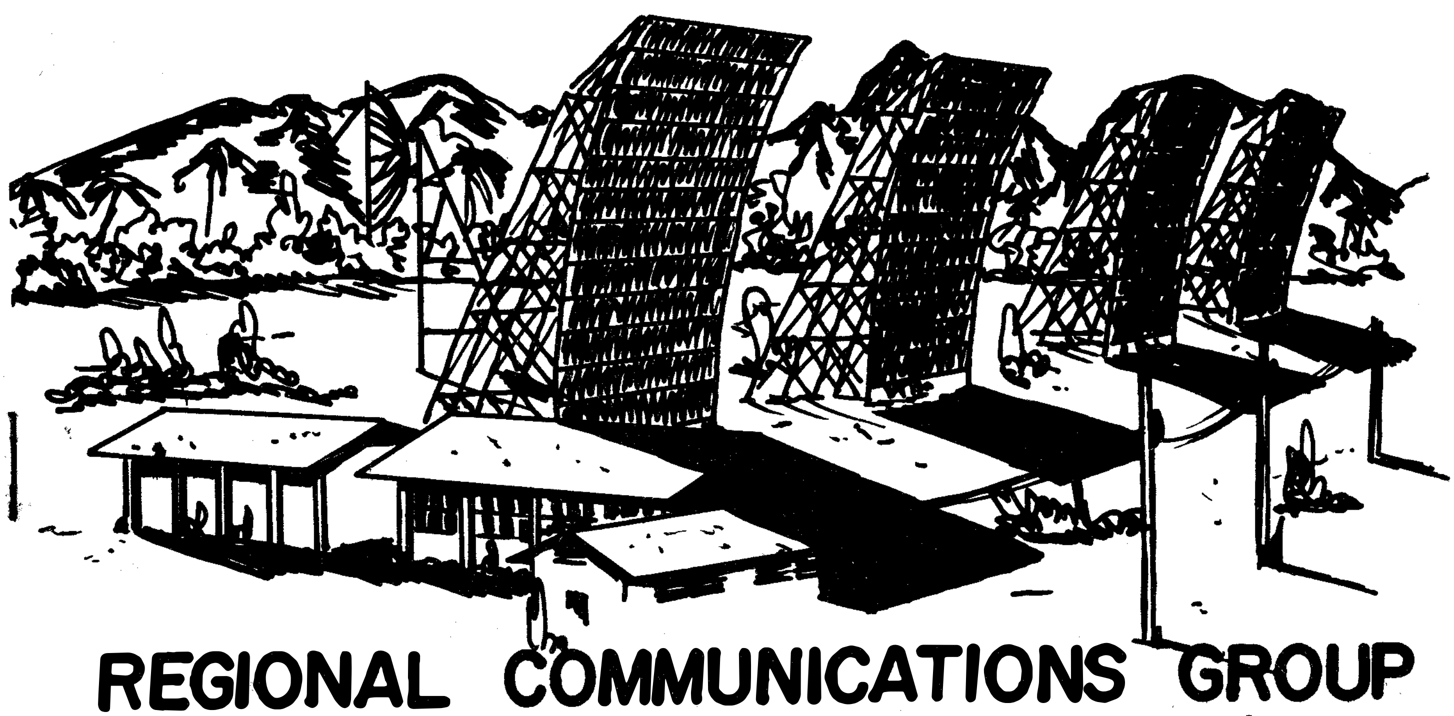
ICS

ORIENTATION



REGIONAL COMMUNICATIONS GROUP

1st SIGNAL BRIGADE (USASTRATCOM)

ICS ORIENTATION

Prepared by

Engineering Branch
Plans & Operations Division
US Army Regional Communications Group
Viet Nam
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DEPARTMENT OF THE ARMY
HQ. USASTRATCOM REGIONAL COMMUNICATIONS GROUP (VIETNAM)
APO SAN FRANCISCO 96243

IN REPLY REFER TO

SCCPV-RG-PO-EB

SUBJECT: Integrated Communications System (ICS) Orientation Manual (Third Edition)

All Concerned

1. The Integrated Communications System (ICS) Orientation Manual is designed to introduce you to the operation of the ICS, its history, and the highly sophisticated equipment used for communications within the Republic of Vietnam.

2. This updated edition of the ICS manual provides the most accurate and current information available.

JOSEPH F. PARADIS
Colonel, SigC
Commanding

Note From The Editor Of The Third Edition

This edition of the Integrated Communications System Orientation Manual reflects changes in operations, procedures and organization that have occurred in the ICS since the second edition was published in April 1968. It also incorporates many corrections and additions to the text material of the previous edition.

The editor expresses his appreciation to MAJ H. M. Akagi, Chief, ICS Operations Branch and 1LT Ross J. Stark, Chief, Engineering Branch, who provided valuable suggestions for the updating of the material as well as proof-read large portions of the manuscript. Important contributions to the revision of text material were also made by Specialist Five Robert DePaola and Specialist Five Sheldon Daitch of the Regional Communications Group Training Branch.

Numerous consultations with Dean A. Mathis, B. B. Rico and D. B. Shannon of Page Communications Engineers were highly beneficial in resolving various questions pertaining to engineering changes or modifications of ICS equipment.

Nikolai Tschursin

September 1970

MR. NIKOLAI TSCHURSIN
GS-12, DAC

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I. COMMUNICATIONS IN VIETNAM

Communications in the Republic of Vietnam (RVN) encompasses everything from the AN/PRC-6 to the REL-2600. It is little wonder that the newly arrived communicator finds himself swamped by a virtual flood of new terms and unfamiliar items of equipment. In this chapter we intend to discuss the detailed development of the transportable and fixed-station portion of Vietnam communications. This discussion will include at least a general introduction to the major items of equipment found in this portion of the communications system. Of prime interest in this general survey of Vietnam communications will be the ICS.

A. INTRODUCTION:

1. What is the ICS?

The ICS is the Integrated Communications System installed in Southeast Asia in support of Free World Military Allied Forces. It provides multichannel voice, teletypewriter and data communications. The ICS has been especially designed for optimum performance in this region and has the necessary flexibility to respond to command and control requirements in an ever-changing combat environment.

2. General Background:

The ICS was conceived by CINCPAC in the summer of 1964 and submitted to the JCS in October 1964, the proposal prepared as a DCA system plan in December was approved in principle by the Deputy Secretary of Defense in April 1965. It was developed as a Department of the Army Telecommunications Program Objective (TPO) in June 1965. The ICS was finally approved by the Deputy Secretary in August 1965. Contracts were awarded in September to Page Communications Engineering, Inc. of Washington, D.C. for the Vietnam portion (Area I) and to Philco-Ford Corporation of Philadelphia for the Thailand portion (Area II). The basic ICS is commonly referred to as Phase I. In January and February two expansions to the ICS were approved by the Deputy Secretary of Defense. These two expansions are commonly referred to as Phase II. Further expansion referred to as Phase III was approved in August 1966.

3. Southeast Asia Mainline Communications:

The ICS constitutes the backbone of U.S. Military Communications in SEA. Its purpose is to increase the overall capacity and quality of the existing communications systems by extending, upgrading and expanding the tactical and transportable communications facilities.

The ICS makes use of the most advanced techniques and equipment available such as high quality microwave systems that will function in line of sight, diffraction or troposcatter propagation modes. An expansion capability provides for future increases in channel requirements and for extensions into tactical systems. The mainline and spur links of the ICS total approximately 470,000 circuit miles.

The ICS is composed of a series of wideband radio links between mainline stations, with spurs to subscribers at fixed locations. The trunking capability can be extended to tactical systems through the terminating facilities which have been installed at each station.

Diversified signalling equipment throughout the system permits extension of customer service regardless of the signalling method used on the subscriber links. Conditioning equipment is available in the system for interface requirements. The arrangements for future expansion and changing requirements include complete flexibility in the use of the various types of multiplex equipment. Technical control facilities are provided for all ICS stations. Selected stations have been equipped with master alarm systems and status displays to permit control and supervision of the entire network in each area.

B. HISTORY OF INITIAL VIETNAM COMMUNICATIONS:

1. "BACKPORCH" and "WET WASH":

The initial long lines system in Vietnam consisted of several vans mounted, transportable troposcatter systems installed by the Air Force in 1962, utilizing AN/MRC-85 equipment.

These were turned over to the Army in July 1963, and operated initially by the 362D Signal Co. (Tropo).

In December of 1964, the Wet Wash undersea cable from the Philippine Islands was extended into Nha Trang. At Clark, circuits from this cable are routed over the transpacific cable to Hawaii where access to the US AUTOVON system is obtained. To provide access to this cable from the Saigon area, another AN/MRC-85 system was installed between Phu Lam and Nha Trang. This AN/MRC-85 system, which is still operational, has been called the "Wet Wash Tropo System".

In September 1965, another AN/MRC-85 link was added between Pleiku and Danang. To improve propagation, the Danang terminal was later moved to Monkey Mountain and extended down to Danang by an AN/TRC-29 transportable microwave system.

This, then, is what is commonly referred to as the "Backporch" and "Wet Wash" systems, the backbone of Vietnam communications until augmented by the Integrated Communications System (ICS) in 1967.

2. AN/MRC-98 System:

In October 1965, two (2) AN/MRC-98 links were added between Ubon and Monkey Mountain, and between Cam Ranh Bay and Vung Tau. The AN/MRC-98 is similar to the AN/MRC-85 in equipment and operation, the major difference being that it provides only 60 channels of AN/FCC-17 multiplex as compared to the 72 channel AN/MRC-85.

3. LRC-3 System:

In 1965, a contract was let with Philco-Ford Corporation to establish an LRC-3 ("Land Radio, Communication" Model 3) microwave system between Phu Lam and Vung Tau and an LRC-3 troposcatter system between Vung Tau and Green Hill, Thailand. Both LRC-3 systems have a 60 channel capacity; however, the link Vung Tau to Green Hill is not being used to maximum capacity due to poor propagation conditions. The link from Vung Tau to Green Hill carries only 24 channels. The Phu Lam - Vung Tau link carries the full 60 channels. These links were cut to traffic in November 1965.

4. Status in 1965 - 1966: (See Figure 1-1)

There were many problems associated with long lines communication as they existed in 1965-66. Terminal locations were selected for their security not for the best propagation conditions for the equipment utilized. As a result, none of the links met DCA channel standards. Second, there was a definite vulnerability in the system at the Nha Trang site which was, and still is, a major entry and nodal point. Third, requirements greatly exceeded capacity in that a critical lack of channels existed between the Nha Trang - Pleiku areas and Saigon.

Finally, existing technical control facilities were not adequate to perform their required mission. As a result of these deficiencies the long lines upgrade in Vietnam was established under two separate, but related, contracts which will be discussed later.

5. Operating Agencies:

The original Backporch system was installed by Page Communications Engineering, Inc., under an Air Force contract. It was also initially operated by the Air Force. Similarly the Wet Wash cable and tropo system were installed and operated by the Air Force. The operation of these long lines facilities was later assigned to the Army. The operating unit was the 39th Signal Battalion, the first Army Battalion assigned to Vietnam. The 39th was later transferred to USARV. The operational responsibility for the long lines systems was transferred from the 39th Signal Battalion to STRATCOM (Vietnam) on 19 August 1965. Prior to this, STRATCOM had been operating the high frequency radio and tape relay facility at Phu Lam. In April 1966, when the 1st Signal Brigade was formed from STRATCOM (Southeast Asia) STRATCOM (Vietnam) became the U.S. Army Regional Communications Group (Vietnam). Regional Communications Group operated both the long lines systems (AN/MRC-85's) and the STRATCOM Facilities at Phu Lam, Nha Trang, and Da Nang.

The expansion of the Backporch system in September, 1965, and the installation of the AN/MRC-98's in October, 1965, was performed by the Air Force for STRATCOM.

The Defense Communications Agency began operations in Vietnam at the same time as STRATCOM, August 1965. At first, the small detachment of 7 in Saigon was a part of DCA-SEA (Southeast Asia) with headquarters in the Philippines. Later, DCA-SAM (Southeast Asia Mainland) was formed to operate here in Vietnam and in Thailand through DCA-SAM, Thai.

6. SEAWBS:

SEAWBS stands for the "Southeast Asia Wideband Systems". The SEAWBS consists of all communications systems in SEA that are part of the Defense Communications System. SEAWBS is under the operational and management direction of DCA-SAM.

C. DEVELOPMENT OF THE PRESENT COMMUNICATIONS SYSTEM IN SEA:

As mentioned previously, there were three major contracts let by the Army and Air Force to provide improved long lines communications in SEA. There were the Integrated Communications System (ICS), Area I (Vietnam), awarded to Page Communications Engineering Inc.; ICS Area II (Thailand) awarded to Philco-Ford; and project Seed-Tree (439L) undersea cable, also awarded to Page. The ICS contracts are STRATCOM projects and 439L was under the Air Force. This discussion will cover only the 439L project and the Area I ICS effort.

1. 439L Cable:

(Figure 1-2) The 439L undersea cable is a 60-channel system connecting the major communication points along the coast of Vietnam and Thailand. The cable terminals, located near the beach, are operated by the Air Force. They are connected to the ICS terminal at each location through a microwave link installed under the ICS contract. The cablehead terminal is operated by the Army. The only operation performed at the cable terminal is control and patching of 12-channel groups. The control of each individual channel is performed in one of the ICS technical control buildings.

2. Area I ICS: The ICS effort in RVN has been divided into three phases as follows:

a. Phase I, ICS:

(Figure 1-3) Phase I of the ICS was intended primarily to relieve the problem of insufficient circuits up-country by providing links from Saigon, Pleiku, and Nha Trang to a nodal point at Pr'Line in the center of this triangle. The Wet Wash system remained as before; however, the Backporch AN/MRC-85 system from Phu Lam (Saigon) to Nha Trang was moved to connect Pleiku and Vung Tau, providing an alternate entry to Pleiku from the south. The remainder of the Backporch and other systems remained in the same locations. The AN/MRC-85's were fully integrated into the IWCS, and some of their terminal equipment was removed from the vans and installed in the ICS technical control buildings. The AN/MRC-98's remained in place but were not terminated in ICS buildings. Phase I ICS also provided a link to Phu Bai, replaced the transportable microwave systems (AN/TRC-29) being used in the intercity system in Saigon, and added a high capacity microwave system from Saigon to Vung Tau. Phase I, ICS, was completed with the acceptance of the Pleiku to Vung Tau AN/MRC-85 system on 25 January 1968.

b. Phase II, ICS:

The additional links being added to the ICS during Phase II are shown in Figure 1-4. In addition, several of the Phase I links were upgraded to a higher capacity (increased capacity indicated by Phase I links in Figure I-4 Phase II was completed on 29 February 1968 with the acceptance of the Long Binh to Vung Tau link.

The two AN/MRC-98 systems (Cam Ranh Bay to Vung Tau and Monkey Mountain to Ubon) scheduled for replacement by fixed plant systems during Phase II had been deactivated.

c. Phase III, ICS:

(Figure I-5). During Phase III, no major links were established. The primary changes were the addition of numerous light capacity systems around major nodal points and in the delta region. There was a considerable redistribution of equipment presently installed; under project MARV (Multiplex Assets Rearrangement Vietnam). The final capacities of Phase III upgrades to Phase II links are indicated by the Phase II links in Figure 1-5. The complete ICS-439L program, excluding transportable augmentation discussed previously, is shown in Figure I-6.

d. The long lines capability as of 1 April 1968 is as follows (See also Figure 1-7):

(1) Phase I ICS is complete.

(2) The 439L cable system is complete.

(3) Phase II ICS is complete.

(4) Phase III ICS is complete.

(5) The AN/MRC-85's in the Backporch system have been fully integrated into the ICS.

(6) The Wet Wash tropo system is still installed from Nha Trang to Phu Lam (Saigon).

(7) The LRC-3 link to Thailand is still in operation. The AN/MRC-98 system Vung Tau to Cam Ranh Bay was deactivated and removed in July 1967 to permit installation of the ICS system on the same path. The AN/MRC-98 system between Monkey Mountain and Ubon has been deactivated. In January 1968 it was decided to place the Vung Tau and Phu Lam LRC-3 terminals inside the ICS buildings at those sites. This was completed in July 1968.

(8) In addition under Phase III TSC-82 recoverable microwave terminals with supporting mux and tech controls were installed at Dong Tam, Dong Ba Thin, Sa Dec and Di An.

(9) The first Phase III link was accepted 29 December 1967 (Vung Chua Mountain - Phu Cat). The last link was accepted on Dec 11 68 (Bac Lieu)

(10) The ICS also includes a large number of Voice Frequency Carrier Telegraph (VFCT) systems. In Figure 1-8 are shown the ICS VFCT systems programmed through Phase III. In this program both Contractor Furnished Equipment (CFE) and Government Furnished Equipment (GFE) are utilized to provide the ICS VFCT terminals. CFE is either AN/FCC-19 or AN/FCC-25 equipment, whereas GFE is normally AN/FGC-60 equipment. The VFCT program is presently undergoing an active relocation program (TARV).

D. SATELLITE COMMUNICATIONS:

In addition to the out-of-country channels to the Philippines and Hawaii by the Wet Wash cable, there are also three (3) Satellite systems presently providing high-quality voice trunks (Figure 1-9).

The first system to become operational was the AN/MSC-44 located at Ba Queo which is near Tan Son Nhut Air Base. This system provided one (1) voice circuit and one (1) teletype tone pack. The AN/MSC-44 became operational in June 1966. The voice circuit was used as a common user trunk from Saigon to Hawaii. The system went out of service on 31 December 1967.

During the latter part of 1966, two AN/MSC-46 Satellite ground terminals were deployed in Vietnam on an R&D basis. One was installed at Ba Queo and the other at Nha Trang. Each terminal originally provided five voice channels and both were fully operational on 18 July 1967. The Ba Queo terminal was upgraded to twelve channel operation in December 1967 and in January 1968 the Nha Trang terminal was also upgraded to twelve channels. Normal operation of these terminals is in the five channel mode, however, due to propagation condition.

In addition to the military systems, there are also, at present, six circuits leased from COMSAT. The commercial terminals are in Thailand

and Hawaii. The circuits are extended to Saigon through the undersea cable from Sattahip to Vung Tau. These circuits became operational in April 1967. Further detailed information on satellite communications is provided in Chapter XVI.

E. SUMMARY:

This has been only a brief discussion of the development of communications in Vietnam. With all Phases fully completed, the ICS now provides the bulk of the long haul channels of the SEAWBS. However, the importance of the contribution of the transportable systems to the SEAWBS should not be overlooked. In circuits alone, the transportables would probably equal the ICS, although in circuit miles this would not be true.

The term "transportable" is used above to avoid a problem in semantics that often arises when discussing the various systems found here in Vietnam. The types of equipment referred to, AN/TCC-7, AN/TRC-29, AN/GRC-50, etc., are usually called "tactical equipment" however, in Vietnam that description for a system carries a special connotation. Figure 1-10 illustrates the distinction. The basic "ICS" consists of the ICS tech control building (commonly called "EE" electronic equipment buildings). Prior to the activation of the ICS EE buildings, there had been either locally fabricated (commonly referred to as "old" technical control") or mobile technical controls such as the AN/MSQ-73. These facilities are now connected to the EE buildings by cable. It is in the old technical control that most of the SEAWBS transportable systems were terminated. Many of the DCS transportable systems have been terminated in the ICS EE buildings in order to provide better technical control facilities. In the future it is envisioned that several more DCS transportable systems will be terminated in the ICS technical controls.

The transportable equipment freed by the activation of the ICS, has been utilized to establish the Corps Area Comm System (CACS). This is not part of the DCS and is under the control of the 1st Signal Brigade. This concept will create more corps Area technical controls which will not be part of the DCS.

The final system found in Vietnam is the "tactical system". This term has been used to refer to those systems installed by the units in direct support of the tactical headquarters, i.e, Division Signal Battalions. They are of interest since they often provide the connection to the subscriber for a circuit routed over the ICS. These systems are often terminated in the area technical controls.

The descriptions of the three types of systems as given in USARV and 1st Signal Brigade publications are as follows:

1. The Tactical System is the command system for the divisions and field forces. Equipment for the tactical system is provided by the signal units organic to the divisions and field forces.

2. The Corps Area Communications System is a network of tactical multi-channel systems interconnecting base camps in a geographical area to provide "Local Area Service". This system is operated and managed by the 2d, 12th, 21st and 160th Signal Groups of the 1st Signal Brigade. It provides supplementary communications support to the tactical units primarily for operational type traffic, but includes administrative and logistical traffic as well. It supplements the SEAWBS by providing extension of SEAWBS circuits into local areas from major SEAWBS nodal points.

3. SEAWBS is the long haul, wideband communications system providing high quality communications channels throughout Vietnam. It is operated in the main by the Army with scattered Air Force systems. It consists of the ICS, 439L cable, transportable troposcatter and microwave systems.

F. CURRENT STATUS OF ICS SYSTEMS:

Figure 11 shows current status of ICS as of 1 Sept 70. As a result of reduced military requirements the stations at Dong Ha, Phu Tai and Tai Ninh were deactivated. In addition, to improve the communications by utilizing REL-2600, the MRC-85 shots between Da Nang-Qui Nhon and Qui-Nhon-Nha Trang were also deactivated.

Fig. I - 1
LRC-3 SYSTEM TO THAILAND
NOVEMBER 1965

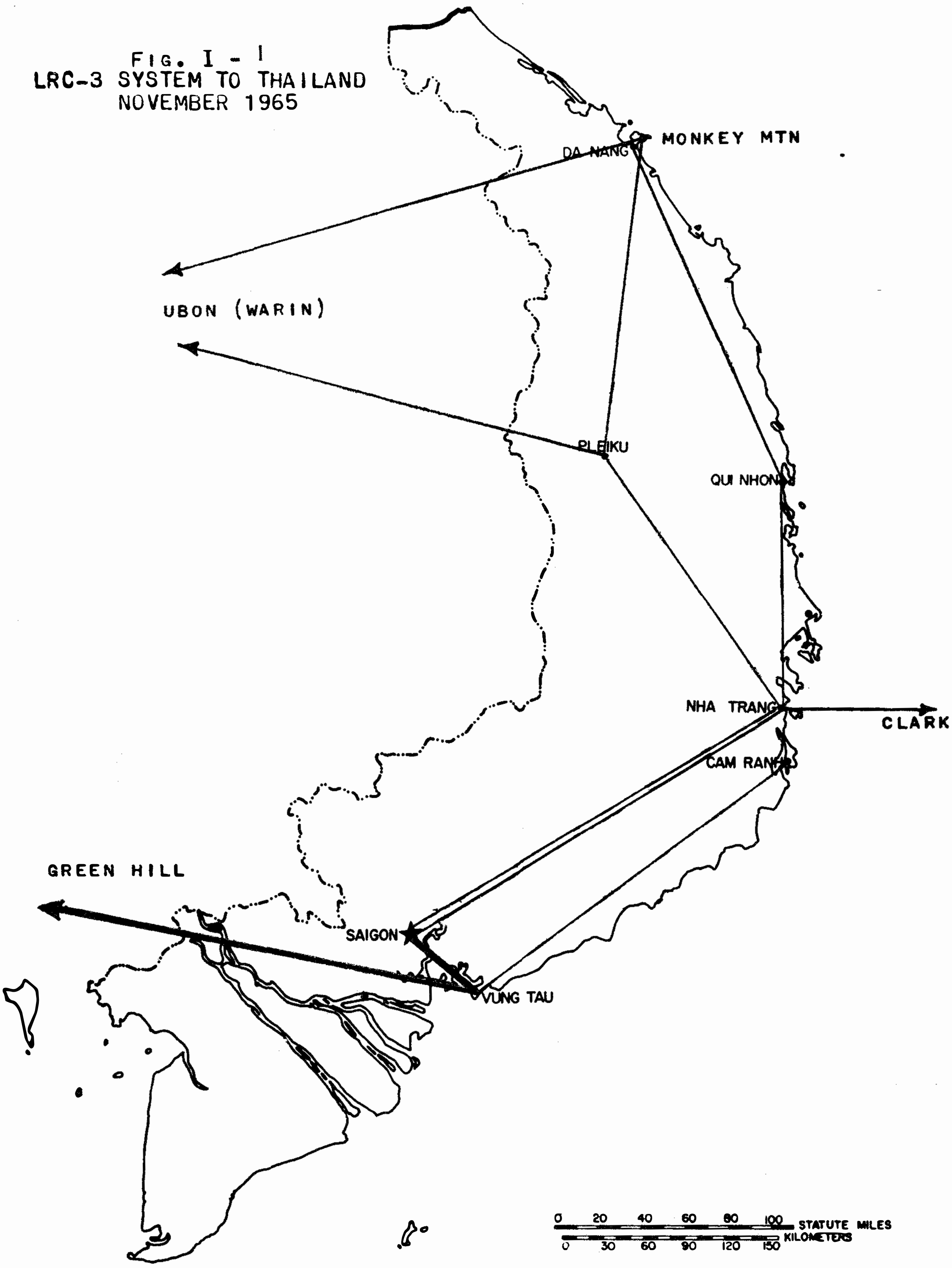


FIG. I - 2
439-L CABLE
JUNE 1967

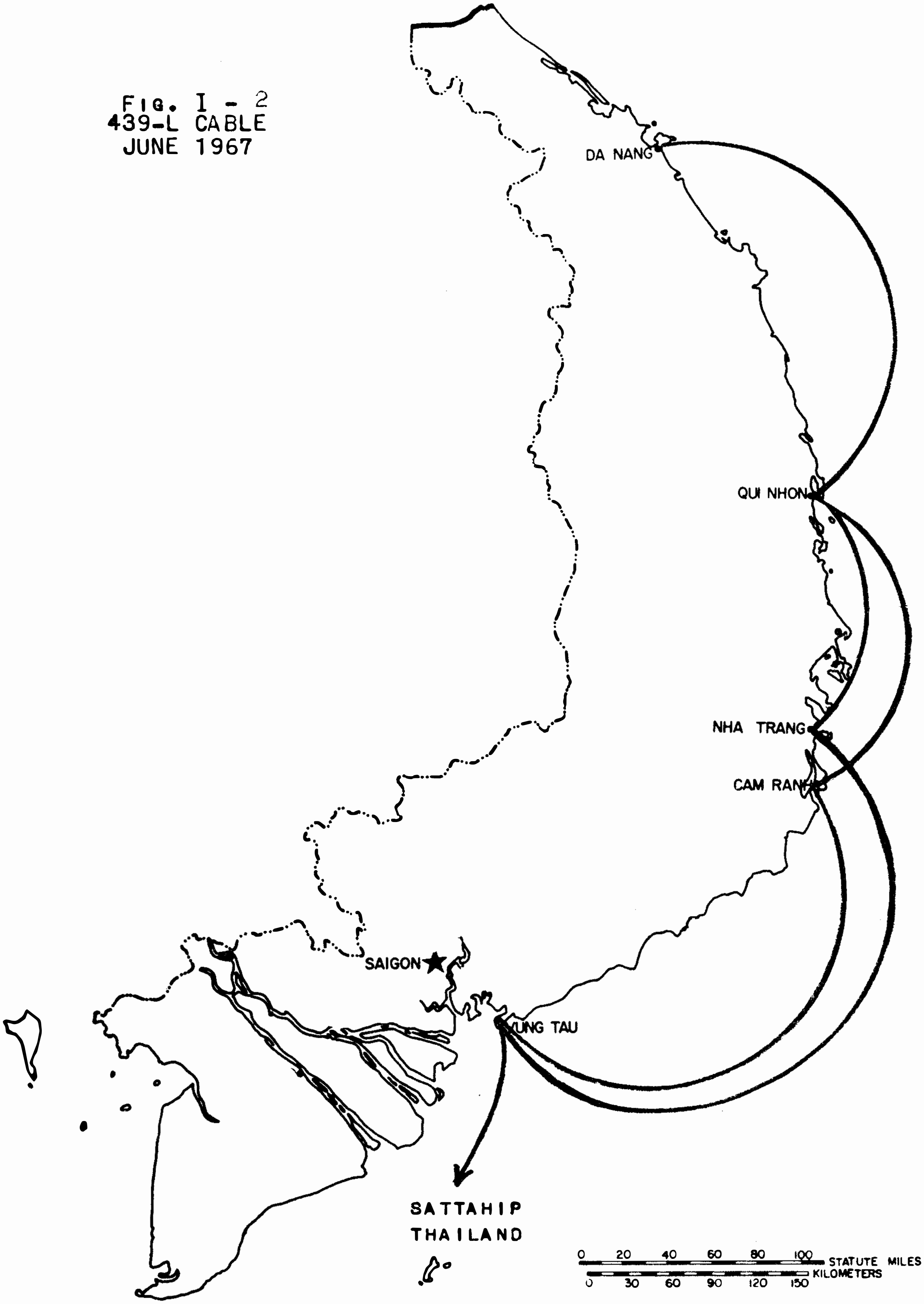


Fig. I-3
PHASE I
ICS
1967-1968

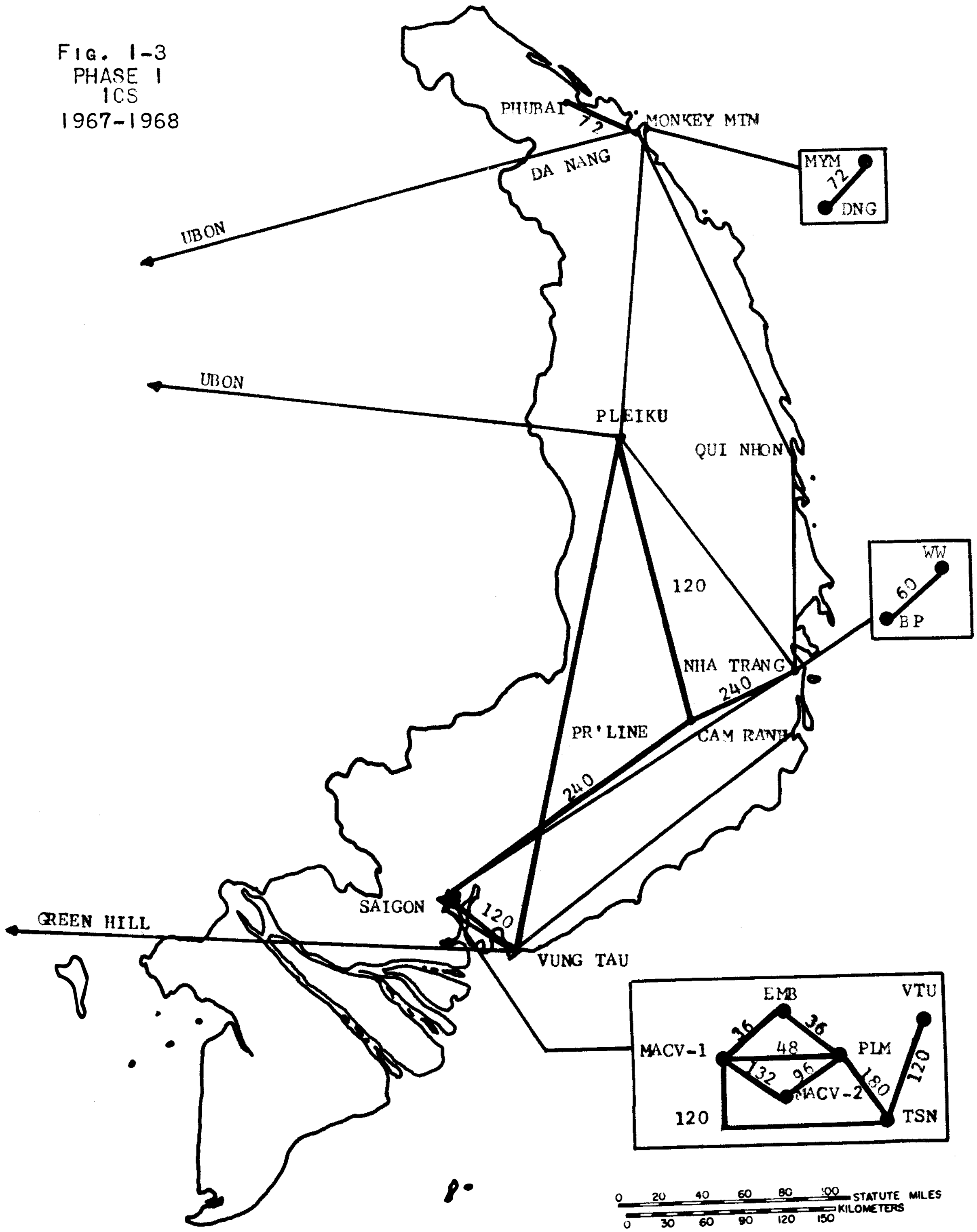


FIG. 1 - 4
PHASE 2
ICS
1967-1968

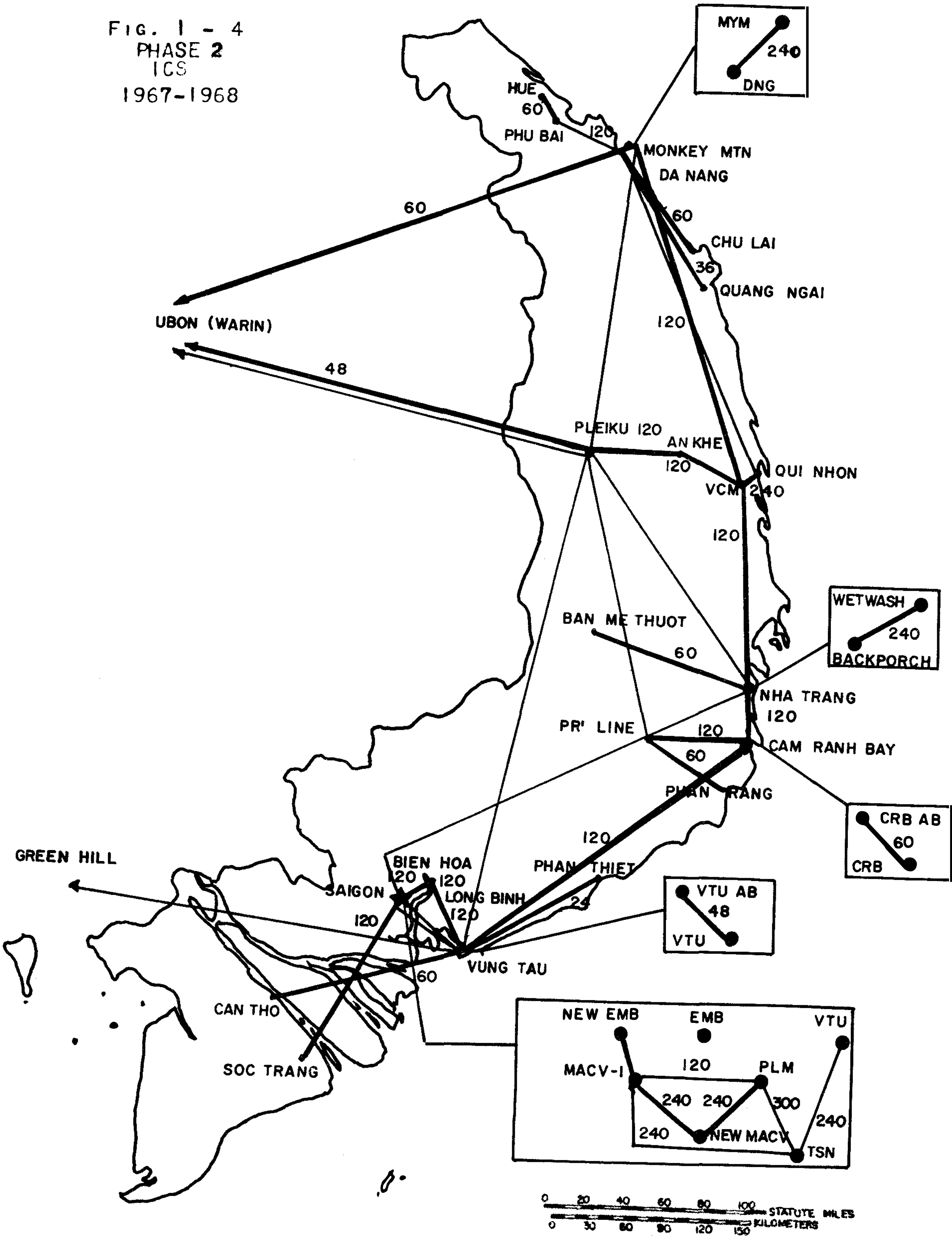


FIG. I - 5
PHASE 3
ICS
1967-1968

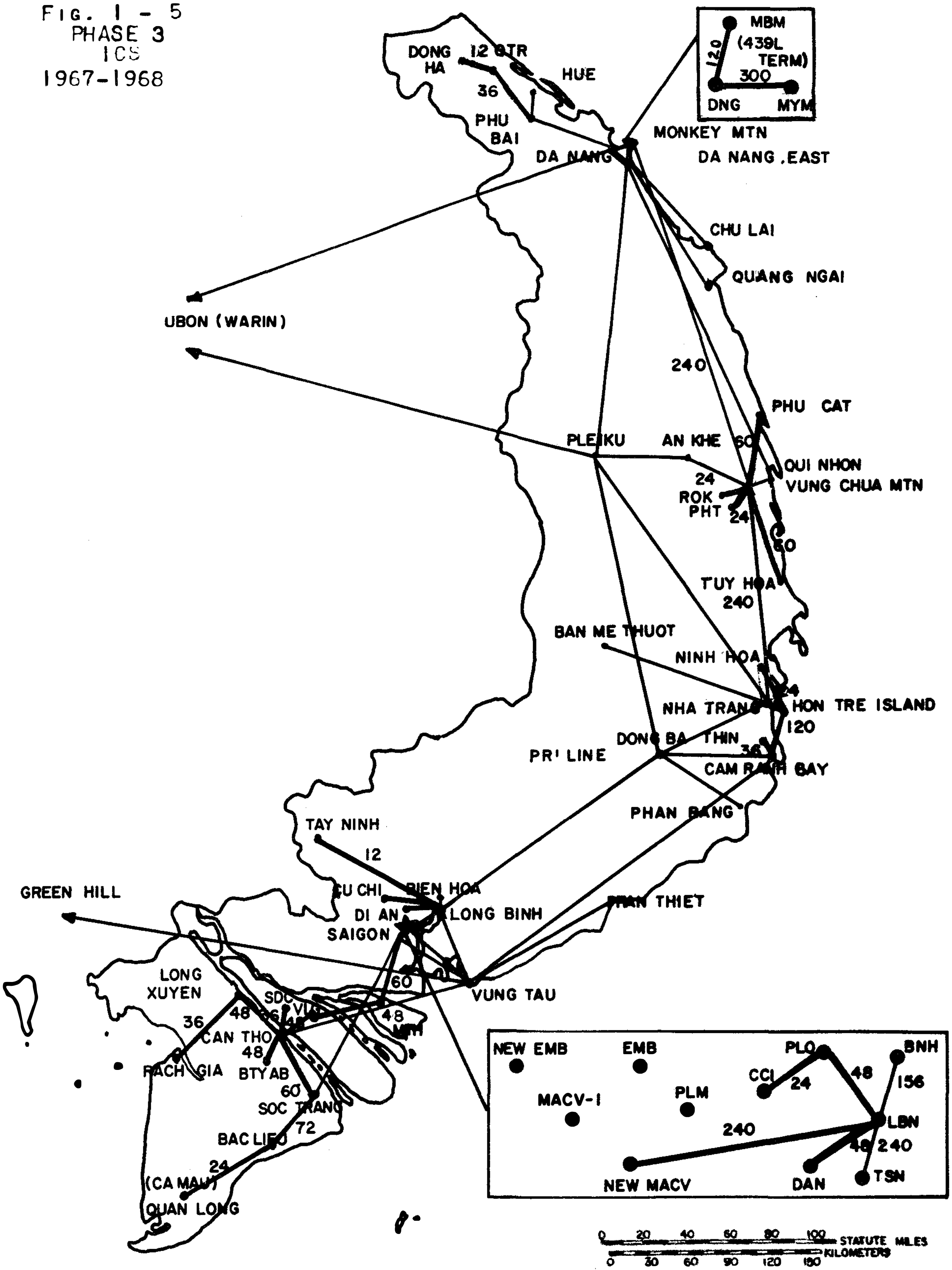


Fig. I -6
THRU PHASE 3
ICS
439L

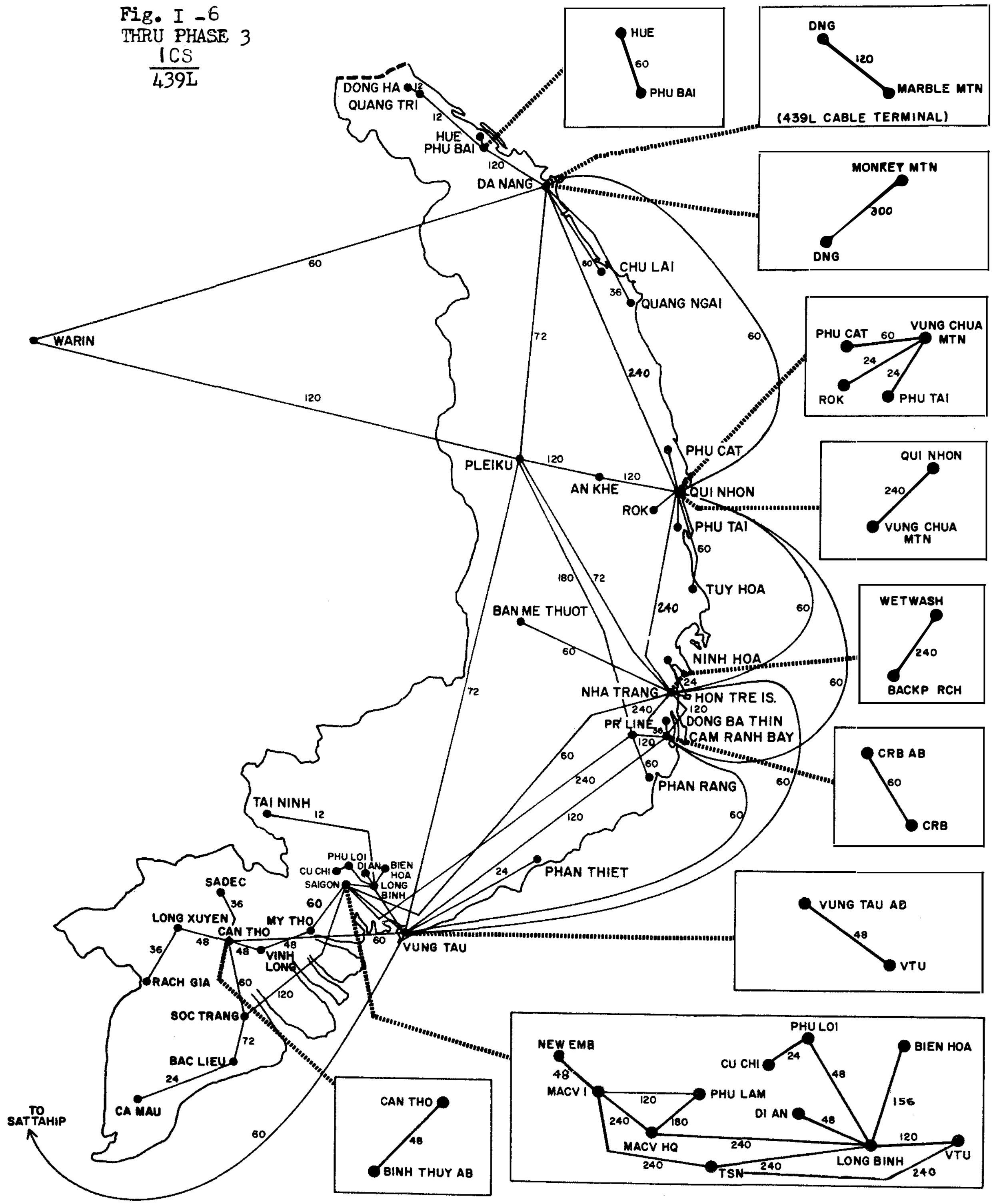


Fig. I - 7
STATUS AS OF
1 April 1968

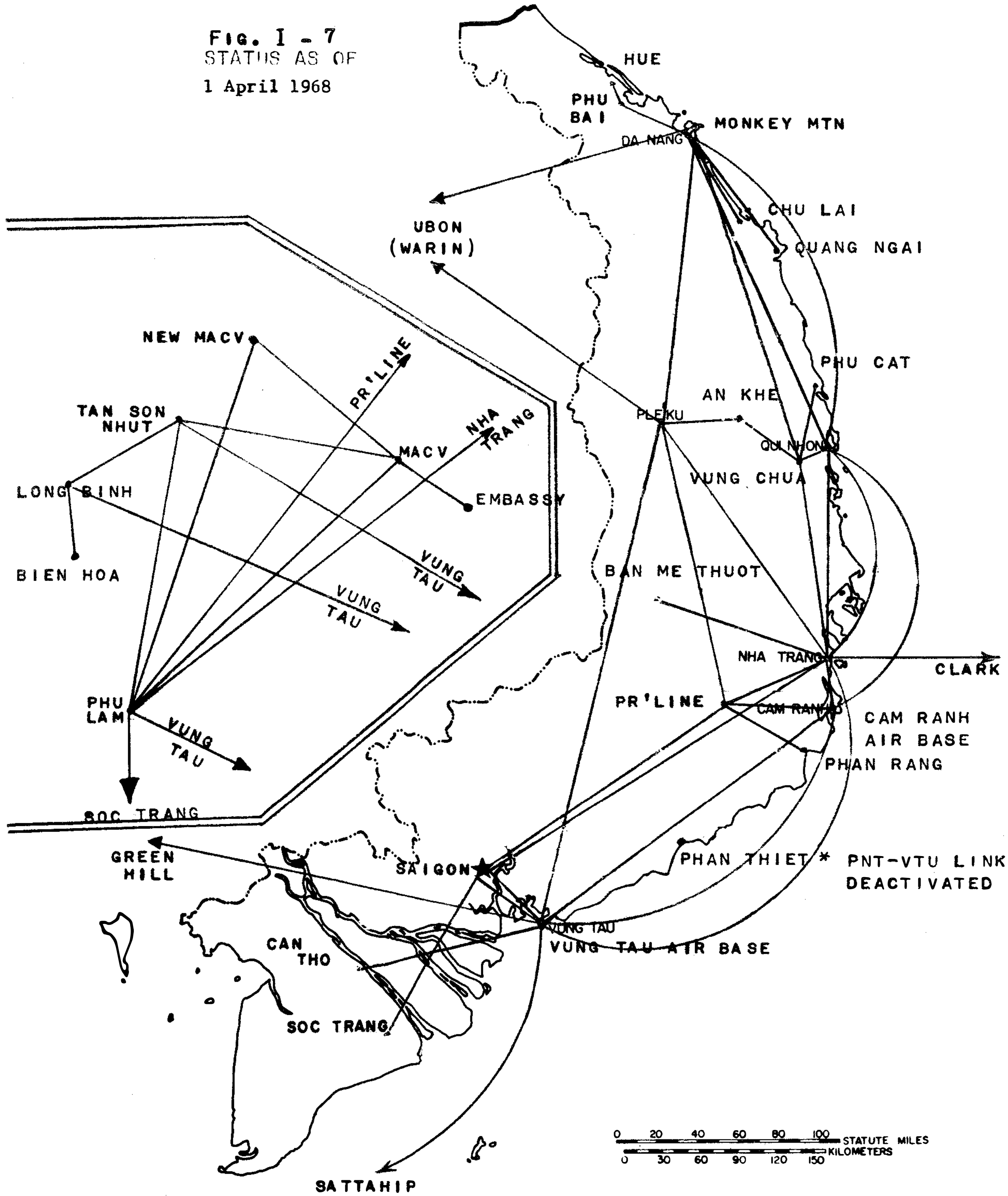


Fig. I-8
ICS VFCT SYSTEM

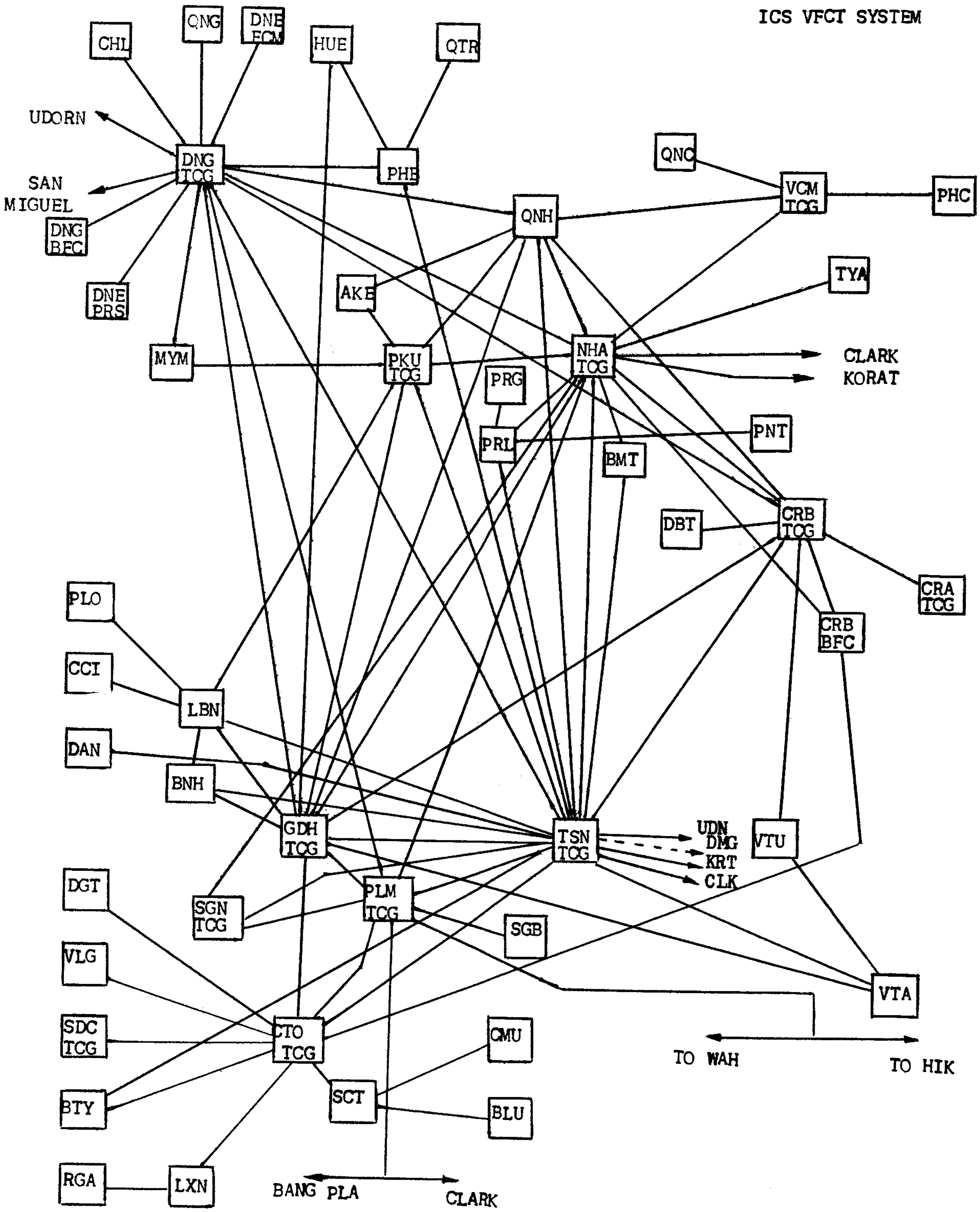
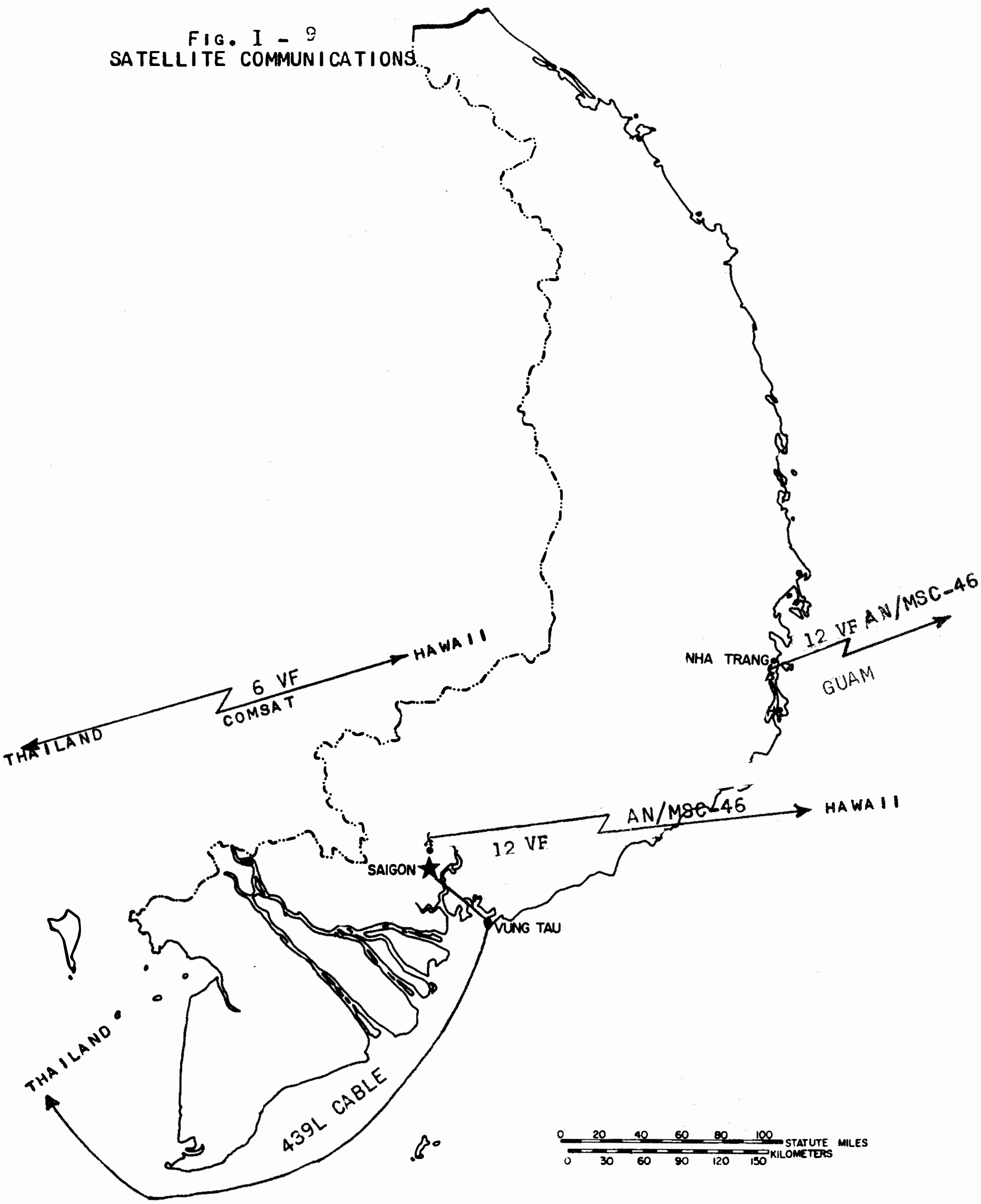
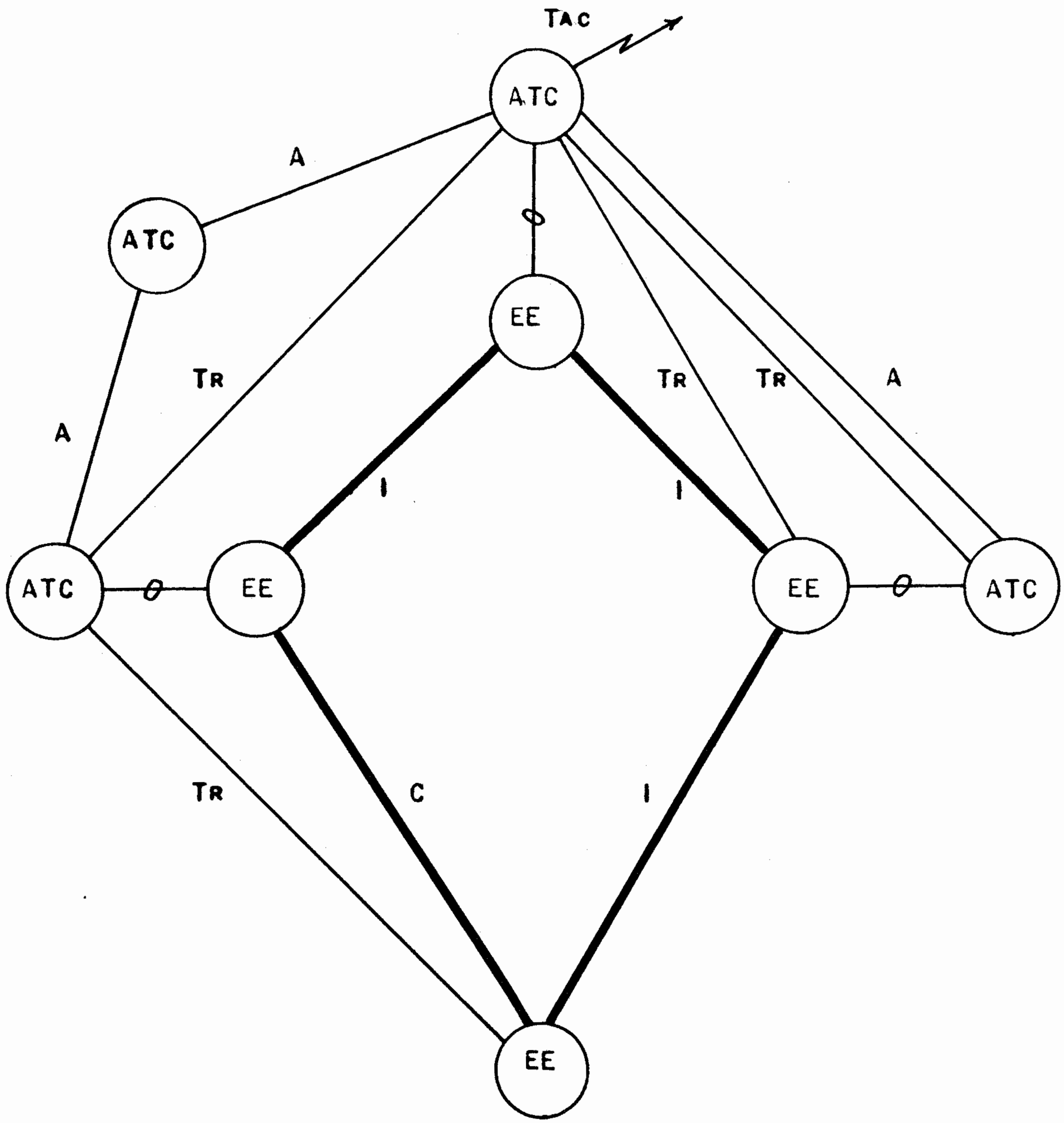


FIG. I - 9
SATELLITE COMMUNICATIONS

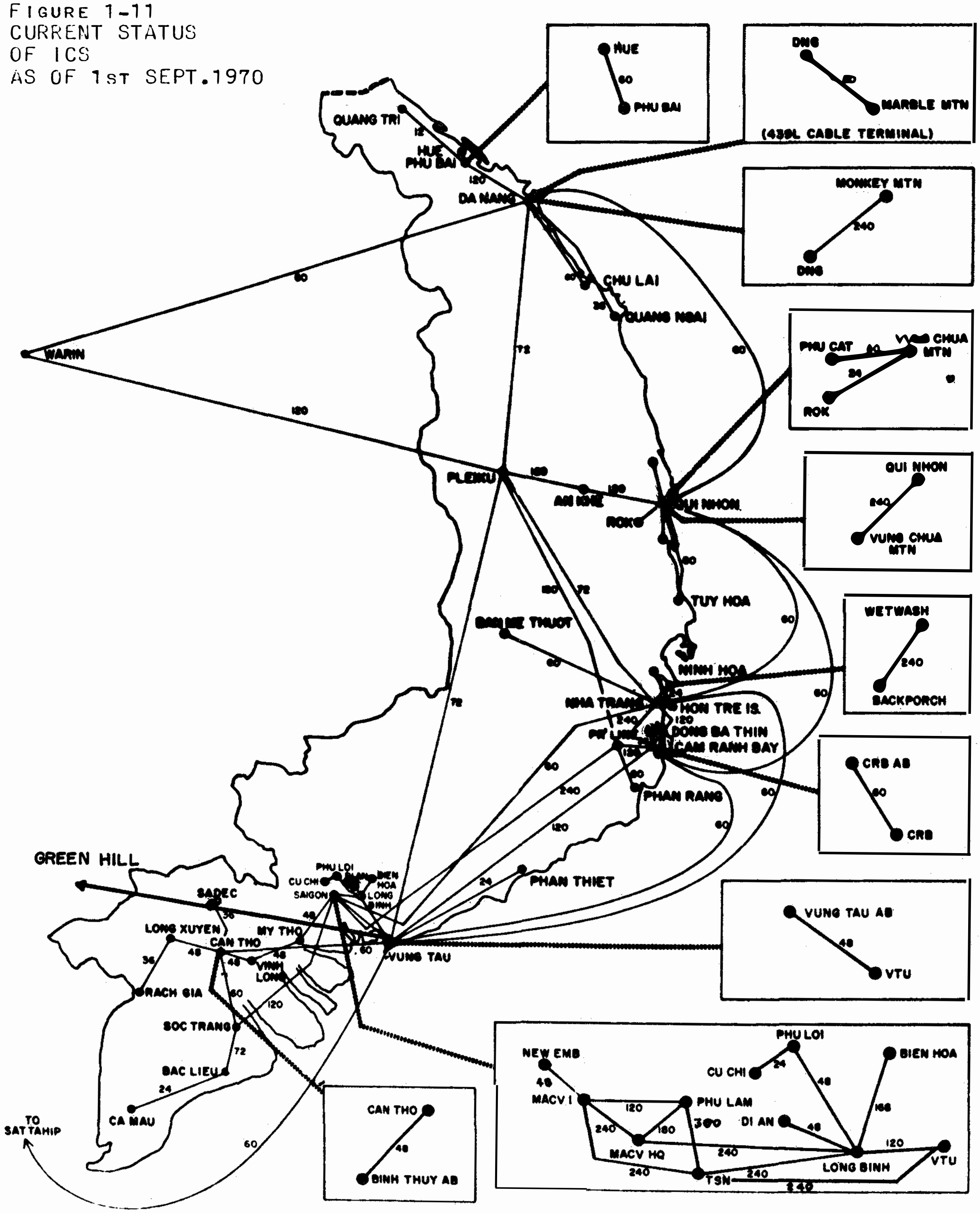




LEGEND:
C 439L CABLE
I ICS LINK
EE ICS TECHNICAL CONTROL
TR "TRANSPORTABLE" SYSTEM
A AREA SYSTEM
TAC "TACTICAL" SYSTEM

FIGURE I - 10 DIFFERENT COMMUNICATION SYSTEMS IN OPERATION IN VIET NAM.

FIGURE 1-11
CURRENT STATUS
OF ICS
AS OF 1st SEPT.1970



II. CONTROL AND OPERATING AGENCIES

One of the most difficult items for the newcomer to grasp is the complex relationship between the various agencies involved with installing, operating, managing, and controlling the ICS. This section will briefly cover each agency and illustrate the more important relationships by means of charts.

A. MAJOR ORGANIZATIONS OF INTEREST:

Although is does not normally directly ffect us here in Region 1 Communications Group, it is important to understand the basic relationship between the major headquarters involved (Figure II-1). The most obvious feature is that all organizations in Vietnam are under operational control of MACV although they may be commanded by another headquarters such as STRATCOM-PAC.

1. 1st Signal Brigade (USASTRATCOM):

The 1st Signal Brigade (Figure II-2) is the largest communications organization in Vietnam. Responsible for planning, engineering, inst lling, operating and maintaining the Army portion of the Defense Communications System in Vietnam and Thailand, and the Corps Area Communications System. Operates local communications centers, DCS tape relay centers, performs maintenance on C-E equipment, and has the general mission of performing communications-electronics functions in support of US military and other governmental activities in Southeast Asia.

2. US Army Regional Communications Group (Vietnam):

Subordin te command of 1st Signal Brigade, operates the fixed-plant portion of the SEAWBS in Vietnam. Operates and maintains all ICS sites in Vietnam and one minor tape relay at Phu Lam. Responsible for operation and maintenance of the Joint Overseas Switchboard (JOSS) and the AUTOSEVOCOM system in SEA (Figure II-3). The Group Headquarters is located in the Phu Tho Hoa district of Saigon.

3. 2nd Signal Group:

Subordinate command of 1st Signal Brigade operating primarily in the (ARVN) Military Region III and IV providing the Army Area Communications System, augmentation to the SEAWBS, and general communications support (Figure II-4). The Group Headquarters is located at Long Bing, RVN.

4. 12th Signal Group:

Subordinate command of 1st Signal Brigade, operating primarily in the (ARVN) Military Region I providing the Corps Area communications System, augmentation to the SEAWBS, and general communications support (Figure II-4) the Group Headquarters is located at Phu Bai, RVN.

5. 21st Signal Group:

Subordinate command of 1st Signal Brigade, operating primarily in the (ARVN) Military Region II providing the Army Area Communications System, augmentation to the SEAWBS, and general communications support (Figure II-4). The Group Headquarters is located at Nha Trang, RVN.

6. 29th Signal Group:

Subordinate command of the 1st Signal Brigade. Provides communications support to Military Assistance Command, Thailand, including operation of the Thailand portion of the ICS (Area 2). Under the operational control of MACTHAI; however, technical control remains with 1st Signal Brigade. The Group Headquarters is located in Bangkok, Thailand.

7. 160th Signal Group:

Subordinate command of the 1st Signal Brigade, operating primarily in the Capital Military District (Saigon - Long Binh Area) and providing the Corps Area Communications System there. Responsible for operating and maintaining communication facilities at MACV and USARV Headquarters, other than the ICS. The Group Headquarters is located at Long Binh, RVN.

8. 1964th Communications Group (Air Force):

Subordinate command of the 7th Air Force and is the largest Air Force communications unit in Vietnam. Its Headquarters is located at Tan Son Nhut AFB. (Figure II-5).

Responsible for telecommunications and air traffic control services for the Air Force and other governmental activities in Vietnam. Operates and maintains Air Force dial central office's (DCO's), tandem switch, and associated outside cable plant and the 439L submarine cable system. Also provides and maintains the secure equipment for Air Force AUTOSEVOCOM subscribers. Composed of ten (10) communications squadrons which provide the above services in their respective area of responsibility.

9. Defense Communications Agency-Southeast Asia Mainland (DCA-SAM):

An agency of the Department of Defense. Responsive to the requirements of COMUS MACV/COMUS MACTHAI, and tasked as the single system manager having operational and management direction of the SEAWBS. Makes circuit channel assignments and engineers circuits for the ICS. Operates five (5) DCA-SAM detachments at major communications nodal points throughout Vietnam. The Master Complex is located at Tan Son Nhut AFB (Figure II-6).

B. <u>STAFF AGENCIES AND OTHER CONTROL ELEMENTS</u>:

1. MACV J-6:

Responsible for staff supervision of all C-E activities in Vietnam. Responsible for validating requests for circuits on the SEAWBS and directing the effort of DCA based on requirements from the field (Figure II-1).

2. USARV Assistant Chief of Staff for Communications-Electronics:

Formerly the USARV Signal Officer. Responsible for staff supervision of all C-E activities of units within USARV. Also Commanding General, 1st Signal Brigade.

3. ACOC-Army Communications Operation Center:

ACOC is the major information gathering agency of 1st Signal Brigade. It is located at Long Binh, 1st Signal Brigade, and monitors reports from DCS (Defense Communications System) reporting stations. Also directs the preparation and maintenance of circuit control and system control procedures and practices for use by all elements of the Signal Brigade. Maintains 1st Signal Brigade records of system/channel fill for the SEAWBS and CACS (Corps Area Communications System).

4. Brigade Operations Directorate:

Provides operational guidance and staff supervision for the installation, operation and maintenance of all C-E systems. Also develops operational planning for C-E activities which will be initiated within a 90 day time frame. Exercises staff supervision over the ACOC and other staff agencies as directed.

5. Communications Systems Engineering and Management Agency (CSEMA):

The ICS Branch, a branch of Special Projects Division of CSEMA, represents the Commanding General, 1st Signal Brigade, on all ICS matters in Vietnam and Thailand. They are responsible for monitoring and supervising the execution of the ICS contracts in Southeast Asia. The Test and Evaluation Division of CSEMA provides technical assistance to test and evaluation teams prior to the governmental signing of the Material and Receiving Report, DD Form 250 (see Para C 2 below).

6. Southeast Asia Telephone Management Agency (SEA-TELMA):

Provides overall staff guidance and supervision for operation and maintenance of the Southeast Asia Telephone System. Coordinates directly with Telephone Management Officers (TMO's) at each numbered group headquarters of the 1st Signal Brigade.

8. DCA-SAM Detachments:

Located at major communication nodal points to maintain liaison with, and be responsive to major commander, operating commands and users with assigned geographical areas. These detachments are presently located at Da Nang, Nha Trang, Pleiku, Long Binh and Can Tho. The detachments act as a focal points for emergency requirements and assistance to the commands, service components, operating commands, and users in their area (Figure II-6).

C. CONTRACTORS:

1. Page Communications Engineers, Inc.:

Under supervision of the Plans and Operations Division. Regional Communications Group. Responsible under contract for providing technical support for the operation and maintenance of that portion of the ICS in Vietnam and Thailand which has been accepted by the Army and placed under the command of the CO, USA Regional Communications Group, and 29th Signal Group.

2. Kentron of Hawaii, Limited:

Under supervision of the 1964th Communications Group, 7th Air Force, which operates the 439L cable system. Responsible for the operation and maintenance of the cable terminating equipment at Nha Trang.

D. CONTROL OF THE ICS:

The overall management of the Defense Communications System (DCS) is the responsibility of the Defense Communication Agency (DCA). RCG controls the operation of all ICS stations in Vietnam and forwards technical information and operational directives to the sites.

1. The specific documents involved in circuit actions (TSO and CLR) are fully described in RCG LL TCG S&P. Because of the complexity of the ICS some special control procedures have been established.

a. For ICS circuits TSO's are sent to the Engineering Branch, P&O Division, Regional Communications Group, who are responsible for making conditioning equipment assignments and controlling the activation, changes and deactivations as prescribed by the TSO.

b. The primary difference between operations in the field in the ICS and in the remainder of the SEAWBS is the restriction on local engineering changes to a circuit. Experience has shown that changes on ICS circuits are best made at a central location where they can be fully coordinated. (For this reason no engineering changes will be made in the field by either the tech control or the DCA-SAM detachment. The changes required will be made by DCA-SAM Engineering and/or Engineering Branch. RCG, as appropriate). This policy is defined in RCG LL TCG S&P. Exceptions to this are emergency expedited circuit actions which are also discussed in RCG LL TCG S&P. This policy has been fully coordinated with and agreed to by DCA-SAM.

