CHAPTER 6

TELETYPEWRITER AND FACSIMILE EQUIPMENT

BASIC PRINCIPLES

To see how intelligence is sent via teletype, we will first consider one of the simpler devices for electrical communication, the manual telegraph circuit. This circuit, shown in figure 6-1, includes a telegraph key, a source of power (battery), a sounder, and a movable sounder armature. If the key is closed, current flows through the circuit and the armature is attracted to the sounder by magnetism. When the key is open, the armature is retracted by a spring. With these two electrical conditions of the circuit, "closed" (current flowing) and "open" (no current flowing), it is possible, by means of a code, to transmit intelligence. These two conditions of the circuit are referred to as MARKING and SPACING. The marking condition occurs when the circuit is closed, and a current flows; the spacing condition occurs when it is open, and no current flows.

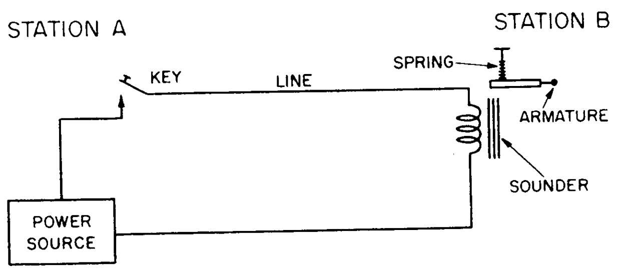

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Figure 6-1.—Manual telegraph circuit.

If the key at station A is replaced by a transmitting teletypewriter and the sounder arrangement at station B is replaced by a receiving teletypewriter, the basic teletypewriter circuit (loop) shown in figure 6-2 is formed.

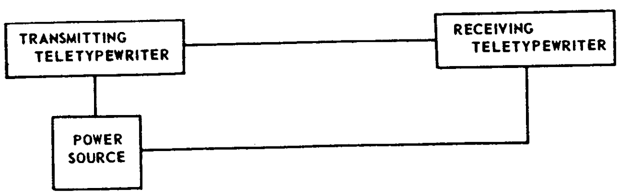

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Figure 6-2.—Simple teletypewriter circuit.

If a teletypewriter signal could be drawn on paper, it would resemble figure 6-3a. This is the code combination for the letter R. Shaded areas show intervals during which the circuit is closed (a mark), and the blank areas show the intervals during which the circuit is open (a space). There are a total of seven units in the signal. Five of these are numbered, and are called INTELLIGENCE units. The first and last units of the signal are labeled START and STOP. They are named after their functions: the first starts the signal, and the last stops it. These are a part of every teletypewriter code signal: the START unit is always a space, and the STOP unit is always a mark.

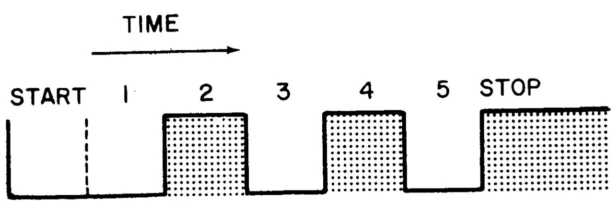

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Figure 6-3a.—Mark and space signals in the teletypewriter character R.

Examine figure 6-3a again. This is theoretically a perfect signal. The time between each unit remains the same during its transmission and the shift from mark to space (and vice versa) is called a TRANSITION. A transition occurs at the beginning and end of each unit when it shifts from mark to space (or space to mark), and there will be only two, four or six transitions for each character.

When figuring the time duration of a signal character, no allowance for transition time is made since the transition is instantaneous and is considered to have zero time duration. The time duration for each unit is measured in milliseconds.

CODES

Manual Telegraphy

In manual telegraphy, the most widely used code is the Morse code. In this code, two distinctive signal elements are employed—the dot and the dash. The difference between a dot and a dash is usually one of time duration, a dash being three times as long in duration as a dot. Each character is made up of a number of dots and/or dashes. The dot and dash elements constituting any character are separated from each other by a time interval equal to the duration of one dot. The time interval between the characters for each word is equal to seven dots.

In teletypewriter operation, the code group for each character is of uniform length. Since the Morse code is an uneven length code, it cannot be used in teletypewriter operation without additional code converters.

Teletypewriter Message Transmission

Teletypewriter message transmission systems have been used in Department of Defense communications for a number of years and it is expected that their use will continue for some time. The five-unit teletypewriter coded character set used throughout these systems has for many years been established as a standard. In the past decade, an extensive automatic electronic information processing industry has been developed. Numerous codes and media practices have been developed for input and output use with a great variety of processing equipment.

The coded character set of figure 6-3b has not been extensively used for input or output in automatic information processing for a number of reasons. One reason is the requirement for a case shift to represent the characters in the set. Another reason is the lack of order in code assignments from the standpoint of information processing by machine methods.

Automatic Information Processing

Recognizing that a standard coded character set was required to transmit data between the various automatic information processing centers and their associated equipment, the Department of the Army developed an eight-unit code (FIELDATA) which was approved as a Military Standard in 1960. This code has been used in a number of communications and automatic data systems developed by the Department of Defense, as well as in some commercial automatic data processing equipment. The great majority of data processing equipment has, however, used codes, media, and recording formats chosen by each manufacturer. The problem of information interchange between these equipments has grown more acute as their use has increased, not only in the government, but in commercial applications as well.

During recent years, through the cooperative effort of representatives of the data processing industry, the communications industry, and the Federal Government, a coded character set has been developed and approved as a USA Standard Code for Information Interchange (USASCII) X3.4-1967, revision of X3.4-1965. This coded character set, in addition to having many of the features of the FIELDATA code, possesses a character order more acceptable for data manipulation and processing purposes. The USASCII is intended to serve as a universal code for input/output purposes and for information interchange in automatic data processing, data transmission and data capture where coded characters are used. The general use of a standard coded character set will minimize requirements for code conversion and related types of intermediate processing operations

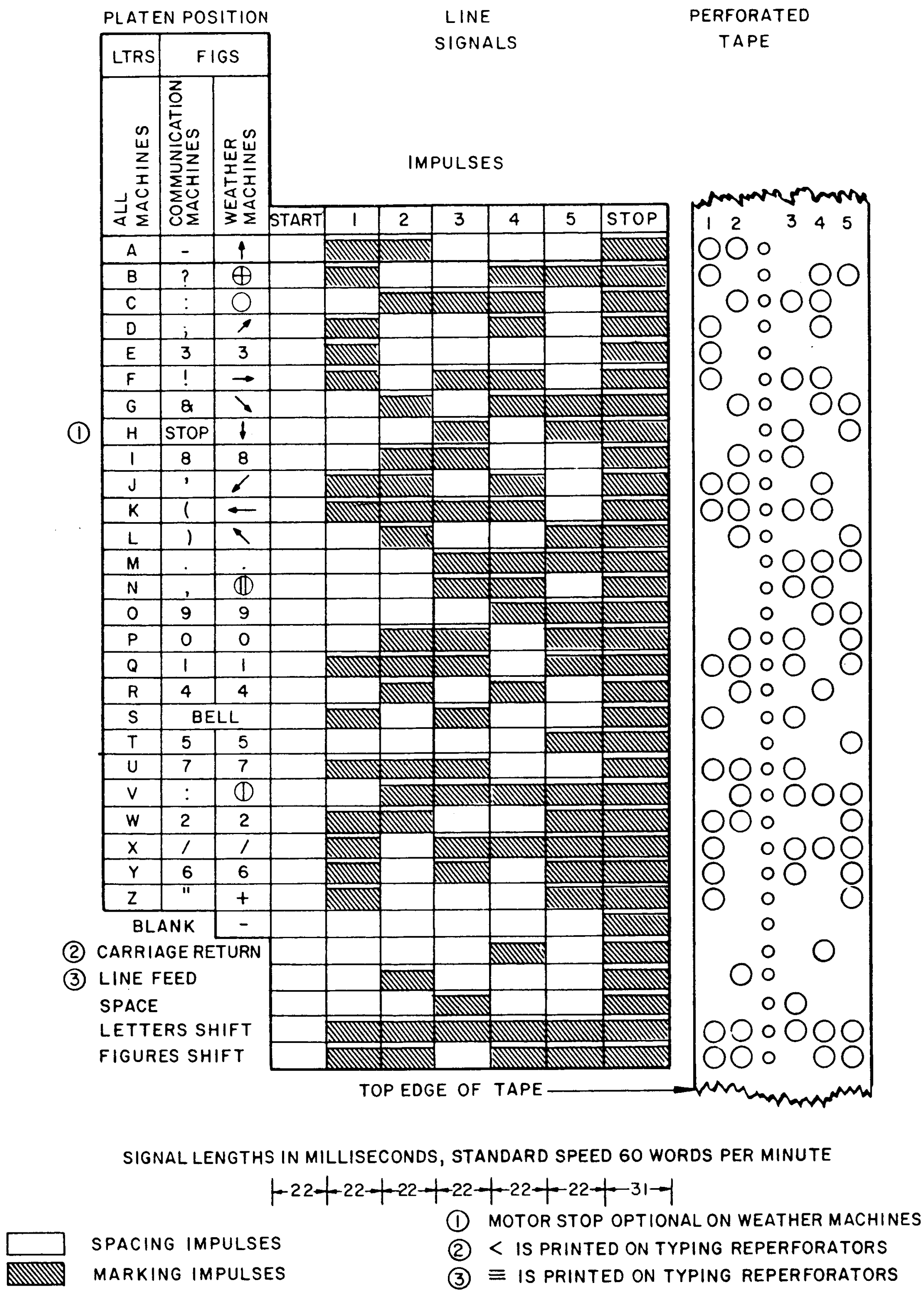

Figure 6-3b.—5 Unit Start/Stop TTY Code.

when exchanging information in machine code form throughout the Department of Defense.

During the past few years, intensive effort has been applied to obtain international agreement on a code for information interchange. The coded character set shown in figure 6-3c reflects a considerable amount of international consideration before May 1966. At that time the International Standards Organization (ISO) and the International Consultation Committee Telegraph and Telephone (CCITT) of the International Telecommunications Union (ITU) as a specialized agency of the United Nations, and the USA Standards Institute (USASI) proposed certain minor changes incorporated in figure 6-3c. In 1966 the CCITT announced that the international version of the code would be known as the International Telegraph Alphabet No. 5 (ITA No. 5).

The USA Standard Code for Information Interchange, commonly referred to as USASCII or ASCII, was made a Federal Standard by a Memorandum of the President of the United States on 11 March 1968. This information is therefore in accordance with the July 7, 1967 revision of USASCII and the Federal Standard established in the Presidential Memorandum.

Certain major equipment procurements were made based upon the pre-1966 version of USASCII. These equipments should not be considered nonstandard unless operational incompatibilities result, but a planned effort should be made to convert to figure 6-3c operation as early as possible, depending upon operational difficulties. Further information on tty codes is presented in the MIL-STD 188 Series and in Principles of Telegraphy, 0967-LP-225-0010.

MODES OF OPERATION

There are two basic modes of teletypewriter operation: nonsynchronous (start-stop) and synchronous. A common mode of operation is the nonsynchronous mode. Synchronous operation is used more in high-speed data systems.

In the nonsynchronous mode of operation the receiving device is allowed to run for only one character and is then stopped to await the reception of a start signal indicating that the next character is about to start. In this manner any difference in speed between the transmitting and receiving devices can accumulate only during the duration of one character. However, there is a penalty to pay for this advantage. The length of each character must be increased to include an element to start the receiving device and another to stop it.

The start element precedes the first code (intelligence) element and is always a space signal. Its purpose is to start the receiving machine. The stop element follows the last code element and is always a mark signal. Its purpose is to stop the receiving machine in preparation for receiving the next character. The start element must be equal to at least one element of the code. The standard mode uses a stop element 1.42 times the length of one code element. It is common practice to refer to a code element as a unit and the duration of a unit as the unit interval. The term "baud" (inverse of unit interval) is more often used in practice and is explained under MODULATION in this chapter.

The length of time required to transmit the entire character is called the character interval. Character interval becomes very important in some transmissions because certain items of equipment are "character length conscious" or "code conscious." Stop unit intervals of various lengths, such as 1.0, 1.27, 1.5, 1.96, 2.0 and the like, are used or produced by various equipment. Basically, the only difference between the equipment is the length of time required to transmit one character.

Synchronous teletypewriter operation, as opposed to start-stop operation, does not, in all cases, have to rely upon elements of the transmitted character to maintain proper position in relation to the receiving device. External timing signals may be used, allowing the start and stop elements to be discarded. Then, only the elements necessary to convey a character (and in some cases a reference element) need to be transmitted.

