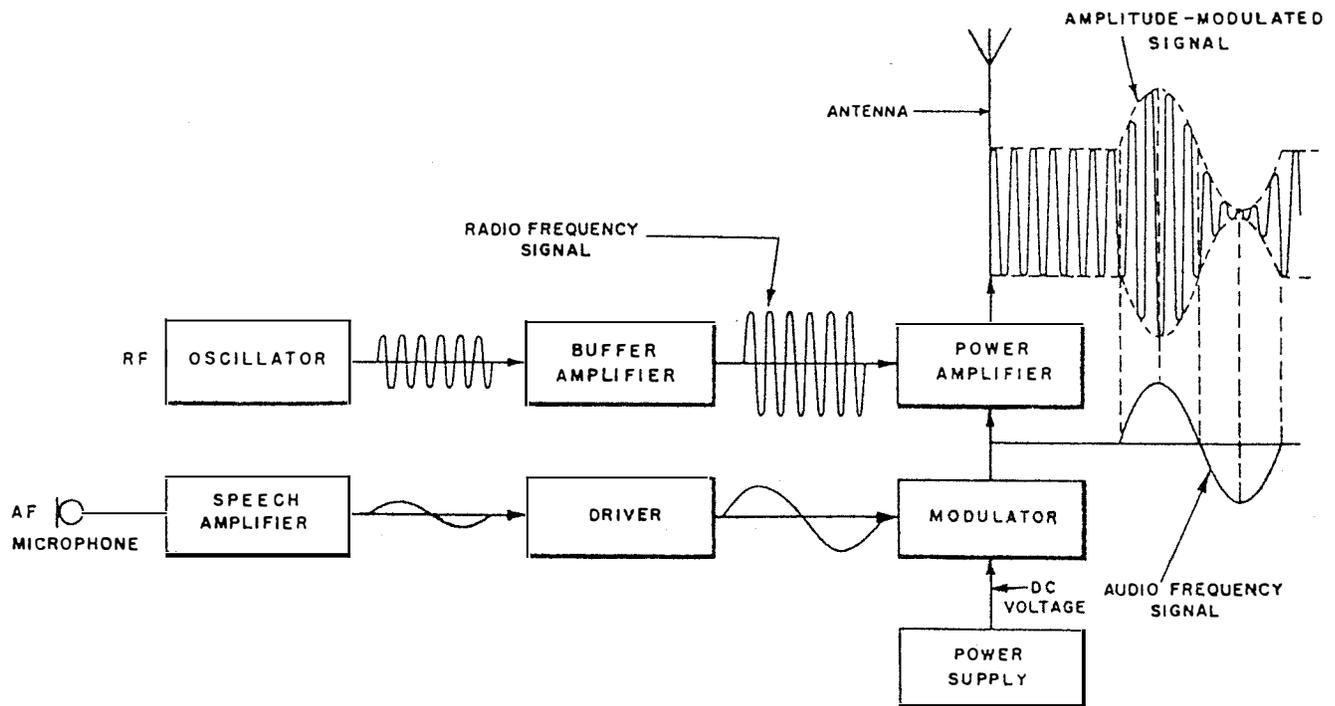


Figure 1-4.—AM transmitter block diagram.

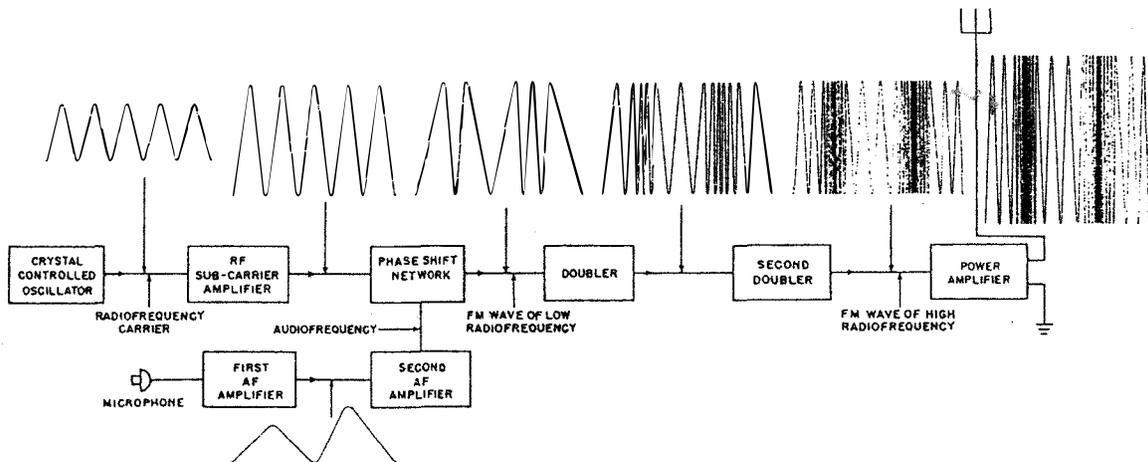


Figure 1-5.—FM transmitter block diagram.

transmission. Other advantages are a narrower receiver bandpass and the ability to place more signals in a small portion of the frequency spectrum. Figure 1-6 is a block diagram of a ssb transmitter.

RECEIVERS

Earlier you were introduced to one link in a communications system, the transmitter. All that is needed to complete the system is a radio receiver. A receiver processes modulated signals and delivers, as an output, a reproduction of the original intelligence. The

signal can then be applied to a reproducing device, such as a loudspeaker or a teletypewriter.

RECEIVER FUNCTIONS

To be useful, a receiver must perform certain basic functions. These functions are reception, selection, detection, and reproduction.

Reception

Reception occurs when a transmitted electromagnetic wave passes through the receiver antenna and induces a voltage in the antenna.

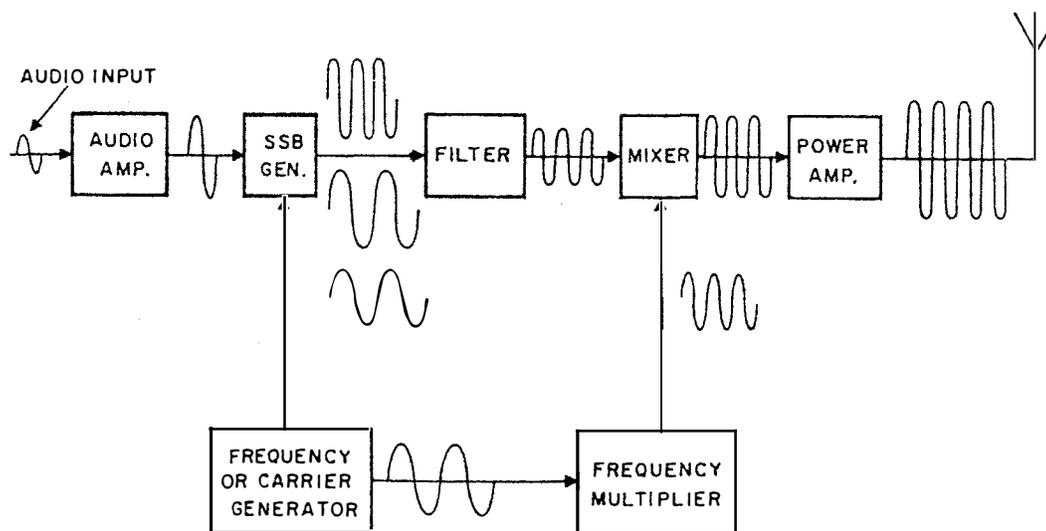


Figure 1-6.—SSB transmitter block diagram.

Selection

Selection is the ability to distinguish a particular station's frequency from all other station frequencies appearing at the antenna.

Detection

Detection is the extraction of the modulation from an rf signal. Circuits that perform this function are called detectors. Different forms of modulation require different detector circuits.

Reproduction

Reproduction is the action of converting the electrical signals to sound waves that can be interpreted by the ear.

RECEIVER CHARACTERISTICS

Understanding receiver characteristics is mandatory in determining operational condition and for comparing receivers. Important receiver characteristics are sensitivity, noise, selectivity, and fidelity.

Sensitivity

Sensitivity is a measure of a receiver's ability to reproduce very weak signals. The weaker the signal that can be applied and still produce a certain signal-to-noise (S/N) ratio, the better that receiver's sensitivity rating. Usually, sensitivity is specified as the signal strength in microvolts necessary to cause a S/N ratio of 10 decibels, or 3.16:1.

Noise

All receivers generate noise. Noise is the limiting factor on the minimum usable signal that the receiver can process and still produce a usable output. Expressed in decibels, it is an indication of the degree to which a circuit deviates from the ideal; a noise figure of 0 decibels is ideal.

Selectivity

Selectivity is the ability of a receiver to distinguish between a signal at the desired frequency and signals

at adjacent frequencies. The better the receiver's ability to exclude unwanted signals, the better its selectivity. The degree of selectivity is determined by the sharpness of resonance to which the frequency determining components (bandpass filters) have been engineered and tuned. Measurement of selectivity is usually done by taking a series of sensitivity readings in which the input signal is stepped along a band of frequencies above and below resonance of the receiver's circuits. As the frequency to which the receiver is tuned is approached, the input level required to maintain a given output will fall. As the tuned frequency is passed, the input level will rise. Input levels are then plotted against frequency. The steepness of the curve at the tuned frequency indicates the selectivity of the receiver.

Fidelity

Fidelity is a receiver's ability to reproduce the input signal accurately. Generally, the broader the bandpass, the greater the fidelity. Measurement is taken by modulating an input frequency with a series of audio frequencies and then plotting the output measurements at each step against the audio input. The curve will show the limits of reproduction.

Good *selectivity* requires a narrow bandpass. Good *fidelity* requires a wider bandpass to amplify the outermost frequencies of the sidebands. Knowing this, you can see that most receivers are a compromise between good selectivity and high fidelity.

AM SUPERHETERODYNE RECEIVER

The superheterodyne receiver was developed to overcome the disadvantages of earlier receivers. A block diagram of a representative superheterodyne receiver is shown in figure 1-7. Superheterodyne receivers may have more than one frequency-converting stage and as many amplifiers as needed to attain the desired power output.

FM SUPERHETERODYNE RECEIVER

Fundamentally, FM and AM receivers function similarly. However, there are important differences in component construction and circuit design because of

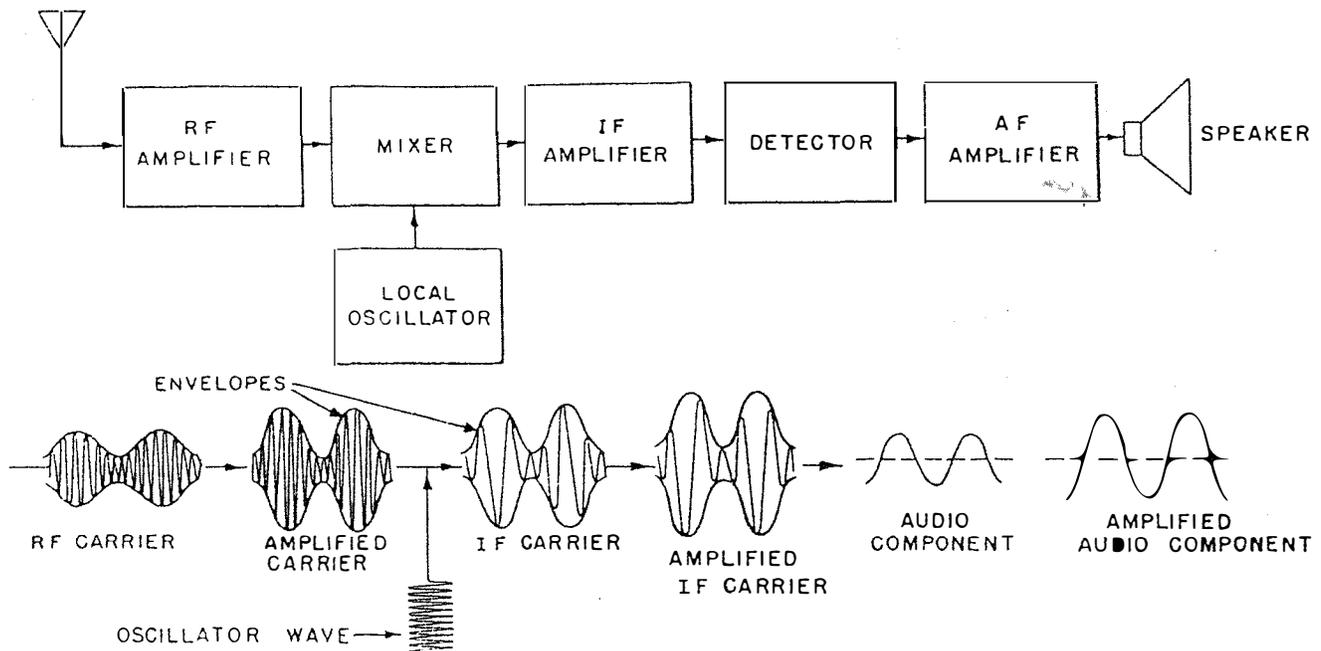


Figure 1-7.—AM superheterodyne receiver and waveforms.

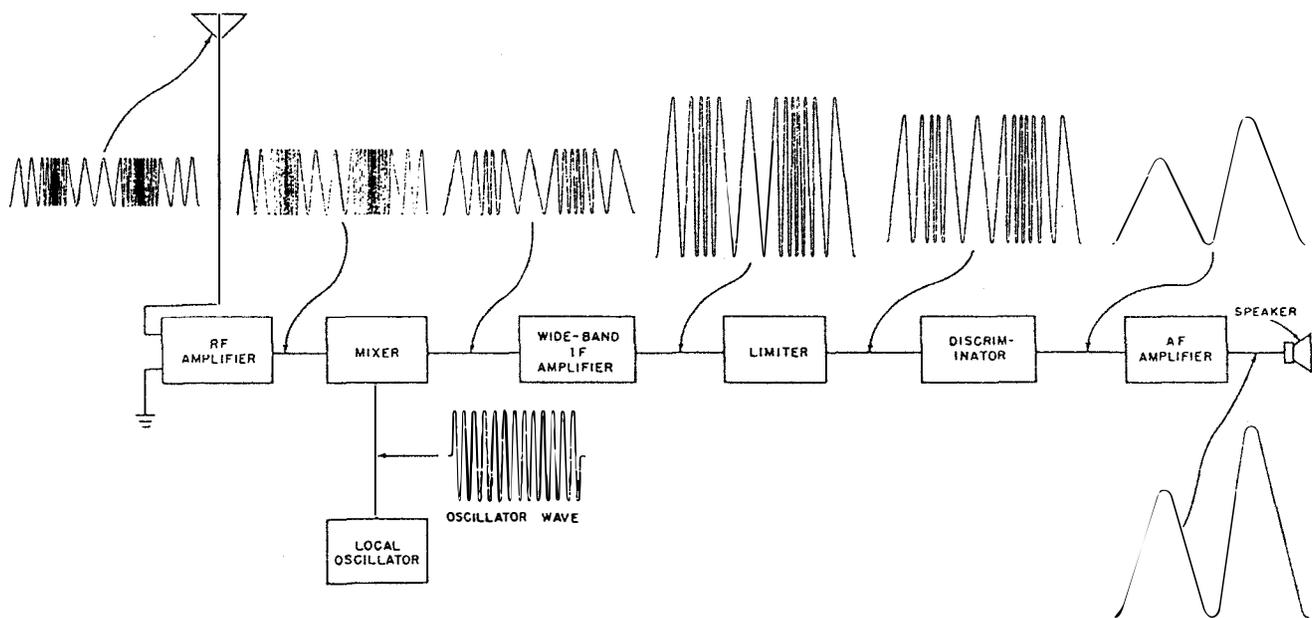


Figure 1-8.—FM superheterodyne receiver and waveforms.

differences in the modulating techniques. Comparison of block diagrams (figures 1-7 and 1-8) shows that electrically there are two sections of the FM receiver that differ from the AM receiver: the discriminator (detector) and the accompanying limiter.

FM receivers have some advantages over AM receivers. During normal reception, FM signals are static-free, while AM is subject to cracking noise and whistles. Also, FM provides a much more realistic reproduction of sound because of the increased number of sidebands.

SINGLE SIDE-BAND (SSB)

Figure 1-9 is a block diagram of a basic ssb receiver. Though the ssb receiver is not significantly different from a conventional AM superheterodyne receiver, it must use a special type of detector and a carrier reinsertion oscillator. The oscillators in a ssb receiver must be extremely stable. In some cases, a frequency stability of plus or minus 2 hertz is required. You can see that frequency stability is the most important factor of ssb equipment.

Ssb receivers may use additional circuits that enhance frequency stability, improve image rejection, or provide automatic gain control (agc). However, the circuits shown in figure 1-5 will be found in all single side-band receivers.

AMPLIFICATION

Because the incoming signal may be weak and because a certain minimum voltage level is required for the auxiliary equipment to operate, considerable amplification must take place before the receiver output is used to drive speakers, headphones, or terminal equipment. This is usually called the *gain* of the receiver. Gain is a term used to describe an increase in current, voltage, or power. For example, if the detector, which removes the desired intelligence, requires 1 volt to operate and if the input to the receiver is 1 microvolt, a total amplification of 1 million is required before detection. If the loudspeaker requires 10 volts, another voltage amplification of 10 is necessary between the detector and the loudspeaker.

The gain of an amplifier is expressed in decibels (dB). The decibel is a means of measuring relative levels of current, voltage, or power. Most often it is used to show the *ratio* between input power and output

power. This ratio is expressed as gains and losses, where a minus (-) sign placed before dB indicates a loss and a plus (+) (or no sign at all) indicates a gain. The number of decibels change between two power values can be computed by the formula:

$$db = \log_{10} \frac{P1}{P2}$$

The comparison of dB's to power ratio is shown in table 1-3. You can see instantly the reason behind using the decibel system. It is much easier to say the signal level has increased 40 dB than to say it has increased 10,000 times.

Examining table 1-3 again, you can see that an increase of 3 dB indicates a doubling of power. The reverse is also true. If a signal decreases by 3 dB, half the power is lost. For example, a 100-watt signal *decreased* by 3 dB will equal 50 watts, while the same 100-watt signal *increased* by 3 dB will equal 200 watts. It's important to understand that **no matter how much power is involved**, a loss or gain of 3 dB always represents a halving or doubling of the output power.

Technically, the dB level of a signal is a logarithmic comparison between the input and output signals. Table 1-4 shows the common logarithms used to calculate dB. Normally the input signal is used as a reference. However, sometimes a standard reference signal is used. The most widely used reference level is a 1 milliwatt signal. Decibels measured in reference to 1 milliwatt are abbreviated dBm. A signal level of 3 dBm is 3 dB above 1 milliwatt and a level of -3 dBm is 3 dB below 1 milliwatt. The formula for dBm is a variation of the dB power formula:

$$dbm = 10 \log \frac{\text{actual power } (P2)}{.001 \text{ watt } (P1)}$$

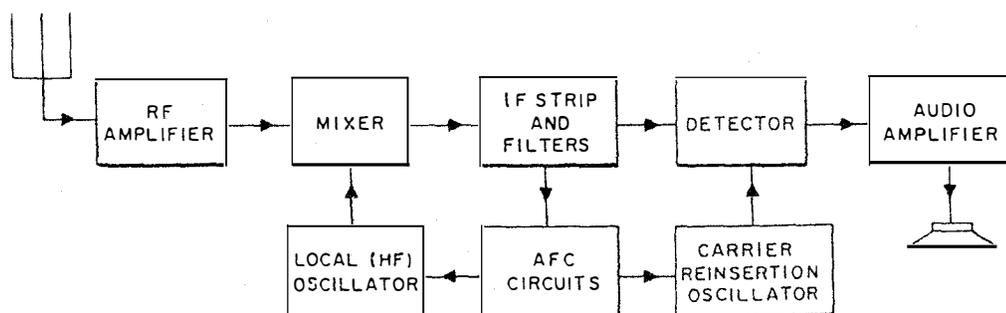


Figure 1-9.—Basic ssb receiver.

Table 1-3.—Decibel to Power Ratio

DB Loss or Gain	=	Power Ratio Loss or Gain
1	=	1.3
3	=	2.0
5	=	3.2
6	=	4.0
7	=	5.0
10	=	10
20	=	100
30	=	1000
40	=	10,000
50	=	100,000
60	=	1,000,000

Table 1-4.—Logarithms

LOG 1 = 0.0000	LOG 8 = 0.9031
LOG 2 = 0.3010	LOG 9 = 0.9542
LOG 3 = 0.4771	LOG 10 = 1.0000
LOG 4 = 0.6021	LOG 20 = 1.3010
LOG 5 = 0.6990	LOG 30 = 1.4771
LOG 6 = 0.7782	LOG 40 = 1.6021
LOG 7 = 0.8451	LOG 50 = 1.6990
	LOG 60 = 1.7782

As a Navy technician, you will use the dBm system of measurement often to perform receiver sensitivity tests. For example, a receiver rated at -110 dBm will detect a signal 110 dB below 1 milliwatt. Suppose the receiver's sensitivity drops to -107 dBm. Since a loss of 3 dB reduces the sensitivity by 1/2, the input signal will have to be twice as large to be detected.

TRANSCIVERS

A transceiver is a unit, usually enclosed in a single case, that combines a transmitter and receiver using a

common frequency control. Transceivers are used extensively in two-way radio communications at all frequencies, and in all modes.

The primary advantage of using a transceiver rather than a separate transmitter and receiver is cost. In a transceiver, many of the components can be shared during both transmit and receive operations. Another advantage is that transceivers can be tuned more easily than separate units.

A disadvantage of using a transceiver is that while duplex operation is not possible with most

transceivers, communication must sometimes be carried out on two different frequencies. Although this is a problem with most transceivers, some do have provisions for separate transmit and receive operations, allowing them to overcome the problem.

ANCILLARY EQUIPMENT

Now that we have looked at the basic components of a communications system, let's identify some of the ancillary equipment required to make a transmitter and receiver useful.

HANDSET

A handset converts acoustical (sound) energy into electrical energy, which is used to modulate a transmitter. It also converts electrical energy into acoustical energy for the reproduction of the received signal.

To key a transmitter, the push-to-talk button is depressed, closing the dc keying circuit, which places the transmitter on the air. The handset is normally connected to a radio set control but can be used locally at the transmitter. Using the "local" option is a good way to determine whether a problem exists in the transmitter or remote equipment.

RADIO SET CONTROL

The radio set control provides the capability to control certain transmitter functions and the receiver output from a remote location. Some control units contain circuits for turning the transmitter on and off, voice modulating the transmission, keying when using CW, controlling receiver output, and muting the receiver when transmitting.

A representative radio set control unit is shown in figure 1-10. As many as four of these units may be paralleled to a single transmitter/receiver group to provide additional operating positions. This setup is often found aboard ship when a transmitter or receiver is controlled from various locations like the bridge or combat information center.

TRANSMITTER TRANSFER SWITCHBOARD

The transmitter transfer switchboard allows the remote control station functions and signals to be transferred selectively to the transmitters. Figure 1-11 shows a transfer switchboard that allows the functions and controls of any one, or all, of 10 remote control

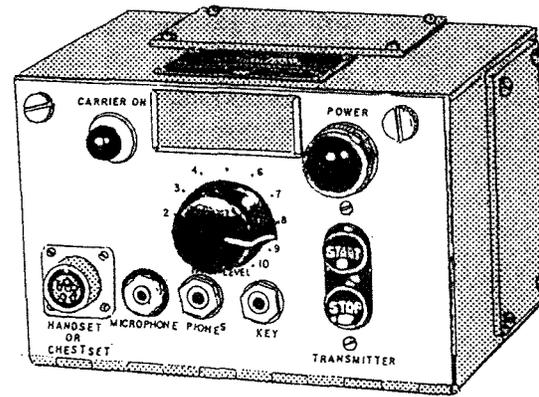


Figure 1-10.—Radio set control.

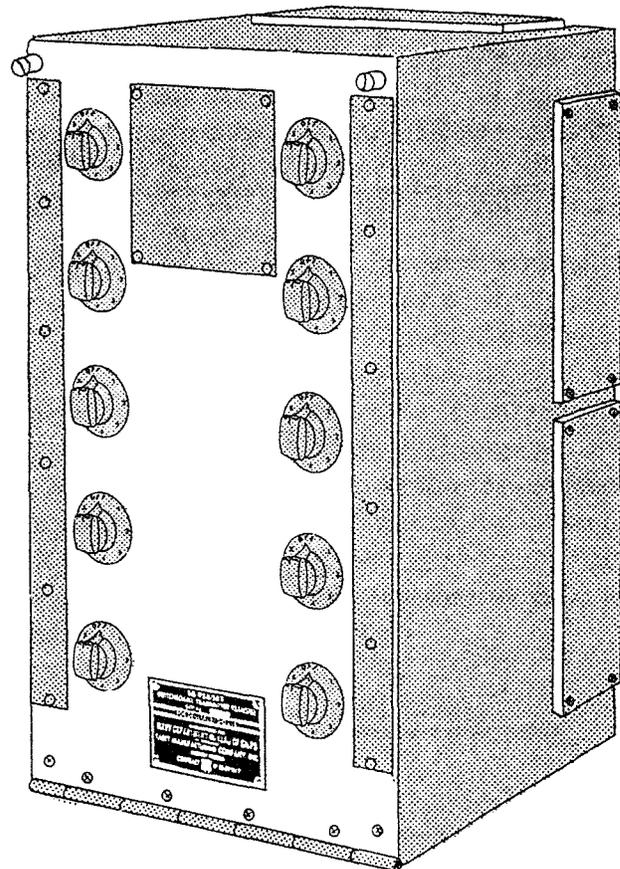


Figure 1-11.—Transmitter Transfer Switchboard (SB-988/SRT).

station functions and signals to be transferred selectively to any one of six transmitters. Each knob corresponds to a remote control station and has 8 operating positions. Positions 1 through 6 correspond to attached transmitters. The seventh position (X) allows

for switching of the transmitters to another switchboard. The eighth position (OFF) removes the remote from the system.

RECEIVER TRANSFER SWITCHBOARD

The receiver switchboard allows the audio outputs from the receivers to be transferred to remote control station audio circuits. A representative receiver transfer switchboard is shown in figure 1-12. This switchboard contains 10 seven-position switches. Each switch corresponds to a remote control station and each switch position (1 through 5) represents a receiver. Position X allows the circuits attached to the switch to be transferred to another switchboard.

ANTENNAS

An antenna is a conductor or system of conductors that radiates or intercepts energy in the form of electromagnetic waves. An antenna can be simply a piece of wire; but in practice, other considerations make the design of an antenna system complex. The height above ground, conductivity of the earth, antenna shape and dimensions, nearby objects, and operating frequency are just a few of the factors affecting the radiation field pattern.

Information on antenna theory, basic antennas, and wave propagation will be available in *Antennas & Wave Propagation*, volume 7, of this training series. Currently, you can find information in Navy Electricity and Electronics Training Series (NEETS), Module 10, *Introduction to Wave Propagation, Transmission Lines, and Antennas*, NAVEDTRA 172-10-00-83.

SYNCHROS AND SERVOS

In many electromechanical systems the angular position of a shaft must be transmitted from one location to another without an actual mechanical linkage. You have seen examples of this in mast-mounted rotating directional antennas and the automatic tuning function of receivers and transmitters from remote locations. A widely used method employs ac machines that operate as single-phase transformers. These machines are called *synchros*.

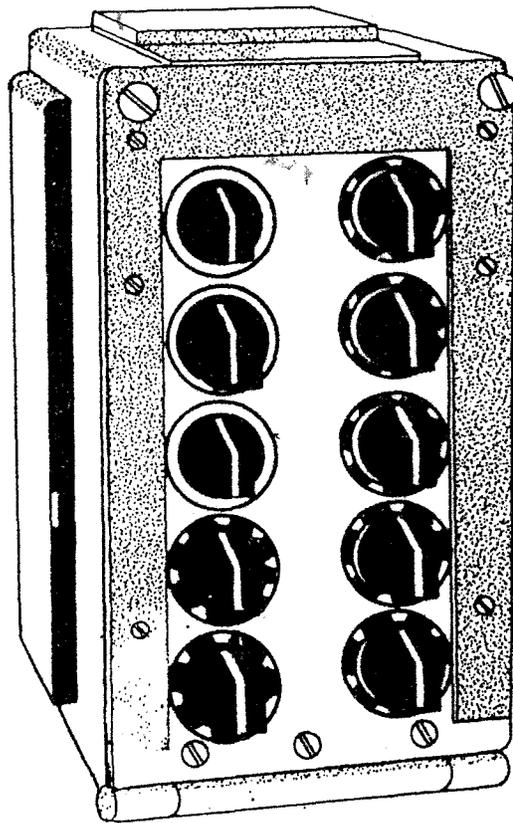


Figure 1-12.—Receiver Transfer Switchboard (SB-973/SRT).

Synchro receivers contain sets of gears that do the actual moving of the device to which the synchro is attached. These receivers are light-duty devices, designed to move small loads or to produce small amounts of torque. When the shaft to be driven at the remote location is connected to an indicating device or some light load, the synchro receiver is capable of developing the necessary torque. But, if the load is a heavy load and more torque is required, torque (power) amplification is required. A control system capable of delivering larger amounts of power or torque is known as a servo mechanism, or *servo*.

You will encounter many systems that use synchros and servos. You can find detailed information about these devices in the *Military Standards Handbook*, MIL-HDBK-225 and NEETS, Module 15, *Synchros, Servos, and Gyros*, NAVEDTRA 172-15-00-85.

CHAPTER 2

SYSTEMS EQUIPMENT CONFIGURATIONS

INTRODUCTION

In chapter 1, we discussed basic system requirements. In this chapter, we will look at each equipment configuration. We will then link them together, forming a block diagram of the systems covered. We will discuss naval equipment from extremely-low-frequency through super-high-frequency. We also will look at microwave communications, the Single Audio System, Naval Tactical Data System, teletype equipment, portable and pack radio equipment, and the Communications Link Interface Planning System.

At various points in the chapter, we review basic principles associated with the larger topic. The purpose of those reviews is to refresh your memory, in case you have not worked in the area for sometime.

SHIPBOARD COMMUNICATIONS OVERVIEW

Shipboard communications are now highly sophisticated. Nearly all the communications requirements for a ship can be met with fewer, more versatile, pieces of

equipment. This versatility came about through improved equipment design and installation.

As communications equipment became more capable and complex, the need for an orderly process of identifying equipment by designation became apparent. The process that was developed identified equipment from the system level down to the part level. The highest level designator, *system*, describes pieces of equipment that work together for a specific function. The lowest level designator, *part*, describes one piece, like a resistor. The following paragraphs describe the various levels in greater detail.

SYSTEM

Recall from chapter 1 that a communications system is a collection of equipment used together to satisfy a specific communications requirement. Further, as the following paragraphs explain, a *system* is a combination of *sets*, *units*, *assemblies*, *subassemblies*, and *parts*. The requirement placed on the system could be to send or receive voice, cw, or teletype information. Figure 2-1 illustrates the equipment

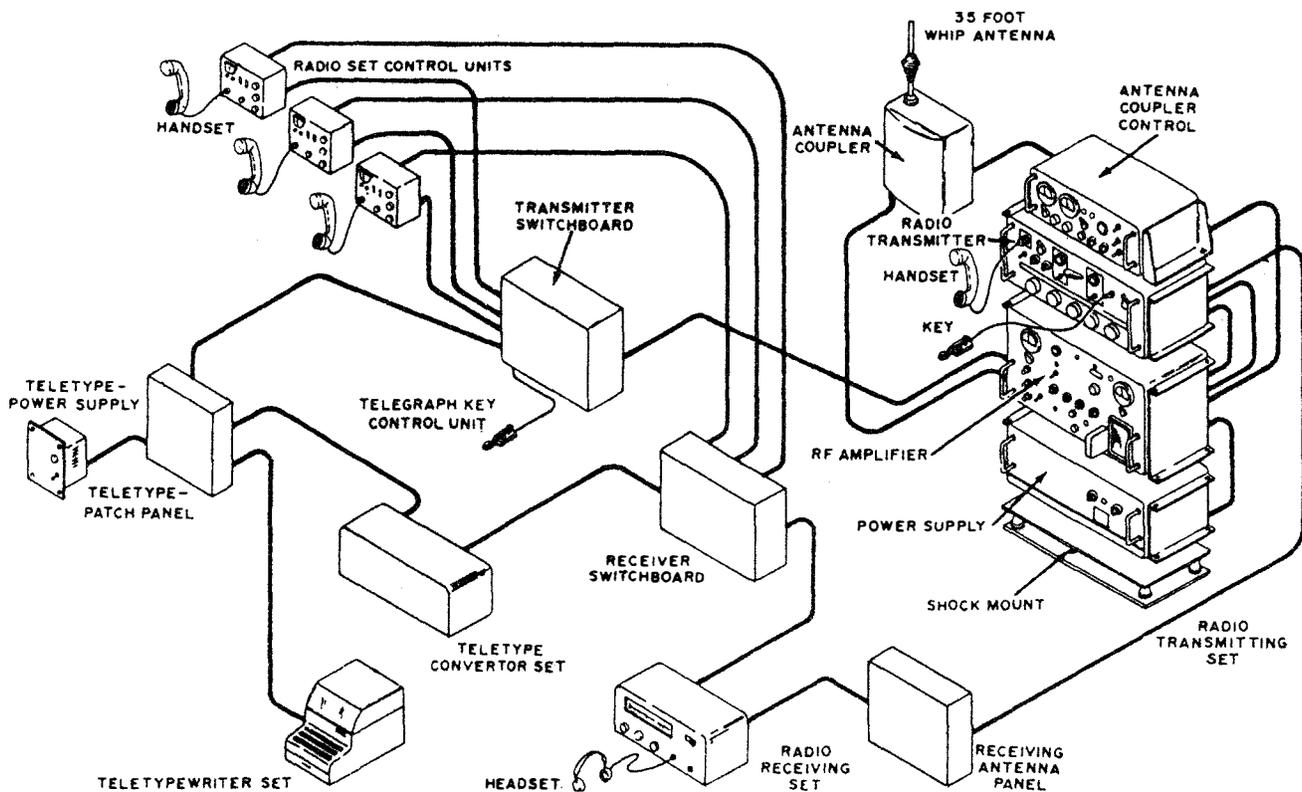


Figure 2-1.—Communications system pictorial view.

included in a typical system to meet these communication requirements.

SET

A *SET* consists of a unit or units and the assemblies, subassemblies, and parts connected to perform a specific function. Two examples are radio receiving sets and radio transmitting sets.

GROUP

A *GROUP* is a collection of units, assemblies, subassemblies, and parts that (1) is a subdivision of a set or system and (2) cannot perform a complete operational function. A good example is an antenna coupler group.

UNIT

A *UNIT* is a combination of parts, subassemblies, and assemblies mounted together that can normally operate independently of other equipment. An example of a unit is the power supply.

ASSEMBLY/SUBASSEMBLY

An *ASSEMBLY* is a combination of two or more subassemblies joined to perform a specific function. A *SUBASSEMBLY* consists of two or more parts that form a portion of an assembly. It can be replaced as a whole, but some of its parts can be replaced individually.

The distinction between an assembly and a subassembly is not always clear. An assembly may be considered a subassembly when it is part of a larger or more complex assembly. A computer keyboard is a good example. By itself, it is an assembly. However, it is also a subassembly in a total computer system. Another example you are very familiar with is a circuit card.

PART

A *PART* is one component or a combination of two or more components. A part cannot normally be disassembled without being destroyed. Resistors, capacitors, and transistors are examples of parts.

EQUIPMENT CONFIGURATIONS

The wide variety of communications equipment aboard ship can be overwhelming. This section separates that equipment into types of systems and identifies typical equipment associated with each type of system.

EXTREMELY-LOW-FREQUENCY/VERY-LOW-FREQUENCY COMMUNICATIONS

The extremely-low-frequency (elf) communications system is used to send short "phonetic letter spelled out" (PLSO) messages from the Continental United States (CONUS) to submarines operating at normal mission speeds and depths. Elf can penetrate ocean depths to several hundred feet with little signal loss. This allows submarines to operate below the surface, improving their survivability by making detection more difficult.

The elf system is a one-way communications system from CONUS to at-sea submarines. The large size of elf transmitters and antennas makes transmission from submarines impractical.

The principal use of the very-low-frequency (vlf) communications system is to provide fleet broadcasts to the submarine fleet and associated ships and activities throughout the world. Additional uses are in long-range navigation and time and frequency broadcasts.

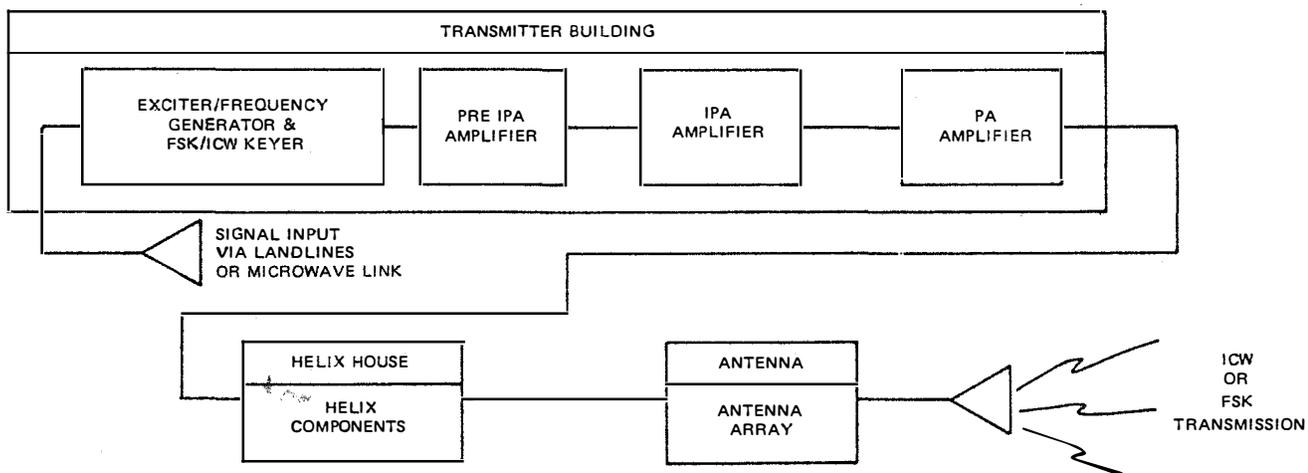


Figure 2-2.—Vlf radio transmitting station block diagram.

Vlf Transmit

Vlf transmission is normally considered a broadcast; that is, a one-way transmission, with no reply required. The extent and location of the area to be covered determine the transmitter location and power out.

For worldwide coverage, the Navy has installed seven transmitters whose power out ranges from 0.25 to 2.0 megawatts. These transmitters, such as the AN/FRT-87, can operate in either the interrupted

continuous wave (icw) or frequency shift keying (fsk) mode. A typical vlf radio transmitting station is shown in figure 2-2.