E. AREA COMMUNICATIONS COMMANDERS (1ST SIGNAL BRIGADE REG 10-10):

The provisions of 1st Signal Brigade Reg 10-10; Area Communications Commanders, are extremely important to the subordinate units of Regional Communications Group. Most of the operating detachments are under the command of units other than RCG, for the specific areas covered in Reg 10-10. Because of it's importance, a complete copy of this regulation is reproduced on pages II-14 through II-17.

F. CONTRACTOR RELATIONS:

The contractor may provide for various aspects of the operation and maintenance of the ICS. However, regardless of the provisions of the contract, the ultimate responsibility for communications is a command responsibility. The execution of government contracts is supervised by the Contracting Officer through the Contracting Officer's Representative (COR) The (COR) is the point of contact between the U. S. Army and the contractor. In this capacity, the (COR) must oversee the contractor to insure that he fulfills the provisions of the contract. The (COR) also recommends approval or disapproval on any proposed modifications that require action by a higher headquarters. Specific responsibilities of the site commander relating to contractor personnel include the following (for a complete listing see 1st Sig Bde Reg 105-4; Military/Contractor Relationships and Responsiblities):

1. Monitor contractor actions to insure that the contractor is performing the functions required by the contract.

2. Bring to the attention of the contractor site supervisor, in writing, any apparent discrepancies in contractor performance.

3. Report all items of difference between himself and the contractor site supervisor through command channels.

The site OIC is the military's liaison with the contractor on site. As such, he is to see that the contractor does what the contract calls for and that the government receives full value. Below are a few useful facts that the site OIC should know in his relationship with the contractor:

1. Contractor employees are not members of the military and do not come under full military authority.

2. The contractor has a supervisor at each site who is responsible for the contractor employees at the site. The site OIC should deal directly with the site supervisor on all technical and administrative problems.

3. Good relationships between the military and the contractor will make operating and maintaining of the ICS much easier for all concerned.

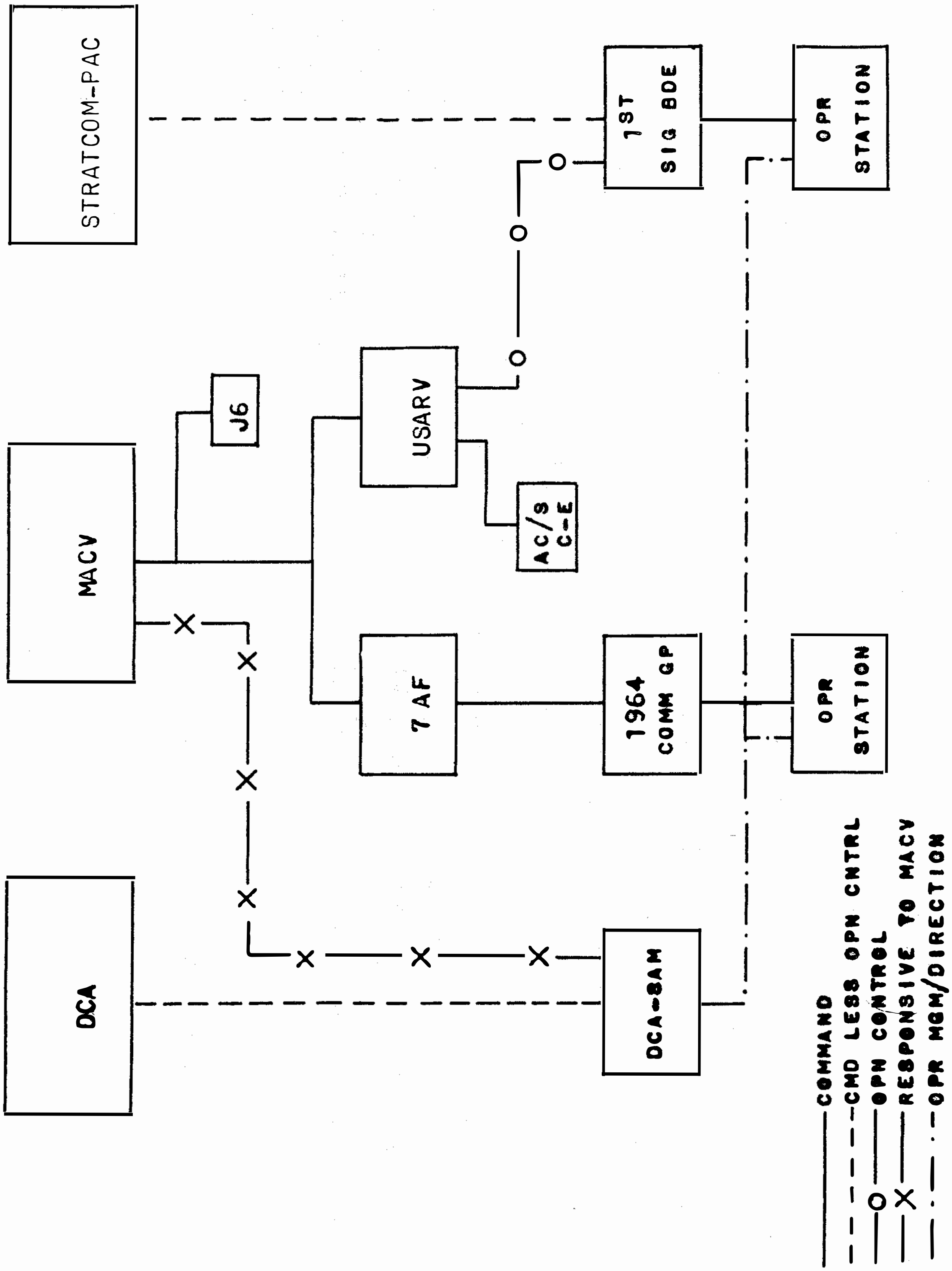
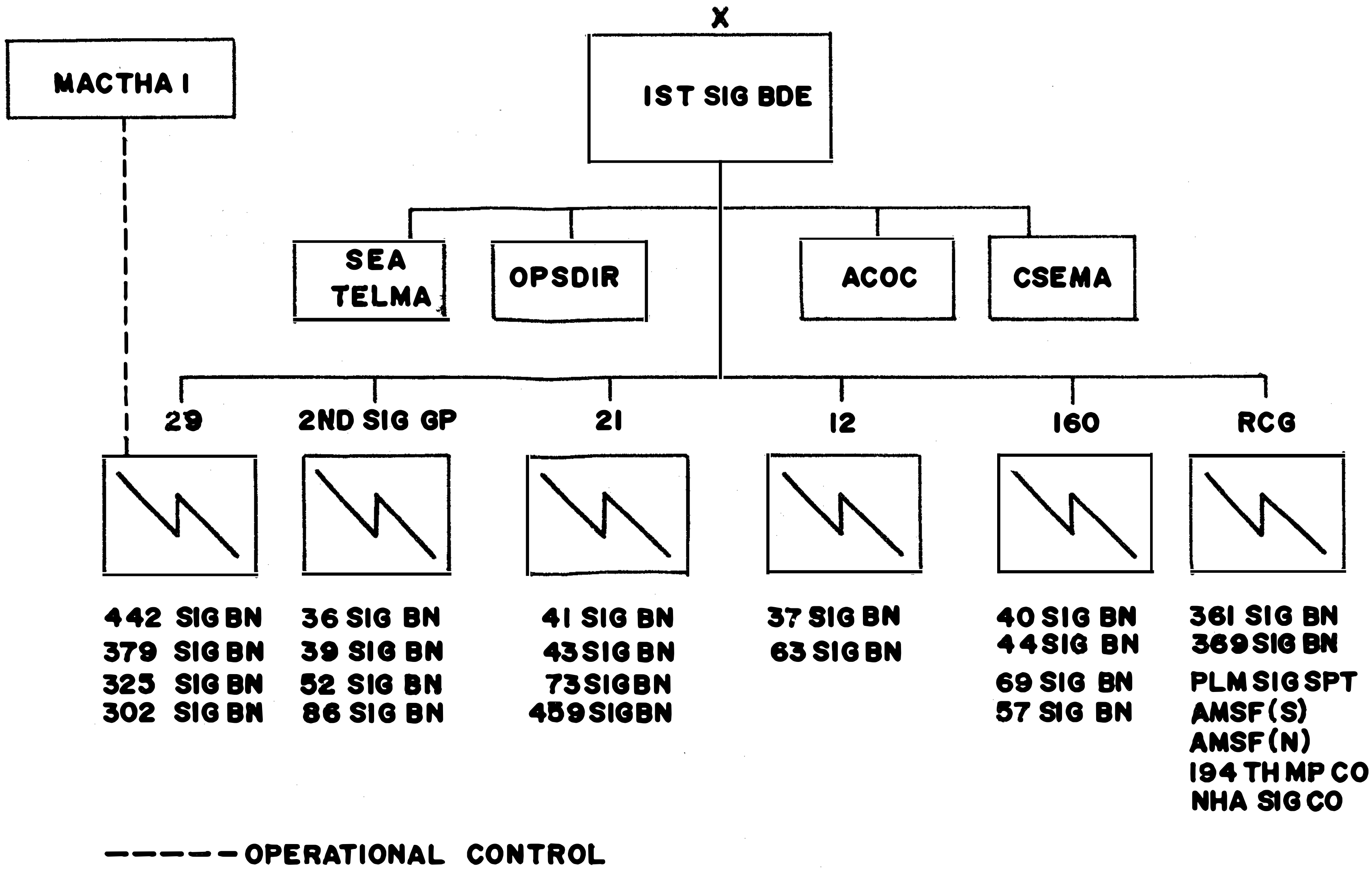


FIGURE II-1 MAJOR HEADQUARTERS


X
IST SIG BDE
MACTHA I
SEA TELMA
OPSDIR
ACOC
CSEMA
29
2ND SIG GP
21
12
160
RCG
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379 SIG BN
325 SIG BN
302 SIG BN
36 SIG BN
39 SIG BN
52 SIG BN
86 SIG BN
41 SIG BN
43 SIG BN
73 SIG BN
459 SIG BN
37 SIG BN
63 SIG BN
40 SIG BN
44 SIG BN
69 SIG BN
57 SIG BN
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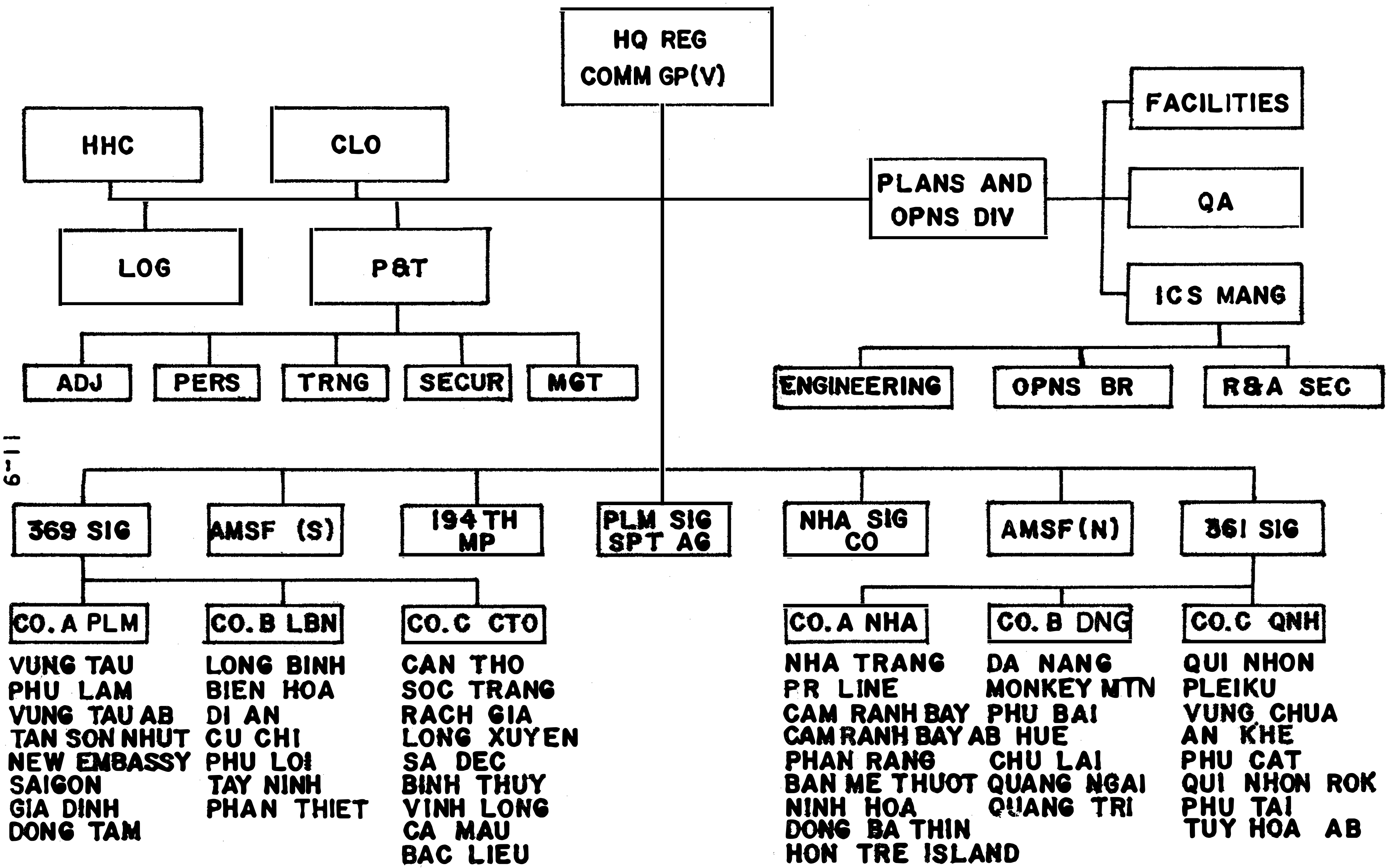
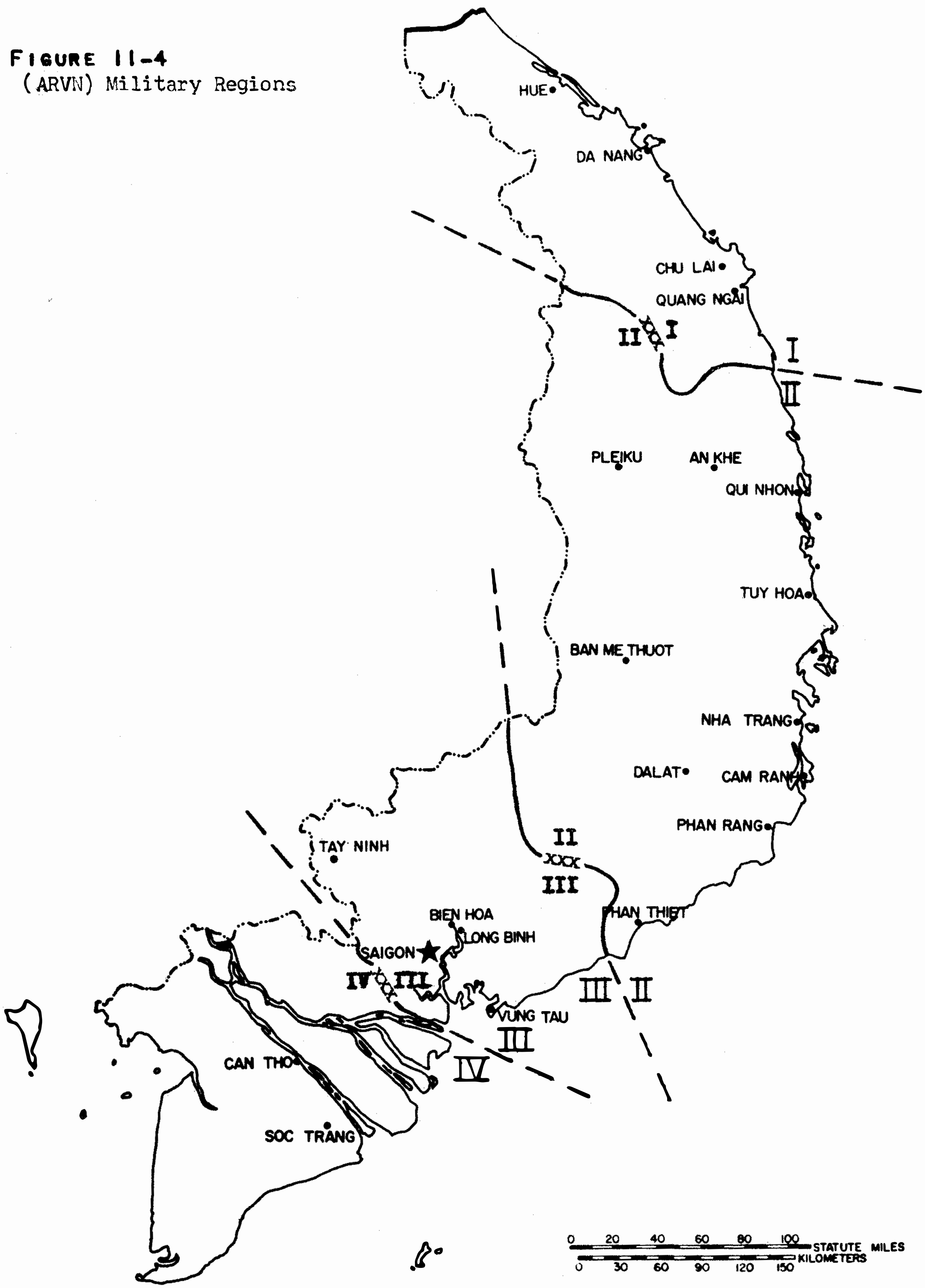
PLM SIG SPT
AMSF (S)
AMSF (N)
194 TH MP CO
NHA SIG CO
------ OPERATIONAL CONTROL

IST SIG BDE


HQ REG COMM GP(V)
HHC
CLO
LOG
P&T
ADJ
PERS
TRNG
SECUR
MGT
PLANS AND OPNS DIV
FACILITIES
QA
ICS MANG
ENGINEERING
OPNS BR
R&A SEC
369 SIG
AMSF (S)
194 TH MP
PLM SIG SPT AG
NHA SIG CO
AMSF (N)
361 SIG
CO. A PLM
VUNG TAU
PHU LAM
VUNG TAU AB
TAN SON NHUT
NEW EMBASSY
SAIGON
GIA DINH
DONG TAM
CO. B LBN
LONG BINH
BIEN HOA
DI AN
CU CHI
PHU LOI
TAY NINH
PHAN THIET
CO. C CTO
CAN THO
SOC TRANG
RACH GIA
LONG XUYEN
SA DEC
BINH THUY
VINH LONG
CA MAU
BAC LIEU
CO. A NHA
NHA TRANG
PR LINE
CAM RANH BAY
CAM RANH BAY AB
PHAN RANG
BAN ME THUOT
NINH HOA
DONG BA THIN
HON TRE ISLAND
CO. B DNG
DA NANG
MONKEY MTN
PHU BAI
HUE
CHU LAI
QUANG NGAI
QUANG TRI
CO. C QNH
QUI NHON
PLEIKU
VUNG CHUA
AN KHE
PHU CAT
QUI NHON ROK
PHU TAI
TUY HOA AB

REG COMM GP(V)

FIGURE II-4
(ARVN) Military Regions



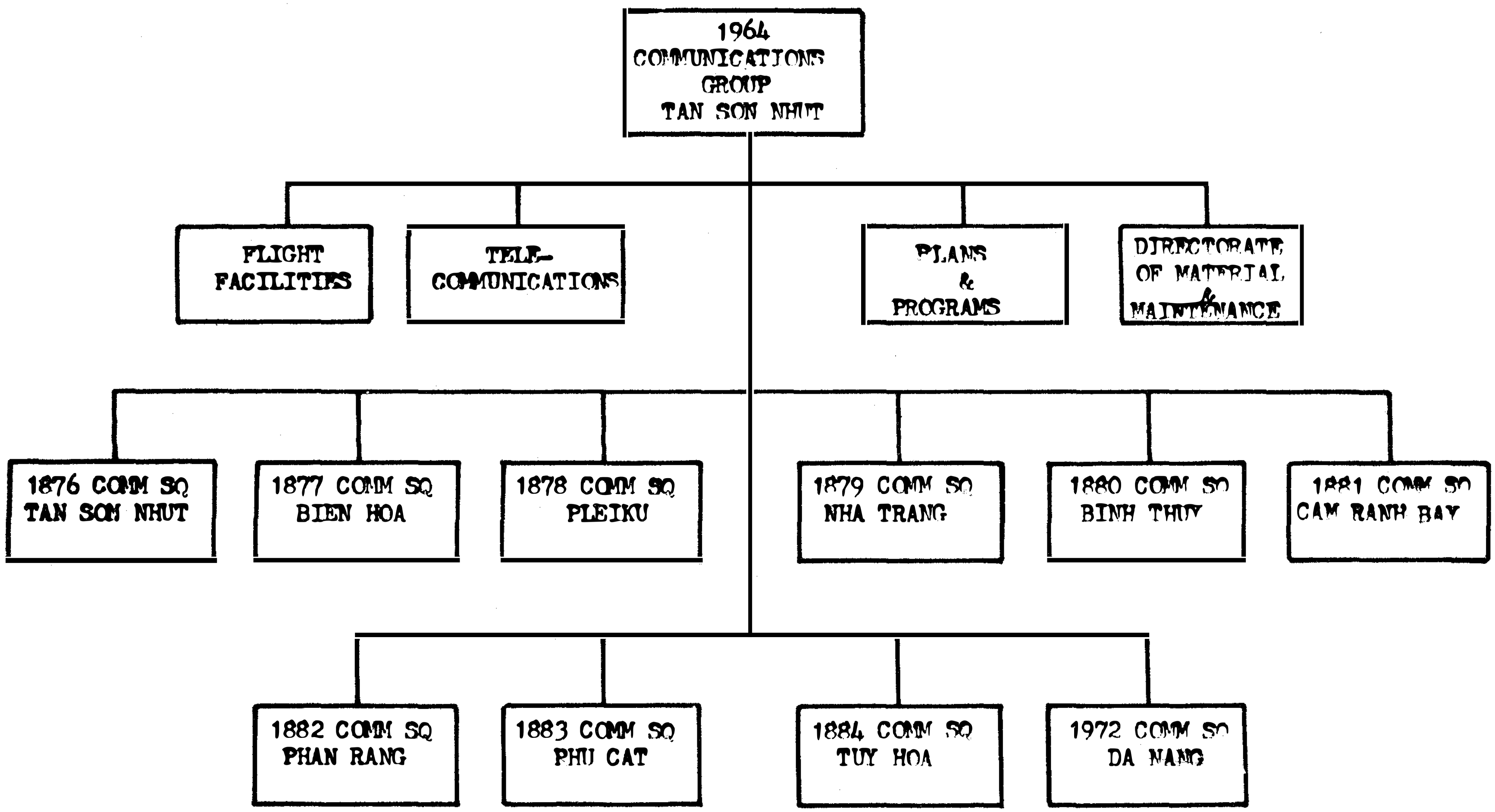


Figure II-5 1964th Communications Group

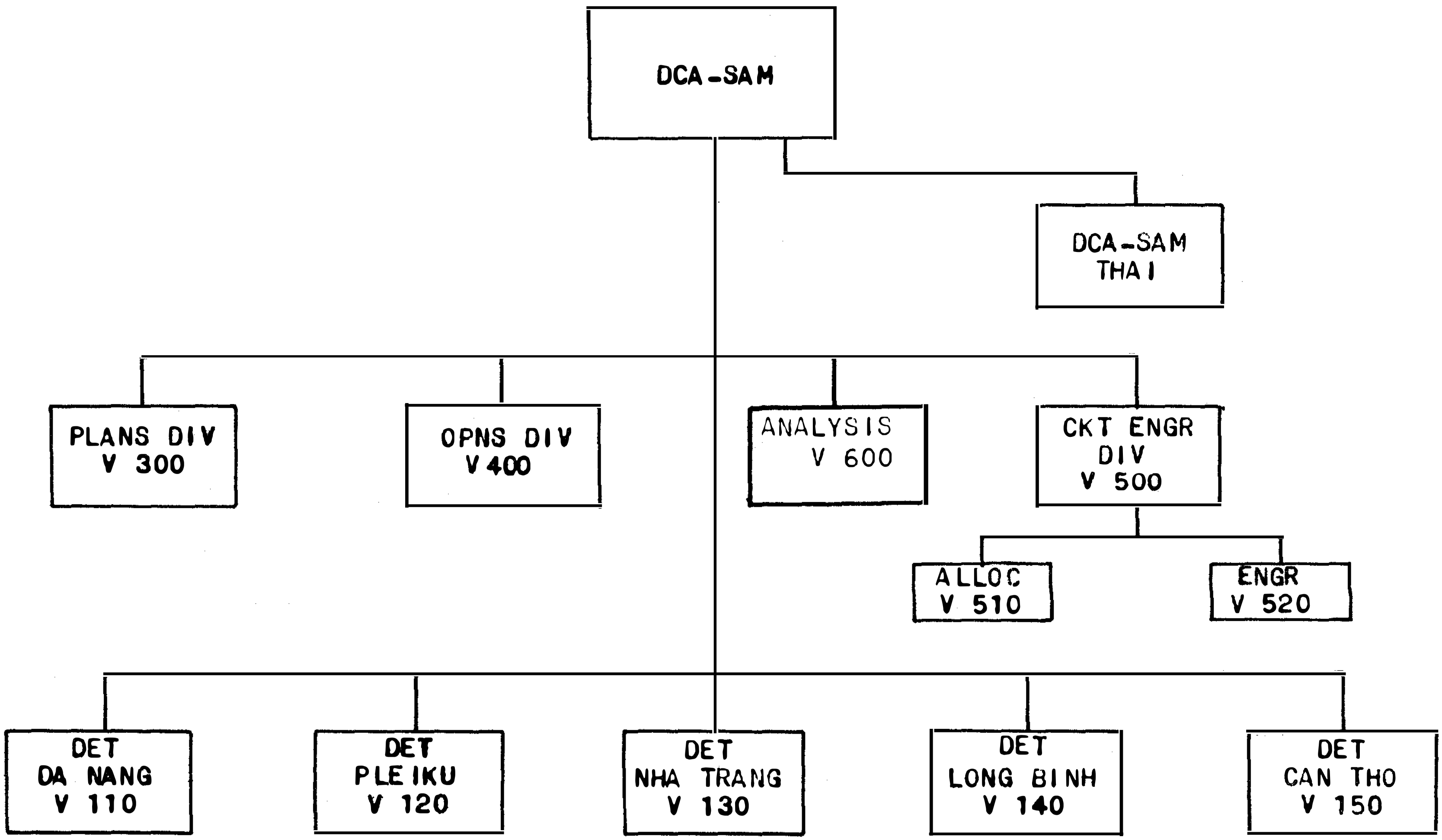


FIGURE II-6 DEFENSE COMMUNICATIONS AGENCY-SOUTHEAST ASIA MAINLAND, DCA-SAM

DEPARTMENT OF THE ARMY
HEADQUARTERS, 1ST SIGNAL BRIGADE (USASTRATCOM)
APO San Francisco 96384

Regulation
Number 10-10

10 December 1969

ORGANIZATION & FUNCTIONS
Communications Site Commanders and
Area Coordinators

1. PURPOSE: This regulation sets forth the concept and procedures for establishement of communication site commander and area coordinators and defines their authority and responsibilities.

2. SCOPE: This regulation is applicable to all communications elements assigned, attached to, or under the operational control of the 1st Signal Brigade (USASTRATCOM) within Vietnam.

3. DEFINITIONS: For the purpose of this regulation the following definitions apply:

a. Communications Area: A specific area, consisting of two or more communications sites, for which responsibility has been assigned a major subordinate organization reporting directly to Headquarters, 1st Signal Brigade.

b. Communications Sub Area: A portion of a communications area for which responsibility has been assigned to a subordinate commander reporting directly to a communications area commander.

c. Communications Site: A single communications installation or facility operated entirely or in part by one or more elements of the 1st Signal Brigade.

d. Communications Area Coordinator: A signal group commander or other subordinate commander so appointed on orders by HQ, 1st Signal Brigade.

e. Communications Sub Area Coordinator: A signal group commander or other commander of a signal organization so appointed on orders by a communications area coordinator.

f. Communications Site Commander: The Senior 1st Signal Brigade element commander, officer, or non-comissioned officer permanently assigned to a communications site and eligible to command under the porvisions of AR 600-20. Responsibility is assumed immediately upon arrival at the site.

* This regulation supersedes CCPVR 10-10 dated 30 December 1968

g. Coordination Authority: The authority to compel coordination, but not agreement.

h. Isolated Unit: A 1st Signal Brigade unit whose commander acts as the local tactical commander or is colocated with a 1st Signal Brigade unit whose commander is the local tactical commander. Each 1st Signal Brigade unit at an isolated site is considered an isolated unit.

i. Tenant Unit: 1st Signal Brigade unit on a facility commanded or controlled by someone not in the 1st Signal Brigade.

4. CONCEPT: a. Elements of the 1st Signal Brigade are stationed at approximately 200 sites throughout the Republic of Vietnam. At many of these sites, units or detachments from different signal groups and/or from different battalions or companies of the 1st Signal Brigade operate separate or integrated communications facilities. This regulation establishes communications area and sub coordinators and site commanders to improve coordination between 1st Signal Brigade elements. It also provides for coordination between 1st Signal Brigade units and other US and allied military elements in Vietnam.

b. To provide a single command focus within each area, signal group commanders are assigned certain additional responsibilities on special orders for all elements of the 1st Signal Brigade that operate in their areas. In turn, these signal group commanders assign the same additional responsibilities to subordinate commanders to insure that each element in each communications area has an individual specifically responsible for coordinating defense, support and other common matters. The communications site commander, as defined in paragraph 3f, is responsible for the physical security of his site. The site commander is responsible to the area defense zone commander for defense matters. The manning requirements necessary to implement the communications site physical security plan will be equitably divided amoung all site elements. Each element will contribute a proportionate share based upon its assigned strength.

5. DUTIES, RESPONSIBILITIES AND AUTHORITY: a. The Communications Area Coordinator (or a subordinate who exercises his delegated authority).

(1) Acts as the point of contact for coordination between 1st Signal Brigade units and local US Army Commanders.

(2) Coordinates signal planning and operations amoung 1st Signal Brigade elements and between them and other US and allied units.

(3) Assists the site commanders in the resolution of local problems which are beyond the capability of the site commander to resolve, to include physical security.

to resolve, to include physical security.

(4) Coordinates administrative and logistical matters amoung 1st Signal Brigade elements in his area and between them and other US and allied units. This responsibility includes engineer construction and real estate.

(5) Advises local US Army commanders on communications support matters in accordance with para 6b, USARV Regulation 105-9.

(6) Has authority as shown in the table below over 1st Signal elements stationed in his area:

UNIT STATUS	ISOLATED UNIT		TENANT UNIT	
FUNCTION	Under Cmd of Comm Area Cmdr	Not under Cmd of Comm Area Cmdr	Under Cmd of Comm Area Cmd	Not under Cmd of Comm Area Cmdr
DEFENSE	CMD AUTH	COORD AUTH	CMD AUTH LESS OPCON*	COORD AUTH
SIGNAL PLANNING &OPERATIONS	CMD AUTH	COORD AUTH	CMD AUTH	COORD AUTH
ADMINISTRATION & LOGISTICS (INCL ENGINEER CONSTRUCTION)	CMD AUTH	COORD AUTH	CMD AUTH	COORD AUTH

* Local Tactical Commander has OPCON for defense

b. The Communications Site Commander.

(1) Prepares, publishes and has responsibility for the implementation of the site physical security plan as required by USARV Regulation 190-30. In addition, he is responsible for the coordination of site defense with adjacent US and allied units.

(2) Acts as the initial point of contact in coordination planning for new projects within his area of site responsibility, which affect communications or site physical security.

(3) Assumes operational control of all elements within the communications site in the event of emergency. Imminent or actual attack and emergency evacuation will be considered sufficient justification for the assumption of this responsibility. Operational control will be returned to individual elements immediately upon termination of the emergency condition. In the event of such action the Commanding General, 1st Signal Brigade will be notified through chain of command by the most rapid means available.

6. ADMINISTRATION: a. Headquarters, 1st Signal Brigade will publish special orders to identify communications areas and communications area coordinators.

b. Signal group commanders who are designated as communications area coordinators will publish special orders to identify communications sub area coordinators.

7. REFERENCES: a. USARV Regulation 10-4

b. USARV Regulation 105-9

c. USARV Regulation 190-30

d. 1st Signal Brigade Regulation 105-13.

SCCPV-OP

FOR THE COMMANDER:

OFFICIAL:

J. N. MEDINGER
Colonel, GS
Chief of Staff

T. E. MULLENIEX
LTC, AGC
Adjutant General

DISTRIBUTION
A Plus
1 each Communications Site

III. CIRCUIT REQUEST PROCEDURES
(See also USARV SSI Item Nr. 82-2)

A. COMMUNICATIONS SYSTEMS:

1. The communications system in Vietnam is divided into three separate and distinct sub-systems. This division is characterized by the equipment used and by the organizational mission.

2. The first of these sub-systems is composed of the units and equipment organic to the combat elements in country. The equipment concerned is generally the 12 channel AN/TRC 24 type equipment or newer pulse code modulation equipment, housed in vans or shelters. This equipment is highly mobile, which is a basic requirement to fulfill the units mission of signal support of its parent unit.

3. The second sub-system is the Corps Area Communications System (CACS) which is operated and maintained by the numbered signal groups under 1st Signal Brigade. This system is generally composed of AN/TRC 90 series type radios and AN/MSQ 73 transportable Tech. Controls. The mission of the system is as the name implies, to supply semi-permanent corps area communications.

4. The last sub-system is the Integrated Communications System (ICS) which is operated and maintained by the Regional Communications Group under 1st Signal Brigade. This system is composed entirely of the fixed station equipment using commercial radios and standard commercial Tech. Controls. The mission of this system is to provide commercial quality extremely wideband, long haul communications throughout Vietnam.

5. There are two areas of responsibility in every communications system. One is management, and the other is operation and maintenance. The management, operation and maintenance of the systems organic to combat units is the responsibility of the division signal officer. However, all of the ICS and a portion of the CACS have been designated as Defense Communications System (DCS) assets and the management responsibility lies with the Defense Communications Agency-Southeast Asia Mainland (DCA-SAM). The remainder of the CACS is managed by 1st Signal Brigade.

B. REQUEST PROCEDURES:

Requests for circuits will be sent through normal command channels and will be in the format shown in paragraph C. below. Requests will be met with organic capability whenever possible (e.g., a requirement of a divisional unit will be satisfied by the Division Signal Battalion, if it has the capability). If the unit cannot provide the communications with it's organic capability, the request for the circuit will be sent to the appropriate 1st Signal Brigade unit.

Although there are some variations possible, (emergencies, etc.), the normal flow for circuit request is from the "user" or "requester" to the Signal Battalion providing Area Communications Support. If the area battalion has the capability to fill the request, it is forwarded to the Group that is in support of the area. If the group does not have the capability to fill the request, it is forwarded to 1st Signal Brigade. If 1st Signal Brigade cannot fill the request by routing the circuit on the AACS, the request is forwarded to MACV, through USARV, for a validation on the SEAWBS. All denials for service must be forwarded to the USARV commander for final action.

C. TELECOMMUNICATIONS SERVICE REQUEST FORMAT:

The following format is used for a circuit request:

a. Address of signal unit

b. Type and grade of service

(1) Voice, teletype, data, facsimile

(2) Full-duplex (FD), Half-duplex (HD)

(3) Baude rate

(4) Special requirements

(a) Signalling or supervision

(b) Type and level of teletype (e.g. 20 ma polar)

c. Purpose of circuit

d. Dates required

e. Installation priority

f. Contact personnel-name and telephone Nr.

g. Terminal locations

h. Type equipment

i. Recommended restoration priority

D. PROCESSING OF DCS CIRCUIT REQUESTS:

1. The Defense Communications System in Vietnam is managed by DCA-SAM. The utilization of the system is controlled by COMUSMACV in that circuit requests are validated by MACV J6 prior to engineering and activation.

2. When it has been ascertained that a Telecommunications Service Request (TSR) cannot be fulfilled by either the requesting units organic signal element, or the portion of the CACS managed by the 1st Signal Brigade, the TSR will be forwarded to MACV J-6 throughout USARV where the requirement for the circuit will be weighted against other signal requirements. If the MACV J-6 decides to validate the circuit, a validation number will be assigned and the TSR sent to DCA-SAM for allocation of facilities.

3. DCA-SAM is responsible for the allocation of DCS assets. When a validated TSR is received from MACV J-6, DCA-SAM will determine routing of the circuit, and will make all necessary engineering determinations. A Telecommunications Service Order (TSO) will then be issued to all concerned units. The TSO will contain all necessary information to activate the circuit, and will serve as the official justification to activate the circuit.

IV. EQUIPMENT - GENERAL

In this chapter we will briefly discuss the modes of radio propagation used in the ICS the antennas used to support the radio systems, the basic modulation schemes, and the multiplex terminals, both voice frequency and telegraph. More detailed information on the specific items of equipment is provided on these topics in Chapter VII.

During the discussion, it will be assumed that the reader has a background in communications, but that his strength falls in the areas of transportable and tactical systems. The level of instruction presented on the ICS will be equal to that of the Basic Signal Officers Course.

A. RADIO*:

Two types of radio systems are found in the ICS the tropospheric scatter system and the line-of-sight (LOS) system. Most of the long haul links of the ICS employ the tropospheric scatter system. The low power LOS systems are used for inter city links in the Saigon area and on many of the short links (tails) of the ICS where LOS propagation is possible.

A general comparison of the various ground-to-ground modes of communication in the microwave portion of the radio spectrum is given in Figure IV-A-1.

1. Tropospheric Scatter:

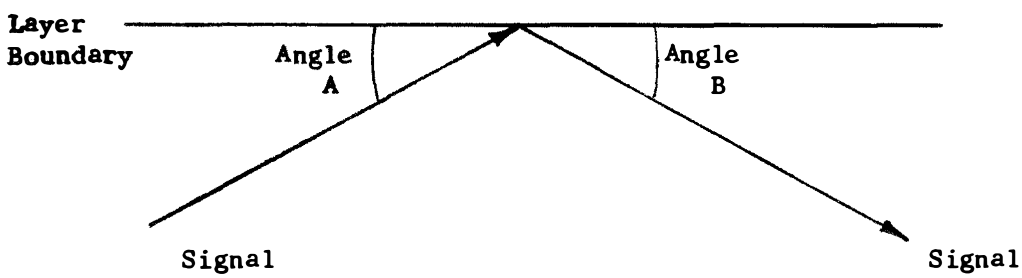
Historically, reliable multi-channel communications across rough or impassable terrain had been extremely impractical. Difficulties in site location, and transportation problems generally prohibited the use of wire lines or cables. While microwave LOS appeared to offer a partial solution, the requirement for fairly close spaced stations, ruled out LOS in numerous applications. Therefore, the need for reliable communications systems capable of operation over distances beyond the horizon remained unfilled.

To solve this problem, engineers looked back at propagation investigations undertaken by Bullington of Bell Telephone Labs, and others, shortly after World War II. The various investigations had been undertaken in an effort to explain conditions of abnormally long range transmission of UHF radio and radar signals. During these investigations it was determined, that, contrary to earlier theories, such signals were being propagated far beyond the line-of-sight, and that it was possible to receive them at distances of hundreds of miles. It was also established that the

* Portions from the REL Training Course. Reproduced with the permission of Radio Engineering Laboratories, Long Island City, New York.

loss of signal strength (path loss) was far less than would be predicted by the accepted theories of propagation at that time. It was therefore determined, that the earlier theories of UHF propagation, while capable of very accurate path loss calculations up to approximately 60 miles, produced serious errors in path calculations for 100 miles or more.

Several theories have been proposed to explain the inaccurate loss calculations. One of the most popular theories (by Friis, Crawford, and Hogg of Bell Telephone Labs, and others) assumes that the over-all atmosphere is made up of various individual layers. It further assumes, that the layers are of varying thickness, temperature, and moisture content. Therefore, each layer differs somewhat from the adjacent layer, and is in effect, an "invisible cloud". The differences in the layer temperature and moisture contents results in each layer having a different index of refraction (amount of bending of the signal as it passes through the layer). Furthermore, the different indices of refraction cause the establishment of firm boundaries between each layer. These boundaries become reflecting surfaces, and the signals reaching these surfaces are reflected from the surface at an angle equal to the angle at which they hit the surface. This is illustrated as follows:



* Angle A = Angle B

The reflection and refraction is thought to occur in the troposphere (part of the atmosphere from the earth surface up to the stratosphere) in an area defined as the "common volume". The signal reaches the common volume in accordance with the normal laws of UHF propagation, and after refracting and reflecting (scattering) in the common volume, a very small portion of the signal returns to the distant receiver, again in accordance with normal UHF propagation. On a typical path, a loss of over 200 db (from transmitter to receiver) can be considered normal. The height of the common volume varies according to the path length, and will be somewhere from over 1000 feet up to approximately 50,000 feet (within the troposphere).

From the above discussion, the derivation of the nomenclature "tropospheric scatter" for this type of propagation can be seen. In addition, the terms "beyond the horizon propagation", "forward scatter", and "forward propagation tropospheric scatter (FPTS)" have been used. In general, "tropospheric scatter" has become the accepted normenclature, and in common usage, has been shortened to "tropo".

In general, the above concepts hold true in the RF range of above 100 mHz to approximately 5000 mHz, and for path lengths of 100 miles to approximately 500 miles. While the above theories of tropo are not capable of rigorous mathematical proof, reliable system designs are possible as a result of numerous path loss measurements, and extensive emperical data obtained from numerous measurements on various paths.

While signals transmitted by tropo are relatively stable, they do exhibit some fading. The fades are generally divided into:

a. Seasonal variations (summer to winter)

b. Daily variations (day to night)

c. Rapid variations (scintillation)

Seasonal and daily fading are brought about by changes in the various layers temperature and moisture contents. There can be an approximately 10 to 15 db difference between a summer day and a winter night, with the best transmission fading occuring during the summer day. Rapid, or scintillation, fading is fast fades, with a fade rate as high as 20 fades per second. Fast fades are brought about by the basic nature of tropo. As a signal travels from a transmitter to a receiver, portions of the signal are reflected and refracted differently as they pass through the various layers. Some portions of the signal arrive at the receiver simultaneously and in phase, and therefore tend to add to each other. However, some portions of the signal travel longer or shorter distances, and arrive at the receiver out-of-phase and tend to cancel each other. Since the tropospheric layers are continuously in some motion, fast fades are generally always present.

This has been a brief discussion of the history, development, and terminology of tropospheric scatter propagation. Amplifying remarks on this subject may also be found in Figure IV-A-2 (REL Fact Sheet No. 1) and Figure IV-A-3 (REL Fact Sheet No. 20).

2. Diversity:

As mentioned in the previous paragraph, one of the major problems of reliable, stable communications is fading. There are a number of ways that this could be overcome. One is to substantially increase the transmitter power output. This could produce a receiver signal-to-noise ratio so high that the effect of fading would not be noticeable. However, this is not always practical, due to the high path loss (usually over 200 db) encountered in tropo propagation, and to the amount of power which would be required to maintain even a modest fade margin (doubling the transmitter power only produces a 3 db increase). Another way of overcoming fading would be to increase antenna size. This is not always a practical solution, since doubling the antenna size only increases the antenna gain by approximately 6 db, therefore, it is possible that the mechanical complexity, and the cost increase, would outweigh the higher gain. Increasing the sensitivity of the associated receiver will also help to overcome fades, but the practical state-of-the-art is such that the present receivers cannot be readily improved upon as far as noise figure and sensitivity are concerned.

A solution to improving operation during fades, while staying within the realm of technical complexity and cost, is to go to diversity operation. Basically diversity operation can be divided into three methods: space diversity, frequency diversity, and polarization diversity.

Space diversity utilizes two antennas placed somewhat greater than 100 wavelengths apart. A signal transmitted to these two antennas, generally will not fade simultaneously at both antennas. Therefore, if a receiver is connected to each antenna, there stands a good chance that there will always be at least one receiver with a good signal-to-noise ratio. Frequency diversity operates under the concept that if two signals are transmitted on frequencies approximately 5% apart, both signals generally will not fade simultaneously at a given antenna. Thus, if receivers set to the two frequencies are connected to the antenna, there usually will be a receiver with a good signal-to-noise ratio. The third method of diversity operation, polarization, is the transmission of two signals of different polarities, one in the vertical plane and one in the horizontal plane. Generally, both signals will not fade at a given antenna, thus as above, there will usually always be a receiver with a good signal-to-noise ratio.

Generally in a tropo system, all three of the above diversity techniques, or a combination thereof, are used. In addition, a combiner configuration is used to select the receiver with the best signal-to-noise ratio (Figure IV-A-4). In this way, a receiver with a poor signal-to-noise ratio, which would tend to degrade the over-all system signal-to-noise ratio, is effectively disconnected. In operation, the REL combiner when operating with 2 receivers (dual diversity) can provide an improvement of up to 3 db in system signal-to-noise ratio. That is, the over-all system signal-to-noise ratio will be 3 db better than that of the best receiver. When operating with 4 receivers in quadruple (quad) diversity, a 6 db improvement can be obtained. There are three types of combiners: variable gain, equal gain and optional switching. Each of these will be discussed below.

Variable gain combining is a process whereby the output from two (or more) diversity receivers are each amplified according to their signal-to-noise ratio (Figure IV-A-5a). In this manner the signal with the largest signal-to-noise ratio will be amplified most and, therefore, supply a larger percentage of the output. To accomplish this, a control unit monitors the noise and signal outputs from the receivers, and continuously provides a gain control signal to the variable amplifiers. The operation of a variable gain combiner circuit is illustrated in Figure IV-A-6. When the signal-to-noise ratio is equal in all receivers, the variable amplifiers will be at the same gain, and each receiver will contribute equally to the output. On the other hand, if the signal-to-noise ratio on one of the receivers should decrease, the gain of its amplifier will decrease, and the gain of the other amplifier(s) will increase, thereby maintaining the same signal level. This system is very effective in combating fast fading. If the pilot tone from one receiver disappears entirely, the gain of its amplifier will be reduced to zero with increase(s) on the other receiver(s). If the noise in any receiver reaches a set level, the noise monitor switch will open, disconnecting the noisy receiver entirely. If the noise in all receivers reaches this level at the same time all receivers will be disconnected and there will be no output.

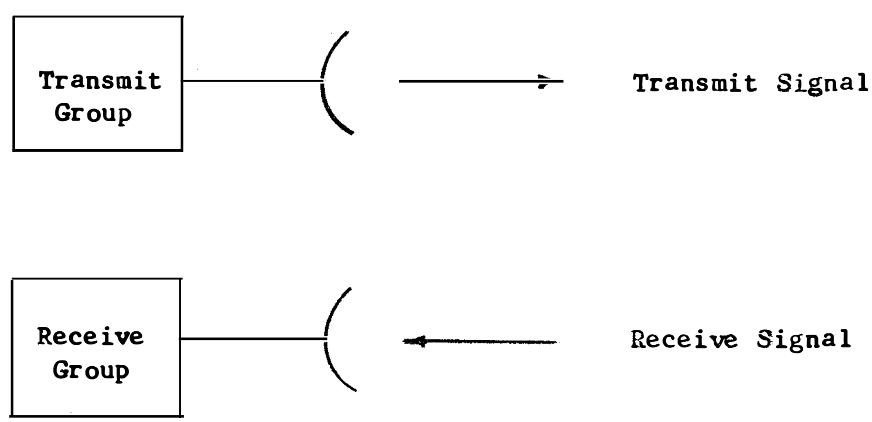
An equal gain combiner (Figure IV-A-5b) can never have a signal-to-noise ratio which is better than that of the variable gain combiner. This is because the noisier circuit is not de-emphasized in the equal gain combiner as it is with the variable gain method.

The third type of combining, optimal switching, is not actually combining, although it is usually considered as such. With optimal switching (Figure IV-A-5c), the best of several signals is used alone. The primary weakness of this system is that the process of switching often causes difficulty with data circuits. When the several inputs are at approximately the same level, there is often, continuous, unnecessary switching associated with using the better of two, almost identical signals. A combination of the optimal switching and equal gain techniques is often used (Figure IV-A-7). In this system, the two signals are combined, unless the signal-to-noise ratio in one receiver reaches a certain level, at which time the low signal input is disconnected.

A condensed discussion of diversity can be found in Figure IV-A-8 (REL Fact Sheet No. 2).

3. Tropo Site Configuration:

To provide two-way communications at a given site, two basic equipment groupings are required: the transmit group, and the receive group. This is illustrated as follows:



In respect to configuration, a typical tropo station follows the same layout. Reference to Figure IV-A-9 shows two paralleled transmit groups. Transmission by two groups is used so as to obtain the benefits of diversity operation. Since the two transmit groups are similar, except for the RF operating frequencies, the following discussion will trace through only one transmit group.

The incoming voice frequency (VF) traffic signals are connected to the multiplex wherein they are applied to the individual channels. Each channel is 4 kHz wide, and the channels are frequency stacked one above another (frequency division multiplex - FDM). Within a given channel, the VF signal is used to produce a single sideband signal occupying approximately 3 kHz of the over-all channel frequency spectrum. If data information, such as teletype, etc, is to be transmitted, it is generally pre-processed in a data modem, wherein it is coverted to a specific audio frequency. Approximately 16 data signals can be stacked into one VF channel. The output of the multiplex is applied to the terminal facility. Since there are two transmit groups, the multiplex correspondingly has a dual output with both outputs identical in content and frequency range.

The terminal facility serves many functions, but at this point, only the functions related to the transmit group will be covered. The outputs of the multiplex are connected to the modulation patching panel. Here they are either terminated or connected to the baseband input of the appropriate exciter. The connections are made by patch cords, or patch connectors. The exciter baseband input signal is used to frequency modulate the exciter RF operating frequency. The exciter output is a nominal 10 watts RF, fully frequency modulated, and at the desired RF operating frequency. Since there are two exciters in the configuration, and the subassemblies of each from the modulation input to a common 70 mHz signal point are similar, it is possible to use one modulator to drive the two exciters. This is called "dual modulator operation". In this way, additional reliability is obtained by redundancy, and it is possible to perform scheduled maintenance on the subassemblies not in use.

The exciter RF output is connected to the 1KW (10KW) power amplifier. Herein, it is amplified straight through to 1 KW or to 10 KW, and the output connected to the duplexer. The grouping of the exciter and 1KW(10KW) power amplifiers is referred to as the transmit group.

The duplexer (or diplexer) is used to permit simultaneous transmission and reception with one antenna (see Figures IV-A-10 and IV-A-11). The duplexer is configured such that the 1KW(10KW) RF output of the power amplifier is connected to the antenna and radiated out. At the same time, the antenna is receiving a signal transmitted to it from the next site. The duplexer separates this weak received signal from the 1KW(10KW) transmitted signal and applies it to the appropriate receiver. At the same time, it prevents the 1KW (10KW) transmitted signal from interefering with the associated receiver. This essentially completes the transmit group main equipments.

In addition to the transmission and reception outlined above, the antenna also receives a second signal transmitted from the next site. However, since this signal is in a different plane than the two signals outlined above, it is connected directly to the second receiver associated with the antenna. Due to the difference in polarization the transmitted 1KW (10KW) RF doesn't interfere with the receiver RF signal.

The input to the receive group is taken from the antenna in one of the manners outlined. In general, the receive group consists of an RF preselector, a parametric amplifier, or a tunnel diode amplifier, and the basic receiver. The over-all grouping is referred to as the receive group.

The RF preselector (Figure IV-A-12) is a bandpass filter set to the RF operating frequency of the associated receiver. It is used to attenuate all received and extraneous RF signals, other than the desired signal. Following the RF preselector is the parametric amplifier, or the tunnel diode amplifier. Either is a low-noise amplifier with approximately 20 db of gain. The parametric amplifier noise figure is approximately 2.5 db, and the tunnel diode approximately 4.5 db. The output of the amplifier is connected to the basic receiver. The basic receiver generally has a noise figure of approximately 8 db. It converts the received RF signal to the IF frequency of 70 mHz. Following the IF, the FM signal is demodulated, amplified, applied to the combiner, and then further amplified. In diversity operation, the receiver combiners are interconnected to provide an output with the optimum signal-to-noise ratio, and under certain conditions, provide a signal-to-noise ratio improvement of 6 db. Under any circumstances, the output from the receive group is always equal to, or better than, the output of any one receiver. The receive outputs are then applied to the terminal facility.

At the terminal facility, the receive outputs are connected to the modulation patching panel, wherein they can be terminated, or patched to the multiplex. At the multiplex, the received signal is demultiplexed and connected to the appropriate VF or data facilities.

In addition to the transmit and receive equipments, there are the common equipments. These generally consist of the terminal facility, the performance monitor, and the fault indicator. These common equipments are discussed in detail in Chapter VII. Another group of support equipment, the heat exchanger, dummy load and the dehydrator, will also be discussed in that chapter.

The foregoing discussion has been basically for a quad-diversity system, Figure IV-A-13 is a simplified diagram of a dual-diversity configuration.

4. LOS Site Configuration:

LOS site configuration is not radically different from tropo. The VF multiplex equipment can be (in ICS it is) the same type for LOS or tropo. Antennas are different and the radio equipment between VF mux and antenna is usually different. ICS has four LOS shots that use tropo radio equipment TSN-VTU, LBN-VTU, PRG-PRL and HUE-PHB. Of course they all use much less power than a tropo shot.

Figure IV-A-14 is a highly simplified block diagram of an LOS radio terminal. As in a tropo terminal, there is a transmit group and a receive group.

The functions of the major components are:

Input Unit - Filters out unwanted input and amplifies the desired signal.

Exciter - The basic FM transmitter with about 10 watts output.

Demodulator - Restores signal to original form.

Output Unit - Filters and amplifies desired output signal.

Figure IV-A-15 depicts a frequency diversity LOS system.

5. Antennas:

Tropo and LOS systems use basically the same types of antennas, but the tropo antennas are much larger. A tropo antenna receives a very low level signal from the distant site compared to an LOS system. Therefore because antenna gain depends on size (among other things), a tropo antenna is usually considerably larger than a LOS antenna. REL Fact Sheet No. 14 presents a good explanation of tropo antennas (Figure IV-A-16). The type of antenna system used for a particular tropospheric scatter installation depends on the frequency, gain requirements, environmental conditions, and mobility requirements. The types range from 120-foot antennas for fixed installations to air-inflatable types for mobile terminals.

Figure IV-A-17 is a photograph of a high-gain antenna system used for tropospheric scatter systems operating in the frequency range of 700-1000 mHz. The reflector is a four-sided steel structure which is shaped into a parabolic reflector at its face by steel plates. The structure is 60 feet wide and has an over-all height of 65 feet. At 1000 mHz, this 60-foot reflector will provide a gain of approximately 42 db. The feed system, consisting of wave guide, wave guide horn and supporting tower, is located approximately 30 feet directly in front of the reflector. The wave guide feedhorn is mounted at the top of the tower and is located at the focal point of the reflector.

Figure IV-A-18 shows a different type of feed system. In this case, the feed system extends through a hole in the center of the reflector instead of being supported in front of the reflector. The energy is directed out to the feed system and then reflected back to the reflector. The parabolic reflector is 30 feet in diameter. The focal length is 9 feet. Gain provided by this system at 1000 mHz is approximately 36 db.

Figure IV-A-19 shows a 28-foot parabolic reflector and feed system. The wave guide feed system is supported in front of the reflector. The weight and wind resistance is reduced considerably by using a grating surface for the reflector instead of a solid reflector. The openings can be regarded as short wave guides designed to be far beyond cutoff for the frequency band over which the antenna is to be used.

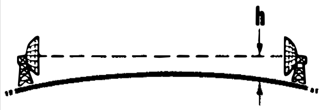
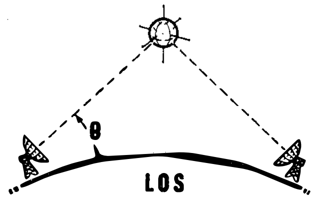
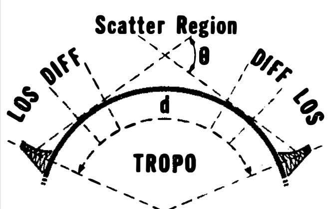
An antenna system designed for used with transportable scatter terminals is shown in Figure IV-A-20. The 15-foot parabolic reflector on this type of antenna consists of a circular envelope, formed of two fiberglas fabric sections. The inner surface of the rear fabric section is coated with aluminum to serve as the reflector. The reflector assumes the shape of a true parabolic form when the envelope is inflated. Focal length of the reflector is six feet. The inflation equipment consists of a motor-driven centrifugal blower, relief valve and check valve, and hose connections. The blower and accessories are mounted on the supporting tower.

Figure IV-A-1

Communication Modes

REL FACT SHEET NO. 38

PRINCIPAL GROUND-TO-GROUND COMMUNICATION MODES UTILIZING MICROWAVE (70 MHz to 20 GHz) REGION OF RADIO SPECTRUM; CHARACTERISTICALLY WIDE-BAND SERVICE (100 kHz to 20 MHz).

	Useful Range	Characteristics	Comments
 LINE OF SIGHT (LOS)	0 to 35 miles, depending on (h).	0.1 to 10 watts, two to 10-foot antennas	Low-cost, high-performance wide-band system; replaces costly right-of-way maintenance of coaxial or multiple cable or overhead wiring.
 LOS Space Communications	up to 1/2 circumference of earth depending on satellite orbit and (Θ)	1 to 15 kW, 30 to 85-foot antennas	Only practical system of global coverage using three active synchronous satellites (22,000 miles from earth) or a number of orbiting satellites (dependent on distance covered and altitude) in conjunction with multiple earth earth stations.
 DIFFRACTION (Plane Surface)	30 to 70 miles, depending on (h) and N_S)	0.1 to 100 watts, six to 28-foot antennas	Diffraction mode is very specialized form of UHF used only rarely where rugged terrain prevents use of direct LOS and permits longer path with obstacle gain.
 DIFFRACTION (Knife Edge)	30 to 120 miles, depending on (h), (N_S) and (G_O)	0.1 to 100 watts, six to 28-foot antennas	Great attention is being given to refining propagational computation in the diffraction region because of need for utilization in tropo path predictions.
 DIFFRACTION (Rough Surface)	30 to 120 miles, depending on (h), (N_S), (G_O), and (A_O)	0.1 to 100 watts, six to 28-foot antennas	
	70 to 600 miles, depending on many factors	1 to 100 kW, 10 to 120-foot antennas, refined modulation and receiver techniques	Only practical wide-band, reliable ground-based method of achieving 70 to 600 mile hop where unsuitable intervening territory prevents use of LOS or diffraction modes.

(h) = height of antenna center
(N_S) = refractive index
(G_O) = obstacle gain
(A_O) = obstacle absorption
(d) = distance between stations
(Θ) = scatter angle or angle of elevation

Figure IV-A-2

WHAT IS TROPO ?

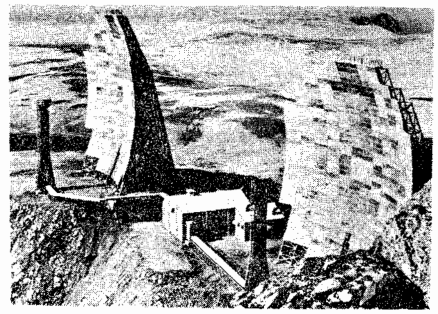
REL FACT SHEET NO. 1

WHAT IS FM TROPOSPHERIC SCATTER RADIO WAVE PROPAGATION?

Forward Propagation Tropospheric Scatter is a method of ultra-high frequency FM radio communication that permits reliable multi-channel telephone, teletype and data transmission without line-of-sight restrictions or the use of wire or cable systems.

In order to understand "tropo" it is necessary to know certain principles about the earth's atmosphere. The troposphere is the lowest area of the atmosphere extending from the ground to a height of slightly over six miles. It is in this tropospheric area that virtually all weather phenomena take place. Just as the atmosphere is made up of various layers such as the troposphere, stratosphere and ionosphere, the troposphere itself is made up of various layers. These constantly shifting but sharply defined layers differ in temperature and moisture content and, therefore, in refractive index. In addition, the boundaries between layers act as reflecting surfaces.

It is because of the phenomena of refraction and reflection within the troposphere (the most popular theory holds) that the scatter method is possible. Radio energy, like light and other forms of propagated energy, is subject to the laws of refraction and reflection. A radio frequency signal directed upward from a transmitting antenna through the stratified air of the troposphere undergoes a complex series of partial reflections and refractions. Most of the energy is scattered and diffused, but a minute portion is scattered downward over the horizon. This small fraction of radio energy (over a 200-mile span about one-hundredth-quintillionth of the transmitted power) reaching the receiving site has been made usable for communications by the development of

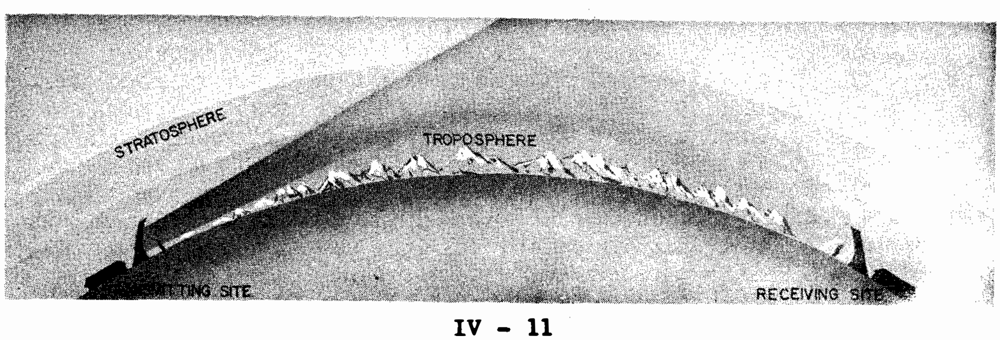


powerful transmitters and sensitive receivers.

Numerous communications networks extending for thousands of miles are now in operation utilizing "tropo" terminals with hops of 300 miles or more. These relay hops are accomplished by the use of both transmitting and receiving equipment and antennas at each terminal. At the initial transmitting point, many separate telephone conversations and telegraph messages are combined into a single radio signal. A "feed horn" on a tower beams it out toward the horizon like a huge, precisely aimed searchlight. The minute reflected portion of the signal is picked up by a parabolic receiving antenna well over the horizon. There it is re-amplified and sent on its way again, if necessary, for another leap over the horizon toward its destination at the other end of the circuit.

"Tropo" has many advantages over other methods of long distance communications. In addition to being more economical in areas where construction and maintenance present problems, it is relatively free from atmospheric interferences which affect other transmission methods.

In the struggle for the balance of power, REL's "tropo" scatter equipment, both stationary and mobile, provides the free world with a vital means of reliable communications.



History of Tropo

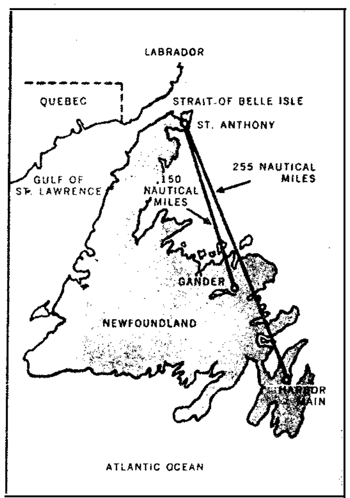
REL FACT SHEET NO. 20

Communication by means of tropospheric scatter propagation is a method of point to point communication by a common reflection volume in the lower atmosphere known as the troposphere. It is a relatively new method of communication and has only come into widespread application in the last decade. In fact, it is so new that the mechanism of propagation is still being argued by experts. Some years ago, it was believed that practical transmission of high frequency energy was possible only to the horizon because of the extreme reduction of received signal strength beyond the horizon. This theory was eventually questioned because of certain long - distance transmissions observed during wartime use of radar, postwar highpower FM and TV broadcasts and long-distance amateur communications.

The development of tropo as a practical means of communication is an interesting chapter in the history of communications:

GUGLIELMO MARCONI

The earliest recorded experimental work was carried out during the period 1928 to 1933 by Marconi. In a report written in 1933, he stated: "Further improvements in the apparatus are likely again to revolutionize radio communications." In the mid and late thirties, many amateur and professional radio engineers conducted experiments in the VHF and lower UHF bands. By the end of this period many theories were expounded to account for beyond the horizon propagation. The affects on received signals because of weather were noted, the phenomena of rapid fading were observed and various theories were put forward to account for this propagation.

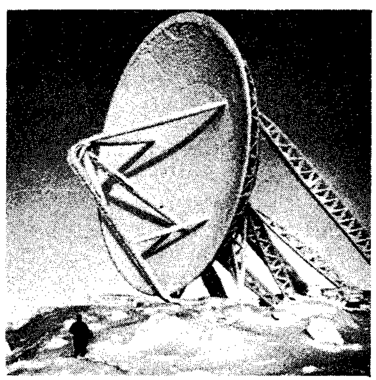


NORTHERN TESTS: Paths of the first far northern tropo propagation tests using REL gear in 1953, which proved the practicability of a planned tropo scatter system.

With World War II came a rapid advance in research in microwaves. The introduction of radar and UHF communication sets caused some unexplainable interference difficulties and the observation of radio reception at great ranges.

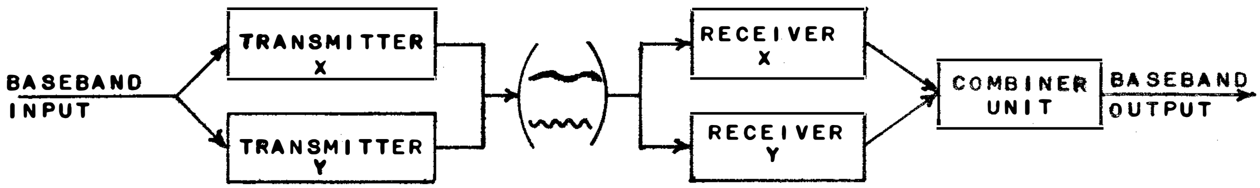
After the war more research took place. In the U.S., the licensing of VHF television stations had to be suspended when ranges exceeded predictions and interchannel interference took place. By 1950 sufficient research had been conducted so that the first methods of estimating performance for multichannel over the horizon communications were expounded. Based on the combination of the experimental evidence which had been gathered, the availability of high powered transmitters, sensitive receivers, large antennas, and diversity receiving techniques, practical tropo communications systems became possible.

The natural advantages of this form of communication for the military became obvious and on the basis of experiments and tests the first operational multichannel tropospheric scatter system was installed. This was in 1954 in Canada and became known as the Polevault system. Since that time equipment developments, better understanding of tropospheric scatter propagation and better prediction methods have brought about operational systems meeting the highest international standards. In addition, tropo can be installed anywhere in the world and provide great reliability in both commercial and military systems.

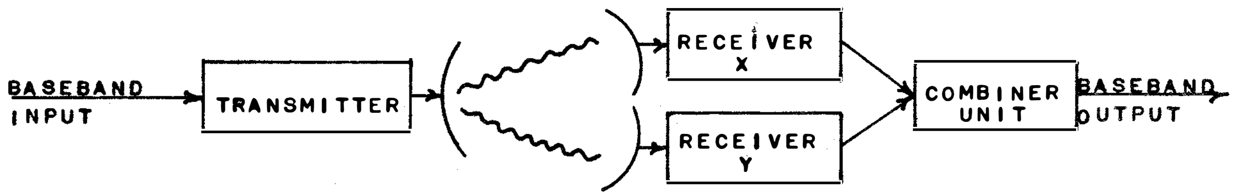


POLEVAULT: REL designed and produced the FM radio equipment for the first major tropo scatter system.

Marconi's predictions were proven correct by the practicality of tropospheric scatter communications systems. The development of the right equipment twenty years after his original work started a new branch of multichannel communications that has become a significant factor in the overall communications art.

