AACSM 100-6

AIRWAYS AND AIR COMMUNICATIONS SERVICE MANUAL

(USAF)

USAF GLOBAL COMMUNICATIONS SYSTEM ENGINEERING

DEPARTMENT OF THE AIR FORCE

Major Weatherbee

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1 JUNE 1956

AIRWAYS AND AIR COMMUNICATIONS SERVICE
MILITARY AIR TRANSPORT SERVICE
UNITED STATES AIR FORCE
Washington 25, D. C., *1 June 1956*

Foreword

1. *Purpose.* This manual describes the types, general arrangements, interconnections, and utilization of equipments used in the United States Air Force Global Communications System (Globecom). It also describes the capabilities and limitations of the facilities and various types of circuits which compose Globecom.

2. *Applicability.* This manual is informative in nature and is published for the information of Air Force personnel who require a knowledge of the system concept, the circuitry, and the equipment components of Globecom.

3. *Scope.* Since this manual is primarily concerned with the engineering aspects of Globecom, operational and maintenance procedures are not described since such procedures are outside the scope of the primary concern.

4. *Arrangements of Text:*

a. The format of this manual conforms with AFR 5-22, "Publications: Air Force Manuals." The variety of material pertinent to the objective of the manual is presented in a manner and sequence that is considered to be the most logical and comprehensible.

b. This manual is intended to be an exposition of the concept of the current function and circuitry of Globecom; it is not intended to be a textbook or a maintenance manual. The theory of operation of equipment is presented only to the extent necessary to more clearly present the functions of the equipment in the system. Detailed and comprehensive descriptions of circuit components, as well as of theories of operation and operating and maintenance procedures, are contained in current Technical Orders and commercial manuals.

c. In order to present most clearly the concept of a Globecom station, a typical beltline station and Communication Plan were developed, and the manual has been divided into seven parts to describe the components of the station. Although the antenna, power and intersite facilities are common to the three sites that compose the station, each facility is discussed in its respective part of the manual in the same manner in which the three sites are discussed. Consequently, the manual is divided into major parts as follows:

(1) Part One, "The USAF Global Communications System."
(2) Part Two, "Antenna Facilities."
(3) Part Three, "Receiver Site."
(4) Part Four, "Transmitter Site."
(5) Part Five, "Communications Relay Center."
(6) Part Six, "Power Facilities."
(7) Part Seven, "Intersite Facilities."

d. The typical station developed to serve as the medium for presenting the Globecom engineering concept is not identified with any one Globecom station, but is, rather, a composite of Globecom stations; and the circuits selected for this typical station are representative of those that may be encountered in any Globecom station.

5. *Authority.* This manual is published under authority delegated to the Commander, Airways and Air Communications Service, in AFR 20-51 and AFR 55-15.

6. *Changes.* Changes to this manual will be accomplished in accordance with AFR 5-22.

BY ORDER OF THE COMMANDER:

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PART ONE

THE USAF GLOBAL COMMUNICATIONS SYSTEM

Chapter 1

INTRODUCTION

1-1. General

a. The USAF Globecom Communications System, hereafter referred to as Globecom, is the world-wide, long-range, teletypewriter and facsimile point-to-point and air-ground voice communication system designed for control of air operations on a global scale. It is officially known as the USAF Strategic Communications System.

b. Globecom comprises a system of interconnected Air Force radio stations together with leased or allocated long-distance wire and radio channels (see fig. 1-1). It does not include local tactical and special-purpose communications circuits except as directed by Headquarters, USAF. Globecom facilities are available for use by all echelons of the USAF, and long-distance circuits may be permanently or temporarily allocated to any approved user.

c. The typical station developed for this manual is a Globecom beltline station. The Communication Plan for the station is shown in figure 1-2. The typical station is Alfa, and the adjacent beltline stations are Delta and Juliet. Bravo, Coca, Golf, Hotel, Kilo, and Lima are tributary stations associated with Alfa. Echo, Foxtrot, and India are connected to Alfa through landlines which are backed up by radio circuits. Facsimile and radio teletypewriter weather broadcast, a CW weather intercept, and ten air-ground voice channels also are assigned to station Alfa. Base Operations, Base Weather, and the Base Message Center are connected to the station by landline to receive messages addressed to the station.

1-2. Systems Characteristics

It is essential in the study of Globecom that the reader have a clear understanding of the prime concepts and policies that governed the engineering of the USAF Global Communications System.

a. *Communication System.* A communication system may be defined as a collection of individual circuits, of compatible electrical characteristics and appropriate switching facilities, which are capable of fast and reliable interconnection and interoperation with circuits of similar type, with adequate provision to overcome normal degradation of the signals in the interconnected links.

b. *Concept of Facilities.* There are elements of the USAF located at many places in the world, and it is logical that there must be a system of electrical communications facilities for support and control of these far-flung air units. This system has become know as Globecom. At any time, some area of the world may become embroiled in an emergency which would seriously affect our national security. This consideration alone, and there are many others, makes it necessary that any one of these elements have the capability of rapid and direct communi-

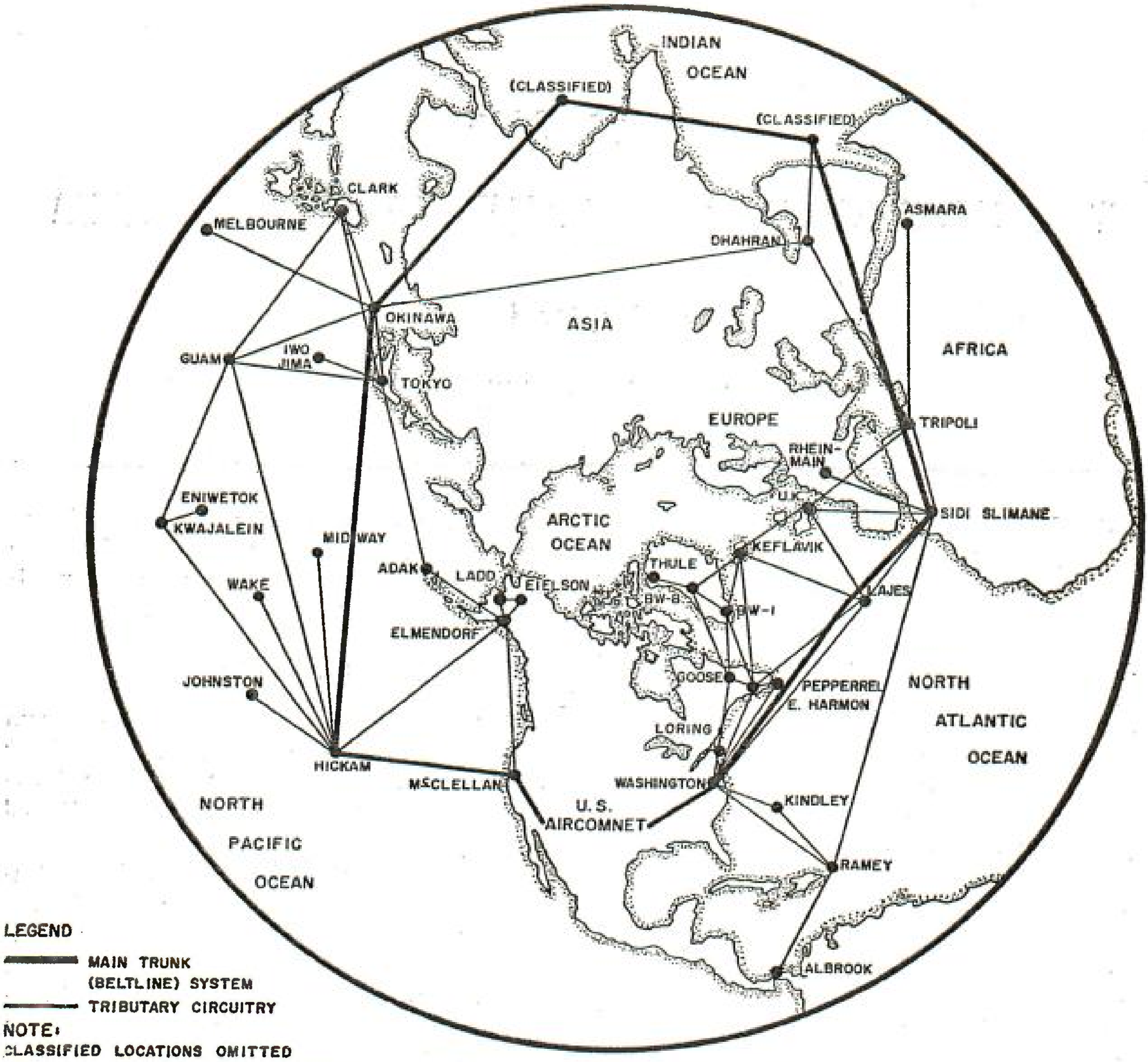


Figure 1-1. Major Globecom Point-to-Point Circuit Objective.

cations with any other element in the system, regardless of location.

(1) In order that any one element may have the capability of communicating with any other element, all components of the system, such as terminal equipment, switchboards, keyers, transmitters, and receivers must be designed functionally in a similar fashion. For instance, one terminal of a teletypewriter circuit based on a 6-unit code principle cannot operate with a distant teletypewriter facility based on a 5-unit start-stop code principle.

(2) Probably the best example of a communication system in the United States is the telephone system operated by A. T. & T. Consider for a moment the speed and ease with which a telephone subscriber in Philadelphia can talk with a subscriber in Los Angeles. Between these two points is a variety of circuit media: open wire, cable, or radio, plus a maze of switching, testing, carrier, and repeater facilities, all of which have to be electrically compatible and have to fit into a "system" so that any subscriber can communicate with any other subscriber.

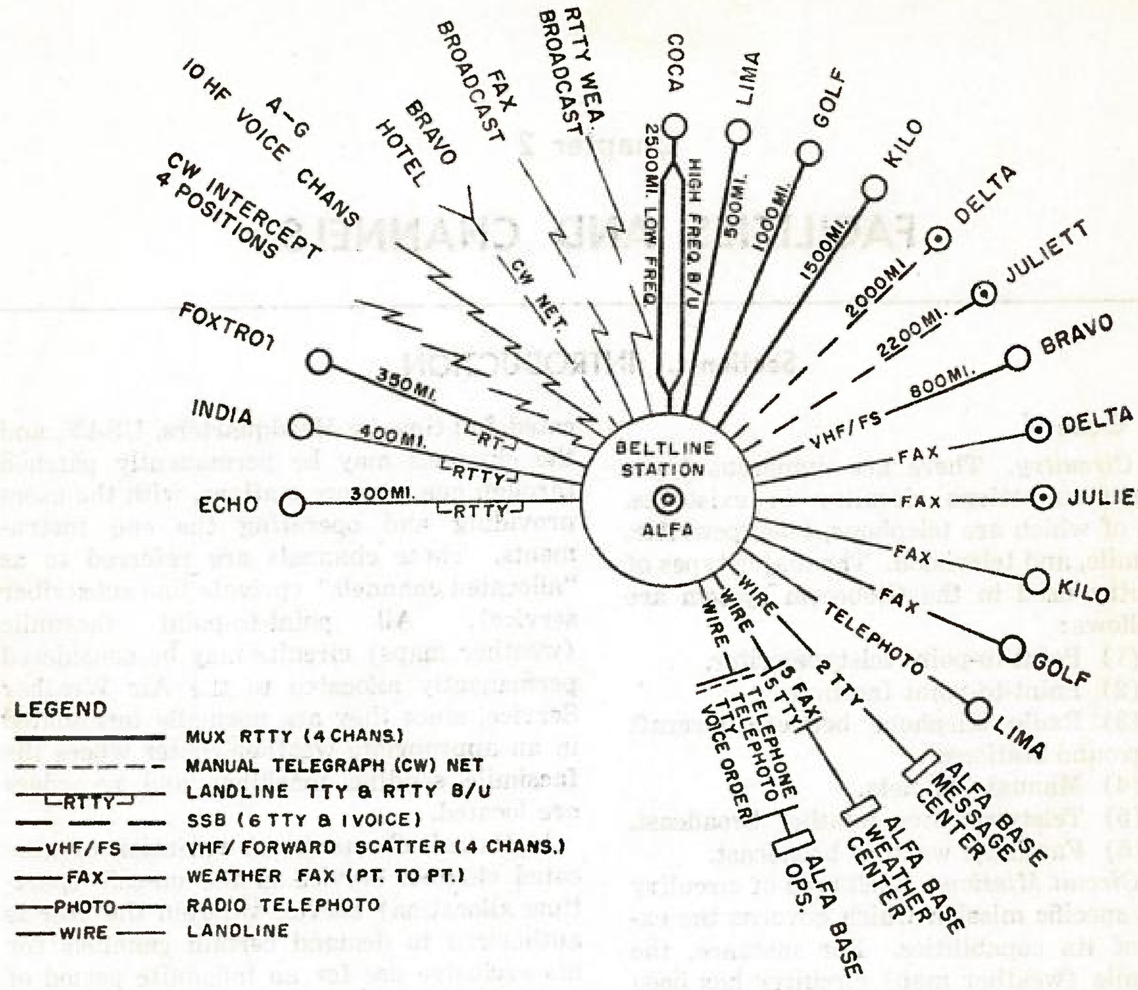


Figure 1-2. Communication Plan for Typical Beltline Station.

If an east coast system had been conceived and designed independently of a west coast system, then interoperation between the two would not be possible, and there would not be a nationwide telephone communication system.

c. *Concept of Flexibility.* Not only must the Globecom system have complete flexibility within itself, but it must also be fully capable of interoperation with point-to-point communications systems of the Army and Navy. It would be sheer folly to permit the growth of three separate systems incapable of interconnection and interoperation with each other, particularly in these times of joint military operations. Consequently, Globecom was developed within the framework of "Military Communication System Technical Standards" adopted by the Department of Defense. These standards are intended to insure the provision of equipment components to the several services, with compatibility of equipment to the extent, at least, of generating and receiving signals of like electrical characteristics even though tactical needs (such as size, weight, or service condition) may require special physical characteristics for the individual service.

Chapter 2

FACILITIES AND CHANNELS

Section I. INTRODUCTION

1-3. General

a. *Circuitry.* There are numerous types of communications circuitry in existence, some of which are telephone, teletypewriter, facsimile, and television. The major types of circuitry used in the Globecom system are as follows:

(1) Point-to-point teletypewriter.

(2) Point-to-point facsimile.

(3) Radio telephone between aircraft and ground stations.

(4) Manual CW nets.

(5) Teletypewriter weather broadcast.

(6) Facsimile weather broadcast.

b. *Circuit Missions.* Each type of circuitry has a specific mission which governs the extent of its capabilities. For instance, the facsimile (weather map) circuitry has been designed for scheduled map transmission; if at some future time voice line-up procedures should be employed, certain technical modifications of the facsimile circuits would be necessary. Likewise, communications circuitry between aircraft and ground stations has been designed for voice operation; if teletypewriter communications should be required in the future, additional equipment in the ground facilities, as well as in the aircraft, would be necessary.

1-4. Channelization

a. *Allocated Channels.* A teletypewriter circuit may contain from one to sixteen channels. Some users of Globecom teletypewriter facilities have sufficient volume of traffic to justify full-time use of one or more channels. For these users, channels may be allocated full-time by Headquarters, USAF, and the channels may be permanently patched through one or more stations, with the users providing and operating the end instruments. These channels are referred to as "allocated channels" (private line subscriber service). All point-to-point facsimile (weather maps) circuits may be considered permanently allocated to the Air Weather Service, since they are normally terminated in an appropriate weather center where the facsimile sending machines and recorders are located.

b. *On-call Channels.* A variation of allocated channel service is the on-call (part-time allocation) service wherein the user is authorized to demand certain channels for his exclusive use for an indefinite period of time. This type of service is available only to authorized agencies having vital national defense missions.

c. *Common User Channels.* A major mission of Globecom is to furnish teletypewriter message relay service between elements of the USAF. This type of service meets the needs of users whose message traffic volume is insufficient to justify allocation of channels. In this type of service, messages are prepared according to established procedures and are relayed through the Globecom system from originator to addressee.

1-5. Station Facilities

A Globecom station is normally comprised of three separate facilities: the Transmitter Site, the Receiver Site, and the Relay Center.

a. *Transmitter and Receiver Sites.* The

Transmitter and Receiver Sites are usually established at separate locations off base and at varying distances, but with a minimum of eight miles separation between sites. The separation of sites is necessary to isolate the receiving equipment from intense electrical fields developed by the transmitters. Normally, troop mess and quarters are provided at remote sites.

b. *Relay Center*. The Relay Center may be located either on or off an air base. The most recent policy prescribes an off-base location. When situated off-base, it may share a site jointly with the transmitter or receiver facilities and may or may not be in the same building. The location of the Communication Relay Center with respect to the base determines whether troop housing will be constructed at the site. The Message Center should not be confused with the Relay Center. The Relay Center is the switching facility for Globecom circuits and does not normally house the base Message Center, although it may do so in specific instances. The Base Message Center normally is located on the base at the direction of the base commander. Just as the name implies, the Relay Center is responsible only for relaying traffic, all of which originates at some other point. The function of the Message Center is to serve as a "clearing house" for messages between the various base activities and other points.

c. *Intersite Links*. The remote (off-base) installations are tied together through the Relay Center by Intersite facilities. Usually microwave radio link equipment provides the communications between the Relay Center and Receiver Site and between the Relay Center and Transmitter Site. This equipment operates at frequencies in the vicinity of 7000 megacycles. The equipment now used for these links provides up to 24 voice channels, each of which can be further channelized to accommodate a number of teletypewriter narrow-band channels. At some stations, it is economically more feasible to link the three sites with telephone cable or v.h.f. radio link. Regardless of the method selected, a back-up link (microwave, cable, or v.h.f.) will be provided. Any combination of primary and back-up links may be encountered.

Section II. TYPES OF CIRCUITS

1–6. Point-to-Point Circuits

a. The network of circuits in the Globecom system is substantially as shown in figure 1–1. The main feature of this system is the trunk circuitry, known as the "Beltline", which encircles the world and usually is provided with high-powered transmitters. The Beltline consists of seven stations joined together by multi-channel single sideband circuits and facsimile circuits implemented using conventional double sideband equipment. The single sideband circuits provide for the transmission of two independent group frequencies, one of which is utilized for six teletypewriter channels and the other utilized for a voice channel. Facsimile circuits provide transmission and reception of weather map information and other pictorial presentations between Beltline stations.

b. Tributary circuits may include types of communications similar to those described for the Beltline circuit, and, in addition, may provide for continuous wave (CW), single-channel radio teletypewriter (RTTY), and four-channel multiplex radio teletypewriter (MUX) operation. The CW, RTTY, and MUX circuits are all implemented with double sideband equipments.

1–7. Air-Ground Circuits

a. The air-ground voice circuits of the system are, in a sense, extensions of the point-to-point teletypewriter network. Not only does the air-ground station carry out its regular air traffic mission of handling position reports and other enroute data, but it relays messages between the aircraft and the point-to-point network as well.

b. An air-ground station is located at each Globecom station. The station operates on groups of from four to fourteen frequencies, depending upon the location of the station. The present policy is to provide voice operation only, but certain voice air-ground stations that were developed in early stages of the Globecom program have provisions for manual CW operation. Also, certain air-ground stations use CW operation to satisfy ICAO and Weather Reconnaissance responsibilities.

1-8. Weather Broadcast Circuits

Certain stations throughout the system are equipped with facilities for receiving the blind transmission of weather information. These stations are selected to provide adequate signal reception by interested Air Force installations throughout the world. Both single-channel radio teletypewriter and radio facsimile intelligence are transmitted by conventional double sideband equipments.

1-9. Frequencies

Globecom circuits are operated in three different frequency bands: low frequency (LF), from 30 to 300 kilocycles; high frequency (HF), from 3 to 30 megacycles; and very high frequency (VHF), from 30 to 300 megacycles. By far the greater majority of circuits, including air-ground and weather broadcast, utilize the HF band. The LF and VHF bands, when employed, are used principally for tributary circuits in the far northern areas of the world. The LF and VHF band frequencies are utilized for certain circuits since they are not as susceptible as are high frequencies to the undesirable atmospheric effects encountered in northern areas which degrade the HF circuits for long periods of time.

Chapter 3

ENGINEERING FEATURES

1-10. Circuit Characteristics

a. *Propagation Characteristics.* Radio frequency propagation characteristics were calculated for each circuit path to determine the proper operating frequencies, critical angles of wave arrival and degree of absorption. These factors dictated design of the antennas. All circuits are designed for optimum operation throughout each 24-hour period during the entire eleven-year sunspot cycle.

b. *Rhombic Antennas.* A single rhombic antenna is not efficient over the entire band of radio frequencies required for day and night operation. Consequently, two separate transmitting antennas, properly designed, are provided for each circuit, one for the lower frequencies and one for the higher frequencies of the HF band. Rhombic antennas are used for space diversity reception which requires two low-band and two high-band receiving antennas for each HF circuit.

1-11. Frequency Change-Over

In the course of an operating day, it is usually necessary to change frequency at least once in order to meet the requirements imposed by varying propagation conditions. Since there is no certainty, except by actual test, that a particular frequency is suitable at a particular time, much circuit outage can occur during change-over periods. To reduce such outage, facilities have been provided on point-to-point HF circuits to test the suitability of the new frequency before diverting traffic from a working circuit.

1-12. Frequency Control

It is mandatory that transmitters and receivers be kept on the assigned operating frequency (within certain tolerances) if destructive adjacent-channel interference is to be avoided. This is accomplished by crystal frequency control of both the transmitting and receiving ends of all circuits. Furthermore, in time of war, deliberate attempts are made by the enemy to interrupt communications by creating destructive interference. Since any system depending upon a fixed group of frequency assignments would fail under such interference, other means of frequency control are provided which have the same stability as those which are crystal controlled but which provide complete flexibility for changing frequencies rapidly.

1-13. Technical Control Facilities

a. To insure the proper operation of the point-to-point communications system, means have been provided for rapid coordination between the terminals of all circuits. This coordination must go beyond the mere ability to talk from one terminal to the other. Precise measurements of circuit variables must be made as the need arises, and facilities for taking these measurements are provided.

b. A means to rapidly perform all patching, switching and equipment transfer operations is provided to insure efficient circuit performance and a minimum of circuit interruption. Provision is made within the station circuit arrangements for the isolation of any major equipment for servicing or reassignment to other than its normal circuit function. The capability is also provided to monitor the condition of equipment and circuits both at the equipment itself and at some centrally located point in each of the three sites.

1-14. On-Line Encryption

In the engineering of Globecom, provision is made for automatic encryption of all teletypewriter traffic between any two points in the system. Provision is also made to by-pass the crypto apparatus if clear text operation should be prescribed for any reason. The number of channels, circuit priority, key distribution, and other security factors establishing the manner in which on-line encryption is to be introduced to the system will be directed by Headquarters, USAF.

1-15. Power

The communications equipment used in the Globecom system includes many components which are voltage and frequency sensitive to the extent that stable sources of power must be provided. Base power, when sufficiently reliable and stable, is used as the primary source for on-base facilities. Base power sources are seldom used to supply the remote sites because of the vulnerability and cost of electrical transmission lines. Commercial power, when suitable and available, may be used as a primary source at the remote sites. In Globecom, power generating equipment is provided at each of the three sites. If base or commercial power is provided, Globecom power generating equipment is supplied for emergency use only. If base or commercial power is not available, primary and back-up power generating plants are furnished for each site.

Chapter 4

TYPICAL CIRCUITS

1-16. General

In order to understand the Globecom system, it is necessary to know the type of circuits in general use. The circuits discussed in the following paragraphs are the types encountered at Globecom stations.

1-17. Radio Telegraph

a. *Manual Radio Telegraph (CW) Transmitting Circuit.*

(1) A typical manual radio telegraph transmitting circuit is shown in figure 1-3. Operation of the manual key opens and closes a direct-current (DC) circuit, sending DC pulses to the narrow-band voice frequency telegraph (VFTG) tone keyer. This tone keyer converts the DC pulses to frequency-shift (FS) audio signals which are sent to the CMT-4 Time Division Multiplex Equipment. One voice band channel of the CMT-4 equipment will pass the output frequencies of one group of twelve narrow-band VFTG tone keyers. The CMT-4 transmitting terminal samples each channel with narrow pulses, and the amplitude of these pulses is caused to vary with the amplitude of the input signal. All twenty-four voice band channel outputs of the CMT-4 are combined to form one common pulse amplitude modulated (PAM) signal. This PAM signal is coupled to the CLR-6 Microwave Radio Link Equipment by coaxial cable and is used to frequency modulate the CLR-6. A waveguide connects the frequency-modulated radio frequency output of the CLR-6 to a parabolic antenna where it is focused into a narrow beam and directed to the Transmitter Site.

(2) At the Transmitter Site, the incoming signal is intercepted and coupled to the CLR-6 through waveguide. The CLR-6 demodulates and amplifies the signal and couples the resultant PAM signal to the CMT-4 by coaxial cable. Separation of the pulses into the original twenty-four separate voice band channels is accomplished in the CMT-4 receiving terminal. Within each voice band channel the pulses are detected, and the amplitude variation is coupled to the channel output. The output of the one channel containing the twelve frequency-shift audio tones is connected to the input of the VFTG tone converter group. The individual VFTG tone converters accept only those tones that are associated with it and convert them to DC pulses. The one tone converter associated with the CW signal uses the DC pulses to key the transmitter on and off.

b. *Manual Radio Telegraph (CW) Receiving Circuit.*

(1) A typical manual radio telegraph (CW) receiving circuit is shown in figure 1-4. The incoming CW signal is intercepted by the antenna and coupled through an RF jack panel to the AN/FRC-502 receiver. The high frequency oscillator (HFO) of this receiver is crystal controlled, but the beat frequency oscillator (BFO) is remotely controlled. The output of the receiver is an on-off audio tone. This on-off audio tone is coupled into one voice band channel of the CMT-4 transmitting terminal. The PAM output of the CMT-4 is used to frequency modulate the CLR-6 microwave equipment. The RF output of the CLR-6 is beamed to the Communications Relay Center.

(2) At the Communications Relay Center, the incoming RF signal is amplified and demodulated by the CLR-6, and the

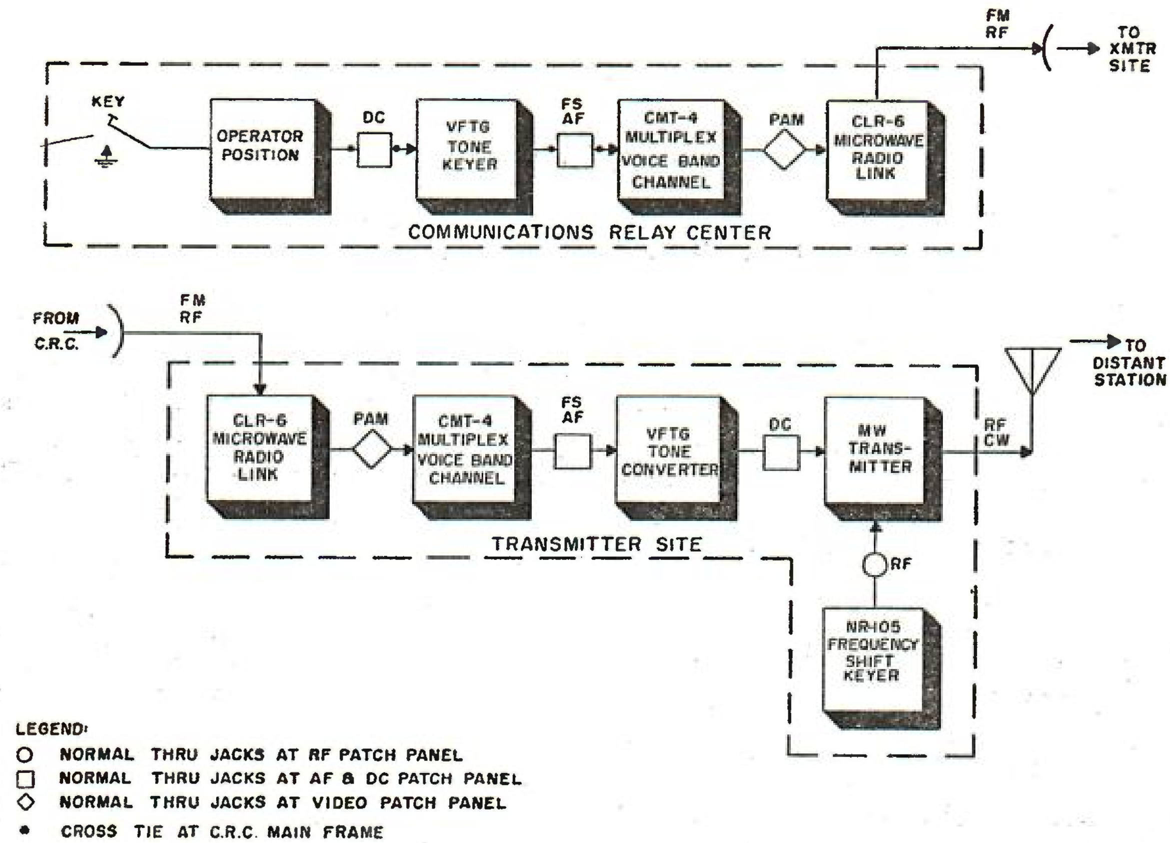


Figure 1-3. Typical Manual Radio Telegraph (CW) Transmitting Circuit.

resultant PAM signal is coupled to the CMT-4 receiving terminal. The demodulated audio on-off signal output of the CW channel of the CMT-4 is passed to the operator's position where it is amplified in an audio amplifier and coupled to the headphone circuit.

(3) Remote tuning of the BFO is accomplished by a potentiometer on the operator's console. The potentiometer controls the amplitude of the audio tone output of the tone oscillator. The tone oscillator puts out thirteen tones, twelve of which are used to control the HFO's and BFO's of up to six receivers; the thirteenth tone, called "pilot tone", is maintained at a constant amplitude and used as a reference tone. The thirteen tones are combined and coupled to one CMT-4 voice band channel. The CMT-4 samples the input tones in the voice band channel, combines the channel with the other channel, and applies the combination as a pulse amplitude modulated signal to the CLR-6. The PAM signal is used to frequencv modulate the klystron oscillator of the CLR-6, and the RF output of the CLR-6 is beamed back to the Receiver Site.

c. *Manual Radio Telegraph (CW) Intercept Receiving Circuit:*

(1) A typical manual CW receiving circuit for weather intercept is shown in figure 1-5. Because the receiver frequently must be manually tuned, the operator's position is located at the Receiver Site instead of at the Communications Relay Center. The incoming signal is received, amplified and detected, and the receiver output is coupled directly to headphones. The operator interprets the incoming code and copies it on a teletypewriter. Any necessary retuning of the receiver is accomplished directly by the operator. The DC teletypewriter signal output is used to key a VFTG tone keyer. This tone keyer converts the DC pulses to frequency shift audio tones. The output of this

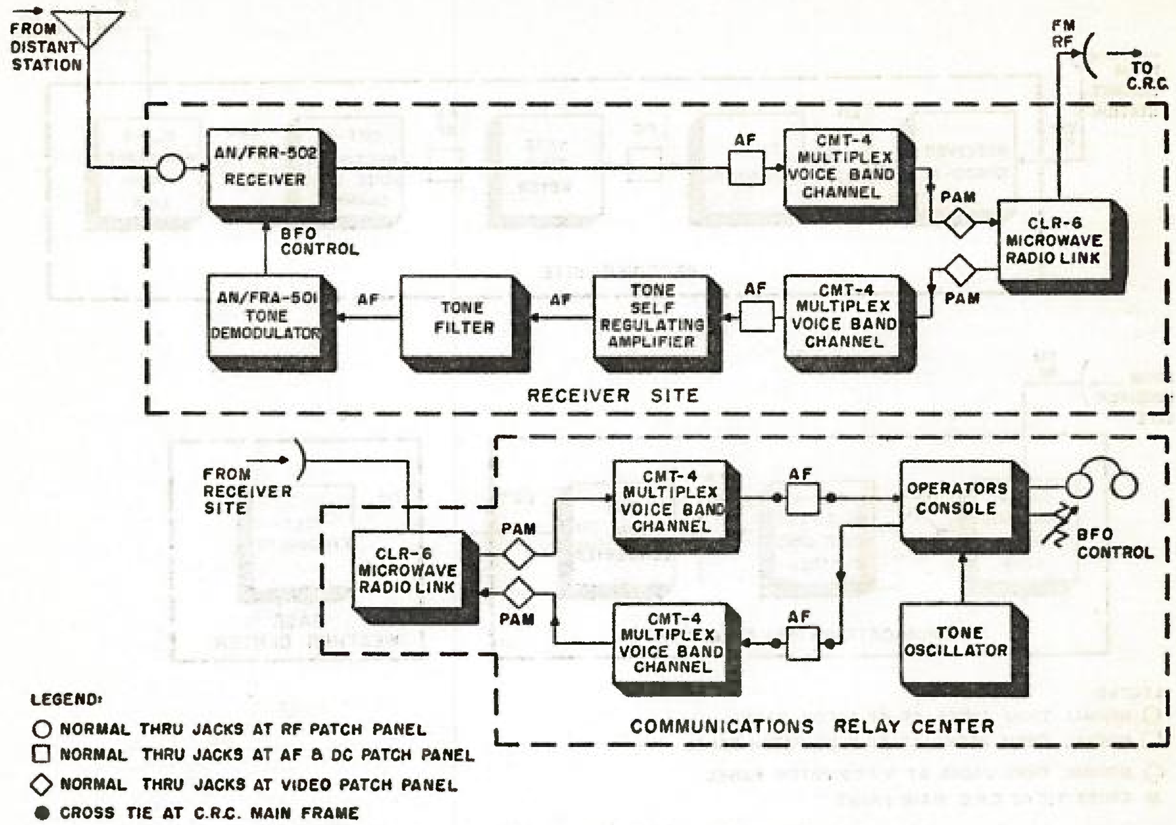


Figure 1–4. Typical Manual Radio Telegraph (CW) Receiving Circuit, Point-to-Point.

and eleven other VFTG tone keyers in the same group are coupled into one CMT–4 voice band channel. All twenty-four voice band channels of the CMT–4 are combined into one pulse amplitude modulated signal output which is coupled to the CLR–6 microwave equipment. The PAM signal frequency modulates the CLR–6 the RF output of which is beamed to the Communications Relay Center.

(2) At the Communications Relay Center, the incoming frequency-modulated signal is received, amplified and detected by the CLR–6, and the resultant PAM signal is coupled to the CMT–4. In the CMT–4, the pulses are separated into their respective channels and demodulated. One of the voice band channel outputs contains the frequency shift audio tones of the VFTG group. These tones are coupled to the VFTG tone converter group. Each VFTG tone converter accepts only those signals in its pass band and converts them to DC pulses. The DC pulses operate a teletypewriter which is usually located at the Base Weather Center.

1–18. Radio Teletypewriter Telegraph

The radio teletypewriter telegraph (RTTY) system is an improvement on the manual radio telegraph (CW) system of radio communication. In the RTTY system, the conversion from character to code and from code to character is made electro-mechanically. A code is used in which, unlike International Morse code, each character is identical in length. The five character, start-stop code is used in Globecom. In this code, each character has a start pulse, called a "space", and five identifying pulses, either "marks" or "spaces" of equal time duration, and finally a stop pulse called a "mark" of longer time duration. In operation, depressing a key on the teletypewriter key-

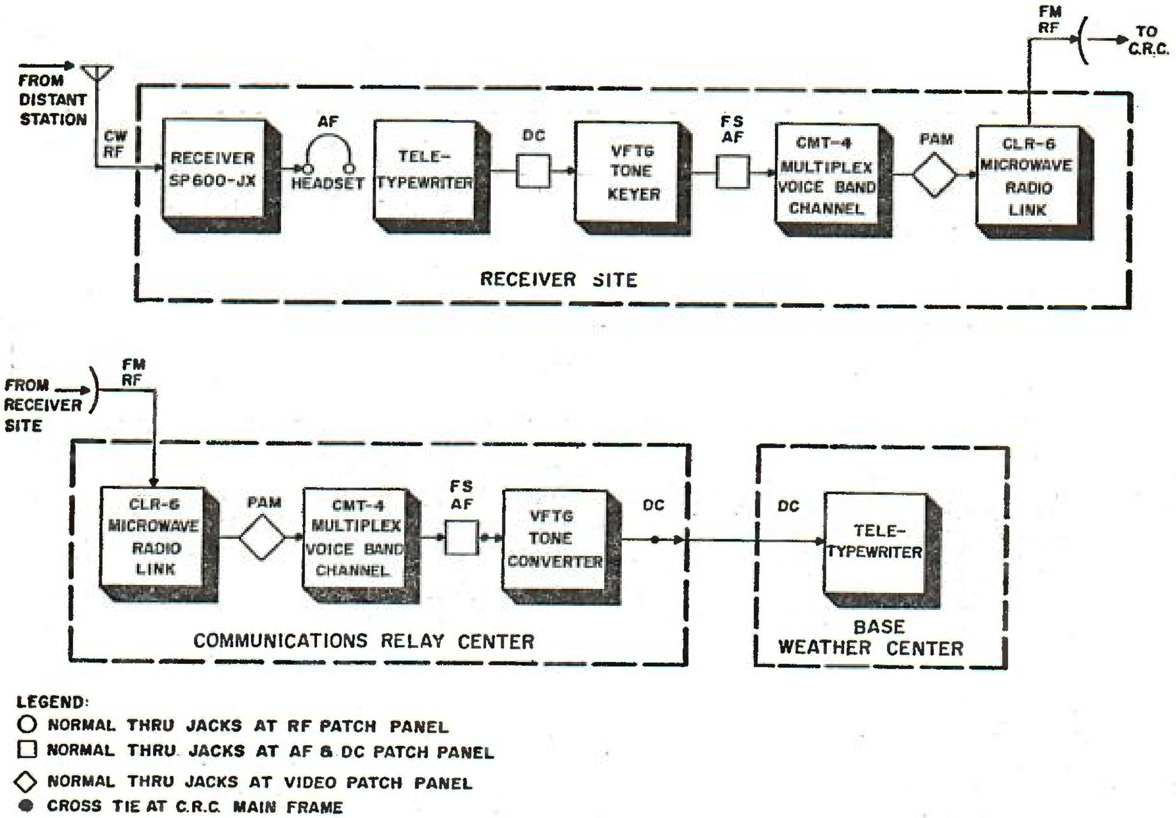


Figure 1-5. Typical Manual CW Weather Intercept Receiving Circuit.

board transmits the signal which represents the character on the key. At the receiving end, the incoming signal causes the identical character to be automatically printed by the receiving teletypewriter. The system of HF radio teletypewriter telegraph transmission most often used in Globecom is called frequency-shift (FS). In this system, a mark signal causes an upward shift in the radio carrier frequency, usually 425 cycles per second (cps), and a space signal causes a downward shift in the radio carrier frequency, usually 425 cps. Therefore, mark and space signals are separated by 850 cps.

a. *Radio Teletypewriter Telegraph (RTTY) Transmitting Circuit.*

(1) A typical single channel radio teletypewriter telegraph transmitting circuit is shown in figure 1-6. A DC teletypewriter signal is sent from the tape relay terminal equipment through the TT-160/FG cryptographic equipment (except when encryption is not desired) to the VFTG tone keyer group. One narrow-band tone keyer converts these DC pulses into frequency-shift audio tones. These tones are combined with the output tones of the other eleven tone keyers in the same group and connected to one voice band channel of the CMT-4 multiplex equipment. The output of this channel is added to the output of the other twenty-three voice band channels and coupled to the CLR-6 microwave link in the form of a pulse amplitude modulated signal. This signal frequency modulates the CLR-6 the output of which is beamed to the Transmitter Site.

(2) At the Transmitter Site, the incoming frequency-modulated signal is received, amplified, and demodulated by the CLR-6. The PAM output of the CLR-6 is coupled to the CMT-4 where the pulses are separated into their respective channels and demodulated. One voice band channel output of the CMT-4 containing the frequency-shift audio tones is coupled to the VFTG tone converter

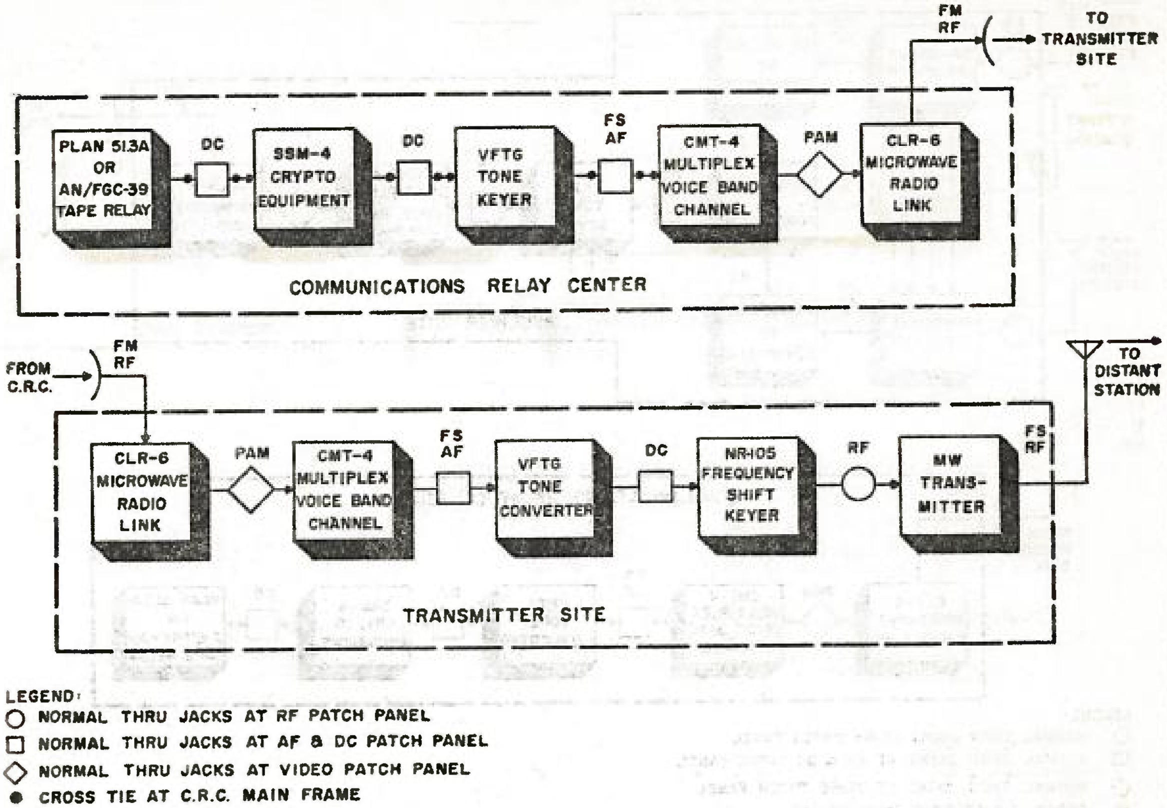


Figure 1–6. Typical Radio Teletypewriter Telegraph (RTTY) Transmitting Circuit.

group. Each VFTG tone converter accepts only those signals that are in its pass band and rejects all others. The VFTG tone converters change the frequency-shifted audio tones into DC pulses. These DC pulses cause the NR–105 FSK output to vary about the assigned frequency, above for mark and below for space. An MW Transmitter multiplies and amplifies the NR–105 FSK r–f output. The final RF signals radiated from the antenna will be 425 cps above the assigned carrier frequency for mark signals and 425 cps below the assigned carrier frequency for space signals.

b. *Radio Teletypewriter Telegraph (RTTY) Receiving Circuit.*

(1) A typical radio teletypewriter telegraph receiving circuit is shown in figure 1–7. An incoming frequency-shifted RTTY signal is received by two separate antennas in space diversity which are connected to two receivers. Space diversity reception is used to lessen the effects of rapid fading. Such fading usually does not occur simultaneousl[y] in two locations that are separated by abou[t] five wave lengths. Thus, when the antenna[s] are separated by at least five wave length[s] one antenna will be receiving a stron[g] signal during a fade on the other antenna. The two receiver outputs are coupled to th[e] AN/URA–8B Frequency-Shift Converte[r] Comparator Group. The converter portio[n] of the AN/URA–8B converts the frequenc[y] shifted audio outputs of the two receive[rs] into DC pulses. The comparator selects th[e] better of the two signals and couples it to [a] narrow-band VFTG tone keyer as a DC tel[e]typewriter signal. The frequency-shift ou[t]put of this tone keyer is combined with th[e] output of up to eleven other VFTG ton[e] keyers in the same group and applied to o[ne] CMT–4 voice band channel. This frequenc[y] shifted signal is sampled by pulses, and th[e] pulses of all twenty-four CMT–4 channels a[re] combined. The combined output is used [to] frequency modulate the CLR–6 microwa[ve]

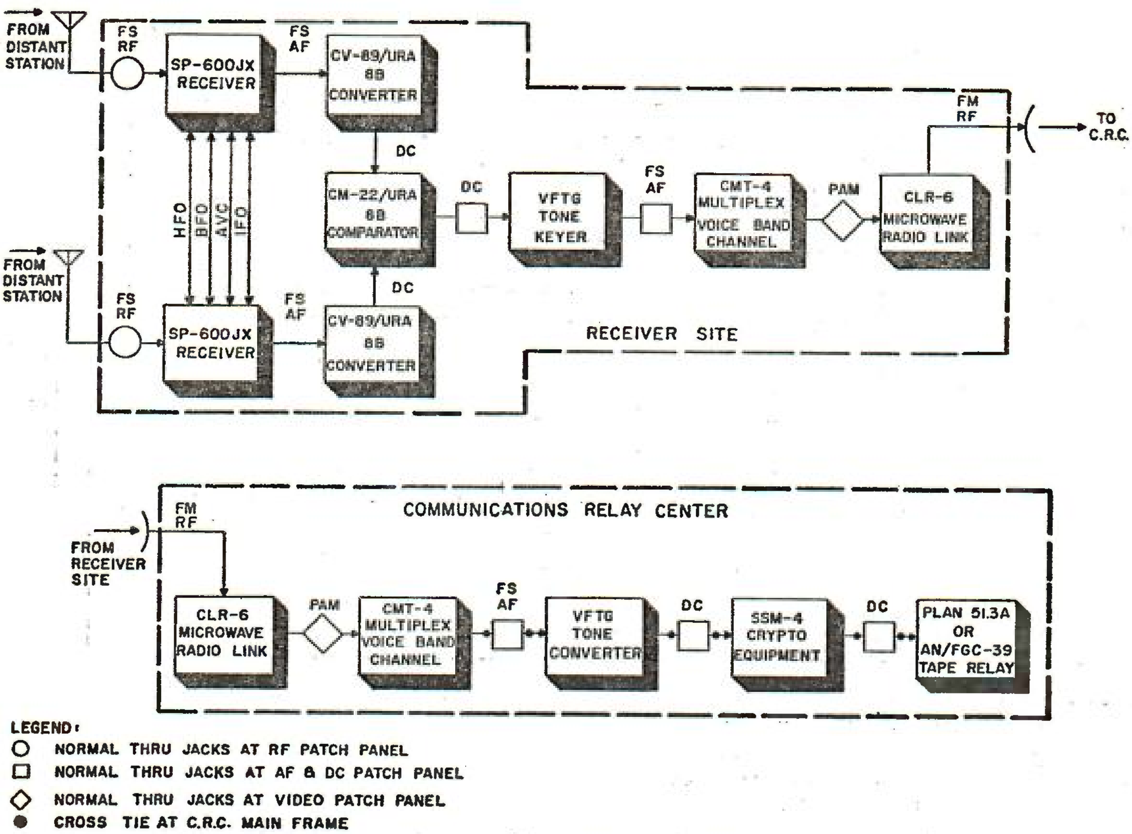


Figure 1–7. Typical Radio Teletypewriter Telegraph (RTTY) Receiving Circuit.

quipment the RF output of which is beamed o the Communications Relay Center.

(2) At the Communications Relay ;enter, the incoming signal is received by he CLR–6, amplified, demodulated, and assed on to the CMT–4 as a PAM signal. n the CMT–4 the pulses are separated into heir respective channels and demodulated. 'he voice band channel containing the RTTY ıtelligence is applied in the form of freuency-shifted audio signals to the inputs of velve VFTG tone converters. The VFTG one converters change the frequency-shifted gnals into DC teletypewriter pulses and end them through the cryptographic equipient (except where not encrypted) to the ıpe relay equipment.

-19. Multiplex Radio Teletypewriter Telegraph

To increase the traffic a circuit can handle, ·veral conventional teletypewriter signals are combined into one composite signal before they are broadcasted. This process is known as multiplexing. The equipment generally used in Globecom for multiplexing is the AN/FGC–5 Teletypewriter Time Division Multiplex Equipment. Four-channel multiplex radio teletypewriter telegraph (MUX) combines four independent teletypewriter signals in time sequence in AN/FGC–5 equipment. The AN/FGC–5 reduces the standard teletypewriter signal for one character by a factor of approximately four. Thus, four characters, one from each of four different teletypewriter circuits, can be combined into one composite signal and transmitted in the time normally required to transmit one standard character. The composite or MUX signal is transmitted to the distant receiver. At the receiver end the MUX signal is separated into its four component signals which are sent to the applicable teletypewriters. Generally, frequency-shift radio transmission is used (as in (RTTY) with mark signals being above and space signals below the assigned carrier frequency.

a. *Four-Channel Multiplex Radio Teletypewriter Telegraph (MUX) Transmitting Circuit.*

(1) A typical four-channel multiplex radio teletypewriter telegraph transmitting circuit is shown in figure 1–8. Normally, there are four teletypewriter inputs to the AN/FGC–5 Teletypewriter Time Division Multiplex Equipment. These inputs usually come from the tape relay equipment through the TT–160/FG cryptographic equipment to the AN/FGC–5. The AN/FGC–5 combines the four teletypewriter inputs in time sequence into one common output which is coupled to the VFTG tone keyer group. Because of the increased keying speed, a wide-band tone keyer is necessary. The outputs of three wide-band tone keyers can be passed by one voice band channel of the CMT–4 equipment; consequently, three MUX circuits can be combined in one voice band channel of the CMT–4. The output of this channel is added to the output of the other twenty-three channels and coupled to the CLR–6 as a pulse amplitude modulated signal. This PAM signal frequency modulates the CLR–6 the output of which is beamed to the Transmitter Site.

(2) At the Transmitter Site, the incoming frequency-modulated signal is received, amplified, and demodulated by the CLR–6. The PAM signal output of the CLR–6 is coupled to the CMT–4 where the pulses are separated into their respective channels and demodulated. The frequency-shift audio output of the one channel is fed to the VFTG tone converter group. Each VFTG tone converter accepts only those signals for which it is tuned and rejects all others. These frequency-shifted audio signals are converted

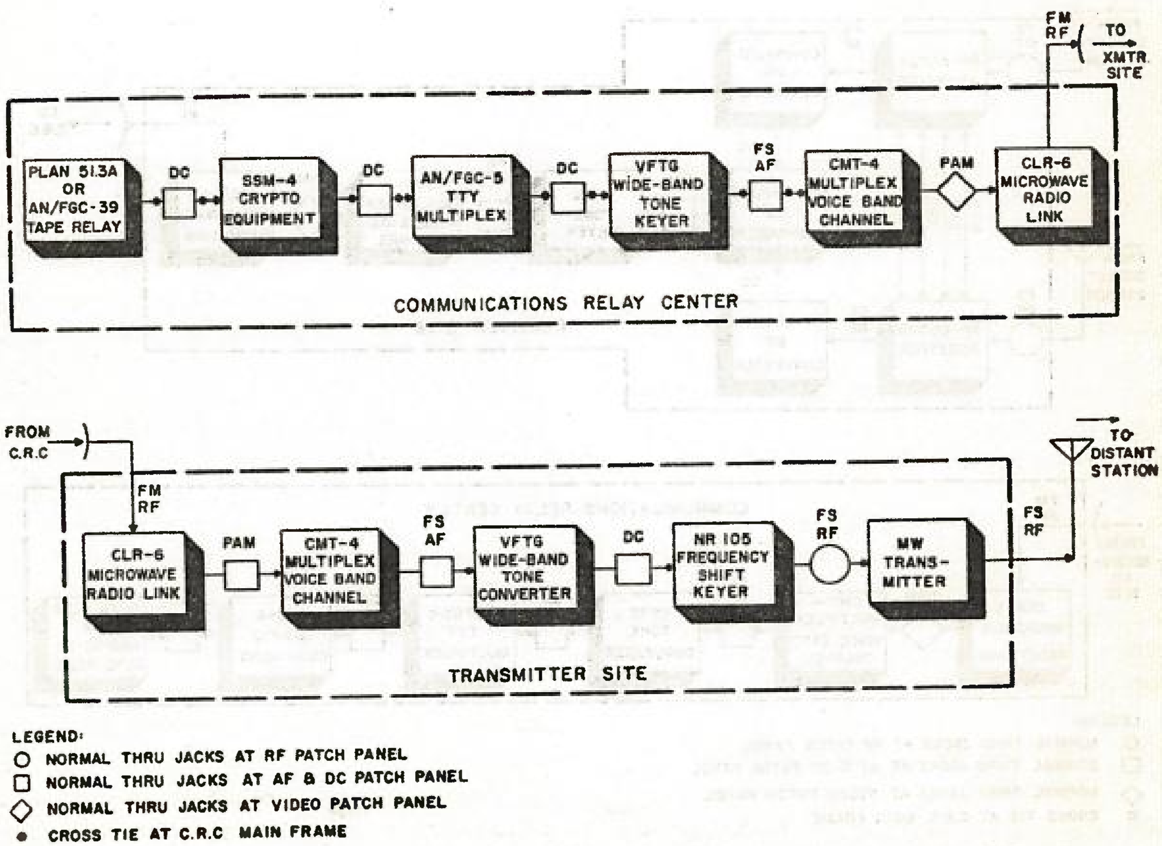


Figure 1–8. Typical Four-Channel Multiplex Radio Teletypewriter Telegraph (MUX) Transmitting Circuit.

nto DC multiplexed telegraph signals by he wide-band tone converters and coupled o the NR-105 FSK. The frequency-shifted F output of the FSK is coupled to the transmitter where it is amplified and fed to the ntenna.

b. *Four-Channel Multiplex Radio Teletypewriter Telegraph (MUX) Receiving Circuit.*

(1) A typical four-channel multiplex adio teletypewriter telegraph receiving circuit is shown in figure 1-9. The incoming requency-shifted signal is received by two P-600-JX Receivers which are fed by two ntennas in space diversity. The frequency-shifted output of the two receivers is fed o the AN/URA-8B Frequency-Shift Converter-Comparator Group. The CV-89/URA-8B converts the frequency-shifted udio outputs of the two receivers into DC ulses. The CM-22/URA-8B comparator elects the better of the two signals and couples it to a wide-band VFTG tone keyer as a DC teletypewriter signal. Three wide-band VFTG tone keyers are combined and passed on one voice band channel of the CMT-4. All twenty-four channels of the CMT-4 are combined into one output and coupled to the CLR-6 as a PAM signal. This PAM signal frequency modulates the CLR-6 the RF output of which is beamed to the Communications Relay Center.

(2) At the Communications Relay Center, the incoming frequency-modulated signal is amplified and demodulated by the CLR-6 and coupled to the CMT-4 as a PAM signal. The CMT-4 separates the pulses into their respective channels and demodulates them. One voice band channel output containing the MUX frequency-shifted audio tones is coupled to a wide-band VFTG tone converter. The tone converter accepts the frequency-shifted signals in a given band and rejects all others. The frequency-shifted

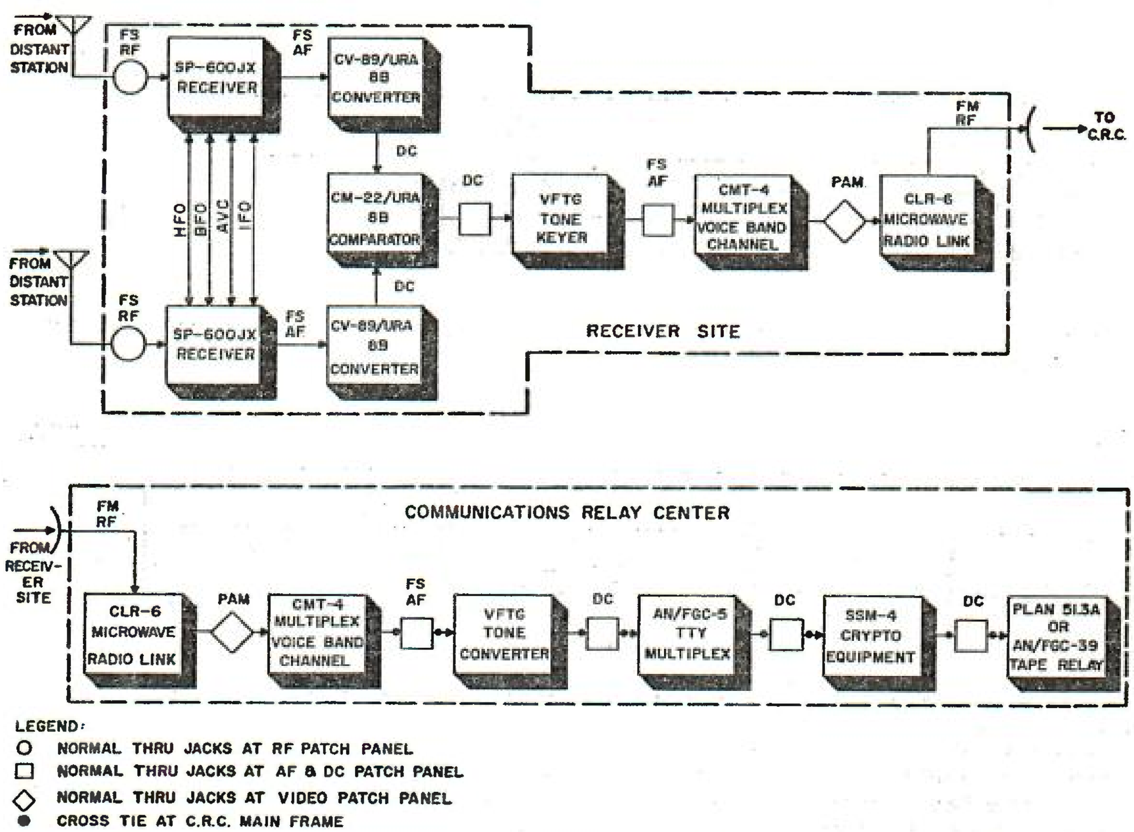


Figure 1-9. Typical Four-Channel Multiplex Radio Teletypewriter Telegraph (MUX) Receiving Circuit.

signals are changed into multiplexed DC teletypewriter telegraph signals and coupled to the AN/FGC-5. The AN/FGC-5 separates the multiplexed signal into the original four separate DC teletypewriter signals. These DC signals are fed through the TT-160/FG cryptographic equipment to the appropriate typing reperforator units in the tape relay equipment.

1-20. Facsimile

Facsimile is a process of transmitting a picture, map, or other graphic material from one terminal to another. At the transmitting equipment, the picture is mounted on a circular drum, or cylinder. The picture is then scanned by an electro-mechanical device. Picture variations along the scanning lines are converted to light variations and finally into electrical impulses which are used to modulate a transmitter. At the receiving end, the demodulated electrical impulses are fed to a facsimile recorder which reproduces the picture using an electro-mechanical scanning device similar to that used at the transmitting end, except that it reverses the process and converts electrical impulses to light variations.

a. *Facsimile Transmitting Circuit.*

(1) A typical facsimile transmitting circuit is shown in figure 1-10. The signal originates at a facsimile machine such as the AN/TXC-1. The output signal of this equipment is an amplitude-modulated 1800 cps tone which is modulated by the picture information. A band pass of approximately 900 to 2700 cps is required by this signal, the frequency range of which easily fits into one voice band channel of the CMT-4 Time Division Multiplex Equipment. The CMT-4 combines the output of one channel with the output of twenty-three other channels and applies the combination as a pulse amplitude modulated signal to the CLR-6 Microwave Radio Link Equipment. This PAM signal frequency modulates the CLR-6 the RF out-

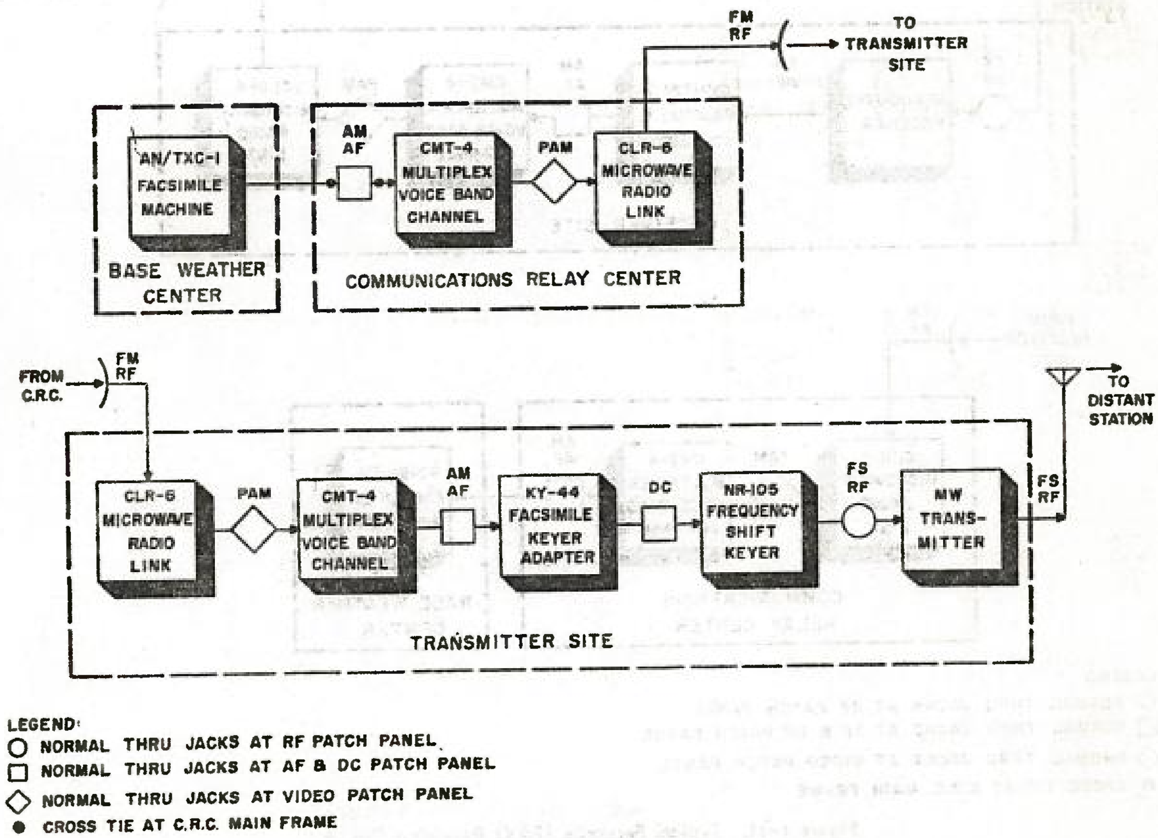


Figure 1-10. Typical Facsimile (FAX) Transmitting Circuit.

put of which is beamed to the Transmitter Site.

(2) At the Transmitter Site, the incoming frequency modulated RF signal is amplified and demodulated by the CLR–6 whose output is passed on to the CMT–4 as a PAM signal. The CMT–4 separates the pulses into their respective channels and demodulates them. The KY–44/FX Facsimile Keyer Adapter demodulates the 1800 cps facsimile signal and applies its amplitude variations as a varying d–c signal to the NR–105 Frequency Shift Keyer. The varying d–c signal shifts the RF output of the FSK. An MW Transmitter multiplies and amplifies the RF output of the FSK and couples the output to the antenna.

b. *Facsimile Receiving Circuit.*

(1) A typical facsimile receiving circuit is shown in figure 1–11. The incoming frequency-shifted RF signal is received, amplified, and demodulated by the SP–600–JX receiver. The CV–172/U Frequency Shift Converter changes the frequency-shifted audio tone to an amplitude modulated audio-frequency signal which is coupled to one voice band channel of the CMT–4. The CMT–4 combines the output of this channel with the output of the other twenty-three channels and applies them as a PAM signal to the CLR–6. Frequency modulation of the CLR–6 is accomplished by the PAM signal, and the RF output of the CLR–6 is beamed to the Communications Relay Center.

(2) At the Communication Relay Center, the incoming signal is received, amplified, and demodulated by the CLR–6. The resultant PAM signal is separated into its respective channels by the CMT–4. The pulses are demodulated and the amplitude-modulated tone output of the channel carrying the FAX signal is coupled to the RD–

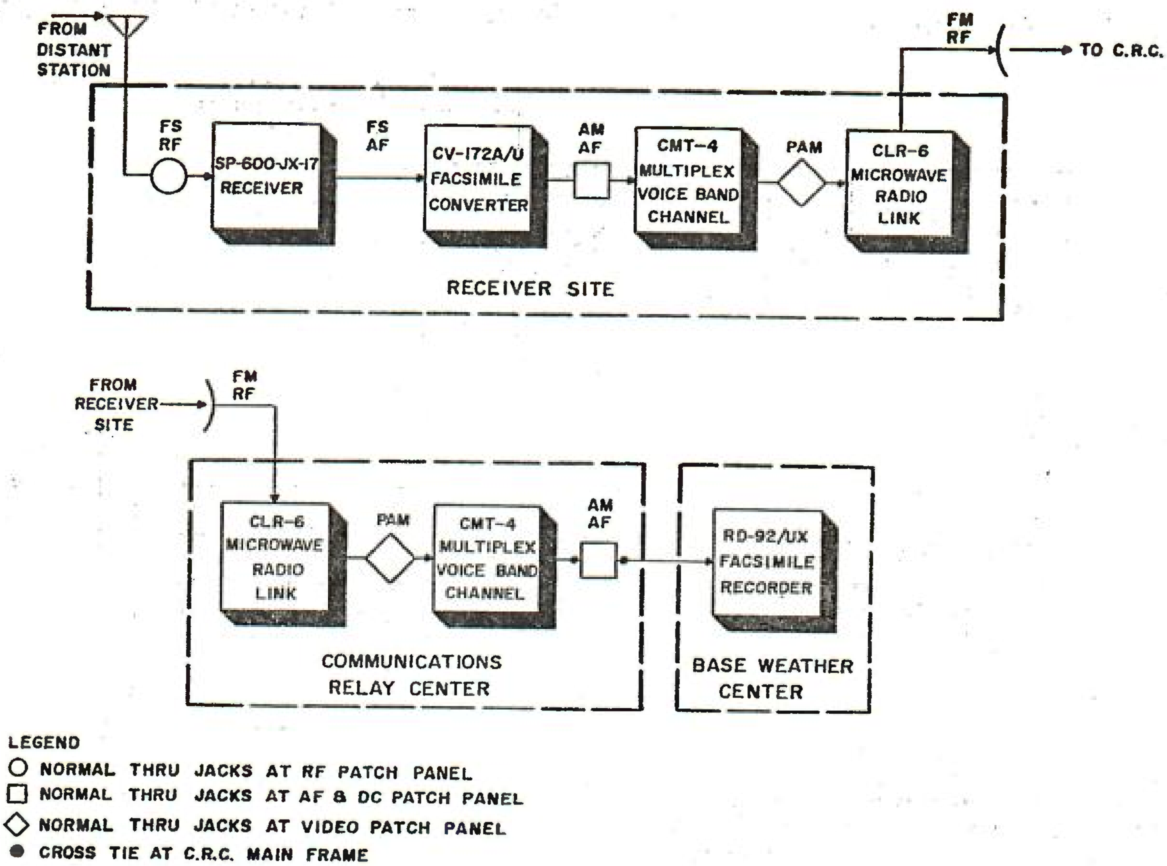


Figure 1–11. Typical Facsimile (FAX) Receiving Circuit.

92/UX (or similar) Facsimile Recorder. The facsimile recorder takes the tone output and converts it into a picture.

1-21. Radio Telephone (H-F Air-Ground)

Radio telephone circuits, frequently called voice circuits, are employed in Globecom for communication between aircraft and ground stations. A microphone converts the sound energy of the voice into electrical signals which are used to modulate a transmitter. At the receiving end, the demodulated signals are fed into a speaker, and the speaker converts the electrical signals back into sound energy.

a. *Radio Telephone Transmitting Circuit.*

(1) A typical radio telephone transmitting circuit is shown in figure 1-12. Provision must be made to key the transmitter remotely. A foot switch closes a DC keying circuit to the VFTG tone keyer which converts the DC pulses into frequency-shifted audio tones. The frequency-shifted audio output is combined with the output of eleven other narrow-band tone keyers and fed into one voice band channel of the CMT-4 Time Division Multiplex Equipment. To provide the voice information, the microphone output is amplified at the operator's position and fed into a second voice band channel of the same CMT-4. These two channels, plus the other twenty-two channels, are combined into one pulse amplitude modulated output which is coupled to the CLR-6. The PAM signal frequency modulates the CLR-6 the output of which is beamed to the Transmitter Site.

(2) At the Transmitter Site, the incoming frequency modulated RF signal is amplified and demodulated by the CLR-6, and the resultant PAM signal is coupled to the CMT-4. The CMT-4 separates the pulses into their respective channels and demodulates them.

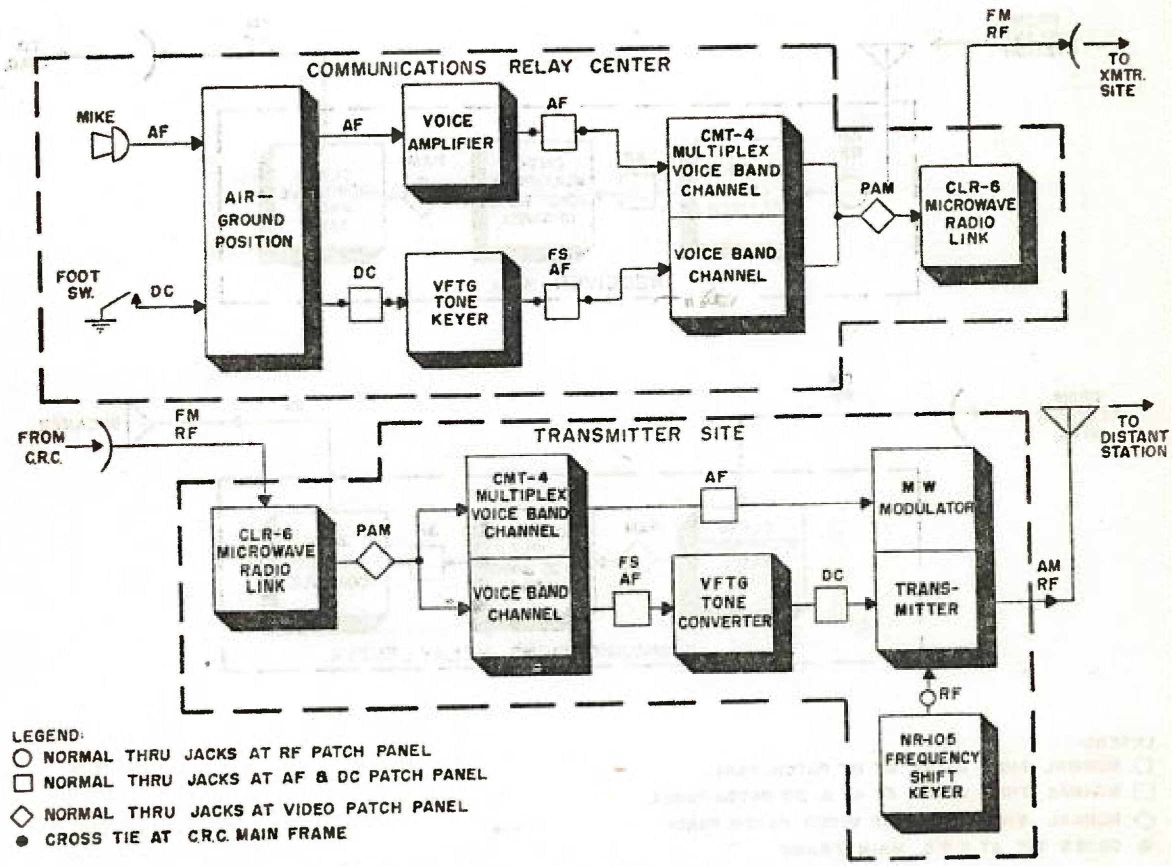


Figure 1-12. Typical Radio Telephone Transmitting Circuit.

One channel output which is used to key the transmitter contains the frequency-shifted audio tones which are fed into a narrow-band VFTG tone converter group. Filter circuits in each VFTG tone converter accept only those signals in their respective pass bands and reject all others. The VFTG tone converter assigned to the keying function converts the frequency-shifted audio tone into DC signals which are used to key the MW Transmitter on and off. Another CMT-4 voice band channel carrying the voice information is coupled directly to the modulator of the assigned transmitter. The combination of key and microphone inputs causes an amplitude modulated RF signal to be transmitted. An NR-105 Frequency Shift Keyer normally provides the RF excitation for the transmitter.

b. *Radio Telephone Receiving Circuit.*

(1) A typical radio telephone receiving circuit is shown in figure 1-13. An incoming amplitude-modulated signal is intercepted by the antenna and coupled to an SP-600-JX Receiver. The receiver amplifies and demodulates the signal, and the audio output of the receiver is coupled to one CMT-4 voice band channel. In the CMT-4, narrow pulses are amplitude modulated by the audio signal. The output pulses of one CMT-4 voice band channel are combined with the pulses from the other twenty-three channels and coupled to the CLR-6 as a PAM signal. This PAM signal frequency modulates the CLR-6 the RF output of which is beamed to the Communications Relay Center.

(2) At the Communications Relay Center, the incoming frequency-modulated RF signal is amplified and detected by the CLR-6, and the resultant PAM signal is coupled to the CMT-4 equipment. In the CMT-4, the pulses are separated into their respective

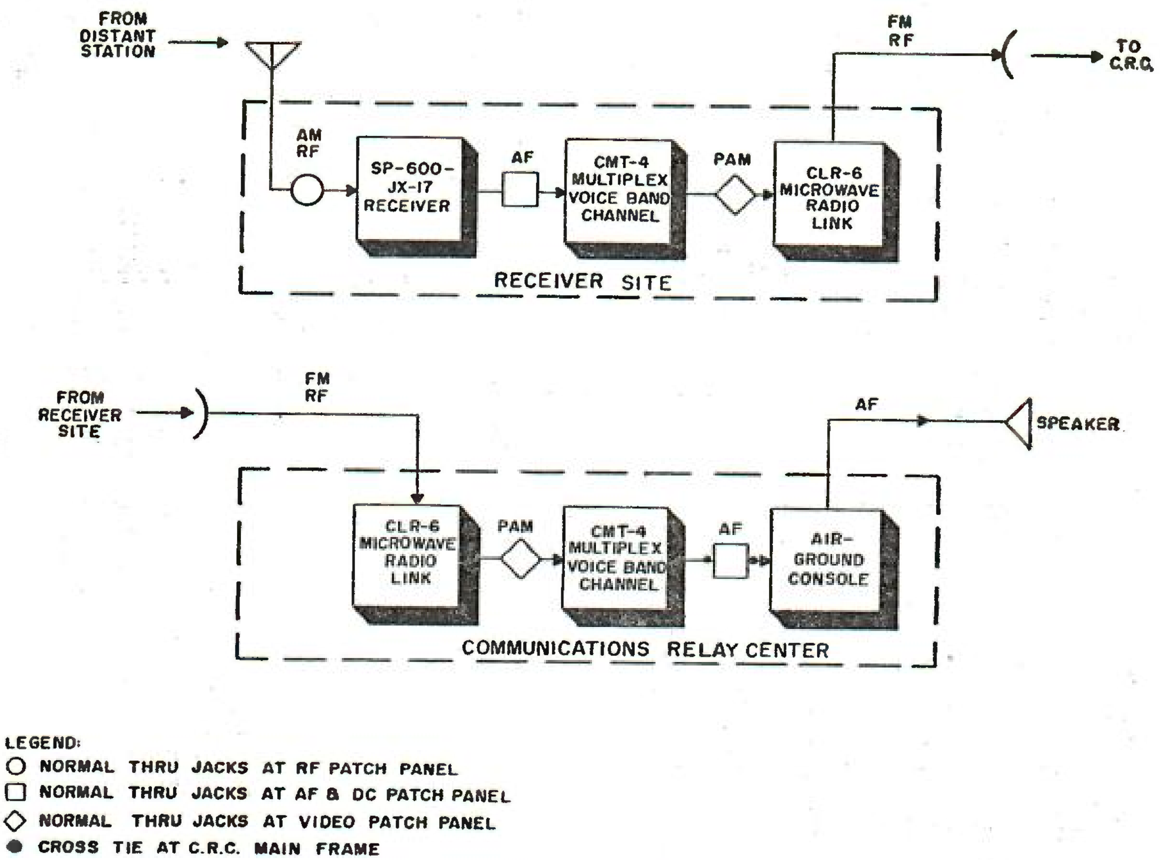


Figure 1-13. Typical Radio Telephone Receiving Circuit.

channels and demodulated. The output of one voice band channel is coupled through an AF amplifier in the A-G Console to a speaker.

1-22. Single Sideband

In all forms of modulation, the intelligence is produced in upper and lower sidebands, each of which contains the same intelligence. By eliminating one of the sidebands, a considerable saving in frequency spectrum and power is realized. As a further means of saving power, it is common to reduce the carrier power. The SSB transmitter used in Globecom utilizes one sideband for transmission of voice and another sideband for the transmission of multichannel teletypewriter signals.

a. *Single Sideband (SSB) Transmitting Circuit.*

(1) A typical single sideband transmitting circuit is shown in figure 1-14. Twin-channel SSB transmitters are used in Globecom. Each channel is independent of the other, and usually different types of signals are handled by each channel.

(a) One input is a normal telephone input from the base switchboard. If necessary, Channel and Technical Control can connect to this input at the AF patch panel in the Communications Relay Center. The C-3 Telephone Control Terminal provides the change-over from two-wire to four-wire operation and the necessary ringing functions. The output of the C-3 terminal is coupled to an A2 channel shifter thence to one wide-band channel of the CMT-4 multiplex equipment.

(b) The second input to the single sideband circuit comes from the switching equipment in the Tape Relay Room. A DC teletypewriter signal is passed through the TT-160/FG cryptographic equipment which couples the signal to the OA-63 and OA-64 Teletypewriter Frequency Division Multiplex Equipment. The OA-63 and OA-64

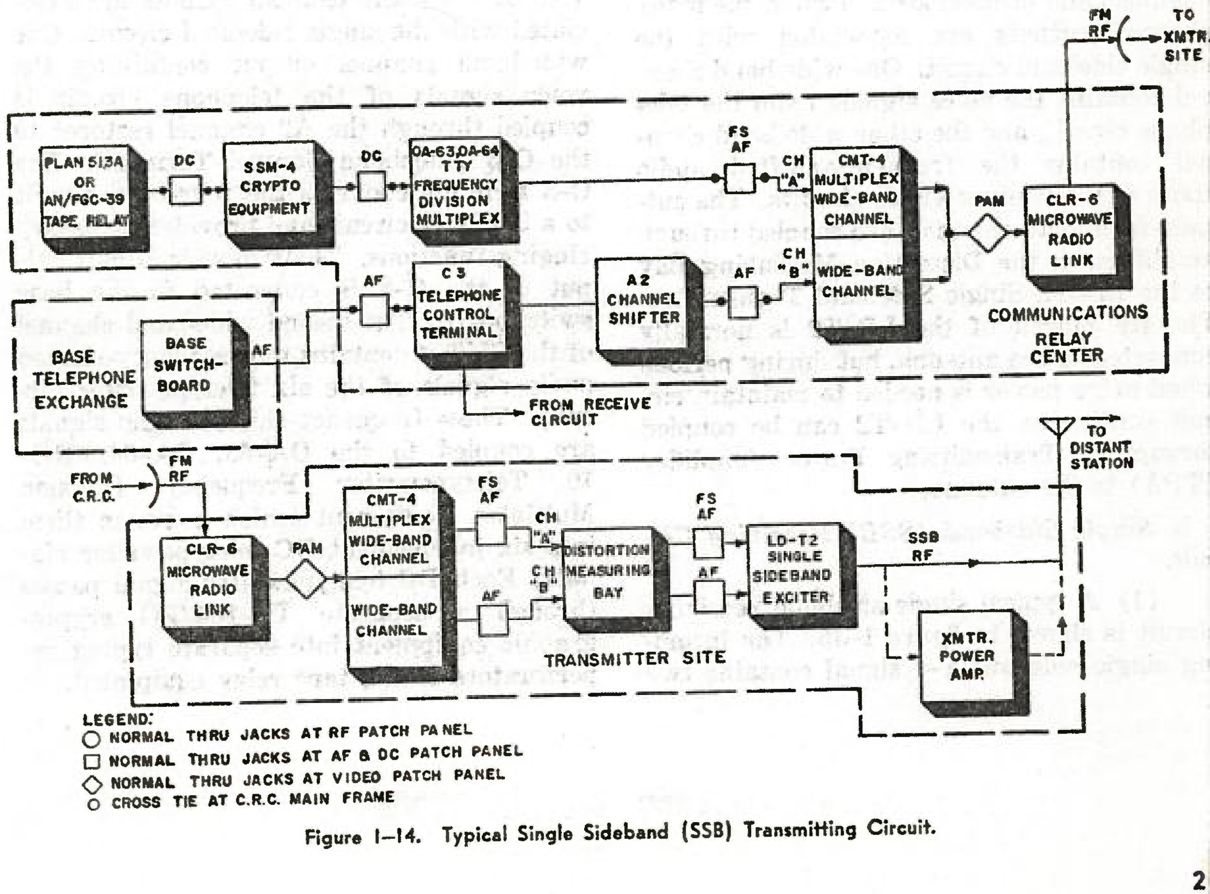


Figure 1-14. Typical Single Sideband (SSB) Transmitting Circuit.

convert the DC signals into frequency-shifted audio signals. Five other teletypewriter signals pass through duplicate paths to the same OA-63 and OA-64. The frequency-shifted audio tones of all six circuits are combined into one output signal in the OA-63 and OA-64 equipment, and the output signal is coupled to one wide-band channel in the CMT-4. Because the output signal requires a band pass of 400 to 5000 cycles, a CMT-4 wide-band channel is used. The CMT-4 combines the output of these two channels with all the other channels and couples the combination as a pulse amplitude modulated signal to the CLR-6 microwave equipment. The PAM signal frequency modulates the CLR-6 the RF output of which is beamed to the Transmitter Site.

(2) At the Transmitter Site, the incoming frequency-modulated RF signal is amplified and detected by the CLR-6, and the resultant PAM signal is coupled to the CMT-4 multiplex equipment. In the CMT-4, the pulses are separated into their respective channels and demodulated. Two of the many channel outputs are associated with the single sideband circuit. One wide-band channel contains the voice signals from the telephone circuit, and the other wide-band channel contains the frequency-shifted audio tones of the teletypewriter circuits. The outputs from both channels are coupled through amplifiers in the Distortion Measuring Bay to the LD-T2 Single Sideband Transmitter. The RF output of the LD-T2 is normally connected to the antenna, but during periods when extra power is needed to maintain circuit continuity, the LD-T2 can be coupled through a Transmitting Power Amplifier (TPA) to the antenna.

b. *Single Sideband (SSB) Receiving Circuit.*

(1) A typical single sideband receiving circuit is shown in figure 1-15. The incoming single sideband r-f signal contains two independent channels. The LD-R1 Receiver receives, amplifies, and detects the signal and separates the signal components into two independent channel outputs. One channel containing the voice signals of the telephone circuit is coupled into one wide-band channel of the CMT-4 multiplex equipment. The other channel containing the frequency-shifted audio signal from the teletypewriter circuits is coupled into a second CMT-4 wide-band channel. The CMT-4 combines the outputs of both of these channels with all of its other channels into one PAM signal output. This PAM signal output frequency modulates the CLR-6 microwave equipment the RF output of which is beamed to the Communications Relay Center.

(2) At the Communications Relay Center, the incoming frequency-modulated RF signal is amplified and detected by the CLR-6, and the resultant PAM signal is coupled to the CMT-4 multiplex equipment. The CMT-4 separates the pulses into their respective channels and demodulates them. Two of the many channel outputs are associated with the single sideband circuit. One wide-band channel output containing the voice signals of the telephone circuit is coupled through the A2 channel restorer to the C-3 Telephone Control Terminal. The C-3 terminal converts the four-wire circuit to a two-wire circuit and provides necessary ringing functions. The two-wire circuit output of the C-3 is connected to the base switchboard. The second wide-band channel of the CMT-4 contains the frequency-shifted audio signals of the six teletypewriter circuits. These frequency-shifted audio signals are coupled to the OA-63, OA-64/FRC-10 Teletypewriter Frequency Division Multiplex Equipment which converts them into six independent DC teletypewriter signals. Each DC teletypewriter signal passes through a separate TT-160/FG cryptographic equipment into separate typing reperforators in the tape relay equipment.

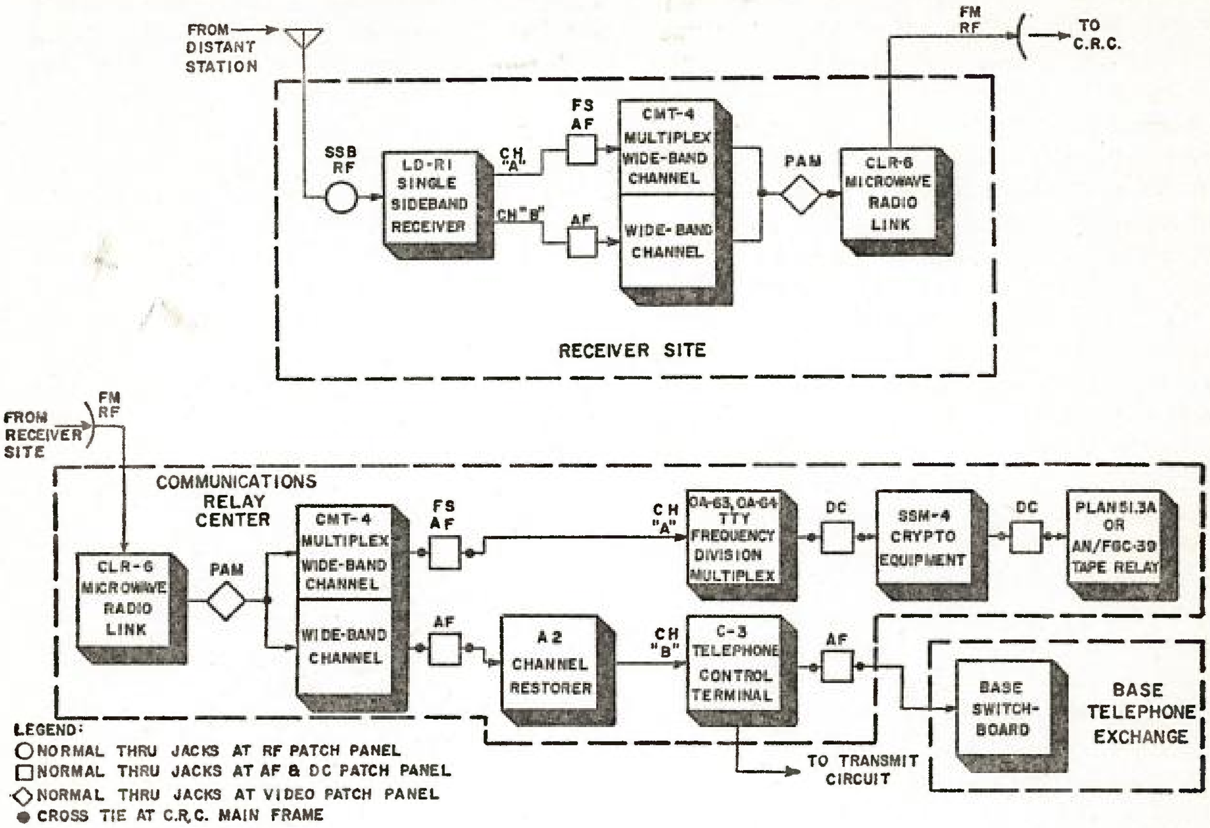


Figure 1-15. Typical Single Sideband (SSB) Receiving Circuit.

PART TWO

ANTENNAS

Chapter 1

INTRODUCTION

2-1. Purpose

This part of the manual is published for the information and guidance of personnel concerned with antennas and antenna systems selected for transmitting and receiving in the Air Force STRATCOM System (Globecom).

2-2. Scope

Discussed in this part are the various types of antennas employed, policies and criteria pertaining to the selection of antennas, and information pertinent to the capabilities, design, and use of antenna facilities. Also discussed are transmission lines, dissipation lines, grounding systems, and counterpoises as functional components of antennas.

Chapter 2

ANTENNA SELECTION CRITERIA

2-3. General

a. An antenna is defined as an electrical conductor or system of conductors used to radiate (transmit) or intercept (receive) electromagnetic energy.

b. The prime requirement to be considered in the selection of an antenna for any application is that the antenna provide the most reliable and efficient operation under the conditions contemplated for the specific circuit path involved.

c. The principal factors to be considered in the selection of antennas are as follows:

(1) Nature of propagation and polarization of the electrical component of the electromagnetic wave to be employed.

(2) Type of antenna and its angle of radiation or reception to be employed.

(3) Type of circuit involved.

(4) Specific frequency or range of frequencies to be employed.

(5) Propagation characteristics applicable to each circuit path.

(6) Amount of power available for transmission.

2-4. Transmitting Antennas

a. *Frequencies.*

(1) Low frequencies which utilize the ground-wave portion of the radiated electromagnetic wave provide reliable transmission over long distances, provided the conductivity of the path is good. Transmission of low frequencies, however, requires large amounts of input power, involves the use of large and expensive antennas, and requires large land areas for antenna sites.

(2) High frequencies which utilize the sky-wave portion of the radiated electromagnetic wave also may be used for transmission over long distances, but they are subject to "fading" when under the influence of certain ionospheric phenomena. High frequency transmission, however, when compared with low frequency transmission, involves smaller and less expensive antennas.

(3) After due consideration of the foregoing characteristics, it was decided that the high frequency (HF) band would be utilized for transmitting on beltline circuits. The low frequency (LF) band would be utilized for primary circuits, with HF or VHF/Forward Scatter (VHF/FS) facilities as back-up, in northern areas of the world in which propagated electromagnetic waves are subject to severe electrical interference caused by aurora borealis. Low frequencies also are used for transmitting over circuit paths which have high absorptive characteristics.

b. *Polarization.* Horizontal polarization of the electromagnetic waves is used by most Globecom transmitting stations. However, in areas of the earth above 50 degrees north latitude, the effects of the strong magnetic fields are very pronounced and for extended periods of time completely "blanket out" horizontally polarized waves. The antennas selected for use in the northern areas, therefore, were those most effective in radiating vertically polarized waves which are least affected by magnetic fields.

c. *Point-to-Point Circuit Antennas.*

(1) For long-distance point-to-point circuits, the high-frequency antennas normally employed should possess the property of high directivity and should have the

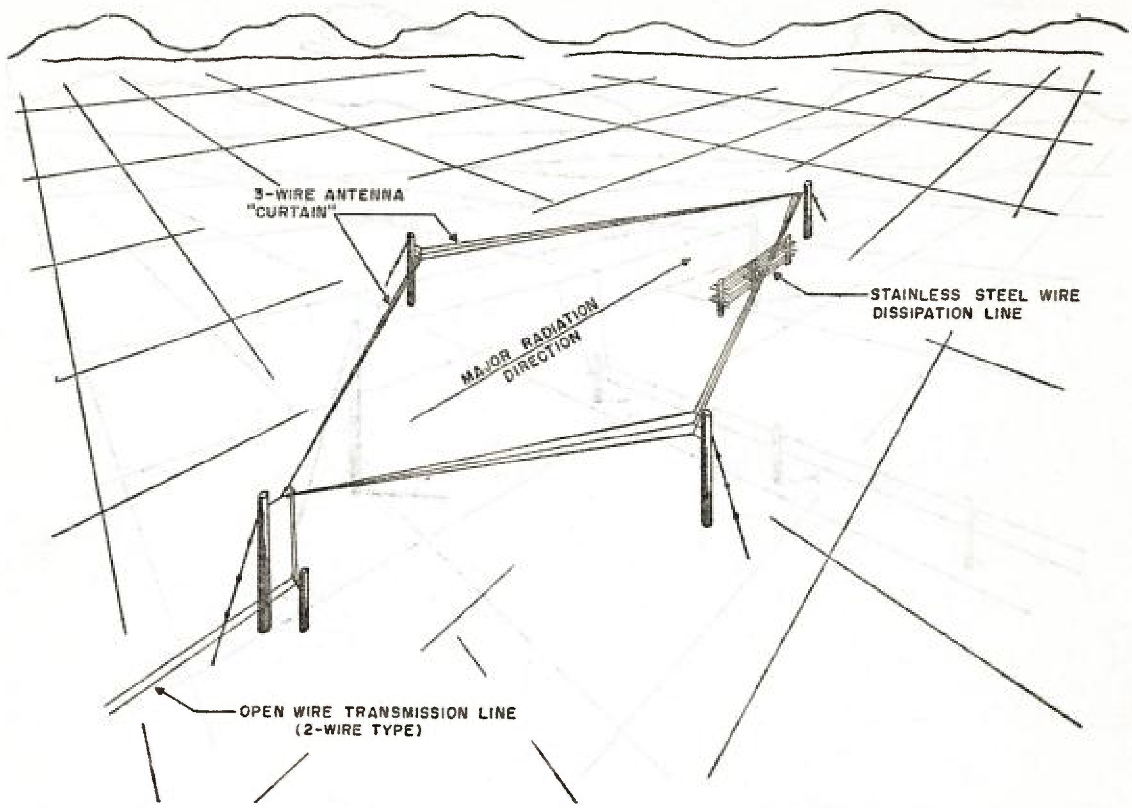


Figure 2-1. Three-Wire "Curtain" Rhombic Antenna With Transmission and Dissipation Lines, Perspective View.

ability to handle large amounts of input power from a radio transmitter. In addition, the antenna should be efficient over a relatively wide frequency range and should have high gain. The terminated 3-wire "curtain" rhombic antenna (fig. 2-1) was selected for long-distance point-to-point circuits because it is highly directional. Antenna gain up to 20 db is practicable with this antenna as the horizontal and vertical beam widths approach 5 degrees. The normal reliable working range of the antenna lies between 600 and 2,500 miles.

(2) Horizontal delta-matched half-wave doublet antennas (fig. 2-2) were selected to provide satisfactory signal radiation over short-distance point-to-point circuits of less than 800 miles in length. These antennas provide maximum bi-directional radiation and optimum signal propagation between 10 and 70 degrees in the vertical plane. These are essentially narrow-band antennas which provide satisfactory radiation over a range of 1 megacycle. In Globecom application, the radiating elements of these antennas are specifically designed for maximum radiating efficiency on a pre-determined frequency, so deviation beyond the band width of the designing frequency will considerably reduce the radiating efficiency of the antenna.

(3) The delta-matched half-wave doublet antenna was selected also for use on air-ground circuits because of its characteristic radiation pattern and its normally effective range of up to 800 miles. Maximum radiation is produced broadside to the antenna, with a reduction in radiation of only 25 percent off the ends. As in the case of short-distance point-to-point and broadcast circuits, separate antennas are required for each frequency to be transmitted.

(4) Discone antennas (fig. 2-3) were selected for back-up use on air-ground circuits. These antennas produce a vertically polarized electromagnetic wave, and it is

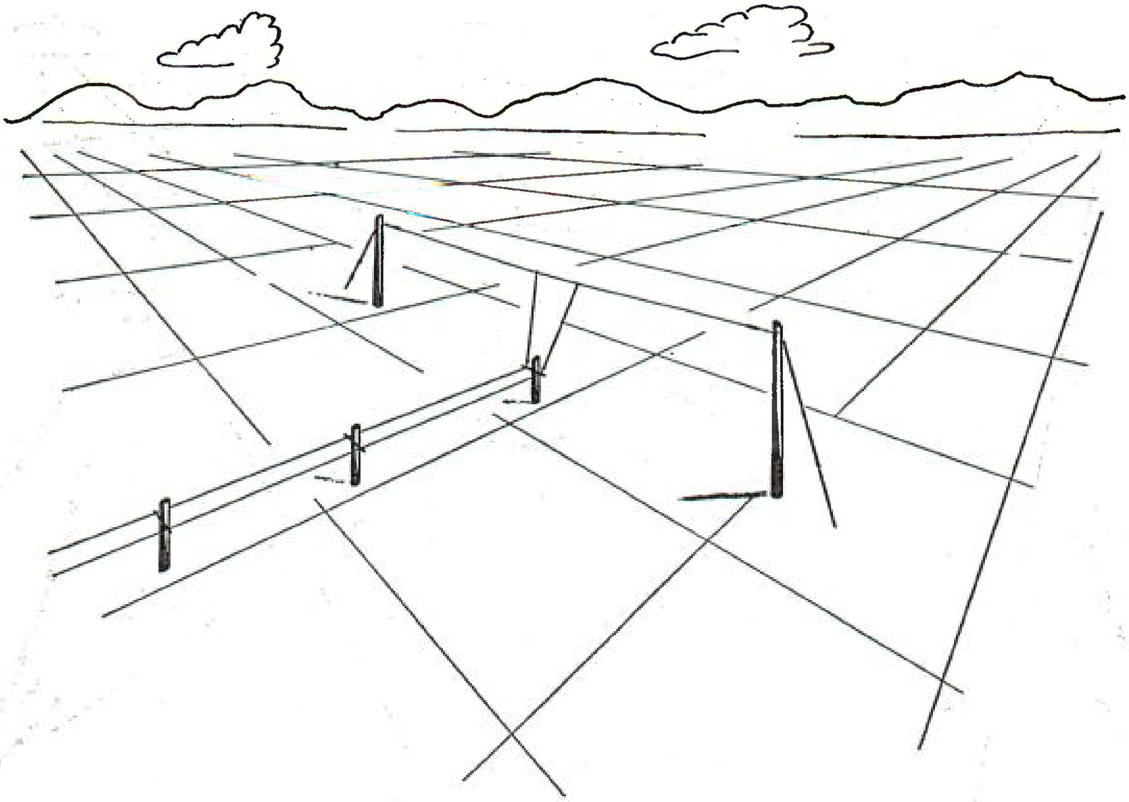


Figure 2-2. Delta-Matched Half-wave Doublet Antenna with Transmission Line, Perspective View.

essential that they be mounted on non-metallic supports. Characteristics of these antennas are as follows:

(a) Omni-directional radiation in the horizontal plane.

(b) Effective radiation between 0 and 60 degrees in the vertical plane.

(c) Broad band coverage, covering the frequency range of 3 to 18 mc. This broad band coverage is necessary to permit the use of one multi-channel back-up transmitter operating with a single antenna to cover the entire air-ground frequency range.

(5) A relatively recent development in radio frequency transmission known as Forward Propagation Ionospheric Scatter (FPIS) or VHF Forward Scatter (VHF/FS) involves the use of frequencies in the VHF band (30 to 300 mc.). The principle of transmission involved deviates from the conventional principle of sky-wave transmission, and antenna types that differ from conventional HF types are required for this new application. The antenna selected, except for a few early installations where the rhombic antenna was used, is the corner reflector (fig. 2-4) which consists essentially of a V-shaped reflector composed of wires, and colinear radiating elements centrally located in the V. The antenna may be erected in either a horizontal or a vertical position, depending upon the desired polarization of the radiated wave; however, in Globecom the antenna is erected in the horizontal position exclusively. The radiation pattern of the corner reflector antenna is uni-directional along the line bisecting the apex angle. The beam width is dependent upon the apex angle and the radiating elements employed. The gain of the antenna is approximately 13 to 15 db. Appropriate provisions have been made in Globecom for the utilization of this new method of transmitting for point-to-point communications on circuit paths between 600 and 1,200 miles in length.

(6) The vertical tower antenna (fig.

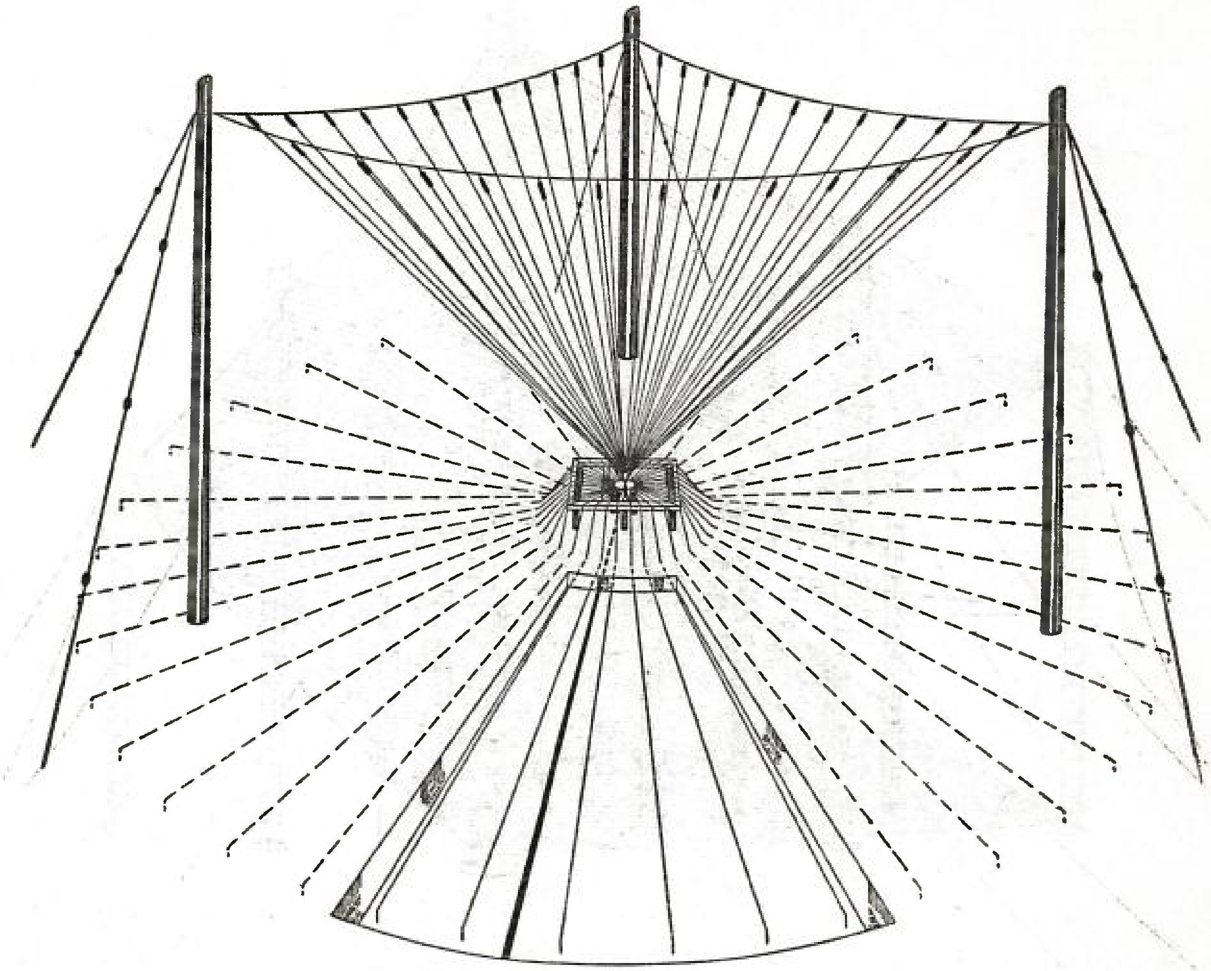


FIG. NO. 2-3 DISCONE ANTENNA AND COUNTERPOISE, PERSPECTIVE VIEW

Figure 2–3. Discone Antenna and Counterpoise, Perspective View.

2–5) was chosen to radiate low-frequency, vertically polarized waves with a high degree of radiating efficiency. This type of antenna is used primarily in those latitudes in which vertically polarized waves are used to combat the effects of severe magnetic storms.

2–5. Receiving Antennas

a. *General.*

(1) A difference exists in the number of antennas required for transmission and the number required for reception. Separate antennas are provided for each of the frequencies being transmitted at one time. A receiving antenna can be made to serve up to six different receivers by means of branching amplifiers (multicouplers). Thus, up to six different circuits can be received by one antenna, provided that the frequencies and orientation fall within the design limits of the antenna.

(2) On some long-distance circuits where fading effects are severe, space diversity reception is used. Space diversity reception utilizes the output of two antennas that are separated by more than one wave length to produce a nearly constant output. This overcomes to a considerable degree the effects of signal fading experienced with a single antenna. Space diversity reception is used on RTTY and MUX circuits, but not on voice or facsimile circuits.

b. *Selection.*

(1) Similar antennas are usually provided at both the transmitting and receiving ends of a circuit. In some instances

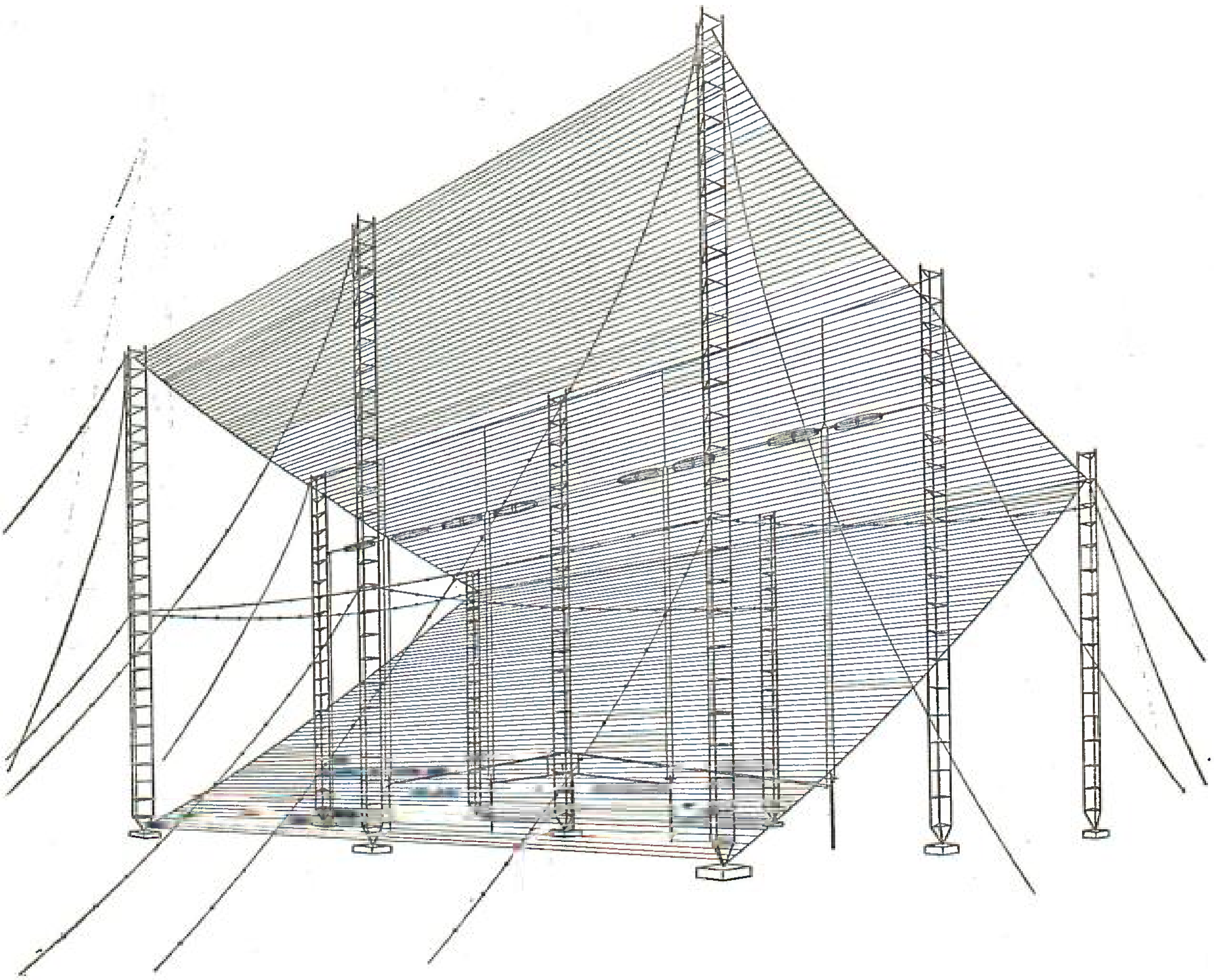


Figure 2–4. Horizontally Polarized Corner Reflector, Perspective View.

where ground space is at a premium, delta-matched doublet antennas are employed for reception on circuits that employ rhombic antennas for transmission. This results in some loss in received signal strength and has been resorted to only as an expedient.