Vlf Receive

The vlf receive system receives fsk and icw radio transmissions and then reproduces the intelligence that was broadcast. Receivers used for vlf communications are the AN/BRR-3, AN/FRR-21, AN/WRR-3, and URR-R389. Figure 2-3 illustrates a typical vlf

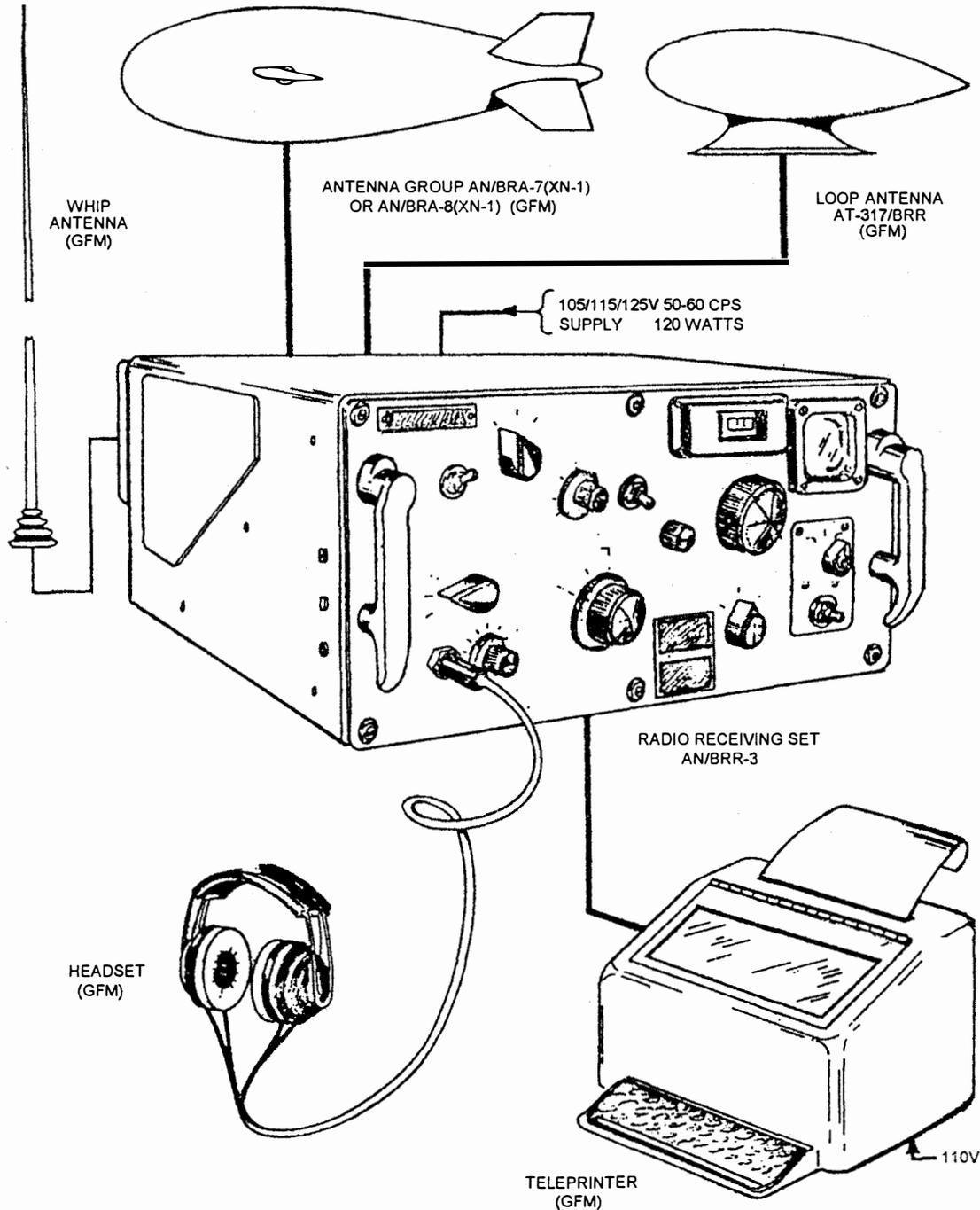


Figure 2-3.—Typical vlf receiving system.

receiving system, using the AN/BRR-3 receiver. Most surface ships no longer receive vlf broadcasts. However, you will probably find one of these receivers mounted somewhere in your message center or radio room.

LOW-FREQUENCY COMMUNICATIONS

The low-frequency (lf) band occupies a very small portion of the radio frequency spectrum. However, the Navy's requirement to provide the best possible communications to the fleet requires operation on all frequency bands. The low-frequency band is used for long-range direction finding, encrypted medium- and long-range communications, and aeronautical radio navigation.

Lf Transmit

The low-frequency transmitter is a part of the Fleet Multichannel Broadcast System, operating at high power over long distances. It provides eight channels of frequency-division multiplex rtty traffic on each transmission. The AN/FRT-72 transmitter is designed specifically for this purpose. It produces 50-kW peak-envelope power (25-kW average power) and covers a frequency range of 30 to 150 kHz. Low-frequency transmitters are normally used only on shore stations.

Lf Receive

The low-frequency receive system receives lf broadcasts and reproduces the intelligence that was transmitted. A typical lf receive system is shown in figure 2-4. The antennas receive the lf signal and send it to the multicoupler and patch panel. The multicoupler and patch panel (AN/SRA-17 and AN/SRA-49) allow

the operator to select different antennas and connect them to various receivers. In the system shown in figure 2-4, the receiver can be either the AN/SRR-19A or the R-2368A/URR. These receivers operate in the frequency ranges of 30 to 300 kHz and 14 kHz to 30 MHz, respectively.

The receiver audio is fed to the SB-973/SRR receiver transfer switchboard. As we explained earlier, this allows the received audio to be connected to numerous pieces of equipment. In figure 2-4, the audio is connected to either an AN/URA-17 or CV-2460 convertor comparator, which converts the received signal to dc for use by the teletype (tty) equipment. From the convertor, the dc signal is fed to a dc patch panel (SB-1203/UG). The signal can then be sent to any crypto equipment attached to the patch panel. The crypto equipment decrypts the signal and routes it to the red patch panel (SB-1210/UGQ). The signal can then be patched to a teletype printer for plain text printing, or to a reperforator, where a paper tape will be punched and stored for later printing.

HIGH-FREQUENCY COMMUNICATIONS

The high-frequency (hf) band is shared by many domestic and foreign users. Portions scattered throughout the band are assigned to the military. The Navy's communications requirements have grown rapidly, severely taxing its portion of the spectrum. Satellite communications has relieved some of this congestion and, for some types of service, has replaced hf for long-distance communications, pushing hf into a back-up role. However, even with the use of satellite communications, hf will continue to be in high demand for

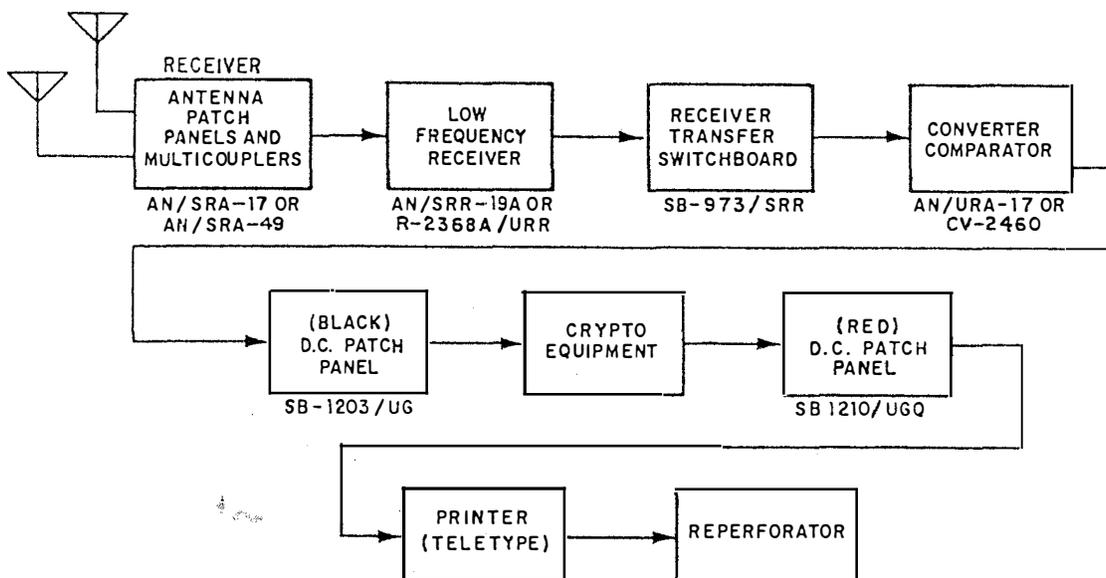


Figure 2-4.—Lf receive.

sometime. We will cover satellite communications in chapter 3.

Naval communications within the hf band are grouped into four general types: point-to-point, ship-to-shore, ground-to-air, and fleet broadcast. All but the fleet broadcast are normally operated two-way.

Point-to-Point

Point-to-point systems provide communications over long-distance trunks or via links between fixed terminals. A *trunk* is normally a message circuit between two points using cable, fiber, or telephone circuits. A *link* is a transmitter/receiver system connecting two locations. The two locations normally use directional, high-gain antennas that increase the effective radiated power, reduce the chance of interference, and boost the sensitivity of the receiving system. With the path length and direction fixed, propagation factors are simplified. This provides highly reliable hf communications.

Ship-to-Shore

High-frequency atmospheric communications between shore stations is relatively easy because shore stations have sufficient space for efficient omnidirectional antennas or arrays that provide hf coverage of large areas. Ship-to-shore hf communications are more difficult because the ship is moving and constantly changing direction. This change of direction and severe space limitations aboard ships make the installation of large, efficient hf antennas impractical.

To overcome these problems, ship-to-shore systems have two major differences from point-to-point systems. First, shipboard antennas are

omnidirectional. Second, several frequencies are usually assigned for each circuit. If one frequency starts to drop out, another can be selected to match the propagation path conditions between the ship and the shore terminal.

Ground-to-Air

The use of hf radio for ground-to-air communications is similar to its use for ship-to-shore communications. An additional problem, though, is that an aircraft moves much more rapidly than a ship. This rapid movement (plus additional space limitations) requires that all major circuit improvements be made at the ground stations. Examples of improvements that can only be made to the ground station are higher powered transmitters, lower noise receivers, and more efficient antennas.

Fleet Broadcast

As the name implies, this service involves broadcast area coverage from shorebased transmitters to ships at sea. To overcome propagation problems, messages are sent on several frequencies at the same time (frequency-diversity). Space-diversity with physically separated receive antennas also helps overcome propagation problems.

Now let's look at typical shipboard high-frequency transmit and receive systems.

Shipboard Hf Transmit

The high-frequency transmit signal can contain either voice or teletype information. Figure 2-5 shows a typical shipboard high-frequency transmit system.

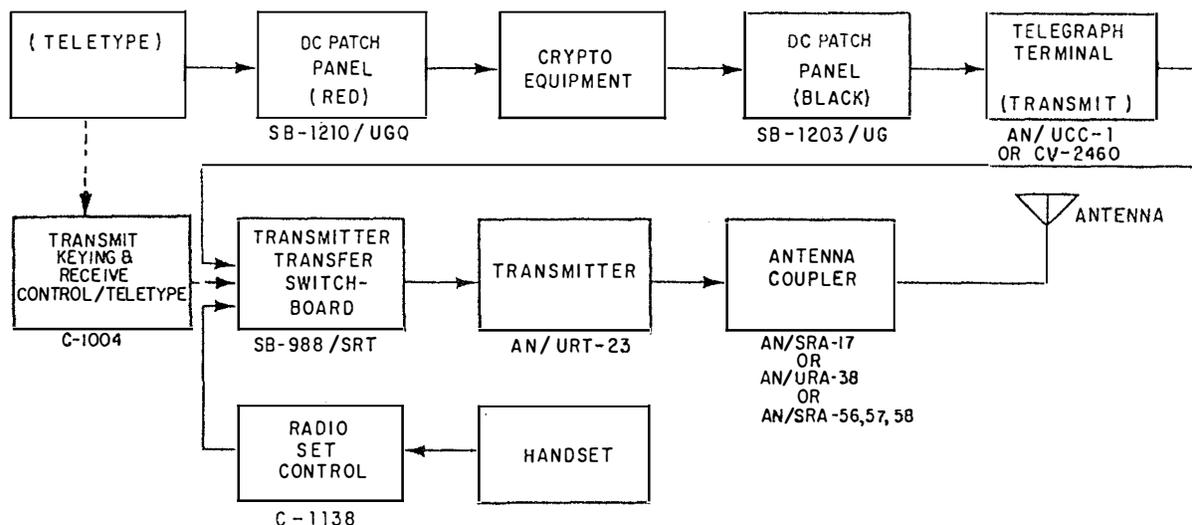


Figure 2-5.—Shipboard hf transmit system.

The same equipment used to receive teletype messages on low frequencies (teletype, DC Patch Panel SB-1210/UGQ, crypto equipment, and DC Patch Panel SB-1203/UG) are used to send teletype messages on the high-frequency system, but of course, in reverse order.

An AN/UCC-1(V) or CV-2460 telegraph terminal converts a dc signal into a tone signal. This signal is fed to the SB-988/SRT transmitter transfer switchboard. A C1004 transmit keying and control/teletype is used to key the transmitter during tty operation. Voice communications also can be connected to the SB-988/SRT switchboard. The voice communications are developed at a handset connected to the C-1138 radio set control. The output of the radio set control is then fed to the switchboard.

The transmitter transfer switchboard allows operators to select the proper transmitter for the selected frequency. The AN/URT-23 transmitter receives its input from the switchboard and changes the signal to a modulated rf signal that is fed to the AN/SRA-34,56,57, 58, or AN/URA-38 antenna coupler. The antenna coupler matches the output impedance of the transmitter to the input impedance of the antenna. Antenna couplers also allow more than one transmitter to be connected to the same antenna as long as certain conditions are met. When the signal reaches the antenna, it is radiated into the atmosphere.

Shipboard Hf Receive

A typical shipboard hf receive system is shown in figure 2-6. A transmitted signal similar to the one previously discussed is received by the antenna and converted from electromagnetic energy to electrical energy. The signal is fed to an antenna patch panel where it can be distributed to any number of receivers.

In figure 2-6, a receiver (R-1051/URR, R-2368/URR, or R-1903/URR) converts the rf signal into either a teletype signal (fsk) or voice. The receiver output is then fed to the SB-973/SRR receiver transfer switchboard. The teletype signal from the switchboard follows the same path used by the low-frequency signal we discussed earlier. Identical pieces of equipment are used. The voice signal from the receiver switchboard is sent to the C-1138 radio set control and fed to a handset. The voice signal also can be sent from the switchboard to an AM-3729 remote speaker amplifier and then to a speaker. This allows the user to listen to the signal without having to hold the handset.

VERY-HIGH-FREQUENCY COMMUNICATIONS

The Navy uses the very-high-frequency (vhf) band for mobile communications such as bridge-to-bridge, among boat crews, and for amphibious operations and landing parties.

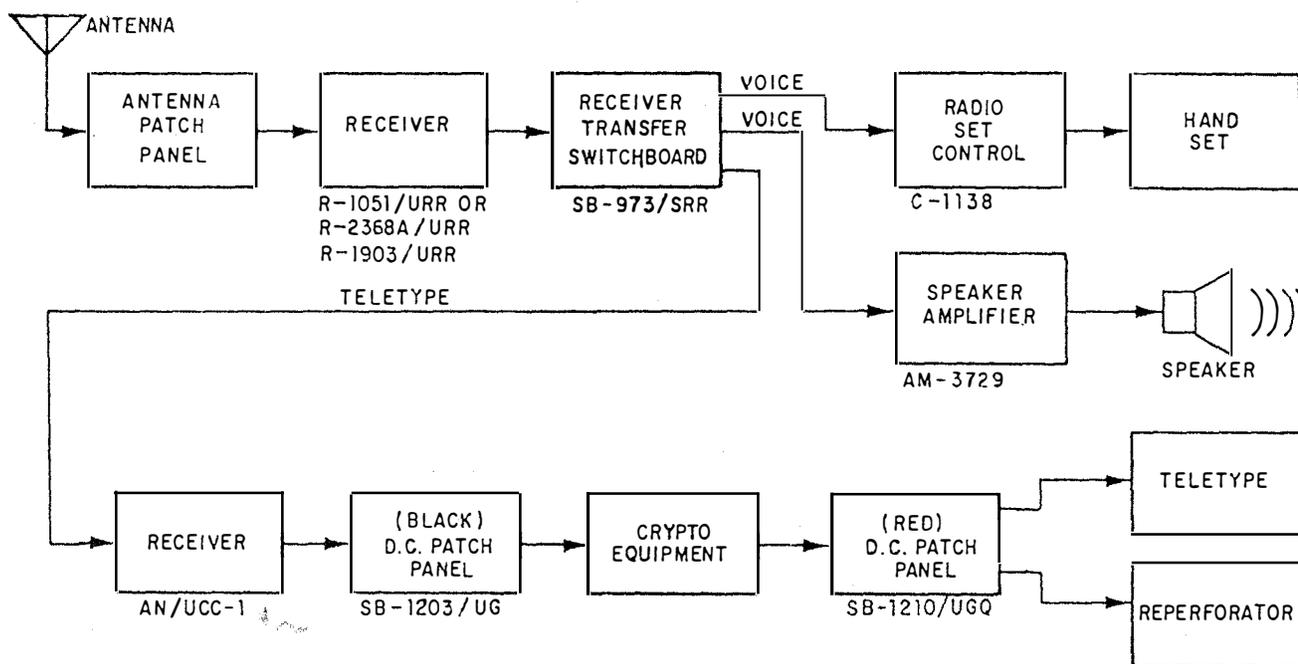


Figure 2-6.—Shipboard hf receive system.

Vhf Transmit

A typical vhf transmit and receive system is shown in figure 2-7. On the transmit side, the operator, at a remote location, talks into the handset. The handset is connected to radio set control, C-1138. The radio set control output is fed to transmitter transfer switchboard, SB-988/SRT. The switchboard performs the same function as it does in the lf and hf systems. The output of the switchboard is connected to the transmit side of the transmitter/receiver (transceiver), AN/VRC-46 or AN/VRC-80. The transceiver converts the input signal to an rf signal for transmission and the rf is radiated into the atmosphere by the antenna.

Vhf Receive

Again, look at figure 2-7. The incoming signal is picked up by the antenna. This signal is fed to the

receive side of the transceiver. The transceiver output is fed to the receiver transfer switchboard. The switchboard output is connected to either radio set control or to a speaker amplifier, AM-3729, or both, depending on the user's preference. The output of the radio set control is fed to the handset and the speaker amplifier output is routed to the speaker.

ULTRAHIGH-FREQUENCY COMMUNICATIONS

The ultrahigh-frequency (uhf) band is used for line-of-sight (short range) command and control communications. As we stated earlier, line-of-sight means that both antennas are aimed at one another, with no obstruction in between.

This band is also used for satellite communications. Satellite communications are line-of-sight communications because the antennas remain in sight of each other, though the distance traveled by the signal is much greater than for surface communications.

The uhf system uses a transceiver. However, we will still describe the transmit and receive functions separately. Although this description pertains to voice communications, uhf equipment can process tty data in the same way that the hf system does.

Uhf Transmit

A basic block diagram of a uhf transmit system is shown in figure 2-8. On the transmit side of the

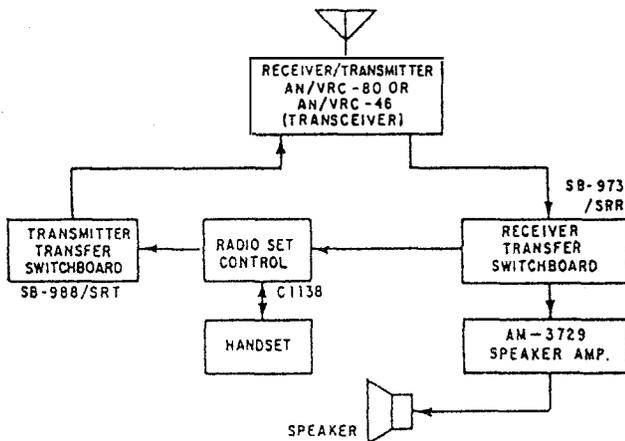


Figure 2-7.—Vhf transmit and receive system.

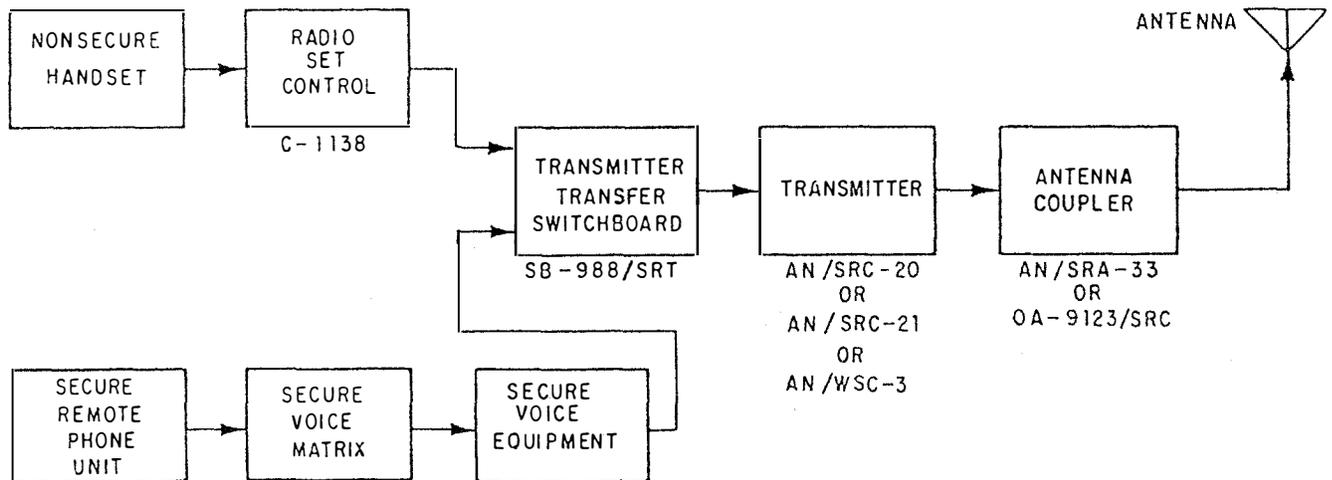


Figure 2-8.—Uhf transmit.

nonsecure voice system, the operator at a remote location talks into the handset. The handset is connected to a C-1138 radio set control. The radio set control is connected to an SB-988/SRT transmitter transfer switchboard, which is connected to the transmitter.

On the transmit side of the *secure* voice system, the operator talks into the secure voice remote phone unit (RPU). The RPU is connected to the secure voice matrix, which is the tie point for the connection of multiple remote phone units. The matrix output is fed to the secure voice equipment that encrypts the information. This encrypted information is then fed to an SB-988/SRT transmitter transfer switchboard.

The transmitter switchboard performs the same function we described for previous systems. The switchboard output is connected to the transmit side of the AN/SRC-20/21 or AN/WSC-3, which is connected to an AN/SRA-33 or OA-9123 antenna coupler. The coupler output is then fed to an antenna.

Uhf Receive

A basic block diagram of a uhf receive system is shown in figure 2-9. Most of the components are the same as those used in the transmit function. We will,

therefore, identify by specific designator only the components that are unique to the receive function. The receive signal is picked up by the antenna and fed to the receive side of the transceiver through the antenna coupler. The receiver output is connected to an SB-973/SRR receiver transfer switchboard. It is then connected to either the nonsecure or secure voice system, depending upon the received transmission mode.

When a nonsecure signal is received, the output of the receive transfer switchboard is fed to either the radio set control or to the AM-3729 speaker amplifier, or both, depending on user preference.

If a secure voice transmission is received, the output of the switchboard is connected to the secure voice equipment and decrypted. This output is fed to the secure voice matrix. The secure voice matrix output is fed to the RPU, where the signal is converted back to its original form.

SUPERHIGH-FREQUENCY COMMUNICATIONS

As we discussed in the previous chapter, two primary uses of the superhigh-frequency (shf) band

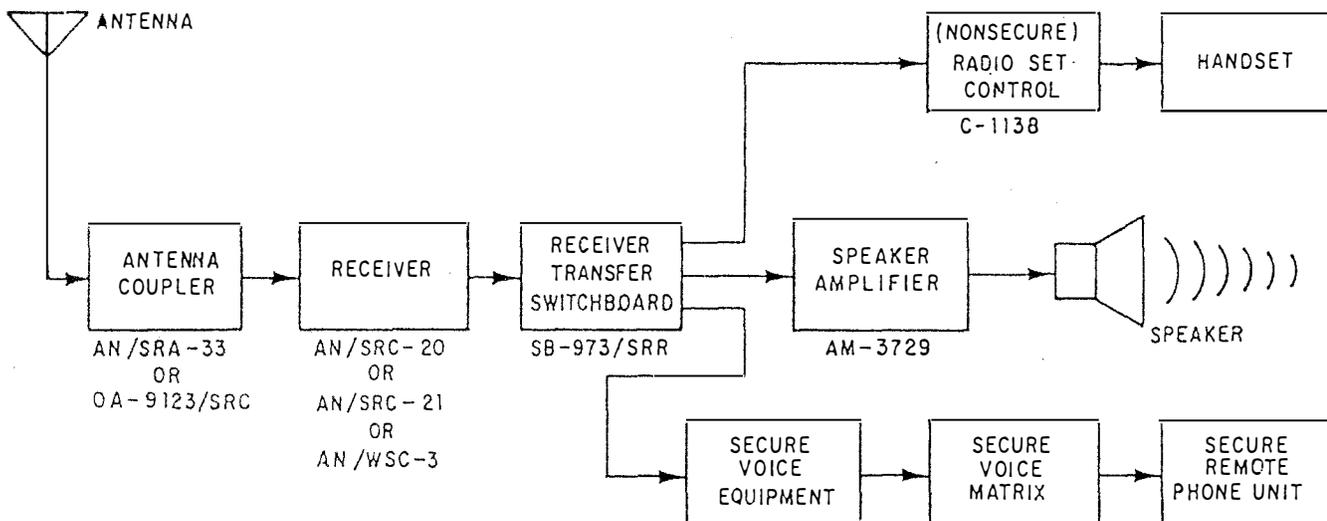
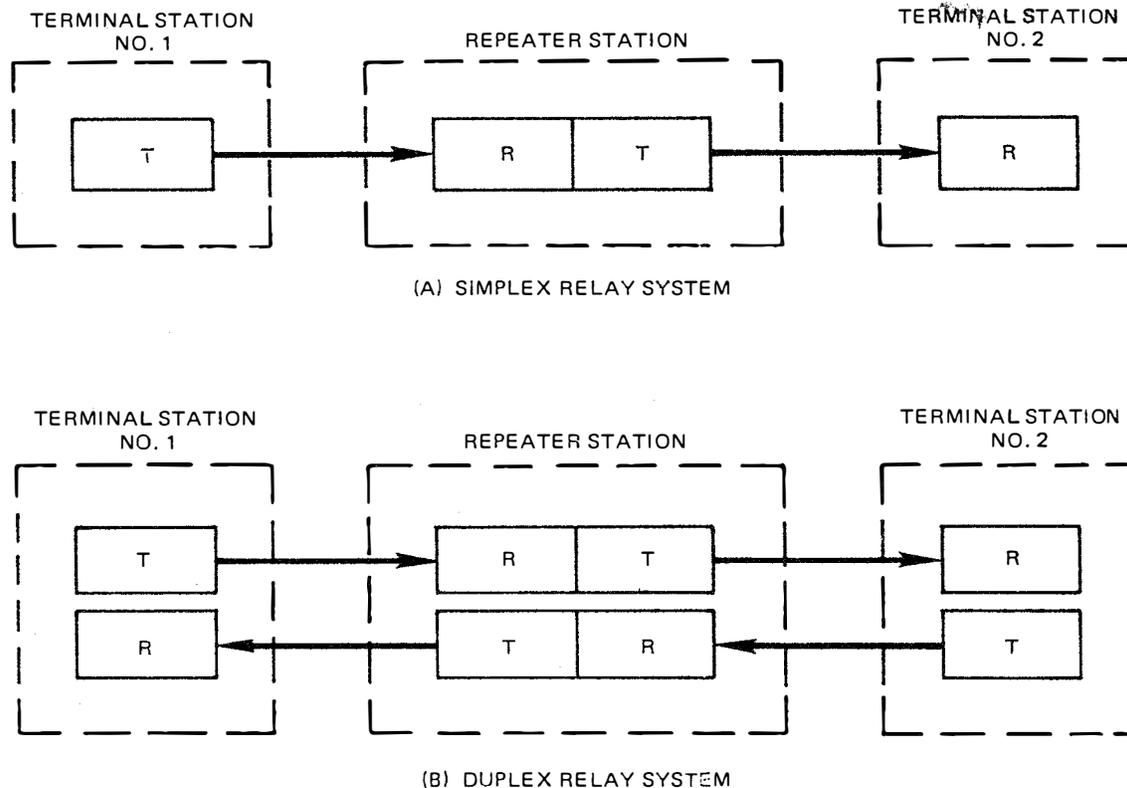


Figure 2-9.—Uhf receive.



NOTE:
 R IS ABBREVIATION FOR RECEIVER
 T IS ABBREVIATION FOR TRANSMITTER

Figure 2-10.—Basic microwave relay system.

are microwave and satellite communications. The AN/FSC-79 SHF terminal and satellite communications will be covered in the next chapter. In the following paragraphs, we will discuss line-of-sight and tropospheric scatter microwave communications.

MICROWAVE COMMUNICATION SYSTEMS

Microwave systems, such as the AN/FRC-84 and AN/FRC-170(V), are used to relay multiplex signals from point to point. A simplex relay system provides one-way communications and consists of a transmitting terminal, a certain number of repeaters, and a receiving terminal. Figure 2-10A shows you such a system. A

duplex relay system (figure 2-10B) provides two-way communications by using two simplex systems, one transmitting in one direction and the other transmitting in the opposite direction. The duplex system is further refined by using a single antenna for transmitting and receiving. This is done by using different transmitting and receiving frequencies and by using a duplexer in the transmission line.

The rf equipment in terminal and repeater stations are basically the same. Terminal equipment can be converted to repeater equipment and vice versa. Let's take a look at a typical microwave transmitter and receiver.

MICROWAVE TRANSMITTER

A typical microwave transmitter is shown in figure 2-11. In operation, the output of a telephone multiplex terminal, which consists of a frequency multiplexed AM carrier signal, is applied to the terminal transmitter. This input signal (baseband signal)

also could be a television signal or any other form of signal to be transmitted. A pre-emphasis network accentuates the high frequencies, relative to the low, to improve the signal-to-noise ratio. The insertion amplifier accepts the signal, amplifies it, and then applies the signal to the klystron oscillator. With this method, the input signal directly modulates the carrier

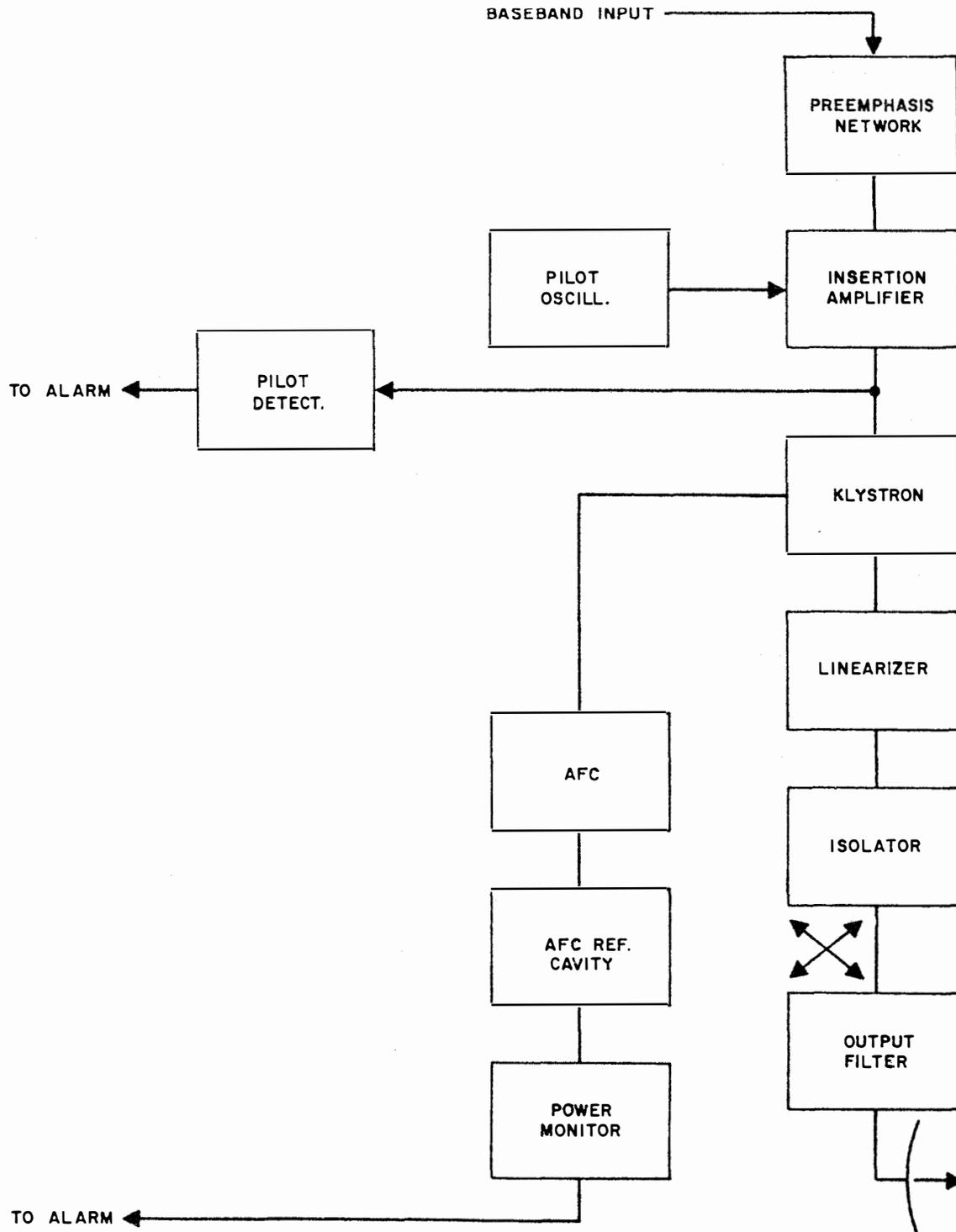


Figure 2-11.—Typical microwave transmitter.

frequency, resulting in a frequency-modulated wave. The "linearizer" couples a portion of the output power back to the klystron to compensate for its nonlinearity. This technique allows for optimum performance with modulation densities as high as 1200 channels. You should be aware that solid-state devices are replacing most klystrons.

MICROWAVE RECEIVER

A typical microwave receiver is shown in figure 2-12. Though not shown, sensing and alarm functions are integral to all microwave communications equipment.

During system operation, the signal from the antenna passes through a waveguide preselector that eliminates interference from adjacent rf channels. The signal then enters a waveguide filter tuned to its frequency, which rejects all other unwanted frequencies. Next, the signal passes through an isolator that minimizes intermodulation noise and holds the VSWR below 1.2:1. The signal is then mixed with the local oscillator (LO) output to produce the standard 70-MHz intermediate frequency (IF). The IF output is amplitude-limited and applied to an automatic frequency control (afc) discriminator, which controls the frequency of the LO. The signal is also applied to an IF discriminator, a de-emphasis circuit, and a squelch circuit that disconnects the baseband amplifier and

demultiplexing equipment if noise increases above a preset level. After the squelch circuit, the signal passes through a baseband amplifier and then to the demultiplexing equipment, where the original intelligence is retrieved.

Microwave communications systems operating in the shf portion of the frequency spectrum use the principle that propagation approaches an optical straight-line path. Propagation takes place in the lower atmosphere and is affected by meteorological factors. Communications in this medium are usually either line-of-sight or tropospheric scatter.

LINE-OF-SIGHT (LOS)

A line-of sight microwave system consists of one or more point-to-point hops. Each hop is designed to be integrated into a worldwide communications network. Los system characteristics are as follows:

- Propagation—Free space as affected by the troposphere.
- Communications Capacity/Bandwidth—Up to 600 - 4kHz voice channels; wideband, can accept TV.
- Range—Usually 50 to 150 km (31 to 95 statute miles). This depends upon antenna height, earth curvature, and intervening terrain.
- RF Power—Usually less than 10 watts.

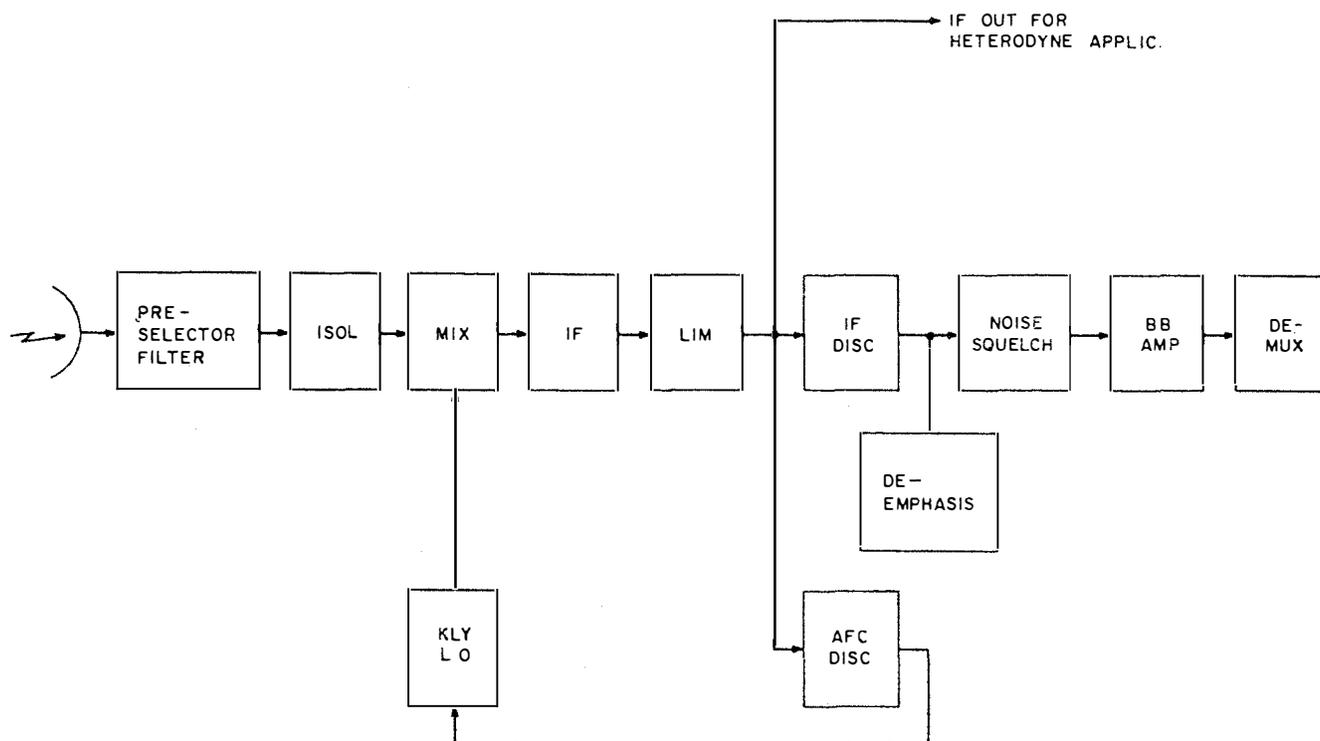


Figure 2-12.—Typical microwave receiver.

- **Antennas**—Both transmitting and receiving antennas are horn-driven paraboloids, providing high gain and narrow beam widths. In some applications, plane reflectors are used with the paraboloids.

- **Reliability**—Designed to be operational more than 99% of the time, including the periods of poor propagation.

- **Countermeasures**—Because of antenna directivity, the system is difficult to jam. Additionally, the system should not be susceptible to nuclear disturbances of the ionosphere.

- **Application**—Because of the bandwidth capability and minimum site requirements, los is well adapted to moderate distance point-to-point multichannel communications (with repeaters), transmission of closed circuit TV, transmission of radar information from outlying sites, communications relay between locations in congested areas, and “antenna farms.”

TROPOSPHERIC SCATTER SYSTEM

At microwave frequencies, the atmosphere has a scattering effect on electromagnetic fields that allows for over-the-horizon communications. This type of communications is called tropospheric scatter, or *troposcatter* for short. Troposcatter takes place mostly at low altitudes, but some effect takes place at altitudes of up to 10 miles. Under the right conditions, troposcatter can take place over hundreds of miles.

A tropospheric scatter microwave system consists of one or more point-to-point hops (or sections). Each hop is designed so it can be integrated into the worldwide communications network of the Defense Communications System (DCS). Troposcatter links have the following characteristics:

- **Propagation**—Free space as affected by the troposphere.

- **Communications capacity/bandwidth**—Up to 600 4-kHz voice channels; wideband, can accept TV.

- **Range**—Up to 800 km (500 statute miles).

- **RF Power**—High; up to 75 kilowatts depending upon bandwidth, quality, and range.

- **Coverage**—Point-to-point only.

- **Antennas**—Both transmitting and receiving antennas are horn-driven paraboloids providing high gain and narrow beam widths.

- **Reliability**—Designed to be operational more than 99% of the time, including periods of poor propagation.

- **Countermeasures**—Extremely difficult to jam. Should not be susceptible to nuclear disturbances of the ionosphere.

- **Application**—Meets the communications requirements between HF sites within its minimum sky-wave one-hop distance of about 400 miles and line-of-site of about 30 miles. It is especially useful where conditions prevent the use of line-of-sight communications or if adverse propagation conditions interfere with other transmission methods.