Synchronous systems have certain advantages over start-stop systems. The amount of time taken to transmit stop and start elements is made available for information transmission rather than for synchronizing purposes, since only the intelligence elements are transmitted. In start-stop signaling the ability of the receiving device to select the proper line signal condition is dependent upon interference to the start-stop

128-SYMBOL PRINTING SET

COLUMN →	0	1	2	3	4	5	6	7	
b7 b6 b5	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1	ROW ↓
b4 b3 b2 b1	NON-PRINTING (4)		96-SYMBOL PRINTING SUBSET						
0 0 0 0	NUL \	DLE ⊖	SP	0	@	P		p	0
0 0 0 1	SOH Γ	DC1 ◶	!	1	A	Q	a	q	1
0 0 1 0	STX ⊥	DC2 ◵	"	2	B	R	b	r	2
0 0 1 1	ETX ┘	DC3 ◴	#	3	C	S	c	s	3
0 1 0 0	EOT ⫣	DC4 ◷	$	4	D	T	d	t	4
0 1 0 1	ENQ ✢	NAK ⊗	%	5	E	U	e	u	5
0 1 1 0	ACK ⊸	SYN ⦶	&	6	F	V	f	v	6
0 1 1 1	BEL ♫	ETB ⊕	' (APOS)	7	G	W	g	w	7
1 0 0 0	BS ◅	CAN ⊠	(	8	H	X	h	x	8
1 0 0 1	HT ▻	EM ⊞	)	9	I	Y	i	y	9
1 0 1 0	LF ≡	SUB ◫	*	:	J	Z	j	z	10
1 0 1 1	VT ∇	ESC ⊟	+	;	K	[	k	{	11
1 1 0 0	FF ⊻	FS ⧉	,	<	L	\	l	¦	12
1 1 0 1	CR «	GS ⧉	-	=	M	]	m	}	13
1 1 1 0	SO ʌ	RS ⧉	.	>	N	^	n	~	14
1 1 1 1	SI ∨	US ⧉	/	?	O	_	o	DEL ▭	15

NOTES:
(1) Columns 0 & 1 show the mnemonic abbreviations and the printing symbols for the control characters.
(2) The diamond (◊) is printed to indicate the detection of an error.
(3) The heart (♡) may be printed to indicate a character of the control character sub-set.
(4) Non-printing codes in the 96-symbol Printing Set.

Figure 6-3c.—American Standard Code for Information Interchange.

arrival. This means that if the stop-to-start transition arrives before it should, all subsequent selection positions in that character will appear earlier in time in each code element. A synchronous system, therefore, has a higher capability to accept distorted signals than does a start-stop system.

MODULATION RATE

There are several methods of referring to teletypewriter modulation rates or signaling speeds. These include baud, bits per second (bps), and words per minute (wpm). Baud is the only one that is technically accurate without using additional qualifying terms. The others are either approximations or require explanation.

The word "baud," by definition, is a unit of modulation rate. It is sometimes used to refer to a signal element, but this reference is technically incorrect. Baud rate is the reciprocal of the time in seconds of the shortest unit interval. Hence, to find the modulation rate of a signal in bauds, the number 1 is divided by the time duration of the shortest unit interval present in the signal. For example, 22 milliseconds (.022) is the time interval of the shortest unit in the five-unit code at 60 words per minute. To find the number of bauds corresponding to 60 wpm, divide 1 by .022. Rounding off the results of the division provides the figure 45.5, which is the baud equivalent of 60 wpm. Each increase in wpm will correspondingly decrease the signal unit time interval. (The Defense Communications System standard speed for teletype operation is 100 wpm.)

Words per minute is used only when speaking in general terms for an approximation of speed. The term "100 wpm" means that 100 five-letter words with a space between them can be transmitted in a 60-second period. However, it is possible to obtain this nominal words-per-minute rate in several systems by varying either modulation rate or the individual character interval (length). For this reason, the modulation rate (baud) method of reference rather than words per minute is used.

Formulas for baud and wpm are as follows:

$$\text{baud} = \frac{1}{\text{Unit interval}}$$

$$\text{wpm} = \frac{\text{10X modulation rate in bauds}}{\text{character interval}}$$

The term "bit" is a contraction of the words "binary digit." In binary signals, a bit is equivalent to a signal element. As a result of the influence of computer and data processing upon our language, modulation rate is sometimes expressed as "bits per second" (bps). When it is expressly understood that all signal elements being transmitted are of equal length, the modulation rate expressed in bits per second is the same as the modulation rate expressed in bauds.

D.C. CIRCUITS

It has been pointed out that the two conditions, mark and space, may be represented by any convenient means. The two most common are neutral operation, in which current flow represents the mark, and no current flow represents the space; and polar operation, in which current impulses of one polarity represent the mark, and impulses of the opposite polarity and of equal magnitude represent the space.

Neutral circuits make use of the presence or absence of current flow to convey information. These circuits use 60 milliamperes (mA) (or, in some cases, 20 mA) as the line current value. A neutral teletypewriter circuit is composed of a transmitting device, a battery source to supply current, a variable resistor to control the amount of current, a receiving device, and a line for the transmission medium.

Polar operation differs from neutral operation in two ways. Information is always present in the system, and it is either in a positive or negative condition. A polar teletypewriter circuit is composed of the same items as a neutral circuit plus an additional battery source. The reason for having an extra battery source is that the standard polar circuit uses positive battery for mark and negative battery for space.

The most significant advantage to polar operation is that for all practical purposes it is almost impossible to distort a signal through low line currents, high reactance, or random patching of signal circuits or equipment. Another advantage of polar signaling is that a complete loss of current (a reading of ZERO on the milliammeter) indicates line or equipment trouble, whereas the same condition with neutral signaling may indicate only that a steady space is being transmitted.

BASIC SYSTEMS

When two teletypewriters are wire-connected (looped), the exchange of intelligence between them is direct. When the teletypewriters are not joined by wire, exchange of intelligence is more complex. Direct-current mark and space intervals cannot be sent through the air. The gap between the machines must be bridged by radio using a radio transmitter and receiver. The transmitter produces a radio frequency carrier wave to carry the mark and space intelligence. Also, a device such as a KEYER is needed to change the d.c. pulses from the teletypewriter into corresponding mark and space modulation for the carrier wave in the transmitter. The radio receiver and a CONVERTER are required to change the radio frequency signal back to d.c. pulses.

The Navy uses two basic radio-actuated teletype (RATT) systems: the tone-modulated system, referred to as audio frequency tone shift (AFTS), and the carrier frequency shift system, referred to as radio-frequency carrier shift (RFCS). The RFCS system is more commonly called frequency shift keyed (fsk).

RADIO TELETYPE (RATT) SYSTEMS

In recent years, the U.S. Navy has vastly improved its radio teletype capabilities by the introduction of several new items of equipment provided either single or multi-channel radio teletype (RATT) transmission modes. An added dividend acquired along with this new equipment has been an increased flexibility in the specific combinations of ancillary equipment that can be used. This situation, however, has caused certain problems in the specification of frequencies for radio teletype transmissions. In addition, there has also been some confusion over the proper emission designators to be used. This section should clarify some of these areas.

The Navy presently uses two types of RATT emissions:

1. RFCS RATT (Radio Frequency Carrier Shift Radiotelephone)
2. AFTS RATT (Audio Frequency Tone Shift Radiotelephone)

Both variations require the use of two discrete radio frequencies to produce one channel of radio teletype: one frequency for the mark signal and the other for the space signal. At any given instant of time, one and only one of these frequencies is being emitted by a transmitter.

RFCS

RFCS is accomplished by shifting (See EIMB Handbook, Communications, NAVSEA 0967-LP-000-0010 for the various emission descriptors.) an unmodulated radio frequency carrier back and forth between the two discrete frequencies of a teletype channel, one frequency being the mark signal and the other the space signal (fig. 6-4). This is commonly referred to as FSK (frequency shift keying) RATT and is single channel teletype unless time division is employed on the two discrete frequencies to achieve multichannel operation. For reasons of clarity, it is more descriptive if this emission is referred to as RFCS RATT (Radio Frequency Carrier Shift Radio teletype) instead of FSK RATT. See figure 6-5 for a basic RFCS system.

AFTS

AFTS is accomplished by keeping the radio frequency carrier constant and shifting back and forth between two discrete audio frequency tones to produce the mark/space signals of a teletype channel. Each channel of radio teletype information in an emission requires its own pair of tones. If frequency diversity operation is desired, the teletype channel information is duplicated on a second pair of tones. By international definition, this would be A7 type emission

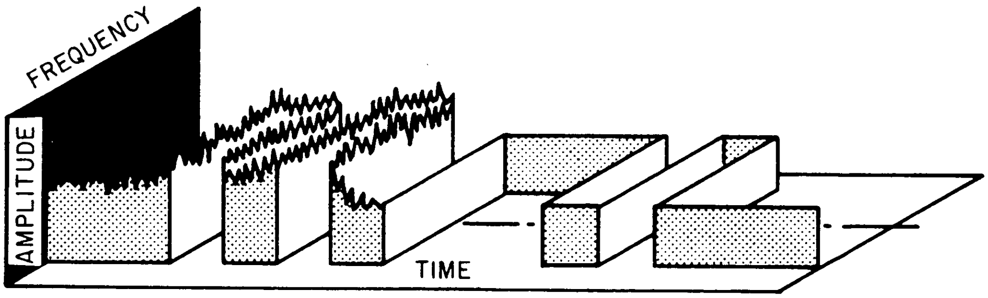

Figure 6-4.—RFCS telegraph signal.

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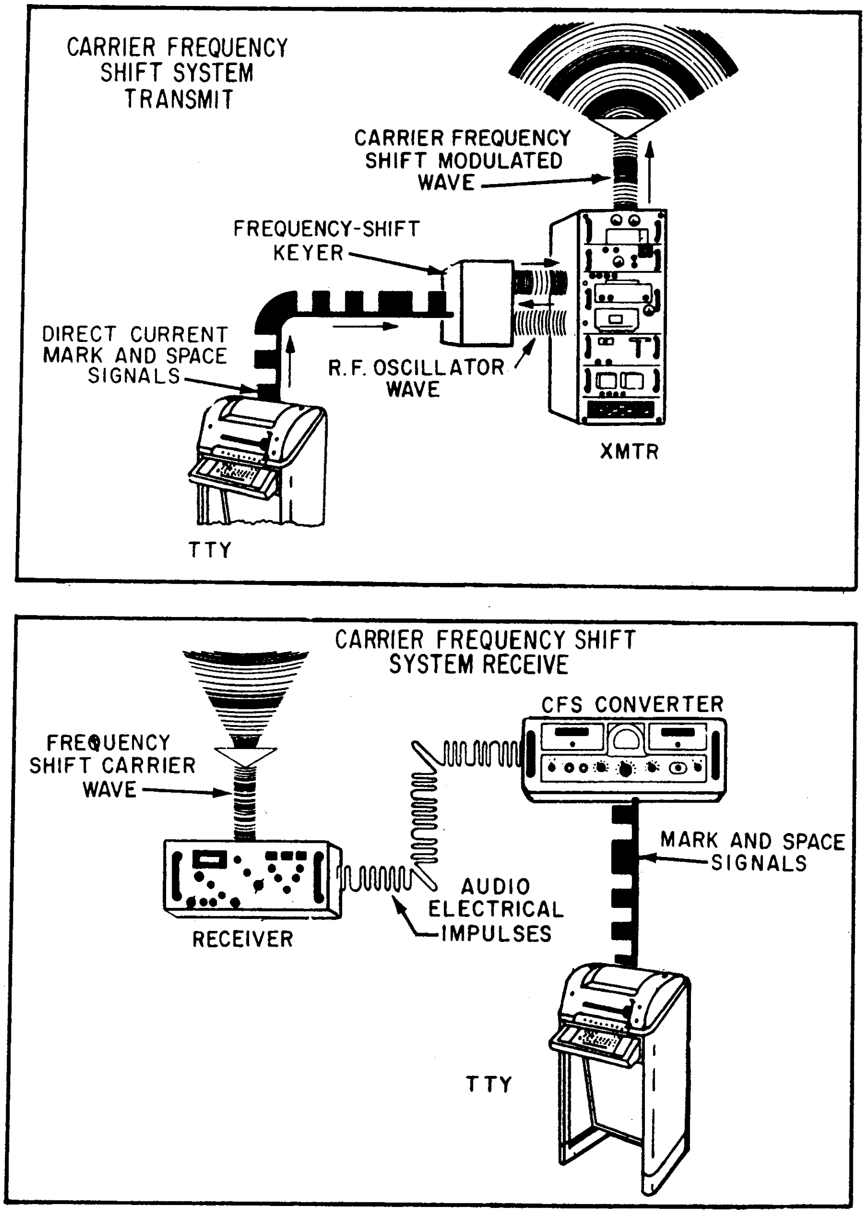

1.230

Figure 6-5.—Basic carrier frequency-shift (RFCS) system.

only if two or more pairs of teletype tones (multichannel) are being transmitted. As there is no internationally agreed emission designator to be used when only one pair of teletype tones is being transmitted, the Navy uses A7 to denote single as well as multichannel RATT of this type. A7-type emissions have been referred to by a variety of terms, including Tone Modulated RATT, FSK RATT, VFTG, SSB RATT, DSB RATT, and ISB RATT. It is more descriptive if A7-type emissions are referred to as AFTS RATT (Audio Frequency Tone Shift Radioteletype) instead of the various foregoing terms. See figure 6-6 for a basic AFTS system.