(2) Where low-frequency transmission is employed, ground space permitting, long-wire (Beverage) antennas (fig. 2–6) have been provided for reception, since their directivity tends to reduce the ambient radio noise level. When space limitations will not permit a long-wire installation, a specially designed loop antenna is provided. Long-wire antennas are of the single-wire or two-wire types generally varying in length from 1¼ to 1½ wavelengths and elevated 16 feet above the ground. The Globecom application of the long-wire antenna is for low-frequency reception only.

(3) Discone antennas are employed frequently in Globecom for reception on short-distance point-to-point and air-ground circuits in which doublet antennas are utilized for transmission.

(4) Although the principle of space diversity reception is utilized primarily with rhombic antennas, the same principle can be applied to all types of antennas and has been applied to discone antennas in particular instances.

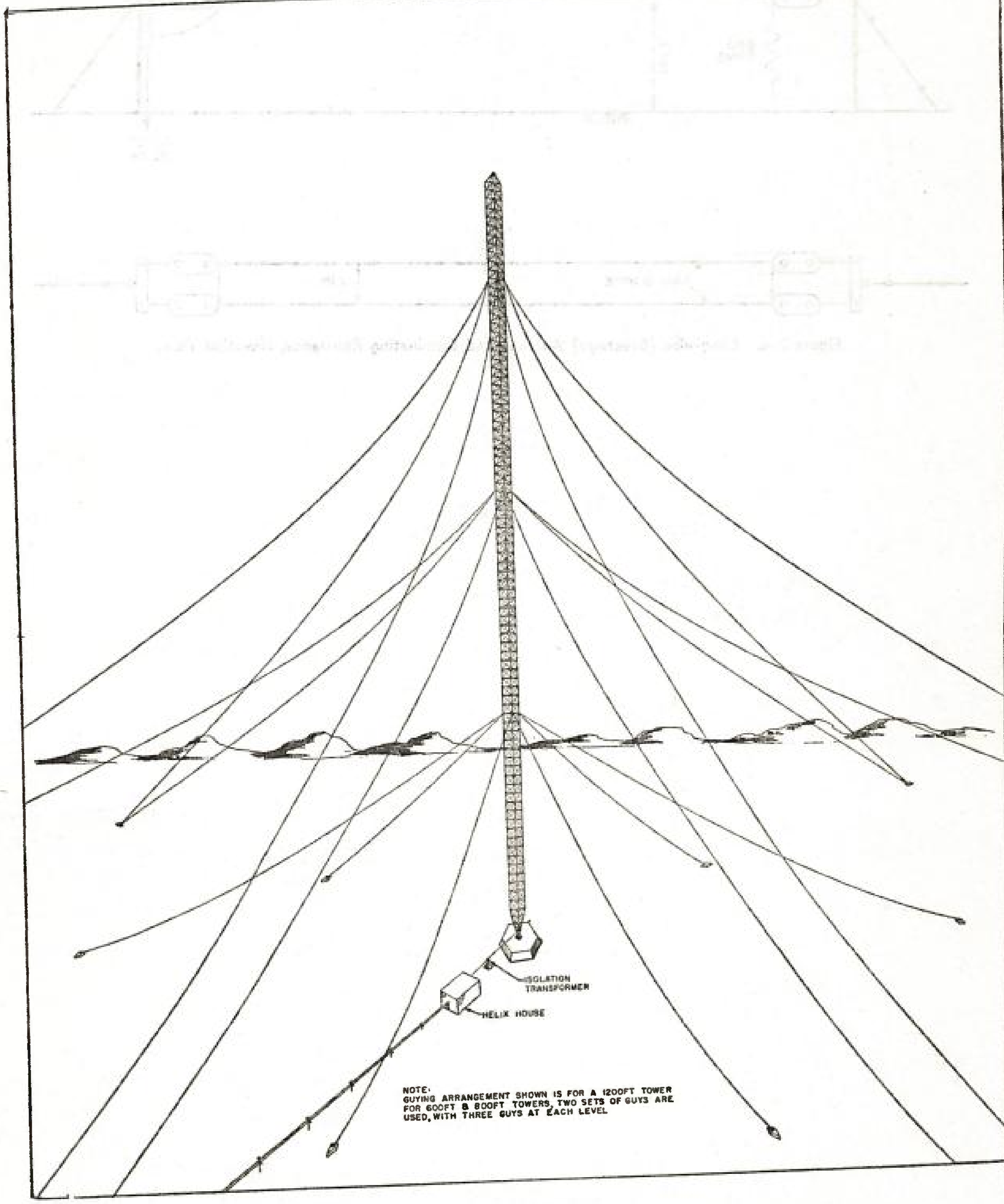


Figure 2–5. Vertical Antenna (Tower), Perspective View.

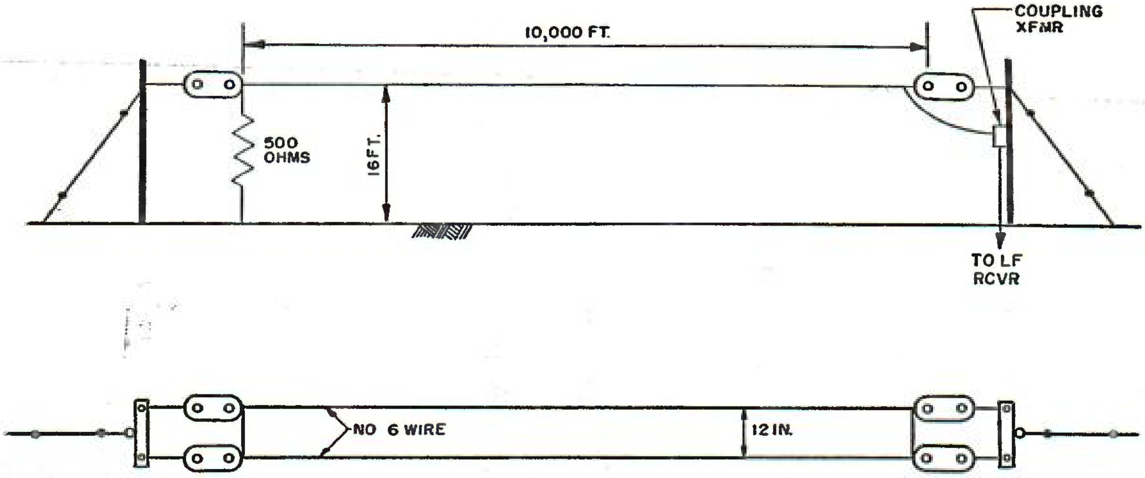


Figure 2–6. Long-wire (Beverage) Antenna and Terminating Resistance, Elevation View.

Chapter 3

ANTENNA DESIGN CRITERIA

2-6. General

It is not the intent here to consider at any great length the specific problems involved in the designing of transmitting and receiving antennas, but it is desirable to make a few remarks pertinent to the problems. With the exception of long-wire antennas, certain specific information must be obtained and utilized in connection with the designing of all antennas.

2-7. Design

a. In order to "tailor" the physical and electrical characteristics of an antenna for a specific application, certain data must be known. The primary data required are as follows:

(1) Specific frequency or frequencies to be utilized.

(2) Great circle length and direction of the circuit.

(3) Nature of transmission, such as RTTY, MUX, voice, or FAX.

(4) Noise level at the Receiver Site.

(5) Range of conditions anticipated for the specific transmission path during the eleven-year sunspot cycle.

b. In connection with the design of Globecom high-frequency facilities, it was assumed that a minimum of two frequencies would be utilized to provide maximum day and night reception. It was then determined that two transmitting rhombic or doublet antennas, one for high-band frequencies and one for low-band frequencies, would be provided for each circuit. The higher frequency rhombic or doublet would be utilized for transmission of the high-band frequencies, and the lower frequency rhombic or doublet would be utilized for transmission of the low-band frequencies. At the receiving end, two rhombics would be provided for the high-band frequencies and two more rhombics for the low-band frequencies in space diversity reception. The "tilt angle" of each rhombic antenna must be selected for the desired characteristic of the signal pattern to be radiated. The angle of radiation for transmitting antennas and the angle of arrival of receiving antennas must be computed for each circuit path.

Chapter 4

ANTENNA FARMS

2-8. General

"Antenna farm" is the term applied to the site upon which antennas are erected for transmitting or receiving purposes.

2-9. Selection of Sites

a. In the selection of sites for antenna farms, it is the policy of Globecom to provide a separation of at least eight miles between the transmitting and receiving antenna farms to prevent mutual interference. It is also Globecom policy to provide a separation of at least five miles between the receiving antenna farm and the Relay Center which is usually located at an existent Air Force base, but which may be located at the Transmitter site in some cases.

b. In the selection of suitable sites for antenna farms, the principal criteria involved are as follows:

(1) The area should be as flat as possible.

(2) The area of the site should be elevated with respect to the general surrounding area.

(3) The area should be devoid of any metallic obstructions such as buildings, towers, and pole lines, as well as of trees and vegetation (see paragraph 2-10a).

(4) Sufficient ground area should be available for erection of all antennas of the various types involved.

(5) The soil should be as highly conductive as practicable.

(6) The locations of the sites should be adaptable to microwave radio link from the Relay Center Site to facilitate intersite communication.

c. It was not always possible to obtain sites meeting all of the criteria listed above, and some compromises have been necessary.

2-10. Site Clearance

In the selection of suitable sites for Globecom transmitter and receiver antenna farms, it is desirable in each instance to secure a site devoid of trees and vegetation over 4 feet in height. It is not always possible to secure such a site, so the following criteria were established to govern clearance of the sites selected.

a. Clearance must be in accordance with AFR 90-1, "Improved Ground, Covering Clearing, Grubbing, and Rough Grading."

b. All areas designated as obstruction clearance slopes must be cleared, but grubbing is not required.

Chapter 5

TECHNICAL CONSIDERATIONS

2–11. General

The criteria mentioned in this chapter were used for the development of the Globecom high- and low-frequency antenna installations. These criteria take into consideration the radiation characteristics of the individual antennas and the coupling effects between atennas.

2–12. Building Location

The building is located near the center of the site, with the antennas distributed in a circular pattern around it. It is oriented for the most direct transmission line runs and the maximum utilization of the equipment areas.

2–13. Rhombic Antenna Siting

a. In the siting of rhombic antennas, the following definitions are applicable:

(1) *Low-band Rhombic.* A rhombic antenna designed for operation in the lower frequency range of the HF band, usually from 4 to 10 megacycles.

(2) *High-band Rhombic.* A rhombic antenna designed for operation in the higher frequency range of the HF band, usually from 8 to 25 megacycles.

(3) *Diversity Pair.* Two antennas of the same design which are appropriately separated for space diversity operation.

(4) *Antenna Height.* The height of the plane of the antenna above the mean ground level.

(5) *Angle of Departure.* The optimum useful radiation or reception angle of the antenna, measured vertically with respect to the mean ground level.

(6) *Reflection Zone.* The ground area immediately below the antenna, and an area equal to the width of the minor axis extending in the transmitting or receiving direction for a distance determined by the antenna height and the angle of departure. The distance may be determined from the clearance zone chart (fig. 2–7).

(7) *Forward Clearance Zone.* The zone above the angle of departure. This zone is equal to the width of the minor axis and begins at the end of the reflection zone.

b. The following conditions must be met in the installation of any rhombic antenna:

(1) *Orientation.* The terminated end shall be toward the distant station, and the major axis shall be directed along the true bearing for the radio path.

(2) *Horizontal Placement.* The radiating element (curtain) shall be parallel to the surface plane of the earth.

(3) *Reflection Zone Terrain.* The surface of the reflection zone should not have any abrupt changes greater than 10 percent of the antenna height or a slope greater than 10 percent in any direction.

(4) *Reflection Zone Clearance.* The surface of the reflection zone must be clear of buildings, antennas, trees, and other obstructions. Brush and other natural growth shall be kept to a minimum, must not exceed four feet in height, and shall not occupy more than 20 percent of the zone area (see fig. 2–8).

(5) *Forward Clearance Zone Clearances.* The forward clearance zone shall be clear of all obstructions wider than 20 percent of the minor axis (see figure 2–8).

(6) *Antenna Spacing.* The minimum

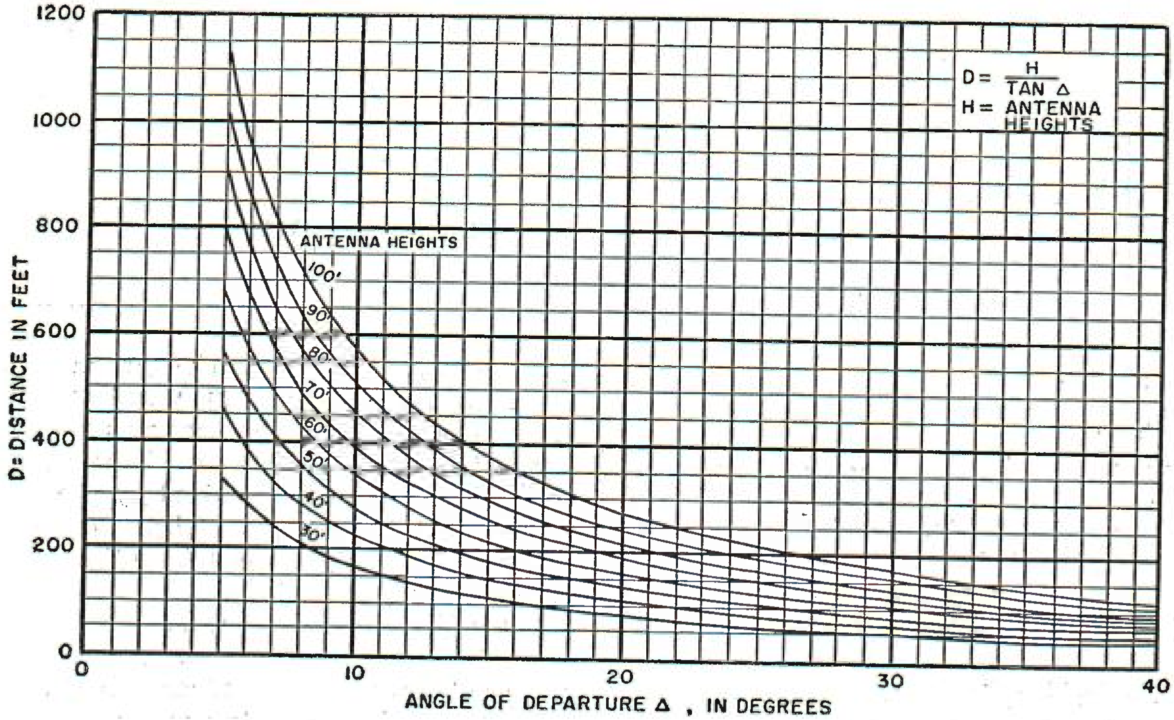


Figure 2-7. Clearance Zone Chart.

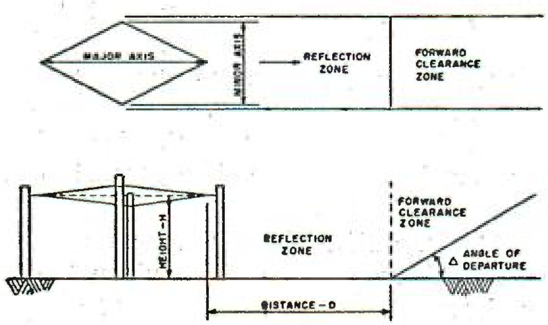


Figure 2-8. Rhombic Antenna Clearance.

listance between any part of adjacent antenıas or radiating elements shall not be less han two-thirds of the minor axis of the arger antenna or element (see fig. 2-9).

(7) *Antenna Location.* The *antennas* hall be located around the building, with he transmission line end of the high-freuency rhombics on the circumference of a ircle having a radius of 800 feet. The lowrequency rhombics shall be similarly located n a circle having a radius of 2,000 feet see fig. 2-10).

(8) *Diversity Spacing.* The center-to-center spacing normally shall be six or more and never less than four wave lengths at the lowest operating frequency, or 1,500 feet and 1,000 feet, respectively, for the low-band rhombics, and 600 feet and 400 feet, respectively, for the high-band rhombics (see fig. 2-11).

2-14. Horizontal Half-Wave Doublet Antenna Siting

a. In the siting of horizontal half-wave doublet antennas, the following definitions are applicable:

(1) *Antenna Height.* The height of the center of the antenna above mean ground level.

(2) *Angle of Departure.* The useful radiation angle of the antenna (8 to 90 degrees), measured vertically with respect to the surface plane of the earth.

(3) *Rejection Zone.* The ground area below the antenna extending the length of the antenna from each end, and to each side of the antenna a distance which is a function of the antenna height and the angle of radia-

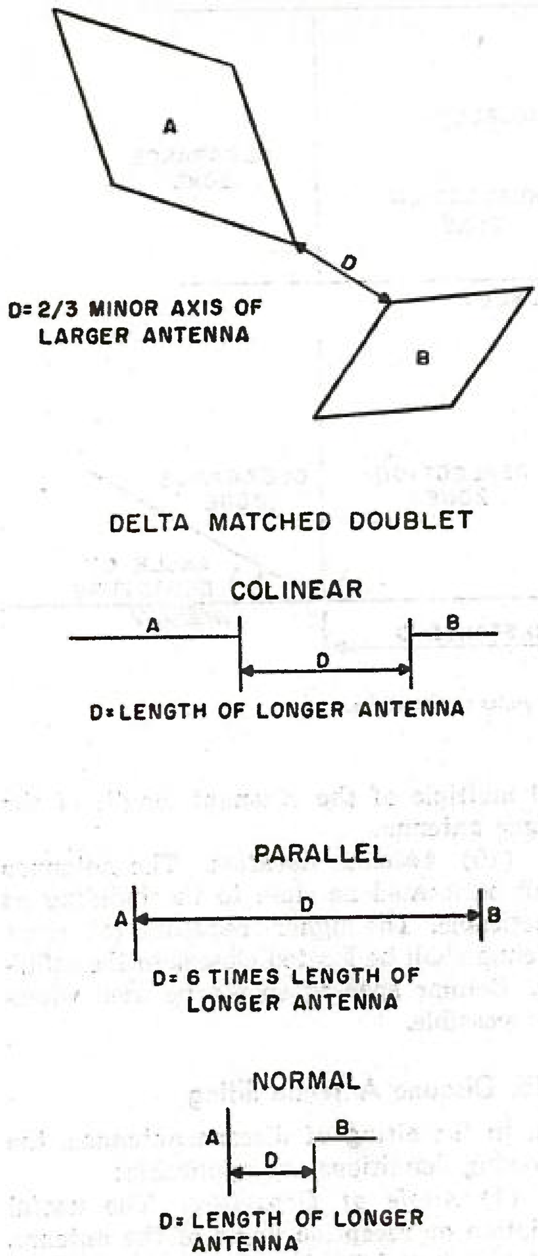


Figure 2-9. Antenna Spacing.

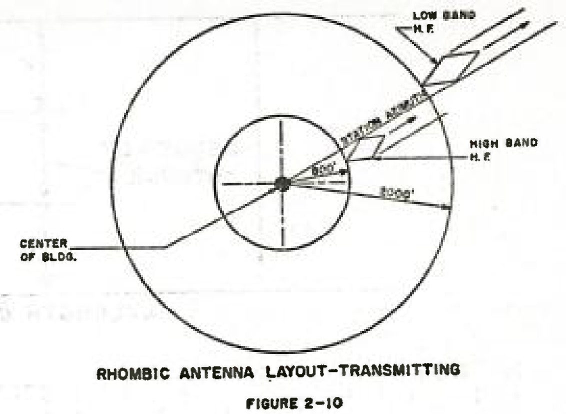


Figure 2-10. Rhombic Antenna Layout, Transmitting.

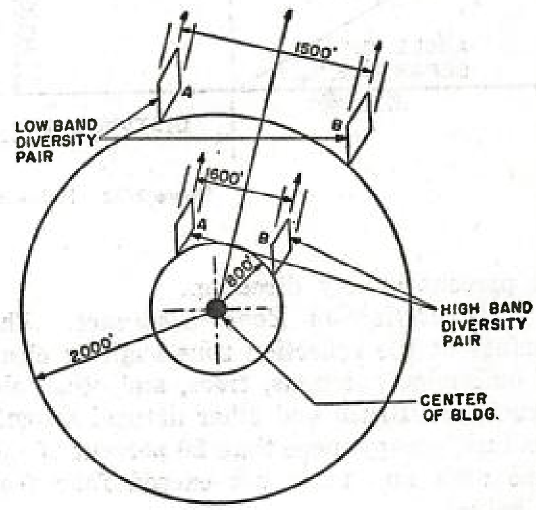


Figure 2-11. Rhombic Antenna Layout, Receiving, Diversity Spacing.

tion. This distance may be determined from the clearance zone chart (see fig. 2-7).

(4) *Clearance Zone.* The space which begins at the edge of the reflection zone and lies above the angle of radiation (see fig. 2-12).

b. The following conditions must be met in the installation of doublet antennas:

(1) *Orientations Point-to-Point.* The antenna should be broadside to the great circle azimuth of the distant station. A compromise of up to 20 degrees in either direction is permissible.

(2) *Orientation: CW Nets, Broadcast, and Air-Ground.* The antenna shall be oriented to permit maximum coverage in the desired directions.

(3) *Horizontal Placement.* The antenna radiating elements shall be parallel to the surface plane of the earth.

(4) *Reflection Zone Terrain.* The surface of the reflection zone shall not have abrupt changes greater than 10 percent of the antenna height or a slope greater than

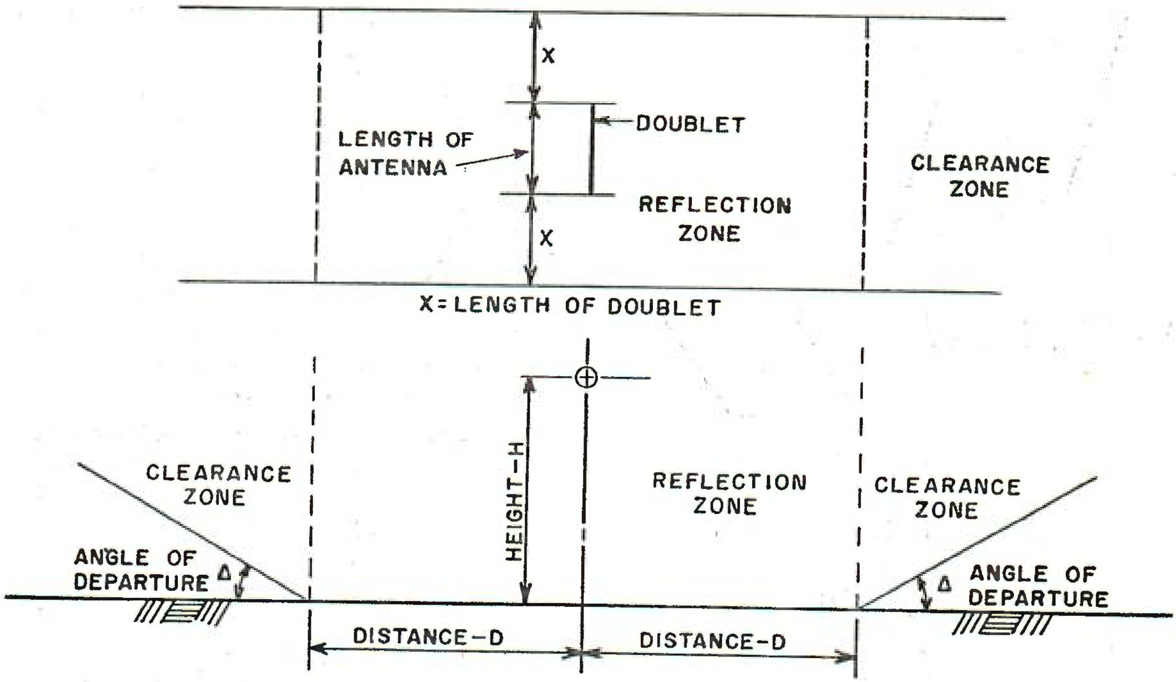


Figure 2-12. Half-wave Doublet Antenna Clearance.

10 percent in any direction.

(5) *Reflection Zone Clearance.* The surface of the reflection zone shall be clear of buildings, antennas, trees, and other obstructions. Brush and other natural growth shall not occupy more than 20 percent of the zone area and must not exceed four feet in height.

(6) *Clearance Zone Clearance.* The clearance zone shall be clear of all obstructions.

(7) *Antenna Spacing, Colinear.* The spacing between colinear antennas shall not be less than the length of the longer adjacent antenna (see fig. 2-9).

(8) *Antenna Spacing, Parallel.* The spacing between parallel half-wave doublet antennas should be six times the length of the longer adjacent antenna and seldom less than 600 feet (see fig. 2-9).

(9) *Antenna Spacing, Normal.* The minimum spacing between doublet antennas at right angles to each other shall not be less than the length of the longer adjacent antenna (see fig. 2-9), and the resonant length of the shorter antenna shall not be an odd multiple of the resonant length of the longer antenna.

(10) *Antenna Location.* The antennas shall be located as close to the building as practicable. The higher frequency (shorter) antenna shall be located closest to the building. Colinar spacing should be used whenever possible.

2-15. Discone Antenna Siting

a. In the siting of discone antennas, the following definitions are applicable:

(1) *Angle of Departure.* The useful radiation or reception angle of the antenna (between 0 and 70 degrees) measured vertically with respect to the surface plane of the earth.

(2) *Construction Zone.* The area within a radius of 110 feet around the center of the antenna (fig. 2-13).

(3) *Reflection Zone.* The area within a radius of 500 feet around the center of the antenna (see fig. 2-13).

(4) *Clearance Zone.* The zone whose lower limit intercepts the earth at the outer edge of the reflection zone at an angle of

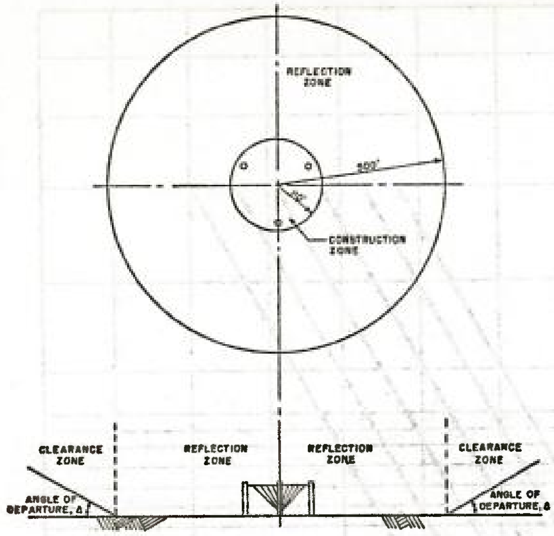


Figure 2–13. Discone Antenna Clearance.

10 degrees above the horizon (see fig. 2–13).

b. The following conditions must be met in the installation of a discone antenna:

(1) *Construction Zone Surface.* The surface of the construction zone must be smooth, level, and clear of all obstructions, and the soil must be suitable for the installation of the ground radial system.

(2) *Reflection Zone Terrain.* The surface of the reflection zone shall not have any irregularities greater than 10 feet or a slope greater than 10 percent from the horizon of the earth in any direction.

(3) *Reflection Zone Clearance.* The surface of the reflection zone shall be clear of buildings, antennas, trees, and other obstructions. Brush and other natural growth shall be kept to a minimum and must not exceed four feet in height.

(4) *Antenna Spacing.* The spacing between discones and adjacent antennas shall not be less than 500 feet.

(5) *Antenna Location.* The antennas shall be located within the circle formed by the high-frequency rhombics. Where several discones are employed, they will be placed in a circle around the building. Transmission line runs should not exceed 800 feet since attenuation becomes excessive beyond that length.

(6) *Diversity Spacing.* Spacing for diversity reception should never be less than 600 feet.

2–16. Vertical Antenna (Tower) Siting

a. The location of this antenna with respect to the distant station is not critical because of the omni-directional characteristics of the antenna. Usually, the antenna with its grounding system and guys is located as near the perimeter of the antenna farm as practicable.

b. Adjacent towers should be so spaced as to limit to plus or minus 10 percent any change in electrical characteristics which may be caused by the mutual effect of the two towers.

2–17. Long-Wire (Beverage) Antenna Siting

a. The long-wire (Beverage) antenna, when terminated, is unidirectional and is used in Globecom for receiving purposes only. The antenna must be pointed at the distant station, with the transmission line end closest to the receiver building.

b. The antenna is 16 feet in height and requires a cleared area 60 feet wide for the length of the antenna.

c. The antenna follows the contours of the land, but the radio path of reception must not be obstructed by mountainous terrain.

d. The antenna should be at least 100 feet from other horizontal conductors.

e. The antenna should be kept away from the receiver building and other sources of noise to prevent noise pick-up.

2–18. Corner Reflector Siting

The siting criterion for corner reflectors is essentially the same as that used for radar siting.

2–19. Transmission Lines

a. *General.* An RF transmission line is a conductor, or conductors, employed to conduct radio-frequency energy between antennas and equipment.

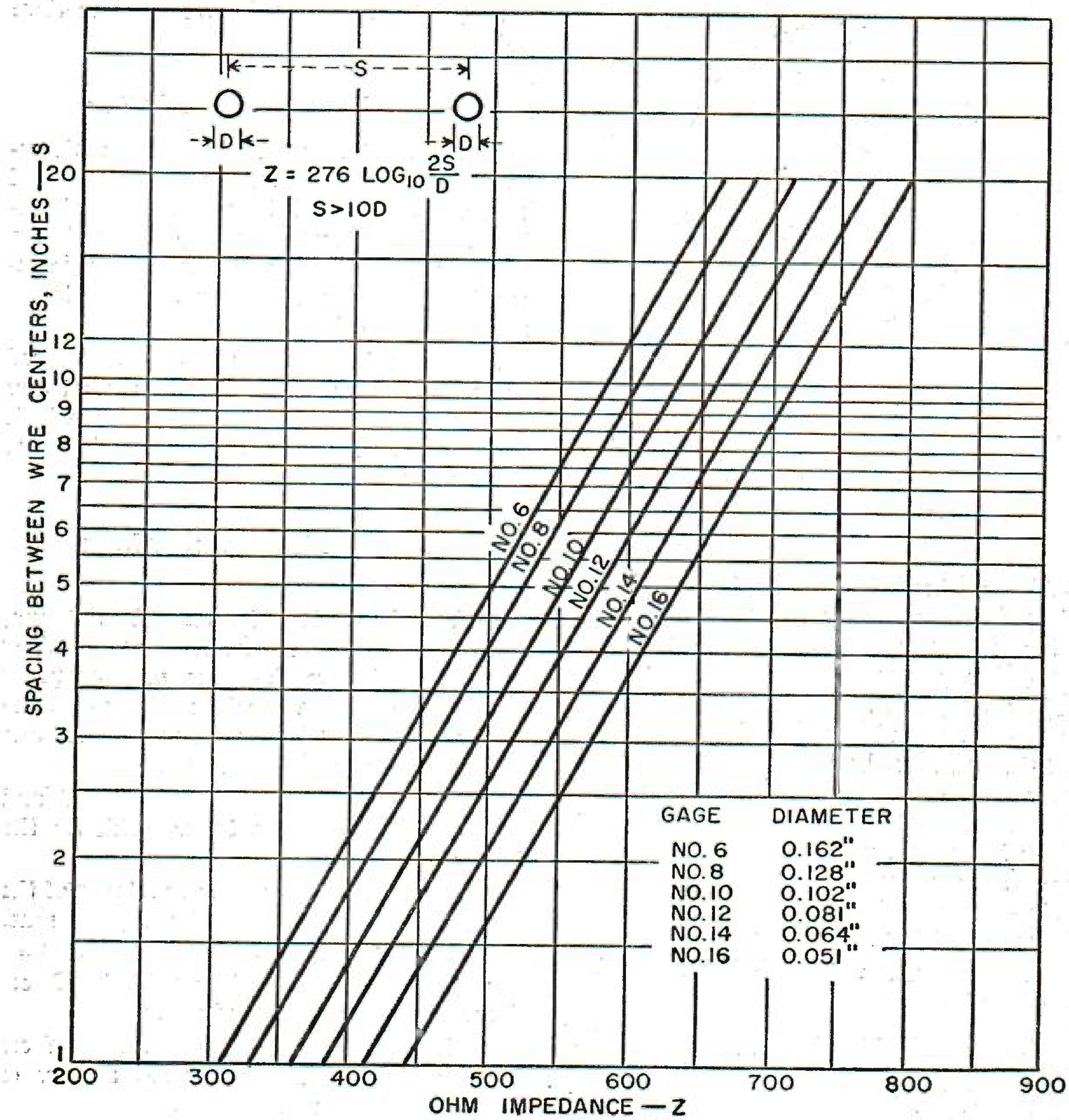


Figure 2–14. Transmission Line Wire Spacing Chart.

b. *Two-wire Line.*

(1) A two-wire line consists of a pair f parallel copper wires of precisely the same ength. The size and spacing of the wires re determined by the impedance require-nents (see fig. 2–14). The line is supported n wooden poles a minimum distance of 16 eet above the ground.

(2) This type of line is easy and eco-omical to construct, efficient, and well suited to a variety of applications. It is used in Globecom to feed transmitting antennas.

(3) Adequate separation should be maintained between adjacent transmission lines and between transmission lines and metallic objects to avoid mutual coupling and unbalance. A minimum separation of two feet is desirable between parallel trans-mission lines within the transmitter build-ing. The minimum separation between par-

allel transmission lines outside the transmitter building is six feet in the vertical plane and six feet in the horizontal plane. No single change in the direction of a transmission line run should exceed 60 degrees.

c. *Coaxial Line.*

(1) A coaxial transmission line consists of an inner and outer conductor separated by a dielectric (insulator) or ceramic beads.

(2) A coaxial line is inherently a ground-shielded line. Its major disadvantages are that it is quite expensive and has excessive attenuation at high frequencies.

(3) The coaxial line is used in Globecom as the transmission line to all discone antennas and as the transmission line from all receiving antennas.

(4) Coaxial lines in Globecom may be suspended on poles, laid on the ground, or buried. The buried installation is preferred because it minimizes the possibility of damage to the line.

2-20. Grounding Systems

Radio frequency grounding systems are an integral part of vertical towers and long-wire antennas and are essential to their operation. Arc-gap grounding systems, which are not an integral part of an antenna, provide lightning protection and discharge precipitation static.

2-21. Counterpoises

a. A counterpoise is a network of wires above and parallel to the ground surface extending radially from the base of the vertical antenna. The counterpoise is insulated from earth ground.

b. A counterpoise is normally used instead of a ground system when local electrical ground conditions are such as to make the ground system either impractical or unsatisfactory.

2-22. Dissipation Lines

a. The dissipation line is essentially a form of resistive load used to absorb a portion of the electrical energy fed to a directional antenna. The portion of energy absorbed represents that which would have been radiated in undesired directions. A dissipation line associated with a rhombic antenna is shown in figure 2-1.

b. The dissipation line used with Globecom antennas consists of a pair of No. 10 AWG stainless steel wires, 1,200 feet long, which are connected to the firing end of rhombic transmitting antennas. The line is constructed on a pole line with a separation of 8.5 inches between wires. The line is terminated to ground.

c. Low wattage dissipation resistors are bridged across the far end of receiving rhombic and long-line antennas to produce unidirectional reception.

Chapter 6

TYPICAL STATION ANTENNA FARMS

2-23. General

a. In order to effectively illustrate the implementation of criteria and utilization of facilities discussed in this chapter, a typical Globecom beltline station has been developed. The numbers and types of facilities located at this representative station were predicated upon the specific circuitry (number of circuits, type of intelligence to be transmitted, operating frequencies, and length of circuits) which was assumed. Table 2-1 is a delineation of the assumed circuitry. (Also see Chapter 1 of Part One)

b. Table 2-1 provides assumed data relative to the number and types of transmitting and receiving antennas which must be provided to satisfy the requirements of the typical beltline station in accordance with current policies and practices.

c. Studies are being conducted continuously with a view to improving the performance characteristics of antennas, to simplifying installation techniques, and to reducing costs. A number of such developments may later be introduced in Globecom to replace some current types of antennas.

2-24. Transmitter Antenna Facilities

Following are explanations of the bases for selection of the transmitter antenna facilities listed in Table 2-1.

a. *Circuits 1, 2, 13, 14, 17, 18, 22, and 23.*

(1) These circuits are point-to-point circuits with lengths within the range of 500 to 2,500 miles which require highly directional antennas. The directional antenna capable of operation on circuits in this range and requiring this directivity is the 3-wire (curtain) rhombic.

(2) It was assumed that three operating frequencies, namely high-band, low-band, and mid-band, would be assigned for each of these circuits to provide day and night operation. A high-band antenna and a low-band antenna are provided for each circuit, with both antennas capable of operating on the mid-band frequency. When changing from one frequency to another, operation on the new frequency is established before changing over from the operating frequency; that is, while one antenna is operating on the one frequency, operation of the other antenna on the other frequency is established prior to frequency change-over.

b. *Circuits 3 through 12.*

(1) These circuits are used for air-ground communication on 10 pre-selected channels. Each circuit requires a type of antenna that has a wide azimuth range and an operational range of 800 miles. The delta-matched doublet antenna meets the foregoing antenna requirements, and one antenna for each channel is provided.

(2) It is standard policy to erect back-up discone antennas which are omni-directional and capable of broad-band frequency coverage.

c. *Circuits 15 and 16.* These are short-distance point-to-point circuits 500 miles in length. Three frequencies are assigned to each of the circuits to provide day and night operation, and delta-matched doublet antennas are employed to provide uni-directional radiation. Since the doublet antennas normally are sharply tuned, a separate antenna is provided for each frequency.

d. *Circuits 19, 20, and 21.* These circuits back up landline circuits which vary from

Table 2-1. *Circuitry for Typical Globecom Beltline Station.*

CIRCUITS								ANTENNAS			
								TRANSMITTING		RECEIVING	
NO.	LENGTH (MILES)	CLASS	TYPE	OPERATION	FREQ BAND	AZIMUTH (DEGREES)	DISTANT STATION	NO.	TYPE	NO.	TYPE
1	2,200	BELTLINE	P-P	SSB	HF	271	JULIETT	2	RHOMBIC	4	RHOMBIC
2	2,200	BELTLINE	P-P	FAX	HF	271	JULIETT	2	RHOMBIC		
3-12	800		A-G	VOICE	HF	295	AIRWAYS	10 2	DOUBLET DISCONE B/U	10/6	DISCONE 2-3
13	1,500	TRIBUTARY	P-P	MUX	HF	312	KILO	2	RHOMBIC	4	RHOMBIC
14	1,500	TRIBUTARY	P-P	FAX	HF	312	KILO	2	RHOMBIC		
15	500	TRIBUTARY	P-P	MUX	HF	325	LIMA	3	DOUBLET	4/6	DISCONE-DIV 1-5
16	500	TRIBUTARY	P-P	TELEPHOTO	HF	325	LIMA	3	DOUBLET	2/6	DISCONE 4
17	2,000	BELTLINE	P-P	SSB	HF	73	DELTA	2	RHOMBIC	4	RHOMBIC
18	2,000	BELTLINE	P-P	FAX	HF	73	DELTA	2	RHOMBIC		
19	350	TRIBUTARY	LL-BU	RTTY	HF	126	FOXTROT	2	DOUBLET	4/6	DISCONE-DIV 1-5
20	400	TRIBUTARY	LL-BU	RTTY	HF	224	INDIA	2	DOUBLET	4/6	DISCONE-DIV 1-5
21	300	TRIBUTARY	LL-BU	RTTY	HF	90	ECHO	2	DOUBLET	4/6	DISCONE-DIV 2-6
22	1,000	TRIBUTARY	P-P	MUX	HF	163	GOLF	2	RHOMBIC	4	RHOMBIC
23	1,000	TRIBUTARY	P-P	FAX	HF	163	GOLF	2	RHOMBIC		
24-27			WX BCST	RTTY	HF	145		4	DOUBLET		
28-31			WX BCST	FAX	HF	325		4	DOUBLET		
32	800	TRIBUTARY	NET	CW	HF	2	BRAVO	3	DOUBLET	3/6	DISCONE 4
33	450	TRIBUTARY		CW	HF	182	HOTEL				
34	800	TRIBUTARY	P-P	MUX	VHF	2	BRAVO	1	CORNER REFLECTOR	2	CORNER-REFLECTOR
35	2,500	TRIBUTARY	P-P	MUX	LF	29	COCA	1	TOWER	1	LONG-WIRE
36	2,500	TRIBUTARY	B-U	MUX	HF	29	COCA	2	RHOMBIC	4	RHOMBIC
37-40	1,500		INTCP	CW	HF					8/6	DISCONE 6-7

LEGEND:
A-G —— AIR-GROUND
B-U —— BACK-UP
BCST —— BROADCAST
CW —— MANUAL TELEGRAPH
DIV —— DIVERSITY
FAX —— FACSIMILE
INTCP —— INTERCEPT
L-L —— LAND-LINE
MUX —— MULTIPLEX
P-P —— POINT TO POINT
RTTY —— RADIO TELETYPEWRITER
SSB —— SINGLE SIDEBAND
WX —— WEATHER

300 to 400 miles in length. Since these circuits are used only for back-up, two delta-matched doublet antennas are provided, one for operation on the high-band frequency and the other for operation on the low-band frequency.

e. *Circuits 24, 25, 26, and 27.* These circuits are used for radio teletypewriter weather broadcasts. One delta-matched doublet is provided for each circuit.

f. *Circuits 28, 29, 30 and 31.* These circuits are used for simultaneous radio facsimile broadcasts of weather data charts to several intercepting points within an 800-mile range. Each of these circuits operates continuously on one frequency and utilizes a delta-matched doublet antenna.

g. *Circuits 32 and 33.* These circuit numbers signify two distant points operating with the "typical" station in a CW net. For this net operation, three frequencies have been assigned, and three delta-matched doublet antennas are provided, one for each frequency.

h. *Circuit 34.* This circuit employs the principle of forward propagation ionospheric scatter (frequently referred to as VHF/Forward Scatter) and utilizes a single frequency in the VHF band. One corner reflector is utilized for transmitting purposes.

i. *Circuit 35.* This circuit is over 600 miles in length and is used for point-to-point transmission to a station in the high latitudes. Low-frequency vertically-polarized groundwave transmission is employed. The antenna best suited to this type of circuit is the vertical tower. One frequency is assigned to this circuit.

j. *Circuit 36.* This circuit is provided as HF back-up to Circuit 35. Three frequencies are assigned to the circuit, and two rhombic antennas are provided.

k. *Circuits 37, 38, 39 and 40.* These circuits are used for intercepting (receiving) purposes only, and no transmitting antennas are required.

2-25. Transmitter Antenna Farm Layout

Figure 2-15 illustrates an acceptable layout for the antennas selected for use at the typical Transmitter Site. The antenna siting criteria discussed in Chapter 5 in this part of the manual were used as a guide in preparing the layout.

2-26. Receiver Antenna Facilities

Following are explanations of the bases for selection of the receiver antenna facilities listed in Table 2-1.

a. *Circuits 1, 13, 17, and 22.*

(1) These long-distance point-to-point circuits are provided with rhombic antennas. Space diversity reception is employed, so four antennas are provided for each circuit, two for reception of the low-band frequency and two for reception of the high-band frequency.

(2) Circuits 1 and 17 are single sideband (SSB) circuits. Circuits of this type which provide six teletypewriter channels utilize a tone diversity technique inherent in the equipment which makes space diversity reception unnecessary. Current Globecom planning provides for increasing the channel capacity for all SSB circuits from 6 to 16 channels which will require space diversity reception. For this reason, space diversity normally has been provided in current engineering.

b. *Circuits 2, 14, 18, and 23.* No separate receiving antenna facilities are provided for these circuits since, by employing branching amplifiers, reception is accomplished with the same antennas provided for Circuits 1, 13, 17 and 22. Space diversity reception is not used with these circuits. (Refer to Part Three, Receivers, for information about the use of branching amplifiers).

c. *Circuits 3 through 12.*

(1) These are air-ground antenna circuits used for reception of high-frequency signals from air-ground stations within an 800-mile range. The discone antenna, which is omni-directional and covers a wide frequency range, is provided for this application.

(2) Since each receiving discone antenna is capable of being connected simultaneously to six separate receivers by the use of branching amplifiers, the antenna re-

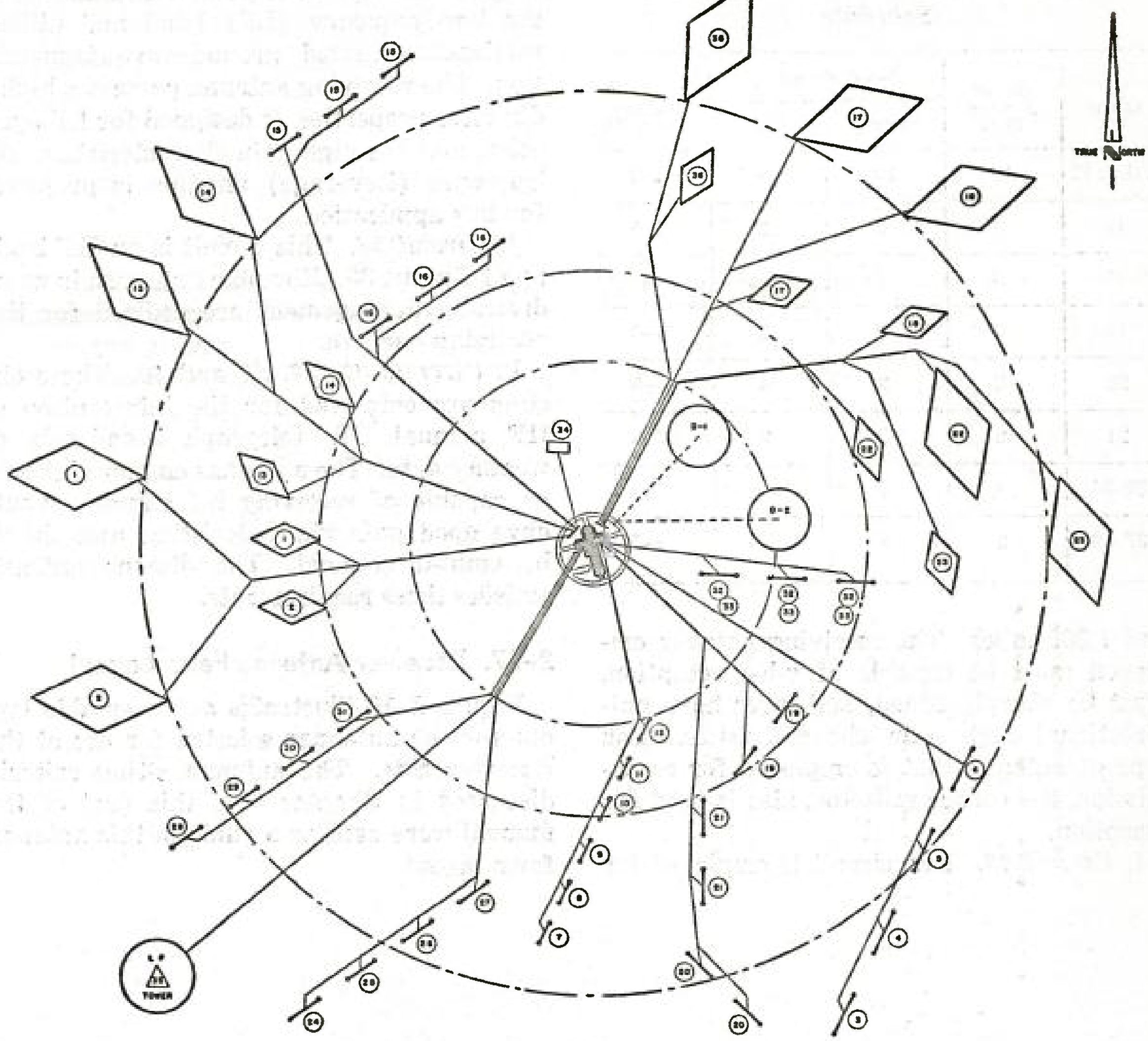


Figure 2-15. Typical Station Transmitting Antenna Layout.

quirements for the A-G circuits can be shared with the balance of the circuits which use discone antennas. See Table 2-2 for the receiving discone antenna schedule.

d. *Circuits 15, 16, 19, 20 and 21.* These circuits are used for short-distance (less than 600 miles) point-to-point communication. For reception, the antenna employed possesses high gain characteristics and has an adequate frequency band coverage. Since the receiving antennas need not have highly directional properties, the discone antenna has been selected for reception in these circuits.

e. *Circuits 24, 25, 26 and 27.* These circuits are used for radio teletypewriter broadcast of weather data. Receiving antennas are not required.

f. *Circuits 28, 29, 30 and 31.* These circuits are used for facsimile broadcasts of weather data. Receiving antennas are not required.

g. *Circuits 32 and 33.* These are manual CW telegraph circuits for transmitting special traffic. Three frequencies are employed and a discone antenna is utilized.

h. *Circuit 34.* This circuit employs frequencies in the VHF band (30-300 megacycles) and is used for point-to-point communication over distances ranging between 60

Table 2–2. Receiving Discone Antenna Schedule

Circuit No.	No. of Assigned Freq.	No. of Receivers		Assigned Discone No.
		Normal	Diversity	
3 thru 12	10	10	–	2–3
15	3	2	2	1–5
16	3	3	–	4
19	2	2	2	1–5
20	2	2	2	1–5
21	2	2	2	2–6
32–33	3	3	–	4
37–40	2	8		6–7

and 1,200 miles. The receiving antenna employed must be capable of v-h-f reception, must be sharply tuned, and must have unidirectional high gain characteristics. The type of antenna that is employed for transmission, the corner reflector, also is used for reception.

i. *Circuit 35.* This circuit is employed for long-distance point-to-point transmission in the low-frequency (LF) band and utilizes vertically-polarized ground-wave transmission. The receiving antenna possesses highly directive properties, is designed for LF operation, and has high gain characteristics. The long-wire (Beverage) antenna is preferred for this application.

j. *Circuit 36.* This circuit is an HF back-up of Circuit 35. Rhombic antennas in space diversity arrangement are utilized for this receiving purpose.

k. *Circuits 37, 38, 39 and 40.* These circuits are employed for the interception of HF manual CW telegraph broadcasts of weather data. The antennas employed should be capable of receiving h-f signals, should have good gain characteristics, and should be omni-directional. The discone antenna satisfies these requirements.

2–27. Receiver Antenna Farm Layout

Figure 2–16 illustrates an acceptable layout for the antennas selected for use at the Receiver Site. The antenna siting criteria discussed in Chapter 5 of this part of the manual were used as a guide in this antenna farm layout.

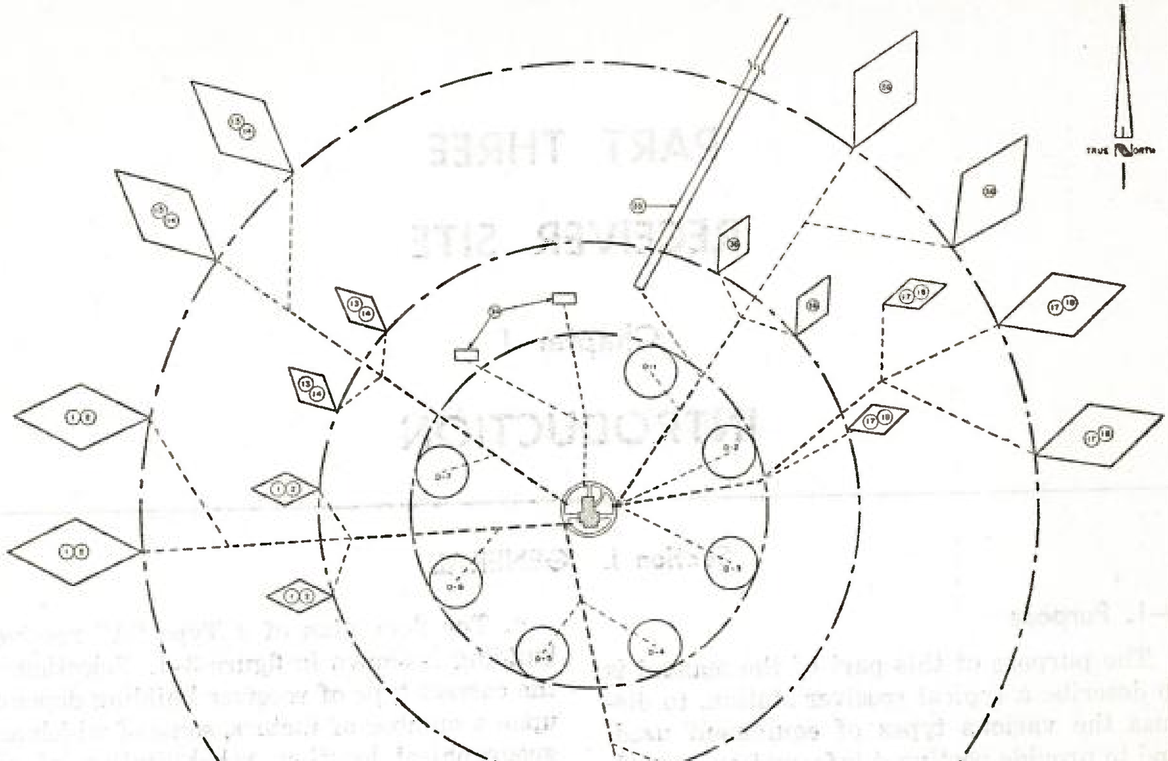


Figure 2-16. Typical Station Receiving Antenna Layout.

PART THREE

RECEIVER SITE

Chapter I

INTRODUCTION

Section I. GENERAL

3-1. Purpose

The purpose of this part of the manual is to describe a typical receiver station, to discuss the various types of equipment used, and to provide pertinent information regarding the operational capabilities of the equipment.

3-2. Scope

For the purpose of illustration, it is necesary to include in the typical receiver station he various types of equipment which might e found at any receiver station, regardless f location or size. It should be understood, owever, that the amount of traffic handled t each station determines the equipment equired, and since the local requirements f all stations are not the same, no two Reeiver Sites will be identical. Some types of quipment (common) will be employed at all eceiver stations, whereas employment of ther types will depend upon the circuits andled at each particular station.

-3. Policy

Every effort is made to standardize the omponents of the Air Force Global Commuication System; but due to the wide variety f buildings and local conditions at individual tes, complete standardization is not always ossible.

a. The floor plan of a Type "A" receiver building is shown in figure 3-1. Selection of the correct type of receiver building depends upon a number of factors, some of which are geographical location, rehabilitation of existing buildings, utilization of existing facilities, and operational circuit requirements. The Type "A" receiver building was chosen for the typical Globecom station because the equipment room provides the maximum floor space for future expansion. The first floor includes the Equipment Utility Wing, the Equipment Room, and the Personnel Utility Wing. The second floor, immediately above the equipment room, provides quarters for station personnel. The commanding officer's room is located at the head of the stairs above the personnel utility wing.

b. Figure 3-2 shows the method of numbering the various equipment cabinets located in the receiver building. Each floor space has an assigned number which is automatically given to any piece of equipment which occupies that particular space. This lends flexibility to the system without disturbing the consecutive order of the cabinets.

c. Practically all receiving equipment is mounted in standard 19-inch equipment cabinets (CY-597 A/G). These cabinets are seven feet high and can accommodate equipment from the top to the bottom. A sliding

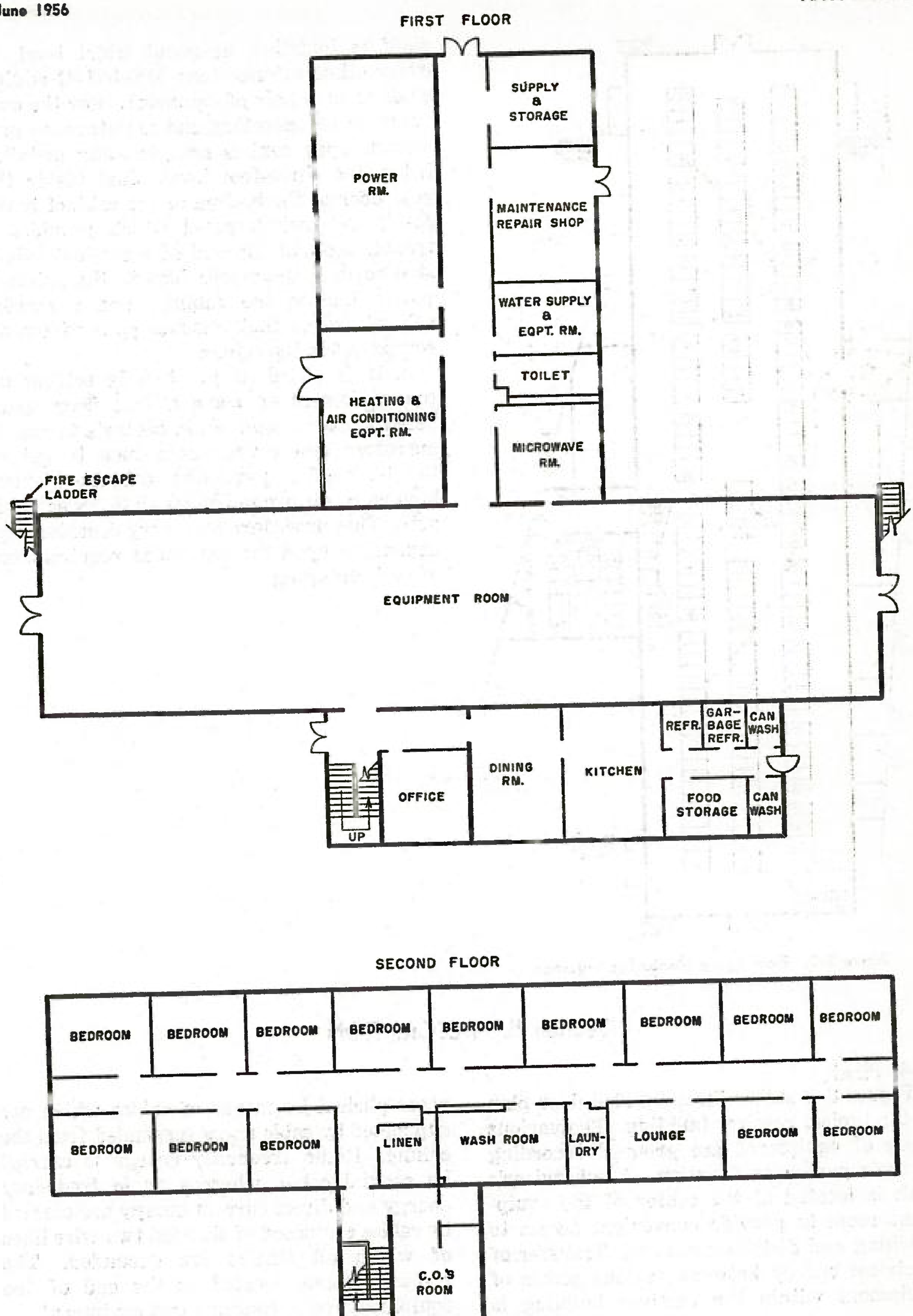


Figure 3-1. Receiver Building Floor Plan.

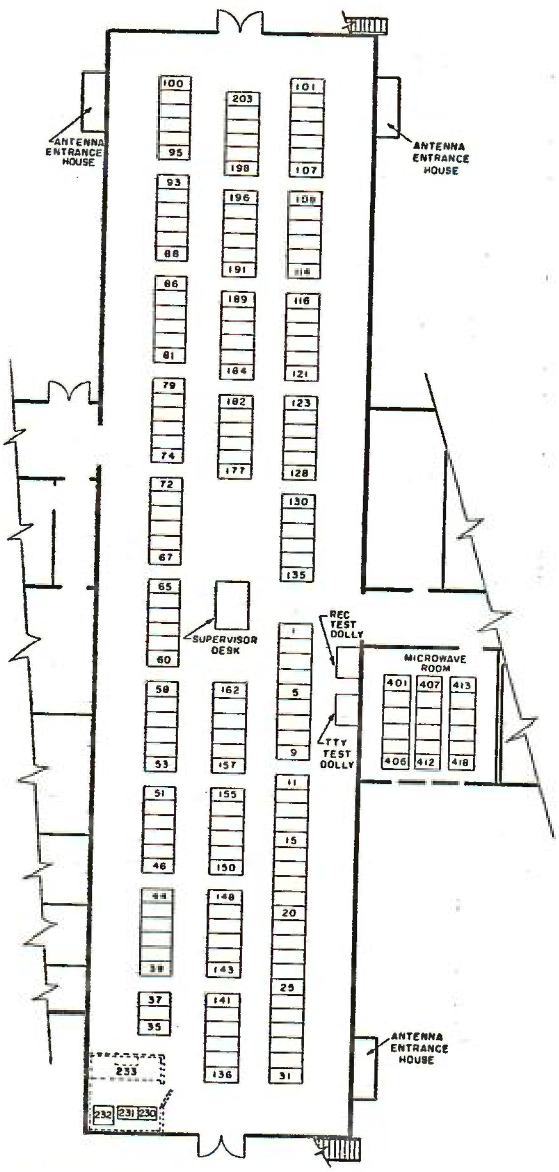


Figure 3–2. Floor Space Numbering Sequence.

shelf is installed, at about waist level, in every other cabinet (one MT–571–G sliding shelf to each pair of cabinets). For the convenience of operators and maintenance personnel, equipment is not generally installed below the three-foot level. Just inside the rear door at the bottom of the cabinet is the SA–238/G switch panel which provides a trouble light at the end of a six-foot extension cord, a 10-ampere fuse in the primary power line to the cabinet, and a master cabinet switch that removes power from all equipment in the cabinet.

d. It is standard practice in setting up the equipment to leave a free floor space between each group of six cabinets to enable operators and maintenance men to get to the back of a particular cabinet without having to go around more than three cabinets. This procedure may vary considerably, depending upon the particular requirements of each grouping.

Section II. DESCRIPTION

–4. Plant

Figure 3–3 shows the simplified floor plan f the typical receiver building. The various ypes of equipment are grouped according o their particular function. A supervisor's esk is located at the center of the equipient room to provide convenient access to atching and distribution bays. Transfer of lectrical energy between various pieces of quipment within the receiver building is accomplished by means of cables which are supported by cable racks suspended from the ceiling. Radio frequency energy is carried by coaxial cable, whereas audio frequency energy and direct current energy are carried by cables composed of shielded two-wire lines of which all shields are grounded. The screened room, located at the end of the equipment room, contains test equipment.

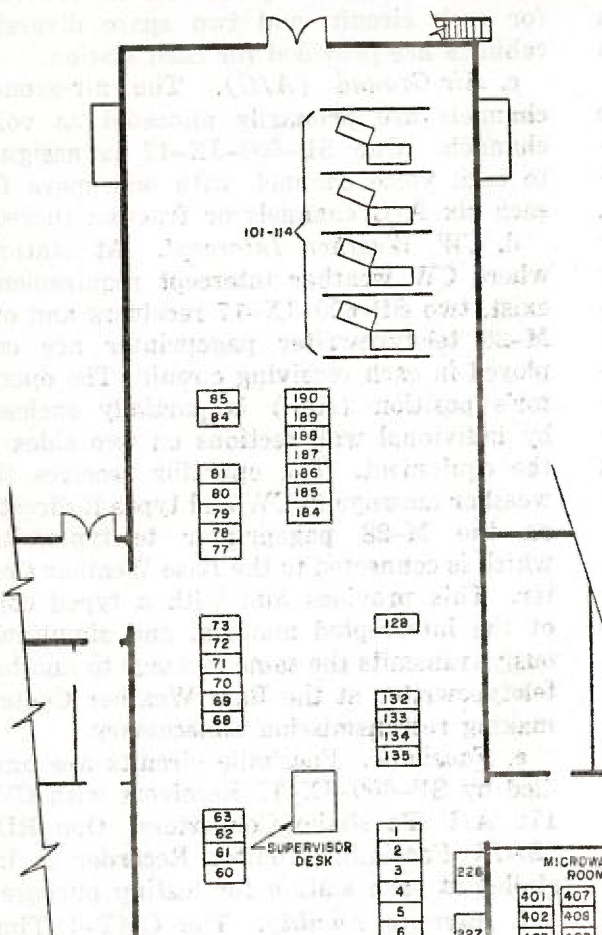


Figure 3–3. Typical Equipment Room Floor Plan.

EQUIPMENT DISPOSITION	
FLOOR SPACE NUMBERS	CABINETS
1	MISCELLANEOUS EQUIPMENT
2–3	AF & DC PATCH
4–6	VFTG KEYERS
11–12	BRANCHING AMPLIFIERS
13	RF PATCH
14	MONITOR RECEIVER
15–16	VFO
24	VOLTAGE REGULATOR
25	LOCAL BATTERY
38–39	FACSIMILE
40	FACSIMILE MONITOR
41–42	FACSIMILE
49–51	SINGLE SIDEBAND
53–54	DIVERSITY (LINE UP)
60–63	DIVERSITY
68–73	DIVERSITY
77–81	DIVERSITY
84	DIVERSITY (BACK UP)
85	LOW FREQUENCY
101–114	CW INTERCEPT
128	REMOTE CW (NET)
132–135	AIR-GROUND
183–190	FORWARD SCATTER
226	RECEIVER TEST DOLLY
227	TTY TEST DOLLY
230	TEST CABINET 1
231	TEST CABINET 2
232	TTY-TD
233	FREQUENCY METER
401–416	MICROWAVE MULTIPLEX

3-5. Equipment

The many types of signals handled in Globecom make it necessary to employ a wide variety of receiving equipment.

a. *Single Sideband (SSB).* The beltline circuit is primarily handled by single sideband equipment (frequency division multiplex and frequency diversity transmission). Each SSB circuit requires one SSB receiver and one line-up cabinet. The SSB receiver currently in use is the R-369/FRC-10 (LD-R1). The line-up receiver (diversity cabinet) includes two Hammarlund Model SP-600-JX-17 Receivers with the AN/URA-8B Audio Frequency-Shift Converter-Comparator Group. One spare SSB receiver is installed for each three circuits or fraction thereof. Preparatory to changing the frequency of the SSB receiver, contact is established at the new frequency with the line-up equipment to determine when reception will be satisfactory. In the future, the AN/FRC-10 Receivers (R-369 and D-99945) will be replaced by the AN/FRR-41 Receivers for space diversity reception of frequency division multiplex SSB transmission.

b. *Radioteletypewriter (RTTY& MUX).* The Hammarlund Model SP-600-JX-17 Receiver is the standard receiver which handles radio teletypewriter signals in each of the tributary circuits. Two SP-600-JX-17 Receivers, in conjunction with the AN/URA-8B Audio Frequency-Shift Converter-Comparator Group, is used for space diversity reception of frequency shift teletypewriter signals. Two diversity cabinets are provided for each circuit, and two spare diversity cabinets are provided for each station.

c. *Air-Ground (A/G).* The air-ground channels are primarily allocated as voice channels. One SP-600-JX-17 is assigned to each voice channel, with one spare for each six A/G channels or fraction thereof.

d. *CW Weather Intercept.* At stations where CW weather intercept requirements exist, two SP-600-JX-17 receivers and one M-28 teletypewriter pageprinter are employed in each receiving circuit. The operator's position (stall) is partially enclosed by individual wall sections on two sides of the equipment. The operator receives the weather message in CW and types it directly on the M-28 pageprinter teletypewriter which is connected to the Base Weather Center. This provides him with a typed copy of the intercepted material and simultaneously transmits the same message to another teletypewriter at the Base Weather Center, making retransmission unnecessary.

e. *Facsimile.* Facsimile circuits are handled by SP-600-JX-17 Receivers with CV-172 A/U Facsimile Converters. One RD-92/UX Facsimile Monitor Recorder is installed at each station for testing purposes.

f. *Intersite Facility.* The CMT-4 Time Division Multiplex Equipment and the CLR-6 Microwave Radio Relay Equipment provide the necessary two way radio linkage between the Communications Relay Center, the Transmitter Site and the Receiver Site.

Chapter 2

EQUIPMENT

Section I. RADIO FREQUENCY EQUIPMENT

3–6. Antennas

Table 3–1 shows the functional use of antennas at Globecom sites. The discone receiving antenna system is utilized in air-ground, CW intercept, and point-to-point circuits for omnidirectional, broad-band reception of radio signals from transmitting stations which are less than 800 miles away. If space will not permit the erection of a discone antenna, doublet antennas may be used. It must be remembered, however, that the doublet is a high-Q antenna and will operate efficiently only at frequencies which fall within its narrow band pass which is approximately plus-or-minus one-half megacycle from the frequency for which it was designed. Therefore, when doublet antennas are used, a separate one is required for each frequency employed. The rhombic receiving antenna system is utilized in point-to-point circuits for directional, broad-band reception of radio signals from transmitting stations which are more than 800 miles away. The size of receiving antenna farms will vary according to the number and types of circuits terminating at the respective sites. For long-distance point-to-point circuits, receiving antennas are usually installed in pairs to permit space diversity reception.

Table 3–1. Antenna Function

Antenna types	Air-Ground channels		Point-to-Point over 800 miles		Point-to-Point under 800 miles		Other intercept & WX broadcast	
	XMTR	RCVR	XMTR	RCVR	XMTR	RCVR	XMTR	RCVR
Discones	X1	X				X		X
Doublets	X				X	X2	X	
Rhombics			X	X				

(X_1) Secondary function
(X_2) If space will not permit a discone

3–7. Coaxial Feed Lines

Each antenna feeds into an RG–85 coaxial cable which is armored to protect it against breakage and treated to protect it against the elements. The cable is generally buried 18 inches below the surface of the groun
At the antenna entrance house, the RG–8
armored coaxial cable is physically termi
nated and connected through a connecto
adapter (CA) to WECO 724 coaxial cabl

which enters the receiver building through the entrance port. There are three entrance houses at each receiver building (see figure 3–2), and the coaxial cables from each antenna entrance house are brought into the receiver building on overhead cable racks. Overhead racks are used to support cables and trunk lines between all cabinets in the receiver building. To maintain maximum flexibility in the receiving system, all input and output circuits of all equipment cabinets are terminated in jacks at main patching and distribution panels, and all coaxial antenna feed lines are terminated in the RF Patch Cabinet. Bell Telephone System installation practices are followed as closely as possible.

3–8. RF Patch Cabinet

The RF Patch Cabinet is the point of distribution for all coaxial cabling between equipment cabinets and between antennas and equipment within the receiver building. This cabinet provides the necessary flexibility in use of equipments by patching between jacks mounted in the cabinet. The :abinet also includes pads, which are terninated at jacks, for attenuating or paraleling the inputs of equipment or antennas. All antennas terminate at the RF Patch Cabinet and can be patched directly or hrough branching amplifiers to any receiver. nputs and outputs of all branching ampliiers are terminated at the patch panel to nake it possible to connect any antenna to ny branching amplifier. The HFO and BFO utputs from the variable frequency master scillator terminate at the patch panel and an be connected to any receiver. All coaxial runks from each cabinet in the equipment oom and from patch panels in the screened oom and maintenance room terminate in he RF Patch Cabinet. This arrangement llows for handling miscellaneous signals or testing purposes or for other-thanormal operation. The jack strips in the RF 'atch Cabinet are arranged to allow for norıal operation when using only WECO 341–C ɔaxial plugs for patching purposes. RF atch cords (fig. 3–4) are used to connect

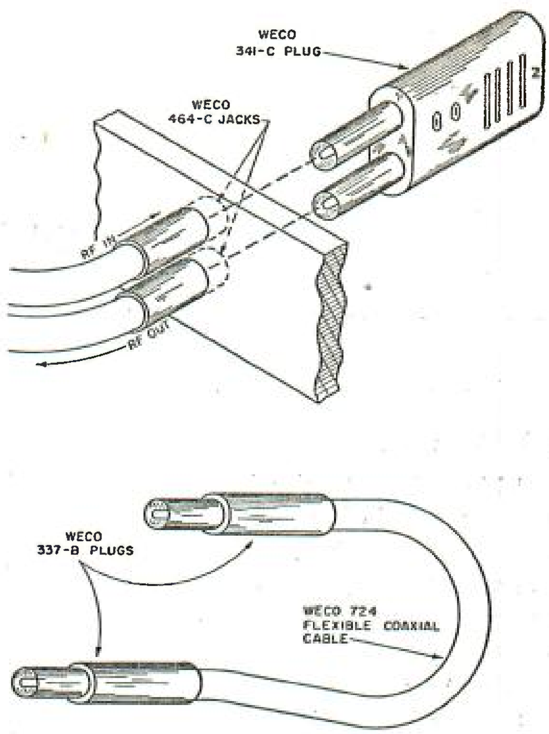


Figure 3–4. Patch Plug and Cord.

circuits for other-than-normal operation or for termination in pads.

3–9. Branching Amplifier Cabinet

Each branching amplifier cabinet contains ten branching amplifier units (Telectro TA–230). The purpose of the branching amplifier is to provide up to six radio-frequency outputs to radio receivers when its input is connected to a receiving antenna. The range of the branching amplifier is from 2.5 to 30 MC. The input signal should not exceed three millivolts since cross talk will occur at higher levels. Each receiver may be tuned to any frequency within the frequency limits of the receiving antenna and its branching amplifier. There is at least one branching amplifier for each antenna at the Receiver Site. By cascading branching amplifiers (fig. 3–5), it is possible to increase the utility of the antenna used. However, Globecom engineering normally does not employ branching amplifiers in cascade due to the resultant increase in vulnerability and noise level, so it is mentioned here only to indicate an emergency capability.

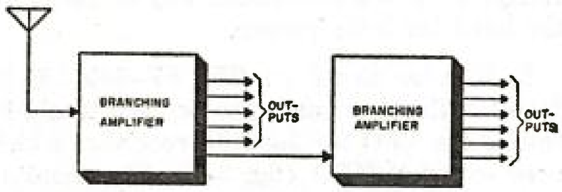
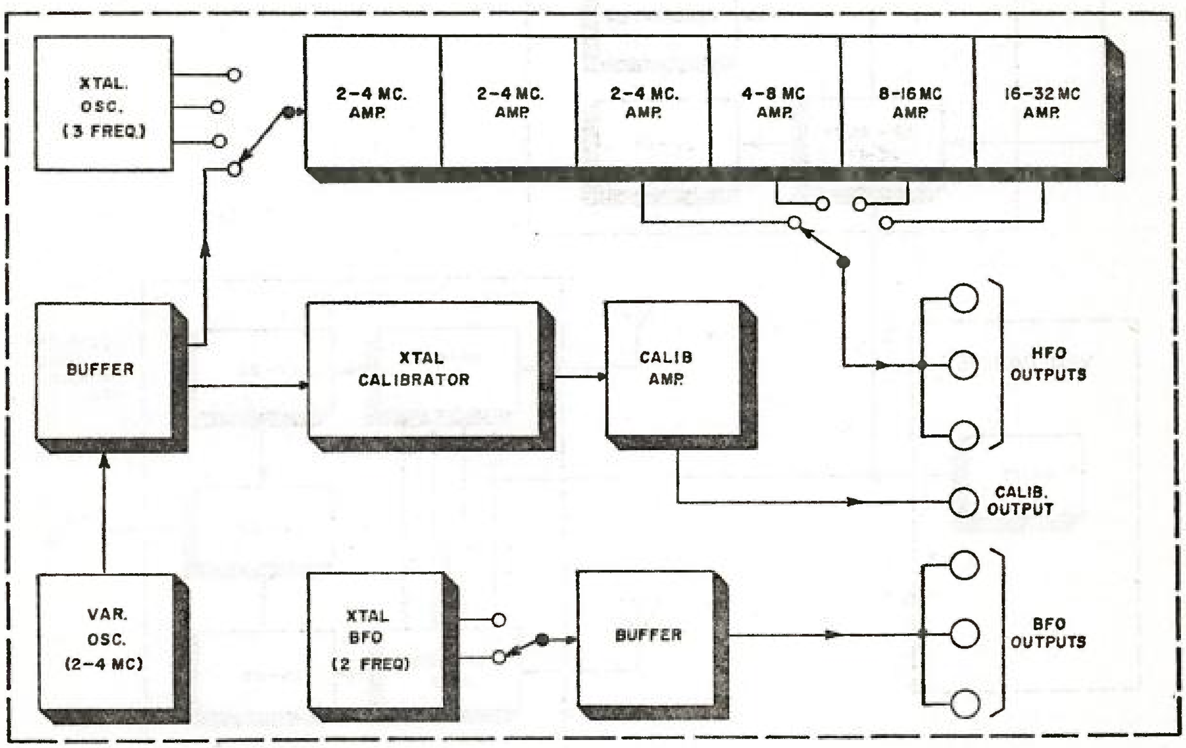


Figure 3-5. Branching Amplifier Cascade Block.

3-10. Variable Frequency Master Oscillator Cabinet

The NR-115, Model 1, Variable Frequency Master Oscillator (VFO) is mounted in the standard 19-inch equipment cabinet. Its purpose is to supply local oscillator injection voltage to the receiver when a crystal for a particular frequency is not available. Its variable frequency is designed to give stability equivalent to that obtained by non-temperature-compensated crystal oscillators. The entire unit is adequately shielded to eliminate interference with adjacent receiving equipment. A block diagram of the VFO is shown in figure 3-6. The circuit consists of a high-frequency variable oscillator covering the range of 2 to 4 MC, followed by buffers and multipliers which provide outputs of from 2 to 32 MC. A low-frequency crystal oscillator provides for receiver BFO operation. The output level of each oscillator can be adjusted to suit a wide variety of requirements. Three coaxial connectors are provided for each of the VFO and BFO outputs. A 100 KC crystal is provided for spot calibration of the variable HFO. An additional feature which is not normally used in Globecom is a crystal controlled oscillator which also covers the range of 2 to 4 MC. A front panel switch switches the oscillator into the circuit in place of the variable frequency oscillator to provide a choice of three fixed frequencies in the 2 to 32 MC range.



NOTE: SHADED BLOCKS INDICATE NORMALLY USED CIRCUITRY.

Figure 3-6. Functional Block Diagram of the Variable Frequency Master Oscillator.

3-11. Monitor Cabinet

The Monitor Cabinet contains an SP-600-JX-17 Receiver, a CV-89 Frequency Shift Converter, and an SA-8A-T-200 Panadapter.

a. *Panadapter.* The panadapter is an automatically-scanning superheterodyne receiver which permits many RF signals to be analyzed at one time. The input of the panadapter is connected through an isolating element to the output of the mixer in the SP-600-JX-17 Receiver. The frequency of the panadapter is varied between established limits so that its selectivity sweeps a given band of frequencies. In the course of the frequency excursions, the oscillator beats successively with each signal in the band. These signals, according to their nature, are depicted on the cathode-ray tube as a series of vertical pulses along the horizontal axis. The amplitude and position of each pulse, as seen through the calibrated screen, indicate signal strength and frequency, respectively. This is a convenient way of checking the band for interference.

b. *Monitor Receiver.* The SP-600-JX-17 Monitor Receiver may also be used to aid in tuning the VFO for use with receivers which need external HFO (fig. 3-7). The monitor receiver and the diversity receivers are patched into the same VFO, and the RF section of the monitor receiver is tuned to the desired signal and the HFO adjusted to the proper frequency. Since the VFO cabinets are adjacent to the monitor cabinet, the operator can make all necessary HFO adjustments without leaving the RF equipment group; to complete the tuning, only the RF sections of the diversity receivers need to be tuned at the diversity cabinet.

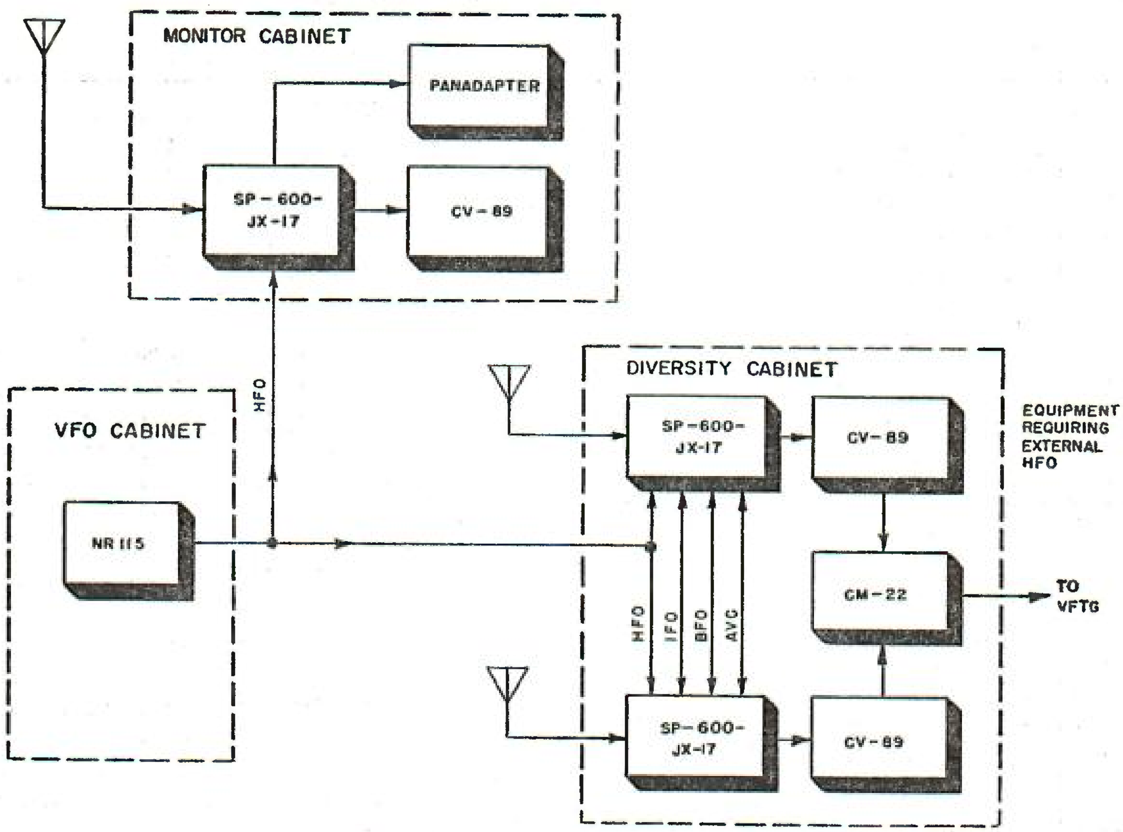


Figure 3-7. Block Diagram of the Monitor Tuning Circuit.

Section II. RECEIVING EQUIPMENT

3-12. Hammarlund Model SP-600-JX-17 Receiver

The Hammarlund Model SP-600-JX-17 Radio Receiver is the primary receiver used in the Globecom system and is mounted in a standard 19-inch equipment cabinet. It is a 20-tube radio communications receiver which covers six frequency bands to provide continuously variable tuning within the frequency range of 0.54 MC to 54.0 MC for fixed-frequency, crystal-controlled reception. It finds especial use in space diversity reception wherein advantage is taken of the more usable (stronger) signal provided by one of two receivers whose antenna systems are spaced more than one wavelength apart. The radio receiver provides for the reception of keyed, amplitude modulated, and frequency shift carrier signals. The carrier signal intelligence may be composed of slow-speed (manual) telegraph, high-speed (automatic) telegraph, teletypewriter, facsimile, or telephone signals. The receiver uses single heterodyne conversion for its three lower frequency bands (below 7.4 MC) and double heterodyne conversion for its three higher bands (above 7.4 MC) (fig. 3-8). The receiver will operate with high stability on any one of six fixed frequencies by utilizing the crystal controlled HFO in place of the variable HFO. Six crystals can be mounted in the receiver for use with the crystal controlled HFO. The selectivity of the receiver (band width) may be varied between 13 KC and 500 cps in six steps. The three narrower band widths employ crystal filters in the IF section of the receiver to reduce signal interference by rejecting unwanted signals which are closely adjacent to the desired signal.

a. *Heterodyne Frequency Oscillator (HFO).* In space diversity reception, the system output may be from one receiver at one instant and from the other receiver at another instant. The relative drift between heterodyne oscillators in each receiver is avoided by using one receiver as the master and the other as the slave. When connected in this manner, the HFO injection voltage normally is supplied to both receivers by the internal crystal-controlled HFO of the master receiver. If a crystal for the desired frequency is not available, the HFO injection voltage can be patched to both receivers from the very stable external NR-115 Variable Frequency Master Oscillator (VFO). A higher degree of stability can be obtained with the external VFO than with the internal variable HFO of the receiver.

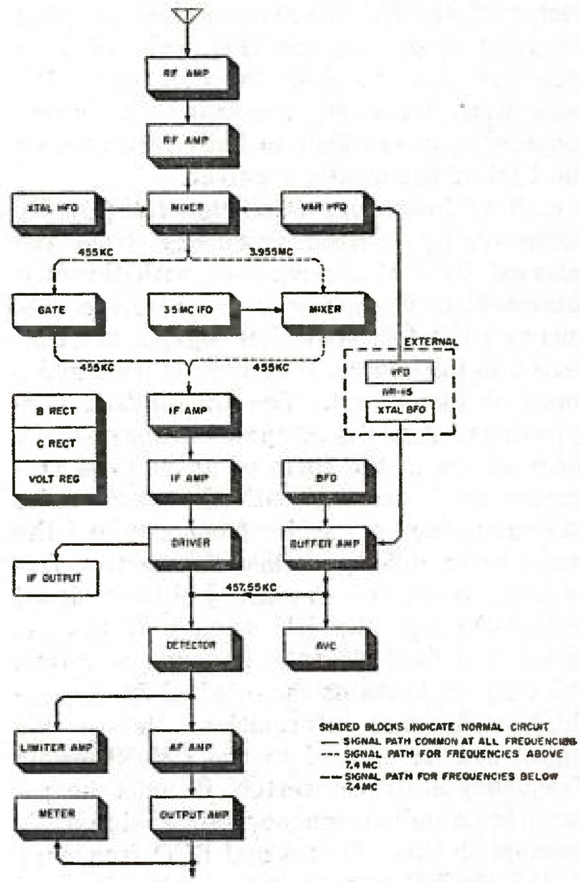


Figure 3-8. Functional Block Diagram of the SP-600-JX-17 Receiver.

b. *Intermediate Frequency Oscillator (IFO).* When receiving frequencies above 7.4 MC, the receiver utilizes dual conversion. In the first converter, the incoming signal is heterodyned with the HFO to produce the first intermediate frequency of 3.955 MC. In the second converter, the first intermediate frequency is heterodyned with the output frequency of 3.5 MC from a crystal controlled IFO to produce the final intermediate frequency of 455 KC. When connected for space diversity operation, the IFO jacks of both receivers are coupled together, and the heterodyne frequency necessary for second conversion is supplied to both receivers by the IFO of the master receiver.

c. *Beat Frequency Oscillator (BFO).* By heterodyning a fixed frequency from the internal BFO of the receiver with the final intermediate frequency of the receiver, frequency shift teletypewriter signals are converted to modulated, frequency-shifted audio tones at the output. The transmitted teletypewriter signal is composed of mark-space information in the form of an 850 cps frequency shift carrier, with the mark pulse 425 cps above the carrier frequency and the space pulse 425 cps below the carrier frequency. When this frequency-shifted signal passes through the RF section of the receiver, the final IF (455 KC plus or minus 425 cps) still retains the original frequency-shift mark-space information. Before this signal can be applied to the CV-89 Audio Frequency-Shift Converter, it must be reduced to an audio frequency-shifted signal. To accomplish this, the internal BFO frequency of 457.550 KC is heterodyned with the final IF to produce the desired audio frequency of 2550 cps with the proper frequency shift of plus or minus 425 cps which operates the audio discriminator in the CV-89 converter. Should the need arise for more stability in the operation of the BFO, the low-frequency crystal-controlled oscillator located in the NR-115 Variable Frequency Master Oscillator may be used in place of the internal BFO of the receiver.

d. *Automatic Volume Control (AVC).* The AVC terminals of both receivers (master and slave) are tied together so that the circuit which has the stronger signal will automatically control the gain of both receivers.

3-13. Radio Teletypewriter Reception

A means is provided to convert the frequency-shifted mark-space information to DC pulses which can be used to activate VFTG tone keyers or teletypewriter machines. The conversion is accomplished by the AN/URA-8B Frequency-Shift Converter-Comparator Group which is a combination of two CV-89A/URA-8B converters and one CM-22A/URA-8B comparator. Since it is standard policy to install only diversity cabinets for radio teletypewriter circuits, the circuit components will normally be connected as shown in figure 3-9.

a. *CM-22 Comparator.* A three-position switch (not shown) at the input of the CM-22 selects the output from either receiving system (A or B) for non-diversity reception, or from both receiving systems (A and B) for space diversity reception (fig. 3-9). The frequency-shifted audio signal from the output of each receiver is converted to DC pulses by the action of the discriminator in the associated CV-89 Converter. The DC pulses from both CV-89 Converters are applied to the selector circuit (one to channel A and one to channel B) in the CM-22 Comparator where the stronger signal is used to activate the keyer-trigger which in turn controls the electronic relay. The output from the electronic relay appears on the diversity cabinet jack strip and is normalled through to the AF and DC Patch Cabinet. A small indicator lamp, located in the jack panel of the CY-597 A/G equipment cabinet, indicates whether or not the teletypewriter circuit is handling signal current. The indicator lamp is shunted by a 900-ohm resistor and is connected in series with the 60 MA loop circuit (see figure 3-10). The 60 MA loop circuit is broken by a space pulse and closed by a mark pulse; consequently, the indicator lamp glows only when a mark pulse is present. If the indicator lamp should burn out, the 900-ohm resistor would carry sufficient loop current to maintain signal continuity. The unshaded blocks in figure 3-9 show the circuitry for producing a keyed tone output. The audio oscillator may be switched to any one of eight present tones, or it may be switched to the external position at which the oscillator acts as a straight-through amplifier to apply the external tone to the tone modulator. When the mark pulse is present, a tone is produced in the output; when the space pulse is present, no tone is produced in the output. This results in a keyed tone carrying the mark-space information. The terminals of this portion of the circuit do not appear on the diversity cabinet jack strip because keyed tone (on-off) teletypewriter signals are not used in Globecom.

b. *CV–89 Converter.* Figure 3–11 shows the circuits normally used in the CV–89. The frequency-shifted audio signal from the receiver is applied to the audio frequency discriminator in which the high and low frequency shift tones are converted to positive and negative DC pulses, respectively. In frequency shift communication, the transmitted signal shifts above and below the carrier. Under normal conditions, the mark pulse is carried by the higher frequency and the space pulse is carried by the lower frequency. There will be times, however, when the frequency shift relationship will be reversed. In the reversed condition the mark will be carried by the lower frequency and the space will be carried by the higher frequency. A manual reversing switch (not shown) is incorporated following the audio frequency discriminator to correct the reversed frequency shift relationship. The circuitry following the discriminator in the CV–89 is essentially the same as the circuitry following the selector circuit in the CM–22. The teletypewriter output from the electronic relay in the CV–89 appears on the diversity cabinet jack strip. The CV–89 may be used by itself to convert teletypewriter signals from frequency-shift audio to on-off DC suitable for operating the VFTG tone keyer or the teletypewriter pageprinter. When the CV–89 is used by itself, the discriminator converts the frequency-shift audio to DC pulses and applies them to the keyer-trigger which in turn operates the electronic relay.

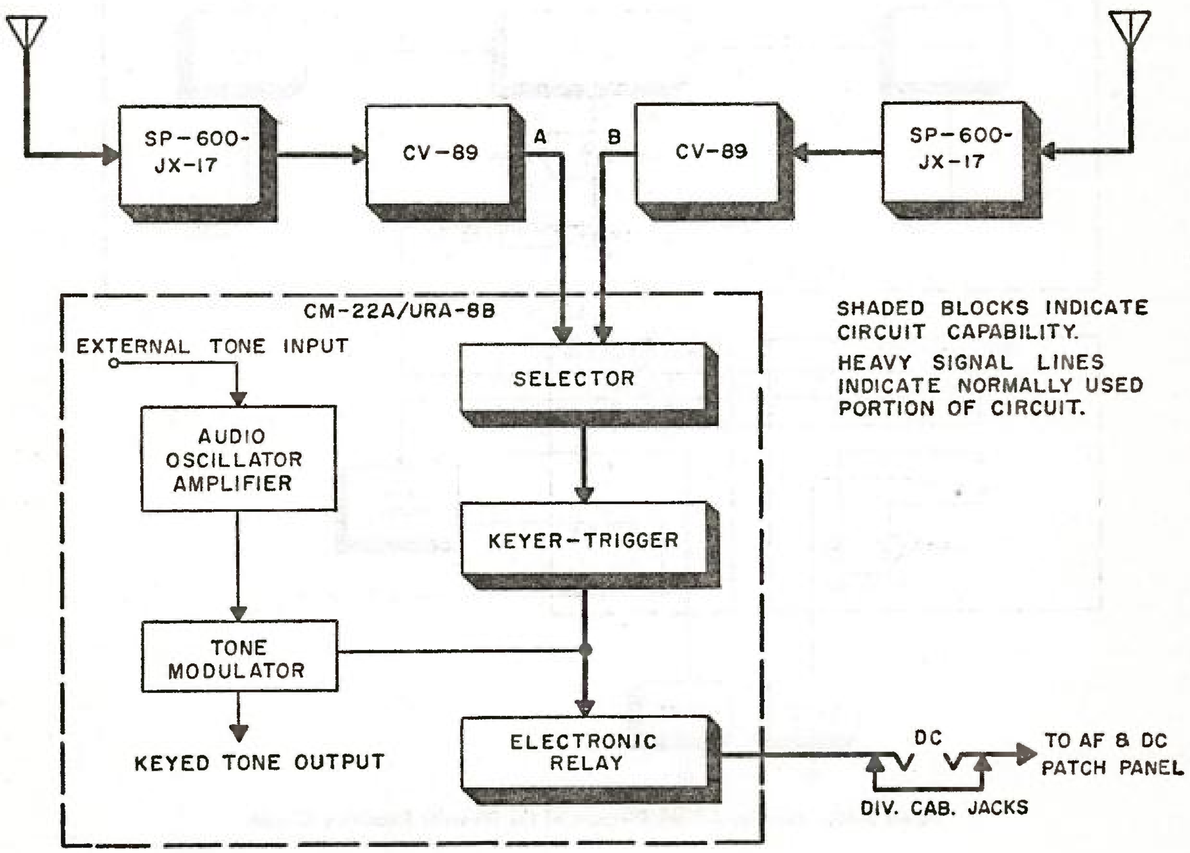


Figure 3–9. CM–22 Comparator Diversity Connection.

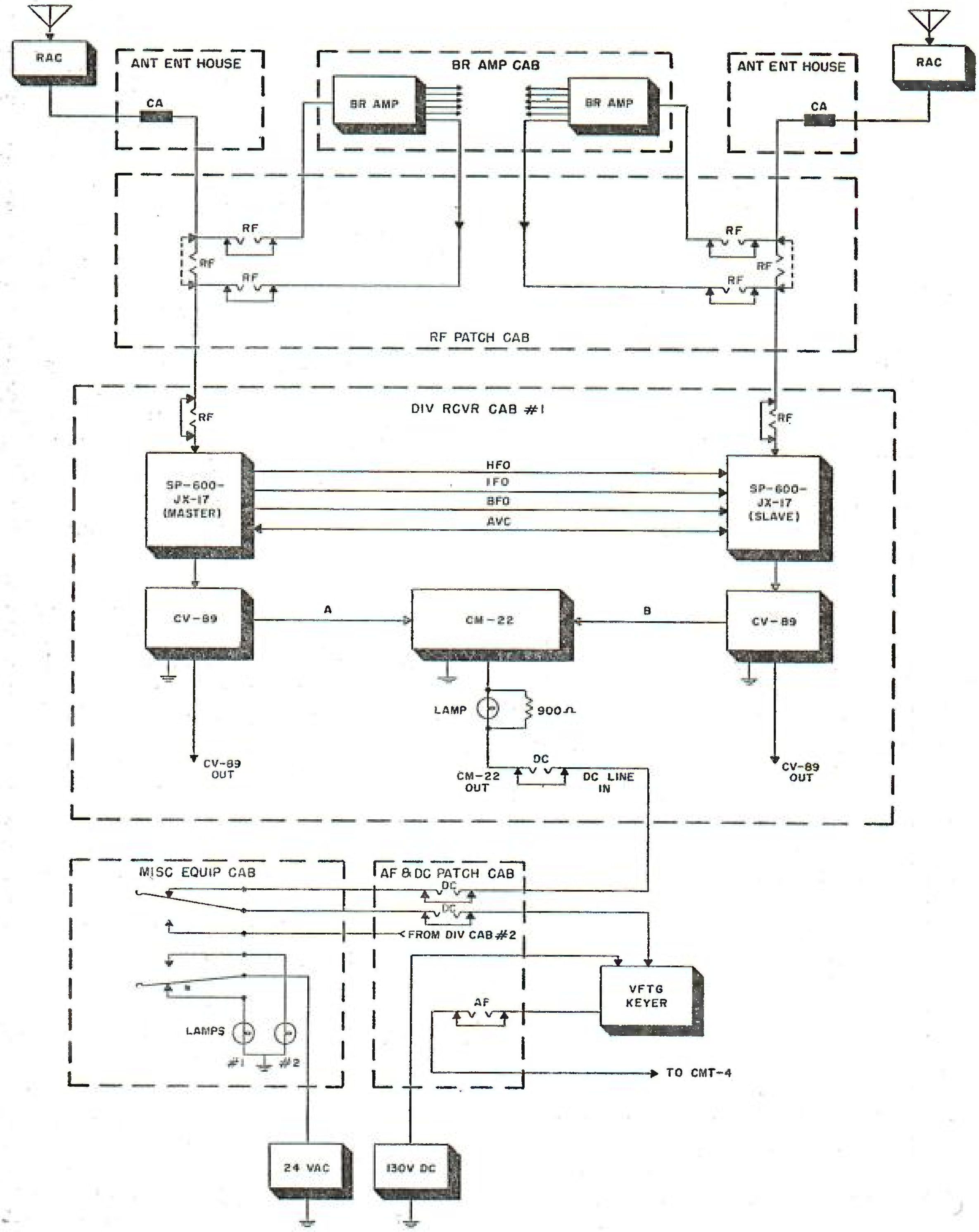


Figure 3-10. Functional Block Diagram of the Diversity Receiving Circuit.

The output of the CV–89 is then patched to the DC line input (see figure 3–10).

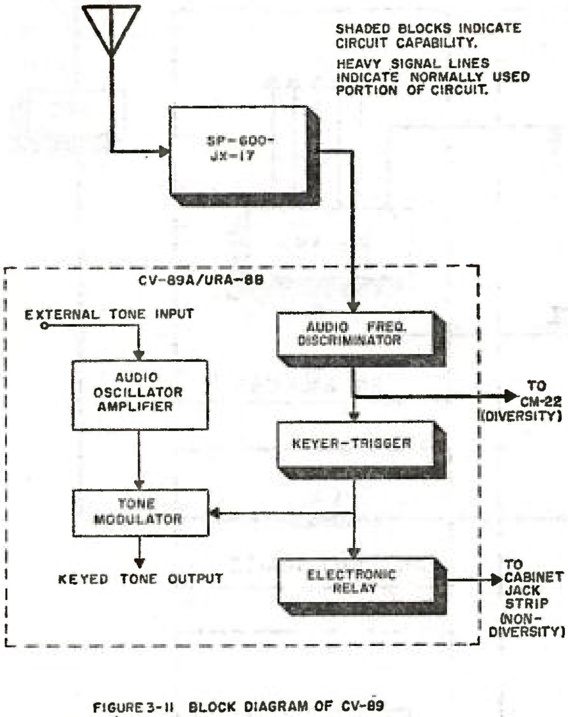


Figure 3–11. CV–89 Converter Diversity Connection.

3–14. Radio Facsimile Reception

Facsimile equipment is used to transmit fixed images from one point to another over an electrical communication system such as a radio circuit or a landline. In Globecom, these circuits are used primarily for facsimile transmission of weather maps. The distant facsimile transmitter resolves the image (map) into very small component areas and transmits the average density of each area in sequence to the receiver station in the form of frequency-shift RF. The RF signal is detected at the receiver and converted to amplitude variations by the converter. The converted signal is transmitted to the Communications Relay Center over Intersite Link Facilities, then proceeds by landline to the Base Weather Center. The facsimile recorder at the Base Weather Center amplifies the facsimile signal and converts it back into corresponding density variations on the recording sheet. When the entire picture has been scanned at the facsimile transmitter, it has been copied on the recording paper at the facsimile recorder.

a. *Receiving Circuit.* The incoming frequency-shifted RF facsimile signal terminates at the RF Patch Cabinet. By using WECO 341–C coaxial plugs, the signal may be patched to the input of a branching amplifier and from one of the amplifier outputs to the antenna input of the receiver cabinet; or it may be patched directly from the antenna to the antenna input of the receiver cabinet (fig. 3–12). Before the signal can get to the receiver, however, it must again be patched at the receiver cabinet jack strip to the antenna input of the receiver. External HFO and BFO may be obtained from the variable frequency master oscillator by using WECO P2AW flexible coaxial patch cords at the RF Patch Cabinet. In the receiver, the frequency-shifted RF signal is detected and applied to the output audio pad as a frequency-shifted audio signal in which 1500 cps represents the black portion of the image and 2300 cps represents the white portion of the image. The LS–139/G Loudspeaker Assembly at the output of the receiver is used for audible monitoring of the signal during tuning. The audio pad attenuates the signal from loudspeaker level to the correct input level of approximately 0 db for the facsimile converter. The amplitude of the signal may drop as much as 50 db due to transmission effects on the radio circuit before the amplitude of the output signal is seriously affected; consequently, the final image contrast is practically constant even under conditions of severe fading.

b. *Frequency Shift Facsimile Converter.* The CV–172A/U Frequency Shift Converter is used as part of the terminal equipment at the receiving end of a radio facsimile circuit. It converts 1500 cps and 2300 cps audio frequency-shift facsimile signals to amplitude modulated signals which operate a facsimile recorder. The connection is normal-through from the audio pad to the input of the CV–172A/U Facsimile Converter. The facsimile signal continues through the input amplifier, limiter, and frequency discriminator to the output amplifier. The loudspeaker which is built into the converter is used to indicate the proper level when signal

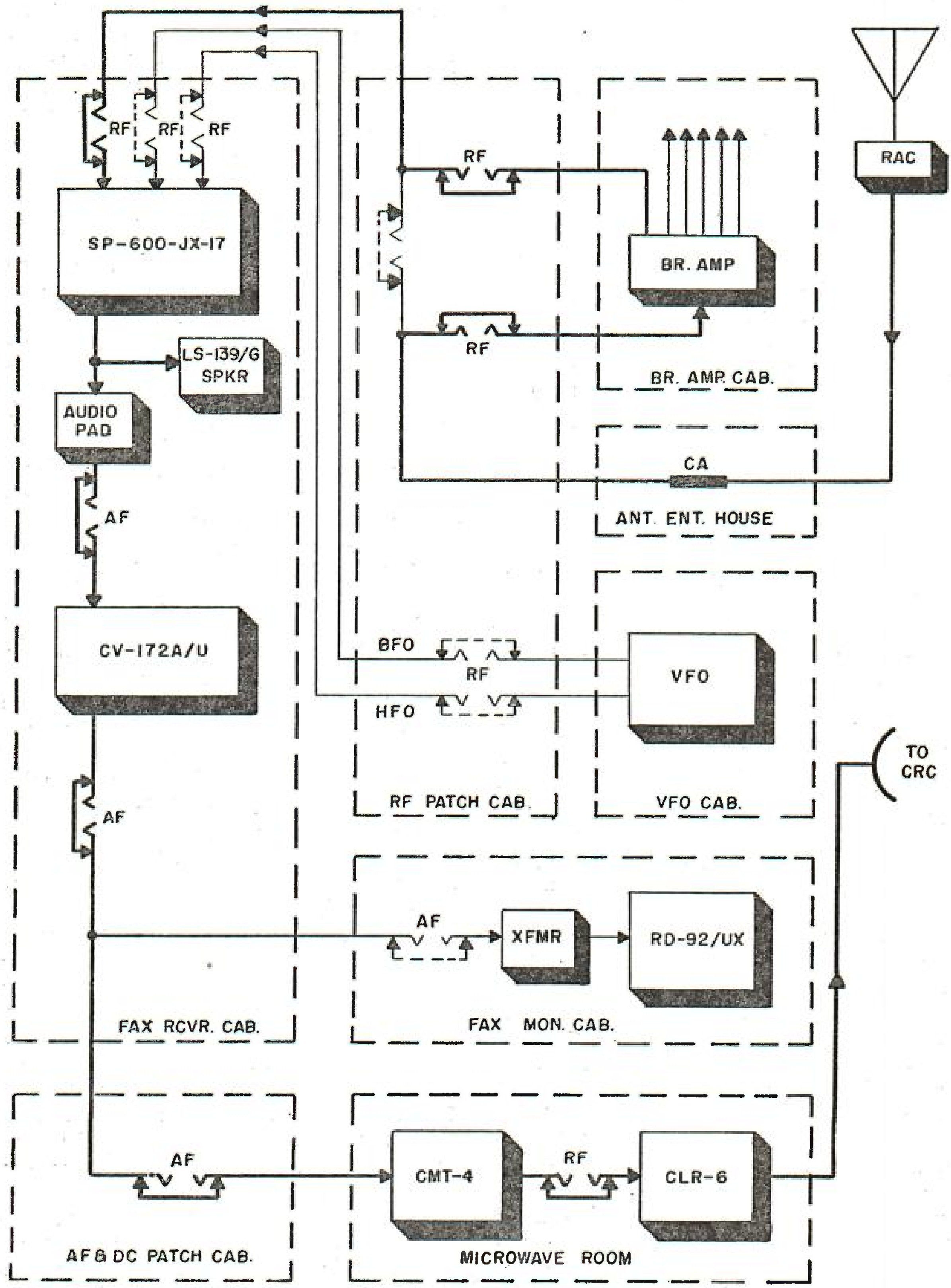


Figure 3-12. Functional Block Diagram of a Facsimile Receiving Circuit.

adjustments are made at the input of the converter. In the limiter, all amplitude variations (noise signals) are removed from the facsimile signal, leaving a frequency-shifted audio tone of constant amplitude. At the limiter, a small portion of the signal is applied to the frequency indicator (electron-ray tube) for visual indication of the frequency limits of the signal. The constant amplitude frequency shift signal from the limiter is applied to the frequency discriminator where amplitude variations are added in proportion to the frequency shift of the facsimile signal (fig. 3–13). The circuit is normal-through from the output amplifier of the CV–172 A/U through the AF and DC Patch Cabinet to the Intersite link facility. For testing purposes, a facsimile recorder is employed at the Receiver Site and may be patched into the circuit at the jack strip on the facsimile monitor cabinet.