MULTIPLEXING

As we mentioned earlier, the rf spectrum has become very congested. The maximum number of transmissions taking place in the rf spectrum is being increased through the use of *multiplexing*. Multiplexing refers to the simultaneous transmission of two or more messages over the same medium or channel at the same time. Multiplexing may be achieved in various ways, but the most common methods are time-division multiplexing (tdm) and frequency-division multiplexing (fdm). Although several types of multiplexing equipment are available in the fleet today, the AN/UCC-1D is the most common.

TIME-DIVISION MULTIPLEXING

Time Division Multiplexing (Tdm) is a method of combining analog signals for serial transfer. The signals are sampled at intervals and interwoven for transmission. The speed of this multiplexed signal is faster than the original individual channel speed by a multiple equal to the number of combined signals. For example, if 5 signals are multiplexed, the data speed of each signal must be multiplied by 5 to keep the signals in synchronization. Tdm also results in an increase in the signal bandwidth because of the increased data speed.

Time-division multiplexing also can be used with digital signals, but this method is usually called *synchronous* multiplexing.

FREQUENCY-DIVISION MULTIPLEXING

Unlike tdm, which samples a portion of the sine wave, frequency-division multiplexing (fdm) transmits and receives for the full 360 degrees of the sine wave. A channel is subdivided into smaller segments of equal size, called *subchannels*. Each subchannel carries a separate signal. Fdm used by the Navy can generally be divided into two categories, voice and tty

communications. You can find more information on multiplexing in NEETS, volume 17.

SINGLE AUDIO SYSTEM (SAS)

The Single Audio System (SAS) was developed to fulfill the requirement for an integrated secure/nonsecure shipboard voice communications system. It consists of telephone sets, voice-signal switching devices, various control devices, and field changes to existing equipment, in conjunction with other elements of the overall shipboard radio communications system. The SAS is essentially the baseband (AM and/or FM) hf, vhf, or uhf audio subset of the shipboard exterior communications system. It incorporates voice communications circuits, user control over the operating mode (both secure and nonsecure), and various degrees of operator control over voice circuit selection. Figure 2-13 shows the major equipment groups, subsystems, and their interrelationship.

There are two versions of SAS: an automated system (ASAS) and a manual system (MSAS). The voice switching equipment and means provided for user control over circuit selection are the two primary differences. Information in this section applies to both ASAS and MSAS, unless otherwise specified.

There is no specific list of equipment that make up every SAS installation. There can be different types and quantities of equipment in each of the groups identified in figure 2-13. Equipment types and quantities are dictated by the communications requirements of individual ships and ship classes. The publication, *Operation and Maintenance Instructions, Single Audio System*, NAV-ELEX EE109-CA-OMI-010/E110 SAS, identifies, in

tables 1-1 and 1-2, the SAS equipment commonly used in the fleet.

SYSTEM CAPABILITIES

The SAS incorporates basic capabilities for setting up and operating voice communications circuits. An SAS installation provides the unique capability to communicate in a secure or nonsecure mode, at the discretion of the operator, from a single telephone or NTDS device. This single audio interface with various crypto or plain subsystems is the essence of the SAS. The SAS provides the following options:

- The user can select the transmit operating mode except for FLTSATCOM secure voice and PLAIN configurations.
- The system can notify the user of the transmit operating mode selected, both visually and with audio indications.
- The system can notify the user by visual indication if the voice station equipment is not connected to a crypto or plain subsystem.
- The system can notify the user of any incoming secure (CIPHER) signals by both visual and audio indications except for the FLTSATCOM secure voice configuration.
- The user can select a voice channel and have it indicated visually.
- In addition to these capabilities, the ASAS version has the following features:

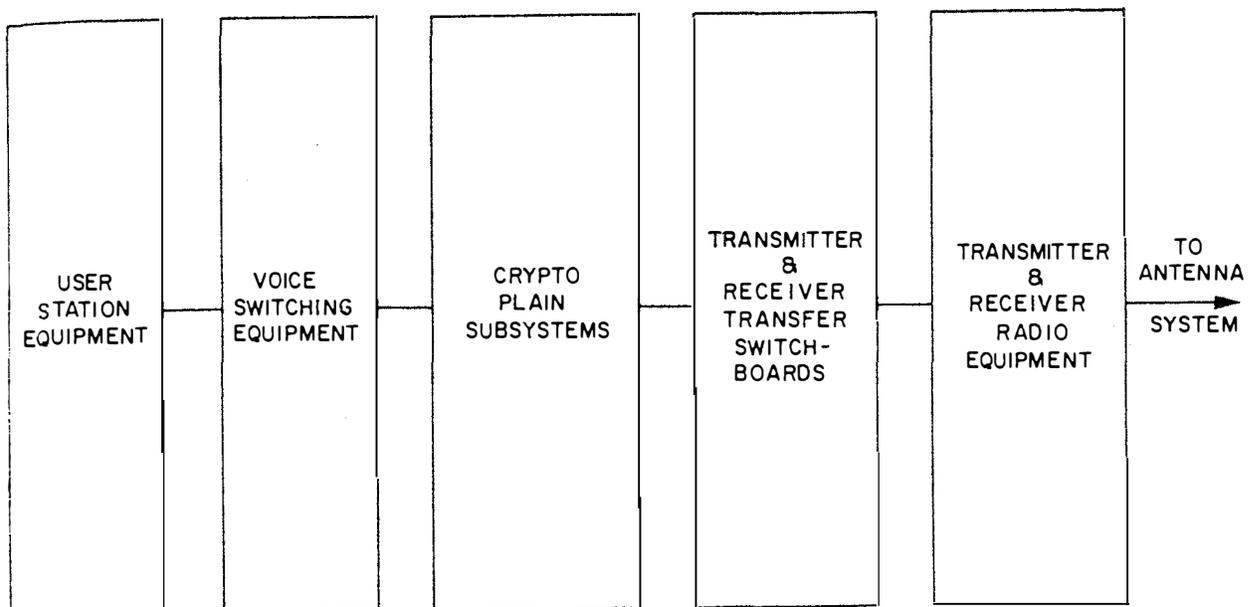


Figure 2-13.—Single Audio System (SAS).

- A processor controlled, programmable voice switch.
- A voice switch self-test and fault location read-out (built-in test).
- An audio indication to the user when the voice switch built-in-test (BIT) detects a trunk line short.
- A technical control monitor phone, incorporated into the voice switch, which can access all voice channels.

SYSTEMS EQUIPMENT AND LOCATION

The following paragraphs provide a brief description of the major equipment included in a typical SAS installation. Figure 2-13 illustrates the audio path of the system and the order in which we will discuss the equipment.

User Station Equipment

User station equipment is located in operations centers throughout the ship, like the bridge, combat information center (CIC), flag plot, secondary conn, and other stations where exterior voice communications are required by the ship's mission. This equipment consists of telephone sets, audio amplifiers, loudspeakers, headsets, recorders, audio jackboxes, Naval Tactical Data System (NTDS) consoles and intercom units, and local switching devices for added system flexibility.

Voice Switching Equipment

The voice switching equipment is a major component of the SAS. It is the interface and primary switch between the user's equipment and all crypto and plain subsystems. It is designed for very high interchannel isolation, which is a TEMPEST requirement for all equipment that handle both secure and nonsecure signals at the same time. (The ASAS and MSAS use different switches for this purpose.)

Crypto and Plain Subsystems

The various crypto and plain subsystems are located in the main communications spaces. Cryptographic devices and other "red" equipment are located in a secure area within these spaces. There are five crypto and plain subsystems used within the SAS: NESTOR, VINSON, PARKHILL, FLTSATCOM secure voice, and PLAIN ONLY. Additional classified information on these subsystems is available on a need-to-know basis.

Transmitter and Receiver Transfer Switchboards

These equipment are part of the overall exterior communications switching system and are located in the main communications spaces, generally in the vicinity of the technical control working area. The switchboard equipment group interconnects crypto and plain subsystem equipment with the appropriate radio equipment. You should recall from chapter 1 that these switchboards are also the interconnecting points for other subsystems within the overall exterior communications system. Therefore, they are not unique to the SAS.

Transmit and Receive Radio Equipment

These equipment may be located in both the main communications spaces and in separate rooms located in various parts of the ship. This equipment group consists of the various transceivers, transmitters, and receivers used for voice nets. The more common transceivers you will encounter are the AN/SRC-20 series, AN/VRC-46, AN/WSC-3(V)3 and (V)7, AN/URC-93, and AN/WSC-6. Common transmitters include the AN/URT-23, AN/URT-24, T-1322/SRC, and AN/GRT-21. Common receivers are the R-1051 series, R-1903, and AN/GRR-23. For additional information on individual equipment, refer to that equipment's technical manual.

NAVAL TACTICAL DATA SYSTEM (NTDS)

The nature of naval warfare has been radically altered with the introduction of new, ultracomplex, and extremely effective combat systems. These continually evolving systems have not solved or eased the basic command problems that face the U.S. Navy. During combat, the shipboard combat information center (CIC) must deal with extremely complex tactical situations. These situations require that a multitude of intelligent and highly significant real-time decisions be made instantly.

The Naval Tactical Data System (NTDS) is a practical approach to ensuring the most effective use of both decision time and full fleet capability. Integrated design and major components of the NTDS provide the fleet with automated data handling capability.

Operationally, this computer-centered control system coordinates the collection of data from the ship's sensors (radar, sonar, navigation systems, electronic warfare, and fire control) and from external sources via communications links. It also allows commanders in the fleet to communicate tactical information between ships rapidly. Computers transfer, at extremely high

speeds via tactical data communications nets, information previously handled by voice communications or manual means. Figure 2-14 shows the typical NTDS input/output configuration.

NTDS uses separate data transmission links to maintain tactical data communications with other units as shown in figure 2-15. Link 11 and Link 4A are transmit/receive systems. Link 14 is a receive-only

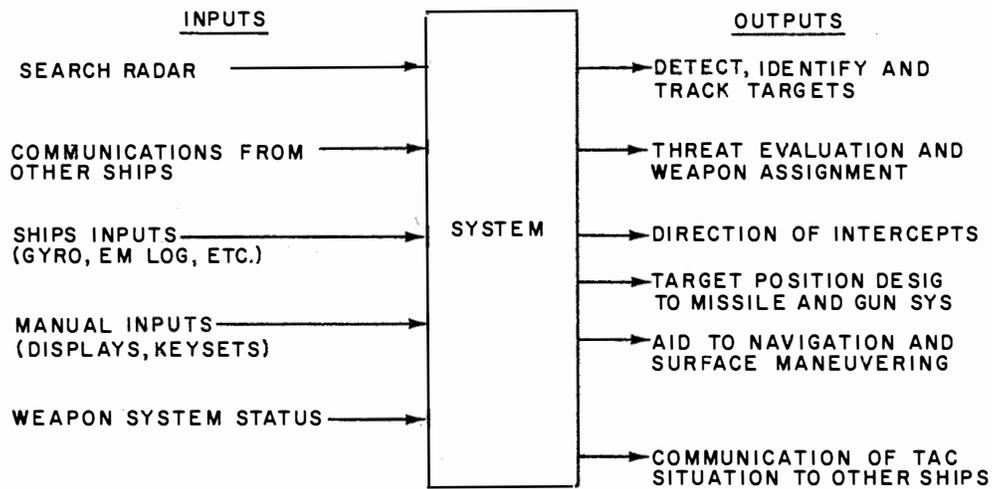


Figure 2-14.—Typical NTDS input/output configuration.

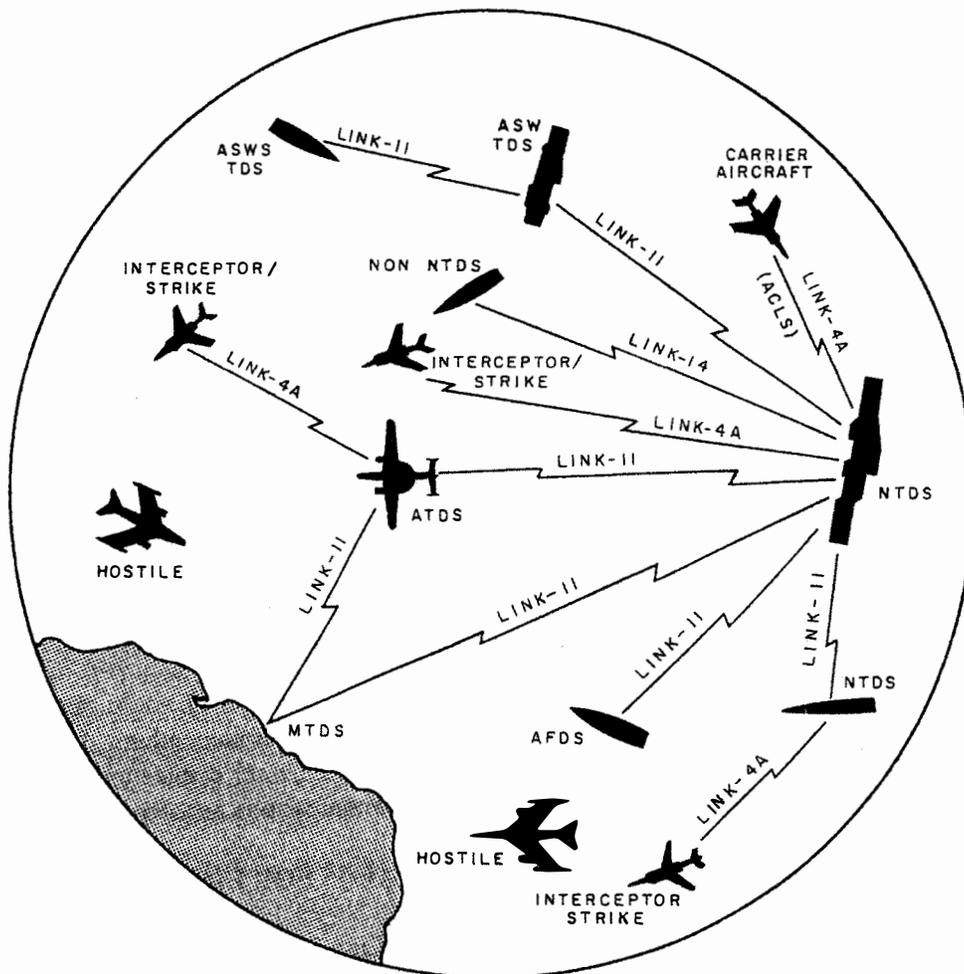


Figure 2-15.—NTDS intersystem communications.

system. In the following paragraphs, we will briefly describe each link system. Then we will discuss the equipment that Electronics Technicians are responsible for by looking closely at Link 11 operation.

LINK 11

Link 11 provides high-speed computer-to-computer transfer of tactical environment information, command orders, and participating unit status to all other tactical data systems with a nominal range of 300 miles. Tactical information currently transferred consists of surface, subsurface, air, and ECM track information on friendly, hostile, and unknown identity tracks.

LINK 14

Link 14 provides a means of transmitting track information, identity, engagement status, drop track reports, and gridlock information to ships not capable of participating in the Link 11 net. Basically, this is a manual link relying on voice and tty communications.

LINK 4A

Link 4A enables an operational program to take control of the autopilot in a suitably equipped aircraft to control landing and takeoff, to pursue, or to follow collision intercept geometry. It can control a flight to the strike area and return it to the base without requiring pilot action. The pilot has the option of (1) going fully automatic, (2) using the visual display to aid in interpreting the intercept controller's dialogue, or (3) totally ignoring the Link 4A transmission.

LINK 16

Link 16 is basically the same as Link 11. It is an automatic, high-speed data communications link that provides the same information as Link 11. But, Link 16 uses a merged message format, allowing interservice and NATO link operations, expanding our overall link capabilities. Link 16 may have either of the following titles, depending on its use:

TADIL J (Tactical Data Information Link J)—This is the NATO term for Link 16.

JTIDS (Joint Tactical Information Distribution System)—This is the interservice term for Link 16.

JTIDS is a high-capacity, digital system that combines integrated communications and relative navigation and identification capabilities. The system

permits secure, jam resistant data, and voice transfer in real time among the various elements of the military services. The JTIDS system provides broadcast and point-to-point data communications for weapons systems, sensors, and command centers.

NTDS SYSTEM OVERVIEW

NTDS accomplishes its objectives in real time by receiving data from various sensing devices that are in continuous contact with the outside environment. It then uses the data to evaluate each event as it happens. The rate of sampling of each sensing device is determined by how frequently data is needed to update the system. Figure 2-16 illustrates a typical Naval Tactical Data System. In the remainder of this section, we will cover one part of the NTDS, Link 11.

LINK 11 OPERATION

Link 11, or Tactical Digital Information Link (TADIL)A, uses netted communications techniques (group of participating units) and a standard message format for exchanging digital information among airborne, land-based, and shipboard tactical data systems. Link 11 communications are conducted in the hf and uhf bands or through limited range intercept satellite communications (LRI SATCOM). In the hf band, Link 11 provides omnidirectional coverage up to 300 nautical miles (nm). When operating in the uhf band, Link 11 provides omnidirectional coverage of approximately 25 nm ship-to-ship, or 150 nm ship-to-air. Various symbols are used to represent hostile and friendly units. These symbols are displayed on a crt for tracking and analysis to determine battle group strategy.

LRI SATCOM

LRI SATCOM extends the uhf LOS range for battle group tactical link operations. Known as the Tactical Relay Information Link (TACRIL), it uses an AN/ARQ-49 pod attachment to a task force aircraft, which provides one Link 11 channel and two channels for voice communications. Using TACRIL reduces satellite channel congestion, and uhf provides good communications security.

RADIOS FOR LINK 11 COMMUNICATIONS

Link 11 transmitters and receivers provide point-to-point connectivity between widely separated units in the net. Hf and uhf radios are used to establish this

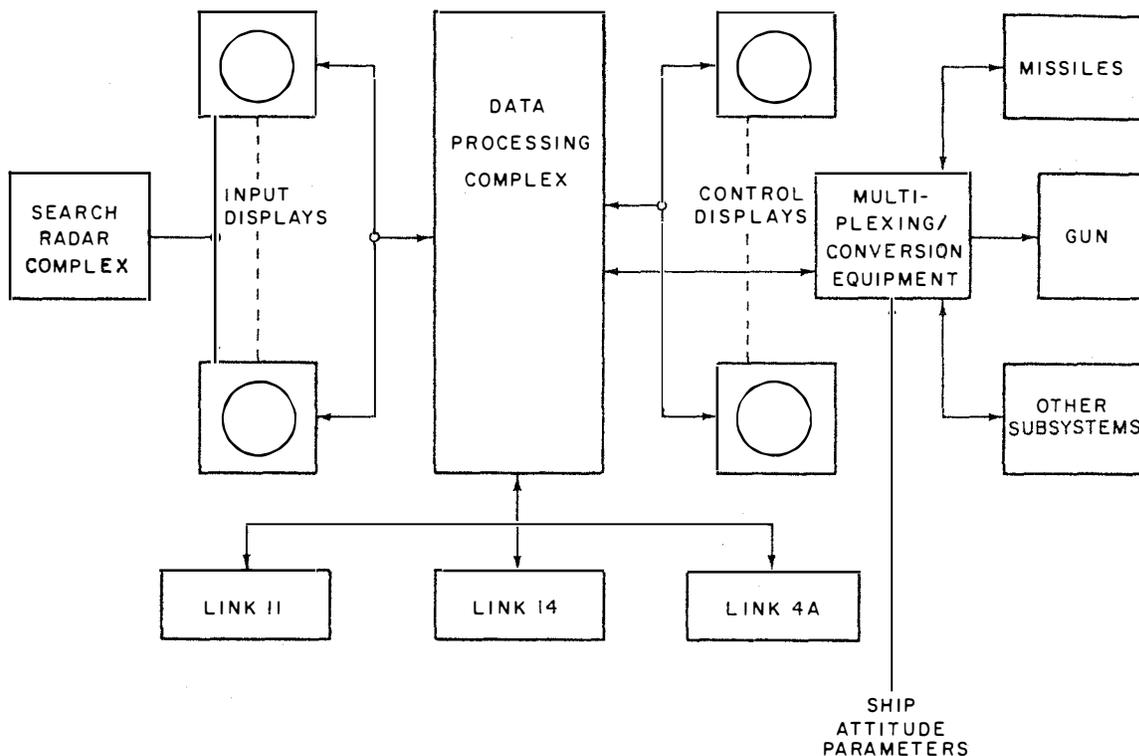


Figure 2-16.—NTDS simplified system diagram.

communications net. These radios are the part of the NTDS that ETs will be most concerned with. Hf is used to establish the communications net when the range between participating units is from 25 to 300 NM. An exception to this is hf Limited Range Intercept (LRI), which can be used for ranges less than 25 NM. Uhf is used when the range between units is less than 25 NM. These ranges and modes are not set in stone. Propagation difficulties may, and often do, result in net control stations (NCS) switching modes to find a point at which all units can exchange tactical data accurately and completely.

General Requirements

The speed of the link requires that all communications equipment used be able to keep up with the

repetitive transmission and reception cycles. This requires Link 11 radios to meet requirements different from radios designed for voice-only use. Primary differences include the transmit-to-receive switching time, the keyline interface, the audio bandpass characteristics, the fast automatic gain control, the attack and release timing, and the audio input/output level set at 0 dBm.

On most ships, communications equipment used for link operations is hard-wired for link use only. Do not try to use other equipment for link operations unless they are link-capable and emergency or battle conditions create a need. Familiarize yourself with the particular equipment on board your ship that is used for link. This will save you a lot of time when

problems arise. Figure 2-17 shows you the communications systems currently in use.

Hf Radios

Hf radios used for link operations use the link audio signal to modulate the carrier amplitude. For Link 11 operation Independent Sideband Suppressed Carrier (ISBSC) is used. In this mode, the Link 11 audio signals are applied to both the upper and lower sidebands for transmission. Recall from chapter 1 that in single sideband, the carrier is removed and all the power is put in the sidebands to extend the effective signal range. This also allows the receiver to select the best data from the upper or lower sidebands, which reduces fading and noise problems.

Uhf Radios

In uhf radios the Link 11 signal is used to modulate the radio frequency about a center frequency, producing frequency modulation (FM). Since we covered FM in depth in chapter 1, we will not go into further detail here.

Link 11 Multicouplers

Since link is a radio system, it must be able to tune or impedance-match the radio's output impedance to the transmission line and antenna. The resulting configuration is called a *multicoupler group*.

Multicouplers require frequency management to prevent influence across adjacent channels. Normally, a 15-percent frequency separation is required between adjacent channels. Without this frequency separation, serious signal distortion and costly equipment failure could happen.

Antennas

Antennas used for link communications are identical to those used for voice communications.

Frequency Standards

Link 11 data terminal sets, transmitters, and receivers can use an internal or external frequency standard. Typically, the external standard is used, which helps remove the chance of frequency error. Some currently used frequency standards are the URQ-9, URQ-10, and URQ-23. The URQ-23 is replacing the other two standards.

NTDS FAULT ISOLATION

In the following paragraphs, we will discuss some of the problems ETs may encounter in troubleshooting NTDS problems. This is by no means an all inclusive list. Understanding your NTDS system and working closely with the other ratings involved will ensure proper system operation. When a problem is discovered, don't assume your equipment is not at fault. Get

	System	Class
HF	AN/SRC-16	CG, CGN, CV, CVN, DDG, LCC
	AN/SRC-23	CG, CGN, CV, CVN, DDG, LCC, FF
	T1322/R1903	DDG, DD, CG
	AN/URC-75	LHA
	AN/URC-81	DDG
	AN/URC-109	LHD
	AN/URT-23C/R1051G	DDG, FFG, SSN
	AN/URT-23D/R1051H	CG
UHF	AN/URC-93	CGN, CG, CVN, CV, DG, LCC, LHD
	AN/WSC-3	FF, DD, DDG, FFG, BB, AGF, SSN, CG
	AN/URC-85	CGN, DDG, DD
	AN/URC-83	LHA

Figure 2-17.—Operational communications systems.

involved in the fault isolation process throughout the system. If you fail to become involved, other technicians may use the trial and error method of fault isolation. In most situations, this will simply cause more problems to be added to the system.

You may have heard the phrase, "There's link all over the place, it's on every circuit." Typically, this happens when the rf power out of a link transmitter causes induction or coupling of energy to other circuits. The "ping-pong" sound of Link 11 over the 1MC, Site T.V., and other circuits is rarely forgotten, and unfortunately causes many headaches for ETs. There are other types of Link 11 interference that are more subtle than too much power out. One of these is *intermodulation distortion*.

Intermodulation distortion is the mixing of signals and their harmonics to produce new frequencies. Link 11 uses 16 audio tones to modulate rf transmitters. This broadband signal covers a wide area of the spectrum when transmitted. If these audio tones mix with other frequencies, an even wider occupation of the spectrum occurs. You need to avoid this at all cost. Do so by strictly following PMS procedures and other link maintenance publications.

You can avoid intermodulation and energy cross coupling problems by keeping the transmitter power at the minimum required to maintain net connectivity. Also, keep the transmitter audio input level at 0 dBm and the transmitter grid and plate currents within rated tolerances.

Electromagnetic interference (EMI) and radio frequency interference (RFI) often effect shipboard communications circuits. Sometimes hf Link 11 signals can completely obliterate circuits operating in the uhf band. The preferred way to isolate this problem is to quiet the active data and voice circuits selectively. Once the problem transmitter has been found, changing antennas, frequency, or adjusting power out may solve the problem. Be aware that you may spend many frustrating hours isolating these types of problems.

Remember, keep the power levels of link transmitters to a minimum. Don't be fooled by output meters. A meter indication on a link circuit is average power. Applying a single-tone audio signal rather than the 16-tone Link 11 signal will provide you with a true power out indication.

Some other problems you may encounter are atmospheric interference and improperly set audio levels. You can prevent some atmospheric interference problems, but many will be beyond your control. Understanding how the transmitted signal is affected will enable you to recognize the problems you can do something about.

The audio input/output for Link 11 radios is 600 ohms balanced. *Balanced* means the input/output is not at ground potential. As we discussed before, all link hf and uhf transmitters should have a 0-dBm audio input applied from the data terminal set. The receivers should have their outputs set at 0 dBm. When you perform PMS, you must take measurements at both the transmitter input and the data terminal set input. Your goal should be to have 0 dBm applied to both the transmitter and the data terminal set regardless of line or patch panel loss.

If you become extremely familiar with link, you will start to recognize the ping-pong sound of the Link 11 call-up and response sequence. A transmitter "off-freq" is indicated by a squeak or squeal happening every time you transmit. The sound of voices or code superimposed upon the Link 11 signal is a good indication that frequency separation is the problem. Monitoring can be a big help to you and is often the fastest way to isolate problems.

TELETYPEWRITER/FACSIMILE EQUIPMENT

In chapter 1, we discussed different methods of voice communications. Sometimes, the message is too long for practical transmission by voice, so to get your message or idea across, you may need to use a chart, map, or photograph. Teletype (tty) and facsimile (FAX) equipment allow us to do this.

In the following paragraphs, we will discuss some common terms associated with tty and FAX equipment. We will then look at some basic systems.

MODES OF OPERATION

There are two basic modes of teletypewriter operation: asynchronous (start-stop) and synchronous. The *asynchronous* mode is the most common. The *synchronous* mode is used primarily in high-speed data systems.

Asynchronous Mode

In this mode, the receiving device is only allowed to run for one character and is then stopped to await the start signal for the next character. Any differences in speed between the transmitting and receiving devices can only accumulate during the time assigned to one character. There is a penalty for this advantage. Character length is increased to include the start (space) and stop (mark) signals. These start and stop

signals are part of the five unit code (BAUDOT CODE) shown in figure 2-18.

Synchronous Mode

Synchronous systems have an advantage over asynchronous systems. The start and stop elements are not used. This allows more room for information transmission. Time is not wasted on start and stop units. Additionally, this mode has a higher capacity to accept distorted signals because it does not depend on the start and stop signals for timing.

MODULATION RATE

The terms used in referring to tty modulation rates or signaling speeds are *baud*, *words per minute (wpm)*, and *bits per second (bps)*. Baud is the only term that is technically accurate. The others are either approximations or require explanation.

Baud

By definition, the word *baud* is a unit of modulation rate. To find the modulation rate of a signal in bauds, divide 1 by the time interval of the shortest unit in the signal. For example, 22 milliseconds (.022 sec) is the time interval of the shortest unit in the five-unit code at 60 wpm. To find the number of bauds equal to 60 wpm, divide 1 by .022. Rounding off the results provides the figure 45.5, which is the baud equivalent of 60 wpm. You can see that increasing the wpm means the unit time interval has decreased.

The most common baudot data speeds range from 45.45 to 100 bauds, or about 60 to 133 wpm. Higher speeds are obtained using the American National Standard Code for Information Exchange (ASCII). This is a seven-unit digital code used for the transmission of teleprinter information. ASCII is used primarily with computer systems, but it is also used in some teletypewriter applications. The Defense Communications System standard speed for teletype operation is 100 wpm or 75 baud.

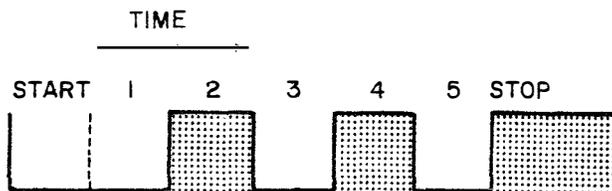


Figure 2-18.—Mark and space signals in the teletypewriter-character R.

Words Per Minute

Words per minute is used only when speaking in general terms about an approximation of speed. At a speed of 100 wpm, 100 five-letter words with a space between them can be transmitted in a 60-second period. But, you can also get this wpm rate by varying the modulation rate or the length of individual characters. Because of this, the baud method of reference rather than wpm is used.

Bit

In binary signals, the term *bit* is equivalent to one place in a binary number. Because of the influence of computer language, modulation rate is sometimes expressed as *bits per second (bps)*. When it is expressly understood that each unit in the baudot character is the same length, the modulation rate expressed in bps is the same as the modulation rate expressed in baud.

DC CIRCUITS

The two most common methods of creating the mark and space conditions are *neutral* and *polar* operation. In neutral operation, current flow represents the mark and no current flow represents the space. In polar operation, current impulses of one polarity represent the mark and impulses of the opposite polarity represent the space.

Neutral circuits use the presence or absence of current flow to convey information. These circuits use high level (60/20 milliamperes) as the line current value. (Low level operation uses ± 6 vdc at 20 microamps and can be balanced or unbalanced). A neutral teletypewriter circuit consists of a transmitting device, a current source, a variable resistor to control current, a receiving device, and a transmission line.

Polar operation differs from neutral operation. In a polar system information is always present in either a positive or negative condition. The circuit composition is the same, but polar operation requires an additional current source. This current source is usually a solid-state dc power supply that provides variable current to the teletypewriters. The extra current source normally provides current from the positive side for marks and current from the negative side for spaces.

There are some advantages to using polar circuits rather than neutral circuits. In a polar circuit, it is almost impossible to distort a signal by high reactance, low-line currents, or random patching of circuits or equipment. A big advantage for the ET is that a complete loss of current (a zero reading on the milliammeter) quickly indicates line or equipment trouble. Using neutral signaling, this may only indicate that a steady space is being transmitted. This condition is known as

running open. The teletype appears to be running because it is decoding the constant spaces that cause the type hammer to continually strike the type box, but there is no printing or movement across the page.

BASIC SYSTEMS

When teletypewriters are wire-connected (looped), the exchange of information between them is direct. When they are not physically joined, exchange of information is more complex. Dc mark and space intervals cannot be sent through the air. The gap between the machines must be bridged using transmitters and receivers. The transmitter carrier wave is used to carry the mark and space information. A *keyer* is used to change

the dc pulses from the tty into mark and space modulation for the transmitter carrier wave. The receiver and a *converter* are needed to change the rf signal back to dc pulses.

RADIO ACTUATED TELETYPE (RATT) SYSTEMS

The Navy's two basic RATT systems are the tone modulated system known as *audio frequency tone shift* (AFTS), and the carrier frequency shift system known as *radio frequency carrier shift* (RFCS). The RFCS system is commonly called *frequency shift keying* (fsk).

For fsk systems, the transmitter provides a source of rf excitation. Figure 2-19 illustrates a basic fsk

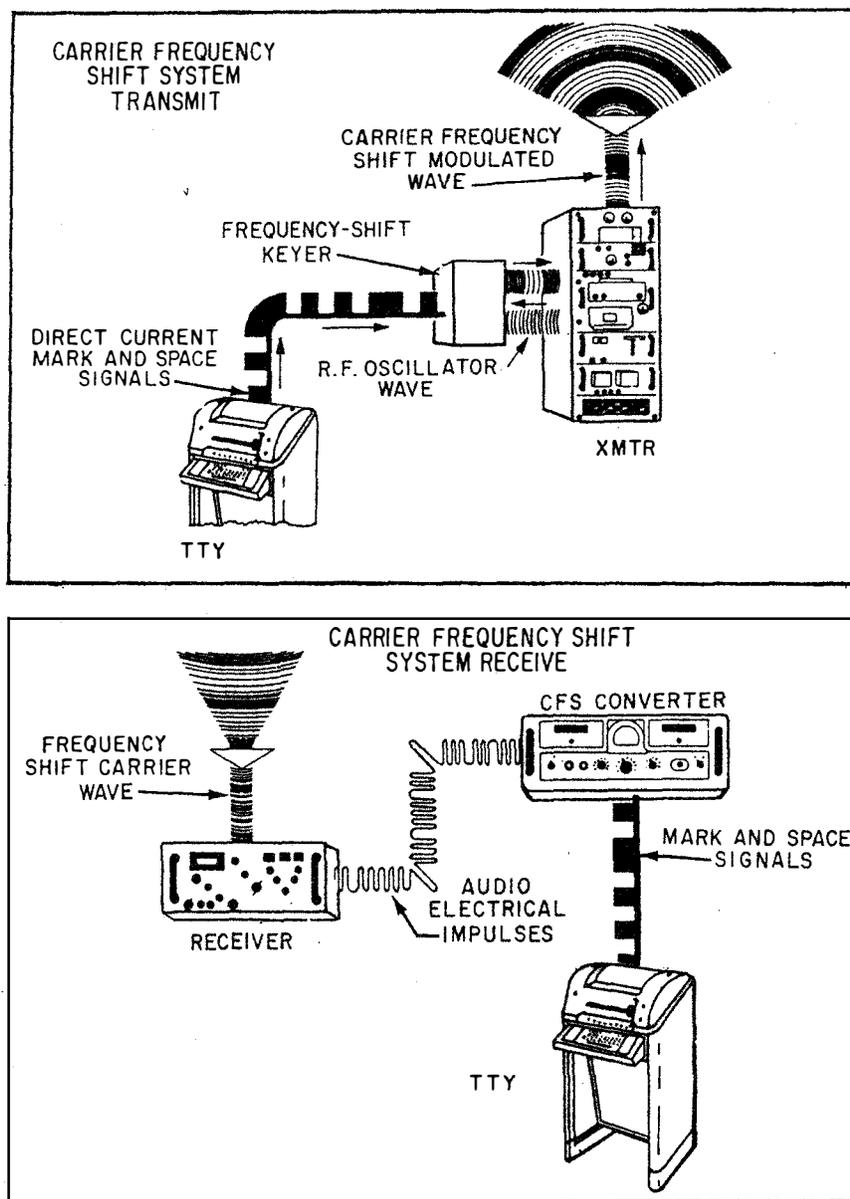


Figure 2-19.—Basic carrier frequency shift (RFCS) system.

system. You will find that the keyer is part of the transmitter in modern systems. The keyer shifts the signal below or above the assigned frequency, corresponding to the mark or space required for tty transmission. Usually, the keyer is adjusted for 850 Hz (425 Hz above and 425 Hz below the assigned frequency.) A space will be 425 Hz above and a mark will be 425 Hz below the operating frequency.

AFTS systems use amplitude modulation to change dc mark and space pulses into audio. A basic tone-modulated system is shown in figure 2-20. The audio conversion is done by an audio oscillator in the tone convertor. Varying the tone according to the

characters transmitted from the tty equipment amplitude-modulates the transmitter carrier wave. The receiver demodulates this signal, separating the audio signal from the carrier.

In both the RFCS and AFTS systems, the tty signals pass through the panel that controls looping current. Looping current is the current supplied by the tty solid-state power supply. The tty panel integrates the tone-modulated and carrier-frequency shift systems. By allowing the tty equipment to be set up in any configuration desired, this panel gives the operators maximum operational flexibility with the least amount of circuitry and equipment.

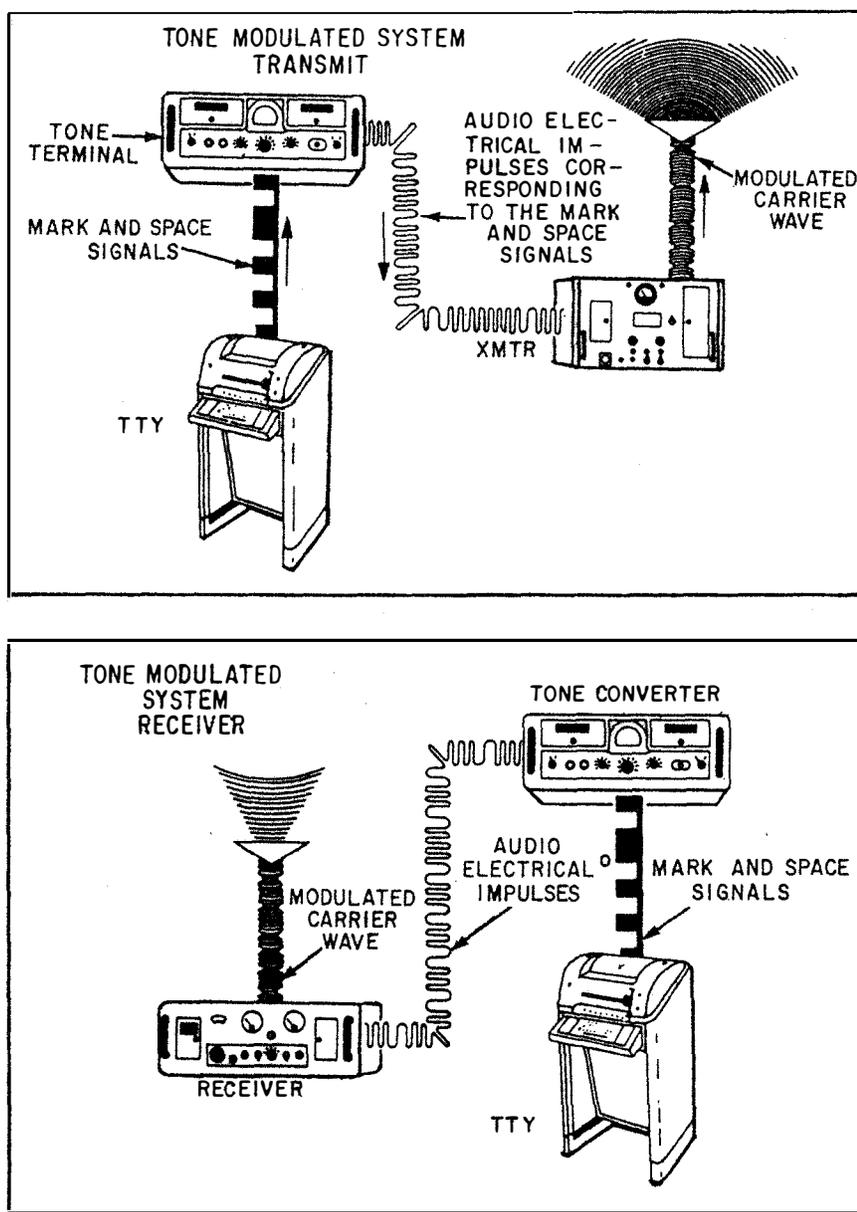


Figure 2-20.—Basic tone-modulated (AFTS) system.

SIMPLEX RFCS TELETYPE SYSTEM

A simplex communications circuit consists of a single channel, which may have two or more stations communicating over it. However, they cannot communicate at the same time. The stations have to alternate using the channel.

RFCS teletype systems are used in the lf to hf band for long-range communications. To reduce fading and interference, the Navy uses two methods of diversity reception called *space diversity* and *frequency*

diversity. In space diversity reception, the transmitted signal is received by two or more antennas spaced at distances greater than one wavelength. Because of the spacing requirements, space diversity is normally limited to shore stations. In frequency diversity, two or more signals are transmitted on differing frequencies, but carry the same intelligence. Another type of frequency diversity is called *af diversity* or *tone diversity* and is used with multichannel broadcasts.