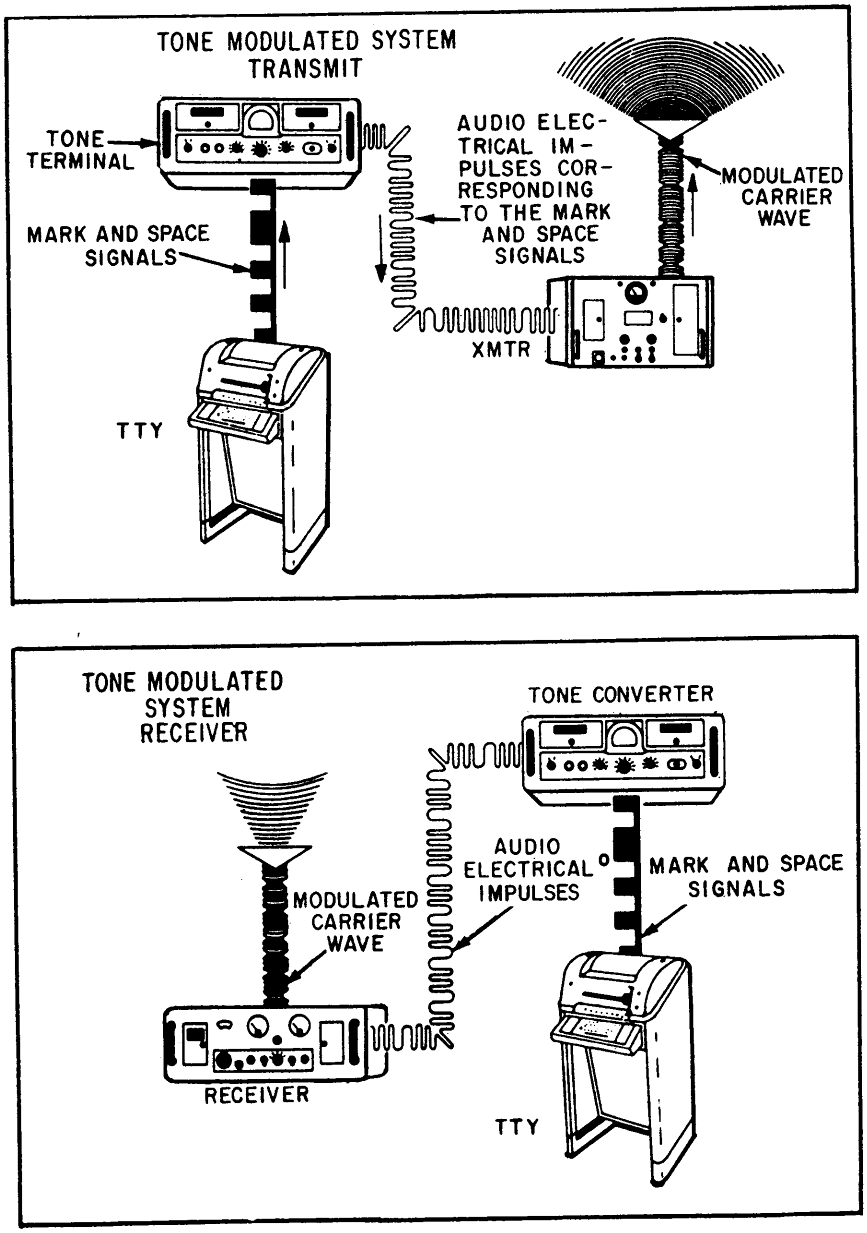

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Figure 6-6.—Basic tone-modulated (AFTS) system.

COMMUNICATION SYSTEM OPERATION

The capability of a communication system to transmit and receive can be classified as simplex, half duplex, or duplex operation.

Simplex Operation

A simplex operation is that type of operation which permits the transmission of signals in either direction alternately. NOTE: In radio telegraph or data transmission systems, it may be either (1) the use of a single frequency, time slot, or code address for transmission, and another frequency, time slot, or code address for reception; or (2) the use of the same frequency, time slot, or code address for both transmission and reception. In wire telegraph systems, simplex operation may be employed over either a half-duplex circuit, or over a neutral direct current circuit.

Half-Duplex

Half-duplex is that type of simplex operation which uses a half-duplex circuit. Half-duplex also pertains to an alternate, one way at a time, independent transmission. Synonym: ONE WAY REVERSIBLE OPERATION.

Duplex Operation

Duplex operation is that type of operation in which simultaneous two-way conversations, messages, or information may be passed between any two given points. Synonym: FULL-DUPLEX OPERATION. Further information may be found in MIL-STD 188C and MIL-STD 188-120.

SIMPLEX RFCS TELETYPE SYSTEM

Radio frequency carrier shift teletype systems are used in the lf to hf bands for long-range communications. To reduce fading and interference problems in these bands, the Navy uses two methods of DIVERSITY RECEPTION. These methods are SPACE DIVERSITY and FREQUENCY DIVERSITY.

In SPACE DIVERSITY reception, one signal is transmitted, and this signal is received by two or more receivers. The receiver antennas are separated by a distance greater than one wavelength. The outputs of the receivers are fed into frequency-shift converters which convert the audiofrequency-shift signals into d.c. mark and space signals. The d.c. signals are then fed into a comparator which selects the best mark and space signals for the teletypewriter. Because of required spacing between the receiver antennas, space diversity is mostly limited to shore stations.

In FREQUENCY DIVERSITY reception, two or more signals carrying the same intelligence are transmitted on different frequencies. The signals are received by receivers and processed in the same manner as for space diversity to operate teletype equipment from the best of the transmitted signals. This form of frequency diversity is known as rf diversity. Another form of frequency diversity called af diversity or tone diversity is used with multichannel broadcasts.

A simplified block diagram of a simplex mf/hf RFCS teletype system is shown in figure 6-7.

A SIMPLEX communication circuit consists of a single channel over which two or more stations may communicate. Each station may transmit and receive, but not simultaneously. On the transmit side (fig. 6-7), the teletypewriter (tty) set keyboard or transmitter distributor applies the d.c. teletype signals to the communication patch panel where they are patched to the transmitter. The d.c. mark and space signals shift the frequency of the rf carrier generated by the transmitter as explained previously.

On the receive side, the rf frequency-shift signal is received and demodulated by the receiver, resulting in an audio signal which shifts 850 Hz between marks and spaces. This audiofrequency-shift signal is fed to a converter in the converter/comparator group where it is converted into the original d.c. mark and space signals. The d.c. mark and space signals are then patched through the communication patch panel to the tty set.

RFCS SEND SYSTEM

The following is a functional description of an RFCS teletype transmit communications system. See the pictorial diagram (fig. 6-8).

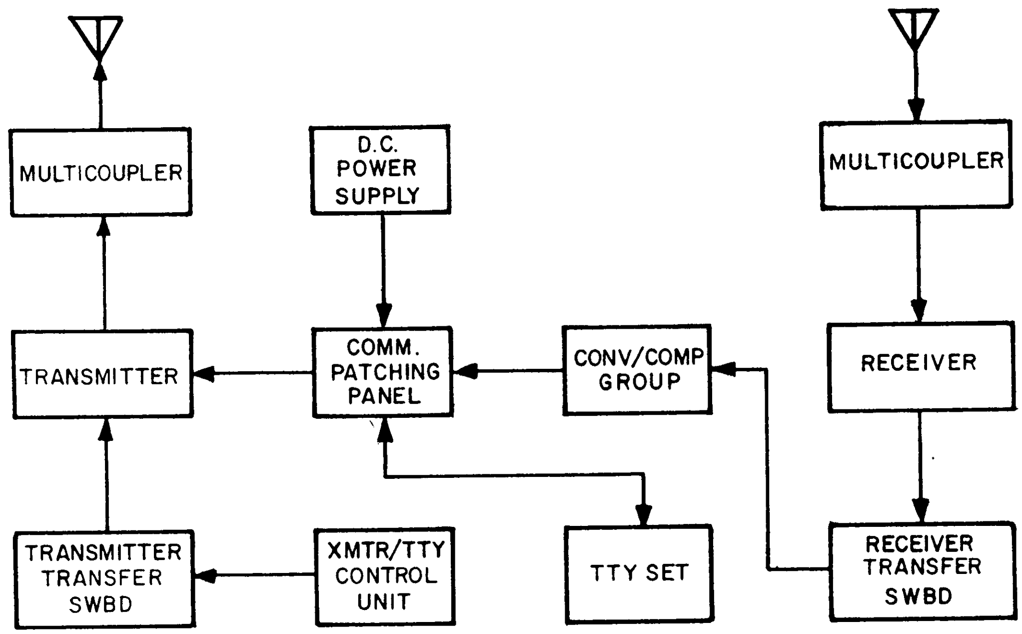

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Figure 6-7.—Simplex RFCS teletype system.

Tty Sets

Most of the teletypewriter sets used by the Navy belong to the model 28 family of teletypewriter equipment. The model 28 equipments feature various weights and sizes, quiet operation, and high operating speeds. They present relatively few maintenance problems, and are particularly suited for shipboard use under severe conditions of roll, vibration, and shock.

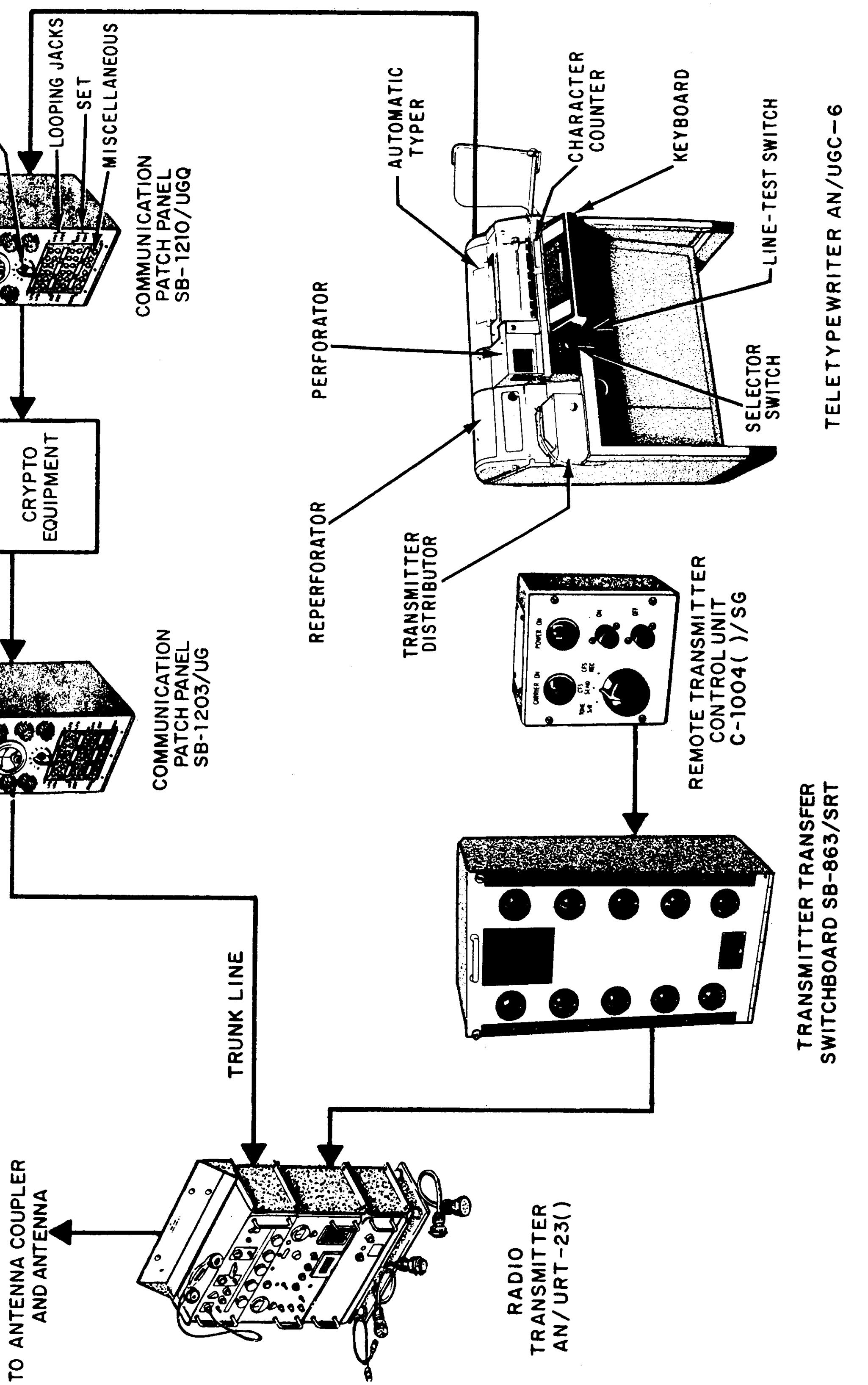
Another feature of the model 28 teletypewriters is their ability to operate at speeds of 60, 75, or 100 words per minute. Conversion from one speed to another is accomplished by changing the driving gears that are located within the equipment. The majority of the Navy's teletypewriters are presently operated at 100 words per minute.