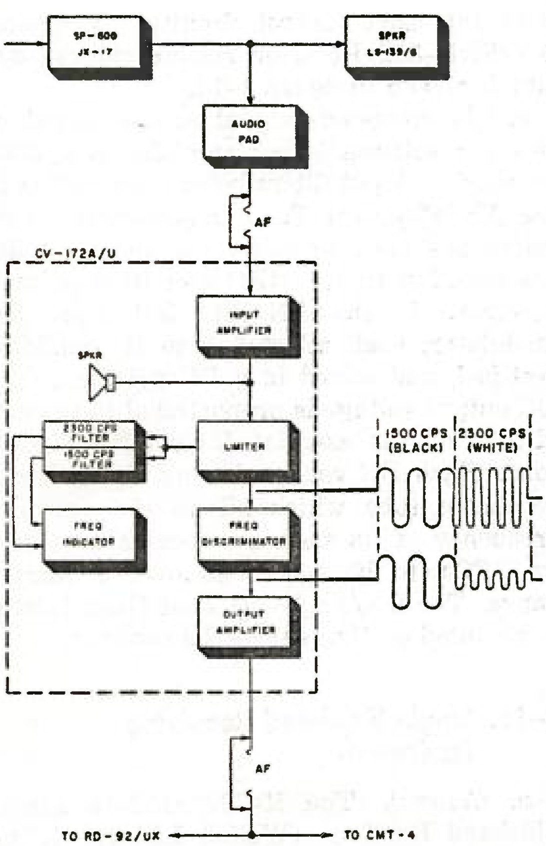


Figure 3–13. Functional Block Diagram of the Facsimile Con

c. *Facsimile Monitor Cabinet.* The facsimile monitor cabinet contains an RD–92A/UX facsimile recorder.

(1) The recorder is used to monitor the outputs which go from the facsimile receiver to the Relay Center. A jack strip is provided in the fascimile monitor cabinet for monitoring the outputs of up to five facsimile receiver cabinets, one circuit at a time.

(2) The facsimile recorder may also be used to record maps, pictures, sketches, printer text, or handwriting. The recorder was designed primarily for recording black and white copy. It records some half-tone shadings, but these do not accurately represent the copy transmitted when the original copy is a half-tone photograph or picture. For this reason, the recorder is not recommended for recording facsimile signals transmitted from photographic copy.

3–15. AN/FRR–502 Remote CW Receiver

a. The AN/FRR–502 Model FRR Receiver (fig. 3–14) is a single-frequency communications receiver which covers the frequency range from 2 to 32 mc by means of four plug-in drawers which contain the first and second RF, VFO, and mixer circuits. The AN/FRR–502 is a 15-tube superheterodyne receiver using single conversion throughout its frequency range and an intermediate frequency of 455 kc. The receiver may be operated on internal VFO, crystal, or external HFO.

b. Remote control tuning of the HFO and BFO is possible on a tone basis using a tone self-regulating amplifier and an AN/FRA–501 Tone Demodulator. The output of the AN/FRA–501 is DC, on the order of 0 to plus or minus 3 volts. This voltage controls the center frequency of the oscillator by varying the output impedance of the reactance modulator. It provides for plus or minus 0.05 percent variation of the HFO and plus or minus 0.5 percent variation of the BFO. In other words, by remote control, the frequency of an HFO operating at 10 mc could be varied about 5 kc in either direction, and a BFO frequency of 455 kc could be varied about 2 kc in either direction.

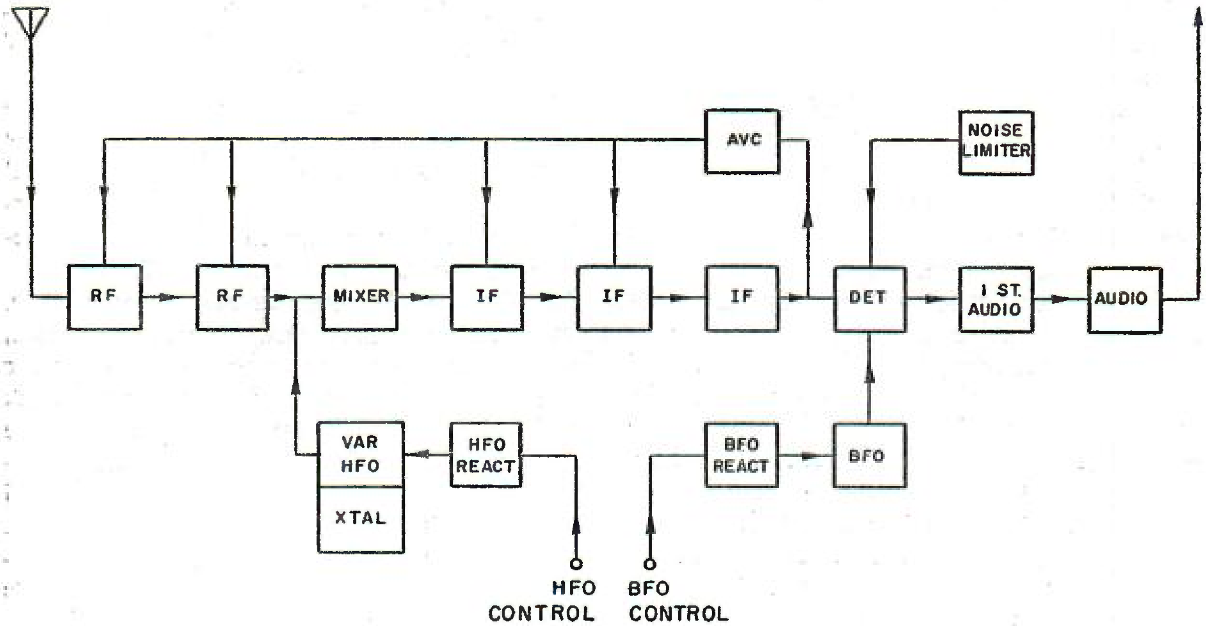


Figure 3–14. Functional Block Diagram of the AN/FRR—502 Receiver.

c. In the event it becomes necessary to operate a CW circuit by remote control, the tone self-regulating amplifier and the AN/FRA–501 will be used with the AN/FRR–502 Receiver. The purpose of the amplifier is to amplify the control tones used for remotely tuning the AN/FRR–502 Receivers. Since tuning of the AN/FRR–502 Receivers is accomplished by a change in amplitude of the control tone, it is important that the output of the amplifier remain constant, except when it is desired to change the frequency of the receiver. For this reason, a constant amplitude pilot tone is also transmitted with the control tones. The pilot tone is employed to actuate the AGC (automatic gain control) of the amplifier and to reduce amplitude variations which are caused by fading. This maintains the output of the amplifier constant to within 1 db for a 10 db change in amplitude of the pilot tone over the range of 0 dbm to −30 dbm.

d. A composite signal containing all twelve control tones plus the pilot tone may be transmitted from the remote operator's position to the receiver location. The twelve control tones provide remote HFO and BFO control for six receivers with one control tone for each control facility. A typical AN/FRR–502 Receiver remote control circuit is shown in figure 3–15.

e. The composite signal at the output of the tone self-regulating amplifier is applied to selective input filters before proceeding to the AN/FRA–501 Tone Demodulator. Two filters are used to select the control tones associated with the HFO and BFO of each receiver. In the AN/FRA–501 Tone Demodulator, each selected tone is amplified, rectified, and mixed in a DC network. The DC output voltage is proportional to the amplitude of the associated incoming control tone. Each DC voltage is then applied to a reactance tube which allows the resonant frequency of its associated oscillator (HFO or BFO) to be controlled over a limited range. The AN/FRA–501 Tone Demodulator is mounted on the rear of the receiver.

3–16. Single Sideband Receiving Equipment

a. *General.* The R–369/FRC–10 Single Sideband Receiver (WECO LD–R1) is designed for reception of single sideband, reduced carrier signals in the range of 4 to 28

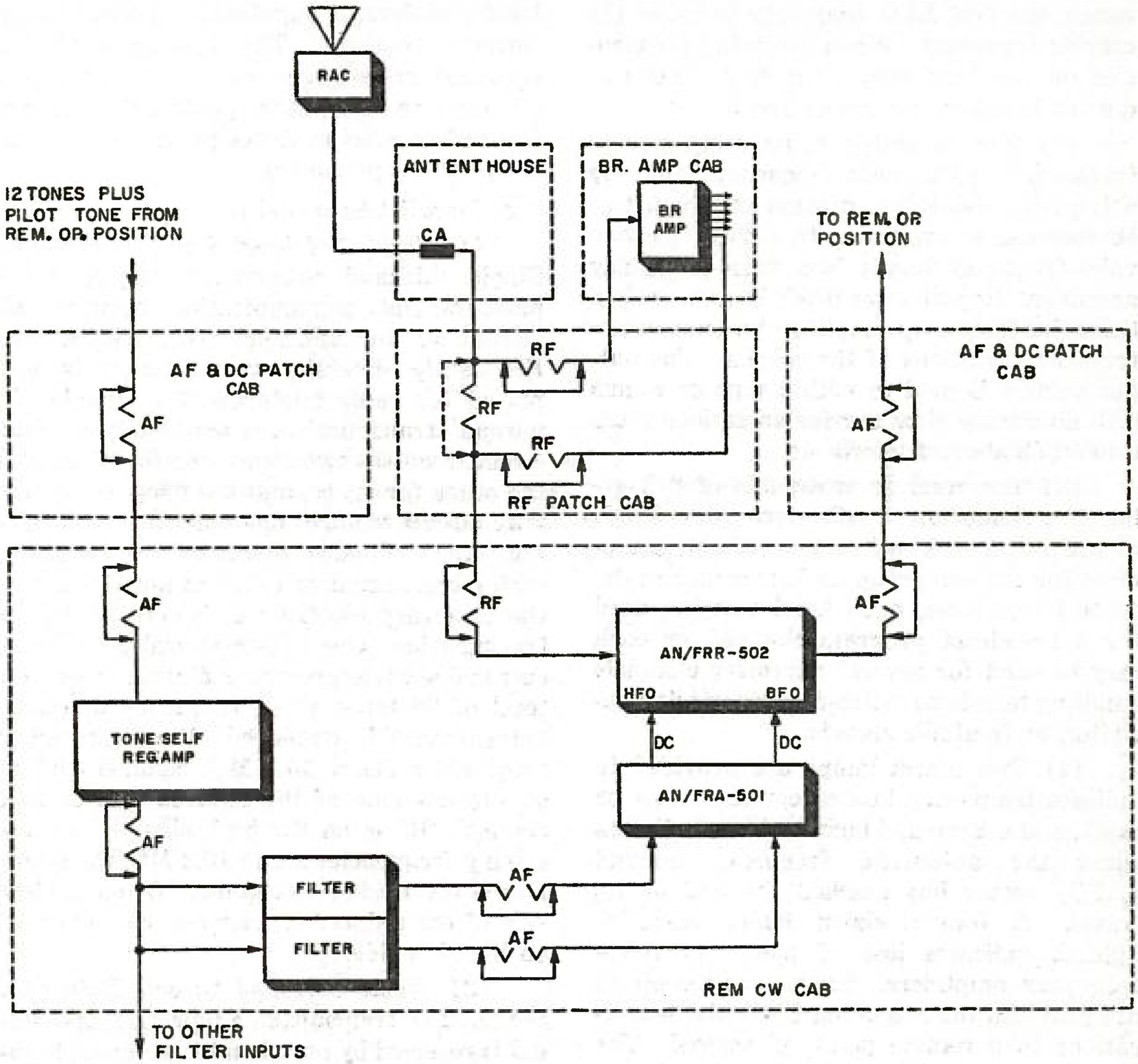


Figure 3-15. Functional Block Diagram of the AN/FRR-502 Receiver Remote CW Control Circuit.

MC over long-distance point-to-point circuits. It is used primarily at the receiving terminal of an LD type radio system in which the single sideband, multi-channel signal is emitted by a WECO LD-T2 Transmitter. The R-369/FRC-10 (WECO LD-R1) Receiver may be used also as a replacement for the D-99945 Radio Receiver (WECO LC-R1) used in the LC type of system.

b. *Description.*

(1) The receiver is connected to a rhombic antenna through a 72-ohm coaxial transmission line and a rhombic antenna coupler (RAC). When using the variable 1st beating oscillator, the receiver operates on any frequency within its range of 4 to 28 megacycles. When employing the crystal controlled 1st beat frequency oscillator (BFO), it operates on any one of 10 predetermined frequencies. Facilities are provided for mounting as many as 10 plug-in type crystal units. A two-position switch divides the total frequency range at the input of the receiver. The low range is from 4 to 10.3 MC, and the high range is from 10.3 to 28 MC. When receiving frequencies on the low

range, the first BFO frequency is above the carrier frequency. When receiving frequencies on the high range, the first BFO frequency is below the carrier frequency.

(2) The incoming radio frequency is transposed to the voice frequency range by a triple demodulation process in which two IF frequencies are used. In each of the two voice-frequency bands is a voice-frequency amplifier. Negative feedback is employed in the voice-frequency amplifier to compensate for slow variations of the carrier. The output volume is held to within plus or minus 0.75 db during slow carrier variations from 0 to 60 db above 1 microvolt.

(3) The receiver is capable of delivering two independent voice-frequency bands of 100 to 6000 cps each. When suitable equipment for channel grouping is provided at the control terminals, each band may be used for a broadcast program channel, or each may be used for several narrower channels handling telephone, voice-frequency teletypewriter, or facsimile signals.

(4) Two alarm lamps are provided to indicate temporary loss of carrier (slow or fast), and a lamp and buzzer alarm indicates when the automatic frequency control (AFC) motor has reached the end of its travel. A fourth alarm lamp, normally lighted, indicates loss of power to voice-frequency amplifiers. Extra relay contacts are provided for extending these alarm indications to a remote point, if desired. The alarm buzzer and the alarm indicator lamps are energized by a separate 6.3-volt winding on one of the vacuum tube heater transformers.

(5) The receiver requires a primary power source with a capacity of 500 watts, a frequency of 50 to 60 cycles per second, and an output voltage of 115 volts AC, plus or minus 5 percent. Two regulated rectifiers supply all the DC plate and grid bias power required by the receiver. One of these rectifiers furnishes a positive 130 volts DC at 175 MA and a negative 130 volts DC at 30 MA. The other rectifier delivers a positive 250 volts DC at 350 MA. Power for the heaters of all vacuum tubes, except those in the regulated rectifiers, is supplied by 6.3-volt transformer windings. The primaries of the transformers are separately fused. All power circuits are adequately protected by fuses, and safety panel switches provide protection to operating personnel.

c. *Circuit Characteristics.*

(1) *Single Sideband Signal (fig. 3–16).* Single sideband circuits are employed for point-to-point communication between all beltline stations and some tributary stations. Frequently diversity transmission is employed for radio teletypewriter signals. In normal transmission, each teletypewriter circuit requires two tones, one for mark and the other for space, and the telegraph order wire circuit requires one tone for on-off keying. In frequency diversity transmission, each circuit requires twice as much space in the frequency spectrum as it does in normal transmission. One telegraph order wire circuit and six teletypewriter circuits require a total of 26 tones when frequency diversity transmission is employed. When receiving frequencies below 10.3 MC, channel "A" is on the low side of the reduced carrier and channel "B" is on the high side. When receiving frequencies above 10.3 MC, the situation is reversed, with channel "B" on the low side of the reduced carrier and channel "A" on the high side.

(2) *Single Sideband Circuit Path (fig. 3–17).* The transmitted single sideband signal is received by one rhombic antenna, high-band or low-band, and carried by coaxial cable to the RF Patch Cabinet. Either antenna can be patched to the R–369/FRC–10 Single Sideband Receiver. A branching amplifier makes it possible to connect several receivers to the same antenna. In this manner, one set of high- and low-band antennas can be used to receive single sideband, facsimile, and line-up signals from the same station. The signal from the selected antenna is applied to the single sideband receiver where it is detected. The two sidebands are divided into two channels ("A" and "B") at the output of the receiver and applied to the CMT–4. Two wide-band CMT–4 channels of 300 to 6600 cps, one for each

115 / 5.75   109.25 to 120.75 volts

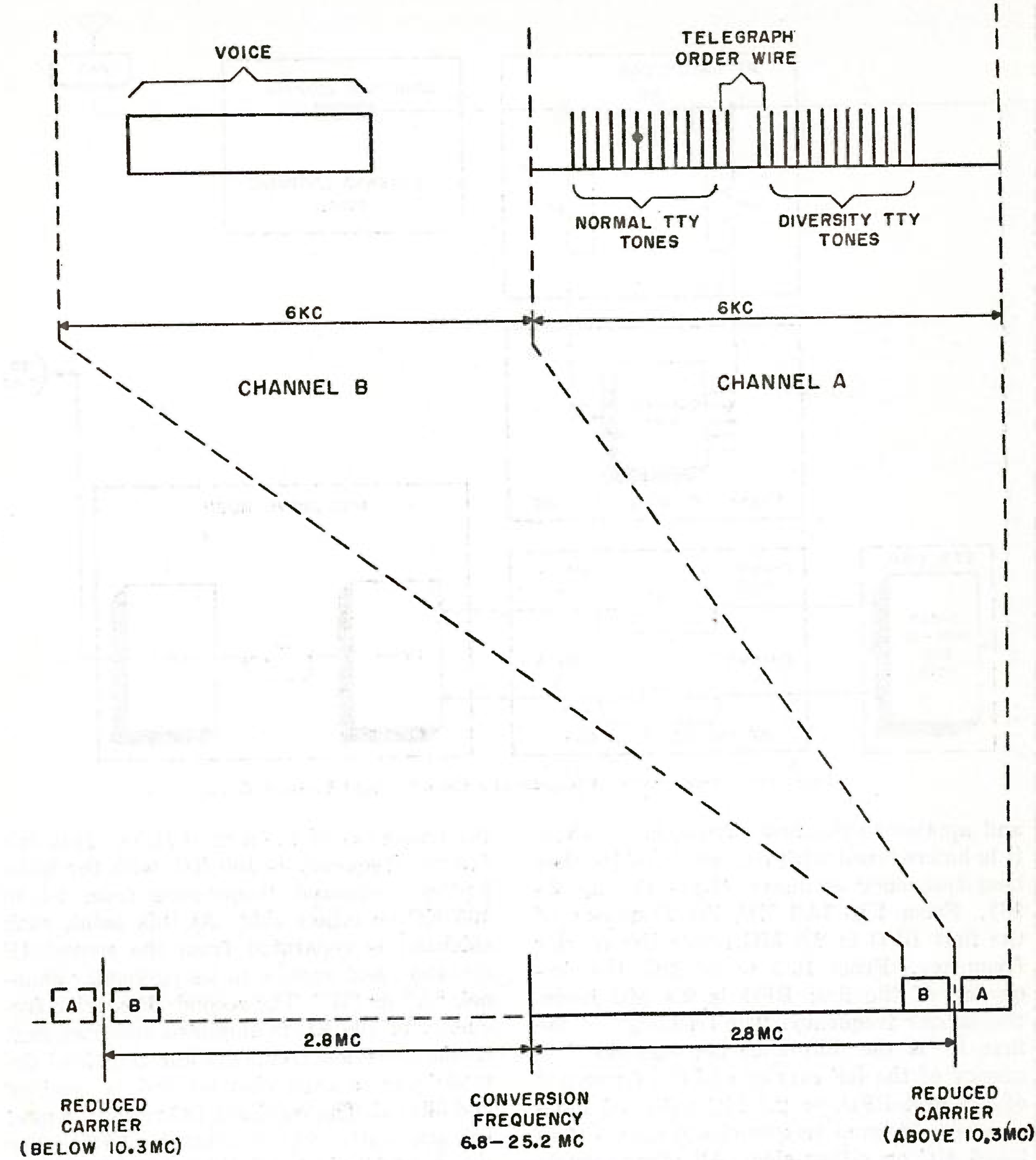


Figure 3–16. Single Sideband Signal.

sideband channel, are needed to handle the single sideband circuit. The signal is transmitted to the Communications Relay Center by means of Intersite link facilities.

(3) *Single Sideband Frequency Conversion Breakdown.* The single sideband signal consists of a reduced carrier frequency in the range between 4 and 28 MC, and two independent sidebands, "A" and "B," one on each side of the carrier. Each sideband includes a band of frequencies approximately 6 KC wide. The RF input signal is amplified

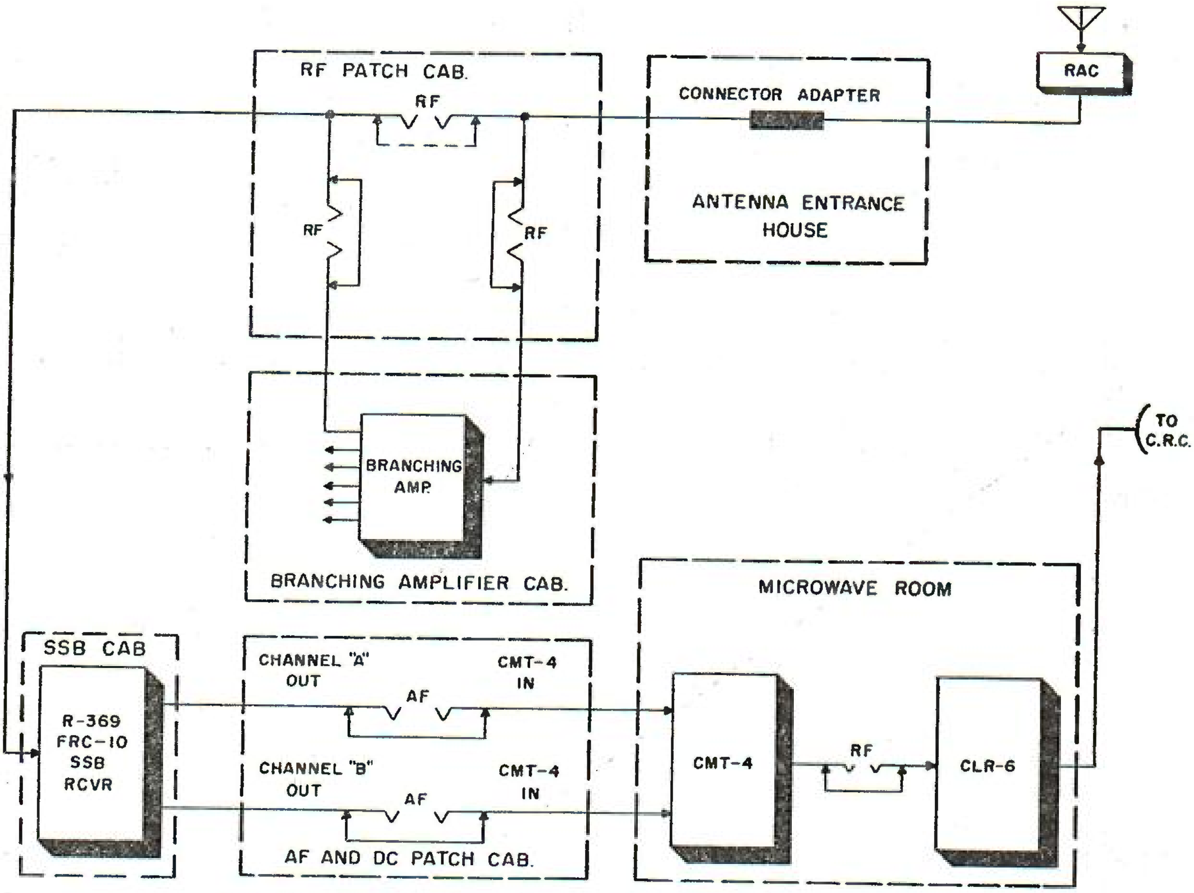


Figure 3-17. Functional Block Diagram of a Single Sideband Receiving Circuit.

and applied to the first demodulator where it is heterodyned with the output of the first beat frequency oscillator (BFO-1) (fig. 3-18). From 4 to 10.3 MC, the frequency of the first BFO is 2.8 MC above the carrier frequency. From 10.3 to 28 MC, the frequency of the first BFO is 2.8 MC below the carrier frequency. The frequency of the first IF is the difference between the frequency of the RF carrier and the frequency of the first BFO, or 2.8 MC with the independent sideband frequencies from 2.794 to 2.806 MC on either side. All other signals are removed by filtering. Crystal control or automatic frequency control maintains the frequency of the first IF constant at 2.8 MC. The output of the first IF is applied to the second demodulator where it is heterodyned with 2.7 MC from the second BFO. The frequency of the second IF is the difference between the frequency of the first IF and the frequency of the second BFO. This difference frequency is 100 KC, with the independent sideband frequencies from 94 to 106 KC on either side. At this point, each sideband is separated from the second IF by filters and applied to its particular channel, "A" or "B." The second IF carrier frequency of 100 KC is amplified and used first as the injection frequency for the third demodulator in each channel and is rectified and filtered. The resultant DC voltage is used for automatic volume control (AVC). The channel "A" sideband (94.0 to 99.9 KC) is heterodyned with 100 KC in demodulator 3A, and the channel "B" sideband (100.1 to 106.0 KC) is heterodyned with 100 KC in demodulator 3B. In this final demodulation process, all that remains in each channel is the original modulation frequencies between 100 and 6000 cps.

d. *Line-up Receiver*. Line-up receivers are

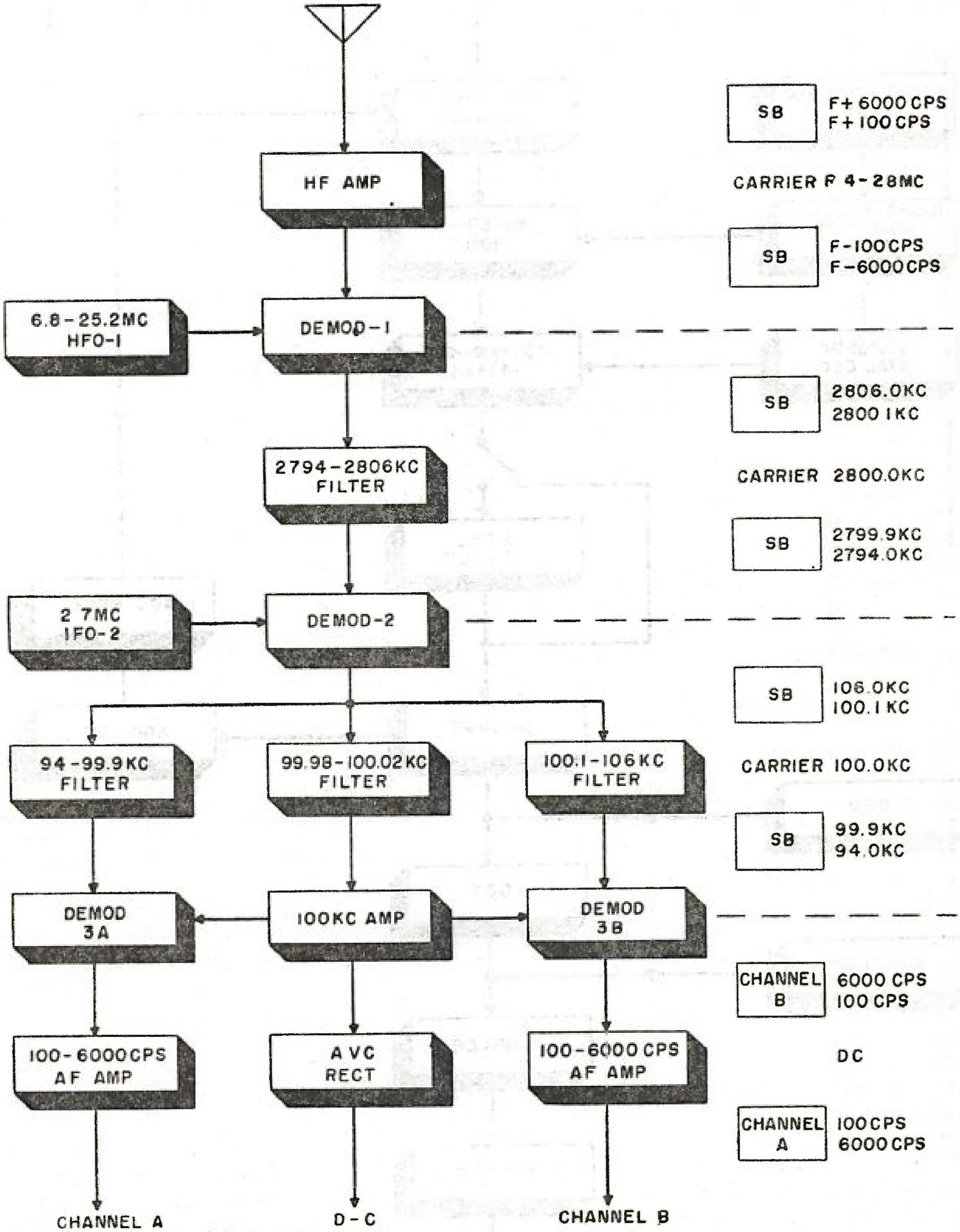


Figure 3-18. R-369/FRC-10 Receiver Frequency Conversion Block.

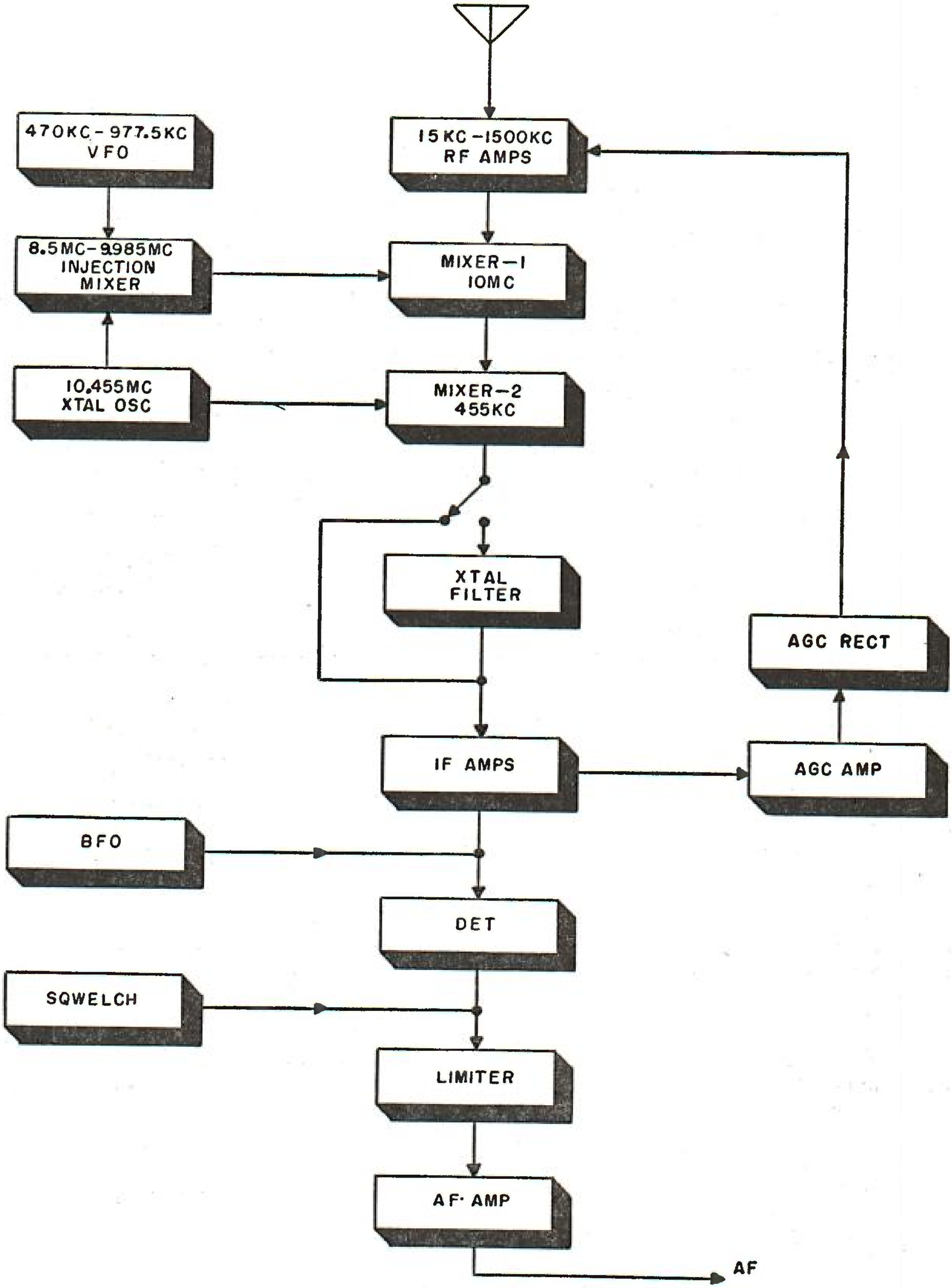


Figure 3-19. Simplified Functional Block Diagram of the R-389/URR Low-Frequency Receiver.

provided to check the usability of a new frequency before stopping traffic on a working circuit to make a frequency change. One diversity cabinet is supplied with each single sideband circuit for line-up purposes.

3-17. R-389/URR Low-Frequency Receiver

R-389/URR Low-Frequency Radio Receiver (fig. 3-19) is a stable, general-purpose receiver for use in fixed and mobile service. The receiver provides reception of radiotelegraph, voice, and frequency-shift keyed signals within a frequency range of 15 to 1500 KC. It is of unitized construction with the RF section, IF section, AF section, and power supply circuits situated on individual removable subchassis. These subchassis can be removed readily with ordinary hand tools for checking and repair in a minimum of time.

a. *Receiver Characteristics.* At the receiver, the carrier frequency undergoes double conversion, with the first IF at 10 MC and the second IF at 455 KC. All operating controls are located on the front panel. The frequency to which the receiver is tuned is indicated on counters within the dial escutcheon.

(1) The output frequency of the VFO (470 to 1955 KC) and the output frequency of the local crystal oscillator (10.455 MC) are applied to the injection mixer where they are heterodyned to produce the necessary injection frequency signal (8.5 to 9.985 MC) for the first mixer.

(2) The low frequency RF input signal (15 to 1500 KC) is amplified and applied to the first mixer. In the mixer, the signal is heterodyned with the signal from the injection mixer to produce the first conversion frequency of 10 MC, which is the sum of the frequencies.

(3) The 10 MC signal is applied to the second mixer where it is heterodyned with the 10.455 MC signal from the crystal oscillator to produce the final conversion frequency of 455 KC, which is the difference between the two frequencies.

(4) A crystal filter which provides band widths of 100 or 1000 cps allows the receiver to reject adjacent signals which would interfere with the desired carrier.

(5) The BFO signal is heterodyned with the IF signal to produce the audio beat note necessary for reception of frequency-shift signals and on-off teletypewriter signals. The AGC circuits maintain the output of the receiver at a constant level, even under severe variations of signal strength.

(6) The limiter circuit removes any amplitude variations present at the output which are greater than the desired signal.

(7) The squelch circuit eliminates noise signals in the output of the audio amplifier when signals are not being received or when the signal level of the desired carrier is too low for useful reception.

(8) Power circuits provide regulated B plus voltage to all stages, heater voltages to the filaments of all tubes, AC voltage for oven heaters and the tuning motor, and DC voltages to operate relay circuits.

b. *Circuit Characteristics (fig. 3-20).* Th low-frequency signal arrives at the long-wir Beverage antenna and is matched to th coaxial cable by means of the Beverage an tenna coupler (BAC). At the RF Patc Cabinet, the signal is patched to the LI cabinet. The branching amplifier is not use with the low-frequency receiver, because it frequency range does not cover the low frequency band (15-1500 KC).

(1) When receiving MUX or RTTY, th output of the R-389/URR Low-Frequenc Receiver is applied to the CV-89 Frequenc Shift Converter. The audio frequency shif information is converted to 60 MA on-off D pulses to operate the VFTG keyer.

(2) When receiving on-off RTTY, th output of the R-389/URR Low-Frequenc Receiver is applied to the SFO-2 Regenera tive Repeater.

c. *SFO-2 Regenerative Repeater.* Th SFO-2 Regenerative Repeater is specificall designed to correct for bias distortion i teletypewriter signals. At the input, it a cepts on-off audio teletypewriter signa (also polar or neutral DC signals) havi up to 45 percent bias distortion, and rege erates the signal to have not more than

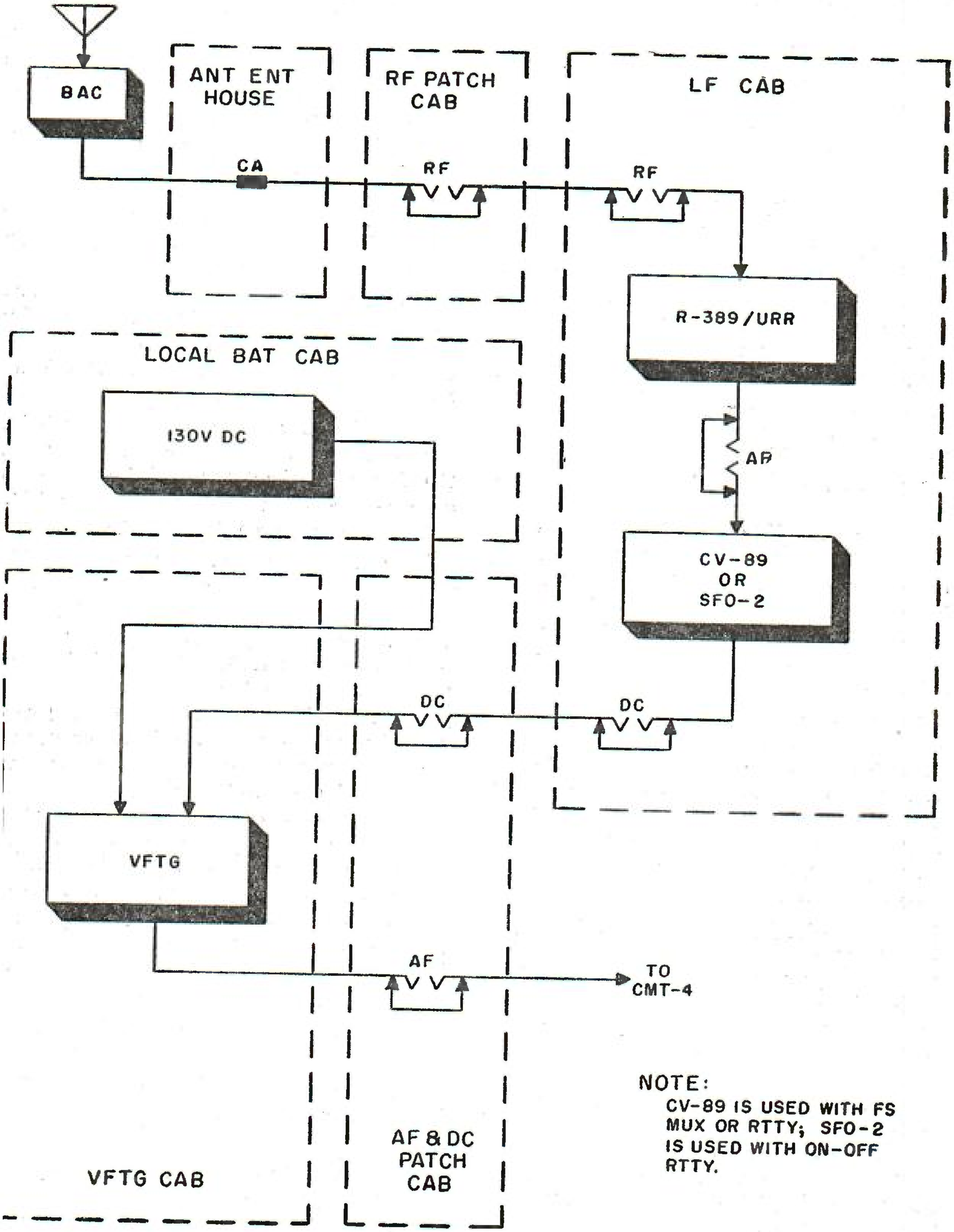
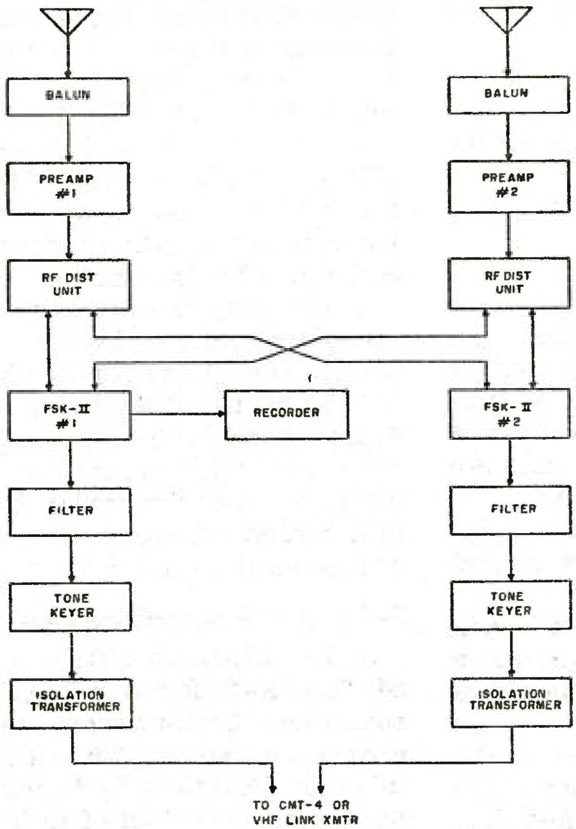


Figure 3-20. Functional Block Diagram of the Low-Frequency Circuit.



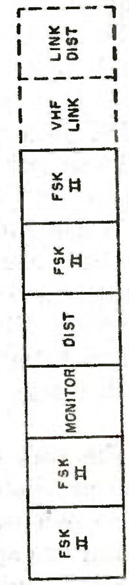


Figure 3–21. Functional Block Diagram of the FSK–II Equipment.

percent distortion at the output. Regeneration within the SFO–2 is accomplished by sampling the center of each teletypewriter pulse. If the sampling pulse coincides with a mark, the circuit operates to produce a regenerated mark at the output. If the sampling coincides with a space, the circuit operates to produce a regenerated space at the output. The output circuit consists of a one-shot multivibrator operating a mechanical relay in the 60 MA loop to the VFTG keyer.

3–18. Forward Scatter

a. The Forward Scatter receiving system is similar to conventional radio teletypewriter systems to the extent that frequency shift keying and diversity reception are employed.

b. The receiving equipment is fixed-tuned to the forward scatter signal and is arranged for dual space-diversity operation. Two independent receiving antennas are used, and the receiver converter selects the stronger signal (fig. 3–21). The output of the receiver is sent from the Receiver Site ove Intersite facilities to the Communication Relay Center where it operates teletype writer terminal equipment.

c. The FSK–II system is designed to allow for moderate Doppler shifts without ad versely affecting reception, and to functio properly with sudden variations in signa strength as great as 80 decibels. The FSK II equipment is contained in six standar racks (fig. 3–22).

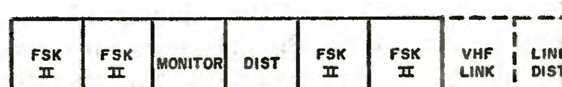


Figure 3–22. FSK–II Equipment Line-up.

(1) The Monitor Rack contains the fo lowing equipment:

(a) MUX synchro unit.

(b) Monitor switching unit.

(c) Oscilloscope.

(d) Signal generator.
(e) Tunable receiver.
(f) Recorder.
(g) Recording amplifier.

(2) The Distribution Rack contains the following equipment:
(a) Power distribution panel.
(b) AF and DC jack panels.
(c) Antenna monitor.
(d) DC jack panel.
(e) Two distribution amplifiers.

(3) There are four FSK-II receiver racks (two in use and two spares). At locations where there are no Globecom Intersite facilities available, two additional racks are added to supply a VHF link facility:

(a) The Intersite link rack contains two VHF link transmitters (one in use and one spare).

(b) The link distribution rack contains the power distribution panels, audio and DC patch panels, and two tone-keyers (one in use and one spare).

(4) The transmission line used is the RG-18/AU coaxial cable for runs up to 200 feet. For runs in excess of 200 feet, line losses are compensated for by using RG-8/AU coaxial cable and a preamplifier at the antenna.

3-19. CW Intercept

a. The CW Intercept Position is partially enclosed on two sides by sound absorbent wall sections which extend up to the overhead cable racks. These wall sections not only reduce the ambient noise level in each stall, but they also provide a degree of isolation by blocking off distracting activities from the view of the operator.

b. CW weather broadcasts are scheduled for certain periods of time during which a local operator types the message as it comes in. As the signal comes in, the operator types it on the keyboard of an M-28 teletypewriter printer. The M-28 printer makes an original copy of the message as it is being typed and simultaneously sends the same message to another teletypewriter at the Base Weather Center (fig. 3-23). The output of the M-28 printer is applied to the VFTG keyer where it is converted to frequency shift tones. The message is sent over Intersite facilities to the Communications Relay Center, from which it is sent by landline to the Base Weather Center.

c. A metal duct which is mounted on the side of the CW Intercept Cabinet contains the necessary wiring and receptacles for plugging in the M-28 printer to relay intercepted weather information.

d. The operator may listen to the Number 1 receiver output on his headset or combine both Number 1 and Number 2 receiver outputs by the use of a selector key. The loudspeaker panel in the receiver cabinet allows the operator to monitor the band without having to wear the headset between scheduled broadcasts. Each loudspeaker has its own attenuator control and disabling switch.

3-20. Air-Ground Reception

a. The Air-Ground Cabinet contains one SP-600-JX-17 Receiver for each air-ground voice channel, with a maximum of three receivers per cabinet. The cabinet also contains an LS-139/G loudspeaker panel for monitoring the output of each receiver, and two jack strips to provide the necessary patching functions.

b. The Air-Ground Room, where operators handle all air-ground radio traffic, is usually located at the Communications Relay Center. The Air-Ground Room is described in Part Five.

c. The signal arriving at the discone antenna is matched to the coaxial cable by the discone antenna coupler (DAC). Its wide frequency range and omni-directional azimuth coverage make the discone antenna especially useful in the air-ground circuit. Figure 3-24 shows the air-ground receiving circuit functional block diagram. The connector adapter in the antenna entrance house adapts the outside coaxial cable to the inside coaxial cable. At the RF Patch Cabinet, the signal is patched to the receiver cabinet through the branching amplifier. In the SP-600-JX-17 Receiver, the desired air-ground channel is selected, amplified, and detected. The audio output may be monitored at the received cabinet by patching one of the LS-139/G Speakers into the monitor

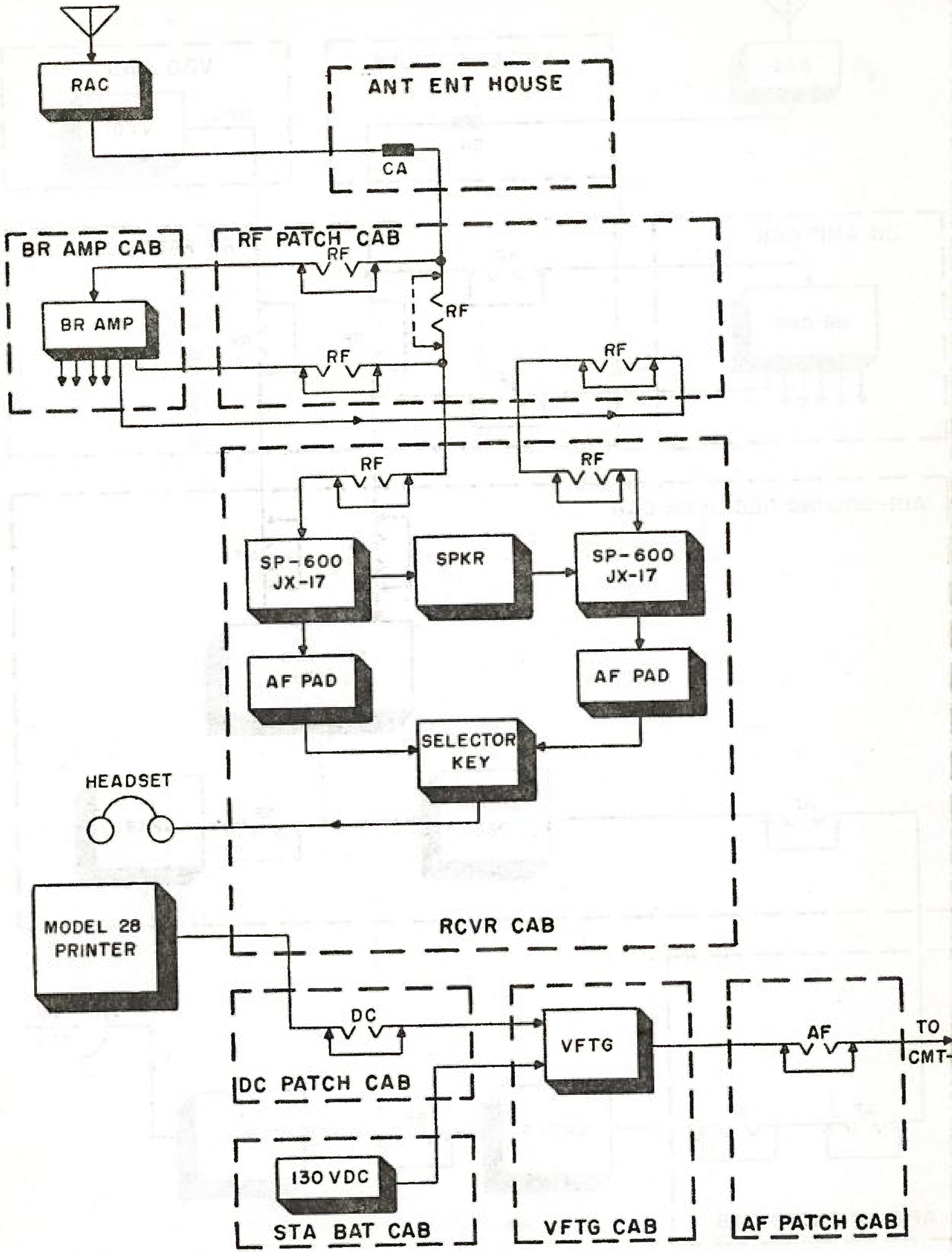


Figure 3-23. Functional Block Diagram of the CW Intercept Circuit.

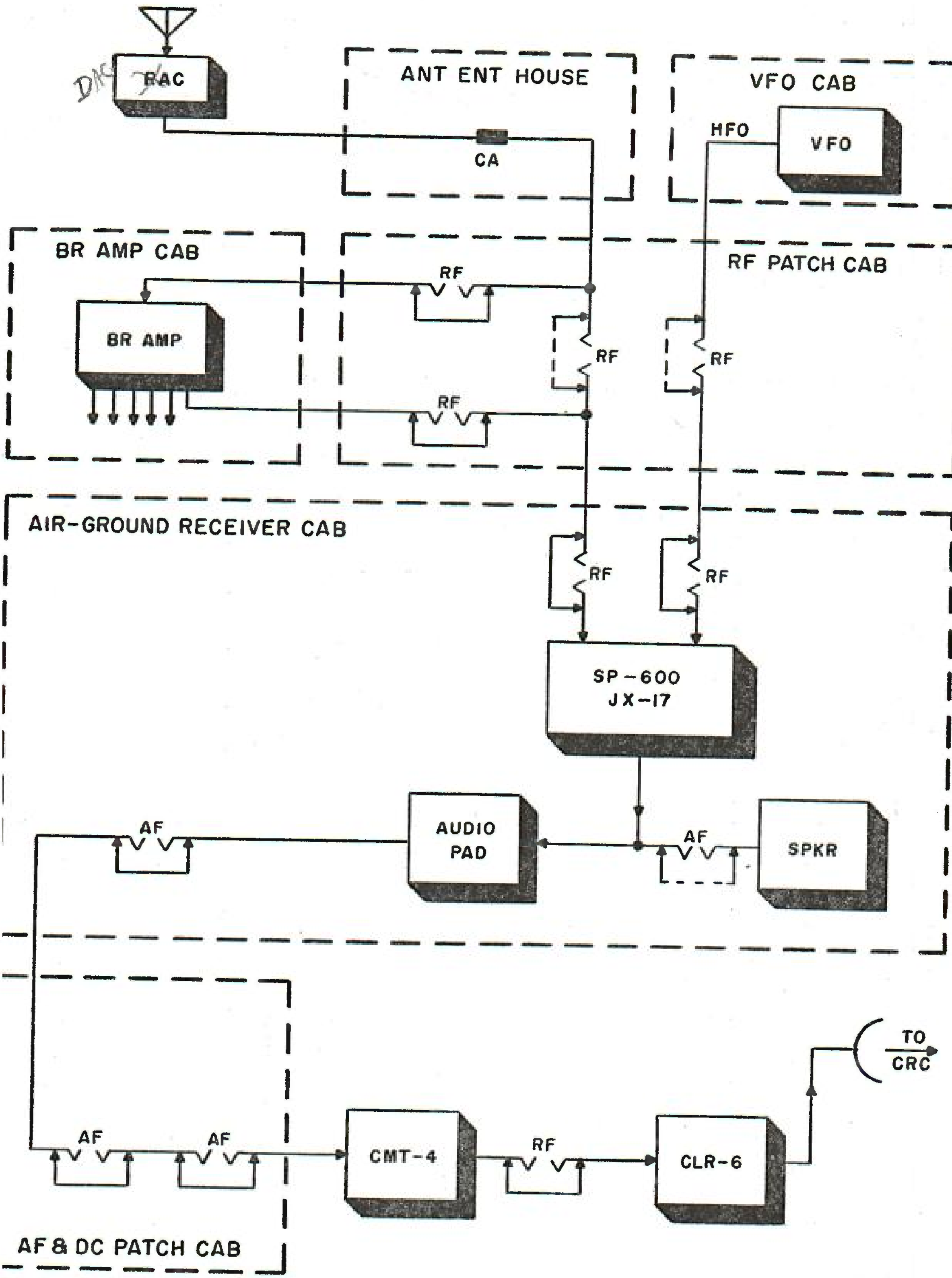


Figure 3-24. Functional Block Diagram of the Air-Ground Receiving Circuit.

jacks on the test strip. The audio output is reduced to the correct level by the audio pad and continues normal-through at the AF & DC Patch Cabinet to the CMT-4 multiplex equipment. Each air-ground channel requires one narrow band CMT-4 channel.

d. Figure 3-25 shows the air-ground monitor patch schematic diagram. The audio pad provides a high output to the loudspeaker and at the same time provides a reduced output to the AF and DC Patch Cabinet.

e. Figure 3-26 shows a simplified block diagram of a 10-channel air-ground circuit. Twelve receivers are needed, 10 in use and two spares. One spare receiver is required for each six channels or fraction thereof.

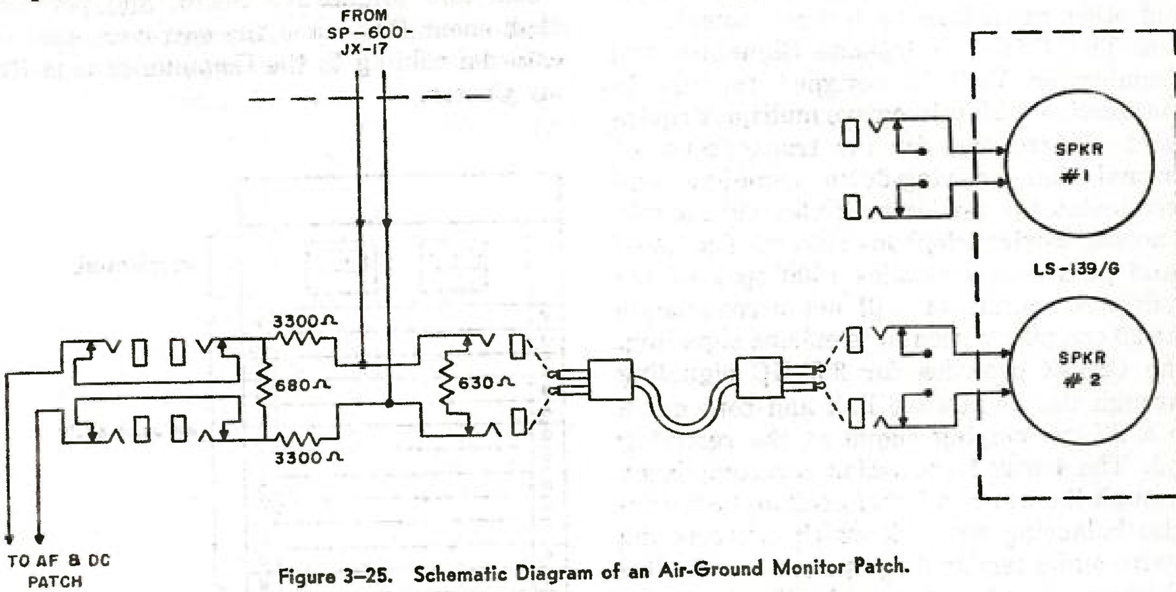


Figure 3-25. Schematic Diagram of an Air-Ground Monitor Patch.

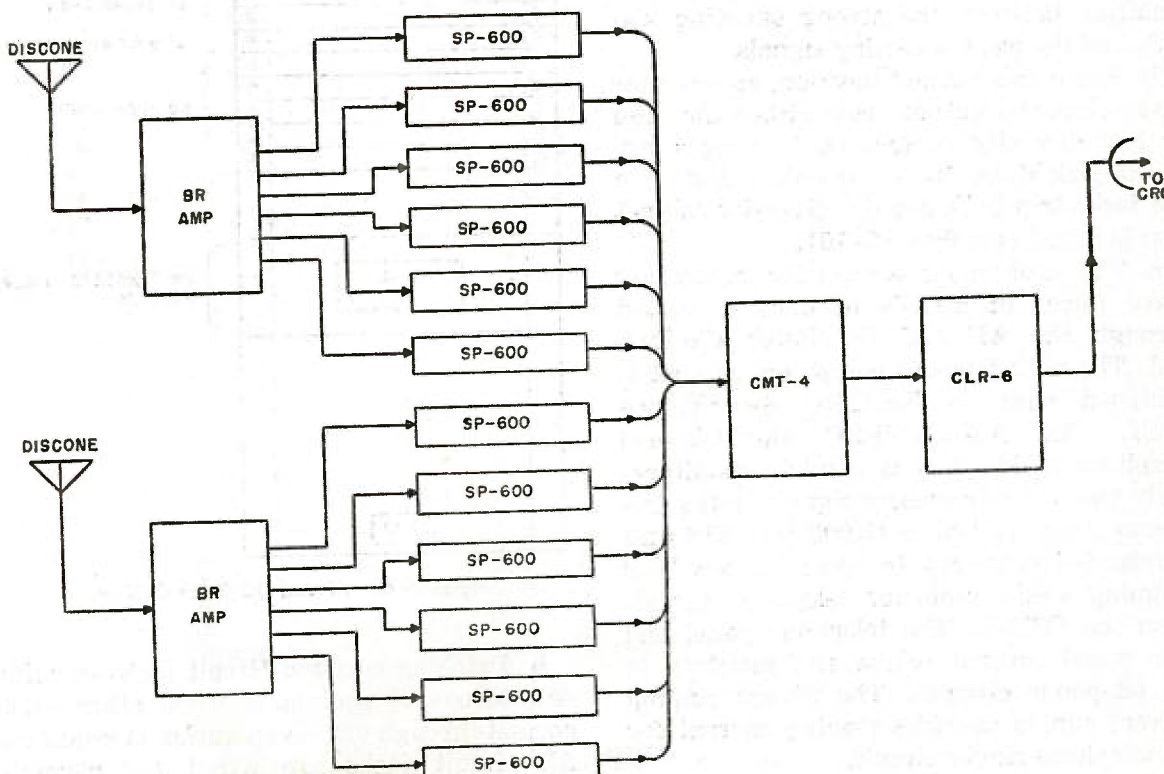


Figure 3-26. Simplified Block Diagram of the Air-Ground Receiving Circuit.

Section III. AUDIO FREQUENCY EQUIPMENT

3–21. Miscellaneous Equipment Cabinet

The Miscellaneous Equipment Cabinet is located adjacent to the AF and DC Patch Cabinet. It contains the CST–2 Telephone Signaling and Termination Unit, keys for selecting diversity cabinets, an oscilloscope, and other miscellaneous test equipment.

a. The CST–2 Telephone Signaling and Termination Unit is designed for use in conjunction with microwave multiplex equipment. It provides for the transmission of normal dial or ring-down signaling and terminates the 4-wire multiplex circuit into a normal 2-wire telephone circuit. The lower band pass characteristics (300 cps) of the multiplex equipment will not accommodate the 20 cps pulses used in telephone signaling. The CST–2 provides for 3.5 KC signaling through the microwave link and conversion to a 20 cps ringing signal at the receiving end. The 4-wire termination is accomplished through the use of a hybrid coil and compromise balancing network which converts the 4-wire audio terminal equipment to a 2-wire telephone circuit, and provides the necessary isolation between the strong outgoing signals and the weak incoming signals.

b. From this cabinet position, an operator may select the output from either the high or low diversity cabinet by turning a key on the jack strip. Indicator light installed in the jack strip indicates the diversity cabinet that is in use (see figure 3–10).

c. The oscilloscope is used for monitoring wave forms of signals in lines connected through the AF and DC Patch Cabinet.

d. The miscellaneous equipment cabinet is equipped with an FN–28/G Switchboard Shelf. An AM–43C/FRC Dual-Channel Amplifier is designed to amplify simultaneously two voice-frequency signals in the frequency range of 300 to 10,000 cps. The unit is intended primarily to boost the low-level outgoing audio-frequency telephone signals from the CST–2. The telephone panel and fuse panel contain relays and resistors in the telephone circuits. The 20 cps ringing current supply provides ringing current for the telephone ringer circuit.

3–22. AF and DC Patch Cabinet

a. The AF and DC Patch Cabinet (fig. 3–27) is the distribution point for audio and DC wiring between equipment cabinets in the Equipment Room, between Equipment Room and Microwave Room, and between Equipment Room and the entrance point of external cabling to the Communications Relay Center.

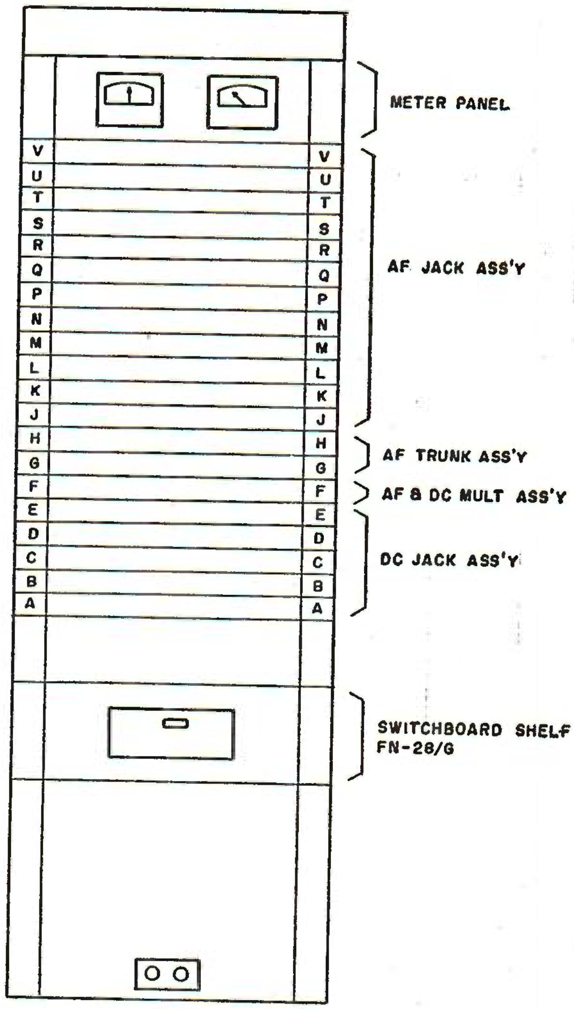


Figure 3–27. AF and DC Patch Cabinet.

b. Patching between circuit jacks permits flexible use of equipment when other than normal-through circuit operation is required. All circuit jacks are wired for normal-through operation which does not require patchcords.

c. Jacks are provided for audio and DC circuits, audio and DC trunks, monitoring, audio and DC multiple patching, and for matching circuit impedance through repeater coils and bridging transformers. A VU meter is installed on the panel to measure audio levels on lines, and a DC milliammeter is installed on the panel to measure line currents. Circuits can be monitored without interfering with the circuit operation. AF and DC patch plugs are shown in figure 3–28.

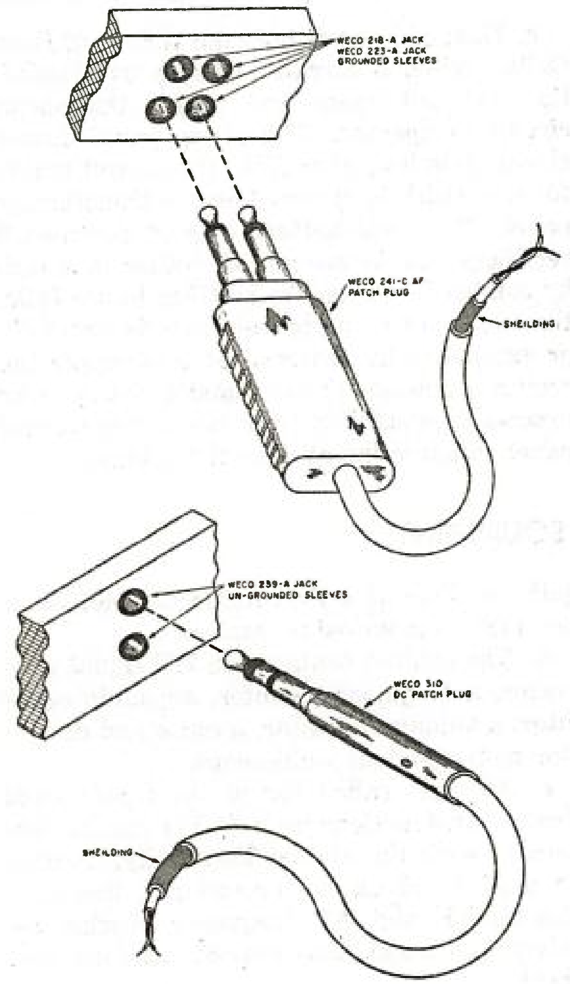


Figure 3–28. AF and DC Patch Plugs.

3–23. VFTG Cabinets

a. Voice frequency telegraph (VFTG) tone keyers are used with multi-channel communications equipment to provide the terminal equipment operating over the Inter-site link facility. One VFTG cabinet wil accommodate up to 12 VFTG tone keyers (six dual-channel units). Each tone keye is completely self contained, including powe supply. By changing the plug-in network the keyer will operate on any of the standar tone channels.

b. Mark-space signals in the form of on off 60 MA DC pulses from the comparato are converted in the VFTG tone keyer t two frequency-shift audio tones, one fo mark and one for space. A straight radi teletypewriter signal can be handled by narrow-band VFTG unit which produces frequency shift of plus and minus 42.5 cps but a multiplex radio teletypewriter signa requires a wide-band VFTG unit which pr duces a frequency shift of plus and minu 120 cps.

c. The outputs of the VFTG's are com bined in frequency division multiplex an applied to one of 24 voice bands in the CMT 4. Due to the channel spacing and outpu band width of the keyer, one voice band i the CMT–4 will accommodate up to 12 na row-band keyer outputs or three wide-ban keyer outputs.

d. All 24 voice bands in the CMT–4 a combined in time division multiplex an applied to the CLR–6 for microwave tran mission to the Communications Relay Cente The frequency-shift audio tones from t VFTG keyer are converted to DC signals VFTG converter at the Communicatio Relay Center to operate teletypewriter te minal equipment. VFTG equipment is e plained in greater detail in Part Seven.

Section IV. POWER SUPPLY EQUIPMENT

3–24. Type IE–5105 Voltage Regulator

a. The voltage regulator (VR) cabinet contains two AC voltage regulators, one operating and one spare. The regulated A output voltage is adjustable from 110 to 1 volts and is used to operate the variab frequency master oscillators. One regulator is capable of supplying primary power to three cabinets of VFO's.

b. The output voltage does not vary more than plus or minus 0.25 volt from the established voltage during changes in line voltage from 95 to 135 volts AC, during changes in frequency from 55 to 65 cps, or during changes in load from 0 to 5 kilovolt-amperes.

c. Additional items installed in the VR cabinet include the following:

(1) A meter panel for monitoring each phase of the station primary voltage and the single phase of the regulated AC output voltage.

(2) Circuit breakers in the lines to variable-frequency master oscillator cabinets.

(3) A switch for selecting power from either voltage regulator and for interrupting power from both regulators.

3-25. Local Battery Cabinet

a. The local battery cabinet furnishes DC voltage and current for 60 MA teletypewriter loops, clock circuits (where applicable), microwave control circuits, and test circuits in the screened room.

b. There are three sizes available in rectifier units: the 1.7-ampere unit, the 3-ampere unit, and the 8-ampere unit. The 1.7 ampere unit will furnish about 60 outputs, and the 8-ampere unit will furnish about 120 outputs. The number of outputs in the station determines the rectifier unit to be used. The output bus is set for 130 volts DC. Each output is fused at the local battery cabinet by a heat coil and is terminated at a terminal strip in the AF & DC Patch Cabinet. Cross-connections are made from the terminal strip to circuits requiring local battery voltage.

c. Heat coil panels hold the WE 74–E Heat Coils. When a circuit becomes overloaded, its heat coil opens and causes the alarm circuit to operate. The alarm panel buzzer circuit gets its power from the 24-volt transformer which is mounted on the transformer panel. The local battery cabinet contains 2 rectifiers, one in use and the other in stand-by condition. When the rectifier in use fails, the one in the stand-by condition is manually or automatically switched over to supply the required power. The automatic change-over process is controlled from the power control panel which is installed in the cabinet.

Section V. TEST EQUIPMENT

3-26. Teletypewriter Test Dolly

a. Each receiver station is equipped with a teletypewriter test dolly. An M–19 teletypewriter is mounted on the top of the wagon, and the power source is mounted on the shelf below.

b. The teletypewriter can be used to monitor working circuits or to check the operating characteristics of teletypewriter receiving equipment. When it is connected in series with a working circuit, it utilizes the 60 MA loop current from the circuit to operate its relays. When it is employed as a terminal teletypewriter, it supplies its own 60 MA loop current.

3-27. Mobile Test Dolly

a. Each receiver station is equipped with a Mobile Test Dolly (see figure 3–29). This dolly consists of a Bud Radio Cabinet number 1780–G mounted on casters.

b. The cabinet contains an RF signal generator, a frequency counter, an audio oscillator, a volume indicator, a noise and distortion meter, and an oscilloscope.

c. All tests called for in the Operational Testing Instructions book (OTI) can be performed with the Mobile Test Dolly. It may be used in check-out procedures, line-level checks, RF and AF frequency checks, receiver alignment, and over-all performance checks.

3-28. Screened Room

a. The Screened Room contains a work bench, rack-mounted test equipment, and patching facilities. The work bench provides the necessary space to perform tests and maintenance on equipment removed to

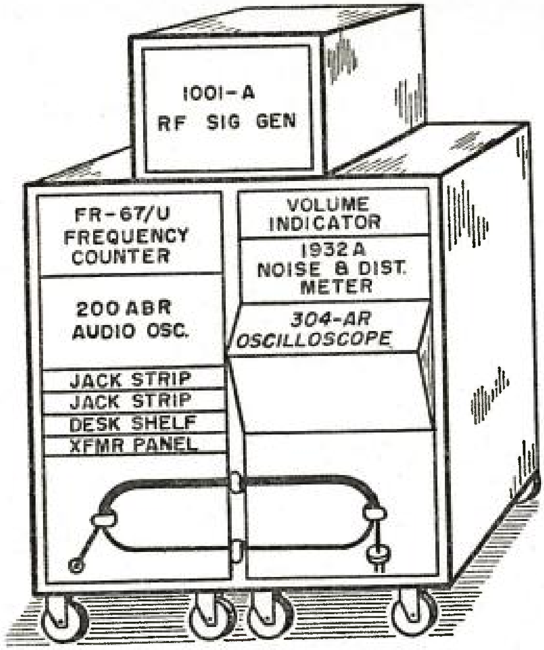


Figure 3-29. Mobile Test Dolly.

the screen room. A double copper mesh screen completely encompasses the room on all sides to prevent extraneous signals from interfering with any equipment tests. Signal and power cabling are run through conduit to their respective terminations.

b. Test Rack Number 1 contains a speaker panel, an SP-600-JX-17 Receiver, an oscilloscope, a noise and distortion meter, an audio frequency meter, and a switchboard shelf.

c. Test Rack Number 2 contains a volume indicator, a frequency-shift keyer with power supply, a variable-frequency master oscillator, a dual-channel audio amplifier, an audio oscillator, a switchboard shelf, repeater coils, and bridging transformers.

d. In addition to the rack mounted equipment, the screened room contains an RF attenuator box, five jack strips for patching between external and internal equipment, and a transmitter-distributor (TD). The TD is used with the frequency shift keyer and variable-frequency master oscillator to furnish a signal for diversity cabinet check-out. The screened room also contains an RF frequency meter mounted on a table.

3-29. Tributary Test Cabinet

The Tributary Test Cabinet contains test equipment necessary for maintenance of the radio equipment. This cabinet is installed when no screened room exists at the Receiver Site. The Tributary Test Cabinet contains an HF receiver, an RF frequency meter, an AF frequency meter and an audio oscillator, an oscilloscope, a speaker panel, and two jack strips. The jack strips provide the necessary patching functions between equipment and test instruments.

3-30. Clock System

a. The clock system at the Receiver Site includes a series of slave clocks which are synchronized by a sub-master clock every hour on the hour. A lamp located on each clock face glows when the synchronizing pulse is received.

b. The sub-master clock is synchronized with the time signal from WWV at fifteen minutes after the hour. The time signal is received by the SP-600-JX-17 Receiver in the monitor cabinet. The synchronizing button, located on the monitor cabinet, closes a relay, when depressed, and energizes the clock setting magnet in the sub-master clock. With the setting magnet energized, the second hand is positioned to zero and held and the minute hand is positioned to 1[illegible] minutes after the hour and held, when th[illegible] synchronizing button is released at the star[illegible] of the time signal from WWV, the rela[illegible] opens to de-energize the clock setting mag[illegible] net, and the released second and minut[illegible] hands start from the corrected position.

c. Each clock is driven by a spring moto[illegible] which is electrically wound each hour. Whe[illegible] the automatic winding contacts in the cloc[illegible] motor close, power from two dry cells [illegible] applied to the spring motor. Manual windin[illegible] contacts are also provided.

d. At scheduled times, or upon reque[illegible] from the Communications Relay Center, th[illegible] WWV time signal is patched from the SP[illegible] 600-JX-17 Receiver in the monitor cabin[illegible] to the Time Service Channel on the AF a[illegible] DC Patch Panel and sent to the Relay Ce[illegible] ter to synchronize the master clock. T[illegible] master clock supplies pulses for synchroni[illegible] ing the sub-master clock at the Transmitt[illegible] Site.

PART FOUR

TRANSMITTER SITE

Chapter 1

INTRODUCTION

4-1. Purpose

The purpose of this section of the manual is to present a typical Globecom transmitter station and to describe the equipment and its application, and techniques employed in the various types of radio circuitry used.

4-2. Policy

Due to varying operational circuit requirements, Transmitter Sites are seldom identical in either size or equipment complement. Equipment arrangement and installation conforms as closely as possible to the basic engineering principles of maintaining standard installations, insofar as local conditions permit. The information contained herein reflects the current engineering policy for the selection, installation, and application of all Globecom transmitter facilities.

4-3. Scope

This part of the manual covers the aspects of radio transmission in the Globecom system and the association of transmitting equipment. Engineering plans for the Globecom system have been revised many times as a result of additional operating experience and changes in operational concepts. The overall operation currently utilizes many types of equipment to provide the facilities required. Some items of equipment now used found frequent use in past operations of the Airways and Air Communications Service (AACS), whereas others are appearing in AACS for the first time as a result of operating requirements encountered in the planning of the Globecom system. Chapter 2 contains brief descriptions of the items of equipment currently provided to implement Globecom transmitting station facilities. The basic principles of equipment operation are explained and illustrated, and peculiarities in operation of the equipment within Globecom are noted. A general discussion of the policies regarding transmitter buildings and equipment allocation and installation is given in Chapter 3. To facilitate a better understanding of the application of equipment, a hypothetical transmitting station is presented in Chapter 4. The circuitry explained is representative of the types of circuits used in Globecom. The text is informative in nature and reflects the engineering concept of the Transmitter Site components of the system. Information on power, applicable to the Transmitter Site, is presented in Part Six of this manual. Intersite communication and terminal equipment are covered in Part Seven.

Chapter 2

EQUIPMENT

Section I. TRANSMITTERS

4–4. T–265/FRC–10B and T–409/FRC–30 Transmitters

a. *General.*

(1) The T–265/FRC–10B and T–409/ FRC–30 are similar items of equipment, either of which is known as the LD–T2 Transmitter. Both transmitters are designed for long-distance radio communications and liffer only in the respective ranges covered. Model T–265 covers the frequency range of ł to 23 MC, and Model T–409 covers the fre- ιuency range of 4.5 to 28 MC. The transmit- ers are intended primarily for use in cir- uits employing the multi-channel single ideband type of transmission and normally adiate two independent sidebands and a educed carrier, sometimes referred to as 'twin-channel single sideband." The trans- nitters are also capable of conventional ouble sideband transmission.

(2) The LD–T2 transmitters will accept wo independent audio signal bands, each rithin the range of 100 to 6000 cps. Each ignal is converted and appears as either the pper or lower sideband in the RF output f the transmitters. The two signal circuits ay be used as separate voice channels, or ey may be used with terminal equipment r simultaneous transmission of several arrow-band telephone signals, voice fre- uency multiplex teletypewriter signals, or csimile signals. A load control device in e transmitter controls the gain at a point hich follows the first modulation process prevent overloads and to allow utilization the full peak power of the transmitter, gardless of the number of channels in use.

(3) Each transmitter consists of eighteen separate units, all housed in a single floor-supported cabinet. The cabinet is approximately 7 feet tall and requires a floor space of approximately 7 feet by 4 feet. The transmitter produces a peak RF output of 4 KW when operated as a single sideband transmitter, and its nominal output is 1 KW when operated as a double sideband transmitter.

(4) An X–75153 Distortion Measuring Cabinet is associated with each LD–T2 Transmitter. The cabinet contains equipment which is used to make distortion measurements and tests of transmitter functions, and amplifiers and equalizers which are used in conjunction with audio input lines. The distortion measuring cabinet is approximately 7 feet tall, 22 inches wide, and 17 inches deep. It is normally installed adjacent to the transmitter.

b. *Principles of Operation.*

(1) A functional block diagram of an LD–T2 Transmitter is presented in figure 4–1. To illustrate the methods used to modulate these transmitters, a frequency block diagram for the T–409 is shown in figure 4–2. Four channels of speech input are assumed in the latter diagram: Channels A1 and A2 in Group A, and B1 and B2 in Group B. Group A audio signal input channels are fed into Low Frequency Modulator 1. Within the balanced modulator, a 100 KC carrier is combined with the audio signals to produce two sidebands, one above and one below the 100 KC carrier. The upper sideband is selected by a crystal filter having band pass

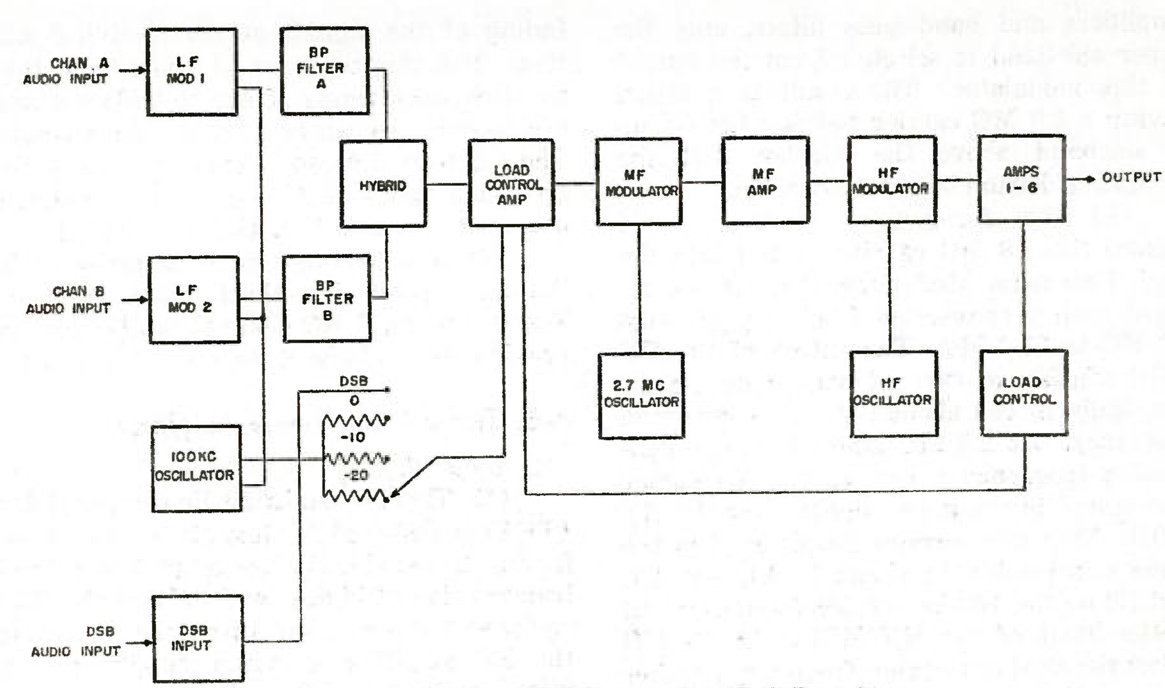


Figure 4–1. Functional Block Diagram of an LD–T2 Transmitter.

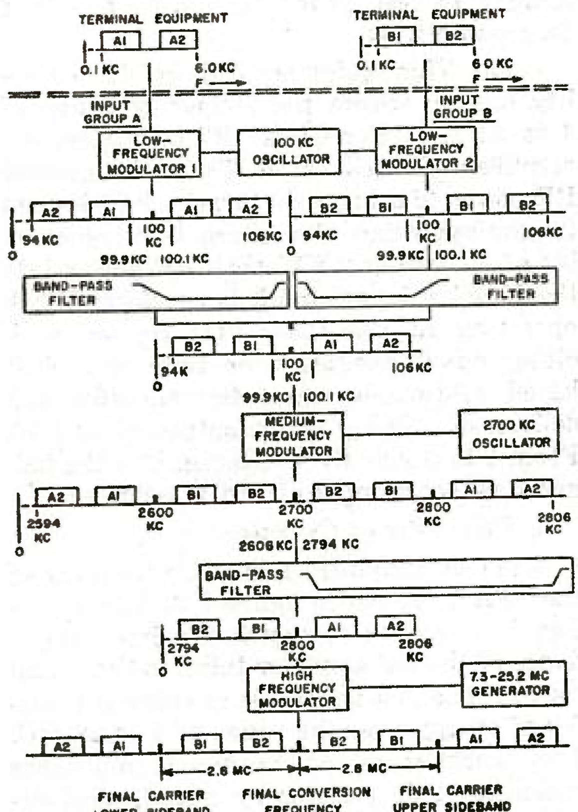


Figure 4–2. Frequency Block Diagram of the T–409/FRC–30 Transmitter.

characteristics of the pertinent band-pass filter block in figure 4–2.

(2) Group B audio input channels may be followed through similar steps into Low Frequency Modulator 2. The carrier frequency is received from the same 100 kc oscillator that supplies LF MOD 1. In this case, however, the lower sideband is selected by another crystal filter having band pass characteristics of the pertinent band-pass filter block in figure 4–2.

(3) The two sidebands, 94 to 99.9 KC and 100.1 to 106 KC, are then combined in a hybrid coil and fed into a load control amplifier. Following the load control amplifier is a combining amplifier which is arranged to reinsert the 100 KC carrier at reduced level between the two sidebands. At this point, the carrier is essentially modulated by two audio signals, each independent of the other.

(4) The combined signals from the combining amplifier are fed to the Medium Frequency Modulator where they are mixed with a 2.7 MC signal supplied from another oscillator. Two new sidebands are created in this modulator, each containing the two original sidebands. By means of a series of

amplifiers and band pass filters, only the upper sideband is selected from the output of this modulator. The result is a signal having a 2.8 MC carrier bearing the Group A sideband above the carrier, and the Group B sideband below the carrier.

(5) The foregoing signal, centered around the 2.8 MC carrier, is fed into the High Frequency Modulator where it is combined with a conversion frequency of from 7.3 MC to 25.2 MC. The output of the HF MOD consists of two sideband groups symmetrically placed about the final conversion frequency. At 2.8 MC above the final conversion frequency a new carrier frequency is centered in the upper sideband of the HF MOD. This new carrier frequency has the same relationship to channels A1, A2, B1, and B2 as the 100 kc carrier frequency had at the input of the MF MOD. At 2.8 MC below the final conversion frequency another new carrier frequency is centered in the lower sideband. Within this sideband, the channels A1, A2, B1 and B2 are in an inverted position with respect to the upper sideband. Both of these sidebands are suitable for amplification and transmission, but only one is finally transmitted.

(6) For operation on a frequency below 10 mc, the lower sideband is selected. For operation on a frequency above 10 MC, the upper sideband is selected. Selection of the proper sideband from the output of the HF MOD is effected by a six-stage final frequency amplifier. The discrimination presented by these amplifiers eliminates the residual conversion frequency and the rejected sideband output of the final modulator.

c. *Globecom Application.*

(1) In the Globecom system, one-half of the total available band of 12 KC is used for the transmission of six teletypewriter signals. The teletypewriter signals are multiplexed at the associated terminal equipment by a frequency division system and are sent to the transmitter as twenty-six different audio tones. Two of the twenty-six tones are available for a manual telegraph (CW) circuit. Normal and diversity mark and space frequencies for each teletypewriter channel are transmitted to overcome selective fading of the signals at the receiving station. The thirteen normal tones lie within the frequency range of 425 to 2465 cps and are usually transmitted on the A1 channel. The thirteen diversity tones lie within the frequency range of 2805 to 4845 cps and are usually transmitted on the A2 channel.

(2) A telephone circuit is provided in the upper channel of the B-group sideband. The remaining 3 KC channel can be used to provide an additional facility if required.

4-5. Transmitting Power Amplifier

a. *General.*

(1) The Transmitting Power Amplifier (TPA) is designed for installation as a fixed facility to provide for the amplification and transmission of high-power RF signals. The equipment consists of three major units: the RF amplifier, a power supply, and a water cooling system. The amplifier and power supply require a floor area of approximately 14 feet by 8 feet, and 21 feet by 8 feet respectively.

(2) This equipment is designed to amplify signals within the frequency range of 4 to 22 MC. For Class "B" operation, the amplifier will deliver 50 KW peak envelope RF power to a properly terminated 600-ohm transmission line. An external exciter capable of delivering 2 KW peak RF power into the 200-ohm input circuit is required. When operating in the Class "C" region, with either on-off excitation or frequency shift keyed continuous wave, the amplifier can deliver an average power output of 50 KW. From 1 to 5 KW RF excitation into the balanced 600-ohm input circuit is required.

b. *Principles of Operation.*

(1) A simplified schematic diagram of the TPA is shown in figure 4-3. Link coupling is employed to match the input impedance of the RF amplifier tubes to the signal source. The link is capable of efficient transfer of energy over the range of 4 to 22 MC. The tracking of an optimum impedance match is made possible by the physical design of the link.

(2) The amplifier tubes are operated in a tuned-grid, tuned-plate, push-pull circuit.

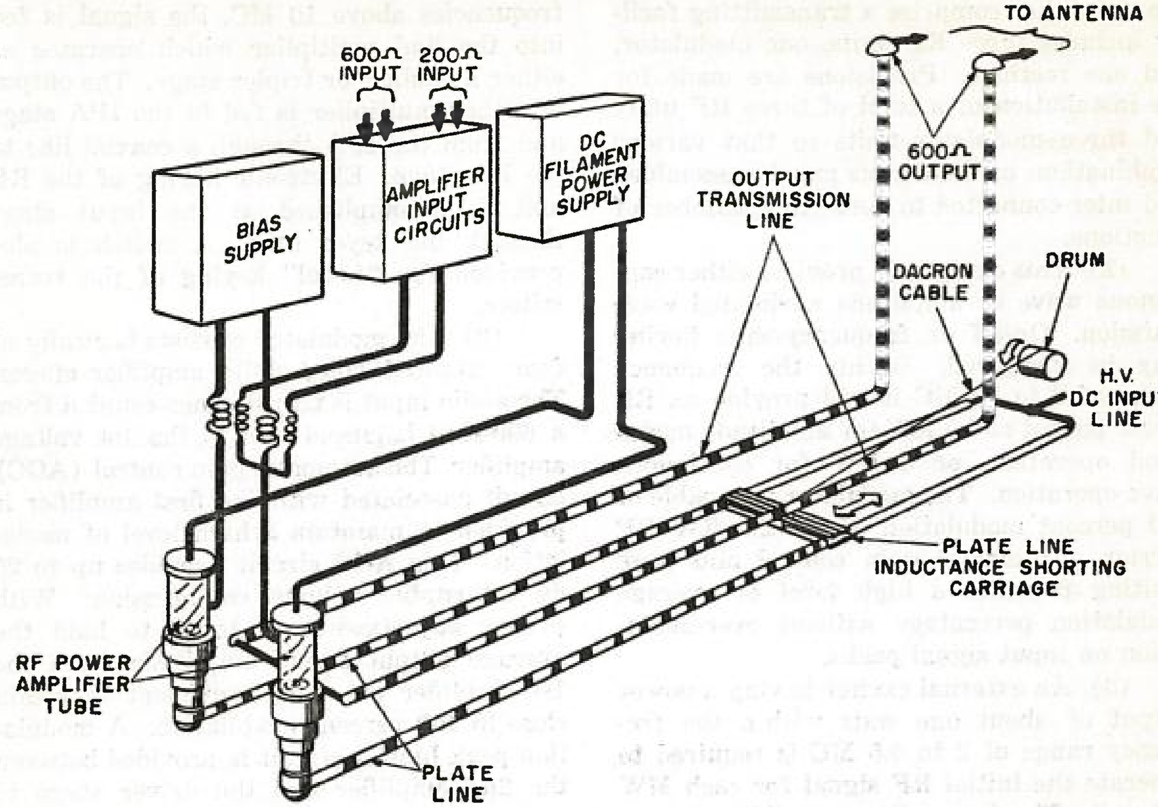


Figure 4-3. Simplified Schematic Diagram of the Transmitting Power Amplifier (TPA).

A conventional type two-wire, short-circuited quarter-wave length line is used as the primary portion in an inductively coupled output network. To prevent operational instability of the amplifier and possible reaction in the exciter unit, cross neutralization of the amplifier tubes is employed.

(3) Heat generated in the RF amplifier tubes is dissipated by the water cooling system. Removal of the heat is accomplished by continuous circulation of the cooling water through a specially designed plumbing system. The plumbing system includes two bronze water jackets which surround the anode of each tube. These jackets also provide the mechanical support required by the large amplifier tubes. Heat carried away from the amplifier tubes by the water is released to the atmosphere through cooling radiators.

c. *Globecom Application*. The TPA is currently utilized in the single sideband circuits. The amplifier is excited by a single sideband signal from the LD-T2 Transmitter, and is operated as a Class "B" amplifier into a rhombic antenna to provide 50 KW peak envelope RF power for long-distance communications. Generally, these amplifiers are employed in the single sideband beltline circuits. The equipment is also used to amplify a signal from a line-up transmitter that is usually associated with the single sideband facilities. Provisions are made for switching the amplifier to either the line-up transmitter or the LD-T2 Transmitter.

4-6. MW Transmitter

a. *General*.

(1) The MW Transmitter is designed for use in a fixed transmitting station to provide the facilities for point-to-point, air-ground, and similar circuits. It is especially adapted to stations requiring either simultaneous or intermittent use of several different frequencies. A typical combination of

the units that comprise a transmitting facility includes three RF units, one modulator, and one rectifier. Provisions are made for the installation of a total of three RF units and three modulator units so that various combinations of these units may be assembled and inter-connected to perform a number of functions.

(2) This equipment provides either continuous wave or amplitude modulated wave emission. On-off or frequency-shift keying may be employed. Within the frequency range of 2 to 30 MC it will provide an RF power output of 2.5 KW for amplitude modulated operation, or 3 KW for continuous wave operation. The modulator is capable of 100 percent modulation of the 2.5 KW RF carrier. Automatic gain control and peak limiting provides a high level of average modulation percentage without over-modulation on input signal peaks.

(3) An external exciter having a power output of about one watt within the frequency range of 2 to 4.5 MC is required to generate the initial RF signal for each MW RF unit. The transmitter amplifies the exciter signal and multiplies the frequency as necessary to obtain the desired transmitting frequency.

(4) Each of the major units is 6 feet high and 2 feet deep. The rectifier is 2 feet wide, and the modulator and RF unit are each 1 foot wide. A 5.25-inch control panel designed for installation in a standard 19-inch rack also is provided. The control unit consists of a bank of switches for centrally controlling the basic units of an MW transmitter installation.

b. *Principles of Operation.*

(1) The functional operation of the MW transmitter components is illustrated in figure 4–4. The RF unit contains an intermediate power amplifier (IPA) and a power amplifier (PA) stage. The RF signal from the exciter is fed to the 1st voltage amplifier. The output of this amplifier is fed to the 1st frequency multiplier which operates as either a straight-through amplifier, doubler, or tripler. For operation on frequencies below 10 MC, the output of the 1st multiplier is fed directly to the driver. For operation on frequencies above 10 MC, the signal is fed into the 2nd multiplier which operates as either a doubler or tripler stage. The output of either multiplier is fed to the IPA stage and from the IPA through a coaxial line to the PA stage. Electronic keying of the RF unit is accomplished at the input stage through the keyer tube. A switch is also provided for "Local" keying of the transmitter.

(2) The modulator consists basically of four balanced (push-pull) amplifier stages. The audio input is transformer-coupled from a 600-ohm balanced line to the 1st voltage amplifier. The automatic gain control (AGC) circuit associated with the first amplifier is provided to maintain a high level of modulation. This AGC circuit provides up to 20 db adjustable volume compression. With proper adjustments, it tends to hold the average output signal amplitude from the 1st amplifier at a level sufficient to attain close to 100 percent modulation. A modulation peak limiter circuit is provided between the 2nd amplifier and the driver stage to prevent over-modulation. This circuit limits, at an adjustable set value, signal peaks on the grids of the driver stage. When the signal drops below the set value, the peak limiter ceases to operate. For voice operation, the output of the modulator is switched in series with the RF power amplifier high-voltage supply by a relay actuated by the controls on the MW control panel.

c. *Globecom Application.*

(1) The MW Transmitter is the primary transmitter employed in the Globecom System to provide the facilities for double sideband high-frequency circuits. For point-to-point and broadcast circuits, a 3–1–1 combination (3 RF units, 1 modulator, and 1 rectifier) is provided. For air-ground voice operation, a 3–3–1 combination (3 RF units, 3 modulators, and 1 rectifier) is provided.

(a) A simplified block diagram of an MW 3–1–1 installation is shown in figure 4–5. The modulator can be switched to any of the three RF units, and either on-off or frequency-shift keying can be selected by the control unit.

(b) A simplified block diagram of an

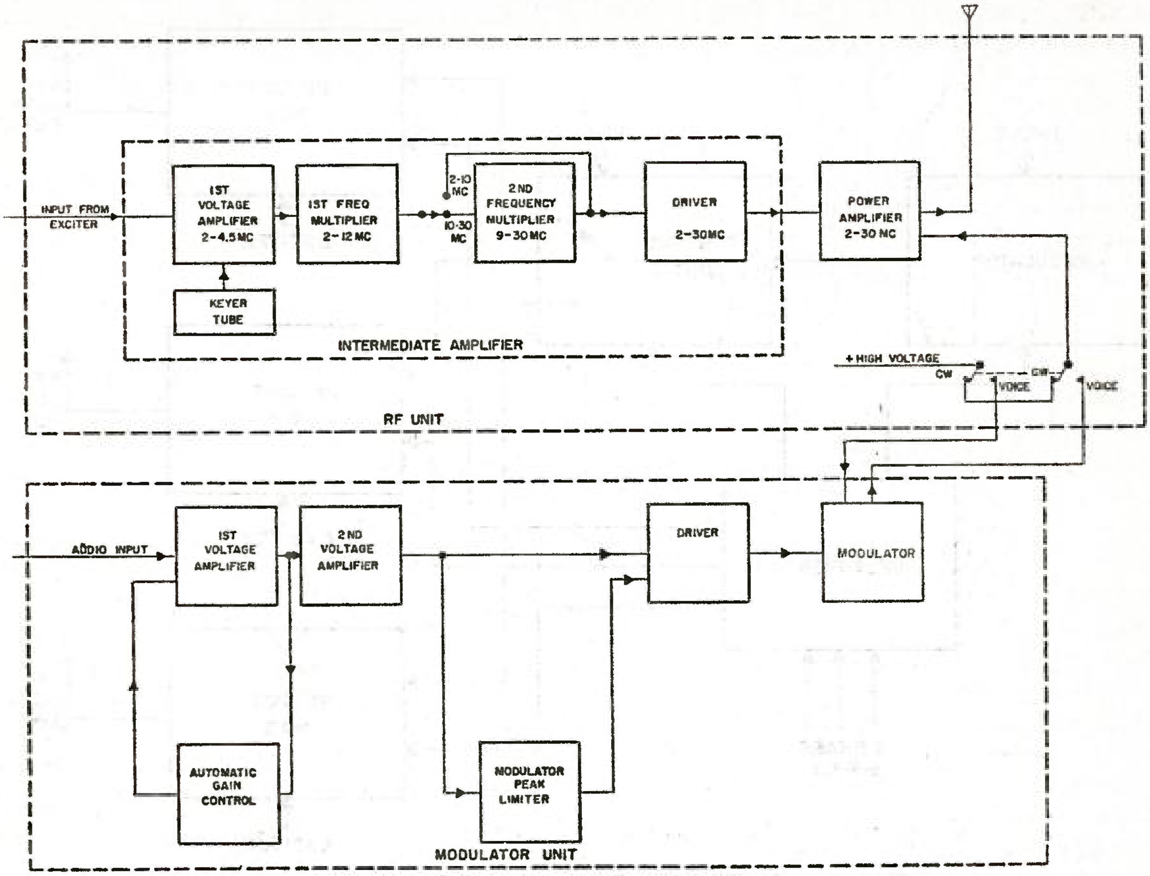


Figure 4-4. Functional Block Diagram of an MW Transmitter.

MW 3-3-1 installation is shown in figure 4-6. Simultaneous operation of the three transmitters with any type of emission within the capability of the equipment can be realized with this type of installation. Each of the three modulators is connected directly to its corresponding RF unit through relays which are activated by the control unit. The control unit does not provide for switching the modulators to different RF units, but it does provide for the control of filament and plate voltages which are applied to the various components, and for the selection of either CW, FSK, or phone operation.

(2) Each MW RF unit is operated in conjunction with an NR-105 Frequency Shift Keyer which provides the initial RF signal that excites the MW transmitter. This equipment is discussed later in this chapter.

4-7. AN/FRT-4 Transmitter

a. *General.*

(1) The AN/FRT-4 Transmitter is a continuous-wave transmitter which delivers an RF power output of 50 KW in the frequency range of 50 to 150 KC.

(2) Three types of keying may be employed with this equipment. The transmitter may be operated with DC line keying at any speed up to 500 words per minute, facsimile keying, or frequency-shift keying.

(3) The entire transmitter is enclosed in a unit assembly 36 feet long, 9 feet high, and 17 feet deep. Basically, it consists of a 2-KW RF exciter unit and a 50-KW RF power amplifier unit. A helix house, located apart from the transmitter building, contains antenna tuning equipment.

(4) The exciter unit output frequency is made continuously variable by a master oscillator (self-contained within the exciter) over the frequency range of 50 to 150 KC in six tuning bands. In addition, frequency shift keying provides for shifting of the master oscillator frequency to a maximum of plus or minus 100 cycles.

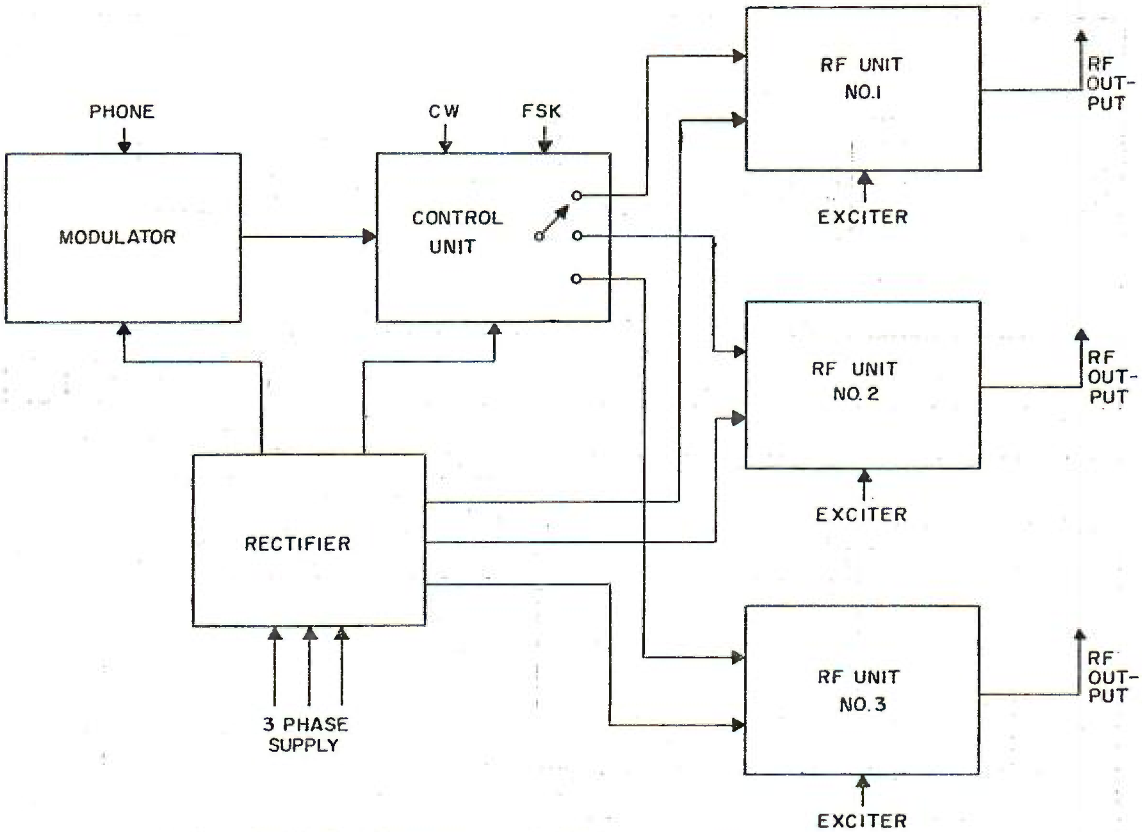


Figure 4–5. Simplified Block Diagram of an MW 3–1–1 Installation.

b. *Principle of Operation.*

(1) A functional block diagram of the AN/FRT–4 is shown in figure 4–7. The 2-KW RF exciter is composed of the master oscillator (MO), two power amplifier stages (exciter IPA and PA), and the frequency shift keyer. The RF signal is generated by the master oscillator and is amplified sufficiently by the exciter IPA and PA to drive the 50-KW power amplifier final stage.

(2) The vacuum tube keyer circuitry controls the master oscillator for either DC line keying or facsimile keying. For these two methods of operation, the master oscillator is cut off in the absence of a keying signal, and caused to oscillate when a DC or facsimile signal is applied to the keyer circuit.

(3) The frequency shift keyer causes the oscillator (MO) to shift above and below the center frequency in accordance with a varying d-c intelligence voltage.

c. *Globecom Application.*

(1) The AN/FRT–4 is used to implement a low-frequency circuit in those areas in which propagation conditions make it impossible to maintain reliable communications by utilizing the high-frequency radio band. Frequency shift keying is usually employed for the transmission of four-channel multiplex teletypewriter signals.