A simplified block of a simplex RFCS system is shown in figure 2-21.

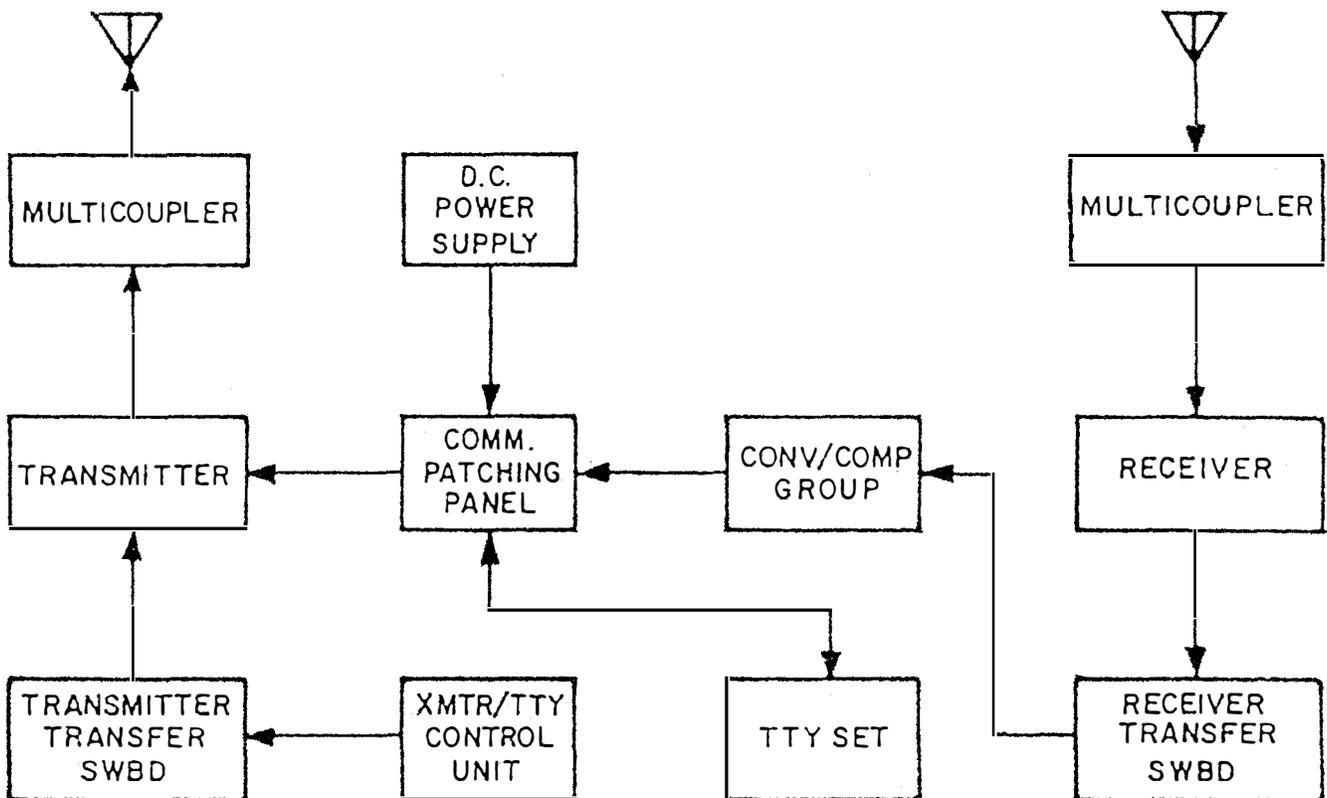


Figure 2-21.—Simplex RFCS system.

RFCS SEND

In the following paragraphs, we will discuss the equipment shown in the RFCS transmit (send) system in figure 2-22.

Teletypewriter Sets

The Model 28 family and the AN/UGC-143 series are the two tty sets currently used by the Navy. Although the AN/UGC-143 is not shown in figure 2-21, we will discuss its characteristics later. There are several tty sets included in the Model 28 family, with varying weights and sizes. They feature high operating speeds, quiet operation, and are particularly suited for shipboard use under the severe conditions of roll, vibration, and shock.

Model 28 tty's may be composed of the following components, depending upon their specific function: a cabinet, keyboard, page printer, typing perforator, transmitter distributor, typing reperforator, power distribution panels, and power supply.

All equipment components are housed in the cabinet. Transmissions are initiated through the keyboard or transmitter distributor. Received signals are printed on the page printer. Monitored transmissions can also be printed on the page printer. The typing perforator and reperforator are used for preparing tapes that can be stored for future transmission through the transmitter distributor.

The AN/UGC-143A(V) is also known as the Navy Standard Teleprinter (NST) and has the following characteristics:

- Fully automated
- Accepts Baudot code or ASCII
- Bulk storage unit contains tape drives similar to those found in the AN/USH-26
- Can be configured to interface with Navy standard personal computers
- Fully compatible with current crypto devices
- Capable of supporting paper tape operations

Patch Panels

Tty panels SB-1203/UG and SB-1210/UGQ are used for interconnection and transfer of shipboard tty equipment. The SB-1203/UG is a general-use panel and the SB-1210/UGQ is intended for use with crypto. In addition, tty panels furnish a central point for connecting the dc supply into the teletypewriter circuits. So, one source of supply can be used for all the circuits passing through a particular panel.

One procedural note: Anyone patching or unpatching circuits from a tty panel must be sure to pull the plug from the looping jack before removing the other plug from the set (machine) jack. Pulling the set jack first interrupts all tty message traffic on that channel. **IT ALSO PRODUCES A DANGEROUS DC VOLTAGE ON THE EXPOSED PLUG!**

Cryptographic Equipment

Cryptographic equipment is used to encode and decode messages that require security handling. To do this, the crypto equipment must be compatible on both the transmit and receive ends.

Remote Transmitter Control

The remote transmitter control unit is mounted close to the tty keyboard, and permits remote control of the transmitter. For RFCS operation, the operator sets the three-position rotary switch to CFS SEND to transmit and CFS REC for receiving. The TONE S/R position is used for AFTS transmit and receive.

Transmitter Switchboard

The SB-863/SRT switchboard is used in this system to connect the remote transmitter control to the transmitter to be used.

Transmitter

The transmitter is used to transmit the RFCS signal. It is important that the operator tune the transmitter to the proper frequency.

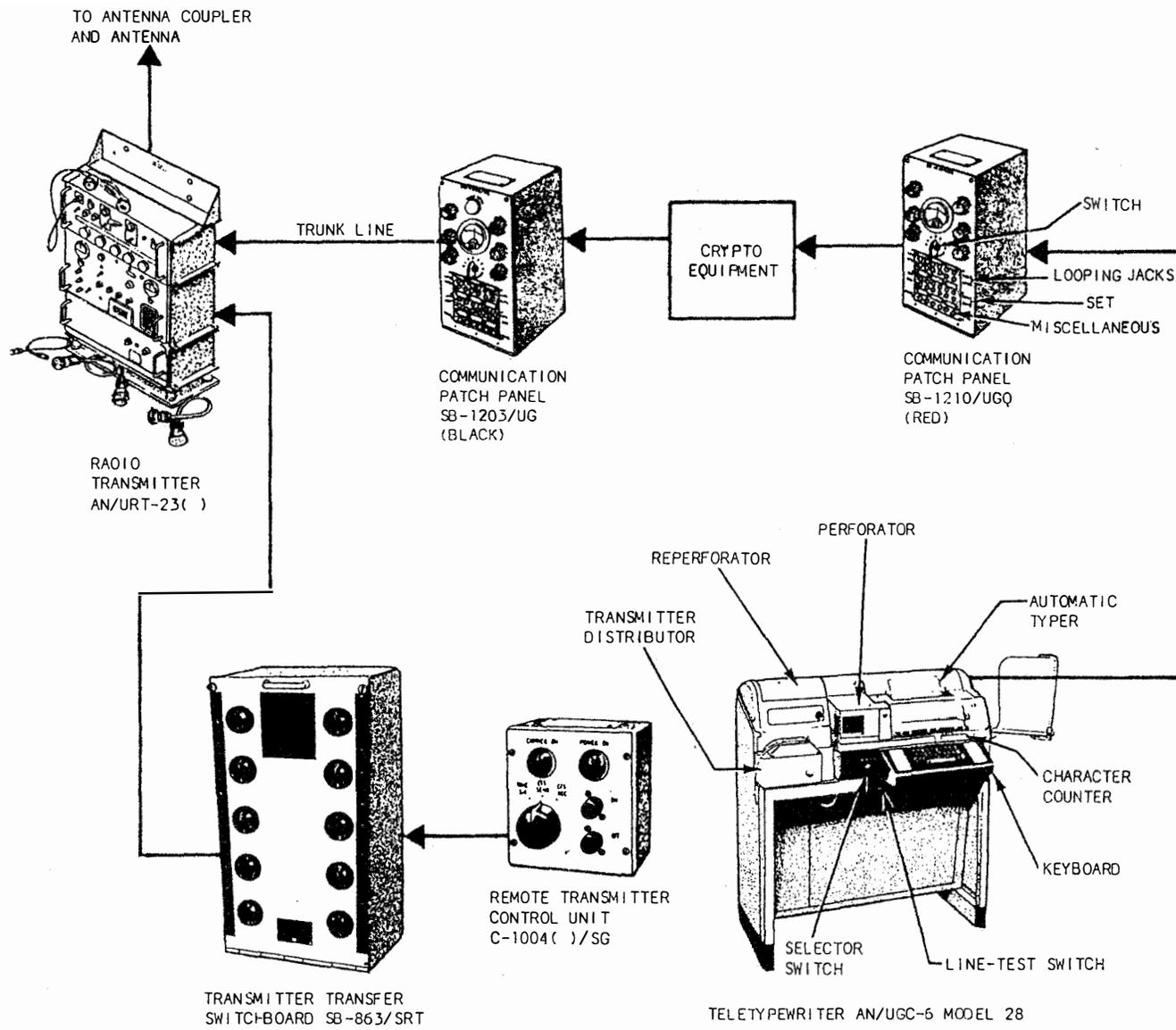


Figure 2-22.—RFCS transmit (send) system.

RFCS RECEIVE SYSTEM

The RFCS receive system shown in figure 2-23 is used to receive the transmitted signal and convert it back to a usable tty output.

Antenna Filter

The antenna filter receives the rf signal from the antenna and filters out any unwanted signals so only the proper band of frequencies are passed on to the receiver.

Radio Receiver

The receiver translates the rf signal to an audio signal.

Receiver Transfer Switchboard

The switchboard is used to connect the receiver to any one of the converters in the convertor group.

Convertor/Comparator Group

The convertor/comparator group is used with receivers in either space diversity or frequency diversity operation to convert the frequency shift of signal from the receiver into dc pulses that open and close the dc loop according to the mark and space characters received. When the system is not using diversity operation, each convertor can be used with a separate receiver.

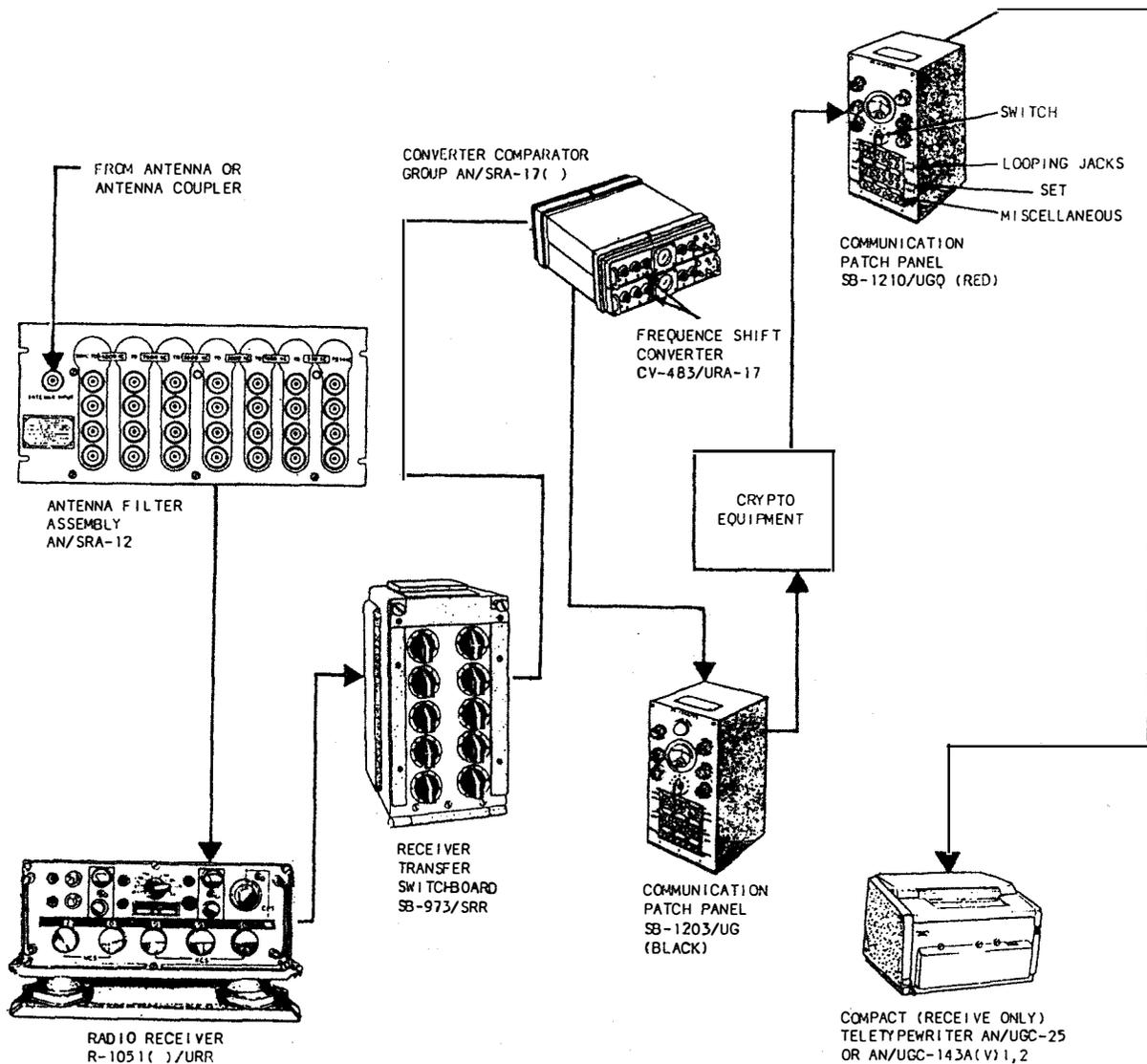


Figure 2-23.—RFCS receive system.

The comparator section of the convertor compares the signals received in the diversity mode and allows only the stronger signal to be passed on to the communication patch panel.

Communication Patch Panel

The communication patch panel performs the same function on the receive side as it does on the transmit side.

Crypto Equipment

The crypto equipment decodes the received signal so it can be printed out in its original form.

Teletype

The tty equipment converts the dc pulses from the patch panel to a printed copy of the original message. The tty shown is a page printer only and does not have transmit capability.

AFTS SYSTEM

Figure 2-24 is a block diagram of a half-duplex uhf AFTS system. Half-duplex communication can be in either direction, but cannot happen at the same time. The term *half-duplex* is qualified by adding *send only*, *receive only*, or *send or receive*.

AFTS Transmit

Dc signals from the tty are sent to the communications patch panel where they are fed to the tone terminal set. The tone terminal set converts the dc signals into audio tone-shift signals. The audio tone-shift signals are patched to the transmit side of the transceiver through the transmitter transfer switchboard. The audio tone-shift signals are then used to modulate the rf carrier for transmission.

AFTS Receive

The rf tone-modulated signals are received at the antenna and then patched, via the multicoupler, to the receive side of the transceiver, where demodulation to audio tone-shift signals takes place. The signals are then patched to the tone terminal set through the receiver transfer switchboard, where they are converted back to dc signals. The dc signals are then

patched through the communication patch panel to the tty.

FACSIMILE

Facsimile (FAX) is a method of transmitting still images over a communications system. The images may be weather maps, photographs, sketches, typewritten or printed text, or handwriting. Military use of FAX is primarily limited to transmission and reception of weather maps. Because of long transmission times, its tactical uses are limited.

TEMPEST

Compromising emanations, generally called TEMPEST, are *unintentional data-related or intelligence-bearing signals which, if intercepted or analyzed, can disclose the classified information transmitted, received, handled, or otherwise processed by electrical information processing equipment or systems*.

The Navy uses MIL-STD-1680 (SHIPS), *Installation Criteria for Shipboard Secure Electrical Processing Systems*, as the guide for TEMPEST. Within communications centers, ETs must understand and be

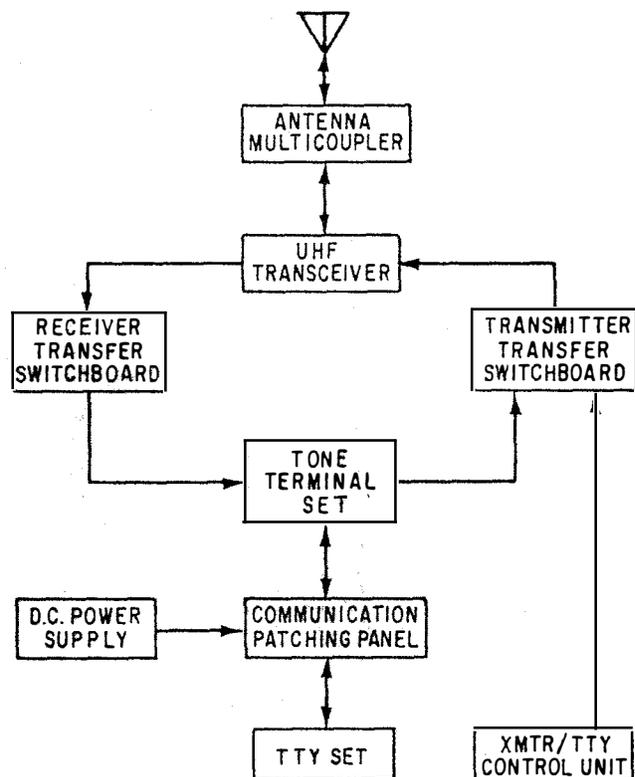


Figure 2-24.—Half-duplex AFTS teletype system.

familiar with both **RED** and **BLACK** designated systems and equipment. The **RED** and **BLACK** designations are explained in the following paragraphs.

RED CRITERIA

The **RED** designation applies to all crypto equipment, subscriber terminal equipment, and interconnecting conductors involved in processing classified plain language information. It also applies to primary power circuits, dc circuits, control wiring, and ground conductors serving cryptographic equipment and subscriber terminal equipment that are designated **RED**.

The **RED** designation also applies to junction boxes, distribution frames, terminal boxes, conduit, ducts, cable racks and hangers, patching and switching panels, cabinets, power distribution panels (both ac and dc), and other ancillary equipment serving the conductors and equipment mentioned above.

Primary Red

Any conductor intended to carry classified plain language terminating in **RED** equipment or the **RED** side of crypto equipment is designated **PRIMARY RED**.

Secondary Red

Any conductor, other than **PRIMARY RED**, that connects to **RED** equipment, the **RED** side of crypto equipment, or the **RED** side of isolation devices, and does not intentionally carry classified information, but because of the coupling mechanism with the **RED** equipment *might* carry compromising information, is designated **SECONDARY RED**. Some examples you are probably familiar with are indicator lines, and control and timing lines. Power distribution panels and grounding systems serving **RED** conductors are also designated **SECONDARY RED**.

Black Criteria

The **BLACK** designation applies to all conductors and equipment involved in handling or processing unclassified plain language and encrypted information in electrical form. It also applies to all facilities and circuits that are not designated **RED**.

PORTABLE AND PACK RADIO EQUIPMENT

Because portable and pack radio sets must be lightweight, compact, and self-contained, they are usually battery- or generator-powered, have low output power, and are either transceivers or transmitter-receivers. Navy ships and Special Forces carry a variety of these radio sets for amphibious and

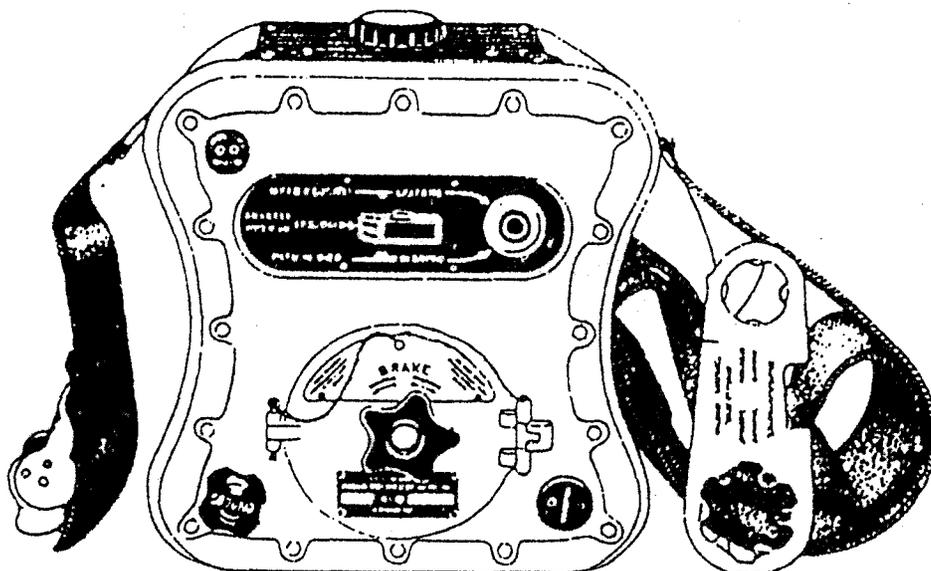


Figure 2-25.—Emergency Transmitter AN/CRT-3A.

emergency communications, with the equipment type varying according to the needs of the ship or command. The following paragraphs introduce some of these equipment.

AN/CRT-3A

Radio transmitter AN/CRT-3A, popularly known as the "Gibson girl," is a rugged emergency transmitter carried aboard ships and aircraft for use in lifeboats and liferafts. Shown in figure 2-25, it operates on the international distress frequency (500 kHz) and the survival craft communication frequency (8363 kHz). No receiving equipment is included.

AN/PRC-70

The AN/PRC-70 is a multimode (FM, CW, FSK, SSB, AM) manpack radio set operating in the 2.0- to 75.9999-MHz frequency range.

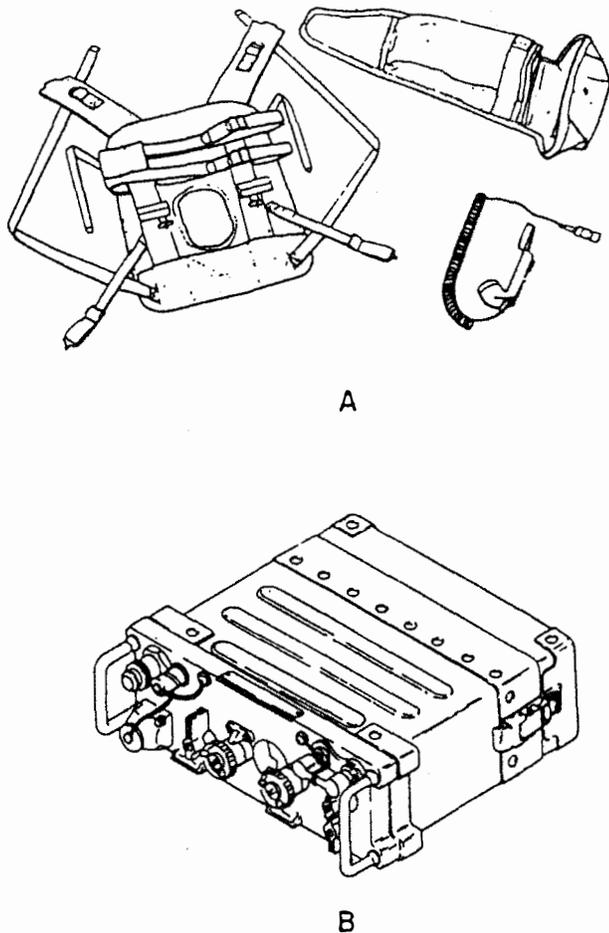


Figure 2-26.—Radio Set AN/PRC-77.

AN/PRC-77

The AN/PRC-77, shown in figure 2-26, is an FM, short-range, 920 channel vhf radio operating in the 30- to 75.95-MHz frequency range. Figure 2-26 (view A) shows the pack frame, the handset, and accessory pouch. View B shows the transmitter-receiver. When not in use, the equipment is stored in a special aluminum case.

AN/PRC-96

The AN/PRC-96 portable transceiver, shown in figure 2-27, is dual-channeled, battery-powered, and provides homing and two-way voice communications between liferafts and searching ships and aircraft, on the 121.5 and 243 MHz "guard" channels.

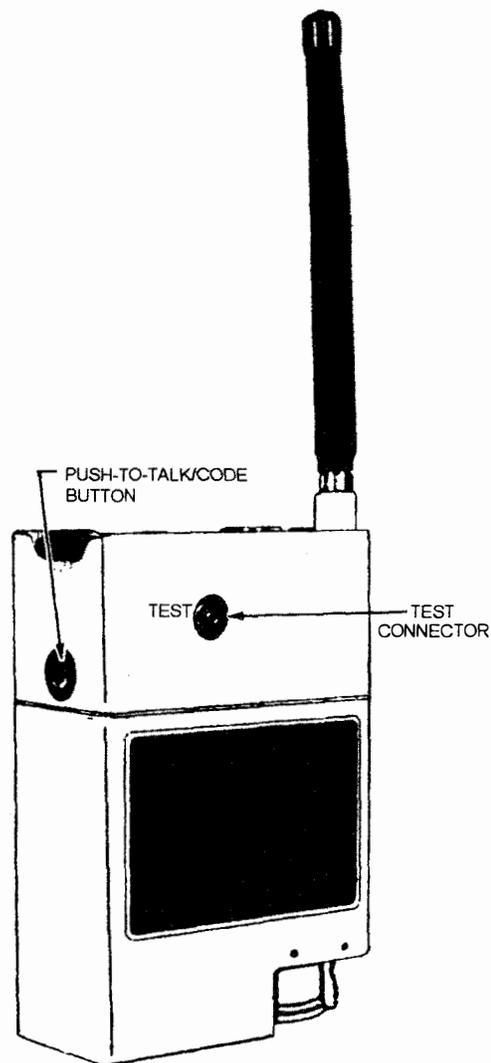


Figure 2-27.—Transceiver AN/PRC-96.

AN/PRC-104

The AN/PRC-104, shown in figure 2-28, is a lightweight radio transceiver that operates in the hf band and can be tuned from 2.0 to 29.9999 MHz. It operates in the ssb (usb or lsb) modes for voice communications, CW for Morse code, and FSK for transmission of tty or other data. It can be used in the man-pack

configuration or can be configured for vehicular or fixed station operation.

Unlike older radio sets, there are no front panel meters or indicator lights on the AN/PRC-104. All functions are monitored by the radio itself and communicated through the handset in the form of audio tones. This is extremely useful during tactical blackout operations. Newer versions of the AN/PRC-104

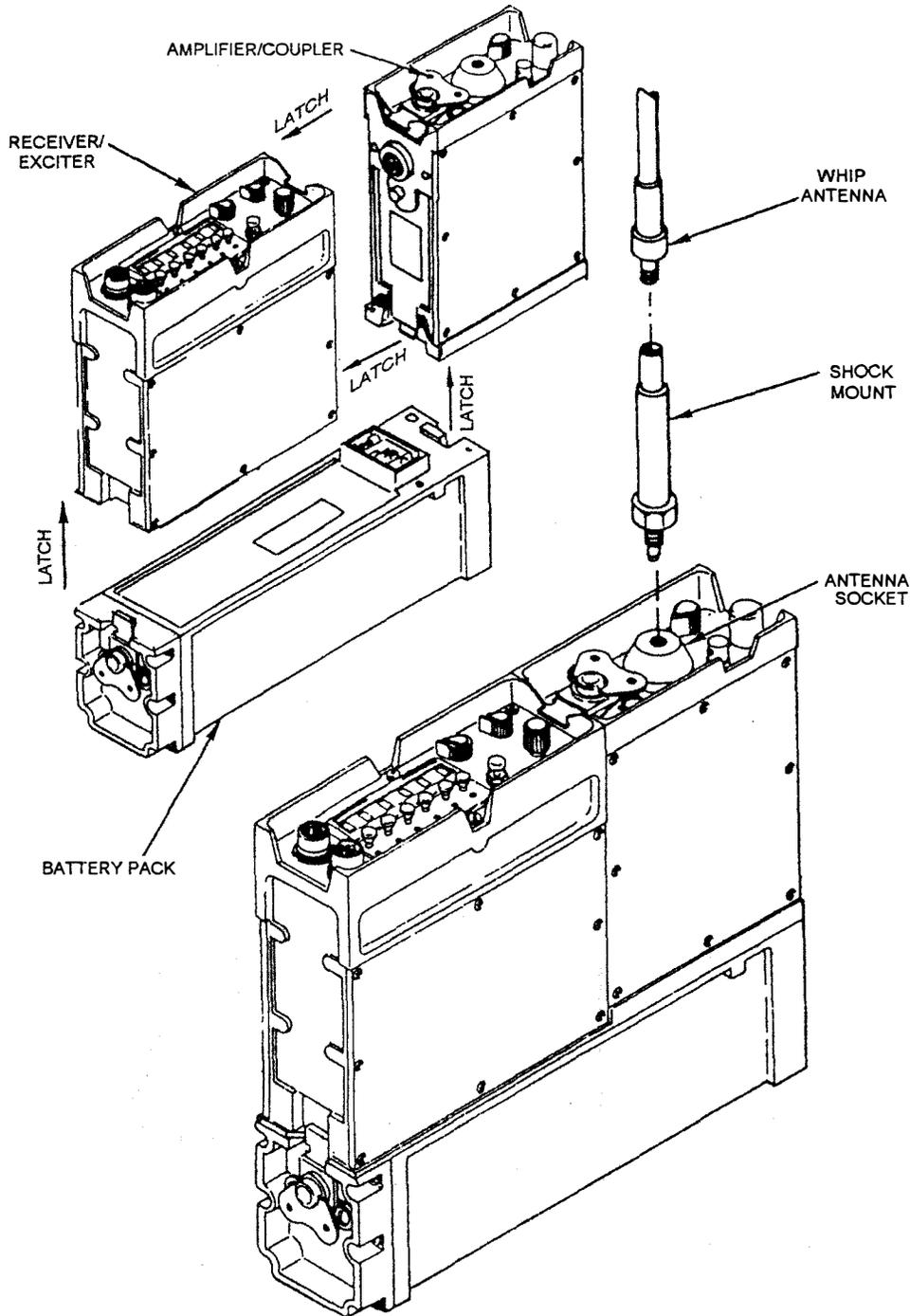


Figure 2-28.—Transceiver AN/PRC-104.

have modified the R/T section of the radio, but the above information still applies.

AN/PRC-113

The AN/PRC-113 is a two-band (vhf and uhf) amplitude modulated transmitter-receiver, which operates at 116.0 through 149.975 MHz in the vhf band and 225.0 through 399.975 MHz in the uhf band.

When interfaced with TSEC/KY-57 crypto equipment, this radio can operate in AM voice, or AM secure voice.

AN/PRC-117

The AN/PRC-117 Full-Band Frequency-Hopping VHF-FM Manpack Transceiver with integrated COMSEC, shown in figure 2-29, operates in the 30-to-

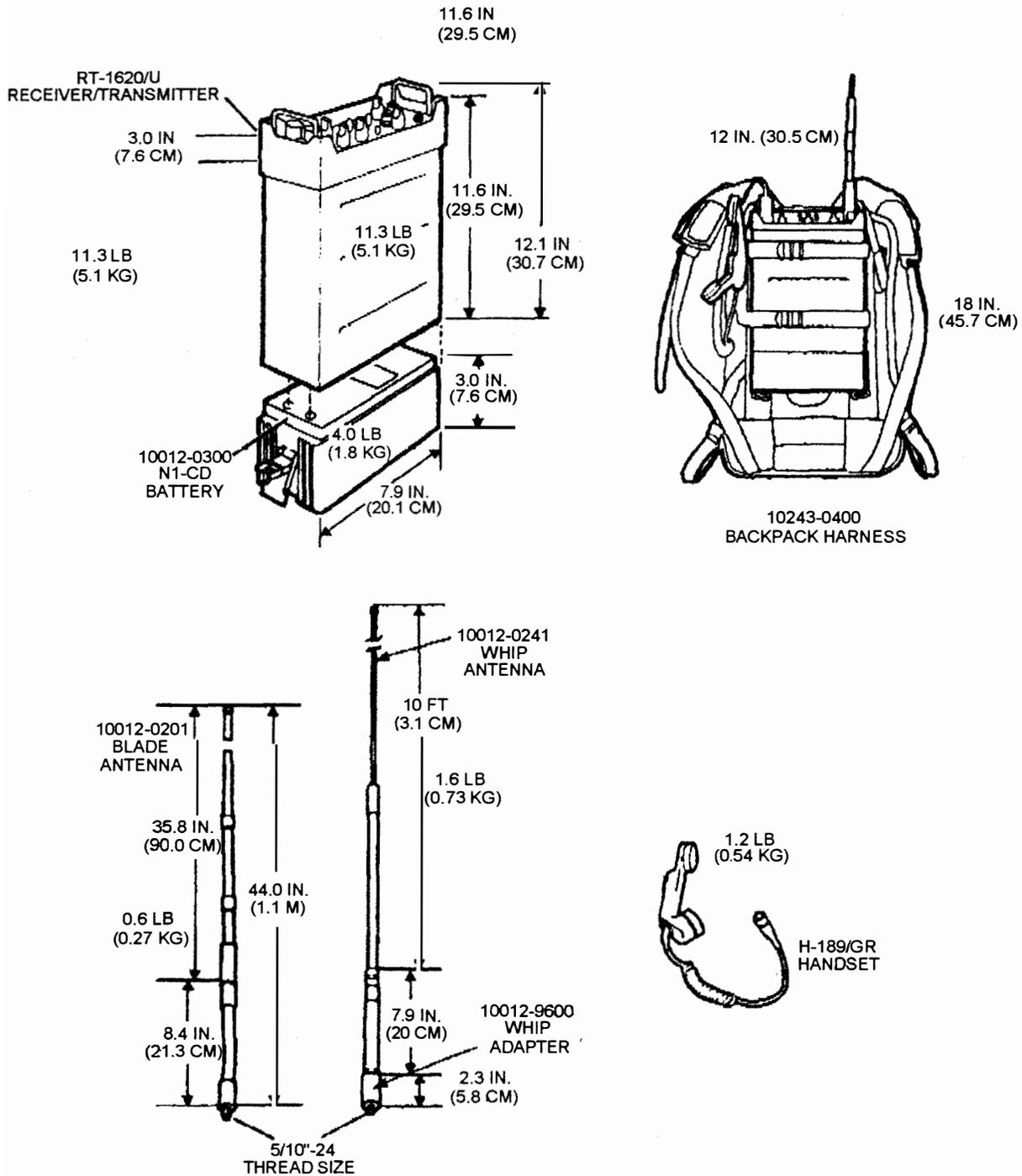


Figure 2-29.—Transceiver AN/PRC-117.

89.975-MHz frequency range and contains a built-in COMSEC capability that is compatible with VINSON KY-57/58 equipment.

Frequency-hopping is an advanced method of ECCM (Electronic Counter-Counter-Measure). You should remember that a standard FM transmission is centered on a specific carrier frequency, which means it can be easily detected, monitored, or jammed. In frequency hopping, no single carrier is used. Instead, the transmitter hops around the band in a random pattern, spending only a few milliseconds on any one frequency. This makes the signal difficult to detect and extremely difficult to monitor or jam.

AN/PSC-3

Backpack radio set AN/PSC-3 is a portable, battery-powered, half-duplex uhf transceiver operating in the 225.0- to 399.995-MHz range. It provides two-way voice (secure and plain) and data communications via satellite relay (SAT) or line-of-sight (los) modes.

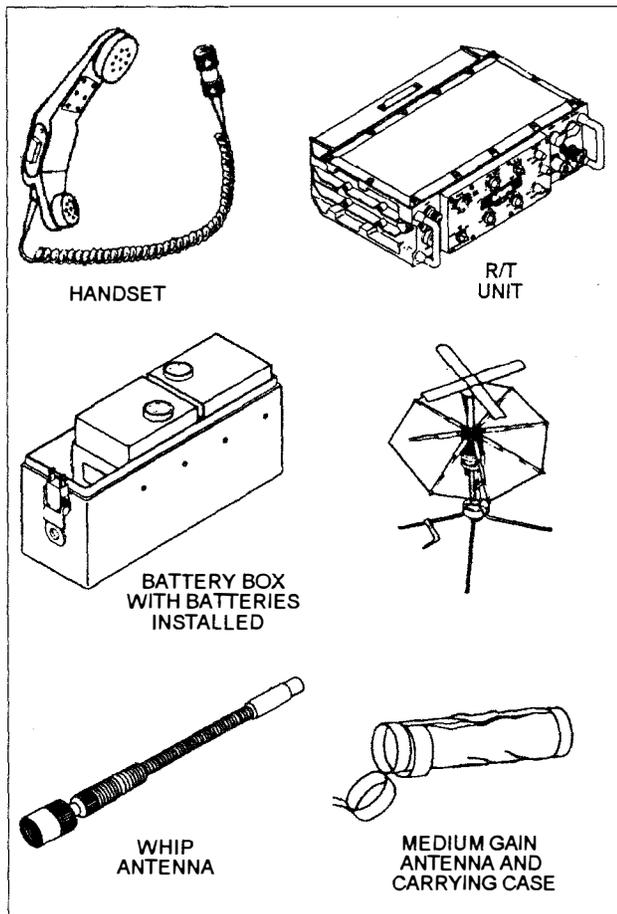


Figure 2-30.—Radio Set AN/PSC-3.

Radio set AN/PSC-3 components are shown in figure 2-30.

One important feature of the AN/PSC-3 is its ability to interface directly with the AN/PRC-70, AN/PRC-77, and other vhf-capable radios, which provides a satellite link for vhf tactical equipment. This provides a way to retransmit vhf information from one of these radios by (1) converting vhf to uhf, (2) transmitting through a satellite to another AN/PSC-3, (3) demodulating it and passing it directly to another AN/PRC-70/77, which could then (4) retransmit the information as vhf. This greatly enhances communications capability and extends the communications range. A basic retransmission setup is shown in figure 2-31.

DIGITAL MESSAGE DEVICE GROUP (DMDG)

The DMDG is part of the Special Forces Burst Communications System. It is used with radio sets AN/PRC-70/74 and AN/PSC-3 to send and receive messages. Messages are typed on the KY-879/P keyboard (shown in figure 2-32), which displays the message as it is being typed and stored in memory. When the message is ready to be sent, the operator selects the proper mode and the device converts the message to digital information. The digital information is sent to one of the above radios for transmission. After the information is received at the other end, it is sent to another KY-879/P, where the message can be read on the device's display screen.

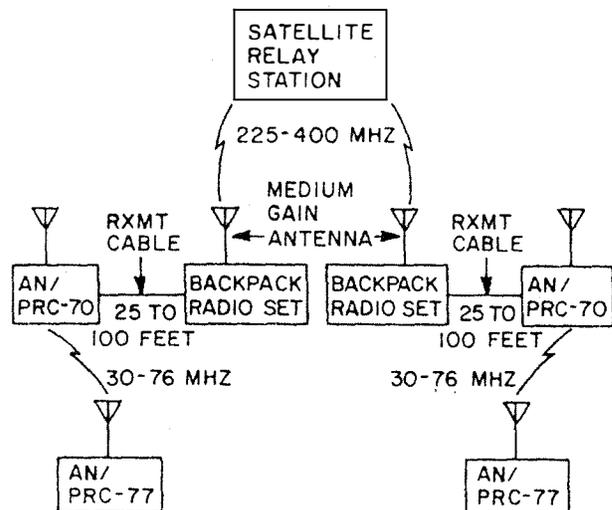


Figure 2-31.—Basic retransmission scheme.