Teletypewriters may be send/receive units or receive only units. They may be designed as floor models, table models, and rack and wall mounted sets. A representative send/receive floor model set is shown in figure 6-8.

The tty set (fig. 6-8) receives teletype messages from the line and prints them on page-size copy paper. In addition, it can receive messages and record them on tape and in printed form. With page-printed monitoring, the set transmits messages that are originated either by perforated tape or by keyboard operation. It mechanically prepares perforated and printed tape for separate transmission with or without simultaneous transmission and page-printed monitoring.

The teletypewriter set may be composed of the following components: a cabinet, a keyboard, a page printer, a typing perforator, a transmitter distributor, a typing reperforator, power distribution panels, and power supply.

In operation, the components are linked by electrical or mechanical connections to offer a wide range of possibilities for sending, receiving, or storing teletypewriter messages. All equipment components are housed in the cabinet. Transmission signals are initiated through the keyboard or through the transmitter distributor. Signals are received, or local transmission can be



162.376

Figure 6-8.—RFCS transmit (send) system.

monitored, on the page printer. The typing perforator and typing reperforator are devices for preparing tapes on which locally initiated or incoming teletypewriter messages can be stored for future transmission through the transmitter distributor.

The keyboard, typing perforator, page printer, and transmitter distributor are operated by the motor mounted on the keyboard. Selection of these components for either individual or simultaneous operation is by the selector switch located at the front of the cabinet, to the left of the keyboard. All these components are connected in series in the signal line, but the selector switch has provisions for excluding various components from the line. The external signal line is connected to the equipment through a line-test switch. This switch is located below the selector switch on the front of the cabinet. This arrangement provides a means of disconnecting the equipment from the line for local testing of the components. The typing reperforator is operated by a separate motor and power distribution system. It also is connected to a separate external signal line.

To become a part of the Naval Tactical Data System (NTDS), the AN/UGC-6 is modified (and designated AN/UGC-13) to provide input/output communications with a selected data processing computer.

Communication Patching Panels

To provide flexibility in teletype systems, the wiring of all teletypewriters and associated equipment is terminated on jacks in communication patching panels usually referred to as teletype patch panels. The equipment then is connected electrically in any desired combination by means of patching cords.

The plugs on the cords are inserted into the jacks at the front of the panel. In some instances, commonly used combinations of equipment are permanently wired together within the panel (called "normal-through"). They are wired so that individual pieces of equipment can be "lifted" from the combination, and then used alone or in other combinations.

In addition to providing flexibility, teletype panels also furnish a central point for connecting the d.c. voltage supply into the teletypewriter circuits. Thus, one source of supply can be used for all circuits passing through a particular panel.

Teletype panels SB-1203/UG and SB-1210/UGQ (fig. 6-8) are used for interconnection and transfer of teletypewriter equipment aboard ship. The SB-1203/UG is a general-purpose panel; whereas, the SB-1210/UGQ is intended for use with cryptographic devices. The colors RED and BLACK are used to identify secure and nonsecure information. Red indicates that secure (classified) information is being passed through the panel, and black indicates that nonsecure (unclassified) information is being passed through the panel.

Each of the panels contains six channels, with each channel comprising a looping series circuit of looping jacks, set jacks, and a rheostat for adjusting line current. The number of looping and set jacks in each channel varies according to the panel model. Each panel includes a meter and rotary selector switch for measuring the line current in any channel. There are six miscellaneous jacks. Any teletypewriter equipment not regularly assigned to a channel, may be connected to one of these jacks.

If the desired teletype equipment is wired in the same looping channel as the radio adapter (keyer or converter) to be used (normal through connection), no patch cords are required. But, if the desired teletypewriter (for example, in channel 1) is not wired in the same looping channel as the keyer or converter to be used (for example, channel 3), one end of the patch cord must be inserted in the set jack in channel 1, and the other end in either one of the two looping jacks in channel 3.

In any switching operation between the various plugs and jacks of a teletype panel, the cord plug must be pulled from the looping jack before removing the other plug from the set (machine) jack. Pulling the plug from the set jack first opens the circuits to the channel, causing all teletype messages in the channel to be interrupted. IT ALSO PRODUCES A DANGEROUS D.C. VOLTAGE ON THE EXPOSED PLUG.

Crypto Equipment

Crypto equipment is used to encrypt teletype output for transmission. ("Encrypting" is coding a message.) To code or decode any transmitted messages, the sending and receiving crypto machines must be of the same type.

Transmitter/Tty Control

The transmitter/tty control unit (fig. 6-8) is mounted close to the teletype keyboard, and permits remote control of the transmitter. It has a transmitter power on-off switch, a power-on indicator lamp, a carrier-on indicator lamp, and a three-position rotary selector switch. For RFCS operation, the operator sets the switch to CFS SEND for transmitting and to CFS REC for receiving. The TONE S/R position is used for both transmitting and receiving AFTS signals.

An audio frequency tone-shift (AFTS) system will be discussed later in this chapter.

Transmitter Switchboard

The transmitter switchboard (SB-863/SRT) (fig. 6-8) is used in this system to connect the tty control to the transmitter that is to be used to transmit the signal on the proper frequency.

Transmitter

The AN/URT-23 transmitter (fig. 6-8) is used to transmit the proper frequency for the teletype signal. Care must be taken when tuning the transmitter for RFCS operation. The carrier frequency must be set to ensure proper frequency is obtained at the output of the transmitter.

RFCS RECEIVE SYSTEM

The RFCS receive system (fig. 6-9) is used to receive the transmitted signal and translate it back to a usable teletype output.

Antenna Filter

The antenna filter AN/SRA-12 (fig. 6-9) is connected to the antenna and receives the rf signal from the antenna. It filters out any unwanted rf signals so that only the band of frequencies desired will be passed on to the receiver.

Radio Receiver

The radio receiver R-1051/URR (fig. 6-9) receives the rf signal passed on by the antenna filter and translates the rf signal to an audio signal.

Receiver Patch Panel

The receiver patch panel SB-973/SRR (fig. 6-9) is a panel used to tie the receiver to any one of the converter units that are connected to it. This allows a wide selection of equipment to be connected to the same receiver.

Converter/Comparator Group

The converter/comparator group (fig. 6-9) is used with receivers in either space or frequency diversity operation. When diversity operation is not required, each converter can be used separately with a single receiver.

Each converter (fig. 6-9) has its own comparator circuitry. This built-in design feature results in a considerable reduction in size from older units where the comparator is located in a separate chassis. A further reduction in size is achieved by the use of semiconductors and printed circuit boards.

The simplified block diagram (fig. 6-10) shows the basic function of converting the frequency-shift rf signal into a signal for controlling the d.c. loop of the tty. The frequency shifts of the af output from the receiver are converted into d.c. pulses by the af discriminator. The d.c. pulses are fed into the loop keyer which opens and closes the d.c. loop of the tty according to the mark and space characters received.

The comparator section of the converter/comparator compares the strength of the signals from the receivers in diversity operation. Signals from each converter are fed into a comparator circuit which compares the signals and allows only the stronger signal to be fed to the communication patching panel for patching to the tty.

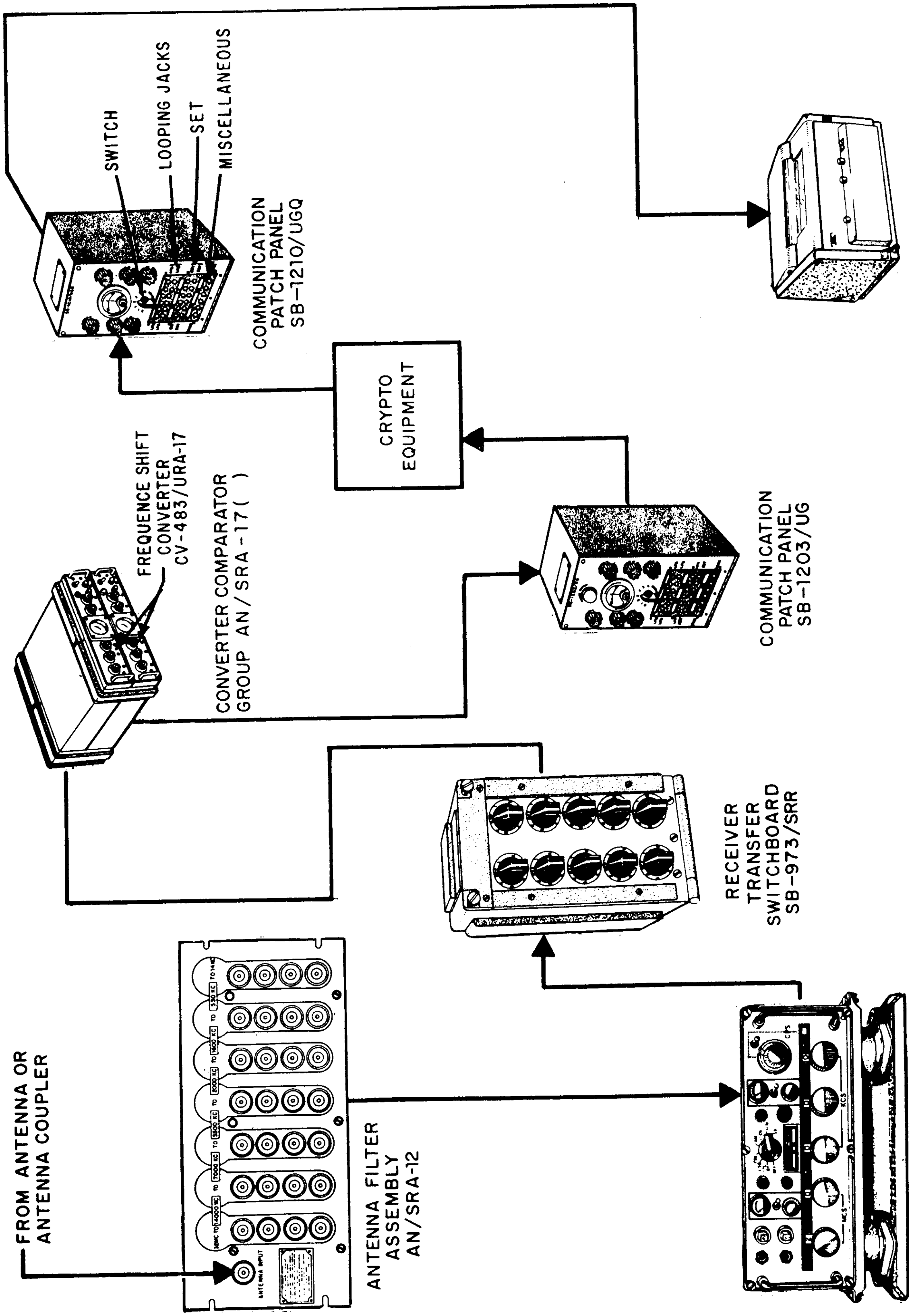


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Figure 6-9.—RFCS receive system.