(2) A system of "moduplexing" is also employed with this equipment whereby an audio tone is used to effect a low-level amplitude modulation of the frequency shifted carrier to provide a navigational aid. The tone producing the amplitude modulation is interrupted by an identifying code. The transmitted signal can be detected and utilized to facilitate navigation in the same manner as any other low-frequency beacon signal. Relatively low audio power is required to effect the amplitude modulation because the tone signal is used to modulate

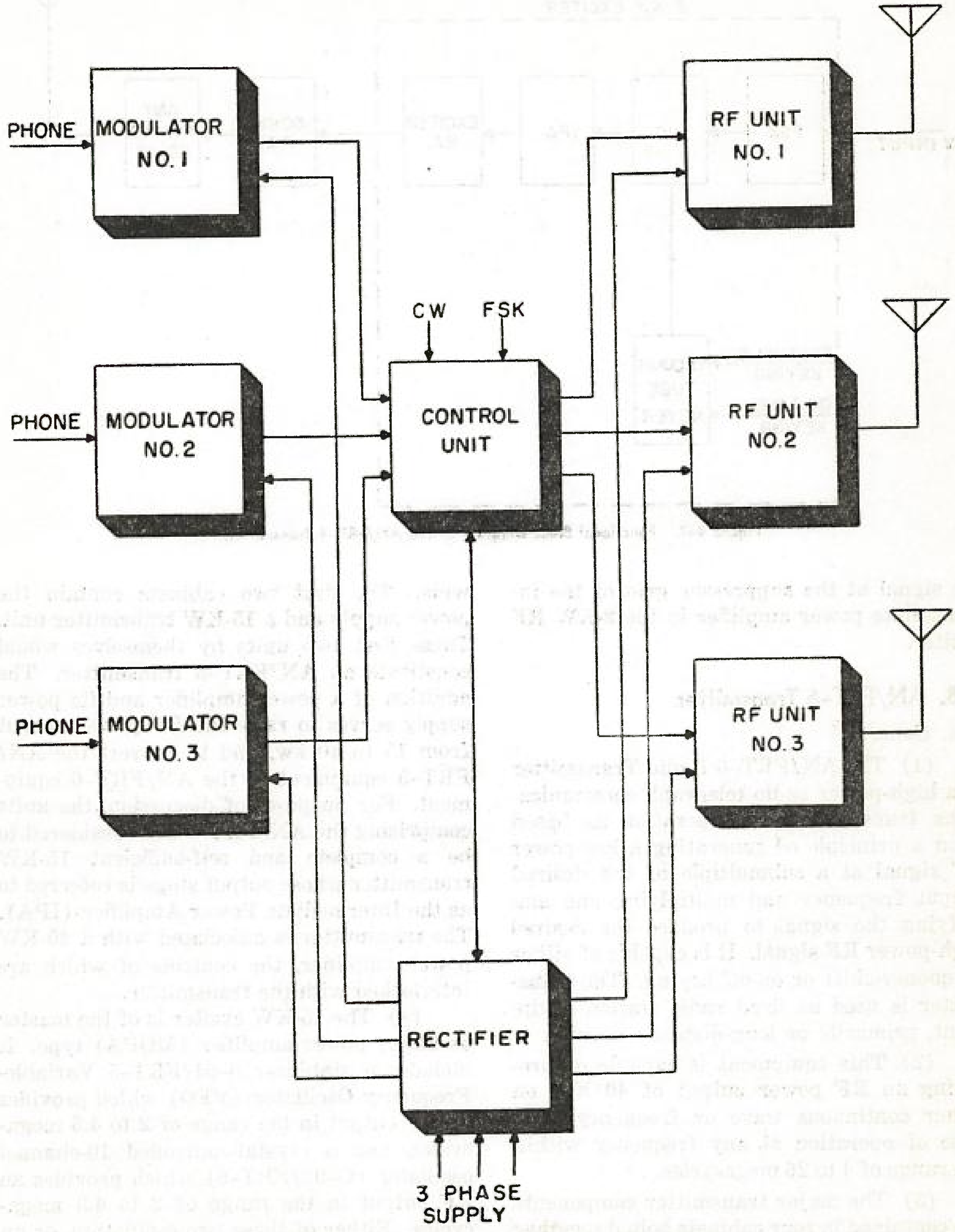


Figure 4-6. Simplified Block Diagram of an MW 3-3-1 Installation.

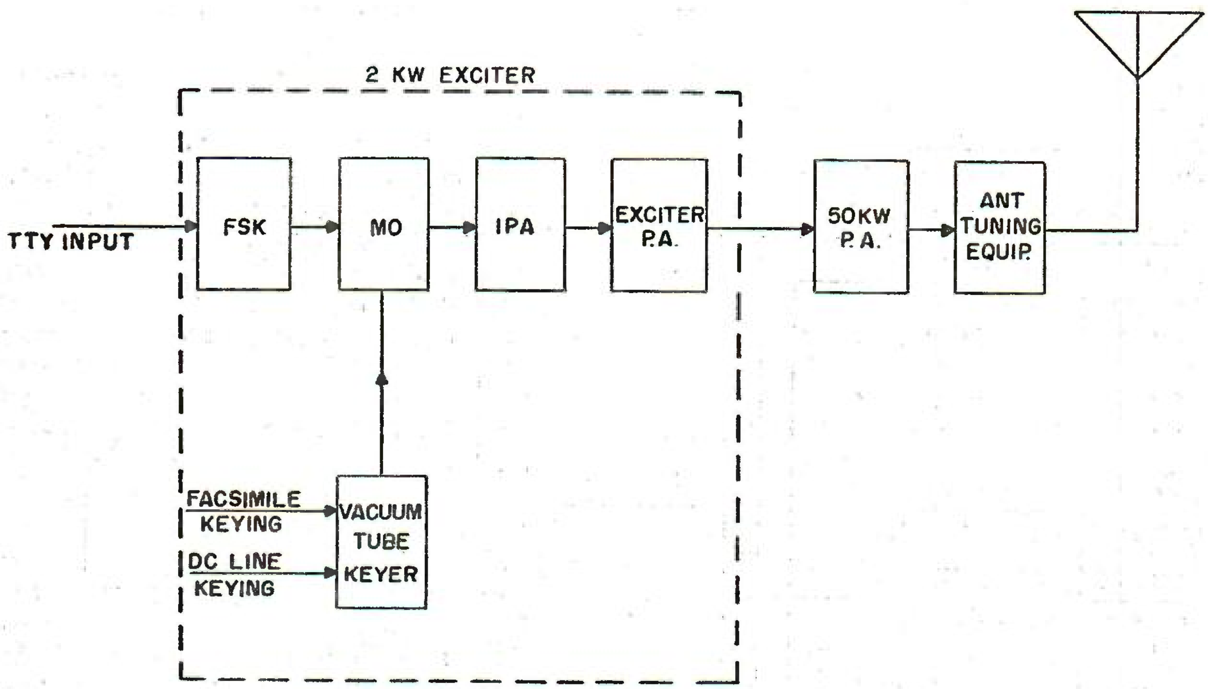


Figure 4–7. Functional Block Diagram of the AN/FRT–4 Transmitter.

the signal at the suppressor grid of the intermediate power amplifier in the 2-KW RF exciter.

4–8. AN/FRT–6 Transmitter

a. *General.*

(1) The AN/FRT–6 Radio Transmitter is a high-power radio telegraph communications transmitter. Its operation is based upon a principle of generating a low-power RF signal at a submultiple of the desired output frequency and multiplying and amplifying the signal to produce the desired high-power RF signal. It is capable of either frequency-shift or on-off keying. The transmitter is used as fixed radio station equipment, primarily on long-distance circuits.

(2) This equipment is capable of providing an RF power output of 40 KW on either continuous wave or frequency shift type of operation at any frequency within the range of 4 to 26 megacycles.

(3) The major transmitter components are contained in four cabinets bolted together to form a single unit which requires a floor space approximately 21 feet long by 5 feet wide. The first two cabinets contain the power supply and a 15-KW transmitter unit. These first two units by themselves would constitute an AN/FRT–5 transmitter. The addition of a power amplifier and its power supply serves to raise the RF power output from 15 to 40 kw, and to convert the AN/FRT–5 equipment to the AN/FRT–6 equipment. For purposes of discussion, the units comprising the AN/FRT–5 are considered to be a complete and self-sufficient 15-KW transmitter whose output stage is referred to as the Intermediate Power Amplifier (IPA). The transmitter is associated with a 40-KW power amplifier, the controls of which are interlocked with the transmitter.

(4) The 15-KW exciter is of the master oscillator power amplifier (MOPA) type. It includes a stabilizer 0–91/FRT–5 Variable-Frequency Oscillator (VFO) which provides an RF output in the range of 2 to 4.5 megacycles, and a crystal-controlled 10-channel oscillator (O–92/FRT–5) which provides an RF output in the range of 2 to 4.3 megacycles. Either of these two oscillators, or an external oscillator, may be selected as the source of the RF signal. A KY–45/FRT–5

Frequency Shift Keyer (FSK) is also included within the exciter transmitter to effect a linear frequency shift with respect to an input keying voltage. The description and operating principles of the VFO and the FSK are discussed later in this chapter.

b. *Principle of Operation.*

(1) A functional block diagram of the AN/FRT-6 Transmitter is shown in figure 4-8. Three separate sources of excitation are illustrated. The input switching panel, which consists of coaxial jacks with short coaxial jumpers, provides a convenient means of selecting and interconnecting the desired excitation source. On-off or frequency shift keying input can be selected with the switch on the electronic keyer unit. For on-off keying, the first buffer and first frequency multiplier are controlled by the electronic keyer circuit in accordance with the keying pulses.

(2) For frequency shift keying operation, the output signal from the selected exciter is injected into the FSK at a frequency 200 KC higher than the desired output of the FSK. This injected signal is mixed with a 200-kc frequency-shifted voltage from a source within the FSK to produce an RF output voltage in the frequency range of 2 to 4 mc. The output of the FSK is applied to the input of the buffer amplifier.

(3) The exciter is isolated from the first multiplier stage by the broad-band buffer stage which also provides the necessary voltage gain. The buffer output, which is in the range of 2 to 4 megacycles, is applied to the first multiplier which acts as a doubler, tripler, or quadrupler. The second multiplier, which operates in the frequency range of 4 to 26 MC, is used as a doubler or as a straight-through amplifier.

(4) The output of the multiplier is coupled to the driver stage which amplifies the signal sufficiently to drive the push-pull IPA stage which is normally operated Class "C". The output of the IPA is fed into the coupling network which provides for coupling the RF signal to either the low-impedance input of the power amplifier stage (PA), or to a 600-ohm transmission line when the equipment is converted for operating at reduced power.

(5) The output of the coupling network drives the push-pull PA which provides the

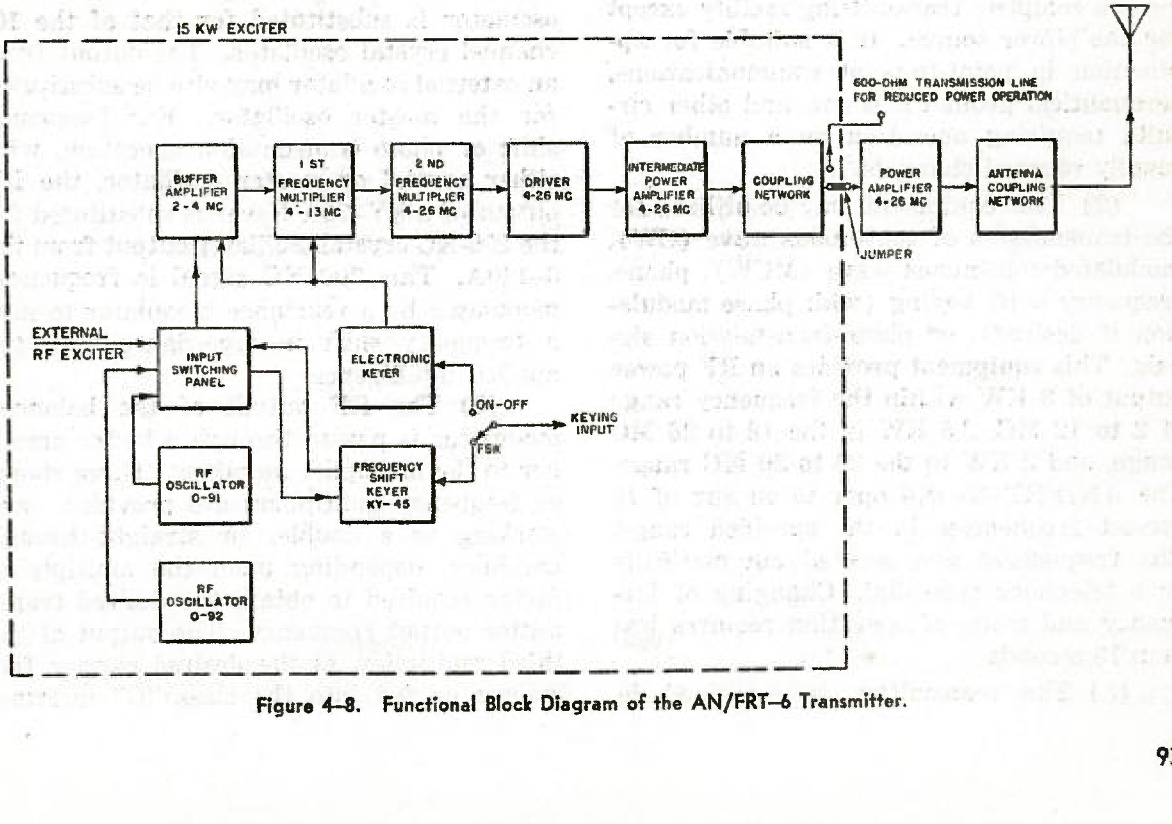


Figure 4-8. Functional Block Diagram of the AN/FRT-6 Transmitter.

40 KW of RF power which is fed to the antenna coupling network and finally to the transmission line and antenna.

c. *Globecom Application.*

(1) The AN/FRT-6 transmitter is provided as a back-up for certain point-to-point circuits which employ the MW type transmitter as primary equipment. Each AN/FRT-6 may be utilized as a back-up transmitter for up to three circuits when higher power is required. A system of trunk transmission lines and antenna contactors has been designed for use within Globecom to effect switching of the RF output from an AN/FRT-6 transmitter to the antennas normally fed by the MW transmitters.

(2) The AN/FRT-6 transmitter modified for operation in the VHF band of the frequency spectrum is also employed to implement communications through the medium of forward propagation by ionospheric scatter. Frequency shift keying is utilized for this type of operation.

4-9. AN/FRT-15 Transmitter

a. *General.*

(1) The AN/FRT-15 Transmitter is used in fixed ground installations and provides a complete transmitting facility except for the power source. It is suitable for application in point-to-point communications, aeronautical ground stations, and other circuits requiring operation on a number of readily selected channels.

(2) This equipment may be utilized for the transmission of continuous wave (CW), modulated continuous wave (MCW), phone, frequency shift keying (with phase modulation if desired), or photo-transmission signals. This equipment provides an RF power output of 3 KW within the frequency range of 2 to 12 MC, 2.5 KW in the 12 to 26 MC range, and 2 KW in the 26 to 30 MC range. The AN/FRT-15 will operate on any of 10 pre-set frequencies in the specified range. The frequencies are selected automatically by a telephone type dial. Changing of frequency and mode of operation requires less than 15 seconds.

(3) The transmitter is contained in three cabinets that are bolted together to form a single unit which requires a floor space of approximately 7 feet wide by 3 feet deep. A separate control unit, consisting of a telephone-type control dial, a handset, and an amplifier, may be used for remote control of the transmitter.

b. *Principle of Operation.*

(1) A functional block diagram of the AN/FRT-15 Transmitter is shown in figure 4-9. All units shown, with the exception of the C-745A/FRT-15 Remote Control Unit, are located within the transmitter cabinets.

(2) The basic frequency-determining circuits are the 10-channel crystal oscillator circuit in the AN-483A/FRT-15 Oscillator-Amplifier, the 200-KC crystal oscillator circuit and the 1.8 to 4 MC synthesized output from interpolation oscillators in the 0-140A/FRT-15 RF Oscillator, and the 200-KC frequency shift oscillator in the KY-70A/FRT-15 Frequency Shift Keyer. For crystal operation on CW, the output of the 10-channel crystal oscillator is mixed with the output from the 200-KC crystal oscillator in the balanced modulator stage to give the fundamental operating frequency of the transmitter. For master-oscillator operation, the 1.8 to 4 MC RF output of the 0-140A oscillator is substituted for that of the 10-channel crystal oscillator. The output from an external oscillator may also be substituted for the master oscillator. For frequency shift or photo transmission operation, with either crystal or master oscillator, the RF output of a KY-70A Keyer is substituted for the 200-KC crystal oscillator output from the 0-140A. This 200 KC signal is frequency-modulated by a reactance modulator to give a frequency shift in accordance with the applied intelligence.

(3) The RF output of the balanced modulator is passed through a buffer amplifier to the multiplier amplifier. Three stages of frequency multipliers are provided, each working as a doubler or straight-through amplifier, depending upon the multiplying factor required to obtain the desired transmitter output frequency. The output of the third multiplier, at the desired carrier frequency, is fed into the class "C" interme-

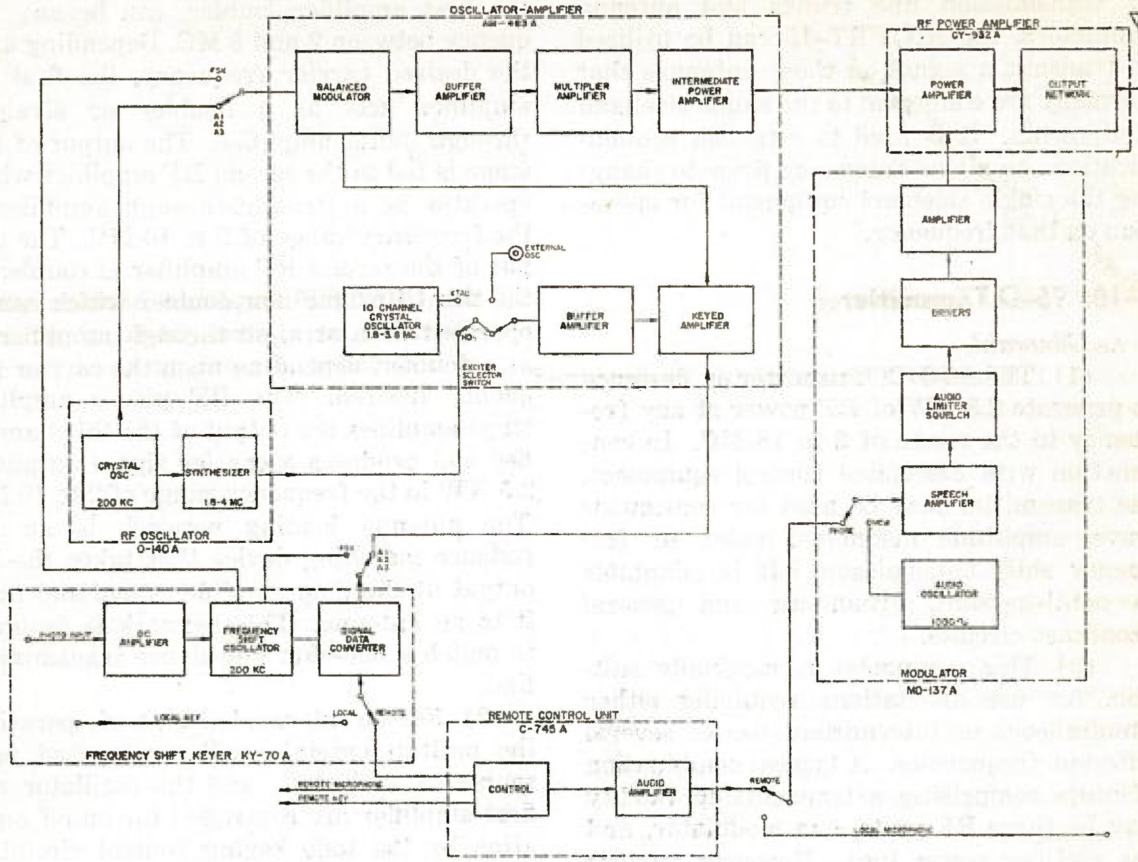


Figure 4–9. Functional Block Diagram of the AN/FRT–15 Transmitter.

diate power amplifier which drives the final RF power amplifier stage in the CY–932A Cabinet.

(4) The MD–137A/FRT–15 Radio Modulator includes the audio circuits for voice modulation or MCW signals. Either a 1000-cps audio oscillator or the output from a microphone drives the speech amplifier stage. The speech amplifier output is fed through a limiter and squelch stage which provides compression for modulation over 70 percent. This output feeds the driver stage which in turn drives the modulator stage. The output of the modulator is fed through a modulation transformer to effect plate-and-screen modulation of the final RF power amplifier.

(5) The C–745A Control Unit includes an audio amplifier which is used to voice modulate the transmitter from a remote point over a landline. Its output is fed into the transmitter speech amplifier. Control circuits provide selection between manual and automatic keying, and voice modulation.

(6) Variable coupling and capacity tuning, within the output network in the CY–932A Cabinet, facilitate loading and matching the output of the transmitter to a transmission line of any impedance from 70 to 800 ohms.

c. *Globecom Application.*

(1) The AN/FRT–15 is employed as back-up equipment for the primary air-ground transmitters and is operated into a broad-band discone antenna. Due to its 10-channel pre-set capability, this transmitter can be readily selected as a substitute for the equipment normally utilized on the air-ground circuits.

(2) This equipment is also employed as a line-up transmitter on the single sideband circuits and is included in the single side-band equipment groups. By using a system

of transmission line trunks and antenna contactors, the AN/FRT-15 can be utilized to transmit a signal on those antennas that normally are connected to the single sideband equipments. It is used to establish communications on a new frequency prior to changing the single sideband equipment for operation on that frequency.

4-10. 96-D Transmitter

a. *General.*

(1) The 96-D Transmitter is designed to generate 2.5 KW of RF power at any frequency in the range of 2 to 18 MC. In conjunction with associated control equipment, the transmitter may be used for continuous wave, amplitude modulated voice, or frequency shift transmission. It is adaptable to point-to-point, ground-air and general broadcast circuits.

(2) This equipment is especially suitable for use at stations requiring either simultaneous or intermittent use of several different frequencies. A typical combination of units comprising a transmitting facility may be three RF units, one modulator, and one rectifier power unit. However, various combinations of these units may be assembled and inter-connected to perform a number of functions. The 3-1-1 combination requires a floor space area approximately 8 feet wide by 2½ feet deep.

(3) The modulator provides 100 percent amplitude modulation of the RF carrier. Included within the modulator unit is a telephone type dial and auxiliary relay unit which provide local control for switching the modulator to any RF unit within the group.

(4) An internal crystal-controlled oscillator may be used to excite each RF unit for CW and voice operation. For frequency shift operation, an external source of RF excitation is required. A tone oscillator is required to key the transmitter for interrupted operation (CW or voice) from a remote position.

b. *Principle of Operation.*

(1) A functional block diagram of the 96-D Transmitter is illustrated in figure 4-10. The source of excitation, as applied to the first amplifier-doubler, can be any frequency between 2 and 5 MC. Depending upon the desired carrier frequency, the first RF amplifier acts as a doubler or straight-through buffer amplifier. The output of this stage is fed to the second RF amplifier which operates as a straight-through amplifier in the frequency range of 2 to 10 MC. The output of the second RF amplifier is coupled to the third RF amplifier-doubler which can be operated as a straight-through amplifier or as a doubler, depending upon the carrier frequency desired. The RF power amplifier stage amplifies the output of the third amplifier and produces a carrier signal output of 2.5 KW in the frequency range of 2 to 18 MC. The antenna loading network is an impedance matching device that takes the RF output of the final amplifier stage and feeds it to an antenna. This network is designed to match a 600-ohm impedance transmission line.

(2) For an interrupted type of operation, the built-in crystal oscillator is used as a source of excitation, and the oscillator and first amplifier are controlled for on-off operation by the tone keying control circuitry. When the transmitter is keyed from a remote position, this circuit acts as a relay and causes the crystal oscillator and first amplifier to function, thus exciting the transmitter. In the key-down condition, a 1000 cps tone from the remote tone keyer oscillator is fed into the tone keying control circuit; this effects a change in the voltages applied to the oscillator and first amplifier stages, and causes these stages to operate.

(3) The modulator consists basically of a phase inverter, speech amplifier, driver, power amplifier, dialing unit and auxiliary control relay unit. The audio signal received from the remote operating position is channeled through the dialing unit to the phase inverter. There are two outputs from this stage, 180 degrees out of phase with each other, which are used to drive the push-pull speech amplifier. The output of the speech amplifier is amplified by the driver stage to a level sufficient to drive the modulator power amplifier. The output of the modulator is used to plate-modulate the trans-

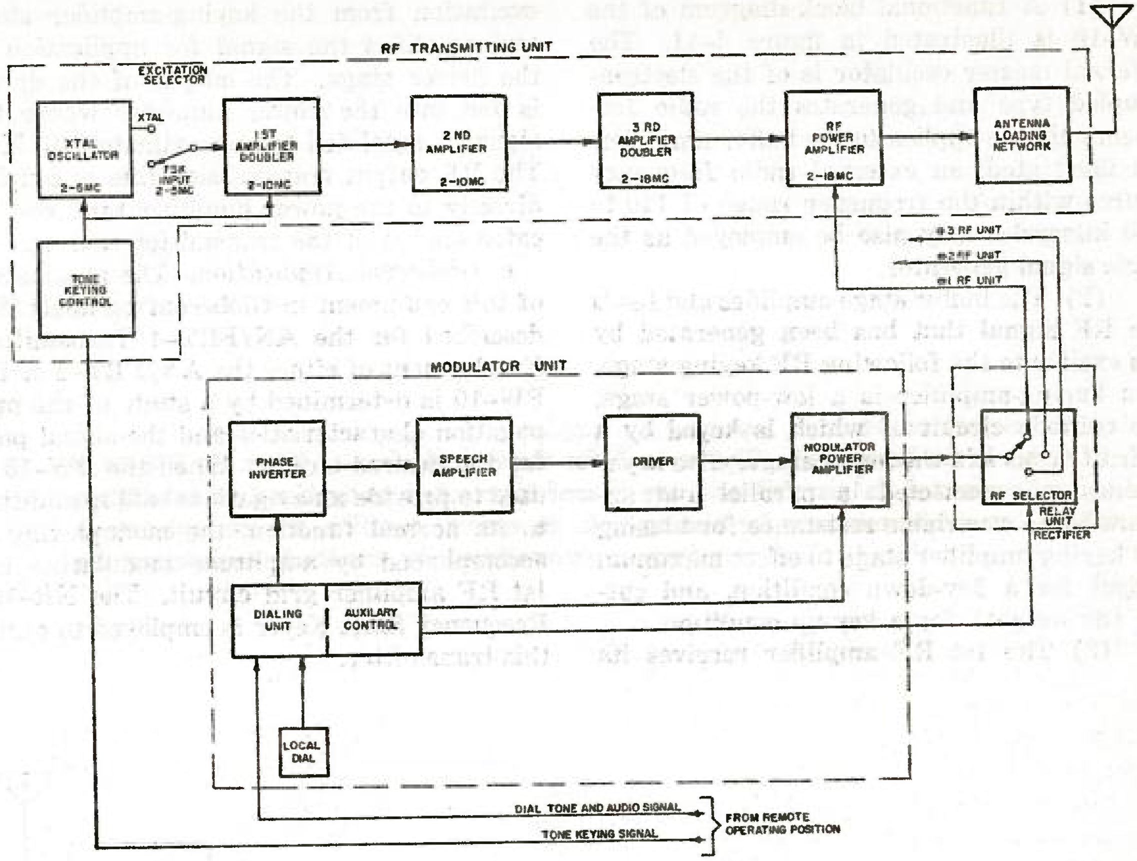


Figure 4–10. Functional Block Diagram of the 96–D Transmitter.

mitter r-f power amplifier.

c. *Globecom Application.*

(1) The 96–D Transmitter is utilized within Globecom to provide the facilities for secondary circuits and local theatre requirements. For point-to-point circuits, a 3-1-1 combination (3 RF units, 1 modulator, and 1 rectifier) is usually provided.

(2) All 96–D RF units are operated in conjunction with an NR–105 Frequency Shift Keyer. This unit provides the initial RF signal for excitation of the transmitter.

4–11. PW–10 Transmitter

a. *General.*

(1) The PW–10 Transmitter has been designed for radio-telegraph operation with an output carrier power of 15 KW in the frequency range of 110 to 140 KC. This transmitter is capable of handling keying speeds up to 350 words per minute with a minimum of wave-form distortion. It works into a single-wire transmission line having a surge impedance of approximately 600 ohms.

(2) The PW–10 consists of two major components installed adjacent to one another on a common base plate requiring a floor space of 9 feet by 5 feet. The RF exciter and rectifier are grouped together on the left-hand side of the transmitter, and the RF power amplifier and its externally mounted tank coil on the right-hand side.

(3) Transmitter excitation is obtained from either an internal master oscillator or an external RF oscillator producing an output in the frequency range of 110 to 140 KC. A stage provides for local or remote keying of the transmitter. A helix house, located apart from the transmitter building and containing components to facilitate antenna tuning, is also provided.

b. *Principle of Operation.*

(1) A functional block diagram of the PW-10 is illustrated in figure 4-11. The internal master oscillator is of the electron-coupled type and generates the radio frequency that is applied to the buffer amplifier. As illustrated, an external radio frequency source within the frequency range of 110 to 140 kilocycles may also be employed as the basic signal generator.

(2) The buffer stage amplifies and feeds the RF signal that has been generated by the exciter to the following RF keying stage. The keying-amplifier is a low-power stage, the cathode circuit of which is keyed by a pair of triodes in the keyer stage. The keyer triodes are connected in parallel and are operated as a variable resistance for biasing the keying-amplifier stage to effect maximum output for a key-down condition, and cut-off (no output) for a key-up condition.

(3) The 1st RF amplifier receives its excitation from the keying-amplifier stage and amplifies the signal for application to the driver stage. The output of the driver is fed into the power amplifier where the signal is amplified to approximately 15 KW. The RF output transmission line is coupled directly to the power amplifier tank coil located on top of the transmitter cabinet.

c. *Globecom Application.* The application of this equipment in Globecom parallels that described for the AN/FRT-4 Transmitter. Employment of either the AN/FRT-4 or the PW-10 is determined by a study of the propagation characteristics and the signal path for the desired circuit. When the PW-10 is used to provide a navigational aid in addition to its normal function, the moduplexing is accomplished by amplitude modulating the 1st RF amplifier grid circuit. The NR-109 Frequency Shift Keyer is employed to excite this transmitter.

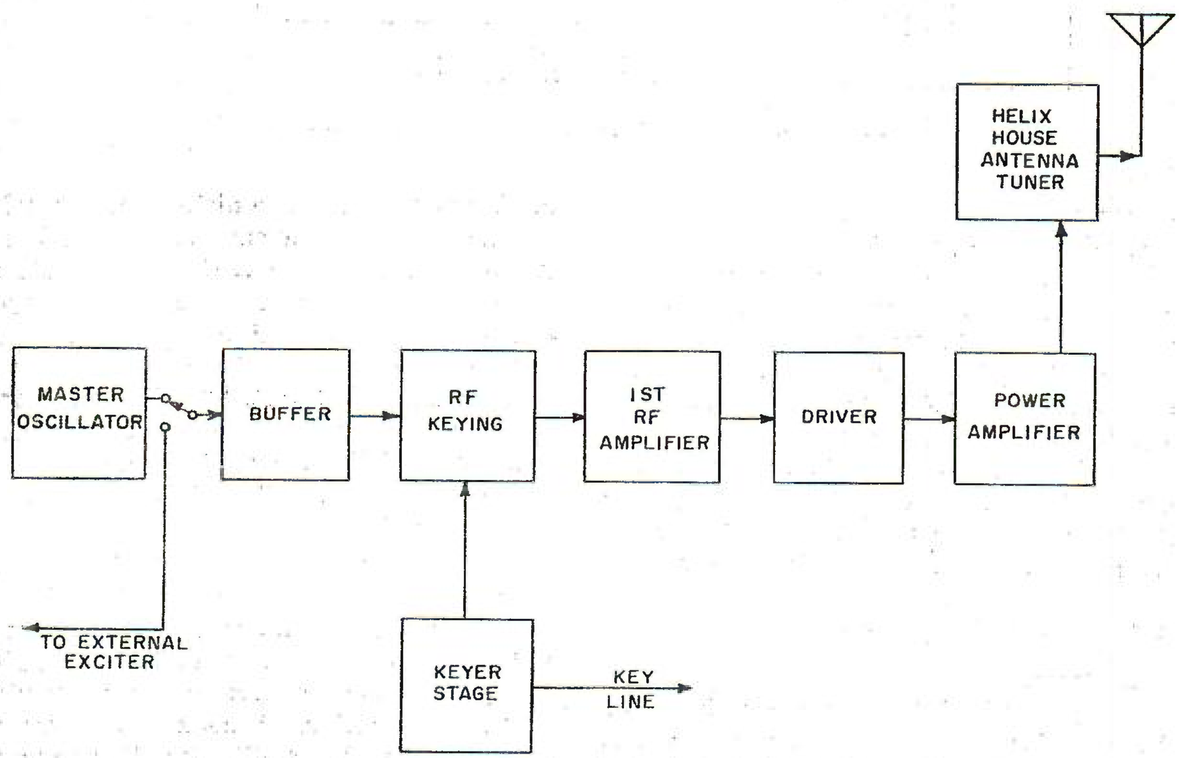


Figure 4-11. Functional Block Diagram of the PW-10 Transmitter.

Section II. AUXILIARY EQUIPMENT

4-12. NR-105 Frequency Shift Keyer

a. *General.*

(1) The frequency shift keyer unit is a highly stable crystal-controlled radio frequency oscillator with circuity which provides for shifting the RF signal to either side of a center frequency in accordance with a varying DC input signal.

(2) The exciter replaces the oscillator in a transmitter and produces a carrier shift for transmission of teletypewriter or facsimile signals over a radio circuit. For teletypewriter operation, a front panel control provides for adjustment of the frequency shift up to 1000 cycles per second. For facsimile operation, the shift is entirely dependent upon the amplitude of the DC input voltage. A shift of up to plus or minus 700 cycles per second, linear with respect to input voltage, may be utilized for facsimile operation.

(3) A three-position switch provides for selection of any one of three operating frequencies, depending upon the frequency of the crystals installed. The crystal frequency is 200 kilocycles less than the center frequency output of the keyer.

(4) The frequency shift keyer and associated power supply are mounted in a standard 19-inch equipment cabinet and require a combined rack space of 16 inches.

(5) An NR-163 Adapter Unit is available for use with this equipment to permit substitution of an external oscillator for the internal crystal oscillator of the frequency shift keyer. The adapter also provides for connections between the internal crystal oscillator and other equipment when a constant RF signal without frequency shift is required.

b. *Principle of Operation.*

(1) A functional block diagram of the frequency shift keyer is illustrated in figure 4-12. The keyer consists of six basic units: a keying circuit, reactance tube, 200-kilocycle oscillator, crystal oscillator, balanced modulator, and power amplifier.

(2) When used for teletypewriter operation, the mark and space signal pulses are injected into the keying stage, where the signal is limited and shaped, and then fed to the reactance tube as a positive or negative voltage. The reactance tube in turn acts to lower or raise the frequency of the 200-kilocycle oscillator in accordance with the space or mark signal pulses applied at the input.

(3) When used for facsimile operation,

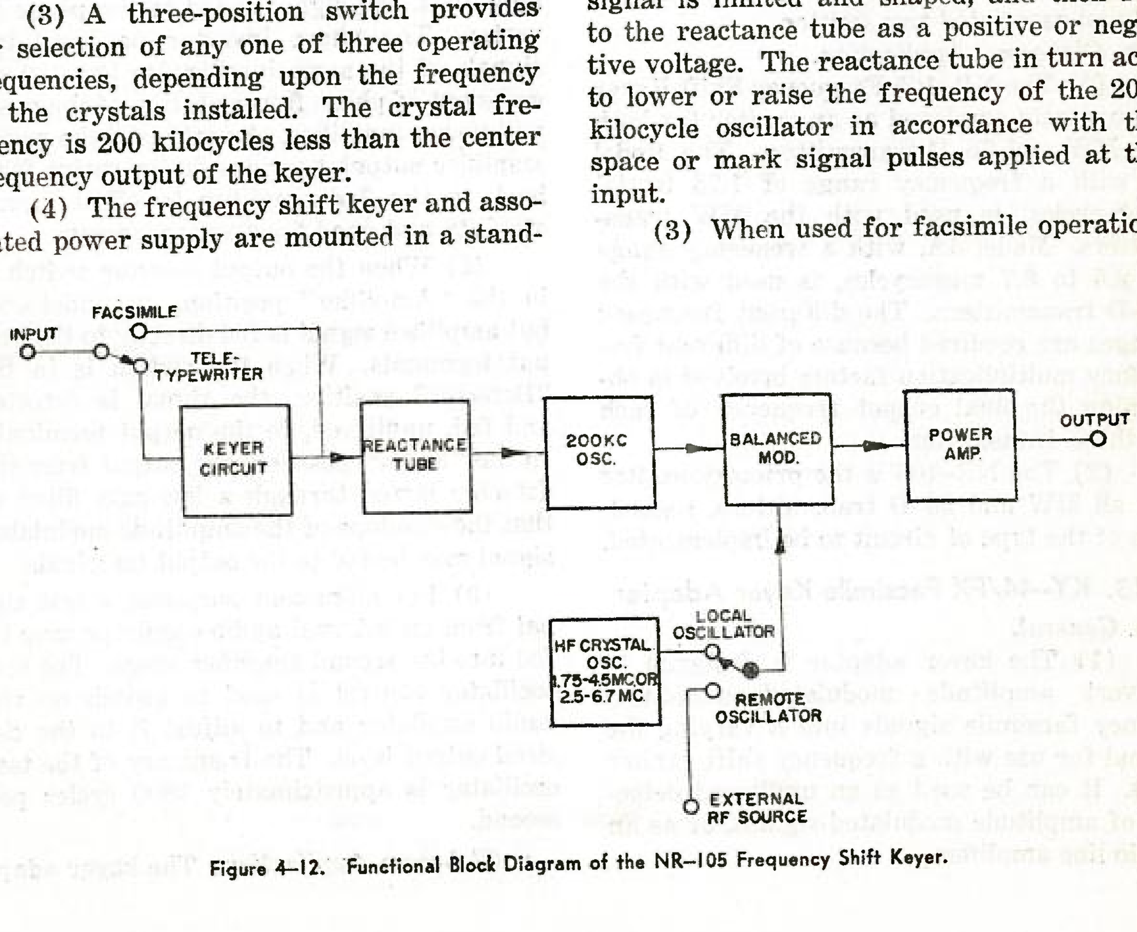


Figure 4-12. Functional Block Diagram of the NR-105 Frequency Shift Keyer.

the keying circuit is by-passed and the reactance tube is controlled directly by the amplitude of the input voltage. For this type of operation, the reactance tube acts to lower or raise the frequency of the 200-kilocycle oscillator linearly in accordance with the varying DC facsimile signal applied at the input. The output of the 200-kilocycle oscillator and the output of the high-frequency crystal oscillator are combined in a balanced modulator circuit.

(4) The frequency of the crystal oscillator is selected so that its resonant frequency is 200 kilocycles below the desired output frequency of the frequency shift keyer. The output of the balanced modulator contains both the sum and difference frequencies which result from the heterodyning of the two signals applied to the stage, but it contains neither of the fundamental frequencies. The difference-frequency is eliminated by use of filter circuits, and only the sum-frequency is passed on to the power amplifier for amplification before being fed into an associated transmitter.

c. *Globecom Application.*

(1) The NR–105 Frequency Shift Keyer is currently employed as an exciter for both the MW and 96–D transmitters. The Model 4, with a frequency range of 1.75 to 4.5 megacycles, is used with the MW transmitters. Model 4A, with a frequency range of 2.5 to 6.7 megacycles, is used with the 96–D transmitters. The different frequency ranges are required because of different frequency multiplication factors involved in obtaining the final output frequency of each of these transmitters.

(2) The NR–105 is the primary exciter for all MW and 96–D transmitters, regardless of the type of circuit to be implemented.

4–13. KY–44/FX Facsimile Keyer Adapter

a. *General.*

(1) The keyer adapter is designed to convert amplitude modulated audio-frequency facsimile signals into a varying d-c signal for use with a frequency shift exciter unit. It can be used as an unfiltered detector of amplitude modulated signals, or as an audio line amplifier.

(2) The keyer adapter and power supply are assembled on 19-inch panels for mounting in a standard rack. The adapter is designed for a 600-ohm balanced input with a signal of 100 to 7000 cycles per second within a level of minus 20 to plus 6 dbm. A balanced or unbalanced 600-ohm output is available at an amplitude up to 20 volts into a 600-ohm load.

b. *Principle of Operation.*

(1) The basic principle of operation of the keyer adapter is illustrated in figure 4–13. The incoming amplitude modulated facsimile signal is fed through an RF filter to a multi-stage audio amplifier. An input meter monitors the db level of the incoming signal. The band-pass filter may be switched into the circuit to remove excess hum or noise if an 1800-cycle carrier facsimile signal is being received from the facsimile transmitter. The output control provides for adjustment of the signal level applied to the 1st amplifier. After passing through the amplifiers, the signal is fed to the phase inverter. The phase inverter produces two signals of the same intelligence but 180 degrees out of phase for excitation of the push-pull power amplifier. A portion of the power amplifier output provides degenerative feedback to the 3rd amplifier to effect circuit stability and good frequency response.

(2) When the output selector switch is in the "Amplifier" position, an undetected but amplified signal is fed directly to the output terminals. When the switch is in the "Detector" position, the signal is detected and fed, unfiltered, to the output terminals. In the "Keyer" position, the output from the detector is fed through a low-pass filter so that the envelope of the amplitude modulated signal may be fed to the output terminals.

(3) For alignment purposes, a test signal from an internal audio oscillator may be fed into the second amplifier stage. The test oscillator control is used to switch on the audio oscillator and to adjust it to the desired output level. The frequency of the test oscillator is approximately 1800 cycles per second.

c. *Globecom Application.* The keyer adap-

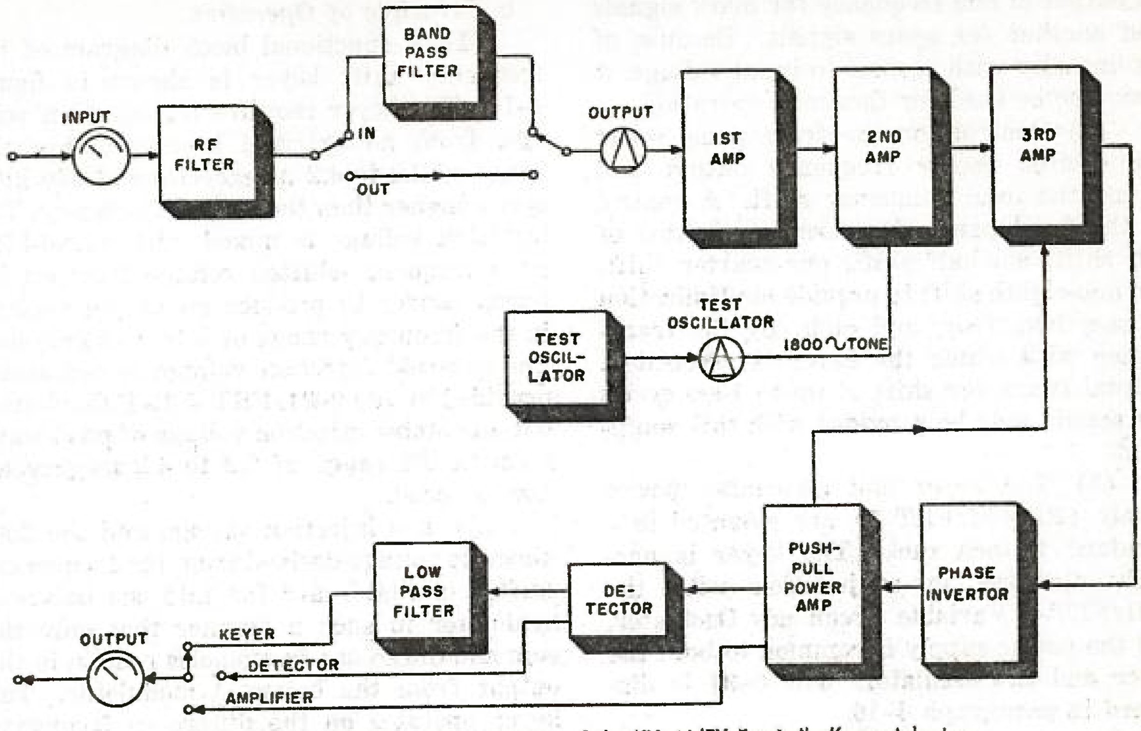


Figure 4-13. Functional Block Diagram of the KY-44/FX Facsimile Keyer Adapter.

ter is used to rectify the amplitude modulated audio facsimile signal and to filter out the carrier frequency in order to obtain the envelope of the intelligence wave as a varying DC voltage. The resultant DC voltage is then applied to the input of a frequency shift keying unit to produce a shift in the basic radio frequency signal in accordance with the amplitude of the original facsimile signal.

4-14. NR-115 Variable Frequency Oscillator

a. *General.* The NR-115 Variable Frequency Oscillator (VFO) is common to both transmitting and receiving stations throughout Globecom. Since this equipment has been illustrated and described previously in Part Three, Chapter 2, only those items peculiar to transmitter station application of the equipment are presented in this section of the manual.

b. *Globecom Transmitting Station Application.*

(1) The NR-115 provides an RF output which is variable from 2 to 32 megacycles. Its stability is equivalent to that obtained with crystal oscillators without temperature control, and it may be employed as an external RF source to drive the NR-105 Frequency Shift Keyer in the event operation is required on a frequency which cannot be generated with the crystals available for the NR-105 equipment.

(2) The NR-115 receives power from a source of regulated voltage within the transmitter building to maintain a high stability output. This high degree of accuracy permits utilization of the equipment as a secondary frequency standard for all transmitting equipment for measuring purposes.

4-15. KY-45/FRT-5 Frequency Shift Keyer

a. *General.*

(1) The frequency shift keyer provides an r-f output in the range of 2 to 4 megacycles, the frequency of which is shifted linearly with respect to an input keying voltage. In a teletypewriter system, it produces

an output of one frequency for mark signals and another for space signals. Because of its linearity with respect to input voltage, it may also be used for facsimile operation.

(2) Controls on the front panel select the desired center frequency output and adjust the total frequency shift. A control on the front panel also permits selection of full shift, one-half shift, one-quarter shift, and one-eighth shift to provide multiplication of one, two, four, and eight by the transmitter with which the keyer is associated. A total frequency shift of up to 1000 cycles per second may be provided with this equipment.

(3) The keyer and associated power supply (PP-454/FRT-5) are mounted in a standard 19-inch rack. The keyer is normally operated in conjunction with the 0-91/FRT-5 Variable Frequency Oscillator, and the power supply is common to both the keyer and the oscillator. The 0-91 is discussed in paragraph 4-16.

b. *Principle of Operation.*

(1) A functional block diagram of the frequency shift keyer is shown in figure 4-14. The keyer requires an injection voltage, from an external source, within the range of 2.2 to 4.2 megacycles and 200 kilocycles higher than the output frequency. The injection voltage is mixed with a 200-kilocycle frequency-shifted voltage from an internal source to produce an output voltage in the frequency range of 2 to 4 megacycles. The external injection voltage is ordinarily provided by the 0-91/FRT-5 R-F Oscillator, but any stable injection voltage of good wave form in the range of 2.2 to 4.2 megacycles may be used.

(2) The injection voltage and the 200-kilocycle voltage derived from the frequency-shifted oscillator are fed into the balanced modulator in such a manner that only the sum and difference frequencies remain in the output from the balanced modulator. The keyer operates on the difference frequency

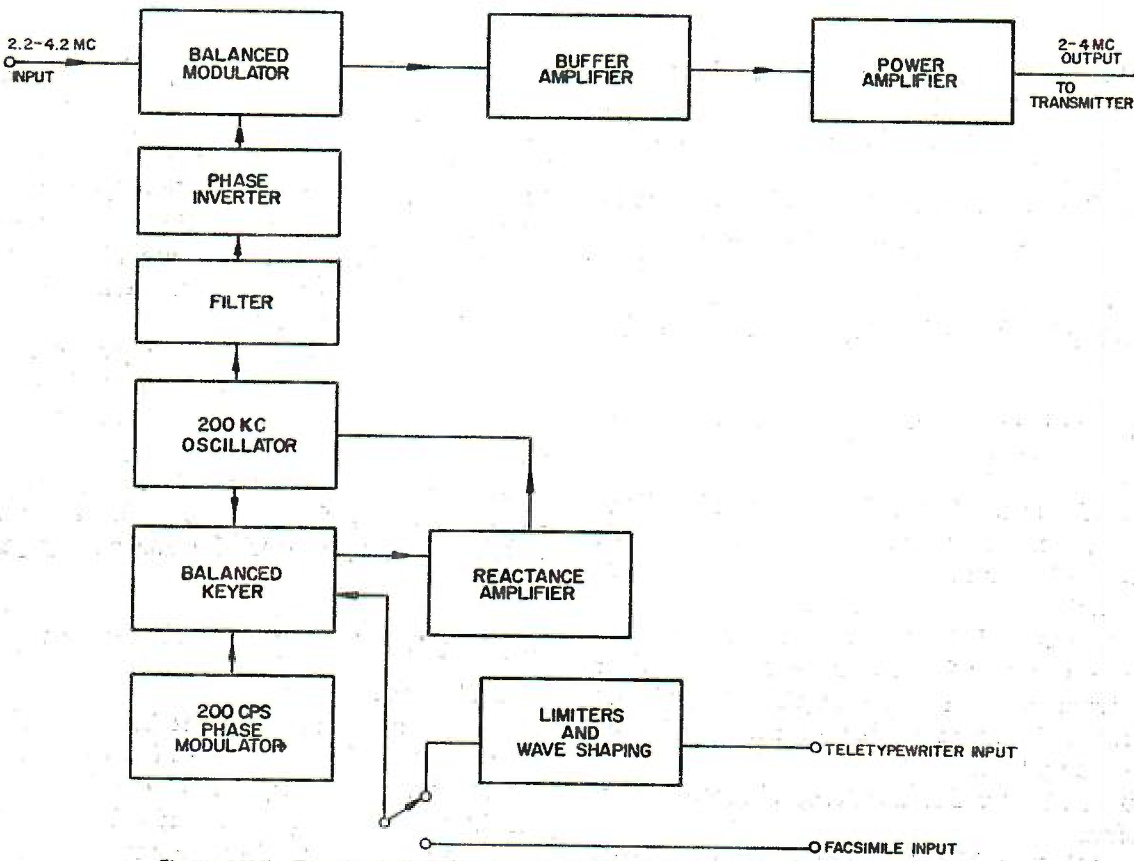


Figure 4-14. Functional Block Diagram of the KY-45/FRT-5 Frequency Shift Keyer.

which is 200 kilocycles below the injected high-frequency signal. The difference frequency is selected by the buffer amplifier and power amplifier tuned circuits and is applied to an associated transmitter. All other frequencies are eliminated from the output of the keyer.

(3) The portion of the frequency shift keyer which produces the frequency-shifted signal consists of the 200-kilocycle oscillator, balanced keyer, and reactance amplifier. One section of the balanced keyer tube is operated at a constant bias, while the bias of the other section is varied in accordance with the applied intelligence signal. A portion of the 200-kilocycle output is also injected into the balanced keyer, and the circuitry of the balanced keyer contains a certain reactive impedance when no intelligence voltage is applied to the variable bias section of the keyer tube. When an intelligence signal voltage is applied to the keyer tube, a phase shift results across the reactive component. The phase shift is amplified by the reactance amplifier, and the output voltage from the reactance amplifier is applied across the tank circuit of the 200-kilocycle oscillator. The voltage from the reactance amplifier either lags or leads the original voltage across the oscillator tank circuit and results in an upward or a downward shift in oscillator frequency in accordance with the applied intelligence signal voltage.

(4) The output of the frequency-shifted oscillator is fed through a filter circuit which passes the fundamental frequency with very little attenuation and offers a high degree of rejection to the second and higher harmonics of the 200-kilocycle oscillator. The harmonics must be suppressed because they would fall within the pass-band of the high-frequency circuits of the keyer. The output of the filter circuit is fed into the phase inverter which applies a push-pull output voltage to the balanced modulator.

(5) For teletypewriter operation, the mark and space signals are applied to the limiter and wave-shaping circuits. The teletypewriter signals are passed through the limiter circuits so that essentially fixed-voltage positive keying impulses having square-wave characteristics are applied to the wave-shaping circuit. Wave shaping is introduced at this point to materially reduce the side-band frequency components which are present with square-wave keying.

(6) For facsimile operation, the intelligence is applied directly to the balanced keyer stage, and the output of the 200-kilocycle oscillator varies linearly in accordance with the applied varying DC intelligence signal voltage.

(7) The phase modulation oscillator is a simple Hartley oscillator tuned to 200 cycles per second. This 200-cps oscillator provides a voltage across the balanced keyer circuit so that up to one radian of phase modulation at 850 cps total shift is possible in the output signal. The use of phase modulation permits frequency diversity reception which is a decided advantage in the presence of severe multipath distortion in radio transmission.

c. *Globecom Application.* The KY-45/FRT-5 Frequency Shift Keyer is provided as part of the auxiliary equipment at all transmitting stations employing facsimile circuits. It is provided for those facsimile circuits wherein the material to be transmitted requires greater definition than that which can be attained by using the NR-105 Frequency Shift Keyer which is normally used for facsimile transmission. The KY-45 is also included as an internal component of all AN/FRT-6 transmitters.

4-16. O-91/FRT-5 Variable Frequency Oscillator

a. *General.*

(1) The 0-91 RF oscillator is a very stable automatic frequency-controlled (AFC) oscillator which covers a frequency range of 2 to 4.5 megacycles. In addition, a 100 kilocycle and a 450 kilocycle source is incorporated in this equipment, and external jacks are provided so that these signals may be used in conjunction with other equipment requiring a signal source at these frequencies.

(2) The main components of the equipment that provide RF output power to driv

a transmitter are the master oscillator, multiplier, and final amplifier. The remaining circuits are frequency-control circuits. Stability is derived from a 100 kilocycle crystal standard located in the 0-91A unit. An external oscillator may also be employed as a standard.

(3) The variable frequency oscillator and its associated power supply (PP-454/FRT-5) are mounted in a standard 19-inch rack. The 0-91 is normally operated in conjunction with the KY-45/FRT-5 Frequency Shift Keyer, and the PP-454/FRT-5 Power Supply is common to both the keyer and the oscillator. The KY-45 is discussed in paragraph 4-15.

b. *Principle of Operation.*

(1) A functional block diagram of the variable frequency oscillator is presented in figure 4-15. The master oscillator supplies an r-f output in the frequency range of 1000 to 1500 kilocycles. The output frequency of the master oscillator is determined by the position of a tuning slug which is adjusted by the front panel controls and the setting of a capacitor across the tank circuit. The setting of the capacitor is adjusted by the AFC motor through a mechanical link. The motor operates in response to the output of the automatic frequency control circuit. The output of the master oscillator is fed into the multiplier which produces an output in the range of 2 to 4.5 megacycles. The output of the multiplier is fed into the final stage which operates as a straight-through amplifier and delivers an output in the range of 2 to 4.5 megacycles to the transmitter or associated equipment.

(2) The stability of the 0-91 oscillator is derived from the 100-kilocycle standard. The 100-kilocycle standard is converted by the divider circuit to 25 kilocycles and then passed into the harmonic amplifier circuit whose output signal is in the range of 9.125 to 21.625 megacycles. This signal is mixed with the fifth harmonic of the multiplier out-

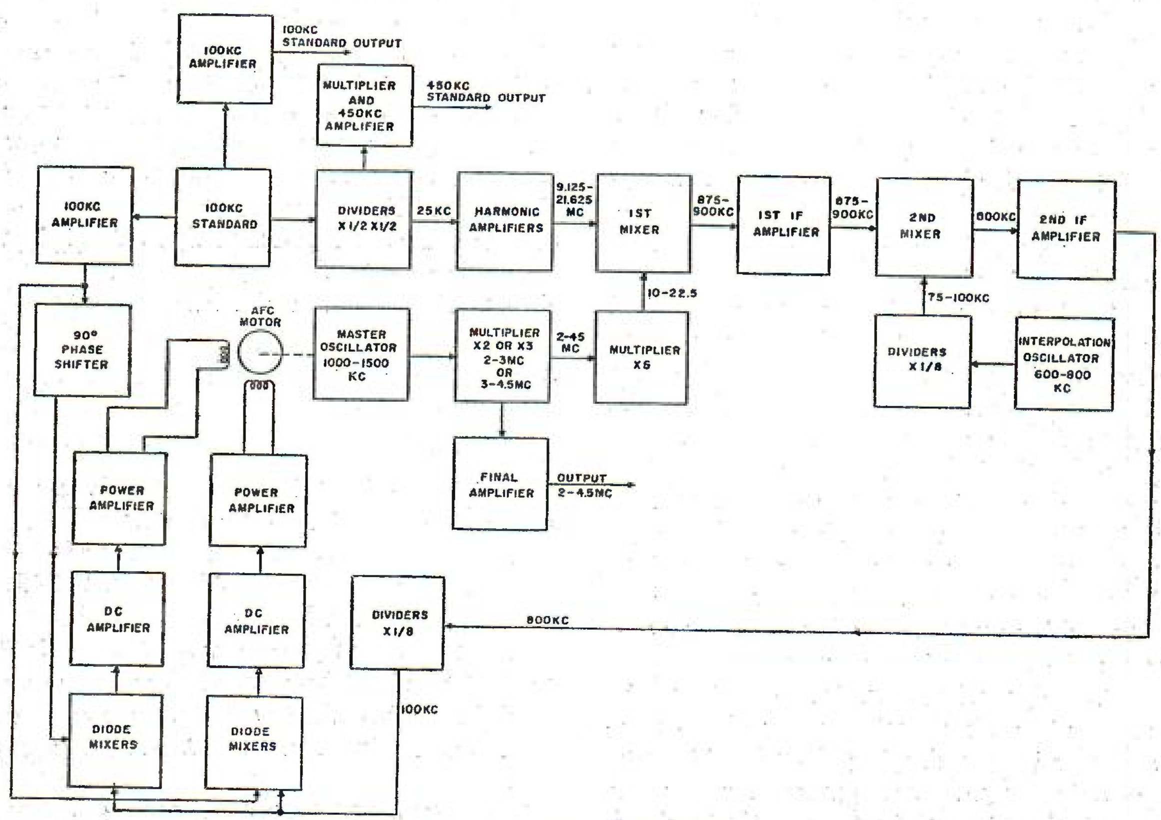


Figure 4-15. Functional Block Diagram of the 0-91/FRT-5 Variable Frequency Oscillator.

put to produce an intermediate frequency in the output of the 1st mixer. The fifth harmonic of the output frequency covers the rangs of 10 to 22.5 megacycles, and the intermediate frequency produced and amplified by the 1st IF amplifier is in the range of 875 to 900 kilocycles.

(3) The signal amplified by the 1st IF amplifier is fed to the 2nd mixer wherein it is combined with a 75 to 100 kilocycle signal which is obtained from the subdivided output of the 600- to 800-kilocycle interpolation oscillator. The IF signal from the second mixer is a fixed-frequency signal centered at 800 kilocycles.

(4) The 800-kilocycle signal is converted to 100 kilocycles in a regenerative divider circuit. Any error involved in setting up the master oscillator appears in the 100-kilocycle signal. The 100-kilocycle signal is then combined with a signal from the 100-kilocycle standard in a pair of diode mixers. Any audible output resulting is fed into the d-c amplifier and is a definite measure of the frequency error. In one of the diode mixers, the 100-kilocycle standard signal is shifted 90 degrees by the phase shift circuit preceding that mixer. The 90 degree shift within the one diode mixer results in a two-phase audio output. The audio output from the DC amplifiers is passed to a pair of power amplifiers, and the resultant two-phase output from the power amplifiers is fed to the AFC motor which rotates in such a manner that it adjusts the master oscillator to the desired frequency.

c. *Globecom Application.* The 0–91 variable frequency oscillator is provided in Globecom transmitting stations as a source of RF injection voltage for the KY–45/FRT–5 Frequency Shift Keyers. These units are provided on the basis of one for each KY–45 installed. The 0–91 is also an internal component of all AN/FRT–6 transmitters.

4–17. NR–109 Frequency Shift Keyer

a. *General.*

(1) The NR–109 Frequency Shift Keyer is employed as a source of radio-frequency excitation for transmitters when carrier shift communications is desired in the frequency range of 50 to 500 kilocycles. This unit is a crystal controlled oscillator with circuitry which provides for shifting the RF signal to either side of a center frequency in accordance with a varying d-c input signal.

(2) This exciter replaces the oscillator in a radio transmitter and produces a shift for radio transmission of teletypewriter and facsimile signals. For teletypewriter operation, a front panel control provides adjustment of the frequency shift over a range of 50 to 650 cycles per second. For facsimile operation, the shift is entirely dependent upon the amplitude of the DC input voltage. A shift of up to plus or minus 30 cycles per second, linear with respect to input voltage, may be utilized for facsimile operation.

(3) A three-position switch provides for selection of any one of three crystal-controlled operating frequencies. The frequency of the crystals employed is 2000 kilocycles greater than the center output frequency of the frequency shift keyer.

(4) The NR–109 includes a self-contained power supply and is mounted in a standard 19-inch equipment rack. A rack space of 10.5 inches is required to accommodate this unit.

b. *Principle of Operation.*

(1) The low-frequency output from the NR–109 is obtained from a system of double conversion. A functional block diagram of this unit is presented in figure 4–16. It is similar to the NR–105 Frequency Shift Keyer, with the exception that additional crystal oscillator and mixer stages and frequencies are involved.

(2) The frequency-shifted output from the 200-kilocycle oscillator is obtained in the same manner as that described for the NR–105 Frequency Shift Keyer for both teletypewriter and facsimile operation. The shifted 200 kilocycle signal and the signal from the 1800-kilocycle oscillator are then combined in the first mixer, and a resultant 2000 kilocycle signal, shifted in accordance with the applied intelligence signal, is fed to the 2nd mixer. A second crystal signal,

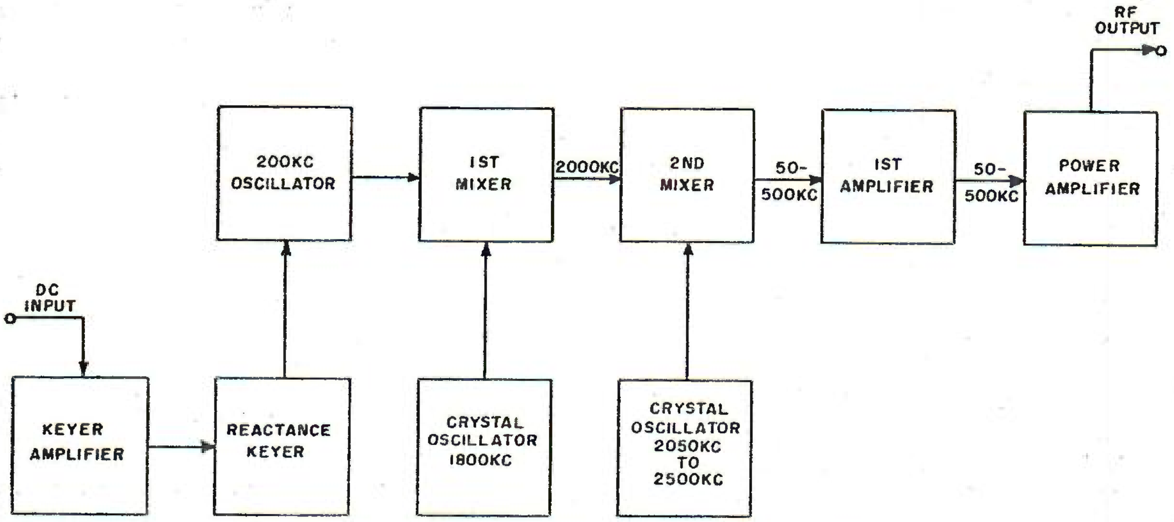


Figure 4-16. Functional Block Diagram of the NR-109 Frequency Shift Keyer.

the frequency of which is in the range of 2050 to 2500 kilocycles, depending upon the crystal selected from the three-position front panel control, is also injected into the 2nd mixer. The difference-signal is selected as the output of the 2nd mixer, and the resultant frequency, the center frequency of which is in the range of 50 to 500 kilocycles, is applied to the input of the 1st amplifier stage. The output of the 1st amplifier is fed to the power amplifier which produces a minimum RF output of two watts over the entire frequency range of equipment.

c. *Globecom Application.* The NR-109 Frequency Shift Keyer is provided as an exciter for all PW-10 Low-Frequency Transmitters employed on radio teletypewriter circuits.

4-18. CV-172/U Facsimile Converter and RD-92/UX Facsimile Recorder

a. *General.* The facsimile converter and recorder equipments are common to both transmitting and receiving stations throughout Globecom. Since these equipments have been previously discussed in Part Three, Chapter 2, only those peculiarities pertinent to transmitter station application of the equipments are presented in this section of the manual.

b. *Globecom Transmitting Station Application.* The facsimile converter and recorder are provided to facilitate operational checks on radio facsimile transmissions. The equipment may be utilized to record the facsimile signal received at the Transmitter Site from the Communications Relay Center, or, when used in conjunction with a receiver at the Transmitter Site, to detect and record the facsimile signal radiated as an RF signal from the Transmitter Site. The prime purpose of the equipment at this location is to determine the source of trouble in the event a distorted or otherwise unsatisfactory signal is reported.

4-19. Antenna Contactors

a. *General.*

(1) To attain operational flexibility, it is often desirable to switch the RF output of a transmitter from one antenna to another, or to feed the RF signal from one transmitter to an additional piece of equipment for the purpose of increasing the power level of the signal applied to the antenna.

(2) Various combinations of a basic contactor have been assembled to implement the foregoing switching within the Globecom transmitting stations. The electrical circuitry of a single contactor unit is illustrated in figure 4-17. In regard to the contacts associated with the RF paths, each contactor is essentially a double-pole double-throw switch which can be operated so that a one-path in-

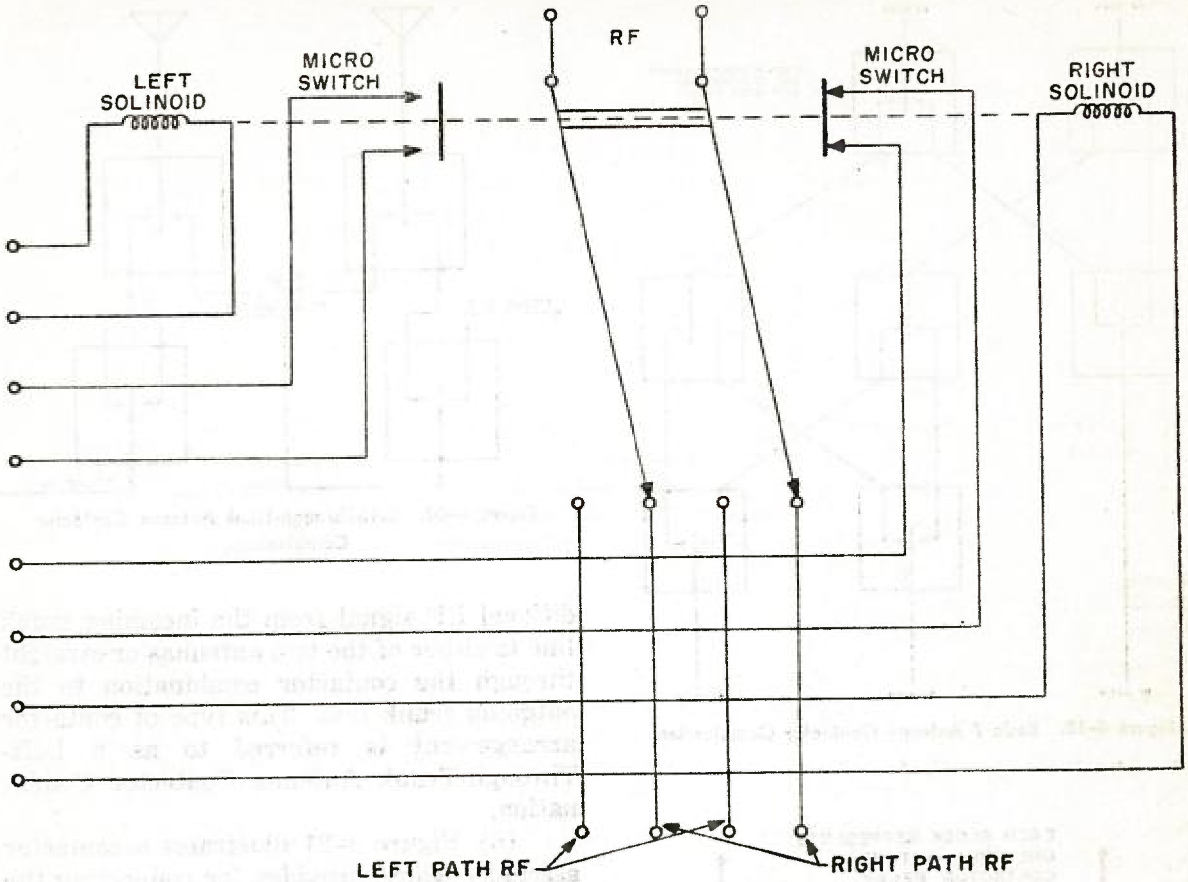


Figure 4-17. Electrical Circuitry of the Antenna Contactor.

put can be routed to one of two possible outputs, or one of two inputs may be selected as the output signal.

(3) In addition to the RF switching contactors, a microswitch provides continuity for coding relay circuitry for either of the two positions of the contactor. The association of the microswitch with the coding relay circuitry is discussed later.

(4) The basic contactor illustrated is of the mechanical hold type in which the contacts are held in the position selected by momentarily energizing the applicable (left or right) solenoid.

b. *Contactor Assemblies.*

(1) Six different combinations of the basic contactor are required to facilitate all types of antenna switching performed in the transmitting stations. For certain applications, two or more of the six combinations may be grouped together to provide the complete switching facilities.

(2) Figure 4-18 illustrates the arrangement of seven contactors and shows the possible RF routing through the contactor assembly employed for switching any of three RF sources to either of two antennas. This arrangement is referred to as the Basic 7 Antenna Contactor Combination.

(3) Figure 4-19 illustrates the arrangement of four contactors and shows the possible RF routing through the contactor assembly employed for switching either of two RF sources to either of two antennas. An arrangement of this type is referred to as the Basic 4 Antenna Contactor Combination.

(4) Figure 4-20 illustrates the contactor assembly employed to connect the output of a Basic 7 or Basic 4 combination to the two associated antennas, or to switch an ad

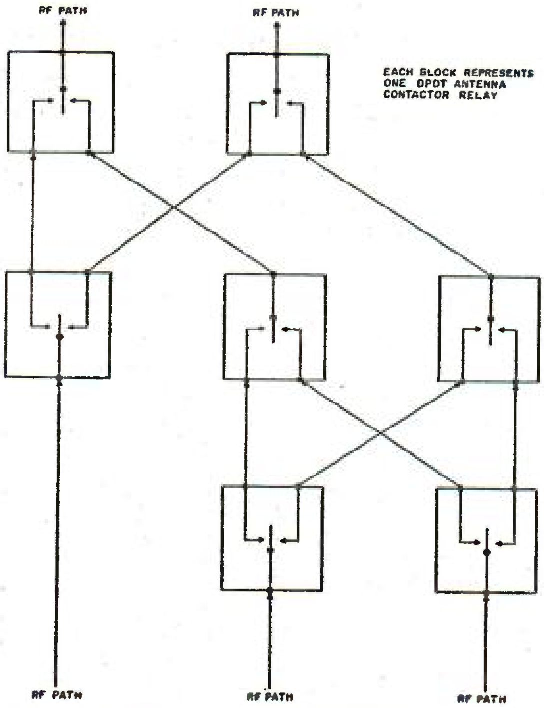


Figure 4-18. Basic 7 Antenna Contactor Combination.

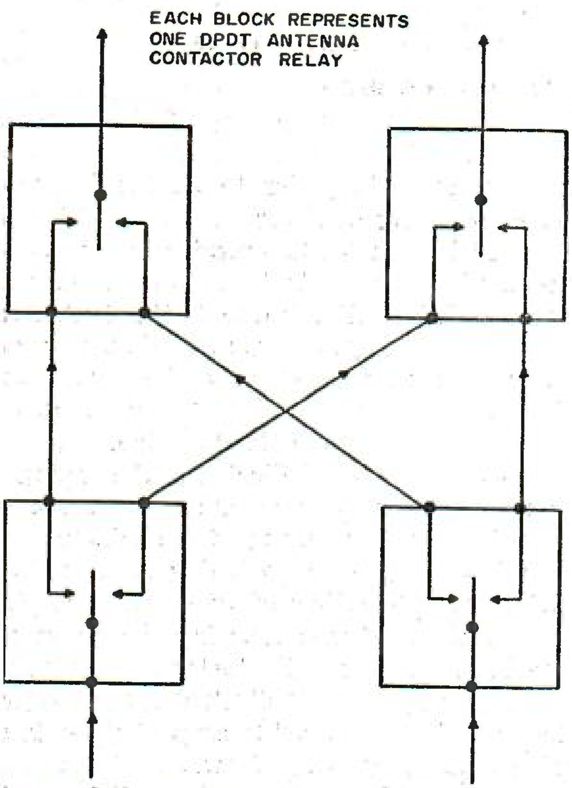


Figure 4-19. Basic 4 Antenna Contactor Combination.

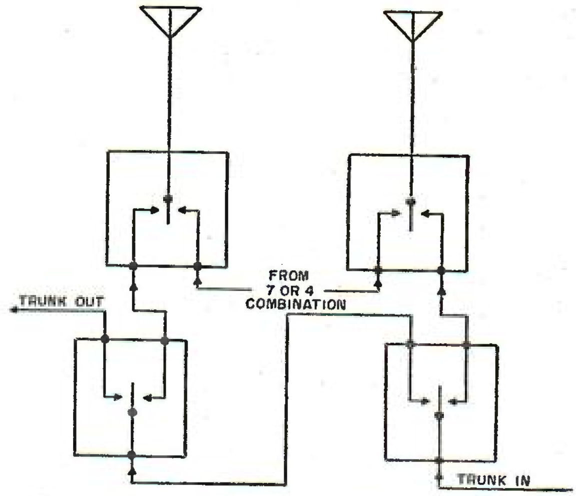


Figure 4-20. Left-Through-Trunk Antenna Contactor Combination.

ditional RF signal from the incoming trunk line to either of the two antennas or straight through the contactor combination to the outgoing trunk line. This type of contactor arrangement is referred to as a Left-Through-Trunk Antenna Contactor Combination.

(5) Figure 4-21 illustrates a contactor assembly which provides for connecting the output of a Basic 7 or Basic 4 combination to two associated antennas, or for connecting

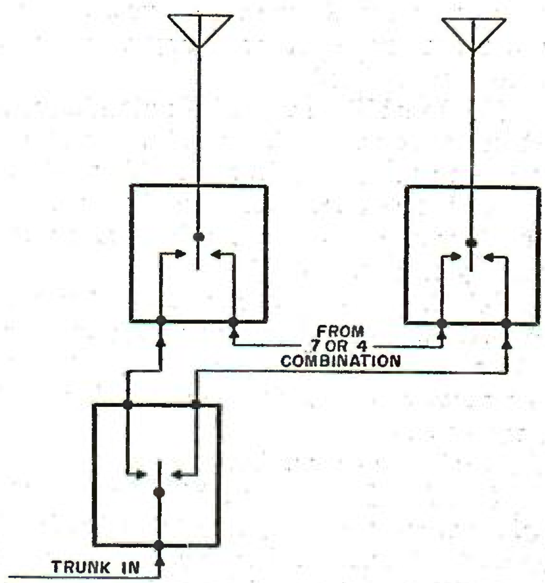


Figure 4-21. Left-Dead-End-Trunk Antenna Contactor Combination.

an additional RF signal from the trunk line to either of the two antennas. This arrangement is referred to as a Left-Dead-End-Trunk Antenna Contactor Combination.

(6) Figures 4–22 and 4–23 are referred to as "Right-Through-Trunk Antenna Contactor Combination" and "Right-Dead-End-Trunk Antenna Contactor Combination," respectively. These assemblies provide for an operation similar to that described for the left-hand trunk combinations, with the exception that the direction of the trunk line routing is reversed.

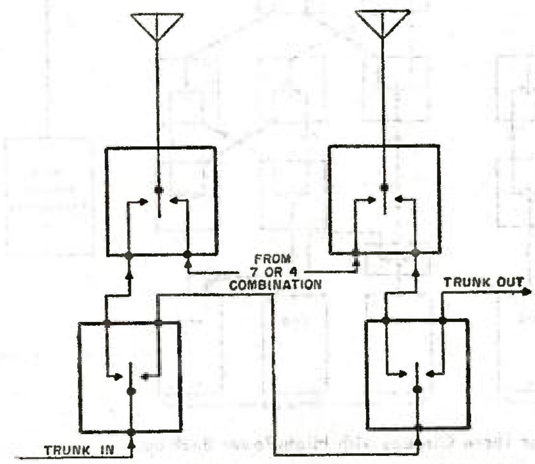


Figure 4–22. Right-Through-Trunk Antenna Contactor Combination.

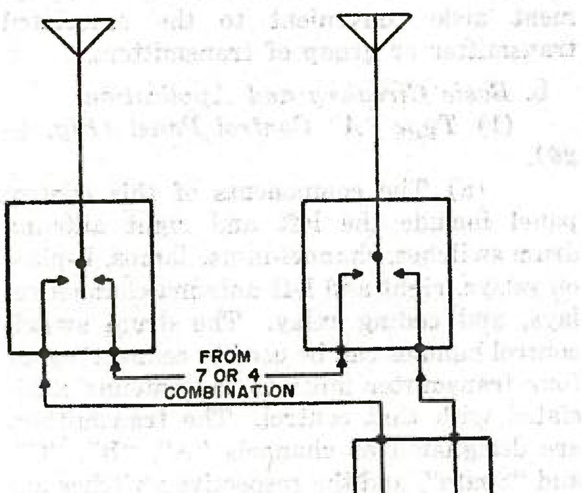


Figure 4–23. Right-Dead-End-Trunk Antenna Contactor Combination.

c. *Application.*

(1) *Circuit Switching Other Than Single Sideband.* Antenna switching systems employed for this type of operation are of three general types: back-up on the right, back-up on the left, and no back-up. When no back-up is involved, and antenna switching is required, the Basic 7 contactor combination is employed to connect any of the three RF units to either of two antennas. When back-up is involved, various contactor combinations are operated as a group to provide the switching facilities. Figure 4–24 illustrates the contactor combinations employed to provide high power back-up to three double sideband circuits, each employing three RF units, and all located to the left of the back-up transmitter. Three Basic 7 combinations, two left-through-trunk combinations and one left-dead-end-trunk combination are required for this operation. If the back-up transmitter was physically located to the left of the transmitters normally associated with the three circuits, a similar arrangement would be used, but right trunk contactor combinations would be employed.

(2) *Single Sideband Circuit Switching.* The single sideband switching presents some new problems in addition to those presented in the foregoing paragraphs. The spare system is no longer a single transmitter, but a group of equipments which consists of the line-up transmitter, a power amplifier, and a single sideband transmitter, in that order. When associated with two or more single sideband circuits, the spare group is capable of operating into either of two trunks, with each of the three possible RF outputs of the spare available to either trunk. This is accomplished by using a Basic 7 combination with the spare group, with trunks connected to the two outputs normally connected to the antennas. An arrangement which provides for connecting the spare facilities to the antennas associated with two single sideband circuits is shown in figure 4–25. If the spare is to provide back-up for an additional single sideband circuit, a through-trunk combination may be employed for either of the dead-end-trunk combinations, and the dead-end trunk combination may be used with the

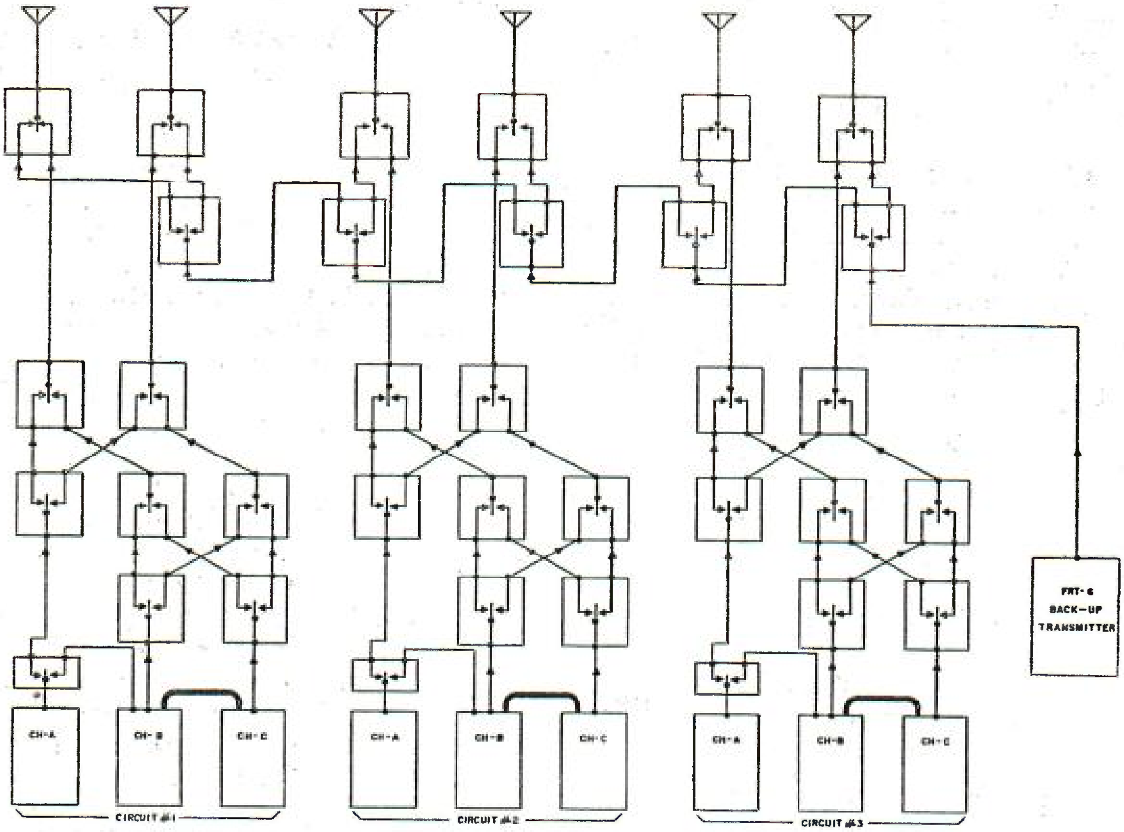


Figure 4-24. Antenna Contactor Arrangements for Three Circuits with High-Power Back-up.

third circuit single sideband equipment group. In the event a single sideband equipment group is not provided with a power amplifier, a Basic 4 contactor combination is employed to provide the facilities for switching either the line-up transmitter or single sideband transmitter to either of the two associated antennas.

4-20. Antenna Contactor Switching Control Panels

a. *General.* The Type "A" Contactor Switching Control Panel and the Type "C" Contactor Switching Control Panel are both used for controlling the antenna contactor combinations discussed in the preceding paragraph. The electrical circuitry of the control panels includes antenna contractor control circuitry, supervisory console display circuitry, interlock circuitry, and carrier failure circuitry. The control panels are mounted in a standard 19-inch rack, and are usually located in a cabinet along the equipment aisle convenient to the associated transmitter or group of transmitters.

b. *Basic Circuitry and Application.*

(1) *Type "A" Control Panel (Fig. 4-26).*

(a) The components of this control panel include the left and right antenna drum switches, channel-in-use lamps, B-plus-on relays, right and left antenna channel relays, and coding relay. The drum switch control handles can be used to connect one of four transmitter units to the antenna associated with that control. The transmitters are designated as channels "A", "B", "C", and "Spare", and the respective switches are identified on the control panel in that sequence. Each drum switch is of the 4-position multiple-contact type and includes a make or break switch so designated mechanically that all associated control circuits are deactivated before the position of the switch

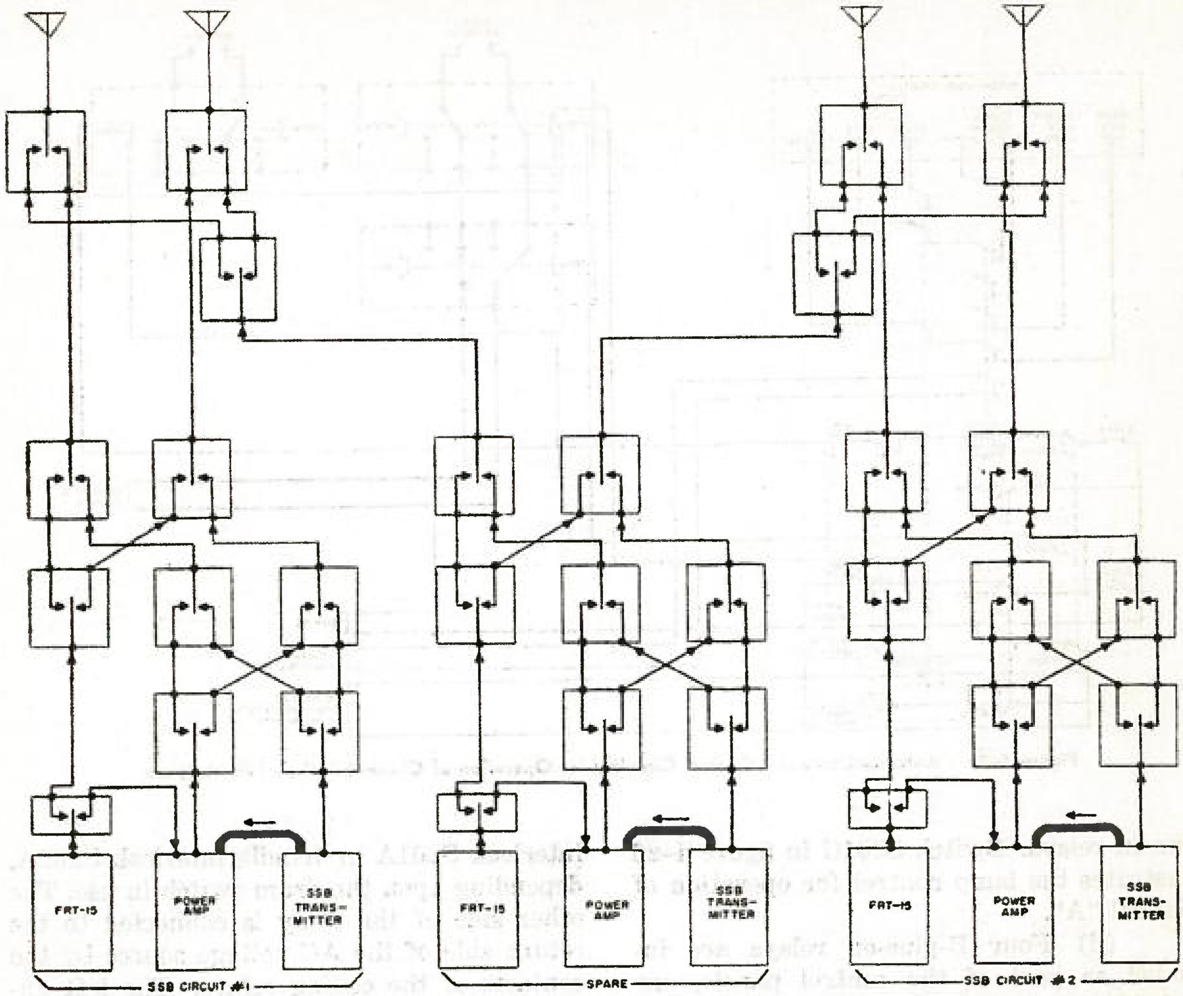


Figure 4–25. Antenna Contactor Arrangement for Two SSB Circuits Sharing One Spare Equipment Group.

can be changed. The handle of each switch must be depressed before another channel can be selected. This operation deactivates all channel antenna relays. After the switch has been repositioned, the springloaded handle returns to its normal position to condition the channel antenna relay circuitry. One section of each switch selects the desired channel relay according to the position of the switch. The make and break switches which are controlled by the longitudinal motion of the control handles are identified as switches S201A and S202A, and the four-position switches, which select the channel relays, are identified as switches S201B and S202B in figure 4–26.

(b) Other contact sections associated with each switch distribute the AC voltages to the coils of the antenna contactors. Two of these switch sections are identified as S201C and S202C in figure 4–26. This portion of the switch works in conjunction with switch S203A, and voltage is applied to the contactor coils only as long as switch S203A is depressed. Switch S203A is a push-button switch in the center of the control panel. The other side of the antenna contactor coils is connected to the microswitches and the a-c bus line to complete the circuit which activates the desired contactor coil.

(c) Other contact sections on each drum switch control the eight channel-in-use lamps associated with each panel. The lamp circuitry works in conjunction with the B

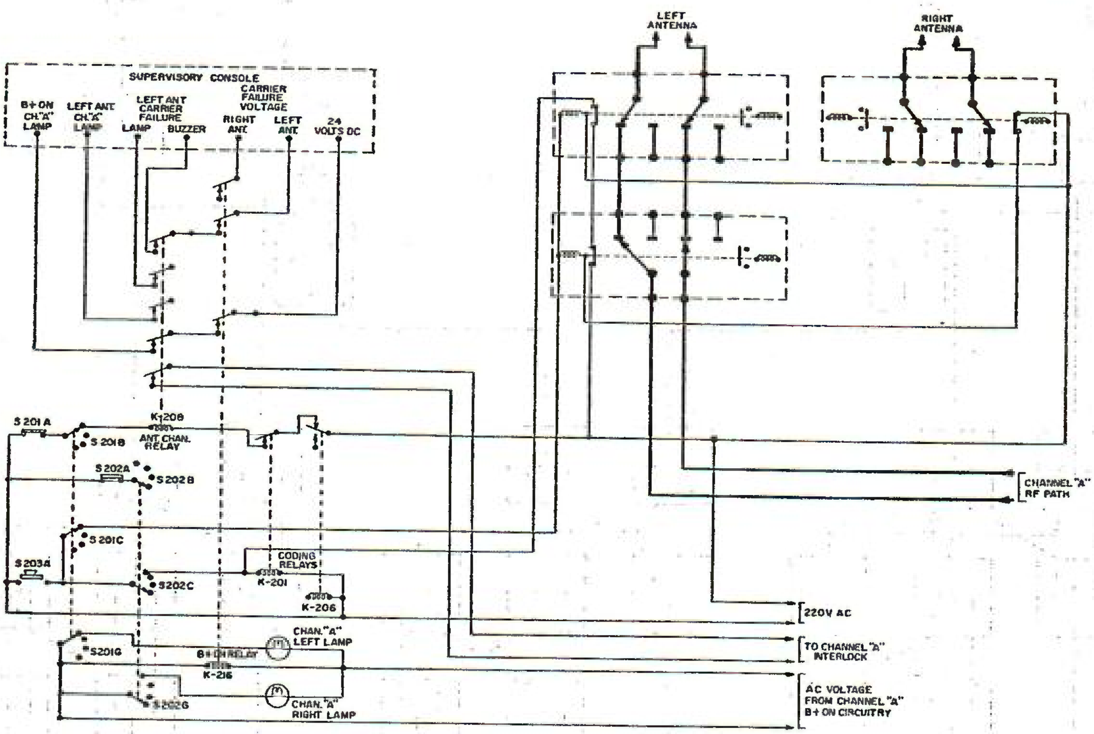


Figure 4-26. Antenna Contactor Control Circuitry for Operation of Channel "A" on Left Antenna.

plus-on relays. Switch S201G in figure 4-26 illustrates the lamp control for operation of channel "A".

(d) Four B-plus-on relays are included as part of the control panels, one each for channel "A", "B", "C", and "Spare". These relays are parts of the transmitter circuitry and are energized when high voltage is present at the associated transmitter, regardless of the position of the drum switch. The eight channel-in-use lamps are paralleled across these relays through the four drum switch contact sections mentioned in sub-paragraph (c). Figure 4-26 illustrates K216, the B-plus-on relay associated with channel "A".

(e) Four left-antenna channel relays and four right-antenna channel relays also are included in the control panels. These relays are energized only when a channel has been selected and the chosen antenna is available. One side of each relay is connected to a terminal on the "B" section of each drum switch to complete the circuit to an AC voltage source through either handle interlock S201A or handle interlock S202A, depending upon the drum switch in use. The other side of the relay is connected to the return side of the AC voltage source by the contacts of the coding relays. The left antenna relay associated with channel "A" is identified as K208 in figure 4-26. Left and right antenna relay operation is similar; that is, in each case, at least one coding relay must be energized to complete the circuit which operates the antenna relays.

(f) Seven coding relays also are provided as part of the control panels. These relays are positioned in accordance with the position of the antenna contactors. One side of each coding relay coil is connected to one side of an AC voltage source, and the other side is returned to the AC voltage line through the microswitches on each contactor. The microswitches are so located physically that they indicate the position (either left or right) of the antenna contactors. Figure 4-26 illustrates coding relay K201 in an energized position, and coding relay K206 in a de-energized position for the condition presented in the illustration; that is, with channel "A" on the left antenna.

(g) Other circuits also are provided by the components of the control panels, such as contact circuits associated with the left and right antenna relay control interlock circuits, supervisory console display circuits, antenna lamp circuits, carrier failure circuits, and, where applicable, carrier level change-over circuits. The overall circuitry, and the association of relays, switches and transmitters, are quite complex and beyond the scope of this manual. However, the basic principle of operation can be realized by tracing the circuitry presented in figure 4–26. This figure illustrates the antenna contactor and control circuits involved when channel "A" of three RF units allocated to one circuit is selected for operation with the left antenna. Only three contactors of the Basic 7 antenna contactor combination which is required for an operation of this type are shown in this illustration.

(2) *Type "C" Control Panel.* All components of this panel are similar to those of the type "A" panel. One drum switch of the three-position type is provided. The type "C" panel is used primarily to switch the transmitters employed with the single sideband type of operation. The panel provides for switching the output of the line-up transmitter to a bank of antenna contactors and consequently to an antenna or into the power amplifier. The Type "C" Panel also provides switching from the output of the single sideband transmitter to a bank of antenna contactors or into the power amplifier. The three positions of the drum switch in reference to the power amplifier (TPA) are all identified by labels as "FRT–15 Drive," "LD–T2 Drive," and "TPA Off."

4–21. R–F Monitor

a. *General.*

(1) This equipment provides for the monitoring of the relative power level of a radio-frequency signal within the range of 2 to 30 megacycles between the power limits of 500 to 50,000 watts. It also provides an audio output corresponding to the amplitude modulation envelope.

(2) The monitor is contained in a metal cabinet, the dimensions of which are approximately 6 x 6 x 8 inches. Operation of this equipment is concurrent with the activation of the transmitter. Independent switching and controlling is not required.

(3) The R–F Monitor provides only the voltages relative to the RF carrier envelope level. An indicator for visual presentation of this information must be provided as additional equipment.

b. *Principle of Operation.*

(1) Figure 4–27 is a functional block diagram of this unit. The input circuitry of the carrier monitor consists of a voltage divider which is center tapped to ground through a capacitor. The voltage divider is capacity coupled to each side of a transmission line, and the RF voltage appearing across the divider is applied to the plates of a high-voltage RF rectifier. The positive voltage output from the rectifier is fed through a filter circuit to one side of a voltage divider, the other side of which is connected to a negative voltage supply.

(2) The voltage divider has two branch circuits, each fed from a variable tap. The negative voltage, which is equal to the difference between the positive rectified voltage and the negative bias voltage, is applied to the control grid of the cathode follower stage. A relay between the voltage divider and the grid circuit permits the selection of one of the two taps on the voltage divider. The selection of a tap conditions the equipment for operation within the power ranges to 500 to 6,000 or 2,000 to 50,000 watts when these different ratings of RF power are applied to the transmission line associated with the monitor unit. Both taps are adjustable to compensate for different levels within the given ranges.

(3) The varying negative voltage on the grid of the cathode follower, being less negative on RF power maximum excursions and more negative on RF power minimum excursions, causes varying cathode current to flow in the cathode follower circuit. The

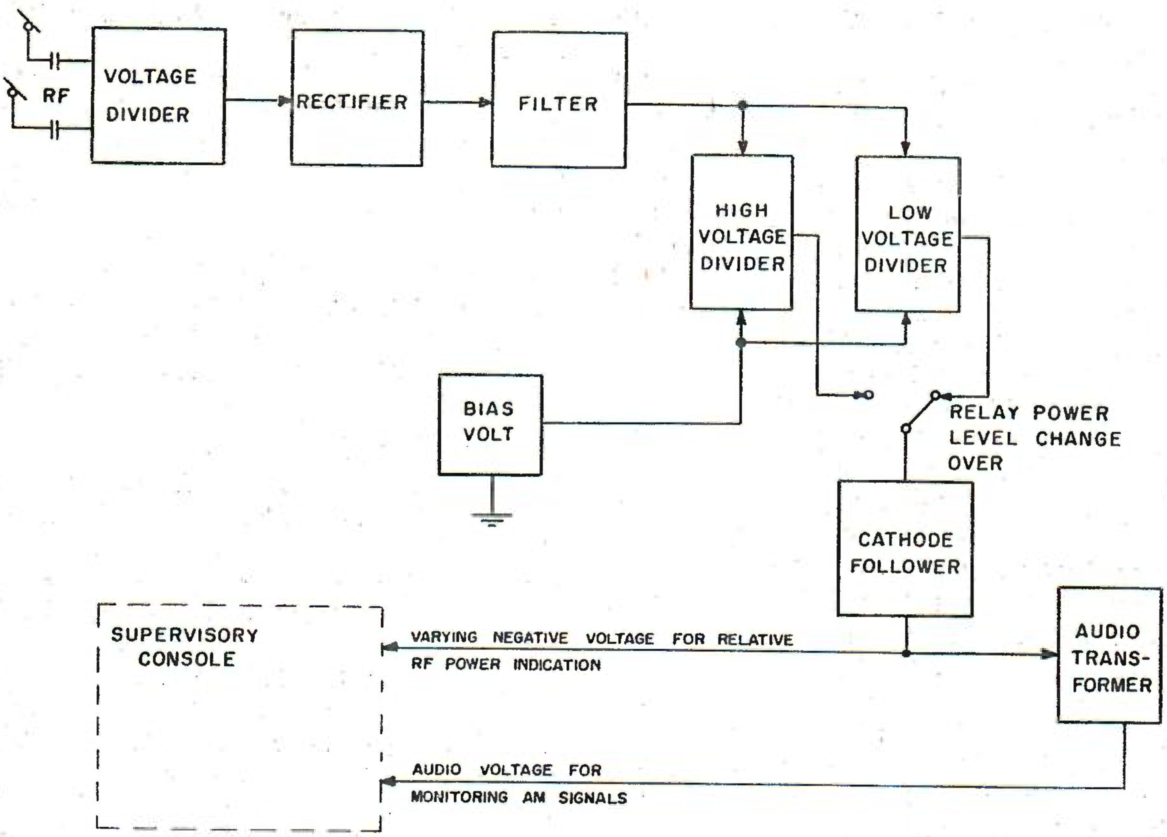


Figure 4-27. Functional Block Diagram of the R-F Monitor.

output voltage from this stage is fed to the supervisory console to indicate the relative RF power applied to the transmission line. This output also is used to operate the relay which provides "carrier on" and "carrier failure" indications at the console. The audio voltage across the cathode resistor is fed to a transformer, the output of which can be used to facilitate monitoring of the amplitude modulated signal when that type of signal is employed.

c. *Globecom Application.*

(1) An RF monitor is provided for each transmission line except those employed for LF and VHF operation. The unit is installed directly beneath the antenna ports accommodating the transmission line at those stations using the Supervisory Console.

(2) The monitor is provided for checking the transmitted signals. It is used in conjunction with a supervisory console, which is explained later, to dislay the relative power of each RF output. The carrier power level is observed on a meter mounted in the supervisory console. The RF monitor also provides a sample of the modulation wave form.

4-22. Carrier Failure Alarm Relay Panel

a. *General.* The Carrier Failure Alarm Relay Panel is used in conjunction with the supervisory console on circuits which do not employ antenna contactors and antenna contactor switching panels. This unit includes circuitry required to furnish "B plus On", "Carrier On", and "Carrier Failure" indications at the supervisory console for both uninterrupted and interrupted carrier operation. The complete unit is assembled on one side of a 2-inch panel for installation in a standard 19-inch cabinet.

b. *Principle of Operation and Application.*

(1) The carrier failure alarm relay

panel consists basically of three relays with coils and contacts interconnected to provide the desired continuity for the various circuit condition indications. A switch is also provided to condition the unit for either interrupted carrier operation (CW or Voice transmission) or uninterrupted carrier operation (frequency shift radio teletypewriter or radio facsimile transmission).

(2) Figure 4-28 illustrates the basic circuitry and the terminal wiring function. Switch S-1 is placed in the closed position to condition relay K-3 for uninterrupted carrier operation. With no voltage applied to the coil of relay K-1, the contacts of the relay are open. Relay K-1 is energized when B plus is applied to the associated transmitter, and the closing of the contacts of K-1 completes the "B plus On" lamp circuit to the supervisory console to condition the "Carrier Failure" lamp circuitry.

(3) The contacts of K-2 are in the closed position for a no-voltage condition on the relay coil. In the no-voltage position, K-2 connects one side of the upper coil of K-3 to ground. If a voltage is present on the other side of the upper coil of K-3, the contacts of the relay close and complete the "Carrier Failure Lamp" circuit to the console as well as the circuit to the lower coil of K-3. The upper coil of K-3 is the "pulling" coil and the lower coil is the "holding" coil. For interrupted operation, K-3 can be energized only if no voltage is applied to the coil of K-2 from the "carrier on" relay in the console. If K-2 is de-energized simultaneously with the appearance of a voltage from the "carrier off" relay in the console, the upper coil of K-3 will be energized and the "Carrier Failure" indicator circuitry will be completed.

(4) For interrupted operation, S-1 is in the open position, and the upper coil of K-3 is energized by a voltage from the keyer when the contacts of K-2 are closed. Relay K-2 is energized from a 24-volt source

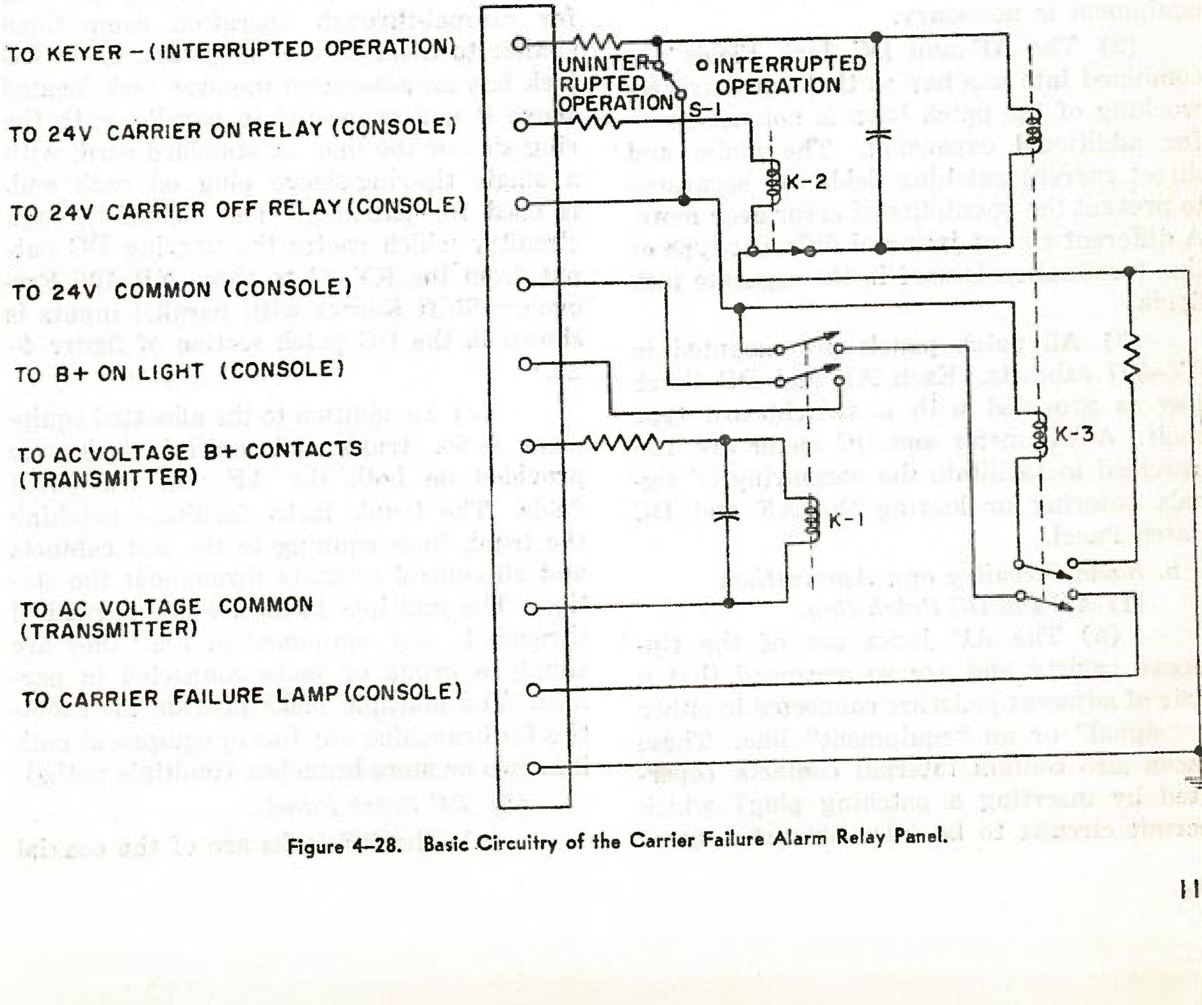


Figure 4-28. Basic Circuitry of the Carrier Failure Alarm Relay Panel.

through the "carrier on" relay for the duration of each keying period of normal interrupted carrier operation. If the keying circuit is completed but no carrier exists, relay K-2 will not be energized, and the upper coil of K-3 will be energized to complete the "Carrier Failure" indication circuitry.

4-23. Patch Panels

a. *General.*

(1) In order to maintain the maximum flexibility for equipment utilization, patching facilities are provided in Globecom by jack and plug connections arranged in panels. All equipment normally used in a particular circuit are provided with normal-through connections at the patch panel so that patching is not required for normal operation. Normal-through connections are made through contacts on the jacks, cross connections on terminal strips in the patch cabinets, and, in RF circuits, through double coaxial plugs at the RF Patch Panel. Patching is required only when substitution of equipment is necessary.

(2) The AF and DC Jack Fields are combined into one bay so that extensive reworking of the patch bays is not necessary for additional expansion. The audio and direct current patching fields are separated to prevent the possibility of error even more. A different size of jack and different type of line termination is used in the separate jack fields.

(3) All patch panels are mounted in CY-597 cabinets. Each AF and DC Patch Bay is provided with a switchboard type shelf. A VU meter and DC meter are also provided to facilitate the measuring of signals entering or leaving the AF and DC Patch Panel.

b. *Basic Circuitry and Application.*

(1) *AF and DC Patch Bay.*

(a) The AF jacks are of the tip-sleeve variety and are so arranged that a pair of adjacent jacks are connected to either a "signal" or an "equipment" line. These jacks also contain internal contacts (operated by inserting a patching plug) which permit circuits to be inter-connected (normalled through) without the use of a patch cord. When a patch cord plug is inserted into a set of jacks which serves a "signal" line or an "equipment" line, the normal-through connection is broken and the circuit is completed through the patch cord. A set of "monitor" jacks is located above the line jacks and connected in parallel with the line so that a properly terminated patch cord can be inserted into the jacks for the purpose of monitoring the signal without interrupting the circuit. Standard cords with double plugs on each end are used for patching. The AF patch section of figure 4-29 illustrates the normal-through connections for routing an audio output signal from the CMT-4 Microwave Terminal Equipment to a KY-44 Facsimile Keying Converter.

(b) The DC jacks are of the tip-ring-sleeve variety and are arranged singly with an apparatus blank in the unoccupied jack space between each used jack. Each jack represents a line by itself. The jack also contains internal contacts to the tip and ring for normal-through operation connections similar to those in the AF jacks. Each DC jack has an associated monitor jack located above it and connected in parallel with the ring side of the line. A standard cord, with a single tip-ring-sleeve plug on each end, is used for patching. The normal-through circuitry which routes the varying DC output from the KY-44 to three NR-105 Frequency Shift Keyers with parallel inputs is shown in the DC patch section of figure 4-29.