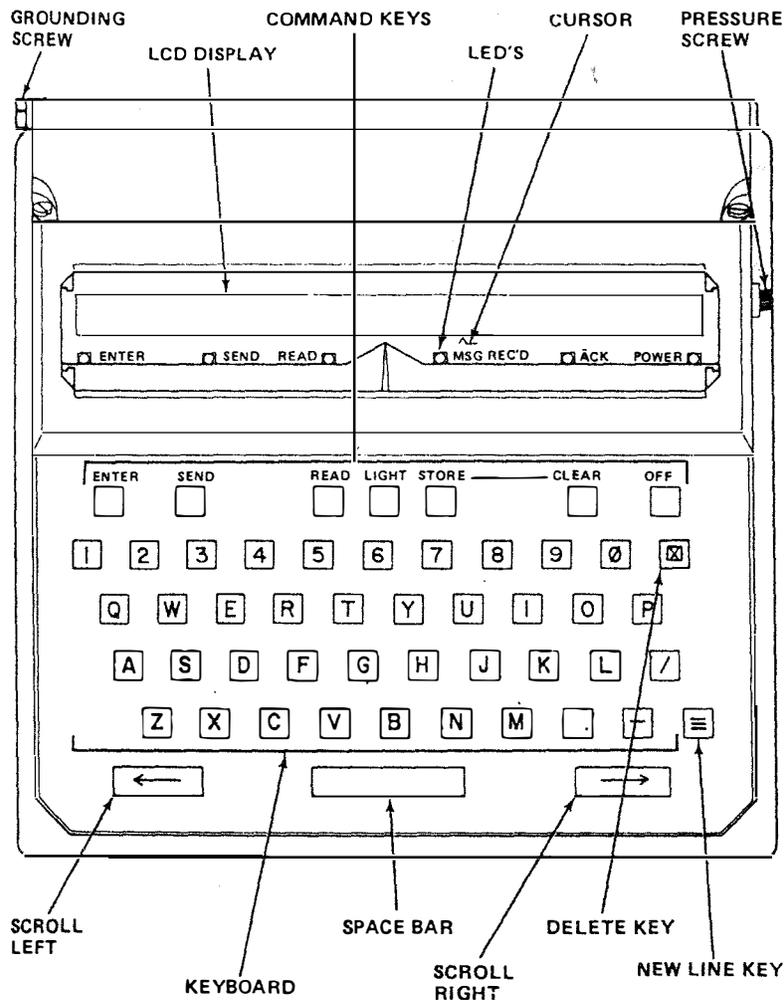


Figure 2-32.—KY-879/P keyboard.

The device can send messages at 300 or 1200 baud in the satellite mode and 266.6 baud when connected to the AN/PRC-70/74.

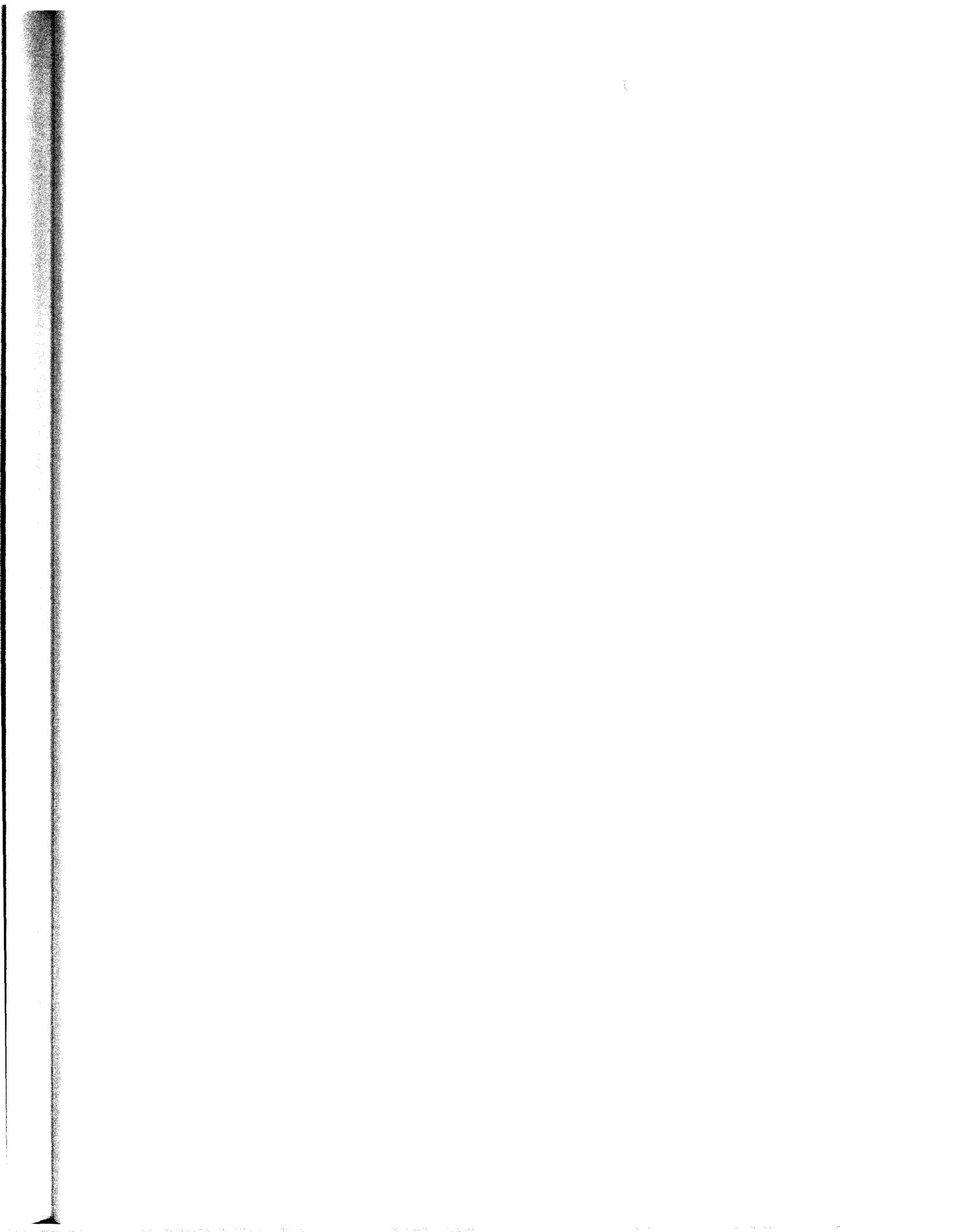
INTRODUCTION TO COMMUNICATIONS LINK INTERFACE PLANNING SYSTEM (CLIPS)

The Communications Link Interface Planning System (CLIPS) was introduced to the Joint Special Operations Community in 1986. CLIPS is a system designed to help the communications planner determine interoperability in joint operations involving single-channel tactical radio equipment.

Equipment planning in the Special Operations Community is complicated by the wide variety of equipment used and the highly variable and rapidly changing nature of the operational settings. Because

most communications requirements for this community are satisfied by single-channel, full-duplex radio links, CLIPS was designed primarily to help plan this type of communications link. Equipment covered under CLIPS is specifically limited to radios, modems, crypto devices, input/output data terminals, and packet controllers normally used to establish these radio links.

The CLIPS program is designed for use with IBM PC or compatible computers using MS-DOS. It is designed to provide solutions to equipment planning and link configuration problems by considering all the factors involved and automatically determining the "best" system to be used by each participant in the communications link. The CLIPS program incorporates the knowledge of experienced communications personnel, equipment specifications, circuit planning rules, and equipment inventories in a way that makes communications planning straightforward, easy, and objective.



CHAPTER 3

SATELLITE COMMUNICATIONS

INTRODUCTION

In the past, the Navy relied upon hf communications as its primary method of sending messages. With the overcrowding of the hf spectrum, the need for new and advanced long-range communications became apparent. Satellite communications (SATCOM) systems have shown they can provide survivable, reliable, high-capacity, secure, and cost-effective telecommunications for the military.

In this chapter, you will be introduced to satellite communications fundamentals, fleet SATCOM subsystems, shore terminals, current and future satellites, and some specific SATCOM equipment and racks. SATCOM is a natural outgrowth of modern technology and the continuing demand for greater capacity and high-quality communications. This information will be crucial to you in understanding the communications technology of both today and the future.

SATELLITE COMMUNICATIONS FUNDAMENTALS

A typical SATCOM link uses an **active** satellite that receives and retransmits, and two earth terminals. (A **passive** satellite simply reflects radio signals back to earth). One station transmits to the satellite on the *uplink* frequency. The satellite translates the signal to the *downlink* frequency, amplifies the signal, then transmits it to the receiving terminal. Figure 3-1 shows some of the various earth terminals and how they interface. The end use or purpose determines the system's complexity and how the system is used.

ROLE OF SATELLITE COMMUNICATIONS

SATCOM links, one of several kinds of long-distance communications links, interconnect communications centers located strategically throughout the

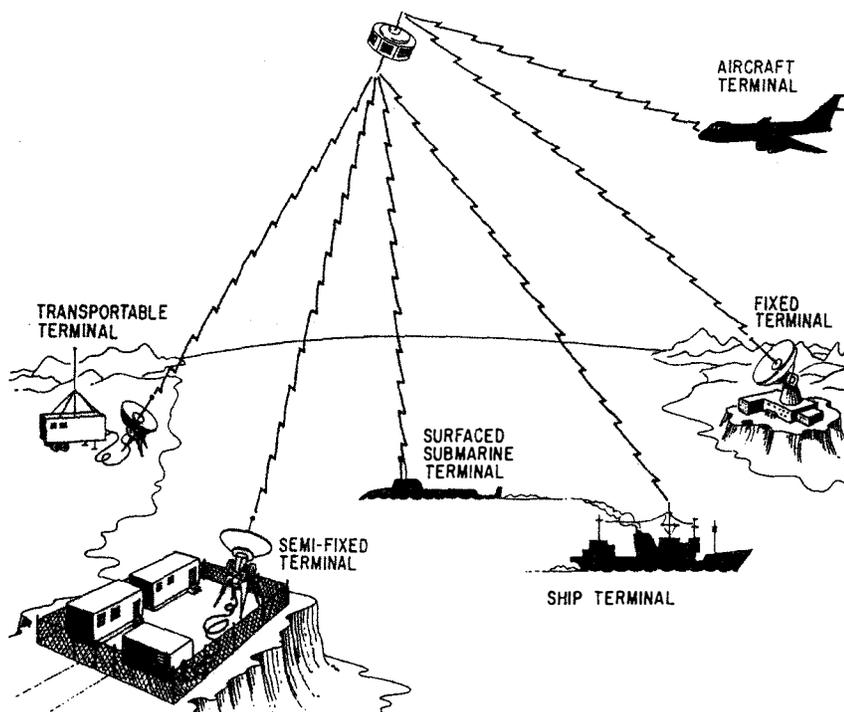


Figure 3-1.—Satellite communications system.

world. These SATCOM links are part of the Defense Satellite Communications System (DSCS) and Fleet Satellite Communications.

Satellite communications systems are very important to the worldwide military communications network for two primary reasons. First, they continue to operate under conditions that cause problems for other methods of communication. Second, they provide reliable and secure communications to previously inaccessible areas. In many cases, these communications requirements can only be satisfied by sophisticated satellite communications systems. By satisfying such needs, SATCOM makes a significant contribution to the improved reliability of naval communications.

ADVANTAGES OF SATELLITE COMMUNICATIONS

Some of the unique advantages SATCOM has over conventional long-distance communications are as follows:

- SATCOM links are unaffected by the propagation problems associated with hf radio communications.
- SATCOM links are free from the high-attenuation problems of facilities that use wire or cable for routing communications.
- SATCOM links span long distances.
- The numerous repeater stations required for line-of-sight and troposcatter systems are not needed.

As you can see, satellite links provide the required flexibility and reliability needed to support military operations. In the following paragraphs, we will look at SATCOM capacity, reliability, vulnerability, flexibility, and limitations.

Capacity

Currently, military SATCOM systems can provide communications between backpack, shore, airborne, and shipboard terminals. These SATCOM systems can handle thousands of communications channels at the same time.

Reliability

SATCOM frequencies are only slightly affected by atmospheric phenomena and do not depend on reflection or refraction. Reliability is based on the skill of operators and maintenance personnel and the condition of the satellite communications equipment.

Vulnerability

Communications satellites are relatively safe from threats of harm. Because these satellites are in such high orbits, any attempt to disable or destroy them from the Earth would be difficult and expensive. However, Earth terminals are a different story. They offer a more attractive target for destruction by conventional methods. But these terminals can be protected by the same methods taken to protect other vital installations. So overall, the satellite system is nearly free from harm by an enemy.

Operationally, highly directional earth terminal antennas provide a high degree of freedom from jamming. The wideband system can use antijamming techniques, which also reduces vulnerability.

Flexibility

Mobile military satellite earth terminals with trained crews can be deployed and put into operation anywhere in the world within hours.

Limitations

The technical characteristics of the satellite and its orbital parameters are the main limitations to a satellite communications system. Two additional limiting factors for active satellites are transmitter power and receiver sensitivity. Energy for electricity is limited to whatever can be produced by the solar cells, which limits the satellite's output power. This problem is made worse by users who increase their output power to the satellite, causing the satellite to try to retransmit at the new power level, at the expense of reducing signals to other users.

FLEET SATELLITE COMMUNICATIONS

The Fleet Satellite Communications (FLTSATCOM) System provides communications, via satellites, between designated mobile units and shore sites. These links provide worldwide coverage between the latitudes of 70 degrees north and 70 degrees south.

Three satellites are currently in use with a fourth to come on line soon: GAPPILLER, LEASAT, FLTSATCOM, and UHF Follow-on (UFO).

System installations are located on ships, submarines, mobile vans, aircraft, and shore stations. Though these installations could operate separately, integrating the system provides message traffic and voice communications to all DOD long-range communications networks. In addition, certain shore stations provide a back-up capability to other users in case of an outage of any kind, which maintains net connectivity.

The Navy SATCOM system consists of information exchange subsystems that use the satellites as (1) relays for communications and control, and (2) quality monitoring subsystems that provide data required to manage satellite resources. Each subsystem is structured for specific naval communications requirements. The following subsystems make up most of the Navy's FLTSATCOM system.

- Fleet Satellite Broadcast Subsystem. This is an expansion of the "Fleet Broadcast," which has been the central communications medium for operating naval units.
- Common User Digital Information Exchange Subsystem (CUDIXS) and Navy Modular Automated Communications Subsystem (NAVMACS). These two installations form a communications network for transmitting general-service message traffic between ships and shore installations.
- Submarine Satellite Information Exchange Subsystem (SSIXS). This subsystem complements other communications links between SSBN and SSN submarines and shore terminals.
- Secure Voice Subsystem. This is a narrowband uhf subsystem that links voice communications between ships and connects with wide-area shore voice networks.
- Tactical Intelligence Subsystem (TACINTEL). This subsystem is specifically designed for special intelligence communications.
- Teletypewriter Subsystem. This subsystem is an extension of terrestrial teletypewriter transmission networks.

- Tactical Data Information Exchange Subsystem (TADIXS). This is a one-way broadcast of tactical information from command centers ashore to afloat units primarily in support of over-the-horizon targeting (OTH-T).
- Officer in Tactical Command Information Exchange Subsystem (OTCIXS). This subsystem continues to provide inter- and intra-battle group communications and is now also designated as the return path for ship-to-shore OTH-T communications.
- Demand Assigned Multiple Access (DAMA) Subsystem. This subsystem was designed to multiplex several subsystems, or users, on one satellite channel, allowing more satellite circuits to use a single uhf satellite channel.
- Control Subsystem. This subsystem is a communications network that provides status reporting and management of system assets.

The installation of subsystem baseband equipment and rf terminals aboard ships is driven by communications traffic levels, type of communications, and mission requirements. For example, Fleet Broadcast, a common subsystem in naval communications, is received by many different types of ships. A typical suite on a large ship may include Fleet Broadcast, CUDIXS, NAVMACS, Secure Voice, TADIXS, OTCIXS, Teletypewriter, and TACINTEL equipment.

Most subsystems have very rigid control and accountability of message and data-link traffic. All subsystems have some form of backup mode. Within the constraints of equipment capability, each subsystem addresses the unique requirements of the user and the environment in which the user operates. On board your ship, you may not use all these systems, but during your career you will probably come across all of them. Now that we have identified the satellite communications subsystems, we need to provide you with a basic understanding of how they operate. But first, we need to discuss FLTSATCOM Shorebased Terminals.

FLTSATCOM SHOREBASED TERMINALS

SATCOM installations at shore terminals operate from existing naval communications centers and certain command operations centers. Four Naval Computer and Telecommunications Area Master Stations

(NCTAMS) have primary responsibility for naval communications via satellite. They are:

- NCTAMS LANT, Norfolk, Virginia
- NCTAMS MED, Naples, Italy
- NCTAMS WESTPAC, Finegayan, Guam
- NCTAMS EASTPAC, Wahiawa, Hawaii

The Naval Computer and Telecommunications Station (NCTS), San Diego, California, as part of TADIXS, provides connectivity between NCTAMS EASTPAC and NCTAMS LANT.

Ten NCTSs are used to retransmit Fleet Broadcast message traffic via hf links. In addition, an rf terminal at Yokosuka, Japan, transmits SSIXS and Secure Voice communications to the western Pacific and Indian Oceans. Also, there is landline connection between Japan and NCTAMS WESTPAC to support TADIXS and OTCIXS transmissions.

Within these facilities, each subsystem consists of two parts: the baseband equipment (used to collect and control the transmitted or received communications) and the rf terminal (used by the baseband system to transmit and receive via satellite link). Some subsystems have the baseband equipment and rf terminals in the same building, while others have the baseband equipment installed at a remote facility located some distance from the rf terminal. Most subsystems use a common rf terminal. However, the Fleet Broadcast has an rf terminal specifically designed for that subsystem.

FLEET SATELLITE BROADCAST SUBSYSTEM

The Fleet Satellite Broadcast Subsystem provides the capability to transmit Fleet Broadcast message traffic in a high-level jamming environment. The subsystem has 15 subchannels of encrypted message traffic at an input data rate of 75 bps per channel. These subchannels are time-division multiplexed and are transmitted in a one-way rf transmission at 1200 bps. The shore terminal transmits this data on a direct-sequence, spread-spectrum shf signal to the satellite, where the signal is translated to uhf and down-linked to the subscriber. Figure 3-2 shows a block diagram of the Fleet Satellite Broadcast Subsystem.

The High-Speed Fleet Broadcast (**HSFB**) is a planned upgrade to the Fleet Satellite Broadcast

Subsystem. This upgrade will improve broadcast transmission speed, information through-put (capability of equipment to process or transmit data during a specific period of time), and flexibility.

Message Traffic Input

The Fleet Satellite Broadcast message traffic is queued and/or channel selected by two processor-controlled message switching systems before transmission. These systems are the Naval Communications Processing and Routing System (**NAVCOMPARS**) for general service message traffic, and **STREAM-LINER** for special intelligence message traffic. Fleet weather data from Naval Oceanographic Command Centers is also transmitted on nonprocessor controlled channels.

Rf Transmission

The FLTSATCOM satellites have two rf channels allocated for Fleet Satellite Broadcast message traffic. The primary channel is configured for an shf uplink to the satellite and for translation within the satellite for transmission as uhf in the downlink. The second rf channel is designed for backup use only.

Since two channels are available, and several different modulation techniques are used for the uplink, there are seven different modes in which the rf link can be transmitted.

In modes 1 through 6, the shf transmissions are made by the Satellite Communications Terminal AN/FSC-79. Mode 7 operates the rf uplink and downlink at ultra-high frequencies and uses the uhf transceiver AN/WSC-5(V).

Reception

Subscribers receive the uhf downlink signal through the AN/SSR-1 receiver system, which demodulates and demultiplexes the signal. The demuxed signal is decrypted and read into the NAVMACS and TACINTEL processors for message screening and printing. (Refer to the discussion of these two systems.) Weather data is sent directly to printers after decryption. Ships not equipped with one or both of these systems will normally output the broadcast to teletypewriters.

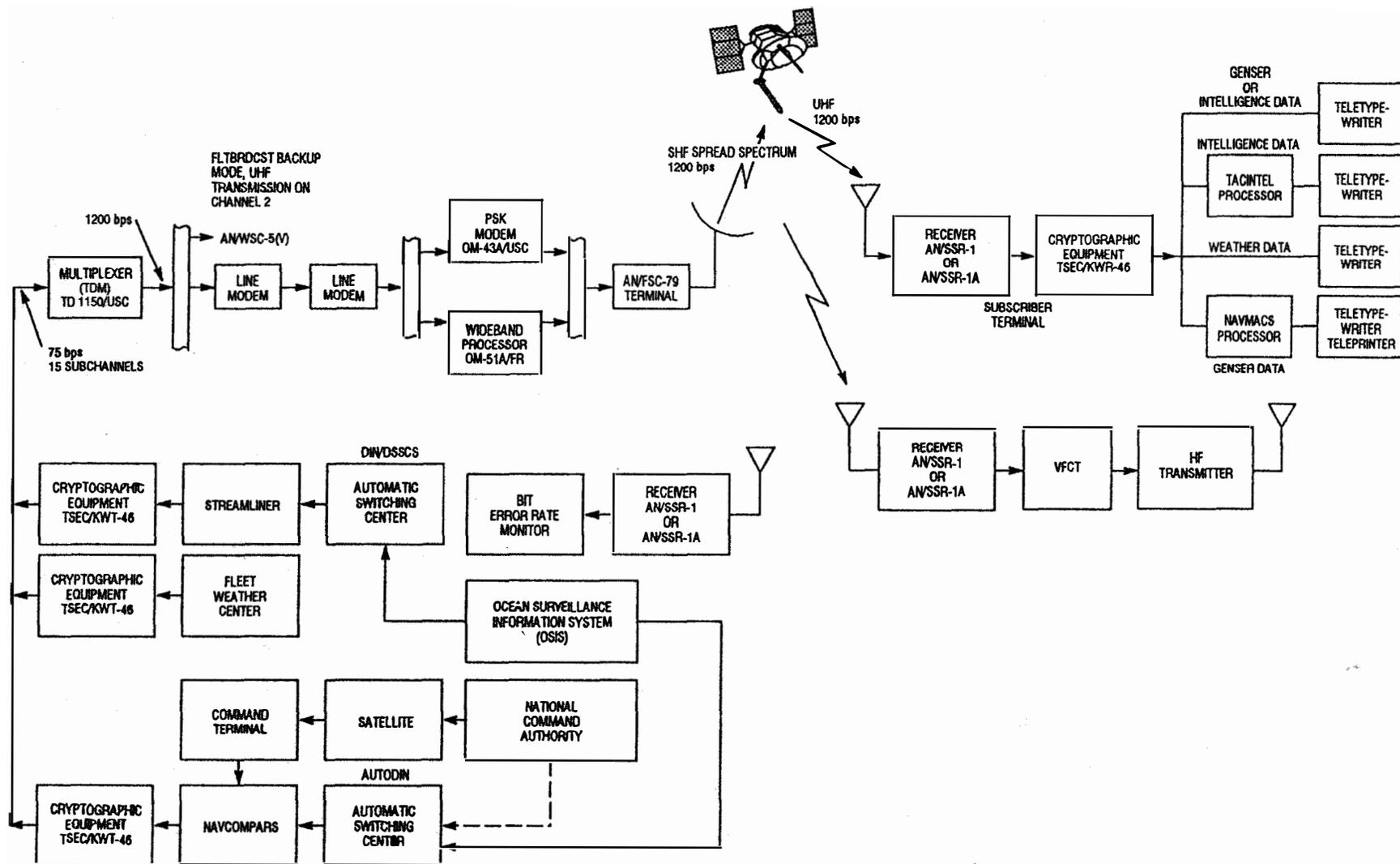


Figure 3-2.—Fleet Satellite Broadcast Subsystem.

Fleet Broadcast Retransmission

At selected shore stations, Fleet Broadcast message traffic is retransmitted on hf links. These stations receive the tdm data directly via cable or satellite.

CUDIXS/NAVMACS

The CUDIXS subsystem is a shorebased installation of processors and peripheral equipment that provides rf link control of the network and processing at shore installations. Figure 3-3 shows a typical CUDIXS installation.

NAVMACS is a shipboard message processing system that automatically guards a minimum of four broadcast channels, serves as an automated shipboard terminal for CUDIXS, and provides accountability for all incoming and outgoing message processing needs for ships of the fleet. NAVMACS subscriber terminal equipment is similar to CUDIXS terminal equipment.

The NAVMACS program is designed to address the growth requirements in existing installations and the unique requirements of ships having a high volume of message traffic. In ships that have a message processing and distribution system (MPDS), the NAVMACS processor interacts with the MPDS processor. A basic NAVMACS system is shown in figure 3-4.

NAVMACS reads the headings of incoming message traffic and separates all messages addressed to the ship or commands for which it is guarding. The system compares every addressee on each incoming first run message against entries in its command guard list (CGL). When the system finds one or more matches between addresses on the first run message and the entries of the CGL, the message is printed (copied) onto a line printer. If an emergency or Flash precedence message on a first run is received, it is printed completely, regardless of whether or not a match is found. For nonmatches of messages with precedence lower than Flash, only the heading of the message is printed.

Together, CUDIXS and NAVMACS provide improved ship-to-shore and shore-to-ship operational communications. These improvements help increase message traffic through-put rates and traffic volume, and improve link reliability. Figure 3-5 shows both sides of the CUDIXS/NAVMACS subsystem.

Message Traffic Input

At shore facilities, the primary collection point for message traffic to be transmitted or received on the CUDIXS/NAVMACS rf link is NAVCOMPARS.

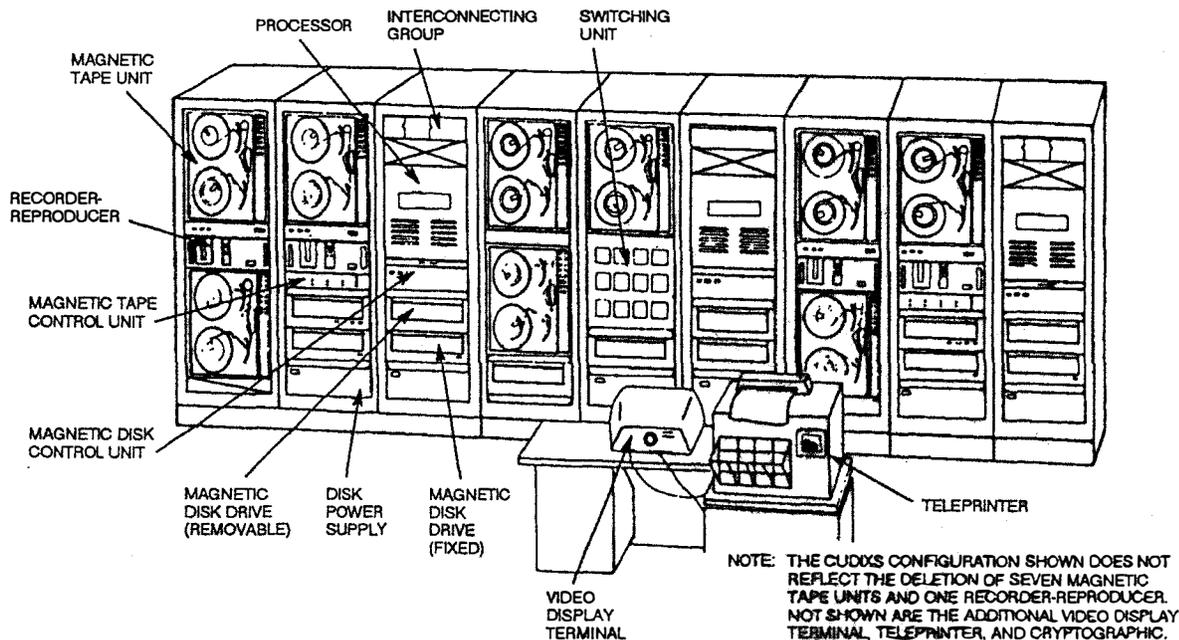


Figure 3-3.—CUDIXS equipment configuration.

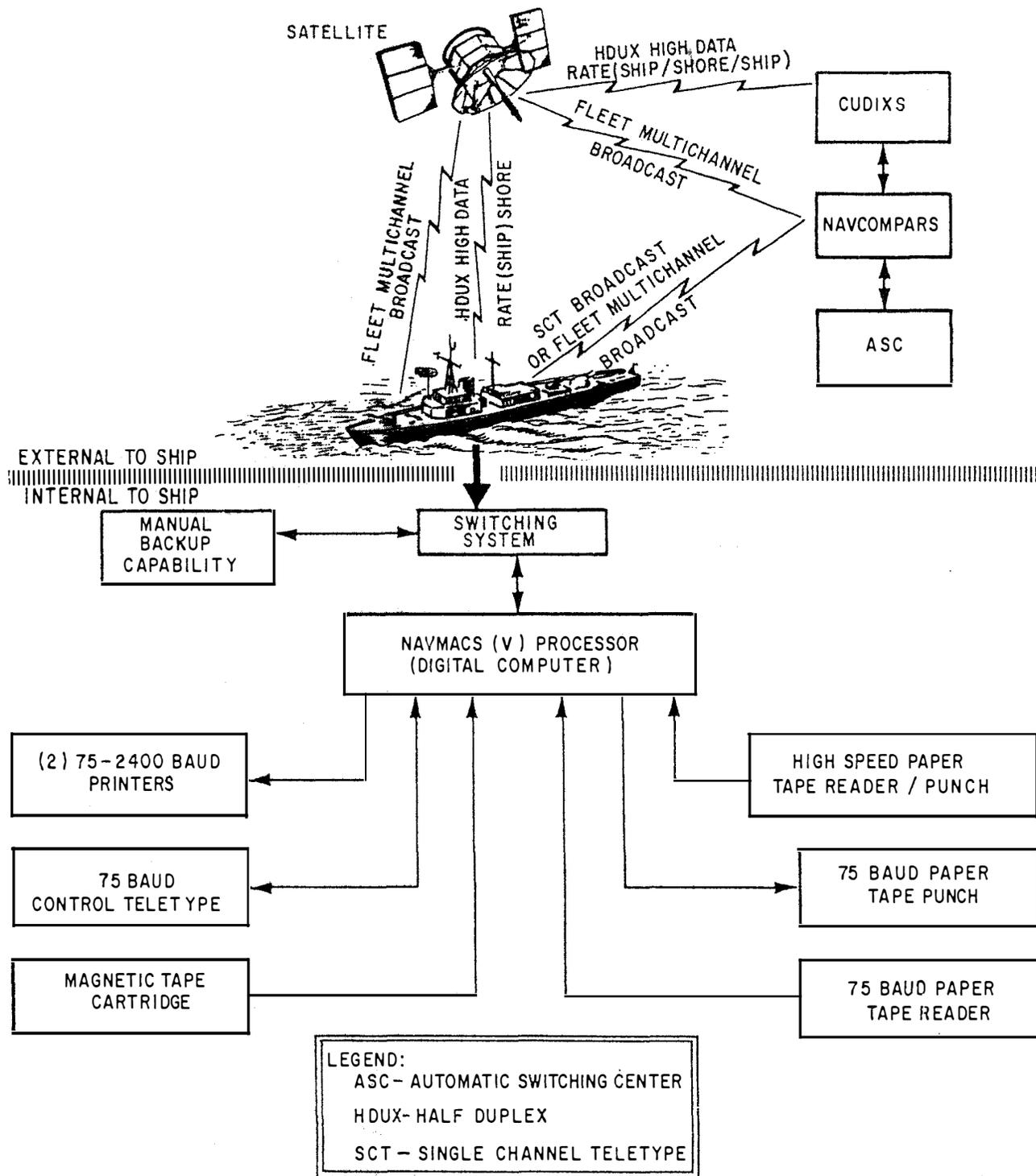


Figure 3-4.—NAVMACS (V) communications interface.

Rf Transmission Link Control (Non-DAMA)

The CUDIXS baseband equipment shares a common rf terminal with other subsystems. At the shore facilities this terminal is a uhf transceiver, AN/WSC-5(V). Aboard ship, NAVMACS uses a uhf transceiver,

AN/WSC-3(V). All uhf satellites have 25-kHz-wide channels allocated for CUDIXS/NAVMACS transmissions. Each channel is operated as a half-duplex uhf link, with a data transmission rate of 2400 bps. The rf modulation is differential encoded phase-shift keying (DPSK).

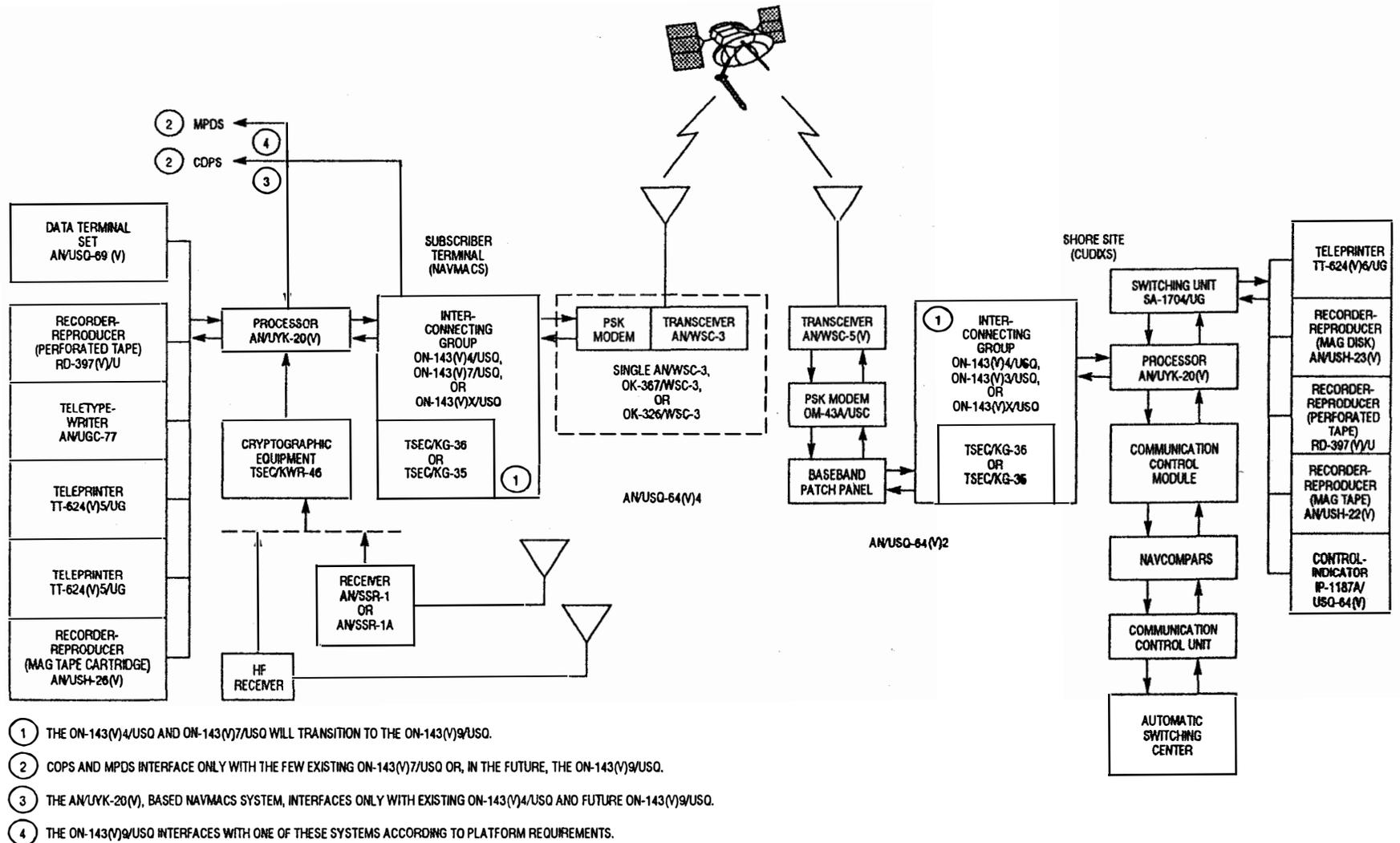


Figure 3-5.—CUDIXS/NAVMA CS subsystem (non-DAMA).

SUBMARINE SATELLITE INFORMATION EXCHANGE SUBSYSTEM (NON-DAMA)

SSIXS was designed to compliment vlf and mf/hf communication links between shorebased submarine broadcast control authorities (BCAs) and submarines. Figure 3-6 shows a SSIXS subsystem.

This subsystem provides the submarine commander the ability to receive messages transmitted via satellite at scheduled intervals ("Group Broadcasts"). Between Group Broadcasts, submarines may transmit messages to the BCA, including a request for messages held in queue. The shore terminal responds with acknowledgements for the received messages and transmits all messages addressed to that particular submarine. Two modes, Group Broadcast and Query/Response, permit the submarine to be active or passive, depending on what the submarine commander wants. One 25-kHz wideband channel on each of the four FLTSATCOM satellites has been allotted to SSIXS. A single SSIXS network may have up to 120 submarine subscribers.

SSIXS has undergone an upgrade (SSIXS II) that replaces the SSIXS shore equipment with new computer equipment.

Message Traffic Input

At the broadcast control authority (BCA), the console keyboard operator, high-speed paper tape reader, or Submarine Message Automated Routing Terminal (SMART) enters into the SSIXS shore terminal messages addressed to submarines that have been received from AUTODIN, NAVCOMPARS, or locally over the counter in the message center. Aboard the submarine, message traffic is input via the teletypewriter or tape reader equipment. SSN submarines that have the Data Link Control System (DLCS) installed have an additional input/output capability via the sensor interface unit (SIU) for over-the horizon targeting (OTH-T) messages.

Rf Transmission Link Control

Ashore, the SSIXS subsystem shares access to the same satellite rf terminal equipment as the other uhf

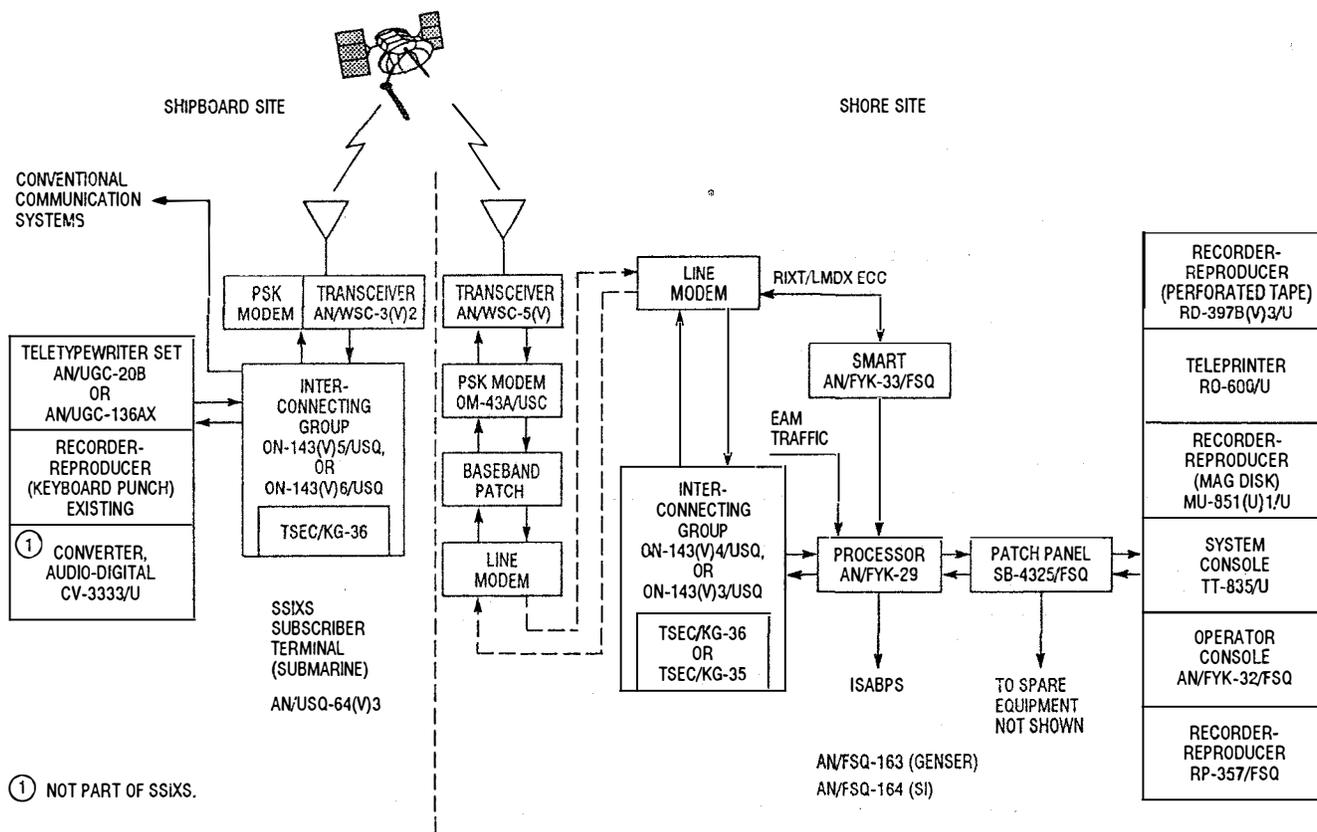


Figure 3-6.—SSIXS subsystem.