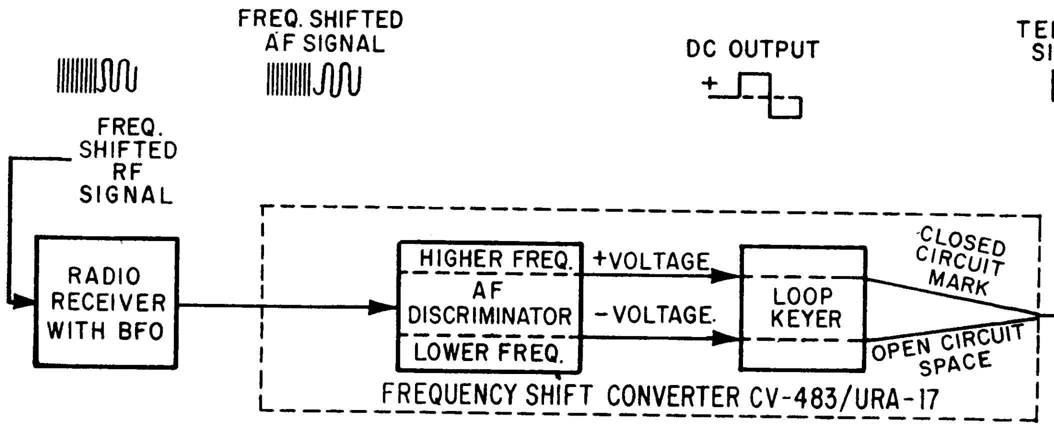

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Figure 6-10.—Frequency shift receiving system simplified block diagram.

Communication Patch Panel

The communication patch panels (fig. 6-9) serve the same function on the receive side of the RFCS system as they did on the transmit side; that is, to route the d.c. signal to the proper crypto equipment, and to route the decoded teletype signal from the crypto equipment to the proper teletype equipment.

Crypto Equipment

The crypto equipment (fig. 6-9) is used to convert the coded signal that was transmitted to a decoded signal that can be printed out in its original state.

Teletype

The teletype equipment is used to convert the d.c. signal received from the communication patch panel to a printed copy of the original transmitted message. The teletype equipment shown, AN/UGC-25 (fig. 6-9), contains a page printer only, therefore it is used for receive and does not have the capability to transmit.

AFTS SYSTEM

A simplified block diagram of a half-duplex (send or receive) uhf AFTS system is shown in figure 6-11. A half-duplex communication circuit permits unidirectional communication between stations. Communication can be in either direction, but cannot occur simultaneously. The term half-duplex is qualified by adding "send only," "receive only," or "send or receive."

A FULL-DUPLEX (or DUPLEX) communication circuit permits uninterrupted exchange of information between stations by using two separate circuits. Each station may transmit and receive simultaneously.

Signal Flow

On the transmit side (fig. 6-11), d.c. signals from the tty set are fed to the communication patching panel where they are patched to the tone terminal set. The tone terminal set converts the d.c. signals into audio tone-shift signals, which are patched to the transmitter section of the transceiver through the transmitter transfer switchboard. The audio tone-shift signals modulate the rf carrier generated by the transmitter. The rf tone-modulated signals are then radiated by the antenna.

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

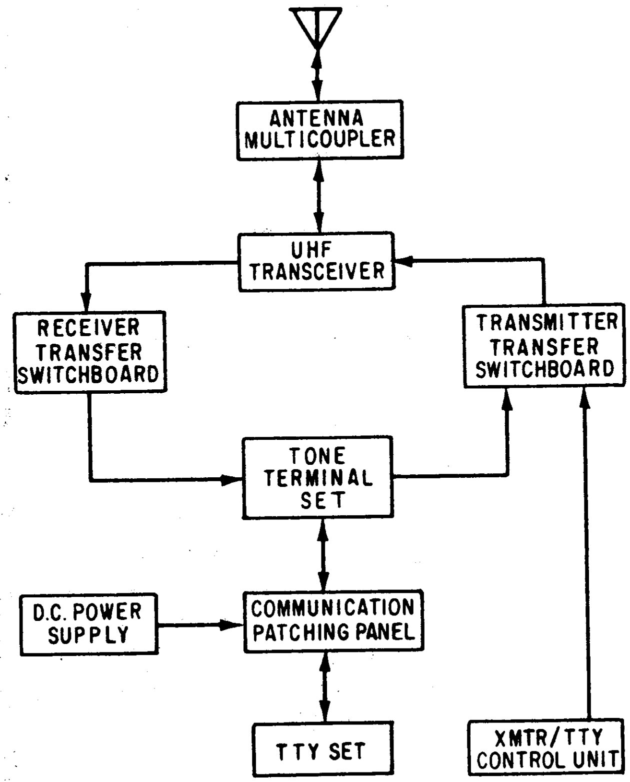

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Figure 6-11.—Half-duplex AFTS teletype system.

converted back to the d.c. signals. The d.c. signals are patched through the communication patching panel to the tty set.

Tone Terminal Set

In tone modulation transmission, the teletypewriter pulses are converted into corresponding audio tones, which amplitude modulate the rf carrier in the transmitter. Conversion to audio tones is accomplished by an audio oscillator in the tone converter.

An internal relay in the tone converter closes the control line to the transmitter which places the transmitter on the air when the operator begins typing a message. The control line remains closed until after the message has been transmitted.

When receiving messages, the tone converter accepts the mark and space tones coming in from an associated receiver and converts the intelligence of the tones into signals suitable to operate a relay in the converter. The make and break contacts of the relay are connected in the local teletypewriter d.c. loop circuit. This action causes the teletypewriter to print in unison with the mark and space signals from the distant teletypewriter.

MULTIPLEXING EQUIPMENT

The discussion of teletypewriter equipment and systems has, thus far, dealt only with single circuits or channels. However, more than one teletypewriter channel might be transmitted over a single path using multiplexing techniques. The application of time division multiplexing, however, is presently limited to specialized situations. Therefore, only the more universal frequency division multiplexing equipment will be described in this chapter. Telegraph terminal equipment AN/UCC-1( ) may be configured to handle up to 16 channels owing to its modular construction.

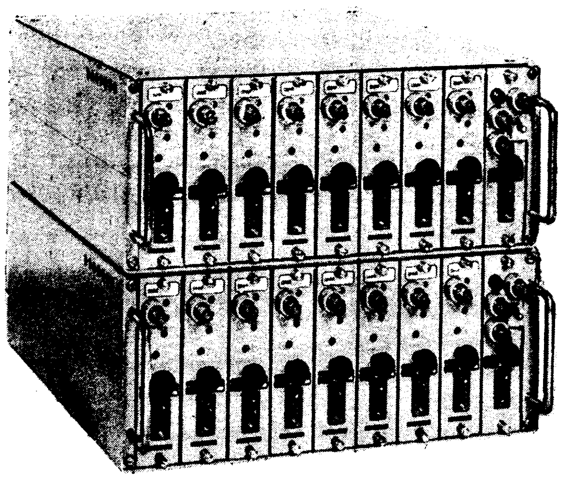
Because of this versatility, it is widely installed in one configuration or another throughout the fleet.

Telegraph Terminal AN/UCC-1D(V)

Since the EMO may encounter either equipment, the following information is provided:

The AN/UCC-1D is high-level capable or low-level capable while the AN/UCC-1 is high-level only. This text discusses the AN/UCC-1D.

Telegraph Terminal AN/UCC-1D(V) (fig. 6-12) is a frequency division multiplex carrier-telegraph terminal equipment for use with single sideband (ssb) or dual sideband (dsb) radio circuits, audio-frequency wire lines, or microwave circuits. Each of the two electrical equipment cabinets shown in figure 6-12 houses one control attenuator (right side) and up to a maximum of eight frequency shift keyers or eight frequency shift converters, or any combination of both.



120.26(120C)
Figure 6-12.—Telegraph Multiplex Terminal AN/UCC-1D(V).

Since the control attenuator, keyers and converters are solid state, integrated circuit plug-in modules, the number of channels may be varied by increasing or decreasing the total number of modules. Depending upon the number of modules and the configuration used, the terminal can provide up to 16 narrow-band channels within a 382-3017 Hz bandwidth. For example, if the unit in figure 6-12 is considered to have keyers in the top cabinet and converters in the bottom cabinet, the system would be capable of transmitting different information on eight channels. Each keyer would represent a channel on the transmit side and each converter a channel on the receive side.

Each frequency-shift keyer accepts a d.c. telegraph signal input from an external loop, and generates the appropriate audio-frequency mark/space frequency-shift output. The individual keyers each contain two oscillators operating on opposite sides of a center frequency. For example, in figure 6-13 the center frequency for keyer number one is 425 Hz, the mark frequency is 382.5 Hz, and the space frequency is 467.5 Hz. These audio frequency mark/space outputs are referred to as tones; thus keyer one has a one channel, two-tone output. (The mark and space frequencies may be reversed in local equipment manuals. Figure 6-13 represents frequency assignments in accordance with inter-service usage.)

The input from the tty set on channel 1 will determine which frequency is gated from the keyer to the group attenuator. Each individual channel works in the same way, accepting an input from the tty set patched to that channel and providing an output audio-frequency mark/space frequency-shifted signal (tone) according to the input. The individual tones are combined at the keyers into a composite tone package. The control attenuator ensures that the composite tones remain at a constant amplitude for modulating the transmitter.

At the receiving end of the communication link the telegraph terminal reverses the process performed at the transmitting end and applies the information on each of the channels to the tty set connected to that channel's converter.

In this circuit configuration each channel has an input from a different tty. If for some reason (atmospheric conditions, poor reception at a particular frequency, etc.) this channel fades, the information on it is lost or distorted and must be retransmitted. To aid in preventing this, diversity switches that will permit the use of more than one channel for the same intelligence have been provided. In position ONE, only the normal channel is used; in position TWO, a single teletypewriter signal provides input for two adjoining keyers; in switch position FOUR, four keyers are connected to the same input loop. The switches on all keyers must be in the same position to provide the same intelligence to the selected combination of channels.

When identical intelligence is transmitted on two or four channels, it is less likely to be lost or distorted. At the receiving end, two or four corresponding converters may be used; the converter having the stronger signal input provides the signal to be used by the receiving teletypewriter.

In the shipboard multiplexing system consisting of 16 channels, two channels normally carry the same intelligence. This process is called twinning. The twinned channels have a center frequency separated by 1360 Hz (e.g., 425-1785, 595-1955, 765-2125).

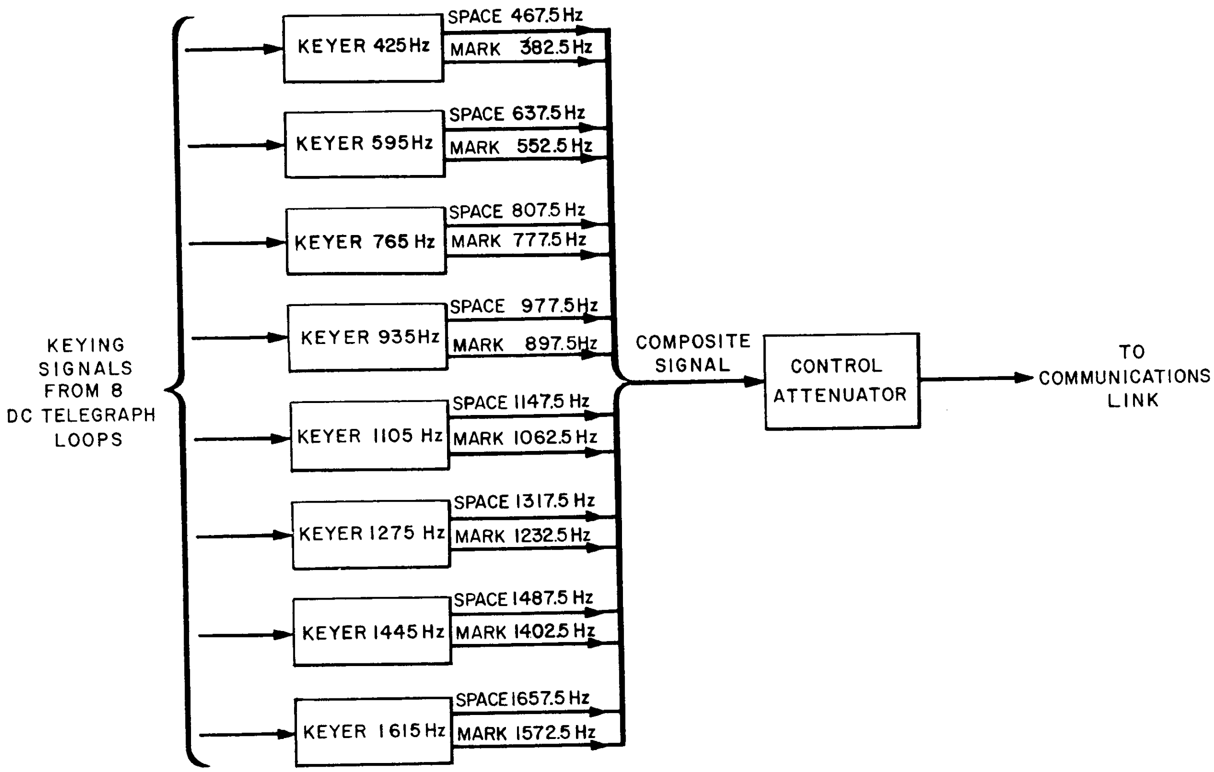


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Figure 6-13.—Keying frequencies of the AN/UCC-1D(V).