(c) In addition to the allocated equipment jacks, trunk and multiple jacks are provided on both the AF and DC patch fields. The trunk jacks facilitate patching the trunk lines running to the test cabinets and all control cabinets throughout the station. The multiple jacks are not normalled through to any equipment or line; they are simply a group of jacks connected in parallel. The multiple jacks provide the facilities for branching any line or equipment path into two or more branches (multiple paths).

(2) *RF Patch Panel.*

(a) The RF jacks are of the coaxial

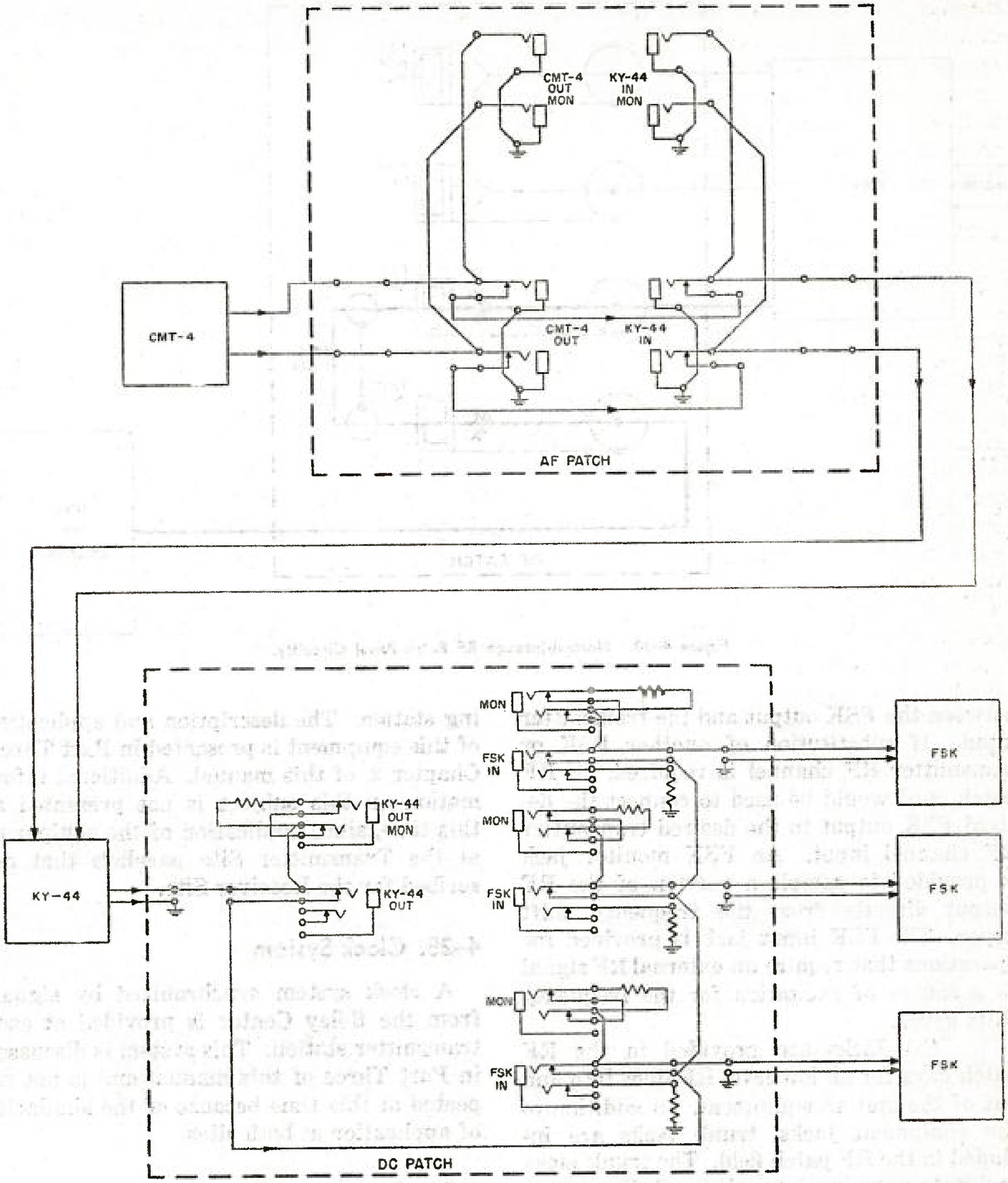


Figure 4–29. Normal-through AF and DC Patch Panel Circuitry.

variety arrange singly so that each jack represents a line. Associated equipment RF inputs and outputs are located in a vertical line, and adjacently, to facilitate a normal-through connection which is made by inserting a 341–C coaxial plug. Figure 4–30 illustrates the RF Patch Panel circuitry for th normal-through operation of an RF signa from the frequency shift keyer to one chan nel of an MW Transmitter. Four jacks ar provided for this portion of the circuit. Fo normal operation, the 341–C plug is inserte

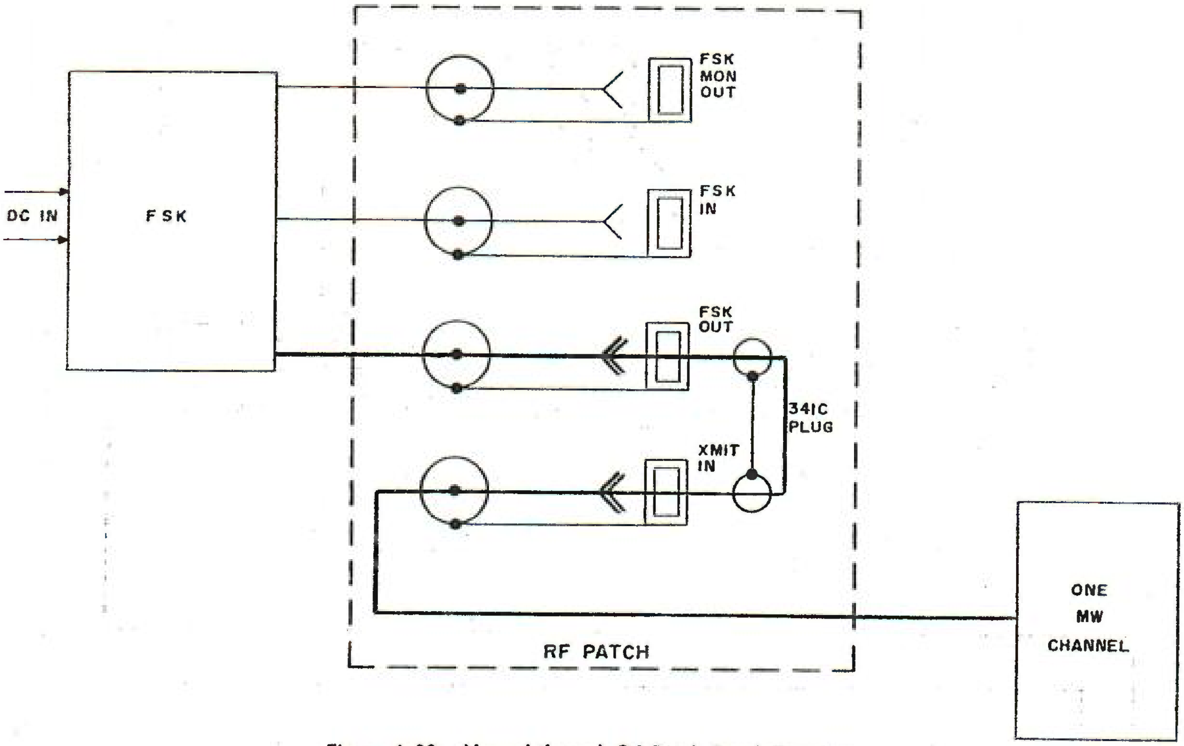


Figure 4-30. Normal-through RF Patch Panel Circuitry.

between the FSK output and the transmitter input. If substitution of another FSK or transmitter RF channel is required, an RF patch cord would be used to connect the desired FSK output to the desired transmitter RF channel input. An FSK monitor jack is provided to sample a portion of the RF output directly from the frequency shift keyer. The FSK input jack is provided for operations that require an external RF signal as a source of excitation for the frequency shift keyer.

(b) Jacks are provided in the RF patch bays for all low-level RF lines into and out of the station equipment. In addition to the equipment jacks, trunk jacks are included in the RF patch field. The trunk jacks facilitate patching into RF trunk lines from various cabinets throughout the building equipment wings and the test equipment cabinets.

4-24. CST-2 Telephone Signaling and Termination Unit

The CST-2 is provided at each transmitting station. The description and application of this equipment is presented in Part Three, Chapter 2, of this manual. Additional information on this subject is not presented at this time, since application of the equipment at the Transmitter Site parallels that described for the Receiver Site.

4-25. Clock System

A clock system synchronized by signals from the Relay Center is provided at each transmitter station. This system is discussed in Part Three of this manual and is not repeated at this time because of the similarity of application at both sites.

4-26. Supervisory Console

a. *General.*

(1) The Supervisory Console provides a visual display of the status of the transmitting equipments. When used in conjunction with carrier monitor and other control circuitry, it provides indications of "carrier and B plus on", "antenna in use", and the

relative carrier power level. Also included as components of the console are four amplifiers with associated phone inputs, volume controls and VU meters, a monitor receiver, and an inter-communications system.

(2) The amplifiers and associated controls and meters are provided to facilitate voice modulation of transmitters from the Supervisory Console.

(3) A 51J Receiver is provided for local monitoring of the transmitted signals.

(4) The inter-communications master station is provided for use in conjunction with up to nine slave stations to facilitate direct communications throughout the transmitter building.

b. *Indicator Lamp Application.*

(1) The indicator lamps and switches may be assigned to any of the station transmitters. However, in the interest of standardization, and to achieve a greater efficiency in the overall operation of this unit, a standard system of lamp and switch assignments has been adopted.

(2) Circuits requiring switching are assigned indicators from left to right, beginning with SSB and followed by other point-to-point circuit designations. Non-switched circuit indicators are located on the right side of the indicator positions.

(3) Figure 4-31 illustrates the lamps and switches associated with two SSB circuits, each employing the LD-T2 Single Sideband Transmitter, the AN/FRT-15 Lineup Transmitter, the Transmitting Power Amplifier (TPA), and a back-up transmitter equipment group shared by the two circuits. All red lamps, with the exception of those in the horizontal strip labeled "B/U", indicate whether or not B plus voltage is applied to the equipments provided as the primary facilities and the back-up SSB equipment group. The red lamps in the back-up strip are used to indicate that the back-up equipment is being employed for a particular circuit. The green lamps associated with each circuit indicate that the left or right antenna is connected to a particular transmitter or to the trunk line that is fed by the back-up transmitter group. The green lamps associated with the back-up equipment group indicates that the particular transmitter in that group is being fed into the left trunk or right trunk transmission line. The blue lamps indicate which transmitter (the AN/FRT-15 or the LD-T2) is being used to drive the power amplifier when the power amplifier is employed. The green lamps labeled "Carrier On" are illuminated only when an RF signal is applied to the transmission line. The relative strength of the signal applied to the left and right antenna is measured by the "Carrier Level" meter in the center of the console when the "Carrier Read" button directly below the "Carrier On" lamps is depressed. The crystal red lamps associated with each antenna indicate a loss of the carrier signal. A buzzer alarm also is activated when the "Carrier Failure" lamps are energized. The turn key switches below the "Carrier Failure" lamps are provided to deactivate the buzzer alarm after the operating personnel have been alerted to the carrier failure.

(4) Figure 4-32 illustrates the lamps and switches associated with a MUX circuit

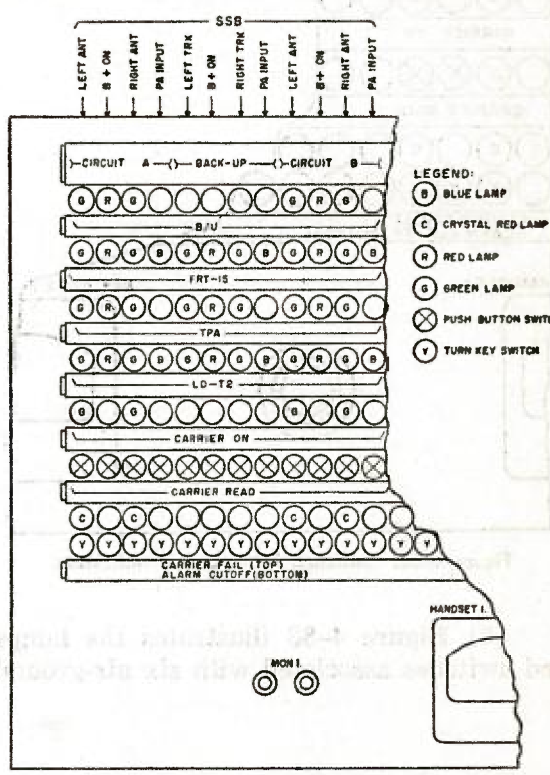


Figure 4-31. SSB Circuit Indicators.

employing three RF channels of an MW transmitter and an AN/FRT-6 high power back-up transmitter, any one of which can be switched into one of two antennas. All lamp and switch functions are similar to those described for the SSB circuit in the preceding paragraph.

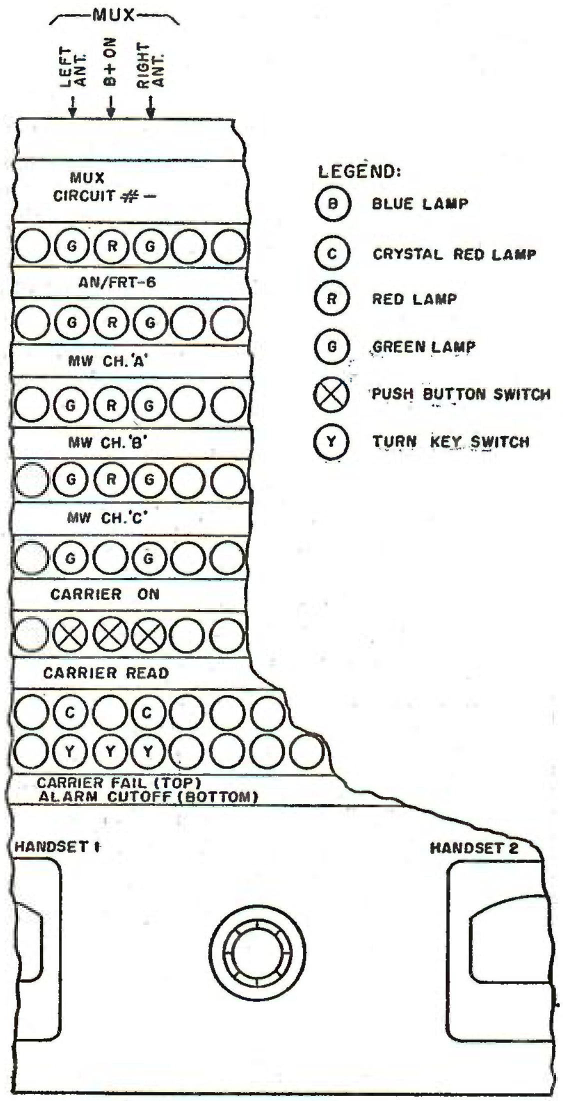


Figure 4-32. Switched MUX Circuit Indicators.

(5) Figure 4-33 illustrates the lamps and switches associated with six air-ground channels and the AN/FRT-15 transmitter provided as back-up for the air-ground circuits. Since each of the primary air-ground channels is connected directly to a doublet antenna, the left and right antenna lamp indications are not required. The function of lamps and switches for these circuits is similar to that described for the circuits covered in the two preceding paragraphs with the exception of the six green and one red "Channel Indicator" lamps appearing in the top row of the air-ground section of the panel. The red lamp is energized when the AN/FRT-15 is used on a circuit normally implemented with one of the six primary RF transmitters. One of the green lamps is then energized to indicate which RF channel is being replaced by the backup transmitter.

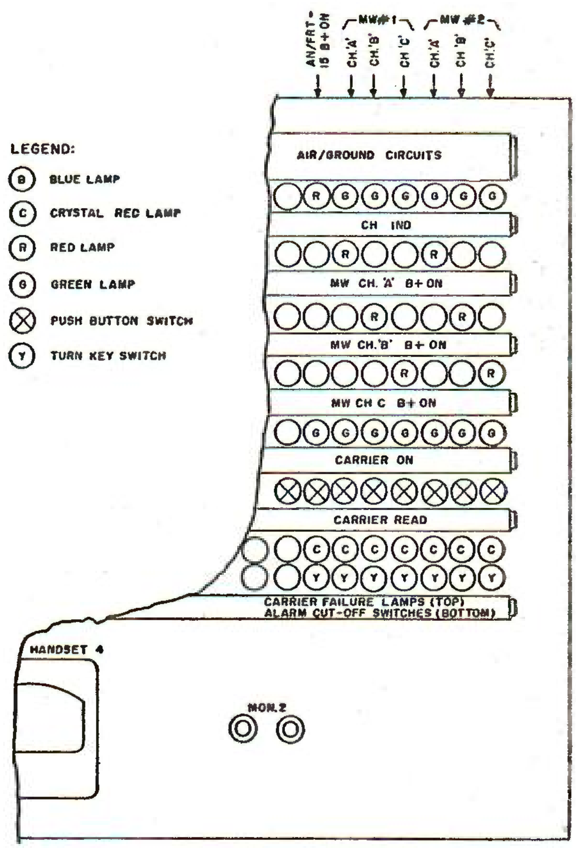


Figure 4-33. Air-Ground Circuit Indicators.

Section III. TEST EQUIPMENT

4–27. General

Within each transmitting station, some testing facilities are required to measure circuit variables. Three different test cabinets, each containing a definite arrangement of equipment, are available within Globecom to provide these facilities. Depending upon the size of the station and the type of communications service employed, any combination of the three cabinets may be installed at any one station. Each test cabinet consists of a CY–597 cabinet and the components as listed in paragraphs 4–28, 4–29, and 4–30. All test equipments listed in this section of the manual are common to both the receiver and transmitter stations.

4–28. Test Cabinet "A"

a. The equipment contained in this cabinet are one speaker panel, one CV–89 Frequency Shift Converter, one SP–600 Receiver, one FR–47/U Frequency Meter, and two jack strips.

b. The receiver, speaker, and converter are provided to monitor the transmitted signals. The FR–47/U Frequency Meter covers the range of 15 KC to 30 MC and is used as the secondary frequency standard for all transmitting equipment. The jack strips provide maximum flexibility for the use of the test equipment in connection with rerouting the RF and AF inputs and outputs.

4–29. Test Cabinet "B"

The equipment contained in this cabinet are one 754–B Audio Level Indicator, one 1932–A Distortion and Noise Measuring Indicator, one 1176 Audio Frequency Meter, one 304–HR Oscilloscope, one 200–ABR Audio Oscillator, two jack strips, and two AM–43 Dual-Channel Audio Frequency Amplifiers. This cabinet contains all the facilities required for making tests and adjustments involving the audio frequencies. Maximum flexibility for the use of the equipment is obtained with switching provided by the jack strips.

4–30. Test Cabinet "C"

The equipment contained in this cabinet are one 1176 Audio Frequency Meter, one 304–HR Oscilloscope, one 200–ABR Audio Oscillator, and one AM–43 Dual-Channel Audio Frequency Amplifier. This cabinet is similar to the type "B" cabinet and is used in a similar manner at small stations.

Chapter 3

TRANSMITTER SITE ENGINEERING CRITERIA

Section I. BUILDINGS

4-31. General

The type and size of buildings selected for any one Transmitter Site is determined by a combination of factors which include existing facilities, the geographical location of the site, and the circuit requirements. In some parts of the world, prefabricated buildings have been erected which were designed especially to provide the most expeditious and least expensive means of obtaining the necessary construction. At other locations, existing buildings will be or have been rehabilitated to provide adequate housing of the equipments consistent with the engineering criteria for Globecom. Requirements involving new sites, and new facilities to replace totally inadequate existing facilities, have resulted in the construction of a new type of building which has become a standard for the Globecom Transmitter Sites. This type of building is designed to provide housing for the personnel as well as for all equipment. At most installations, a separate power building is provided to house power generating facilities.

4-32. Transmitter Building

a. *Equipment Wings.*

(1) The standard Globecom Transmitter Building is composed of four wings in the form of a cross, as illustrated in figure 4-34. Three of these wings are allocated entirely to the housing of transmitting equipment. The designing of transmission lines to maintain the proper electrical characteristics of the lines between the equipment and the antennas with which they are connected presents one of the greatest problems in the engineering of a transmitter station. These lines must be carefully engineered and installed, and should enter the building as closely as possible to the associated equipment. Since open wire transmission lines are used, it is desirable that all transmitting equipment be located along an outside wall. To provide a maximum outside wall area, the cross-shaped building is used.

(2) Standard transmitter buildings are available in different sizes to provide for varying space requirements, but the only major difference between the several sizes is in the length of the wings. The buildings are so designed that they may be readily expanded in size by extending the end of each wing to accommodate additional equipment which may be required for future operations. The smallest standard transmitter building now in use consists of wings 60 feet in length. The wings of each successively large building are increased in increments of 20 feet. Equipment wings with a length of 60, 80, 100, and 120 feet are currently provided. The width of the equipment wings for all of the standard type transmitter buildings has been established at 30 feet.

(3) Another characteristic feature of the standard building is the location of transmission line ports along the top of the wall of each equipment wing. These ports are fitted with an insulating material through which the transmission lines may be safely extended to the outside of the building. The size and location of the ports have been selected to provide the maximum number of transmission lines permissible

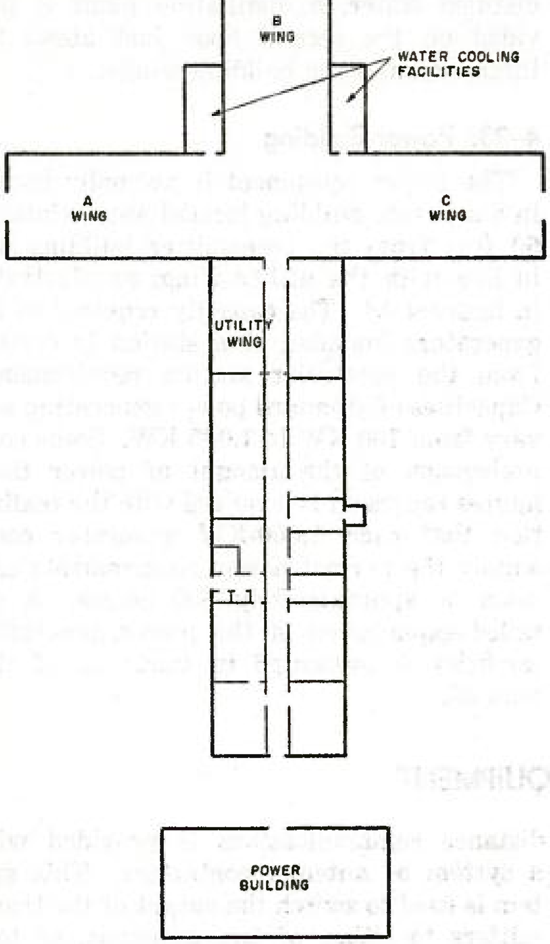


Figure 4-34. Standard Globecom Transmitter Building Configuration.

per unit length of wall space. The center of each port is four feet from the center of each adjacent port. Each port is approximately two feet square.

(4) Expectionally high ceilings in the equipment wings provide considerable space above the transmitters. This space accommodates large air ducts which are used to ventilate the wings, and a system of antenna trunk lines and switching devices.

(5) Although it would be ideal to have the transmission line to one antenna connected directly and permanently to a transmitter located under the port of entry of the line, it is often desirable for operational reasons to switch the transmitter from one antenna to another. This switching is accomplished by the action of specially designed switching devices. The switching devices are controlled electrically from antenna contractor control panels located adjacent to the transmitters.

(6) Included in the initial construction of the building is a network of trenches in the floor which are provided to accommodate all power and control cables required for the equipment. The transmitters and auxiliary equipment cabinets are positioned over the trenches so that the cabling is accessible through an opening in the bottom of each unit. The trenches provide for great flexibility in respect to the placement of the equipment and permit control and power cable routing in a manner which minimizes the length of cabling required.

b. *Utility Wing.*

(1) The width of the utility wing for a standard transmitter building is 38 feet, but the length of the wing may be varied to provide sufficient space to accommodate the utilities required at different sites. Lengths of 137 feet and 150 feet have been selected as standards for this wing.

(2) Within the utility wing is a space normally allocated to the microwave and intersite terminal equipment. This equipment includes microwave transmitters and receivers, pulse amplitude time division multiplex units for combining and separating the signals transmitted and received on the microwave link, landline cable termination if required, and voice frequency keyers and converters. Details on the operation and application of this equipment are presented in Part Seven of this manual.

(3) Other space in the utility wing is allocated to maintenance, supply, and administration facilities, and to living quarters for the assigned personnel. In addition to separate rooms for the personnel, the living quarters include a combination lounge, game room, and complete messing facilities.

c. *Water Cooling Requirements.*

(1) Some Transmitter Sites include transmitting equipment which utilizes a water cooling system to dissipate the heat generated by the amplifier tubes. Wherever

a water cooling system is employed, special provisions are made to house the additional equipment required.

(2) When water-cooled transmitting equipment is employed, it is always installed in the center equipment wing (that wing on a common axis with the utility wing), and an additional structure is provided on each side of the equipment wing, adjacent to the intersection of the equipment wings, to house the pumps and radiators of the cooling system (see figure 4-34).

(3) Within water-cooled transmitters, the heat is carried away from the amplifier tubes by a specially designed plumbing system which includes bronze water jackets surrounding the anode of each tube. For obvious reasons, the electrical conductivity of the water used in a system of this type must be maintained at a minimum. When the instruments associated with the system indicate that the conductivity of the water has been excessively increased due to contamination, the cooling system must be drained and refilled with freshly distilled water. At each site requiring a supply of distilled water, a distillation plant is provided on the second floor just above the intersection of the building wings.

4-33. Power Building

The power equipment is normally housed in a separate building located approximately 60 feet from the transmitter building and in line with the utility wing, as illustrated in figure 4-34. The capacity required of the generators installed at a station is derived from the particular station requirements. Capacities of standard power generating sets vary from 100 KW to 1,000 KW. Some comprehension of the amount of power these figures represent is acquired with the realization that each 1,000-KW generator could supply the normal power requirements of a town of approximately 500 homes. A detailed explanation of the power generating facilities is presented in Part Six of this manual.

Section II. EQUIPMENT

4-34. General

a. The equipment utilized as transmitting facilities throughout the Globecom System has been chosen to insure maximum frequency stability, adequate carrier frequency range, and sufficient but not excessive band width for the type of intelligence to be transmitted. Efforts were made to avoid the selection of unduly complex equipment.

b. The necessity to change frequency at least once in the course of an operating day, in order to overcome the effects of varying propagation conditions, was another factor that had to be considered in the planning of equipment to be utilized. To verify that a particular frequency is suitable at a particular time of day, facilities are provided to indicate suitability in advance and to establish operation on a new frequency before diverting traffic from a working frequency.

c. Some equipment employed for long-distance communications is provided with a system of antenna contactors. This system is used to switch the output of the transmitters to either of two antennas, or to a trunk line feeding other equipment or antennas. The contactor arrangements are discussed in Chapter 2. Throughout the remainder of this part of the manual, circuits employing this type of operation will be referred to as "switched circuits". Reference to "non-switched circuits" will imply that the RF units and transmitters under discussion are connected directly to a transmission line feeding one antenna only.

d. Each link in a communications system requires facilities for the measurement of circuit variables if proper operation is to be maintained. Testing facilities are included in the Globecom Transmitter Sites, and, in addition, provisions are made in the station circuit arrangements for the isolation of any equipment for servicing or for reassignment to other than its normal circuit function. The ability to perform all switching and equipment transfer operations rapidly is provided to assure maximum circuit utilization. This latter provision is effected by the employment of the RF Patch Panel and the AF and DC Patch Panels described in Chapter 2.

e. All inputs to the transmitters and all inputs and outputs of the associated equipment within the station are connected to appropriate patch panels. This includes RF lines, audio lines, keying lines, and control lines. All lines from equipment to the patch panels are also provided with normal-through connections at the patch panels to the lines of associated equipments when allocated to a particular circuit. However, any items of the equipment may be interchanged with similar items within the station by means of the patching facilities.

f. In addition to providing point-to-point circuits to other Globecom stations, the transmitting facilities must meet weather broadcast and air-ground requirements in accordance with a world-wide plan. Similar transmitting facilities are used at all Globecom stations, with only one major difference: a high-power amplifier is normally provided for each single sideband transmitter employed on Beltline circuits to combat the effect of abnormal absorption of the transmitted signal or possible interference on the transmitting frequencies employed. This power amplifier requires special consideration, and its use involves additional equipment and utilities. However, insofar as controllable factors permit, all facilities are planned and built to achieve uniformity of equipment type, arrangement, connection, switching, and facility control to insure flexibility of operation, ease of supply and maintenance, and maximum facility efficiency.

g. In some areas of the world, when utilizing the HF band of the radio frequency spectrum (3–30 MC), propagation is not sufficiently stable to maintain reliable communications, due to severe electrical interference and high absorptive characteristics of the circuit path. In areas where these undesirable conditions persist, a different system of communications is employed to reduce the circuit outage time to a minimum. To maintain satisfactory communications on the primary circuits in these areas, transmission techniques utilizing the LF and VHF band in the radio spectrum are employed. Operation in these bands requires the use of equipments considerably different from those used on the HF circuits and contributes greatly to the variation of facilities installed at certain stations. As a general rule, low-frequency communications and communications employing the principle of Forward Propagation by Ionospheric Scatter (utilizing the VHF band) will be encountered initially only on non-beltline circuits.

h. All of the above mentioned considerations have resulted in variations in the Transmitter Site facilities employed within the Globecom System. However, these variations exist only between the specific items of equipment selected, the amount of equipment required, the types of buildings, and the physical location of the equipment within the buildings at the respective sites. The engineering planning for all circuits is based upon firm criteria that result not only from the above, but from many other considerations.

4–35. Policies

The policies governing the selection and grouping of equipment for each facility provided by Globecom are outlined in the following paragraphs.

a. *Air-Ground.*

(1) For each assigned air-ground frequency, one RF channel and one modulator of a Westinghouse MW Transmitter are provided as the primary transmitting equipment. Transmitters so provided are arranged with three RF units and their associated modulators connected to one power supply; that is, three RF units and three modulators are connected to one rectifier. This arrangement is referred to as an "MW 3–3–1 unit".

(2) Spare MW transmitters are not provided for air-ground use. However, if only a portion of an MW 3–3–1 is used, the entire unit is installed.

(3) Three transmission line ports are

required for each air-ground MW 3-3-1 unit. When more than one MW 3-3-1 is installed, all ports used are adjacent. The transmitters are installed so that the centerline of the middle RF unit of each air-ground MW is in line with the centerline of the middle port that serves that particular MW.

(4) Each air-ground RF unit is connected to a delta-matched doublet antenna by a 600-ohm transmission line. Antenna switching is not provided. If extra RF units are provided (see paragraph (2), above), transmission line ports to accommodate these units are left vacant.

(5) One NR-105, Model 4, Frequency Shift Keyer (FSK) is provided for each RF unit installed. NR-105 spares are not specified as exclusive air-ground spares, since at each station RF patching facilities are provided which permit the use of any FSK unit with any transmitter RF unit.

(6) When both voice and CW operation are specified, installation circuitry includes provisions for remote control of emission, keying, and modulation. For stations having voice-only operation, remote selection of emission is not provided.

(7) One AN/FRT-15 is provided as a back-up transmitter for each seven air-ground channels, or fraction thereof. This transmitter is so connected that it is capable of voice or CW transmission on any of its ten pre-set channels. The transmitter as installed permits channel selection at the Transmitter Site only.

b. *Point-to-Point.*

(1) *Single Sideband (SSB).* The single sideband mode of transmission is employed to interconnect all Beltline and some Tributary Stations. Since the Beltline circuits provide the primary channels along which communications flow to and from the United States and overseas theatres, and between theatres, additional equipment is provided in the Beltline stations to insure continuity of operation.

(a) *Beltline Circuits.*

1. The transmitting equipment for each single sideband beltline circuit consists of one LD-T2 Transmitter, one AN/FRT-15 Transmitter for line-up purposes, and one power amplifier (TPA or similar equipment). Collectively, these equipments are referred to as an "SSB group".

2. Antenna switching of the final RF signal to either of two balanced transmission lines feeding a high-band and a low-band HF rhombic antenna is provided. Antenna switching provides for simultaneous operation of the line-up equipment on one antenna and the SSB equipment on the other antenna.

3. The single sideband transmitter is located to the right and the AN/FRT-15 line-up transmitter to the left of the power amplifier. Sufficient space is left between the transmitters and the power amplifier for servicing.

4. The power amplifier is located so that its antenna insulators are in line with the centerline of the center port of three adjacent antenna transmission line ports. The transmission lines enter the first and third entrance ports.

5. All TPA rectifiers are located as near as possible to the power amplifier, but on the opposite side of the aisle.

6. For each three SSB equipment groups, or fraction thereof, one additional group is provided for back-up. The back-up is located in the available space, and is so arranged that the spare facility is between the primary single sideband facilities when two or more active circuits are employed, and adjacent to the primary facility when only one single sideband circuit is employed.

7. Installation of the back-up single sideband equipment follows the criteria of the primary single sideband equipment, with the exception that the antenna contactor arrangement provides for switching the output of the RF units to any of the antennas associated with the primary single sideband facilities.

(b) *Tributary Circuits.*

1. The transmitting equipment for each single sideband tributary circuit consists of an LD-T2 Transmitter and one AN/FRT-15 Transmitter for line-up purposes. High-power amplifiers (TPA or similar equipment) are provided when required by circuit propagation characteristics.

2. Antenna switching of the final RF signal to either of two balanced transmission lines feeding a high-band and a low-band HF rhombic antenna is provided. Antenna switching also provides for simultaneous operation of the AN/FRT–15 on one antenna and the single sideband transmitter on the other antenna.

3. The AN/FRT–15 is located on the left side and adjacent to the single sideband transmitter when the high-power amplifier is not installed.

4. Alternate transmission line ports are used, and the equipment is so located as to maintain equal feeder lengths from the transmitters to the assigned ports.

5. Single sideband tributary circuits are provided with back-up groups in the ratio of one to three (or less) SSB groups. Some beltline stations have both tributary and beltline SSB circuits. In such cases, back-up is provided for the total number of SSB groups in the station. For example, a station with two beltline and one tributary SSB circuit would be provided with one back-up group; or, two tributary and two beltline SSB circuits would be provided with two back-up groups. Antenna contactor control panels are provided.

(2) *Other Than SSB Circuits.*

(a) *General.*

1. All Globecom circuits, with the exception of SSB, employ conventional transmission techniques. The transmitters that are most extensively used for this type of HF transmission are the MW and 96–D. These transmitters are installed with one modulator to each equipment bank.

2. All circuits that use rhombic antennas are provided with antenna switching contractors. This provision for switching permits the connection of the output from any RF unit in a bank to either of two balanced transmission lines feeding a high-band and a low-band HF rhombic antenna. Antenna switching also provides for simultaneous operation of any two RF units in a transmitter bank.

3. Circuits that use doublet or discone transmitting antennas are not equipped with antenna switching facilities. For a circuit employing two doublet antennas, the end RF units of a 3–1–1 transmitter are utilized for primary operation, and the middle RF unit is designated as a spare.

4. One NR–105, Model 4, Frequency Shift Keyer is provided for each RF unit of the MW transmitters installed. One NR–105, Model 4A, Frequency Shift Keyer is provided for each RF unit of the 96–D Transmitters installed.

5. Point-to-point circuits may be divided into three types of operation, based upon the antenna switching provisions and equipments employed. These types are "the switched circuit with no back up", "the switched circuit with high-power back-up", and "the non-switched circuit."

(b) *Switched Circuits Without High-Power Back-up.*

1. These circuits are provided with the MW 3–1–1 transmitters.

2. Switching of the output of any RF unit in a bank to either of two balanced transmission lines feeding a high-band and a low-band HF rhombic antenna is provided. Antenna switching is also provided for the connection of any two of the RF units to appropriate antennas for simultaneous transmission.

3. Each MW 3–1–1 transmitter requires two adjacent transmission line ports. The equipment is located so that the center of the middle RF unit is in line with the centerline between the two ports.

(c) *Switched Circuits With High-Power Back-up.*

1. These circuits are provided with MW 3–1–1 transmitters as the primary equipment, and an AN/FRT–6 as a back-up transmitter.

2. Each of the primary transmitters requires two adjacent transmission line ports, and the equipment is located so that the center of the middle RF unit is in line with the centerline between the two ports.

3. From one to three MW transmitters may be operated with one AN/FRT–6 as a high-power back-up transmitter. The AN/FRT–6 is located in line with, and at the extreme right or left end of, the line of primary equipment.

4. Antenna switching is provided to connect any RF unit in a transmitter bank to either of two balanced transmission lines feeding a high-band and a low-band HF rhombic antenna. Antenna switching also provides for the connection of any two RF units in each bank to the appropriate antennas for simultaneous transmission.

5. Switching also provides for the connection of the AN/FRT-6 RF output to either the high- or low-band rhombic antenna associated with each primary transmitter.

(d) *Non-Switched Circuits.*

1. These circuits normally are provided with MW 3-1-1 or 96-D 3-1-1 transmitters.

2. One transmission line port is assigned for each RF unit installed, and ports associated with each transmitter bank are adjacent. The 3-1-1 combination is located so that the center RF unit insulators are in line with the center port.

(e) *Forward Scatter Circuits.*

1. All circuits employing the principle of Forward Propagation by Ionospheric Scatter (frequently referred to as VHF/Forward Scatter) were engineered and installed by a private firm.

2. These circuits are provided with AN/FRT-6 Transmitters modified for operation in the VHF band of the radio-frequency spectrum.

3. Forward scatter transmitting equipments are located within the building so as to present a minimum of transmission line loss between the equipment and the associated antennas. Final location is determined by the placement of the antenna and the available space.

4. Auxiliary equipments associated with this facility usually are mounted in two cabinets located adjacent to and in line with the transmitter. The forward scatter facilities can be operated independently of other facilities when housed in a building shared by equipments which are used in other Globecom circuits. The first cabinet contains RF, AF, and DC patch panels, and test equipment peculiar to the forward scatter circuit. The second cabinet contains a specially designed RF oscillator and frequency shift keyer. When located in a building shared by other facilities, the audio and control lines of this equipment are connected to the AF and DC patch panels which are common to all the Globecom facilities within the station to maintain continuity in the overall system.

5. A coaxial line conducts the RF energy from the transmitter to a point external to the building at which the energy is transferred to a balanced line.

(f) *Low-Frequency Circuits.*

1. Low-frequency circuits are provided with the PW-10 Transmitter when nominal power is required, and with the AN/FRT-4 when high power is required. Final selection of equipment is determined by propagation studies.

2. One transmission line port is required for each low-frequency circuit. Each transmitter is connected to a vertical radiator by a balanced transmission line. A helix house is provided to facilitate antenna tuning. Circuitry between the helix house and the transmitter provides antenna current monitoring at the transmitter.

3. Low-frequency back-up transmitters are not provided. High-frequency facilities are provided as a back-up for the low-frequency circuits.

4. One NR-109 Frequency Shift Keyer is provided for each PW-10 Transmitter. Additional frequency shift keyers are not provided for the AN/FRT-4 Transmitters.

5. When identification of the radio signal is specified for navigational aid purposes, the output of a Low-Frequency Identification Unit is connected directly to the suppressor of a low-level RF stage of the transmitter, and adjustments are made to effect a thirty percent amplitude modulation of the radiated RF carrier. The Low-Frequency Identification Unit is located in the common equipment racks.

c. *Broadcast Circuits.*

(1) Circuits used to broadcast teletypewriter and facsimile weather information are provided with MW 3-1-1 or 96-D 3-1-1 transmitters. All weather circuit transmit-

ters are located in the same area when space is available.

(2) One MW 3-1-1 transmitter combination is provided for each two frequencies assigned. One transmission line port is provided for each RF unit installed. The equipment is positioned so that the center RF unit is in line with the center of the middle transmission line port. The center RF unit is designated as a spare. Transmitters assigned for transmission of the same intelligence normally are installed adjacent to each other.

(3) One NR-105, Model 4, Frequency Shift Keyer is provided for each MW 3-1-1 RF unit installed. One NR-105, Model 4A, Frequency Shift Keyer is provided for each 96-D 3-1-1 RF unit installed.

d. *Auxiliary Equipment.*

(1) *CV-172/U Facsimile Converter.* One facsimile converter, mounted in the facsimile monitor cabinet, is provided at each station having facsimile circuits.

(2) *KY-44/FX Facsimile Keyer Adapter.* One keyer is provided for each point-to-point facsimile circuit and each facsimile broadcast facility at each station. One spare keyer adapter is provided for each five units. The keyer adapters are mounted in CY-597 cabinets, with a maximum of six units in each cabinet.

(3) *Ky-45/FRT-5 Frequency Shift Keyers.* This equipment is provided on the basis of one unit for each two point-to-point facsimile circuits, with a minimum of two units at any station employing facsimile point-to-point operation. The equipment is used when a facsimile circuit is desired of a higher quality (photo detail) than can be attained by use of the NR-105 Frequency Shift Keyer.

(4) *O-91/FRT-5 Stabilized Master Oscillator.* This unit is provided on the basis of one for each KY-45 at each station.

(5) *PP-454/FRT-5 Power Supply.* This unit is provided on the basis of one for each combination of a KY-45 and an 0-91. Two KY-45/FRT-5 Frequency Shift Keyers, two 0-91/FRT-5 Stabilized Master Oscillators, and two PP-454/FRT-5 Power Supplies are mounted in one CY-597 cabinet.

(6) *RD-92/UX Facsimile Recorder.* One unit is provided at each station that transmits facsimile signals. The facsimile recorder is mounted in the facsimile monitor cabinet.

(7) *NR-105 Frequency Shift Keyer (High-Frequency).* This unit is provided on the basis of one NR-105, Model 4, for each MW RF unit within a station, and one NR-105, Model 4A, unit for each 96-D RF unit within a station.

(8) *NR-109 Frequency Shift Keyer (Low-Frequency).* This unit is provided on the basis of one for each PW-10 low-frequency transmitter within the station, plus one station spare.

(9) *Supervisory Console.* The supervisory console is provided on the basis of one for each Beltline station and for some large Tributary stations.

Chapter 4

TYPICAL STATION

Section I. EQUIPMENT LAYOUT

4–36. General

The purpose of this chapter is to illustrate the application of the various electronic facilities that are used at the Transmitter Site of the typical Beltline station described in this manual. The number, type, and arrangement of equipment are based on the assumed circuitry for this typical station and on current Globecom engineering policies.

4–37. Equipment Floor Plan

The transmitter building equipment floor plan provides for all transmitters and auxiliary equipment required to implement the circuitry as presented in Chart 2–1 in Part Two of this manual. As illustrated in figure 4–35, floor plan numbers 1 through 30 have been allocated to the Intersite microwave link and associated terminal equipment, and to the VFTG equipment used for transmitter control and signal conversion. These facilities are explained in Part Seven of this manual. The floor plan numbering of all other equipment located in the transmitter building follows in numerical order, beginning in the "A" Wing adjacent to the Power Distribution Panels (see figure 4–36), and progressing along the wall of each wing in a clockwise direction. Certain floor plan numbers are omitted where space has been reserved to accommodate additional equipment that may be required for future use.

a. *"A" Wing (Fig. 4–36).*

(1) Equipment floor plan numbers 32, 33, 35, and 36 are all MW 3–1–1 transmitters provided for radio teletypewriter and facsimile broadcast of weather data. Number 34 is a CY–597 Cabinet in which are mounted the control panels for the MW Transmitters and the carrier failure alarm relay panels associated with these circuits.

(2) Equipment floor plan number 37 is an AN/FRT–4 Low-Frequency Transmitter which provides the facilities for the transmission of a 4-channel multiplex teletypewriter signal and a coded signal to enable aircraft to identify the transmitter station and use its signal for homing purposes.

(3) Equipment floor plan numbers 38, 39, and 41 are MW 3–1–1 transmitters used in point-to-point circuits. Numbers 38 and 39 are provided for facsimile transmission, and is provided for transmission of a multiplex 4-channel teletypewriter signal. Equipment floor plan number 42 is an AN/FRT–6 Transmitter provided for high-power backup for the MW transmitters as required by prevailing propagation conditions. Equipment number 40 is a CY–597 Cabinet in which are mounted the control panels for the three MW transmitters and switch panels for the control of the antenna contactors associated with this group of transmitters.

(4) Equipment number 44, an MW 3–1–1 transmitter, is termed a "spare" and is not used on an active circuit. It is provided to facilitate rapid expansion of the station capability when necessitated by emergency requirements.

(5) Equipment numbered 45 and 47 are MW 3–1–1 transmitters. The former is used

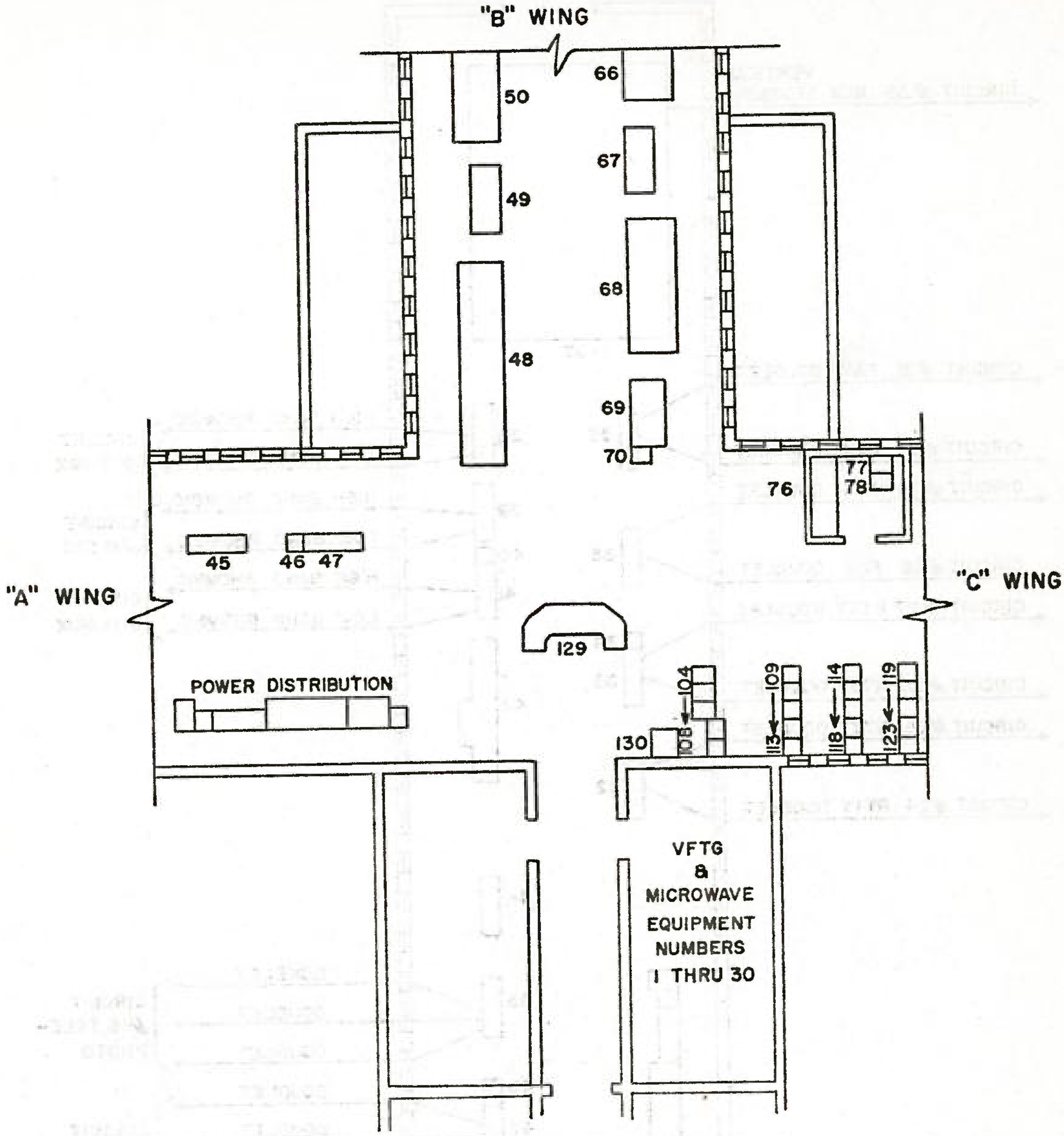


Figure 4-35. Building Intersection Equipment Layout.

for radio telephoto transmission, whereas the latter is used for the transmission of a 4-channel multiplex teletypewriter signal. The control panels and the carrier failure alarm relay panel for both of these transmitters are mounted in a CY-597 Cabinet, number 46.

b. *"B" Wing (Fig. 4-37).*

(1) Equipment numbered 48, 53, and 66 are rectifier and power supply units for the Transmitting Power Amplifiers associated with the three single sideband equipment groups located in this wing. Equipment number 49, 62, and 67 are AN/FRT-15 Transmitters, each of which is associated with a single sideband group. Equipment numbered 50, 63, and 68 are the Transmitting Power Amplifiers (TPA). Equipment numbered 51 and 64 are distortion measuring bays associated with the single sideband equipment, and equipment numbered 52, 65, and 69 are the LD-T2

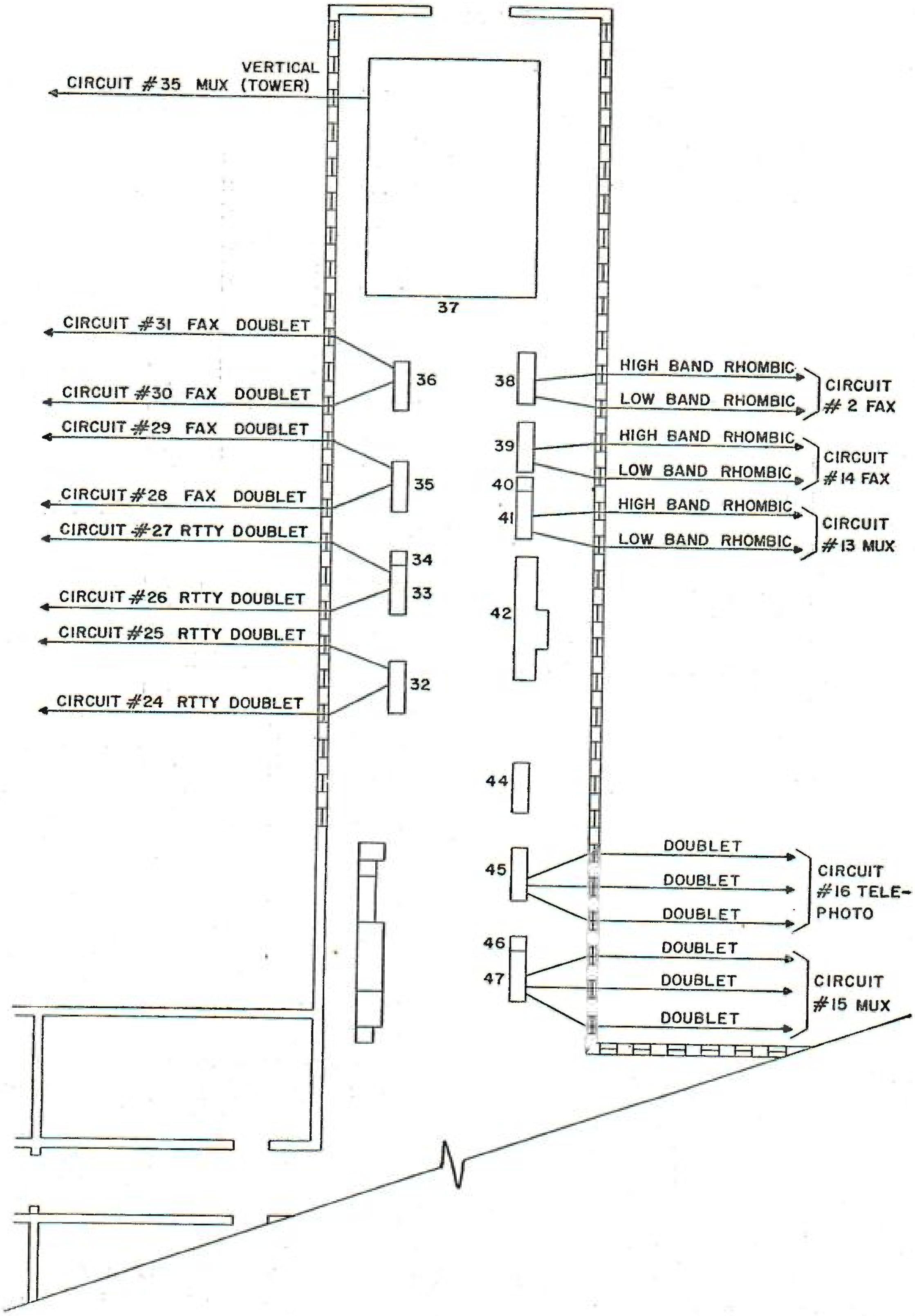


Figure 4–36. "A" Wing Equipment Layout.

Single Sideband Transmitters. All of these items form three complete groups of single sideband equipment.

(a) Equipment numbered 49, 50, 51, 52, and 66 are all associated equipment which constitute a single sideband group. The LD-T2 Transmitter of this group of equipment provides the facility for frequency diversity transmission of six teletypewriter channels and one voice channel.

(b) Equipment numbered 53, 62, 63, 64, and 65 are associated equipment which constitute a single sideband group, and provide facilities for another single-sideband circuit.

(c) Equipment numbered 67, 68, 69 and 48 compose another single sideband group of equipment which is provided as a back-up facility for either of the single sideband groups mentioned in sub-paragraphs (a) and (b), above.

(2) Antenna contactor switching control panels, mounted in the CY-597 Cabinet, number 70, provide the facilities for switching the RF output of the transmitters in the three single sideband groups to the appropriate antennas or to associated equipment.

(3) Equipment numbered 57, 58, and 59 are associated equipment which constitute the group provided for the transmission of a multiplexed 4-channel teletypewriter signal through the medium of Forward Propagation Ionospheric Scatter (FPIS). Number 59 is an AN/FRT-6 Transmitter which is modified for FPIS operation. Number 57 is a cabinet which contains a monitor receiver and the distribution facilities for the associated terminal equipment. Number 58 is a cabinet containing the radio-frequency oscillator from which the basic signal is derived, and the associated frequency shift keyer.

c. *"C" Wing (Fig. 4-38).*

(1) The screened room, equipment floor plan number 76, contains two test cabinets which appear on the floor plan as numbers 77 and 78. Number 77 is a Type "A" Test Cabinet, and number 78 is a Type "B" Test Cabinet. This equipment provides the facilities for checking the performance of transmitting equipment throughout the station. Reference should be made to Chapter 2 for an explanation of the contents of each type of test cabinet.

(2) Equipment numbered 79 and 81 are AN/FRT-15 Transmitters. These particular items provide back-up facilities for the primary air-ground transmitters. Equipment number 80 is a CY-597 Cabinet which contains the carrier failure alarm relay panels for the air-ground back-up circuits.

(3) Equipment numbered 82, 83, and 85 are MW 3-1-1 transmitters. Numbers 82 and 85 are used for radio-facsimile transmission, and number 83 is used for transmission of a 4-channel multiplex teletypewriter signal. Equipment number 86 is an AN/FRT-6 Transmitter which provides high-power back-up for any one of the three MW transmitters in this group, as may be required by the prevailing propagation conditions. Equipment number 84 is a CY-597 Cabinet which contains control panels for the MW transmitters and switch panels which control the antenna.

(4) Equipment number 87 is another MW 3-1-1 transmitter used for transmission of a 4-channel multiplex teletypewriter signal. This transmitter provides a high-frequency back-up to the low-frequency circuit implemented with the AN/FRT-4 (equipment number 37) located in the "A" Wing. A CY-597 Cabinet (equipment number 88) is provided to accommodate the transmitter control panel and the switches for the antenna contactors associated with this circuit.

(5) Equipment numbered 94 and 95 are both Wilcox 96-D 3-1-1 transmitters. The six r-f units in the group are used for radio teletypewriter transmission on three different two-frequency circuits to provide back-up for three landline teletypewriter circuits.

(6) Equipment number 96 is an MW 3-1-1 transmitter which is provided for operation of a three-frequency CW net. Number 97 is a CY-597 Cabinet in which is mounted the control panel associated with equipment number 96, and carrier failure alarm relay panels associated with circuits numbered 19, 20, 21, 32, and 33.

(7) Equipment number 98 is a spare MW 3-1-1 transmitter.

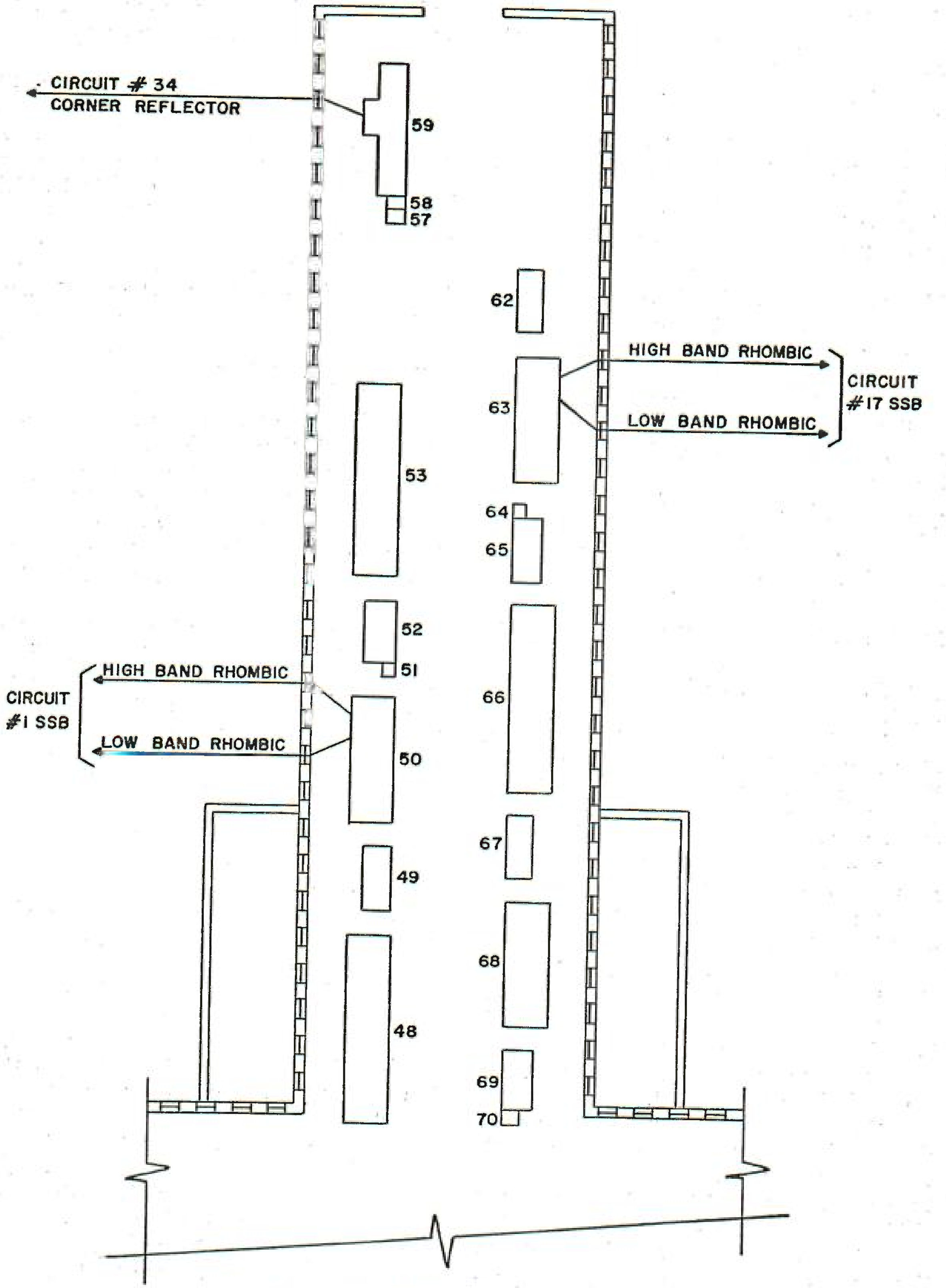


Figure 4-37. "B" Wing Equipment Layout.

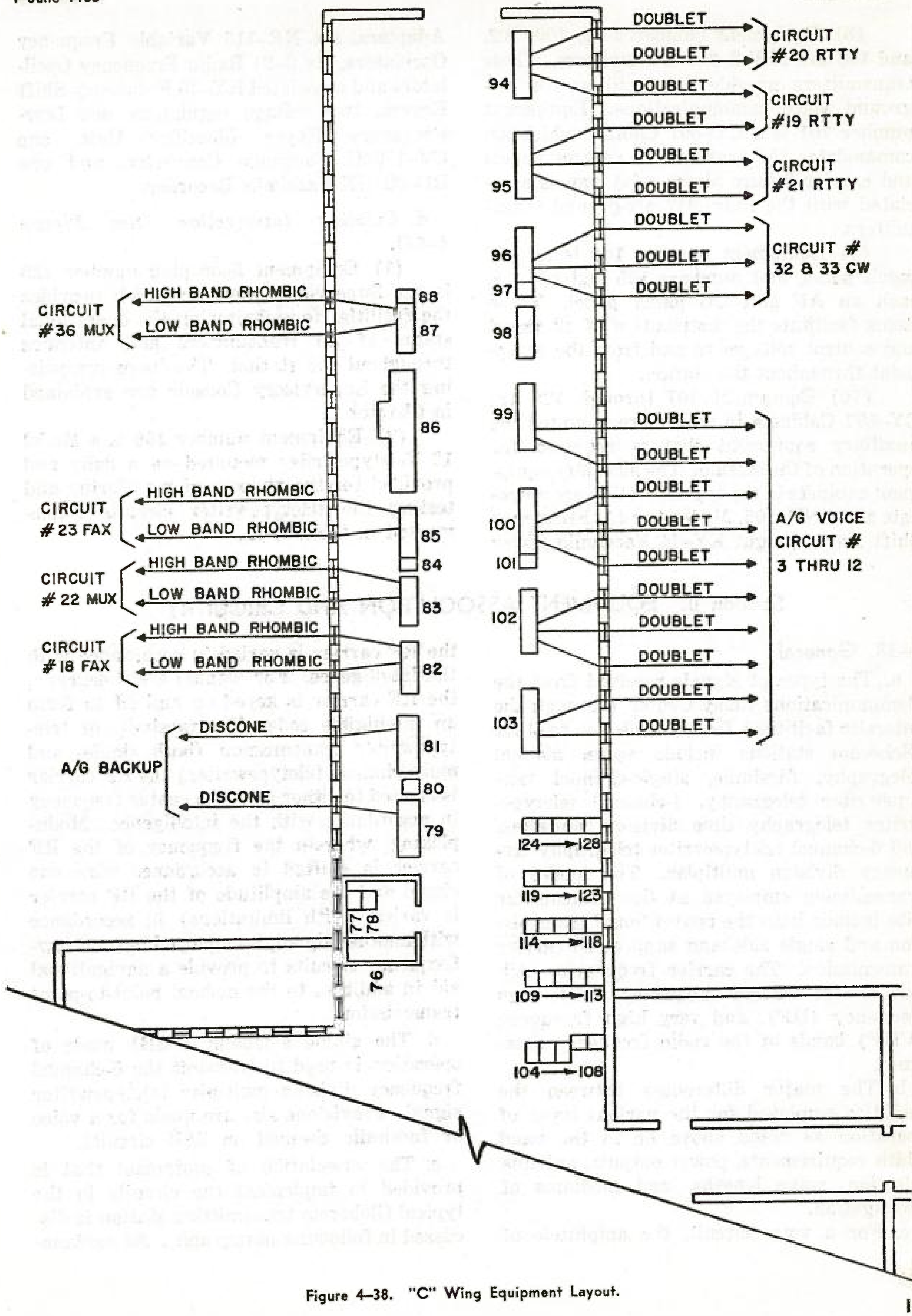


Figure 4-38. "C" Wing Equipment Layout.

(8) Equipment numbered 99, 100, 102, and 103 are MW 3-3-1 transmitters. These transmitters provide the facilities for air-ground voice communications. Equipment number 101 is a CY-597 Cabinet which accommodates the transmitter control panels and carrier failure alarm relay panels associated with the four MW air-ground transmitters.

(9) Equipment number 104 is an RF patch panel, and numbers 105 and 106 are each an AF and DC patch panel. These items facilitate the distribution of all signal and control voltages to and from the equipment throughout the station.

(10) Equipment 107 through 128 are CY-597 Cabinets in which are mounted the auxiliary equipment that is required for operation of the station. The auxiliary equipment cabinets in the typical station accommodate sixty NR-105, Model 4 or 4A, Frequency Shift Keyers, eight KY-44 Facsimile Keyer Adapters, six NR-115 Variable Frequency Oscillators, six 0-91 Radio Frequency Oscillators and associated KY-45 Frequency Shift Keyers, two voltage regulators, one Low-Frequency Keyer Identifier Unit, one CV-172/U Facsimile Converter, and one RD-92/UX Facsimile Recorder.

d. *Building Intersection (See Figure 4-35).*

(1) Equipment floor plan number 129 is the Supervisory Console which provides the facilities for monitoring the operational status of all transmitters and antennas throughout the station. The items comprising the Supervisory Console are explained in Chapter 2.

(2) Equipment number 130 is a Model 19 Teletypewriter mounted on a dolly and provided for the purpose of monitoring and testing the teletypewriter circuits implemented in the station.

Section II. EQUIPMENT ASSOCIATION AND CIRCUITRY

4-38. General

a. The types of signals received from the Communications Relay Center (through the Intersite facilities) for transmission to other Globecom stations include voice, manual telegraphy, facsimile, single-channel teletypewriter telegraphy, 4-channel teletypewriter telegraphy time division multiplex, and 6-channel teletypewriter telegraphy frequency division multiplex. The modes of transmission employed at the Transmitter Site include both the conventional transmission and single sideband suppressed carrier transmission. The carrier frequencies utilized are in the low frequency (LF), high frequency (HF), and very high frequency (VHF) bands of the radio frequency spectrum.

b. The major differences between the facilities employed for the various types of operation as noted above lie in the band width requirements, power outputs, antenna selection, wave lengths, and mediums of propagation.

c. For a voice circuit, the amplitude of the RF carrier is varied in accordance with the intelligence. For manual CW telegraph, the RF carrier is keyed on and off to form an intelligible code. For facsimile or teletypewriter transmission (both single- and multi-channel teletypewriter) the RF carrier is shifted to either side of a center frequency in accordance with the intelligence. Moduplexing, wherein the frequency of the RF carrier is shifted in accordance with one signal and the amplitude of the RF carrier is varied (with limitations) in accordance with another signal, is employed in some low-frequency circuits to provide a navigational aid in addition to the normal point-to-point transmission.

d. The single sideband (SSB) mode of operation is used to transmit the 6-channel frequency division multiplex teletypewriter signal. Provisions also are made for a voice or facsimile channel on SSB circuits.

e. The association of equipment that is provided to implement the circuits in the typical Globecom transmitting station is discussed in following paragraphs. An explanation is given for the normal operation of each type of circuit, and the continuity of inter-equipment circuitry is illustrated. Only that circuitry normalled through at the patch panels to associated equipment is shown in the illustrations. Additional circuitry, which is provided from the equipments to the patch panels to achieve maximum capability and flexibility of operation, is noted throughout the narrative. A detailed explanation of the Intersite facilities over which signals are relayed to the Transmitter Site is presented in Part Seven.

4-39. Air-Ground Facilities

a. *Primary Facilities (Fig. 4-39).*

(1) The RF signal is generated by the FSK unit adjusted for zero shift at a submultiple of the assigned operating frequency and is applied to the appropriate MW channel through a coaxial plug connection at the RF Patch Panel. The RF signal is multiplied and amplified within the transmitter, and as the transmitter is keyed and modulated by the remote operator, the RF signal carrying the intelligence is applied directly to a transmission line feeding a doublet antenna.

(2) An RF monitor is installed in conjunction with a carrier failure alarm relay panel. By utilizing a method of conditioning circuitry, these two units provide for "Carrier On" and "Carrier Failure" indications at the supervisory console. The monitor also provides for indicating the relative RF power output (carrier level) of the transmitter on a meter at the console.

(3) Voice operation of the transmitter is initiated by the remotely located operator. A keying signal, relayed to the Transmitter Site through the Intersite facilities, appears as an audio tone at the output of one voice band channel of the CMT-4. This signal is routed to the AF and DC Patch Panel, and a normal-through connection is provided to the VFTG converter. The NR-152 VFTG Tone Converter converts the tone to a DC

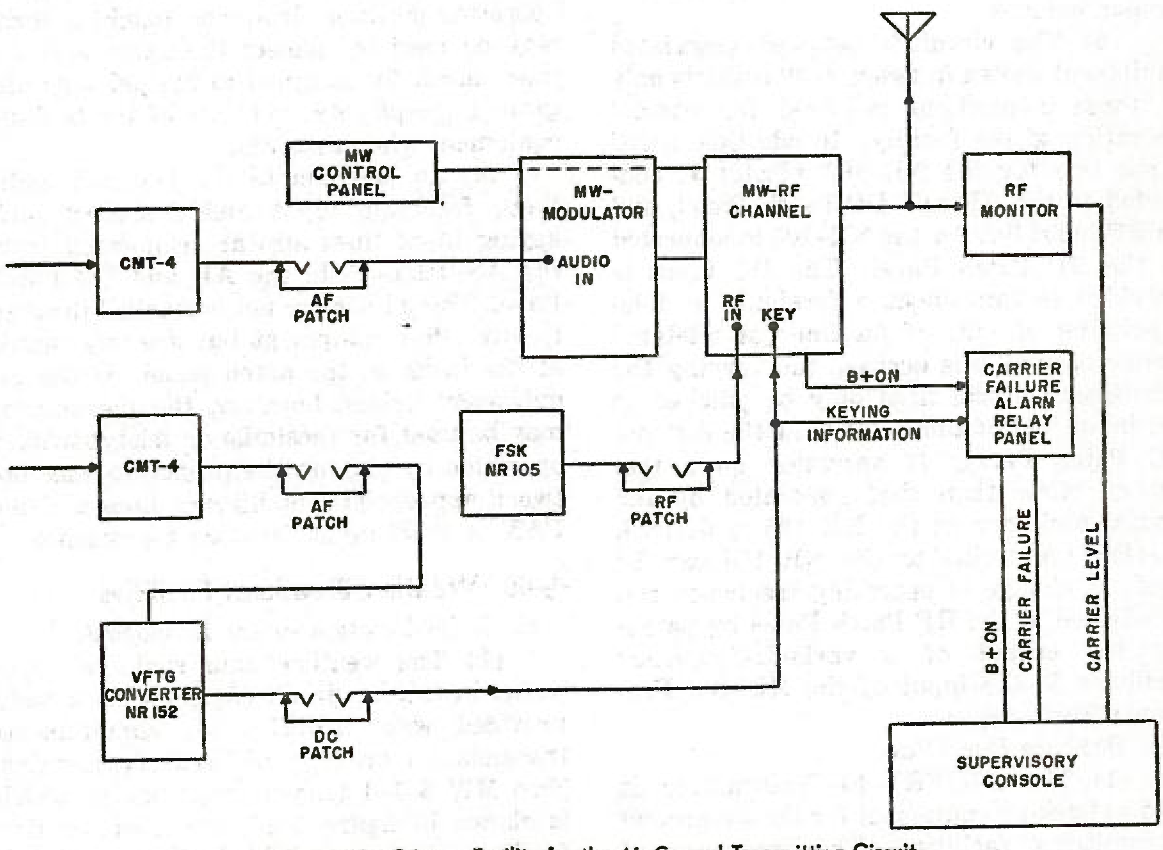


Figure 4-39. Primary Facility for the Air-Ground Transmitting Circuit.

voltage of 110 volts for a key-down condition and zero volts for a key-up condition. The DC push-to-talk line is connected to the AF and DC Patch Panel where it is normalled through to the appropriate MW channel for transmitter push-to-talk operation.

(4) The speech signal initiated by the remotely located operator and relayed through the Intersite facilities is received at the Transmitter Site in its original form as the output of one voice band channel of the CMT-4 equipment. The signal is normalled through the AF and DC Patch Panel and fed directly to the modulator associated with the appropriate MW channel. Within the modulator the audio signal is increased in power to a level sufficient to amplitude modulate the RF carrier.

(5) The foregoing circuitry is duplicated for each air-ground channel installed. Although all associated equipment circuitry is normalled through at the patch panels, substitution of any item for another similar item can be accomplished by making the proper patches.

(6) The circuitry between associated equipment shown in figure 4-39 consists only of those connections required for normal operation of the facility. In addition, a DC input line for the NR-105 (FSK) is connected to the AF and DC Patch Panel, and an RF input line for the NR-105 is connected to the RF Patch Panel. The DC input is provided to implement a facsimile or teletypewriter circuit. If facsimile or teletypewriter operation is desired, the varying DC intelligence signal need only be patched to the input line of the NR-105 at the AF and DC Patch Panel. If operation on a frequency other than that generated by the crystal oscillator in the NR-105 is desired, the RF input line to the NR-105 can be used. A change in operating frequency can be effected at the RF Patch Panel by patching the output of a variable-frequency oscillator to the input of the NR-105 Frequency Shift Keyer.

b. *Back-up Facilities.*

(1) The AN/FRT-15 Transmitter is used as back-up equipment for the air-ground transmitting facilities. The frequency of operation is selected locally by a telephone-type dial from ten crystal- or eleven master-oscillator-controlled preset frequencies of the transmitter. When the transmitter is keyed, the basic RF signal, generated in the AN/FRT-15, is multiplied, amplified, and modulated with the voice intelligence received from the operator. The amplitude modulated RF signal is applied directly to a coaxial transmission line which feeds a discone antenna.

(2) RF monitor and carrier failure alarm relay panels are installed with circuitry and application of equipment similar to that described for the primary equipment air-ground circuit. The RF monitor used for this circuit is modified for use with the low-impedance coaxial transmission line.

(3) Key and audio lines are provided from each AN/FRT-15 to the AF and DC Patch Panel. The installation of the back-up transmitters does not provide for normal-through operation or channel selection of the back-up transmitters from the remote operating position. However, patching cords may be used to connect the audio and key lines, normally assigned to the primary air-ground equipments, to either of the back-up equipment when required.

(4) In addition to the key and audio lines, facsimile input and frequency-shift keying input lines also are connected from the AN/FRT-15 to the AF and DC Patch Panel. These lines are not normalled through to any other equipment but are terminated at the jacks on the patch panel. If the requirement arises, however, the transmitter may be used for facsimile or teletypewriter operation by making the proper patches between appropriate intelligence lines and the FAX or FSK input for each transmitter.

4-40. Weather Broadcast Facilities

a. *Radio Teletypewriter Broadcast.*

(1) The weather data radio teletypewriter broadcast circuit (fig. 4-40) is usually provided with facilities for simultaneous transmission on four different frequencies. Two MW 3-1-1 transmitters, one of which is shown in figure 4-40, are used for this facility. The first and third RF units of each

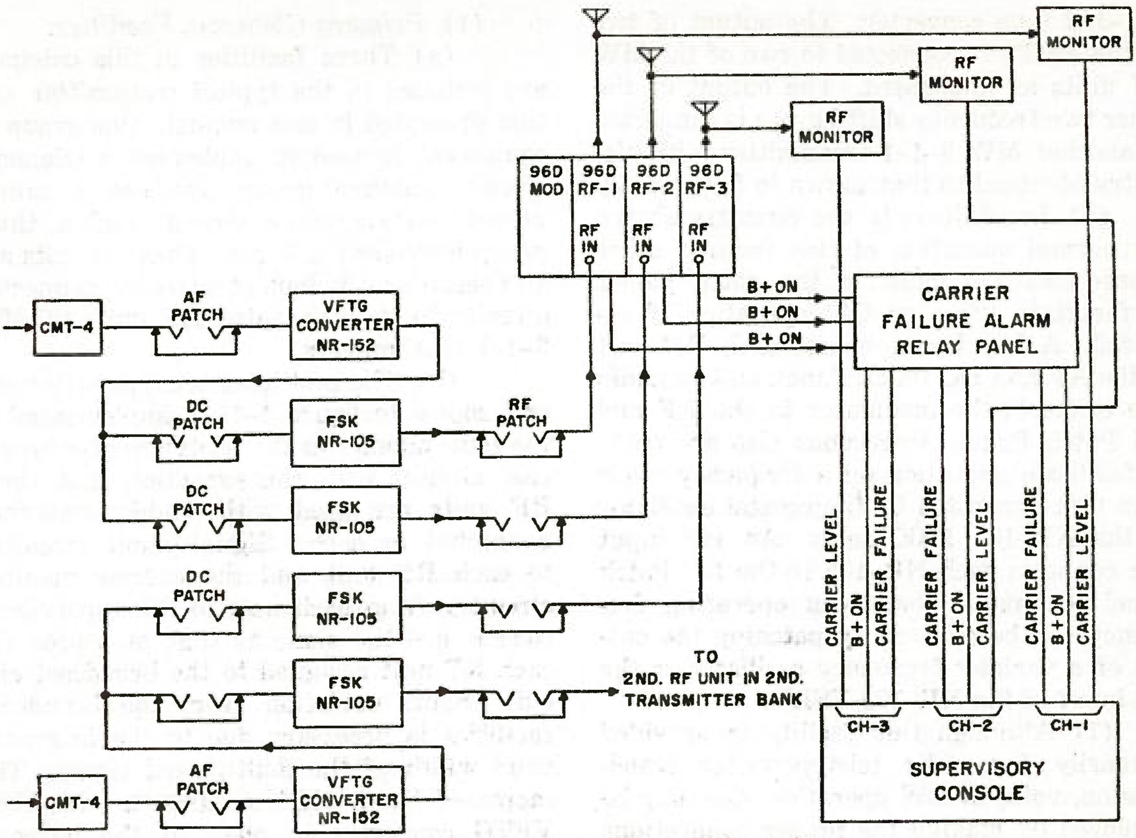


Figure 4-40. Weather Broadcast Transmitting Facilities.

transmitter bank are used for transmission of the weather information, and the middle RF unit is reserved as a spare.

(2) The basic RF signals are generated by the NR-105 Frequency Shift Keyers. The RF output of each FSK is fed to the RF Patch Panel and normalled through to the RF input line of the appropriate MW RF units. Within the transmitters, the input RF signal is multiplied to the assigned operating frequency, amplified, and applied directly to a transmission line which feeds a doublet antenna.

(3) An RF monitor is installed in conjunction with a carrier failure alarm relay panel with circuitry similar to that described for one MW RF unit of the air-ground facilities. In this case, keying information is not required because interrupted carrier operation is not used. "B Plus On", "Carrier Failure," and "Carrier Level" indications are provided at the supervisory console for each assigned RF channel.

(4) A single-channel teletypewriter signal is received from the Relay Center through the Intersite facilities and appears at the output of the CMT-4 equipment as two audio tones. One tone represents a space signal and the other a mark signal. The signal is fed to the AF and DC Patch Panel and normalled through to an NR-152 narrow-band VFTG converter. The DC output of the VFTG converter is fed to the AF and DC Patch Panel and normalled through to the input circuit of the NR-105 Frequency Shift Keyer. The DC pulses fed into the FSK effect a shift in frequency above or below the center RF frequency of the FSK, which results in the final output frequency of the transmitter being shifted plus or minus 425 cps in accordance with the teletypewriter intelligence.

(5) The inputs of all NR-105 FSK's (usually four) associated with the normal operation of the foregoing circuit are paralleled and connected to the output of one

NR-152 tone converter. The output of two of the FSK's is connected to two of the MW RF units as illustrated. The output of the other two frequency shift keyers is connected to another MW 3-1-1 transmitter with circuitry identical to that shown in figure 4-40.

(6) In addition to the circuitry shown for normal operation of this facility, other connections are made to the patch panels to facilitate voice or CW operation if required. A key line connects each RF unit to the AF and DC Patch Panel, and an audio line connects the modulator to the AF and DC Patch Panel. Provisions also are made to facilitate operation on a frequency other than that generated by the crystal oscillator in the NR-105 FSK units. An RF input line connects each NR-105 to the RF Patch Panel so that a change in operating frequency can be effected by patching the output of a variable-frequency oscillator to the RF input of the NR-105 FSK's.

(7) Although this facility is provided primarily for radio teletypewriter transmission, voice or CW operation also may be employed by making the proper connections at the patch panels and by selecting the desired type of emission at the MW control panel.

b. *Radio Facsimile Broadcast.* The equipment arrangement and circuitry provided for facsimile broadcast is similar to that provided for the teletypewriter broadcast facility (see fig. 4-40), with one exception: instead of feeding the intelligence into the NR-152 converter, the facsimile signal is fed into a KY-44 Facsimile Keying Adapter. The keying adapter converts the amplitude in accordance with the facsimile intelligence. The resultant DC voltage is then fed into the NR-105 FSK units at an amplitude which will effect a maximum frequency shift in the transmitted RF carrier of 400 cps above or below the center operating frequency. The shifted frequency varies linearly with the amplitude of the original facsimile signal.

4-41. Point-to-Point Facilities Other Than SSB

a. *High Frequency Non-switched Facilities.*

(1) *Primary Globecom Facilities.*

(a) Three facilities in this category are included in the typical transmitter station presented in this manual. One group of equipment is used to implement a telephoto circuit, another group provides a multiplexed teletypewriter circuit, and a third group provides a CW net. These circuits are all operated with doublet antennas connected directly to the associated RF units of MW 3-1-1 transmitters.

(b) The multiplex teletypewriter circuit shown in figure 4-41 is implemented in the same manner as the teletypewriter broadcast circuit, with the exception that three RF units are used with doublet antennas connected to each. Signal input circuitry to each RF unit and the carrier monitor circuitry from each unit to the supervisory console are the same as that presented for each RF unit assigned to the broadcast circuit. Some deviation from the broadcast facilities is necessary due to the increased band width of the multiplexed signal. The increased band width requires a wide-band VFTG converter in place of the narrow-band unit used in the broadcast circuit. Simultaneous operation of all three RF units in this circuit is possible, but normal operation is conducted with one RF unit employed on a day frequency, another on a night-frequency, and a third on a transition or intermediate frequency.

(c) The circuitry and equipments provided to implement the telephoto circuit (see figure 4-41) parallel that described in the preceding paragraph, with the exception that a KY-44 Facsimile Keying Adapter is used instead of an NR-152 Converter. Application of the keying adapter is identical to that described for the facsimile weather broadcast facility relative to inter-equipment circuitry.

(d) The facilities provided for implementing the CW net are illustrated in figure 4-42. Circuitry and association of equipment used in this net parallel that of the primary air-ground voice facilities, with one exception: only one modulator is provided in the equipment line-up, and the audio line from the modulator is terminated at the

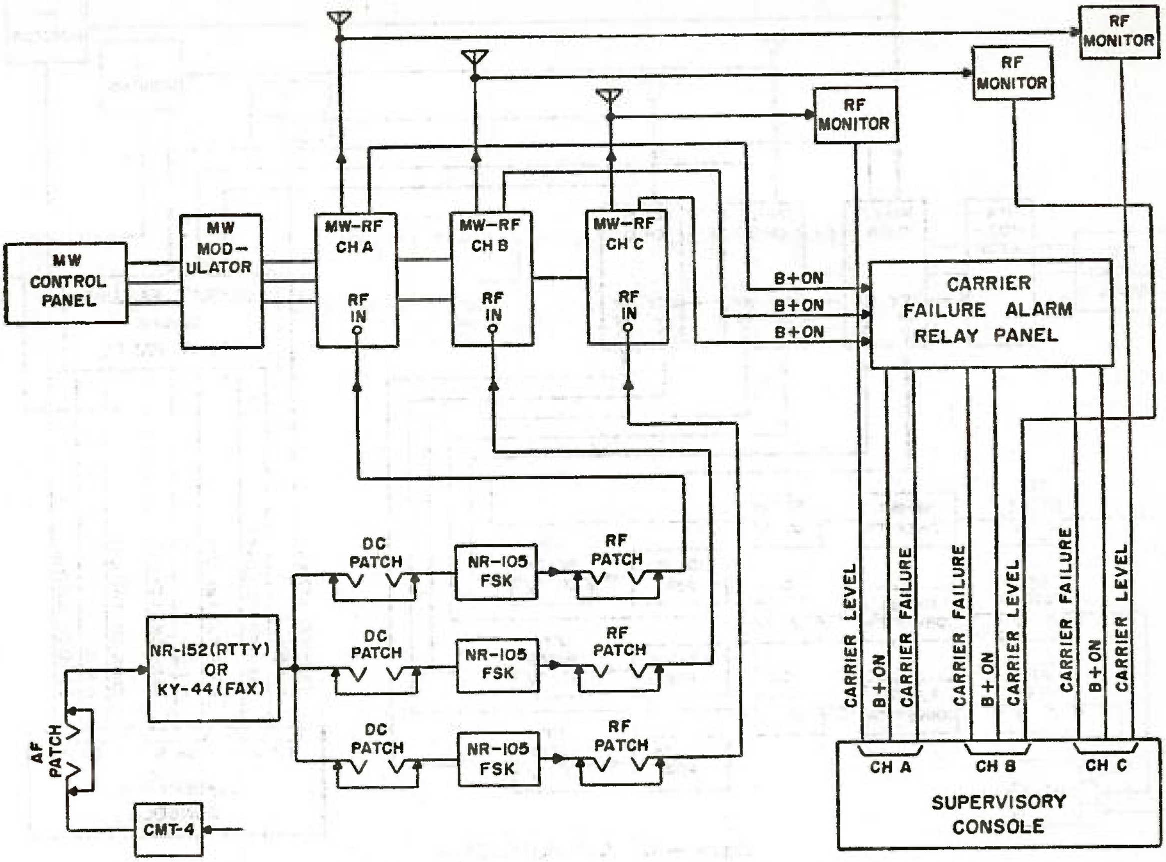


Figure 4–41. Double Sideband Teletypewriter and Telephoto Facilities (Non-switched).

AF and DC Patch Panel instead of normalled through to the Intersite equipment. The keying circuitry applicable to this facility is identical to the push-to-talk circuitry described for operation of the MW air-ground transmitters.

(e) In addition to the normal-through connections shown in figures 4–41 and 4–42, other connections are made from the equipment to the patch panel to facilitate other than normal operation of any of the transmitters. Key lines and a modulation line from the transmitter, and RF input lines from the NR–105, though not used for normal operation, are still connected to the appropriate patch panels. By making the proper patches, any mode and any frequency within the capabilities of the equipment may be used as explained previously.

(2) *Landline Back-up Facilities.*

(a) Facilities are provided in the typical station for backing up three landline teletypewriter circuits. The radio back-up circuits are implemented by employing two banks of 96–D 3–1–1 transmitters. Two RF units of one transmitter bank are used for one teletypewriter circuit, and the other RF unit is used in a second teletypewriter circuit. The components of the second transmitter are distributed in a similar manner, one RF unit being used on the second teletypewriter circuit noted above and the other two RF units providing the facilities for the third teletypewriter circuit.

(b) The association of equipment required for operation of one bank of the 96–D transmitters which is employed for landline back-up facilities is illustrated in figure 4–43. With the exception of the operating frequency, installation and operation of both transmitters are identical. The two transmitter banks combined provide radio

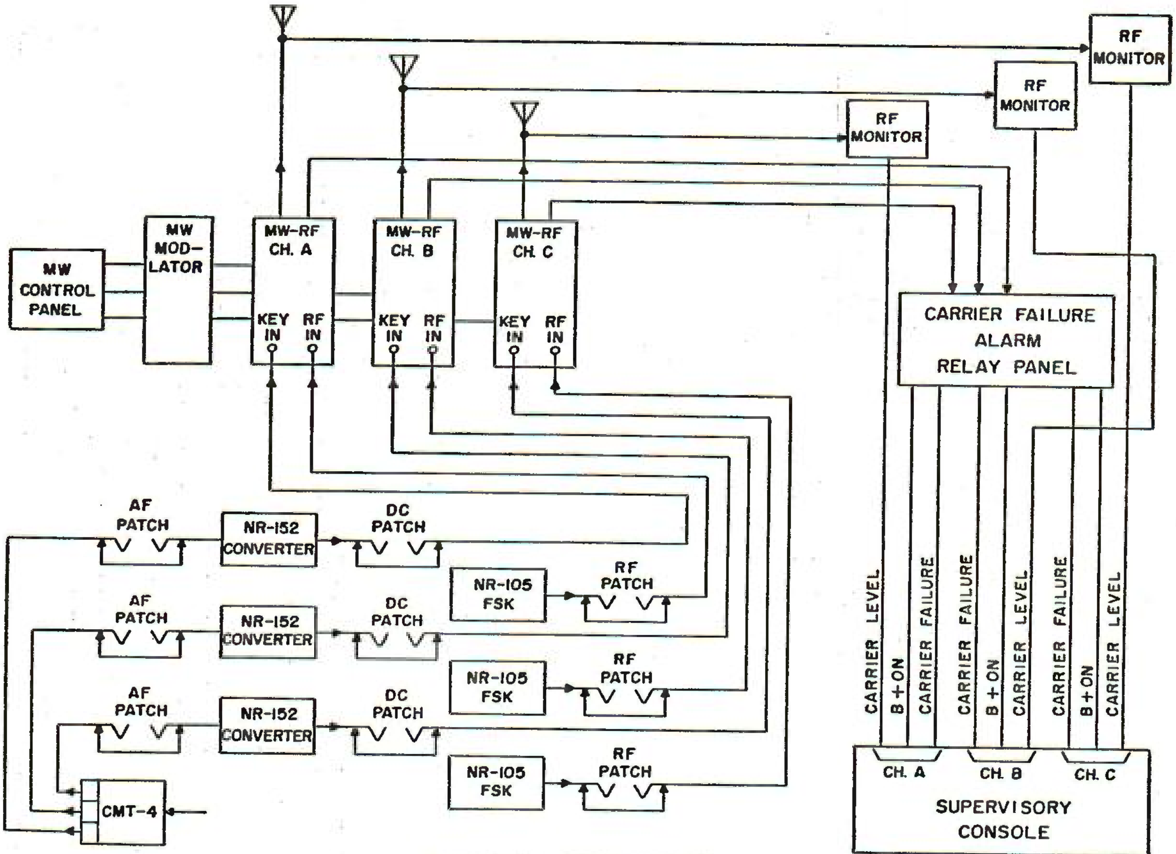


Figure 4–42. CW Net Facility.

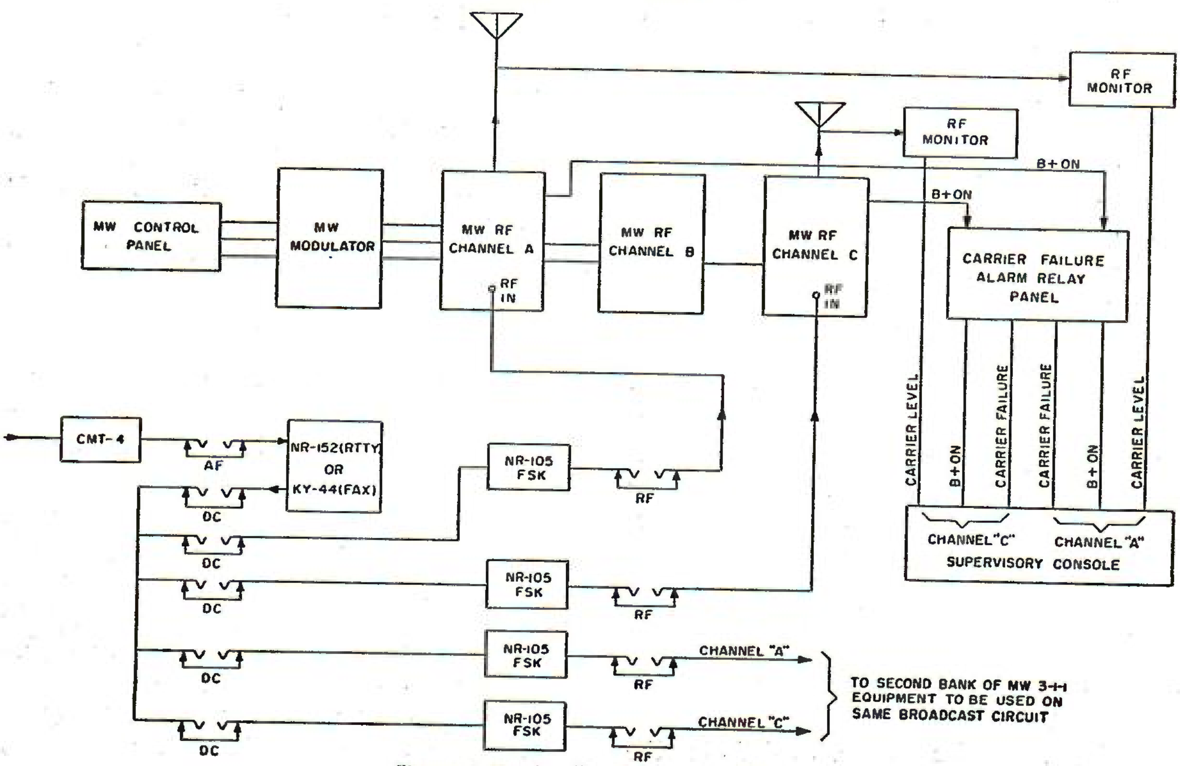


Figure 4–43. Landline Backup Facilities.

back-up for three different landline circuits.

(c) The association of equipment relative to the landline back-up type of operation is very similar to that described for the teletypewriter weather broadcast operation. The teletypewriter signal, received as a tone from the output of the CMT-4 equipment, is fed to the AF and DC Patch Panel and normalled through to the VFTG converter. The DC output from the converter is normalled through to the input of two NR-105 FSK's which effect shifts in the carrier frequencies of the associated RF units in accordance with the teletypewriter intelligence. At the RF Patch Panel, the output of the NR-105 is connected directly to the input of the associated RF unit for multiplication, amplification, and application to a doublet antenna.

(d) RF monitors are installed for each RF unit in conjunction with a carrier failure alarm relay panel. "B plus On", "Carrier Failure", and "Carrier Level" indications are provided at the supervisory console for each RF channel. Circuitry for the equipment is similar to that of the air-ground facility, with the exception that keying information is not required at the carrier failure alarm relay panel, since interrupted carrier operation is not used in the circuit.

b. *High-Frequency Switched Circuits, No High-Power Back-up.*

(1) Figure 4-44 illustrates the association of equipment for facsimile or teletypewriter transmission, with provisions for switching the output from any of the MW 3-1-1 RF units to either of two rhombic antennas.

(2) Routing of the signal received from the Relay Center, generation of the shifted RF signal, and input to each RF unit is identical to that of the circuitry described for the weather broadcast circuit. In addition to the normal-through connections shown in the illustration, other connections

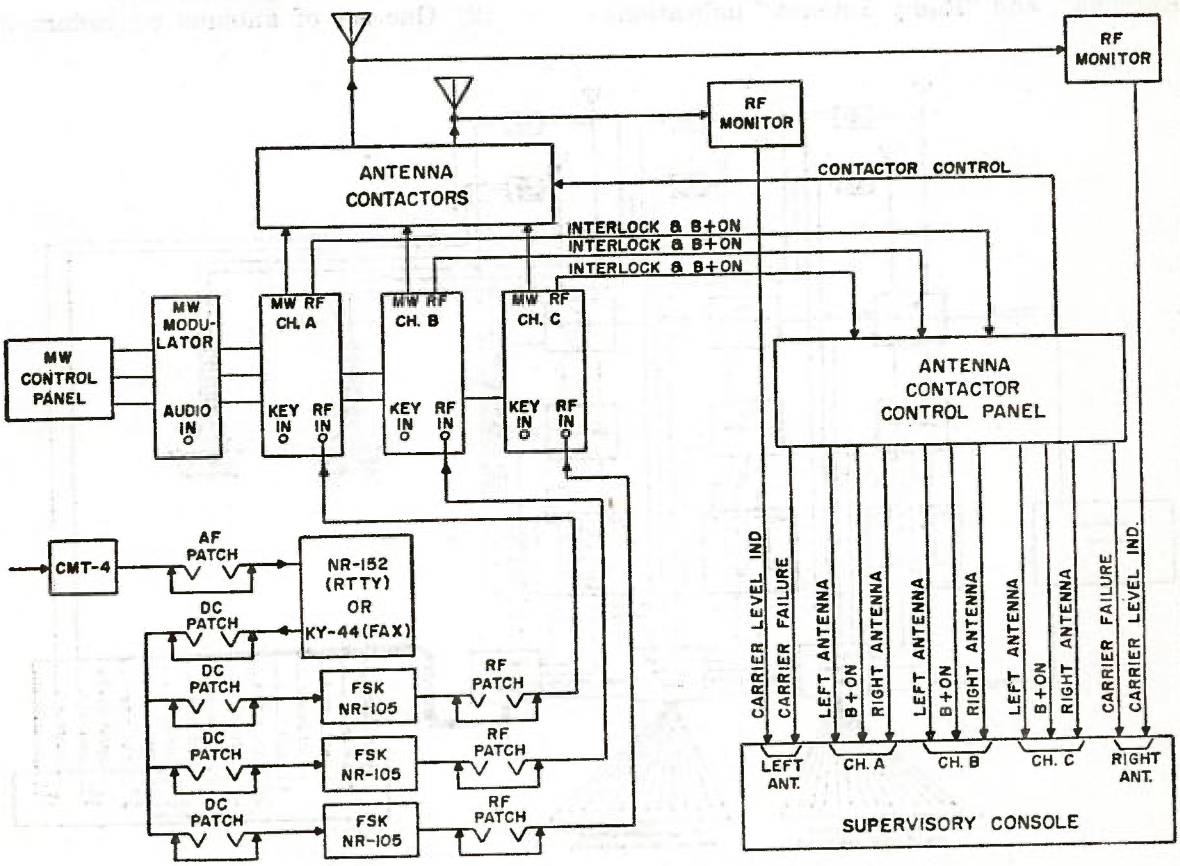


Figure 4-44. Double Sideband Teletypewriter and Facsimile Facilities (Switched).

are made from the equipment to the patch panels to facilitate other than normal operations, as explained for the other circuits.

(3) The output from each MW RF unit is connected to an antenna contactor arrangement which is controlled by the antenna contactor control panel. Also connected to the antenna contactors are two balanced transmission lines, one feeding a high-band rhombic antenna and the other feeding a low-band rhombic antenna. The antennas are designated "Left Antenna" and "Right Antenna" on the control panel. The switches on the antenna contactor control panel are manually positioned by the station operator to connect either antenna to any of the three RF units. Interlocking circuitry between the contactor control panel and each RF unit prevents application of power to any RF unit that is not connected to an antenna.

(4) Circuitry provided in the contactor control panel presents "B plus On", "Left Antenna", and "Right Antenna" indications at the supervisory console for each RF unit of the MW transmitter. An RF monitor installed for each transmission line provides an indication of the average RF power (carrier level) applied to each transmission line and the associated "Carrier On" indication at the supervisory console. The RF monitor, in conjunction with the contactor control panel circuitry, also provides a "Carrier Failure Alarm" indication at the console.

c. *High-Frequency Switched Circuits With High-Power Back-up.*

(1) As stated in chapter 2, one high-power transmitter can be employed to provide back-up for three MW transmitters. Figure 4-45 illustrates the association of equipment for an arrangement of this type and shows the facilities required for implementing three circuits within the typical station. Signal input and control of each MW transmitter are identical with that presented in the preceding paragraph.

(2) One set of antenna contactors in-

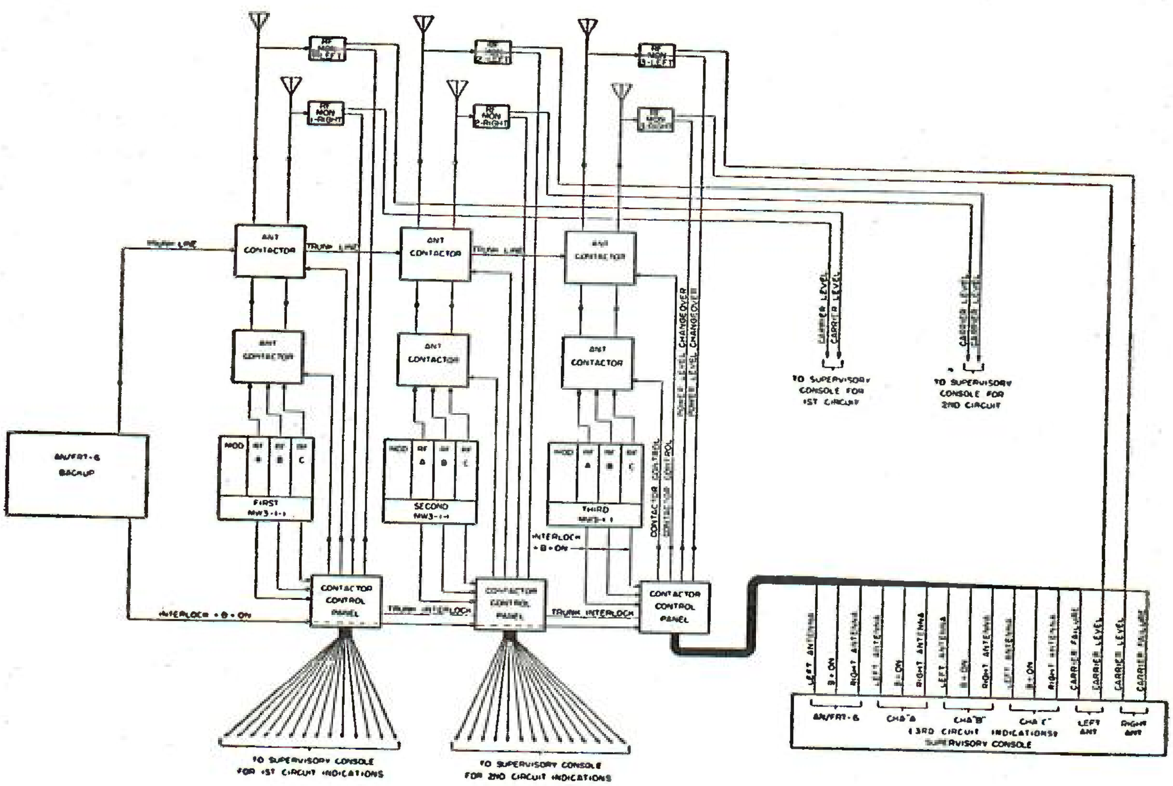


Figure 4-45. Antenna Switching with High-Power Back-up Facilities.

stalled for each two antennas provides for switching any antenna to either the trunk line from the AN/FRT-6 or to either of two transmission lines coming from a second set of antenna contactors. The latter contactors provide for switching the two transmission line paths from the first set of contactors to any one of the three RF units of each MW transmitter bank.

(3) Interlocking circuitry between the antenna contactor control panels and each MW RF unit and the AN/FRT-6, in addition to the trunk interlock circuitry between the three control panels, prevents application of power to any transmitter unit, unless that transmitter is properly terminated into an antenna.

(4) For operation with the high-power transmitter, a power level change-over circuit is provided between the antenna contactor control panels and the RF monitors. When the AN/FRT-6 is selected for operation, the power level change-over circuit actuates a relay in the RF monitor associated with the antenna to which the AN/FRT-6 is switched. The action of this relay reduces the level of the signal fed back to the supervisory console (in respect to the radiated RF signal) so that approximately the same carrier level indication is received at the console for normal operation of either the MW or the AN/FRT-6 transmitter.

(5) A key line, frequency shift keying input line, and facsimile input line are provided from the AN/FRT-6 to the AF and DC Patch Panel. When high-power operation is desired on any of the three associated circuits, the intelligence line used for normal operation of the MW transmitter need only be patched to the appropriate AN/FRT-6 input and the transmitter activated.

d. *Low Frequency Facilities.*

(1) *AN/FRT-4 Transmitter.*

(a) The basic RF signal is generated by an exciter unit contained in the AN/FRT-4 Transmitter (fig. 4-46). The exciter includes a variable-frequency master oscillator from which is derived an RF carrier within the range of 50 to 150 kilocycles. A frequency shift keying unit, which shifts the oscillator frequency in accordance with the DC teletypewriter signal that is applied to the input of the unit, is contained in the exciter. When the transmitter is placed in operation, an RF signal representing a teletypewriter space pulse signal is generated, amplified within the transmitter, and applied to the antenna for radiation. The RF signal frequency representing the mark pulse is 170 cps higher than the space pulse frequency. Remote on-off control of the transmitter radio frequency is not provided.

(b) The teletypewriter signal is received from the Relay Center through the

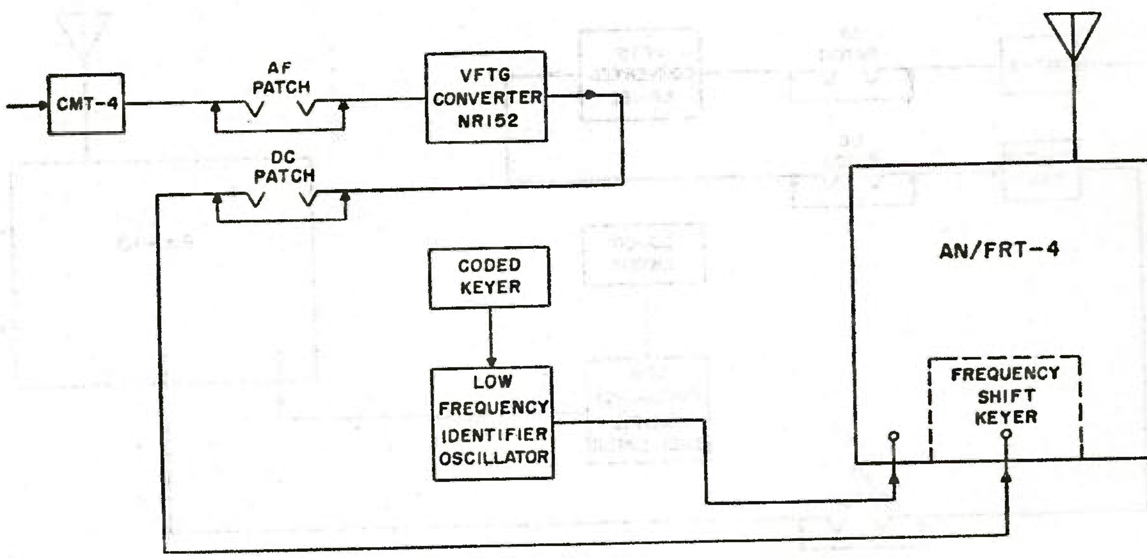


Figure 4-46. Low Frequency Facilities (AN/FRT-4).

Intersite facilities and appears at the output of the CMT–4 receiving equipment as one tone representing a space signal and another tone representing a mark signal. The output of the CMT–4 equipment is fed to the AF and DC Patch Panel and normalled through to the input of an NR/152 VFTG converter. The converter electronically converts the audio tones to DC pulses for application to the frequency shift keyer through a normal-through connection at the AF and DC Patch Panel. Similar equipment circuitry is used for both single-channel and multiplex teletypewriter signals, the principal difference between the two being in the band width requirements imposed upon the Intersite facilities and the VFTG equipments. A narrow-band VFTG is employed for single-channel operation and a wide-band VFTG for multiplex operation.