SATCOM subsystems, with the exception of COM-SUBGRU SEVEN, Yokosuka, Japan, which is equipped with dedicated AN/WSC-3 transceivers.

Since each BCA is located some distance away from the Naval Computer and Telecommunications Area Master Station (NCTAMS), line modems and land lines are required for interconnection. The submarine uhf rf terminal is the single-channel, half-duplex AN/WSC-3. SSIXS transmissions are at 4800 bps. The capability to operate SSIXS in the DAMA net (see the section on DAMA) has been successfully demonstrated and will be used in the future. Each subscriber to a SSIXS network is assigned a unique identification number that is used in all transmissions to or from the subscriber. The identification numbers are stored within the shore station and subscriber processors and are used for the following purposes:

- At the shore stations, the subscriber identification number, when combined with broadcasts, determines the number of times message traffic is transmitted to the subscriber.
- When a subscriber makes a transmission to the shore station, the identification number is included. The shore station will not acknowledge a transmission without receiving the identification number.
- The subscriber uses the number to screen incoming message traffic. Any data that is not addressed to that particular subscriber is discarded.

SECURE VOICE SUBSYSTEM

The Secure Voice subsystem enables the transmission of ship-to-ship, ship-to-shore, and shore-to-ship voice communications via satellite relay. Figure 3-7 shows a Secure Voice subsystem. (AUTOSEVOCOM has been replaced by radio wireline interface (RWI) at all NCTAMS shore activities.) The subsystem transmits and/or receives secure voice communications via a half-duplex, push-to-talk satellite link. Channels on each of the four FLTSATCOM satellites have been allocated for use by the Secure Voice subsystem. Control of the voice channels is maintained by the Secure Voice controller at the responsible NCTAMS/NCTS.

The subsystem uses digitized voice at a data rate low enough to be compatible with a 3-kHz voice channel and is considered narrowband. The sound of Narrowband Secure Voice is very distinctive. Once you hear it, you won't forget it. The system uses special analog-to-digital processing of the speech signal

at the handset terminal and the rf transmission rate is 2400 bps.

The Secure Voice subsystem has dedicated rf channels on the uhf SATCOM satellites as well as dedicated DAMA time slots where DAMA nets have been established.

Voice Transmission

The rf terminal installations on mobile platforms determine the manner in which a Secure Voice transmission is made. These mobile platforms may be categorized into two types:

- The small ship/submarine that share a single-channel AN/WSC-3(V) uhf transceiver and cryptographic equipment between NAVMACS or SSIXS and a Secure Voice terminal.
- Larger ships that have two or more AN/WSC-3(V) uhf transceivers and cryptographic equipment are installed. This installation normally has a transceiver dedicated to Secure Voice.

Secure Voice use is accomplished by either of two methods. In the first method, ships access a Secure Voice channel if the channel is not in use. The ship contacts another ship directly by using the available channel. When coordination of voice communications with shore commands is required, the ship contacts the voice controller who, in turn, tells the recipient(s) of an incoming voice transmission.

The second method requires a different process and is used if the channels are busy or if procedures require this method. For the small ship or submarine, a voice transmission request must be sent by message to the Secure Voice controller. A small ship uses the CUDIXS/NAVMACS network for the message. The submarine may transmit a voice-channel request during a random-access time period in the SSIXS. In both cases, the request is passed from the reception point ashore to the voice controller. The voice controller coordinates the voice transmission by assigning a voice channel, contacting the unit that will receive the voice transmission, and following through with the transmission.

Radio Wireline Interface

The Radio Wireline Interface (RWI) was developed to access and interconnect existing and future Secure Voice subsystems and equipment. It provides the capability to connect shorebased worldwide

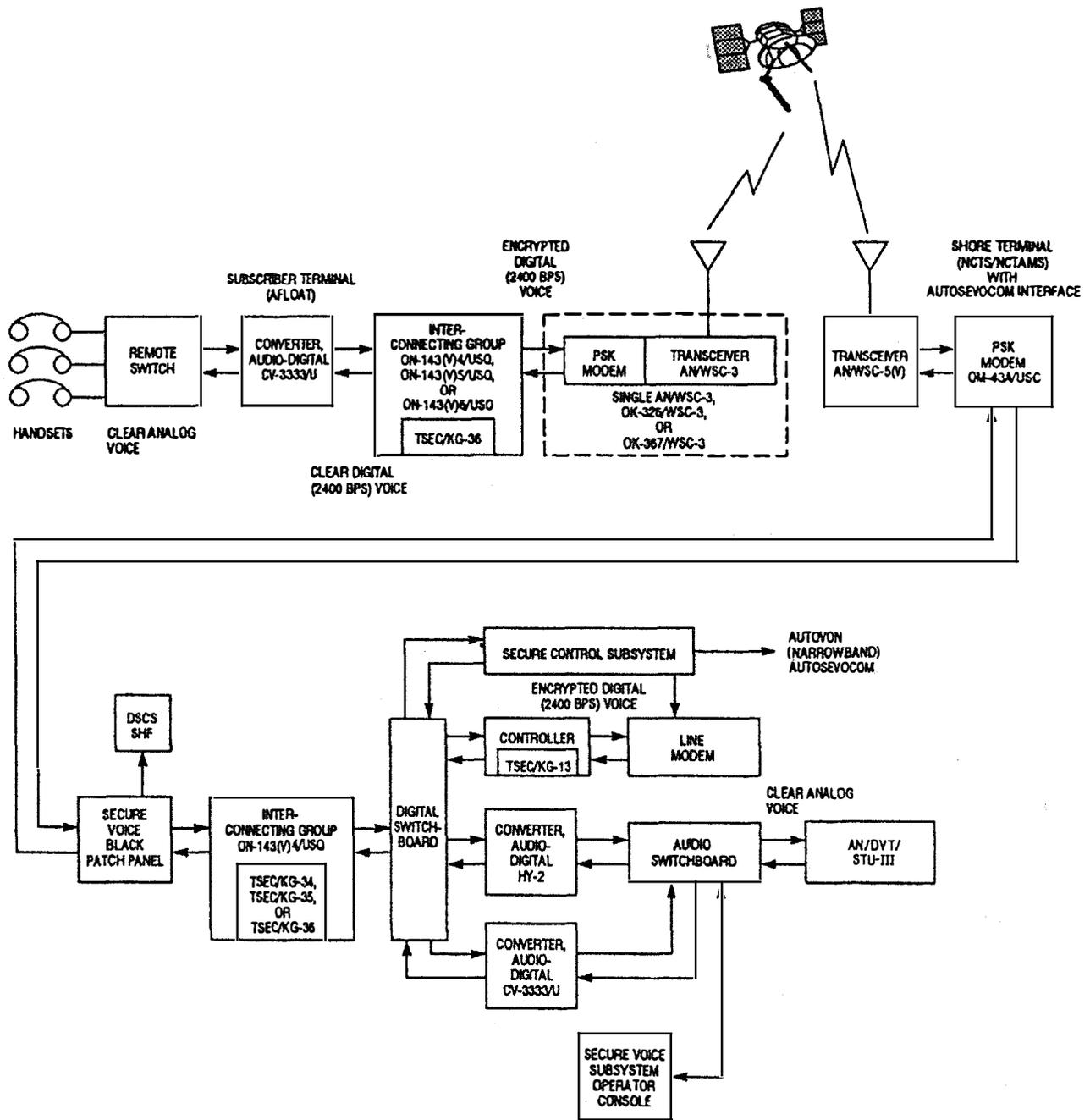


Figure 3-7.—Secure Voice subsystem.

terrestrial (**wireline**) systems with the SATCOM, Defense Satellite Communications Systems, and alternate hf systems. This system extends shore communications seaward and gives commands at sea the same Secure Voice telephone communications currently provided to the worldwide shore establishment. The RWI provides interconnection among the Secure Voice Improvement Program (SVIP) channels (STU-III units), a RED telephone bus, the

Advanced Narrowband Digital Voice Terminal, SATCOM radio terminals (uhf, shf, and in the future ehf), and hf radio links.

TACTICAL INTELLIGENCE SUBSYSTEM

The Tactical Intelligence subsystem (TACINTEL) is used to transmit special-intelligence

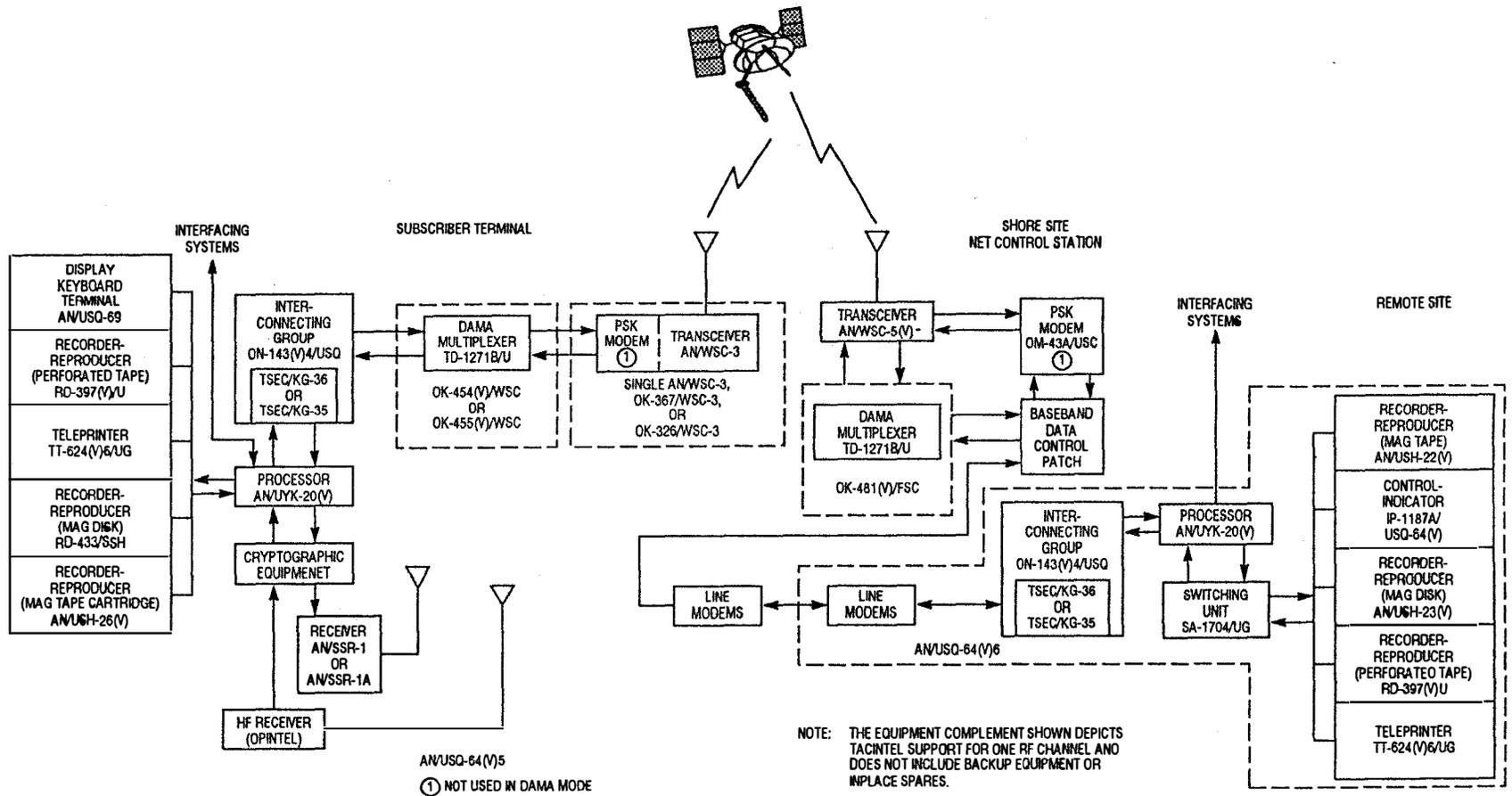


Figure 3-8.—DAMA-configured TACINTEL subsystem.

communications. A link-control protocol has been adapted to a format required for communication across a DAMA-supported channel using a polling scheme that can support a net membership of 23 subscribers. A portion of a DAMA 25-kHz channel on each of the FLTSA TCOM satellites has been allocated for TACINTEL. A TACINTEL subsystem is shown in figure 3-8.

TACINTEL also processes time-sensitive sensor data and other data essential to Indications and Warnings and OTH-Targeting. In addition, this system, unlike CUDIXS/NAVMACS, can be used for direct ship-to-ship interchange of this data.

Rf Transmission

TACINTEL baseband equipment uses an rf terminal in common with other subsystems at both shore facilities and subscriber terminals. Shore facilities use an AN/WSC-5(V); subscribers use an AN/WSC-3(V). The TACINTEL channel operates as a half-duplex uhf link at 1200, 2400, or 4800 bps. Modulation is DPSK.

Subscriber Reception

Each subscriber has an identification number recognized by the subscriber processor. This number serves as the initial basis for incoming message screening. Screened message traffic is sent to the TACINTEL peripheral equipment (printer) or the interfacing systems. The remaining message traffic is discarded without release.

Future TACINTEL

The TACINTEL II program will upgrade the existing TACINTEL and incorporate state-of-the-art hardware and software. It will be a computer-based message communications system, enabling automatic receipt and transmission of Special Intelligence communications for both ashore and afloat users. During the transition, it will be compatible with the present TACINTEL.

TELETYPEWRITER SUBSYSTEM

The Teletypewriter Subsystem expands existing teletypewriter communications networks by using satellites as relay stations.

The Navy continues to have numerous uses for the 75-bps tty. These include dedicated full-time terminations for beyond-line-of-sight tactical and report-back circuits and as backup connectivity for networks such as CUDIXS/NAVMACS and TACINTEL. A non-DAMA-configured teletypewriter subsystem is shown in figure 3-9.

TADIXS/OTCIXS

TADIXS supports the exchange of Over-the-Horizon Targeting (OTH-T) information between shore and fleet-based computer systems that support Navy cruise missile operations. Surface ships and submarines operate in a TADIXS receive-only mode.

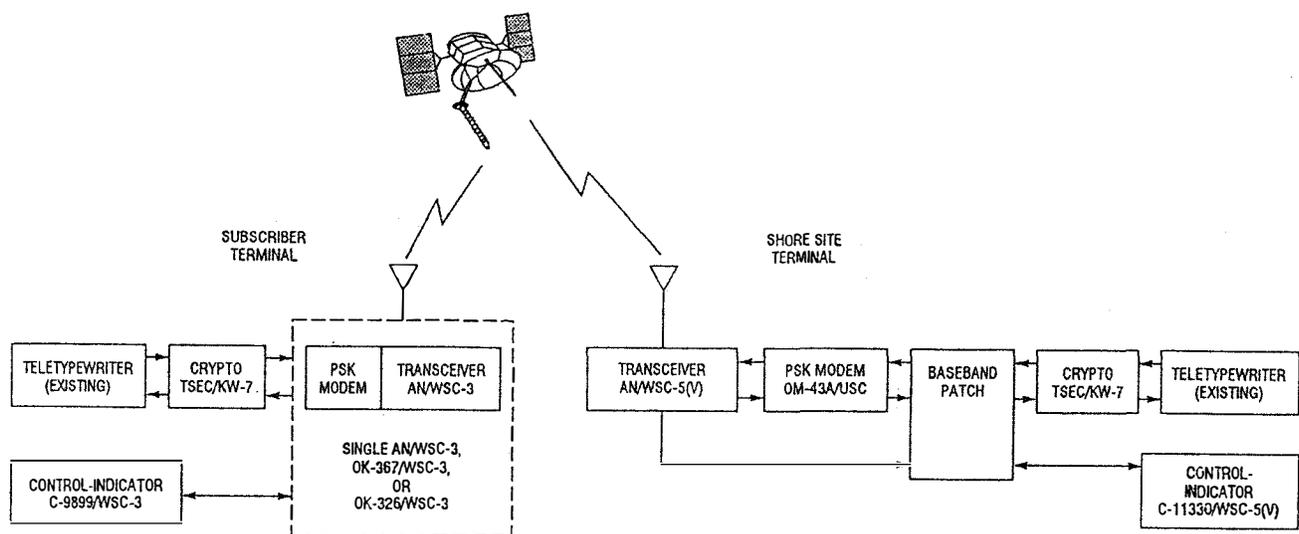
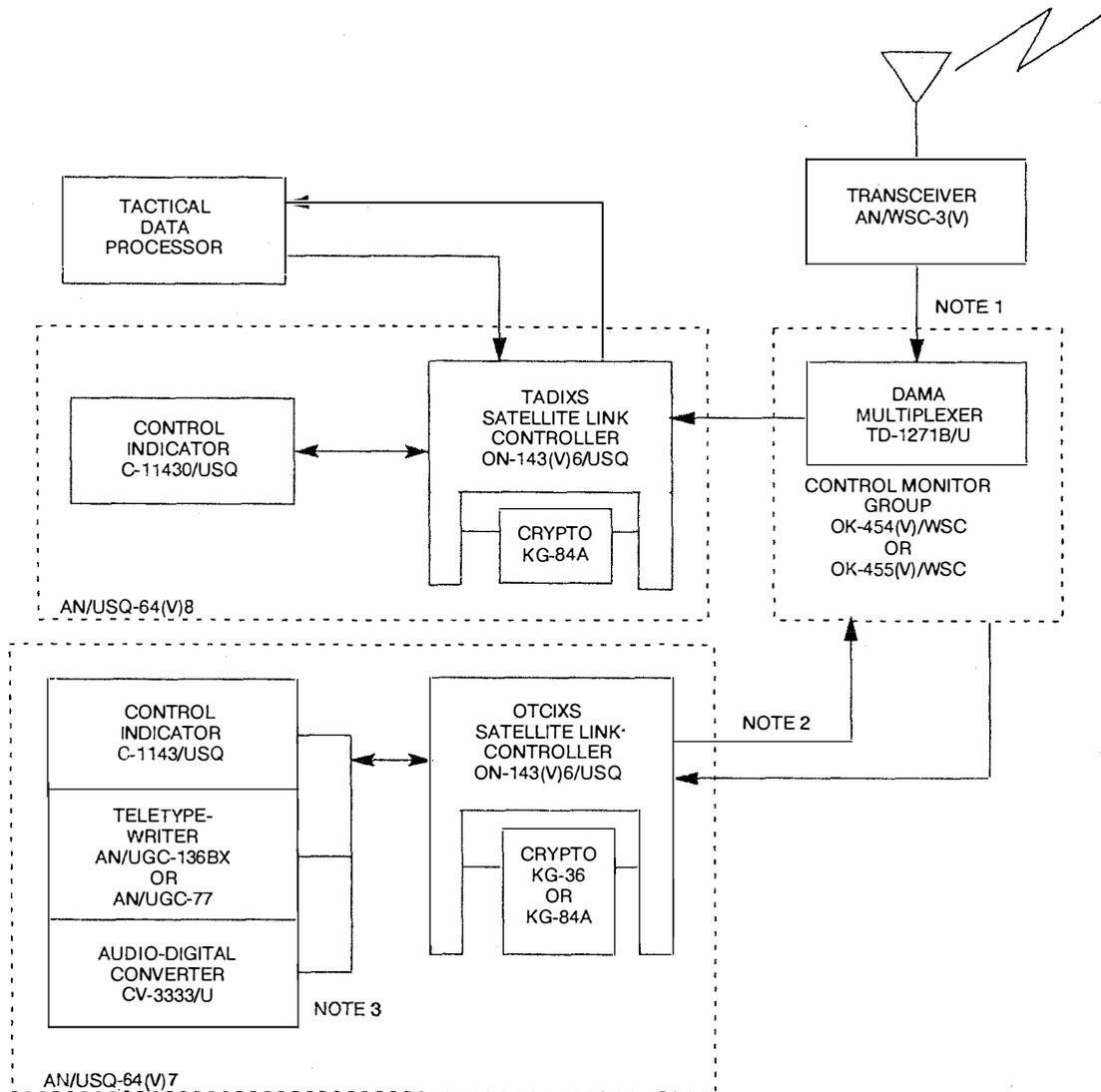


Figure 3-9.—Teletypewriter subsystem-non DAMA.

OTH-T data from the fleet destined for shore or other fleet users is sent by the afloat Tactical Data Processors (TDPs) through the TADIXS ON-143(V)6/USQ to the OTCIXS ON-143(V)6/USQ for transmission over the OTCIXS satellite. A TADIXS surface ship installation is shown in figure 3-10. Each OTCIXS-equipped surface ship or submarine can enter both out-going teletype and TDP traffic simultaneously.

Rf Transmission Link Control

The TADIXS satellite link network operates in a half-duplex manner at a data rate of 2400 bps in a permanently assigned time slot of a uhf DAMA channel. Control of message traffic transmission is achieved by a polling and controlled access protocol installed in the TADIXS radio controller (shore) software and the TADIXS satellite link controller (afloat) software.



NOTES:

1. TADIXS IS RECEIVE ONLY FOR AFLOAT PLATFORMS.
2. CONFIGURATION SHOWN IS FOR AN OTCIXS DAMA NETWORK IN THE NON-DAMA CONFIGURATION. THE OK-143(V)8/USQ CONNECTS DIRECTLY WITH A SECOND AN/WSC-3(V).
3. NOT PART OF AN/USQ-64(V)7, BUT CAN BE INSTALLED FOR FLTSATCOM SECURE VOICE OPERATIONS.

Figure 3-10.—TADIXS surface ship installation.

In the non-DAMA mode, OTCIXS operates in a half-duplex manner at a data rate of 2400 bps using a dedicated uhf channel. When functioning in the DAMA mode, OTCIXS operates at a data rate of 1200 or 2400 bps in a permanently assigned time slot of a uhf DAMA channel. Control of message traffic transmission is achieved by a demand-assigned access protocol installed in the OTCIXS radio controller (shore) and satellite link controller (afloat) software.

Message Traffic Reception

Each subscriber in the TADIXS network has a unique identification number recognized by the subscriber processor. This number serves as the initial basis for incoming message traffic screening. TADIXS or OTCIXS satellite link controllers (on afloat units) compare redundant receptions for accuracy and form the most accurate composite of the traffic received.

For surface ship and submarine users, screened message traffic is sent to the teletypewriter or TDP system, as applicable. The rest of the traffic is discarded. The reception of traffic does not make the satellite link controller send an acknowledgement. This allows afloat platforms to receive traffic while operating in an emission control (EMCON) environment.

DEMAND-ASSIGNED MULTIPLE ACCESS (DAMA) SUBSYSTEM

The uhf DAMA subsystem was developed to multiplex several baseband systems or users on one 25-kHz satellite channel. This had the effect of adding more satellite circuits per channel to the uhf Satellite Communications System. Without uhf DAMA, each satellite communications subsystem requires a separate satellite channel.

DAMA equipment accepts encrypted data streams from independent baseband sources and combines them into one continuous serial output data stream. DAMA interfaces the Navy uhf SATCOM subsystems and the AN/WSC-5(V) and DAMA-compatible AN/WSC-3(V) transceivers. The DAMA unit (TD-1271B/U multiplexer) includes a modem, eliminating the need to use a separate modem at the AN/WSC-5(V) or the modem within the AN/WSC-3(V). The baseband equipment input or output (I/O) data rate with DAMA equipment can be 75, 300, 600, 1200, 2400, 4800, or 16,000 bps. The DAMA transmission rate on the satellite link (**burst rate**) can be 2400,

9600, 19,200, or 32,000 symbols per second (sps). CUDIXS/NAVMACS, Secure Voice, and OTCIXS currently use 2400 bps. TACINTEL operates at 2400 or 4800 bps, depending upon the ocean area.

The DAMA multiplexed data stream is divided into frames, with each frame being 1,386 seconds long. Each frame is subdivided into time slots as shown in figure 3-11. Most of the DAMA frame formats are derived from this basic format. In the following paragraphs, we will name and describe the purpose of each slot.

Channel Control Order Wire (CCOW) Slot

This slot is used to transmit system timing and control information from the channel controller to subscriber units only. It provides subscriber units with system timing, configuration, and satellite rf control information. It occurs at the beginning of each frame.

Return Channel Control Order Wire (RCCOW) Slot

This time slot provides limited order wire capability for DAMA-related subscriber-to-channel controller communications. It is used for transmission from the subscriber to the channel controller.

Ranging Time Slot

This is the time slot during which the user's TD-1271B/U determines the range between the user terminal and the satellite to set the transmitter synchronization required for timing. All DAMA multiplexer transmit times are referenced to the satellite.

Link Test Slot

The link test slot is used to evaluate the performance of the satellite link. Each subscriber is able to

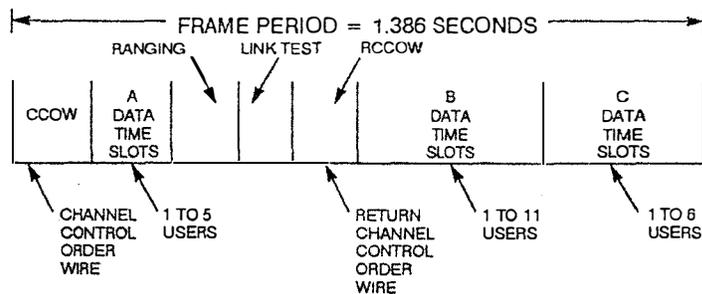


Figure 3-11.—Basic DAMA frame format.

transmit a fixed data stream through the satellite, receive that bit stream, and then perform error analysis automatically.

Data Time Slots

These are the time slots during which users transmit or receive data. There are three segments of time slots in each frame, designated A, B, and C. Segment A may contain from one to five circuits; B may contain from one to eleven circuits; and C may contain from one to six circuits. The number of circuits in each group depends on the baseband data rate, the forward correction rate, and the transmission burst rate, as influenced by the radio frequency interference (RFI) environment.

Current Operation

For communications on the eastern Pacific satellite, a master control station is installed at NCTAMS EASTPAC. This same pattern of DAMA equipment installations has been followed at NCTAMS LANT, MED, WESTPAC, and NTCS. Each master control station has multiple multiplexers installed, and each TD-1271B/U multiplexer can accommodate up to four circuits. The number of multiplexers installed aboard each ship varies according to platform requirements.

Any DAMA-equipped platform with full-duplex capability can be designated a channel controller. This capability provides an emergency backup for the shorebased master controller terminals. A DAMA subscriber who is designated a channel controller will provide all the required CCOW functions for DAMA system control of a particular rf channel.

Operationally, the user terminal will have its baseband port automatically connected to a data time slot when the proper slot number is keyed into the multiplexer front panel keyboard. Each SATCOM subsystem that uses DAMA will have a specific slot number. Circuits will normally be operated on a netted basis, and circuit numbers will be assigned by COMNAVTELCOM and/or FLTCINC.

Transition

Transition to DAMA is taking place in a manner that allows subscribers converted to DAMA to communicate with those who have not been converted. During the transition period, equipment installed at shorebased master stations will form gateways

between DAMA and non-DAMA circuits. In the following paragraphs, we will discuss subsystems that are either currently undergoing conversion to DAMA or are planned for conversion, so you will know what to expect in the future.

Secure Voice—DAMA is now being phased into the Secure Voice Subsystem. A DAMA-configured Secure Voice Subsystem is shown in figure 3-12.

CUDIJS/NAVMACS—NAVMACS platforms will be gradually transitioned to DAMA. This transition will start when CUDIJS shore and CUDIJS/NAVMACS ship hardware and software have been modified for compatibility with DAMA. At that time, a transition will begin allowing DAMA or non-DAMA ships to communicate with the CUDIJS shore terminal. A DAMA-configured CUDIJS/NAVMACS subsystem is shown in figure 3-13.

Teletypewriter—Teletypewriter capability via DAMA becomes available as DAMA is installed on each platform. To provide maximum flexibility during the transition, capability is provided at the shorebased master control stations to interface non-DAMA and DAMA users. Figure 3-14 shows a DAMA-configured teletypewriter subsystem.

CONTROL SUBSYSTEM

The Control Subsystem is structured to perform the following tasks:

- Sense and collect system status information in a defined geographical area and on a worldwide scale.
- Control system resources and the degradation of system capability.

The Control Subsystem is a combination of several areas and levels of command. The major players are listed below:

- The Chief of Naval Operations is the executive authority for all SATCOM systems.
- The Commander, Naval Space Command is responsible for the operational control and management of these systems and for the effective operation and maintenance of assigned Navy resources for the Department of Defense.
- The Naval Computer and Telecommunications Command performs the required functions to provide day-to-day control and operation of naval satellite

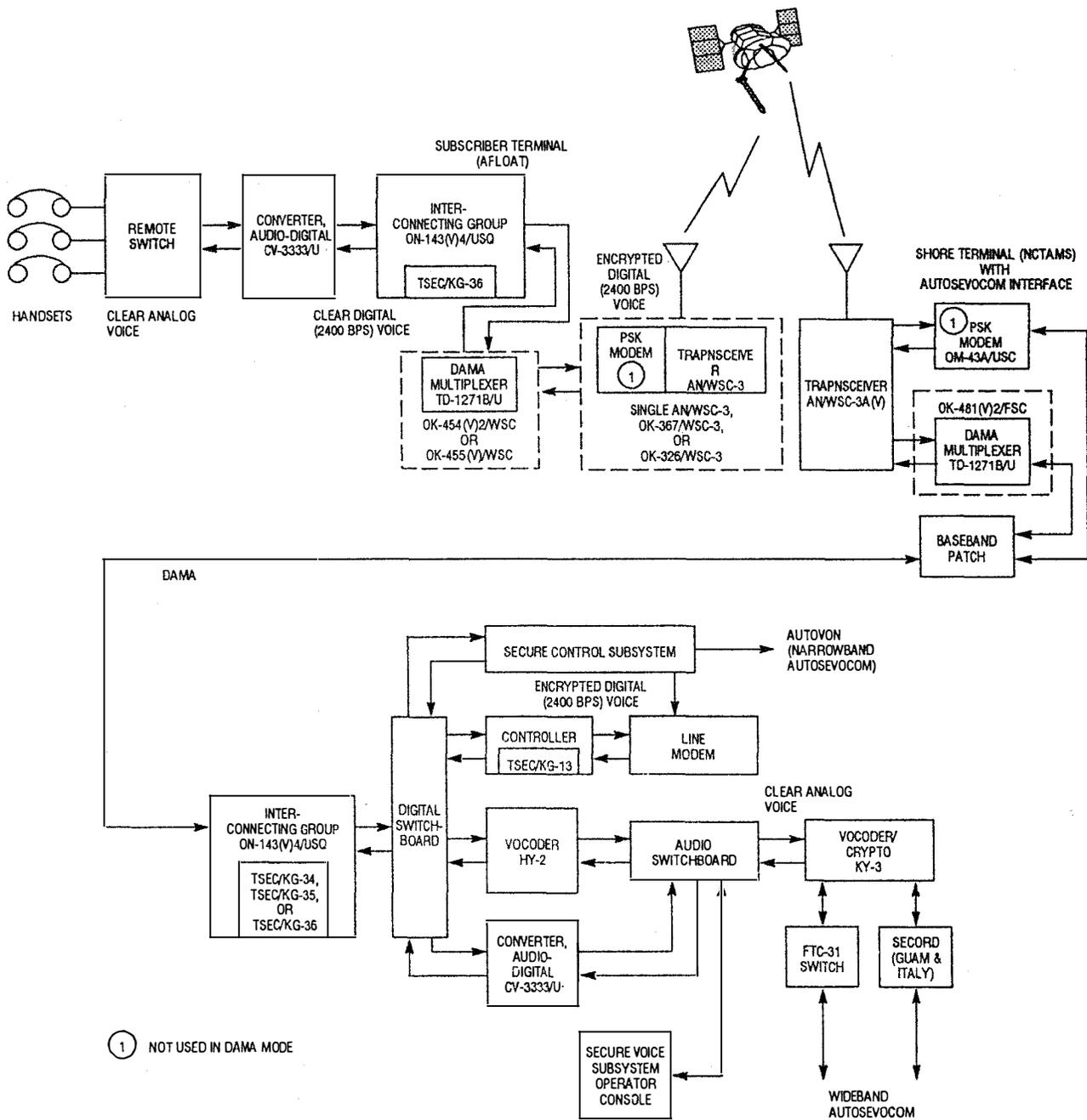


Figure 3-12.—DAMA-configured Secure Voice Subsystem.

communications assets. With coordination, system resources can be adjusted to meet operational needs.

- Supporting the control subsystem are NCTAMS, NCTS, the USAF Satellite Operations Center, and contractor-operated control facilities.

The key to control ability lies in having many points for sensing the status of subsystems and equipment operation. Status data may be collected by operators or by special facilities or equipment. There are many points within each subsystem where subsystem

and equipment operational status is collected. Also, several subsystems/systems have the ability to provide a printout of status information.

Transmission of status data from the NCTAMS, NCTS, and USAF Satellite Operations Center is via teletypewriter order wire. The Naval Computer and Telecommunications Command maintains a substantial quantity of updated status data in computer files. A diagram of the Control Subsystem is shown in figure 3-15.

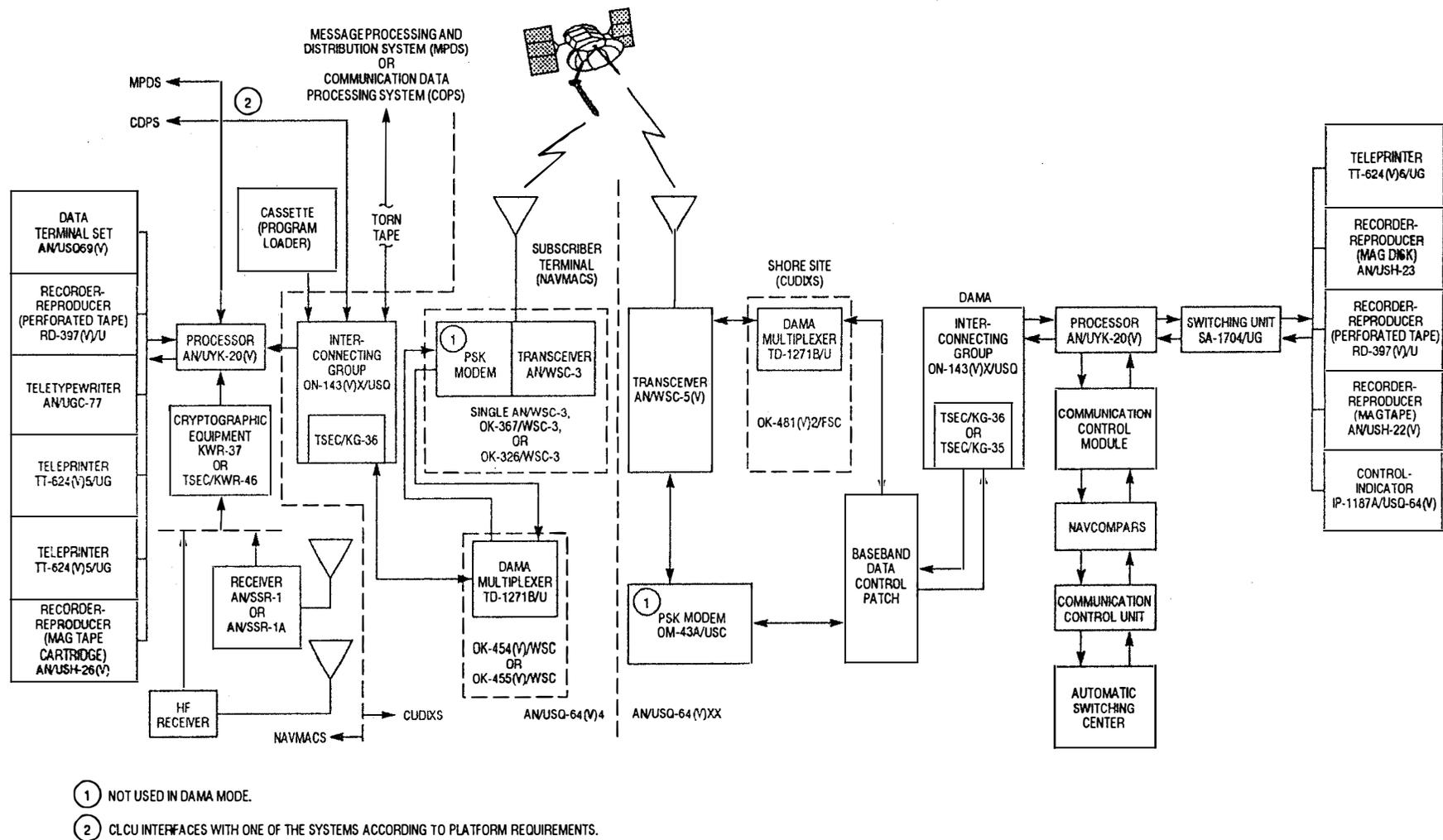


Figure 3-13.—DAMA-configured CUDIXS/NAVMACS subsystem.

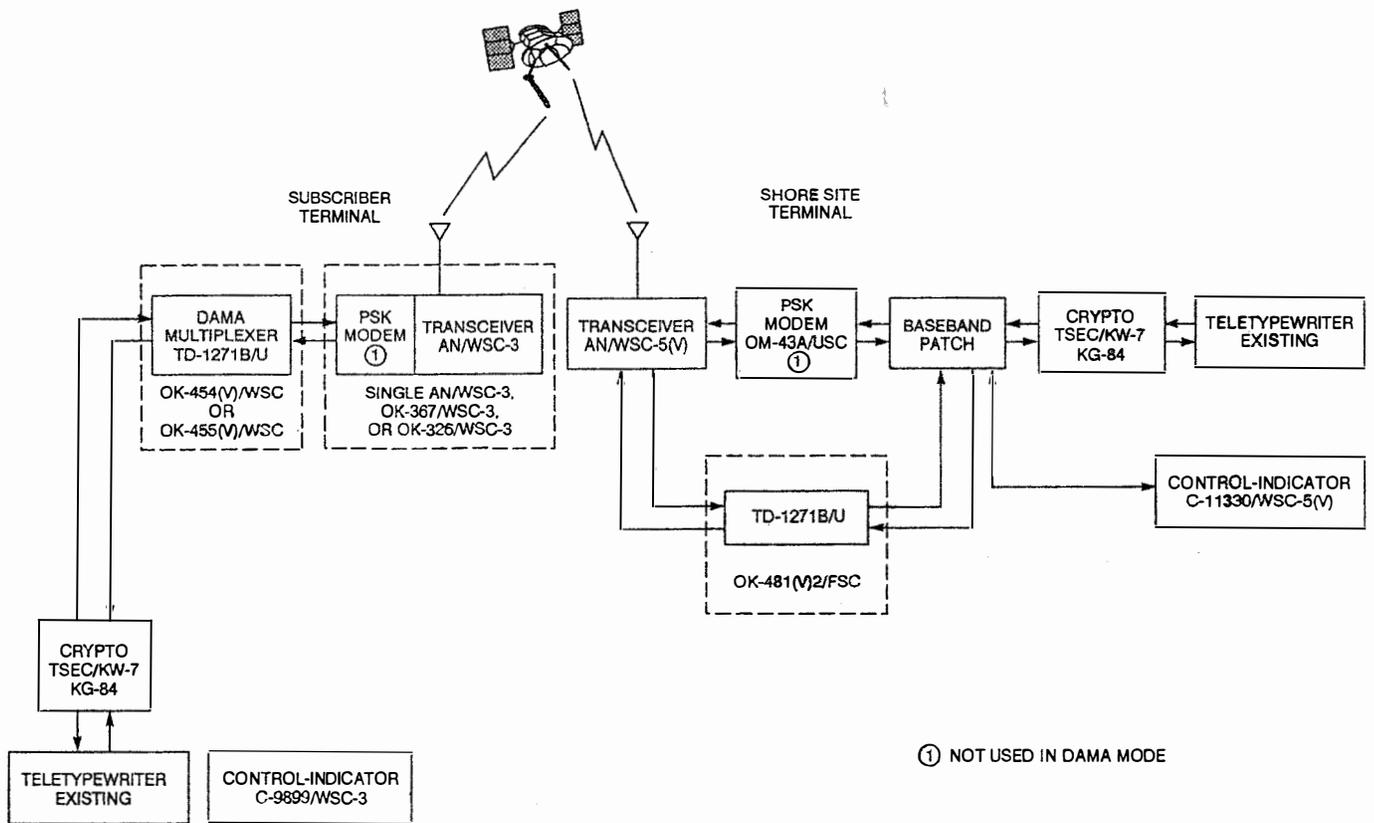


Figure 3-14.—DAMA-configured teletypewriter subsystem.