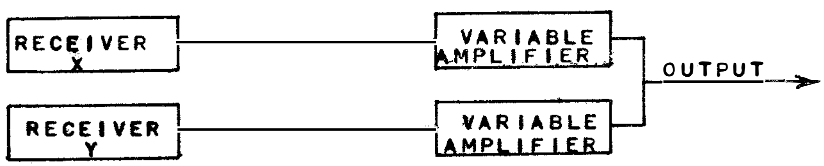


A) FREQUENCY DIVERSITY

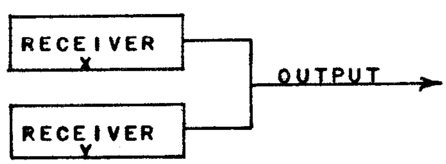


B) SPACE DIVERSITY

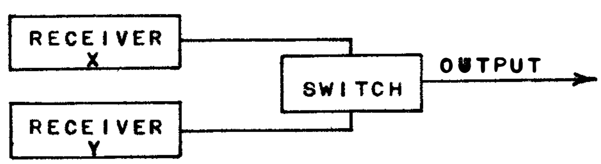
FIGURE IV-A- 4 USE OF COMBINERS



A) VARIABLE GAIN COMBINING



B) EQUAL GAIN COMBINING



C) OPTIMAL SWITCHING COMBINING

Figure IV-A-5 TYPES OF COMBINERS

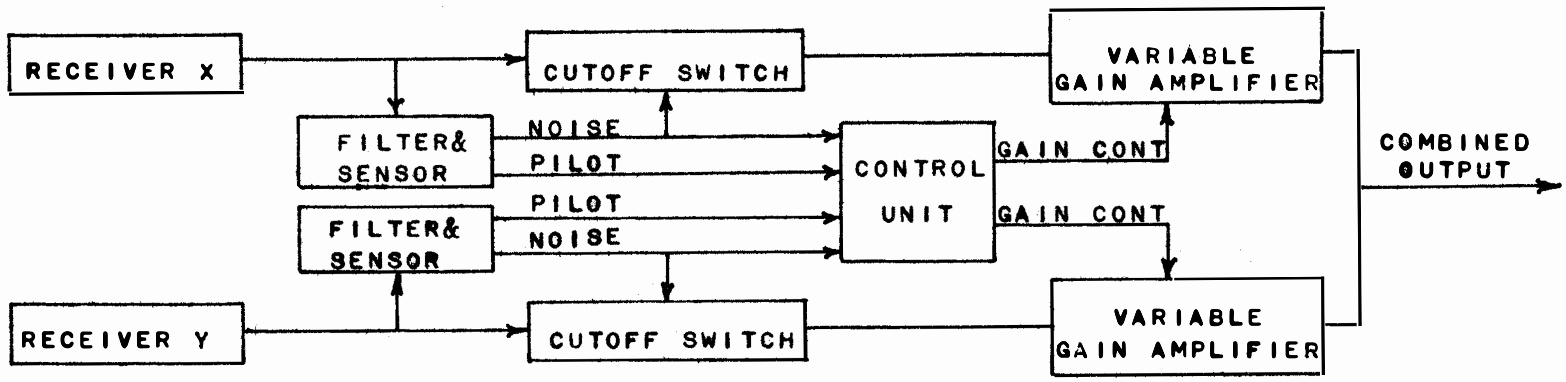


FIGURE IV-A-6 VARIABLE GAIN COMBINER

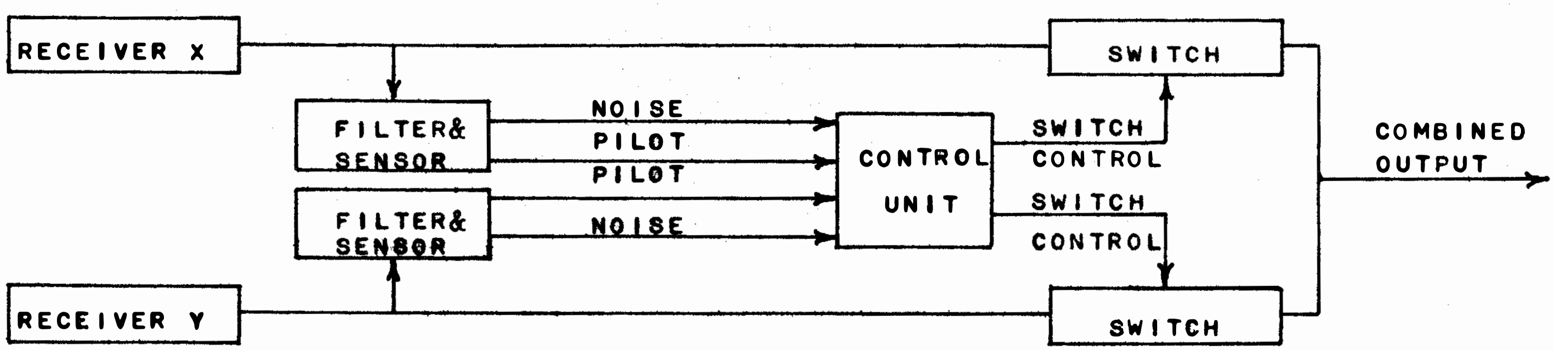


FIGURE IV-A-7 EQUAL GAIN/OPTIMAL SWITCHING COMBINER

Figure IV-A-8

DIVERSITY RECEPTION

REL FACT SHEET NO. 2

EXPLAINING DIVERSITY RECEPTION IN FM TROPOSPHERIC SCATTER SYSTEMS

The development of powerful transmitters, high-gain parabolic antennas and sensitive receivers has made possible reliable communications through FM tropospheric scatter radio wave propagation. By definition alone, most of radio signal beamed over-the-horizon through the troposphere is "scattered" and diffused. This diffusion of radio energy or scatter loss may be defined as the additional loss between transmitter and receiver when compared to the loss over free space that occurs in line-of-sight transmission.

Losses in scatter transmission depend primarily on the distance between terminal hops, scattering angle and frequency. In addition, however, scatter loss itself is statistical in character and is subject to several types of fading. Fading can perhaps be better explained as fluctuations or time variations in the received signal. These are:

FAST FADING — rapid fading (momentary variations as high as 20 fades per second) is the result of turbulent masses of air that cause reflections variating at random according to place and time.

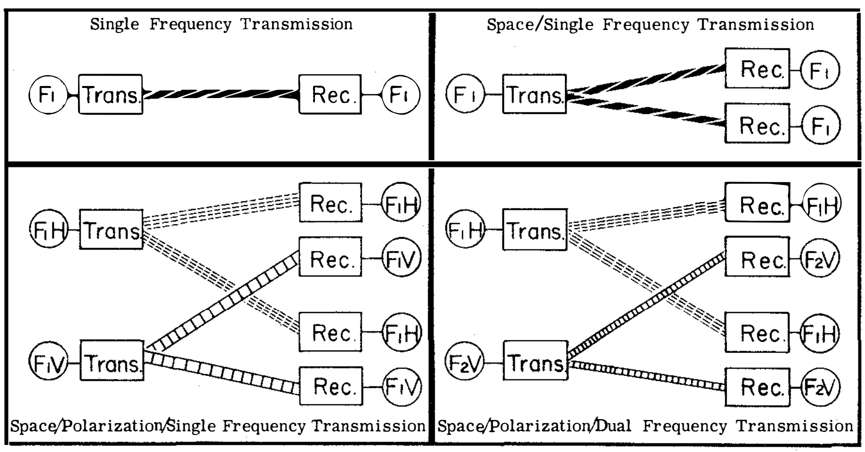
SLOW FADING — slow fading (daily, weekly or monthly variations) is the result of changes in refractive index of the atmosphere and is superimposed on the fast fading.

SEASONAL FADING — in general, scatter loss is minimized in daytime hours of summer. Poorest scatter propagation periods are at night in winter. Transmission is better over water than land, but is no better over frozen water than it is over land.

Fading phenomena can be somewhat overcome by a large increase in the power transmitted by producing a signal-to-noise ratio so large that fluctuations are not noticeable in the communications channel. This high power solution is not practical or economical, since modest amounts of power provide adequate and reliable service when combined with diversity reception and high-gain antennas.

In diversity reception a choice of signals is made from information received along different transmission systems. This may be accomplished by individual use of space diversity, frequency diversity or polarization diversity, or by a combination of any two or all three. Ultimately, each signal received makes a contribution to the final output signal by a combining method which offers a signal-to-noise ratio more favorable than that of the strongest signal alone.

REL tropo equipment designed and manufactured for the Ballistic Missile Early Warning System employs all three diversity methods by using two transmitters, four receivers, and two antennas at each terminal site.



Fl=First Frequency; F2=Second Frequency; H=Horizontal Polarization; V=Vertical Polarization

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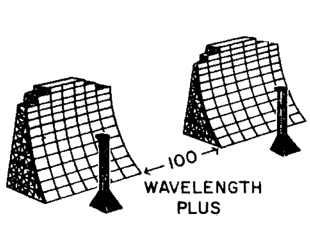
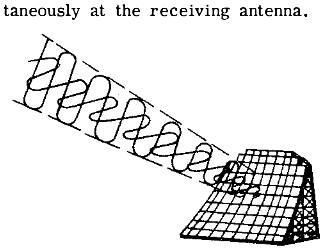
Space Diversity occurs when two antennas are placed at more than 100 wavelengths apart. A signal received generally will not fade simultaneously at both antennas.

Polarization Diversity occurs when two transmitters send signals of different polarity — one horizontally and one vertically. Signals of different polarity generally will not fade simultaneously at the receiving antenna.

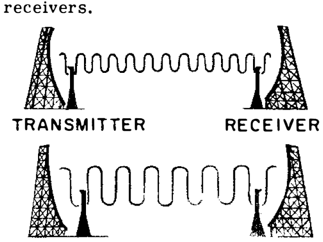
Frequency Diversity occurs when two transmitters send signals on slightly different frequencies. The received signal at a given location generally will not fade simultaneously in the two receivers.



SPACE DIVERSITY



POLARIZATION DIVERSITY



FREQUENCY DIVERSITY

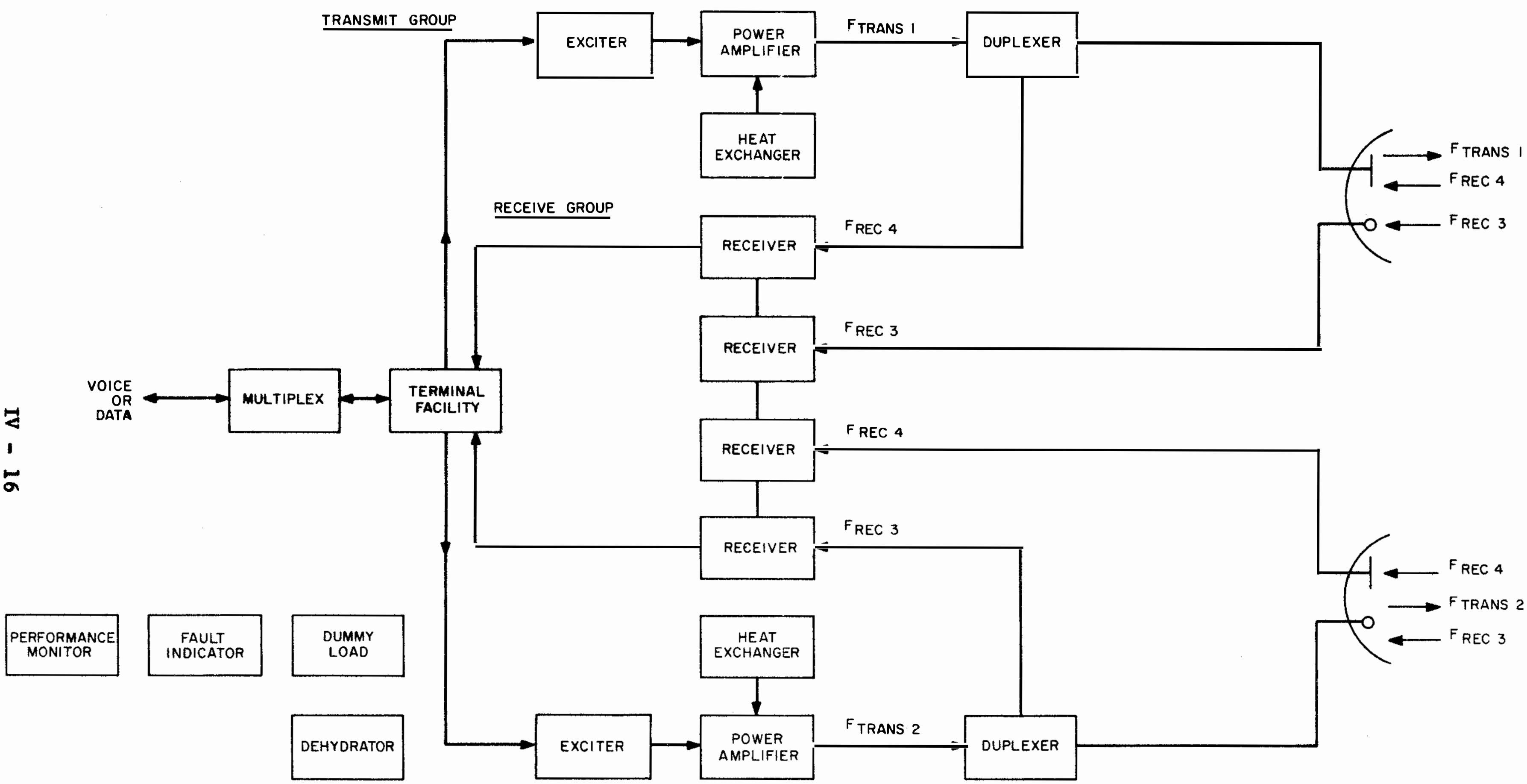


Figure IV-A-9 Typical Tropo Station Configuration (Quad-Diversity)

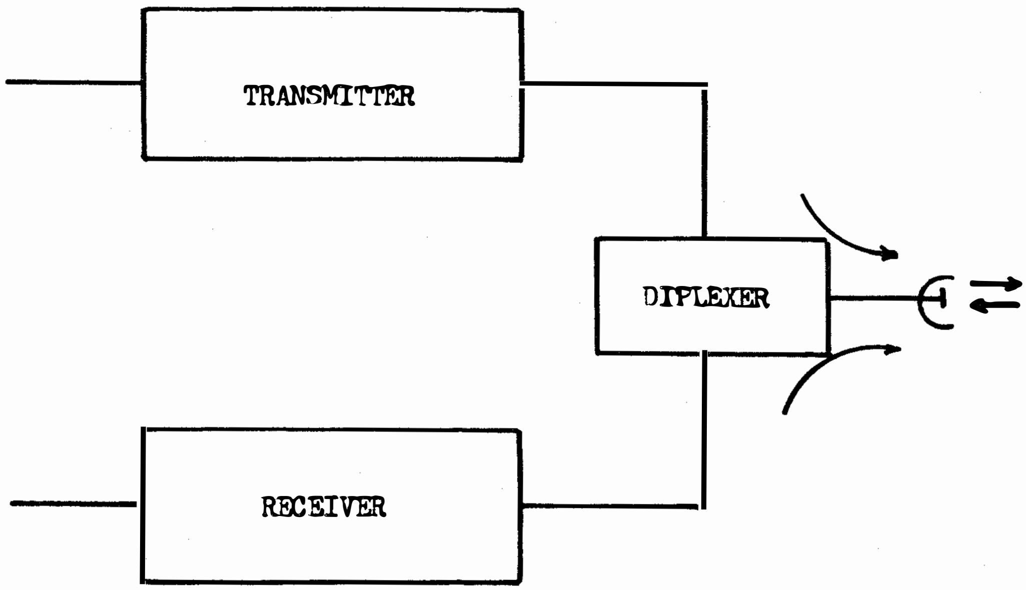


Figure IV-A-10 Use of Antenna Diplexer

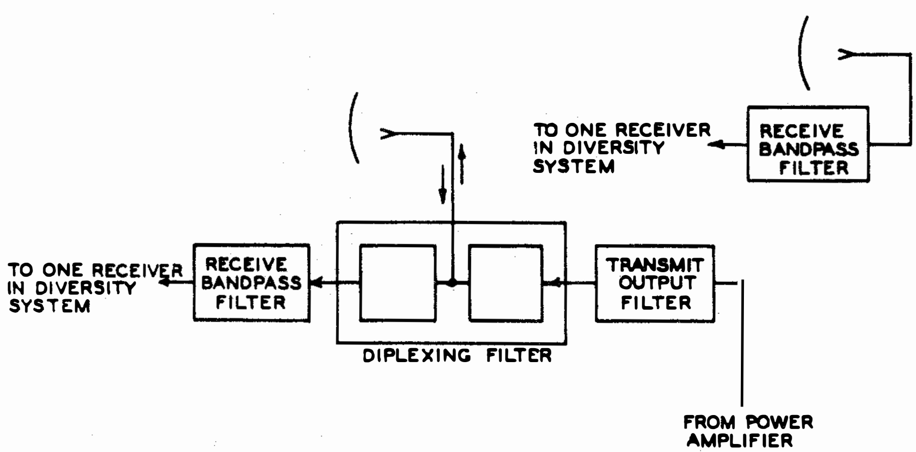


Figure IV-A-11 Typical Filter System for a Tropospheric Scatter Circuit

Figure IV-A-12

RF PRESELECTORS

EXPLAINING RADIO FREQUENCY PRESELECTORS

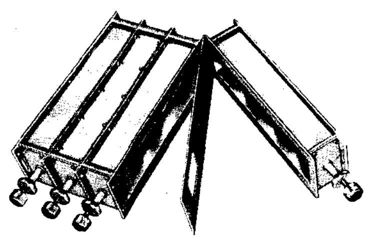
REL FACT SHEET NO. 5

RF preselectors are bandpass filters which improve selectivity in radio reception by rejecting unwanted frequencies at the Radio Frequency input stage.

In non-technical language and using a very simplified analogy, a preselector may be compared to a keyhole in a door between a darkened room and a brightly lit corridor. The keyhole permits only a limited amount of light to pass into the darkened room. In much the same manner the preselector is a selective device which rejects unwanted frequencies and allows only a desired signal to "pass through" at the RF input stage.

In normal radio reception, whether it be AM or FM, signal selection is accomplished at the lower frequencies by means of electrical components such as coils and condensers. At the higher frequencies such as in the microwave bands, however, mechanical devices in the form of coaxial or waveguide-type preselectors are needed to perform the same function.

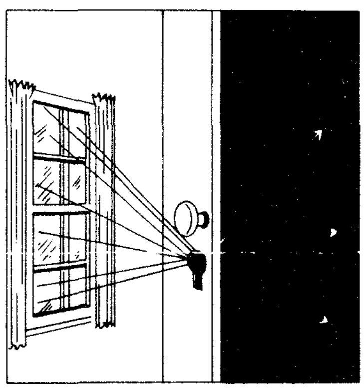
RF preselectors are actually mechanical devices which are capable of "selecting" desired frequencies by virtue of the resonance properties of their physical dimensions. In a coaxial preselector, for example, the tuning to resonance (the desired frequency or limited band of frequencies which is permitted to "pass through") is accomplished by varying the length of the inner conductor of each cavity section. Since these coaxial and waveguide-type preselectors



REL Modular-Type RF Preselectors

consist essentially of metal cavities, rods and plates, they are familiarly referred to as "plumbing" by radio engineers.

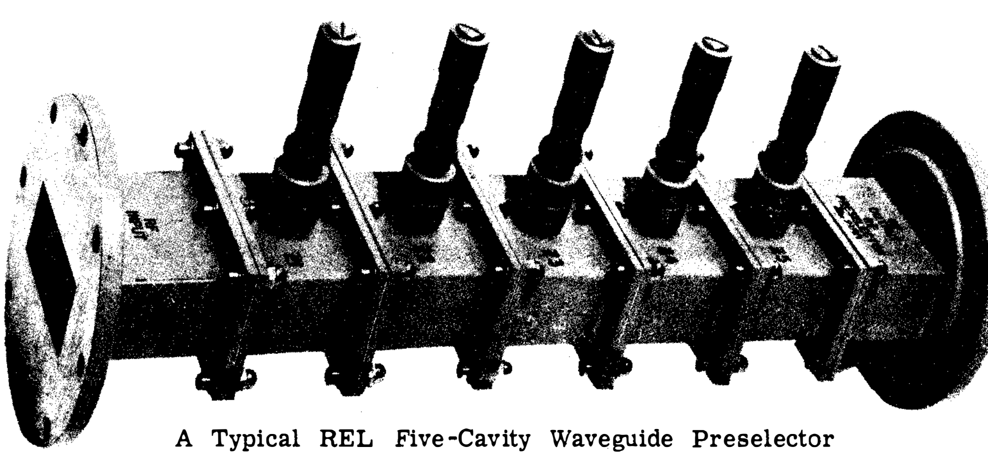
Although these selective devices are also often used as bandpass filters in multiplier strings for the selection of the desired harmonic frequency, or at the RF terminal of exciters for the suppression of unwanted spurious outputs, their most demanding application is in their function as



selective RF input circuits of extremely sensitive high frequency receivers. This is especially true for FM receivers used in the tropospheric scatter mode of operation where the level of signals appearing at the RF input may be as low as a few millionths of a volt. Since the received signal must overcome the so-called thermal noise (random frequencies) generated in the receiver itself in order to produce high quality intelligence at the output, it is of paramount importance that the RF preselector have as low an insertion loss at resonance as possible. In other words, ideally the desired received signals must not be attenuated by the preselector.

In recent years, REL has introduced a new modular concept in RF preselector construction which permits a closer approximation of the theoretical, or ideal, performance characteristics of such devices than was ever possible in the past. Both coaxial and waveguide preselectors have been designed and manufactured by REL for operation in RF tuning ranges covering the region of 100 mc to 10 kmc. Preselectors operating in frequency ranges up to approximately 3 kmc are all of the coaxial type, while those for higher frequencies are of waveguide structure.

REL preselectors, through inherent design and precision manufacturing, now offer the lowest insertion loss believed feasible at the present state of the art.



A Typical REL Five-Cavity Waveguide Preselector

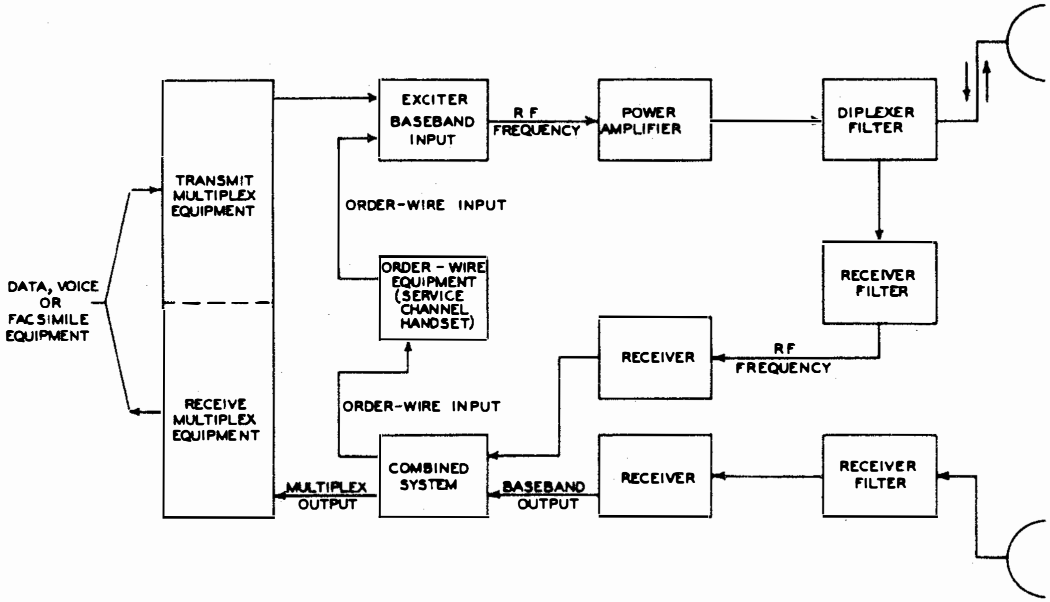


Figure IV-A-13

Typical Receiver-Transmitter Tropospheric Scatter Terminal With Dual-Diversity Reception

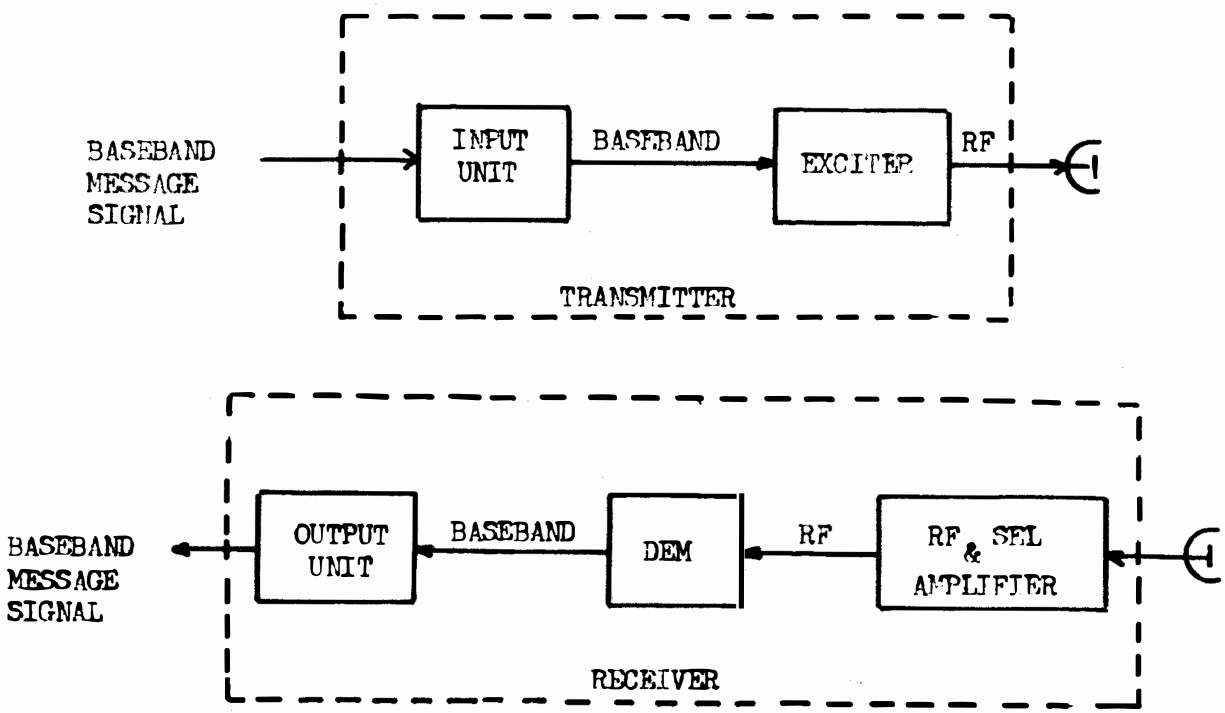


Figure IV-A-14 Basic LOS Microwave Radio Terminal

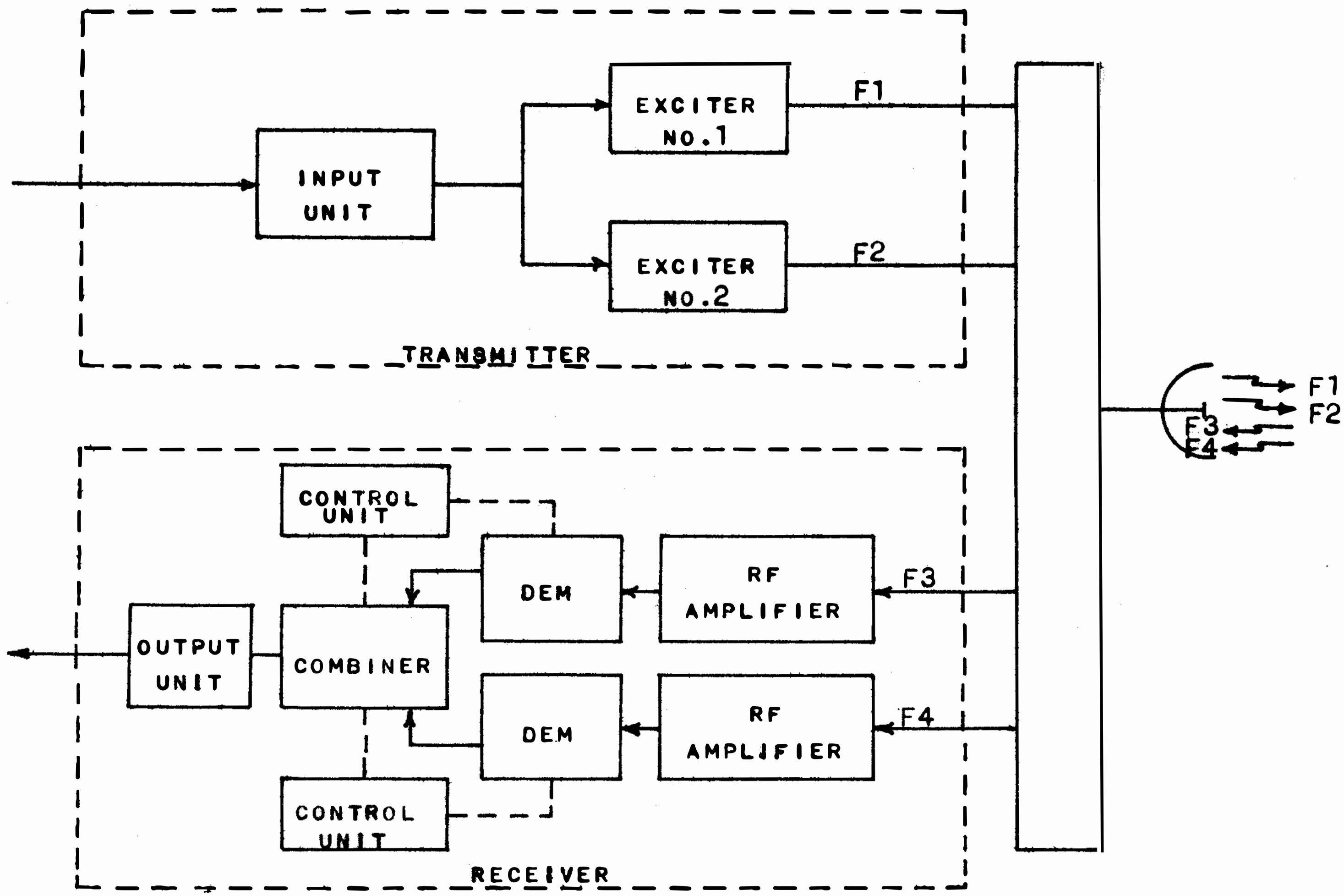


Figure IV-A-15 Frequency-Diversity Line-of-Sight System

Figure IV-A-16

Tropo Scatter Antennas

REL FACT SHEET NO. 14

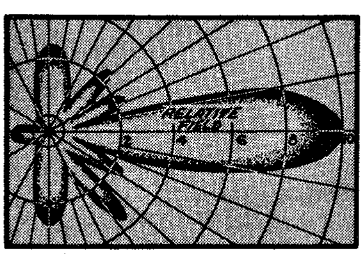
Antennas -- devices used for radiating or receiving radio waves -- act as conducting links in electronic systems which depend upon free space as the propagation medium.

As a basic component in any radio system, the initial function of an antenna is to transfer in the form of an electromagnetic wave, radio frequency energy generated by the transmitter. To complete the conducting link, the radiated wave in traveling through space is intercepted by the receiving antenna.

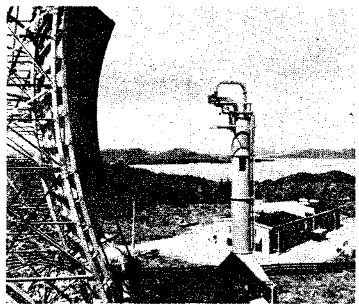
The efficiency of an antenna system depends on how much of the transmitted energy can be retrieved by the receiving antenna. This efficiency is determined to a great extent by radiation pattern and beamwidth.

Broadcast radio has low efficiency because it must radiate energy more or less equally in all directions. Point-to-point radio, by contrast, uses directional transmitting antennas which concentrate power into narrow beams "aimed" toward highly directional receiving antennas. "Gain" is high because as much of the incoming signal as possible is collected and unwanted radiation from other directions is rejected.

In the case of forward tropospheric scatter radio propagation, point-to-point communications is enhanced to permit longer than line-of-sight distances by using free space between earth and the tropopause as an intermediate reflector.



"Pencil-shaped" beam of parabolic antenna radiation pattern.



Radio beams, like light beams, can be formed by reflection as well as by refraction. Since radiation directivity and narrow beamwidth are prerequisites for an efficient high-gain tropo antenna system, the rules of optics have been followed to provide the best possible results at the microwave frequencies.

Antenna designers, utilizing the optical theory of a lens and light source arrangement for narrow beam focusing, have evolved similar antenna - reflector combinations. In the same manner that an optical lens must be illuminated by a light source, a radio beam reflector must have a primary radiator. In a microwave radio system this primary illumination is most often accomplished by an electromagnetic horn -- an "open" end of a waveguide commonly referred to as a "feed horn."

Completing the horn-reflector combination at the present state-of-the-art, REL tropo systems utilize parabolic reflectors in conjunction with "feed horns" to form high-gain parabolic antennas.

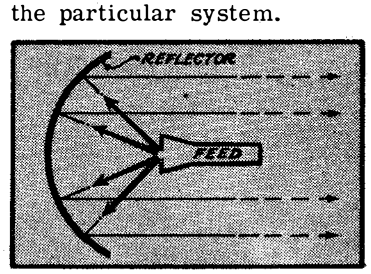
In transportable applications, the tropo antenna, fabricated as a single structure, consists of a paraboloid of revolution illuminated by a center-feed waveguide horn located at the focus of the paraboloid.

For fixed installations, normally involving longer path lengths, a parabolic section is substituted as the reflector; allowing the "feed horn" to be separately located at the focus of the aperture of the antenna. This latter configuration is more efficient since it eliminates aperture blocking and the direct reflection of energy back into the feed.

In either configuration, the principle of operation is similar: During transmission the reflector concentrates the radiation into a parallel beam. For reception, incoming radiation is reflected to the receiving antenna ("feed horn") at the focal point.

Physically, horn-reflector combinations can assume a variety of configurations utilizing optional materials. Depending primarily on geographical location and climate, reflectors (slang: dishes or billboards) can be made of wire screen or sheet metal. The "feed horn" itself, while basically an opening, can assume a variety of shapes such as a flare-out or funnel. The end of the horn is usually capped with an insulating material transparent to the radio frequency involved as a means of maintaining internal pressure within the waveguide system, and as a means of protection from the elements.

Since "gain" is a function of both size and wavelength, antenna sizes vary, again depending upon site elevation, length of "hops" from one tropo terminal to another, and other power, channel and frequency requirements of the particular system.



Parabolic reflector action with "feed horn" at the focal point.

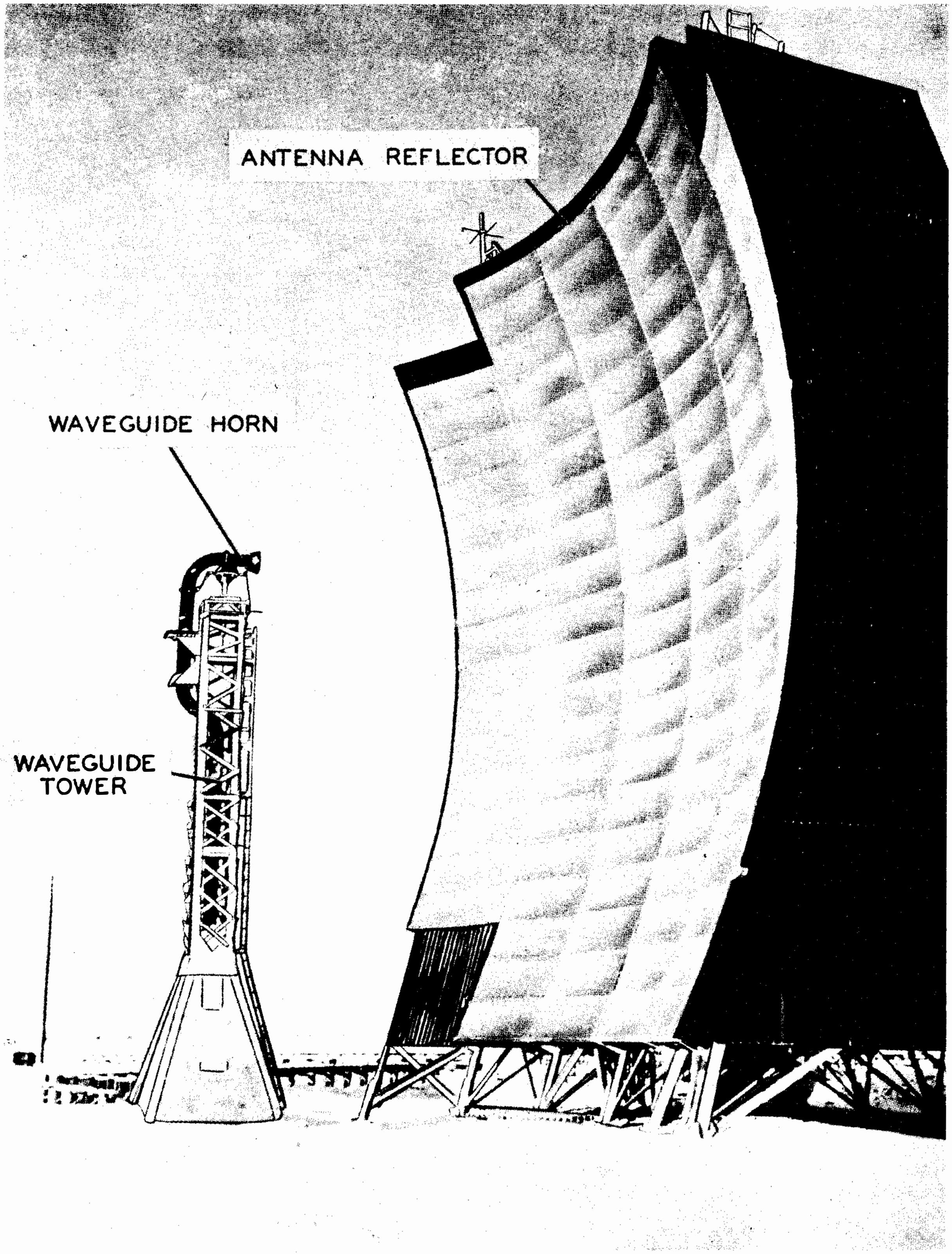


Figure IV-A-17 Sixty Foot Parabolic Antenna System

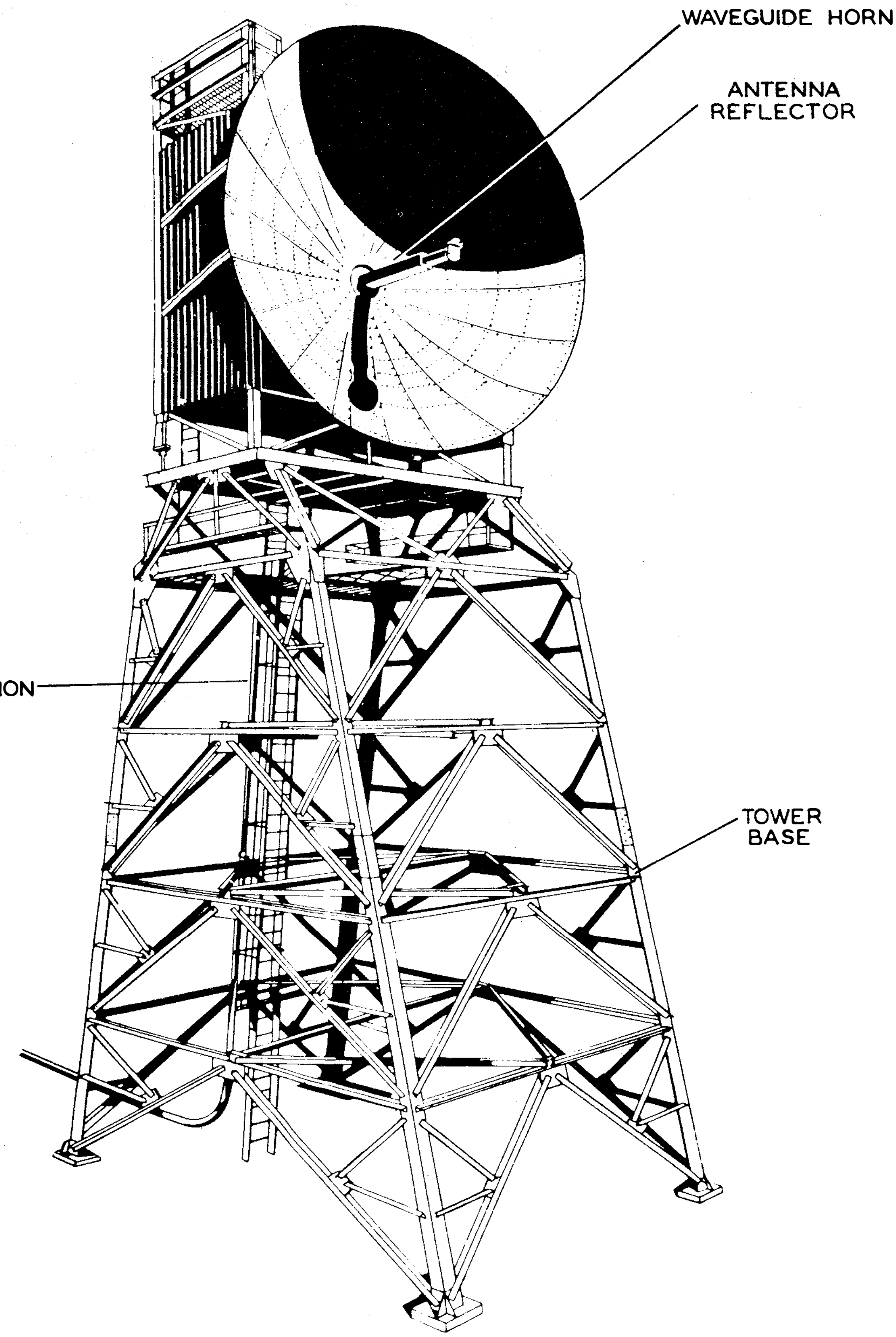


Figure IV-A-18 Thirty-Foot Parabolic Antenna System

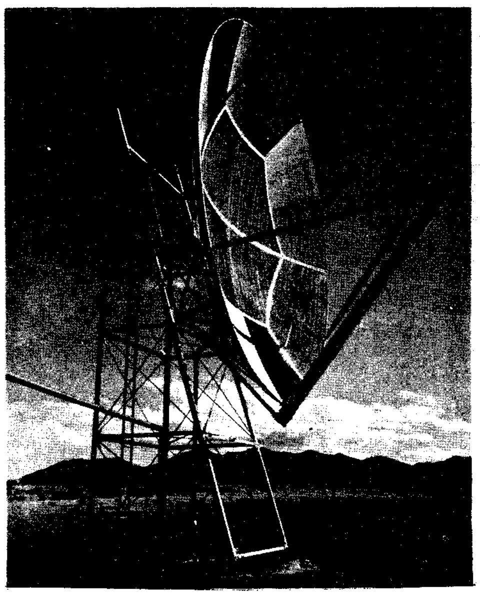


Figure IV-A-19 Twenty-Eight Foot Parabolic Antenna System

**Figure IV-A-20
Air-Inflatable Antenna System**

B. VOICE FREQUENCY MULTIPLEX TERMINAL:

1. Frequency Division Multiplexing:

The primary type of multiplexing utilized in Army communications systems is "frequency-division multiplex" (FDM).

Frequency division multiplex is a system where individual Voice Frequency channels are translated up in frequency so that each channel is occupying a frequency slot 4KHz higher than the preceeding channel. This allows the transmission of many channels over one circuit with maximum economy of spectrum space.
See Figure IV-B-1 for an example of modulation with discrete frequencies. If the original (modulating) signals form a continuous band (such as the components of human speech), Figure IV-B-2 depicts the result. It can be seen that each frequency component in the original signal created two components in the output. It is only necessary to retain one of these to transmit all the information in the original modulating signals. This is done by removing either the upper or lower sidebands with a filter.

The term "multiplex" implies that more than one message will be transmitted at the same time over the same means, wire, radio, cable, etc. This is done by duplicating the process shown in Figure IV-B-2 using different carrier frequencies for each message channel to be transmitted. The normal arrangement of channels is 12 channel "GROUPS". The generation of a single GROUP is shown in Figure IV-B-3. Using the reverse of this translation process at the receiver, it is possible to regain the basic modulating signal. The process of assembling a group, depicted as a sequential procedure in Figure IV-B-3, actually occurs simultaneously in parallel for all channels as shown in Figure IV-B-4.

After the basic GROUP has been formed, there is no reason to stop there. Using GROUPS as the modulating signals with new carrier frequencies, SUPER-GROUPS are formed (Figure IV-B-5). Again, the process takes place in parallel (Figure IV-B-6).

The 60-channel SUPERGROUP is the largest building block normally used in FDM systems. Figure IV-B-7 illustrates how 16 SUPERGROUPS can be combined to form a 960 channel system. Note that SUPERGROUP 2 (SGR 2) undergoes no modulation and comes through at the basic SUPERGROUP frequencies.

Note on Figure IV-B-7 that the lowest frequency found in the composite signal is 60 kHz. The band below this frequency is used for various purposes: voice or teletype order wires, transmission of alarm and monitor signals, or even for an additional 12-channel GROUP.

The complete process of generating a 132-channel system is summarized in Figure IV-B-8. The equipment required for an FDM system is shown in Figure IV-B-9. Here it can be seen that one of the advantages of such a system is that many subassemblies can be used several times. An attractive feature from the maintenance and spare parts of view.

The modulation plan discussed above is not the plan used by Lenkurt in the AN/FCC-17, the multiplex used in the ICS. The Lenkurt plan (to be discussed in detail in Chapter VII) is not compatible with most other multiplex equipment at the channel level because it only uses six different channel carriers instead of the twelve as discussed above. The AN/FCC-17 is however, compatible with other systems at the GROUP and SUPERGROUP levels.

An often used term is the "baseband signal". The baseband found in the ICS REL 2600 equipment, for example, starts at 12 kHz and may extend up to 1052 kHz in the case of a 252 channel system. The baseband is the band of frequencies that contains the composite message channel signal that results from the basic frequency division multiplex scheme. Another term commonly used, to express the same signal is the "RF signal." This term is a slight misnomer, in that "out-of-band" signals, such as some types of order wires (see Section C), are also usually RF (radio frequency) signals, but are not in the baseband.

2. Pilots:

There are two purposes for pilot tones in VF multiplex equipment: The first, the system pilot, is used to synchronize all the carrier oscillators in the system to the same frequency. The second, alarm pilots, is used to warn of system degradation and to assist in locating problems in the equipment.

3. Carrier signals

The channel, GROUP and SUPERGROUP carrier frequencies are derived from a crystal-controlled oscillator. The oscillator is housed in a temperature controlled oven so that the frequency is virtually independent of ambient temperature variations. A 96 kHz synchronization pilot is combined, 16 DB below the normal transmission level, with the line frequency output. The pilot is received at the distant terminal and is fed to the master frequency generator shelf. A phase detector in the master frequency generator shelf compares the phase of the pilot with a locally generated 96 kHz signal and produces an error voltage which is proportional to the phase difference of the two signals. The error voltage then is applied to the oscillator which changes frequency in proportion to this error. Thus, all channel, GROUP and SUPERGROUP carrier frequencies are varied according to the original error, and frequency synchronization is maintained. If the synchronization pilot is lost for any reason, the master frequency generator shelf locks on the last received signal by means of a servomechanism which controls a voltage reference and maintains the phase detector output at zero.

In order to regain the transmitted information at the receiver, it is essential that the demodulating carrier frequency be exactly the same as that used for modulating. This is insured, as discussed above, by using the SYSTEM pilot transmitted by the "master station" to synchronize the local frequencies of all other stations, which operate as "slaves". Referring again to Figure IV-B-5, observe that GROUP 1 is in the frequency range 312-360 kHz after the SUPERGROUP is formed. When demodulating down the SUPERGROUP at the distant terminal, if a carrier frequency of 419.5 kHz were used (only 0.12% error) GROUP 1 would be placed in the frequency range 59.5 to 107.5 kHz. Then, instead of having channel 12 of GROUP 1 in the frequency range 60 to 64 kHz, there will be a portion of channel 12 and a portion of channel 11. If these channels were used for voice circuits, they might still be operational (but with greatly reduced quality). However, if a teletype carrier tone pack were on any of the channels in the entire SUPERGROUP, the small error in the carrier frequency would make the tone pack totally unusable since each channel on the pack is only 170 Hz wide. You can readily see the value of the "master" - "slave" relationship.

4. **Alarm pilots**

Another use of pilots is in automatic level regulation. A GROUP pilot, either 64 kHz or 104 kHz is combined into and transmitted with each 12 channel group. Normally the 64 kHz pilot is used. The GROUP pilot, 16 DB below the GROUP transmit level (34.5 dbm), provides a level index throughout the main signal path. Failure to receive this pilot at the distant terminal is an indication of loss of a complete 12 channel GROUP.

Two other uses of pilots are in alarm systems and in maintenance.

5. Thru-grouping:

Consider the layout of a communications system shown in Figure IV-B-10. An analysis of the system shows the following equipment requirements (Figure IV-B-11).

Term A 1 Group MODEM

3 Channel MODEMS

Term B 2 Group MODEMS

5 Channel MODEMS

Term C 1 Group MODEM

2 Channel MODEMS

Notice, that at Terminal B it is planned to "break down" the entire signal into voice channels and then cross-connect the 8 thru-channels. What was the value of demodulating those 8 channels? All that resulted was that some noise was added to the signals because each had to go through 2 additional channel MODEMS. In fact, if this is done too many times, the signal becomes so noisy it is unintelligible. This problem is overcome by what is called, "thru-grouping", which not only improves the signal-to-noise ratio but also cuts down on the equipment requirement. Figure IV-B-12 shows Terminal B when thru-grouping is used. The savings in equipment amounts to two channel MODEMS, however, it was necessary to add a thru-group filter.

Even though GROUP #3 WEST is connected to GROUP #2 EAST, there is no frequency compatibility problem since all GROUPS occupy the band 60-108 kHz. The purpose of the thru-group filter is to eliminate the noise outside of this band and prevent its transmission over the next link. Since the send and receive paths are separate, two thru-group filters are required for each connection. Regular channel MODEMS do not require filters; however, some special 12-channel systems do (Figure IV-B-13).

When the number of through channels warrant, it is also possible to use thru-supergroup filters. These are not found in the ICS; however, every site has several thru-group filter pairs.

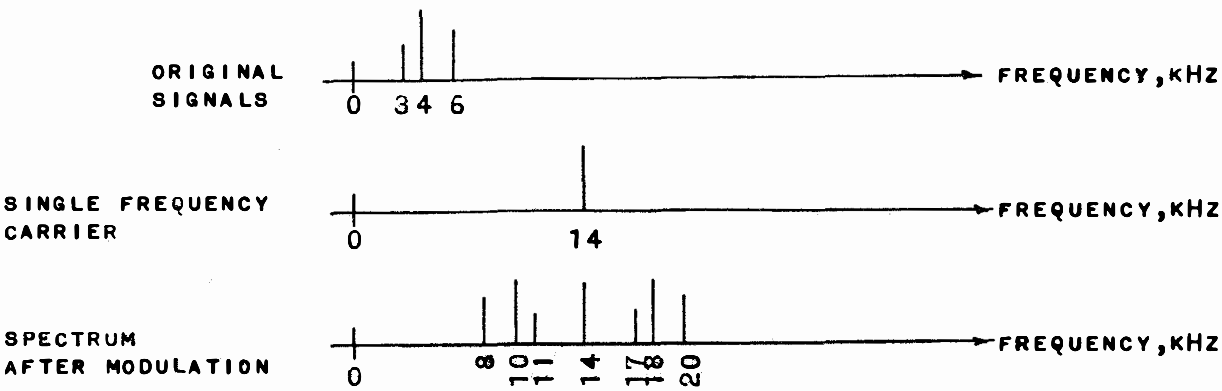


FIGURE IV-B-1 DISCRETE TONE MODULATION

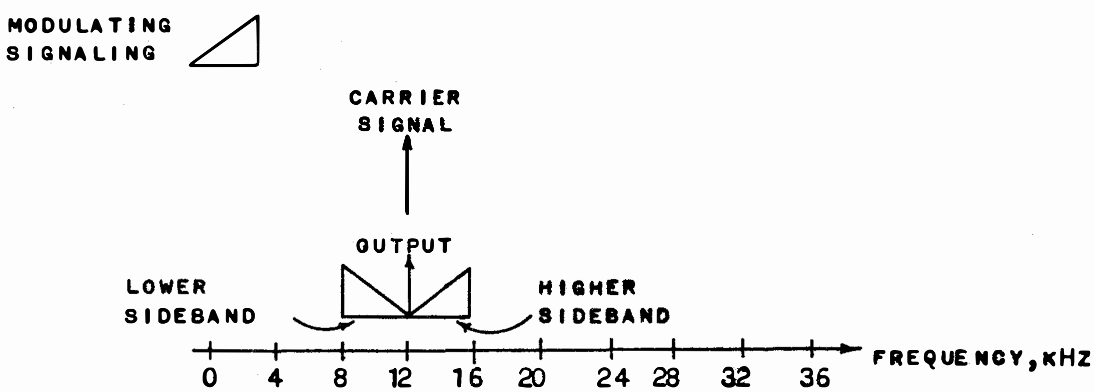
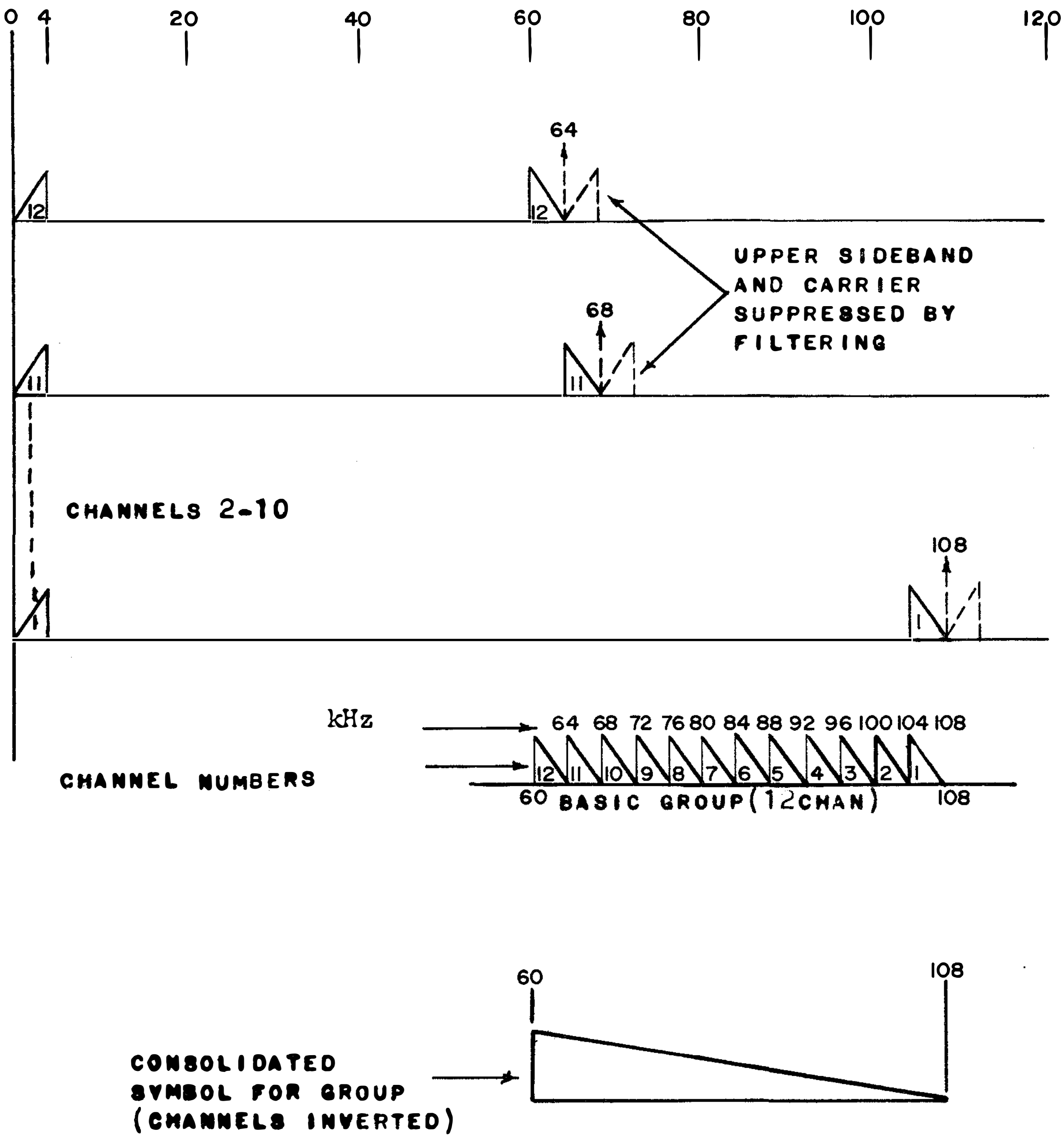


FIGURE IV-B-2 CONTINUOUS BAND MODULATION



CHANNEL TRANSLATION AND ASSEMBLY OF 12 CHANNELS TO FORM BASIC GROUP 60-108 kHz

FIGURE IV-B-3

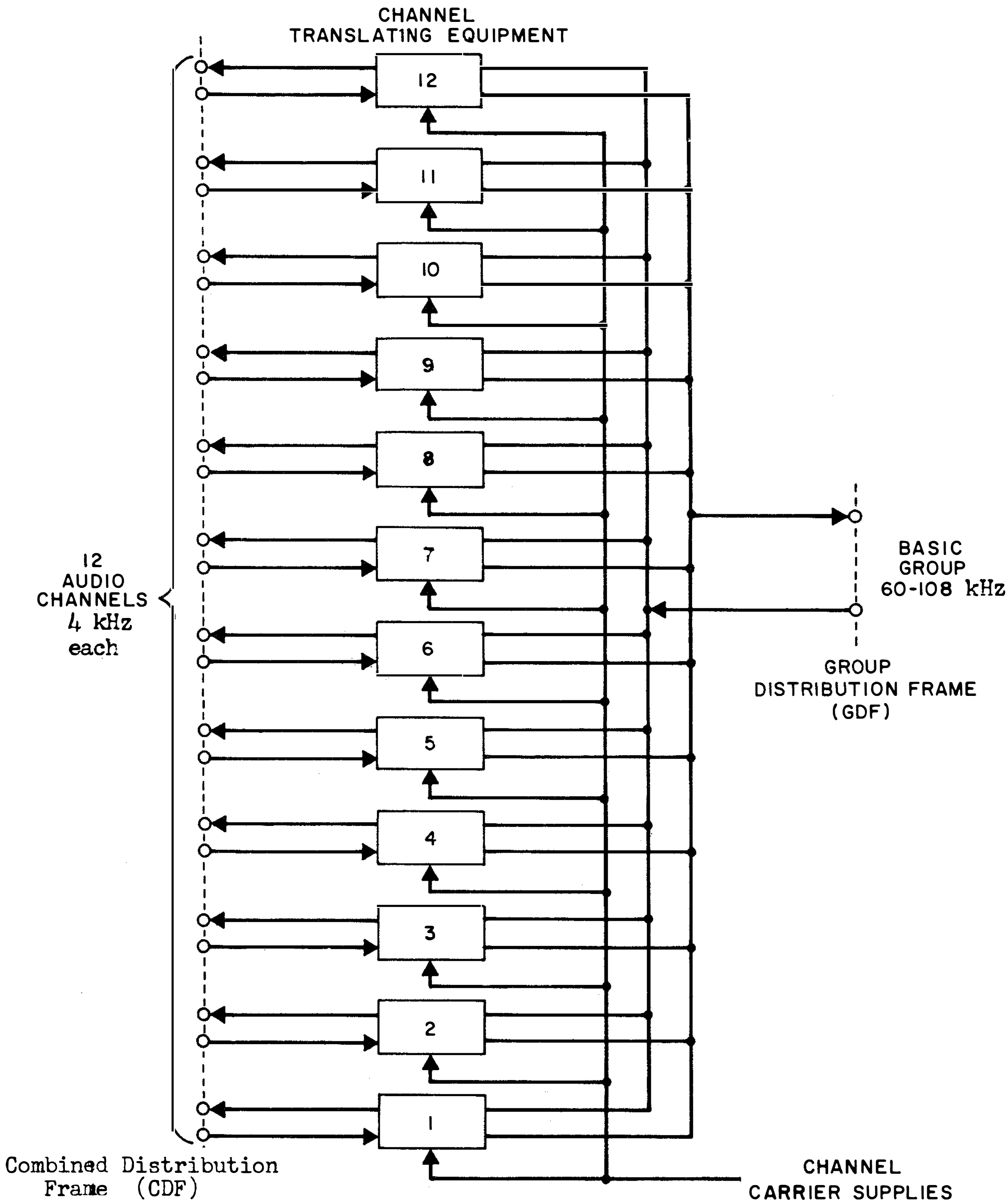


FIGURE IV -B- 4.

CHANNEL TRANSLATING EQUIPMENT BLOCK DIAGRAM SHOWING THE ASSEMBLY OF TWELVE AUDIO CHANNELS INTO A BASIC GROUP OF 60-108 kHz

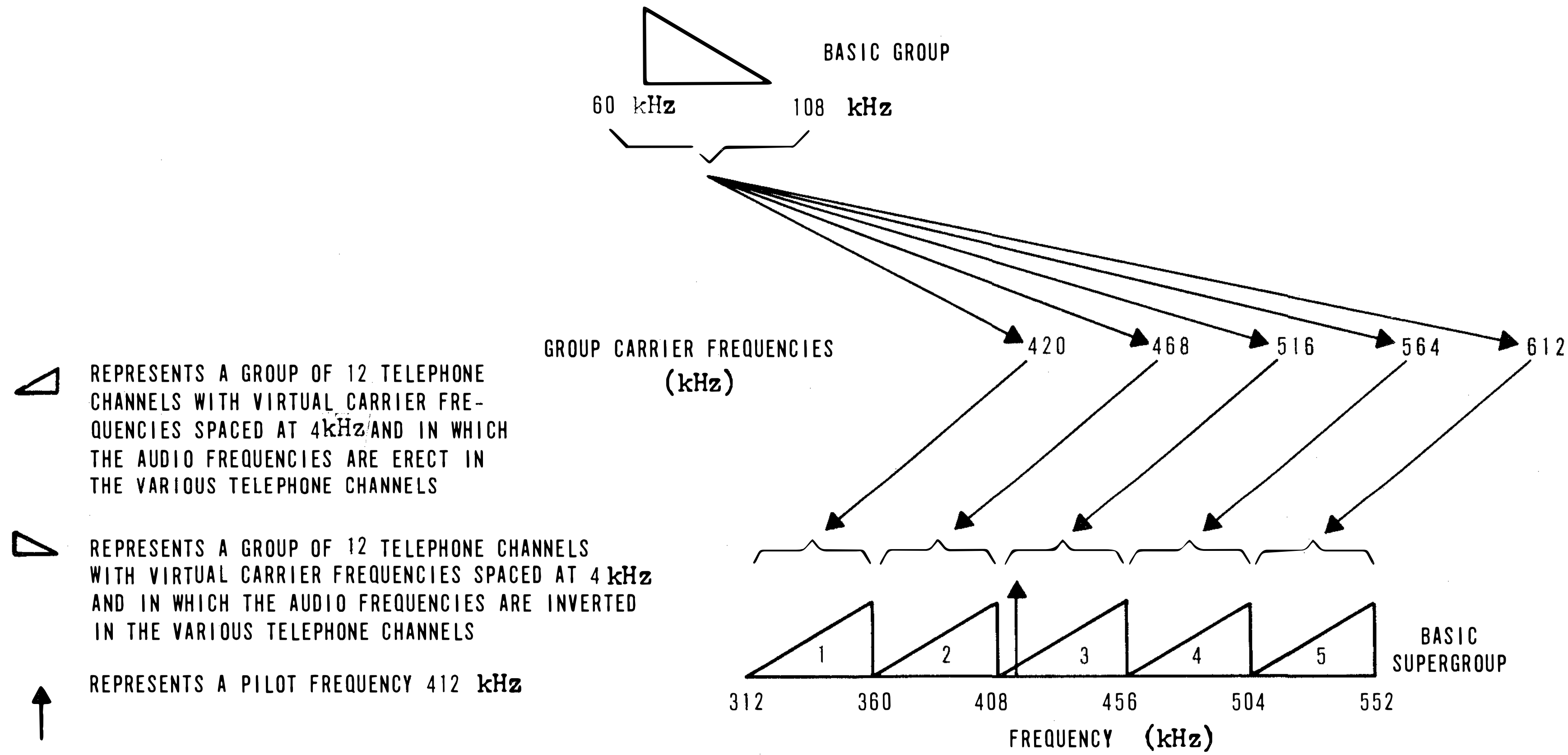


FIGURE IV-B-5.
FREQUENCY ALLOCATION SHOWING A BASIC GROUP, THE GROUP CARRIERS AND THE FREQUENCY SPECTRUM OCCUPIED BY A BASIC SUPERGROUP

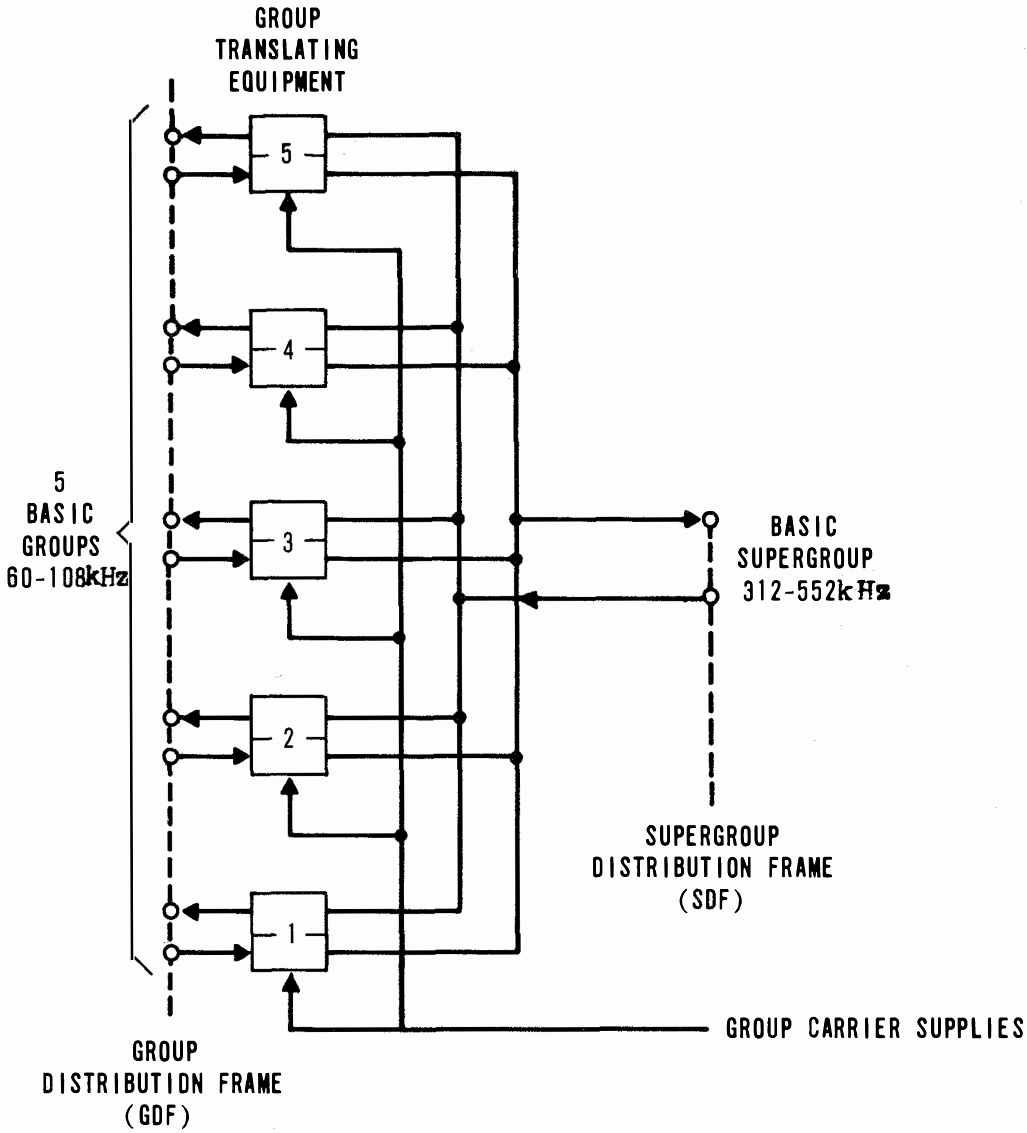
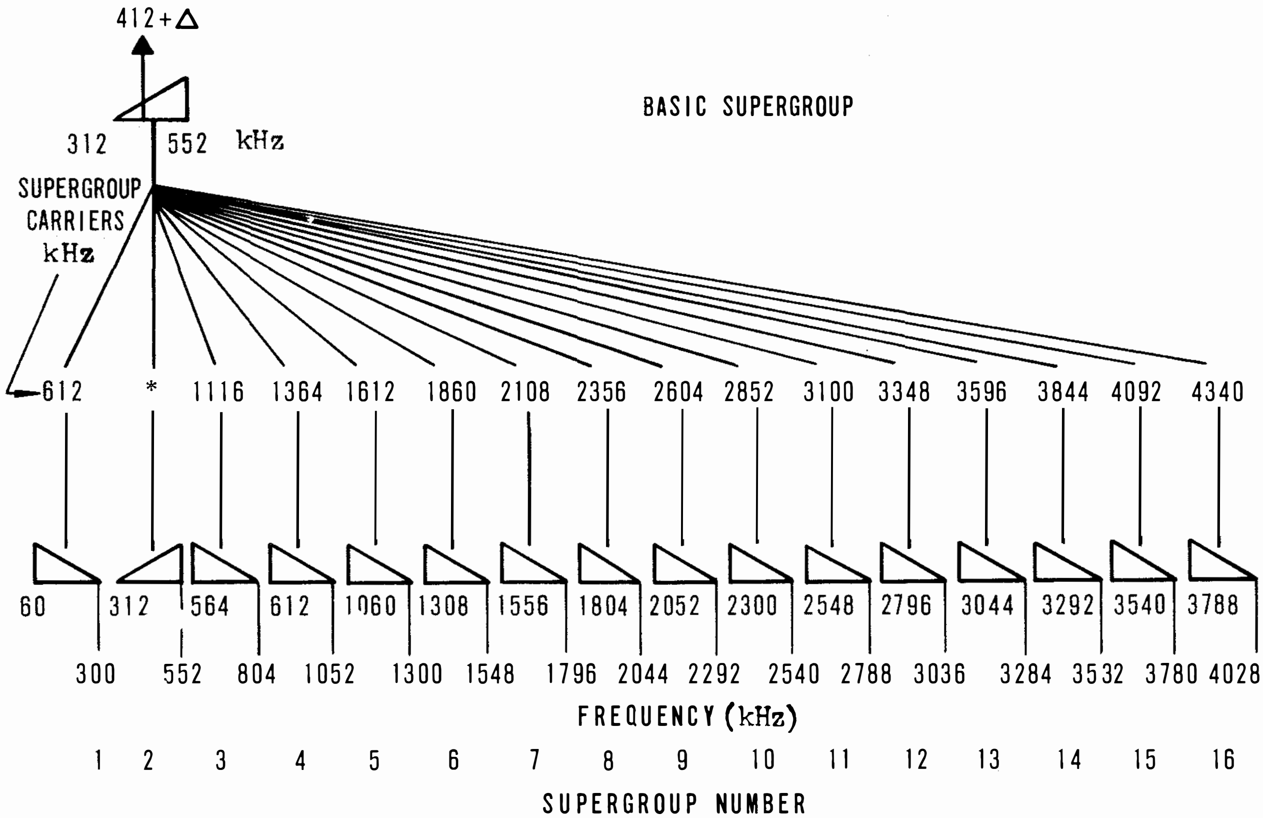


FIGURE IV-B-6.
GROUP TRANSLATING EQUIPMENT - BLOCK DIAGRAM
SHOWING THE ASSEMBLY OF FIVE BASIC GROUPS
IN THE RANGE 60-108kHz INTO A BASIC
SUPERGROUP OF 312-552kHz