LOW LEVEL TELETYPE (TTY)

In the past, tty keying signals typically operated at 60 mA (milliamperes) line current. Because it was possible for unauthorized electromagnetic detection of this high level signal, a method of operation utilizing nondetectable signals became important. Low level keying, at much lower level voltages (±6V), and the use of gold contact points essentially eliminated detectable emissions. This altered the tty (basically electro-mechanical) to include various electronic parts and modules. Electronic technicians are often called upon to repair such equipment.

For older ships with tty equipment that has been modified to operate low level, there are a great many TEMPEST requirements (outlined in MIL-STD-1680 (Series)) that require the EMO's careful observation. However, newer ships are so designed that many of these security concerns are "built in" when the ship is designed. Though TEMPEST requirements are reduced, they do require careful scrutiny and observance in all installations. Further information on low level systems may be found in equipment technical manuals, COMNAVTELCOMINST C2796.1 and MIL-STD-1680 (TEMPEST information).

FACSIMILE

Facsimile (FAX) is a method for transmitting still images over an electrical communication system. The images, called "pictures" or "copy" in facsimile terminology, may be weather maps, photographs, sketches, typewritten or printed text, or handwriting. The still image serving as the facsimile copy or picture cannot be transmitted instantly in its entirety. Three distinct operations are performed. These are (1) scanning, (2) transmitting, and (3) recording or receiving.

The scanning operation consists of subdividing the picture in an orderly manner into a large number of elemental segments. This process is accomplished in the facsimile transmitter by a scanning drum and phototube arrangement.

The picture to be transmitted is mounted on a cylindrical scanning drum, which rotates at a constant speed and at the same time moves longitudinally along a shaft. Light from an exciter lamp illuminates a small segment of the moving picture and is reflected by the picture through an aperture to a phototube. During the transmission of a complete picture, the light traverses every segment of the picture as the drum slowly spirals past the fixed lighted area.

At any instant, the amount of light reflected back to the phototube is a measure of the lightness or darkness of the tiny segment of the picture that is being scanned. The phototube transforms the varying amounts of light into varying electrical signals, which, in turn, are used to amplitude modulate the constant frequency output of a local oscillator. Then, the modulated signal is amplified and sent to the radio circuits.

Electrical signals received by the facsimile receiver are amplified and serve to actuate a recording mechanism that makes a permanent recording (segment by segment) on recording paper. The paper is attached to a receiver drum similar to the one in the facsimile transmitter. The receiver drum rotates synchronously with the transmitter drum. This action continues until the original picture is reproduced in its entirety. The recording mechanism may reproduce photographically with a modulated light source shining on photographic paper or film, or it may reproduce directly by burning a white protective coating from specially prepared black recording paper.

Synchronization is obtained by driving both receiving and transmitting drums with synchronous motors operating at exactly the same speed.

Framing (orienting) the receiver drum with respect to the transmitter drum is accomplished by transmitting a series of phasing pulses just before a picture transmission is to begin. The pulses operate a clutch mechanism that starts the scanning drum in the receiver so that it is phased properly with respect to the starting position of the scanning drum in the transmitter.

The equipment necessary for radio facsimile operation and its relationship to other units in the various receiving and transmitting systems are illustrated by the block diagram in figure 6-14. As shown by part A of the figure, the receiving system consists of a standard radio receiver, a frequency-shift converter, and a facsimile recorder. Part B shows two systems for transmitting facsimile signals. One, the upper row of blocks, is for carrier-frequency-shift transmission and consists of a facsimile transceiver, a keyer adapter, a frequency shift keyer and a transmitter capable of FSK emission. The other, the lower row of blocks, is for audio-frequency shift transmission and employs a facsimile transceiver, a radio modulator, and an AM transmitter.

FACSIMILE TRANSCEIVERS TT-41( )/TXC-1B AND TT-321A/UX

Facsimile Transceiver TT-41( )/TXC-1B (fig. 6-15), is an electromechanical-optical facsimile set of the revolving-drum type for both transmission and reception of page copy. Colored copy may be transmitted, but all reproduction is in black, white, and intermediate shades of gray. Received copy is recorded either directly on chemically treated paper, or photographically in either negative or positive form. The equipment transmits or receives a page of copy 12 by 18 inches in 20 minutes at a regular speed of 60 lines per minute (lpm), or in 40 minutes with half-speed (30 lpm) operation.

The TT-321A/UX facsimile transceiver, also shown in figure 6-15 is the same transceiver as above but has an increase in motor speed. The TT-321A/UX transmits or receives a page of copy 12 by 18 inches in 10 minutes at regular speed (120 lpm), or in 20 minutes with half-speed (60 lpm) operation.

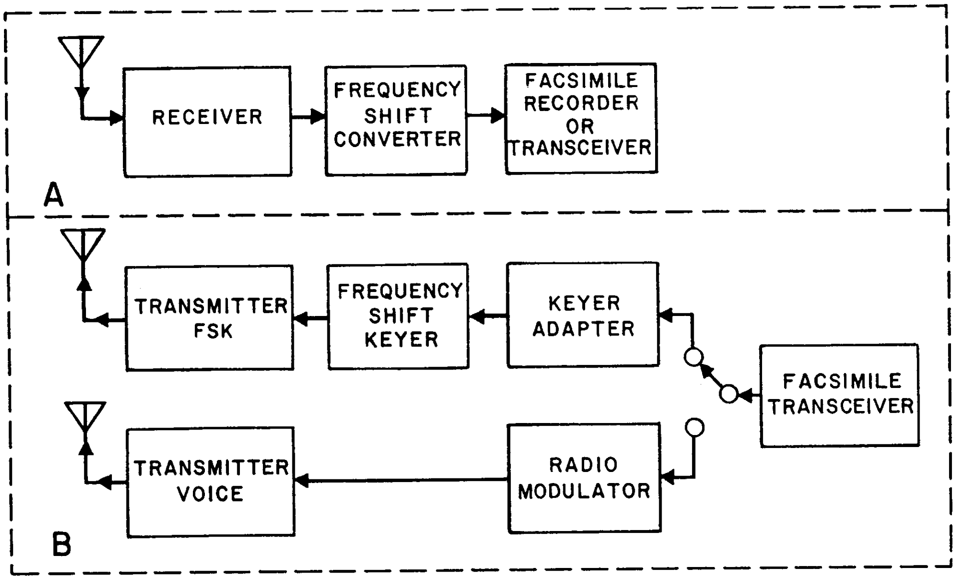

Figure 6-14.—Radio facsimile systems. 70.14

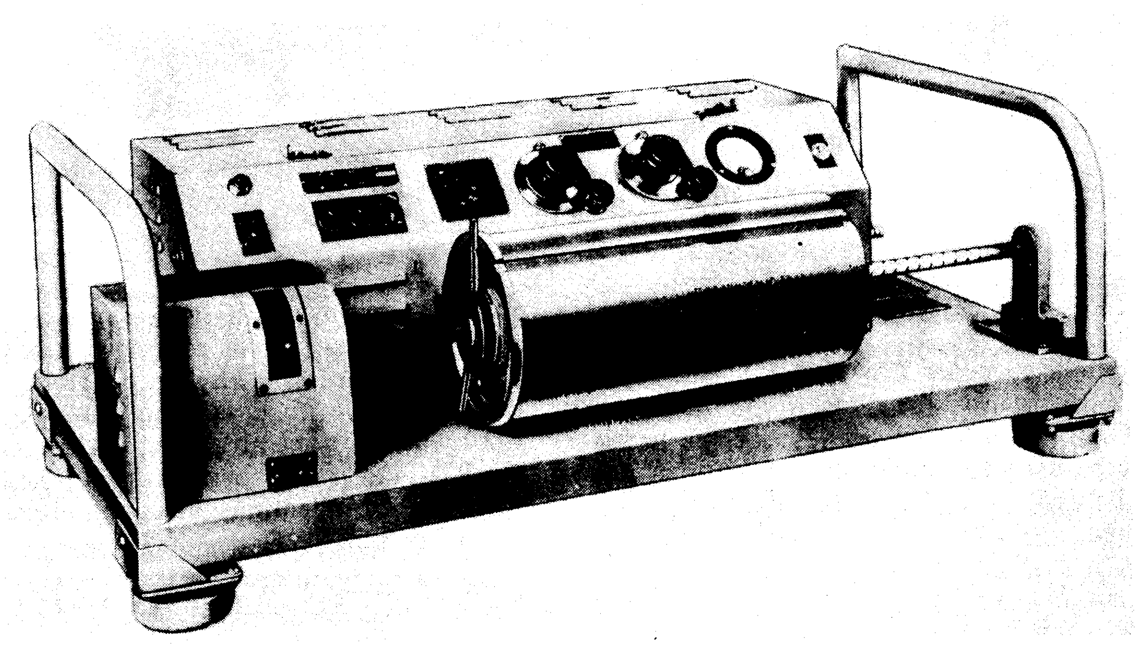

Figure 6-15.—Facsimile Transceiver TT-41( )/TXC-1B and TT-321A/UX. 13.70

A facsimile transceiver (or transmitter) generates an amplitude-modulated signal, and the recorder is designed to operate on this type of signal. The signal generated by the transmitter is unsuitable, however, for transmission by means of radio. For this reason, it is necessary to use signal conversion equipment between the facsimile transmitter and the radio transmitter, and between the radio receiver and the facsimile recorder.

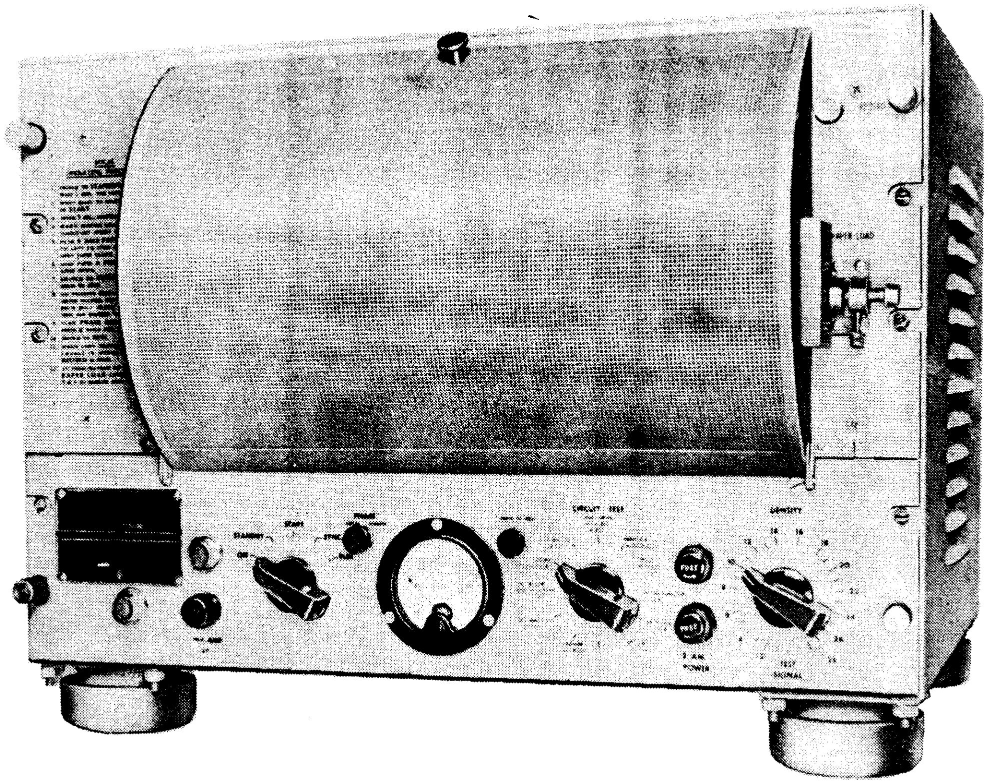

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Figure 6-16.—Facsimile Recorder RD-92( )/UX.