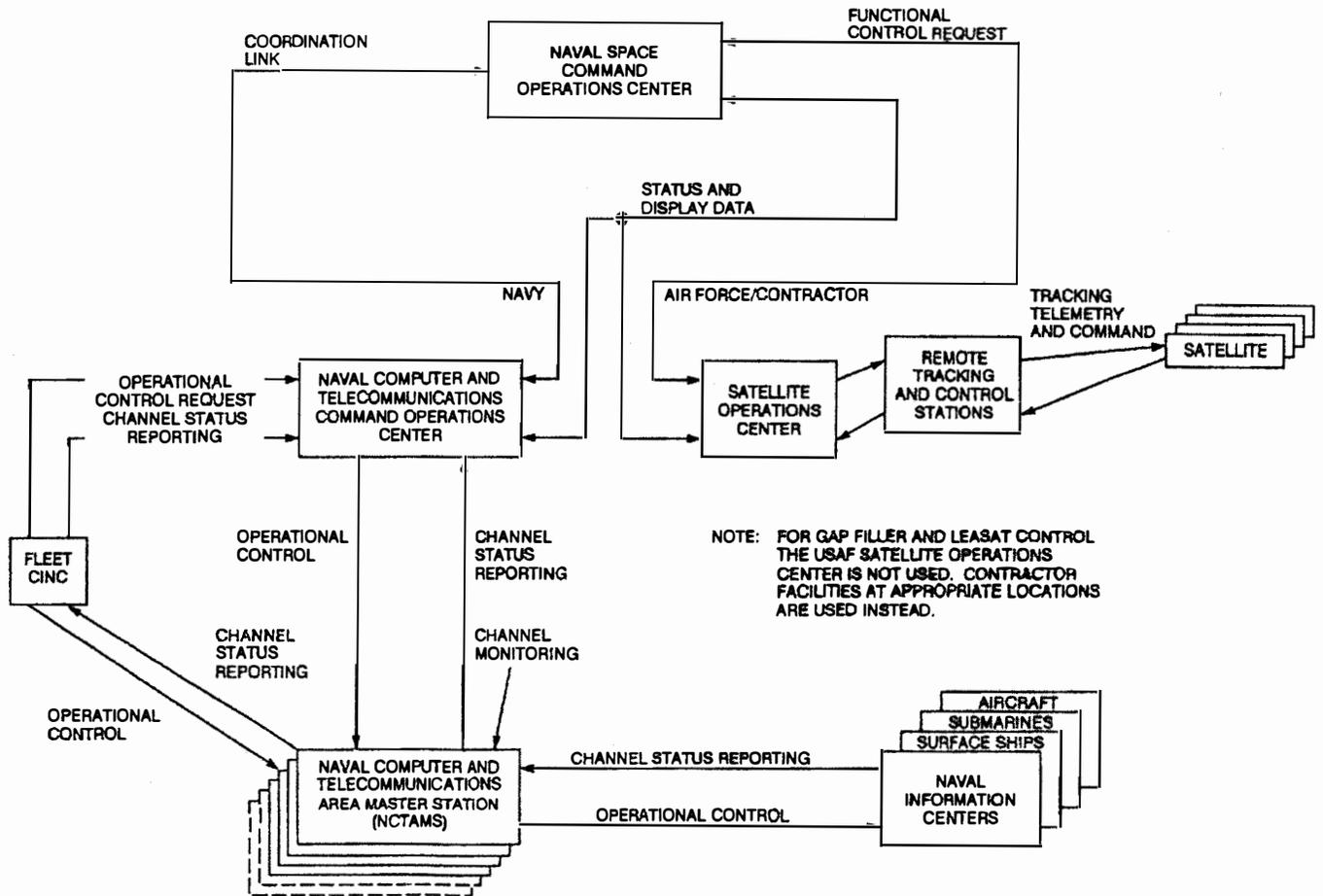


Figure 3-15.—Control Subsystem functional diagram.

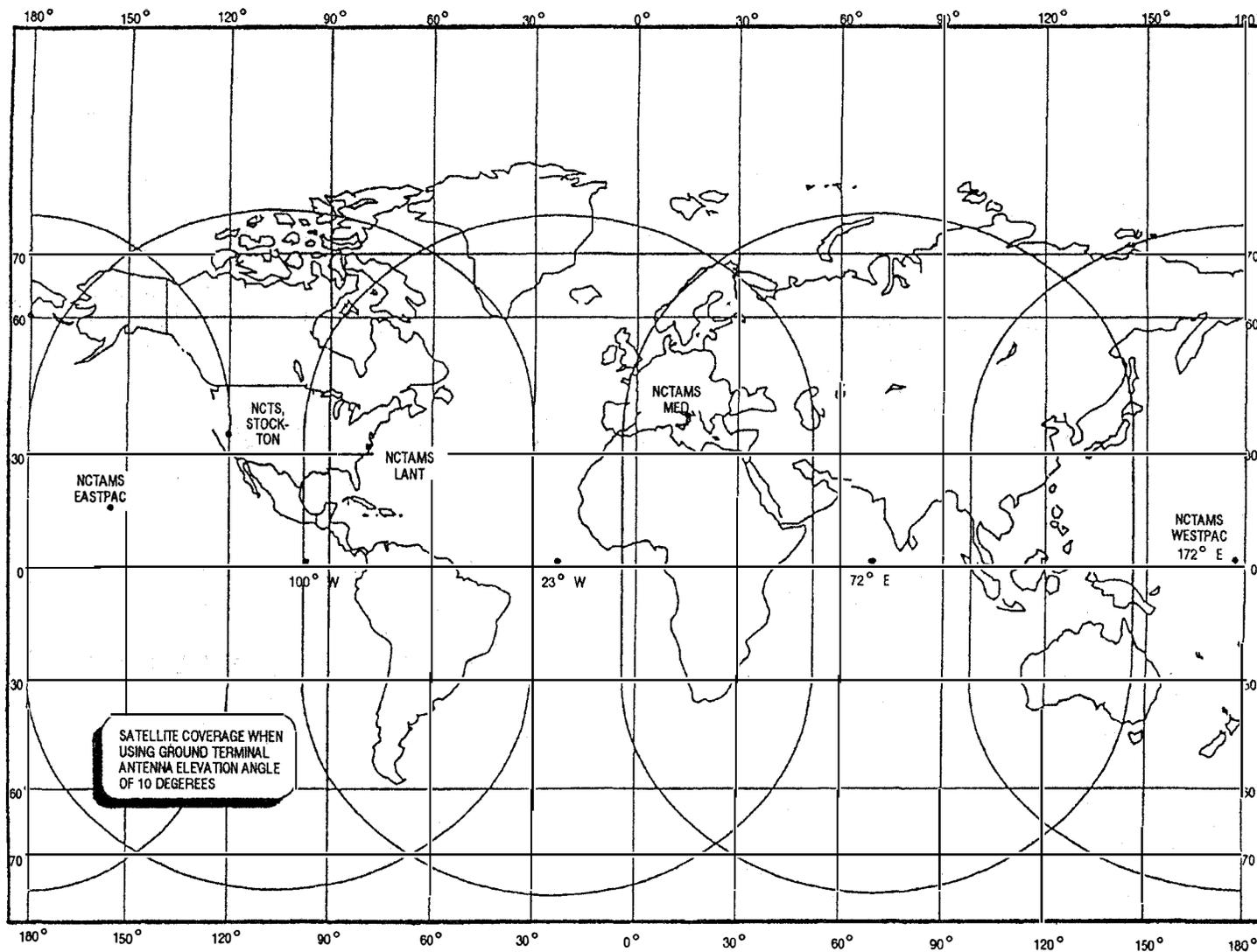


Figure 3-16.—Uhf satellite coverage areas.

SATELLITES

In 1976, three satellites were placed into orbit over the Atlantic, Pacific, and Indian Oceans. These satellites, called **MARISATs**, were procured by and are managed by the COMSAT General Corporation. Each satellite has three uhf channels for military use (one wideband 500-kHz channel and two narrowband 25-kHz channels). The uhf section of each satellite is leased to the Navy for communications. To distinguish the special management and control functions for communications on these uhf channels, the Navy has given the leased MARISAT satellite assets the name **GAPFILLER**.

Current planning calls for no Navy use of **GAP-FILLER** satellites after the mid-1990's. Satellite coverage will then be provided by a combination of **FLTSAT** and **LEASAT** until the new **UHF FOL-LOW-ON (UFO)** satellites are placed into service. The Navy plans to have two operational satellites in each of four satellite coverage areas. Each satellite coverage area can be terminated in at least two NCTAMS, allowing around-the-world connectivity. You can see this connectivity in figure 3-16.

FLTSATCOM SATELLITE

The **FLTSATCOM** satellite consists of two major parts: a payload module that includes the antennas and a space craft module with a solar array. The payload module contains the uhf, shf, and S-band (tracking, telemetry, and command) communications equipment antennas. The communications equipment is mounted internally on side panels that cover this section of the satellite.

The space craft module contains nearly all other subsystem equipment, including sensors, attitude and velocity control, telemetry, tracking and command, and electrical power distribution. The spacecraft is stabilized on three axes, and the body-fixed antennas are kept pointing at the sun by a clock drive. A **FLTSATCOM** satellite is shown in figure 3-17.

Each **FLTSATCOM** satellite can relay communications on 23 separate uhf channels. Of the 23 channels, 10 are 25-kHz channels, 12 are 5-kHz channels, and one is a 500-kHz channel. The ten 25-kHz channels are dedicated for Navy use. Each 25-kHz uhf down-link channel has a separate transmitter. Channel one, used in primary mode for Fleet Broadcast transmissions, incorporates signal processing within the satellite (the shf up-link signal is translated to uhf for

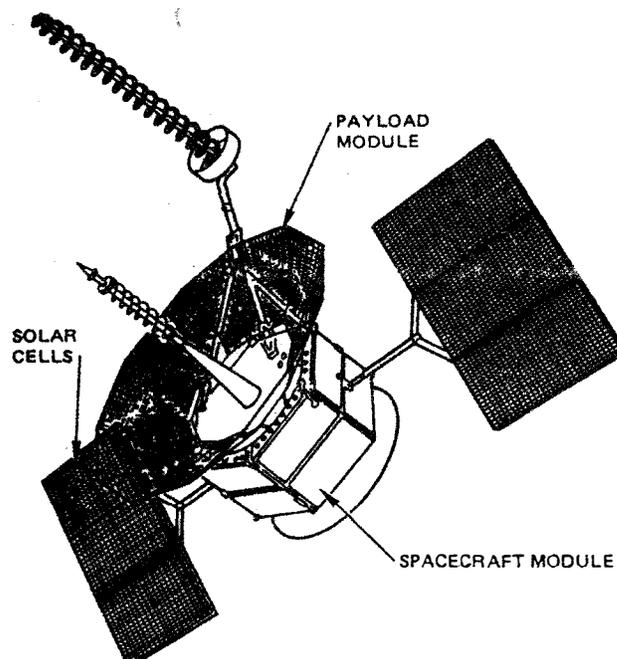


Figure 3-17.—FLTSATCOM satellite.

down-link transmission). In addition, two of the **FLTSATCOM** satellites have ehf packages attached.

FLTSAT Extremely-High-Frequency Package (FEP)

The Fleet Satellite (**FLTSAT**) Extremely-High-Frequency (**EHF**) Package (**FEP**) provides ehf communications capability for Army, Navy, and Air Force ground, airborne, and ocean-going terminals. Two **FEPs** are currently in orbit, carried aboard two modified uhf **FLTSATs**, numbers seven and eight.

FEP operates at ehf frequencies of approximately 20-GHz on the down-link and 44-GHz on the up-link. It has two antenna beams: (1) a dual-frequency spot beam steerable by ground command, and (2) an earth coverage beam that uses separate horn antennas for transmit and receive.

LEASAT SATELLITE

The **LEASAT** satellite has seven 25-kHz uhf down-link channels, one 500-kHz wide-band channel, and five 5-kHz channels. One of the seven 25-kHz down-link channels is used for Fleet Broadcast. The broadcast up-link is shf, with translation to uhf taking place in the satellite. The remaining six channels function as direct

relay channels with separate repeaters. A LEASAT satellite is shown in figure 3-18.

Compared to FLSATCOM satellites, LEASAT satellites have a reduced number of 25-kHz channels. However, they can still serve expanding Navy SATCOM requirements by using the groundbased DAMA technique, effectively using each satellite channel more efficiently.

UHF FOLLOW-ON SATELLITE

The purpose of the Ultra-High-Frequency Follow-On Satellite System (UHF F/O) is to provide satellite communications for DOD and other government agencies through satellites in geosynchronous orbit. The current satellites, GAPFILLER, FLTSATCOM, and LEASAT are approaching the end of their normal mission life. UHF F/O will provide the needed replenishment satellites. The strategy for replacement is to use existing FLTSATCOM and LEASAT assets fully, while deploying the UHF F/O satellites to minimize communications disruptions as the FLTSATCOM and LEASAT satellites fail or reach the end of their useful life. An exploded view of a UHF F/O satellite is shown in figure 3-19.

Communications Capability

The uhf communications subsystem consists of receive and transmit antennas, a low-noise preamplifier, 25- and 5-kHz channel receivers and transmitters, and an output multiplexer. The shf communications

subsystem provides shf anti-jam up-link capability for Fleet Broadcast (which is down-linked as uhf) and consists of receive and transmit antennas, the receiver, a dual channel processor, and the beacon transmitter. Signals received by the shf receive antenna are fed to the shf receiver. In turn, the processor provides Fleet Broadcast outputs that are fed to uhf communications subsystem for down-link. The multiplexed anti-jam broadcast capability of the UHF F/O permits up to three broadcast channels to be up-linked and down-linked simultaneously.

On the fourth and subsequent satellites deployed, an ehf communications subsystem will provide three ehf broadcast channel up-links and seven ehf communications channel up-links. Each of these ehf up-links will be capable of being down-linked as ehf only, uhf only, or simultaneously as uhf and ehf. UHF F/O will also have the capability of transmitting and receiving ehf telemetry and command data.

User interfaces for UHF F/O are identical to those of the current FLTSATCOM and LEASAT constellation. The uhf portion of the UHF F/O system is compatible with all existing Navy uhf terminals except those using frequency-hopping techniques.

Channel Allocations

The UHF F/O satellite channels are allocated and grouped as follows:

- Group I has a single 25-kHz bandwidth channel with a variable satellite translation frequency and a jam resistant shf up-link.
- Group II has nine 25-kHz bandwidth channels with a satellite translation frequency of 41 MHz.
- Group III has eight 25-kHz bandwidth channels with a satellite translation frequency of 33.6 MHz.
- Group IV has eight 5-kHz bandwidth channels with a satellite translation frequency of 73.1 MHz.
- Group V has thirteen 5-kHz bandwidth channels with a satellite translation frequency of 53.6 MHz.

MILSTAR

MILSTAR is a new generation Satellite Communications (SATCOM) system being developed by the Navy, Army, and Air Force for two primary purposes. First, it will provide a survivable communications capability to the National Command Authority (NCA). Second, it will provide sufficient

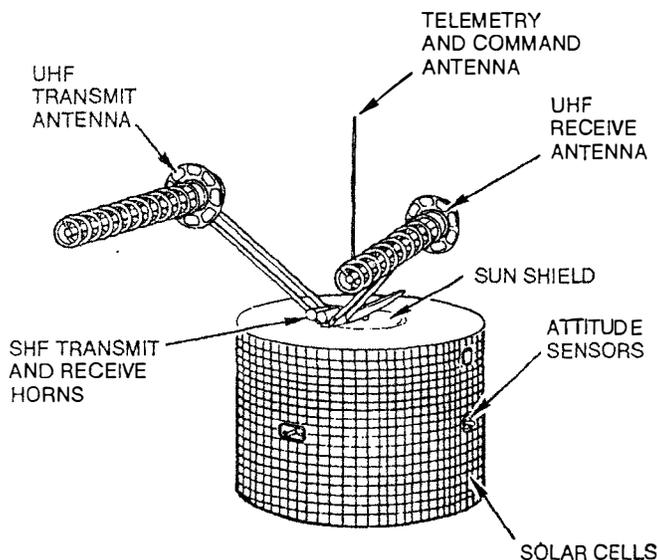


Figure 3-18.—LEASAT satellite.

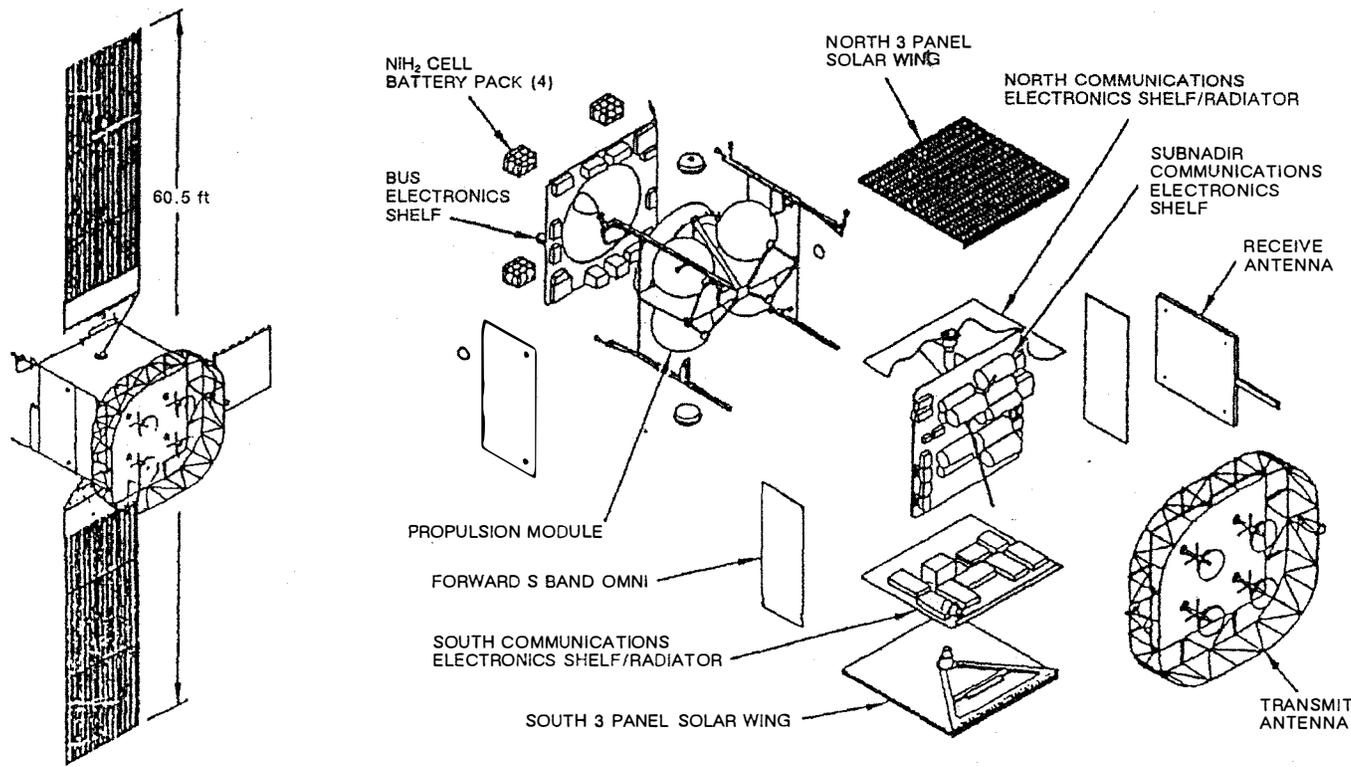


Figure 3-19.—UHF Follow-On satellite exploded view.

communications support for both strategic and tactical missions. The primary objective of the MILSTAR program is to develop and deploy an affordable, jam-resistant SATCOM system that will meet both long-haul and local communications needs.

MILSTAR will use communications terminals that will provide Secure Voice (SV), Teletype (TTY), data, and facsimile EHF SATCOM. MILSTAR terminals will be installed on aircraft, in fixed telecommunications centers, landbased tactical elements, shorebased telecommunications centers, surface ships, and submarines.

In the following paragraphs, we will look at some of the equipment associated with satellite communications.

SATELLITE EQUIPMENT

The equipment used in Navy SATCOM subsystems can be divided into two general groups, rf terminals and the baseband equipment common to a processor installation. The selection of specific equipment is determined by the operating environment—whether installation is to be aboard a ship, submarine,

aircraft, or shore installation. In this chapter, we will limit our discussion primarily to commonly used ship-board and shore equipment.

Satellite Communications Terminal AN/FSC-79

The AN/FSC-79 terminal processes and converts 70-MHz signals to X-band (shf) transmitted signals. It also converts received signals from X-band to 70 MHz. This terminal can simultaneously transmit a spread spectrum carrier and receive a satellite beacon signal. The design of the terminal provides redundancy in many components to ensure a high degree of availability. The terminals are installed at NCTAMS LANT, MED, WESTPAC, EASTPAC, and NCTS, Stockton (contractor operated).

Uhf Transceiver AN/WSC-5(V)

The AN/WSC-5(V) transceiver provides an eight-circuit, full-duplex data operation or, as an alternative, six full-duplex data circuits and two FM audio or tone-group circuits. It also provides an

interface for connectivity to the uhf DAMA equipment. Figure 3-20 shows an AN/WSC-5(V) transceiver installation.

This transceiver is capable of three types of modulation/demodulation:

- Frequency modulation/demodulation with pre-emphasis/de-emphasis for voice transmission/reception.
- Frequency modulation/demodulation without pre-emphasis/de-emphasis for tone-group transmission/reception.
- Differentially encoded phase-shift keying using the OM-43A/USC modem. The transceiver has a 70-MHz interface for connection to either the modem or the TD-1271B/U DAMA multiplexer.

All four NCTAMS have AN/WSC-5(V) transceivers installed.

The C-11330/WSC-5(V) shown in figure 3-21 provides for remote control of the AN/WSC-5(V) for

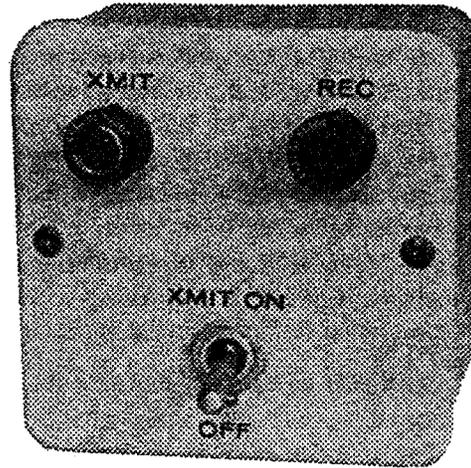


Figure 3-21.—Control-Indicator C-11330/WSC-5(V) or C-9899/WSC-3.

teletype operation. The C-11330/WSC-5(V) is similar to the C-9899/WSC-3, except that it uses +6 Vdc for the keyline signal and indicator lamps. Both units have identical front panels.

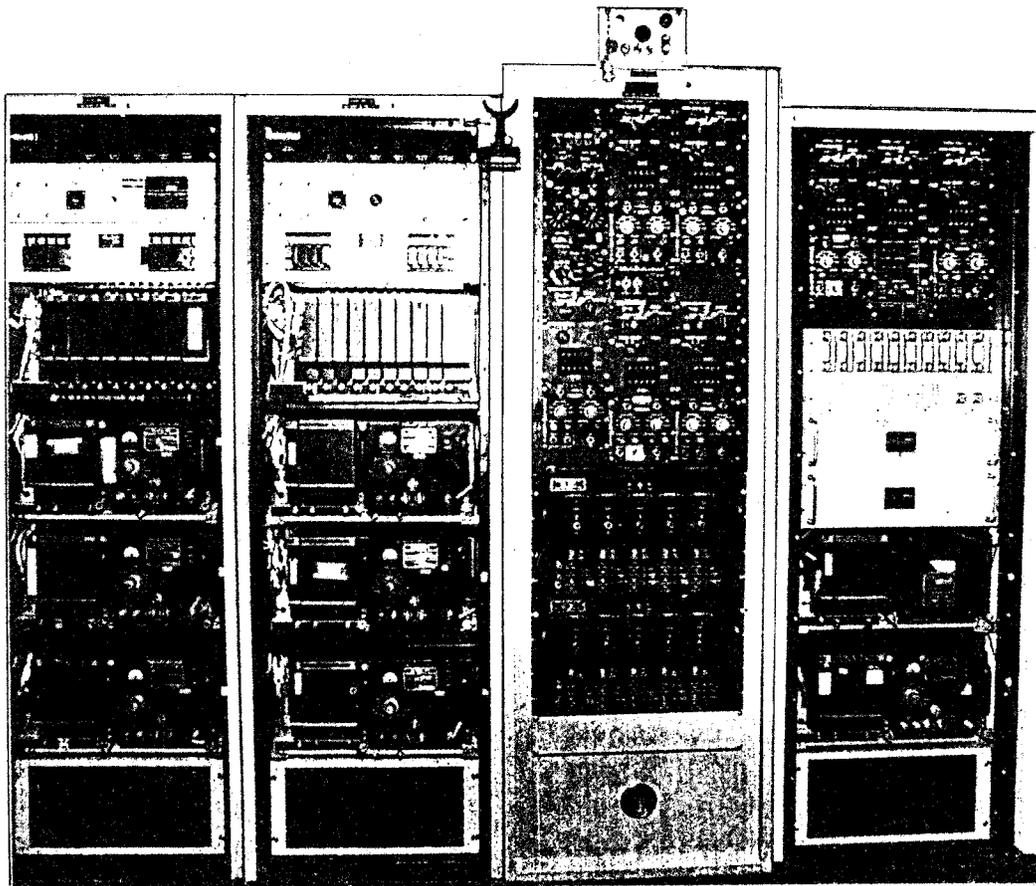


Figure 3-20.—Uhf transceiver AN/WSC-5(V).

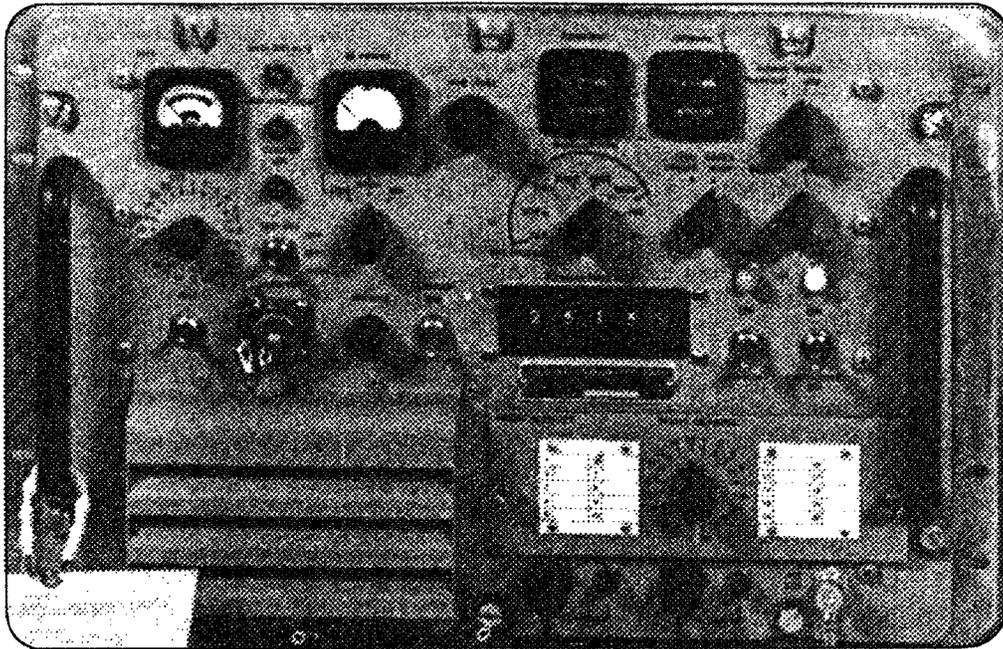


Figure 3-22.—Uhf radio RT-1107/WSC-3.

Transceiver AN/WSC-3(V)

To be consistent in this discussion, we will refer to both the AN/WSC-3 and AN/WSC-3(V) transceivers as AN/WSC-3. A single AN/WSC-3 (RT-1107/WSC-3) is shown in figure 3-22.

The AN/WSC-3 transceiver is used primarily aboard ship, at Marine Corps terminals, and at selected shore installations. It has various configurations designed to meet the particular requirements of these platforms. The configuration differences are identified in the AN/WSC-3 variations table, table 3-1.

The transceiver can be operated in either satellite or line-of-sight mode, either locally or remotely. A modulation control permits selection of PSK data rates from 75 to 9600 bps, FSK modulation at 75 bps, and FM or AM modulation for voice. The rf output is 30 watts AM and 100 watts for FM, PSK, and FSK.

The AN/WSC-3A, AN/WSC-3A(V)2 and (V)3 have been modified for use with the DAMA subsystem. The AN/WSC-3(V)15, (V)17, and (V)19 are manufactured as DAMA-capable.

The transceiver has two control indicators for remote operations. The C-9351/WSC-3, shown in figure 3-23, provides for remote control of the AN/WSC-3 as described in the table 3-1 description. As we mentioned before, the C-9899/WSC-3 provides for remote teletype operation. Two built-in modems are included with the transceiver.

Receiver Systems AN/SSR-1 and 1A

You have probably seen this receiver since it is installed aboard most naval surface vessels. It enables ships to receive Fleet Satellite Broadcast. The received carrier may contain either FM or PSK modulation; the preferred demodulation is selected manually with a switch associated with the receiving set. The AN/SSR-1 can drive high-level teletype equipment. The AN/SSR-1A can drive both high- and low-level

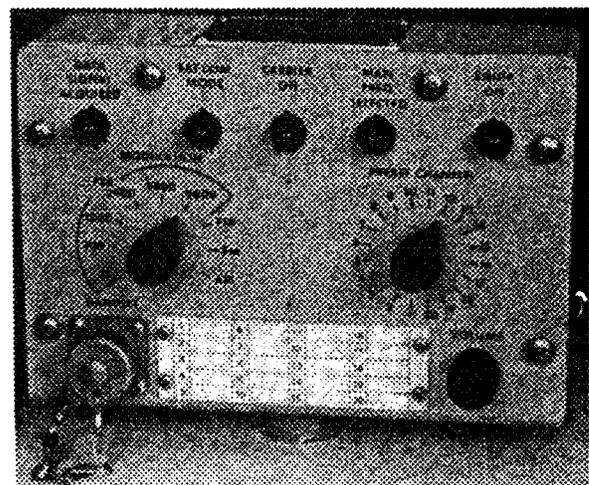


Figure 3-23.—Control-Indicator C-9351/WSC-3.

Table 3-1.—AN/WSC—3 Variations

Nomenclature	Description	
<p>AN/WSC-3 ● RT-1107/WSC-3 ● C-9351/WSC-3</p> <p>AN/WSC-3(V)1 ● RT-1107(V)1/WSC-3(V) ● C-9351/WSC-3</p> <p>AN/WSC-3(V)2 ● RT-1107(V)2/WSC-3(V) ● C-9351/WSC-3</p> <p>AN/WSC-3(V)3 ● RT-1107(V)3/WSC-3(V) ● C-9351/WSC-3</p>	<p>AM Voice, AM Secure Voice, FM Voice, PSK Data at 75, 300, 1200, 2400, 4800, 9600 bps. FSK Data at 75 bps via satellite or LOS, selectable.</p> <p>Similar to AN/WSC-3, SWR meter added. Chassis wired for FM Vinson Secure Voice, Link 11 and SAS but without FM Vinson S/V Link 11 or SAS modules. (SAS = Single Audio System).</p> <p>Similar to (V)1 with FM Vinson S/V and Link 11 modules added. Standard Interface Module.</p> <p>Similar to (V)2 but with SAS module.</p>	<p>SATCOM</p>
<p>AN/WSC-3(V)4</p> <p>AN/WSC-3(V)5</p> <p>AN/WSC-3(V)6 ● RT-1107(V)6/WSC-3(V) ● C-9351/WSC-3</p> <p>AN/WSC-3(V)7 ● RT-1107(V)7/WSC-3(V) ● C-9351/WSC-3</p> <p>AN/WSC-3(V)8 ● RT-1107(V)8/WSC-3(V) ● C-9351/WSC-3</p>	<p>None produced.</p> <p>None produced.</p> <p>Similar to (V)5. FM Vinson S/V, standard interface and Link 11 modules added.</p> <p>Similar to (V)6, but with SAS I/O module</p> <p>Similar to (V)7 with computer-compatible serial frequency and mode control. (USCG)</p>	<p>Line of Sight (LOS)</p>
<p>AN/WSC-3(V)9 ● RT-1107(V)9/WSC-3(V) ● C-9351/WSC-3</p>	<p>Similar to (V)3. Modified for 5-kHz channels vice 25 kHz. Provide 34,995 channels vice 7000.</p>	<p>SATCOM</p>
<p>AN/WSC-3(V)10 ● RT-1107(V)10/ WSC-3(V) ● C-9351/WSC-3</p> <p>AN/WSC-3(V)11 ● RT-1107(V)11/ WSC-3(V) ● C-9351/WSC-3</p>	<p>Similar to (V)6 with AJ capability.</p> <p>Similar to (V)7 with AJ capability.</p>	<p>Line of Sight (LOS)</p>
<p>AN/WSC-3(V)12 ● RT-1107(V)12/ WSC-3(V) ● C-9351/WSC-3</p> <p>AN/WSC-3(V)13 ● RT-1107(V)13/ WSC-3(V) ● C-9351/WSC-3</p>	<p>Similar to (V)3 but modified for Trident SSBN IRR. Blower flow altered.</p> <p>Similar to (V)2. Modified to operate from 400-Hz primary power.</p>	<p>SATCOM</p>

Table 3-1.—AN/WSC—3 Variations—Continued

Nomenclature	Description	
ANWSC-3(V)14 ● RT-1107(V)14/WSC-3(V)	Similar to (V)7 but uses a bidirectional MIL-STD-1553B bus interfaced to an external controller.	LOS
ANWSC-3(V)15 ● RT-1107(V)15/WSC-3(V) ● C-9351/WSC-3(V) ANWSC-3(V)16 ● RT-1107(V)16/WSC-3(V) ● C-9351/WSC-3 ANWSC-3(V)17 ● RT-1107(V)17/WSC-3(V) ● C-9351/WSC-3 ANWSC-3(V)18 ● RT-1107(V)18/WSC-3(V) ● C-9351/WSC-3 ANWSC-3(V)19 ● RT-1107(V)19/WSC-3(V) ● C-9351/WSC-3 ANWSC-3A ● RT-1107A/WSC-3 ● C-9351/WSC-3 ANWSC-3A(V)2 ● RT-1107A(V)2/WSC-3(V) ● C-9351/WSC-3	Similar to (V)2 or (V)3 but is DAMA compatible. Has a switchable audio interface module and can be switched from standard interface or SAS. Similar to (V)2 but has an SSN AFSATCOM system (SAFS) interface drawer (A20) instead of the preset channel. Similar to (V)15 but has modified transmit signal transient and preamble characteristics. (MTSC) Similar to (V)12 but has modified transmit signal transient and preamble characteristics. (MTSC) Similar to (V)17 but has the SAFS A20 drawer installed. Same as AN/WSC-3 but modified for use with UHF DAMA. Modified for use with UHF DAMA.	SATCOM
ANWSC-3A(V)3 ● RT-1107A(V)3/WSC-3(V) ● C-9351/WSC-3	Modified for use with UHF DAMA.	SATCOM
C-9351/WSC-3 C-9351A/WSC-3	Remote control for RT-1107. Contains preset channel control, modulation select, handset control, RT indicator lamps, and RT mode controls. Similar to C-9351 and allows use of longer interface cables.	LOS/SATCOM
C-9899/WSC-3	Remote control for RT-1107/WSC-3, has a keyline switch, transmit and receive indicators. It is used for teletype circuit control; requires 28 volts dc for indicator lamps and provides a ground keyline.	SATCOM

teletype equipment. A receive system is shown in figure 3-24.

The receiver system includes up to four AS-2815/SSR-1 antennas with an Amplifier Converter AM/6534/SSR-1 (fig. 3-25). It also includes a Combiner-Demodulator MD-900/SSR-1 (fig. 3-26) and a Demultiplexer TD-1063/SSR-1 (fig. 3-27). The antenna and converters are mounted above deck in positions that ensure that at least one antenna is always in view of the satellite. The combiner-demodulator and demultiplexer are mounted below deck.

The receiver accepts rf signals between 240 MHz and 340 MHz, a modulation bandwidth of 25 kHz. The combiner-demodulator demodulates the rf input from the amplifier converter and provides a 1200-bps output for the demultiplexer. The demultiplexer accepts an input of 1200 bps and outputs 15 channels at 75 bps. The decrypted demultiplexer output is patched to NAVMACS, TACINTEL processors, or teletypewriters.

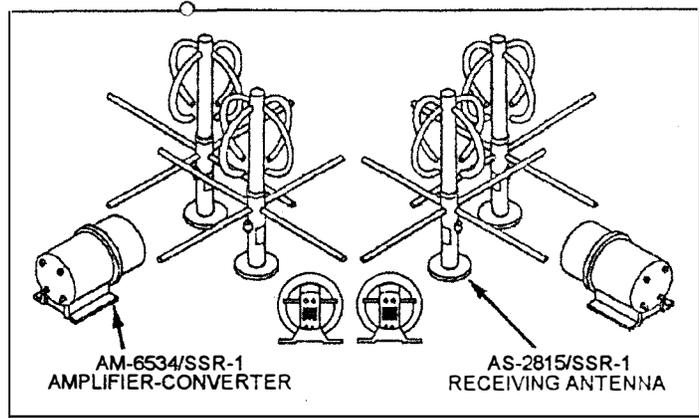


Figure 3-25.—Receiving Antenna AS-2815/SSR-1 and Amplifier Converters AM-6534/SSR-1.

Antennas

SATCOM antennas will be discussed in volume 7 of this training series.