LEGEND

◿ REPRESENTS A 60 CHANNEL SUPERGROUP WITH ERECT SIDEBANDS

◺ REPRESENTS A 60 CHANNEL SUPERGROUP WITH INVERTED SIDEBANDS

↑ PILOT FREQUENCY

* NO MODULATION

FIGURE IV-B-7.
FREQUENCY ALLOCATION SHOWING THE MODULATION SCHEME AND
FREQUENCY SPECTRUM FOR A 16 SUPERGROUP SUBSYSTEM

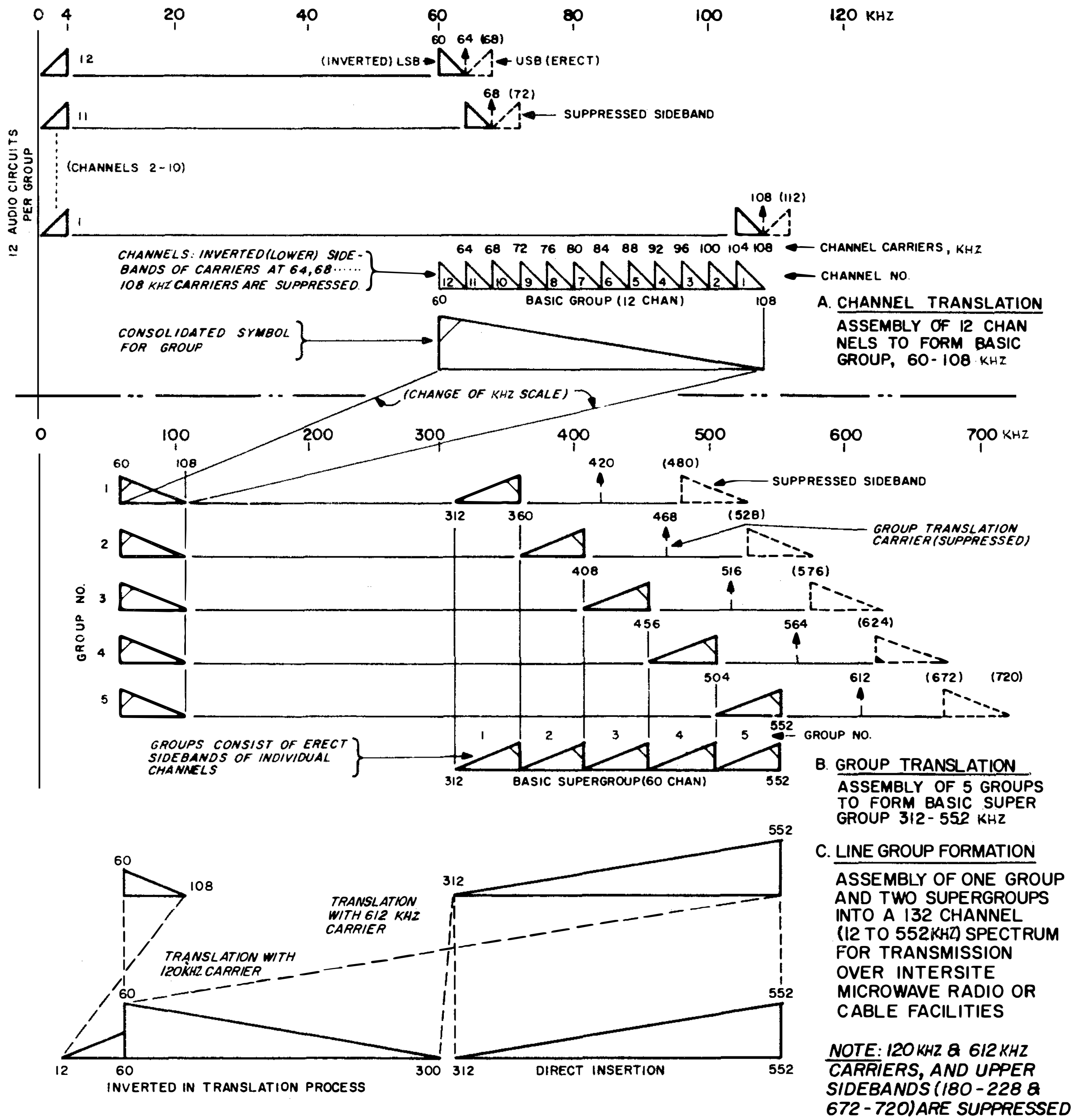


FIGURE IV-B-8.
MODULATION PLAN

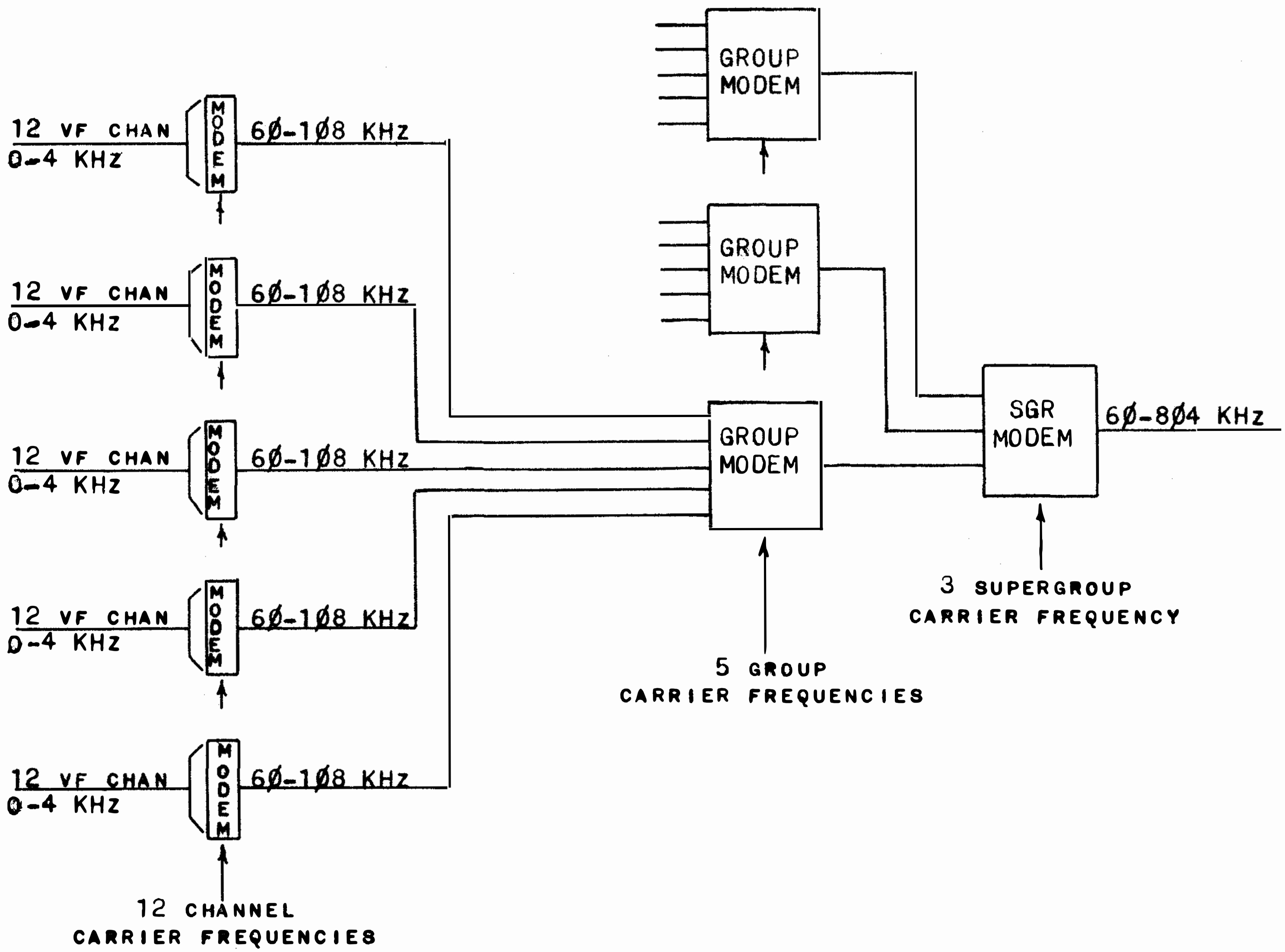


FIGURE IV-B-9 FREQUENCY DIVISION MUTIPLEX TERMINAL

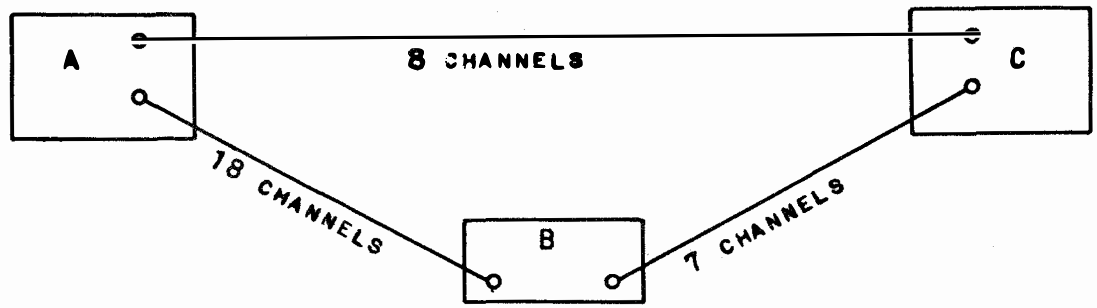


FIGURE IV-B-10 SIMPLE COMMUNICATIONS SYSTEM

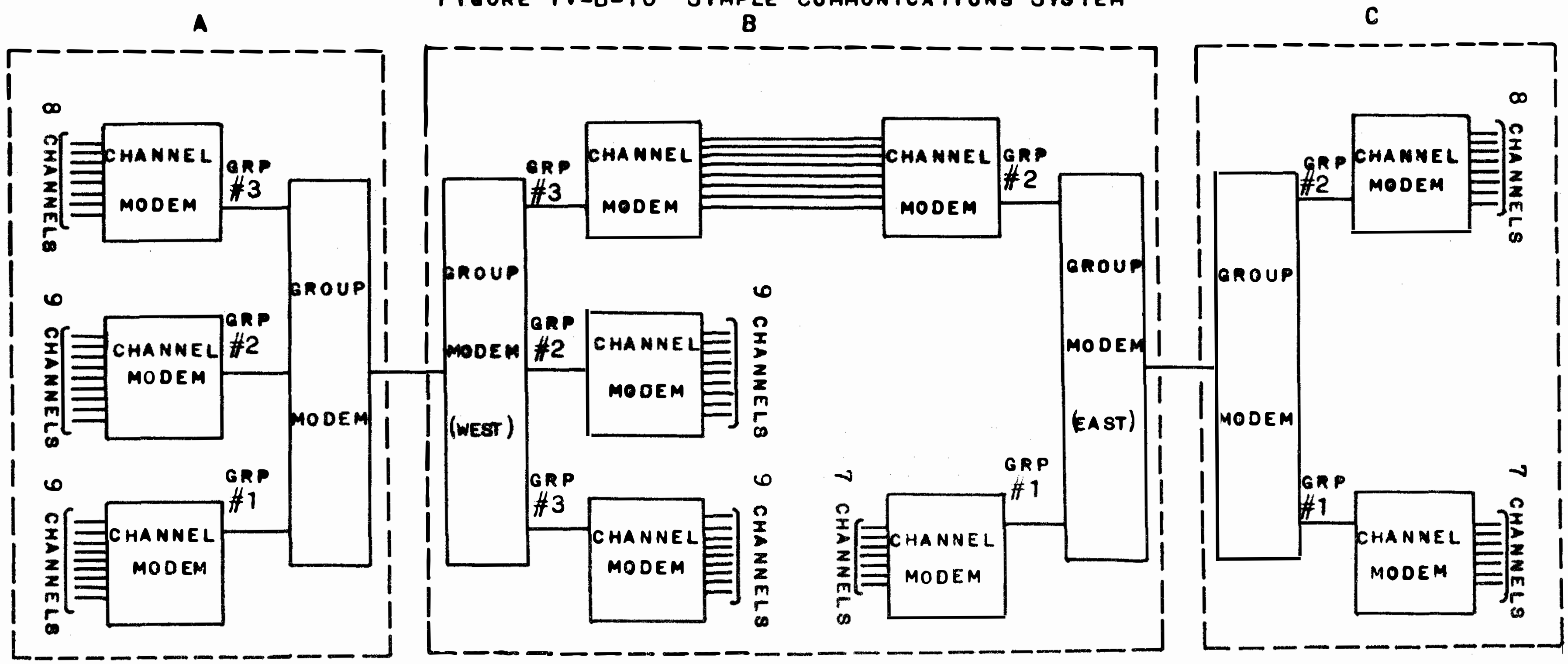


FIGURE IV-B-11 EXAMPLE COMMUNICATIONS SYSTEM

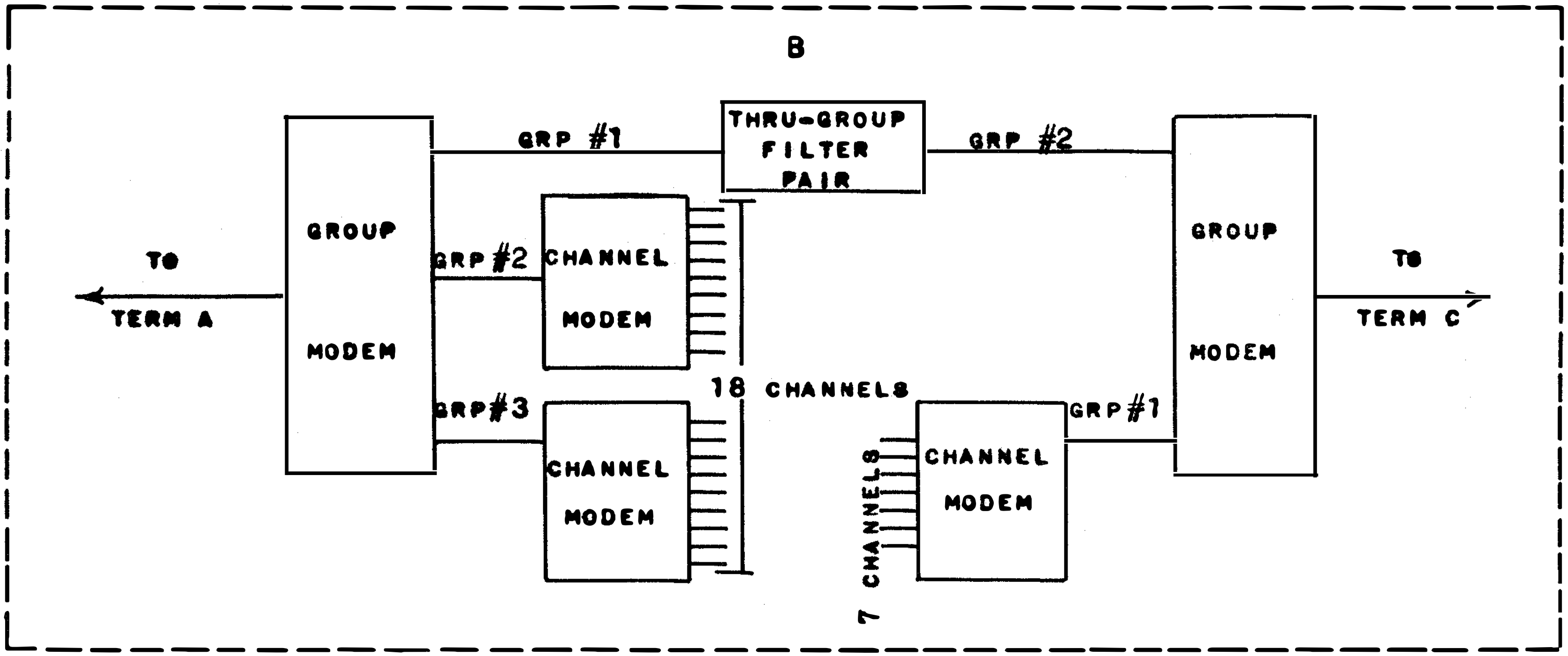


FIGURE IV-B-12 USE OF THRU GROUP FILTER

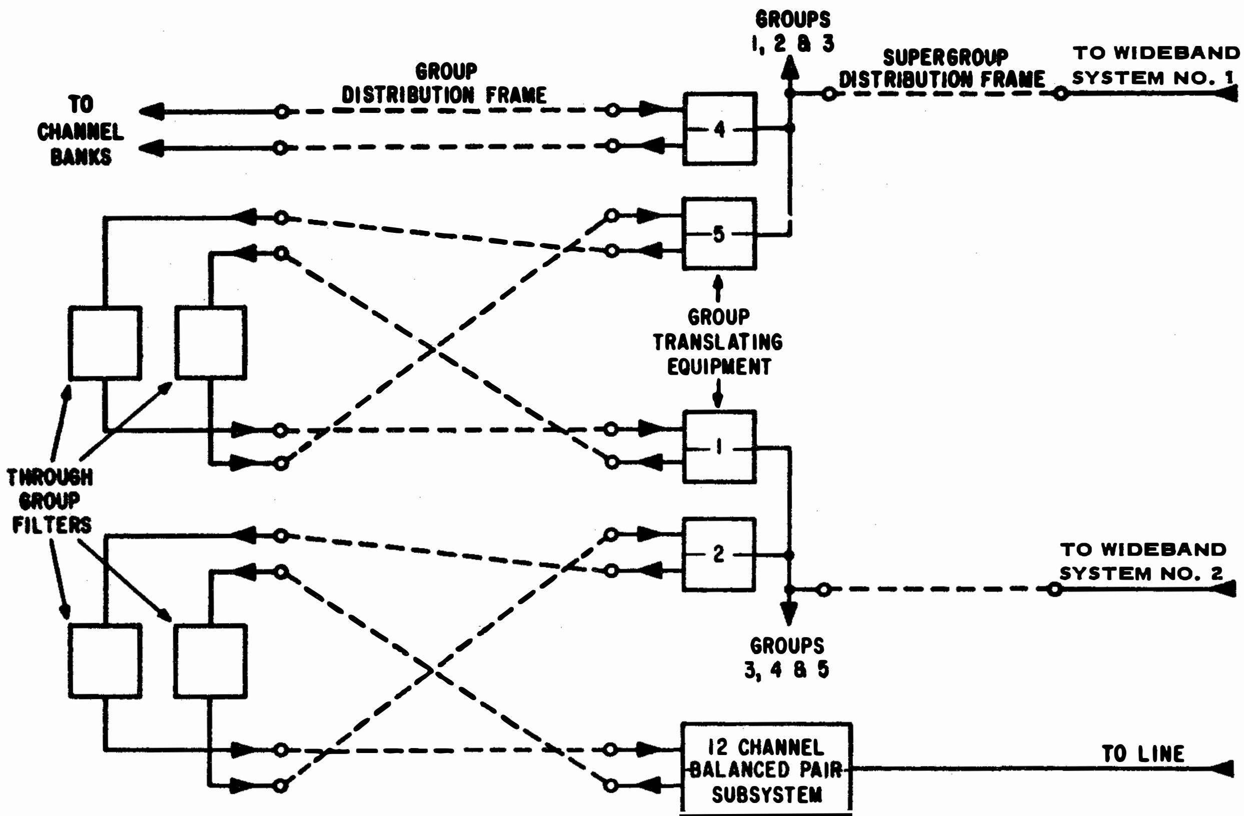


FIGURE IV-B-13.
THROUGH-GROUP EQUIPMENT

Typical Use of Through-Group Filters

C. ORDER WIRES

1. General

In transportable "tactical" equipment there is normally an "order wire" or "engineering channel" associated with the VF multiplex terminal equipment. This is not necessarily the situation in fixed-plant equipment.

There may be a regular voice channel allocated as an order wire from terminal to terminal. This is referred to as an "in-band" order wire. In addition, there is usually an "out-of-band" channel that can be used for order wires, alarm circuits, or other engineering purposes. This channel is called "out-of-band" since it is transmitted over a frequency band outside of the message bandwidth. The "out-of-band" channel, often called the "supervisory channel", does not pass through the VF multiplex equipment but is combined with and extracted from the message signal in the radio terminal equipment (Figure IV-C-1).

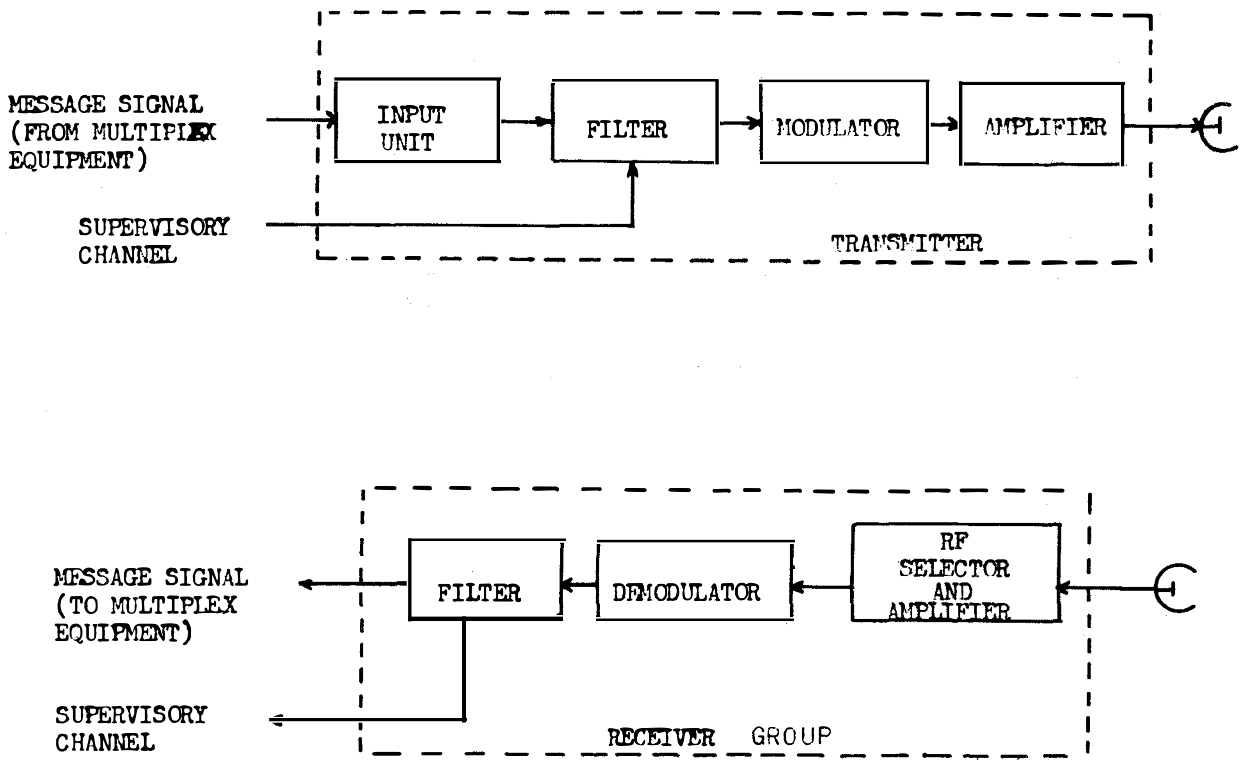


Figure IV-C-1 Supervisory Channel

2. ICS APPLICATION

In the ICS "out of band" or supervisory order wires are used for maintenance of the multiplex and radio equipment. In a typical EE building this equipment is usually separated from the tech control facility. The "in-band order wires are used to maintain the individual circuits.

A simpler explanation is that the "out of band " order wires are used from RF room, and " in-band order wires are used from tech control to tech control.

D. VOICE FREQUENCY CARRIER TELEGRAPH SYSTEMS (VFCT):

1. General

A number of telegraph channels may be obtained in a specific frequency band (such as that of a 4 kHz channel of a multichannel telephone system) by dividing this band into narrower channel bands. Each channel is separated from the others by filters. The most commonly used channel spacing is 170 Hz, which will allow 16 teletype channels for every 4 KHz voice channel.

In some cases, a multichannel telegraph system comprises two channel groups, one using channel frequencies generated directly and the other using higher frequencies provided by moving upward the frequencies of a group of channels similar to the first. This frequency transformation is accomplished by a group modulator after the individual channels have been keyed or modulated by the telegraph signals. At the distant end, the frequencies of the high group are restored by a group demodulator before they are impressed on the ac telegraph channel receiving equipment. This procedure reduces the number of oscillator frequencies and types of filters required. (This is the technique used in the AN/TCC-4).

In multichannel telegraph systems a different carrier frequency is supplied for each channel. This carrier is modulated at the sending end by operation of the (teletype) sending equipment, which originates signals at its contacts in dc form. At the distant end, the carrier signals are demodulated (restored to direct current) to actuate the (teletype) receiving instrument. Military systems generally use carriers in the voice-frequency range; however, some systems use frequencies above this band. These systems can be operated over any good telephone-type circuit, wire or radio; however, radio circuits are less suitable because they are frequently subject to short bursts of interference and sudden changes in attenuation.

In frequency-shift modulation (Figure IV-D-1), the carrier is shifted between two frequencies-one frequency represents marking pulses, and the other frequency represents spacing pulses. These two frequencies are equally spaced with respect to the midband or nominal channel frequency. Frequency-shift modulation (FSK, frequency-shift keying) systems are the most commonly used today.

2. Operating Power Levels

In an ac telegraph system, a channel power level must be used that is high enough to prevent excessive signal distortion from noise or other interference. However, the power level must not be so high that it causes objectionable interference to other communications. A number of channels using the same facility will overload common equipment, such as amplifiers and modulators, if the levels are too high (TM 11-490-2); this results in interference between channels. Also, a power level that is too high may produce objectionable cross induction into parallel communication channels. (See Section D, Chapter XVIII). The ICS uses 60 mA neutral keying for its in- house circuits

3. Channel Layout

A typical DC and audio jack layout is shown in Figure IV- D-2. This arrangement facilitates patching and testing of the DC and audio lines.

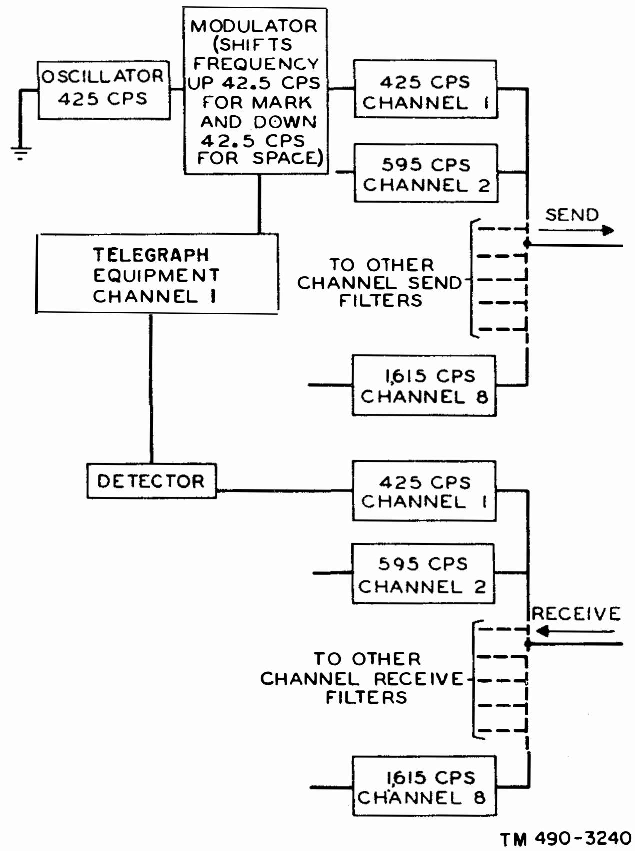
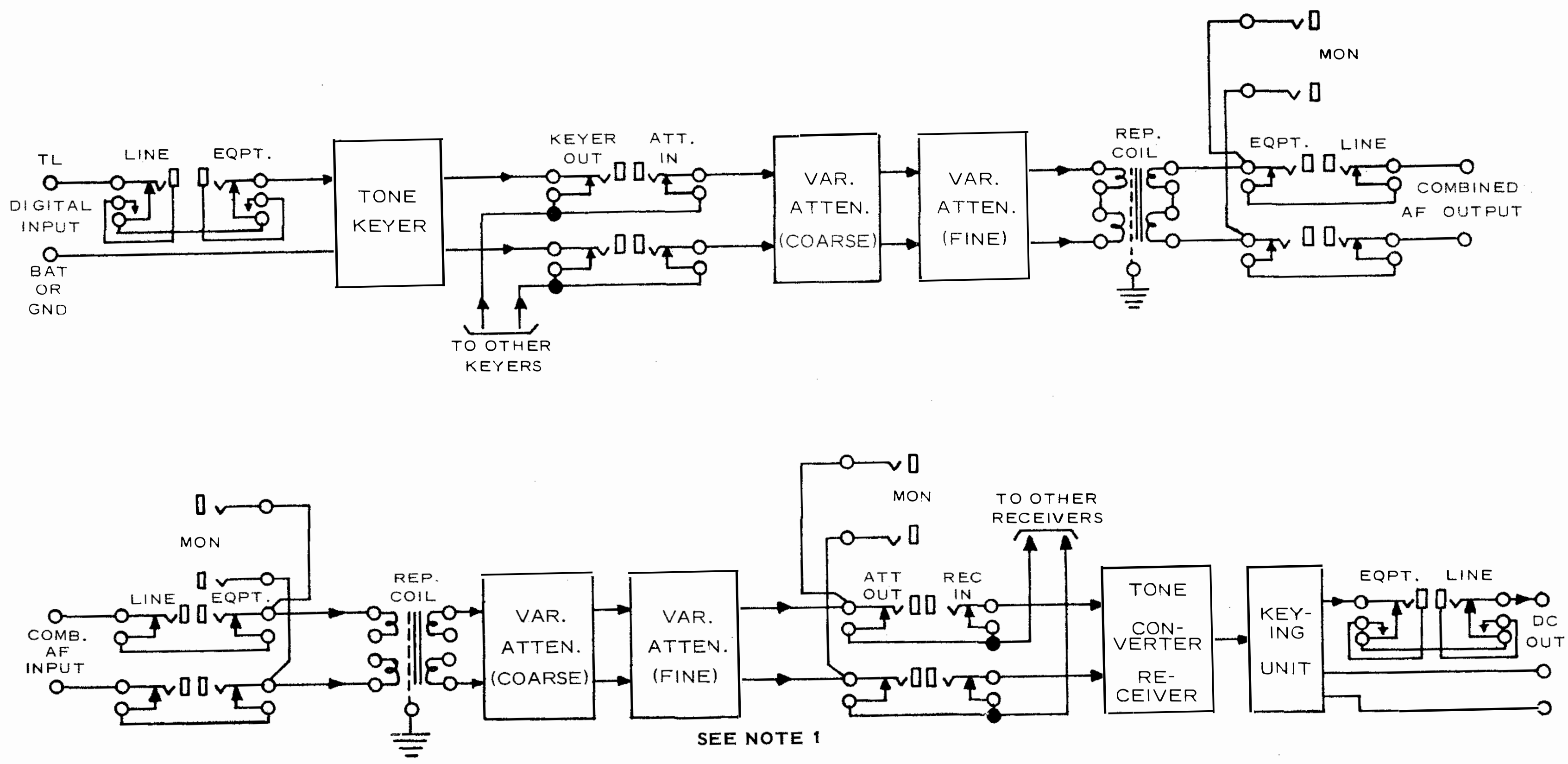


FIGURE IV-D-1. *Elements of frequency-shift carrier telegraph system.*



NOTES

1. DIVERSITY TERMINAL HAS SECOND RECEIVING CIRCUIT IDENTICAL TO THE ABOVE EXCEPT THE DIVERSITY COMBINER IS LOCATED BETWEEN THE TWO RECEIVERS AND KEYING UNIT

FIGURE IV-D-2.

TYPICAL DC AND AUDIO JACK CONNECTIONS

E. PATCH PANELS:

A complete understanding of the various patch panels found in the station is a key to mastering the entire system. The use of numerous patch panels is one of the primary differences between tactical and fixed-plant stations. Although it takes much longer to install a circuit in a fixed-plant than in a tactical system, the patch panels in the fixed-plant provide much greater reroute flexibility and test capability. The capabilities and flexibility of fixed-plant patch panels are much greater than those of tactical equipment such as the SB-675 or 611.

A simplified diagram of several systems is shown in Figure IV-E-1. As each system and circuit is engineered and installed, it is possible to assign to it specific pieces of equipment. However, during operations it is highly desirable to be able to quickly monitor or change the connecting signal paths for either testing or rerouting.

The patch panels to be considered are the :

Circuit Patch Panel

Voice Frequency Patch Panel

Group Patch Panel

as shown in Figure IV-E-2.

After the circuit has been engineered it is "hard-wired" through the station to connect the various items of equipment in the proper arrangement. Each set of jacks on the patch panel has IN and OUT terminals and, under normal conditions, these are connected straight through. See Figure IV-E-3 which depicts a set of voice frequency (VF) jacks. This jack set, for one complete 4-wire circuit, has several features that are common to most patch panels:

1. It is possible to monitor transmission in either direction without disturbing the circuit. (A plug inserted in the MON jack will place the monitoring or test device in the circuit properly; in parallel since this is an audio circuit).

2. The input is connected to the output under normal conditions.

3. Jacks are provided for rerouting purposes (MOD IN, DEMOD OUT, EQ OUT, EQ IN). When a jack is inserted into one of these, the normal IN to OUT path is broken and the new path is through the patch cord.

Nearly all patch panels have these general characteristics, although the name, quantity, and arrangement of jacks will vary. Detailed descriptions of the various patch panels will be given later; however, Figure IV-E-4 shows where all of the various panels, found at ICS Sites, fit into the system.

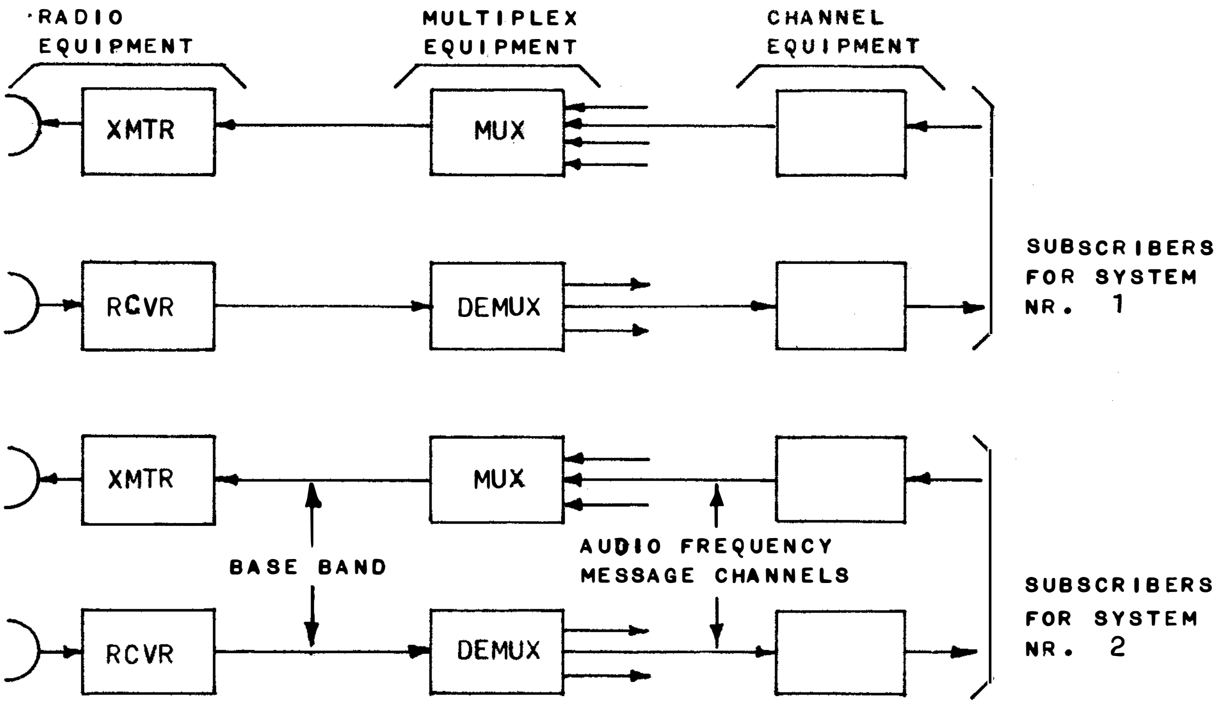


FIGURE IV-E-1 BASIC EQUIPMENT SEQUENCE

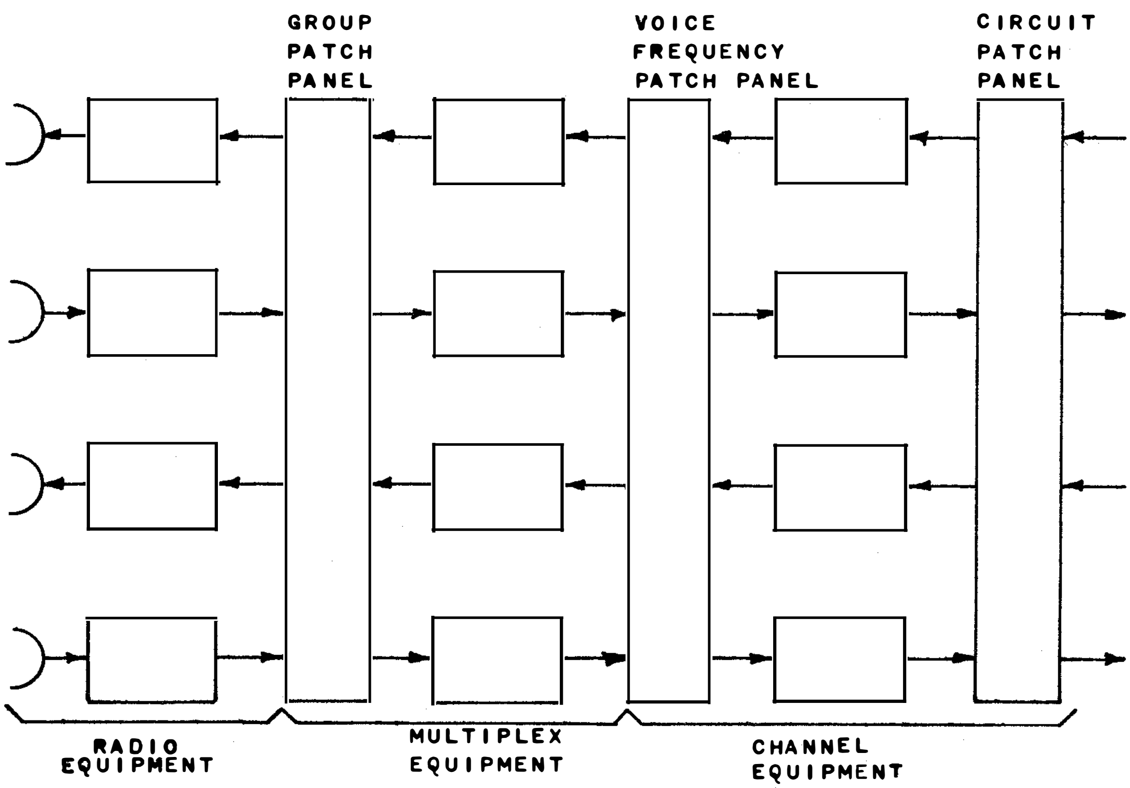


FIGURE IV-E-2 BASIC PATCH PANELS.

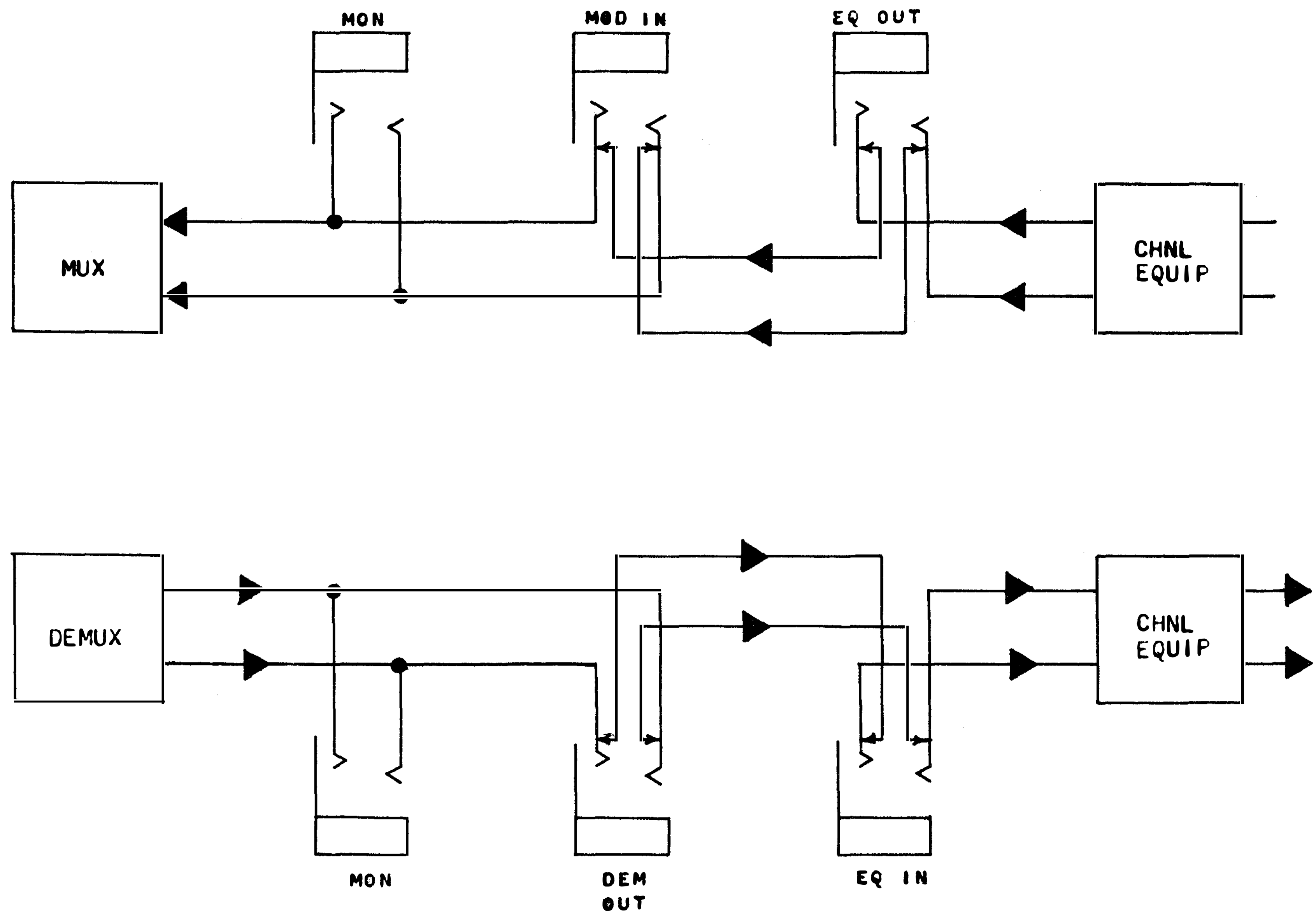


FIGURE IV-E-3 VF-JACK ASSEMBLY

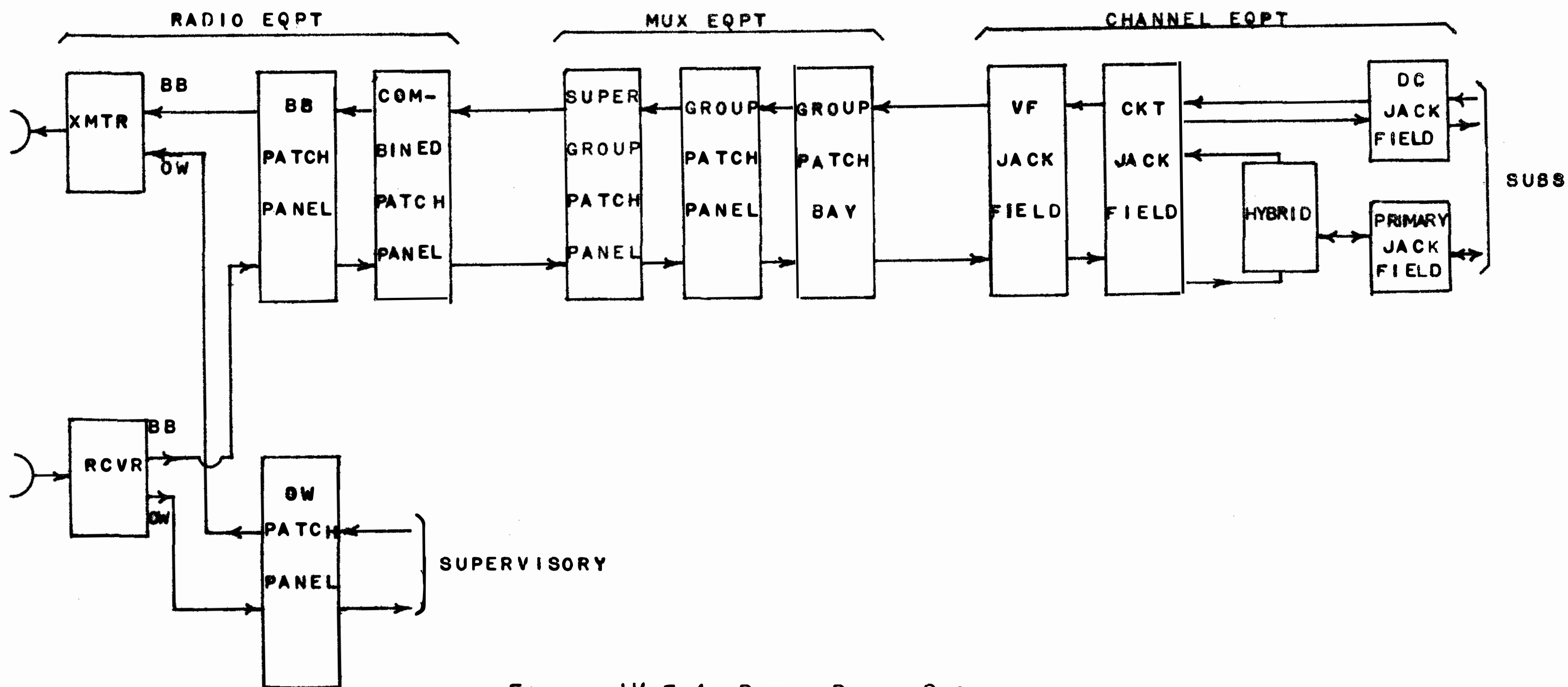


FIGURE IV-E-4 PATCH PANEL SEQUENCE

F. DISTRIBUTION FRAMES:

If it were necessary to run separate lines from one piece of equipment to another to assemble the circuits in a fixed-plant installation, the office would very soon become a rats nest of wires, and orderly trouble shooting would become impossible. The solution to this problem has been the use of distribution frames.

Rather than collect the inputs and outputs of each particular type of equipment at separate terminal points, the inputs and outputs of several types of equipment are brought to a common point-the distribution frame at which the signal may be "distributed" to the various pieces of equipment as required.

Although it is not an essential feature, most distribution frames have two sides; one of which is arranged in vertical columns, and the other in horizontal rows (see Figure IV-F-1). The standard procedure is to place the cables that are terminated on the frame on the vertical side since cable protectors are designed to be installed there. There are no definite rules on where the connections to other pieces of equipment will be placed. Figure IV-F-1 shows two "pin blocks" on the horizontal side. These are used to terminate station equipment but may be used for cable if the cable does not require protection. The inputs and outputs of each piece of equipment are brought to the frame on "house cable" which is "permanently" terminated on the bottom of a horizontal block or the left side of a vertical one. Since the pin terminals go through the block, the top or right side is used to make "temporary" connections between pieces of equipment by running "jumpers". When it is desired to change the configuration of the circuit or deactivate it, the only changes needed are in the short jumpers, not in the house cabling.

In large telephone exchanges it is common to have several distribution frames. There may be one "centrally located" called the "Intermediate Distribution Frame (IDF)". There may also be one at which the outside cables terminate, the "Main Distribution Frame (MDF)". If the office is not too large, there may be only one frame, the "Combined Distribution Frame (CDF)".

The proper operation of a distribution frame requires adherence to some very simple rules as to the routes to be followed when running jumpers and the correct procedure for making connection to terminals. These have been clearly specified in RCG LL TCG S&P Item Nr. 0701. It is strongly recommended that all supervisory personnel become familiar with these standards and frequently inspect the frame to insure compliance. A large number of troubles eventually traced down to wiring problems are a direct result of not following these practices.

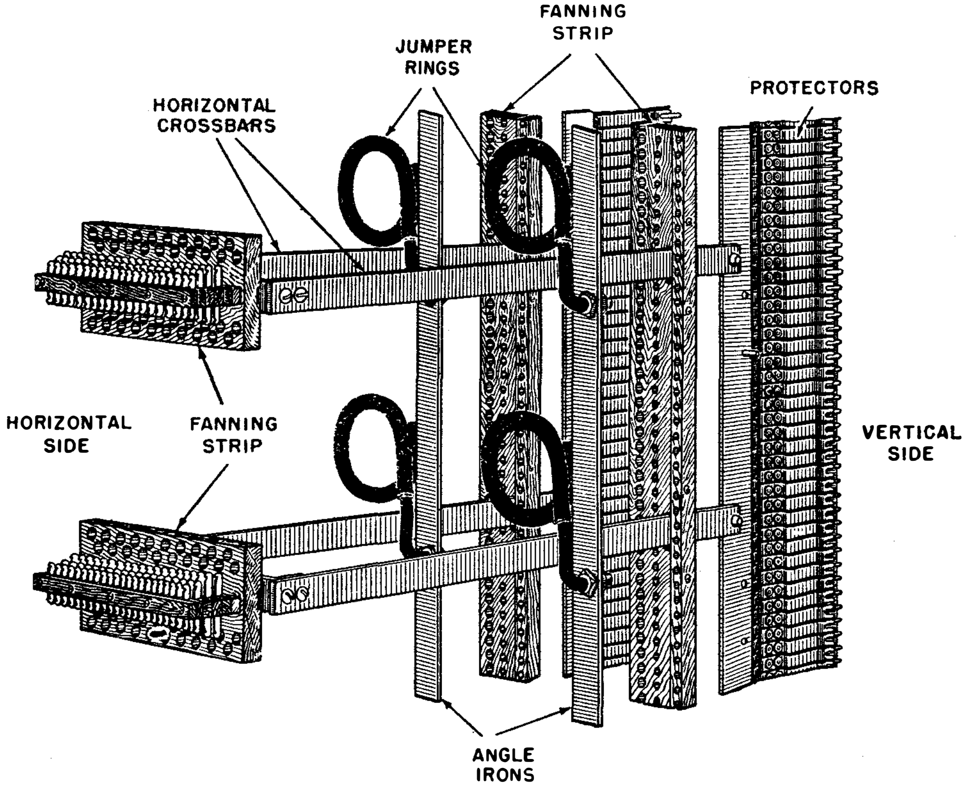


FIGURE IV-F-1. *Section of floor-type distributing frame.*

G. COMPLETE TERMINAL:

A simplified block diagram of a complete terminal is shown in Figure IV-G 1. The diagram is only a guide to the arrangement of major items-detailed layouts applicable to ICS will be covered later.

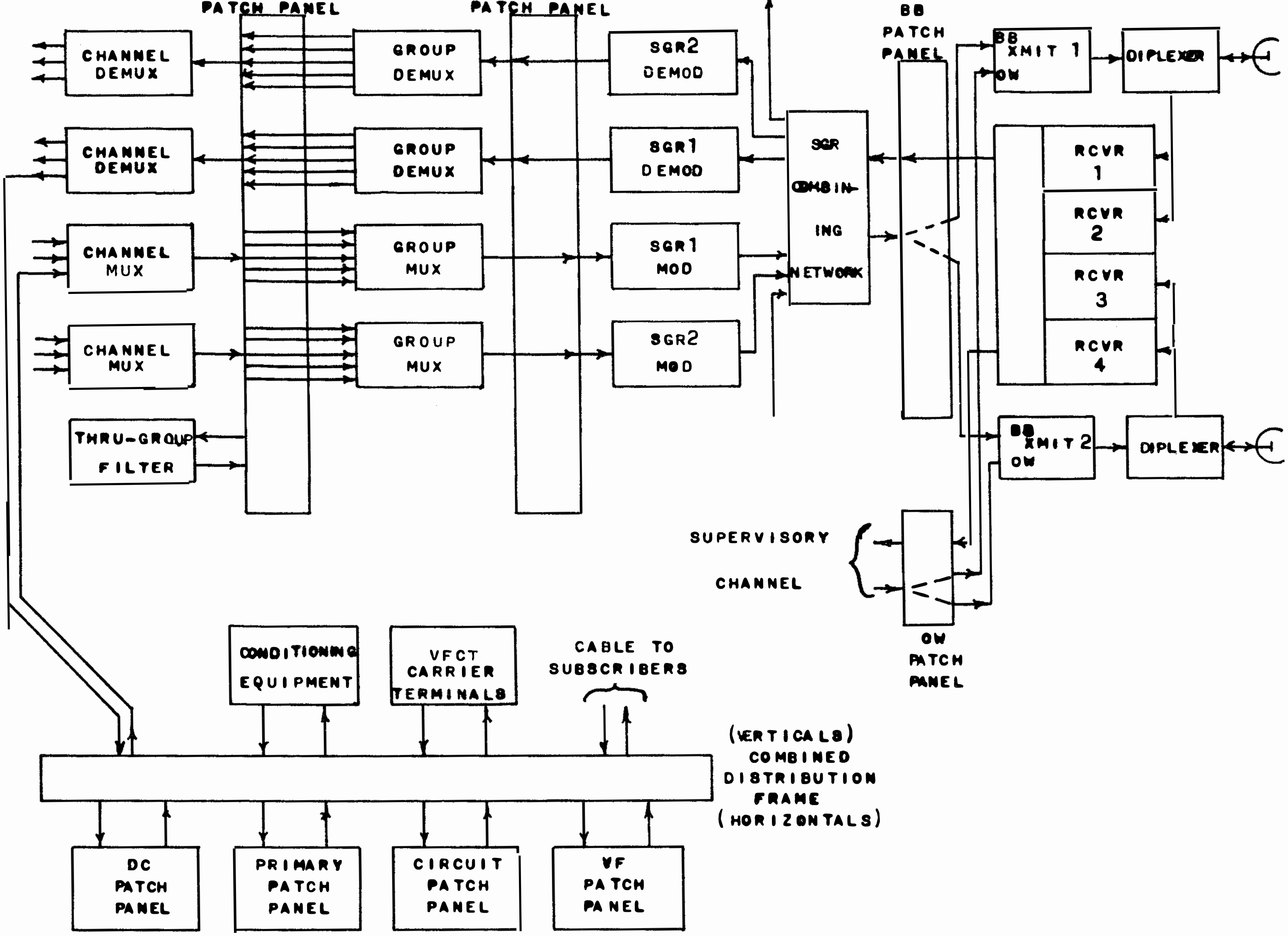


FIGURE IV-G-1 COMPLETE TERMINAL

V. TECHNICAL CONTROL

A. GENERAL:

Technical Control is a term that describes both a function and a physical area. The function is the coordination, operational control, and supervision of communication facilities, including the performance of tests and restoral of service, in consonance with operational requirements and procedures. The physical area is the area that contains the equipment and facilities that enable the technical control personnel to perform these functions.

The purpose of technical control is to provide the broad degree of system flexibility essential for consistent effective utilization of communication resources. Application of this function requires the capability to selectively utilize various combinations of available transmission facilities and terminal equipment.

Most terminal equipment has built-in patching jacks, meters, test points, and alarms that in themselves constitute a type of technical control facility. A technical control facility may be any area within a station where technical control functions are implemented.

The technical control element to be found in many ICS sites will not necessarily contain all of the equipment found in other systems. However, the technical control configuration of these stations should be essentially the same, whether the site is located at a transmission nodal point, an AUTOVON switching center, an AUTODIN switching center, or any combination of these.

B. TECHNICAL CONTROL FUNCTIONS:

Technical Control is responsible for the functions outlined in the following paragraphs.

1. Supervision of Transmission Quality:

In accordance with an established program, the technical control is responsible for circuit, equipment, and system tests to determine the operating condition of all circuits and equipment within the station, as well as all circuits passing through the station. Circuits that have deteriorated to the extent that service to the user is interrupted, and circuits that consistently fail to meet prescribed standards, are removed from service, and any equipment or components that are measured to be out of tolerance are reported to the appropriate maintenance section. Maintenance personnel are notified of any circuits or equipment not in active use that are found to be below standards during the quality control tests. With this approach, all equipment and circuits can be maintained at a level of peak performance at all times.

2. Substituting Equipment:

When equipment failures occur on operational circuits, it is necessary for technical control personnel to make equipment substitutions. Generally, user service can be restored more rapidly by equipment substitution than by attempting immediate repairs on faulty equipment. Equipment substitution also provides the opportunity for effecting any maintenance, scheduled or unscheduled, that might otherwise be impractical due to operational requirements.

3. Coordinating Maintenance:

Technical control personnel are involved in almost every aspect of operation at the ICS site. All user circuit requirements are known to these personnel. The inputs and outputs of most equipment appear at patch bays and testboards in the technical control area. All order-wires terminate on patch panels in the technical control area. For these reasons, the personnel at the technical control are in an ideal position to determine faulty circuits, detect equipment failures, and coordinate the accomplishment of repairs with the appropriate station maintenance sections. This includes guiding maintenance personnel to the defective equipment, reporting observed trouble symptoms, patching around the affected circuits (equipment substitution), assigning priority to the repair work, and coordinating maintenance activities with connected technical control facilities when circuits must be interrupted.

4. Accomplishing On-Call Patches:

A technical control may be required to provide an on-call patch in cases where switching facilities are not otherwise available. For example, the requirement may be for provision of circuitry for a TELECON--a type of on-call patch. The technical control facility tasked to provide the service is responsible for all arrangements incidental to completing the circuit to the desired station, for coordination as may be required during the course of the on-call patch or TELECON, and for coordination in the restoration of the circuitry to its original functions upon completion of the call.

5. Telegraph and Audio Channel Trouble Isolation:

Each technical control is responsible for the receive side of all circuits at the installation. If it is determined that the circuit is not operating satisfactorily, the personnel at the technical control will analyze the circuit to determine the trouble. When it is determined that a circuit is faulty, the technical control at the receive station will proceed as follows:

a. Coordinate with the distant technical control to stop traffic and make necessary tests to determine the quality of the circuit between the connected technical control facilities. If the circuit does not meet standards, restore service to the user on a spare channel or by preemption of a lower priority circuit when a spare channel is not available.

b. If the channel between the connected technical controls meets quality standards, the personnel at each technical control concerned will analyze the circuit between the stations and the connected user to locate the trouble. When circuit or equipment repairs have been completed, and when the circuit meets quality standards, normal service will be restored to the user.

c. When a circuit passes through a number of technical control facilities, each is responsible for connected circuits. However, the first technical control serving the complaining user is responsible for coordination until service is restored to the user (the user is responsible for notification of technical control when trouble appears on his receive side).

6. Circuit Rerouting

During extended outages, individual circuits are rerouted over other facilities in accordance with their restoration priority. Every circuit is assigned a restoration priority in accordance with JCS policy. To assist personnel at the technical control in visualizing the possible reroute paths available, circuit layout cards, block diagrams, and route maps are available at each technical control facility, showing trunks between connected stations and any appropriate extensions that would permit a reroute to be made.

7. Circuit Activations:

The technical controller activates circuits upon order of DCA to satisfy requirements of the military departments (and other government agencies). It is the responsibility of the technical controller (and particularly the technical control designated by DCA as coordinating station) to carry out the orders of DCA and to insure that all units involved in the activation do their part. If other units do not complete their portion of the required work, it is the responsibility of the technical controller to see that the matter is brought to the attention of higher authority. In like manner the technical control deactivates and rearranges circuits, as directed by DCA.

C. "H 500" CONCEPT OF TECHNICAL CONTROL:

You will often hear reference to the "H 500" concept of technical control and may well wonder just what it is. This method of referring to the technical control facility has arisen because the Defense Communication Agency publication specifying the design criteria and organization of the facility was, until recently, "DCS Technical Control Engineering Criteria", DECEO ENGR PUB H 500-12-64 (this manual was recently designated as DCA Circular 370-175-4 but is still referred to by most technicians as "H 500"). "H 500" does not cover the mechanical construction details of the equipment, but rather it is confined to specifying levels that will be present at various patch panels, what patch panels will be provided and how they will be arranged, what capabilities each patch panel must possess, etc.

Figure V-1 shows the general technical control functional flow as specified by "H 500".

Briefly, some of the more outstanding features of "H 500" are:

1. Patching and Testing Arrangements:

a. Cable Testboard (called the Primary Patch Panel in ICS)-Used to provide test and patching capabilities for local subscriber interconnects.

b. Voice Frequency Patch Bay - Permits direct access to the input and output of the multiplex equipment before any conditioning is performed.

c. Circuit Patch Bay - All voice frequency circuits are conditioned to appear in the circuit patch bay at equal levels (-2 dbm), and tone signalling appears as DC control signals (E&M leads). These "equi-level patch bays" are not being installed in Phase 3 ICS sites.

d. DC Patch Panel - All teletype circuits have appearance permitting monitoring or loop testing of both the line and the subscriber loop.

e. Group Patch Bay - Provides the capability for rerouting GROUPS.

2. Order Wires:

a. Local Voice Party-Line Order Wire - Essentially an internal system from the radio and multiplex facility to the technical control facility.

b. Express Voice Order Wire - Interconnects selected technical control facilities. May have automatic interconnection capability.

c. Party-line Data Order Wire - For the dissemination of circuit orders and circuit layout information.

d. Status Report Circuit - Connected to the responsible Operations Center.

3. Alarms:

a. Stations.

b. Radio.

c. Multiplex.

d. Equipment.

4. Standard Levels:

a. Voice Frequency Patch Bay:

Transmit	-16 dbm
Receive	+ 7 dbm

b. Circuit Patch Bay:

Transmit	-2 dbm
Receive	-2 dbm

c. Primary Patch Bay:

As required to properly interface with subscriber.

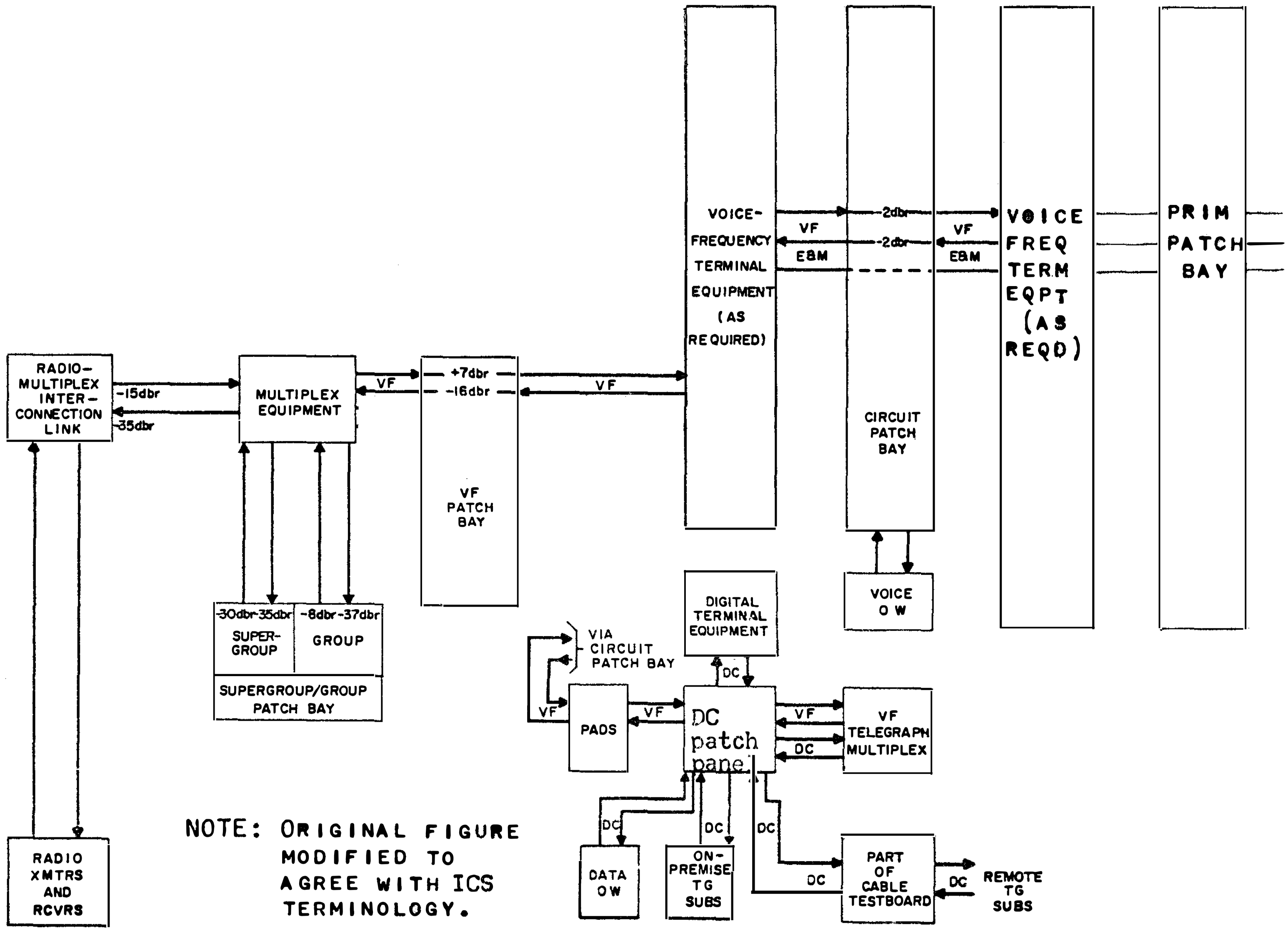
5. Equipment Criteria:

a. Standard names are given for labelling the various jack appearances.

b. Test equipment requirements are given.

6. Signalling:

Standard signalling frequency will be 2600 Hz with an E&M lead arrangement.



NOTE: ORIGINAL FIGURE MODIFIED TO AGREE WITH ICS TERMINOLOGY.

FIGURE V - 1. TECHNICAL CONTROL FUNCTIONAL FLOW DIAGRAM

D. <u>OUTLINE OF TROUBLE SHOOTING AND CIRCUIT RESTORATION RESPONSIBILITIES OF A CONTROLLER</u>:

1. Coordination.

2. Isolation.

3. Restoration.

TROUBLE SHOOTING PROCEDURES

1. Telegraph Circuit

a. Upon notification from sub:

(1) Initiate trouble ticket and assign number

(2) Notify distant sub through distant technical control

(3) Isolate trouble

(4) If channel trouble:

(a) Advise distant end

(b) Restore circuit by alt-route

(c) Test bad channel

(d) If bad:

1. Have break-out points check

2. Check local carrier and have distant end do same

3. Coordinate repair

4. Coordinate with user and restore to normal channel.

(e) If good:

1. Have distant end sub test

2. Check signal and coordinate with distant control to restore.

(4) If all channels bad:

(a) Log out system

(b) Advise distant end stop traffic on all channels and test.

(c) Advise local users

(d) Have Voice and VFCT MUX terminals check equipment and channel.

(e) Have Radio Link Terminal check path

(f) Check test from distant end

(g) Restore user service, by alt-route in accordance with restoration priorities, if tone pack not restored in 15 min.

2. Audio Circuit Trouble Isolation

a. Initiate trouble ticket and assign number

b. Notify distant sub through distant tech control

c. Isolate trouble

d. If between control and sub:

(1) Test local distribution system

(2) Isolate trouble

(3) Advise appropriate maintenance to repair

e. If between control and distant end:

(1) Have distant end tone channel

(2) If channel bad:

(a) Restore service on alt-route

(b) Contact break-out points and isolate

(c) Have proper maintenance repair

(d) Restore circuit to normal channel

(3) If channel good:

Have distant end check link to sub and restore.

REROUTING PROCEDURES

1. Individual controller has responsibility for initiating reroute action.

2. Restore by restoration priority and according to DCAC 310-55-1.

3. Reroute aids.

   a. Systems diagrams

   b. Patch panel labeling

   c. Circuit record cards

   d. Use complete circuit/system number to aid identification

VI CIRCUIT CONDITIONING

A. WHAT IS IT?

Some of the functions of circuit conditioning are:

1. Changing the amplitude of the signal.

2. Changing the form of the signal.

3. Special operations on the signal.

The first two functions are the means by which the signal is made to comply with the standards specified in H-500. Attenuators and amplifiers are used extensively to adjust the amplitude of the signal. The form of the signal is changed when, for example, 20 Hz ringing current is converted to a 2600 or 1600 Hz tone for transmission. Some of the special operations that are performed are 4-wire to 2-wire conversion in hybird units and echo suppression on extremely long circuits. Also included under special operations would be impedance conversion, extension of circuits to subscribers beyond the normal service radius, and reduction of delay distortion.

B. WHY?

The primary reason for conditioning has already been mentioned - to meet DCA standards as specified in H-500. But you might ask "Why is that necessary?" The rationale for having all circuits meet the same standards is to assist the technical controllers in performing their functions of supervision and testing of quality, substitution of equipment, on-call and circuit reroute patching, and trouble isolation. Can you imagine the confusion if every circuit appearing on the patch panel had its own peculiarities? The controllers patching capability would be severely limited to those circuits that "happened" to have the exact same characteristics.

Another major reason for circuit conditioning is "interfacing". This is a much-overworked term. Basically it means getting the signals from two different systems to a common set of specifications so that they may be connected together. This is a relatively common and easily accomplished task for the typical fixed-plant systems. However, here in Vietnam, we are continually faced with the "tactical-fixed-plant interface" problem. A large amount of effort has gone into solving these problems either through equipment modification or the arrangement of conditioning equipment in a special or unusual manner. Although many of these problems have been identified and solved, new ones are continually appearing. Some specific interface problems will be discussed in Chapter IX.

C. CONDITIONING EQUIPMENT:

1. Attenuators - A passive element used to reduce the amplitude of the signal. The attenuator or "pad", as it is often called, is usually in the form of an adjustable H or T-pad that maintains the same value of input and output impedence while allowing various amounts of attenuation to be obtained by changing the "straps" on the resistance elements. (See Figure VI-1).

2. Amplifier - An audio frequency amplifier is used to increase the strength of the signal. It is normally adjusted by a variable control.

3. Single Frequency Signalling Unit:

The SF Unit is used to place a tone on the line in response to a DC signal on the "M" lead (transmits) and to place a DC signal on the "E" lead (receive) when a tone on the line is detected (See Figure VI-2). The E&M leads may come directly from a switchboard with special trunking equipment, from a ringdown converter, or from another SF Unit

4. Ringdown Converter:

The E&M to 20-cycle signal converter connects a 2-way, 20 Hz ringdown circuit (or equivalent) to a signalling system over an M lead when a signal is received from the ringdown trunk circuit. Also, it receives signals over an E lead from a signalling circuit and transmits 20 Hz signals to a ringdown trunk circuit. (See Figure VI-3). This equipment may be arranged to operate with signalling frequencies other than 20 Hz, when required.