FACSIMILE RECORDER RD-92( )/UX

Facsimile recorder RD-92( )/UX, shown in figure 6-16, is used for direct stylus recording only. Unlike the transceivers described earlier, it cannot be used for transmitting facsimile, nor can it be used to receive on photographic film.

When receiving copy, the recorder drum rotates at a speed of 60 rpm. (No provision is made for multispeed operation.) As the drum rotates, a mechanism holding a stylus needle is moved across the drum to the right. The stylus needle records on paper at the rate of one scanning line for each revolution of the drum. When the paper is covered completely, from left to right, the stylus is returned automatically to the left side of the drum so that it will be ready to record the next transmitted copy.

This basic RD-92( )/UX facsimile recorder was updated to meet NATO requirements of 60-90-120 lpm by modifying the recorder and using a combined pair of equipment units to get desired results. The modified model RD-171( )/UX operates from 60-90 lpm; the RD-160( )/UX operates from 60-120 lpm; and the RD-172( )/UX operates from 90-120 lpm. Any two combinations meet requirements of 60-90-120 lpm.

FACSIMILE RECORDER AN/UXH-2( )

A more modern facsimile recorder than the one just described is the model AN/UXH-2( ) shown in figure 6-17. Instead of recording on paper attached to a revolving drum, the AN/UXH-2( ) makes direct recordings across a continuous page of paper. Paper and carbon are supplied from a roll within the machine.

Recording is accomplished by using three recording heads that are carried across the page

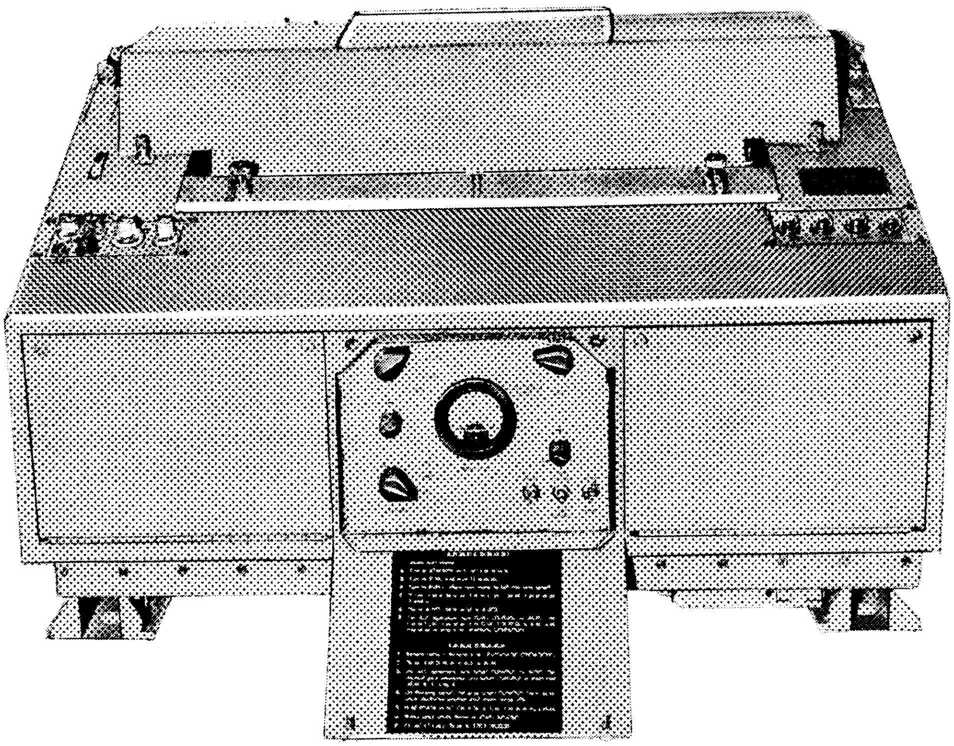

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Figure 6-17.—Facsimile Recorder AN/UXH-2.

on a rubber belt. The heads are spaced on the belt so that only one head is touching the paper at any given time, and the speed at which this head moves across the paper is the same as the scanning speed at the transmitter. Recording speeds can be 60, 90, 120 scans per minute, making this recorder compatible for operation with most Navy facsimile transmitters.

When receiving signals from a transmitter capable of sending the necessary control signals, the AN/UXH-2C can be left unattended. Upon receipt of the proper signals, it automatically phases, starts recording at the beginning of a transmission, stops when the transmission is complete, and compensates for changes in signal level during the recording.

ALDEN 519M(T)-BA MARINE RADIO FACSIMILE WEATHER MAP RECORDER

The Alden 519M(T)-BA Marine Radio Facsimile Weather Map Recorder (fig. 6-18) is a facsimile receiving and recording unit used for the display of transmitted weather charts and other facsimile information. This unit is made up of essentially five primary assemblies: electromechanical recording head, radio receiver, recording amplifier, facsimile converter and the console.

Recording is accomplished by using two electrodes between which a special moist electrosensitive paper is passed. The unit is capable of recording speeds of 60, 90, 120 scans per minute and will start/stop automatically upon receipt of the proper signals.

AN/UXC-4 ( ) (V) TACTICAL DIGITAL FACSIMILE (TDF)

This system replaced the previously described AN/UXH-2 and the Alden 519M(T)-BA.

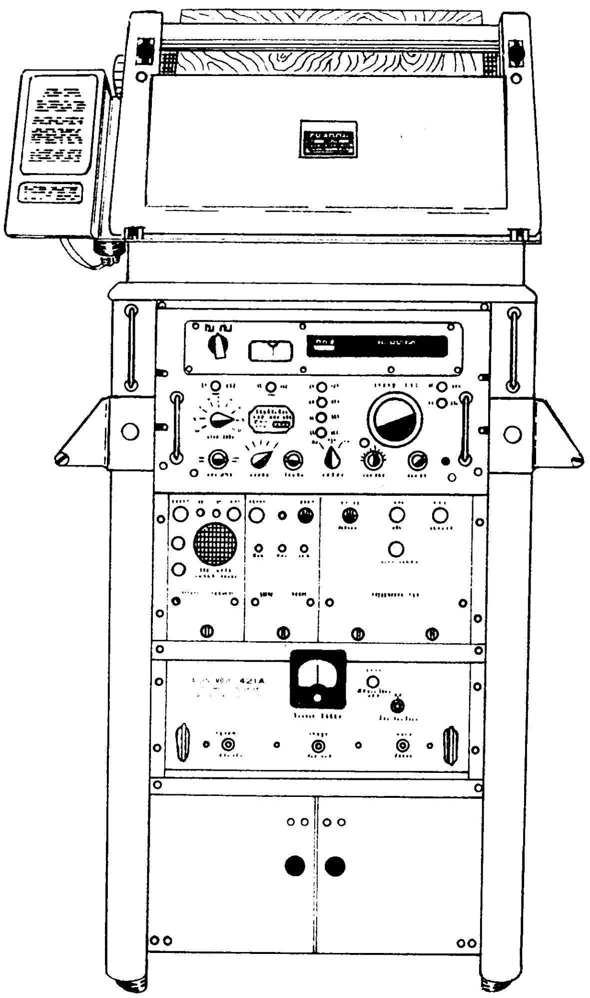

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Figure 6-18.—Alden 519M(T)—BA Marine Radio Facsimile Weather Map Recorder.

This program consists of the following units:

TACFAX (Tactical Facsimile)
MET (Analog Meteorological Facsimile Reception Interface Unit)

The equipment provides a communication capability that is configured for rapid and encrypted transmission and reception of low resolution black and white graphical material. It is also capable of receiving weather information from the World Meteorological Organization (WMO).

The TDF has Department of Defense applications. It will be installed and operated on shore-based command centers, ships, military aircraft (airborne command posts and ASW patrol aircraft), transportable shelters, vehicle-mounted field communication vans, and wheeled and tracked vehicles. It will transmit classified and unclassified documents over standard switched and point-to-point voice and data channels.

TACFAX

The TACFAX unit is configured for rapid and secure transmission and reception of low resolution from black and white graphical material up to 16 shades of gray. TACFAX provides full, as well as half-duplex facsimile capability for communicating photographs, fingerprint records, maps and map overlays and handwritten as well as typewritten documents. TACFAX is capable of operation via 1.2 to 16 kbps wire and communication channels. The alphanumeric print capability of the TACFAX is limited to receiving only at data rates of 45.5, 50.0, 75, 150, 300, 600 and 1200 baud.

MET

Employing the MET, TACFAX is capable of receiving WMO broadcast transmissions. The module accepts the analog fax input signals and converts them to digital output signals that are compatible with the TACFAX receiver. Large format (18-inch wide) meteorological charts are recorded by the TACFAX receiver in nominally one-half scale at doubled resolution to retain all transmitted details in the output copy.

New Features, Configuration, or Material

The TDF employs the latest state of the art in electronic technology including solid state microelectronic techniques. Power input to the TDF equipments uses a connector separate from that used for signals, controls, and timing.

KEYER ADAPTER KY-44( )/FX

For frequency carrier-shift transmission, the amplitude modulated audio signal from the

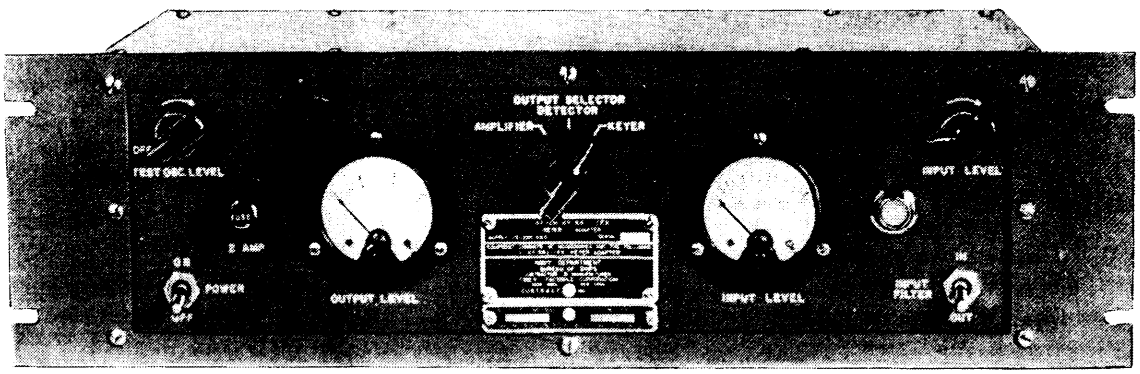

Figure 6-19.—Keyer Adapter KY-44( )/FX. 70.81

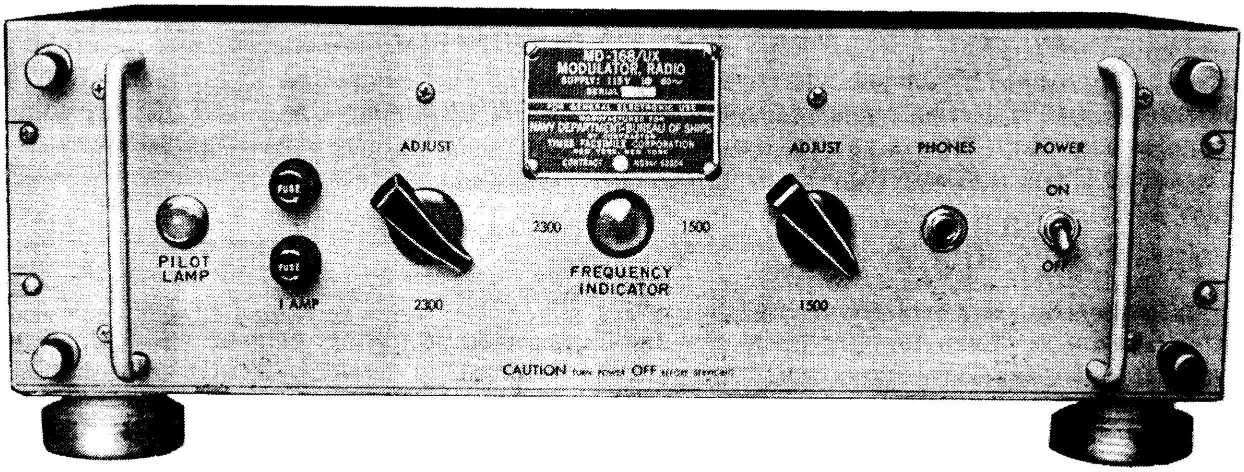

Figure 6-20.—Modulator MD-168( )/UX. 70.82

facsimile transmitter must be converted to d.c. keying voltages before being applied to the frequency shift keyer. This is the function of Keyer Adapter KY-44( )/FX shown in figure 6-19.