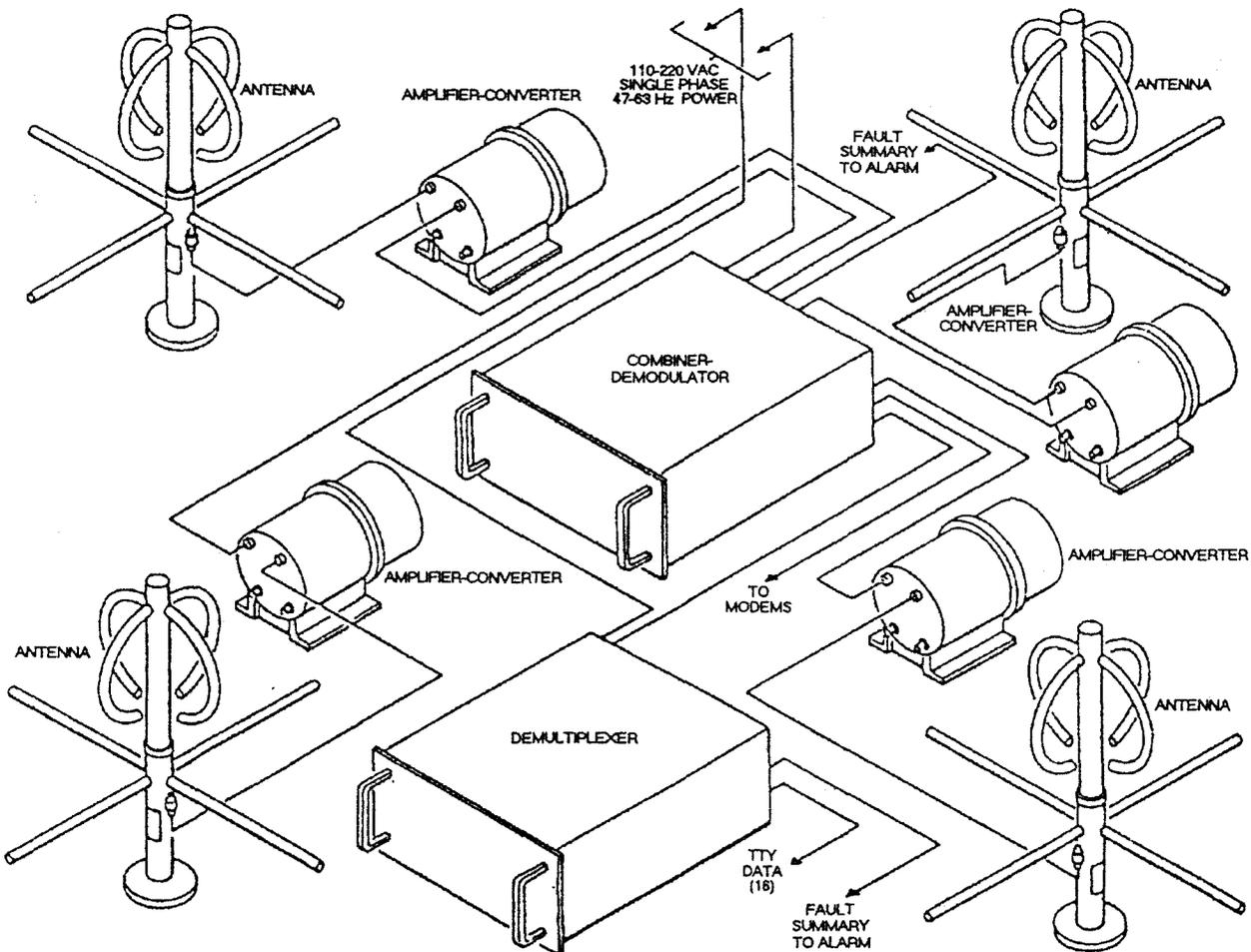


Figure 3-24.—Typical receive-only system.

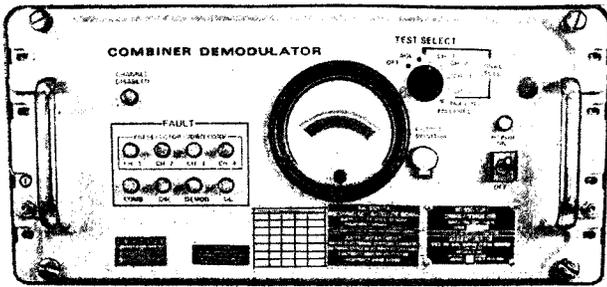


Figure 3-26.—Combiner-Demodulator MD-900/SSR-1.

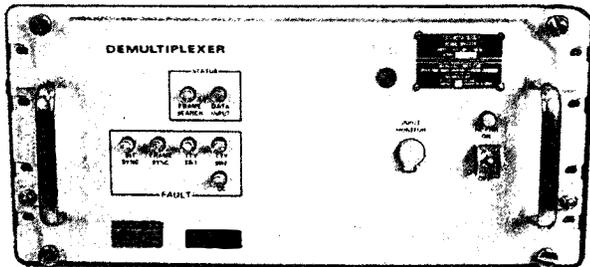


Figure 3-27.—Demultiplexer TD-1063/SSR-1.

Modem Group OM-43A/USC

The OM-43A/USC shown in figure 3-28 is used primarily with the AN/WSC-5(V) transceiver at shore installations. It performs differential phase-shift keying (DPSK) modulation and demodulation of a serial

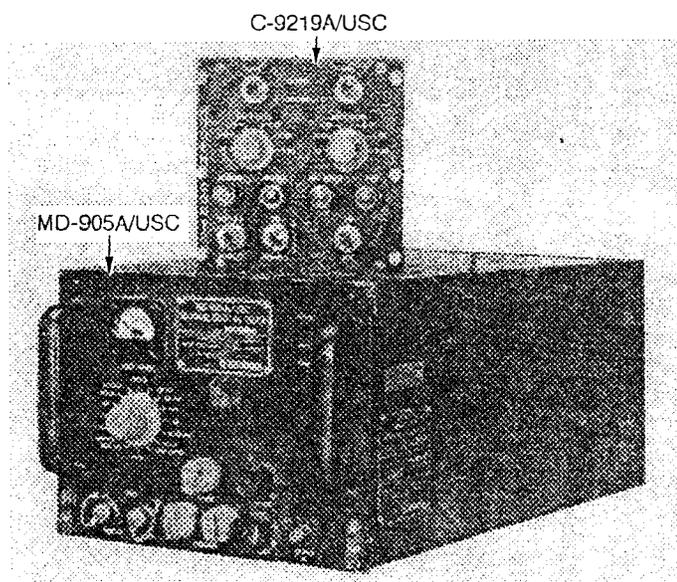


Figure 3-28.—Modem Group OM-43A/USC.

data stream at data rates of 75, 300, 1200, 2400, 4800, and 9600 bits per-second. This modem can be operated in full-duplex, although normal operation is half-duplex.

Modulator-Demodulator OM-51A/FR

This modem is an integral part of the Fleet Satellite Broadcast subsystem. It is a spread spectrum (wide bandwidth with frequency modulation of a transmitter and receiver in exact synchronization) type modem used with the AN/FSC-79 satellite communications terminal to provide rf transmission capability in a high-level jamming environment. Shown in figure 3-29, its basic function is to provide rf analog and digital conditioning circuits and frequency synthesizing for dual-redundant transmission and reception. It interfaces with the AN/FSC-79 terminal and the AM-6534/SSR-1 amplifier-converter.

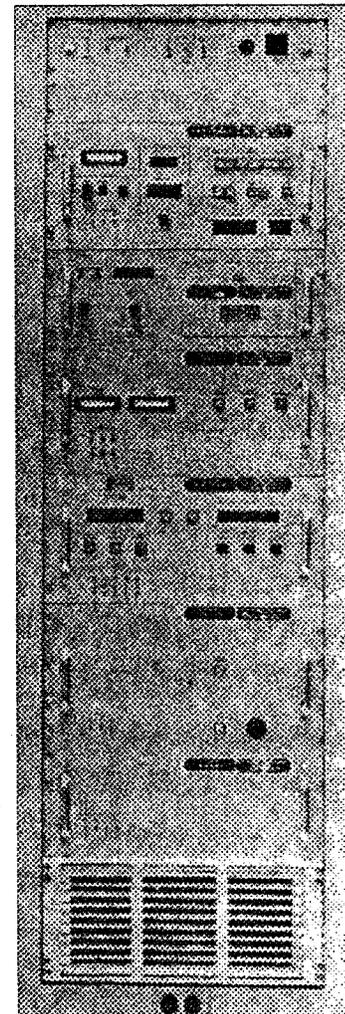


Figure 3-29.—Modulator-Demodulator Group OM-51A/FR.

This installation consists of a standard cabinet containing seven assemblies: a summary control panel, frequency synthesizer, receiver-synchronizer, coder-modulator, demodulator, and two power supplies.

Data Processing Set AN/UYK-20(V)

The AN/UYK-20(V), figure 3-30, is a general-purpose processor designed to meet the requirements of small and medium sized processor applications in shipboard or shore military facilities. The processor is used in the CUDIXS, NAVMACS, SSIXS (shore installations), and TACINTEL subsystems.

Data Processing Set AN/UYK-44(V)

The AN/UYK-44(V), figure 3-31, was designed to meet the same requirements as the AN/UYK-20(V), and to use AN/UYK-20(V) software with minimum modifications. It is used in the TADIXS subsystem.

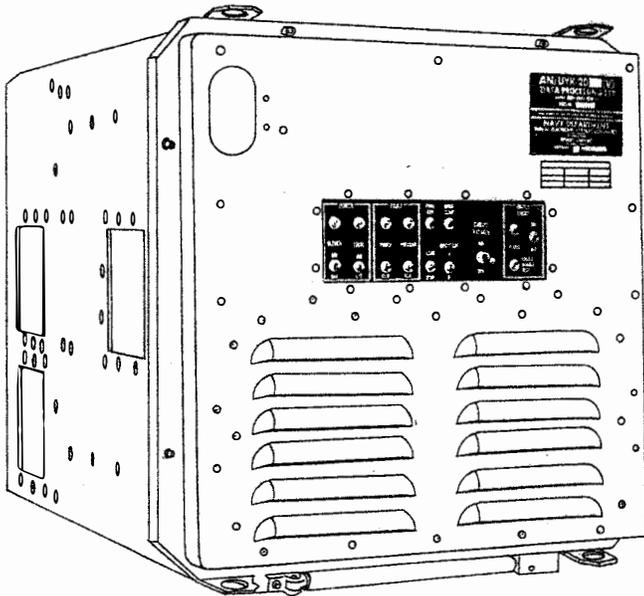


Figure 3-30.—Data Processing Set AN/UYK-20(V).

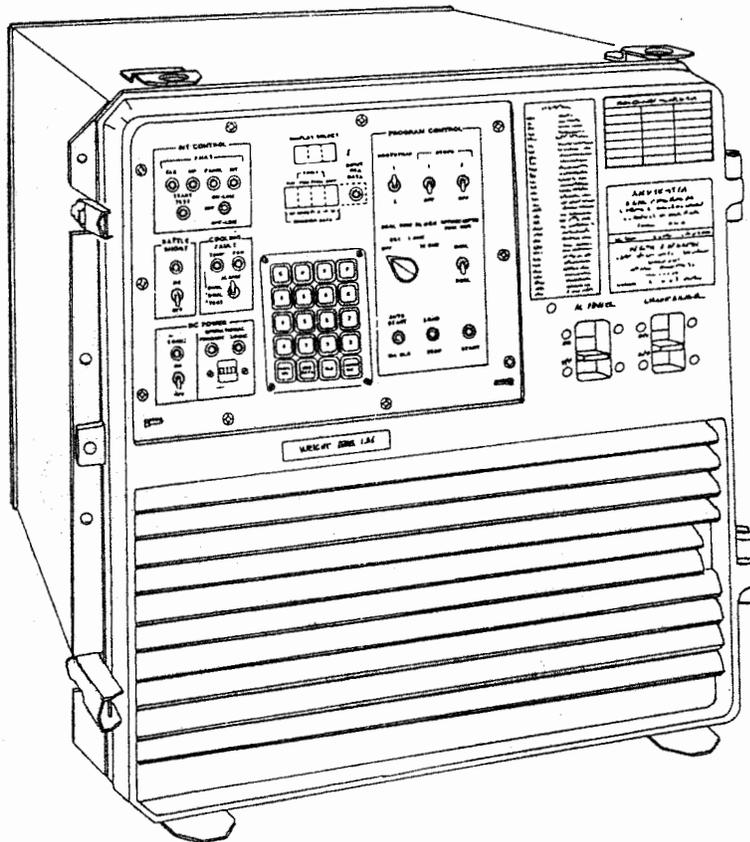


Figure 3-31.—Data Processing Set AN/UYK-44(V).

Communication System Control Center AN/USQ-64(V)

This control center is used to pass satellite data traffic efficiently and bidirectionally between a ship and shore. It turns associated transmitters on and off according to a polling scheme. It also uses detection and correction and sends automatic requests for retransmission to improve received data accuracy. The ten AN/USQ-64(V) variations and their uses are as follows:

- (V)1—SSIXS shore installations
- (V)2—CUDIXS shore installations
- (V)3—SSIXS subscriber installations
- (V)4—NAVMACS shore installations
- (V)5—TACINTEL ship subscriber, for passing Special Intelligence (SI) data traffic bidirectionally between a NCTS and fleet nets
- (V)6—TACINTEL shore installations, for the same purpose as (V)5
- (V)7—OTCIXS: fixed submarine or shipboard installations for passing TDP formatted data and teletypewriter traffic
- (V)8—TADIXS ship and submarine installations
- (V)9—TADIXS Gateway Facility (TGF)
- (V)10—Tactical Data Processor Controller

Interconnecting group ON-143(V)/USQ

Each ON-143(V)/USQ configuration varies, depending on its particular use. It fits within limited spaces aboard small ships and submarines, performing a variety of functions related to several input-output channels of the control processor. It provides red-black isolation, synchronization of crypto units, level conversions, and crypto test and alarm signals. It also provides crypto control and interfaces baseband system components with rf link equipment. An ON-143(V)4/USQ is shown in figure 3-32.

Data Terminal Set AN/USQ-69(V)

The Data Terminal Set shown in figure 3-33 has a 15-inch diagonal screen on which a 2000 character page can be displayed. The memory is available in two

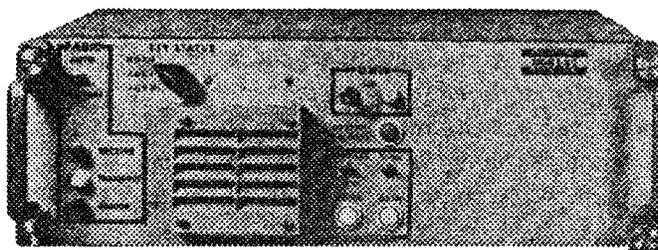


Figure 3-32.—Interconnecting Group ON-143(V)4/USQ.

sizes, 2000 and 6000 characters. When memory overflows as a result of computer output, a computer interrupt is initiated. Overflow as a result of operator input causes an audible alarm. This unit is currently used with TACINTEL (ship) and NAVMACS.

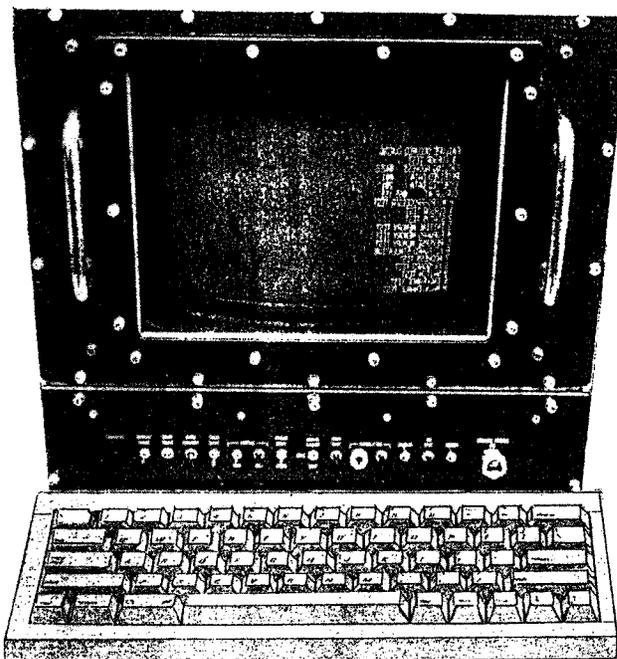


Figure 3-33.—Data Terminal Set AN/USQ-69(V).

Signal Data Recorder-Reproducer RD-397(V)/U

The RD-397(V)/U, figure 3-34, is used in baseband equipment installations with CUDIXS, NAVMACS, and TACINTEL (ship and shore). The (V)3 version is used at SSIXS shore locations. This tape perforator/reader can punch tape at 63.3 characters per second and read tape at up to 300 characters per second. The equipment is self-contained; that is, complete with control logic, buffering, and power supplies.

Navy Standard Teleprinter AN/UGC-143(V)

The Navy Standard Teleprinter (NST) is the standard teleprinter terminal set for surface platforms. The NST is used for netted circuits and for broadcast, ship-to-shore, and ship-to-ship communications circuits. The various configurations of the NST provide

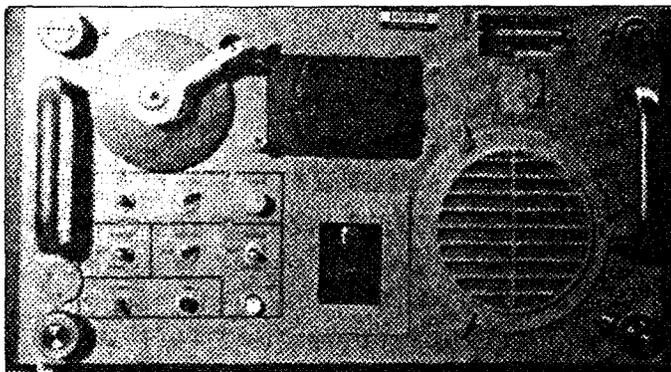


Figure 3-34.—Signal Data Recorder-Reproducer
RD-397(V)/U.

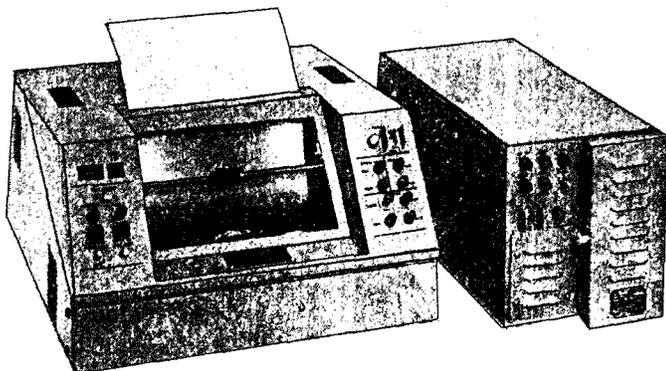


Figure 3-35.—NST AN/UGC-143(V).

for information preparation, editing, printing and receiving of serial data, and buffering and storage of information. An AN/UGC-143A(V)4 NST is shown in figure 3-35.

Audio Digital Converter CV-3333/U

Called a vocoder or voice digitizer, this unit is a solid-state, all-digital speech processor, providing speech output at a data rate of 2400 bps. Shown in figure 3-36, it is capable of full-duplex or half-duplex operation, can be used to provide a single digitized voice circuit, or can have its output multiplexed with other data-bit streams to provide simultaneous voice and data transmission. It is used primarily as an analog-to-digital converter in Fleet Satellite Secure Voice communications.

Switching Unit SA-1704/UG

This unit is used in baseband equipment shore installations of SSIXS, CUDIXS, and TACINTEL subsystems. It is a passive patch panel that shows the equipment configuration in use. Each subsystem unit is slightly different. In CUDIXS, the switching unit may be used to switch in equipment from the spare system; whereas in SSIXS, it is used to switch in standby equipment. The SB-4333/U Patching Switchboard is the planned replacement for this unit.

Time-Division Multiplexer TD-1150/USC

The TD-1150/USC time-division multiplexer is installed at broadcast keying stations ashore. It is used in the Fleet Satellite Broadcast subsystem and consists of two units, one online and the other in standby. It accepts up to fifteen 75-bps data channels and

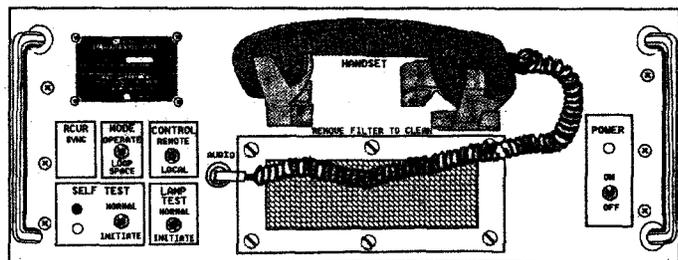


Figure 3-36.—Audio Digital Converter CV-3333/U.

Cryptographic Equipment

Several different models of cryptographic equipment are used in the FLTSATCOM system. Check your command's communications configuration for identification of this equipment. Specific information on this equipment is available on a need-to-know basis.

Electrical Equipment Rack CY-7597/WSC-3, CY-7597A/WSC-3

The CY-7597/WSC-3 (fig. 3-40) and CY-7597A/WSC-3 provide for mounting of one C-9597/WSC-1(V) antenna control, one C-10232/WSC-3, and up to four RT-1107/WSC-3s. These racks contain all the wiring required to interconnect these items. Connectors installed on the top panel provide system interface connections for baseband, teletype, frequency standard, external modem, and control-indicator equipment.

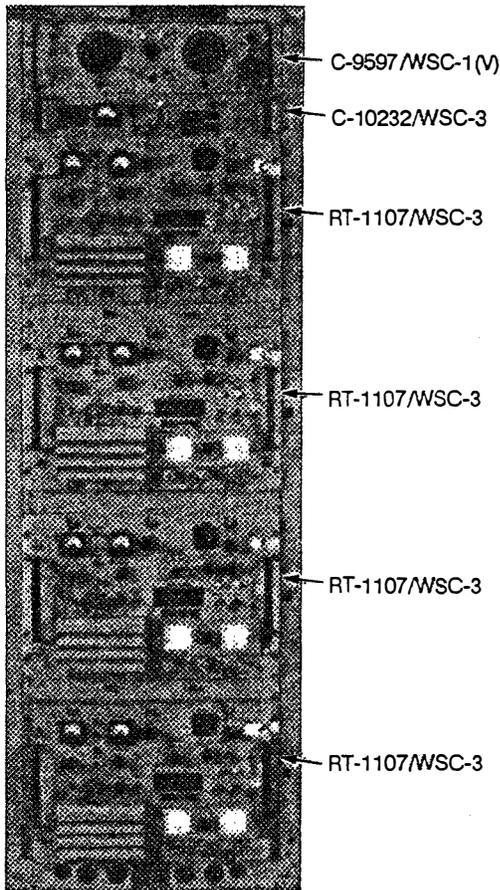


Figure 3-40.—Electrical Equipment Rack CY-7597/WSC-3.

The C-9597/WSC-1(V) antenna controller provides a means of controlling the antennas in the OE-82 dual-shipboard system.

The control indicator can switch the AN/WSC-3s for LOS or SATCOM use, monitor rf output power, and provide power on/off switching.

Electrical Equipment Cabinet CY-7971/WSC

The CY-7971/WSC (fig. 3-41), provides for mounting one MX-10342/WSC, two SB-4124/WSCs, and two TD-1271B/U multiplexers. The cabinet contains all wiring required to interconnect these pieces of equipment. Connectors installed on the top panel provide system interface connections for baseband, teletype, frequency standard, AN/WSC-3, and control-indicator equipment.

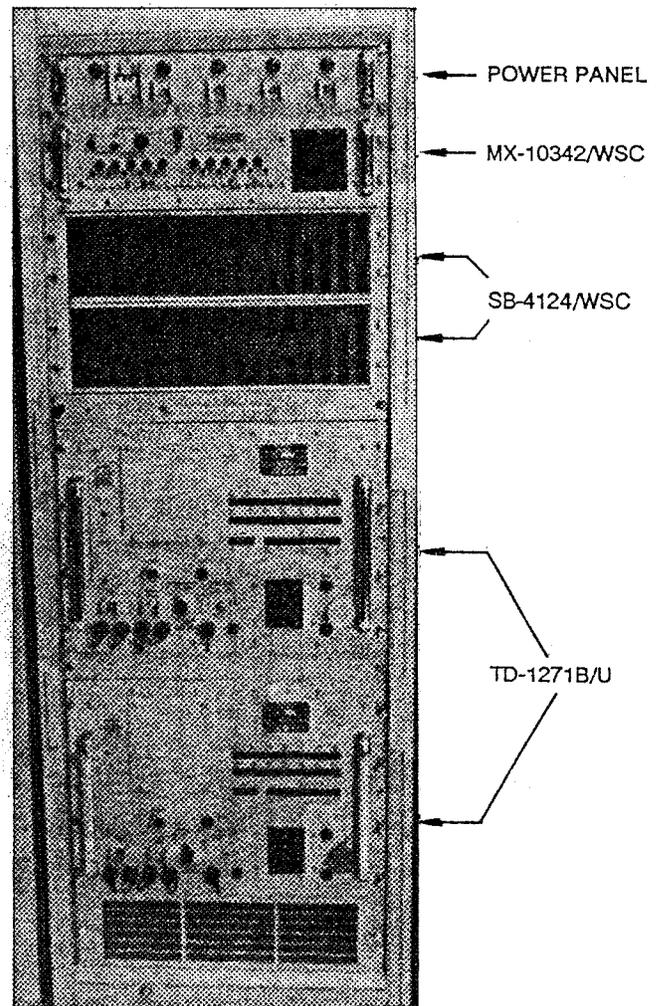


Figure 3-41.—Electrical Equipment Cabinet CY-7971/WSC.

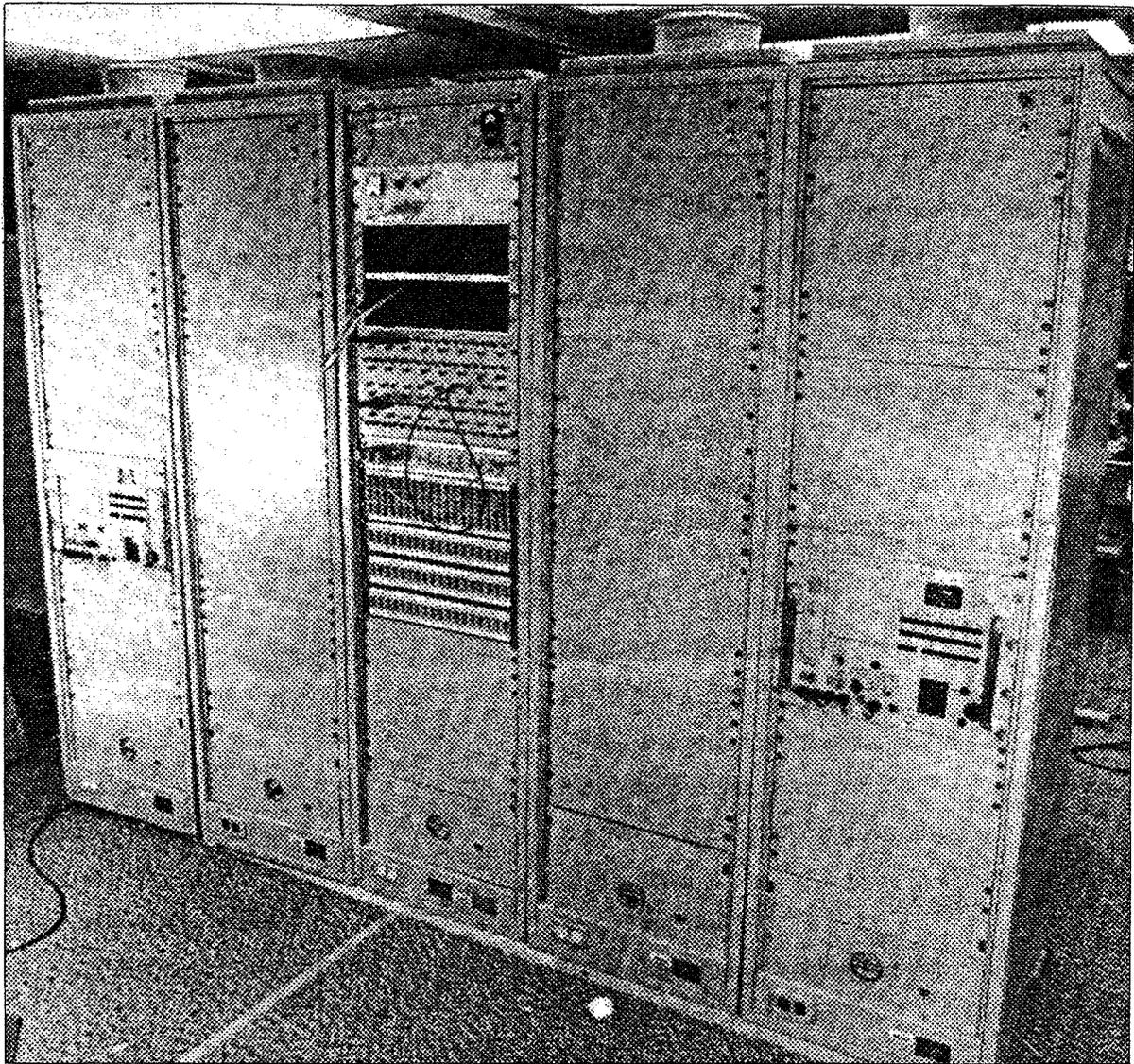


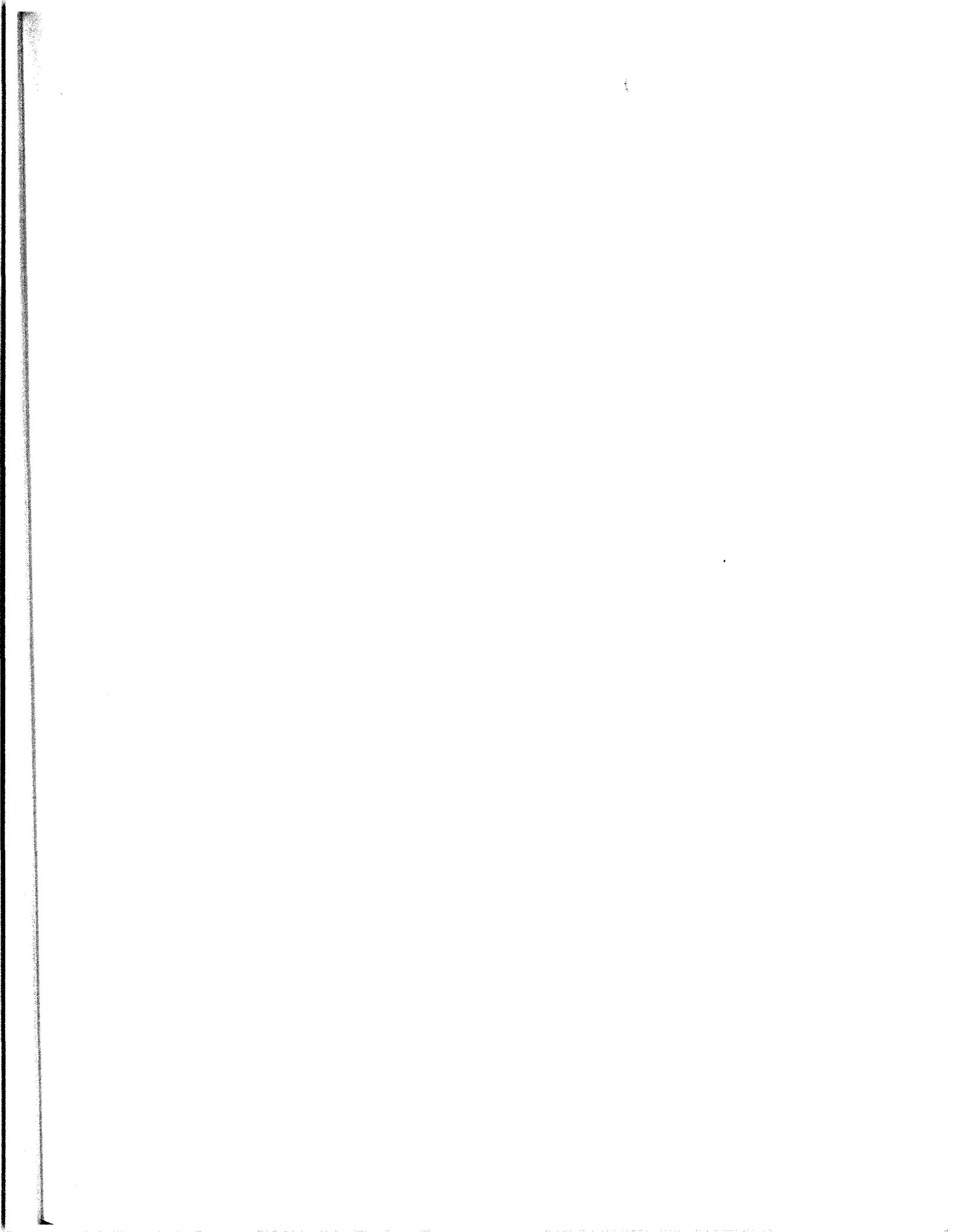
Figure 3-42.—Control Monitor Group OK-481(V)2/FSC.

The MX-10342/WSC provides a means to monitor and test all functions. The SB-4124/WSCs are data- and control-patching switchboards. Since we discussed the multiplexers in depth earlier, we will not go into detail here.

Control Monitor Group OK-481(V)2/FSC

As part of the Navy uhf satellite communications system, this group provides for the interfacing of the

TD-1271B/U multiplexer, the AN/WSC-5(V), and the baseband equipment used at DAMA shore installations. It provides for rapid reconfiguration and monitoring of interfaced equipment using digital, rf, and monitor patching facilities. It can accommodate up to 14 TD-1271B/U's and can multiplex up to 56 baseband circuits. An OK-481(V)2/FSC is shown in figure 3-42.



APPENDIX I

LIST OF ACRONYMS

AC —Alternating current	ECCM —Electronic counter-counter measures
AFC —Automatic frequency control	EHF —Extremely-high-frequency
AFTS —Audio frequency tone shift	ELF —Extremely-low-frequency
AGC —Automatic gain control	EMCON —Emission control
AM —Amplitude modulation	EMI —Electromagnetic interference
ASAS —Automated single audio system	FAX —Facsimile
ASCII —American National Standard Code for Information Interchange	FDM —Frequency division multiplexing
AUTODIN —Automatic Digital Information Network	FEP —Fleet satellite extremely-high-frequency package
AUTOSEVOCOM —Automatic Secure Voice Communications	FLTCINC —Fleet commander-in-chief
BCA —Broadcast control authority	FLTSAT —Fleet satellite
BIT —Binary digit	FLTSATCOM —Fleet satellite communications
BPS —Bits per second	FSK —Frequency shift keying
CCOW —Channel control order wire	HF —High-frequency
CGL —Command guard list	HSFB —High-Speed Fleet Broadcast
CIC —Combat information center	HZ —Hertz
CLIPS —Communications Link Interface Planning System	I/O —Input/output
COMNAVTELCOM —Commander Naval Telecommunications Command	ICW —Interrupted continuous wave
CONUS —Continental United States	IF —Intermediate frequency
CUDIXS —Common User Digital Information Exchange Subsystem	ISBSC —Independent Sideband Suppressed Carrier
CW —Continuous wave	JTIDS —Joint Tactical Information Distribution System
DAMA —Demand Assigned Multiple Access	KW —Kilowatt
DB —Decibel	LF —Low-frequency
DBM —Strength of a signal in decibels, compared to 1 milliwatt, with a load impedance of 600 ohms	LO —Local oscillator
DC —Direct current	LOS —Line-of-sight
DCS —Defense Communication System	LRI —Limited Range Intercept
DLCS —Data Link Communication System	LSB —Lower sideband
DMDG —Digital message device group	MF —Medium-frequency
DPSK —Differential phase shift keying	MPDS —Message processing and distribution system
DSCS —Defense Satellite Communications System	MSAS —Manual Single Audio System
	NAVCOMPARS —Naval Communications Processing and Routing System
	NAVMACS —Naval Modular Automatic Communication Subsystem

NCS—Net control station
NCTAMS—Naval Computer and Telecommunications Area Master Station
NCTS—Naval Computing and Telecommunications Station
NEETS—Navy Electricity and Electronics Training Series
NM—Nautical mile
NST—Navy standard teleprinter
NTCOC—Naval Telecommunications Command Operations Center
NTDS—Naval Tactical Data System
OTCIXS—Officer in Tactical Command Information Exchange Subsystem
OTH-T—Over-the-horizon targeting
PA—Power amplifier
PLSO—Phonetic letter spelled out
PSK—Phase shift keying
RATT—Radio-actuated teletype
RCCOW—Return channel control order wire
RF—Radio frequency
RFCS—Radio frequency carrier shift
RFI—Radio frequency interference
RPU—Remote phone unit
RWI—Radio Wireline Interface
S/N—Signal-to-noise
S-BAND—Tracking, telemetry, and command communications
SAS—Single audio system
SAT—Satellite relay
SATCOM—Satellite communications
SHF—Superhigh-frequency
SI—Special intelligence
SIU—Sensor interface unit
SMART—Submarine Message Automated Routing Terminal
SPS—Symbols-per-second
SSB—Single-sideband
SSIXS—Submarine Satellite Information Exchange Subsystem
STREAMLINER—Special intelligence message traffic
SVIP—Secure Voice Improvement Program
TACINTEL—Tactical Intelligence Subsystem
TACRIL—Tactical relay information link
TADIL—Tactical digital information link
TADIXS—Tactical Data Information Exchange Subsystem
TDM—Time-division multiplexing
TDP—Tactical data processor
TEMPEST—Control of compromising emanations
TGF—TADIXS gateway facility
TTY—Teletypewriter
UFO—UHF follow-on satellite
UHF F/O—UHF Follow-on Satellite System
UHF—Ultrahigh-frequency
USB—Upper-sideband
VHF—Very-high-frequency
VLF—Very-low-frequency
VSWR—Voltage standing wave ratio
WPM—Words per minute
X-BAND—SHF

APPENDIX II

REFERENCES USED TO DEVELOP THE TRAMAN

NOTE: Although the following references were current when this TRAMAN was published, their continued currency cannot be assured. You, therefore, need to ensure that you are studying the latest revision.

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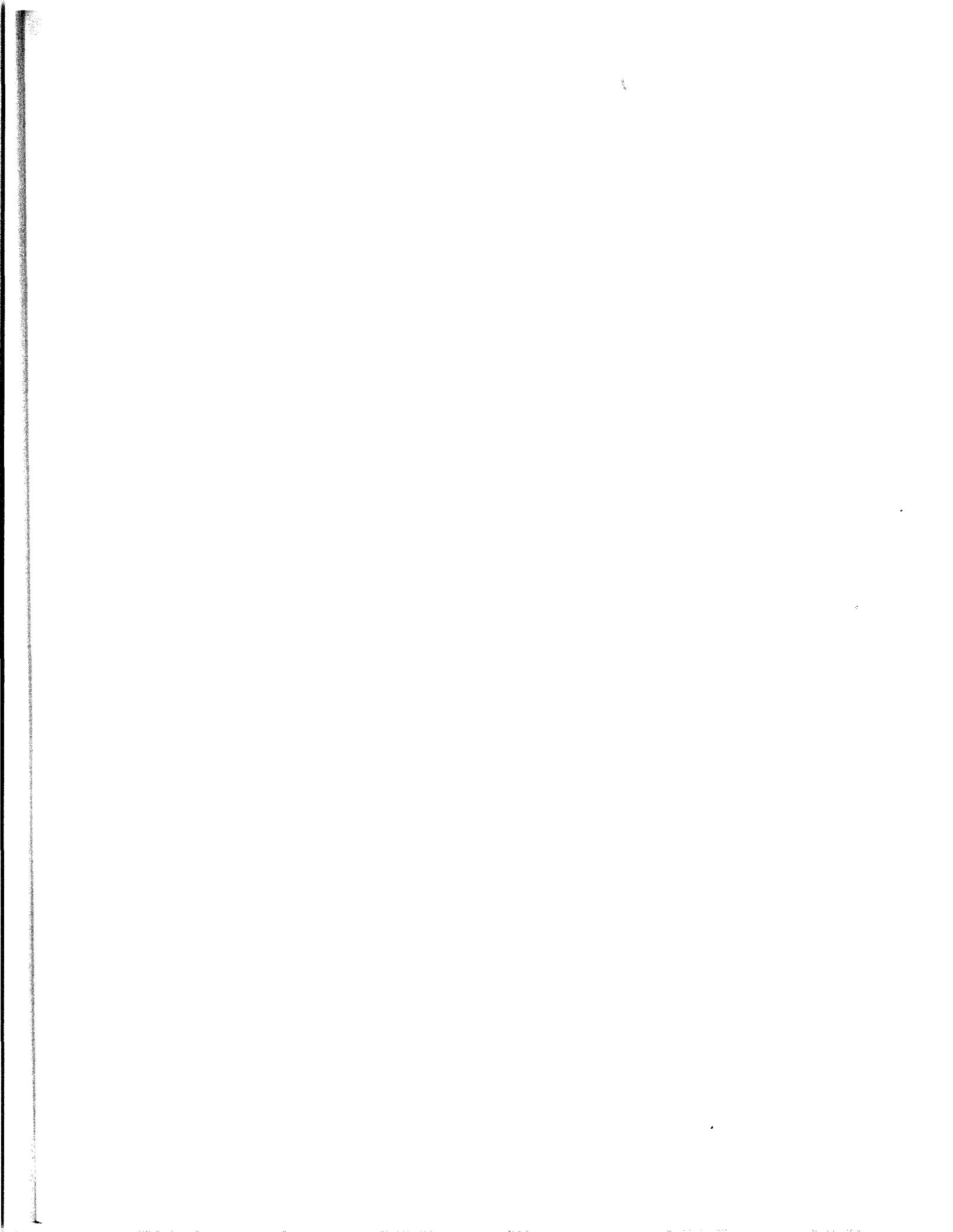
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