5. 4-wire Terminating Set-Hybrid:

A hybrid is a network arrangement that splits the energy in one path between two adjacent paths while offering high impedence between opposite paths (Figure VI-4). In telephone systems such a device is used to join a two-wire circuit and a four-wire circuit when the paths to the hybrid are connected as in Figure VI-4. There is a loss caused by the hybrid since the signal energy in each incoming path is divided between the desired output path and either the balancing network or the REC path input connection.

For proper operation, paths connected to opposite sides of the hybrid should have the same impedence characteristics. Meeting this requirement is the purpose of the "artificial line" or "balancing network" as it is commonly called. Most terminating sets have a built-in balancing network that provides a compromise impedence. However, the "balancing of a hybrid" can become quite critical. For this reason the balancing network is often adjustable or there are provisions for connecting a precision balancing network (Figure VI-5).

6. 4-way, 4-wire Bridge:

It is often necessary to connect more than two subscribers together. Multipoint circuits are very common here in Vietnam. In such a circuit all subscribers must be able to hear and talk to all others and be able to signal them. If the additional subscriber is merely connected into the 4-wire circuit as it goes through the technical control he will not have the full capabilities required (See Figure VI-6).

It is possible to obtain full service with a simple "solder-drop bridge" if it is done at the 2-wire level (See Figure VI-7). This arrangement usually works quite satisfactorily to obtain the talking paths; however, there is considerable difficulty in keeping the circuit balanced well enough for proper signalling operation.

A possible solution to the problem is to use a 4-wire bridge. These normally are designed to have 4-legs but some in the ICS have 6. Referring to Figure VI-8 it can be seen that the principle of the bridge is to provide a low loss path in the proper directions while providing high isolation against feedback. Of course, a high price is paid for dividing the signal power. The loss of the locally fabricated 4-4 bridges now used in ICS is 14-15 db on the low loss paths while providing over 60 db isolation.

If a leg of the bridge is not used, it is essential that it appear to the other legs as if it is. This is accomplished by placing a 600 ohm resistor across both the send and receive sides of all unused legs. This is called "terminating" the unused legs.

7. E&M Signal-Lead Extension Units (DX1 and DX2):

These signal-lead extension units are designed to interconnect two trunk circuits, when the distance between trunk circuits exceeds their operational limits. They are also used to interconnect an E&M signalling circuit (single-frequency unit) to a distant trunk circuit. E&M signal-lead extension circuits are usually required where the connecting facility (Cable) resistance exceeds 25 ohms. These circuits, which have been coded DX1 and DX2, are always used in pairs (a DX1 being connected to the trunk relay circuit and the DX2 being connected to a single-frequency signalling unit or other E&M signalling circuits). The maximum signalling range between E&M signal-lead extension circuits is 5,000 ohms. See Figure VI-9 for block diagrams of these units.

8. Isolation Relays:

DC isolation relays are used frequently in teletype systems when it is desired to have one dc signal control another. They are quite simple in principle (See Figure VI-10). Usually both normally - open and normally - closed contacts are provided on the output to permit greater flexibility. The bias winding is used to adjust the sensitivity of the relay. Shown in dotted lines is a variable resistor in the input and output circuits. These are used to control the current in these two circuits and are found as integgral parts of ICS VFCT equipment (the use of isolation relays will be covered in Chapter X "DC Circuits and Patch Panels").

9. Regenerative Repeaters:

"The primary function of the regenerative telegraph repeater is to retime and retransmit received signal impulses restored to their original strength. It is capable of receiving without error any set of signals that would be satisfactorily received by an ordinary teletypewriter, and of sending these same signals produced by the sending teletypewriter at the circuit terminal".*

Many of the teletype cryptological devices act as regenerative repeaters. This explains why crypto equipment will often work over a circuit not good enough for unsecure equipment.

10. Delay Equlaizers:

Delay equalizers are installed in several ICS sites in support of AUTODIN. Secure voice circuits also require delay equalization, but these equalizers are usually provided at the secure voice switch and at the subscriber's terminal.

The delay experienced by different frequencies within the message bandwidth is not constant. The principle of the delay equalizer is to add sufficient delay in the appropriate frequency ranges to make the total delay constant across the message bandwidth.

11. Pulse Link Repeater:

Pulse Link Repeaters were originally installed in ICS sites to interface the E&M leads when two SF Units were operated back to back. After insatllation, it was discovered they were not really necessary. Page Communications Engineers issued a Field Engineering Work Order (FEWO 226) modifying the PLR's to function as isolation relays for the instances when M leads are extended from the EE to the subscriber and AC signals are being introduced on this lead. These AC signals may interfere with SF Unit operation and must be isolated. Refer to LL S&P Item No. 0214, for installation and use of these modified PLR's.

12. Thru-Group Filters:

Although you might not think of thru-group filters as conditioning equipment, they are. The filtering action taking place is a bandpass from 60-108 kHz to eliminate the noise above and below the frequency range of the group. The thru-group filter may also include a rejection filter network to block the group pilot if necessary.

* From Principles of Electricity Applicable to Telephone and Telegraph Work, A.T. &T. Co., 1961

13. Echo Suppressors:

There are many possible sources of echos in a complex communication system. A common example is an unbalanced hybrid. Echos are normally not objectionable since they occur so quickly; however, if the circuit is an extremely long one, such as through a satellite or the undersea cable, the echo can cause extreme degradation of service. Echo suppressors are installed on the satellite circuits to prevent this problem.

14. Limiters:

In carrier systems, momentarily large peak values of signal power might cause poor communication if networks called "limiters" were not employed. Limiters automatically reduce the large peak values. A limiter is used in the voice-frequency channel, for example, to prevent overloading of the common transmitting amplifier.

The limiters commonly used in telephone carrier equipment are copper-oxide varistors or germanium-crystal diodes. When a limiter is placed on a circuit it is important to be able to remove it quickly and easily without disturbing the circuit operation. This may be done with either special "lifting jacks" or key switches.

D. TYPES OF CIRCUITS:

The basic equipment that is used in the ICS is not very much different in principle from that used with transportable tactical systems. The primary difference is that the various pieces of conditioning equipment are not built into the multiplex terminal. Rather, they are available as "building blocks" that are arranged as necessary to assemble the specific type of circuit being installed. In this section some of the types of circuits found here in Vietnam will be described.

1. Common Characteristics:

The characteristics common to most ICS circuits are those specified in H500:

a. All VF multiplex appears at the same levels:

Receive	+7 dbm
Transmit	-16 dbm

b. In-band single frequency signalling is used.

c. In TCG's built prior to Phase III all multiplex channels have an appearance on the equi-level CKT PATCH PANEL as well as on the VF PATCH

PANEL. Both sides of the circuit are at - 2DBM on the CKT PATCH PANEL. All signalling appears as DC control signals on the E-M leads at the CKT PATCH PANEL.

d. Phase III EE buildings do not have equi-level CKT PATCH PANELS. The E and M leads appear on the VF PATCH PANEL which is a six wire layout.

2. Standard Circuit

There are several types of circuits that occur so frequently in the ICS that they have been "standardized". These have been selected as standard circuit configurations for technical control layout and are described in RCG LL S&P Item Nr. 0241. The details as to types of equipment to be used, their values, and the levels to be set are given there. For this reason, the only equipment shown in the sketches in this section will be that essential to the discussion. All the amplifiers and attenuators used to obtain the desired levels will not be shown.

3. **ICS** Signalling:

Signalling is accomplished in the **ICS** by transmitting either a 2600 Hz or 1600 Hz tone over the V.F. channel between single frequency signalling units in the circuit terminal tech control facilities. The standard signalling frequency is 2600 Hz; however, due to the wide use of 1600 Hz signalling in tactical systems, provisions have been made to incorporate this signalling frequency also in the **ICS.** The terminal signalling units, called SF units, are arranged for "E&M" signalling as described in subsequent paragraph.

4. The "E&M" Signalling System:

Transmission of ringing signals over the 4-wire VF channel is most efficiently accomplished by using a VF tone of 2600 Hz in the voice band. At either VF channel terminal the 2600 Hz signalling tone is converted to DC signals more suitable for use by the switchboard trunk equipment. These signals are transmitted over 2 wires separate from the voice path between the switchboard trunk circuit and the VF channel signalling unit. These leads are designated "M" for signalling toward the VF channel and "E" for signalling toward the switchboard trunk circuit. The entire signalling system is call "E&M" signalling and the 2600 Hz unit is called a 2600 Hz SF (single frequency) unit. Among the advantages of such a system is the ease with which the E&M lead signals can be adapted to many types of trunk equipment. The basic E&M signalling layout is shown in Figure VI-12. In this configuration the E&M leads are extended directly into the switchboard, and all in and out signalling is accomplished by dc signals on these lines. The E and M lead conditions used in the **ICS** for ringdown circuits are not those established as standard by DCA. (See Chart on next page for **ICS** and standard E&M lead configurations).

CONDITION	"M" TOWARD SF	TONE	"E" FROM SF
ON HOOK	GRD	ON	GRD
OFF HOOK	OPEN	OFF	OPEN

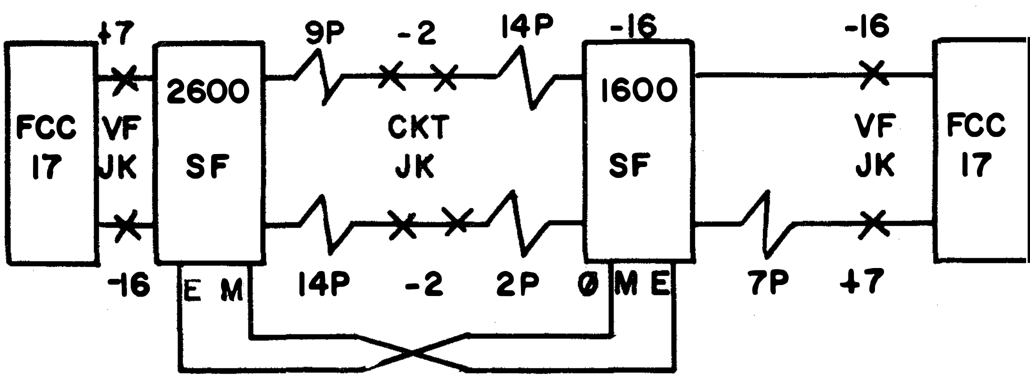
ICS E-M LEAD (Ringdown Circuits Only)

CONDITION	"M" TOWARD SF	TONE	"E" FROM SF
ON HOOK	GRD	ON	OPEN
OFF HOOK	BATT	OFF	GRD

STANDARD E-M LEAD

Thus in the idle or off hook state we, in the **ICS**, have tone-off the line. (Note: Off hook is the idle condition for ringdown circuits only).

Why do we have this non-standard situation? Basically it was brought about by the requirement to interface 2600 Hz and 1600 Hz signalling on the **ICS**. No pulse link repeaters were provided in Phases I and 2, thus requiring the interface to be accomplished as shown below (See VI-B-11 and Figure VI-11 for discussion of pulse link repeaters):



Note how the E and M leads are "rolled" (reversed) between the SF units. Now if the standard E and M lead conditions were used, each M lead would be keyed by "opens" and "grounds" from the E lead which is fine, but the standard condition is E lead grounded in the off hook state (no tone). Thus if the standard option were used this E lead ground would be connected to the second SF unit's M lead. Therefore since a ground on an M lead is an on hook condition, incoming off hook would be sent out as an on hook condition and we have falsely signalled. For this reason then, **ICS** E lead conditions are grounded for on hook and open for off hook.

Bear in mind that this discussion has covered E&M lead conditions for ringdown circuits only. Dial circuits utilize the standard E&M lead option. Phase 3 provides pulse link repeaters for working SF sets back to back and E and M lead conditions could be standard. In Phase 3 sites, the E and M leads will be standard, but in Phase 1 and 2 sites the changeover may not be made. It would require modification of all ring down converters and all SF sets, except those used on dial circuits.

5. 2 Wire Ringdown Circuit:

The E&M signalling system may be adapted to 20 Hz signalling for use in tacical switchboards and other subscriber equipment requiring a 20 Hz signal by using a converter in the 2-wire line of the switchboard trunk as shown in Figure VI-13. 20 Hz is now used to signal in both directions with the E&M leads operating between the 20 Hz converter and the SF unit as shown. When this signalling system is used there is tone on the line only when a subscriber is signalling with 20 Hz (i.e; tone-off while idle). All existing tactical manual switchboards in Vietnam use 20 Hz signalling.

6. Operator Direct Dial Circuit (ODD):

The new dial central offices (DCOs) being installed in Vietnam use a form of E&M signalling directly into a dial trunk relay equipment. Figure VI-14 applies to the E&M system used in dial-to-dial trunk operation. While the line is not in use, on hook, there is ground on the M lead and tone on the line, ie; tone-on while idle. (note: on hook is the idle condition for dial circuits). When the operator plugs into the line, the tone is removed and the distant end receives a ground which causes the dial equipment to seize a line. The dc dial pulses are converted into tone pulses which are detected at the distant end as dc dial pulses used to activate the dial equipment.

7. E & M Lead Extension:

When the cable resistance between the E&M Signalling unit and the subscriber trunk relay equipment exceeds 25 ohms per wire it is necessary to use E&M signal lead extension circuits (DX-1 and DX-2). The use of these circuits will extend the operational limits of the E&M signalling to 5000 ohms. These units are always used in pairs with the

DX-1 at the subscriber trunk relay equipment and the DX-2 at the E&M SF signalling unit. Figure VI-15 shows a method of using DX units in a trunk circuit.

8. Multipoint Voice Circuits:

In a multipoint circuit, it is important that all subscribers be able to signal each other as well as talk. The most satisfactory manner to accomplish this is with a 4-wire, 4-way bridge (see Figure VI-16). In an emergency, it is possible to make a simple two-wire tap by converting the circuit down to two wires at the technical control; however, this usually results in poor signalling performance. Note that all unused legs of the 4-4 bridges must be terminated by a 600 ohm impedence.

9. Signalling Frequency Interface:

Although most of the ICS technical controls are equipped with both 2600 and 1600 Hz signalling units, there are still some situations where it is necessary to make a conversion of signalling frequency. This can be accomplished by the use of two SF units if the E&M leads are used to control each other (this subject was briefly discussed in paragraph 4, page VI-7). Using the modified Collins signalling equipment in the ICS EE buildings it is possible to interconnect the E lead to the M lead directly (Figure VI-17b).

10. 4-Wire Subscribers:

There are several types of subscribers here in Vietnam who desire a 4-wire "drop". A common example of this is the full-duplex data circuit. Providing such service is no problem in the ICS unless signalling is required.

If E&M signalling is to be employed, the circuit is relatively simple (Figure VI-18a). However, if 20 Hz signalling is required, it is necessary to use two ringdown converters and connect the E&M leads to the appropriate unit (Figure VI-18b).

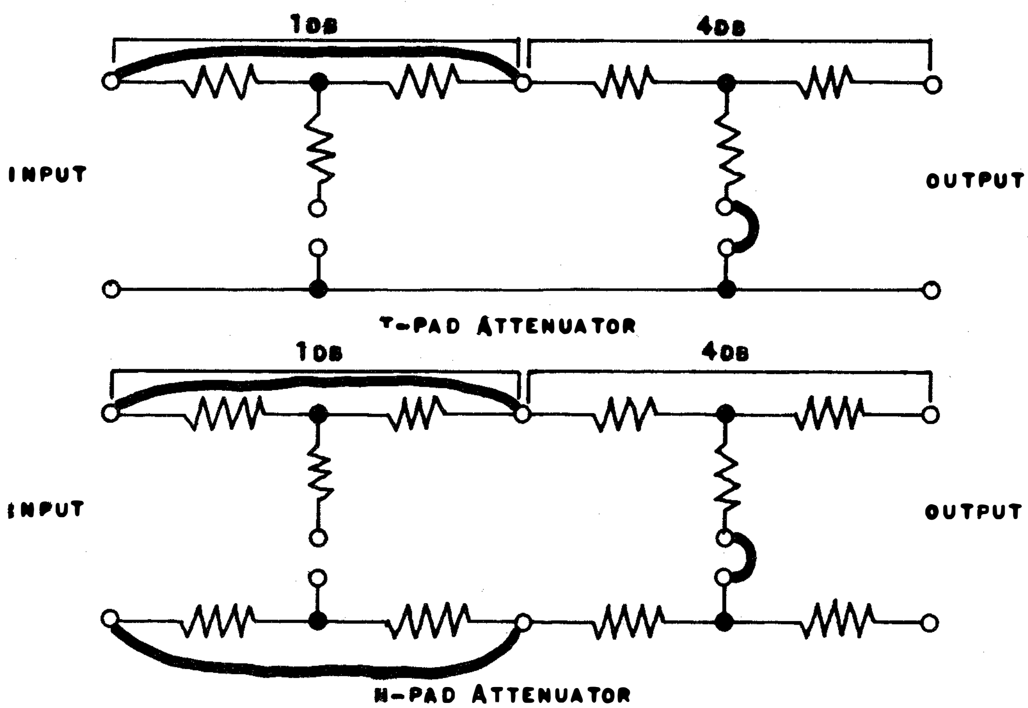


FIGURE VI-1. ADJUSTABLE ATTENUATORS (STRAPPED FOR 4DB LOSS)

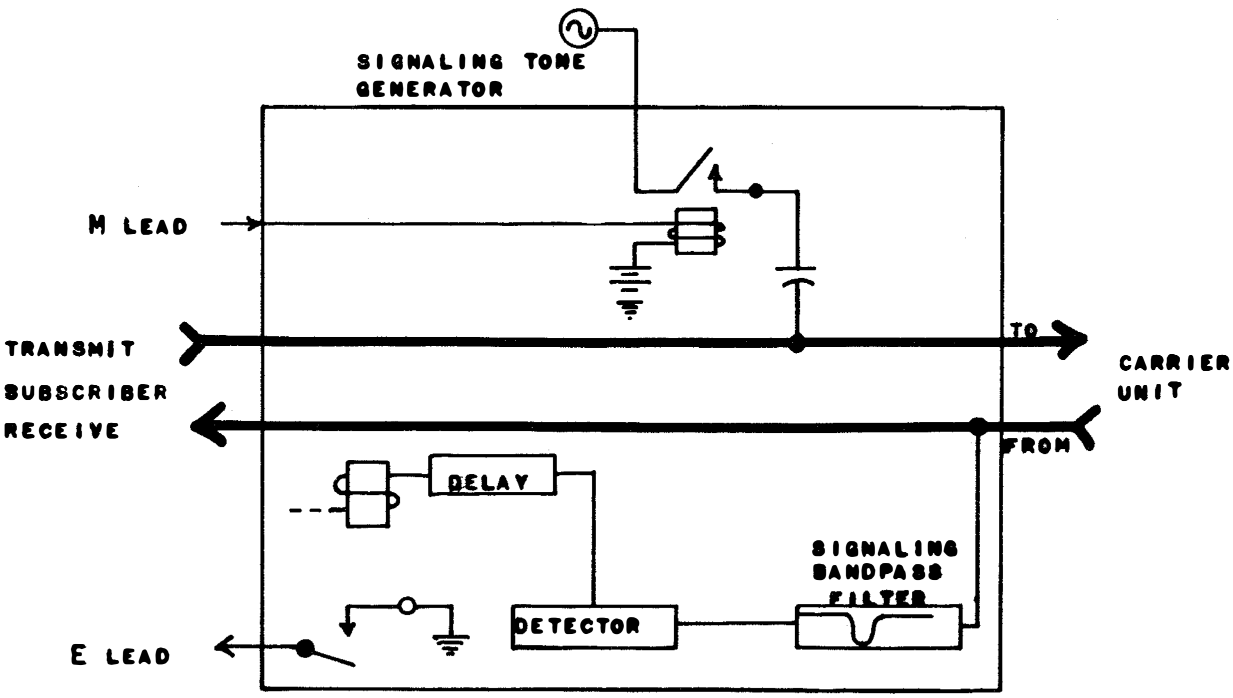


FIGURE VI-2 SIMPLIFIED SF UNIT.

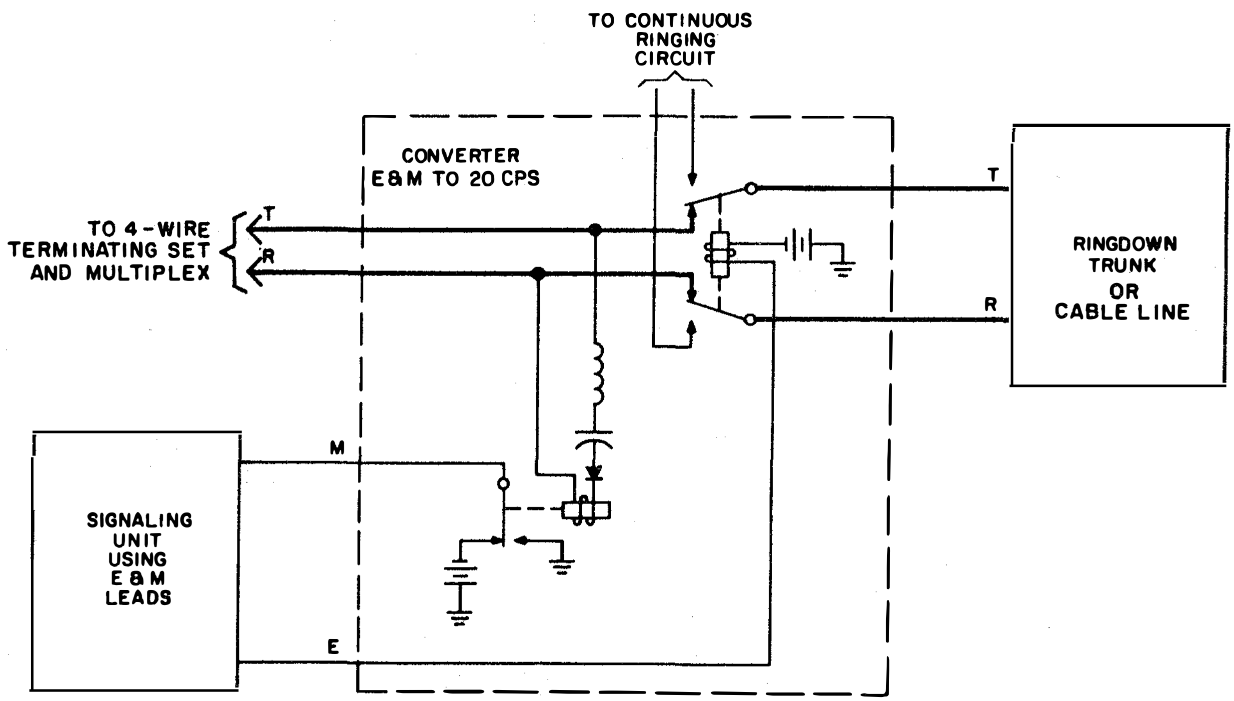


FIGURE VI - 3. SIGNAL CONVERTERS - E&M TO DC AND E&M TO 20 CPS, TYPICAL ARRANGEMENT

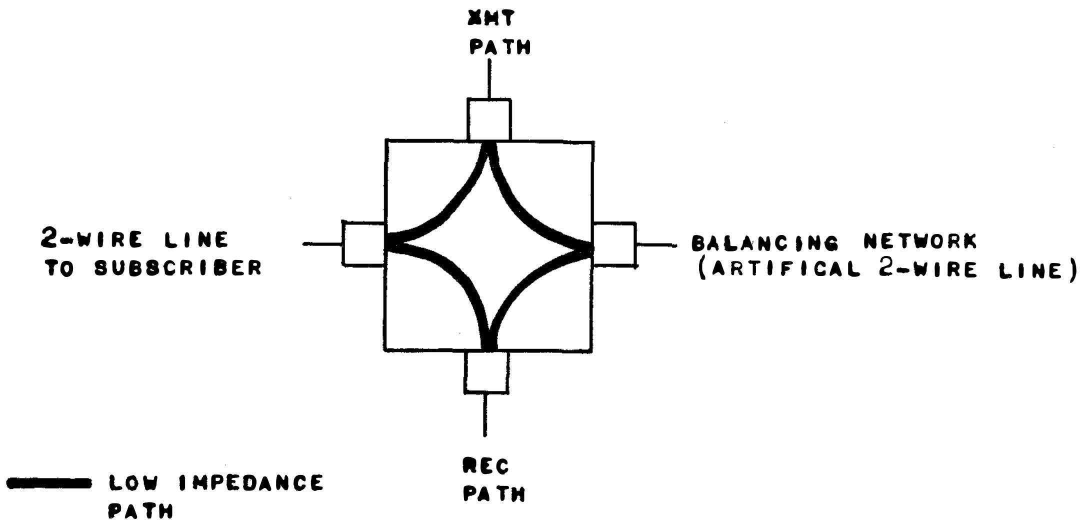


FIGURE VI-4 HYBRID

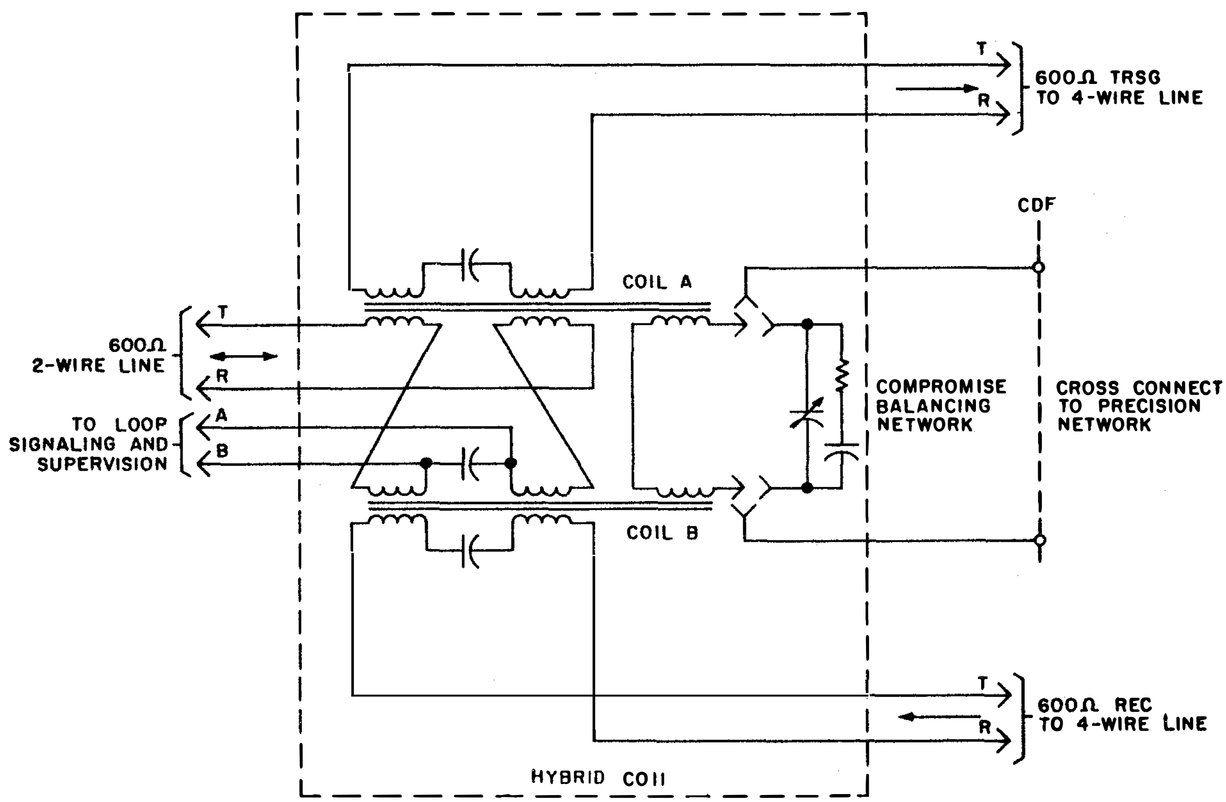
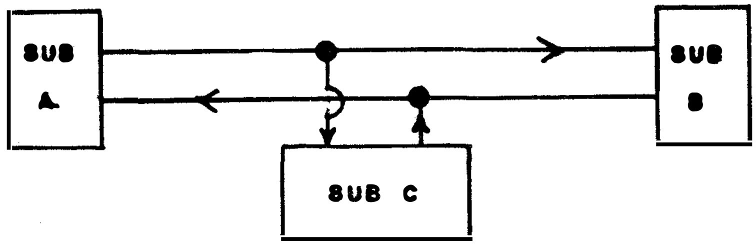
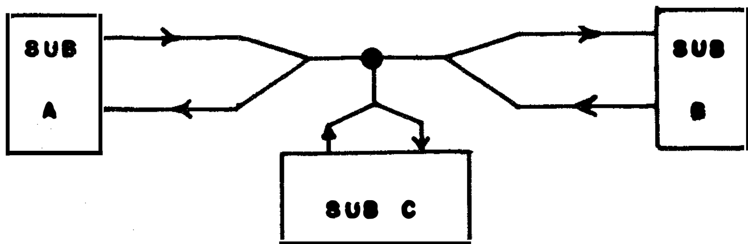


FIGURE VI - 5. FOUR-WIRE TERMINATING SET



SUB C CAN HEAR AND TALK TO ONLY SUB A
NOTE: SINGLE LINE REPRESENTS A PAIR OF CONDUCTORS

FIGURE VI-6 IMPROPER MULTIPOINTING.



NOTE: SINGLE LINE REPRESENTS A PAIR OF CONDUCTORS.

FIGURE VI-7 "SOLDER-DROP BRIDGE" USED IN MULTIPOINT CIRCUIT.

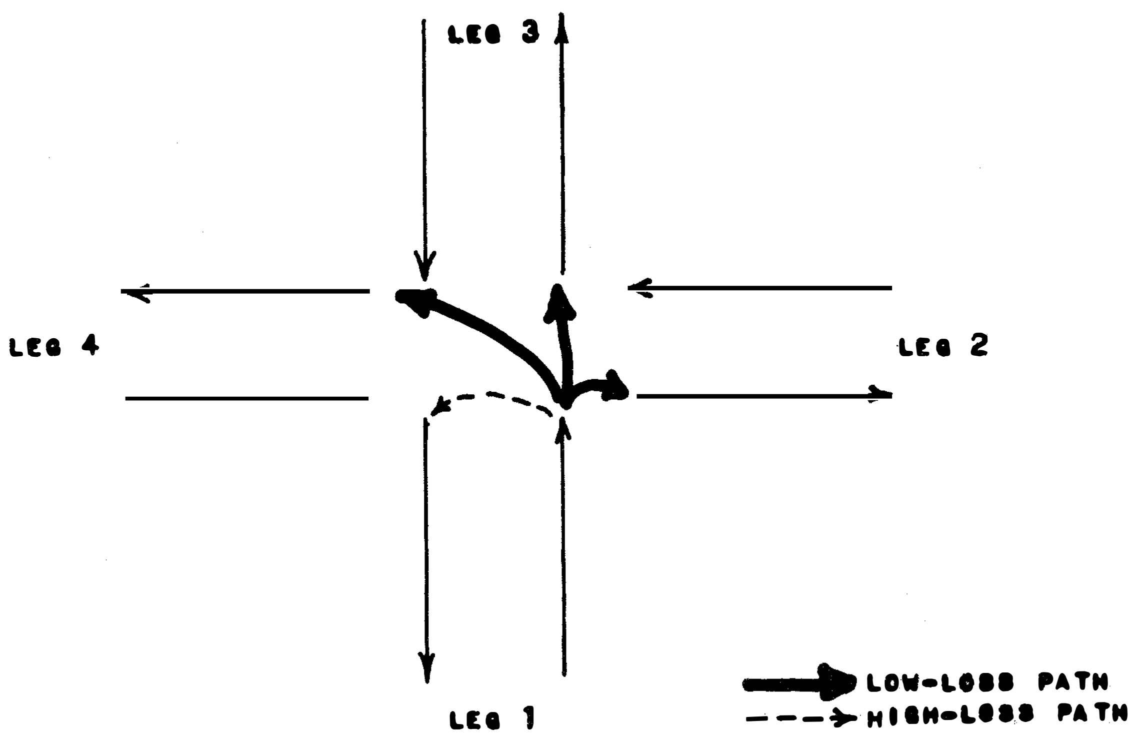
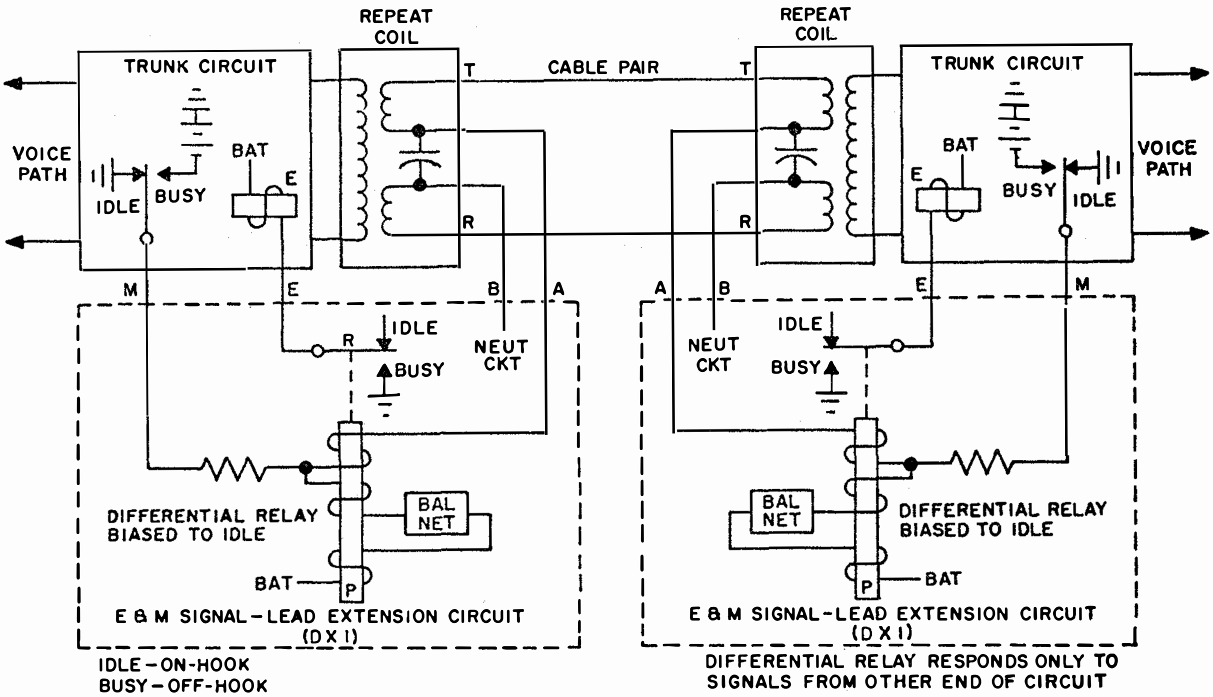
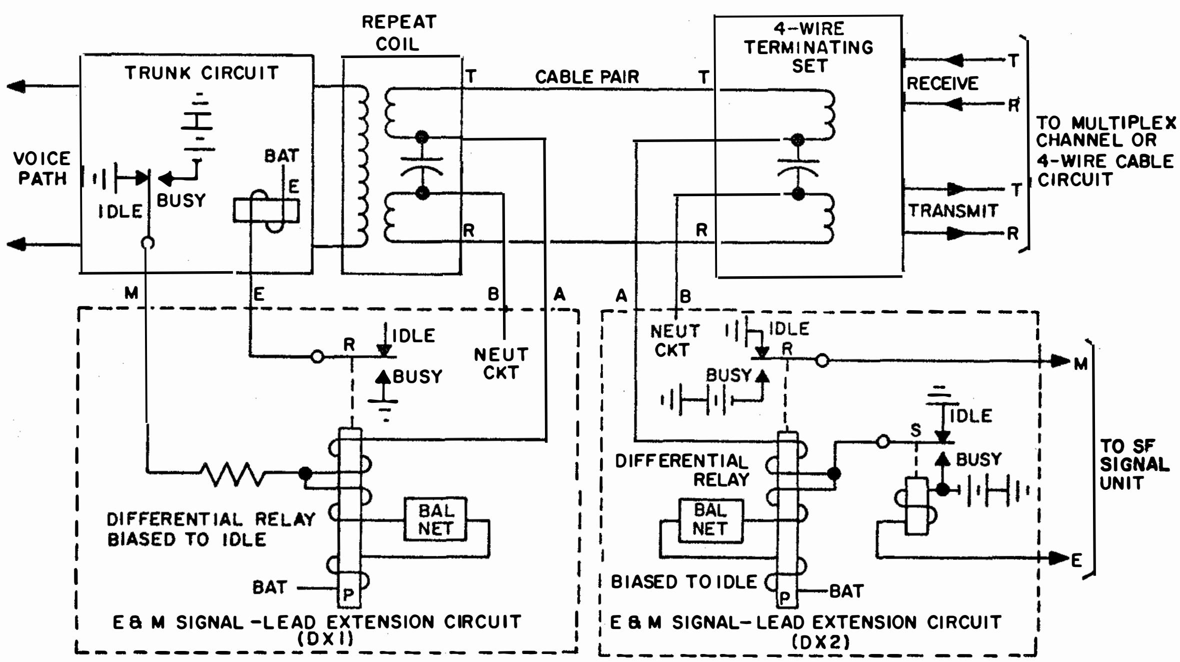


FIGURE VI-8 4-WAY, 4-WIRE BRIDGE, FUNCTIONAL DIAGRAM.



INTERCONNECTION OF TWO TRUNK CIRCUITS



EXTENSION OF SIGNAL LEAD FUNCTION

FIGURE VI - 9. E&M SIGNAL-LEAD EXTENSION CIRCUITS, TYPICAL ARRANGEMENTS

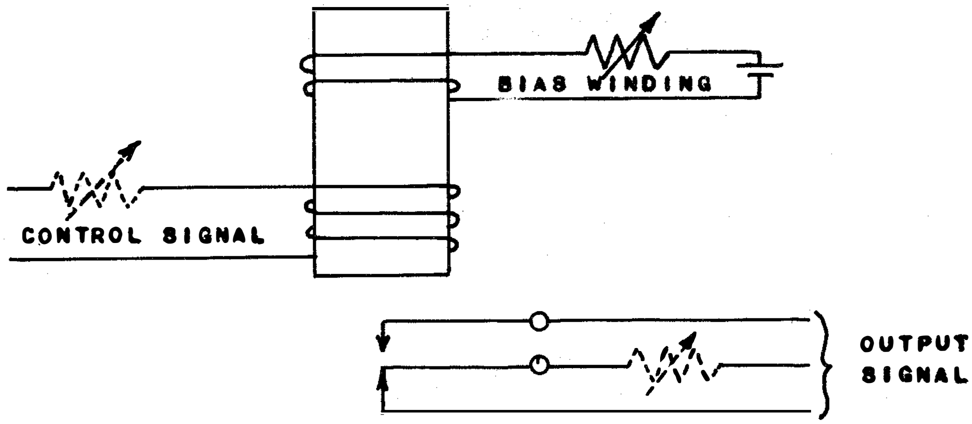


FIGURE VI-10 DC ISOLATION RELAY.

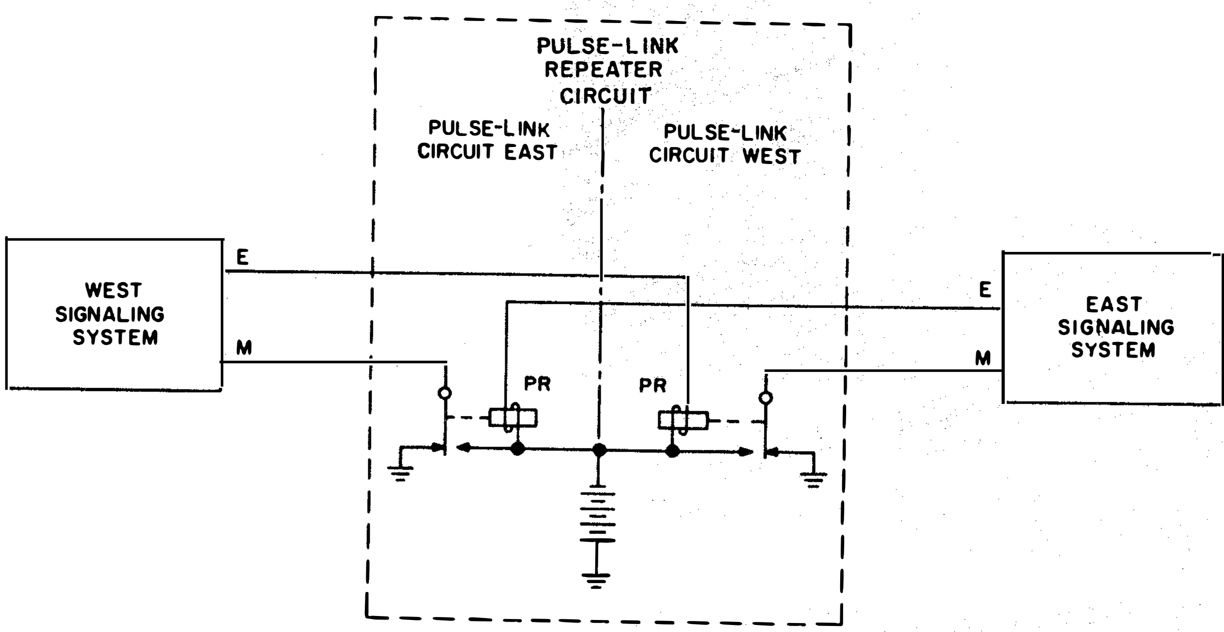


FIGURE VI-11. PULSE-LINK REPEATER, TYPICAL ARRANGEMENT

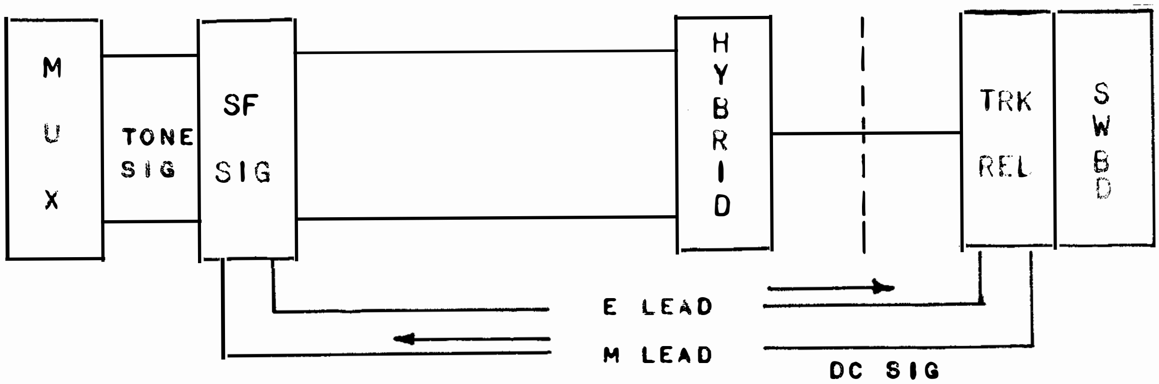


FIGURE VI-12 BASIC E&M SIGNALING

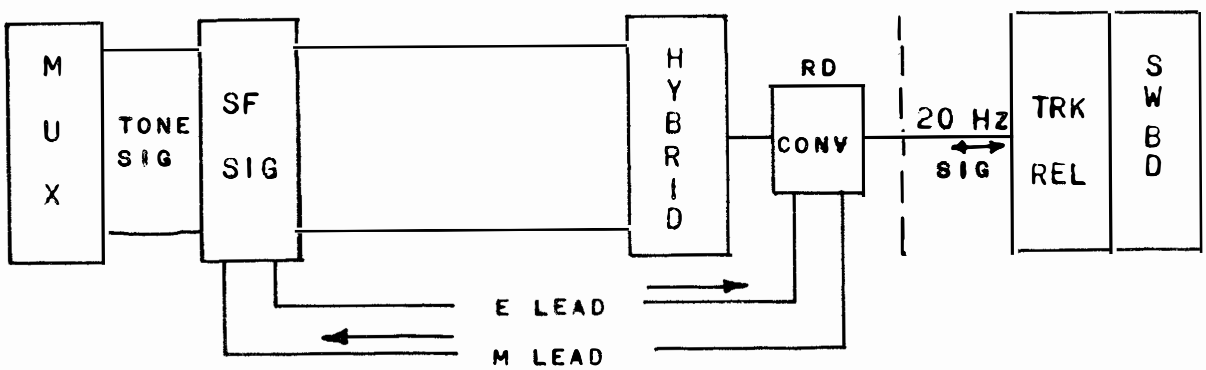


FIGURE VI-13 20Hz RINGDOWN SIGNALING

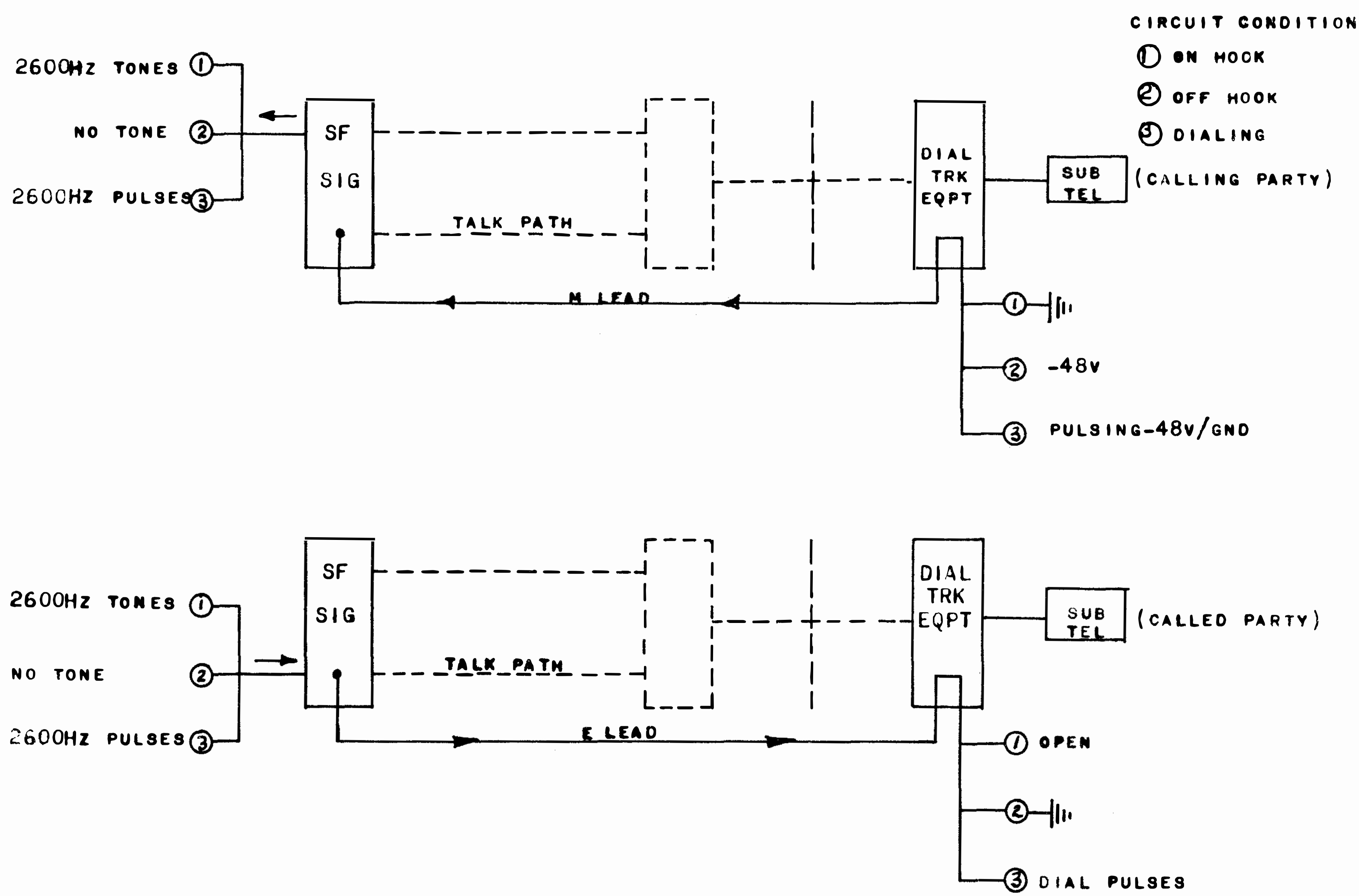


FIGURE VI-14 DIAL-TO-DIAL TRUNK SIGNALLING E&M LEAD OPERATION

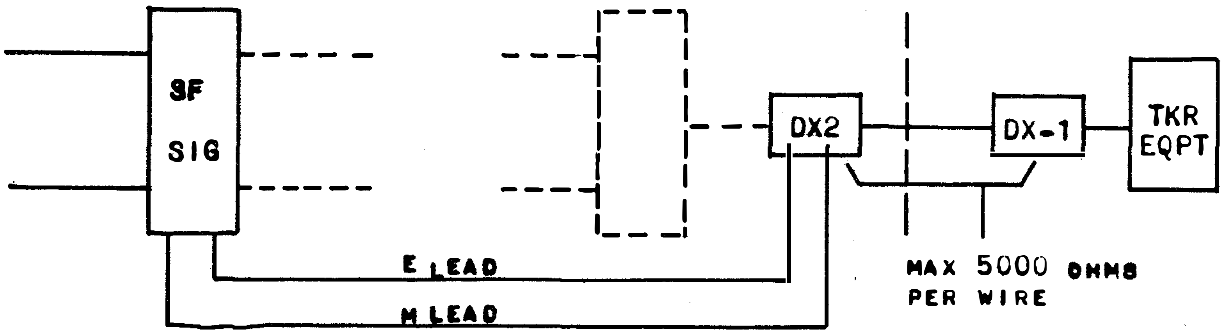


FIGURE VI-15 E&M LEAD EXTENSION UNIT DX-1, DX-2.

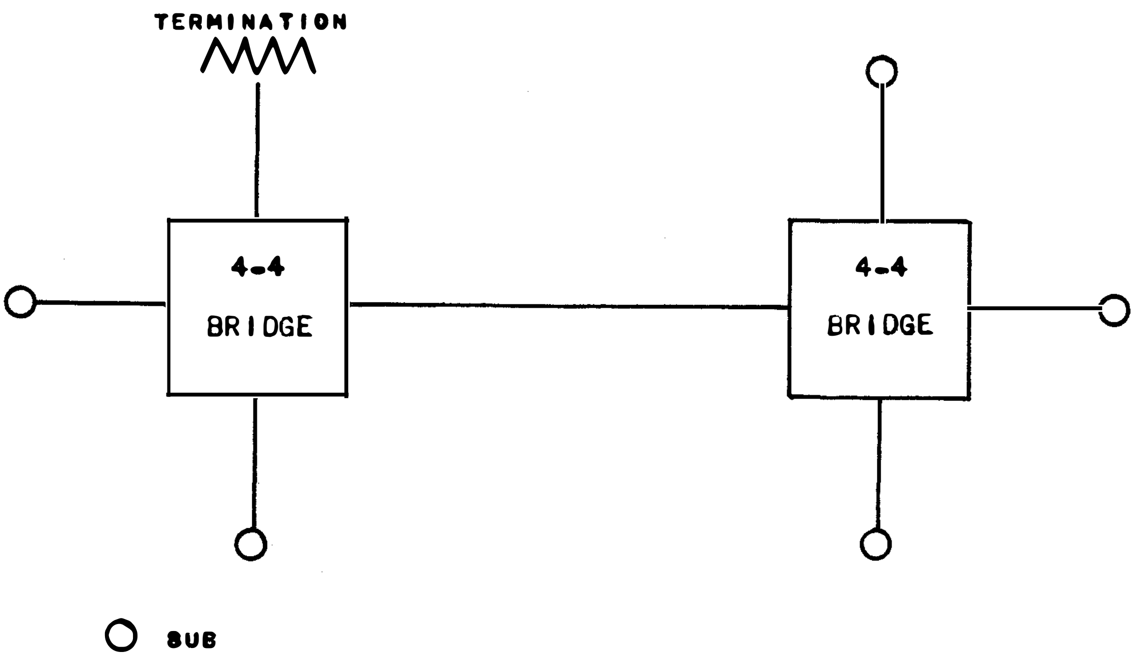
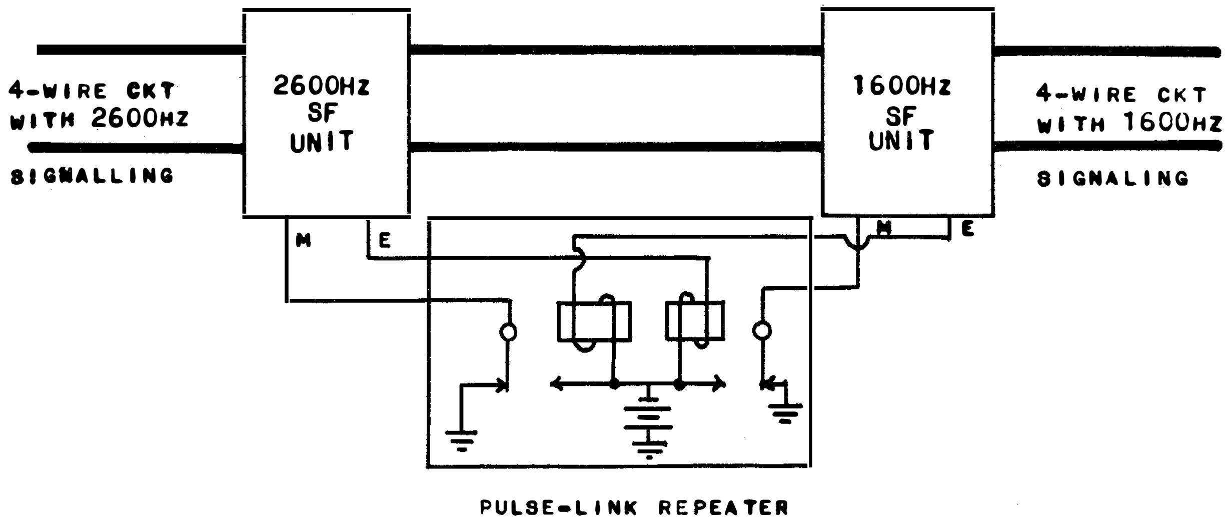
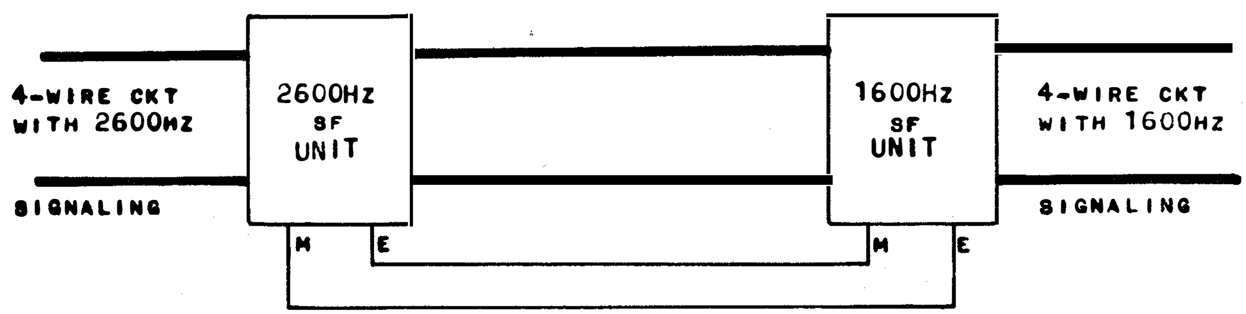


FIGURE VI-16 MULTIPOINT VOICE CIRCUIT

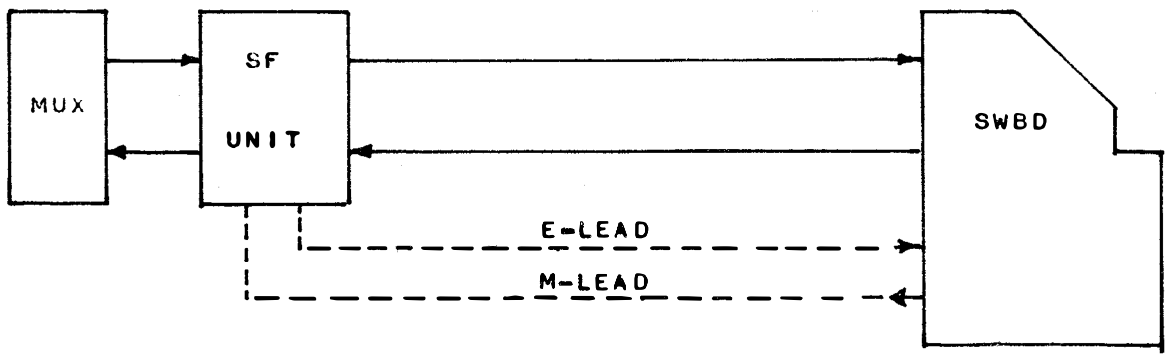


A. Using Pulse-Link Repeater

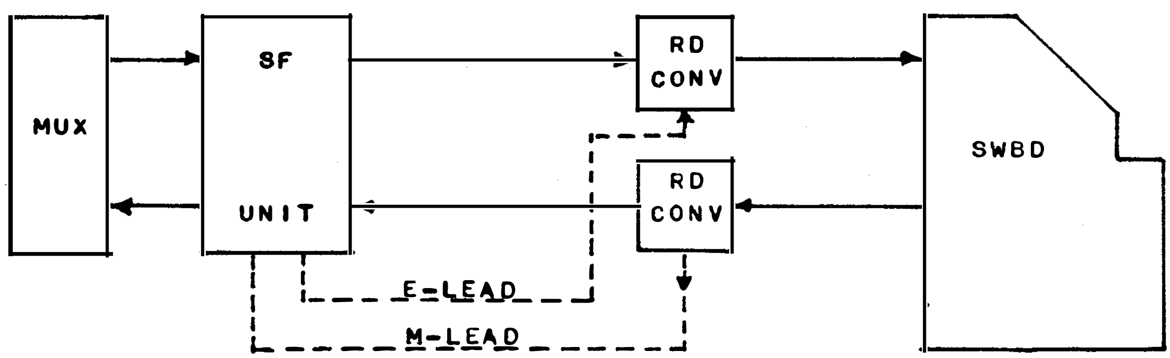


B. Using ICS Modified Collins Signalling Units

Figure VI-17 Signalling Frequency Interface



A. E&M SIGNALLING



B. 20 Hz RINGDOWN SIGNALLING

FIGURE VI-18. FOUR-WIRE SUBSCRIBER.

VII. ICS EQUIPMENT

A. INTRODUCTION:

Most of the ICS equipment at each site is located in the Electronic Equipment Building commonly referred to as the "EE Building". It is here that are found the:

Radio terminals

Voice frequency multiplex terminals (MUX)

Voice frequency carrier telegraph terminals (VFCT)

Conditioning equipment

Patch panels and test positions

Although some of the circuits going through the ICS may be carried over "Non-ICS Systems", pieces of transportable or tactical equipment are not normally found in the EE building. They are located elsewhere and their circuits enter the EE Building through a tie cable to the Army Area System Technical Control. The equipment found in the EE Building is fixed-plant equipment purchased specifically for the ICS contract with the exception of some multiplex equipment associated with the AN/MRC-85's of the BACKPORCH System which have been removed from the vans and installed in the EE Building.

The EE Building is usually divided into two large areas (Figure VII-A-I):

1. Technical Control Room (Figure VII-A-2)

2. Radio and Multiplex Room (Figure VII-A-3)

On the following pages brief descriptions will be given of the items of equipment that are found at the various ICS sites.

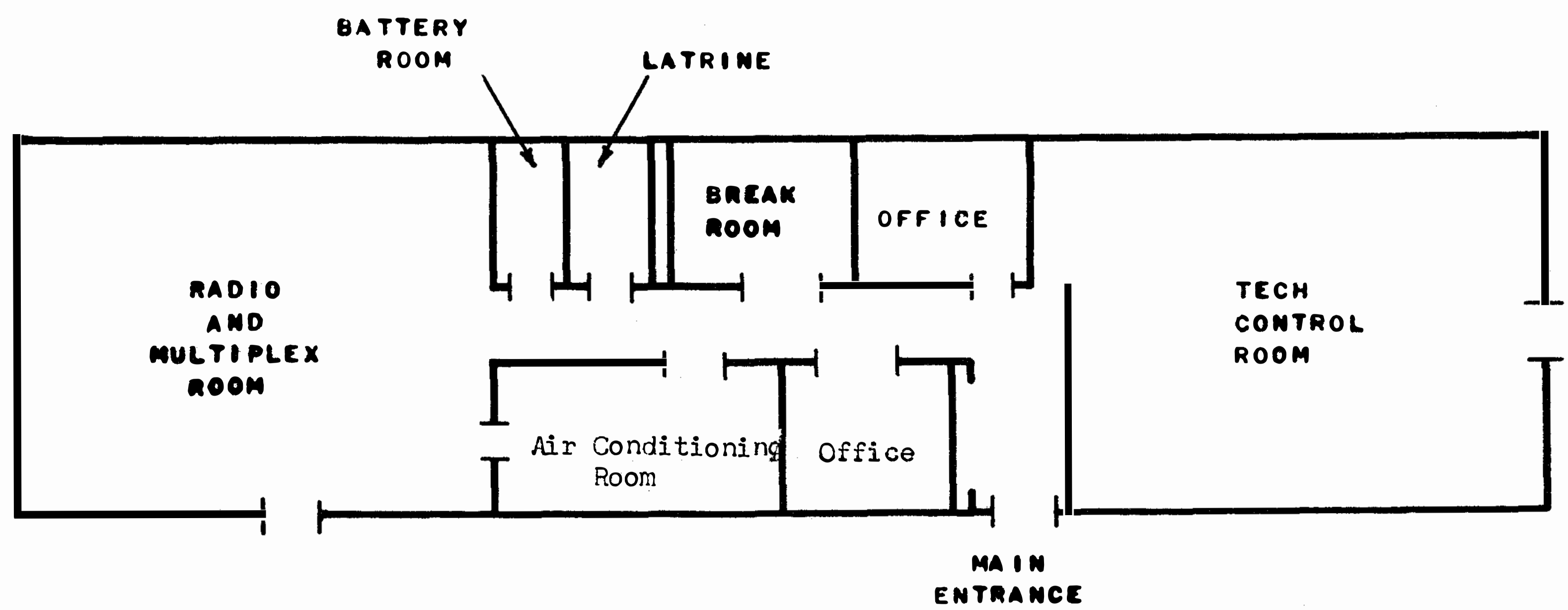


FIGURE VII-A-1 TYPICAL ELECTRONIC EQUIPMENT BUILDING

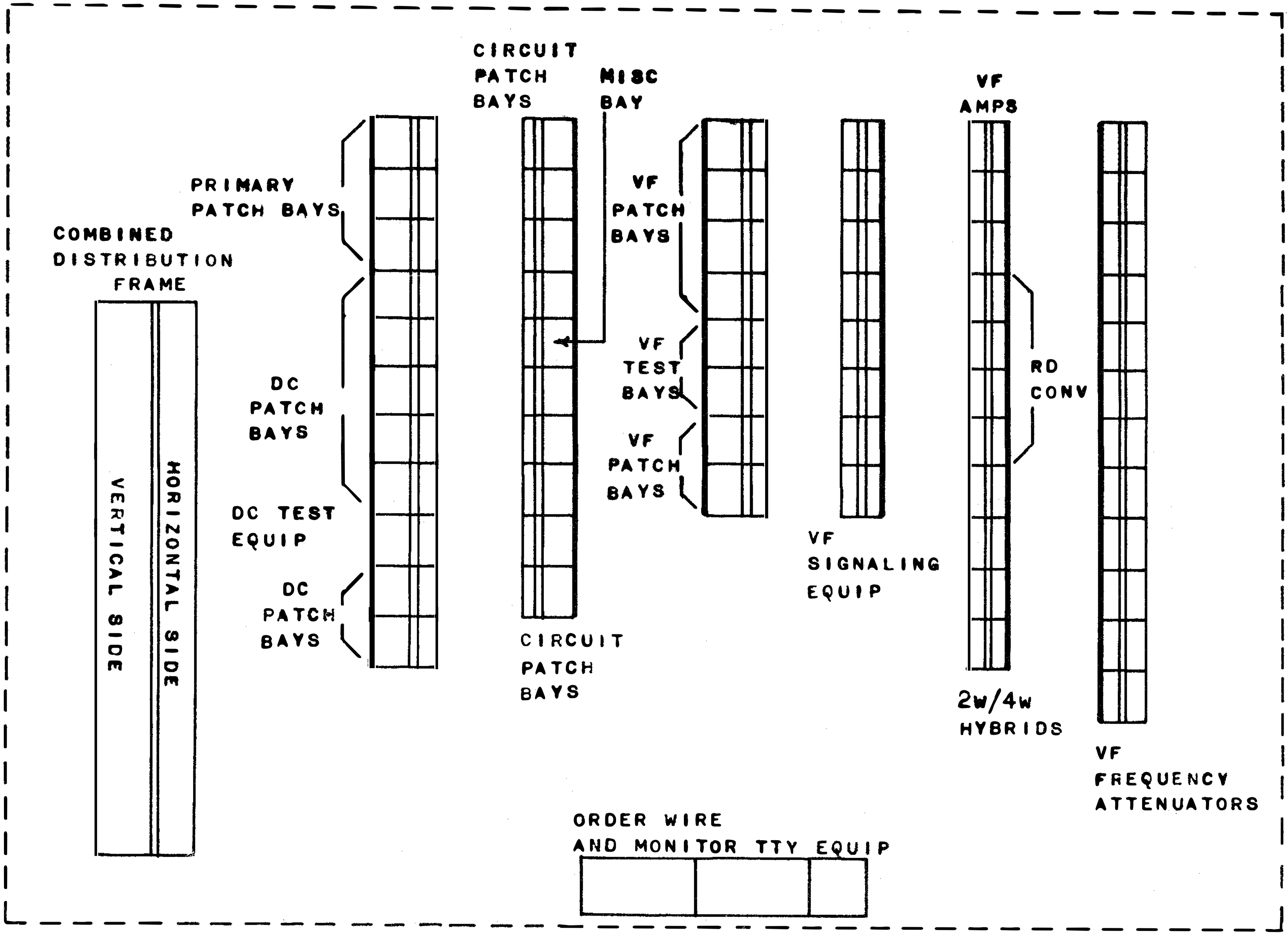


FIGURE VII-A-2 TYPICAL TECHNICAL CONTROL ROOM

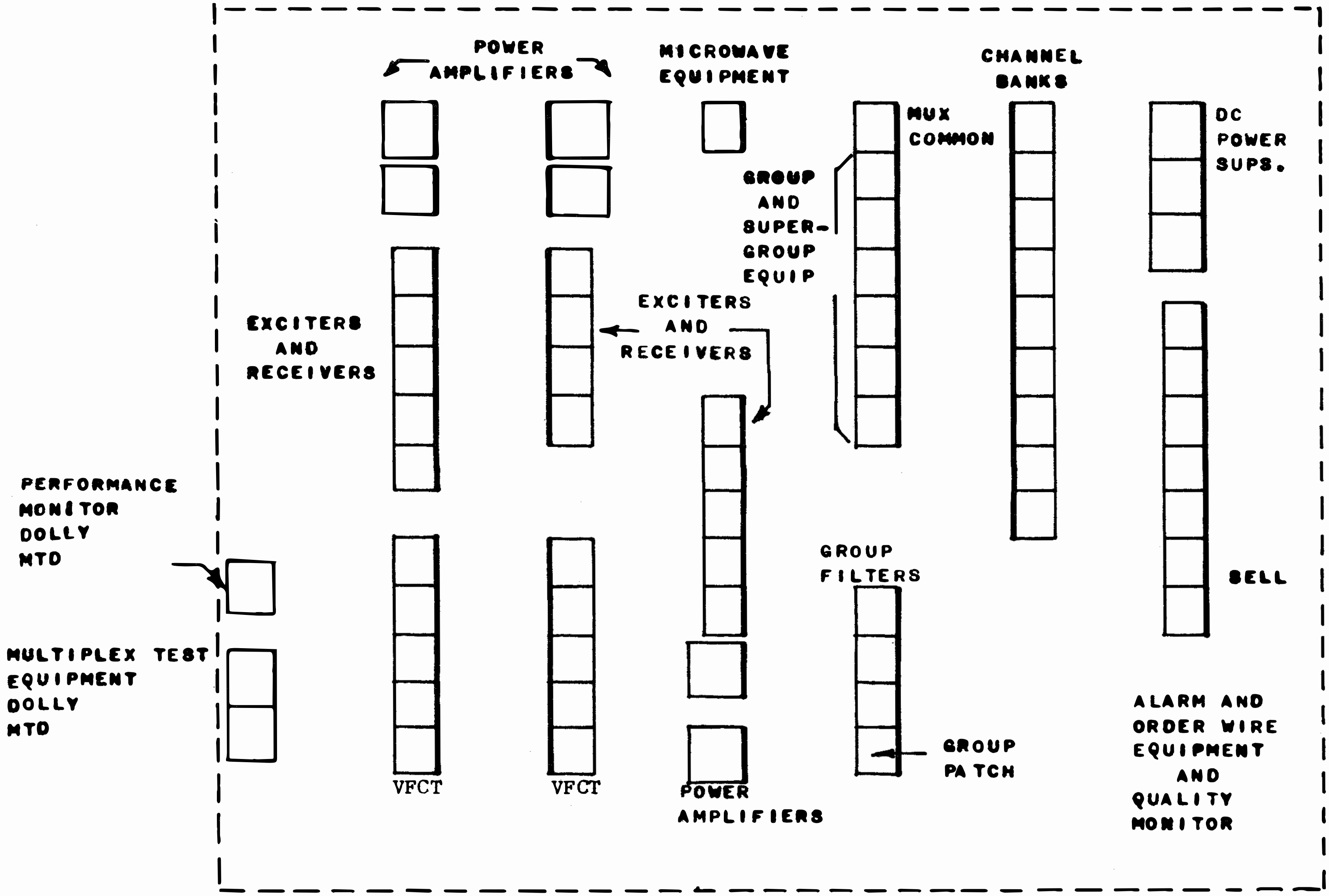


FIGURE VII-A-3 TYPICAL RADIO MULTIPLEX ROOM

B. RADIO EQUIPMENT:

The radio equipments used in the ICS are:

DESIGNATION	MANUFACTURER	MODE OF OPERATION
REL-2600	RADIO ENGINEERING LABORATORIES	TROPO OR LOS
AN/FRC-109	LENKURT ELECTRIC	LOS
AN/MRC-85 (1) AN/FRC-39 (4)	REL (2) REL (3)	TROPO
AN/MRC-98 (1) AN/FRC-39 (4)	BENDIX (2) REL (3)	TROPO
LRC-3 (1) (4)	PHILCO (2) PHILCO (3)	TROPO OR LOS

Notes: (1) These are complete terminal assemblies including radio, multiplex, and control equipment.