The output of the adapter is a d.c. signal that varies in amplitude from 0 to 20 volts, depending on the frequency of the audio input signal. When the d.c. signal is used to key a frequency shift keyer, and when the frequency shift keyer, in turn, is controlling a radio transmitter, the end result is a transmitted frequency carrier-shift signal similar to a radioteletype signal. This method of transmitting facsimile signals is generally used with hf transmitters employing fsk to enhance long range communications.

MODULATOR MD-168( )/UX

For transmission of facsimile signals by the audio frequency shift method, a radio modulator, such as the MD-168( )/UX (fig. 6-20), is required between the facsimile transmitter and the radio transmitter. The modulator converts the amplitude-modulated signal from the facsimile transmitter to constant amplitude frequency modulation, which varies at frequencies between 1500 and 2300 Hz. This frequency variation is used to modulate the radiotelephone transmitter. Modulator MD-168( )/UX can be employed with any transmitter capable of being voice modulated. In general, the audio frequency shift method is used for short-range transmissions.

FREQUENCY SHIFT CONVERTER CV-172( )/U

With either the frequency carrier shift or the audio frequency shift methods of transmitting facsimile signals, the output of the radio receiver at the receiving station is an audio frequency shift signal of constant amplitude. The function of Frequency Shift Converter CV-172( )/U (fig. 6-21) is to convert the receiver's output to an amplitude-modulated signal that varies between 1200 and 2300 Hz, which is the signal required for proper operation of the facsimile recorder.

The CV-172( )/U is not the only frequency shift converter used by the Navy in facsimile installations, but it is the one most commonly found aboard ship. Others you may encounter are models CV-97/UX and the CV-1066( )/UX. They all perform the same function.

SIMPLEX FACSIMILE SYSTEM

A simplified block diagram of a simplex facsimile system is shown in figure 6-22. On the transmit side a 2400 Hz carrier (amplitude modulated corresponding to the various shades of the copy to be transmitted) is produced at the output of the transmitter section of Facsimile Receiver-Transmitter TT-321A/UX and fed to Radio Modulator MD-168A/UX. The MD-168A/UX converts the AM signals to AFTS signals which modulate the rf carrier generated by the transmitter. The transmitter carrier is modulated plus or minus 400 Hz.

If the RFCS method of transmission is to be used, the facsimile receiver-transmitter output is fed to Keyer Adapter KY-44C/FX. Keyer Adapter KY-44C/FX converts the TT-321A/UX AM signal output into d.c. keying signals suitable for use with a frequency-shift exciter unit.

The receiver output (fig. 6-22) is AFTS signals from 1500 Hz to 2300 Hz or 2300 Hz to 3100 Hz, depending upon the setting of the receiver beat-frequency oscillator (bfo). These AFTS signals are fed to Frequency-Shift Converter CV-1066B/UX, where they are converted into equivalent AM signals suitable for operating the facsimile recorder.

TEMPEST

Compromising emanations (ce), generally referred to as TEMPEST, are unintentional

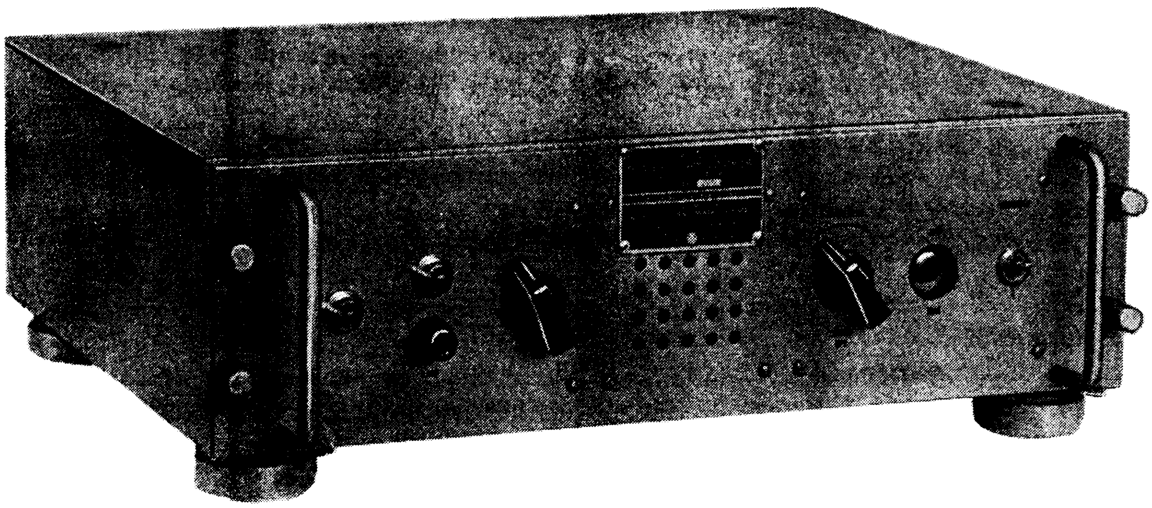

Figure 6-21.—Frequency Shift Converter CV-172( )/U. 70.85

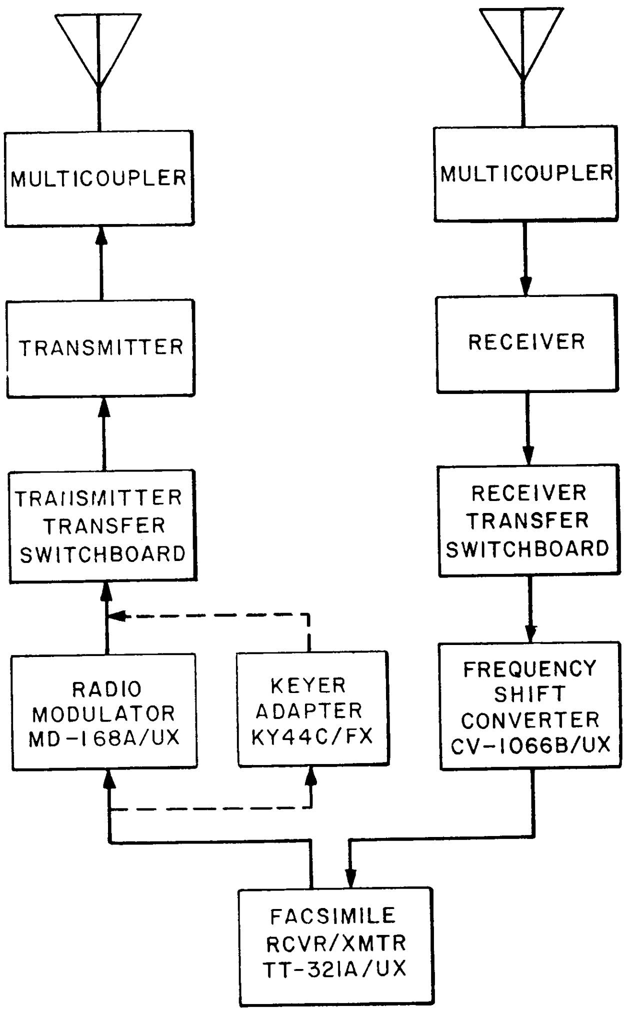

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Figure 6-22.—Facsimile system, AFTS and RFCS modes.

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. Any electrical information processing device, whether an ordinary electric typewriter or a large complex data processor, may emit interceptable compromising emanations. Certain countermeasures are taken to ensure against ce such as:

1. Equipment designs in which ce is suppressed
2. Approved installation criteria that limit interaction between classified and unclassified signal lines, power lines, grounds, equipment, and systems
3. Low level keying and signaling (discussed in this chapter)
4. Shielded enclosures for equipment installations
5. Proper/shipboard grounding of equipment including proper ground straps

The Navy uses MIL-STD-1680 (SHIPS), Installation Criteria for Shipboard Secure Electrical Information Processing Systems as the definitive guidance for TEMPEST. The EMO must have a thorough working knowledge of the requirements outlined in MIL-STD-1680 (SHIPS) to be able to ensure that all system modifications are properly installed and inspected. TEMPEST familiarization courses are taught at all MOTU locations. EMOs should take advantage of the service. It is of paramount importance.

COMMUNICATIONS SECURITY (COMSEC) EQUIPMENT REPAIR AND MAINTENANCE

COMSEC equipment requires special handling during repair and maintenance procedures. Guidance for the EMO may be found in the Communications Security Publication Memoranda (NTP-7).

Most information in these memoranda is classified; however, general unclassified information is provided in the following paragraphs.

NTP-7 provides guidance on repairing and maintaining COMSEC equipment and supporting material.

In coordination with the CMS custodian, the user of COMSEC equipment must arrange with a Cryptographic Repair Facility (CRF) for inspection and overhaul or any repair and maintenance of equipment beyond the capability of the user's maintenance personnel.

In the interest of economy, COMSEC equipment will, if possible, be maintained by qualified personnel attached to the user's command or activity. NTP-7, defines unlimited and limited maintenance qualifications and lists cryptorepair courses and school locations. Limited maintenance procedures for certain equipment are outlined in the associated KAM (cryptographic maintenance manual.) Limitations or stipulations of the degree of repair that may be performed are also stated.

The three general categories of COMSEC equipment maintenance are:

1. Organization Maintenance. Maintenance that is authorized for, performed by, and the responsibility of, a using organization on its own equipment. This consists normally of the inspecting, cleaning, servicing, preserving, lubricating, and adjusting of equipment by authorized personnel. It may also include minor parts replacement not requiring highly technical skills. Operators should receive indoctrination and training from MOTU activities or their own COMSEC equipment repair personnel on how to do this work, while referring to related KAM or KAO (cryptographic operating manuals) for specific instructions.

2. Intermediate (or Field) Maintenance. Maintenance that is authorized and performed by designated maintenance activities in direct support of using organizations or by qualified COMSEC equipment repair personnel attached to a using command or activity. It is normally limited to replacement of unserviceable parts, subassemblies, or assemblies by cleared personnel who graduated from a cryptorepair school for a specific model or type of COMSEC equipment. See NTP-7.

3. Depot Maintenance. Maintenance which involves a major overhaul or complete rebuilding of parts, subassemblies, or the equipment itself. This maintenance is intended to augment stocks of serviceable equipment or to support lower levels of maintenance by using more extensive shop equipment and personnel of higher technical skill than are available in organizational or field maintenance activities.

Tender or yard overhaul of ship COMSEC equipment should normally be done by a CRF.

Where necessary, commands or activities should request authority from CHNAVMAT through their chain of command to establish, reclassify, or disestablish a CRF afloat or ashore. Planned usage, space, power, and test equipment type and quantity available or needed shall be listed. Fleet units and commands outside CONUS should also submit their requests via the appropriate service force and fleet commanders. A copy of the correspondence will be furnished COMNAVSEASYSCOM for afloat requirements and to NAVELEXSYSCOM PME 110-23 and COMNAVTELCOM for all CRF requirements.

Unless excepted by higher authority, every communications, electronics, and cryptographic equipment, ancillary, support kit and related test set should be complete and operable and ready for transfer at all times to the best repair capability and logistic capacity of the using command or activity. Emphasis should be placed on determining defects and correcting them, and, when replacement parts are not carried or have been used up, on the expeditious submission of requisitions to the supply system. MILSTRIP forms should not be accumulated for one-time preparation and lot submission to a supply point at a later date or on a delayed basis. For example, an afloat unit with mail service should request replacements by mail, or by electrical means (if the situation warrants), prior to return to port. Replacement parts not on hand should be requisitioned as the defects occur.

The basic criteria and guidelines in CSPM-1 should be brought to the attention of operating and maintenance personnel concerned with the installation, operation, maintenance, and repair of COMSEC equipment. COMSEC component ordering should be in conformance with SPCC Instruction 5511.24 (Series).