(c) An audio tone signal from the Low-Frequency Identifier Oscillator is fed directly to the transmitter. This signal is fed to the suppressor grid of the intermediate power amplifier stage of the transmitter, and the signal level and circuitry is adjusted to effect a 30 percent amplitude modulation of the RF carrier. An automatic mechanical keyer provides on-off control of the audio oscillator output in a coded sequence which identifies the station. The resultant RF signal provides an aircraft navigational aid in addition to the normal teletypewriter intelligence.

(d) In addition to the circuitry shown for normal operation of this facility, facsimile and DC keying inputs are connected from the transmitter to the AF and DC Patch Panel. If the requirement arises for facsimile or CW operation, either of these two types of operation could be implemented by making the proper patch, at the AF and DC Patch Panel, between a facsimile intelligence line or CW key line and the appropriate input to the transmitter.

(2) *PW–10 Low-Frequency Transmitter.*

(a) When relatively low power is permissible, a low-frequency circuit may be implemented by employing the PW–10 Transmitter (fig. 4–47). The applied inter-station circuitry for this equipment is very similar to that described for the AN/FRT–4; however, the PW–10 does not contain a frequency shift keyer as one of its component parts, so an FSK facility must be provided for it.

(b) The routing of the teletypewriter intelligence signal up to the output of the VFTG converter is the same when applied to the PW–10 transmitter as that shown for the AN/FRT–4 transmitter. For PW–10 operation, the output of the NR/152 con-

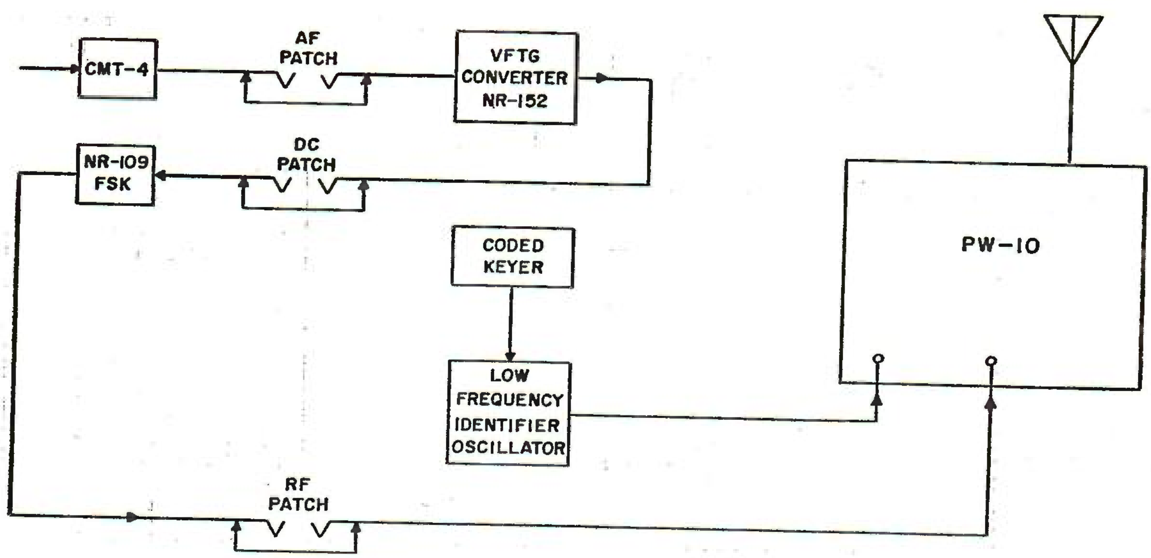


Figure 4–47. Low Frequency Facilities (PW–10).

verter is normalled through at the AF and DC Patch Panel to the input of an NR–109 Frequency Shift Keyer (low-frequency), and the output of the NR–109 is fed to the RF Patch Panel at which the signal is normalled through to the RF input of the PW–10 Transmitter. The basic RF signal is generated by the crystal controlled NR/109 Frequency Shift Keyer, applied to the transmitter for amplification, then fed to the antenna for radiation.

(c) Application of a signal from the Low-Frequency Identifier Oscillator to the PW–10 Transmitter is identical to that described for the AN/FRT–4 Transmitter.

e. *Forward Scatter Facilities.*

(1) The association of equipments utilized for implementing this type of facility is illustrated in figure 4–48. Basically, the inter-equipment circuitry is very similar to that described for the non-switched high-frequency transmitting facilities. The multiplex teletypewriter signal is received from the output of the VFTG converter as a DC voltage varying in amplitude in accordance with the teletypewriter intelligence. The intelligence signal is normalled through the AF and DC Patch Panel to the input of a specially designed frequency shift keyer.

(2) A specially designed oscillator is used to generate the fundamental radio frequency which is normalled through at the RF Patch Panel to the RF input of the frequency shift keyer. The output of the frequency shift keyer is an RF signal shifting above and below a center frequency in accordance with the mark and space pulses of the multiplex teletypewriter signal.

(3) The output of the FSK is routed to the RF Patch Panel where it is normalled through to the RF input of a modified AN/FRT–6. Within the AN/FRT–6, the signal is multiplied in frequency to the desired operating frequency, amplified to the desired level, and applied directly to a coaxial transmission line. The coaxial line is used only to conduct the RF energy to the outside of the building, where it is transferred to a balanced open-wire line connected to a corner reflector antenna.

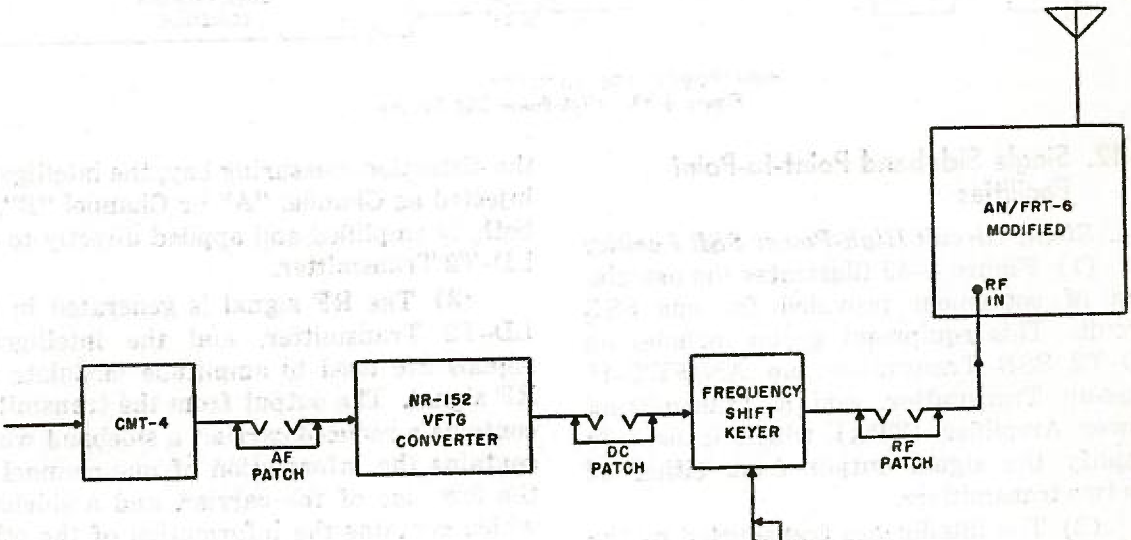
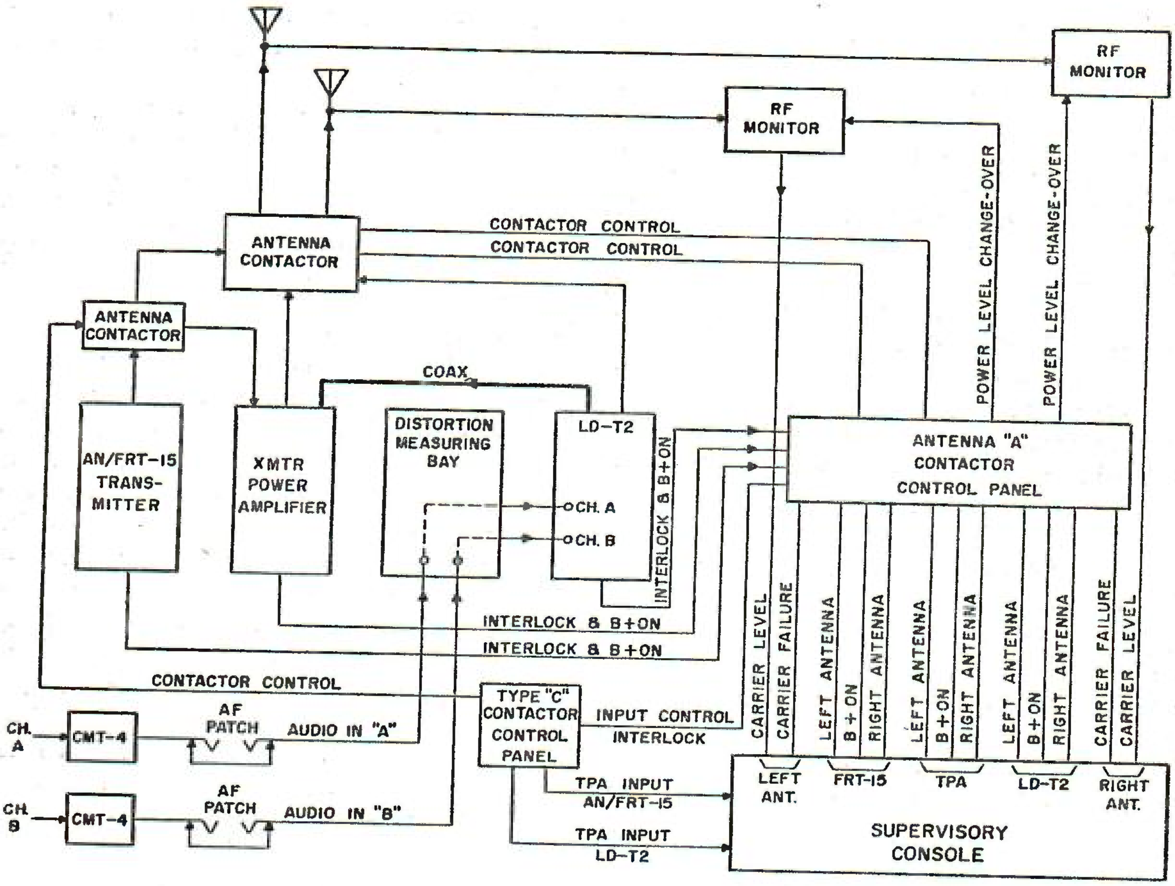


Figure 4–48. Forward Scatter Facility.



HIGH POWER SSB FACILITY

Figure 4-49. High-Power SSB Facility.

4-42. Single Sideband Point-to-Point Facilities

a. *Single-Circuit High-Power SSB Facility*

(1) Figure 4-49 illustrates the association of equipment provided for one SSB circuit. This equipment group includes an LD-T2 SSB Transmitter, an AN/FRT-15 Line-up Transmitter, and a Transmitting Power Amplifier (TPA) which is used to amplify the signal output from either of the two transmitters.

(2) The intelligence transmitted by the SSB equipment is received from the output of the CMT-4 equipment as an audio signal and fed to the AF and DC Patch Panel. The lines carrying the signal (or signals, since two independent frequency groups may be transmitted) are normalled through at the AF and DC Patch Panel to the input of the transmitter distortion measuring bay. Within the distortion measuring bay, the intelligence injected as Channel "A" or Channel "B", or both, is amplified and applied directly to the LD-T2 Transmitter.

(3) The RF signal is generated in the LD-T2 Transmitter, and the intelligence signals are used to amplitude modulate the RF signal. The output from the transmitter contains a reduced carrier, a sideband which contains the information of one channel on the low side of the carrier, and a sideband which contains the information of the other channel on the high side of the carrier.

(4) The output of the LD-T2 can be used to drive the Transmitting Power Amplifier, or it can be fed to an appropriate antenna through the circuitry provided by the contactor control panels and the antenna contactors.

(5) The AN/FRT-15 is self-contained

insofar as the generation of an RF signal is concerned. The type of intelligence selected for a line-up operation with the distant station is patched into the AN/FRT-15 at the AF and DC Patch Panel. A frequency shift keying input, a facsimile input, an amplitude modulation input, and key line are provided between the AN/FRT-15 and the AF and DC Patch Panel so that any type of operation can be implemented with this facility. Normal line-up operation is conducted by applying a single-channel teletypewriter signal to the AN/FRT-15, and then effecting a shift in the final RF output of the transmitter in accordance with the mark and space signals of the teletypewriter intelligence.

(6) The output of the AN/FRT-15 is fed through an antenna contactor to either the Transmitting Power Amplifier or to another arrangement of antenna contactors which is connected to the appropriate antenna.

(7) Line-up operation is used to check propagation characteristics and to determine that satisfactory communications can be conducted on a certain frequency prior to switching the SSB transmitter to operation on that frequency.

(8) As stated previously, the output of the transmitters can be applied to the power amplifier or to the antenna contactors for application to an appropriate antenna. The output of the Transmitting Power Amplifier is also connected to the antenna contactor arrangement. By manually positioning the switches on the antenna contactor control panel, the output of any of the three units can be applied to either a high-band or a low-band rhombic antenna. The antennas are designated "Left Antenna" and "Right Antenna", respectively, on the control panel and "High-Band Antenna" and "Low-Band Antenna", respectively, at the transmission line ports. Correlation between the respective terms for each circuit must be maintained by the operating personnel, since no fixed policy can be established due to antenna placement requirements. Interlocking circuitry between the contactor control panels and each of the three transmitting units prevents application of power to any unit that is not properly terminated into either an antenna or a PTA.

(9) Circuitry provided by the Type "A" Antenna Contactor Control Panel presents "B plus On", "Left Antenna", and "Right Antenna" indications at the supervisory console for each transmitter and the Transmitting Power Amplifier. Circuitry from the Type "C" Antenna Control Panel provides "TPA Input" indications also at the console for both the LD-T2 and the AN/FRT-15 transmitters. An RF monitor that is installed for each transmission line provides for indication of the relative RF power (carrier level) applied to each transmission line and a visual "Carrier on" indication at the Supervisory Console. The RF monitor, in conjunction with the Type "A" contactor control panel circuitry, also provides an audible carrier failure alarm at the console.

(10) For operation with the Transmitting Power Amplifier, a power level change-over circuit is provided between the antenna contactor control panel and the RF monitors. When the TPA is selected for operation, the power level change-over circuit actuates a relay in the RF monitor associated with the antenna to which the TPA is switched. The action of this relay reduces the level of the signal fed back to the Supervisory Console (in respect to the radiated RF signal) so that approximately the same carrier level indications are received at the console for normal operation of either of the two transmitters or the Transmitting Power Amplifier.

b. *Two SSB Equipment Groups With Back-up Facilities.*

(1) As stated in Chapter 3, the SSB equipment groups are provided with a back-up in the ratio of one back-up group for each three equipment groups, or fraction thereof, allocated to specific circuits. Figure 4-50 illustrates the association of three SSB equipment groups in which those groups that are designated system "A" and system "B" are used to implement two individual circuits, and the third group is used to implement a back-up facility which is shared by the other two.

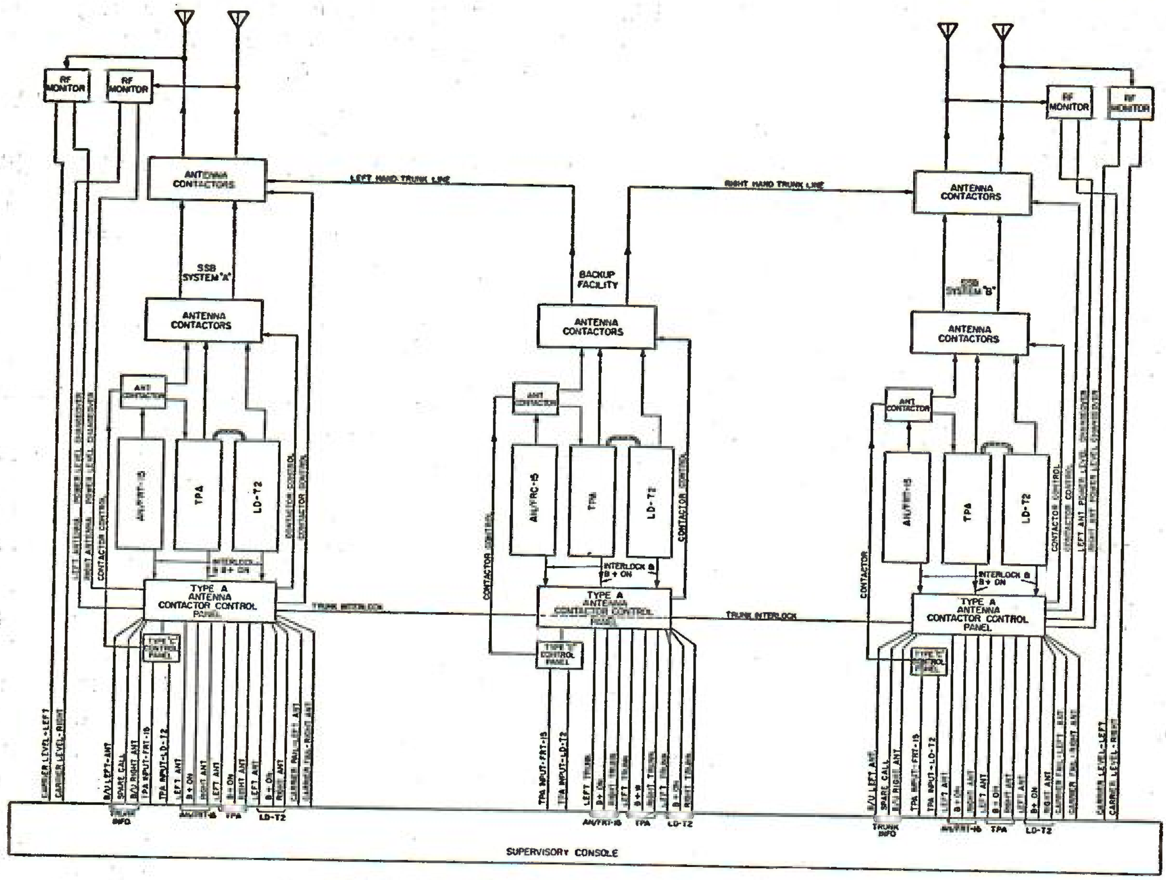


Figure 4-50. High-Power SSB Facilities with Back-up.

(2) Indicator lamp circuitry similar to :hat described previously for one single- ıideband equipment group is provided for ˌach of the three equipment groups. How- ˌver, for this application, the lamps associ- ıted with the back-up equipment, which vould normally be labeled "Left Antenna" ınd "Right Antenna", have been designated 'Left Trunk" and "Right Trunk". In addi- ion to the circuitry described for the single- ircuit SSB facility, systems "A" and "B" nclude a second set of antenna contactors vhich provides for switching either antenna ɔ the trunk line from the back-up facility, r to either of two transmission line paths oming from the antenna contactors directly ssociated with each of the transmitting nits in the primary facilities. At the Super- isory Console, an additional strip of lamps ; used to provide "Back-up Left Antenna", Back-up Right Antenna", and "Spare Call" indications for both primary facilities. Illumination of the "Spare Call" lamp (that lamp normally designated "B plus On" for the other transmitting facilities) in either system indicates that the back-up facility has been selected for operation into the antennas associated with the particular circuit. The actual antenna in use with the back-up facility is then designated by the "B/U Left Antenna" lamp or the "B/U Right Antenna" lamp. Figure 4-31 illustrates the indicator lamps associated with this type of operation.

(3) Control and interlocking circuitry provides the means for selecting any transmitting unit or combination of units in the back-up facility for operation on either the "Right Hand Trunk" or the "Left Hand Trunk". The combined circuitry also provides for operation with one of the primary transmitting equipments working into one

antenna and the back-up facility working into the other antenna associated with the same system. Various combinations of operation are possible. Interlocking circuitry between the contactor control panels and all transmitting units prevents application of power to any unit unless the output of that unit is properly terminated.

PART FIVE

COMMUNICATIONS RELAY CENTER

Chapter 1

INTRODUCTION

5-1. General

a. The Communications Relay Center is the hub of the entire Globecom station. It is the junction point for both transmitting and receiving portions of all circuits. As the name implies, the Relay Center is the switching facility for the relaying of traffic, all of which originates at some other point. Here are located the tape-handling facilities, the on-line cryptographic equipment, the main terminal equipment, the air-ground operating positions, and the channel and technical control facilities. The equipment and facilities are located in separate rooms, all of which are specifically designed to facilitate their particular functions.

b. The Tape Relay Room functions as a switching center for incoming teletypewriter traffic. It receives teletypewriter messages from distant stations and records them in printed and perforated form on tapes which are sorted and switched to the proper outgoing circuit. The only messages that originate here are those that deal with supervisory or maintenance functions.

c. The Crypto Room handles the on-line encrypting facility which is provided for Globecom. The encrypting facility is designed to automatically encrypt and decrypt all teletypewriter traffic passing through the Relay Center. Flexibility in this installation is provided by allowing the crypto apparatus to be by-passed if plain text operation should be prescribed.

d. The Equipment Room houses the terminal equipments necessary to handle the variety of circuits passing through the Relay Center such as:

(1) Voice A-G

(2) Manual CW

(3) Facsimile

(4) Single-Channel Radio Teletpyewriter Telegraph

(5) Four-Channel Teletypewriter Time Division Multiplex

(6) Single Sideband Frequency Division Multiplex (six teletypewriter channels plus one voice channel)

e. The Air-Ground Room contains the operating positions for the communication system which provides the link between ground and airborne stations. The traffic passed over this link deals with tactical, strategic, and traffic control functions between command posts, operational bases, air-traffic control centers, and aircraft. The Air-Ground Room is in effect an individual relay center through which the various messages pass. Very little traffic begins or ends here.

f. The Channel and Technical Control Room, which is also known as Tech Control, is the center of all circuit control functions. The means to perform all patching, switching and equipment transfer operations while insuring efficient circuit performance are provided here. Also provided are the means to monitor the condition of equipment and circuits and to perform precise measurements of circuit variables.

g. The Relay Center contains communications equipment which is voltage and frequency sensitive. The power requirements are therefore quite stringent. Base power, when sufficiently reliable, is used as the primary source; however, when base power is not reliable, the Globecom emergency power generating equipment which is provided at the Relay Center site is used.

5–2. Building Plan

a. There are several types of building plans for Relay Centers, each one specifically tailored to meet various requirements. One determining factor which dictates the type of building plan to be used is the amount of circuits that will be handled by a station; therefore, in stations where the circuit requirements are large, the building will be larger than one located at a station which requires a smaller number of circuits.

b. The building chosen for this typical Relay Center is the Type A Building. As shown in figure 5–1, the building plan offers ample office and storage space and also meets with the specific requirements of operating and maintenance personnel.

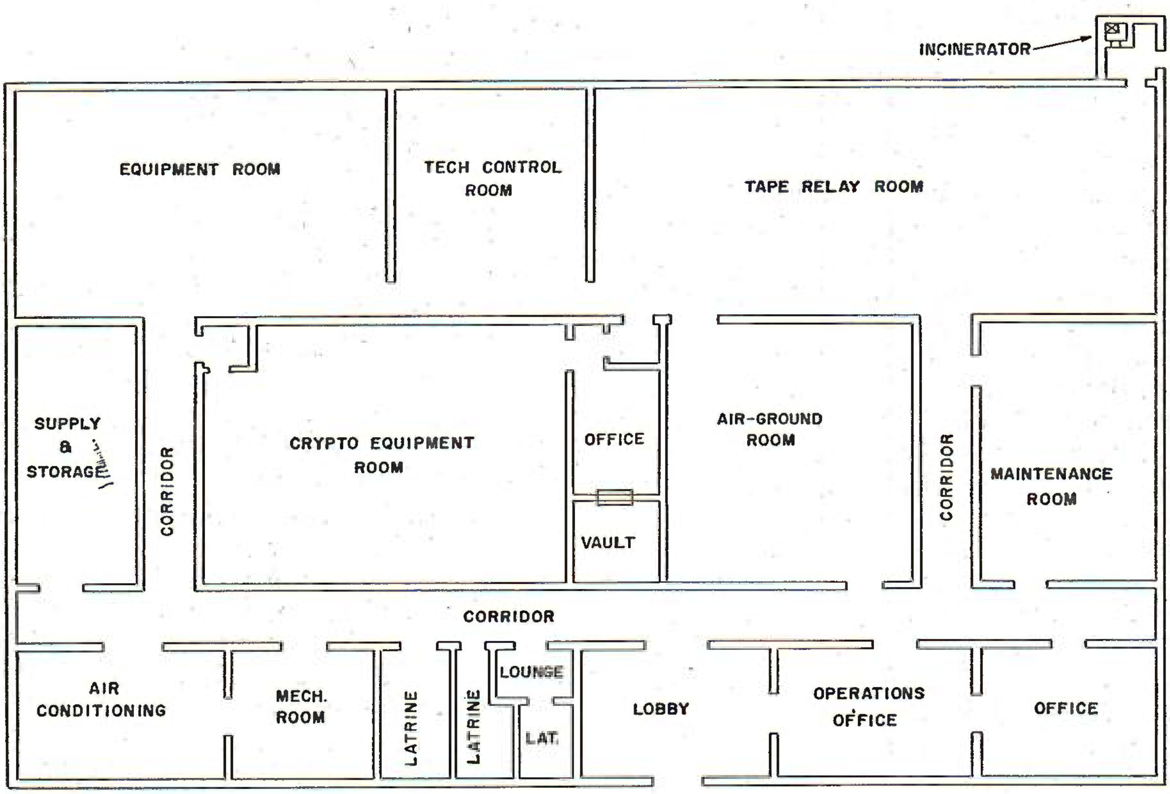


Figure 5–1. Communications Relay Center Building Plan.

Chapter 2

TAPE RELAY ROOM

Section I. PLAN 51.3B SEMI-AUTOMATIC SWITCHING SYSTEM

5-3. General

a. The Tape Relay Room contains the equipment which prints and perforates, numbers, monitors, sorts and relays incoming message traffic.

b. A large bulk of the traffic entering the Tape Relay Room is received from the Crypto Room through the appropriate jacks at the Tech Control patch panel. Traffic that does not require encryption may be patched around the crypto facility at the Tech Control Room patch panel before entering the Tape Relay Room. In either case, however, messages are received at a rate of 60 words per minute. The messages entering the Tape Relay Room appear in the form in which they were originally introduced into the system so that scanning and routing may be accomplished. After handling in the Tape Relay Room, the traffic may be channeled back to the Crypto Room where it is automatically re-encrypted during transmission on the outgoing circuit, or patched around the crypto facility at the Tech Control Room patch panel if encryption is not required.

c. The typical Tape Relay Room employing the Plan 51.3B Switching System is shown in figure 5-2. Overhead racks carry interconnecting cables between equipments and the distributing frame which is located in the Tech Control Room.

d. Plan 51.3B provides up to a total of 60 receiving positions and 60 sending circuits. Messages are received at 60 words per minute on a typing reperforator and are transmitted at 75 words per minute to a tape repeater over the desired sending line circuit by manually depressing a push-button on

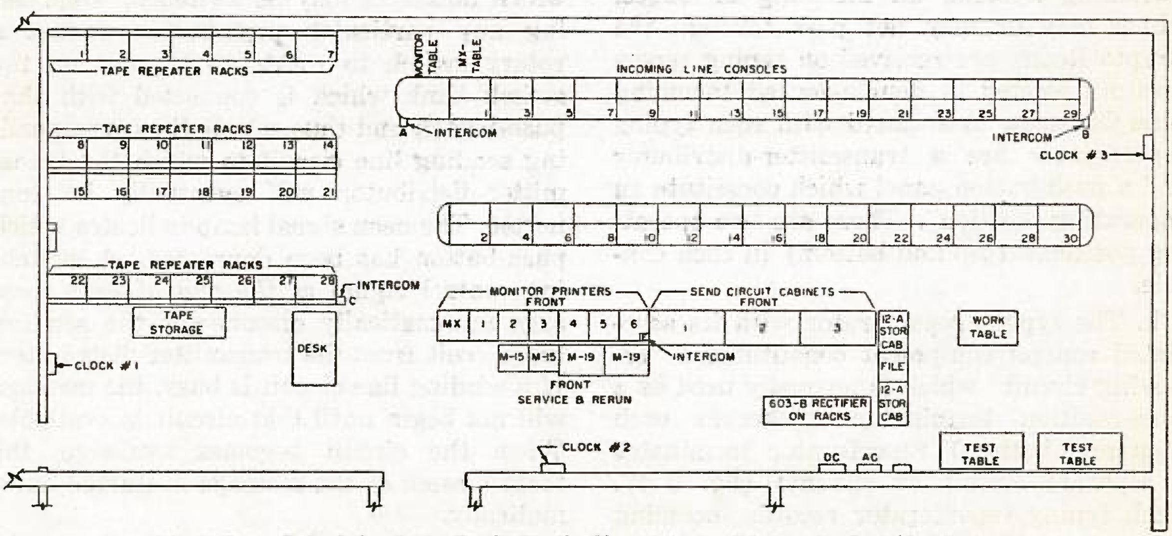


Figure 5-2. Tape Relay Room Employing the Plan 51.3B Semi-Automatic Switching System.

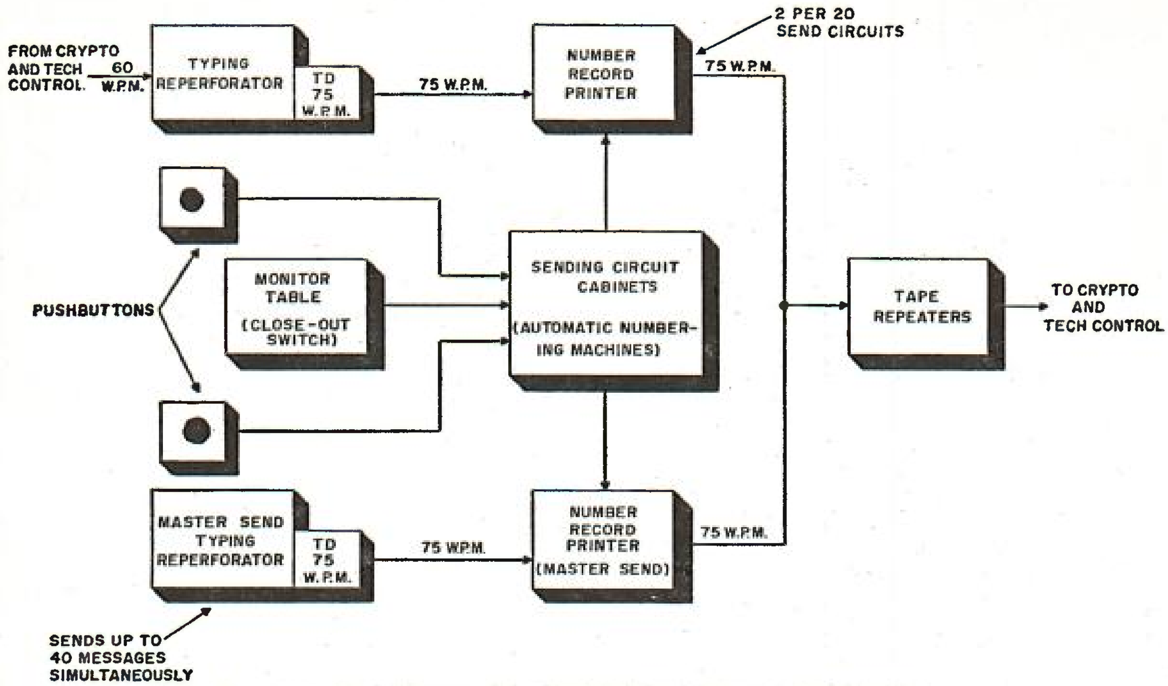


Figure 5-3. Block Diagram of the Plan 51.3B Semi-Automatic Switching System.

the associated panel. The push-button switches the messages directly to the desired channel without manual re-typing or other handling. A block diagram of the Plan 51.3B Semi-Automatic Switching System is shown in figure 5-3.

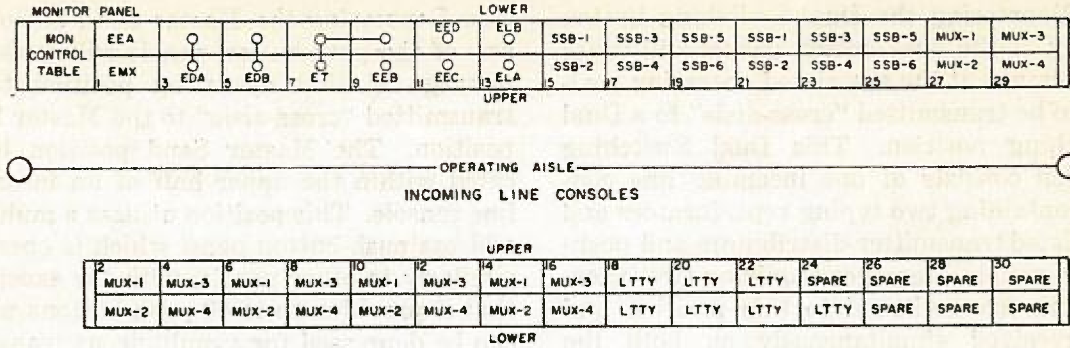
5-4. Incoming Line Consoles

a. In the Plan 51.3B Semi-Automatic Switching System, all incoming messages, which may or may not pass through the Crypto Room, are received on typing reperforators located in double-decked Incoming Line Consoles. Associated with each typing reperforator are a transmitter-distributor and a push-button panel which constitute an "operating position". There are two operating positions (top and bottom) in each console.

b. The typing reperforator with its associated control equipment constitutes a "receiving circuit" which is normally used as a "one-position termination" wherein each (top and bottom) reperforator terminates a separate circuit or channel (fig. 5-4). Each typing reperforator records incoming messages at 60 words per minute in the form of printed and perforated tape.

c. A transmitter-distributor (TD) with its associated push-button panel constitutes a "cross-office circuit" for transmitting the received message tapes to the desired sending line circuit. This cross-office circuit is provided at each top and bottom operating position. Each push-button panel (fig. 5-5) has a push-button and associated neon signal lamp for each station or designation to which messages may be switched. Depressing any particular push-button causes a rotary switch to rotate to a point on the switch bank which is connected with that push-button and thus selects the corresponding sending line circuit to which the transmitter-distributor will eventually be connected. The neon signal lamp indicates which push-button has been depressed. A switching control signal at the end of each message automatically disconnects the sending line circuit from the transmitter-distributor. If a sending line circuit is busy, the message will not begin until that circuit is available. When the circuit becomes available, the transmission of the message is started automatically.

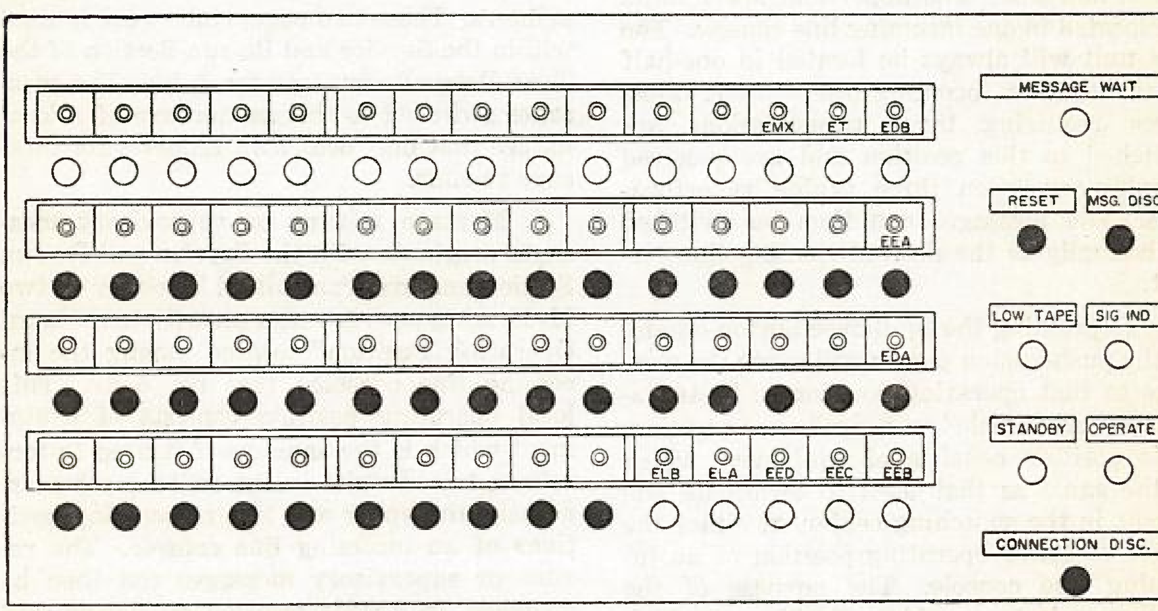
d. In addition to the station-selecting push-



LEGEND:
EE – SPILLOVER
EL – LOCAL
EMX – MASTER
ED – DUAL
ET – TRIPLE
SSB – ONE OF 6 SINGLE SIDEBAND FREQUENCY DIVISION MULTIPLEX RADIO TELETYPEWRITER RECEIVE LINE CIRCUITS
MUX – ONE OF 4 TIME DIVISION MULTIPLEX RADIO TELETYPEWRITER RECEIVE LINE CIRCUITS
LTTY – ONE LANDLINE TELETYPEWRITER RECEIVE LINE CIRCUIT

Figure 5-4. Typing Reperforator Receive-Line Circuit Assignments.

buttons and lamps, each panel at an operating position has other push-buttons and lamps, each panel at an operating position has other push-buttons and lamps which permit switching to "cross-aisle" positions that provide for dual switching, triple switching, spill over, master send, and local functions.



○ NOT ON MASTER SEND PUSH BUTTON PANEL

LEGEND:
EE-SPILLOVER
EL-LOCAL
EMX-MASTER
ED-DUAL
ET-TRIPLE

Figure 5-5. Push-Button Panel.

e. Depressing the Dual Switching button on any of the push-button panels will cause the message at the associated operating position to be transmitted "cross-aisle" to a Dual Switching position. This Dual Switching position consists of one incoming line console containing two typing reperforators and associated transmitter-distributors and push-button panels. Messages requiring two transmissions are switched to this position and are received simultaneously on both the upper and lower typing reperforators. The messages can then be switched individually from this position to the desired sending line circuit.

f. Depressing the Triple Switching button on any of the push-button panels will cause the message at that operating position to be transmitted "cross-aisle" to a Triple Switching position. This Triple Switching position consists of three typing reperforators and associated transmitter-distributors and push-button panels. The three combination receiving and transmitting units which comprise this position are designated upper, lower, and side. The upper and lower units are located in one incoming line console. The side unit will always be located in one-half of an adjacent incoming line console. Messages requiring three transmissions are switched to this position and are received simultaneously on three typing reperforators. The messages can then be switched individually to the desired sending line circuit.

g. Depressing the Spill-over button on any of the push-button panels will cause the message at that operating position to be transmitted "cross-aisle" to a Spill-over position. This position consists of equipment which is the same as that used to terminate one circuit in the switching center, at either the upper or lower operating position of an incoming line console. The purpose of the Spill-over is to provide a facility to which messages may be switched within the Tape Relay Room where they may be temporarily held for later handling in cases where pertinent out-going circuits are interrupted or inoperative.

h. Depressing the Master Send button on any of the push-button panels will cause the message at that operating position to be transmitted "cross-aisle" to the Master Send position. The Master Send position is located within the upper half of an incoming line console. This position utilizes a multiple-address push-button panel which is operated similarly to other panels, with the exception that it provides up to 40 push-buttons which can be depressed for simultaneous transmission of multiple-address messages. If a routing pattern is established on the Master Send push-button panel, and one or more circuits should be busy, the Master Send Spill-over or Dual push-buttons can be depressed for subsequent transmission of the message when the busy circuits become available. This is accomplished by first releasing the routing pattern and then selecting a new one before transferring the message to a Master Send Spill-over or Dual position.

i. Depressing the Local buttons on any of the push-button panels will cause the message at the associated operating position to be transmitted directly to either of two pageprinters. These two pageprinters are located within the Service and Re-run Section of the Tape Relay Room (see fig. 5-2). The messages switched to this section are of a local nature that may deal with requests for message re-runs.

j. Message re-runs or supervisory messages originate with the Service and Re-run Section and are transmitted by either of two M-19 teletypewriter sets directly to a "Local Operating Position" located among the incoming line consoles (see fig. 5-4). This local operating position consists of equipment which is the same as that used to terminate two circuits in the switching center, namely, the upper and lower operating positions of an incoming line console. The re-runs or supervisory messages can then be switched from this position to the desired sending line circuit.

k. The push-button panels are also equipped with other signal lamps and operational push-buttons which are used as described in the following paragraphs.

(1) *Reset Push-Button.* Transmission of bell signals from a station will cause a signal chime to sound and the Message Waiting lamp to flash in the Tape Relay Room. These signals are employed when an incoming message requires immediate attention. Depressing the reset button will cause the chime signal to be discontinued and the lamp to return to its normal function.

(2) *Message Waiting Lamp.* The Message Waiting Lamp glows when a message is waiting to be switched in the transmitter-distributor.

(3) *Stand-by Lamp.* When a push-button on the switching panel is depressed for a channel, the Stand-by lamp will glow, indicating that a channel has been selected.

(4) *Operate Lamp.* The Operate lamp will glow as soon as the switching operation is completed and the transmitter-distributor has been connected to the outgoing channel.

(5) *Connection Disconnect Push-Button.* This push-button is depressed when an incorrect channel selection has been made and it is desired to break the connection.

(6) *Message Disconnect Push-Button.* The Message Disconnect push-button is provided to facilitate disconnection of a previously selected channel in the event of channel trouble.

(7) *Low-Tape Lamp.* The Low-Tape lamp will glow when a new role of tape is required on the typing reperforator associated with that panel.

(8) *Line Signal Indicator Lamp.* The line signal indicator lamp will flash intermittently as messages are being received on the typing reperforator.

5–5. Monitor-Control Console

a. The Monitor-Control is similar in size and general design to the incoming line console, and is located at one end of a row of incoming line consoles. A close-out switch and lamp are provided on the Monitor-Control Console for each station to which messages are sent. This switch can be operated to prevent selection of any circuit switch is inoperative. With the switch in the "close-out" position, a message being transmitted will be completed, but subsequent selection of circuits will be stopped. With the switch in the "stand-by" position, message transmission stops immediately.

b. No typing reperforators or transmitter-distributors are mounted in the Monitor-Control Console. A keyboard-operated perforator, however, is provided for preparing supervisory messages. The Monitor-Control Console houses the control equipment used for master-sending.

5–6. Sending Circuit Cabinet

a. The equipment associated with the sending line circuits is installed in a Sending Circuit Cabinet. Normally, each cabinet provides equipment for 20 sending lines which send to a total of 20 destinations. To provide for the maximum of 60 destinations for which the push-button panels may be equipped, three sending circuit cabinets are required.

b. Each cabinet is arranged to mount 20 automatic numbering machines and 23 relay banks. Twenty relay banks are associated with line circuits, and three are associated with the automatic numbering machine distributors and monitor printer circuits. The automatic numbering machine associated with each sending line circuit is activated when a push-button at one of the operating positions is depressed. This causes an automatic number to precede the transmission of the message tape and to be simultaneously recorded on a number record pageprinter (teletypewriter monitor) located within the station. The numbering machine is disconnected from the line upon the completion of its numbering cycle. The automatic number may include the following information: Designation of the transmitting relay station; designation of the receiving relay station; channel or sending line circuit designation together with the total number of transmissions for that particular channel or sending line circuit. This minimizes manual record keeping within the station and provides a record of messages relayed as well as the continuity of service.

c. The cabinet also houses two transmitter-distributors which transmit the automatic number signals, and rotary switches for connecting these transmitter-distributors and their associated monitor printers to the numbering machines and to the relays associated with the sending lines. A third transmitter-distributor is used for master sending when required.

5-7. Number Record Printers

a. Number Record Printers are utilized in tape relay to provide a complete automatic written record of all automatic numbers, the precedence, and the routing indicators of all stations to which the message is addressed. Two number record (page) printers are associated with each sending circuit cabinet and serve a maximum of 20 sending circuits. Each printer set consists of a standard page-printer mounted in a console with a suitable wiring cabinet. The pageprinter is equipped with contacts that operate on "Line-Feed" and "D" characters to release the printer from the sending line at the end of the second format line of each message, which consequently makes the printer available to some other sending line.

b. The master send position has its own associated monitor printer which is located adjacent to the number record printers. As soon as a routing pattern has been set up and transmission of a multiple-address message begins, the master send monitor printer records the entire message, including all automatic numbers associated with each sending line circuit or push-button depressed on the master send panel.

5-8. Tape Repeater Rack

a. One Tape Repeater Rack contains two operating positions, one above the other. Each operating position consists principally of a typing reperforator and a transmitter-distributor. Messages destined for points outside of the switching center are switched "cross-office" from the incoming line position to a receiving position in the tape repeater portion of the center. All messages that are directed to a channel are received on one typing reperforator. The typing reperforator of a repeater position is used to record in the form of a printed and perforated tape message sent at 75 words per minute (460 OPM) from the center switching aisle. These message tapes include the information supplied by the automatic numbering machines. Contacts that are actuated by the operation of a tape stop arm cause the typing reperforator of a tape repeater to feed out tape at the end of each message any time "tight tape" occurs between the reperforator and the transmitter-distributor.

b. Messages received on the typing reperforator in tape form are transmitted as make-break signals by the transmitter distributor to the Crypto Room. The start magnet of the transmitter-distributor is controlled or stepped by pulses from the coding equipment located in the Crypto Room. These step pulses allow the transmitter-distributor to send message characters at the rate required by the coding equipment. In this way, synchronization is maintained between the transmitter-distributor and the transmit crypto units. A neon Transmitter Pulse Signal lamp is associated with each transmitter-distributor, and flashes with pulses sent out by the coding equipment.

c. Tape repeaters associated with Plan 51.3B switching equipment are normally used in the manner just described. However, it sometimes becomes desirable to bypass the switching equipment in the handling of messages, such as might be the case where specific operational requirements dictate the use of cryptographic equipment on special patched-through circuits. In such cases, the tape repeaters act as a tape loop between the receiving and the transmitting cryptographic equipments, as shown in figure 5-6. Messages coming from the receiving cryptographic equipment are received on tape repeater typing reperforators at 60 words per minute. The messages are then automatically transmitted to the transmitting cryptographic equipment by the transmitter-distributor. To maintain synchronization, the start magnet of the transmitter-distributor is controlled or stepped, as previously mentioned, by the cryptographic equipment.

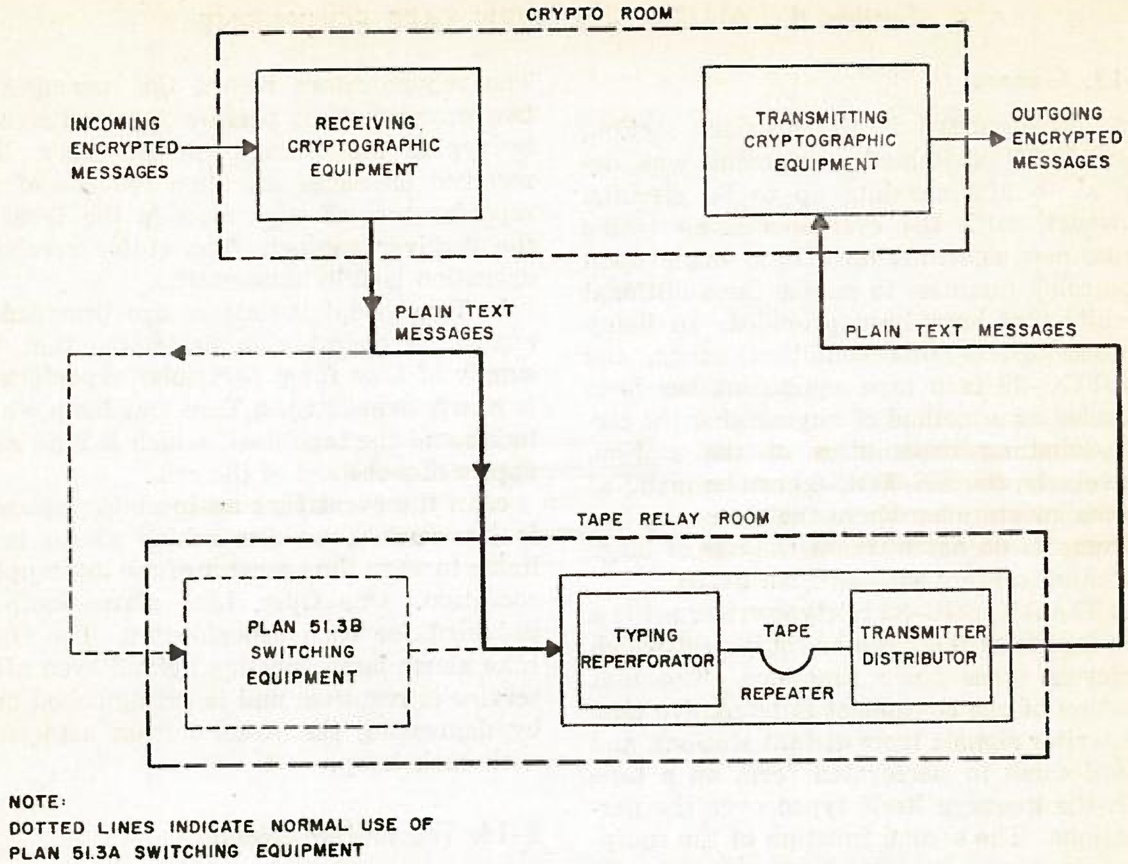


Figure 5-6. The Use of Tape Repeater, by-passing Plan 51.3B Switching Equipment.

5-9. Test Table

The Test Table provides for conveniently testing and adjusting pageprinters, typing reperforators, transmitter-distributors, automatic numbering machines, and relays. The test tables are equipped with a signal lamp for indicating open lines, a buzzer for indicating low tape on any of the typing-reperforators, and jacks connected to test loops extending to the Tech Control Room patch panel.

5-10. Rectifiers 603-B

The 603-B Mercury-vapor Rectifier is a polyphase, full-wave rectifier with a rated capacity of 15 amperes at 120 volts DC. It converts 3-phase, 208-volt, 220-volt, or 230-volt, 60-cycle power to 120 volts DC. The Rectifier supplies power to all incoming line consoles, sending circuit cabinets, and tape repeater racks.

5-11. Variations in Plan 51.3B

One other type of semi-automatic switching equipment presently used in Globecom (within the U.S.) is Plan 51. This equipment is similar to Plan 51.3B with the exception that Tape Repeaters are not used. For on-line crypto operation, the transmitter-distributor unit associated with each incoming line console is stepped or controlled by the crypto equipment.

Section II. AN/FGC-39 TORN TAPE EQUIPMENT

5-12. General

a. As discussed in the previous section, Plan 51.3B switching equipment was designed to accommodate up to 60 circuits. However, with the ever increasing traffic loads, new demands have been made upon tape relay facilities to handle the additional circuits that have been provided. In Relay Centers where this condition exists, the AN/FGC-39 torn tape equipment has been installed as a method of augmenting the circuit handling capabilities of the station. Conversely, the AN/FGC-39 can be installed at smaller stations where the tape relay requirements do not warrant the use of large switching centers such as Plan 51.3B.

b. The AN/FGC-39 teletypewriter set is a torn tape type relay center equipment which performs three basic functions. The first function of the equipment is to receive teletypewriter signals from distant stations, and record them in perforated form on a tape with the message itself typed over the perforations. The second function of the equipment is to produce teletypewriter signals from the perforated tape and to transmit these signals to the distant station. The third function is to automatically reproduce a monitor tape for storage of all messages and numbers.

c. The AN/FGC-39 teletypewriter set consists of three groups: a receiver group, a transmitter group, and a monitor group, each contained in a separate cabinet. The three groups combined make up one teletypewriter set. Each set is capable of handling three teletypewriter circuits.

5-13. Receiver Group

a. The receiver group consists, basically, of three typing reperforators, each of which is connected to a separate incoming signal line. A fourth reperforator, also included, is used as a spare. The receiver group is capable of receiving three messages simultaneously at a rate of 60 WPM. The incoming messages are in the form of teletypewriter signals and are applied to the reperforators. The reperforators record the messages in two ways: first, by perforating; and second, by typing the message on the tapes. The received messages are then fed out of the reperforators through slots in the front of the receiver cabinet. The entire receiving operation is fully automatic.

b. Two visual indicators are provided to enable an operator to determine that the supply of tape for a particular reperforator is nearly exhausted, a Tape Out lamp which lights and the tape itself which is read as it approaches the end of the roll.

c. In the event that an incoming message is interrupted, an Open Line alarm lamp lights to warn the operator of the interrupted condition. One Open Line alarm lamp is provided for each reperforator. The Open Line alarm lamp remains lighted even after service is restored, and is extinguished only by depressing the Reset button associated with each lamp.

5-14. Transmitter Group

a. The transmitter group consists, basically, of six message transmitter-distributors (TD's) and three number transmitter-distributors. Each outgoing signal line uses alternately either one of two message TD's and one number TD.

b. A message tape to be transmitted is manually torn from one of the slots in the receiver group and inserted in either of the two message TD's associated with a particular outgoing line. Prior to transmission, the inserted message is automatically numbered; this is accomplished by the numbering TD's which transmit a number for each message. During transmission of a message, a second tape may be inserted in the associated TD not in use. Upon completion of transmission of the first message, the message in the second TD is automatically numbered and transmitted. Thus, messages are sent continuously with no loss of time. All messages on each outgoing line are numbered according to the number tape inserted in the number TD associated with that line.

If it is desired to transmit a message without a number, the Number-Delete switch on the front panel is held in the delete position.

c. A channel Busy lamp on the front of the transmitter cabinet is provided for each outgoing line. During the transmission of a message over a given line, the channel Busy lamp remains lighted, and extinguishes only when no message is being transmitted on that line. When transmission is interrupted due to an open outgoing line, the TD carrying the message stops automatically and an Open Line alarm lamp, associated with that line, lights.

d. If a message being received is long, the message may be transmitted directly from the receiver group without tearing the tape. This is accomplished by connecting an auxiliary TD unit at the receiver group and inserting the message tape directly into the auxiliary unit. In this operation, the Normal-Long Message switch on the appropriate transmitter group is placed in the Long Message position.

5–15. Monitor Group

a. The monitor group is composed basically of three reperforators, three time stamps, and three tape reeling machines. One reperforator, one time stamp, and one tape reeling machine are connected to the output of a pair of tandem TD's associated with a particular outgoing line.

b. A copy of each transmitted message is produced by the reperforators in the monitor group, and stored on a reel by the tape reeling machine. The time stamp marks the message tape with the year, month, day, hour and minute once every minute as long as the circuit is conditioned for transmission.

c. Message recorded by the monitor group may be retransmitted, if required, through

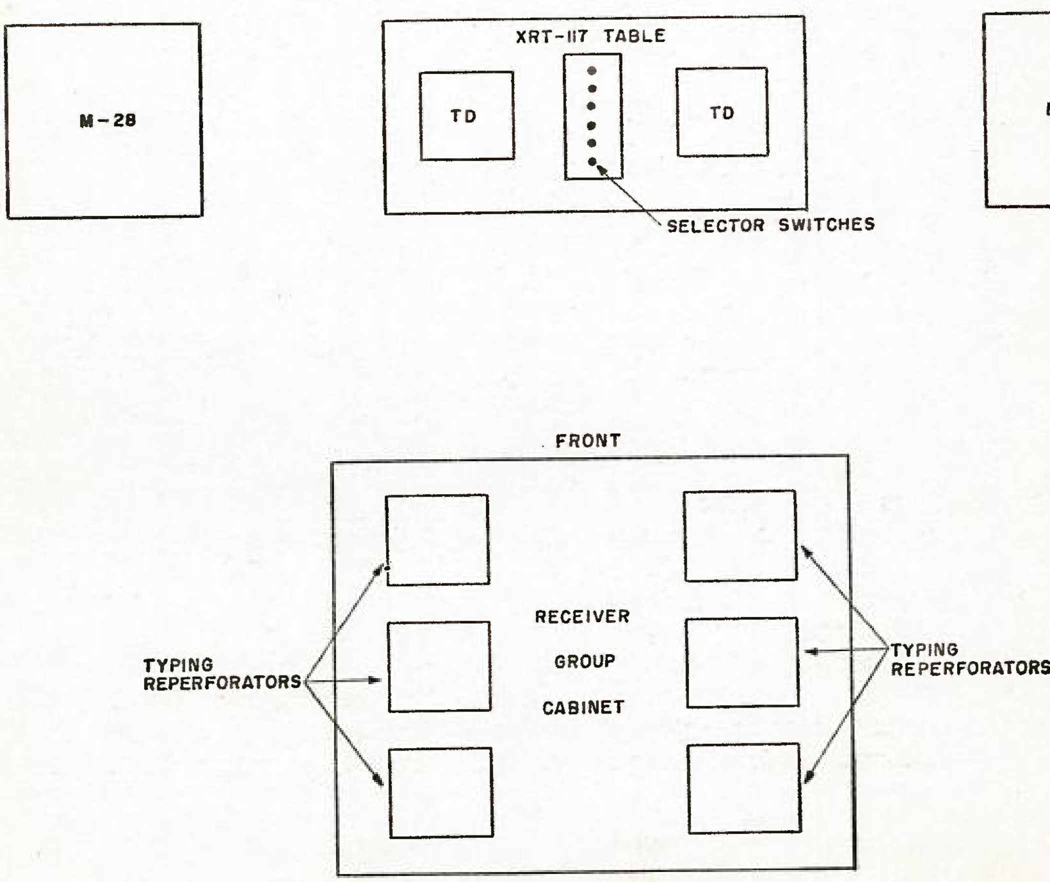


Figure 5–7. AN/FGC–39 ZVA Installation.

the TD's in the transmitter group or through an auxiliary Td unit at the monitor group.

5-16. Crypto Operation

Crypto operation with the AN/FGC-39 is somewhat similar to that used with Plan 51.3B; but, instead of having the Tape Repeater TD's stepped or controlled by the crypto equipment, the TD units associated with the AN/FGC-39 Transmitter Group are stepped or controlled. On receiving line circuits, the decrypted messages coming from the Crypto Room are fed to the AN/FGC-39 Receiver Group instead of the Incoming Line Consoles as is the case in Plan 51.3B equipment.

5-17. ZVA

A ZVA position is included in each tape relay installation employing AN/FGC-39 equipment. Essentially, this position functions as a tape duplicating device for multiple address messages. As shown in figure 5-7, this position consists of two TD's and six selector switches mounted on an XRT-117 table, two M-28 teletypewriter sets located on both sides of the table, and a special receiver group cabinet containing six typing reperforators. This position is used in instances where a message received is to be relayed to more than one station. In this case, the message tape is placed in any one of the two TD's, and the selector switches are placed in the positions which select the desired TD and reperforator combinations. The message is then transmitted to the reperforators where as many as six tape duplicates can be made simultaneously, depending upon the number of reperforators selected. The two M-28 Teletypewriter Sets meanwhile are used to obtain a hard copy of the message tape being duplicated.

Chapter 3

CRYPTO ROOM

Section I. INTRODUCTION

5-18. General

a. The Crypto Room contains cryptographic equipment for encrypting outgoing messages and decrypting incoming messages. The equipment is designed for on-line crypto operation in which all incoming messages are decrypted and all outgoing messages are encrypted automatically. The on-line crypto operation planned for Globecom is accomplished by two systems. One system is known as the "synchronous system," the other as the "non-synchronous system." The on-line cryptographic equipment associated with the "synchronous system" is the TT-160/FG (SSM-4) Synchronous Teletypewriter Mixer. The on-line cryptographic equipment associated with the non-synchronous system is the SSM-3 Teletypewriter Mixer.

b. In the synchronous system, the sending portions of the mixers are controlled by a frequency standard at the transmitting terminal, and the receiving portions are controlled by a frequency standard at the receiving terminal. The receiving frequency standard is synchronized with the transmitting frequency standard by the received teletypewriter signal, when the signal is present. If the teletypewriter signal is lost, the natural stability of the frequency standards is sufficient to maintain synchronization between transmitting and receiving terminals for periods up to one-half hour, and frequently longer.

c. In the non-synchronous system, the send and receive mixers are not synchronized by frequency standards. They are synchronized, however, character by character, by pulses which are part of the teletypewriter signal itself. Such dependence on this signal for synchronization of teletypewriter circuits often proves unsatisfactory, since any line or link disturbance, such as noise and fading, could cause pulses to be added or lost at the receiving end with subsequent loss of synchronization. Once synchronization has been lost, improper decrypting takes place, resulting in a continuous "garbled" output at the receiving station. The non-synchronous system, therefore, is used only on teletypewriter circuits where disturbance such as noise and fading are not likely to occur, as in the case of reliable on-base landline circuits.

d. The teletypewriter coding system employed with the TT-160/FG and the SSM-3 teletypewriter mixers mixes the signal pulses of a plain text teletypewriter message, character by character, with the signal pulses of a crypto key to produce an encrypted message. In this case, the crypto key is set up in a "Transmit Crypto" unit. The encrypted message is automatically decrypted at the receiving station by the combination of the signal pulses of the encrypted message, character by character, with an identical key from a "Receive Crypto" unit. Both the TT-160/FG and the SSM-3 teletypewriter mixers provide some of the circuits which are required to perform this mixing process.

e. The encryption procedure explained above follows the laws of multiplication applying to signs: multiplying like signs produces a positive (plus) sign, and multiplying unlike signs produces a negative (minus) sign. Thus, plus times plus = plus; minus

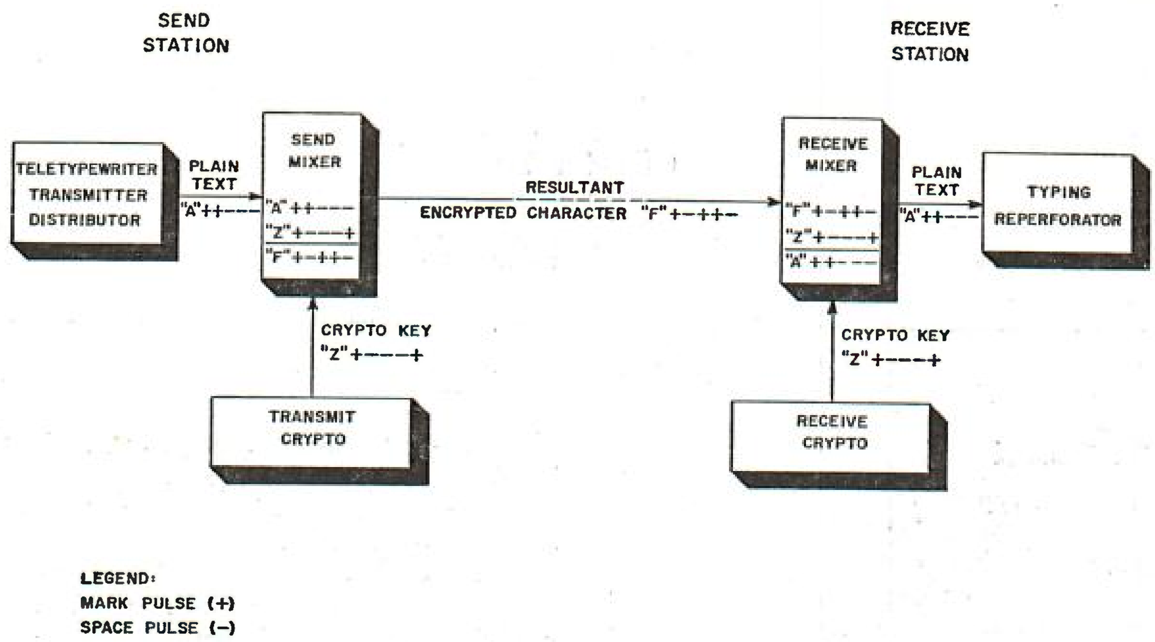


Figure 5-8. On-line Encryption.

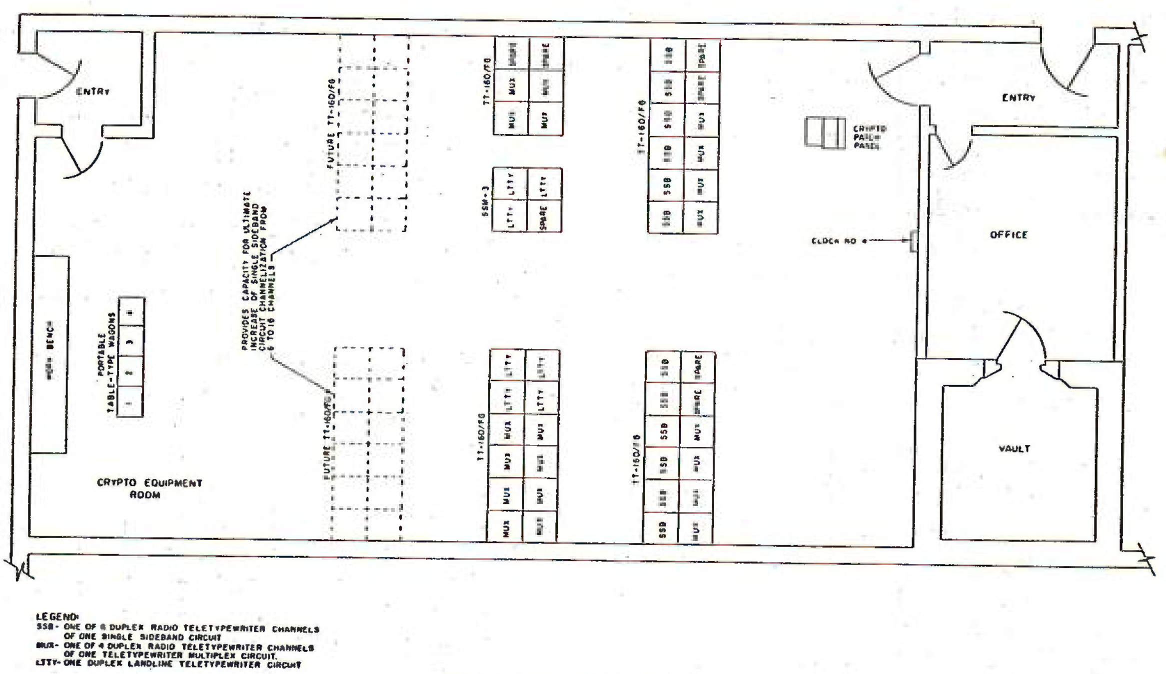


Figure 5-9. Crypto Room.

times minus = plus; and minus times plus = minus. As shown in figure 5-8, if a teletypewriter space pulse is represented by a minus (−) and a mark pulse is represented by a plus (+), then mixing the plain text character "A" with the crypto key character "Z" from the Transmit Crypto unit produces the encrypted character "F" which is transmitted to the distant station. The receive mixer receives the encrypted character "F" and mixes it with the same crypto key character "Z", this time coming from a Receive

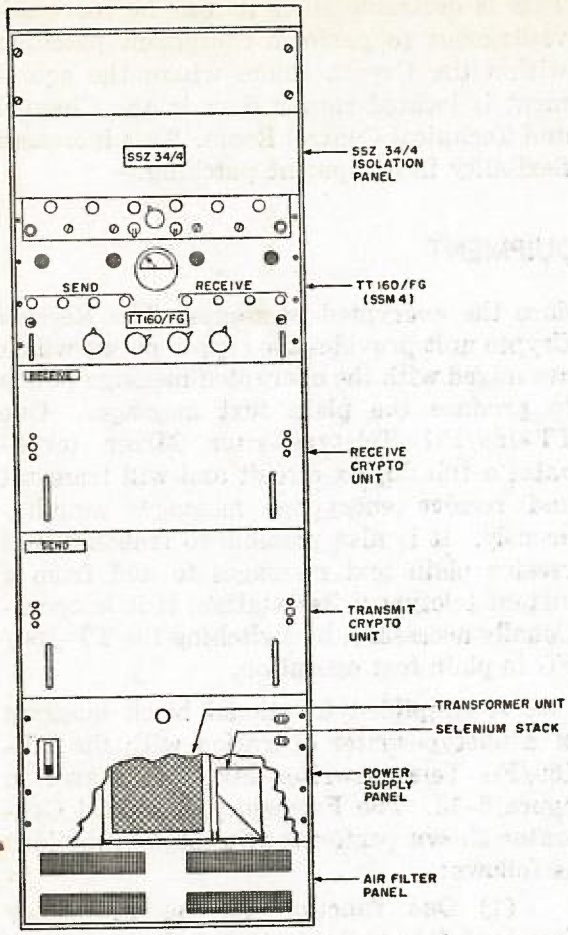


Figure 5–10. Cryptographic Equipment Assembly Rack for Teletypewriter Mixer.

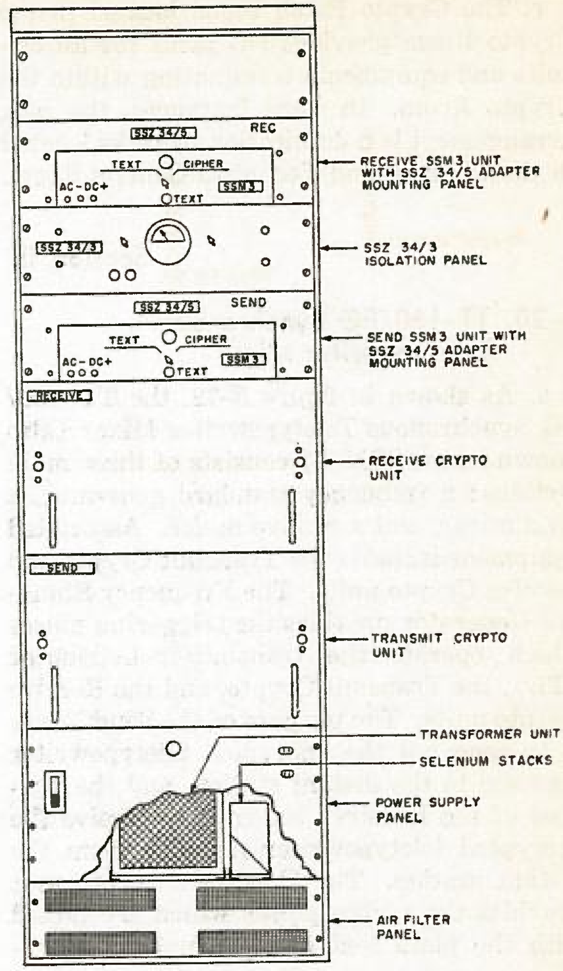


Figure 5–11. Cryptographic Equipment Assembly Rack for SSM–3 Teletypewriter Mixer.

Crypto unit, which produces the same plain text character "A" that was originally introduced into the system. This procedure is repeated for each character contained in a teletypewriter message with the exception that the crypto key character may be different for each plain text character to be encrypted, depending entirely upon the key that is used.

5–19. Plan

a. The Crypto Room floor plan is shown in figure 5–9. The TT–160/FG Synchronous Teletypewriter Mixers are located in special racks (fig. 5–10) which also accommodate two crypto units (one transmit and one receive), and a 120-volt, direct-current power supply. The SSM–3 Teletypewriter Mixers also are located in special racks (fig. 5–11) constructed to accommodate two crypto units and a 120-volt direct-current external power supply. Isolation panels are provided in both racks to permit electrical isolation between the crypto equipment and the DC Patch Bays located in the Channel and Technical Control Room.

b. Portable table-type wagons which can carry various test equipments, such as oscilloscopes for local testing purposes, are provided in the Crypto Room. Other portable wagons also contain M–19 teletypewriters that can be attached to any of the cryptographic equipments for testing purposes as well as for conferring with distant teletypewriter stations.

c. The Crypto Patch Panel located in the Crypto Room provides DC jacks for all circuits and equipments terminating within the Crypto Room. In some instances, the jack arrangement is a duplication of jacks located in the Channel and Technical Control Room. This is desirable since it may be more advantageous to perform equipment patching within the Crypto Room where the equipment is located rather than in the Channel and Technical Control Room. This increases flexibility in equipment patching.

Section II. EQUIPMENT

5–20. TT–160/FG Synchronous Teletypewriter Mixer

a. As shown in figure 5–12, the TT–160/FG Synchronous Teletypewriter Mixer (also known as the SSM–4) consists of three main sections: a frequency standard generator, a send mixer, and a receive mixer. Associated equipment includes the Transmit Crypto and Receive Crypto units. The Frequency Standard Generator provides the triggering pulses which operate the transmitter-distributor (TD), the Transmit Crypto, and the Receive Crypto units. The purpose of the Send Mixer is to send out the encrypted teletypewriter message to the distant station, and the purpose of the Receiver Mixer is to receive the encrypted teletypewriter message from the distant station. The Transmit Crypto unit provides the crypto pulses which are mixed with the plain text message pulses to produce the encrypted messages. The Receive Crypto unit provides the crypto pulses which are mixed with the encrypted message pulses to produce the plain text messages. One TT–160/FG Teletypewriter Mixer terminates a full duplex circuit and will transmit and receive encrypted messages simultaneously. It is also possible to transmit and receive plain text messages to and from a distant teletypewriter station, if it is operationally necessary, by switching the TT–160/FG to plain text operation.

b. A simplified functional block diagram of a teletypewriter operation with the TT–160/FG Teletypewriter Mixer is shown in figure 5–13. The Frequency Standard Generator shown performs two major functions as follows:

(1) One function of the Frequency Standard Generator is to supply the pulses

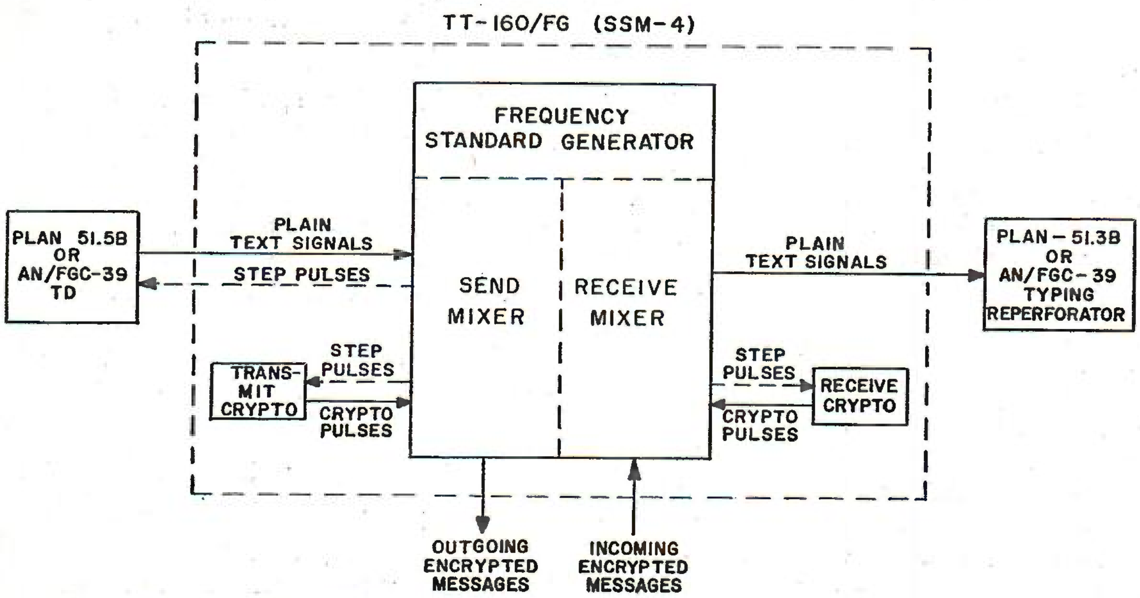


Figure 5–12. Simplified Block Diagram of the TT–160/FG Synchronous Teletypewriter Mixer.

that are used to synchronize the Transmit Crypto and TD unit of a sending circuit with the Receive Crypto unit of the distant station. The synchronizing of the Transmit Crypto and TD units is accomplished through stepping pulses from the Crypto and TD stepping circuits which are located in the Send Mixer section of the TT–160/FG. These stepping pulses operate the start magnets of both the TD and Transmit Crypto unit of a sending circuit at properly timed intervals. The Receive Crypto unit of the distant station is operated by pulses which are obtained from the received encrypted teletypewriter signal.

(2) The other function of the Frequency Standard Generator is to keep the local Receive Crypto unit in synchronism with the Transmit Crypto unit of the distant station in the event of a circuit failure. The Frequency Standard Generator accomplishes this by supplying stepping pulses which operate the start magnet of the Receive Crypto unit. In this manner, the Receive Crypto unit is kept in step with the Transmit Crypto unit of the sending station when there is a complete absence of a received signal.

c. The received signal (see fig. 5–13), when present, provides the timing correction circuit with pulses. This circuit then feeds step pulses to the receive crypto unit so that they occur at the same time interval as identical pulses that feed the transmit crypto unit occur. In other words, the timing correction circuit aligns the step pulses to the Receive Crypto unit with the pulses of the teletypewriter signal coming from the distant Transmit Crypto unit.

d. When there is no output from the TD unit, such as would occur when no messages are being sent, the crypto disable circuit (see fig. 5–13) changes the teletypewriter signal output from a crypto signal to a synchronizing signal which actuates the printer shut-off circuit at the distant station. The printer shut-off circuit stops the printer when a message is not being received.

e. The TT–160/FG Synchronous Teletypewriter Mixer was originally designed to op-

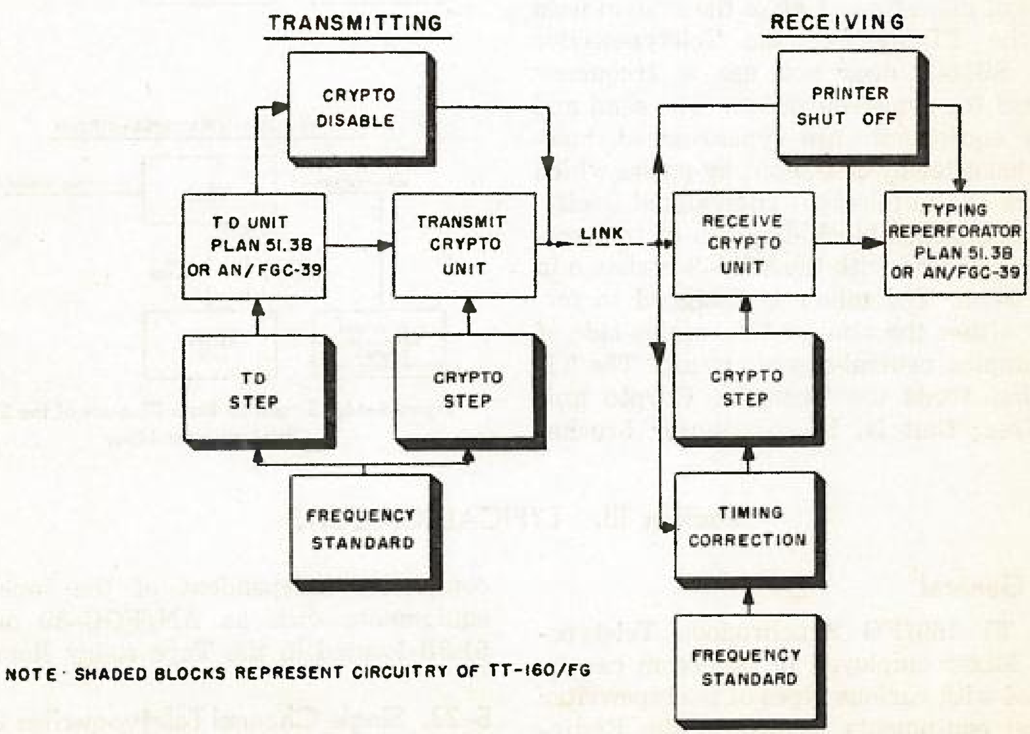


Figure 5–13. Simplified Functional Block Diagram of Teletypewriter Operation with the TT–160/FG Teletypewriter Mixer.

erate in a 60-word-per-minute system. However, with the advent of modern teletypewriter techniques, such as the use of the AN/FGC–5 Multiplex Telegraph Terminal Set (refer to Chapter 4), the TT–160/FG Teletypewriter Mixer and associated equipment were modified. The AN/FGC–5 is a teletypewriter unit which enables simultaneous transmission of as many as four teletypewriter signals. Since the teletypewriter equipment employed with the AN/FGC–5 operates at a rate slightly greater than 60 words per minute, the frequency of the step pulses must be increased. This is accomplished by using the reference frequency employed with the AN/FGC–5 rather than the one associated with the TT–160/FG as the frequency standard. The speed of the TD units employed with the TT–160/FG also must be increased so that the units can operate at the new stepping rate.

5–21. SSM–3 Teletypewriter Mixer

a. The SSM–3 Teletypewriter Mixer (see fig. 5–11) is the on-line cryptographic equipment associated with the non-synchronous system of operation. Unlike the system used with the TT–160/FG, the Teletypewriter Mixer SSM–3 does not use a frequency standard for synchronization. The send and receive equipments are synchronized, however, character by character, by pulses which are part of the teletypewriter signal itself.

b. A simplified block diagram of teletypewriter operation with the SSM–3 is shown in figure 5–14. The mixer is designed to terminate either the send or the receive side of a full-duplex neutral-signal circuit. The TD unit that feeds the Transmit Crypto unit runs free; that is, its distributor brushes rotate without being stopped at any time during transmission of a message. The Transmit Crypto unit, however, is stepped by pulses that are part of the signal coming from the TD unit. On the receive side of the full-duplex circuit, the Receive Crypto unit is stepped by pulses that are part of the incoming signal. As mentioned previously, one disadvantage of this type of operation is the loss of synchronization between the Transmit and Receive Crypto units when circuit failures occur. The reason for this is that the Receive Crypto unit fails to be stepped, due to absence of incoming signal, while the Transmit Crypto unit continues to be stepped through pulses from its associated TD unit.

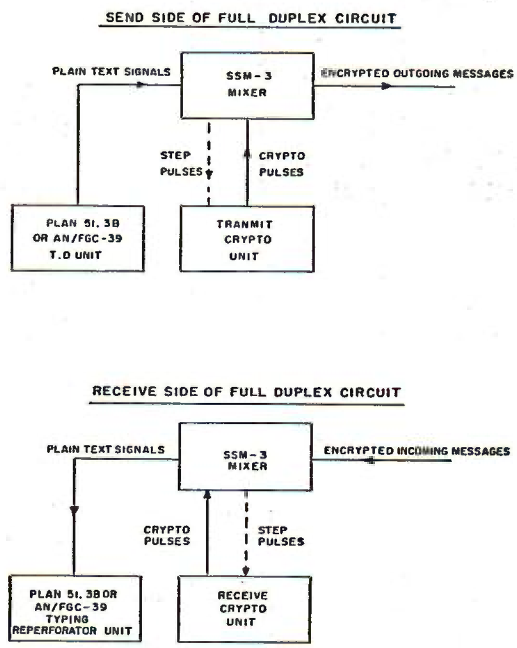


Figure 5–14. Simplified Block Diagram of the SSM–6 Teletypewriter Mixer

Section III. TYPICAL CIRCUITS

5–22. General

The TT–160/FG Synchronous Teletypewriter Mixer employed in Globecom can be operated with various types of teletypewriter terminal equipments located in the Equipment Room. It can be associated with or completely independent of the tape relay equipments such as AN/FGC–39 or Plan 51.3B located in the Tape Relay Room.

5–23. Single-Channel Teletypewriter Circuit

Figure 5–15 shows the TT–160/FG used

in a single-channel radio teletypewriter circuit which is terminated by the tape relay equipment. The frequency standard generator is shown controlling or stepping the transmitter distributor of the tape relay equipments when transmitting.

5-24. Four-Channel Mux Circuit

Figure 5-16 shows the TT-160/FG associated with the AN/FGC-5 Multiplex Telegraph Terminal Set previously mentioned. The transmitting and receiving circuits are both terminated by tape relay equipment. Because of a slightly higher operating speed, the synchronizing frequency of the AN/FGC-5 is used as the frequency standard.

5-25. Single Sideband Circuit

Figure 5-17 shows the TT-160/FG associated with the single sideband terminal equipment which is capable of handling as many as six teletypewriter channels simultaneously. Further explanation of this equipment is given in Chapter 4. The circuits here are also terminated by tape relay equipment.

5-26. Miscellaneous Circuits

Figure 5-18 shows the TT-160/FG used with both the AN/FGC-5 and single sideband terminal equipments. In this case, the messages received do not terminate in the tape relay center proper but are sent through a tape repeater which records the messages and then transmits them to a transmitting circuit. It must be understood, however, that both the receiving and transmitting terminal equipments do not necessarily have to be as shown in figure 5-18. They can be either AN/FGC-5, single sideband, single-channel radio teletypewriter, or any combination, depending upon circuit requirements.

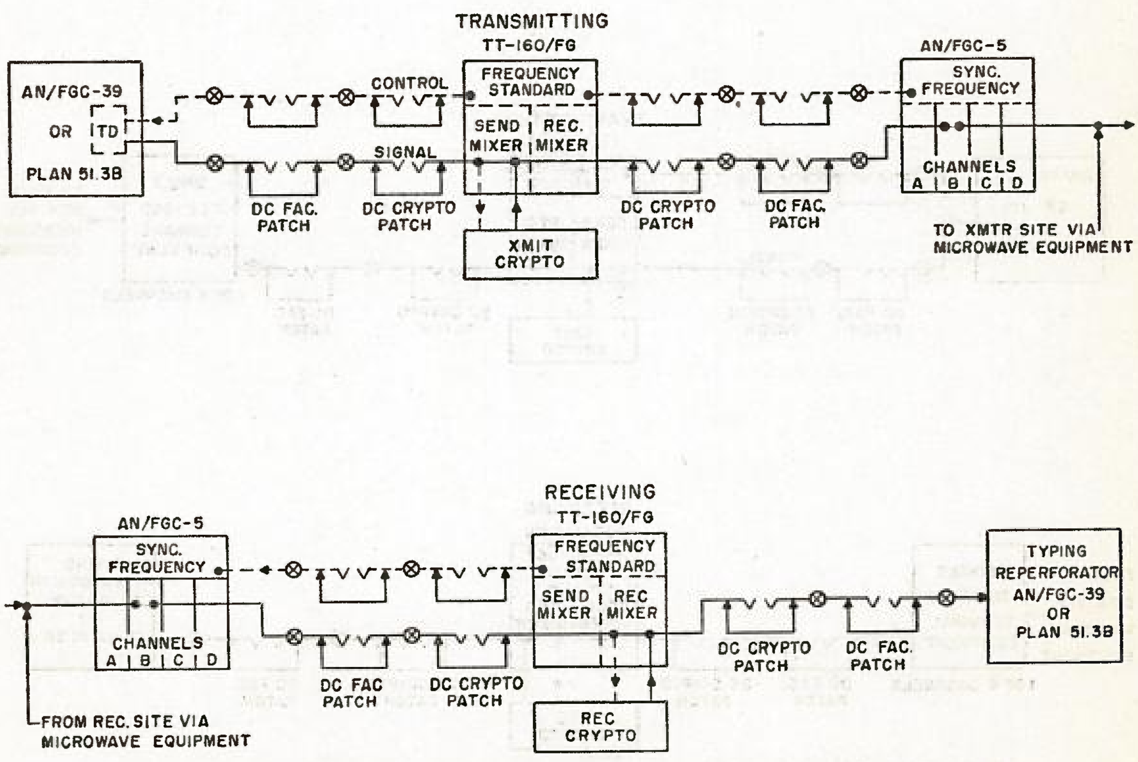


Figure 5-15. TT-160/FG Teletypewriter Mixer, Associated with a Single-Channel Radio Teletypewriter Circuit, Terminated in the Switching Center.

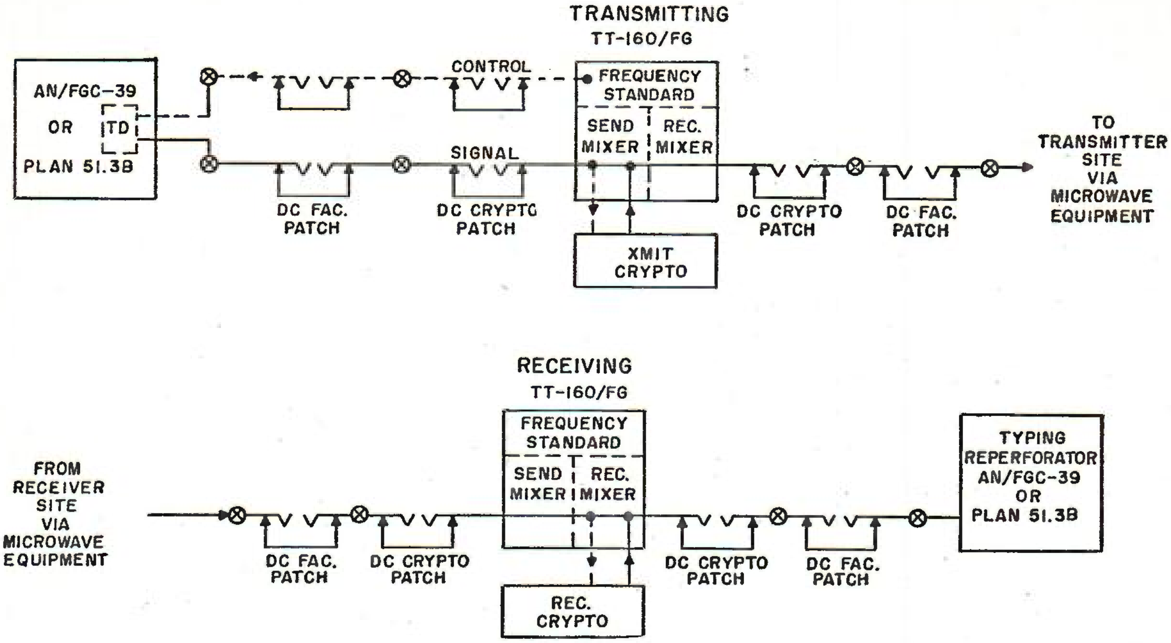


Figure 5-16. TT-160/FG Teletypewriter Mixer, Associated with the AN/FGC-5 Telegraph Terminal Set, Terminated in the Switching Center.

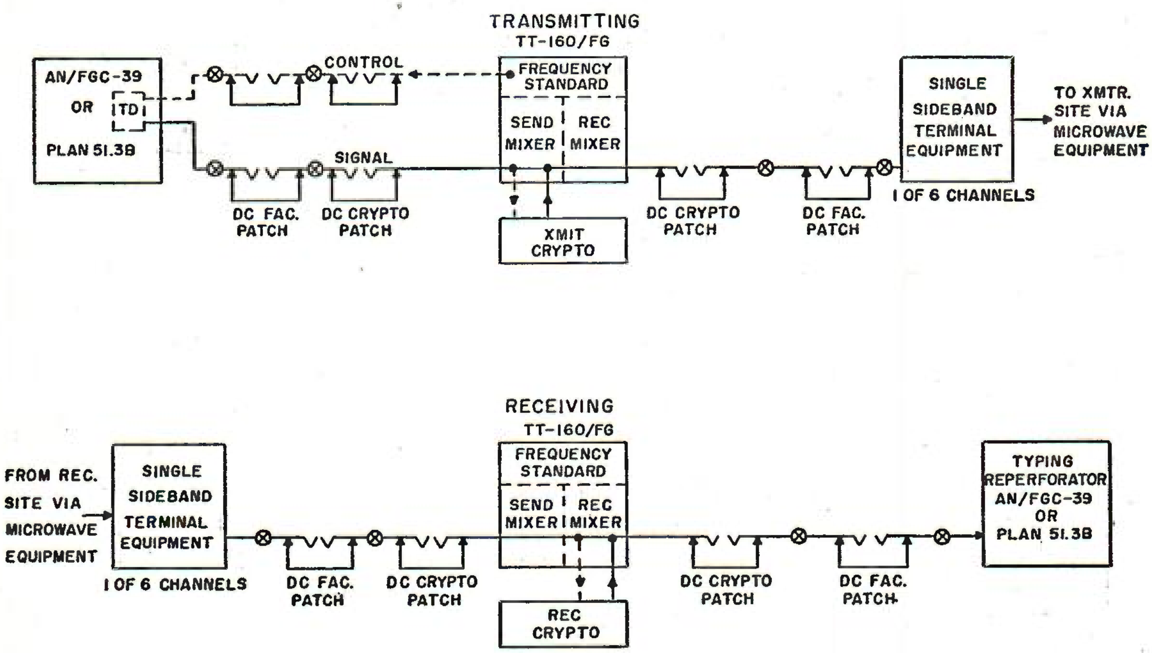


Figure 5-17. TT-160/FG Teletypewriter Mixer, Associated with Single Sideband Equipment, Terminated in the Switching Center.

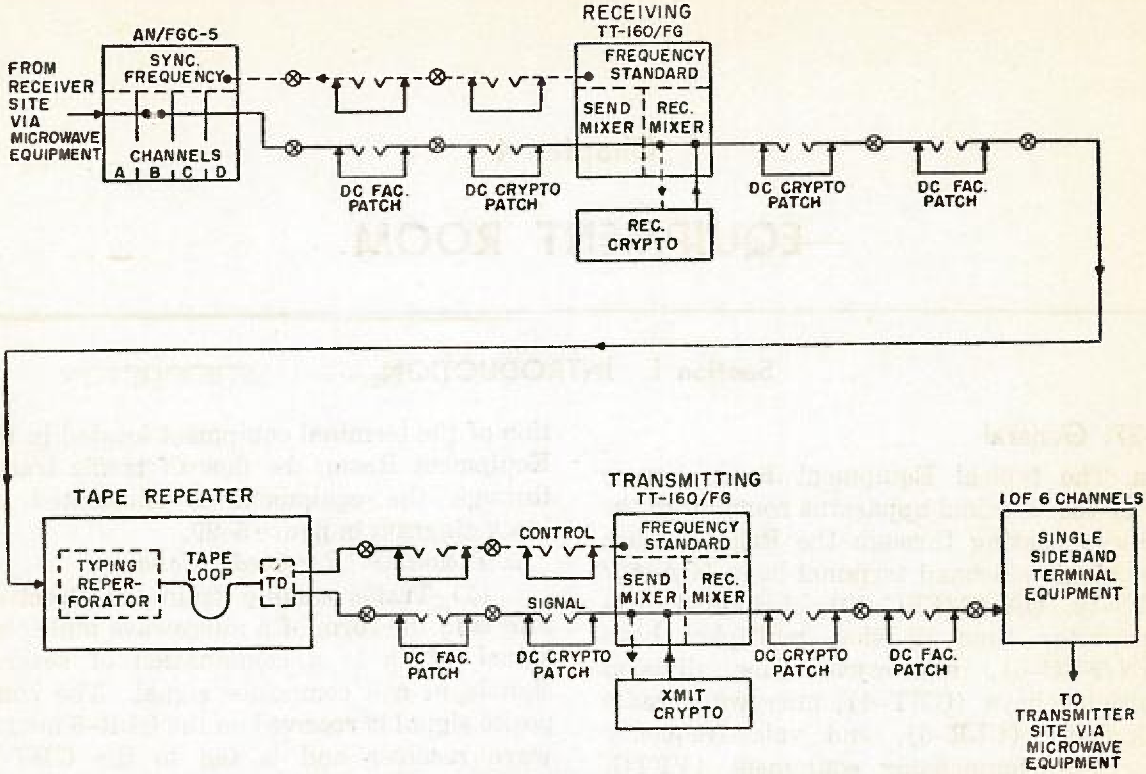


Figure 5–18. TT–160/FG Teletypewriter Mixer, Associated with the AN/FGC–5 Telegraph Terminal Set and Single Sideband Equipment, by-Passing the Switching Center.

Chapter 4

EQUIPMENT ROOM

Section I. INTRODUCTION

5-27. General

a. The typical Equipment Room houses all of the terminal apparatus common to the circuits passing through the Relay Center. The single sideband terminal bays (OA-63/FRC-10, OA-64/FRC-10), 4-channel teletypewriter time division multiplex bays (AN/FGC-5), microwave time division multiplex bays (CMT-4), microwave radio link bays (CLR-6), and voice-frequency telegraph channelizing equipment (VFTG, Type 152, 153) for the microwave links are located in this area.

b. In addition to the main equipment mentioned above, the Equipment Room contains some auxiliary equipment essential to station operation and efficiency. The auxiliary equipment is as follows:

(1) Test Transmitter, 110C 1

(2) Signaling and Termination Unit, CST-2

(3) Regenerative Repeaters, SFO-2

(4) 20-cycle, 24-volt Fuse and Rectifier Bay

(5) 120-volt Fuse Bay

(6) Transmitter Distributor (TD) Control

(7) 120-volt Supply, PP-108-TG

c. The equipment layout for the Equipment Room is shown in figure 5-19. Overhead racks carry inter-connecting cables between equipments and between equipments and the distributing frame located in the Tech Control Room.

5-28. Traffic Flow

In order to more clearly present the function of the terminal equipment located in the Equipment Room, the flow of traffic traced through the equipment is illustrated by block diagram in figure 5-20.

a. *Incoming (Received) Signals.*

(1) Traffic coming from the Receiver Site is in the form of a microwave multiplex signal which is a combination of several signals in one composite signal. The composite signal is received on the CLR-6 microwave receiver and is fed to the CMT-4 microwave multiplex equipment where it is broken down into the original separate audio signals.

(2) The original signals may be carried by the following types of circuits:

(a) A-G Voice

(b) Manual CW

(c) Facsimile

(d) Single-Channel Radio Teletypewriter Telegraph

(e) Four-Channel Teletypewriter, Time Division Multiplex

(f) Single Sideband, Frequency Division Multiplex (six teletypewriter channels plus one voice channel)

(3) The received A-G Voice signals are fed directly to the operating positions in the A-G Room, through an amplifier and headset arrangement.

(4) The received manual CW signals are fed directly to the point-to-point CW positions which may be located in the A-G Room. These signals are the Morse Code dots and dashes in audio tone form.

(5) The received facsimile signals are fed directly to the facsimile equipment nor-

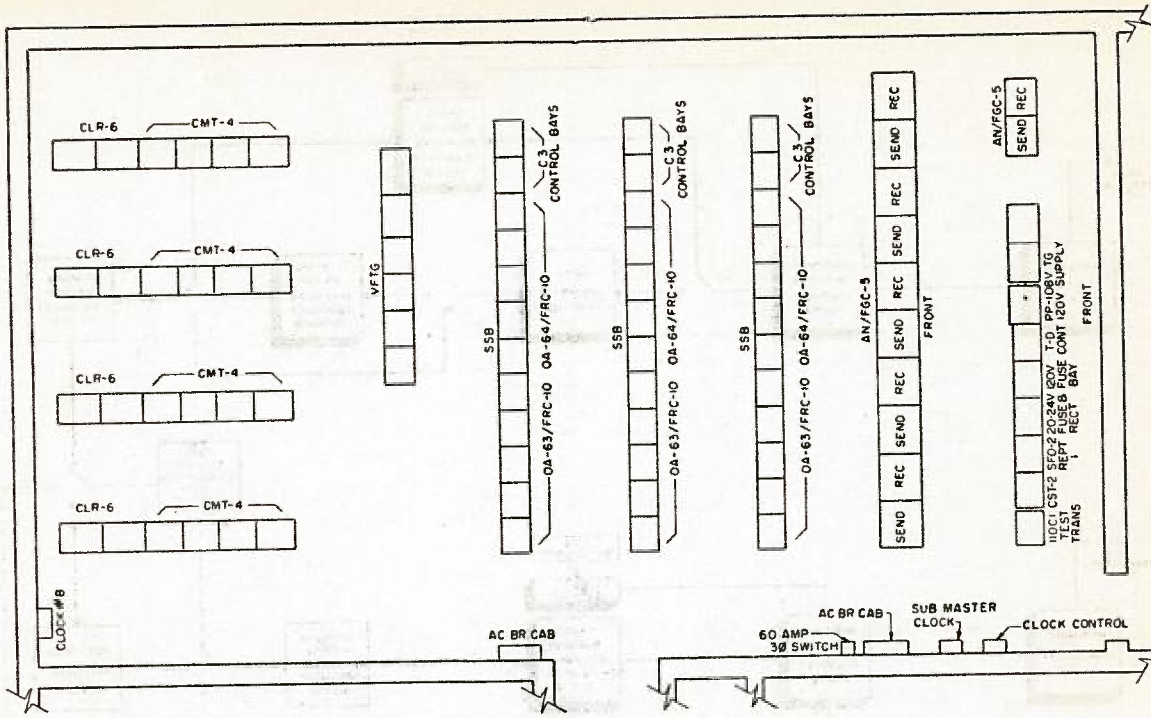


Figure 5–19. Equipment Room.

mally located in the Air Weather Central. These facsimile signals carry the intelligence necessary for the reproduction of weather maps.

(6) If the received signals are those of a single-channel radio teletypewriter circuit, they are fed through a Type 152 VFTG Converter which converts the teletypewriter audio tone signals into neutral DC teletypewriter pulses. The DC pulses are fed into the on-line crypto equipment (TT–160/FG) where the intelligence is decrypted and changed into plain text.

(7) If the received signals are those of a single sideband circuit, they are fed through the single sideband terminal equipment OA–63/FRC–10 and OA–64/FRC–10. The signals consist of several audio tones, separated by 170 cycles, which represent six separate teletypewriter channels in one sideband channel and a voice telephone circuit in the other. The OA–63, OA–64 single sideband terminal equipment demodulates and converts the audio signals on the teletypewriter channel to six separate neutral DC teletypewriter signals. Each of the six teletypewriter signals are fed into six separate on-line crypto equipments (TT–160/FG) where decryption takes place. The telephone portion of this equipment (the C–3 Control Terminal) terminates the voice channel for connection to the base switchboard.

(8) If the received signals are those of a four-channel teletypewriter time division multiplex (MUX) circuit, they are fed through a Type 152 VFTG Converter. The converter converts the MUX audio tone signals representing four separate teletypewriter channels into MUX DC teletypewriter pulses. The pulses are fed to the AN/FGC–5 MUX equipment which separates them into four individual teletypewriter signals. Each of the four teletypewriter signals is fed into four separate on-line crypto equipments (TT–160/FG) for decryption.

(9) After decryption, the plain text teletypewriter messages are fed to either the tape relay equipment (Plan 51.3B or AN/FGC–39) or to separate tape repeaters which are used on encrypted patch-through circuits. In either case, the messages are re-encrypte

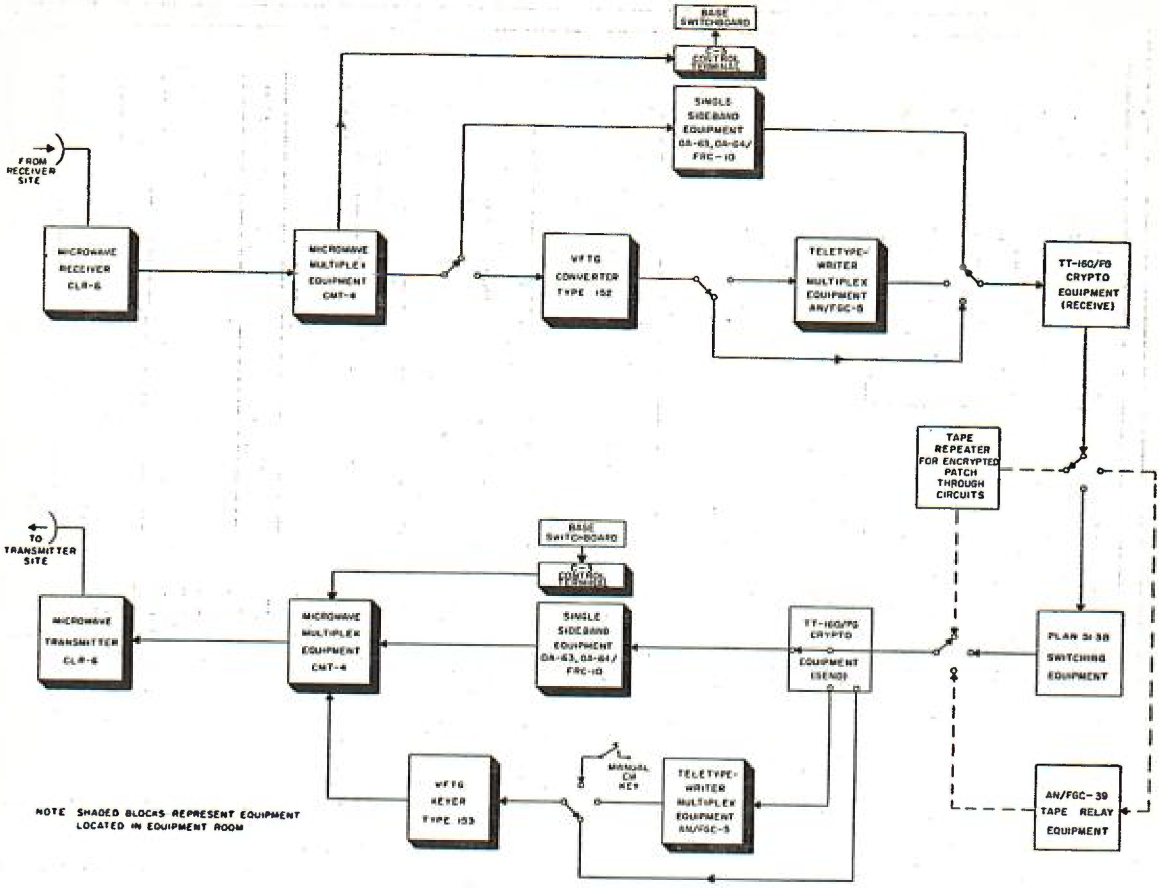


Figure 5–20. Traffic Flow Through the Equipment Room in the Relay Center.

before leaving the Relay Center.

b. *Outgoing (Relayed) Signals.*

(1) If the outgoing signals are relayed over a single sideband circuit, they are fed through the OA–63, OA–64 terminal equipment which is capable of handling the outputs of six separate teletypewriter TD's simultaneously. The signals are combined into a frequency division multiplex signal which consists of several audio tones that are separated by 170 cycles. The MUX signal is fed to the CMT–4 equipment where it is combined with other signals to form one composite signal. The telephone portion of the equipment (C–3 Control Terminal) accepts the voice signals from the base switchboard and prepares them for transmission over the CMT–4 equipment where they, also, become part of the composite signal.

(2) If the outgoing signals are relayed over a four-channel MUX circuit, they are fed to the AN/FGC–5 equipment. This equipment combines the four separate teletypewriter TD outputs into a time division multiplex signal. The MUX signal is a neutral DC teletypewriter signal composed of one character from each of the four teletypewriter channels placed in time sequence. The MUX signal is fed through a Type 153 VFTG Keyer where the DC pulses are converted to frequency shift audio tones. The audio tones from the VFTG Keyer are fed to the microwave multiplex equipment where they become part of the composite output of the CMT–4.

(3) If the outgoing signal is to be relayed over a single-channel radio teletypewriter circuit, it is fed through a Type 153 VFTG Keyer. The VFTG Keyer converts the DC teletypewriter pulses into frequency

shift audio tones which are fed to the CMT-4 equipment.