(2) Manufacturer of complete assembly.

(3) Manufacturer of radio equipment.

(4) Designation of radio equipment.

On the following pages are given technical descriptions of the various radio equipments.

1. REL-2600:

The different models of the REL-2600 terminals used in the ICS vary only in the power amplifier used. The other components are, for the most part, identical at all sites.

a. Exciter (Figures VII-B-1, -2, -3): The exciter provides a frequency modulated carrier, in standard rf bands between 350 and 8500 mHz for the transmission of multichannel voice, telegraph and data signals. It is used in a two-way multichannel communications network in the line-of-sight, diffraction, or tropo-scatter modes of operation. When used in the tropo-scatter mode of operation, it forms the driver for a klystron power amplifier. The exciter is capable of operating with frequency division, time division, or pulse code multiplex equipment. The exciter consists of a modulator, converter-rf amplifier, and power supply units, contained in a rack mounting. The principal variations are found in channel capacity, carrier frequency, and power output. The exciter is tunable over the selected transmit band.

Functionally, the exciter consists of a 70 mHz modulator section and a frequency converter rf section. Optional channel capacities of from 12 to 252 each 4 kHz channels may be exercised by the simple interchange of modules and printed circuit cards. The 70 mHz carrier frequency is standard throughout all 2600-series exciters, and only the frequency converter rf section need be replaced to change from one transmit-frequency spectrum to another.

SPECIFICATIONS FOR REL 2600 EXCITER (ICS APPLICATIONS):

RF Range	755 to 985 mHz (1 GHz) 1700 to 2400 mHz (2 GHz)
Type of Modulation	FM
Output Power	10 watts minimum
Intermediate Frequency	70 mHz
VF Channel Capacity	72, 132 or 252

MODULATION RANGES:

Baseband	12 to 308 kHz (72 channels)
	12 to 552 kHz (132 channels)
	12 to 1052 kHz (252 channels)
Order Wire and Supervisory Channel	250 Hz to 12 kHz
Radio Pilot Frequency	60 kHz

b. Power Amplifier: There are only two types of power amplifiers used in ICS These are the 1 KW and the 10 KW models.

(1) 1 KW Power Amplifier:

The power amplifier is the final amplification stage in the transmitting portion of the radio system. A one to four watt frequency modulated rf drive from the associated exciter is amplified in the tuneable klystron tube to the final power output level of 1 KW, and is then fed to the antenna for transmission. The power amplifier is housed in a single cabinet designed for front access to all components. The power amplifier will opperate at reduced output with driving power as low as 100 mW

Input Characteristics:

Driving power	1 to 4 watts
RF range	1700 to 2400 mHz (ICS application)
Power output	1 kw
Power gain	30 db
Bandwidth	Approximately 7 mHz
Metering capabilities	Forward and reflected power indications of rf input, klystron drive, and output power are provided.
Starting time	Full power output is obtained within 3 minutes after application of primary power.

(2) 10 KW Power Amplifier Group:

A frequency modulated rf drive from the associated exciter, in the frequency range of 755 - 985 or 1700 - 2400 mHz, is amplified in the tuneable klystron tube to the final power output level of 10 KW, and is then fed to the antenna for transmission.

The heat exchanger provides a liquid coolant for the power amplifier and dummy load.

The dummy load provides a nonradiating load for dissipating the output of the power amplifier during tuning and routine maintenance.

The coaxial patch panel permits connecting the output of the power amplifier to either the dummy load or to its assigned antenna.

All components of the power amplifier group, excluding the heat exchanger, dummy load, and coaxial patch panel, are housed in a single two section cabinet designed for front access by use of front hinged panels and pull out drawers.

The klystron assembly is a removable unit, mounted on casters for ease of assembly and maintenance. It consists of the klystron tube, its related circuitry, air cooling, and directional couplers. The directional couplers monitor the reflected and incident rf input and output power. The liquid (provided by the heat exchanger) and air cooling dissipates the heat generated by the klystron operation.

The heat exchanger is housed in a separate cabinet and provides for the flow of a liquid coolant through the power amplifier and the dummy load. The coolant is returned to the heat exchanger which dissipates the heat absorbed by the coolant.

The coaxial patch panel consists of a plate on which five coaxial connectors and two removable U-shaped coaxial links are mounted. The coaxial links have locking clamps on each leg to insure secure connections to the dummy load.

Power Amplifier Specifications:

RF Range	755 to 985 mHz (1 GHz) 1700 to 2400 mHz (2GHz)
Power Output	10 KW
Input Driving Power	5 watts nominal
Starting Time to Full Power	Within 5 minutes after application of primary power and within 3 seconds after application of beam voltage
Recycling Repetion	Will recycle only once within any 5 minute period.
Coolant	
Normal Flow	30 G. P. M.
Minimum Flow	15 G. P. M.

Heat Exchanger:

Coolant Mixture	Distilled water
Coolant Circulation	30 G. P. M. nominal

Dummy Load:

RF Power Level	12 KW Maximum
Coolant Type	Distilled water
Coolant Flow:	
Calibrate	1 G. P. M.
Dummy Load	5 G. P. M.

c. Receiver (Figure VII-B-4, -5): The receiver group provides a means of detecting and amplifying a frequency-modulated carrier contained within the standard rf bands between 350 and 8500 mHz. The receiver group may be used for line-of-sight, diffraction, or tropo-scatter modes of operation without modification. In addition, it may be used singly, or its output may be combined with that of other groups for diversity operation.

(1) Description:

Receiver Group:

The Receiver group consists of a basic receiver with optional front-end equipment. A preselector may be part of this group or part of the antenna system. In addition, the group may contain either a tunnel diode or a parametric rf amplifier.

Preselector:

Selectivity for the receiver group is obtained by using an rf preselector at the front of the group. The preselector is tuneable over the same frequency range as the basic receiver. The preselector is tuned to accept, with a minimum loss, the received carrier frequency and its sidebands. and to reject all other frequencies. Thus the preselector may be generally considered as performing the functions of a bandpass filter.

Rf Amplifier:

Rf amplification is provided by a tunnel diode amplifier.

Receiver:

The 2600-series receiver is a solid state, superheterodyne, frequency modulated receiver, consisting of a frequency converter, a demodulator and a power supply.

Channel capacity options from 12 to 252 may be obtained by the simple interchange of modules and printed-circuit cards. The IF frequency of 70 mHz is standard throughout all 2600-series equipment, and only the receiver rf section need be replaced to change from one receive-frequency band to another.

In the demodulator unit, the 70 mHz IF signal is amplified, limited, and then passed through the discriminator to obtain the original traffic inputs contained within the 250 Hz to 1212 kHz range.

An automatic threshold extension network may be incorporate as an option in the demodulator unit to increase the threshold sensitivity of the receiver under weak signal conditions (Figure VII-B-6). When operative, this network converts the receiver into a double super-heterodyne type.

(2) System Applications:

Operation in the line-of-sight mode is accomplished by two receiver groups, each one associated with a particular reception frequency, to provide dual frequency diversity. The outputs from the two receivers are combined to obtain a single summed output that is less susceptible to signal strength fluctuations. Also of interest in terms of operational reliability is the inherent signal-path redundancy of this configuration. This redundancy means that a major failure in either receiver group will not affect the duplex operation of the complete terminal (apart from the loss of receiver diversity advantage).

Operation with dual frequency diversity in the diffraction and troposcatter modes is essentially the same as that described for line-of-sights, except that the automatic threshold extension option may be used in each receiver to obtain, in the combined output, an even greater independence from signal strength fluctuations.

A quadruple diversity receiver system may be used in the tropo-scatter mode, utilizing four receiver groups. A combination of frequency and space or space and polarization diversity is employed, the outputs of two frequency diversity receiver group pairs being combined for space diversity. The corresponding high and low reception frequencies in these two pairs are the same. This particular receiver system configuration provides the greatest independence from signal strength fluctuations and the most reliable system, due to maximum redundancy.

RF Range	755 to 985 mHz (1 GHz) 1700 to 2400 mHz (2 GHz)
Baseband Frequency Range:	
72 channels	12 to 308 kHz
132 channels	12 to 552 kHz
252 channels	12 to 1052 kHz
Intermediate Frequency	70 mHz
Radio Pilot Frequency	60 kHz
Order Wire & Supervisory Channel	250 Hz to 12 kHz

d. Improper Operation of Combiners: Figure VII-B-7 shows the four receivers in block form. Only the baseband output signals are considered, although the discussion here applies equally well to the orderwire signals also. Since the input signals entering each demodulator are all different, the four baseband inputs to the combiners may all vary in strength and noise quality. The four combiners really function as one. By mean of the "Baseband Combiner Interconnect" the output signal is derived, and the four combiner outputs are identical. These four outputs each go through their own Baseband Amplifier and then appear on the Baseband Patch Panel. The normal practice is to parallel two BB AMP outputs to form the final BB REC SIGNAL. The troubles that usually occur during the maintenance of a receiver are discussed below.

Under normal operation, if a DEMOD output becomes weak or noisy, the COMBINER will deemphasize that signal in obtaining the "combined" output. If a signal becomes extremely strong and free of noise, then it will provide the major portion of the COMBINER output. Remembering these effects, let us examine what happens when a receiver is taken out of service for maintenance.

One common maintenance procedure is to disconnect the antenna input and replace it with a signal generator input. Then with a known input signal, the operation of the receiver can be checked.

Example 1:

1. The ANTENNA is disconnected, but the COMBINER link to the Baseband Combiner Interconnect is left in.

2. The DEMOD BB output of this receiver is all noise and the COMBINER effectively turns it off.

3. A SIGNAL GENERATOR is connected to the RECEIVER input.

4. The DEMOD BB output is now almost completely free of noise and the COMBINER outputs became primarily the SIGNAL GENERATOR signal.

5. The entire system is knocked off the air.

6. This can happen when <u>any</u> of the four receivers are worked on in this configuration.

Example 2:

Applies only to receivers used to form BB OUTPUT (RCVR's 2&3 in Figure VII-B-7):

1. The link between the COMBINER and the Baseband Combiner Interconnect is removed first.

2. The output of this COMBINER is now exactly the same as the DEMOD BB output.

3. The ANTENNA is disconnected.

4. The DEMOD BB output is now all noise.

5. The BB AMP output of this RCVR is also all noise. When this is paralleled with the combined signal output from the other RCVR used to form BB OUTPUT, the noise will usually drown out the useful signal and again the entire system is off the air because the squelch unit is activated.

6. This can happen <u>only with</u> the RCVR's whose BB AMP outputs are used to form the BB OUTPUT signal.

Proper Procedure

1. Arrange connections on the BB PATCH PANEL so that the BB AMP output of the RCVR to be tested is not one of those used to form BB OUTPUT.

2. Remove the link to the Baseband Combiner Interconnect on the RCVR to be tested.

3. Now the ANTENNA may be disconnected and replaced by the SIGNAL GENERATOR.

e. Complete Terminal: A block diagram of a quad-diversity REL 2600 terminal is shown in Figure VII -B-8. This is given primarily to show the signal flow and the functions of the various patch panels. The key points to observe are:

(1) There are three sets of input/outputs:

(a) Message baseband (60 kHz and up) to AN/FCC-17 multiplex equipment.

(b) 12-56 kHz supervisory channel used for transmission of the remote alarm signals and area express order wires.

(c) 0.25-12 kHz low supervisory channel for use as local engineering order wires, major technical control express order wires, and remote alarm system.

(2) The 12-56 kHz supervisory channel and the message baseband (above 60 kHz) are combined and separated by a combination of high and low pass filters connected to the COMBINED PATCH PANEL and electronic equipment in the transmitter and receiver.

(3) At the BB (Baseband) PATCH PANEL the transmit signal power is divided into two equal and identical parts and fed to the two exciters (BB input).

(4) All four BB Amplifier outputs of the receivers appear at the BB PATCH PANEL. These are identical except as noted above and the receiver BB signal is usually formed by putting two of these in parallel.

(5) At the OW (Order Wire) PATCH PANEL the 0.25-12 kHz supervisory channel is split to drive the OW inputs of each exciter.

(6) All four OW Amplifier outputs from the receiver are also available at the OW PATCH PANEL.

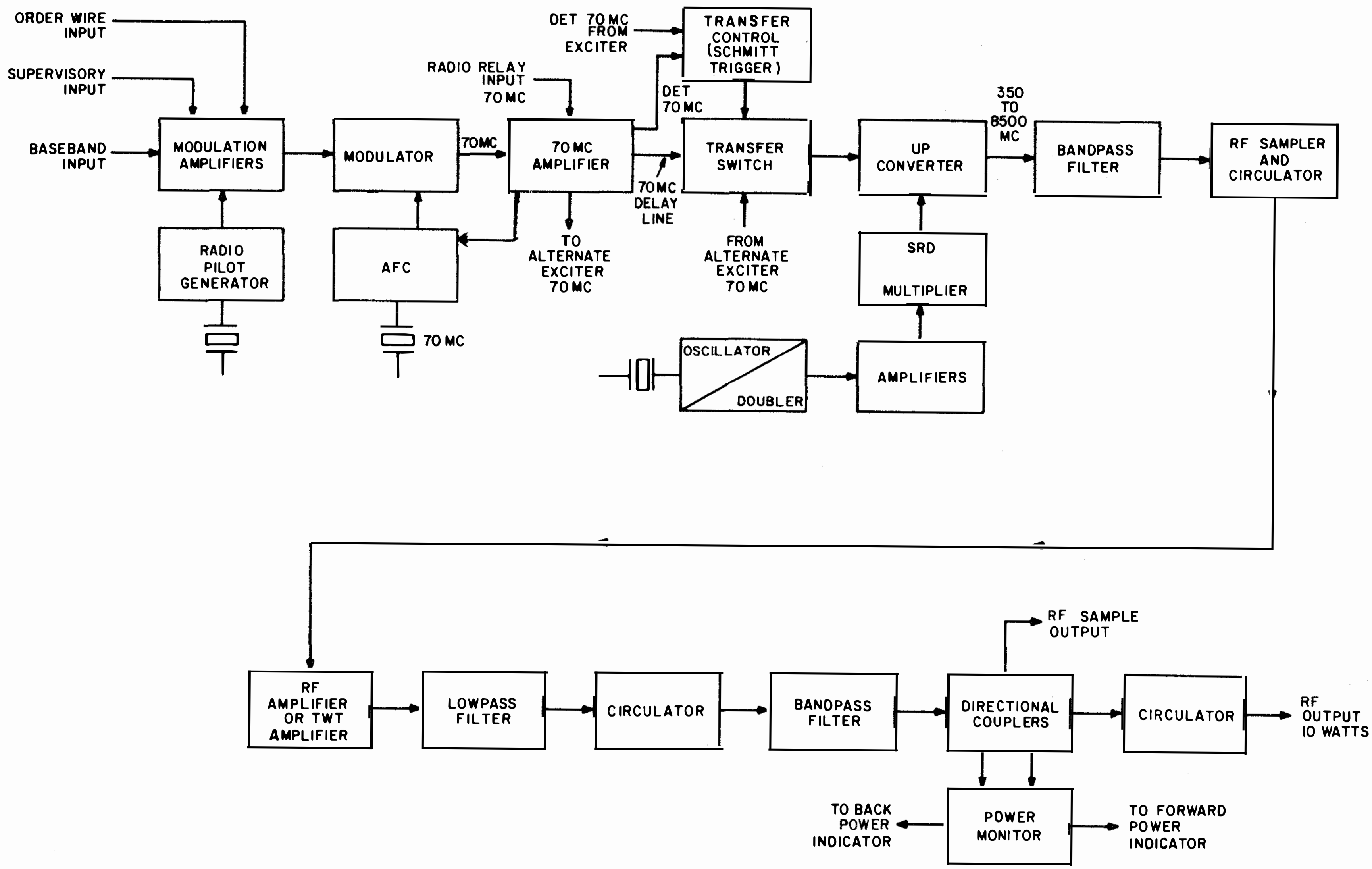
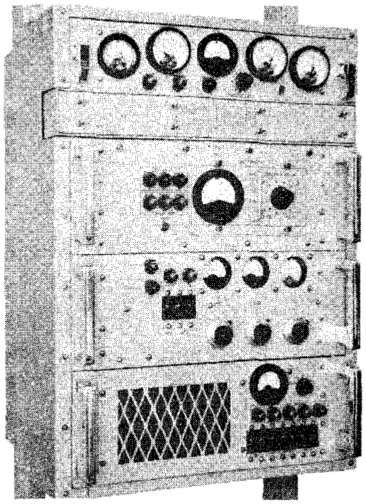


FIGURE VII-B-1. 2600-Series Exciter, Simplified Block Diagram

REL Exciters

REL FACT SHEET NO. 13



Solid-State Exciter

REL Exciters, furnishing frequency-modulated carrier waves, are the "start" of a tropospheric scatter radio system. Together, Exciters and power amplifiers combine to constitute the tropo transmitters in REL radio systems.

REL Exciters are continuous wave, FM units utilized for the generation of multi-channel telephone, telegraph and other wideband communications signals at frequencies from 350 to 5,000 megacycles, taking in the Very High Frequency (VHF), Ultra High Frequency (UHF) and Super High Frequency (SHF) ranges.

Electrically, an Exciter is divided into two basic parts: a Radio Frequency (RF) section and a 70 megacycle modulation section. In operation, the multi-channel signals from a multiplexer unit are introduced to the modulation section, where, after multiplication, pre-emphasis and amplifications, a fully deviated 70 megacycle Intermediate Frequency (IF) is generated. This IF is heterodyned by a local oscillator within the RF section of the Exciter to produce the correct carrier frequency which is amplified to the appropriate power output. This output, in turn, is then fed to a power amplifier.

The multi-channel signals are distributed over two bands of frequencies: an order wire frequency spectrum and a baseband frequency spectrum. In addition, a pilot tone signal is generated to provide a means of monitoring the equipment operation.

In a typical system configuration, there are two Exciters in each terminal of a frequency diversity system. Each Exciter is a self-contained unit incorporating its own power supplies, control panel, alarms and cooling apparatus.

In addition to the wide range of frequencies and power requirements (100 milliwatts to 10 watts) at which REL Exciters may operate, there are options for the acceptance of from 12 to 300 channels.

BLOCK DIAGRAM OF TYPICAL EXCITER

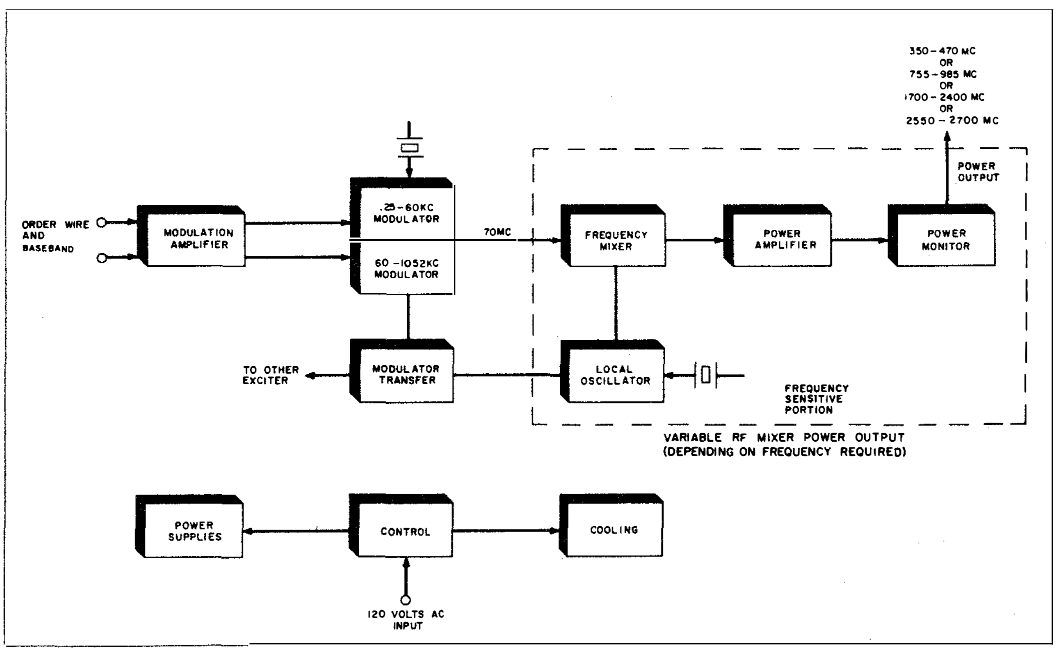


FIGURE VII-B-2

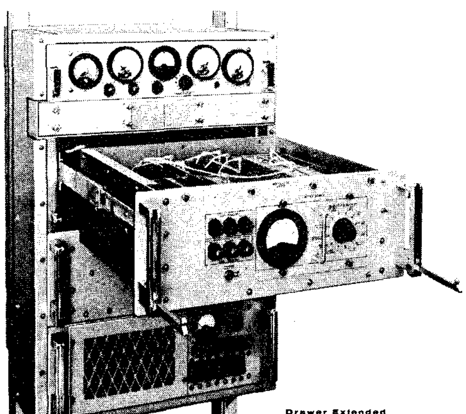
2600 Series Exciters

REL's 2600 Series of solid-state exciters, when used with suitable receivers and power amplifiers, offer a wide variety of applications in the radio relay field, including tropospheric scatter, line-of-sight microwave and ground satellite communications stations.

In each of the aforementioned categories, flexible design provides for suitability in all common installation needs: fixed, transportable, tactical or shipborne.

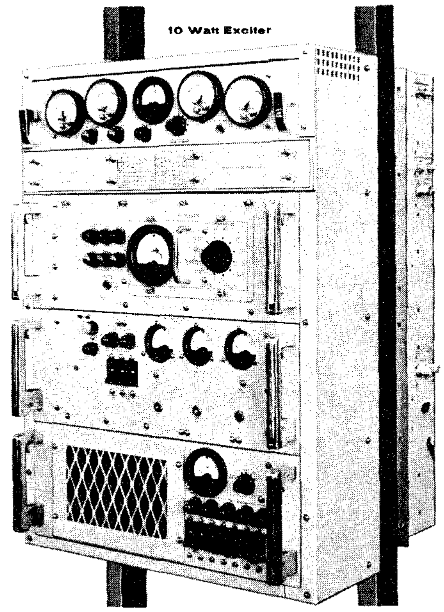
The function of these exciters -- in communications systems employing up to 300 channels and operating in the Radio Frequency range between 350 and 8500 megacycles -- is to enable multiplexed voice, data and telegraph information to be modulated into an FM signal which is converted into an appropriate carrier frequency with a power output suitable for the application. The input of multiplexed information may comprise frequency division, pulse code or time division multiplex. The normal baseband width is 1300 kilocycles, but 2500 kilocycles also may be accommodated for certain line-of-sight applications.

When used in tropospheric scatter or satellite ground communications stations, they form the driver for a klystron power amplifier. When used by themselves the exciters form the transmitting portion of a line-of-sight microwave system. The addition of suitable REL 2600 Series receivers provides a complete terminal for transmission and reception of multi-channel communications traffic.



Drawer Extended for Easy Maintenance

The multiplex input of the exciter is amplified to the appropriate level and modulated into an FM signal with a deviation according to system requirements. This FM carrier is produced at 70 mc and is then translated to the RF operating frequency in a varactor up-converter. The source of frequency control for the local oscillator is either a crystal or frequency synthesizer depending on the application. Following the up-converter is an amplifier which may be either solid-state for small power outputs or a traveling wave tube amplifier for higher power outputs.



10 Watt Exciter

The construction of the exciter is completely modular and a large number of versions are available. The principal variations are found in carrier frequency and power output. A number of other options are available such as pilot frequency, transfer facilities and input levels, as well as the option of crystal or synthesizer control.

The modules of any exciter are arranged in slide-out drawers. The most common arrangement is for the modulator section, baseband-to-IF, to be in one drawer and the converter and output stages in another drawer. The power supply is also contained in a drawer. The basic modules can be packaged into a number of versions depending on the application.

The exciters are designed for great stability with time, very high reliability and performance in accordance with the highest standards.

FIGURE VII-B-3

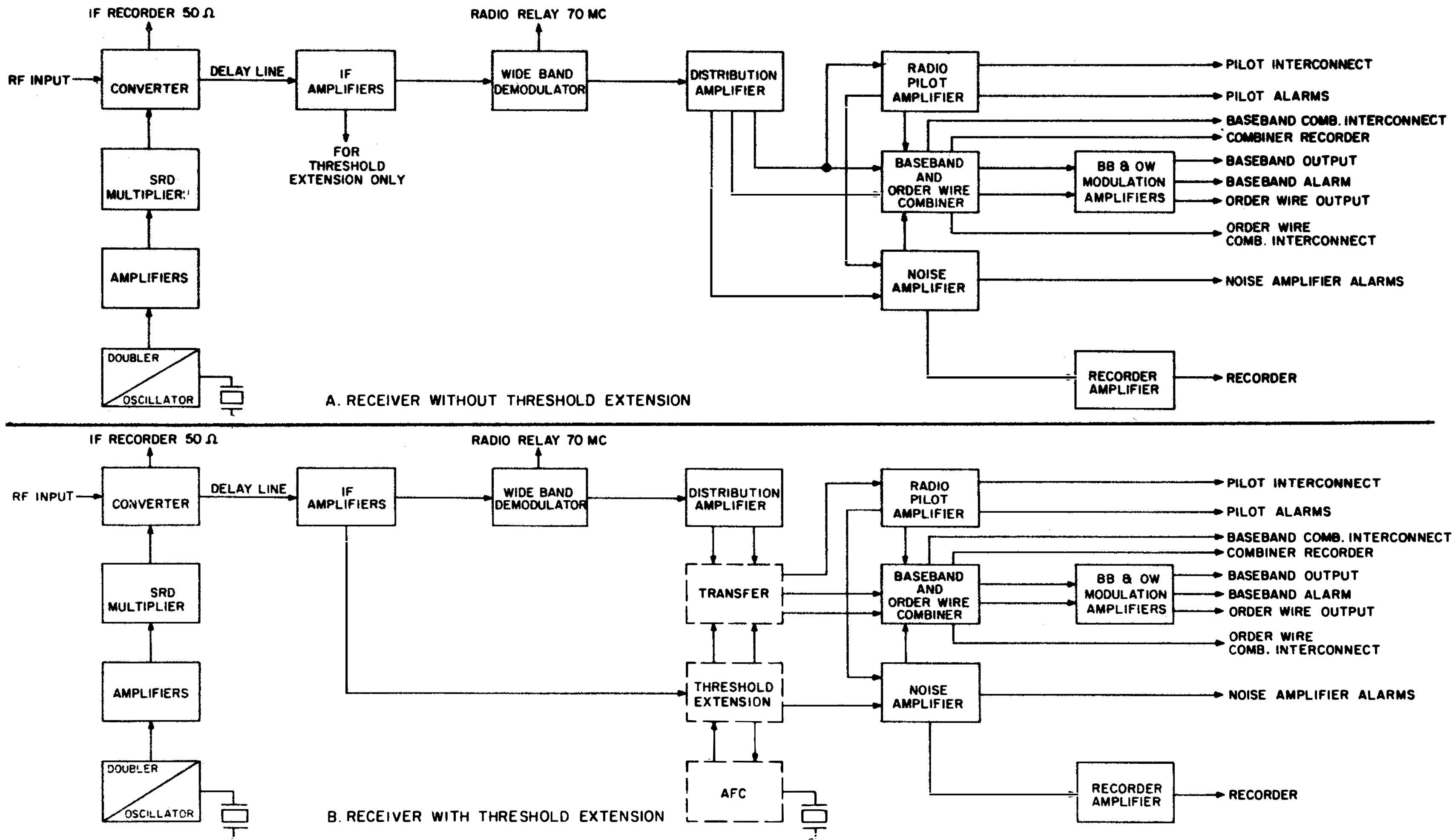


FIGURE VII-B-4. 2600-Series Receiver, Simplified Block Diagram

REL Receivers

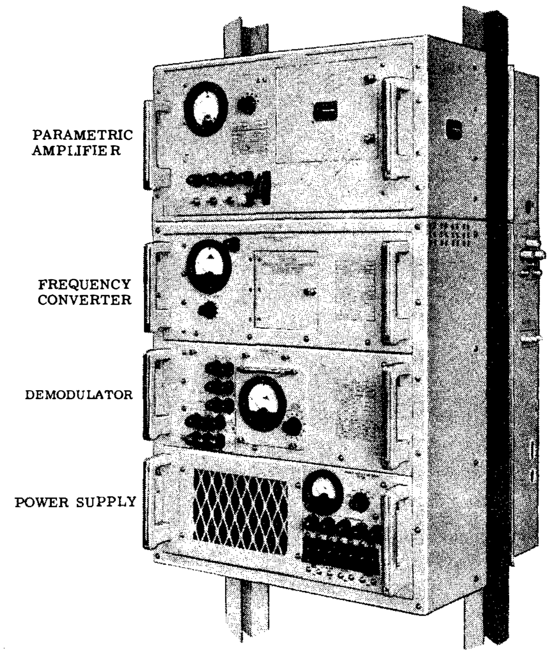
REL FACT SHEET NO. 18

REL's 2600 Series Receiver is capable of detecting and amplifying multi-channel, frequency-modulated voice, telegraph, and data signals in the UHF (ultra high Frequency) band from 350 to 8000 megacycles. Its design is solid-state throughout, and utilizes modular construction with slide-out drawers for ready access and quick module replacement. It can accomodate 12 to 300 channel operation by changing various plug-in modules.

The basic receiver consists of a frequency converter, a demodulator and a power supply-blower. Depending upon the users performance requirements, either a parametric amplifier or tunnel diode amplifier can be added as a preamplifier stage.

A combiner is provided to permit diversity operation, whereby the signal from one receiver is combined with signals of other receivers to obtain the best possible signal-to-noise ratio. Threshold extension is optional to enable detection of signals below the normal threshold of the receiver.

In a typical rack-mounted configuration, the four slide-out drawers which comprise the solid-state receiver measure only 33 inches in height, 21 inches in width and 20 inches in depth.



Weight of the overall unit is approximately 250 lbs.

Ease of operation and maintenance is assured through the utilization of warning and metering devices in conjuntion with the modular construction concept. Warning devices, both visual indicator lights and remote audible alarms, point out the failure of noise amplifier, radio pilot or baseband. Metering is provided for all functions of operation, alignment and maintenance. is achieved by the use of easily accessible test points in association with meters.

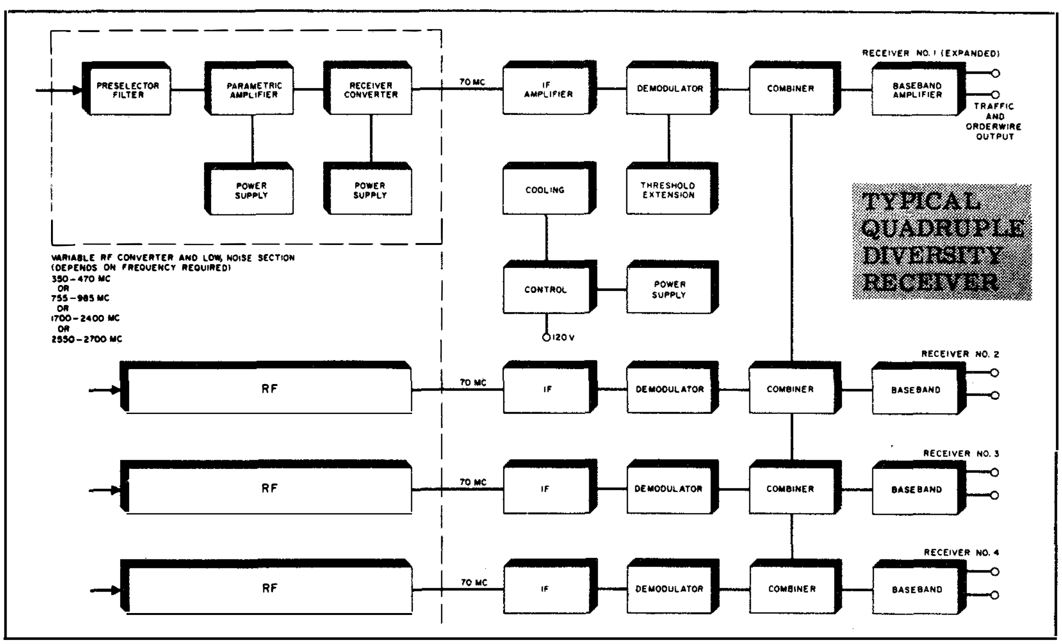


FIGURE VII-B-5.

Threshold Extension

REL FACT SHEET NO. 19

In an FM Receiver the output signal to noise ratio varies linearly with Radio Frequency signal input when the signal is above threshold level. At RF signals below threshold the signal to noise falls off more rapidly than the signal. The threshold is sometimes referred to as the break point and is that signal power which produces signal voltage peaks equal to noise voltage peaks at the first non-linear element (usually amplitudelimiter) of the receiver. The ratio of RF signal power to noise at threshold is 9 to 10 decibels.

The threshold level is a function of the receiver noise figure and radio bandwidth before limiting. To lower the threshold it is necessary to lower the noise figure or bandwidth or both. Since the noise figure is normally fixed, the bandwidth is reduced by one means or another and with varying penalties on performance.

It is important to understand that threshold reduction or extension lowers the signal level to which the receiver output signal to noise remains linear. In this manner the range of receiver input signal level variation is increased and system reliability improved. However, at a given input signal level the output signal to noise remains constant and threshold extension is not a substitute for higher transmitter power.

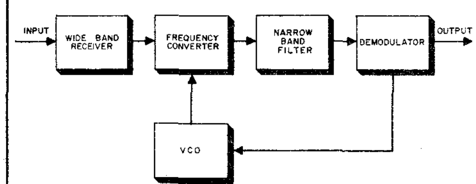
All techniques for threshold extension devices depend on bandwidth reduction or the equivalent to lower the threshold.

During a five-year period of thorough investigation as to various techniques for achieving threshold extension, REL engineers have evolved an FM feedback design especially adapted to meet the special performance requirements of wideband communications systems.

The FM feedback technique, successfully demonstrated in the Telstar Satellite program, has been almost universally applied in tropo scatter systems. Many units designed and manufactured by REL are in the field, and the latest fully solid state models provide the optimum in performance and reliability.

While the concept of threshold extension by FM feedback is simple, the implementation involves substantial and sophisticated circuitry.

The FM feedback technique reduces the frequency deviation by a degenerative process before transmission through a narrow band filter. In this manner threshold may be reduced without excessive distortion. The frequency deviation is reduced by a process of degenerative feedback around a typical loop. The out-of-phase deviation is obtained from a demodulator and voltage controlled oscillator combination. The latter output is applied to a frequency converter which feeds the demodulator and hence closes the loop.



FUNCTIONAL BLOCK DIAGRAM
FM FEEDBACK THRESHOLD EXTENSION

Degeneration of the FM signal takes place in the frequency converter because the modulation at the VCO output is applied out-of-phase to the incoming signal modulation. The reduced FM signal is passed through the narrow band pass filter without serious distortion. The filter establishes a bandwidth lower than normally used and hence, is responsible for reduction of the receiver threshold. The ultimate limit to which the threshold can be lowered occurs at a filter bandwidth of approximately twice the highest modulation frequency. The amount of threshold extension is measured as the ratio of the normal receiver bandwidth to filter bandwidth. Practical extension limits are a function of modulation frequency, deviation, filter bandwidth, and feedback.

Further detailed information on the application of FM feedback threshold extension in REL receivers, and the additional circuitry functions required in practical designs can be found in a data sheet available from REL's Marketing Department. Ask for TE-1, Notes No. 1.

FIGURE VII-B-6.

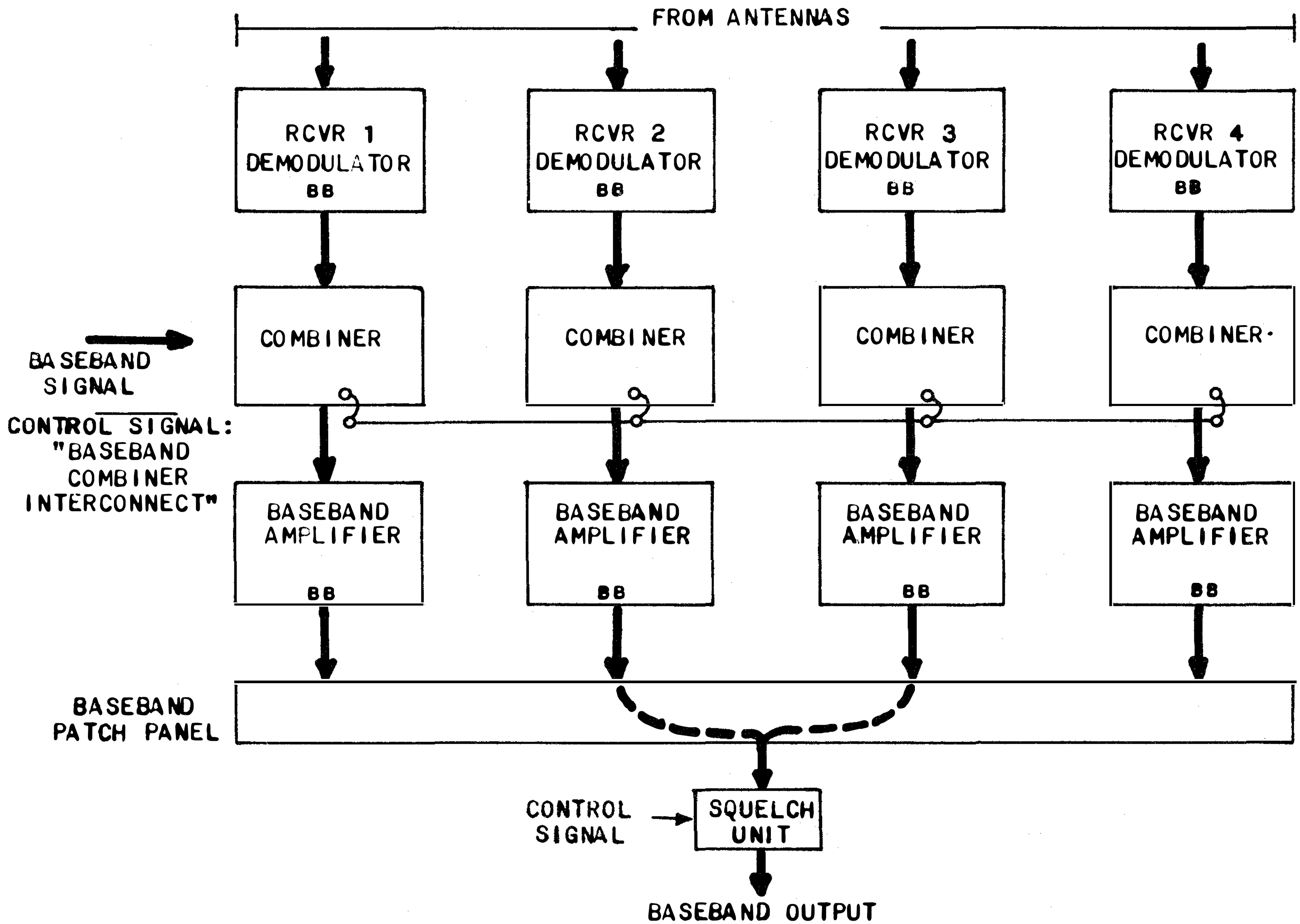


FIGURE VII-B-7 CONNECTION OF COMBINERS AND BASEBAND AMPLIFIERS

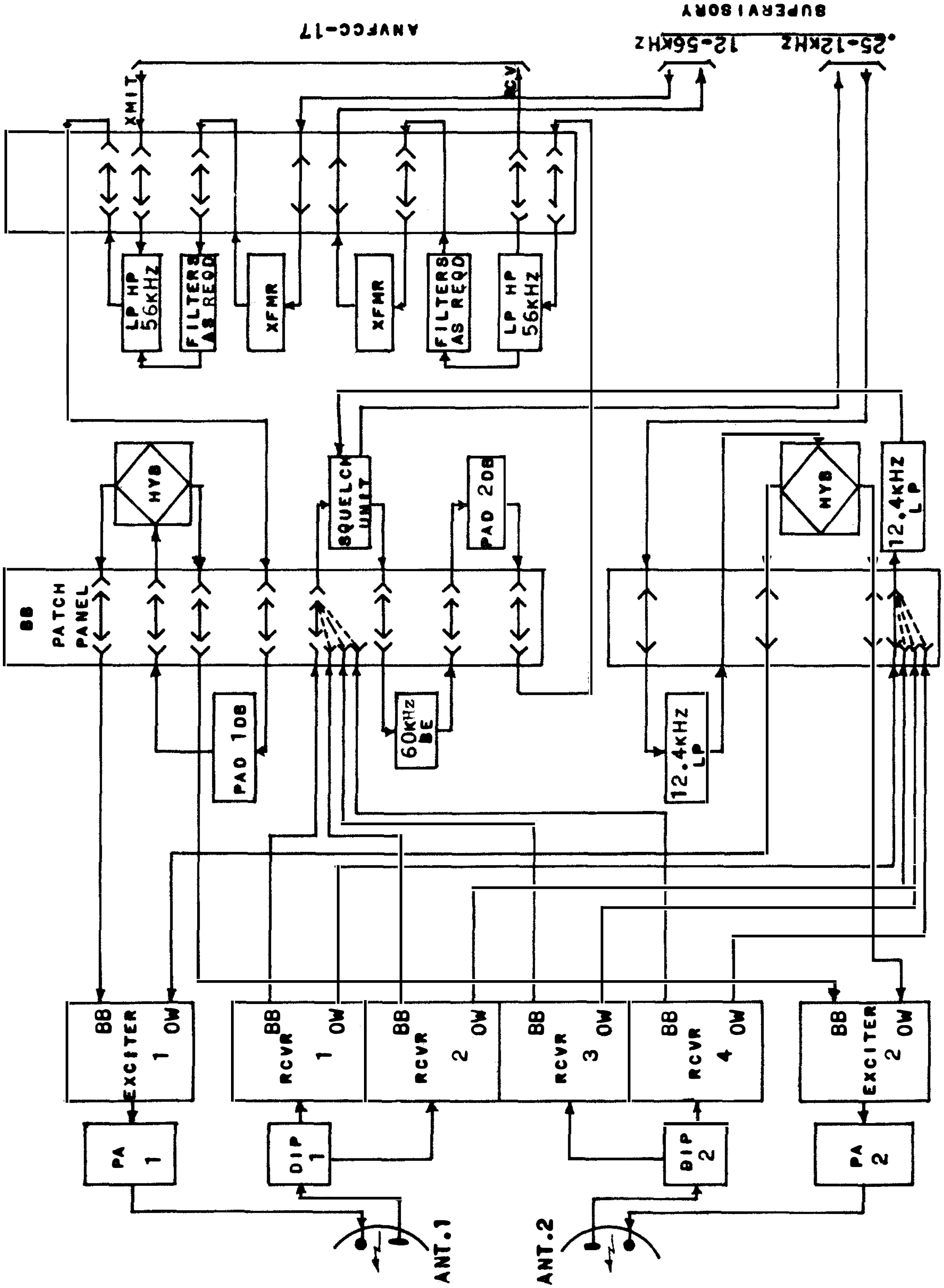


FIGURE VII-B-8 REL 2600 RADIO QUAD DIVERSITY

2. AN/FRC-109:

The principle equipment used for line-of-sight microwave in the ICS is the AN/FRC-109 which is the military version of the Lenkurt 76C (Figure VII-B-9). This system is used in ICS in the dual-diversity mode (frequency diversity only).

Specifications:

Radio Frequency Range	7125 to 8400 mHz
Channel Capacity	Up to 960 4 kHz message channels (ICS uses maximum of 300)

System Pilot Frequencies:

300 - channel systems	3.2 mHz
600 - channel systems	Either 3.2 or 8.5 mHz
960 - channel or video systems	8.5 mHz

Transmitting Klystron Output:

Power	1.0 watt, nominal

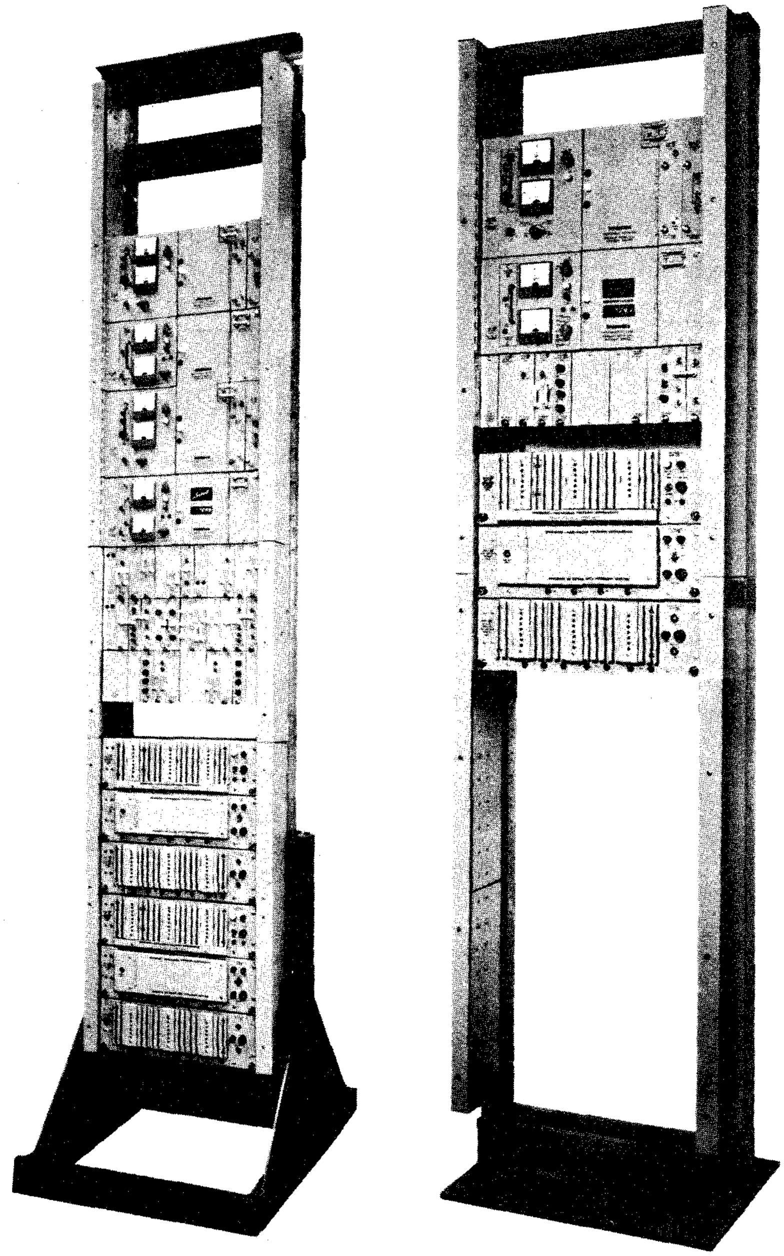
a. System Description: The Microwave Terminal Assembly (Figure VII-B-10) provides broadband microwave transmission in the Government Frequency Band (7125 to 8400 mHz). The system is one of the family of 76-class Lenkurt Radio Systems, and is suitable for the transmission of voice, teleprinter, high-speed data, graphic services, and video, and is available for single-channel operation and space or frequency-diversity operation. The equipment is transistorized except for the klystrons, and is capable of handling up to 960 channels of multiplex, or a black and white or color television channel. A supervisory channel is available in the 0.3 to 52 kHz portion of the baseband. This channel has an input and output separate from the carrier input and output, and is suitable for order-wire use and supervisory tone transmission.

b. Monitor and Alarm: System continuity is verified by transmitting a pilot tone along with the baseband to the far-end receiver, where it is monitored by a pilot detector circuit. This pilot tone is also monitored in the transmitter where it originates, to verify that the pilot oscillator and the baseband transmitting circuits are all functioning correctly. A system pilot of either 3.2 or 8.5 mHz is available for all 76C applications, except 960-channel message service or television service, either of which requires the 8.5 mHz tone.

Transmitting klystron power output, receiver noise level, and, in the case of a diversity system, the difference in noise level between receivers are also monitored. The differential noise monitor causes a transfer to the quieter receiver whenever the noise difference between receivers is approximately 6 db or more. This ensures that the received signal will be as good as or better than that obtained from the better receiver.

Transmission path fading results in a higher noise level, therefore, a noise alarm can be caused by excessive fading as well as equipment failure. Periods of excessive fading are normally short so noise alarms are delayed for approximately one minute to prevent short-duration alarms. Equipment failure will, of course, bring in a sustained alarm. Alarm circuits restore themselves when the signal returns to normal.

RADIO SET AN/FRC-109(V)



TYPICAL DIVERSITY TERMINAL

TYPICAL NON-DIVERSITY TERMINAL

FIGURE VII-B-9. 1.5 WATT MICROWAVE DIVERSITY RADIO SET AN/FRC-109(V)

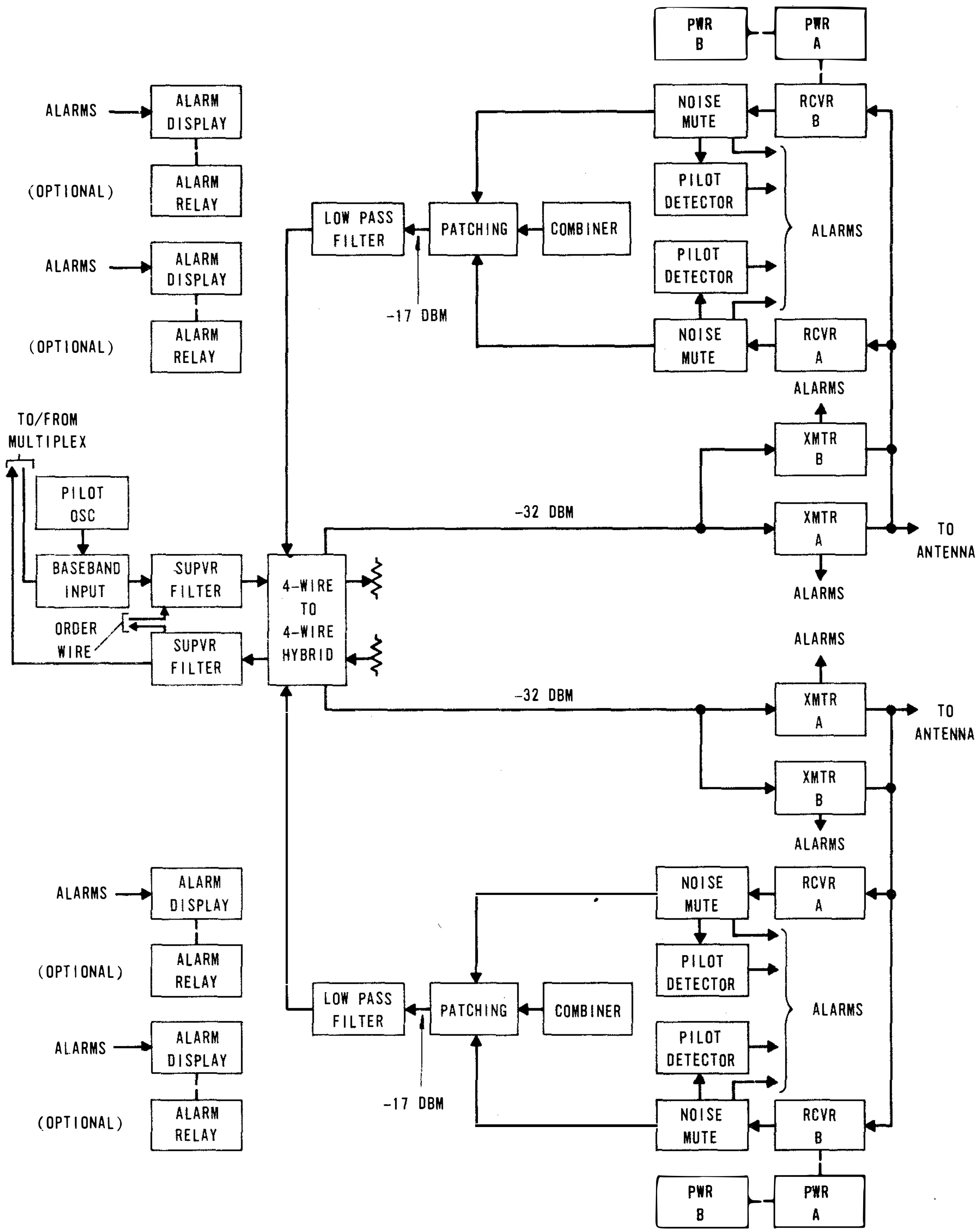


FIGURE VII-B-10.
TYPICAL MESSAGE DIVERSITY REPEATER
BLOCK DIAGRAM

3. AN/MRC-85 (AN/FRC-39)

Radio Set AN/MRC-85 is a completely mobile communications terminal using the tropospheric scatter communications technique in the frequency range of 755 to 985 mHz. The 10 KW system is capable of relaying up to 72 voice channels (ICS application) over single hops up to 200 miles. Quadruple diversity is used primarily, but dual diversity operation can be accomplished using one antenna and part of the radio equipment (Figure VII-B-11).

Installed in three military type vans and two special antenna trailers, the entire terminal is road-and-air-transportable.

The principal components of Radio Set AN/MRC-85 are:

AN/FRC-39(A) Radio Frequency Equipment

AN/FCC-17 Multiplex Equipment

CV/566 In-band Signalling Equipment

4 ea AN/FGC-61B (OA-7008) 12-Channel Teletype Carrier Equipment.

Two 150 KW Diesel Generators

Two 28-foot Parabolic Reflector Antennas

Diesel generators located in the power van are capable of supplying all primary power requirements of Radio Set AN/MRC-85, eliminating dependence upon commercial power. When desired, however, interconnection with commercial power facilities is possible.

a. Radio Frequency Equipment: The AN/MRC-85 Radio Set utilizes the type AN/FRC-39(A) radio equipment suitably modified for the more stringent requirements of vehicular mobile use.

The transmitting equipment consists of an FM exciter-modulator and a 10 KW power amplifier with its associated heat exchanger and dummy load operating in the 755 to 985 mHz frequency range. The principal characteristics of the transmitting equipment are as follows:

Baseband Inputs:

Order Wire	25 Hz to 12 kHz
Multiplex	Split baseband 12 to 60 kHz and 60 to 308 kHz (ICS application)
RF Range	755 to 985 mHz

Power Output	10 KW
Planning Range	200 miles

A frequency modulated, quadruple diversity receiver is used, capable of operating in either space-frequency or space-polarization modes. A threshold extension unit allows detection of signals below the normal threshold level of the receiver. The principal characteristics of the receiving equipment are as follows:

IF	70 mHz
Bandwidth	72 channels 4 mHz (ICS application)

b. Multiplex Equipment: Voice multiplex equipment (AN/FCC-17) and telegraph carrier equipment will be discussed later.

c. Antenna Equipment: The AN/MRC-85 is normally supplied with two 28' solid parabolic reflectors equipped with cross polarized feed horns. Each of the two antennas is a self-contained unit constructed of modular packages which disassemble easily for transporting. The reflector mounts on a stable tripod type tower which eliminates the need for guy wires and supports. When asembled, the antenna tripod tower structure with reflector mounted is stable without ground anchors in winds up to 25 knots. With a ground anchor at each leg of the tripod, the antenna can be operated in winds up to 120 knots with 2 inches of ice.

Erection can be accomplished without the use of winches or other special equipment in 24 man hours. No site preparation such as excavation, footings, and concrete pads are required. The tripod tower is designed to disassemble into a trailer bed upon which all of the component parts of the antenna can be transported. The complete tower and antenna assembly forms a two axle trailer 20 feet long, 7 feet wide, and 8 feet high. The trailer can be towed by standard vehicles. This antenna arrangement is not normally used at ICS installations. Antennas shown in Figures IV-A-2 and 7 are similar to those used at ICS AN/MRC-85 installations).

High power transmission lines are 3-1/8 inch coaxial cable between the transmitter output and the diplexer, and pressurized wave-guide between the diplexer and the feed horn. All low power RF transmission lines are 1-5/8 inch coaxial cable. (ICS installations utilize wave guides in lieu of high power transmission lines).

d. Control and Ancillary Equipment: The AN/MRC-85 is normally supplied with control and ancillary equipment to support its mission. Equipment normally supplied includes protected distribution frames, audio and DC patching facilities, in-band signalling equipment, order wire, system alarm and performance monitor. In addition, two to four wire converters, sources of ringing voltage, special matching devices, teletype loop current controls and other similar equipment can be provided to adapt the system to any special circumstances.

The usual order wire provides a voice and/or teletype channel between terminals to be used for maintenance and operational checks and changes. It uses the 250 Hz to 4 kHz channel in the 25 Hz to 12 kHz order wire band of the radio set. The remainder of this band, 4 kHz to 12 kHz, is available for additional order wire channels.

e. Equipment Alarms: The radio set is equipped with fault indicator panels containing aural and visual indicators indicating abnormal operation of various sections of the radio equipment. The fault indicator panel contains provision for indicating malfunction or reduced performance of 21 separate circuits of the radio set. It is mounted directly over the operator's desk to provide an immediate indication of the location of a malfunction resulting in degradation of system performance. For each malfunction an appropriate indicator lamp is lit and a common alarm bell is sounded. A single common reset switch silences the alarm bell and restores it to the common alarm circuit. The trouble indicating lamp remains lit until the fault is cleared.

Additional contacts on the alarm relays permit remoting of the alarm function to locations such as personnel quarters.

f. Power Equipment: Two tandem generator sets and four diesel engines form an extremely reliable power generating system for the radio set. Each power system consists of one 150 kw generator and two diesel engines, one located on each end of the generator shaft. Either of the two systems is capable of providing full power to the radio set but during normal operation, each generator supplies 50 percent of the load or up to 75 kw each. One diesel engine is used to drive each generator and the other engine is a standby. The system is designed so that one generator and two engines can fail and the dual tandem system will still produce the total 150 kw load. Furthermore, if three engines fail, the remaining engine can still produce 150 Kw for up to three hours without harmful effects on the engine. This method results in the ability to continue producing power under practically all adverse conditions of engine or generator failure.

Automatic monitoring and switching equipment effects transfer in the event of a power failure.

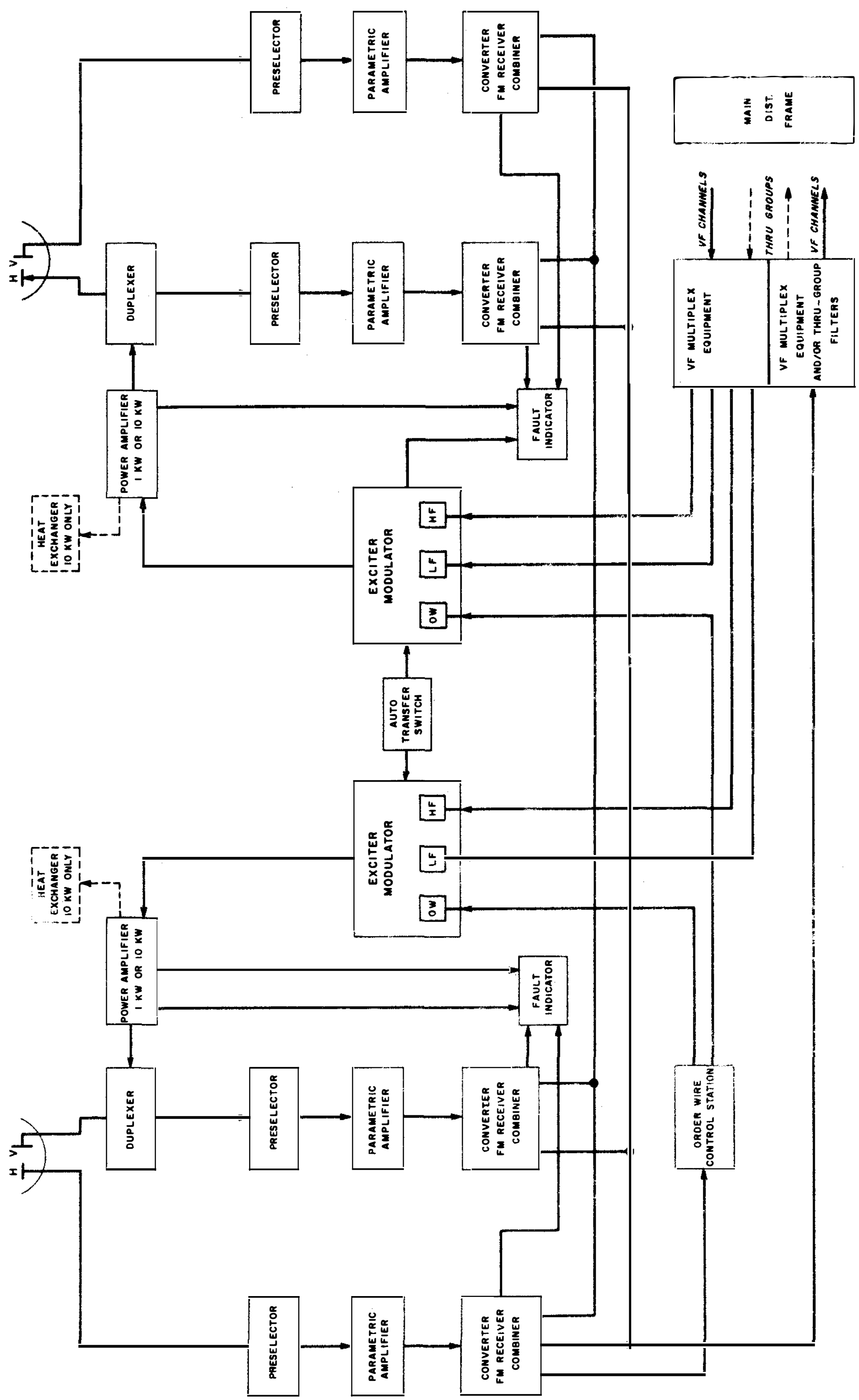


FIGURE VII-B-11. RADIO SET AN/MRC-85 BASIC SYSTEM BLOCK DIAGRAM

4. Radio Set AN/MRC-98 (AN/FRC-39):

General Description: Radio Set AN/MRC-98 is a transportable communication facility operated in the tropospheric scatter mode in the 755 to 985 mHz frequency band. It provides up to 60 nominal 4 kHz VF channels in its modulation baseband. The VF multiplex equipment used is the AN/FCC-17 which is described elsewhere in this material. One voice channel is allocated for telegraph operation permitting full duplex operation of up to 12 teletype channels over the system with the VFCT (voice frequency carrier telegraph) equipment provided. Transmitter output power is 10 KW. Each receiving system has a noise figure of 2 db through the use of parametric amplifiers. Both space and polarization diversity are used to offset fading conditions, resulting in a considerable improvement in overall reliability. Radio Set AN/MRC-98 is housed in two air conditioned semi-trailer vans. A third van houses the two diesel engine generator sets, either of which can supply the complete power requirement for the facility. Two antennas are provided for the system. One leg of the supporting tower of each antenna is provided with wheels; it forms its own trailer bed for an entire antenna assembly when disassembled (Figure VII-B-12). The Radio Set AN/MRC-98 is transportable either by land or by five C-130 aircraft. When at an operational location, approximately 100 manhours are required to put the system in operation.

Interface Characteristics:

Radio Equipment

Frequency Range	755 to 985 mHz
Transmitter Power Output	10 KW

The only MRC-98 deployed in SEA are located in Thailand.

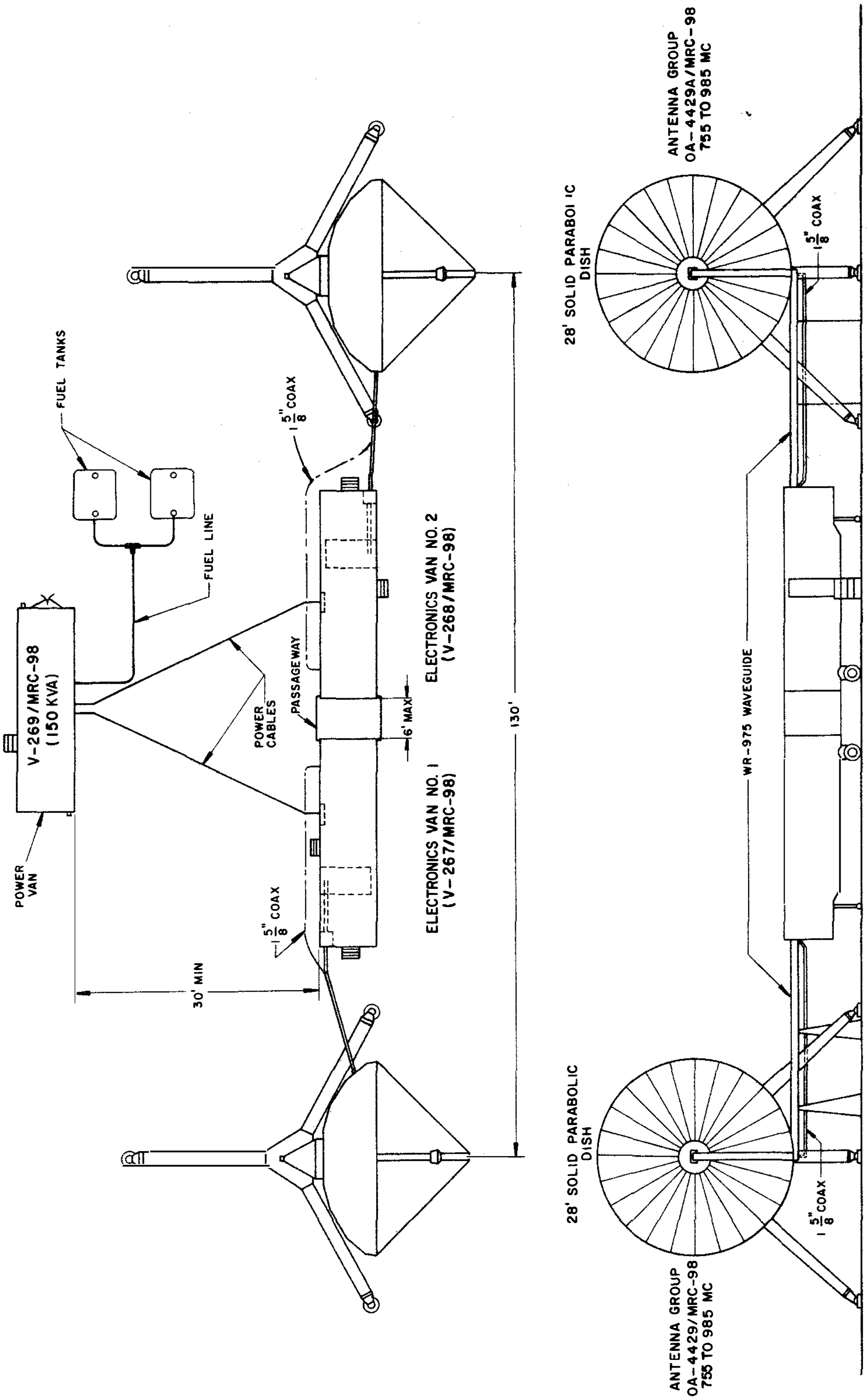


FIGURE VII-B-12. RADIO SET AN/MRC-98 FACILITY SITING PLAN

5. LRC-3:

The LRC-3 equipment is used only on the system providing entry into Thailand via the southern route. This is from Phu Lam to Vung Tau to Green Hill in Thailand.

Radio Set LRC-3, consisting of exciter equipment and receiver equipment, is used for the transmission of multiplex and video information over both line-of-sight distances and tropospheric scatter systems (with a separate high-power RF amplifier). VF multiplex equipment used is the AN/FCC-18, which is described elsewhere in this material.

The mode of transmission is frequency diversity, space diversity, or a combination of the two.

Provisions also are included for communicating over a service channel (order wire) located in the low frequency end of the base band.

The Exciter LRC-3E consists of the following units:

1 Signal Splitter Unit

2 Exciter Units

2 Power Amplifier Units

1 Pilot Tone Unit

2 Main Power Supply Units

2 Power Amplifier Power Supply Units

The Exciters RF Output Power, is from 1 to 10 watts and its RF Range is 1700 to 2200 mHz.

The receiving equipment consists of the following major units:

1 Diplexer

2 Phase-Lock Receivers

1 Dual-Diversity Combiner

1 Common Baseband

Specifications:

Receiver	Frequency modulation, single conversion superheterodyne; fixed tuned; RF preselection.

RF Range	1700 to 2200 mHz
Intermediate Frequency	70 mHz; 1 or 3 mHz bandwidth, as selected

C. VOICE FREQUENCY MULTIPLEX EQUIPMENT:

1. AN/FCC-17

The AN/FCC-17 is the standard VF multiplex terminal used in ICS in Area 1 (Vietnam). It is also used in some of the transportable tropo systems.

a. General: A single Multiplexer Set AN/FCC-17 provides sixty 4-kHz voice channels in the supergroup number 1 frequency (60-300 kHz) allocation (Figure VII-C-1). The physical arrangement of the AN/FCC-17 is such that the set may be used as the basic unit of a high density terminal providing up to 600 channels. The channel capacity of this assembly may be expanded to a maximum of ten supergroups (600 channels within a frequency spectrum of 60-2540 kHz) by the addition of applicable equipment (Figure VII-C-2).

A single Multiplexer Set AN/FCC-17 is contained in five equipment racks. A total of 13 equipment racks are required for a full 600-channel arrangement.

b. Specifications:

Channel Capacity	From 12 up to 600 four-kHz duplex channels in 12 channel increments.
Modulation	SSB, suppressed carrier, Twin Channel.
Type of Multiplex	Frequency division.
Frequency Allocations:	
Channel Drop	300 to 3500 Hz
12-Channel Group	60-108 kHz
60-Channel Supergroup	312-552 kHz
Line Frequency:	
12-Channel Group	12-60 kHz or 60-108 kHz
60-Channel Group	12-252 kHz or 60-300 kHz
240-Channel Group	60-1052 kHz
600-Channel Group	60-2540 kHz

Transmission Facilities	Designed for operation with either FM or single side band radio facilities in line-of-sight or tropospheric scatter links; output may be adapted for cable or open wire transmission by use of appropriate auxiliary equipment, including repeaters, equalizers and regulators.
Processing Capabilities	Voice, Digital Data, Teletype, Facsimile, or other graphic information.
Type of Carrier Frequency Synchronization	Slave terminal synchronized to a 96 kHz pilot introduced into the high frequency line at the master terminal.
Voice Channel Characteristics:	
Frequency Response (6000 mile DCS circuit)	3 db variation, 300 to 3500 Hz, referred to 1000 Hz test tone. 1 db variation, 325 to 3450 Hz, referred to 1000 Hz test tone.
Envelope Phase Delay (6000 mile DCS Circuit)	225u sec, 600-3200 Hz, 130u sec, 1000-2500 Hz.
Impedance	600 ohm, balanced
Levels:	
Input	-16 dbm
Output	+7 dbm
Manufacturer	Lenkurt Electric Company, Inc.