(4) In case the outgoing signal is relayed over a manual CW point-to-point circuit, it is fed through a Type 153 VFTG Keyer which converts the DC morse code pulses into frequency shift audio tones. The audio tones are fed to the CMT-4 equipment where they, also, become part of the composite signal output.

(5) Also fed to the CMT-4 equipment are the A-G Voice and facsimile signals which come from the A-G Room and the Air Weather Central, respectively.

Section II. MAIN EQUIPMENT

5-29. General

a. With the ever increasing traffic load, the need has arisen for more circuits between Globecom stations. These additional circuits could be provided by establishing additional single-channel radio teletypewriter circuits; however, this is not practical since it is becoming increasingly difficult to obtain additional radio frequency assignments. Two methods which already have been developed and which are being used by Globecom to provide additional channels on the same radio frequencies are time division multiplex and frequency division multiplex.

b. The main equipments discussed in this section are AN/FGC-5 time division multiplex equipment and single sideband OA-63/FRC-10, OA-64/FRC-10 frequency division multiplex equipment. A detailed discussion of the microwave CMT-4 Time Division Multiplex Equipment, the CLR-6 Microwave Radio Link Equipment and the voice frequency telegraph channelizing equipment, NR-152 Tone Converter and NR-153 Tone Keyer, is presented in Part VII of this manual.

5-30. AN/FGC-5 Teletypewriter Time Division Multiplex Set

a. The AN/FGC-5 Teletypewriter Time Division Multiplex Equipment consists of two units, the Transmitting Group and the Receiving Group, which together comprise a complete send-receive electronic time-division multiplex teletypewriter terminal.

b. The AN/FGC-5 terminal set and associated teletypewriter equipment, together with similar equipment at a distant station (fig. 5-21) constitute the terminal facilities for increasing the capacity of a single-channel radio teletypewriter circuit to two, three, or four teletypewriter channels by employing the principle of time division multiplex.

c. The Transmitter Group accepts the neutral DC teletypewriter signals from the local sending line circuits such as Plan 51.3B or AN/FGC-39 plus transmitting Crypto equipment, converts them to multiplex (MUX) signals, and applies the MUX signals in sequential order, channel by channel (time division), to the outgoing circuit.

d. The Receiving Group accepts the incoming MUX signals and converts them to their original on-off direct current form for application to the proper local receiving circuits.

e. The four channels of the AN/FGC-5 are designated as A, B, C, and D. Whether or not all of these channels will be used simultaneously depends largely upon the condition of the radio circuit propagation path. Since the multiplexing of four channels is accomplished by dividing the normal teletypewriter pulse length of each channel into smaller increments, the pulse durations are shortened and consequently become more susceptible to wave form distortion. Under weak-signal or fading conditions, it may become necessary to limit operation to three, or even two, multiplex channels until the MUX signal pulses are lengthened to the point where wave form distortion is within tolerable limits.

f. In figure 5-22, the Transmitting Group accepts the four independent teletypewriter signals from the separate transmitting circuits. These teletypewriter signals are delivered to the four corresponding code converters as teletypewriter code pulses which consist of one start pulse and five code pulses

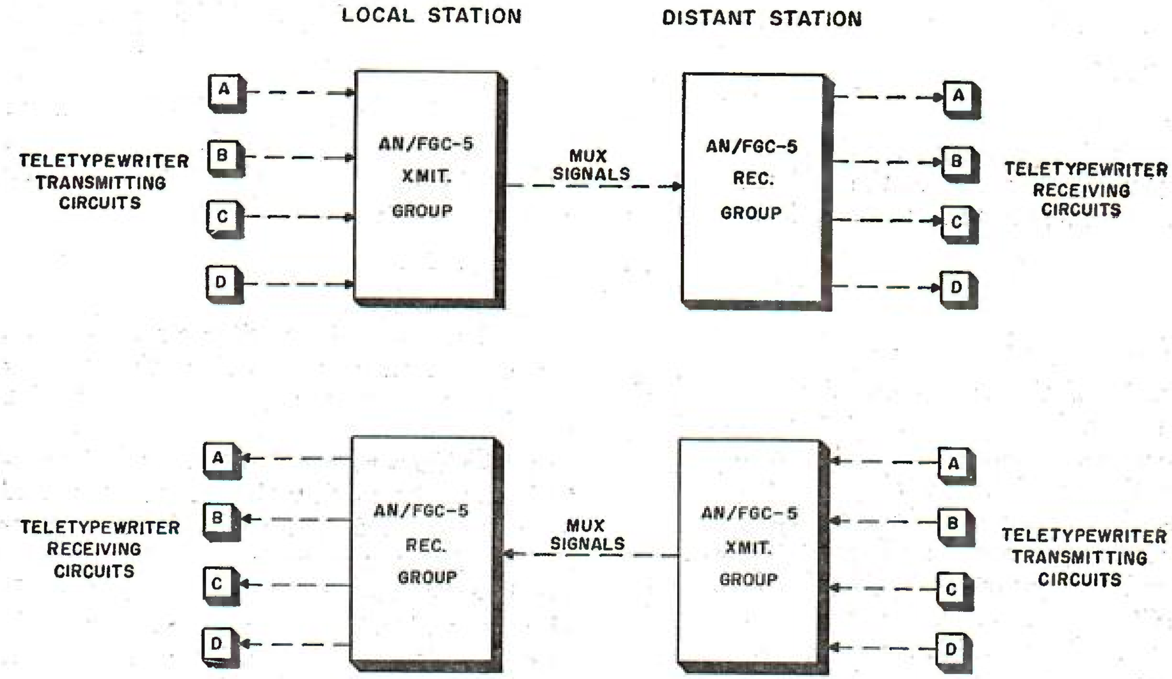


Figure 5-21. System Block Diagram of Duplex Operation with the AN/FGC-5 Telegraph Terminal Set.

of equal time duration, followed by one stop pulse with a time duration determined by the crypto equipment. The code converters remove the start and stop pulses and store the remaining pulses until they are accepted by the Transmitting Signal Distributor. The distributor unit is operating continuously, since it is being driven at constant speed by impulses derived by the signal distributor drive unit. The transmitting signal distributor assembles the code signal pulses into sequential order to form the MUX signal which is applied to the Control Monitor for amplification and coupling to the outgoing circuit. A connection exists from the control monitor to the oscilloscope through which various circuits of the units in the group may be connected for monitoring. The power supply furnishes power to each of the units associated within the Transmitting Group.

g. In the Receiving Group (fig. 5-22), MUX signals received from the distant terminal set are amplified by the Control-Monitor and applied to the Receiving Signal Distributor. The Distributor is driven in synchronism with the received MUX signals by impulses supplied from the signal distributor drive unit. The receiving signal distributor detects the received MUX signals and distributes them to the four Teletypewriter Code Converters. In the converters the MUX signals are restored to their original DC form and connected to the receiving line circuits. The oscilloscope input connection is made through the control-monitor which connects the oscilloscope to the various circuits in the other units through appropriate switches. The control-monitor also supplies synchronizing signals to a frequency correcting circuit in the signal distributor drive unit. The power supply furnishes power to each of the units associated within the Receiving Group.

h. The Transmitting Group output MUX signals may also be directly coupled to the input of the Receiving Group through the respective control-monitor units. This provides a convenient means for testing the equipment.

i. As mentioned previously in chapter 3, the AN/FGC-5 terminal set also supplies a 450 cycles per second reference frequency to the cryptographic equipment, TT-160/FG. The TT-160/FG was originally designed to

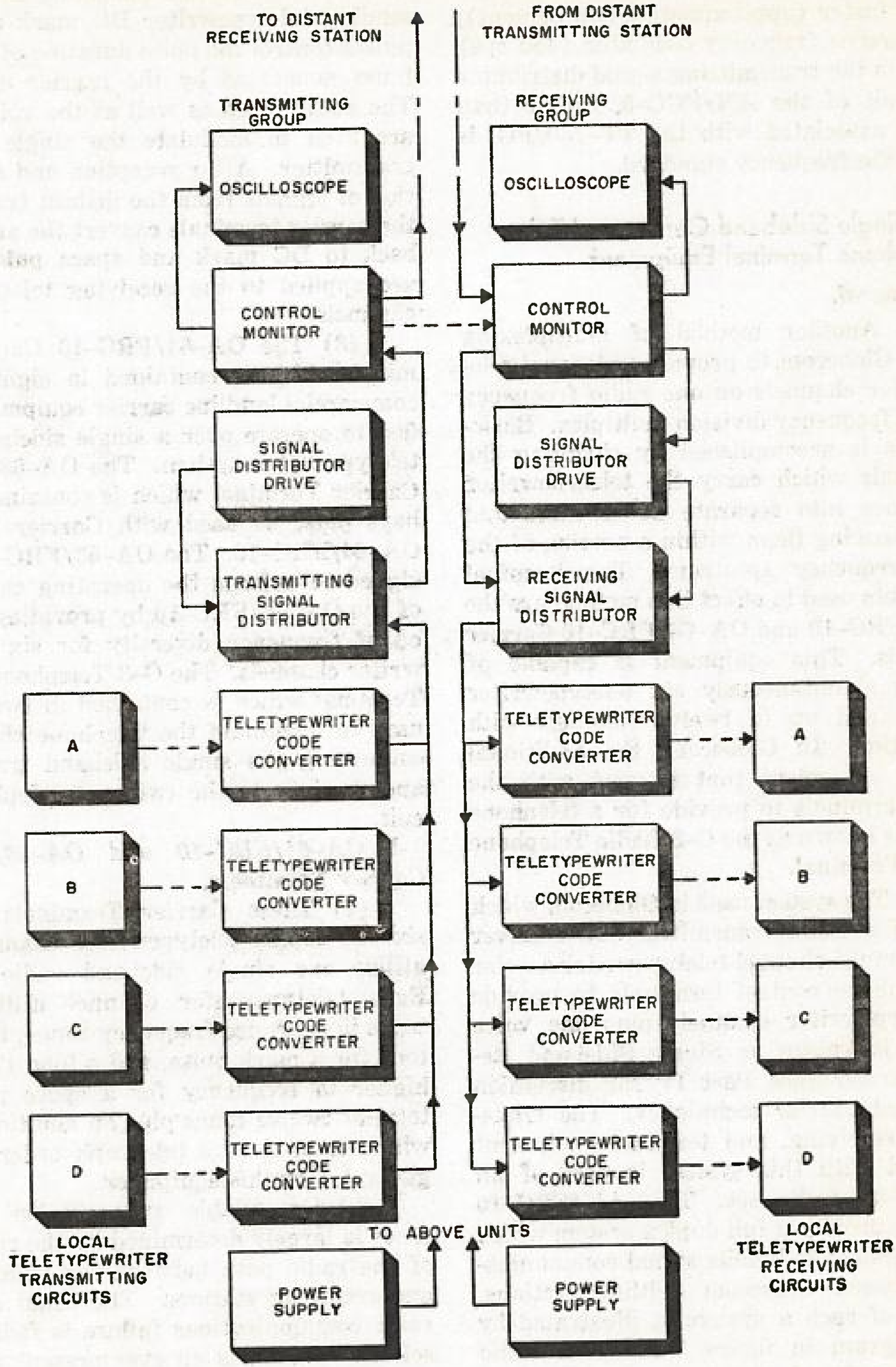


Figure 5-22. Simplified Block Diagram of the AN/FGC-5 Telegraph Terminal Set.

operate in a 60 word per minute system; however, since the MUX system operates slightly faster (approximately two percent), the reference frequency oscillator (450 cps) located in the transmitting signal distributor drive unit of the AN/FGC-5, rather than the one associated with the TT-160/FG, is used as the frequency standard.

5-31. Single Sideband Carrier and Telephone Terminal Equipment

a. *General.*

(1) Another method of multiplexing used by Globecom to provide additional teletypewriter channels on one radio frequency is called frequency division multiplex. Basically, this is accomplished by changing the DC signals which carry the teletypewriter intelligence into separate audio tones and equally spacing them within a portion of the audio frequency spectrum. The terminal equipments used to effect this method are the OA-64/FRC-10 and OA-63/FRC-10 Carrier Terminals. This equipment is capable of handling simultaneously six teletypewriter channels and up to twelve channels with modification. In Globecom, the additional piece of equipment that is used with the carrier terminals to provide for a telephone channel is known as the C-3 Radio Telephone Control Terminal.

(2) The system used in Globecom which combines a radio transmitter and receiver with the multi-channel teletypewriter carrier and telephone control terminals to provide six teletypewriter channels plus one voice channel, is known as Single Sideband Reduced Carrier (see Part IV for discussion of reduced carrier technique). The transmitting, receiving, and terminal equipment associated with this system is part of an AN/FRC-10 radio set. Two AN/FRC-10 radio sets provide a full duplex system which is well adapted to handle signal communications between Globecom beltline stations. One-half of such a system is illustrated by block diagram in figure 5-23. The radio transmitter is of the twin-channel single sideband type, one channel of which can be used for the transmission of teletypewriter messages and the other channel used for voice or inter-station telephone service. The sending teletypewriter DC mark and space pulses control the pulse duration of the audio tones generated by the carrier equipment. The audio tones as well as the voice signals are used to modulate the single sideband transmitter. After reception and demodulation of signals from the distant transmitter, the carrier terminals convert the audio tones back to DC mark and space pulses which are applied to the receiving teletypewriter channels.

(3) The OA-64/FRC-10 Carrier Terminal which is contained in eight bays is commercial landline carrier equipment modified to operate over a single sideband radio teletypewriter system. The OA-63/FRC-10 Carrier Terminal which is contained in two bays must be used with Carrier Terminal OA-64/FRC-10. The OA-63/FRC-10 is designed to enlarge the operating capabilities of the OA-64/FRC-10 by providing a method of frequency diversity for six teletypewriter channels. The C-3 Telephone Control Terminal which is contained in two bays is used to terminate the telephone channel by connecting the single sideband transmitter and receiver to the two-wire telephone circuit.

b. *OA-64/FRC-10 and OA-63/FRC-10 Carrier Terminals.*

(1) These Carrier Terminals provide six full-duplex teletypewriter channels that utilize one single sideband radio circuit. Each teletypewriter channel utilizes two tones in the voice frequency range, the lower tone for a mark pulse, and a tone 170 cycles higher in frequency for a space pulse. A total of twelve tones plus an additional tone which is used as a telegraph order wire is generated by this equipment.

(2) Dependable transmission of the tones is largely determined by the reliability of the radio path between the transmitting and receiving stations. The usual cause of radio communications failure is fading, and selective fading is an ever present phenomena of transmitted waves in the higher radio-frequency spectra. Selective fading usually affects a narrow group of frequencies at any

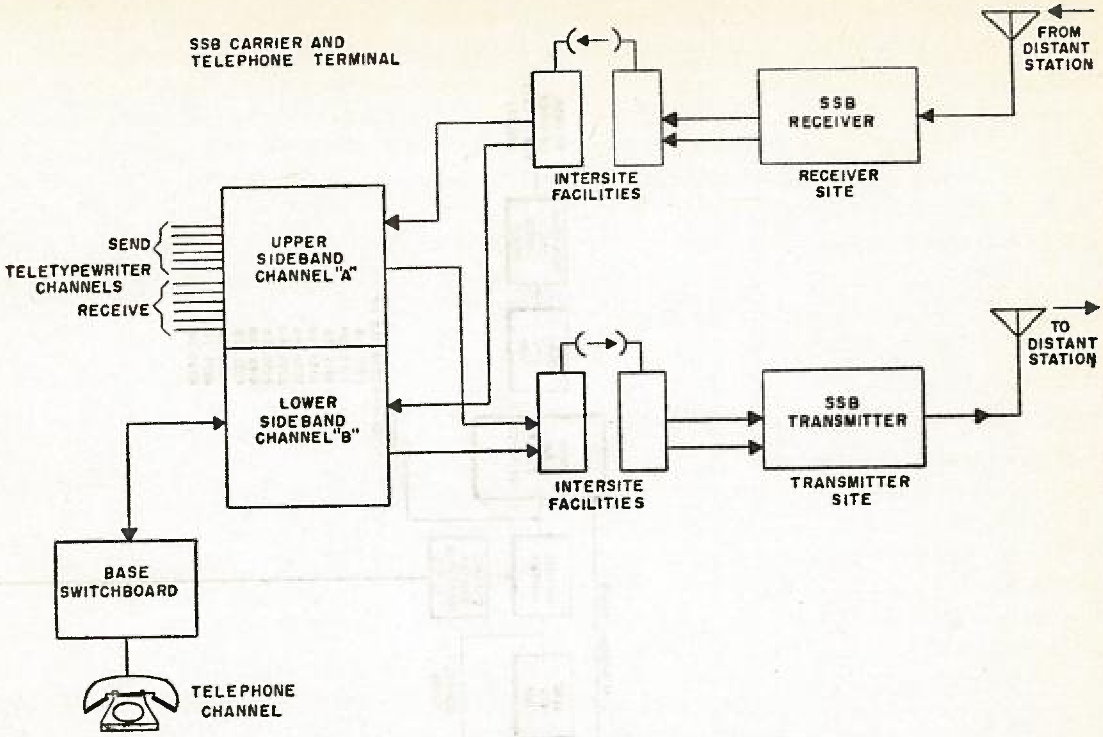


Figure 5–23. Simplified Block Diagram of the Single Sideband System.

instant and rarely occurs simultaneously on frequencies separated by a few hundred cycles; so if the same intelligence is transmitted on two frequencies (two tones for mark pulse and two tones for space) separated by a few hundred cycles, usually one or the other of the frequencies will be received at a satisfactory level.

(3) The OA–64/FRC–10 Carrier Terminal is so arranged that the six teletypewriter channels can be combined to obtain three frequency diversity channels. This arrangement cuts the traffic capacity in half, but it overcomes the effects of fading to a great extent and gets the message through when the other system using one tone for mark and one tone for space fails. Six channel frequency diversity can be obtained by the addition of the OA–63/FRC–10 Carrier Terminal Equipment. This equipment, when used with an OA–64/FRC–10 Carrier Terminal, provides a method of frequency diversity known as DMD (double modulation diversity) which does not cut the traffic capacity by reducing the number of teletypewriter channels. Instead, this equipment, which is contained in two bays, produces a second set of thirteen tones which are higher in frequency and transmitted with the first set so that it is probable that at least one set of signals of satisfactory level will be received.

(4) The carried terminal sending equipment consists of a carrier supply, the sending sections of the channel terminal equipment, the channel shifter equipment, and the send line equipment. A block diagram of the sending equipment is shown in figure 5–24.

(a) The carrier supply furnishes thirteen carrier tones spaced 170 cps apart in order of ascending frequency from 425 cps. The tones are produced by the 12 channel frequency oscillators and the TLG OW (telegraph order wire) oscillator. Separate tones are used for marking and spacing signals. These tones are listed under normal tones and are shown with their associated channel numbers in Table 5–1. The TLG OW tone is provided for inter-station com-

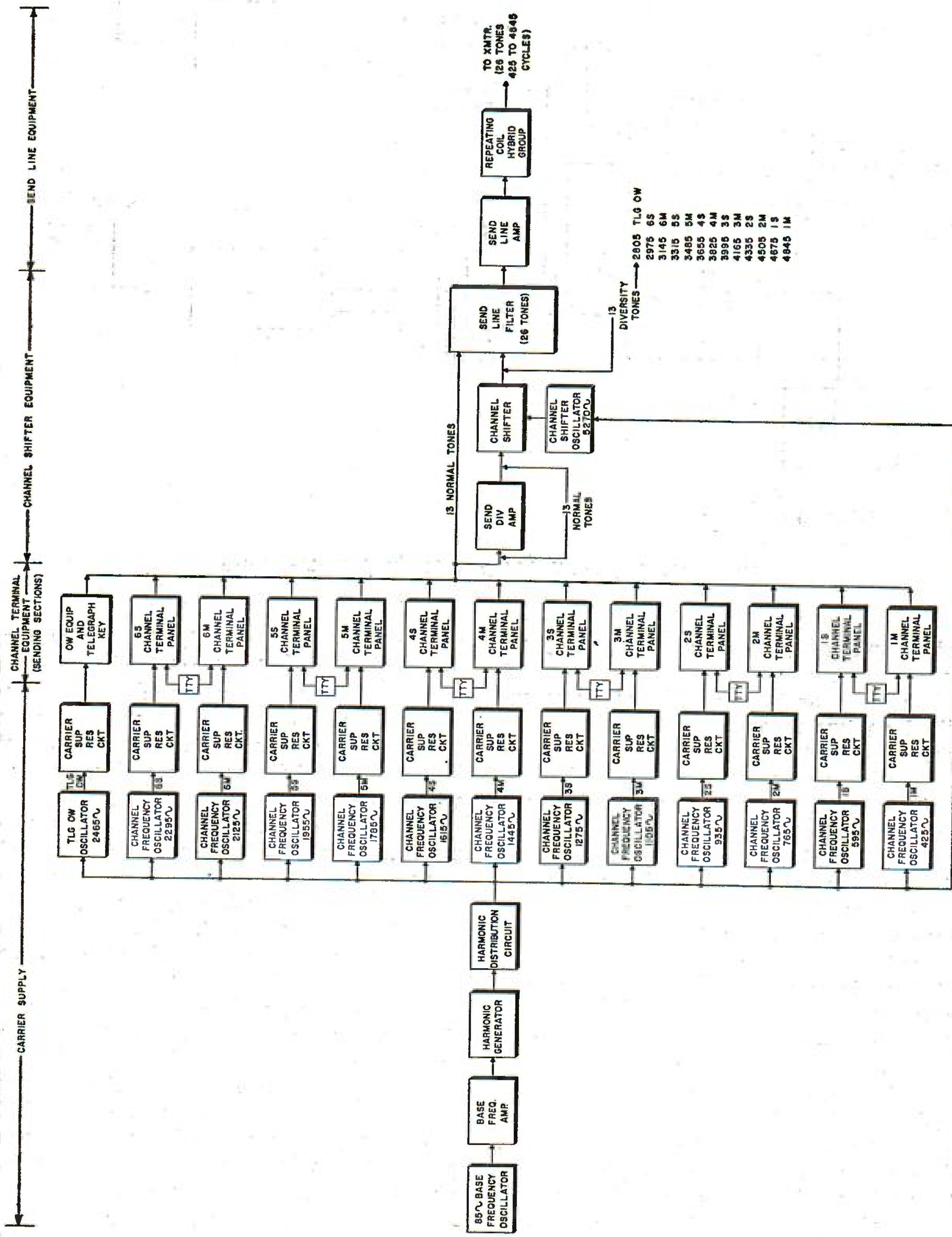


Figure 5-24. Block Diagram of Carrier Terminal Sending Equipment.

munication by operating personnel, and is controlled by telegraph key operation. The thirteen marking and spacing carrier tones are applied through the carrier supply resistance circuits to individual channel terminal mark and space equipment.

(b) The channel terminal equipment controls the connection of the carrier tones to the channel shifter equipment. The sending teletypewriter circuits (TTY) actuate polar relays in the assigned mark and space channel terminal panel. When the teletypewriter circuit is marking, the marking channel terminal panel applies a tone to the channel shifter equipment; when the teletypewriter circuit is spacing, the spacing channel terminal panel applies a tone 170 cps higher to the channel shifter equipment. The mark and space tones use adjacent carrier tones in order that they may be affected similarly by radio fading. All of the mark and space terminal panel outputs are connected in parallel, and the carrier tones are applied to the channel shifter equipment.

(c) The channel shifter equipment consists of a send diversity amplifier, channel shifter (mixer), channel shifter oscillator, and send line filter. The original carrier tones, which are referred to as the normal tones, are applied to the send line filter and to the send diversity amplifier. The output of this amplifier is applied to the channel shifter which is a mixing device. Also fed to the channel shifter is the output of the channel shifter oscillator whose frequency of 5270 cps is stabilized by the locking voltage from the carrier supply. The output of the channel shifter (mixer) is a band of thirteen frequencies which range from 2805 to 4845 cps derived from the original or normal carrier tones of 425 to 2465 cps. These frequencies are known as diversity tones. The diversity tones are applied to the send line filter which also has the normal tones applied to it. The output of the channel shifter send line filter thus contains two sets of carrier tones (26 tones total) carrying identical signals; for example, in channel 1, the intelligence is carried at the mark and space tones of 425 and 595 cps, respectively, as well as at 4845 and 4675 cps, respectively.

(d) The send line equipment consists of a line amplifier and a repeating coil hybrid group. The channel shifter equipment normal and diversity tone output is applied to the send line amplifier which provides sufficient amplification for normal transmission levels. The coil group is used for matching line impedances of various values.

(5) The receiving carrier terminal equipment consists of receiving line equipment, channel restorer equipment, auxiliary and auxiliary-diversity filters, and receiving channel terminal equipment. A block diagram of the receiving equipment is shown in figure 5–25.

(a) The receiver line equipment consists of a repeating coil group and a receive line amplifier. Signals coming from the receiver site are applied to the input side of the coil group. The arrangement of this coil group is similar to that of the send line equipment. The carrier tones are then applied to the receive line amplifier where amplification is adjusted to the proper levels. The output of the receive line amplifier is applied to the channel restorer equipment.

(b) The combined normal and diversity tones (26 total) are applied directly to the receive line filter which has low and high-pass sections. The normal tones are passed directly through the low-pass side of the receive line filter to the auxiliary (AUX) mark and space filters. The diversity tones are accepted by the high-pass side of the receive line filter and are applied to the input side of the channel restorer where they are mixed with the local channel restorer oscillator signal of 5610 cps. At this point, filters are employed to reject the undesirable products of electronic mixing and allow only the difference (lower) frequencies to be passed on to the receive diversity amplifier. The diversity tones are now 340 cps higher than the normal tones. The output of the receive diversity amplifier is applied to the auxiliary-diversity (AUX-D) filters. Table 5–2 shows the input frequencies of the channel restorer equipment and the output frequencies applied to succeeding equipment.

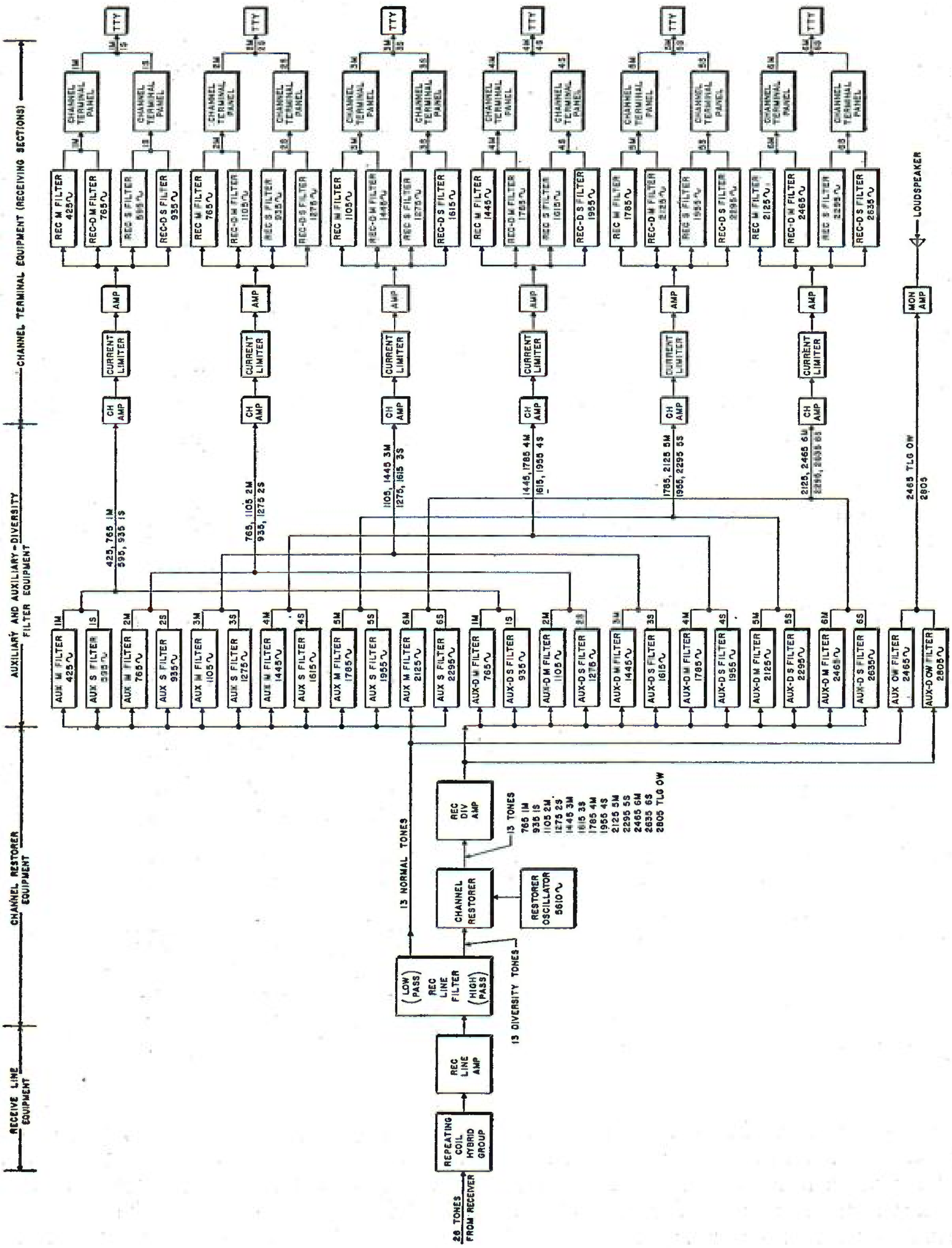


Figure 5–25. Block Diagram of Carrier Terminal Receiving Equipment.

Table 5-1.—Send Equipment Carrier Tones (Normal and Diversity)

Channel No.	Mark and space designation	Normal tones (cps)	Diversity tones (cps)
1	1M	425	4875
	1S	595	4675
2	2M	765	4505
	2S	935	4335
3	3M	1105	4165
	3S	1275	3995
4	4M	1445	3825
	4S	1615	3655
5	5M	1785	3485
	5S	1995	3315
6	6M	2125	3145
	6S	2295	2975
TLG OW	TLG OW	2465	2805

Table 5-2.—Receive Equipment Carrier Tones (Normal and Diversity)

Channel No.	Mark and space designation	Restorer input (cps)		Restorer output (cps)	
		Normal	Diversity	Normal	Diversity
1	1M	425	4845	425	765
	1S	595	4675	595	935
2	2M	765	4505	765	1105
	2S	736	4335	935	1275
3	3M	1105	4165	1105	1445
	3S	1275	3995	1275	1615
4	4M	1445	3825	1445	1785
	4S	1615	3655	1615	1955
5	5M	1785	3485	1785	2125
	5S	1955	3315	1955	2295
6	6M	2125	3145	2125	2465
	6S	2295	2975	2295	2635
TLG OW	TLG OW	2465	2805	2465	2805

(c) The normal and diversity carrier tone output of the channel restorer equipment is applied to the auxiliary (AUX) and the auxiliary-diversity (AUX-D) filters. These filters separate by frequency the various mark and space tones. The associated normal mark and space tones and diversity mark and space tones for each channel are then selected and fed to the respective channel terminal equipment.

(d) The normal OW (order wire) tone from the low-pass side of the receive line filter and the diversity OW tone from the receive diversity amplifier are applied to the AUX OW and AUX-D OW filters, respectively. The outputs of these filters are connected in parallel and their combined energies are applied to the monitoring amplifier and loudspeaker which are located in the common equipment bay. The dots and dashes of a telegraph key in the sending equipment control the length of the tones.

(e) Each of the six channel amplifiers provides sufficient amplification to bring the input signal level of the current limiters within the effective working limits. The output of each current limiter is then amplified and applied to four filters which separate the four carrier tones. The outputs of the REC–M, and REC–D M and REC–S, REC–DS filters are combined and fed to two channel terminal panels where they are amplified, converted to d.c., and amplified again by individual DC amplifiers. The outputs of the mark and space DC amplifiers are then used to actuate a receiving polar relay to mark or space positions in accordance with the incoming message. These DC teletypewriter pulses are then transmitted to the individual receiving teletypewriter circuits.

c. *C–3 Telephone Control Terminal.*

(1) The C–3 Telephone Control Terminal is used in conjunction with a single sideband radio telephone channel in connecting the single sideband transmitter and receiver to the normal two-wire telephone circuit. This control equipment is contained in two bays and is located alongside the carrier terminal equipments OA–64/FRC–10 and OA–63/FRC–10.

(2) The C–3 Control Terminal includes a four wire Terminating Set, an A–2 Vogad (Voice Operated Gain Adjust Device), an A–2 Noise Reducer and 6000–cycle control circuit, a VODAS (Voice Operated Device Anti Sing) and a 1000–20–cycle ringer oscillator. The control terminal is also designed to operate in conjunction with the A–2 channel shifter. The A–2 channel shifter equipment is contained in a separate bay which is shared with portions of the carrier terminal equipment. A B–2 Vogad unit is also included in this arrangement.

(3) A simplified block diagram of the control terminal and associated equipment is shown in figure 5–26. The 4–W Terminating Set is used to connect the transmitting and receiving portions of the control terminal to the base switchboard. Connections to the switchboard may be made on either a 2-wire or a 4-wire basis, depending on transmission line losses. The 6000-cycle control circuit extends to both transmitting and receiving portions of the control terminal and is used in summing up the various circuit gains, losses, and sensitivities to provide an optimum receiving volume.

(4) The A–2 Channel Shifter and Re-

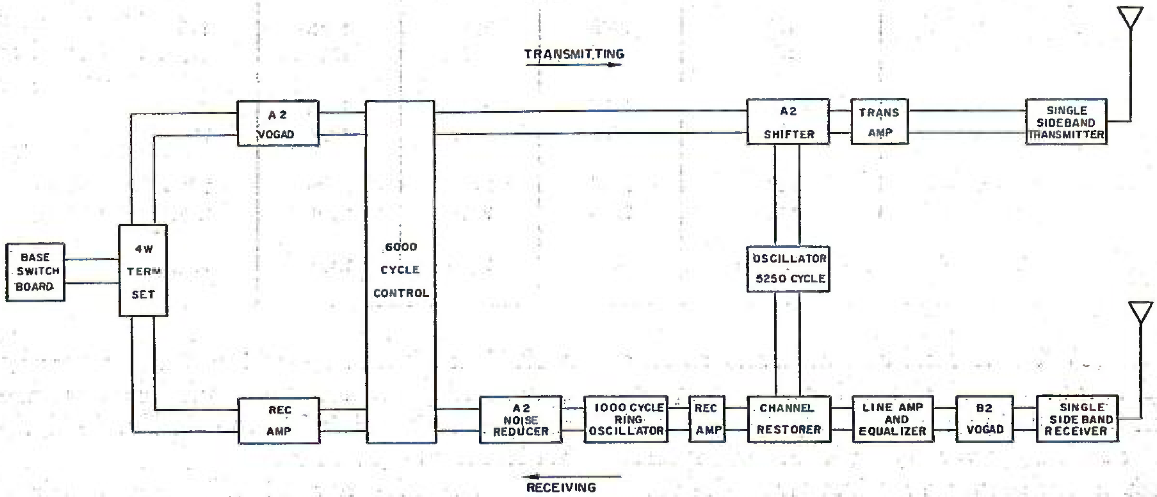


Figure 5–26. Simplified Block Diagram of the C–3 Telephone Control Terminal.

storer is used on twin-channel operation over the same single sideband radio circuit. The channel shifter is used to shift the telephone channel away from the carrier frequency and its normal range of 250 to 3000 cps to a new location in the frequency spectrum between 2250 and 5000 cps. The reason for shifting is to reduce cross-talk between the two channels. The channel restorer is used in the receiving leg of the control terminal to restore the shifted band back to its original location in the frequency spectrum.

(5) The A–2 Noise Reducer is shown in the receiving portion of the control terminal. This device reduces the effects of radio noise and by doing so will permit a higher value of receiving sensitivity to be used without the locking up of receiving relays.

(6) The 1000-cycle ringer oscillator circuit is designed to perform three separate functions as follows:

(a) To act as a selective circuit to receive 1000-cycle signals, interrupted at a 20-cycle rate, from the distant control terminal.

(b) To act as a sending source of 1000-cycle signals, interrupted at a 20-cycle rate, to call the distant control terminal or switchboard.

(c) To function as a source of steady 1000-cycle tone signals for sending tone telegraph signals and to provide test tone for line-up and testing purposes.

(7) The Line Amplifier and Equalizer is used to secure a proper impedance match between the transmission line and equipment. The speech waves which have been distorted by the frequency characteristics at the wire line will be equalized to reduce frequency distortion to a negligible value. The equalizer, however, will not be used if microwave facilities exist between the control terminal and the receiver site.

d. *Future Policies.* At the present time, the OA–63/FRC–10 and OA–64/FRC–10 single sideband carrier terminals can provide six diversity teletypewriter channels and up to twelve non-diversity channels with modification; however, with the ever increasing traffic loads, there has arisen the need for additional teletypewriter channels. In view of the limited capabilities of the present single sideband equipment, the AN/FGC–29 single sideband terminal has been selected as the replacement where requirements exist. The AN/FGC–29 is capable of handling sixteen channels in frequency diversity.

Section III. AUXILIARY EQUIPMENT

5–32. General

The line-up of auxiliary equipment located in the Equipment Room includes the following equipments:

a. 110C–1 Test Transmitter
b. CST–2 Signaling Termination Unit
c. SFO–2 Regenerative Repeaters
d. 24-Volt, 20-Cycle Fuse and Rectifier Bay
e. 120-Volt Fuse Bay
f. Transmitter Distributor (TD) Control
g. PP–108B–TG 120-Volt Supply

5–33. 110–Cl Test Transmitter

The Test Transmitter is essentially a teletypewriter transmitter-distributor which will transmit perfect teletypewriter test signals at 368 opm (60 words per minute) to as many as twenty-four circuits simultaneously. It provides a source of polar test sentence signals used in calibrating start-stop telegraph transmission measuring sets such as the 118–C located in the Tech Control Room. It provides a source of signals for driving the 119–C Signal Distortion Set which is also located in the Tech Control Room. A kit for changing station identification letters is supplied with the Test Transmitter.

5–34. CST–2 Signaling and Termination Unit

The CST–2 Signaling and Termination Unit is designed for use in conjunction with the CMT–4 microwave multiplex equipment. It provides for the transmission of normal telephone dial or ringdown signaling, and terminates the 4-wire circuit of the microwave multiplex equipment into the normal 2-wire telephone circuit. Since the lower band pass characteristics of the microwave multiplex equipment will not accommodate the low-frequency (20-cycle) impulses used in telephone signaling, it is necessary to convert the 20-cycle ringing current to a higher frequency. This is accomplished by the signaling unit which generates a 3500 cps tone and transmits it through the microwave link. This tone is then reconverted to the original signaling frequency by similar equipment at the distant end of the link. Since the microwave multiplex systems are the equivalent of duplex 4-wire circuits, while telephone lines are normally balanced 2-wire circuits, it is necessary to provide a means of terminating the 4-wire microwave multiplex equipment to the 2-wire telephone equipment. This is accomplished by the termination unit which consists of a hybrid coil and a compromise balancing network. The CST–2 has a self-contained power supply and is mounted in a standard 19-inch relay rack.

5–35. SFO–2 Regenerative Repeater

The SFO–2 Repeater is used for correction of mark and space distortion in teletypewriter signals. The repeater is capable of accepting teletypewriter signals in audio form (on-off) or in direct current form (polar and neutral) having up to 45 percent bias distortion and regenerating the signal to have less than 5 percent bias distortion at the output. Regeneration of the teletypewriter signal in the repeater is accomplished by electronic means. Sampling pulses are generated in the repeater to synchronize with the center of each teletypewriter pulse. If a sampling pulse coincides with a mark, the pulse operates a relay circuit to produce a regenerated mark at the repeater output. If the sampling pulse coincides with a space, the relay circuit will produce a space of proper duration at the repeater output. The repeater inputs and outputs appear on jacks located in the Tech Control Room and can be used with any teletypewriter circuit as required.

5–36. 24-Volt, 20-Cycle Fuse and Rectifier Bay

The Fuse and Rectifier Bay provides a source of 20-cycle ringing current with sufficient fuses to accommodate 38 taps. It also provides a source of 24-volt negative DC with sufficient fuses available on the fuse panel to accommodate 75 negative taps. The ringer set is of the telephone sub-cycle type with an output of 75-90 volts, 20-cycles, which supplies the ringing current for the CST–2 Signaling and Termination Unit, and also provides signaling voltage for alarm bells in the case of a blown fuse or a voltage failure. The rectifier is a selenium, full-wave, 24-volt type which supplies the air-ground consoles located in the Air-Ground Room with DC keying and signaling voltages, and also supplies power to all the signal lamps and relays in the Relay Center that require 24 volts. The bay is also supplied with spare ringer and rectifier units which can be interchanged with the regular units by means of separate switches.

5–37. 120-Volt Fuse Bay

The 120-Volt Fuse Bay is used in conjunction with the PP–108B–TG 120-Volt Supply and is equipped with heat coils mounted on panels. The heat coils are similar to some alarm type fuses and will operate in 210 seconds on a current of 0.265 ampere or more. The circuits associated with the fuse bay provide immediate audible and visual warnings in the case of a blown fuse or a voltage failure.

5–38. Transmitter Distributor (TD) Control

The TD Control circuit is essentially a teletypewriter transmitter distributor circuit which provides a source of stepping pulses for operating the start magnets in the transmitter distributors of the Plan 51.3B tape repeaters or the transmitter distributors associated with the AN/FGC–39 torn tape equipment. As was explained previously in chapter 3, Crypto Room, when a single channel radio teletypewriter circuit or single sideband radio teletypewriter circuit is used with on-line encryption, the crypto equipment controls the stepping of the Plan 51.3B tape repeater transmitter distributors. When the 4-channel multiplex equipment is used with on-line encryption, the crypto equipment is slaved or synchronized to 4-channel multiplex equipment, and the crypto equipment in turn controls the stepping of the transmitter distributors. However, if it becomes operationally necessary to by-pass or patch-out the crypto equipment, the transmitter distributors will no longer be controlled. This condition will cause the transmitter distributors to operate at their free-running speed which is considerably higher than the speed required for 60-word-per-minute operation. The TD Control circuit is therefore used to step the transmitter distributors of the tape relay equipments to the normal 60 word per minute (368 opm) rate.

5-39. PP-108B-TG 120-Volt Supply

The 120-volt supply is an electronic, full-wave type rectifier which provides a source of positive or negative 120 volts DC, plus or minus 2 percent, for all DC loops in the relay center. When three rectifiers are furnished, one is used as a positive supply, the other as a negative supply, and the third as a spare.

Chapter 5

AIR-GROUND ROOM

Section I. INTRODUCTION

5–40. General

a. *Description.* The Air-Ground Room is located in the center of the Communications Relay Center. It is approximately 34 feet long by 29 feet wide. Circuit terminations are normally located around the perimeter of the room, with the coordinator's desk and supervisor's desk located approximately in the center of the room.

b. *Purpose.* The purpose of the Globecom Air-Ground (A–G) communications system is to provide the link between ground stations and airborne stations over which pass tactical, strategic, and traffic-control information between command posts, operational bases, air-traffic control centers, and aircraft. The Air-Ground Room is primarily a relay center through which messages pass to their ultimate destination. Very little traffic begins or ends here.

c. *Operation.*

(1) Air-ground circuits are primarily voice circuits. In some stations, facilities also are provided for manual CW operation; but it is currently planned to have all circuits on voice operation. Fixed frequency receivers are used for voice operation, whereas tunable receivers are assigned to CW operation.

(2) In Globecom air-ground circuits at present, the CW functions are not used, and no tunable receivers are installed. In a few stations, the CW functions may be retained for other commitments, such as ICAO. In such cases, tunable receivers will be assigned.

(3) At some Globecom stations, there are other than air-ground CW requirements. In those cases, the CW operator is located in the Air-Ground Room and normally uses a standard Globecom air-ground console. Since only CW signals are to be received, there are no fixed frequency receivers assigned to these circuits, and only the CW functions are operable.

5–41. Plan

a. The physical layout of the Air-Ground Room is shown in figure 5–27. The A–G operators' consoles are along one wall. Normally, each operator monitors two frequencies. In this station, there are ten assigned frequencies—so five operating positions are shown. All messages pass through the coordinator's desk located near the center of the room. Some messages are relayed at this position by telephone or intercom. Other messages are relayed by the teletypewriters located along the wall behind the coordinator's desk. The supervisor's desk is located where he can oversee all that goes on in the A–G room.

b. All A–G transmitters are located at the Transmitter Site and all receivers are located at the Receiver Site. Inter-connection between operators' positions and receivers and transmitters is accomplished by microwave radio link. Voice lines are multiplexed on the microwave radio link by CMT–4 equipment. Key lines are multiplexed through the VFTG and CMT–4 equipment.

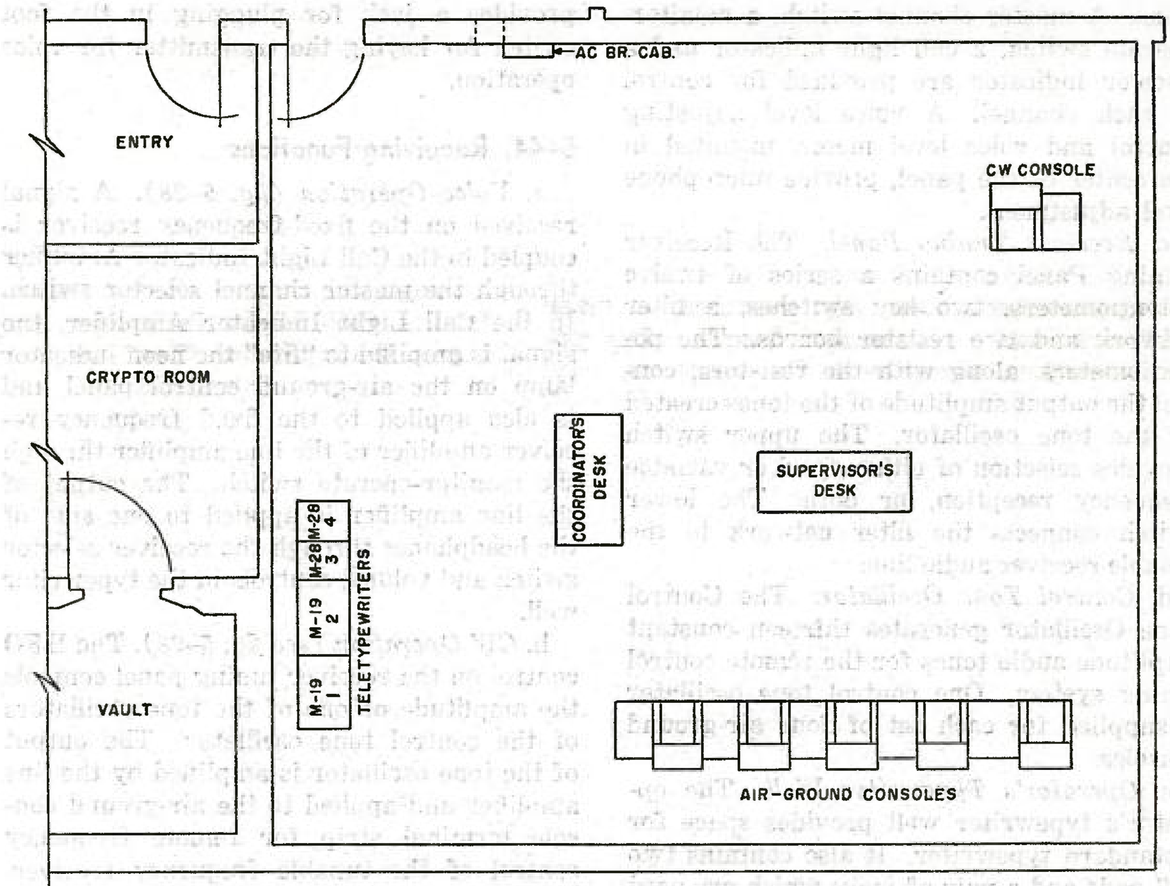


Figure 5-27. Air-Ground Room Equipment Layout.

Section II. EQUIPMENT

5-42. General

The Air-Ground Console provides remote control for phone and CW radio transmission and reception. Each console provides control for six channels of communication. Several consoles may be interconnected to increase traffic capabilities in accordance with operational requirements. The Air-Ground Control Panel provides primary control of transmitting and receiving operations. The Receiver Tuning Panel, in series with the Control Tone Oscillator, provides remote control of the receiver when coupled through a cable or microwave link.

5-43. Description

The Air-Ground Control Console is composed of the following components: Cabinet Rack, Call Light Indicator Amplifier, Air-Ground Control Panel, Receiver Tuning Panel, Control Tone Oscillator, Operator's Typewriter Well, Line Amplifier Panel, Recorder Relay Panel, Footswitch Jack and A-C Power Control, Message File, Operator's Desk and accessories necessary for operation (headset and microphone).

a. *Call Light Indicator Panel.* The Call Light Indicator Amplifier is a six-channel audio amplifier. Each channel receives its signal from a separate fixed-frequency receiver. Each channel provides two outputs, one for audio and one for visual purposes. The visual indication is provided by a light on the call light indicator panel.

b. *Air-Ground Control Panel.* The Air-Ground Control Panel provides primary control of transmitting and receiving operations. A master channel switch, a monitor-operate switch, a call light indicator and a bi-color indicator are provided for control of each channel. A voice level adjusting control and voice level meter, mounted in the center of the panel, provide microphone level adjustment.

c. *Receiver Tuning Panel.* The Receiver Tuning Panel contains a series of twelve potentiometers, two key switches, a filter network and two resistor boards. The potentiometers, along with the resistors, control the output amplitude of the tones created by the tone oscillator. The upper switch provides selection of either fixed or variable frequency reception, or both. The lower switch connects the filter network to the tunable receiver audio line.

d. *Control Tone Oscillator.* The Control Tone Oscillator generates thirteen constant amplitude audio tones for the remote control tuning system. One control tone oscillator is supplied for each set of four air-ground consoles.

e. *Operator's Typewriter Well.* The operator's typewriter well provides space for a standard typewriter. It also contains two "T" pads and a pair of jacks which are used in combination for a split headset and microphone. The "T" pads provide audio gain control of the fixed and tunable receiver outputs.

f. *Line Amplifier.* The Line Amplifier contains four separate amplifier channels. One channel is connected to the fixed receiver output, one is connected to the tunable receiver outputs, one is connected to the control tone oscillator output, and one is connected to the microphone circuit. The gain of the microphone channel is controlled by the voice level adjusting control on the air-ground control panel.

g. *Recorder Relay Panel.* The Recorder Relay Panel contains a series of relays. Each relay taps off the audio signal from a corresponding operating channel for recording purposes.

h. *Footswitch Jack and A–C Power Control.* The Footswitch Jack and A–C Power Control controls the AC power which is applied to the other panels in the rack. It also provides a jack for plugging in the foot switch for keying the transmitter for voice operation.

5–44. Receiving Functions

a. *Voice Operation (fig. 5–28).* A signal received on the fixed-frequency receiver is coupled to the Call Light Indicator Amplifier through the master channel selector switch. In the Call Light Indicator Amplifier, the signal is amplifid to "fire" the neon indicator lamp on the air-ground control panel and is also applied to the fixed frequency receiver amplifier of the line amplifier through the monitor-operate switch. The output of the line amplifier is applied to one side of the headphones through the receiver selector switch and volume controls in the typewriter well.

b. *CW Operation (see fig. 5–28).* The HFO control on the receiver tuning panel controls the amplitude of one of the tone oscillators of the control tone oscillator. The output of the tone oscillator is amplified by the line amplifier and applied to the air-ground console terminal strip for remote frequency control of the tunable frequency receiver. The BFO control on the receiver tuning panel performs the same function with a second tone to control the BFO of the same receiver. The output of the tunable frequency receiver is applied to the tunable frequency receiver amplifier of the line amplifier through the channel selector switch and the monitor-operate switch. The tunable frequency receiver signal is applied to one side of the headphones through the receiver selector switch and the filter switch. During CW operation, the signal may be routed through the filter by the filter switch. By placing the receiver selector switch in the "COMB" position, the air-ground console is conditioned for reception of signals from both the fixed and tunable receivers.

5–45. Transmitting Functions

a. *Voice operation (fig. 5–29)*

(1) *Keying.* The operation of the footswitch de-activates the hand key and applies twenty-four volts DC to the microphone

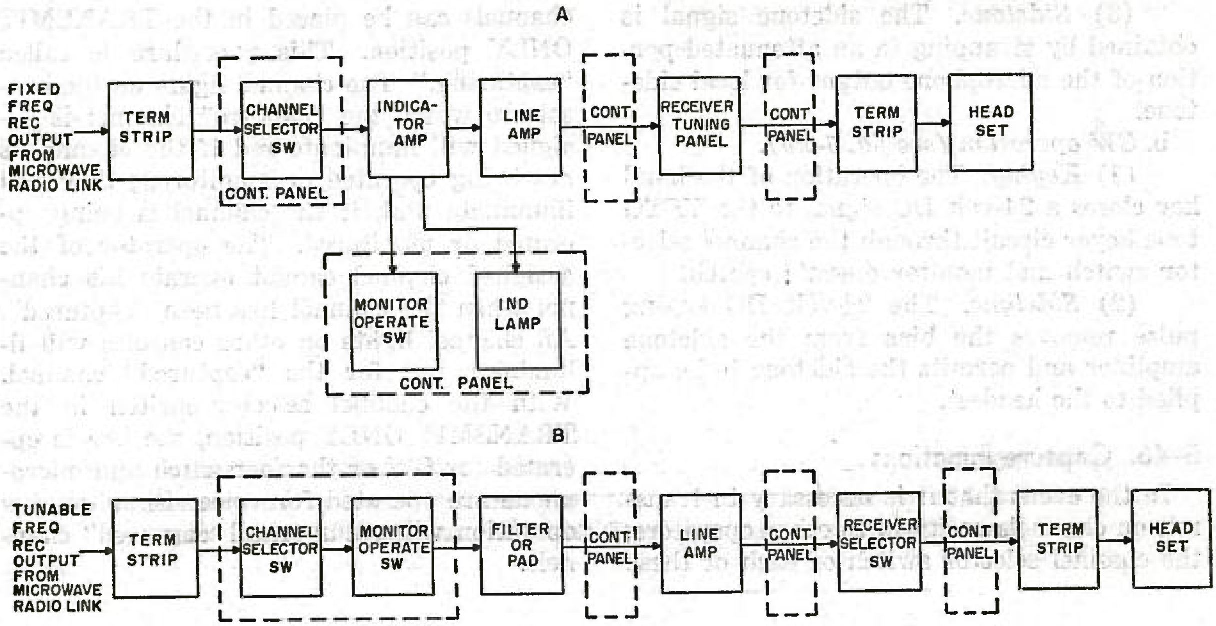


Figure 5-28. Receiving Functions.

circuit. It also causes the output of the fixed and tunable receivers to be short-circuited. The keying function is completed through the channel selector switch and monitor-operate switch to a VFTG tone keyer circuit for transmission to the transmitter site.

(2) *Microphone.* The output of the microphone is connected directly to the microphone channel of the line amplifier. The output of the line amplifier microphone channel passes through a series of attenuators, including the VOICE LEVEL ADJUST control, and is connected to the air-ground console terminal strip through a master channel selector switch and the monitor-operate switch. A VU meter marked VOICE LEVEL is connected across the VOICE LEVEL ADJUST attenuator.

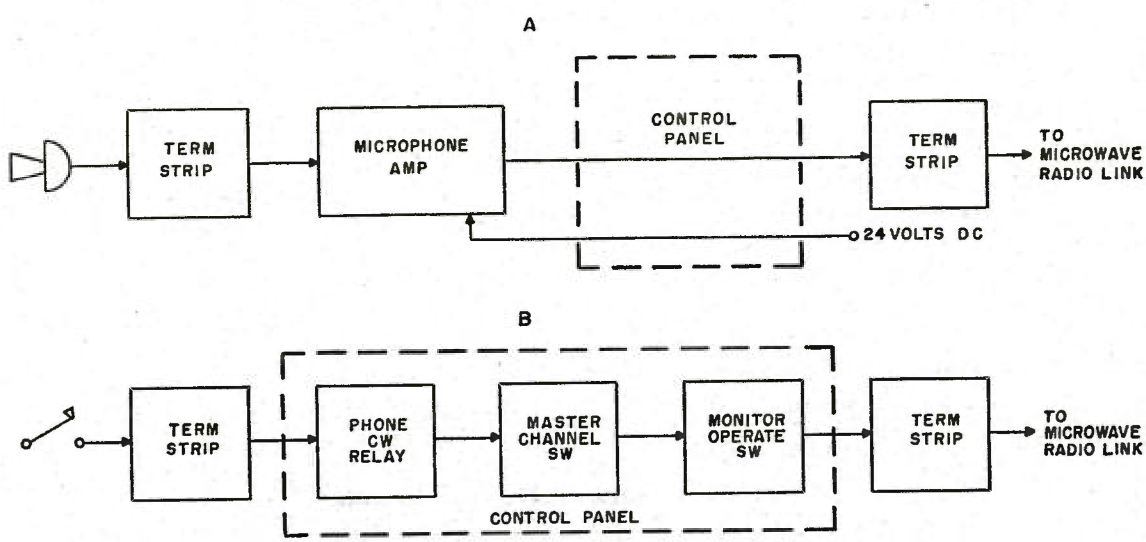


Figure 5-29. Transmitting Functions.

(3) *Sidetone.* The sidetone signal is obtained by strapping in an attenuated portion of the microphone output for local sidetone.

b. *CW operation (see fig. 5-29).*

(1) *Keying.* The operation of the hand key closes a 24-volt DC signal to the VFTG tone keyer circuit through the channel selector switch and monitor operate switch.

(2) *Sidetone.* The 24-volt DC keying pulse removes the bias from the sidetone amplifier and permits the sidetone to be applied to the headset.

5-46. Capture Functions

In the event that it is necessary to transmit on channels assigned to other operators, the channel selector switch of each of these channels can be placed in the TRANSMIT ONLY position. This procedure is called "capturing." The channel lights on the console to which the "capture" channel is assigned will illuminate red if the channel is not being operated or monitored; they will illuminate pink if the channel is being operated or monitored. The operator of the assigned channel cannot operate his channel when the channel has been "captured". All channel lights on other consoles will illuminate red for the "captured" channel. With the channel selector switch in the TRANSMIT ONLY position, the key is operated for CW or the footswitch and microphone are operated for voice. Simultaneous operation will occur on all 'captured" channels.

Chapter 6

CHANNEL AND TECHNICAL CONTROL ROOM

Section I. INTRODUCTION

5-47. General

The Channel and Technical Control Room, which is also known as Tech Control, performs the functions of coordination among various Relay Center components, distant stations with which traffic is exchanged, and military and commercial agencies from which communications facilities are procured or for which facilities are provided. All incoming and outgoing communication traffic passes through and is controlled by the Tech Control Room. In effect, Tech Control is the center of all circuit control functions, and, coupled with similar functions in the other major relay centers, ties all stations together into one system.

5-48. Plan

The Tech Control Room is specifically designed to facilitate its control functions (fig. 5-30). In it are installed the Combination Distributing Frame which provides cross-connections for all communication circuits in the Relay Center; the test and patch panels which permit patching between circuits, between equipments, and between circuits and testing equipment; and the monitor machines provided for inter-station communication and for monitoring of send or receive lines for the purposes of aligning and testing inter-station circuits. Also installed in the Tech Control Room are the master control for all clocks in the Relay Center, intercommunications equipment for voice communication between rooms in the Relay Center, and various testing and measuring equipments for maintaining circuit efficiency.

Section II. EQUIPMENT

5-49. Combination Distributing Frame

The Combination Distributing Frame (CDF) is composed of horizontal and vertical terminal blocks mounted on a common frame assembly. It is here that the cables from all equipments are terminated and the various equipment units are cross-connected to make a circuit or system. Cross-connect wires are normally run from equipment terminations on the vertical frame to test or patching facilities on the horizontal frame.

a. *Horizontal Frame.* The Horizontal Frame is normally located on the side of the combination distributing frame nearest the patch bays. The horizontally-mounted terminal blocks provide terminals for cross-connecting all wiring from the audio and DC patch bays, 120-volt battery tap bays, clocks, 24-volt and ground equipment, 20-cycle ringing equipment, regenerative repeater equipment, and ground feed system. Typical block assignments of circuits on the horizontal frame are shown in figure 5-31. Variations in assignments may be encountered due to differences in number of circuits and local cabling conditions at different stations.

b. *Vertical Frame.* The Vertical Fram

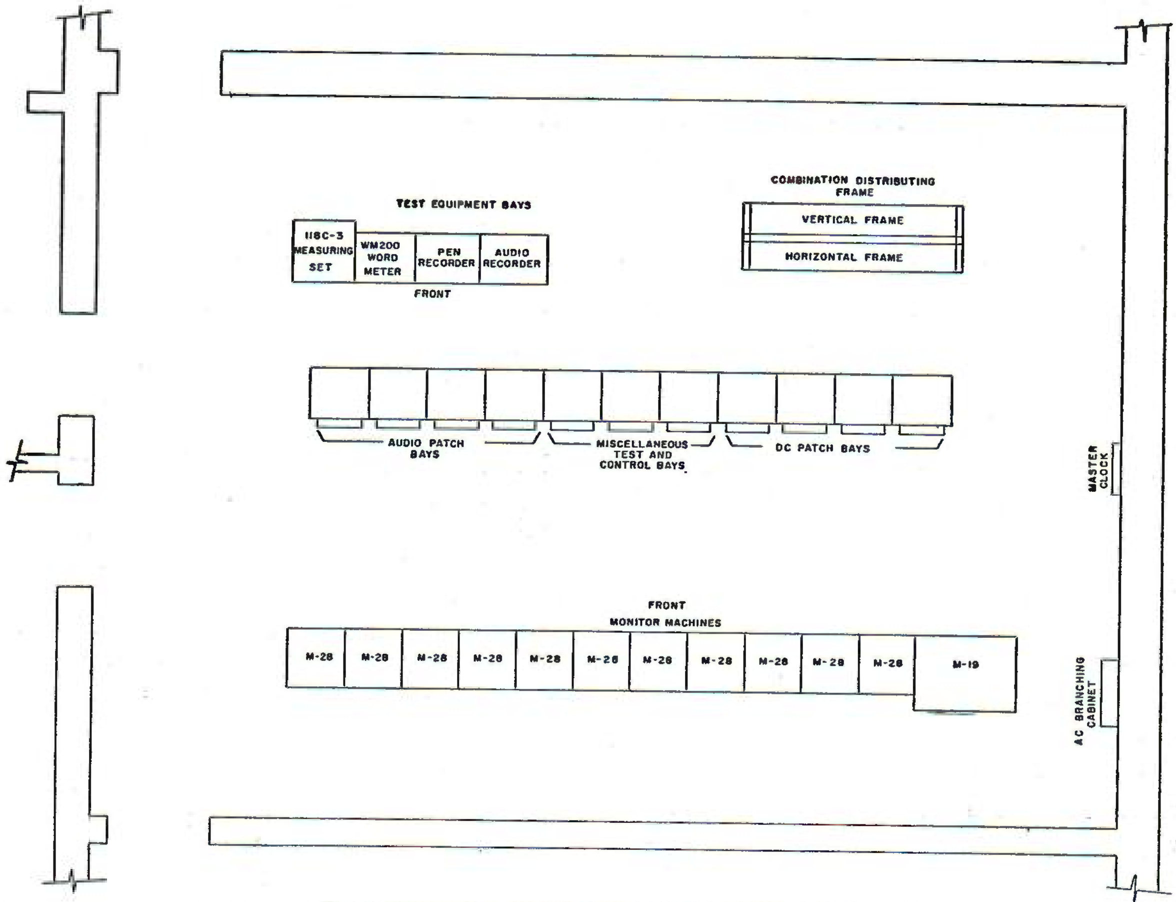


Figure 5–30. Channel and Technical Control Room Plan.

supports the vertically-mounted terminal blocks which provide for terminating wiring from all terminal equipment in the Equipment Room, Tape Relay Room, Air-Ground Room, and Crypto Equipment Room, as well as wires from line relays, monitor teletypewriters, and the test equipment bays in the Tech Control Room. In general, all terminal equipment as well as landline cables and microwave channels are terminated on the vertical frame. Typical block assignments of circuits on the vertical frame are shown in figure 5–32. Variations in assignments may be encountered due to differences in number of circuits and local cabling conditions at different stations.

5–50. Patching Bays and Test and Control Bays

These bays provide facilities for the patching and testing of all communication and test circuits in the Relay Center. These bays are normally divided into three major sections: Audio Patch Bays, Miscellaneous Test and Control Bays, and DC Patch Bays. Standards for wiring the bays are prescribed by common commercial and service practices and by operational requirements.

a. *Audio Patch Bays.* The Audio Patch Bays consist of four identical bays. Each bay is provided with a fold-down shelf one foot wide for use as a writing surface. All audio lines or microwave channels are terminated on double jacks mounted on panels in the bays. Also mounted on double jacks are the audio inputs and outputs of all equipments. The top seven panels in each bay contain the line and equipment patch and monitoring jacks which accommodate ninety-one normal-through audio circuits. The remaining panels in order are: one panel containing miscellaneous patch and monitor-

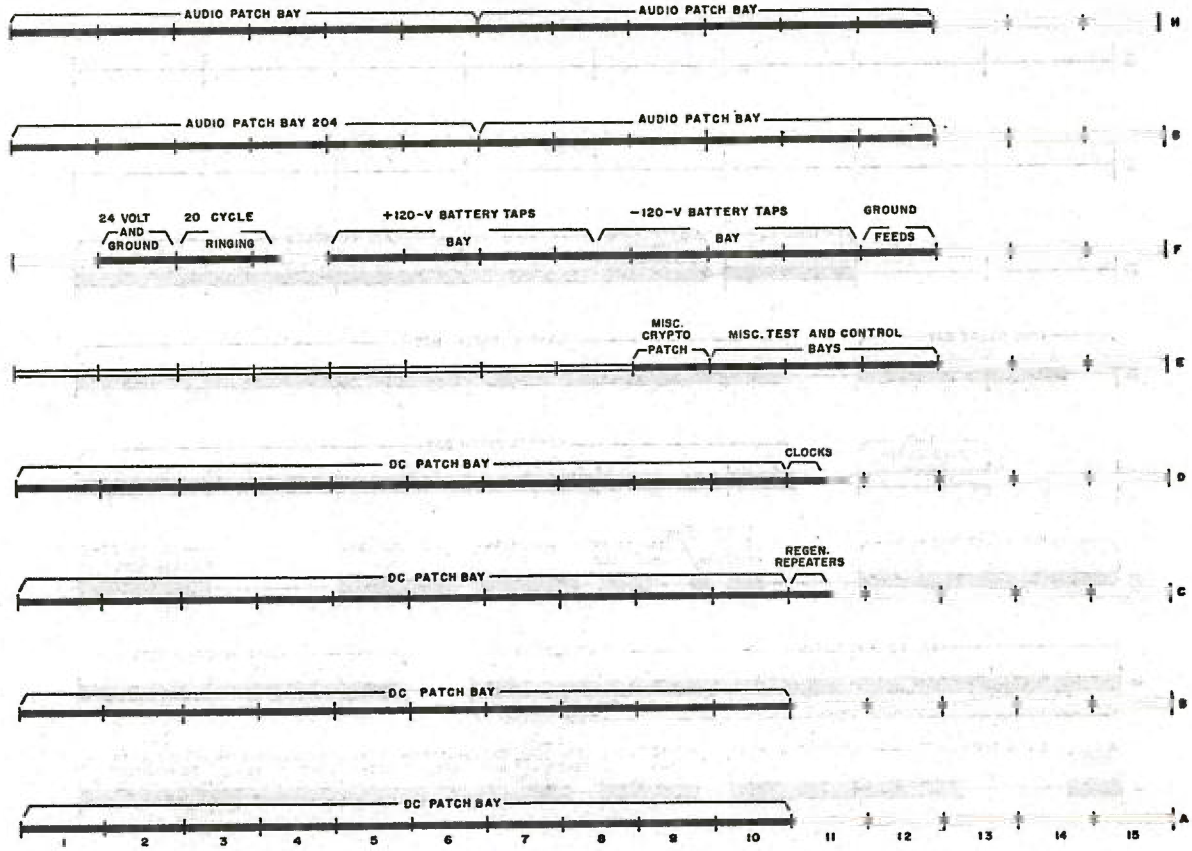


Figure 5–31. Horizontal Frame, Typical Block Assignments.

ing jacks, two miscellaneous jack panels, one transformer panel and two panels upon which are mounted coils, resistors, capacitors, and relays that are associated with the operator's telephone and ring-down trunk circuits. Also included in the audio bay is a volume indicator panel which is located directly beneath the terminal strips at the top of the bay. This indicator panel contains an audio level calibrated in volume units (VU) and is used to measure the instantaneous audio levels being sent out on the lines.

(1) *Line and Equipment Patch and Monitoring Jacks.* These jacks are normalled through so that, with all lines and equipments working properly, no patch cords appear on the panels. Figure 5–33 shows typical connections for the audio portion of a receive MUX circuit. One pair of line patch jacks are shown connected to a CMT–4 multiplex channel, and in parallel with these are a pair of line monitor jacks used for monitoring purposes. A normal-through connection is made to a pair of equipment patch jacks which are connected to the input of a VFTG converter. In parallel with the equipment patch jacks are also a pair of monitor jacks. With this arrangement, should the CMT–4 multiplex channel go bad, one end of a double plug patch cord would be inserted in the line patch jacks of a spare CMT–4 channel. The other end of the patch cord inserted in the equipment patch jacks of the VFTG converter would break the normal-through connection and connect the input of the VFTG converter to the output of the spare CMT–4 channel. Should the VFTG converter become inoperative, the reverse would apply. The line and equipment patch and monitoring jacks can be used on transmitting as well as receiving circuits.

(2) *Miscellaneous Patch and Monitoring Jacks.* These jacks are normalled through and accommodate thirteen audit circuits.

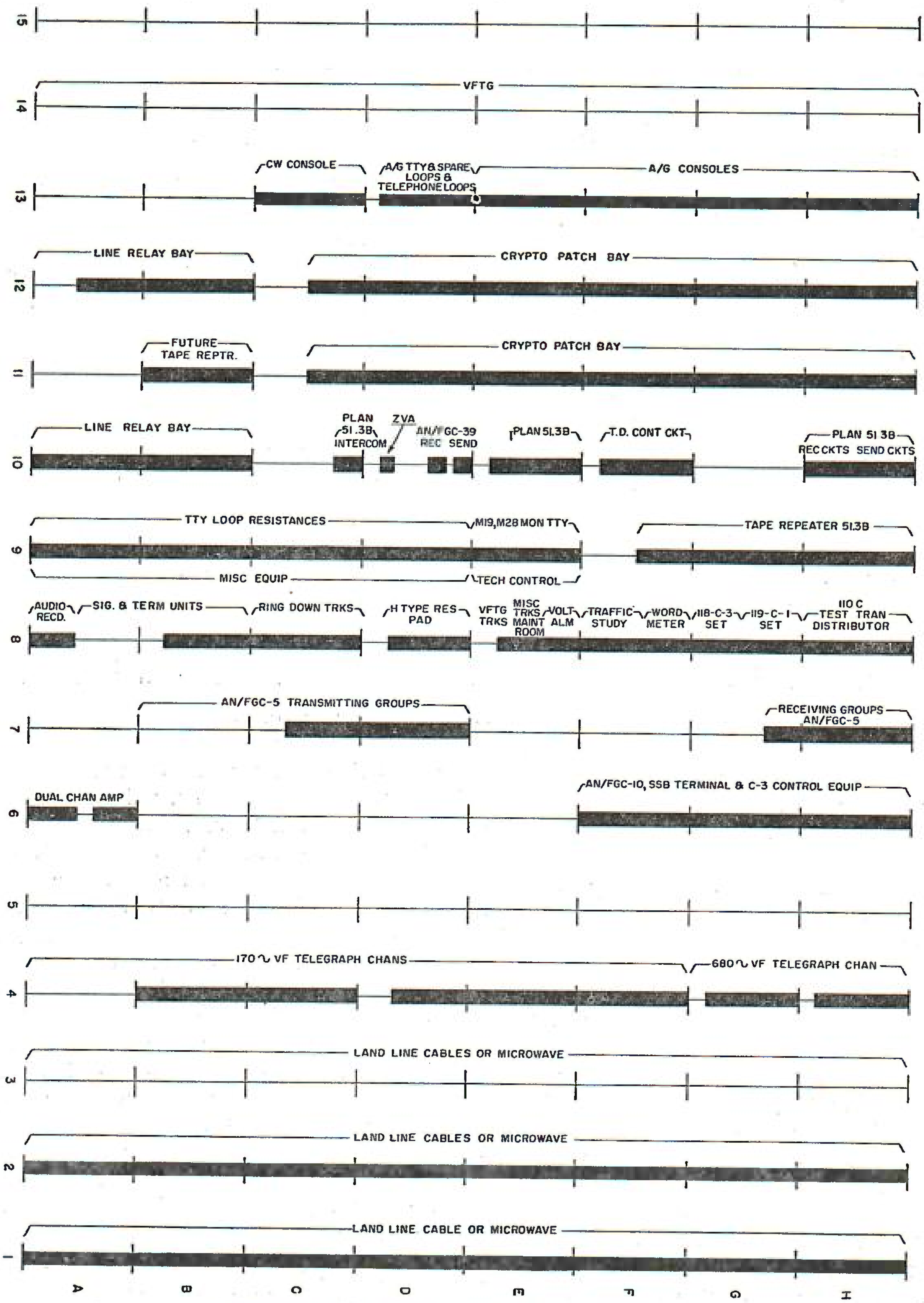


Figure 5–32. Vertical Frame, Typical Block Assignments.

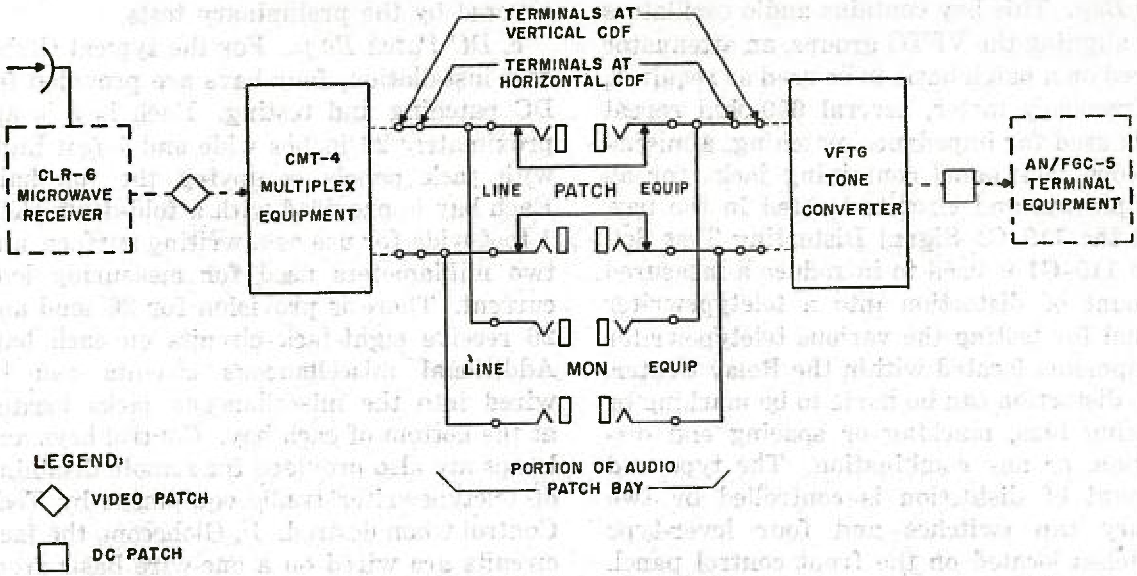


Figure 5-33. Typical Audio Jack Circuit.

They are similar to the line and equipment patch and monitoring jacks, but there is only one half as many of them. The jacks are connected so that patching and monitoring can be accomplished on either the line side or the equipment side, but not on both sides simultaneously.

(3) *Miscellaneous Jack Panels.* The two miscellaneous jack panels provide miscellaneous jacks for test circuits employing various equipments such as oscillograph, audio tape recorder, audio level meter, and bridging transformer. The miscellaneous panels also provide jacks for amplifier and attenuator circuits, intersite telephone and ring-down trunk circuits, indicator lamp circuits, and key circuits.

(4) *Equipment Panels.* These two panels are located at the bottom of the bays and contain the various coils, resistors, capacitors, transformers, and relays associated with the operator's intersite telephone and ring-down trunk circuits.

b. *Miscellaneous Test and Control Bays.* The Miscellaneous Test and Control Bays section consists of three bays: the Radio Receiver and Amplifier Bay, the Attenuator, Oscillator and Distorting Bay, and the Toll Test and Oscillograph Bay. Each bay is equipped with a fold-down shelf for use as a writing surface.

(1) *Radio Receiver and Amplifier Bay.* This bay consists primarily of two radio receivers with associated antenna branching amplifier, speaker assembly, and CV-89 Frequency Shift Converter. This arrangement makes it possible to monitor the various radio teletypewriter circuits directly. Also included in the bay are two dual-channel amplifiers which are to be used on a patch basis as required. At the bottom of the bay are the teletypewriter ring-down trunk panels. These panels contain relay circuits which connect to jacks and indicator lamps located on the miscellaneous jack panels in the bay. The ring-down trunks are used primarily on order wire circuits as a signaling device. When the distant end of an order wire circuit is signaling, the corresponding lamp on the miscellaneous jack panel will light. A monitor printer can then be connected to the appropriate jack for communicating with the distant station. This signaling arrangement will permit the use of fewer printers since it is not necessary for monitor printers to be permanently connected to each circuit. Located immediately below the radio receivers are three miscellaneous jack panels which contain miscellaneous jack terminations for all the equipments and circuits in the bay.

(2) *Attenuator, Oscillator and Distort*

ing Bay. This bay contains audio oscillators for aligning the VFTG groups, an attenuator wired on a patch basis to be used as required, a frequency meter, several 600-ohm repeat coils used for impedance matching, a miscellaneous jack panel containing jacks for all equipments and circuits located in the bay, and the 119–C1 Signal Distorting Test Set. The 119–C1 is used to introduce a measured amount of distortion into a teletypewriter signal for testing the various teletypewriter equipments located within the Relay Center. The distortion can be made to be marking or spacing bias, marking or spacing end distortion, or any combination. The type and amount of distortion is controlled by two rotary tap switches and four lever-type switches located on the front control panel. The 119–C1 is keyed by signals produced in the 110–C1 test transmitter located in the Equipment Room.

(3) *Toll Test and Oscillograph Bay.* This bay contains a Type GR–1932A Distortion and Noise Meter for measuring distortion on audio signals ranging from 50 to 15,000 cps and noise or hum on audio signals from 30 to 45,000 cps. Located directly beneath the noise meter is a Type 304 Oscillograph which is used to monitor the wave shapes of various signals passing through the Relay Center. Also located in the bay is the 9–G–1 Toll Test Board which contains test equipment for the maintenance of landlines. The test board is a manually operated unit which provides means for making volt-ohmmeter and Wheatstone bridge measurements on telegraph or telephone lines and terminal equipment. Line and equipment jack circuits are provided for testing and patching purposes. Line faults are detected by various volt-ohmmeter tests. Such faults may be classified as those due to open or short circuits, excessive leakage or direct connections to ground, and crosses between the two wires of a pair or between wires of two different pairs. While the volt-ohmmeter tests are intended primarily to provide rough preliminary indications of the existence and nature of the fault, the Wheatstone bridge measurements provide means for determining the specific location of the line faults discovered by the preliminary tests.

c. *DC Patch Bays.* For the typical Globecom installation, four bays are provided for DC patching and testing. Each bay is approximately 20 inches wide and 7 feet high, with jack panels occupying the top half. Each bay is provided with a fold-down shelf 1 foot wide for use as a writing surface, and two milliameters used for measuring loop current. There is provision for 26 send and 26 receive eight-jack circuits on each bay. Additional miscellaneous circuits can be wired into the miscellaneous jacks located at the bottom of each bay. Control keys and lamps are also provided for remote disabling of teletypewriter traffic equipment by Tech Control when desired. In Globecom, the jack circuits are wired on a one-wire basis from positive 120 volts to negative 120 volts. There are seven basic types of jack circuits available on each patch panel. The jack circuits are as follows:

(1) *Line and Equipment Receive Jack Circuits.* These are located at the top left half of the bay immediately below the meter panel. The twelve circuits available here are separated by eight wooden plugs from the Line and Equipment Send jack circuits which occupy the right half of the bay. The jacks are wired normal-through with the direction of traffic flow being from the top downward. As shown in figure 5–34, each Line and Equipment position has a patch and monitor jack. These jacks are designed to provide monitoring and patching capabilities in the individual DC outputs (channels) of the receive tone converter (VFTG) groups.

(2) *Line and Equipment Send Jack Circuits.* These are located at the top right half of the bay below the meter panel. The jacks are wired normal-through with the direction of traffic flow being from the bottom upwards. As shown in figure 5–35, each Line and Equipment position has a patch and monitor jack. These jacks are designed to provide monitoring and patching capabilities in the individual DC inputs (channels) of the send tone keyer (VFTG) groups.

(3) *Eight-Jack Receive Circuit.* These jacks are located in the top half of the patch

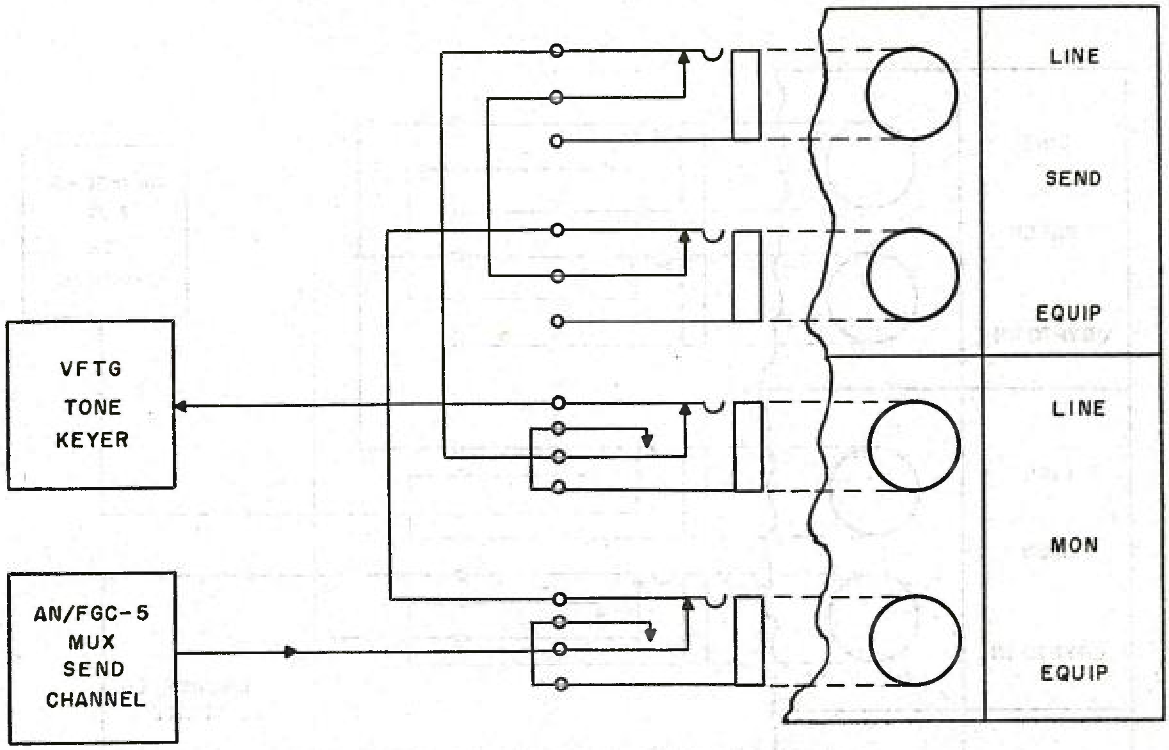


Figure 5-34. Line and Equipment Receive Jack Circuits.

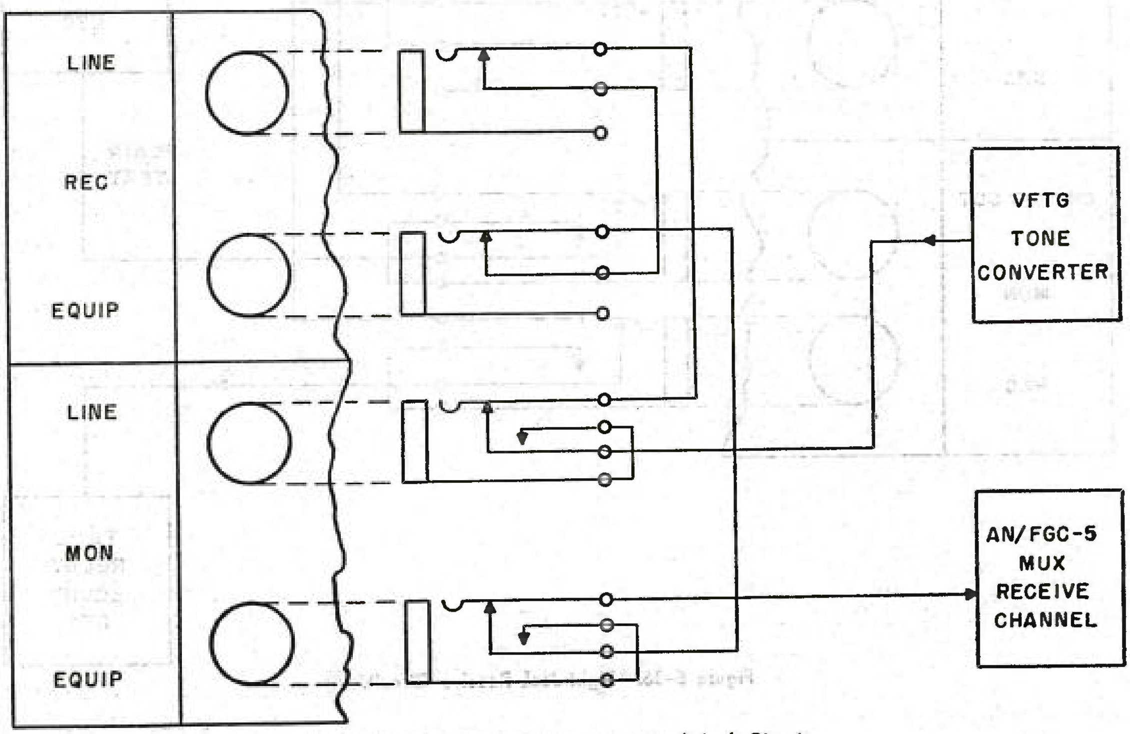


Figure 5-35. Line and Equipment Send Jack Circuits.

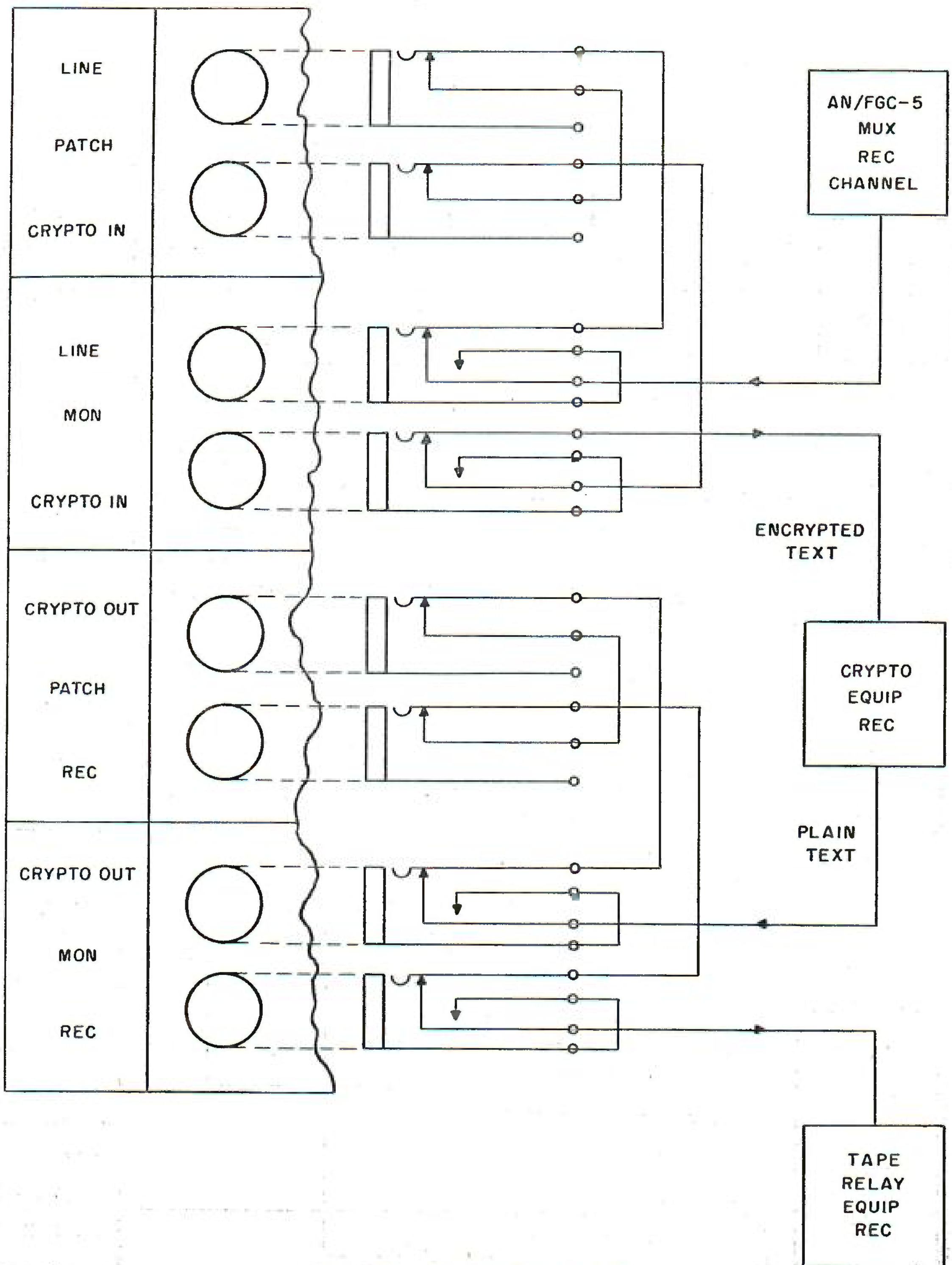


Figure 5-36. Eight-Jack Receive Circuit.

panel and are normal-through. As shown in figure 5-36, each position, Line, Crypto In, Crypto Out, and Rec (Plan 51.3B reperforator), has a patch and monitor jack, making a total of eight jacks. These jacks provide monitoring and patching capabilities in the various portions of the receiving DC teletypewriter circuits. The direction of traffic flow through these jacks is from the top downward.

(4) *Eight-Jack Send Circuit.* These jacks are located in the bottom half of the patch panel and are wired normal-through. As shown in figure 5-37, each position, RPTD (tape repeater TD), Crypto In, Crypto Out and Line, has a patch and monitor jack, making a total of eight jacks. These jacks provide monitoring and patching capabilities in the various portions of the sending DC teletypewriter circuits. The TT-160/FG cryptographic equipment is shown controlling or stepping the TD of the tape repeater. If the crypto equipment is by-passed for any reason, the TD of the tape repeater will then be controlled or stepped by the 368-opm TD control located in the Equipment Room. The direction of traffic flow through the eight-jack send circuit is from the bottom upward.

(5) *Four-Jack Send Circuit.* These jacks are located near the bottom of the patch panel immediately beneath the eight-jack send circuits. The jacks are wired normal-through with the direction of traffic flowing from the bottom upward. As shown in figure 5-38, each position, Rec (Plan 51.3B tape repeater reperforator), and Send (Plan 51.3B incoming line console TD's), has a patch and monitor jack, making a total of four jacks. These jacks provide monitoring and patching capabilities in any portion of the 75-wpm DC teletypewriter "cross-office" circuits. These jacks may also be used to provide termination for the DC portion of a VFTG system.

(6) *Send and Receive Loop Jacks.* Since the Globecom DC patch bays are operated on a 1-wire rather than a loop basis, some means must be provided for terminating the lines entering the Relay Center on a 2-wire basis. This is accomplished by the use of the Send and Receive Loop jacks (fig. 5-39). These jacks appear in approximately the middle of each bay and provide for 26 send and 26 receive circuits.

(7) *Miscellaneous Jacks.* These jacks are located at the extreme bottom of the bays and contain the control key and lamp circuits used for disabling teletypewriter traffic equipment. Also contained in the miscellaneous jack panels are jacks associated with the 110-C1 test transmitter-distributor located in the equipment room. These jacks are wired so that the test transmitter stops operating when the jack is no longer used. Other jacks contained in the miscellaneous jack panels are: reversing jacks used for special test procedures, meter jacks which are connected to the two milliameters located at the top of each bay, series looping jacks designated for use as dummy loops, and leg combining jacks designed for simplex operation on a duplex channel or for combining a receive channel and send channel of the same system to permit the handling of a two-way conversation with the use of one teletypewriter.

5-51. Monitor Printers

As shown in figure 5-30, the Tech Control Room contains one M-19 and eleven M-28 monitor teleprinters. These monitor machines are provided for inter-station communication when aligning and testing inter-station circuits and for monitoring incoming and outgoing message or test traffic to determine the quality of transmission. If inter-station communication is required on circuits involving on-line encryption, the M-19 teletypewriter set is used. This M-19 has installed in it a special TD which can be stepped or controlled by the crypto equipment. All monitor machines are wired on a patch basis and can be connected to any circuit as required.

5-52. Esterline-Angus Pen Recorder

The pen recorder is employed by Tech Control as a means of determining periods of peak traffic on teletypewriter circuits. The pen recorder consists essentially of fou

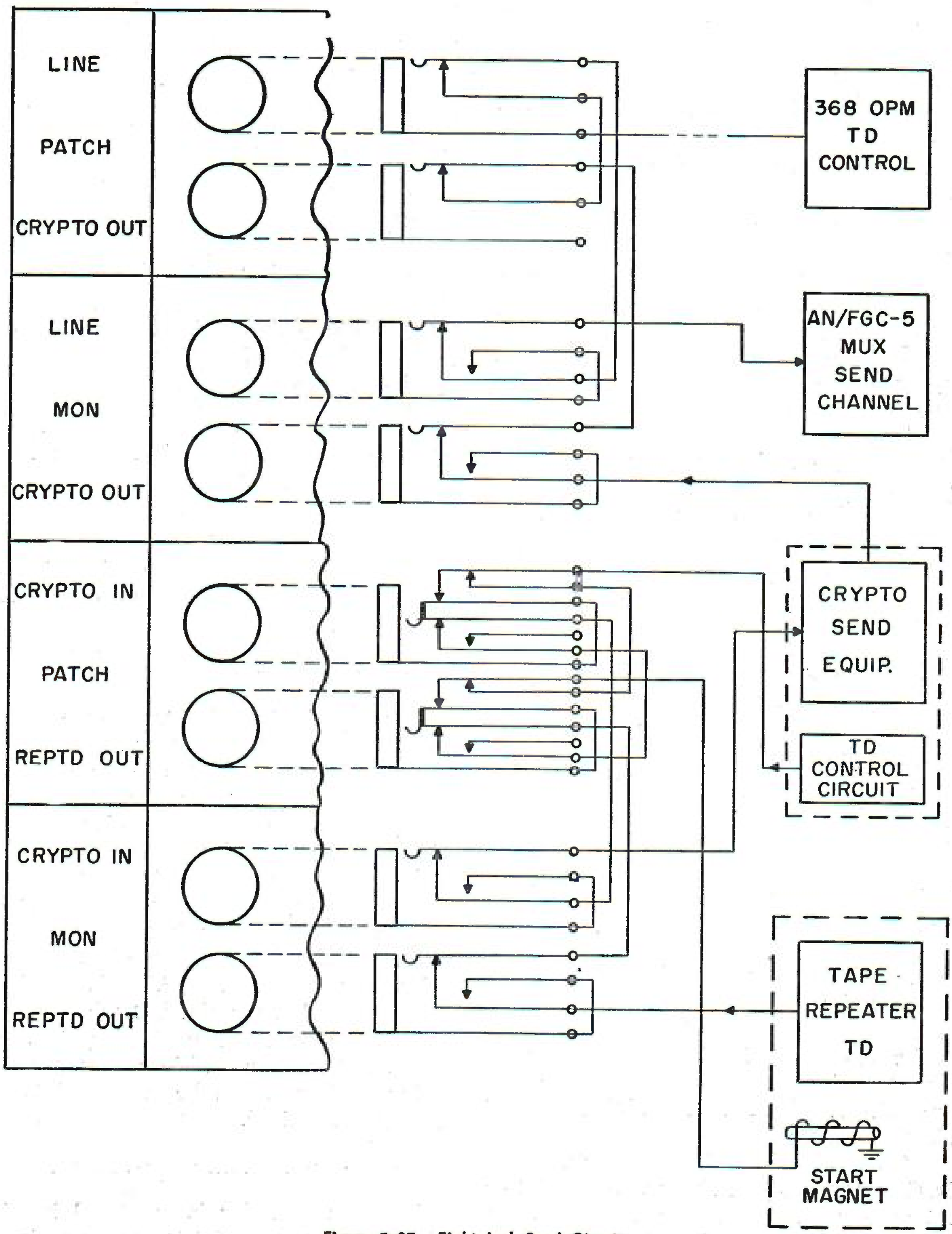


Figure 5-37. Eight-Jack Send Circuit.

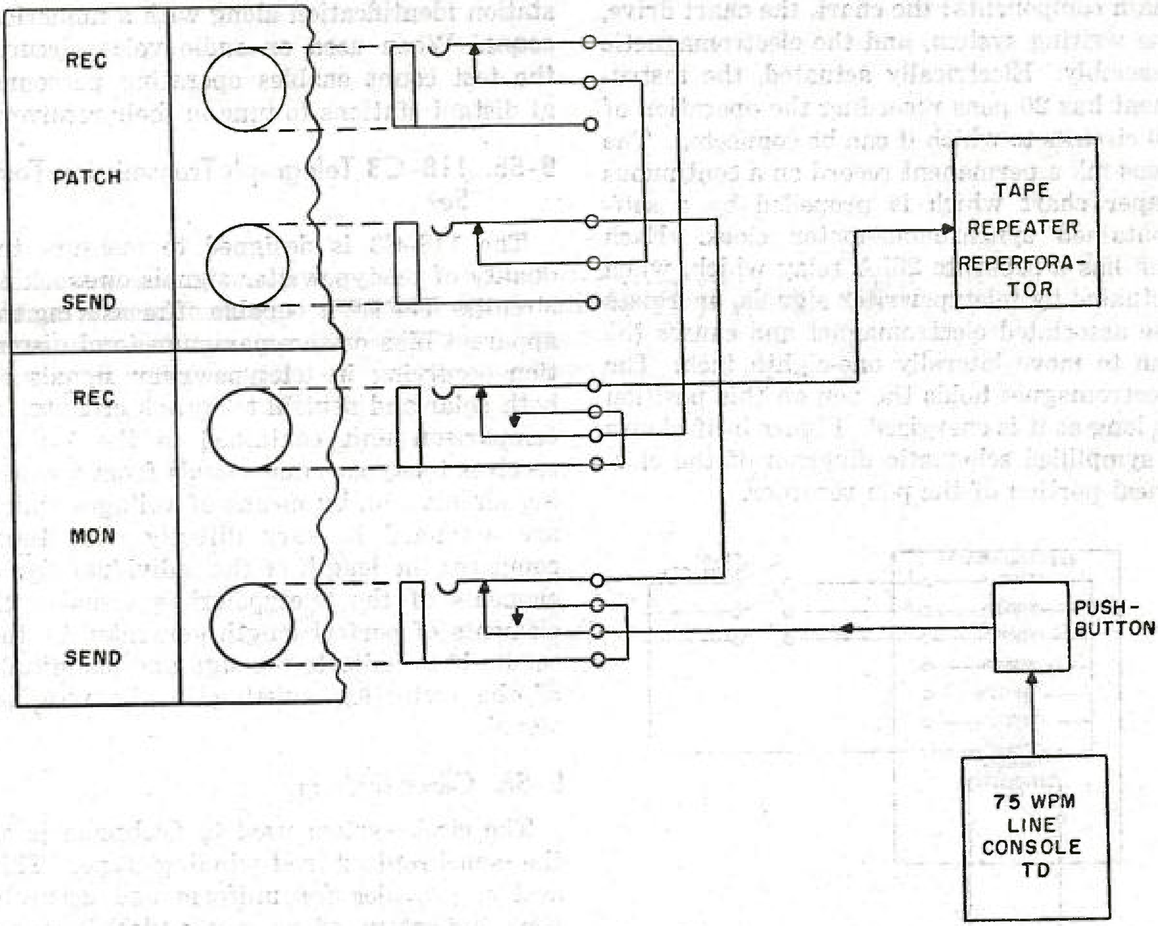


Figure 5-38. Four-Jack Send Circuit.

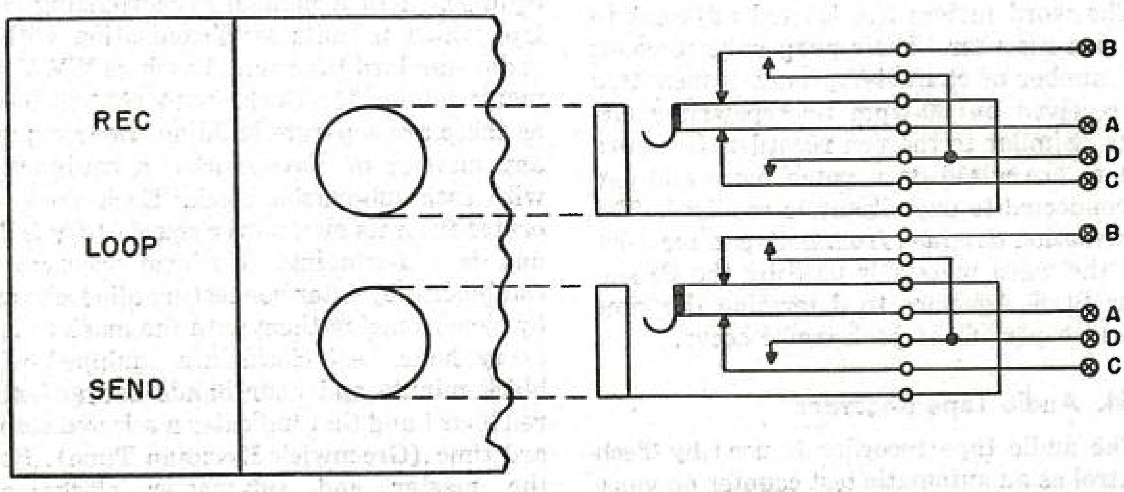


Figure 5-39. Send and Receive Loop Jacks.

main components: the chart, the chart drive, the writing system, and the electromagnetic assembly. Electrically actuated, the instrument has 20 pens recording the operation of 20 circuits to which it can be connected. The pens ink a permanent record on a continuous paper chart which is propelled by a self-contained synchronous-motor clock. Each pen has a separate 255A relay which, when actuated by teletypewriter signals, energizes the associated electromagnet and causes the pen to move laterally one-eighth inch. The electromagnet holds the pen on this position as long as it is energized. Figure 5-40 shows a symplified schematic diagram of the electrical portion of the pen recorder.

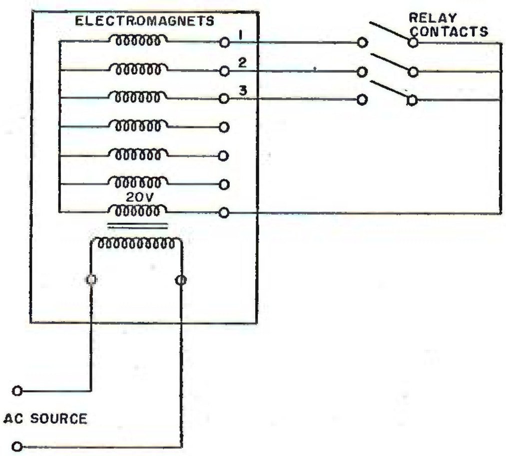


Figure 5-40. Partial Schematic of the Pen Recorder.

5-53. Word Meters

The word meters are located adjacent to the pen recorder. Their purpose is to count the number of character groups transmitted or received on 60-wpm teletypewriter circuits. Similar to the pen recorder, the word meters are wired on a patch basis and can be connected to any circuit as required. The information obtained from both pen recorder and the word meters is used by the Operations Staff Agencies to determine the time at which periods of peak traffic occur.

5-54. Audio Tape Recorder

The audio tape recorder is used by Tech Control as an automatic test counter on voice circuits. The voice test tape used gives the station identification along with a numerical count. When used on radio voice circuits, the test count enables operating personnel at distant stations to tune in their receivers.

5-55. 118-C3 Telegraph Transmission Test Set

The 118-C3 is designed to measure the quality of teletypewriter signals on working circuits. The set is capable of measuring the apparent bias or the maximum total distortion occurring in teletypewriter signals on both polar and neutral telegraph circuits. A comparison unit contained in the 118-C3 receives teletypewriter signals from a working circuit and, by means of voltages which are arranged to vary directly with time, compares the length of the individual signal elements of the teletypewriter signal with elements of perfect length generated by the set itself to indicate the sign and magnitude of the distortion existing in the received signal.

5-56. Clock System

The clock system used in Globecom is of the synchronized self-winding type. This system provides for uniform and accurate time indication of as many clocks as required. Independent operation of all clocks assures uninterrupted service irrespective of current supply or frequency. The typical clock installation is composed of one master clock, located at Tech Control, which is equipped with a manual synchronizing control which permits synchronization with a radio standard time signal such as WWV; as many sub-master clocks with control boxes as there are separate buildings or sites; and any number of slave clocks in conjunction with each sub-master clock. Each clock operates from its own power source (dry cells) and is self-winding. Uniform accuracy is established by inter-connecting all clocks and by synchronizing them with the master clock every hour. All clocks are equipped with black minute and hour hands and an extra red hour hand that indicates a selected standard time (Greenwich Meridian Time). Both the master and sub-master clocks are equipped with a small second hand.

PART SIX

POWER

Chapter 1

INTRODUCTION

Section I. GENERAL

6-1. Purpose

The purpose of this part of the manual is to present information pertinent to the diesel-electric power generating sets used to supply electric power for utilities and electronic equipment at Globecom installations.

6-2. Scope

This part of the manual contains descriptions of equipments, their applications, and the techniques employed in the various types of power circuitry in use in Globecom. Also presented are policies, criteria, and other information regarding the capabilities, design, and use of Globecom diesel-electric power generating facilities.

6-3. Policies

Due to the varying power circuit requirements of different stations and of the different facilities within a station, Globecom power plants vary in size and equipment. Arrangement and installation of equipment in the various plants has been engineered as closely as possible to the supply and maintenance concept of providing standard worldwide installations. The information contained in this part of the manual reflects the current engineering policies pertinent to the selection, installation, and application of the Globecom diesel-electric power generating facilities.

Section II. DESCRIPTION

6-4. Building

a. The Communications Relay Center Type "A" Emergency Power Building is normally butted against the Communications Relay Center Building and houses from two to four generators, depending upon the station requirements. The two structures are separated by a sound deadening wall to reduce external noises in the operating rooms of the Communications Relay Center. In a few isolated cases, this building, or a similar typ power building, is detached and located ap proximately sixty feet from the main build ing.

b. For the receiver facility, a power roor is provided as an integral part of the receive building and is insulated from the othe rooms by sound deadening walls to reduc external noise in the operating rooms c the receiver building. This power room wi house from two to four generators, depending upon the station requirements.

c. The standard transmitter power building will house two or three 350-kw, 600-kw, or 1,000-kw generators. In some instances, the structure may be expanded to accommodate more than three generators. The transmitter power buildings are always detached and located approximately sixty feet from the end of the utility wing of the transmitter building.

6-5. Plants

a. The term "plant" as used in this part of the manual signifies the complete power generating facility. Normally, three complete power plants are provided: one for the Receiver Site, one for the Transmitter Site, and one for the Communications Relay Center. Each plant consists of two or more generating sets with associated controls and auxiliary equipment. The quantity of generating equipment installed is dependent upon the local power requirements.

b. Diesel-electric power generating plants supply prime, emergency stand-by, and back-up power to utilities and electronic equipments. Facilities are provided for parallel operation of generating sets and for synchronization with base power or outside source power when operation in conjunction with such power systems is practical and reliable. When used in conjunction with an outside power source, an outside source power circuit breaker with reverse power relays is provided. The reverse power relays prevent the feeding of power from the Globecom plant into the outside power source system.

c. The following operational criteria apply to diesel-electric power generating equipment used in Globecom power plants:

(1) Voltage variations must be maintained within the limits of plus or minus 5 percent of the prescribed voltage.

(2) Transient voltage must not exceed the limits of plus or minus 10 percent of the prescribed voltage.

(3) Frequency variation must not exceed 0.5 cycle per second from the standard frequency of 60 cycles per second.

(4) A high standard of reliability in electric service must be maintained.

d. Power generating sets provided for Globecom power plants are as follows:

(1) Caterpillar Diesel-Electric Set, 100 kw.

(2) Ready-Power Diesel-Electric Set, 100 kw.

(3) National Supply Diesel-Electric Set, 350 kw.

(4) Worthington Diesel-Electric Set, 350 kw.

(5) Baldwin - Lima - Hamilton Electric Set, 600 kw.

(6) Worthington Diesel-Electric Set, 600 kw.

(7) General Motors Corporation Diesel-Electric Set, 1,000 kw.

6-6. Repeater Sites

a. The following criteria have been established for the microwave attended and unattended sites:

(1) Where repeater sites are located at jointly operating attended sites, manually started generators and manually operated load transfer switches are utilized.

(2) Repeater sites which are unattended are provided generator plants with completely automatic starting and load transfer equipment.

b. The completely automatic generating plants contain the following provisions:

(1) A 5 second delay is incorporated to prevent operation of the automatic system due to monetary electrical disturbances.

(2) In the event of a utility or running generator failure, both stand-by emergency generators will be cranked, and the first unit starting and coming up to voltage will take over the load. Should any one of the protective controls on the running generator operate, the second generator will be started. In the event of an extended utility or running generator power failure, and the back-up generators have not been locked out by one of the protective devices, a cycling timer will operate to start the second generator after a 168-hour period, and, after a 10-minute warm-up period, to transfer the load

to the second generator. This operation will be repeated at the end of each 168 hour period.

(3) At sites which utilize a utility type of outside source power, an adjustable timer will provide a delay of 5 to 110 minutes before returning to the utility source of power after the outside source supply voltage is reestablished. Transfer of load will be accomplished by electrically-operated, mechanically-held contactors.

Chapter 2

EQUIPMENT

6-7. Background

a. Ready-Power Diesel-Electric Sets, with attached controls and low-voltage switchgear, were originally provided as Globecom 100-kw power plants. During subsequent phases of procurement and plant development, Caterpillar Diesel-Electric Sets were provided instead of the Ready-Power sets. With the installation of the Caterpillar sets, it became necessary to install an additional, separate engine control panel to enable operation of the sets with switchgear that had been procured previously for use with Ready-Power sets. Later, the need for the separate control panel was eliminated through the use of an additional low-voltage switchgear with a combined switchboard. The foregoing factors account for the variations to be found in the 100-kw power plants provided for the Globecom system. Previously provided equipment was used where possible to obtain the most economical and practical installation.

b. The 350-kw Worthington Diesel-Electric Sets and the associated Westinghouse switchgear originally were designed for the U. S. Navy. The switchgear was modified to meet AACS requirements, and the sets currently are used only in the Alaskan Area.

c. Four 1,000-kw General Motors Company Diesel-Electric Sets and associated auxiliary equipment were provided at two sites within the continental limits of the United States.

d. Caterpillar and Ready-Power 100-kw generators, National Supply Company 350-kw generators, and Baldwin-Lima-Hamilton 400-kw generators were provided for worldwide Globecom facilities.

e. In addition to the diesel-electric generators listed above, a requirement exists for diesel and gasoline-engine-driven generators which have a generating capacity of 5 kw to 40 kw to furnish prime or emergency back-up power for the microwave repeater sites. At the time of this writing, a standard plant has not been furnished, and the engineering of each site has been based on the individual site requirements and existing local conditions.

6-8. Analysis of Equipment

a. *Electrical.* When analyzing equipment in a Globecom installation, it normally can be assumed that a reliable outside source of power is available. However, if a reliable outside source of power is not available, consideration must be given to the fact that certain variations in equipment are allowed. At locations where no outside source power is available, the outside source circuit breaker cubicle and control panel are deleted and a swinging panel is provided. This swinging panel contains a synchroscope and voltmeter.

(1) The 100-kw power plants generate a using voltage of 120/208 volts. This power is fed from the generator terminal box to a generator circuit breaker cubicle, the load side of which is connected to a common switchgear bus. One or more power distribution sections are provided for each plant and are connected to the common switchgear bus. These distribution sections contain a combination of 100- and 200-ampere, 3-pole, 3-phase circuit breakers which are used to distribute system power to electronic, power and lighting loads.

(2) Power plants utilizing 350-kw units generate a prime voltage of 480 volts. This

power is fed from the generator terminal box to a generator control section which consists of a circuit breaker and control unit. From the control unit, the generated voltage is fed into a 500-kva transformer which is rated at 480 to 120/208 volts. From the 120/208-volt secondary of the transformer, a feeder is connected to a transformer secondary circuit breaker cubicle, the load side of which is connected to the common bus in the low-voltage switchgear line-up. The common bus is extended to a power distribution section which contains a combination of 100-, 200-, 400-, and 600-ampere, 3-pole, 3-phase circuit breakers. The quantity of equipment and the current capacity of the circuit is determined by the demand load requirements of each station.

(3) The 600- and 1,000-kw plants generate 4,160 volts. The generated voltage is fed to a high-voltage generator circuit breaker cubicle which is located in the switchgear line-up in the power building. From the load side of the circuit breaker, the feeder is extended to a 750 or 1,500 kva transformer through a duct bank that terminates at the transformer which is located adjacent to the equipment wing of the transmitter building. This transformer is rated at 2,400/4,160-volt input to a 240-volt output. From the 240-volt secondary side of the transformer, a bus duct is brought inside the transmitter building and connected to a transformer secondary circuit breaker cubicle in the low-voltage switchgear line-up. The switchgear line-up has a common bus to which the load side of the transformer secondary circuit breakers is connected. The bus in turn feeds one or more power distribution sections through a combination of 200-, 400-, and 600-ampere, 3-pole, 3-phase circuit breakers which supply the 240-volt, 3-phase power requirements of the facilities. In order to meet the 120/208-volt system requirements, two 600-ampere circuit breakers on the 240-volt bus are utilized to feed two 225-kva banks of 240/120/208-volt transformers. The secondary of each bank of 225-kva transformers is fed into the 120/208-volt section that is mounted on one end of the main switchgear line-up. The two banks are paralleled on a common bus which in turn supplies 120/208 volts for lighting and utilities.

(4) Originally, paralleling between generators or between generators and outside source supply was accomplished on the low-voltage bus of the system in the 350- and 600-kw plants; but in more recently designed plants, paralleling of 350- and 600-kw generators and outside source is accomplished on the high-voltage bus.

b. *Protective Devices.* The following protective devices are utilized in all Globecom power plants:

(1) The Type ICW reverse power relay prevents excessive power flow in a predetermined direction when synchronizing Globecom and outside source generators. The relay also prevents a generator from motoring when a decrease in frequency of the generator exceeds 3 percent of the rating of the generator with which it is being synchronized. Tripping of the generator breaker on temporary power surges is prevented by the time delay characteristic of the relay.

(2) Type IAC over-current relays protect feeders, generators and transformers in systems in which the current magnitude under short-circuit conditions is always above the magnitude of the maximum load current and in which a reasonable delay can be tolerated before a fault is cleared. The relays are set in such a manner that the relay nearest the fault will operate first, and the remaining relays will operate in time graded sequence under maximum short-circuit conditions. The minimum time difference between successive relay settings is equal to the rated interrupting time of the breaker, the interrupting time being equal to the elapse of time between the instant at which the trip coil is energized and the instant at which the circuit is interrupted. In general, the minimum time difference varies from approximately 0.3 seconds for 8-cycle breakers to progressively increasing differences for breakers having rated interrupting times in excess of 8 cycles.

(3) Type IJC relays protect 3-phase generators and feeders against damaging effects of phase unbalancing and single-phase

operation. The relay compares the current in each of the other phases. Any increase of current, regardless of its magnitude, will not cause the relay to operate so long as the currents in the three phases are balanced. In the event that an unbalanced condition occurs in the system that causes the current in one phase to exceed that in the other phases by 25 percent or more, the breaker will trip and open the circuit.

c. *Mechanical.* The following information is applicable to all Globecom diesel-electric power generating sets and must be considered when analyzing the mechanical aspects of power generating equipment.

(1) *Fuel System.* The fuel is pumped from either of two main underground storage tanks by means of a fuel supply or transfer pump. The fuel passes through a filter into a day or operating tank. The purposes of transferring fuel to the day tank is to permit impurities in the fuel oil to settle, to allow the air that may be trapped in the transfer pump to escape, and to maintain a sufficient supply of fuel oil for the diesel engines. A centrifuge is provided to remove impurities which can cause excessive wear of the cylinders and cylinder walls and to eliminate water accumulation that would lower the efficiency of the system. A fuel pump regulator is furnished with the engine to control the supply of fuel oil from the day tank to the spray valves which admit the oil to the cylinders. Fuel oil by-passed by the regulator is pumped back to the day tank by an automatic drain pump.

(2) *Lubricating Oil System.*

(a) Regulated and continuous lubrication of the diesel engine is necessary because of the intense heat and pressure under which the engine operates. A rotary pump driven by the crankshaft delivers a continuous supply of cooled, clean oil under pressure to lubricate all moving parts. This pump draws clean oil from a reservoir or sump tank, which is part of the engine, and delivers the oil through a lubrication oil cooler to a header. From the header, oil is distributed to the various parts of the engine through risers. The oil travels through passages in the crankshaft to the main bearings, crank pins, connecting rods and piston pins. Other moving parts, such as cams, gears and bearings, are lubricated through branch pipes from the main header. A priming hand pump is provided to prime the system before starting the engine. The oil returns to the sump tank through the bed plate and drain piping. In the sump tank the trapped air, sediment, and water drain out of the lubricating oil, and the lubricating cycle is repeated.

(b) Because oil becomes contaminated with use, a centrifuge is provided. Dirty oil is pumped from the sump to a dirty-oil storage tank by means of a lubrication oil transfer pump. Here the impurities settle out. The centrifuge then takes the oil from the dirty-oil tank and purifies it. Heating coils are installed as a part of the centrifuge to heat the oil for proper purification. Clean oil is returned either to the engine sump or to another storage tank which is designated as a clean-oil tank. This tank serves as a container for a ready supply of clean oil for make-up or for a complete change. Piping arrangements permit continuous purification of oil while the engine is in operation. Strainers of both the "fine edge" and "cloth" type are used to keep the system free from foreign substances.

(c) Since the lubricating oil is hot and thin when it leaves the sump, it must be cooled to maintain its lubricating qualities. An oil cooler is provided for this purpose. The oil cooler consists of an outer casing and a nest of thin-walled tubes through which cool water passes. The oil enters the casing at one end and flows over and around the tubes, through a series of baffles and out of the other end, giving up heat during its passage through the cooler. A temperature regulating valve governs the amount of oil passing through the cooler.

(3) *Jacket Water Cooling System.* Due to the heat developed in the engine while operating, the cylinders and pistons require cooling. They are surrounded by a water jacket which permits cool water to be continually in contact with the cylinder lining. To provide a means of cooling the water, a cooling radiator assembly is furnished. This

assembly consists of a finned radiator core, through which the hot water is passed, and a motor-driven fan which blows cool outside air through the radiator core. An engine-mounted circulating water pump forces the water through the radiator, oil cooler, and engine to insure a continuous flow of cool water. A jacket water temperature regulating valve is installed in the system to maintain the proper operating temperature. Cold water admitted to a hot cylinder could cause piston seizure; therefore, it is important that the water used for cylinder cooling should be maintained at the proper temperature and should be free from scale forming substances. Water taken from an outside source is passed through a water softener, and, to insure an adequate supply, a large storage tank is provided for filling and replenishing the system.

(4) *Starting Air System.* A compressed air system is provided as an outside source of power to start the diesel engines. The system consists of two air compressors, one driven by an electric motor and the other driven by a gasoline engine, and three compressed air receivers which are provided as storage tanks. The gasoline-engine-driven compressor is provided as a stand-by source of air in case of power failure. The compressors furnish air at 250 psi and store it in the three receivers to insure an adequate supply of air for starting the engine. Automatic devices are installed on the compressors to maintain 250 psi air pressure in the tanks, and relief valves are fitted to each tank to prevent rupture. A reducing and regulating valve is provided to reduce the initial 250 psi to 100 psi for bench service.

(5) *Air Filters.* Two air filters are provided for combustion air intake, one outside and one inside the building. Combustion air is usually taken in through the outside filter; however, under adverse weather conditions, the inner filter is used.

(6) *Silencer or Muffler.* Each engine is equipped with a silencer or muffler.

6–9. Parallel Operation

a. Parallel operation is the simultaneous operation of two or more sources of power on the same system.

b. To enable two or more generators or one Globecom generator and an outside source system to operate properly in parallel, the following conditions must exist:

(1) Voltage in both systems, as registered by voltmeters, must be the same.

(2) Frequencies in both systems must be the same.

(3) Voltages in both systems must be in phase.

c. It is necessary to synchronize the systems involved in parallel operation to prevent unnecessary interruption to the electric service during load transfer periods.

PART SEVEN

INTERSITE FACILITIES

Chapter 1

INTRODUCTION

7-1. Description

a. Since most bases do not have the land areas required for antenna sites, and since it is desirable to have the receiving antennas removed from the strong signal fields of the transmitters, the transmitting and receiving antenna sites are located at some distance from both the air base and each other. The Communication Relay Center is frequently located at the air base, but may, in specific instances, be located off-base, usually at the Transmitter Site. In order to make the system operate, the separated sites must be connected by reliable intersite communications.

b. The types of primary interconnecting links used in Globecom are microwave radio link, cable, and VHF radio link, each backed up 100 percent by microwave, cable or VHF. Any combination is possible; however, since microwave is a later development and more likely to be encountered, it is the only one discussed in this manual.

c. Microwave radio links are usually cheaper than wire-line systems and simpler to install. Repeaters usually can be installed at easily accessible sites by avoiding the difficult terrain in the path, and damage from weather conditions is minimized because only a small part of the equipment is exposed to the weather. The system is flexible, and expansion can be accomplished with floor space limitations.

7-2. Purpose

a. The purpose of the microwave system is to provide trunkline service from the remote Receiver Site to the Communications Relay Center and from the Communications Relay Center to the remote Transmitter Site. The number of microwave links installed is determined by the operating requirements of the station.

b. The number of communication channels between sites at a station is determined by the operational requirements. As these requirements change, the number of channels also change. The use of microwave radio links permits a high degree of flexibility in respect to both the number and the characteristics of communication channels between sites.

Chapter 2

EQUIPMENT

Section I. MICROWAVE RADIO LINK EQUIPMENT

7-3. General

a. Philco Model CLR-6 Microwave Radio Link Equipment is designed for simultaneous two-way communication between points. Modulation capabilities are such that, with suitable multiplexing equipment, up to twenty-four voice band channels can be passed over one link.

b. A microwave radio link consists of two terminal stations and repeaters as required. The use of repeater stations is dictated by the distance between terminal stations and the propagation characteristics for the transmission path.

c. The CLR-6 operates on any frequency band from 6125 mc to 7425 mc. In Globecom the Government band frequencies of 7125 mc to 7425 mc are normally used. In some foreign countries where a large number of parallel links exist, frequencies in the band of 6575 mc to 6875 mc are sometimes used. This is the Industrial Band in the United States under FCC control, but is not necessarily the Industrial Band in foreign countries. When operating as a link in which repeaters are used, four frequencies are required. Adjacent repeaters transmitting in the same direction are assigned operating frequencies 90 mc apart. At any repeater station, transmissions in opposite directions are separated by 160 mc (see fig. 7-1).

d. The CLR-6 uses frequency modulation with a nominal two-megacycle peak-to-peak deviation. The modulation band-pass characteristics are plus or minus 0.5 db from 50 cps to 300 kc. The CLR-6 is generally used with the CMT-4 Time Division Multiplex Equipment which divides the broad band into 24 voice band channels.

e. Except for a few components, the ter-

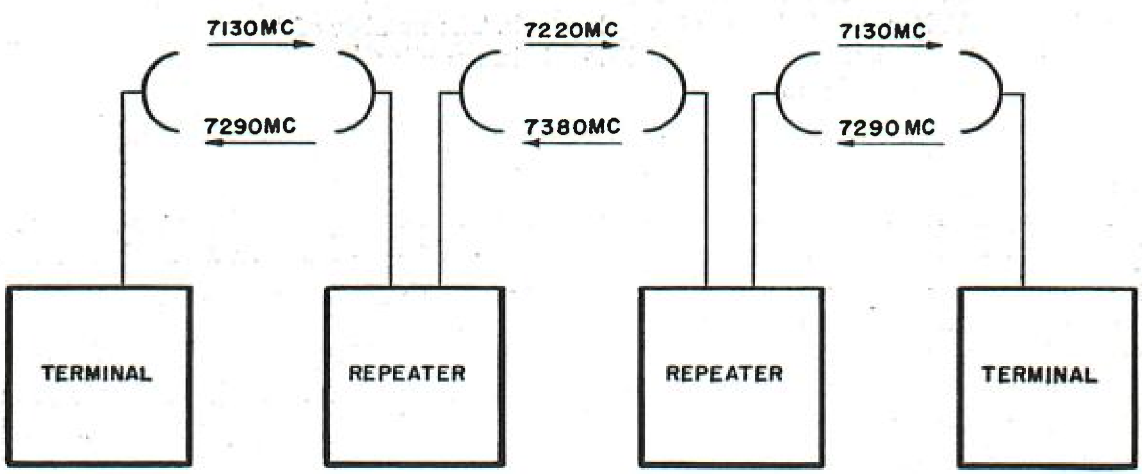


Figure 7-1. Typical CLR-6 Microwave Radio Link.

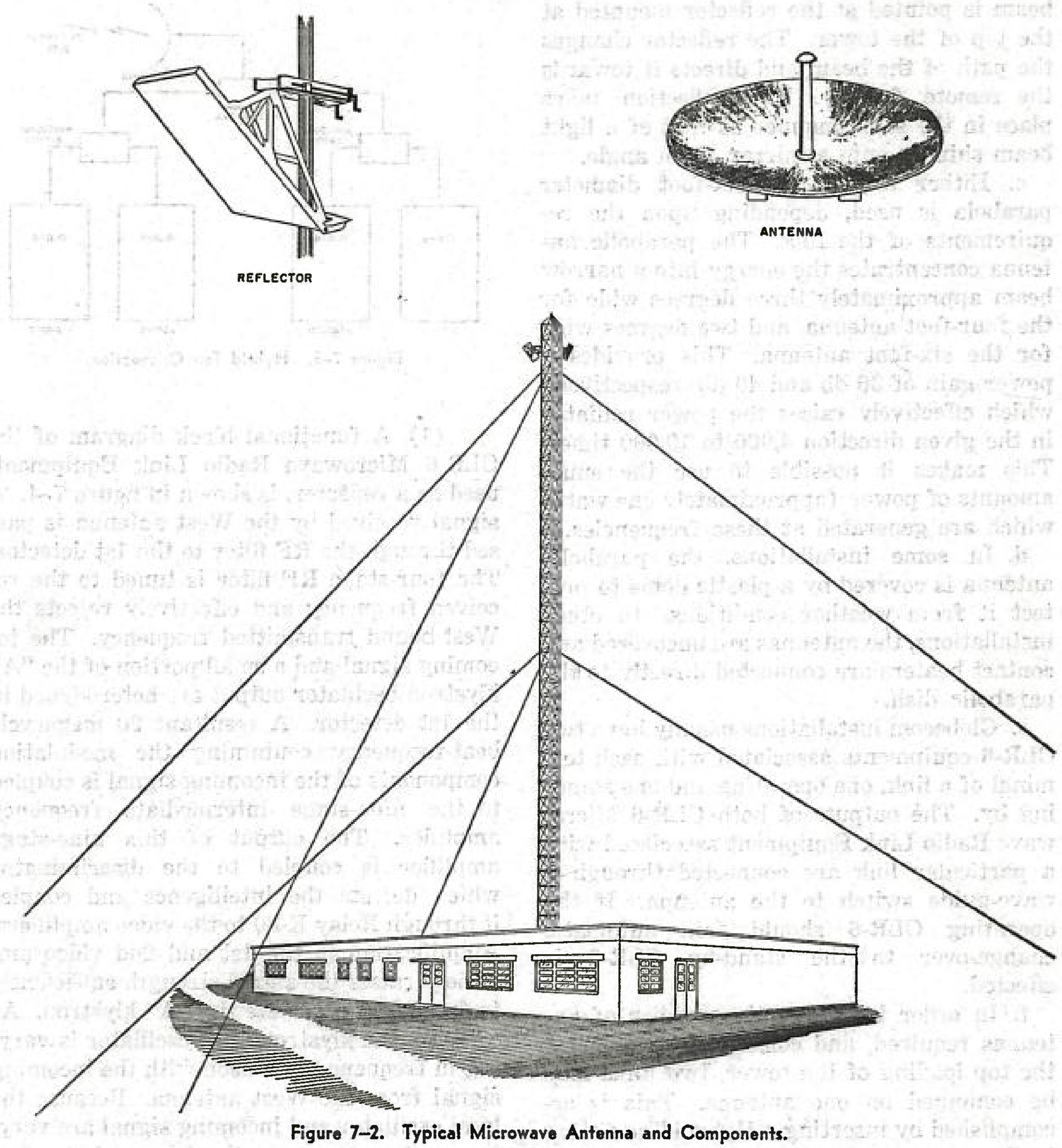


Figure 7-2. Typical Microwave Antenna and Components.

minal and repeater equipment are similiar in appearance and operation. Repeater equipment sends and receives in both directions, while terminal equipment sends and receives in only one direction.

7-4. Antenna Systems

a. The antenna reflectors are mounted on towers of suitable height to provide line-of-sight transmission. At or near the foot of the tower is an associated parabolic antenna for each reflector (see fig. 7-2),

b. The CLR-6 Microwave Radio Link Equipment is located in the building and connected by wave-guide to the parabolic antenna at or near the foot of the tower. Radio-frequency energy is focused into a narrow beam by the parabolic dish and the beam is pointed at the reflector mounted at the top of the tower. The reflector changes the path of the beam and directs it towards the remote facility. The reflection takes place in the same manner as that of a light beam shining onto a mirror at an angle.

c. Either a four- or six-foot diameter parabola is used, depending upon the requirements of the link. The parabolic antenna concentrates the energy into a narrow beam approximately three degrees wide for the four-foot antenna, and two degrees wide for the six-foot antenna. This provides a power gain of 36 db and 40 db, respectively, which effectively raises the power radiated in the given direction 4,000 to 10,000 times. This makes it possible to use the small amounts of power (approximately one watt) which are generated at these frequencies.

d. In some installations, the parabolic antenna is covered by a plastic dome to protect it from weather conditions. In other installations, the antennas are uncovered and contact heaters are connected directly to the parabolic dish.

e. Globecom installations usually have two CLR-6 equipments associated with each terminal of a link, one operating and one standing by. The outputs of both CLR-6 Microwave Radio Link Equipment associated with a particular link are connected through a wave-guide switch to the antenna. If the operating CLR-6 should fail, automatic change-over to the stand-by CLR-6 is effected.

f. In order to reduce the number of antennas required, and consequently to lessen the top loading of the tower, two links may be combined on one antenna. This is accomplished by inserting a Hybrid Tee fitting in the wave-guide between the antenna and the wave-guide switches on the equipment (see fig. 7-3). The Hybrid Tee fitting permits each transmitter to operate into the antenna without being affected by the presence of the other equipment. The Hybrid Tee can be used only on circuits that can stand a 3 DB loss at each end.

7–5. Theory of Operation

a. CLR-6 Repeater

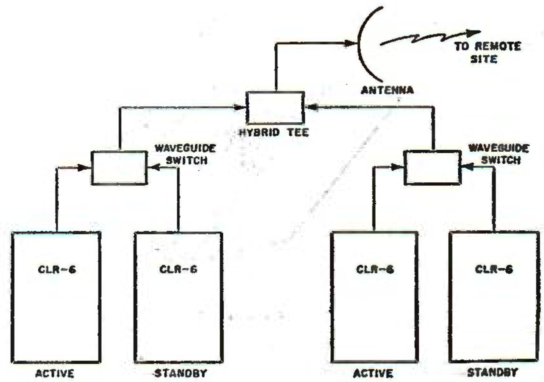


Figure 7–3. Hybrid Tee Connection.

(1) A functional block diagram of the CLR-6 Microwave Radio Link Equipment, used as a repeater, is shown in figure 7–4. A signal received by the West antenna is passed through the RF filter to the 1st detector. The four-stage RF filter is tuned to the received frequency and effectively rejects the West-bound transmitted frequency. The incoming signal and a small portion of the "A" klystron oscillator output are heterodyned in the 1st detector. A resultant 90 megacycle beat-frequency containing the modulation components of the incoming signal is coupled to the nine-stage intermediate frequency amplifier. The output of this nine-stage amplifier is coupled to the discriminator which detects the intelligence and couples it through Relay K-80 to the video amplifiers. Amplification in the 1st and 2nd video amplifiers raises the signal strength sufficiently to frequency modulate the "A" klystron. As a result, the klystron local oscillator is varying in frequency in unison with the incoming signal from the West antenna. Because the local oscillator and incoming signal are varying at the same rate, the intermediate -frequency is maintained at approximately 90 mc. The local oscillator frequency is either 90 megacycles above or below the incoming frequency and contains the same modulation. Most of the "A" klystron power output is coupled to the East antenna through a waveguide and a small portion is coupled back to the 1st detector as the local oscillator signal.

(2) The drop-out and insertion amplifiers are used to remove from or add infor-

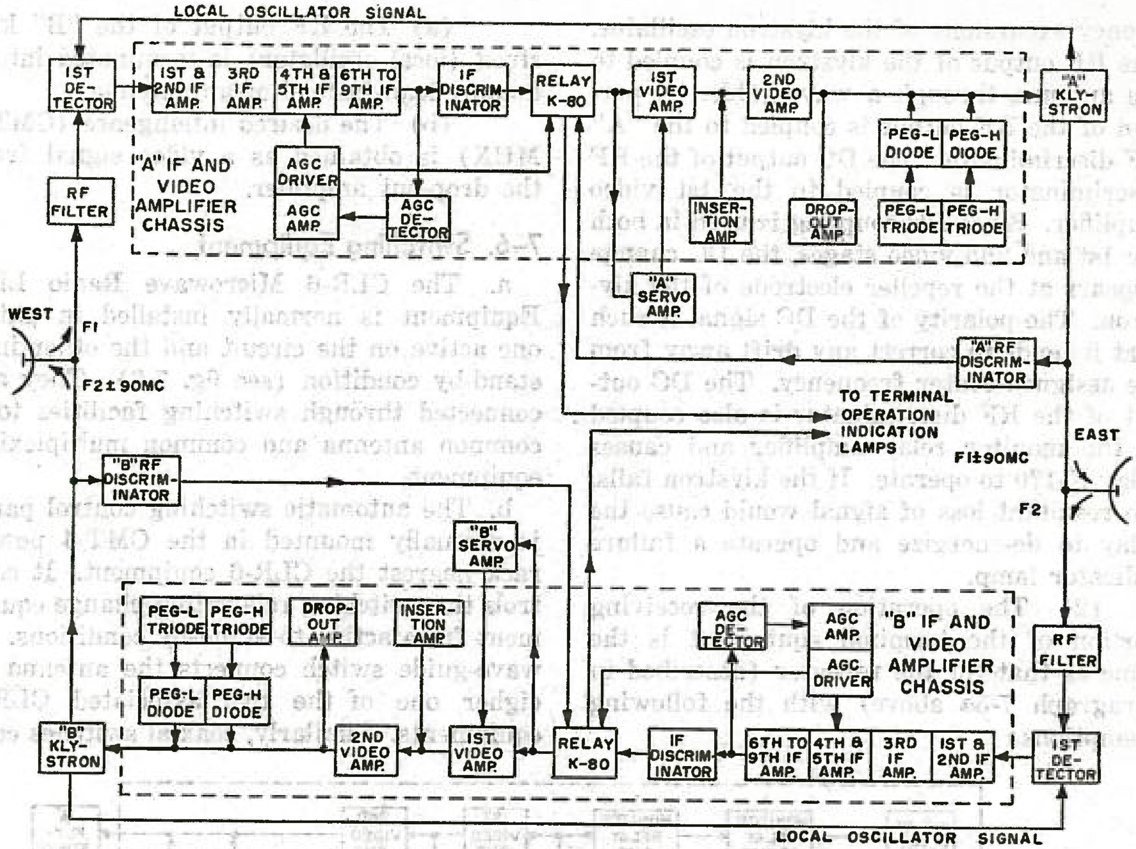


Figure 7–4. Functional Block Diagram of the CLR-6 Repeater.

mation to the video signal at repeater stations.

(3) A portion of the IF signal is fed to an automatic gain control (AGC) detector. The DC output of this detector is amplified in the AGC amplifier and AGC driver stages and used to vary the gain of the receiver with changes in the incoming signal level.

(4) Video and DC signal components appear in the output of the IF discriminator. The DC component exists only when the local oscillator is detuned. The servo amplifier detects the DC error voltage and applies it through the DC coupled video amplifiers to the klystron. As a result of this action, the klystron frequency is changed in direction to reduce the error signal and return to center frequency.

(5) In the event that the received signal is lost, the loss of AGC voltage causes relay K-80 to operate. This connects the d-c output of the "A" RF discriminator to the 1st video amplifier and holds the "A" klystron on assigned frequency until a signal is again received. At the same time, a light on the front panel indicates that the repeater has gone into terminal operation.

(6) Signals arriving from the East antenna follow exactly the same sequence through the "B" IF and video amplifier chassis and are broadcast on the West antenna.

b. CLR-6 Terminal.

(1) The functional block diagram of the CLR-6 Microwave Radio Link Equipment, used as a terminal, is shown in figure 7-5. The pulse amplitude modulated (PAM) signal output of the CMT-4 Time Division Multiplex Equipment is coupled to the input of the insertion amplifier. The insertion amplifier and 2nd video amplifier amplify the signal to a sufficient level to modulate the klystron oscillator. Pegging diodes and triodes operate to limit the low and high fre-

quency excursions of the klystron oscillator. The RF output of the klystron is coupled to the antenna through a wave-guide. A portion of the RF output is coupled to the "A" RF discriminator. The DC output of the RF discriminator is coupled to the 1st video amplifier. Since DC coupling is used in both the 1st and 2nd video stages, the DC change appears at the repeller electrode of the klystron. The polarity of the DC signal is such that it tends to correct any drift away from the assigned center frequency. The DC output of the RF discriminator is also coupled to the monitor relay amplifier and causes relay K-170 to operate. If the klystron fails, the resultant loss of signal would cause the relay to de-energize and operate a failure indicator lamp.

(2) The operation of the receiving portion of the terminal equipment is the same as that for the repeater (described in paragraph 7-5*a* above) with the following exemptions:

(a) The RF output of the "B" klystron (local oscillator) is terminated into a dummy load instead of an antenna.

(b) The desired intelligence (CMT-4 MUX) is obtained as a video signal from the drop-out amplifier.

7–6. Switching Equipment

a. The CLR-6 Microwave Radio Link Equipment is normally installed in pairs, one active on the circuit and the other in a stand-by condition (see fig. 7-3). They are connected through switching facilities to a common antenna and common multiplexing equipment.

b. The automatic switching control panel is normally mounted in the CMT-4 power rack nearest the CLR-6 equipment. It controls the switching relays that change equipment from active to stand-by conditions. A wave-guide switch connects the antenna to eigher one of the two associated CLR-6 equipments. Similarly, coaxial switches con-

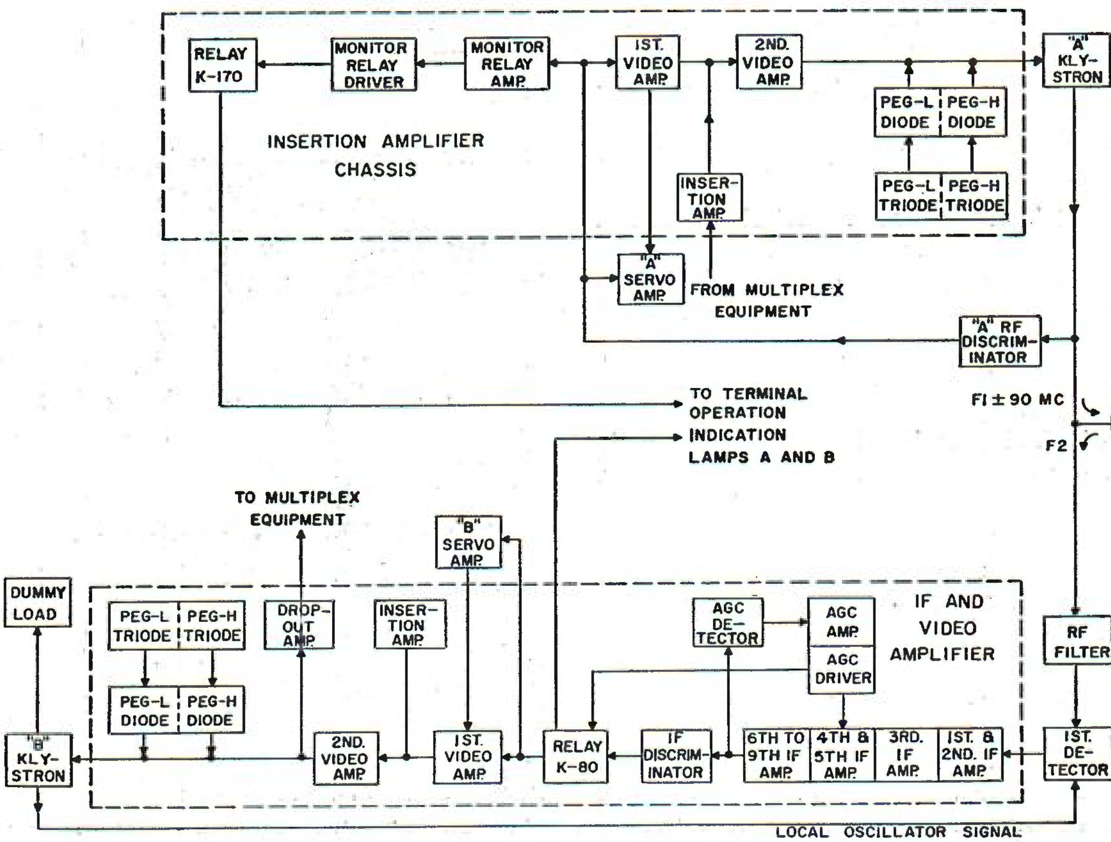


Figure 7–5. Functional Block Diagram of the CLR–6 Terminal.

nect the two cables of the multiplex component to the operating CLR-6.

c. The switching action is automatic and occurs when the received signal falls below-150 DBW (decibels below 1 watt) or when the transmitter output fails. Whenever either of these conditions exists for 15 seconds, the antenna is switched to the stand-by CLR-6 for 2 seconds. If normal signals are received on the stand-by equipment, the coaxial cables are switched, the cycle is completed, and the previously active CLR-6 becomes the stand-by. If normal signals do not exist within the 2-second sampling period, the antenna is switched back to the first CLR-6. The circuits will remain in this condition for 10 minutes, then go through the 17-second cycle again. This action will continue until normal signals are received. The "Remote Control" switch on the automatic switch panel permits selection of either CLR-6 as the active equipment.

d. The automatic switching panel responds to a lack of power on either active or stand-by equipment and will not switch to an equipment which is inoperative due to a power failure.

7-7. Standard Installations

a. CLR-6 Microwave Radio Link Equipment will be installed in conjunction with CMT-4 Time Division Multiplex Equipment in standard eleven-foot rows whenever possible (see fig. 7-6). The standard row consists of two CLR-6 equipments and four CMT-4 racks. One CLR-6 will be the primary or normally operating unit and the second will provide 100 percent stand-by.

b. Because of the smaller Microwave Room in a standard transmitter building, the equipment will be set up in shorter rows in which the last two CMT-4 racks of each standard row are moved into a new row.

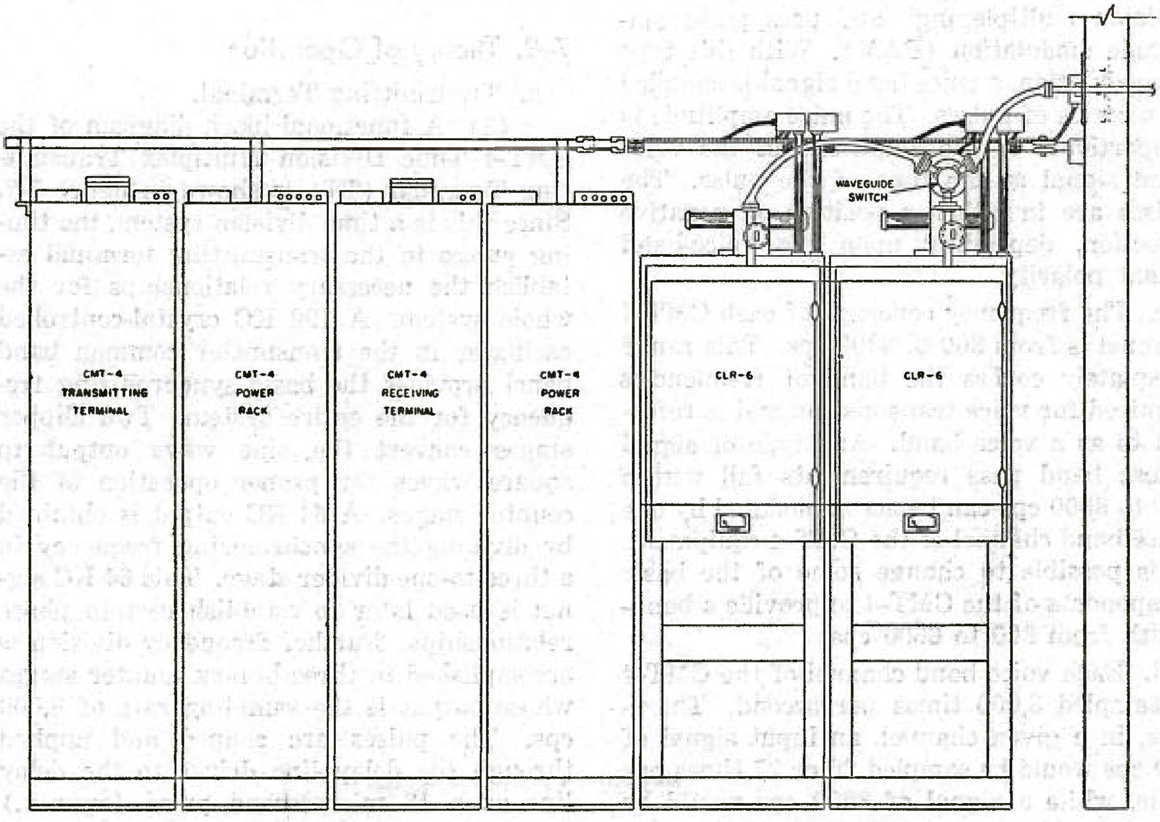


Figure 7-6. Standard Microwave-Multiplex Equipment Line-up.

Section II. CMT-4 TIME DIVISION MULTIPLEX EQUIPMENT

7-8. General

a. The CMT-4 Time Division Multiplex Equipment is used to provide up to 24 voice band channels on one CLR-6 Microwave Radio Link. The equipment is divided into two groups: receiving and transmitting. That equipment used at the transmitting terminals is abbreviated "TT" and that used at the receiving terminals is abbreviated "RT". Every TT at one end of a link has an RT associated with it at the other end.

b. The term "multiplexing" means the combining of several signals into one composite signal, transmitting it from one terminal to another, then breaking down the composite signal into the original separate signals. The composite signal is often referred to as a MUX signal, and the CMT-4 referred to as a MUX equipment. Of the many methods of multiplexing, the one used in the CMT-4 equipment is called "time division multiplexing" and uses pulse amplitude modulation (PAM). With this type of modulation, a voice band signal is sampled by a series of pulses. The pulse amplitude is proportional to the amplitude of the voice band signal at the time of the pulse. The pulses are in either a positive or negative direction, depending upon the voice-band signal polarity.

c. The frequency coverage of each CMT-4 channel is from 300 to 3300 cps. This range adequately covers the band of frequencies required for voice transmission and is referred to as a voice band. Any type of signal whose band pass requirements fall within 300 to 3300 cps can be accommodated by one voice band channel of the CMT-4 equipment. It is possible to change some of the basic components of the CMT-4 to provide a bandwidth from 300 to 6600 cps.

d. Each voice band channel of the CMT-4 is sampled 8,000 times per second. Therefore, in a given channel, an input signal of 300 cps would be sampled 26 or 27 times per cycle, while a signal of 3300 cps would be sampled only 2 or 3 times per cycle. The sampling rate is a limiting factor on the band pass per channel of the CMT-4. When all 24 channels are used, the composite signal contains 192,000 pulses per second.

e. In order to simplify procurement and maintenance, Globecom uses only three variations of terminal equipment as follows:

(1) 12 TT and 12 RT. Used to multiplex 12 voice band channels on one CLR-6.

(2) 24 TT and 24 RT. Used to multiplex 24 voice band channels on one CLR-6.

(3) 16 Plus 4 TT and 16 Plus 4 RT. Used to multiplex 16 voice band channels (300 to 3300 cps) and 4 wide band channels (300 to 6600 cps) on one CLR-6.

f. In microwave radio links where a repeater is installed, a CMT-4 single channel duplex drop-out (1 DD) is used at the repeater station. A DD is essentially two RT and two TT units in one. It provides receiving and sending multiplex circuits to both ends of the link.

7-9. Theory of Operation

a. Transmitting Terminal.

(1) A functional block diagram of the CMT-4 Time Division Multiplex Transmitting Terminal (TT) is shown in figure 7-7. Since this is a time division system, the timing pulses in the transmitting terminal establish the necessary relationships for the whole system. A 192 KC crystal-controlled oscillator in the transmitter common band panel provides the basic synchronizing frequency for the entire system. Two clipper stages convert the sine wave output to square waves for proper operation of the counter stages. A 64 KC output is obtained by dividing the synchronizing frequency in a three-to-one divider stage. This 64 KC signal is used later to establish certain phase relationships. Further frequency division is accomplished in three binary counter stages whose output is the sampling rate of 8,000 cps. The pulses are shaped and applied through the delay line driver to the delay line as a 13 microsecond pulse (approx.) Twenty-four equally spaced taps on the de-

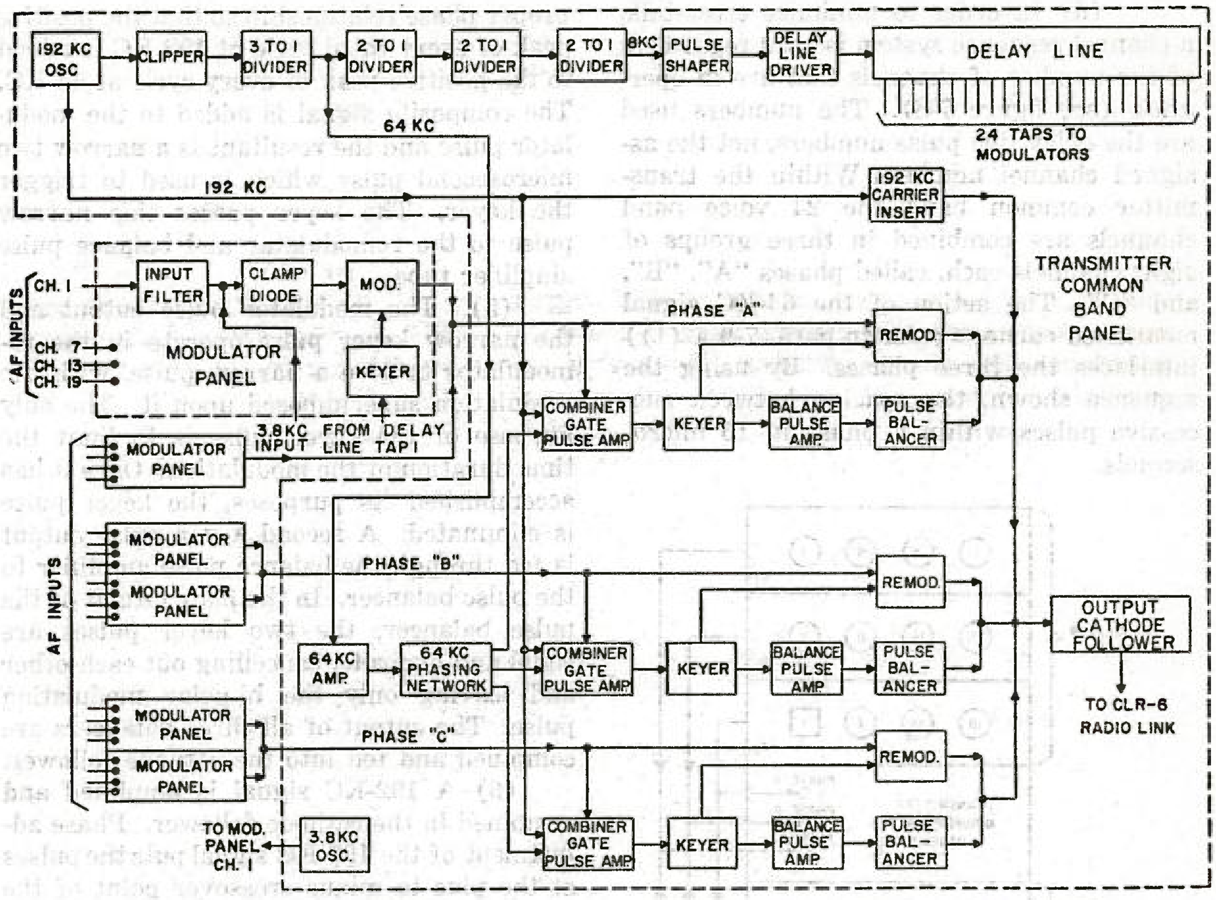


Figure 7–7. Functional Block Diagram of the CMT–4 Time Division Multiplex Transmitter Terminal (TT).

lay line supply a separate output pulse to each channel in each modulator panel in a fixed time relationship.

(2) Six four-channel modulator panels are shown in figure 7-7. These panels are combined in groups of two, called "phases." Since operations are identical for all channels, only one channel will be discussed. Minor variations will be mentioned with respect to channel 1 and wide band modulator panels.

(a) Voice band signals in the band of 300 to 3300 cps pass through the input filter and are applied to the clamping diode. No action takes place until the 13 microsecond pulse from the delay line for this particular channel arrives. This pulse is applied to the keyer stage. During the 13 microsecond pulse, the keyer stage permits the clamping diode to pass the voice band signal. Modulation takes place when the voice band signal and the delay line pulse combine. The modulator amplifies the pulse and applies it to a plate load resistor in the transmitter common band panel. The load resistor is common to eight channels, four in this modulator and four in the other modulator associated with this phase.

(b) Channel 1 has an additional input which is a 3800-cps indexing tone used to keep all channels properly phased at the receiving end.

(c) Certain circuit variations are made when using a wide-band modulator panel. In order to increase the band width, input filters pass a band of 300 to 6600 cps. There are only two channel inputs instead of four, and the sampling pulses of the deleted two channels are used to double the sampling rate of the two wide-band channels. This is necessary to get the increased band width.

(d) In order to minimize cross-talk, a channel sequence system is used regardless of the number of channels that are in operation (see figure 7-8). The numbers used are the delay line pulse numbers, not the assigned channel numbers. Within the transmitter common band, the 24 voice band channels are combined in three groups of eight channels each, called phases "A", "B", and "C". The action of the 64-KC signal mentioned earlier (refer to para. 7-9 a (1)) interlaces the three phases. By using the sequence shown, the spacing between successive pulses within a phase in 15 microseconds.

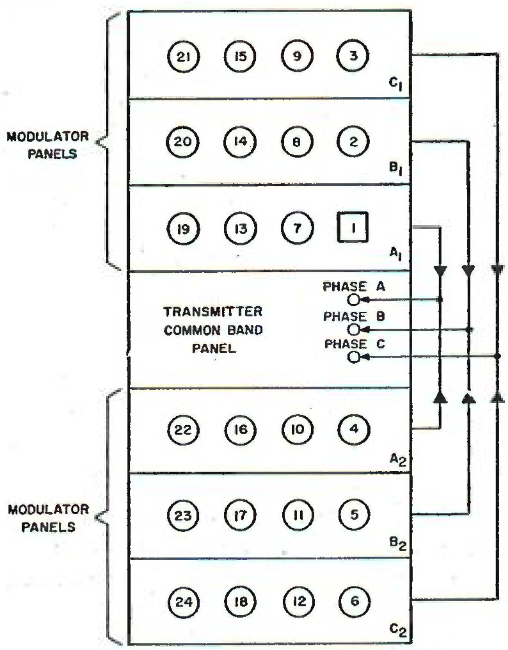


Figure 7-8. CMT-4 Time Division Multiplex Channel Sequence.

(3) The 64-KC pulses are converted into 64-KC sine waves by the tuned amplifiers and split into a three-phase output by the phase splitting network. One output operates with each phase. The operation of each of the three phases is identical, so only one is discussed.

(4) The 64-KC, 192-KC, and modulator signals are added in the combiner tube in proper phase relationship so that the positive peak of every third cycle at 192 KC is added to the positive peak of every cycle at 64 KC. The composite signal is added to the modulator pulse and the resultant is a narrow two microsecond pulse which is used to trigger the keyer. The keyer passes this narrow pulse to the remodulator and balance pulse amplifier tube.

(5) The modulator pulse output and the narrow keyer pulse operate in the remodulator to give a narrow pulse, with the modulation superimposed upon it. The only purpose of the keyer pulse is to limit the time duration of the modulation. Once it has accomplished its purposes, the keyer pulse is eliminated. A second keyer pulse output is fed through the balance pulse amplifier to the pulse balancer. In the plate circuit of the pulse balancer, the two keyer pulses are equal and opposite, cancelling out each other and leaving only the bi-polar modulation pulse. The output of all three balancers are combined and fed into the cathode follower.

(6) A 192-KC signal is amplified and combined in the cathode follower. Phase adjustment of the 192-KC signal puts the pulses at the plus to minus crossover point of the sine wave. The cathode follower output is fed through coaxial cable to the CLR-6 Microwave Radio Link Equipment.

(7) A 3800 cps oscillator provides the index tone for the receiver and is coupled to the channel 1 modulator.

b. Receiving Terminal.

(1) A functional block diagram of the CMT-4 Time Division Multiplex Receiving Terminal (RT) is shown in figure 7-9. The input signal is coupled by coaxial cable from the CLR-6 Microwave Radio Link to the receiver common band panel. Within the common band panel, the keying pulses are re-established so that separation into the respective phases and channels is possible. A series of tuned amplifiers, limiters, and crystal filters separate the pulse amplitude modulated signals from the 192-KC signal. The 192-KC signal is fed through a gating amplifier to a frequency divider system, pulse shaper and delay line identical to the one in the transmitter. As a result, a pulse

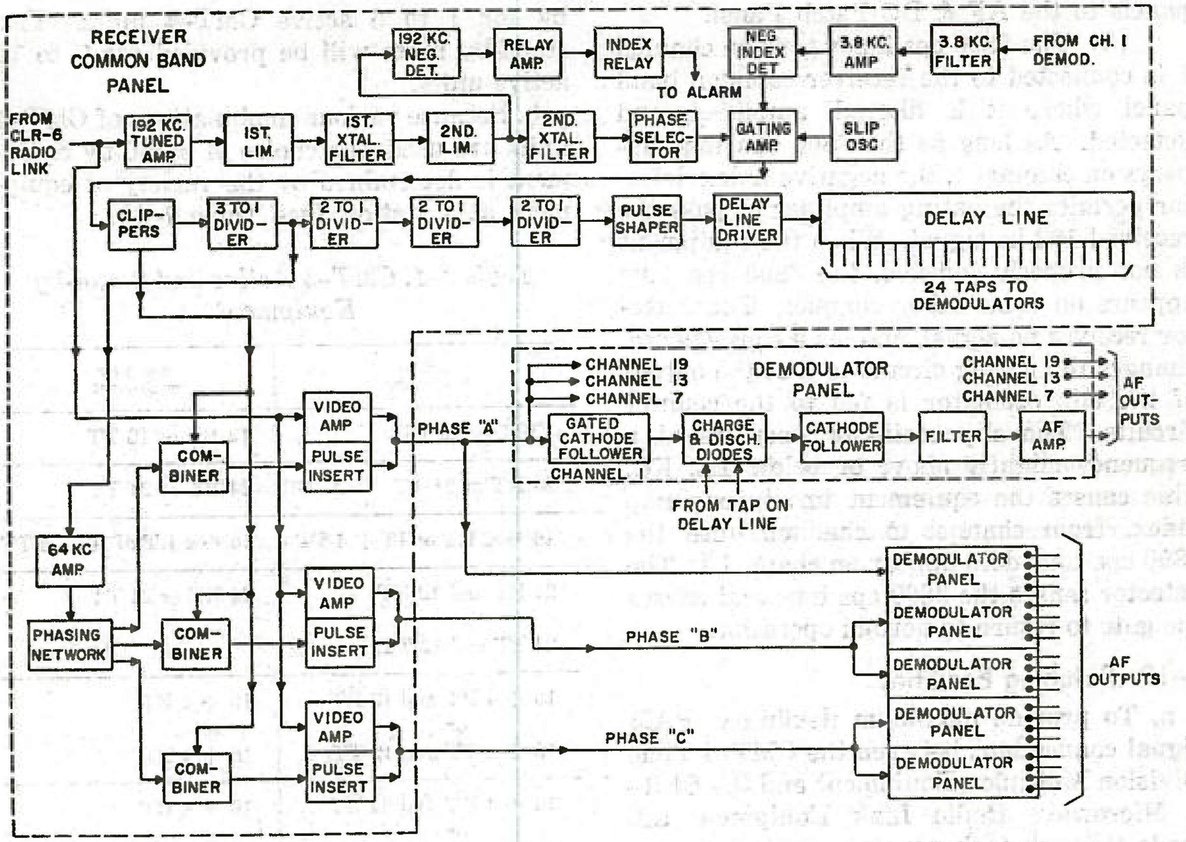


Figure 7-9. Functional Block Diagram of the CMT-4 Time Division Multiplex Receiving Terminal (RT).

output occurs at the same tap number on the delay lines in both the transmitter and receiver terminals.

(2) Three combiner stages, one for each phase, combine the 192-KC and 64-KC signals so as to emphasize every third pulse, just as was done in the transmitter common band panel. The pulses from the combiner stages and the composite signal from the CLR-6 are combined in the common plate load resistors of the pulse inserter and video amplifier stages. The three separate outputs are connected to the six demodulator panels (two for each phase).

(3) All six demodulator panels are identical, and each contains four identical circuits, one per channel. The action of all are identical so only one is discussed. The gated cathode follower receives the output of one phase from the receiver common band. This signal contains the pulses of only eight of the twenty-four channels because of the action of the pulse inserter stage. For example, phase "A" contains channels 1, 4, 7, 10, 13, 16, 19 and 22. One demodulator on phase "A" will act on channels 1, 7, 13 and 19, while the other demodulator accepts channels 4, 10, 16 and 22.

(4) Simultaneous occurrence of the channel 1 pulse from the receiver delay line and the channel 1 amplitude modulated pulse from the receiver common band panel causes the charging diode to charge a capacitor to an amount proportional to the amplitude of the amplitude modulated pulse. This charge is retained on the capacitor until another pulse (channel 19 charge pulse) 98.8 microseconds later causes it to discharge through the discharge diode. In effect, the 2 microsecond amplitude modulated pulse has been widened to 98.8 microseconds. The following filter and amplifier amplify the original audio components. The audio output is connected through the attenuator and jack

panels to the AF & DC Patch Panel.

(5) The 3800 cps index tone on channel 1 is connected to the receiver common band panel where it is filtered, amplified, and detected. As long as the 3800 cps tone appears on channel 1, the negative index detector permits the gating amplifier to pass the received 192-kc signal. When the equipment is not properly indexed, the 3800 cps tone appears on some other channel. The detector receives no signal, and, as a consequence, changes the gating circuit so that the output of the slip oscillator is fed to the counter circuits. The slip oscillator operates at a frequency slightly above or below 192 KC. This causes the equipment to slip or jump index, from channel to channel, until the 3800 cps tone does appear on channel 1. The detector senses the 3800 cps tone and causes the gate to return to normal operation.

7-10. Patching Facilities

a. To provide maximum flexibility, PAM signal connections between the CMT-4 Time Division Multiplex Equipment and the CLR-6 Microwave Radio Link Equipment are made through jack panels.

b. A separate jack panel is provided for each standard line-up of two CLR-6 units and four CMT-4 racks. It is located in the CMT-4 power rack nearest the CLR-6. If more than one standard line-up is required, the jack panels are inter-connected by a triple trunk coaxial system. The trunks are designated as receiving, transmitting, and spare.

c. The input and output jacks of the CLR-6 and CMT-4 are arranged on the jack panel in such a way that for normal operation the interconnecting plugs are aligned vertically. In this way, the CLR-6 is connected to the adjacent CMT-4. If it is desired for maintenance or other reasons to substitute another CLR-6 or CMT-4 for the one in use, it can be accomplished by placing the interconnecting plugs horizontally.

7-11. Standard Policies

a. Stand-by equipment will be provided for substitution during maintenance periods. One CMT-4 unit will be provided as stand-by for 1 to 6 active CMT-4 units. Two stand-by units will be provided for 7 to 12 active units.

b. Because various combinations of CMT-4 units are used, the choice of stand-by equipment is determined by the variety of equipment at a station (see Table 7-1).

Table 7-1. CMT-4 Active and Stand-by Equipment

Active equipment	Stand-by equipment
12RT or 12 TT	12 RT or 12 TT
24 RT or 24 TT	24 RT or 24 TT
16 + 4 RT or 16 + 4 TT	16 + 4 RT or 16 + 4 TT
24 RT and 12 RT or 24 TT and 12 TT	24 RT or 24 TT
16 + 4 RT and 12 RT or 16 + 4 TT and 12 TT	16 + 4 RT or 16 + 4 TT
16 + 4 RT and 24 RT or 16 + 4 TT and 24 TT	16 + 4 RT or 16 + 4 TT

c. In normal installations, the AC input voltage to all of the filaments of both the CMT-4 and the CLR-6 equipment will be regulated by a Sorenson Type 1000S external voltage regulator.

d. Intersite links are identified by a number and letter system, determined by their function at the Communications Relay Center (CRC) as follows:

(1) Odd numbers indicate the receiving terminal of the link located at the CRC.

(a) Link 1 is narrow band VFTG

(b) Link 3 is wide band VFTG

(c) Link 5 is a CMT-4 RT unit

(2) Even numbers indicate the transmitting terminal of the link located at the CRC.

(a) Link 2 is narrow band VFTG

(b) Link 4 is wide band VFTG

(c) Link 6 is a CMT-4 TT unit.

(3) The letters used in this system of numbering differentiate between links of the

same type, such as 1A, 1B, and 1C.

e. The number of links required at a specific station will depend upon the circuits required for that station. The following policies have been observed in assigning channels of the CMT-4 links:

(1) The minimum number of links will be used.

(2) Channel 1 in all links is assigned to maintenance purposes.

(3) Channel 2 in the first link is assigned to the Facility Control order wire.

(4) Channel 3 in the first link is assigned to the A-G order wire where authorized.

(5) Channel 4 in the first link is assigned to base telephone.

(6) If any SSB circuits are required, Channels 5, 6, 11 and 12 will be used. Since these will require wide band modulators and demodulators, Channels 17, 18, 23 and 24 will not be available.

(7) If SSB circuits are not used, channels 5, 6, 11, 12, 17, 18, 23 and 24 are available for assignment to other circuits, such as MUX and RTTY, as needed.

(8) This policy is designed to provide for 1 to 12 A-G voice frequencies.

(a) Channels 7, 8, 9, 19, 20, and 21 on the first and second links are designated for A-G microphones.

(b) Channel 10 of the first link is designated to provide keying for 1 to 12 A-G frequencies.

(9) All other channels are assigned as required.

Section III. VOICE FREQUENCY TELEGRAPH (VFTG)

7-12. General

a. In order to more effectively utilize the band width of each voice band channel of the CMT-4 multiplex equipment, it is possible to multiplex twelve circuits on one voice band channel. Examples of such signals are teletypewriter, manual cw, and on-off keying in air-ground circuits.

b. There are many types of multiplexing methods. The one used in the Northern Radio VFTG units is frequency division. Each VFTG keyer or converter operating on a single CMT-4 voice band channel is assigned one of twelve audio frequencies. These frequencies are separated in 170 cps steps from 935 to 2805 cps. Up to twelve VFTG units can be combined in one group and passed over one voice band channel of the CMT-4 Time Division Multiplex Equipment. Each VFTG unit carries intelligence completely independent of the information carried in the other units.

c. Intelligence is transmitted in the form of frequency-shift pulses. As normally used in teletypewriter service, mark and space signals caused a frequency shift of plus or minus 42.5 cps from the channel reference frequency.

d. At the transmitting end of the link, NR-153, Model 1, Dual Frequency-Shift Tone Keyers are used. Each unit contains two completely independent tone keyers. At the receiving end of the link, NR-152, Model 1, Dual Frequency-Shift Tone Converters are used. Each of these units contains two independent tone converters. The units are usually mounted in groups of six (twelve keyers or converters) in an NR-154, Model 2, Carrier Telegraph Rack which contains the necessary power distribution and terminations for the units.

7-13. Theory of Operation

a. *Tone Keyer.* A functional block diagram of the NR-153, Model 1, Frequency-Shift Tone Keyer is shown in figure 7-10. Since each NR-153 unit consists of two wholly independent keyers, identical in operation, but at different assigned frequencies, only one circuit is shown and discussed.

(1) The normal signal input from a teletypewriter is a neutral signal (60 ma for mark, 0 ma for space). This signal is amplified and applied to the keying amplifier, causing the amplifier to become conducting or non-conducting. The output of the keying amplifier causes the keyed amplifier to con-

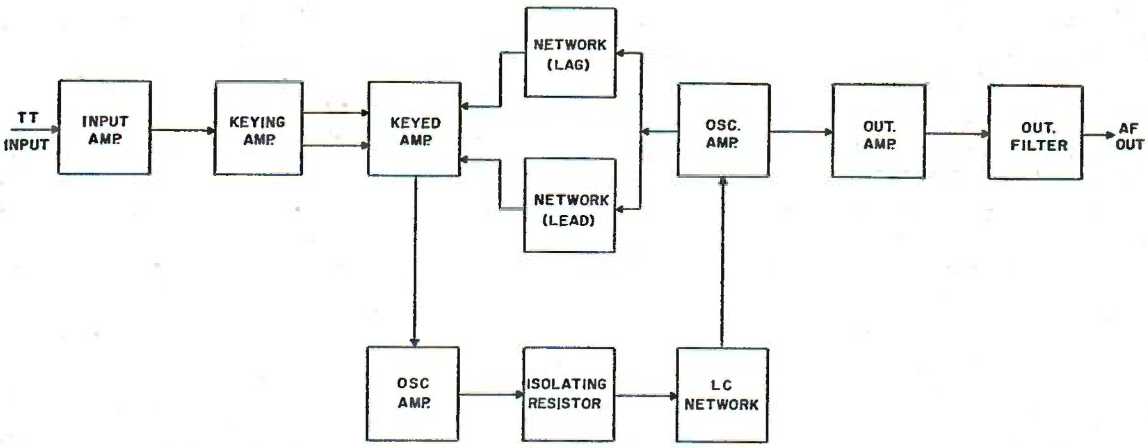


Figure 7–10. Functional Block Diagram of the NR–153, Model 1, Frequency-Shift Tone Keyer.

nect either the leading or lagging network into the oscillator circuit.

(2) The oscillator consists of a complete circuit: oscillator amplifier, isolating resistor, LC tuning circuit, oscillator amplifier, and lead or lag network. The LC components determine the center frequency of the oscillator. When the leading network is in the circuit, the MARK frequency is generated; and when the lagging network is in the circuit, the SPACE frequency is generated. The oscillator is very stable in either connection, and the transition is quickly made. The operating frequency and amount of frequency shift are determined by plug-in components. The standard frequencies used in Globecom are 935, 1105, 1275, 1445, 1615, 1785, 1955, 2125, 2295, 2465, 2635 and 2805 cps, and the amount of frequency shift is usually plus or minus 42.5 cps.

(3) A second output of the oscillator circuit is fed through two output amplifiers and an output filter to a 600-ohm unbalanced line.

(4) The frequency shift output tones of up to twelve tone keyers in one group are connected in parallel in the NR–154, Model 2, Rack. This rack also supplies the AC power distribution circuits for the tone keyers.

(5) Other types of keying signals, such as manual CW, A–G keying, and time signals, operate in the same way as the on-off teletypewriter signal.

(6) When time division multiplex teletypewriter signals are used, a high keying speed is necessary. To pass the keying speed accurately, wide-band VFTG tone keyers are used. These units have the same nomenclature and are identical to the narrow band units described above, except for the plug-in components. Only three oscillator frequencies of 1615, 2295, and 2975 cps are used with these units, and the frequency shift is increased to plus or minus 120 cps.

b. *Tone Converter.* A functional block diagram of the NR–152, Model 1, Frequency-Shift Tone Converter is shown in figure 7–11. Since each NR–152 unit consists of two wholly independent converters, identical in operation but operating at different assigned frequencies, only one circuit is shown and discussed.

(1) The incoming signal contains up to 12 frequency shifted tones. The input filter permits only that frequency assigned to its converter to pass, and rejects all others. The assigned frequency is amplified in the pre-amplifier and coupled to the limiter through a plug-in network. For lower frequencies, the doubler circuit is used to improve the discriminator characteristics. For higher frequencies the pre-amplifier is connected directly to the limiter. The limiter output is fed to the gate generator to produce square wave pulses.

(2) These square waves are fed directly to one pulse selector, and through the phase

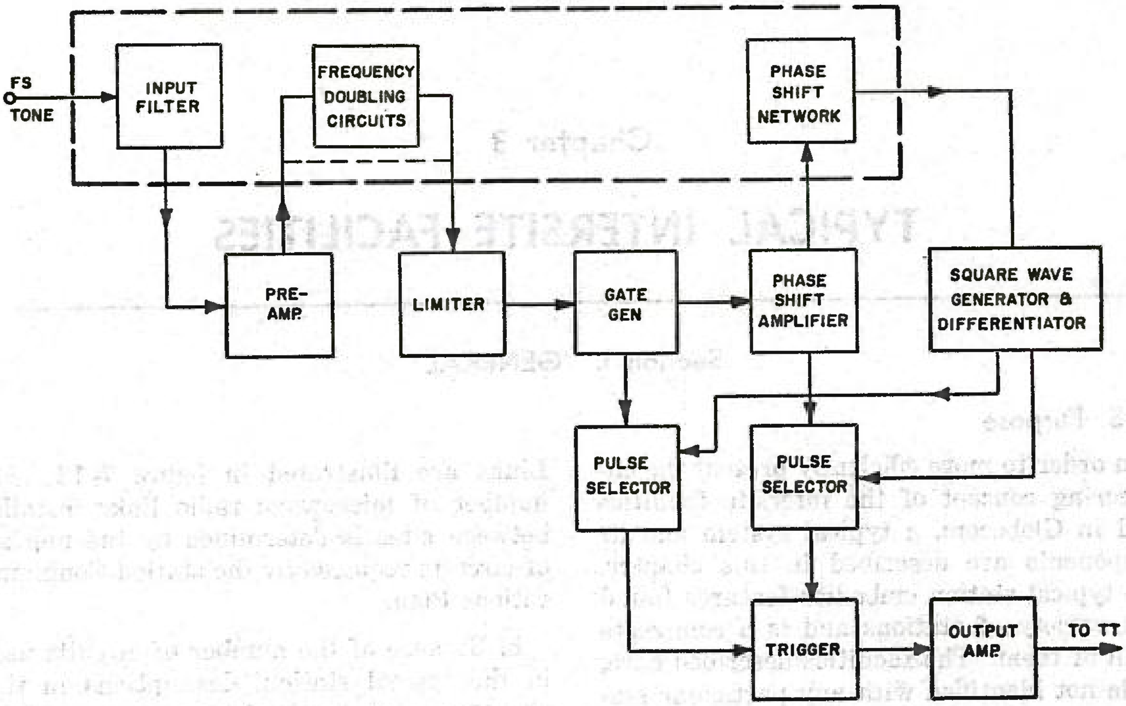


Figure 7–11. Functional Block Diagram of the NR–152, Model 1, Frequency-Shift Tone Converter.

shift amplifier to the second pulse selector. The square waves applied to the two pulse selectors are 180 degrees out of phase. A second output of the phase shift amplifier is fed to a phase shift network. This phase shift network converts the square waves to sine waves with a variable time delay proportional to frequency. The square wave generator and differentiator convert the sine waves to narrow pulses. Because of the time delay, the positive pulses will coincide with the positive part of the square wave on the first selector during mark signals and with the positive part of the square wave on the second selector during space signals. When the two signals coincide at either selector, a negative pulse output appears at the plate.

(3) The negative pulse output of the pulse selector tubes causes the trigger tube to be either conducting or non-conducting. The output of the trigger amplifier is fed to the output amplifier which provides a neutral DC output to operate a teletypewriter.

(4) When time division multiplex teletypewriter signals are used, a wide-band VFTG tone keyer is used. This gives a frequency shift of plus or minus 120 cps. The identical NR–152, Model 1, Tone Converter is used to receive these signals, but the plug-in components are changed to accept the greater band width.

7–14. Standard Policies

Voice frequency telegraph groups (VFTG) are installed with one back-up system for each type of system used. These back-up systems are terminated at the patch panel so that necessary changes can be made easily.

Chapter 3

TYPICAL INTERSITE FACILITIES

Section I. GENERAL

7-15. Purpose

In order to more efficiently present the engineering concept of the intersite facilities used in Globecom, a typical system and its components are described in this chapter. The typical station embodies features found in a variety of stations and is a composite of all of them. The facilities described here, while not identified with any particular station, are representative of those which may be found in a Globecom station.

7-16. Description

a. Typical Intersite Microwave Radio Links are illustrated in figure 7-12. The number of microwave radio links installed between sites is determined by the number of circuits required by the station Communications Plan.

b. Because of the number of circuits used in the typical station, descriptions in this chapter pertain to the four microwave radio links that are required: two for the Receiver Site-Communications Relay Center path and two for the Communications Relay Center-Transmitter Site path.

Figure 7-12. Typical Intersite Microwave Radio Links.

Section II. RECEIVER SITE-CRC LINKS

7-17. General

a. For this typical station, the Receiver Site is located several miles from the air base, while the Communications Relay Center (CRC) is located on the base. The Communications Relay Center and the Receiver Site are interconnected by CLR-6 Microwave Radio Link Equipment.

b. Most of the communications channels in this link are directed from the Receiver Site to the Communications Relay Center. The very light circuitry required in the opposite direction is confined to order wires, base telephone extensions, and maintenance.

7-18. Location of Equipment

a. *Receiver Site.*

(1) The CLR-6 Microwave Radio Link

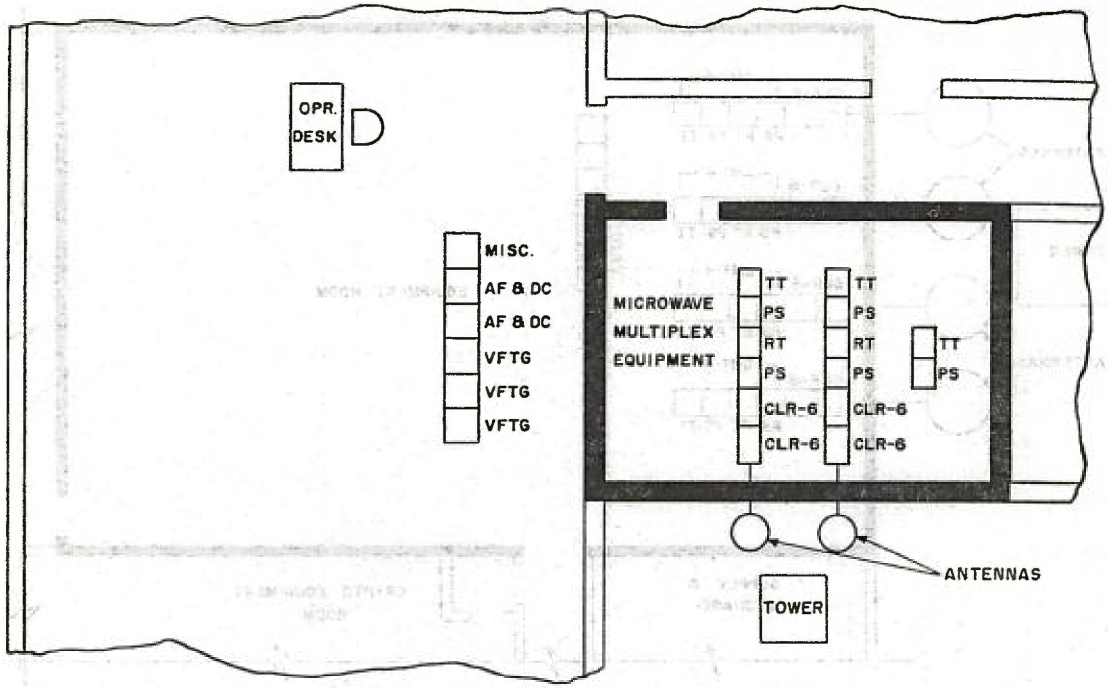


Figure 7-13. Typical Location of Intersite Facilities at the Receiver Site.

and the CMT-4 Time Division Multiplex Equipments are located in the Microwave Room in the Utility Wing of the standard receiver building (see fig. 7-13). The standard arrangement of CLR-6 and CMT-4 equipment is used. The number of rows and types of CMT-4 equipment used depend upon the number and types of circuits required.

(2) The NR-153 VFTG Tone Keyers are located in the main equipment room near the AF and DC Patch Panel (see fig. 7-13). Three wide-band and two narrow-band VFTG groups are required.

b. *Communications Relay Center.* Generally, the Intersite facility equipment will be installed in the Equipment Room, usually along one of the outer walls (see fig. 7-14).

7-19. Number and Types of Circuits From Receiver Site to the CRC

a. *Manual Radio Telegraph (CW) Circuits.*

(1) Two types of CW receiving circuits exist in Globecom. In Globecom CW nets, the operator is usually located at the Communication Relay Center. The circuits require one voice band channel of the CMT-4 equipment per receiver from Receiver Site to Communications Relay Center (refer to fig. 1-4). There is one CW net at this typical station, but three frequencies (day, night, and transition) are assigned. Since all three frequencies must be available to the operator at all times, three receivers tuned to the assigned frequencies are in operation at all times. A total of three voice band channels is required for transmission from the Receiver Site to the CRC.

(2) In the CW intercept circuit, the operator is usually located at the Receiver Site (refer to fig. 1-5). Each circuit of this type requires one narrow-band VFTG circuit to pass the copy to the CRC and Base. Up to twelve VFTG circuits can be fed to one CMT-4 channel. The four CW weather intercept circuits using this arrangement at this station require one-third of one CMT-4 voice band channel.

b. *Radio Teletypewriter Telegraph (RTTY) Circuits.* These circuits require one narrow-band VFTG circuit each (refer to fig. 1-7). Three RTTY circuits at this station require three VFTG circuits or one-

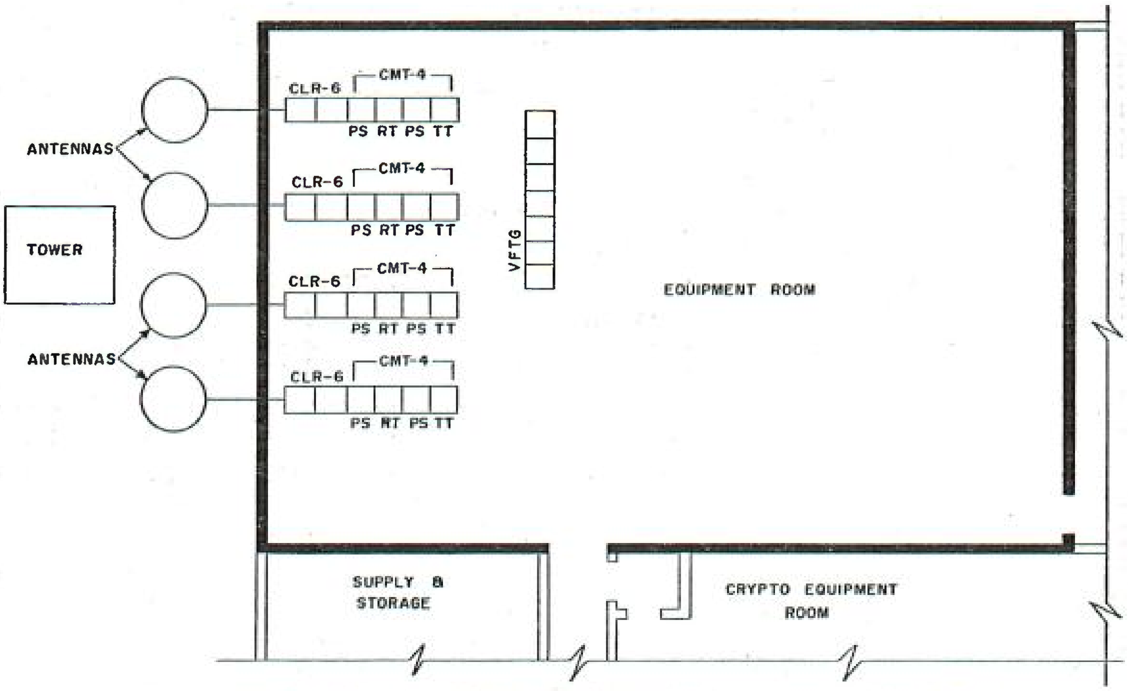


Figure 7–14. Typical Location of Intersite Facilities at the Communications Relay Center.

fourth of one CMT–4 voice band channel.

c. *Four-Channel Multiplex Radio Teletypewriter Telegraph (MUX) Circuits.* These circuits require one wide-band VFTG keyer each (refer to fig. 1–9). A wide-band VFTG circuit is needed to handle the multiplex signal, but three wide-band VFTG units can be used on one CMT–4 voice band channel. A total of five MUX circuits at this station requires one and two-thirds CMT–4 voice band channels.

d. *Facsimile (FAX) Circuits.* These circuits require one voice band channel each on the CMT–4 equipment (refer to fig. 1–11). A total of five point-to-point FAX circuits at this station requires five CMT–4 voice band channels.

e. *Radio Telephone Circuits.* These circuits require one voice band CMT–4 channel each (refer to fig. 1–13). A total of ten air-ground circuits assigned to this station requires ten CMT–4 voice band channels.

f. *Single Sideband (SSB) Circuits.* These circuits require two wide-band channels each on the CMT–4 equipment (refer to fig. 1–15). There are two SSB circuits at this station. The type of SSB equipment used (AN/FRC–10) transmits and receives two independent sidebands with a suppressed common carrier. Each sideband has a band pass characteristic of 100 to 6000 cps and therefore requires a wide-band channel on the CMT–4 equipment. Thus a total of four wide-band channels is required for 2 SSB circuits.

g. *Miscellaneous Circuits.*

(1) *Maintenance.* Channel 1 of each CMT–4 equipment is reserved as a maintenance channel for Intersite facilities maintenance. Two links at this site require two full-duplex maintenance channels.

(2) *Order Wires.* Voice circuits between Facilities Control and the Receiver Site are necessary for line-up and change-over operations. Two order wires (Facility Control and A–G) at this site require two full-duplex CMT–4 voice band channels.

(3) *Base Telephone.* Base telephone service is provided to the Receiver Site and requires one full-duplex CMT–4 voice band channel.

(4) *Time Signal.* This circuit requires one voice channel. The output of a receiver tuned to station WWV is sent to the CRC for

synchronizing CRC and Transmitter Site clocks.

7-20. Number and Types of Circuits From CRC to Receiver Site

a. *Maintenance.* Channel 1 of each CMT-4 equipment is reserved as a maintenance channel for Intersite facilities maintenance. Two links at this site require two full-duplex maintenance channels.

b. *Order Wires.* Voice circuits between Facilities Control and the Receiver Site are necessary for line-up and change-over operations. Two order wires (Facilities Control and A-G when authorized) require two full-duplex voice band channels.

c. *Base Telephone.* Base telephone service is provided to the Receiver Site and requires one full-duplex CMT-4 voice band channel.

d. *CW Receiver Control.* CW receiver circuits which are remotely controlled require one voice band channel for control of up to six receivers (refer to fig. 1-4). The one CW net at this station requires the use of one voice band channel.

7-21. Number and Types of Equipment

a. *Receiver Site.*

(1) *CLR-6 Microwave Radio Link.* Because of the number of circuits involved, two CLR-6 microwave radio links are required between the Receiver Site and the Communications Relay Center. In the typical station discussed, no microwave repeaters are needed in the links between the various sites.

(2) *CMT-4 Time Division Multiplex.* One CMT-4 is associated with each CLR-6 equipment. The large number of circuits from the Receiver Site to the Communications Relay Center can be handled by two sixteen-plus-four transmitting terminals (16 plus 4 TT). Because of the small number of circuits from the Communications Relay Center to the Receiver Site, one twelve-channel receiving terminal (12 RT) is sufficient. One 16 plus 4 TT unit and one 12 RT unit are necessary for stand-by.

(3) *VFTG Tone Keyer Groups.* To accommodate the five incoming multiplex radio teletypewriter (MUX) circuits at this station, two wide-band VFTG groups are furnished. One narrow-band VFTG group is sufficient to handle all of the RTTY and weather intercept circuits. One stand-by wide-band group and one stand-by narrow-band group are installed to provide alternate units for routine maintenance or emergencies.

b. *Communications Relay Center.* The number and type of equipment required at CRC is discussed in paragraph 7-26 *b.*

Section III. TRANSMITTER SITE—CRC LINKS

7-22. General

a. For this typical station the Transmitter Site is located several miles from the air base, while the Communications Relay Center (CRC) is located on the base. The Communications Relay Center and the Transmitter Site are connected by microwave radio link.

b. The bulk of the traffic flows from the Communications Relay Center to the Transmitter Site. Very little traffic flows the other way, being confined to order wires, maintenance channels and base telephone extensions.

7-23. Location of Equipment

a. *Transmitter Site.* The intersite facility equipment is located in the microwave room in the Utility Wing of the transmitter building. This includes the CLR-6 Microwave Radio Link Equipment, CMT-4 Time Division Multiplex Equipment, VFTG equipment, and some miscellaneous equipment. The microwave and multiplex equipment is installed in the standard arrangement illustrated in figure 7-15. The number of line-ups and types of multiplex terminal equipments used depend upon the number and types of circuits in use.

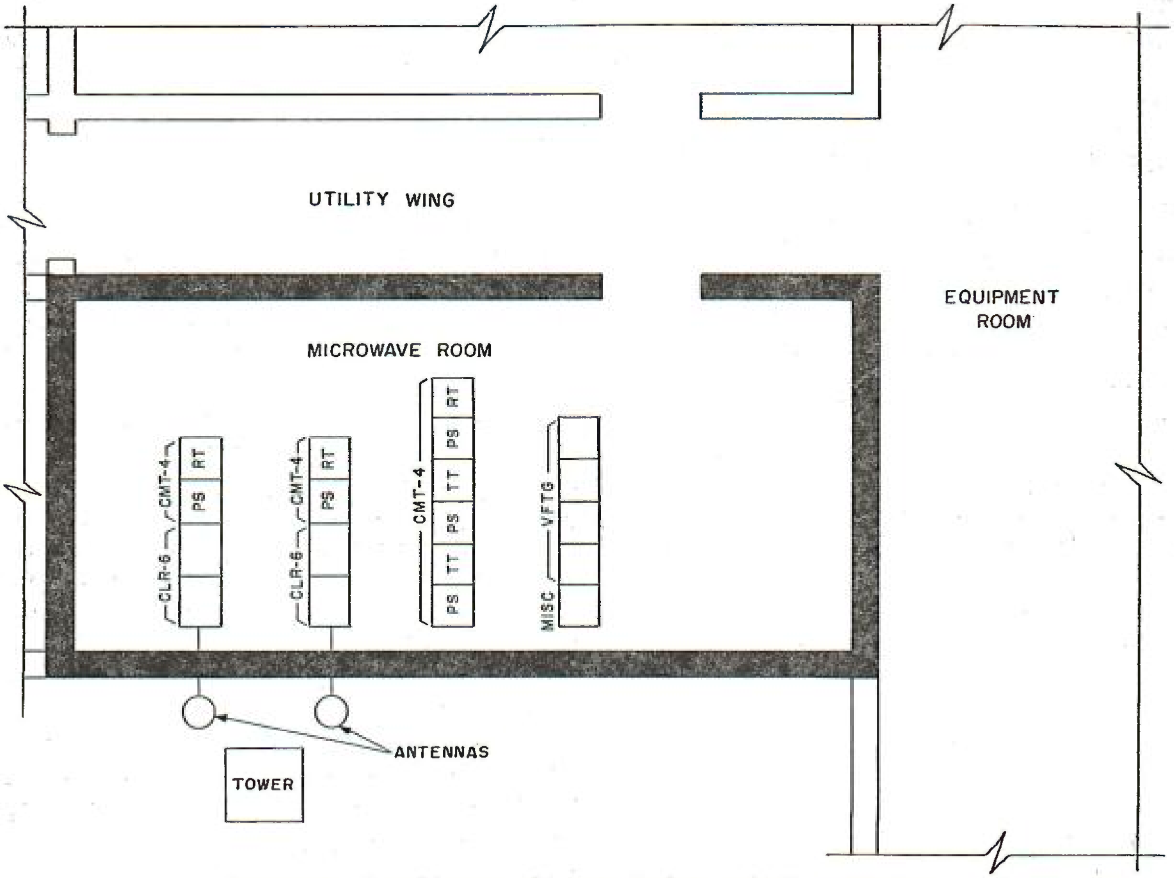


Figure 7–15. Typical Location of Intersite Facilities at the Transmitter Cite.

b. *Communications Relay Center.* The location of the Intersite facilities is as noted in paragraph 7–18 *b*.

7–24. Number and Types of Circuits From CRC to Transmitter Site

a. *Manual Radio Telegraph (CW) Circuits.* These circuits require one narrow-band VFTG circuit each to key the transmitter (refer to fig. 1–3). The one CW net at this station has three assigned frequencies, all three of which are available to the operator. This requires three VFTG circuits or one-fourth of one CMT–4 voice band channel.

b. *Radio Teletypewriter Telegraph (RTTY) Circuits.* These circuits require one narrow-band VFTG circuit each (refer to fig. 1–6). The four RTTY circuits at this station use four narrow-band VFTG circuits or one-third of one CMT–4 voice band channel.

c. *Four-Channel Multiplex Radio Teletypewriter Telegraph (MUX) Circuits.* These circuits require one wide-band VFTG circuit each (refer to fig. 1–8). A wide-band VFTG circuit is needed to handle the MUX signal, and three wide-band VFTG circuits can operate on one CMT–4 voice band channel; so a total of five MUX circuits used at this station requires the use of one and two-thirds CMT–4 voice band channels.

d. *Facsimile (FAX) Circuits.* These circuits require one voice band channel each (refer to fig. 1–10). Six FAX circuits in use at this station require six CMT–4 voice band channels.

e. *Radio Telephone Circuits.* These circuits require one voice band channel each for voice modulation and one VFTG circuit each for keying (refer to fig. 1–12). Ten A–G frequencies are assigned to this station, each having its own voice and key line.

Eleven voice band channels are needed to handle the A–G circuits (10 voice, 1 keying).

f. *Single Sideband (SSB) Circuits.* These circuits require two CMT–4 wide-band channels each (refer to fig. 1–14). Two single sideband circuits at this station, therefore, require the use of four CMT–4 wide-band channels.

g. *Miscellaneous Circuits.*

(1) *Maintenance.* Channel 1 of each CMT–4 is reserved for Intersite facility maintenance.

(2) *Order Wires.* Voice circuits between Channel and Technical Control and the Transmitter Site are necessary for line-up and change-over operations. Two order wires (Facility Control and A–G when authorized) at this site require two full duplex CMT–4 voice band channels.

(3) *Base Telephone.* Base telephone service is provided to the Transmitter Site and requires one CMT–4 voice band channel.

(4) *Time signal.* The pulses used to synchronize the Transmitter Site clocks require one VFTG circuit. One-twelfth of one CMT–4 voice band channel is required.

7–25. Number and Types of Circuits From Transmitter Site to CRC

a. *Maintenance.* Channel 1 of each CMT–4 unit is reserved for Intersite facility maintenance.

b. *Order Wires.* Voice circuits between Channel and Technical Control and the Transmitter Site are necessary for line-up and change-over operations. Two order wires (Facility Control and A–G when authorized) require two full duplex CMT–4 voice band channels.

c. *Base Telephone.* Base telephone service is provided to the Transmitter Site and requires one full-duplex CMT–4 voice band channel.

7–26. Number and Types of Equipment

a. *Transmitter Site.*

(1) *CLR–6 Microwave Radio Link.* In order to handle the number of circuits involved, two microwave radio links are required between the CRC and the Transmitter Site.

(2) *CMT–4 Time Division Multiplex.* Associated with each CLR–6 is one CMT–4 Time Division Multiplex Equipment. The large number of circuits coming from the CRC to the Transmitter Site requires the use of two 16-plus-4 receiving terminals (16 plus 4 RT). The small number of circuits going from the Transmitter Site to CRC needs only one twelve-channel transmitting terminal (12 TT). One stand-by 16-plus-4 RT equipment and one stand-by 12 TT equipment are installed for routine maintenance or emergency operation.

(3) *VFTG Tone Converters.* Because of the number of multiplex (MUX) circuits used, two wide-band VFTG tone converter groups are required. Three narrow-band VFTG tone converter groups are required to handle the variety of signals, such as RTTY, key lines, and time signals, that are sent from the CRC to the Transmitter Site. One stand-by wide-band VFTG group and one stand-by narrow-band VFTG group are installed to provide alternate units during routine maintenance or emergencies.

b. *Communications Relay Center.*

(1) *CLR–6 Microwave Radio Link.* In order to handle the number of circuits involved, two microwave radio links to the Receiver Site are required, and two links to the Transmitter Site are required.

(2) *CMT–4 Time Division Multiplex.* Associated with each CLR–6 equipment is one CMT–4 equipment. Because of the small number of circuits going from the CRC to the Receiver Site, one twelve-channel transmitting terminal (12 TT) is sufficient. The large number of circuits going from the Receiver Site to the CRC requires the use of two 16-plus-4 receiving terminals (16 plus 4 RT). To the Transmitter Site, conditions are reversed: the large number of circuits going from the CRC to the Transmitter Site requires the use of two 16-plus-4 transmitting terminals (16 plus 4 TT). The small number of circuits going from the Transmitter Site to the CRC are handled by one twelve-channel receiving terminal (12 RT).

(3) *CMT–4 Stand-by.* Since all of the

CRC CMT–4 equipment is in the same room, stand-by requirements are reduced. One 16-plus-4 receiving terminal and one 16-plus-4 transmitting terminal are sufficient (see par. 7–11–*b*).

(4) *VFTG Tone Converters.* Multiplexed signals coming from the Receiver Site require two wide-band VFTG tone converter groups. The RTTY signals require one narrow-band VFTG tone converter group. One stand-by wide-band and one stand-by narrow-band tone converter group are provided.

(5) *VFTG Tone Keyers.* Multiplexed signals going to the Transmitter Site require two wide-band VFTG tone keyer groups. RTTY, key lines, time signals, and other circuits require three narrow-band VFTG tone keyer groups. One stand-by wide-band and one stand-by narrow-band tone keyer group are provided.

(6) *Channel Assignment.* Typical channel assignments for the two links from Receiver Site to CRC are shown in figures 7–16 and 7–17. Typical channel assignments for the two links from CRC to Transmitter Site are shown in figures 7–18 and 7–19. Because the equipment for all four links is located in one room, a minimum amount of stand-by equipment is required. The 16-plus-4 TT shown on Link B is stand-by for Links A, C and D. The 16-plus-4 RT shown on Link D is stand-by for Links A, B and C.

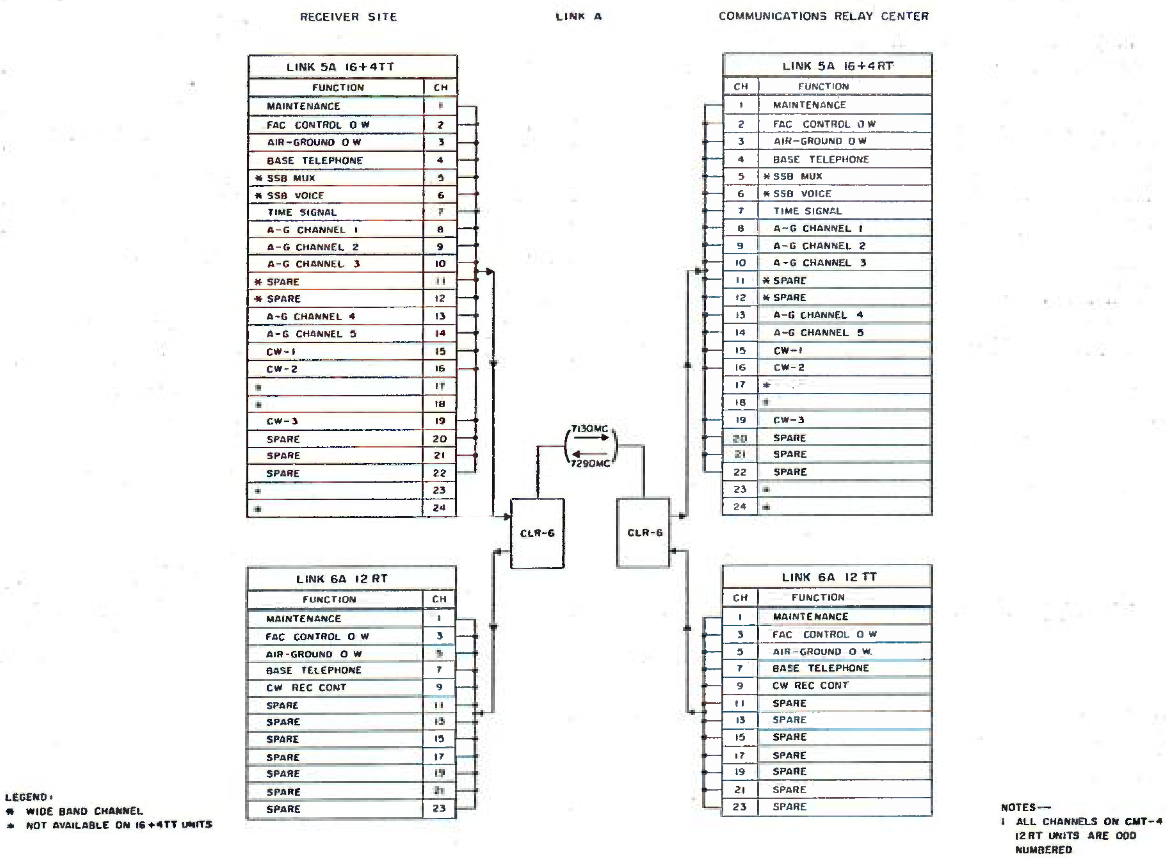


Figure 7–16. Typical Intersite Facilities Channel Assignment, Link "A".

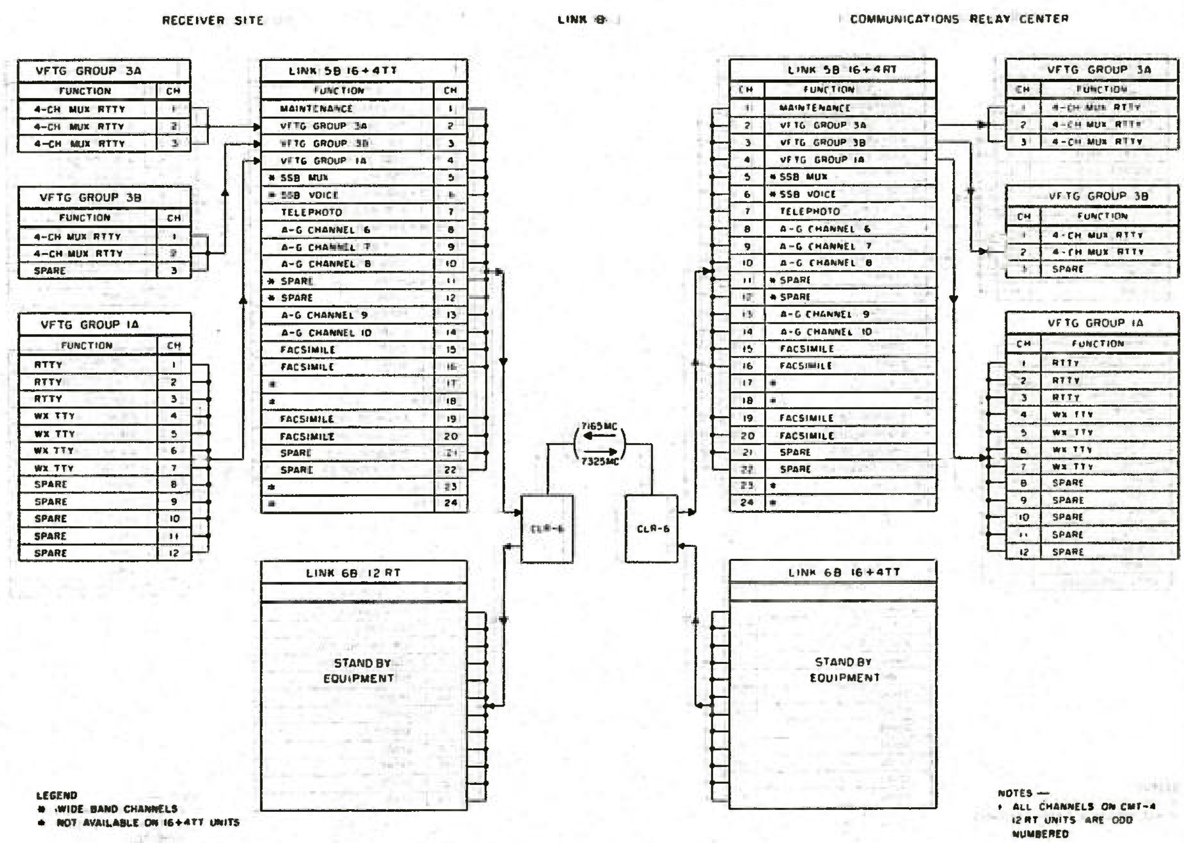


Figure 7–17. Typical Intersite Facilities Channel Assignment, Link "B".

LINK C

COMMUNICATIONS RELAY CENTER

VFTG GROUP 2A	
FUNCTION	CH
A-G KEY CH 1	1
A-G KEY CH 2	2
A-G KEY CH 3	3
A-G KEY CH 4	4
A-G KEY CH 5	5
A-G KEY CH 6	6
A-G KEY CH 7	7
A-G KEY CH 8	8
A-G KEY CH 9	9
A-G KEY CH 10	10
SPARE	11
SPARE	12

VFTG GROUP 2B	
FUNCTION	CH
TIME SIGNAL	1
CW KEY CH 1	2
CW KEY CH 2	3
CW KEY CH 3	4
SPARE	5
SPARE	6
RTTY	7
RTTY	8
RTTY	9
SPARE	10
SPARE	11
RTTY BROADCAST	12

LINK 6C 16+4TT	
FUNCTION	CH
MAINTENANCE	1
FAC CONTROL O.W.	2
AIR-GROUND O W	3
BASE TELEPHONE	4
* SSB MUX	5
* SSB VOICE	6
A-G MIKE CH 1	7
A-G MIKE CH 2	8
A-G MIKE CH 3	9
VFTG GROUP 2A	10
* SPARE	11
* SPARE	12
FACSIMILE	13
SPARE	14
SPARE	15
SPARE	16
*	17
*	18
A-G MIKE CH 7	19
A-G MIKE CH 8	20
A-G MIKE CH 9	21
VFTG GROUP 2B	22
*	23
*	24

LINK 5C 12 RT	
FUNCTION	CH
MAINTENANCE	1
FAC CONTROL O. W.	3
AIR-GROUND O W	5
BASE TELEPHONE	7
SPARE	9
SPARE	11
SPARE	13
SPARE	15
SPARE	17
SPARE	19
SPARE	21
SPARE	23

CLR-6 — 7220MC → / ← 7380MC — CLR-6

TRANSMITTER SITE

LINK 6C 16+4RT	
CH	FUNCTION
1	MAINTENANCE
2	FAC CONTROL O W
3	AIR-GROUND O W
4	BASE TELEPHONE
5	* SSB MUX
6	* SSB VOICE
7	A-G MIKE CH 1
8	A-G MIKE CH 2
9	A-G MIKE CH 3
10	VFTG GROUP 2A
11	* SPARE
12	* SPARE
13	FACSIMILE
14	SPARE
15	SPARE
16	SPARE
17	*
18	*
19	A-G MIKE CH 7
20	A-G MIKE CH 8
21	A-G MIKE CH 9
22	VFTG GROUP 2B
23	*
24	*

VFTG GROUP 2A	
CH	FUNCTION
1	A-G KEY CH 1
2	A-G KEY CH 2
3	A-G KEY CH 3
4	A-G KEY CH 4
5	A-G KEY CH 5
6	A-G KEY CH 6
7	A-G KEY CH 7
8	A-G KEY CH 8
9	A-G KEY CH 9
10	A-G KEY CH 10
11	SPARE
12	SPARE

VFTG GROUP 2B	
CH	FUNCTION
1	TIME SIGNAL
2	CW KEY CH 1
3	CW KEY CH 2
4	CW KEY CH 3
5	SPARE
6	SPARE
7	RTTY
8	RTTY
9	RTTY
10	SPARE
11	SPARE
12	RTTY BROADCAST

LINK 5C 12 TT	
CH	FUNCTION
1	MAINTENANCE
3	FAC CONTROL O W
5	AIR-GROUND O W
7	BASE TELEPHONE
9	SPARE
11	SPARE
13	SPARE
15	SPARE
17	SPARE
19	SPARE
21	SPARE
23	SPARE

LEGEND:
* WIDE BAND CHANNELS
* NOT AVAILABLE ON 16+4TT UNITS

NOTES—
1. ALL CHANNELS ON CMT-4 12 RT UNITS ARE ODD NUMBERED.

Figure 7–18. Typical Intersite Facilities Channel Assignment, Link "C".

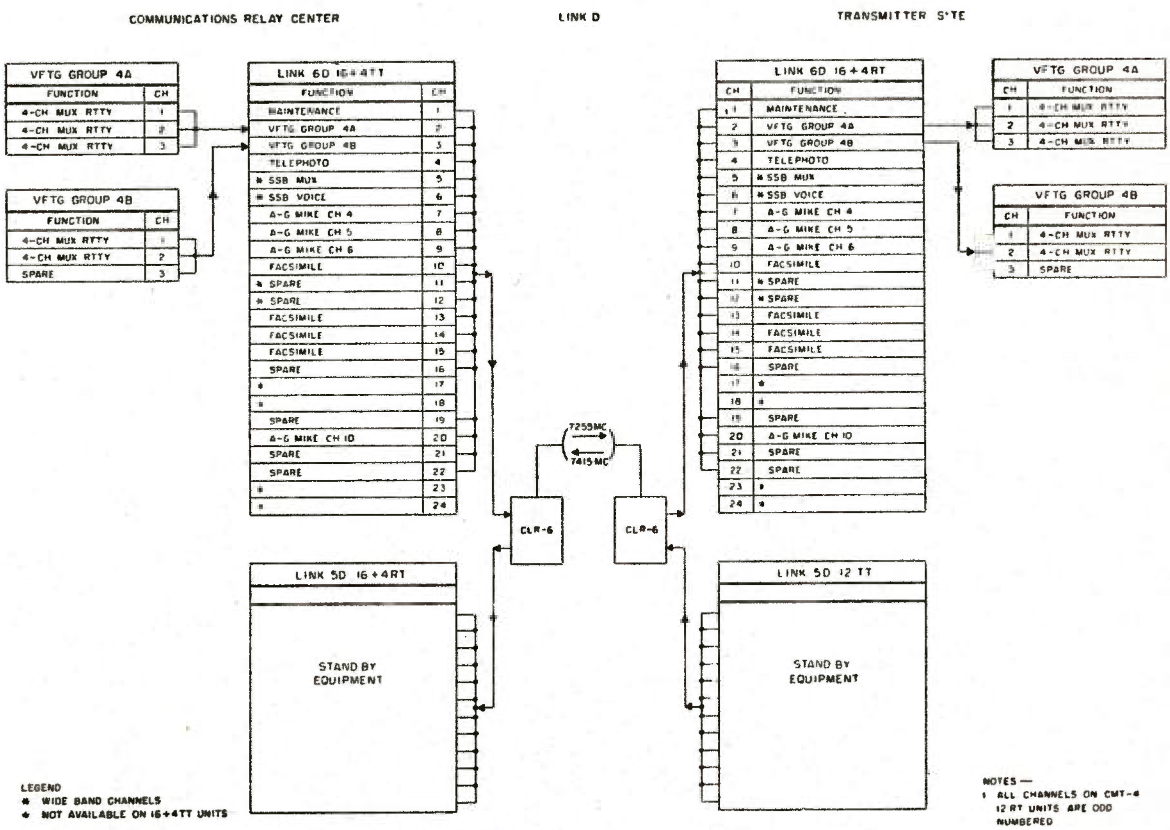


Figure 7–19. Typical Intersite Facilities Channel Assignment, Link "D".

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