The most significant performance characteristic of the AN/FCC-17 is the ability to maintain low channel noise and distortion under 100% data loading.

c. Modulation Plans: Note that the modulation plan, Figure VII-C-2 uses the lower and upper sidebands alternately on adjacent channels requiring only six channel carrier frequencies. This type of modulation is called "Twin Channel Modulation" (TCM).

The diagram of Figure VII-C-3 of the AN/FCC-17 multiplex system shows the relationships of the GROUP patch panels and the SUPERGROUP patch panels to the multiplex gear. The GROUPS go through the GROUP patch panel, where patches can be made if necessary, likewise, the SUPERGROUPS go through the SUPERGROUP patch panel.

The AN/FCC-17 is used with the AN/MRC-85 radio equipment to provide 72 channels (Figure VII-C-4). In this case, SUPERGROUP 1 consists of 60 channels and SUPERGROUP 1A consists of GROUP 5 only, in the frequency range 12-60 kHz. The AN/MRC-98 uses the AN/FCC-17, SUPERGROUP 1 only, to provide 60 channels (Figure VII-C-4).

d. Equipment Configuration: A typical AN/FCC-17 equipment configuration is shown in Figure VII-C-5.

e. Failure Alarm System (Figure VII-C-6):

General: All vital circuits of the AN/FCC-17, including the power supply, carrier frequency supply, supergroup equipment, fuse panel, group pilot and the synchronization pilot circuit, are connected to an alarm system which provides visual (and audible) indications in the event of an equipment failure.

The AN/FCC-17 uses group pilots inserted in the channel multiplexers and picked-off in the channel demultiplexers to monitor operation and activate the alarm system in case of failure in any stage of the transmit and receive path equipment. In addition, the outputs of the various carrier equipment shelves and the power supply sets are also monitored by the alarm system to indicate equipment status. The AN/FCC-17 does not depend on a fuse failure to activate an alarm.

The AN/FCC-17 contains two types of alarm circuits: (1) major alarm and (2) minor alarm. The minor alarm circuit is activated by the failure of any unit which is operated in parallel with an identical unit. The major alarm circuit is activated if both units in a parallel circuit fail, by loss of any one of the incoming group pilots, or by loss of the 96-kHz synchronization pilot; thus a minor alarm indicates only that system reliability is reduced, whereas a major alarm indicates a partial or complete loss of the system.

Master Alarm Panel: The Master Alarm Panel, receives the alarm signals described above and provides a centralized location of the alarm condition of the AN/FCC-17. The alarm conditions indicated on the Master Alarm Panel may be connected to an external alarm circuit to activate remote alarm lamps or buzzers.

Group Pilot Alarm: A 64-kHz group pilot signal is inserted in the 12-channel group output of each Channel Multiplexer. These signals are picked off at the receiving terminal and passed to the Group Pilot Alarm. In the event one of the pilots is not received, a lamp on the front panel of the Group Pilot Alarm lights to indicate which group has been lost. At the same time, a major alarm condition is indicated on the Master Alarm Panel.

* Reprinted from AN/FCC-17 Training Text with permission of Lenkurt Electric Co., Inc.

Equipment Shelf Alarms: In addition to the alarm lamps provided on the Master Alarm and the Group Pilot Alarm panels, alarm lamps and alarm cutoff switches are also provided on the front panels of the various equipment shelves which are monitored by the alarm system. The shelf alarm circuit and lamps isolate the equipment failures to the defective circuit and activate either the minor or the major lamp on the Master Alarm Panel, whichever is applicable. The alarm cutoff switch turns off the alarm lamp on the Master Alarm Panel and lights the alarm cutoff lamp on the defective shelf.

f. Test Facilities*: A Transmission Test Set for monitoring and maintaining equipment and system performance is supplied as an integral part of the AN/FCC-17. It is designed for use by relatively inexperienced operators and technicians. Personnel with very little training can use the Transmission Set to quickly and accurately perform alignment as well as routine maintenance and trouble-shooting procedures. With the exception of a multi-meter, no other test equipment is required to perform all test functions required for lineup and operation of the AN/FCC-17.

Specific functions of the Transmission Test Set are listed below:

(1) Generates a 1-kHz test tone and provides for local terminal alignment of the VF transmitting path and receiving path. The terminal may then be connected to the hf line for end-to-end tests at the correct signal levels.

(2) Measures group pilot signal levels at each modulation and demodulation stage. Thus, by routine checks, any system degradation is readily apparent.

(3) Generates pilots at line frequencies for local terminal alignment of the receiving transmission path. The terminal may then be connected to the hf line for end-to-end testing and operation.

(4) Measures the carrier frequency output levels of all carrier frequency supplies and amplifiers.

The dc and ac supply voltages are checked with a multimeter. Since these meters are standard in all communications centers, this function was not included in the test set.

For large fixed-office applications, the test set can be supplied mounted in a dolly cabinet; for small fixed-office or tactical applications, it can be supplied rack-mounted with the multiplex equipment. One dolly-mounted test set can be used as test facilities for any number of AN/FCC-17 multiplex terminals installed at the same locations.

* Ibid

NOTE:
WHEN DC VOLTAGE IS REQUIRED FOR LAMP POWER, CONNECT TO EXTERNAL DC POWER SOURCE.

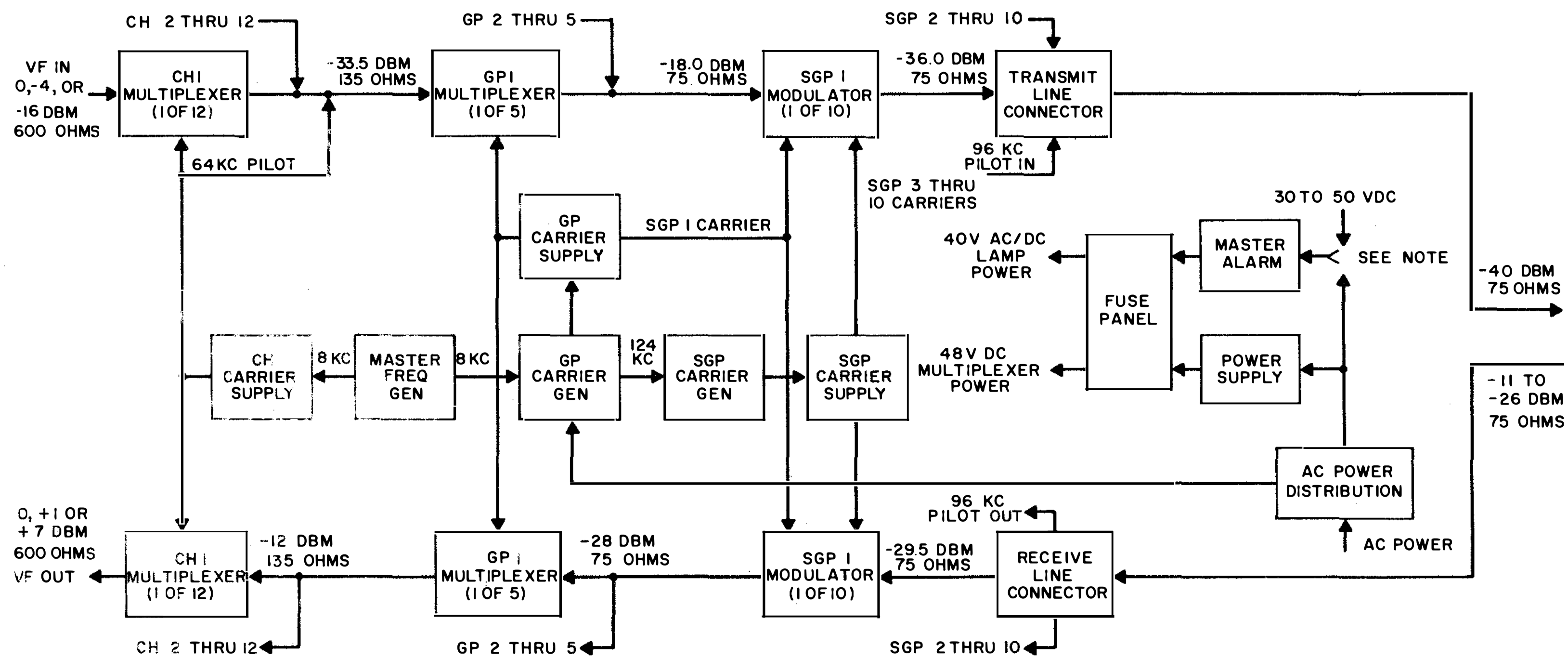


FIGURE VII-C-1. AN/FCC-17 FAMILY OF MULTIPLEXER SETS (600 CHANNEL SYSTEM), DETAILED BLOCK DIAGRAM

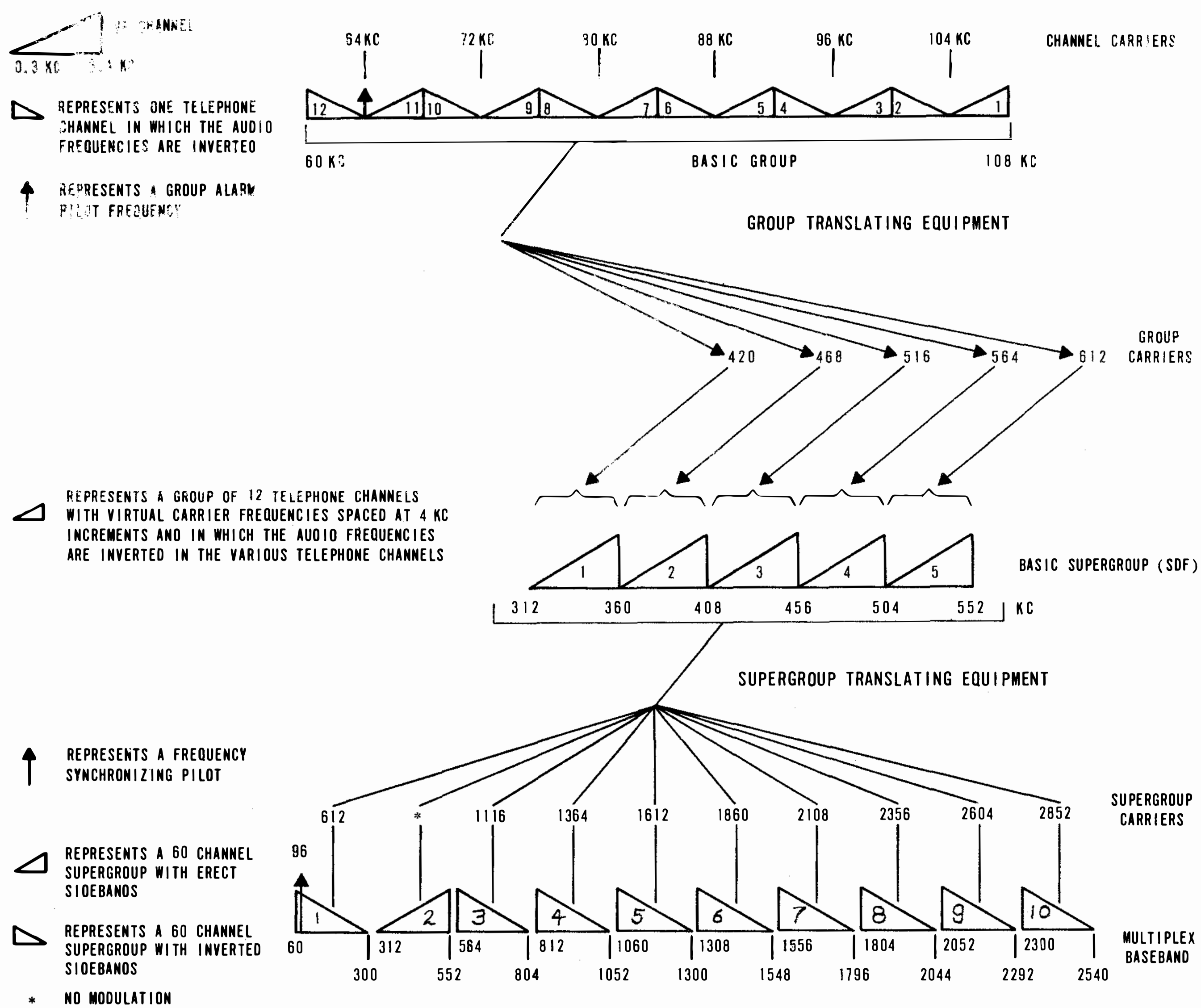


FIGURE VII-C-2. FREQUENCY ALLOCATIONS AND MODULATION PLAN FOR THE AN/FCC-17 FAMILY OF MULTIPLEXERS

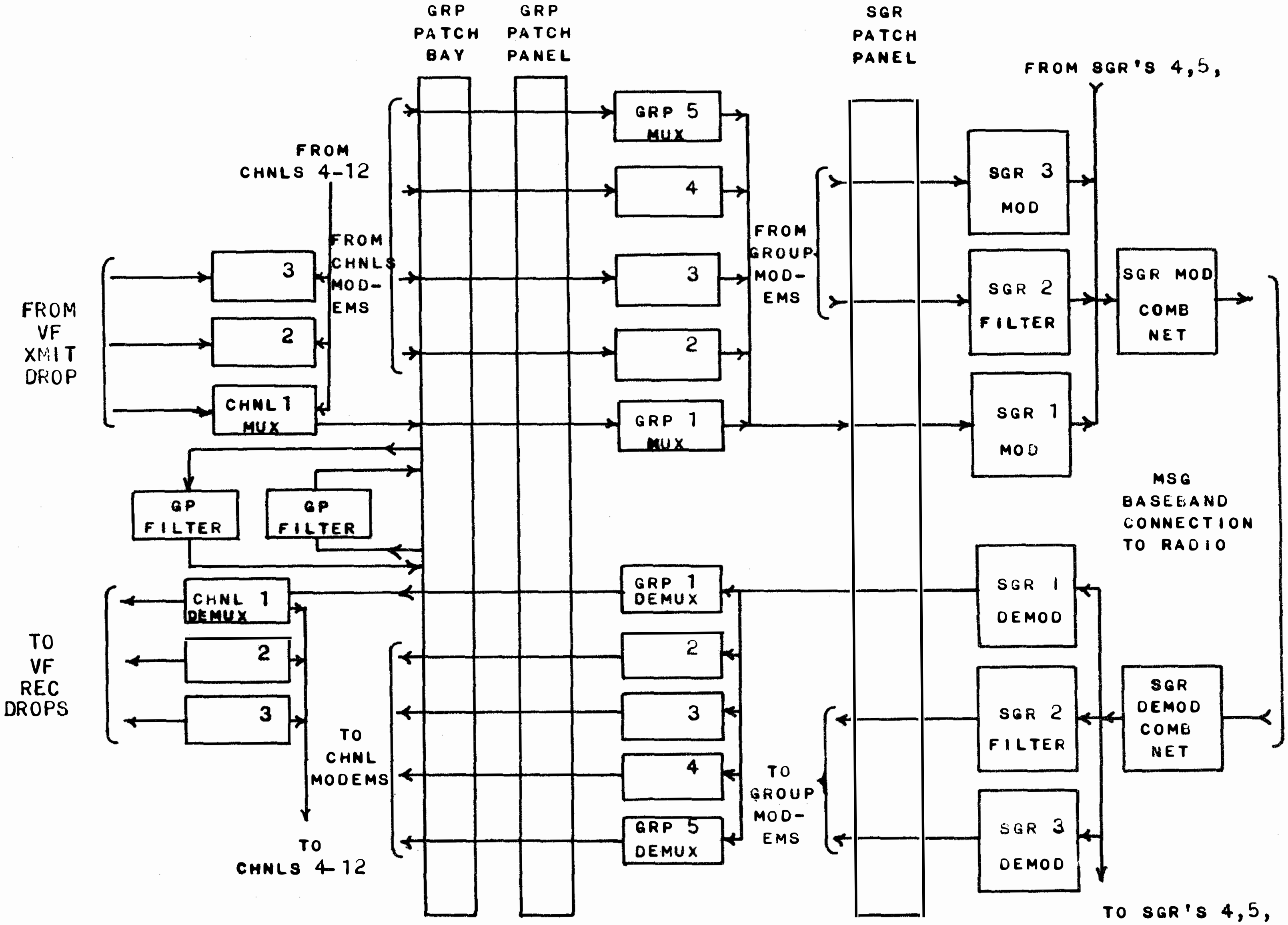


FIGURE VII-C-3 AN/FCC-17 (120,180,240 CHANNELS)

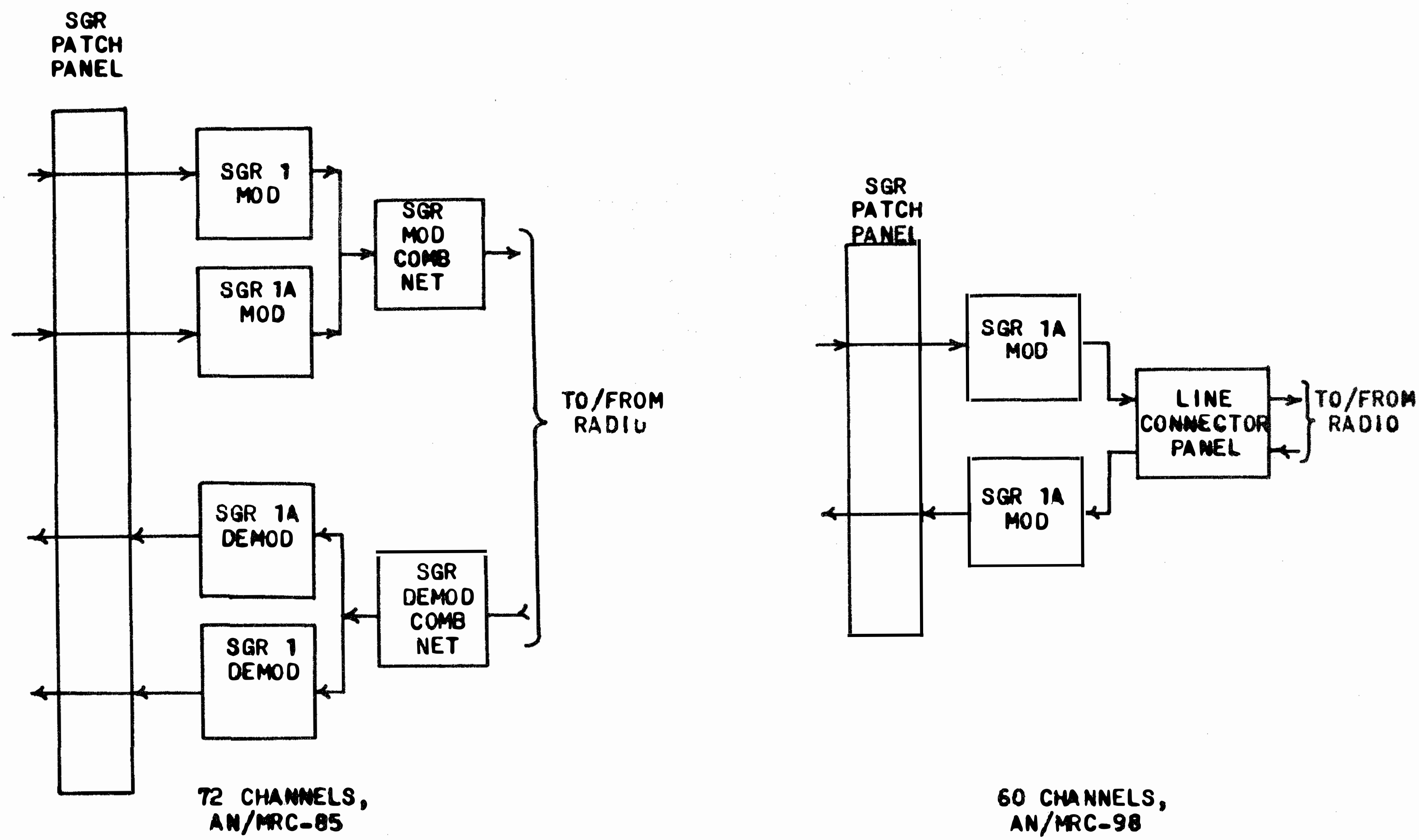


FIGURE VII-C-4 AN/FCC-17, SPECIAL CONFIGURATIONS

Common Equipment (Rack 1)

INDEX	COMMON NAME
1	Terminal Board
2	Power Supply Set (not in ICS)
3	Carrier Supply Fuse Panel
4	Master Alarm Panel
5	Master Frequency Generator
6	Supergroup Carrier Generator
7	Supergroup Carrier Supply
8	Group Carrier Generator
9	Group Carrier Supply
10	Group Carrier Amplifier
11	Channel Carrier Generator (for LSB or twin channel equipment) or Channel Carrier Supply (for twin channel equipment only)
12	Storage Cabinet

Channel Equipment (Rack 3)

INDEX	COMMON NAME
1	Terminal Board
2	Power Supply Set (not in ICS)
3	Channel Demultiplexer Fuse Panel
4	Channel Carrier Amplifier (Even)
5	Channel Demultiplexer (LSB or twin channel as required)
6	Group Pilot Alarm
7	Channel Multiplexer (LSB or twin channel as required)

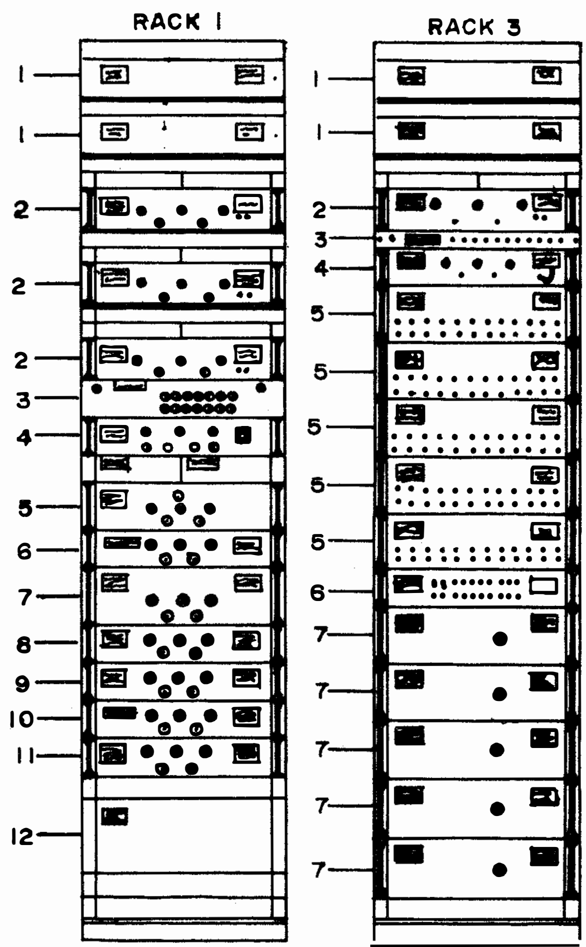


FIGURE VII-C-5. AN/FCC-17, MULTIPLEXER SET, RACK ELEVATIONS (PAGE 1 OF 2)

Group/Supergroup Equipment (Rack 2)

INDEX	COMMON NAME
1	Terminal Board
2	Group/Supergroup Fuse Panel
3	Supergroup Demodulator Combining Panel
4	Supergroup Modulator Combining Panel
5	Supergroup Jackfield
6	Supergroup 1 Modulator
7	Supergroup 1 Demodulator
8	Supergroup 2 Modulator
9	Supergroup 2 Demodulator
10	Supergroup 3 Modulator
11	Supergroup 3 Demodulator
12	Supergroup 4 Modulator
13	Supergroup 4 Demodulator
14	Supergroup Equipment Support
15	Group Receive Jackfield
16	Group Transmit Jackfield
17	Group Demultiplexer
18	Group Multiplexer

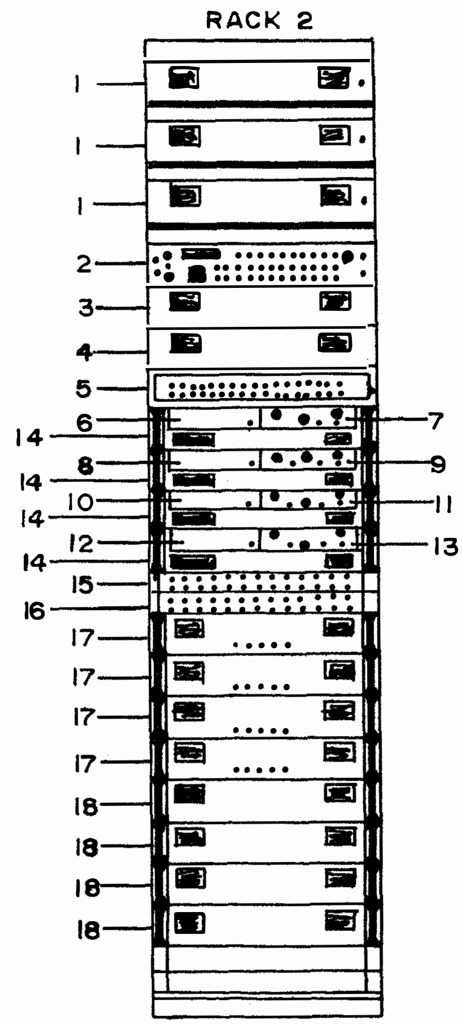


FIGURE VII-C-5. AN/FCC-17, MULTIPLEXER SET, RACK ELEVATIONS (PAGE 2 OF 2)

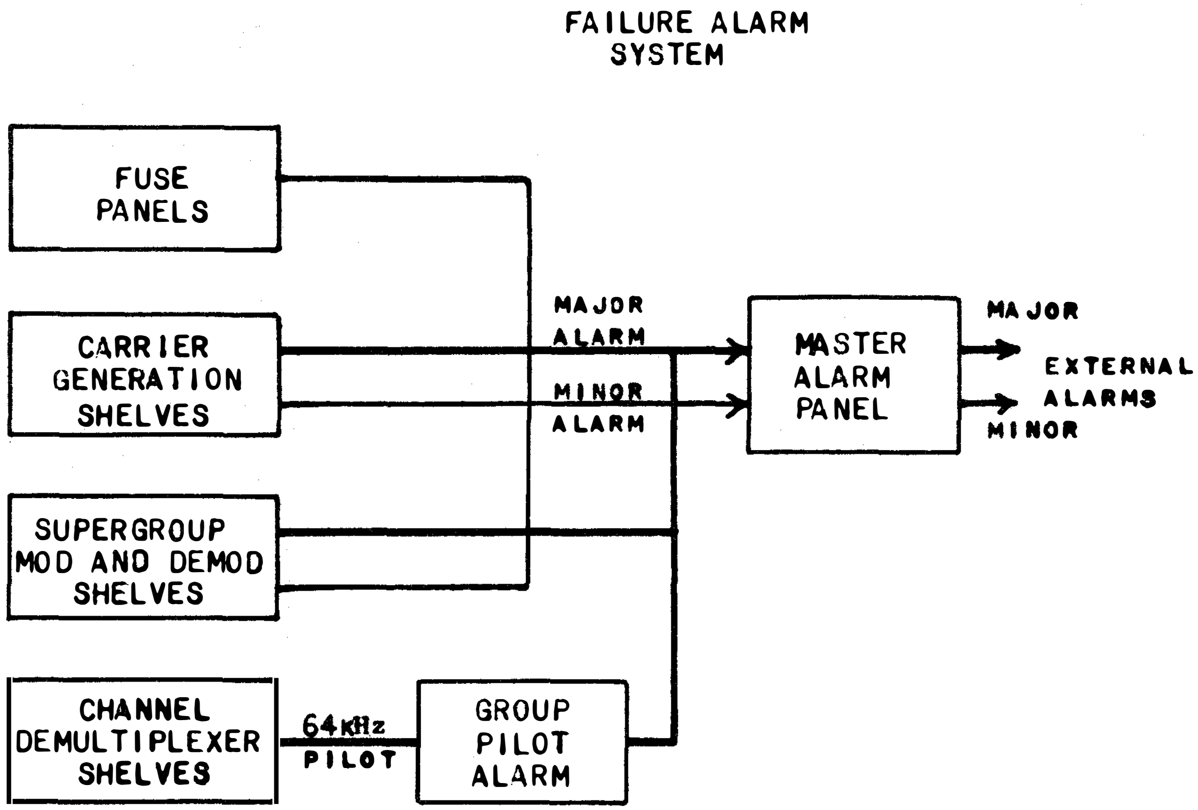


FIGURE VII-C-6 FAILURE ALARM SYSTEM, OVER-ALL BLOCK DIAGRAM

2. AN/FCC-18

The AN/FCC-18 is the VF multiplex terminal used in ICS in Area 2 (Thailand). It is also used in the LRC-3 in Vietnam.

A single multiplexer set AN/FCC-18 provides sixty 4 kHz voice channels in the supergroup one frequency spectrum. The physical arrangement of the AN/FCC-18 is such that the set may be used as the basic unit of a high density terminal providing up to 600 voice channels. The channel capacity of this assembly can be expanded in basegroup (12 channel) increments to a maximum of ten supergroups (600 channels occupying a frequency spectrum of 60-2540 kHz) by the addition of applicable equipment (Figure VII-C-7).

A single multiplexer set AN/FCC-18 is contained in three equipment racks. Internal alarm is provided in the event of loss of channel carrier within the multiplex. Only one means of path alarm and syncronization is provided between terminal points. This is done by the 60 kHz pilot frequency generated by the multiplex terminal set. Additional terminal sets can be employed and slaved to a master terminal for syncronization purposes. In the event of failure of the 60 kHz pilot from the master station, a standby pilot takes over instantly. There are no pilot frequencies generated in each basegroup (12 VF channels) to provide alarm monitoring in case of basegroup failure at the receive terminal.

Multiplexer set AN/FCC-18 does not normally provide for individual channel patching of circuits. If individual patching of channels are desired, special provisions for installation of jack details will have to be made. Multiplexer set AN/FC-18 in the 60 channel (one supergroup) configuration does not provide for group patching facilities.

Technical specifications:

Channel capacity	From 12 to 600 4 kHz duplex channels in 12 channel (one group) increments.
Type of multiplex and modulation	Frequency division, single sideband, suppressed carrier (lower sideband).
Frequency allocations:	
VF Channel	300 to 3450 Hz
12 channel group (one basegroup)	60-108 kHz
60 channel group (one supergroup)	312-552 kHz
240 channel group	60-1052 kHz
600 channel group	60-2540 kHz

Employment	Designed for operation with either FM or SSB radio facilities in line of sight or troposcatter links; output may be adapted for cable or open wire transmission by use of appropriate auxillary equipment, including repeaters, compandors, equalizers, and regulators.
Processing capabilities	Voice, digital data, teletype and facsimile.
Type of carrier frequency synchronization	Slave terminal synchronized to 60 kHz pilot generated into the baseband at the master terminal.
Envelope delay	From 800 to 3000 Hz the differential delay (maximum with respect to minimum) between two frequencies is 350 seconds nominal in a single back-to-back arrangement.
Levels (4-wire)	
Input	-16 dbm
Output	+7 dbm

When the modulation plan for the AN/FCC-18 in compared to that for the AN/FCC-17, a point of incompatibility is noted. In the AN/FCC-18, all of the individual channels in the GROUP are inverted (lower sideband, single-sideband-supressed-carrier), whereas in the AN/FCC-17, the channels alternate, inverted and erect (twin-channel modulation). If it is necessary to connect a GROUP between these two pieces of equipment, only half of the channels would be usable.

MULTIPLEXER SET AN/FCC-18(V)

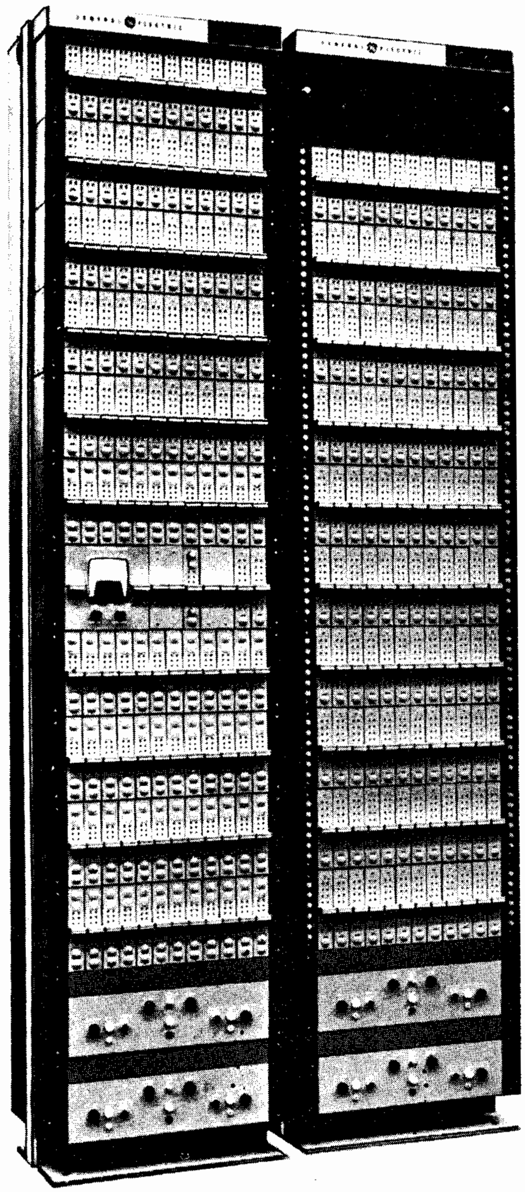
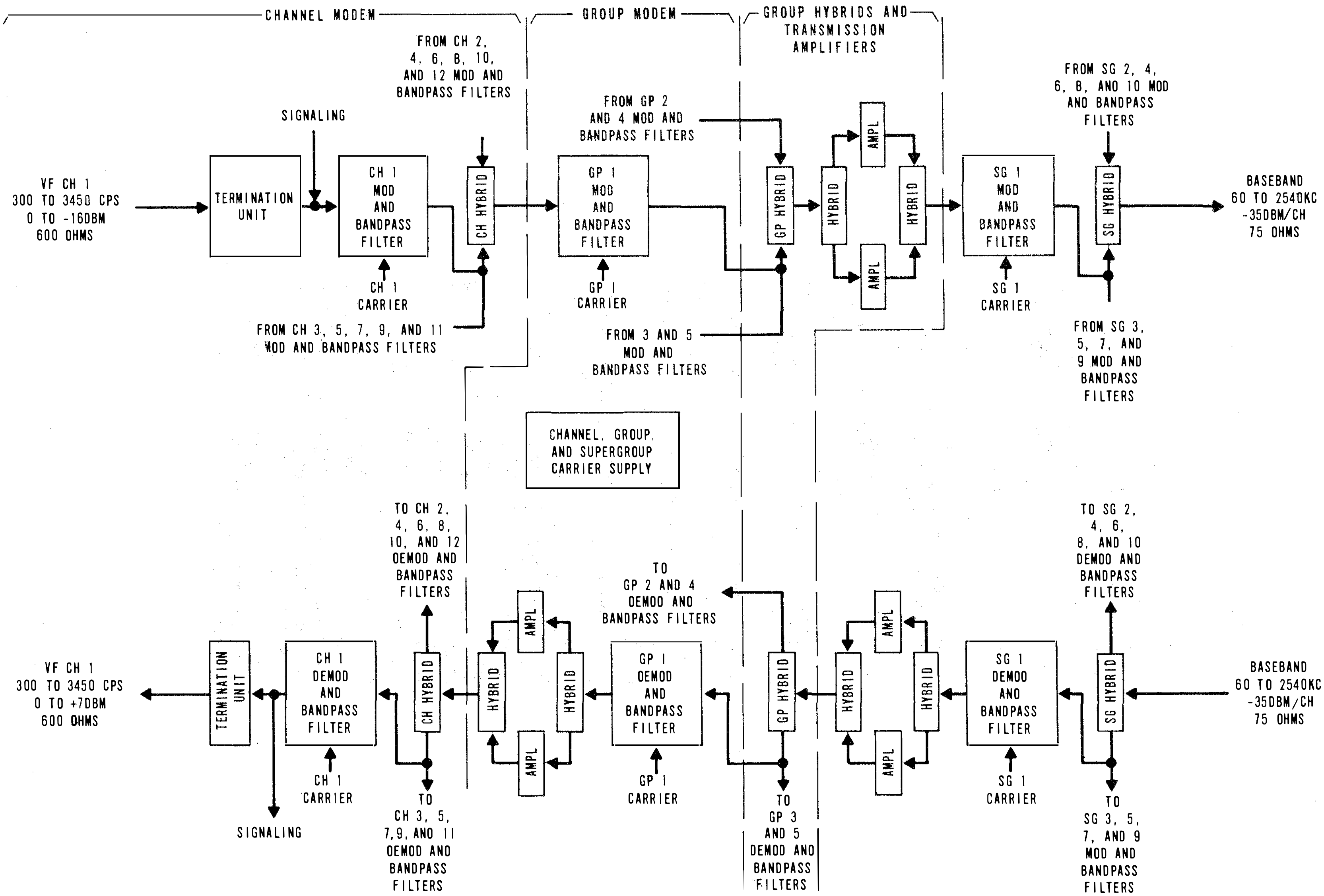
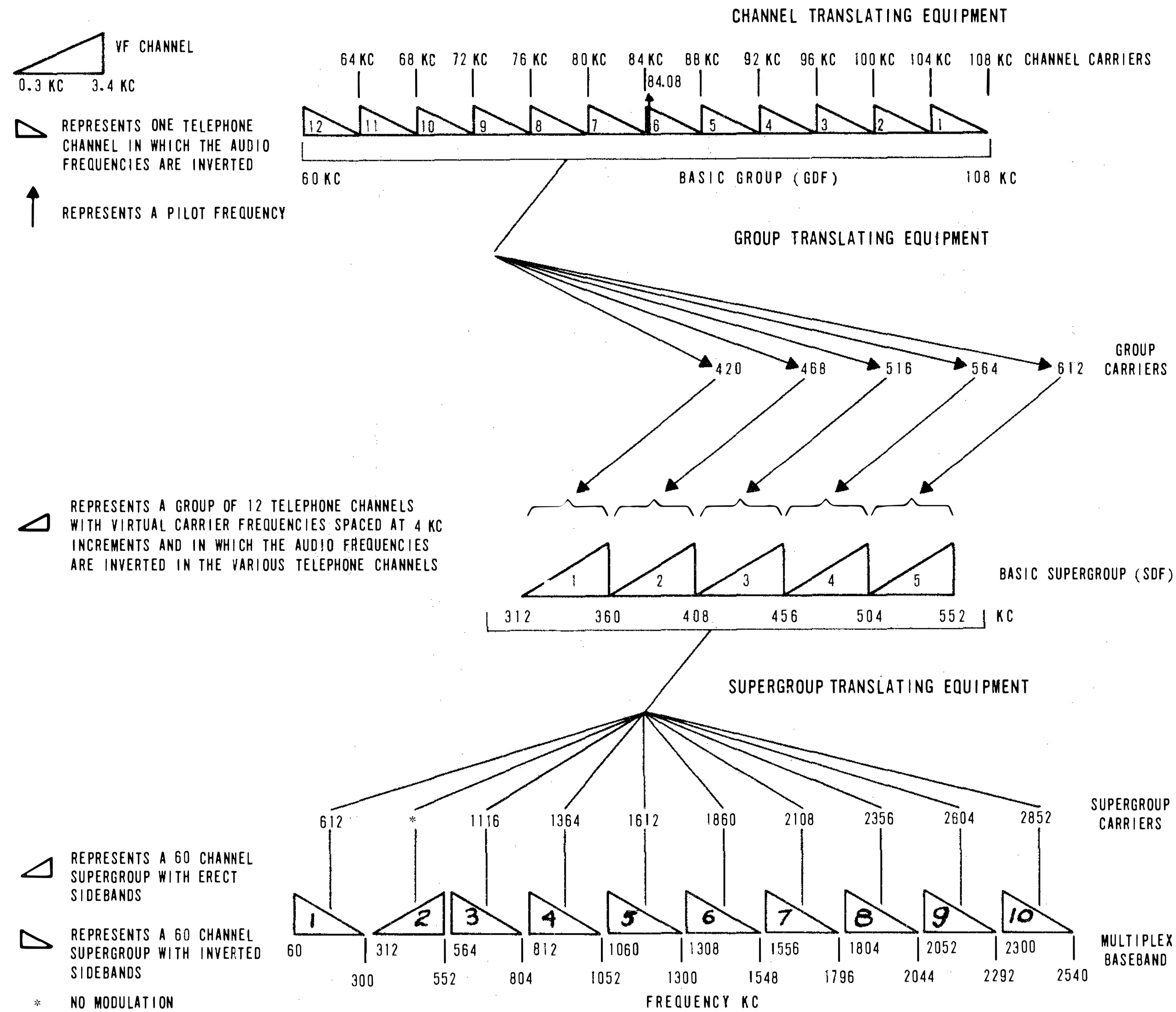


FIGURE VII-C-7.
600 CHANNEL, SOLID STATE, VF MULTIPLEX (FDM)
SET AN/FCC-18(V), 120 CHANNEL CONFIGURATION WITH SIGNALING



MULTIPLEXER AN/FCC-18(V) (600 CHANNEL CONFIGURATION), BLOCK DIAGRAM

FIGURE VII-C-8.



AN/FCC-18(V),
FREQUENCY ALLOCATION AND MODULATION PLAN
FIGURE VII-C-9.

3. ICS System Synchronization:

A 96 kHz pilot frequency is used for synchronization of the entire Area 1 ICS system.

The "Master" 96 kHz is produced by the Master Frequency Generator (MFG) at the Nha Trang cable terminal. This signal is then transmitted via cable or radio to all other sites in the ICS system, whose frequency generators operate as "slaves" (Figure VII-C-10).

This pilot is received at the terminal, separated from the channel signals, and fed into the Master Frequency Generator drawer (Figure VII-C-11). A phase detector compares the phase of the incoming 96 kHz tone and the phase of the locally produced one. If there is an error in phase between the two signals, an error voltage is produced which is proportional to the error. This voltage is then fed back into the oscillator which will produce a frequency change in the local "slave" MFG drawer. The MFG drawer supplies a basic 8 kHz signal which is used in the carrier equipment to generate all channel, GROUP and SUPERGROUP carrier frequencies. As the basic 8 kHz frequency is corrected all carrier frequencies are also corrected and frequency synchronization is maintained.

If the incoming 96 KHz pilot tone is lost, the MFG will lock in on the last received signal. At this time the MFG will continue to supply 96 KHz pilots to all sites "downstream" but the MFG in the absence of the phase lock controls will be subject to drifts. (Figure VII-C-10)

It is not desired for the 96 kHz pilot to enter the channel demultiplexers. Figure VII-C-11 shows how it is eliminated as well as other details as to its routing in the terminals.

Area 2 (Thailand) uses a 64 kHz synchronization pilot. Synchronization between the two areas is provided over the Vung Tau - Sattahip undersea cable and Monkey Mountain - Warin Radio System. Pilot interface is accomplished at the 8 kHz level.

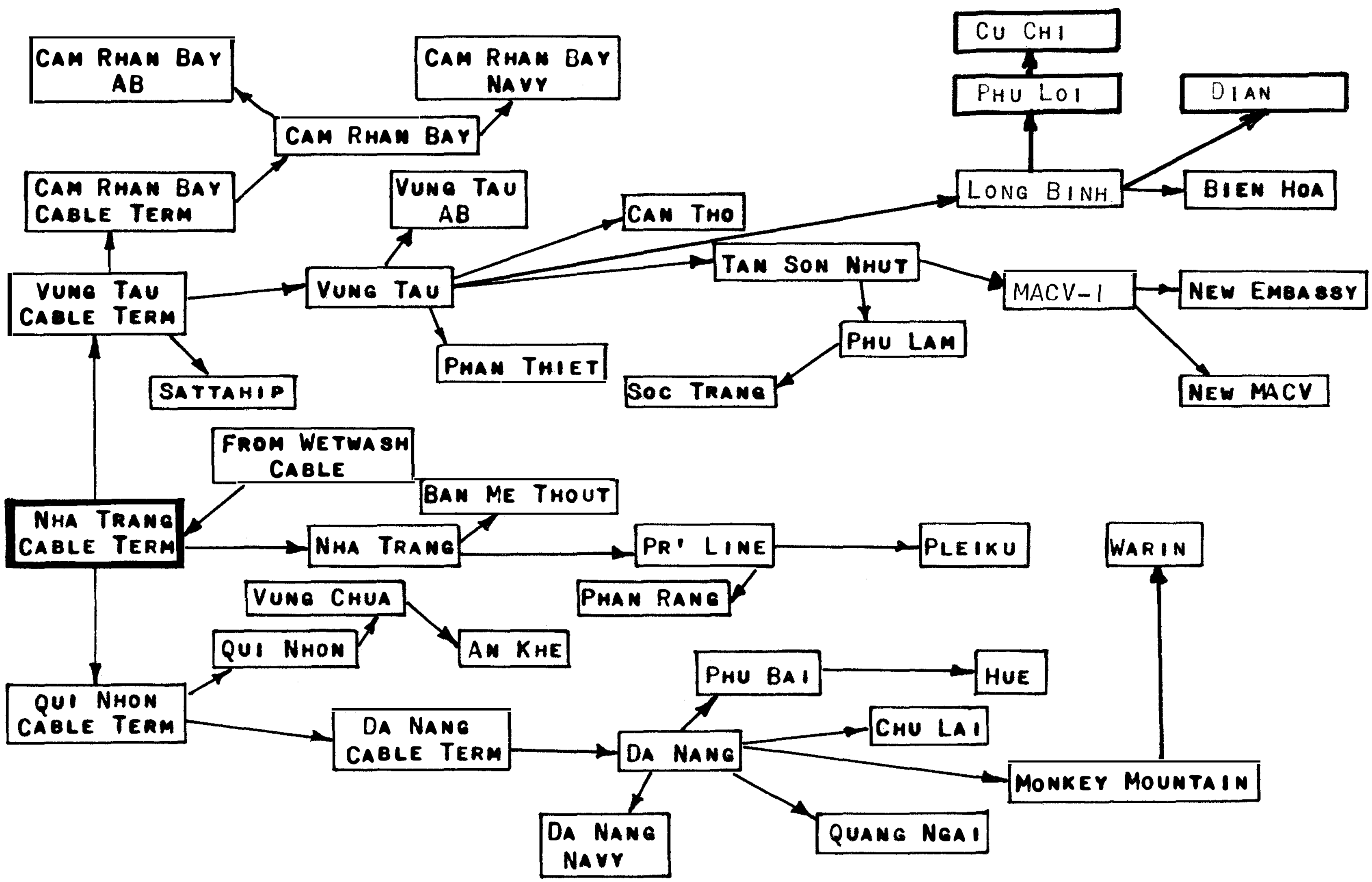
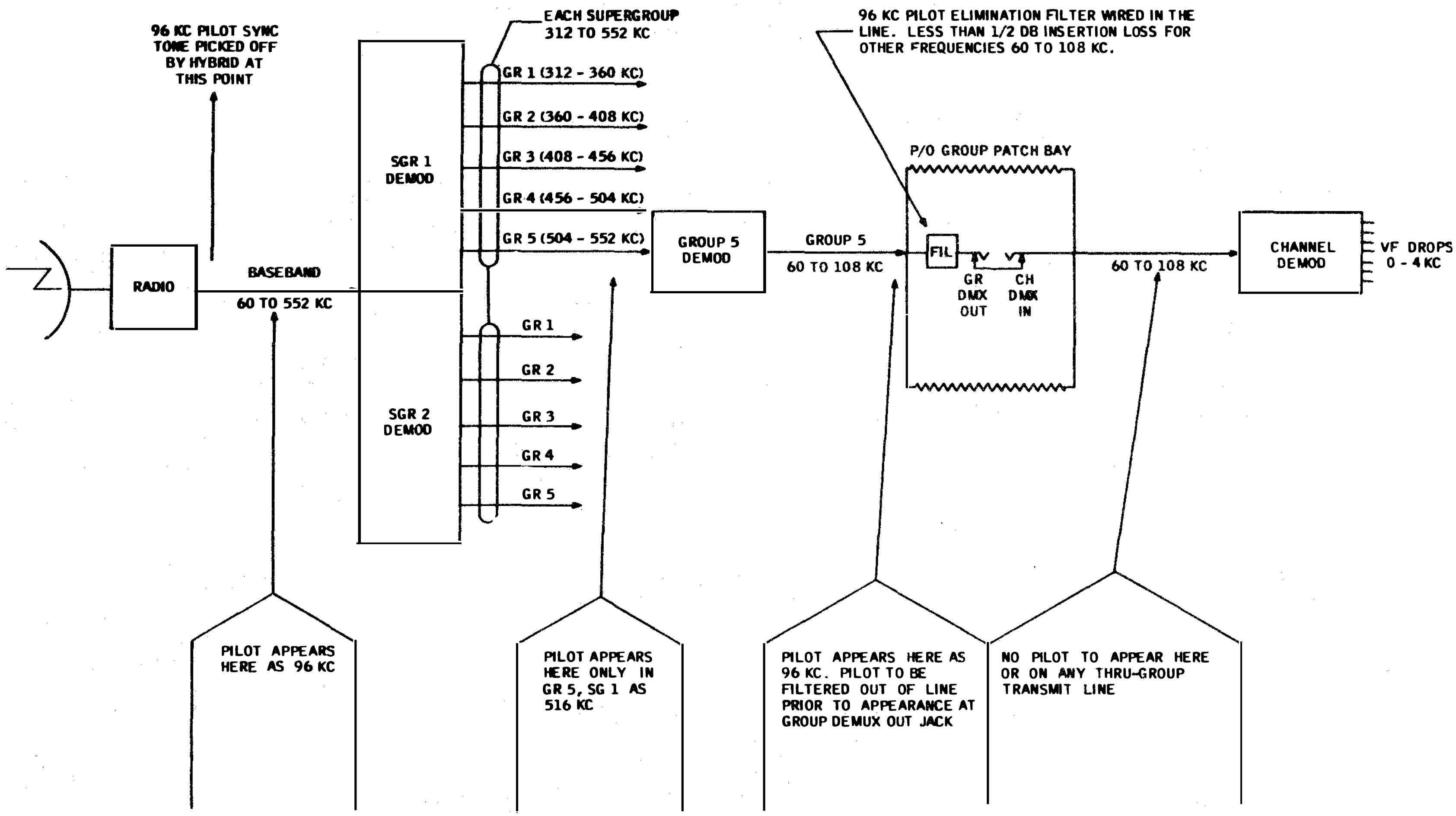


FIGURE VII-C-10 ICS SYSTEM SYNCHRONIZATION, 96 kHz PILOT ROUTING PLAN



NOTE

96 KC PILOT DOES NOT APPEAR IN SUPERGROUP 1A LINE FREQUENCY (PHASE ONE ONLY)

FIGURE VII-C-11. 96KHZ PILOT APPEARANCES.

D. TELETYPE MULTIPLEX EQUIPMENT:

There are two primary types of teletype multiplex equipment in the ICS:

AN/FCC-19, -25 (Contractor Furnished)

AN/FGC-60 (Government Furnished)

It is common to refer to teletype multiplex equipment as VFTG (voice-frequency telegraph) equipment; however, DCA publications use the ABBREVIATION VFCT (voice-frequency carrier telegraph).

1. AN/FCC-19, -25 Telegraph Terminals:

a. General Description: The AN/FCC-19 and AN/FCC-25 are full duplex, non-diversity, frequency division telegraph multiplex equipment for transmitting telegraph information over microwave, tropospheric scatter, or landline facilities, (Figure VII-D-1,2). The AN/FCC-19 multiplexes 16 channels of telegraph information into a single voice channel. The AN/FCC-25 multiplexes 32 channels of telegraph information into 2 voice channels (essentially two AN/FCC-19's in a single rack). The FSK (frequency shift keying) modulation and channel carrier frequencies are in accordance with DCA standards. The AN/FCC-19, -25 has a meter and test panel which provides a 90 baud square wave test signal, a 600 ohm balanced line step-attenuator which may be patched into any VF circuit, a loop meter for measuring telegraph loop current, a delay meter for comparing relative transition times on two independent loop circuits, and VU meter for bridging or terminating measurements on 600 oHm VF circuits.

Manufacturer: Tele-Signal Corporation

b. Technical Characteristics:

DC Loop Input:

Input Keying	10 to 100 ma dc, up to 150 vdc, neutral or polar, positive or negative
Keying Sense	Direct or inverted, positive or negative
Keying Speed	Up to 90 baud
Bias Distortion Tolerance	Bias correction adjustment compensates for up to 10% marking or spacing bias.

DC Loop Output:

Relay Output	Polar relay contacts, electrically floating, for 10 ma to 100 ma loop current
Direct Output	Neutral -12 vdc, 10 ma max (source impedance approx 200 ohms)

Keying Sense	Direct or inverted, switch selectable
Bias Distortion	Less than 5% at 90 baud
Signal Delay Compensation	5 milliseconds minimum adjustable range
Keying Speed	Up to 90 baud

VF Channel Input:

Frequency Range	300 Hz to 3 kHz
Modulation	FSK
Signal Level	-45 to +5 dbm/ch
Impedance	600 ohms

VF Channel Output:

Frequency Range	300 Hz to 3 kHz
Modulation	FSK
Signal Level	-5 to -30 dbm/ch
Impedance	600 ohms

Block diagrams of a send and a receive channel are shown in Figure VII-D-3.

2. Telegraph Terminal AN/FGC-60 (V):

a. General Desciption: The AN/FGC-60 (V) Diversity Telegraph Terminal is intended for use on long distance communications links. It provides for transmission and reception of a number of independent telegraph channels which are simultaneously conveyed over one audio circuit. To insure a high order of realibility, the receiving portion of this system is equipped with dual diversity as well as quadruple diversity facilities. (The ICS does not use the diversity terminal).

The AN/FGC-60 (V) Nondiversity Telegraph Terminal is intended for use on communications links where diversity is not required. The terminal provides for the simultaneous transmission and reception of a number of independent telegraph channels, and contains the identical basic components of the diversity terminal except for the diversity comparators and twinning panels. (This is the terminal found in the EE Buildings).

Both terminals are fully transistorized 16 channel frequency division multiplex systems. All the channels are individually operated and utilize the audion frequency shift keying method of signalling. Maximum keying speed is 100 wpm.

b. Technical Characteristics (Nondiversity Telegraph Terminal):

Number of Channels	16
Channel Speed	100 wpm max
Modulation Type	Independent audio frequency shift keying of each channel
Frequency Band	3 kc nominal speech circuit for 16 each 100 wpm telegraph channels.
Channel Center Frequencies	425 to 2975 Hz, spaced 170 Hz
Frequency Shift	±42.5 Hz
Signal Sense	Positive all channels (mark is center frequency + 42.5 Hz)

Receiving Section:

Input:

Type	Frequency shift keyed audio
Frequency Bandwidth	3 Hz nominal speech circuit
Keying Speed	100 wpm
Impedance	60 ohms balanced (transformer isolated)

Output:

Level and Impedance	Neutral floating output of 65 ma maximum into 200 ohms.
Telegraph Battery	Internally provided (may be disabled if external battery desired)
Loop Current Adjustment	2500 ohm, 25 watt potentiometer internally provided in Electronic Switch.

Transmitting Section:

Input:

General	Electrically floating; input terminal may be grounded or left ungrounded.

Keying	Neutral: ±40 to 65 ma into 220 ohm load, direct or inverted; ±20 ma into 620 ohm load. Neutral: ±1 ma min into 2200 ohm internal load, 10 vdc. Polar: direct or inverted, +1 ma into 2200 ohm internal load polar.
Keying Speed	100 wpm
Power	Sending battery not provided; external battery required.
Output:	
Audio Impedance	600 ohms balanced.

TELEGRAPH TERMINALS AN/FCC-19 AND AN/FCC-25

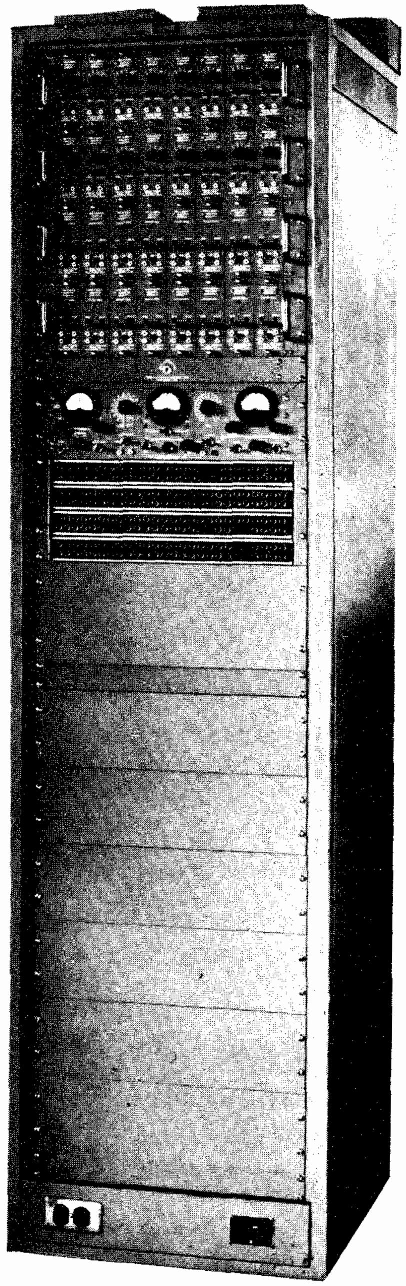


FIGURE VII-D-1. 16 CHANNEL, FULL DUPLEX TELEGRAPH TERMINAL AN/FCC-19

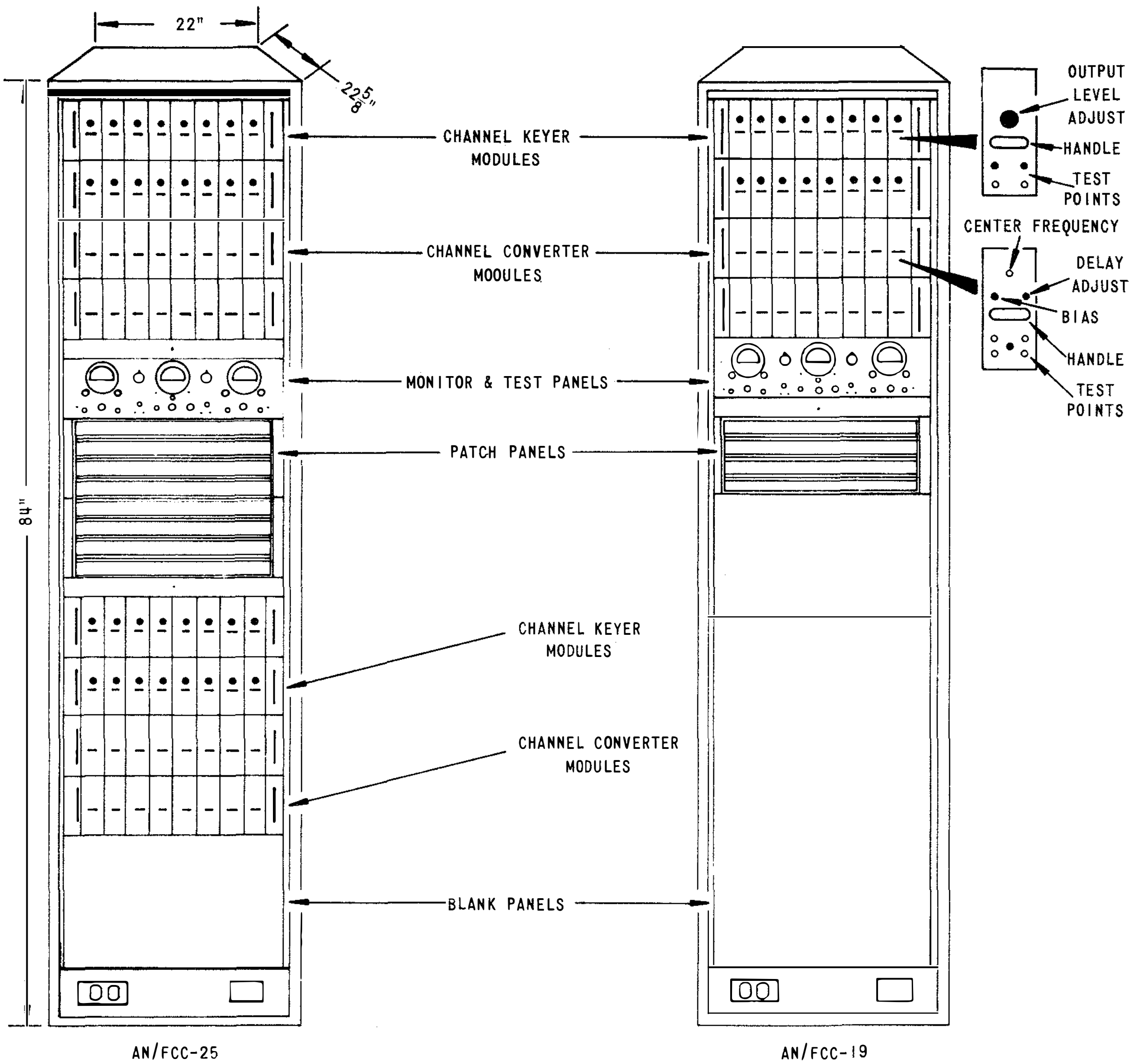


FIGURE VII-D-2.

EQUIPMENT LAYOUT OF TELEGRAPH TERMINALS
AN/FCC-19 AND AN/FCC-25

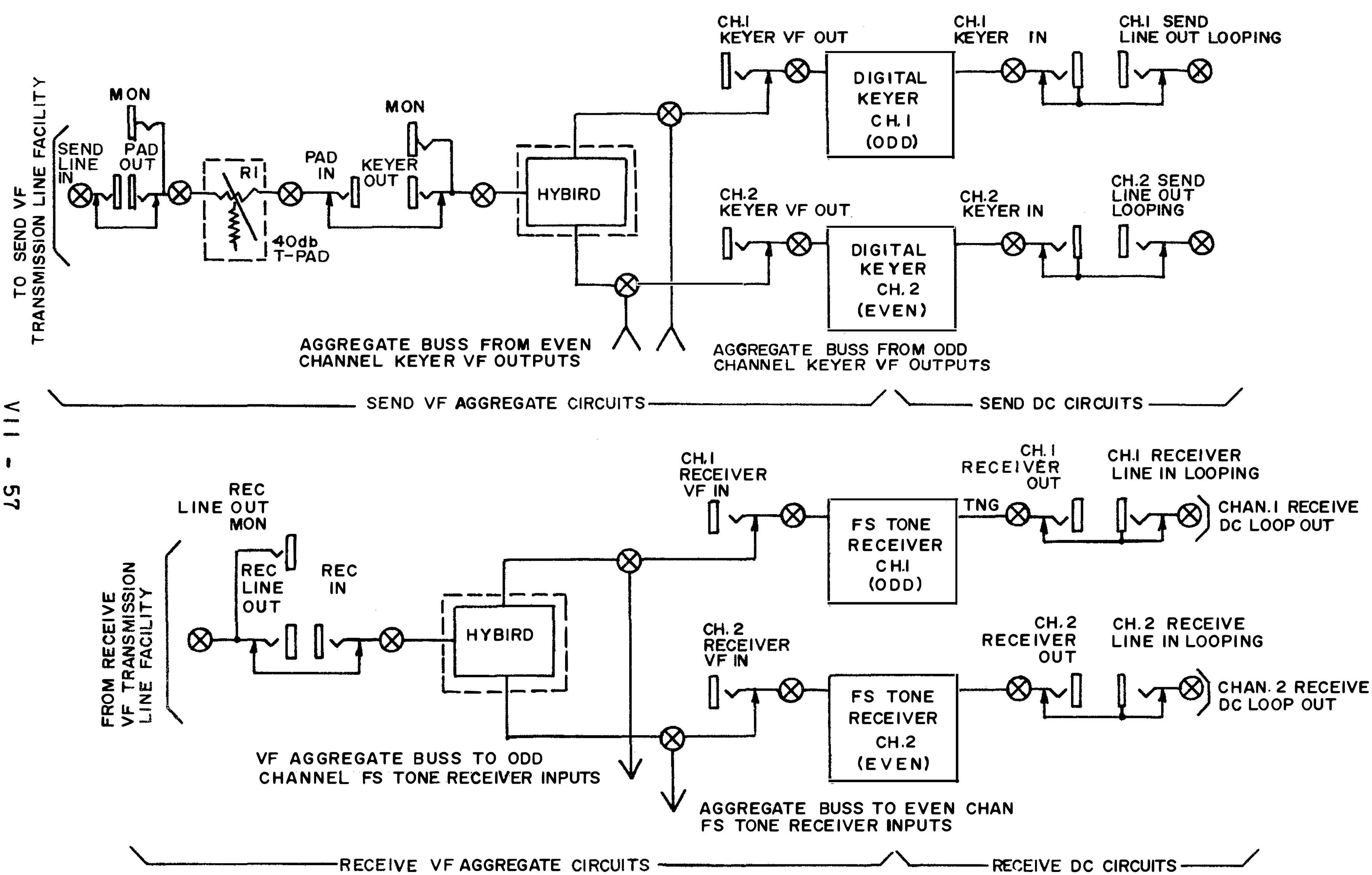


FIGURE VII-D-3 SIMPLIFIED BLOCK DIAGRAMS SEND AND RECEIVE CHANNELS, AN/FCC-19,-25

E. ICS CONDITIONING EQUIPMENT:

1. The following list of conditioning equipment represents what may be expected to be found in all ICS Tech Controls:

a. VF Amplifiers

b. VF Attenuators

c. SF Units (1600 Hz And 2600 Hz)

d. 20Hz Ringdown Converters

e. 2W/4W Term Sets

f. DC Isolation Relays

g. 4Way -4Wire Bridges

h. Limiters

i. DX-2 Units (AT SOME SITES)

j. Pulse Link Repeaters

k. Regenerative Repeaters

l. DC Hubbing Units

2. It may be that additional pieces of specialized gear may be found in one or more EE's, however this equipment is usually installed for special applications and is not common to all sites.

1. Voice Frequency Amplifier:

Model:	456B
Manufacturer:	Altec Lansing

a. Specification:

Frequency Response	+1 db, 200-6000 cycles
Maximum Power Input	-22 dbm (at maximum gain)
Maximum Power Output	+17 dbm

Output Noise Level	-70 dbm
Input Gain Control	Varies gain from -2 db to maximum of 39 db
Operating Voltage	24 or 48 vdc (selected by moving screw, accessible on bottom of amplifier case)
Input Impedance	600 ohms
Output Impedance	600 ohms
Current Drain	20 ma (at 25 and 50 vdc, when selector screw is in proper position)

b. Description: The 456B amplifier is an all-transistor unit, utilizing three silicon transistors and a printed circuit for maximum uniformity of production and minimum variation in operational characteristics when subjected to ambient temperatures as great as 140°F.

The circuitry of the 456B Amplifier has been designed to minimize RF radiation from nearby relays, stepping switches, battery supply spikes, etc., in order that relatively high speed data may be passed through the amplifier without excessive signal mutilation.

The gain control affords a range of approximately 40 db. In order to adjust the gain, the lock nut on the control must be loosened. The level at the monitor pins on the front panel, bridged by 600 ohms, is 11 db below the output level of the amplifier. After adjustment is completed, carefully tighten the locking nut and recheck the gain setting to ascertain the control shaft was not disturbed in the tightening operation.

2. VF Attenuators:

Manufacturer	Lenkurt Electric
Model	5200 A
Mounting	4 to a shelf
Values	0-31 db in 1.0 db steps
Impedance	600 ohm balanced
Levels:	
Input	-20 dbm maximum
Output	Depends on option and input level
Construction	Purely resistive, suitable for use on voice or carrier frequency circuits.

The attenuator consists of a series of balanced H-pads (Figure VII-E-1a).

The desired amount of attenuation is selected by placing straps on the terminals to either connect the appropriate H-pad in the circuit or to short it out. The dotted lines on the schematic in Figure VII-E-1a depict the straps for 10 db. The straps are actually made on the front of the unit. Figure VII-E-1b show the front of the unit properly strapped for 10 db loss.

Problem Areas:

The problem with straps on the attenuator is that the wiremen will fail to place the straps on bottom row of lugs. This causes the circuit to become unbalanced.

3. Single Frequency Signalling Units:

A typical application of the Collins SF Unit is shown in Figure VII-E-2. The theory of E&M signalling was covered earlier in section VI-D-4. Both models of signalling units are small transistorized plug-in modules mounted 20 units to a shelf, 3 shelves to a bay.

The two units are:

2600 Hz	Model 20D3-1MX
1600 Hz	Model 20D4-1MX

These units are quite similar in appearance; however, the 1600 Hz unit can be easily recognized by the presence of a black push button on the front panel. The Collins SF units in the ICS EE buildings have been modified so that it is not necessary to have battery on the M-lead to turn the tone off. The modification is such that either battery or an open condition on the M-lead will cause the tone to be turned off. However, if there is an open on the M-lead, there is the possibility that noise on that lead will cause the tone to be turned on; therefore, for long M-leads (those leaving the EE building) battery-on-the-lead should be used to insure proper operation. This modification becomes especially valuable when it is desired to place two SF Units back-to-back to change signalling frequencies. In this configuration the M-lead of one unit connects directly to the E-lead of the other.

	E Lead (From SF Unit)	M Lead (To SF Unit)
Standard Conditions:		
Tone (on hook)	Open	Ground
No Tone (off hook)	Ground	Battery

Option Possible for Short Control leads:

Tone (on hook)	Ground	Ground
No Tone (off hook)	Open	Open

4. 20 Hz Ringdown Converter:

Manufacturer	Collins
Model	20E1-MX

Converters incoming AC ringing tone bursts into DC signals (M lead) to key a signal tone for transmission. The unit also converts receive DC signals (E lead) into 20 Hz Ringing to provide ringdown conversion.

Input Ringing Tone Requirements:

16-100	Hz
40	volts rms minimum

Output Ringing Tone (determined by local source)

20	Hz
100	Volts

5. 4-Wire Terminating Unit:

Manufacturer:	Lenkurt Electric
Model:	31041

The 4-wire terminating sets, hybrids, installed in the EE buildings have several important features (Figure VII-E-3).

a. The hybrid action causes a loss of 3.5 db in both the receive and transmit paths.

b. There is an adjustable attenuator in each leg that may be set to any value between 0 and 7.75 db in .25 db steps.

c. There is a varistor that may be installed across the XMT Pair to suppress dial transients, etc. When this is done, an additional 6 db of loss is added in the transmit path.

d. There is built-in adjustable "network build-out" available as well as a compromise net and terminals to connect a precision external network as desired.

The normal use of the hybrid in ICS circuits will be (Figure VII-E-4):

a. Varistor connected in XMT line.

b. Total loss in XMT line - 16 db.

c. Total loss in REC line - 4 db.

d. Network build-up set to "Compromise Net".

Strapping

The adjustable attenuators are set by connecting straps on the front of the unit (Figure VII-E-5 a & b). The varistor and COMP NET are connected by straps on the rear of the unit (Figure VII-E-5 d).

The proper method of strapping is not understood by most technical controllers. Any term sets strapped other than shown in figures VII-E-5 b & d should be questioned.

6. Isolation Relay Assembly:

Manufacturer	Northern Radio
Model	304-1A

The isolation relay assembly installed in the EE building is very small and compact. On a panel occupying only 3½ inches in a 19 inch rack there are 9 relays mounted together with the adjustable resistors in the bias winding loop of each relay. The relay itself is the Sigma 72A, a very common plug-in isolation relay. The relay is capable of either dc neutral or polar operation. The bias winding current is obtained from the 48v station battery. The relay assembly panel is mounted beneath the jack strips in the DC Patch Bay.

7. 4-Way, 4-Wire Bridge:

The 4-4 bridges presently in use in the EE buildings were locally fabricated. They are completely passive units with an insertion loss of approximately 14.5 db and provide isolation in excess of 60 db. A schematic of the bridge is shown in Figure VII-E-6. For details as to their construction and use refer to RCG LL TCG S&P Item Nr. 0521.

8. Limiters:

The limiters used in the EE building are WECO 100A varistors. There are 50 of these mounted directly on a vertical pin block. Wired in series with the varistor is a jack that is used to "lift" the varistor off the line (Figure VII-E-7). This lifting is accomplished when either a dummy plug or a plug from a monitoring or test device is inserted in the "Lifting Jack".

The lifting jacks are located in the miscellaneous jack strip on the PRIMARY Patch Panel. However, the WECO 100A varistor are designed for use at the -2 dbm level and must be installed across the line at the CKT Patch Panel point.

9. Repeating coils:

These are standard 600 ohm center-tapped to 600 ohm center-tapped transformers used to provide audio continuity and DC isolation.

10. DX 1 and DX 2 Units:

DX 1 and DX 2 units, made by Stromberg Carlson, are used to extend the capabilities of the E & M leads over circuit paths greater than 25 ohms. These units are generally used at locations where the signal site is located some distance from the dial central office (DCO).

11. Regenerative Repeaters:

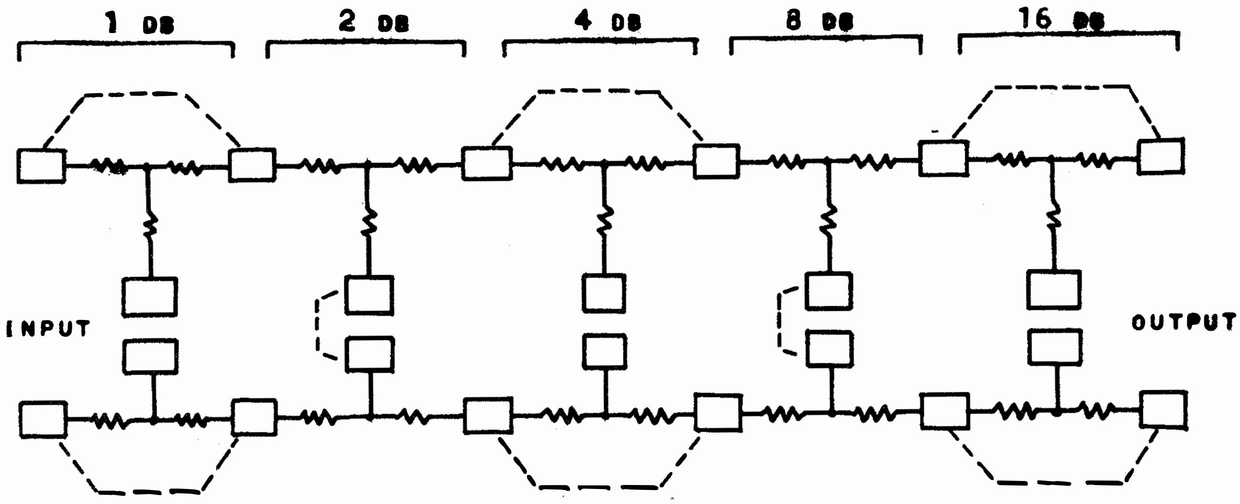
The TH-73/UGA-5 regenerative repeaters are used in the ICS to restore distorted (up to 45%) teletypewriter signals to 5% distortion or less. This is accomplished by circuits that electronically time and regenerate the signal.

12. DC Hub Repeaters:

DC Hub Repeaters, Northern Radio Model 353, are used to provide multipoint terminal operation for teletypewriter subscribers without the usual series circuit configurations. In this fashion, circuit faults in one leg of the multipoint circuit will not disable completely all other legs of the circuit.

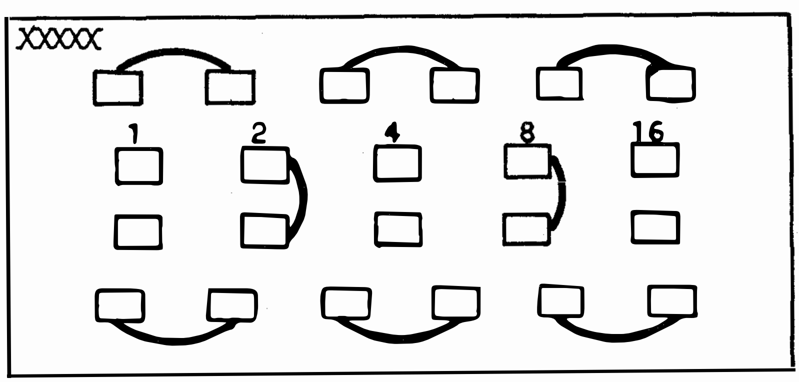
13. Echo suppressors:

The long haul circuits (SATCOM, oversea cable,etc.) require the use of echo suppressors to reduce the amplitude of return signals "echoed" from the distant end. These echos, usually caused by an unbalanced hybrid at the distant end, are not noticeable on short circuits because the returned signal is not distinguishable from the sidetone in the telephone circuit. The longer circuits, because of the transit times involved, have echo problems because the user can easily separate the echoed (and delayed) signal from the telephone sidetone signals.



A. ATTENUATORS SCHEMATIC

(DOTTED LINES-STRAPS FOR 10DB)



B. FRONT VIEW (STRAPS FOR 10DB LOSS).

FIGURE VII-E-1 VF ATTENUATOR

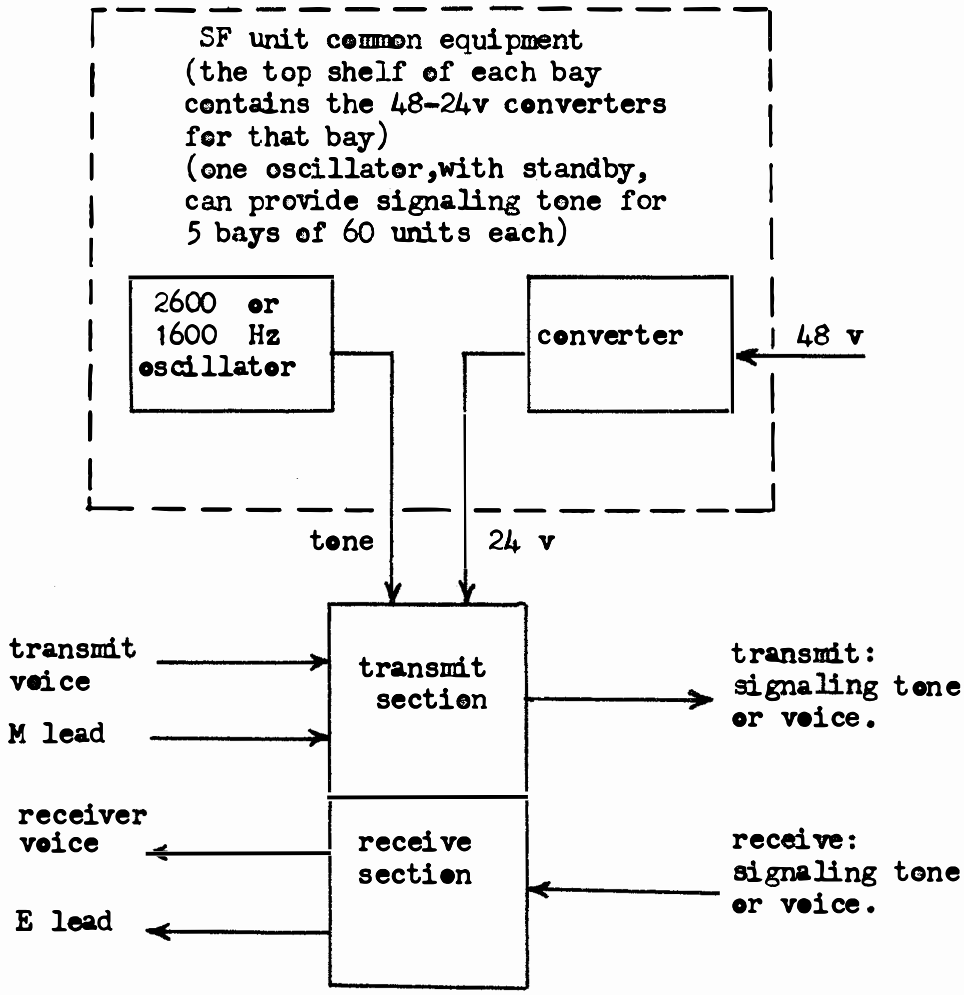


Figure VII-E-2 APPLICATION OF COLLINS SF UNIT

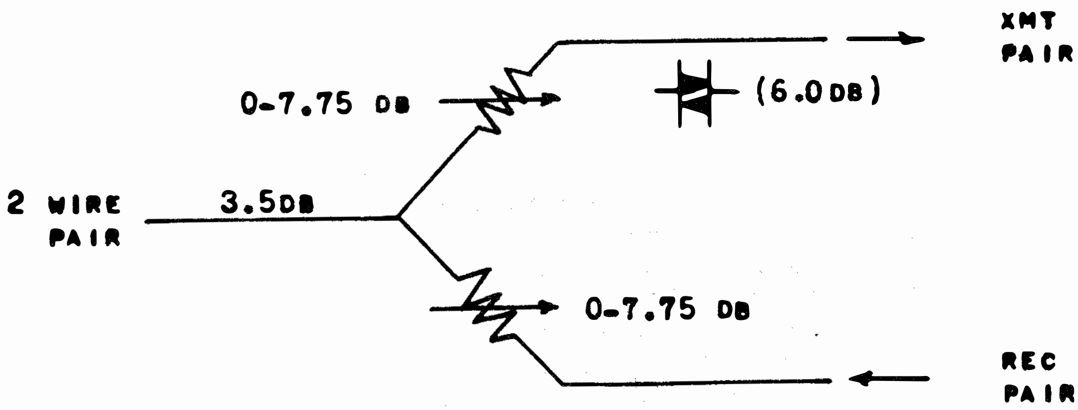
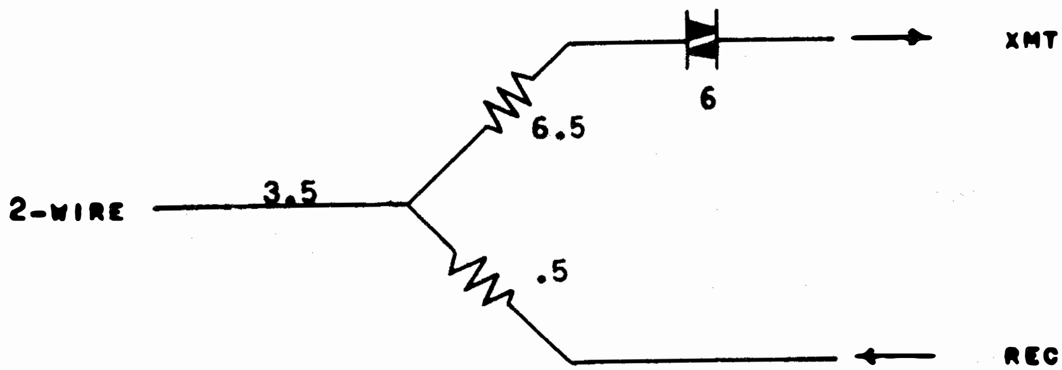
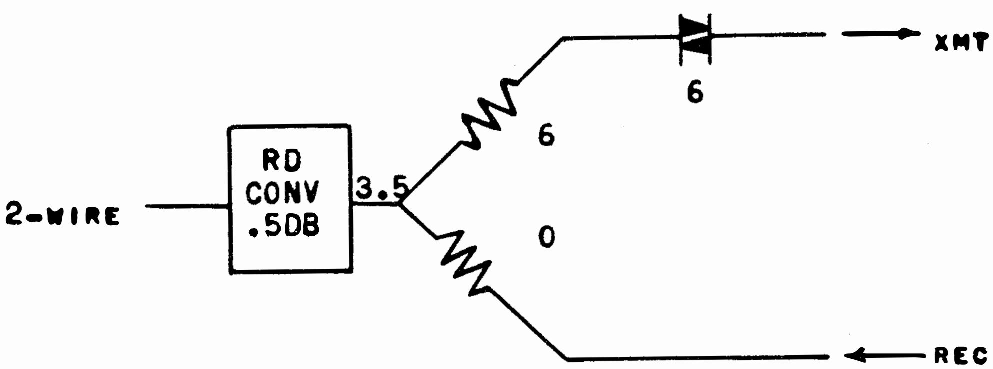


FIGURE VII-E-3 4-WIRE TERMINATING UNIT



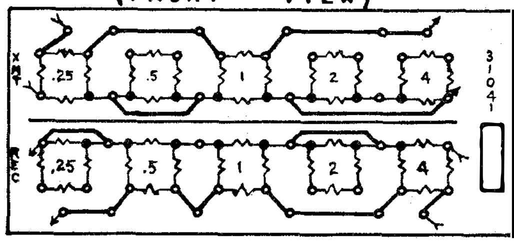
A. WITHOUT RINGDOWN CONVERTER



B. WITH RINGDOWN CONVERTER

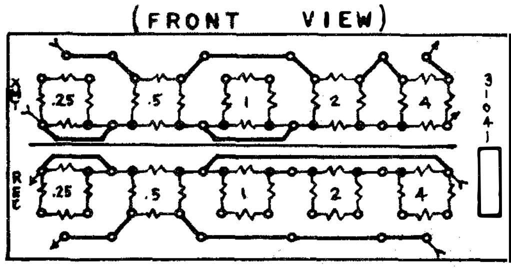
FIGURE VII-E-4 " ICS STANDARD" 4-WIRE TERM SET

(FRONT VIEW)



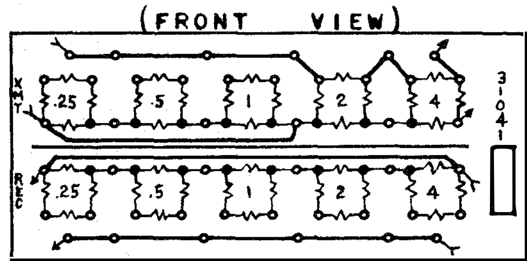
A. Heavy Line Indicates Typical Strapping
XMT Shows Strapped For 1.25 DB
REC Shown Strapped For 5.5 DB

(FRONT VIEW)



W/O Ringdown Converter
XMT 6.5 DB
REC .5 DB

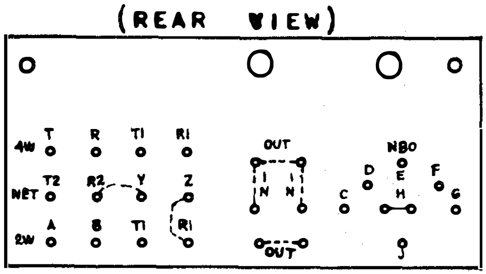
(FRONT VIEW)



With Ringdown Converter
XMT 6 DB
REC 0 DB

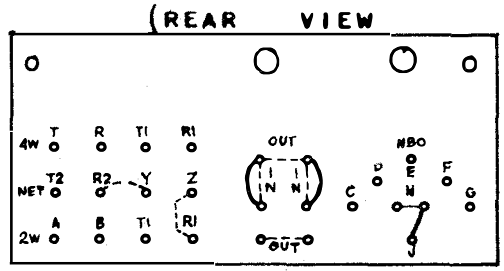
B. " ICS Standard" Strapping

(REAR VIEW)



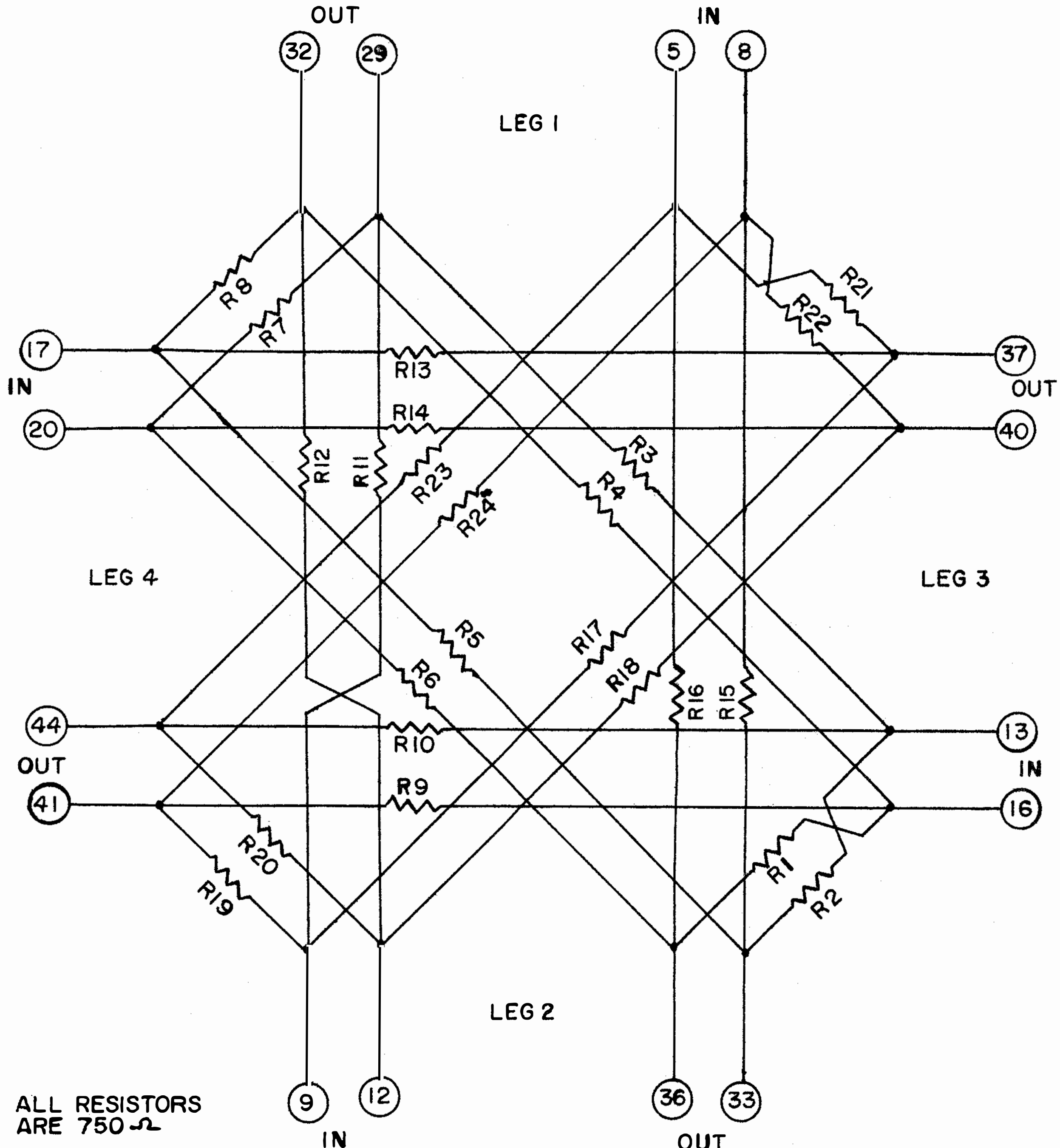
C. Rear View, NO Straps

(REAR VIEW



D." ICS Standard" Strapping
Varistor In
Comp Net In

Figure VII-E-5 Lenkurt 4-Wire Terminating Set, Strapping



ALL RESISTORS ARE 750 Ω

NOTE: TERMINAL NOS ARE PIN NOS ON PIN BLOCKS

FIGURE VII-E-6.

4 WAY-4 WIRE BRIDGE SCHEMATIC 14 DB NET LOSS

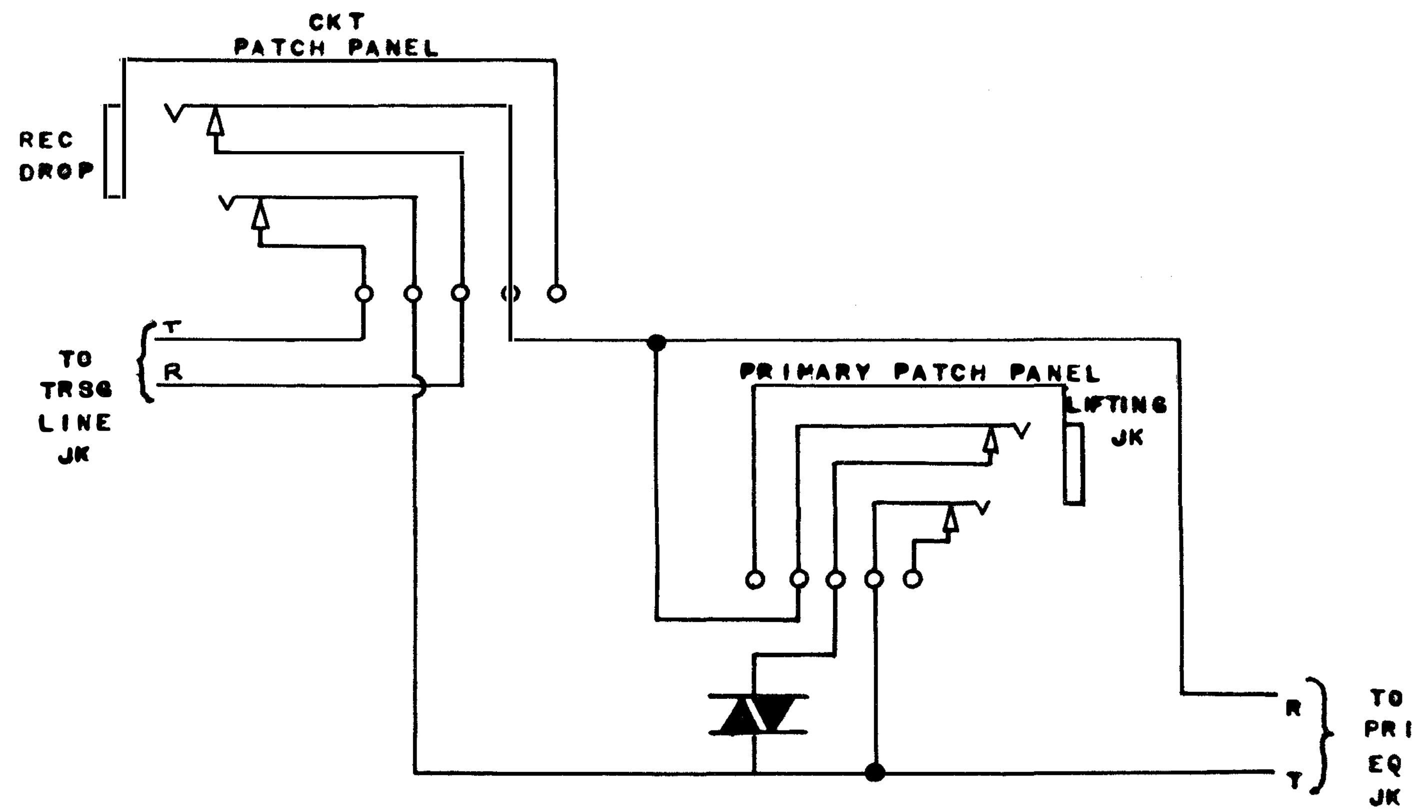


FIGURE VII-E-7 INSTALLATION OF VARISTOR

F. PATCH PANELS:

A number of patch panels are found in ICS EE Buildings, providing the capability for patching circuits and groups, and for testing. This large number of patch panels distinguishes the EE Buildings from tactical technical controls and gives the technical controllers increased capability for restoring circuits by patching, as well as a testing capability.

1. GROUP Patch Panel:

The GROUP Patch Panel, located in the multiplex equipment room of the EE Building, provides a capability of testing and patching at GROUP level (Figure VII-F-1). A group can be rerouted by using a patch cord, just as a circuit can. Each GROUP has two appearances on the GROUP Patch Panel - one for each direction. These are arranged by SUPERGROUPS on two separate jack strips (Figure VII-F-2). Strip JF1 is the transmit side and strip JF9 is the receive side. These two jack appearances for each GROUP have the characteristic common to most patch panels - unless a patch cord is inserted in the jack, the GR MX IN is connected to the CH MX OUT directly below it, and similarly GR MX OUT is connected to CH MX IN. When a patch cord is inserted into a jack, the "normal-through" path is broken and rerouting may be accomplished. There are also jack appearances for the input and output of the through-group filter pairs (JF7 in Figure VII-F-2).

2. Audio Patch Panels:

There are three type of audio patch panels (see Figure VII-F-3):

Voice Frequency	(4 wire)
Circuit	(6 wire)
Primary	(2 wire)

These provide a patching and testing capability at various points in the circuit.

a. VF patch bay - this provides jack appearances at channel modem input and output. A VF patch bay is shown in Figure VII-F-4, Figure VII-F-5 shows the jack module assembly of the VF patch bay and the wiring schematic of a VF jack set is shown in Figure VII-F-6. Figure VII-F-7 shows the VF patch bay arrangement as it is used for testing. An enlarged view of the VF jacks for two 4-wire circuits is shown in Figure VII-F-8.

b. Circuit Patch Bay - this patch bay provides equal-level appearances of all circuits. If there is signalling on the circuit the SIG (E&M) leads have a separate appearance on the CKT patch bay. A circuit patch bay is shown in Figure VII-F-9. Figure VII-F-10 shows a circuit patch bay jack assembly which will handle twelve 6-wire circuits. The wiring schematic of a circuit jack set is shown in Figure VII-F-11 and Figure VII-F-12 shows the in-out wiring of a circuit jack set. An enlarged view of the jacks for one circuit is shown in Figure VII-F-13.

c. Primary patch bay - this patch panel provides a patching capability at the subscriber end of the circuit. A primary jack patch bay is shown in Figure VII-F-14. Figure VII-F-15 shows a primary jack module capable of handling twenty-four 2-wire circuits and Figure VII-F-16 shows the wiring schematic of a primary jack set.

3. DC Patch Panels:

A DC patch bay is shown in Figure VII-F-17 with one DC jack assembly, capable of handling 12 circuits shown in Figure VII-F-18. Figure VII-F-19 is an enlarged view of the jacks for one 4-wire DC circuit.

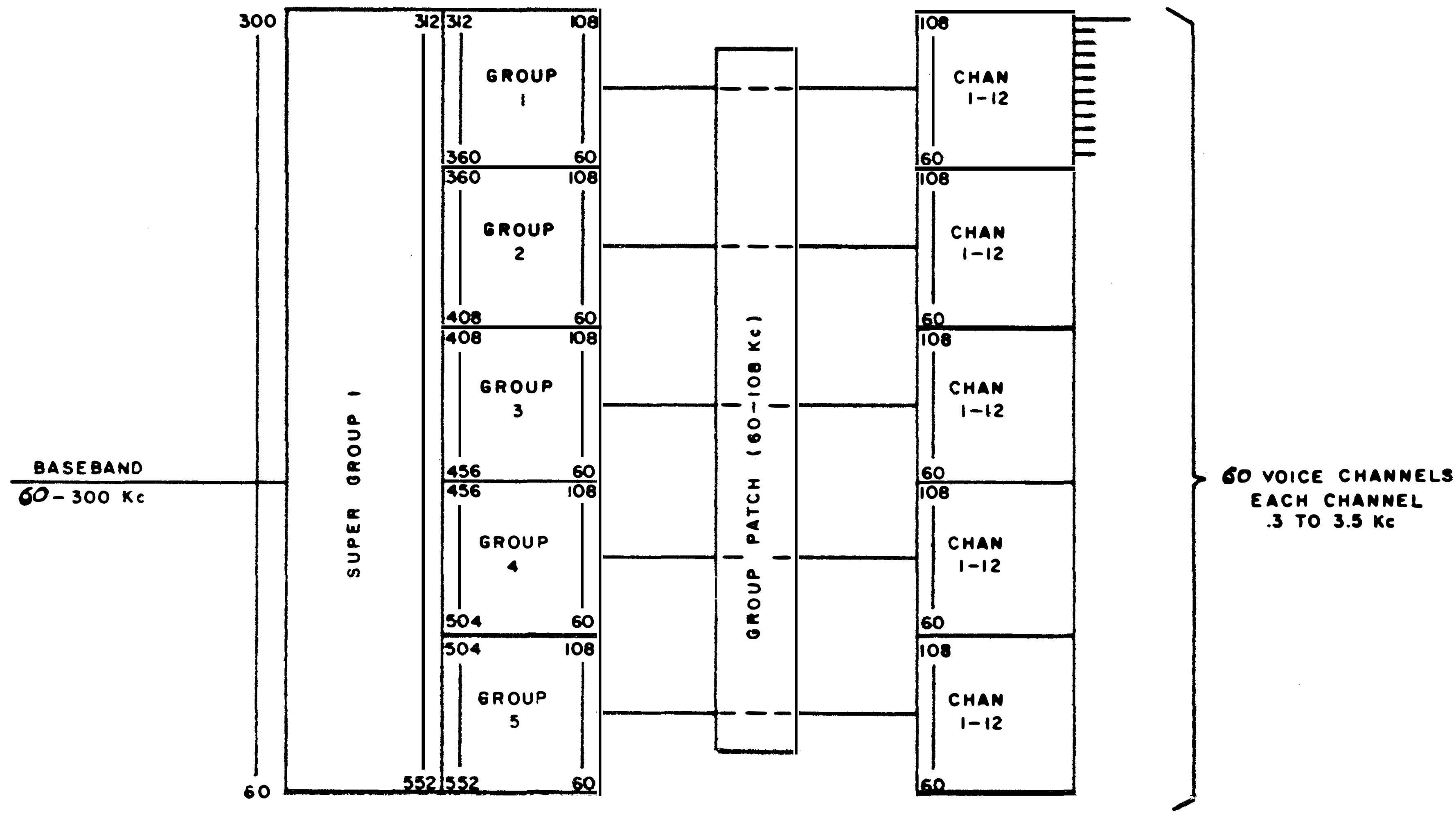


FIGURE VII-F-1. LOCATION OF GROUP PATCH BAY

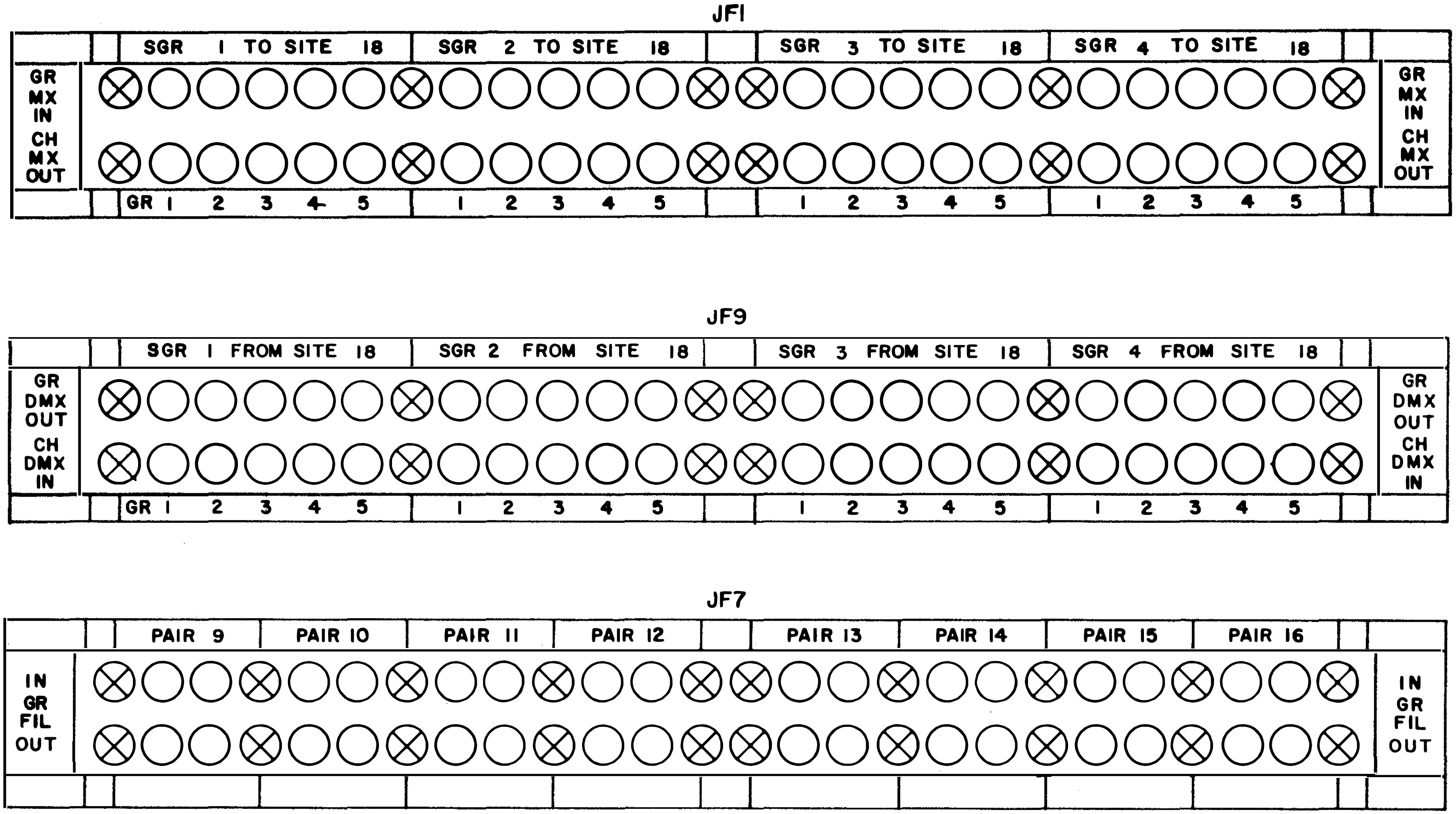


FIGURE VII-F-2. GROUP PATCH BAY, JACK ASSEMBLIES

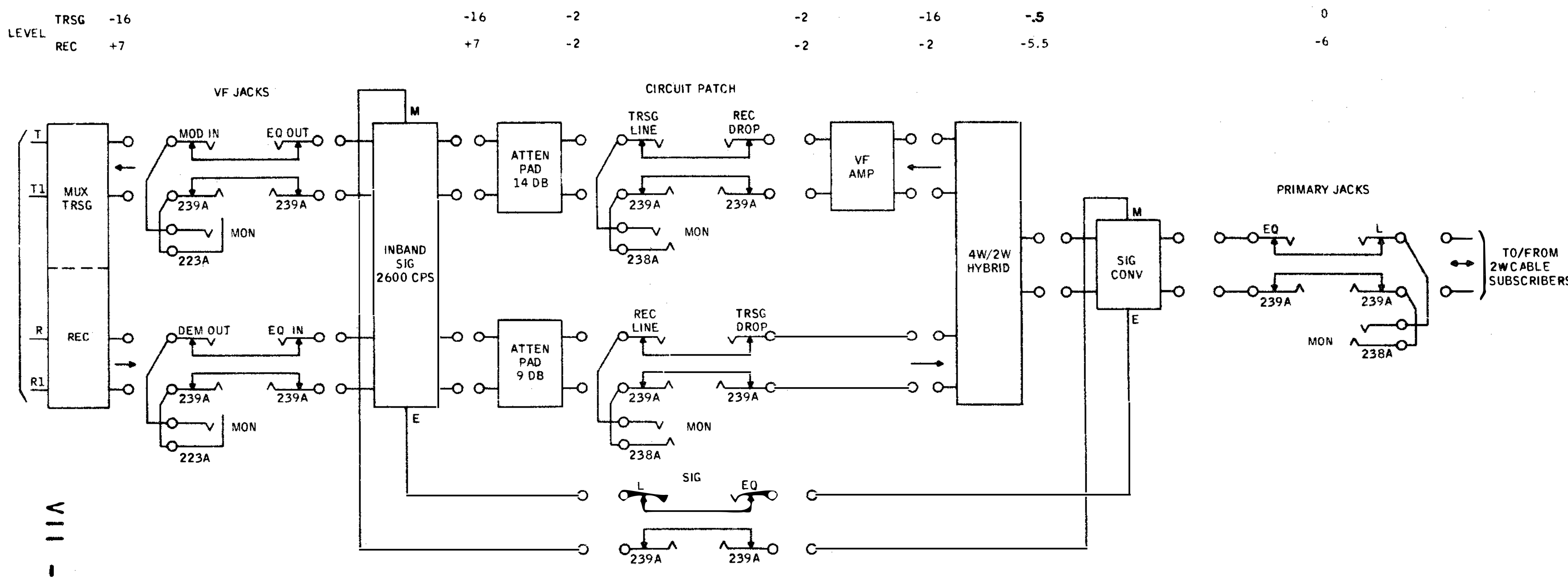


Figure VII-F-3. Typical VF Circuit showing location of VF, Circuit, and Primary Jacks.

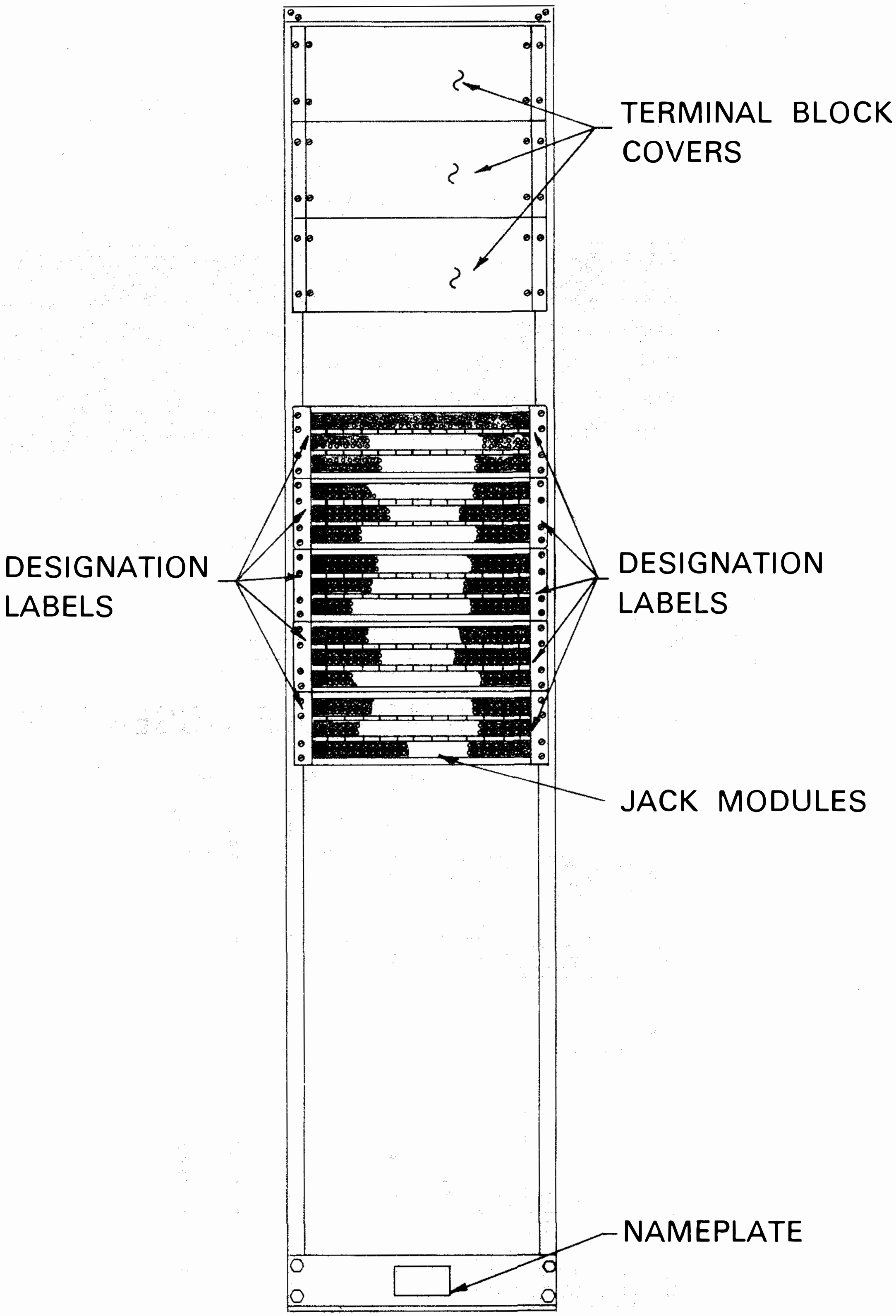


FIGURE VII-F-4. 4-WIRE VF PATCH BAY

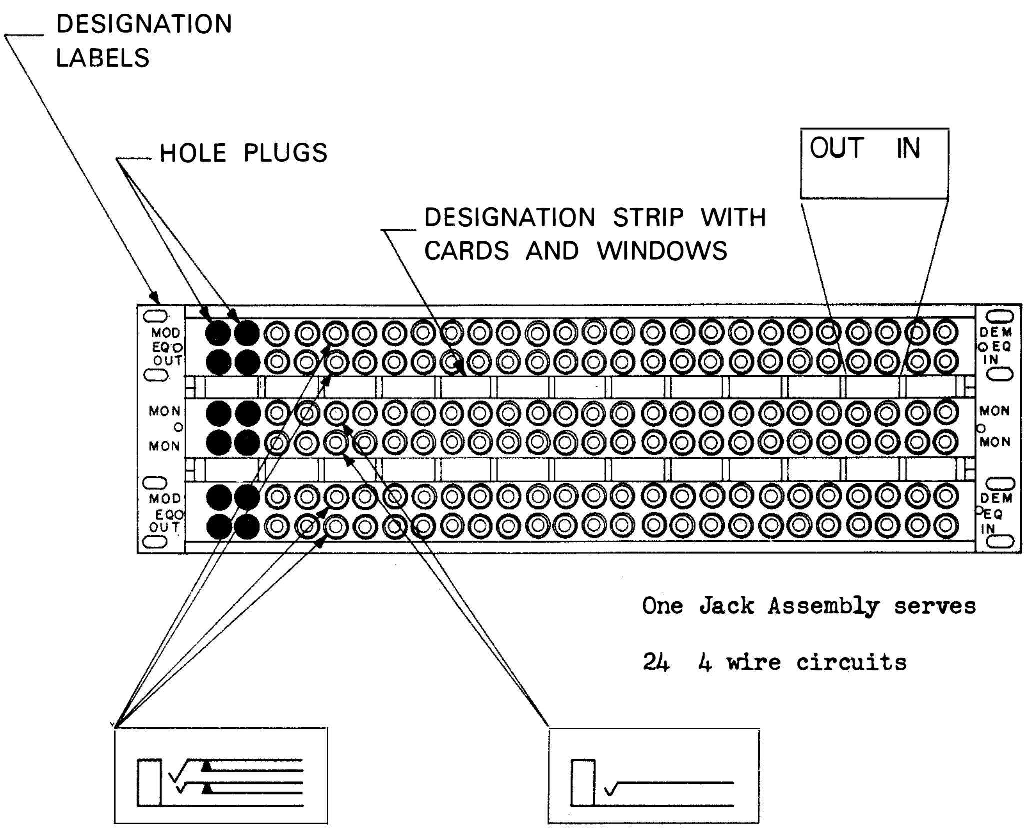


FIGURE VII-F-5. VF JACK MODULE ASSEMBLY

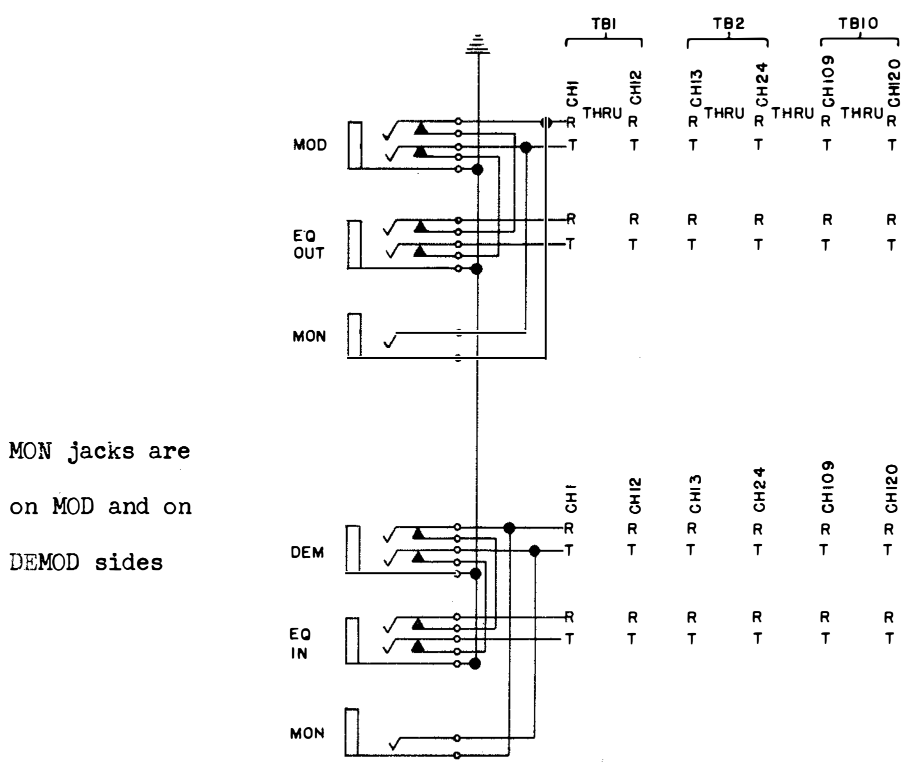


Fig. VII-F-6. VF JACK WIRING SCHEMATIC

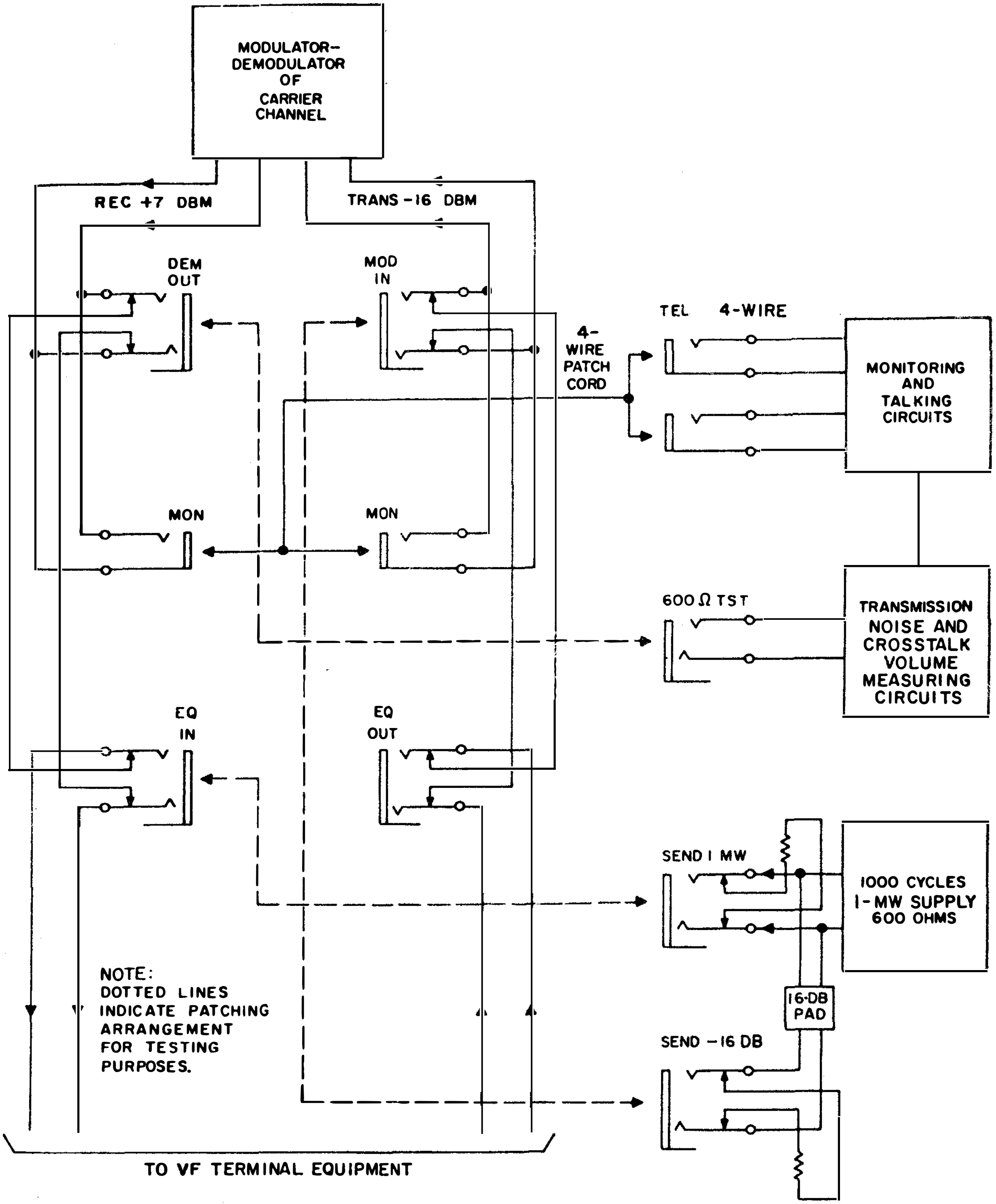


FIGURE VI-F-7. 4-WIRE VF PATCH BAY JACK ARRANGEMENT

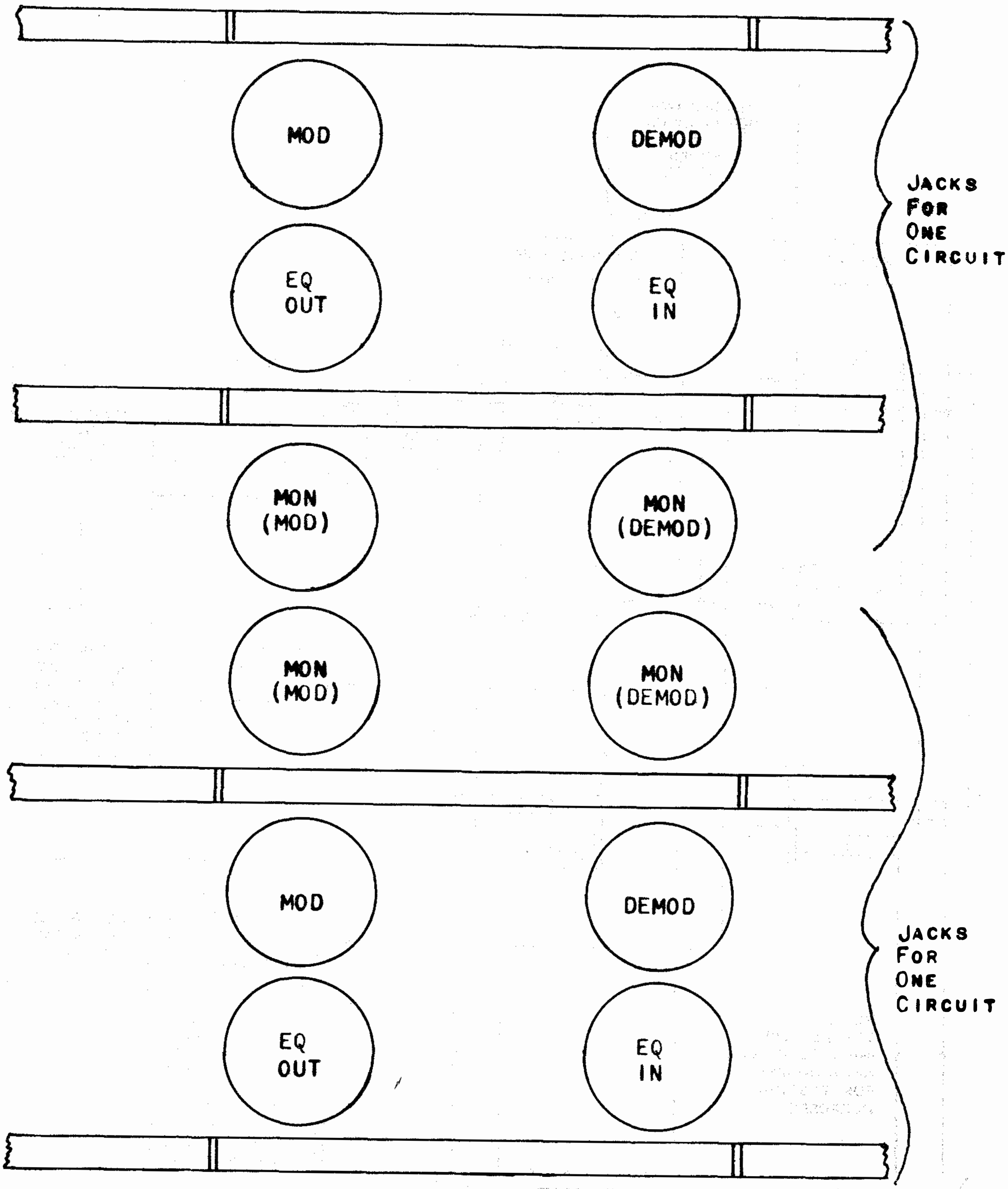


FIGURE VII-F-8, LAYOUT OF VF JACKS (TWO CIRCUITS)

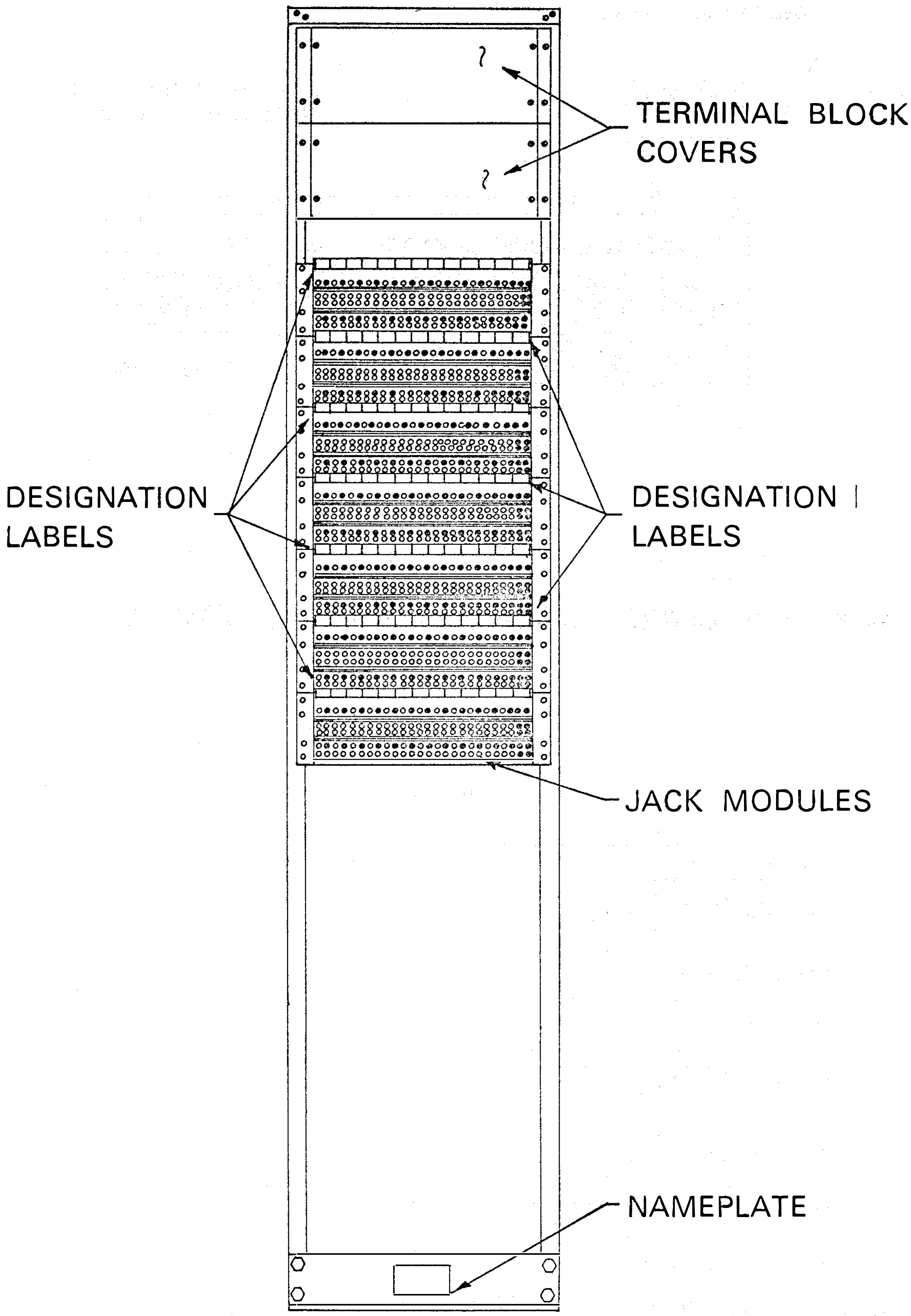


FIGURE VII-F-9. CIRCUIT PATCH BAY

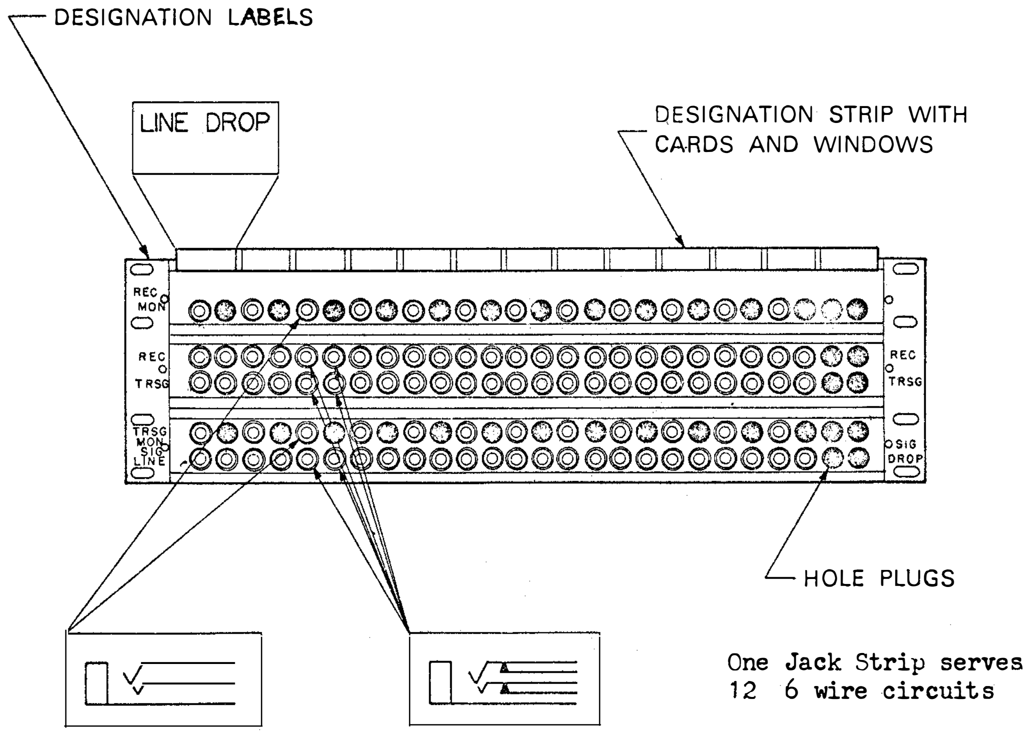


FIGURE VII-F-10. CIRCUIT JACK MODULE ASSEMBLY

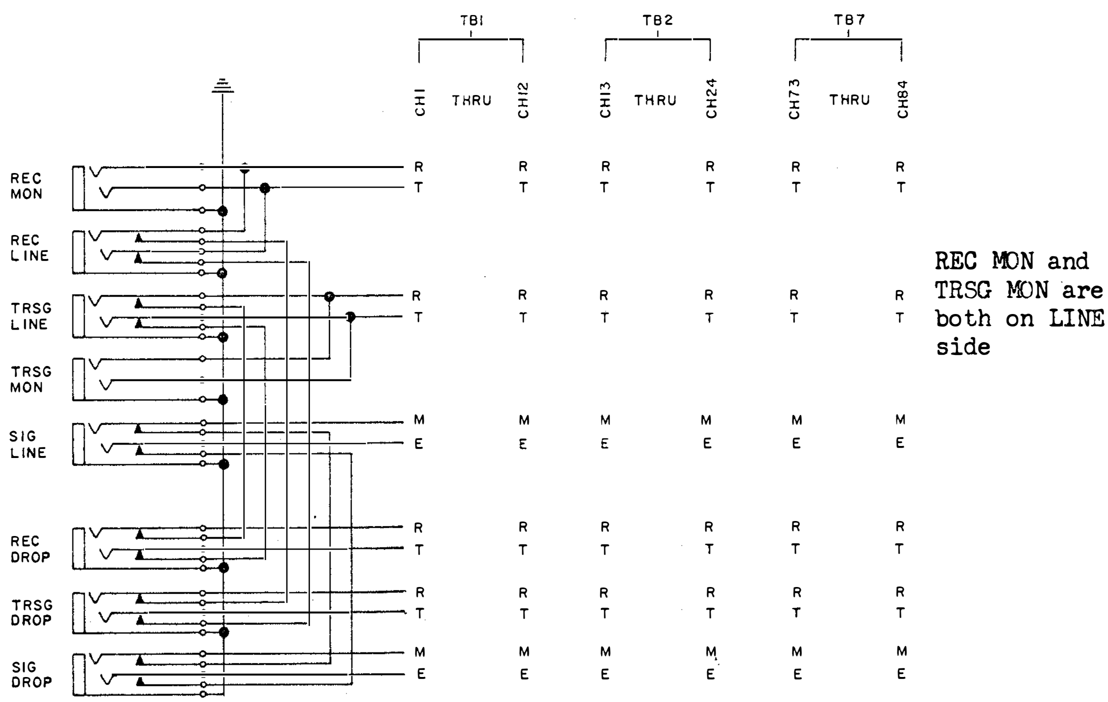


FIGURE VII-F-11. CKT JACK WIRING SCHEMATIC

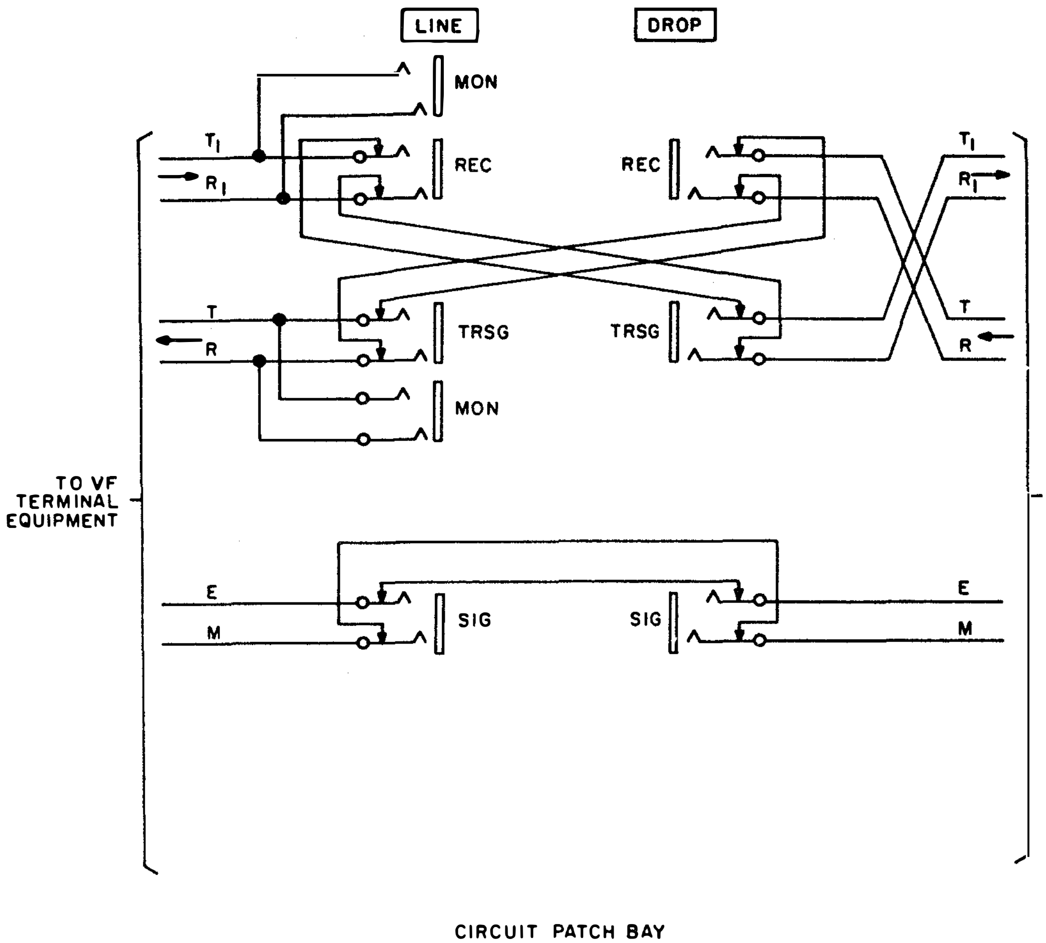


FIGURE VII-F-12. CIRCUIT PATCH BAY JACK ARRANGEMENT

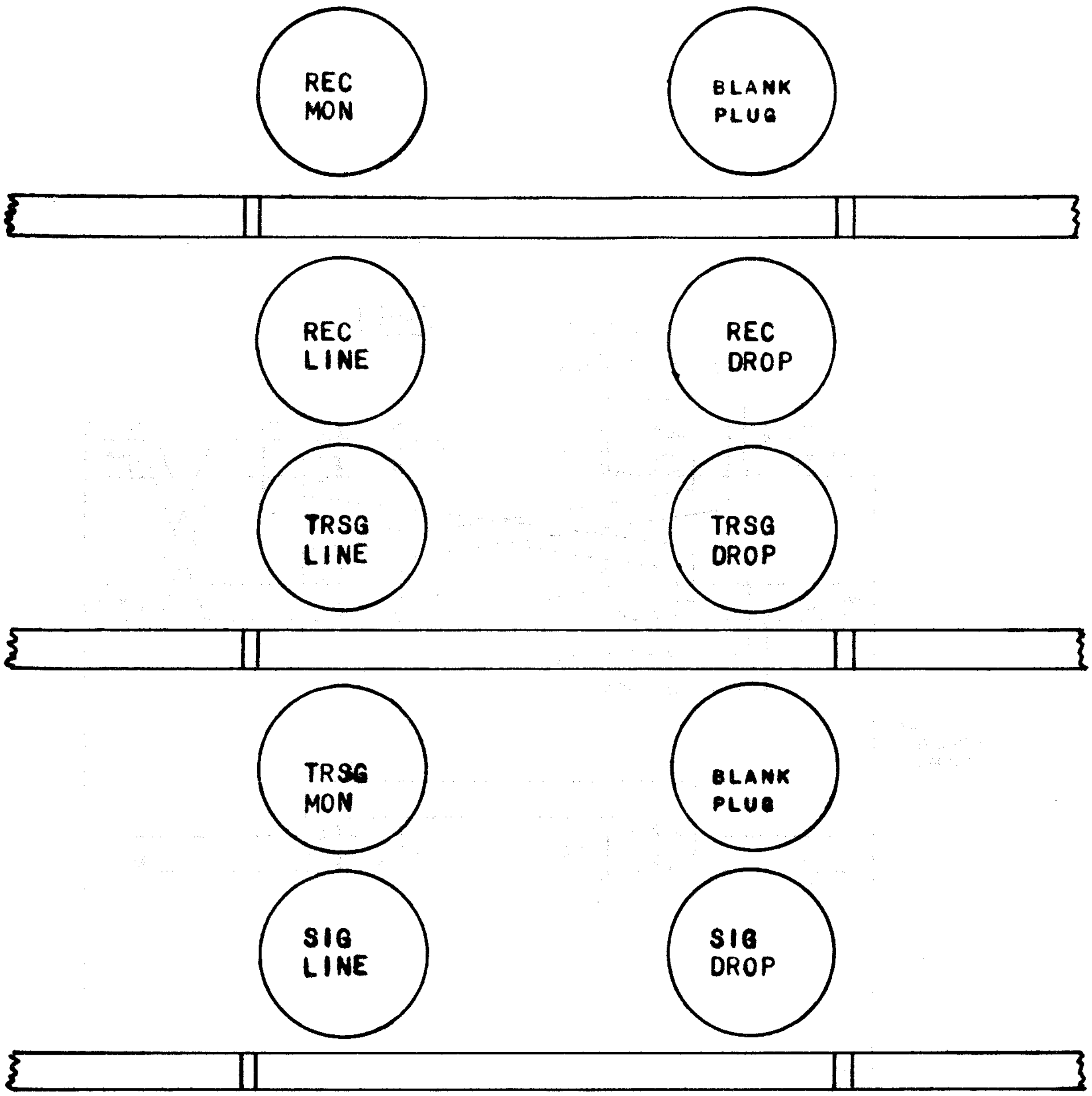


FIGURE VII-F-13. LAYOUT OF CIRCUIT JACKS

(ONE CIRCUIT)

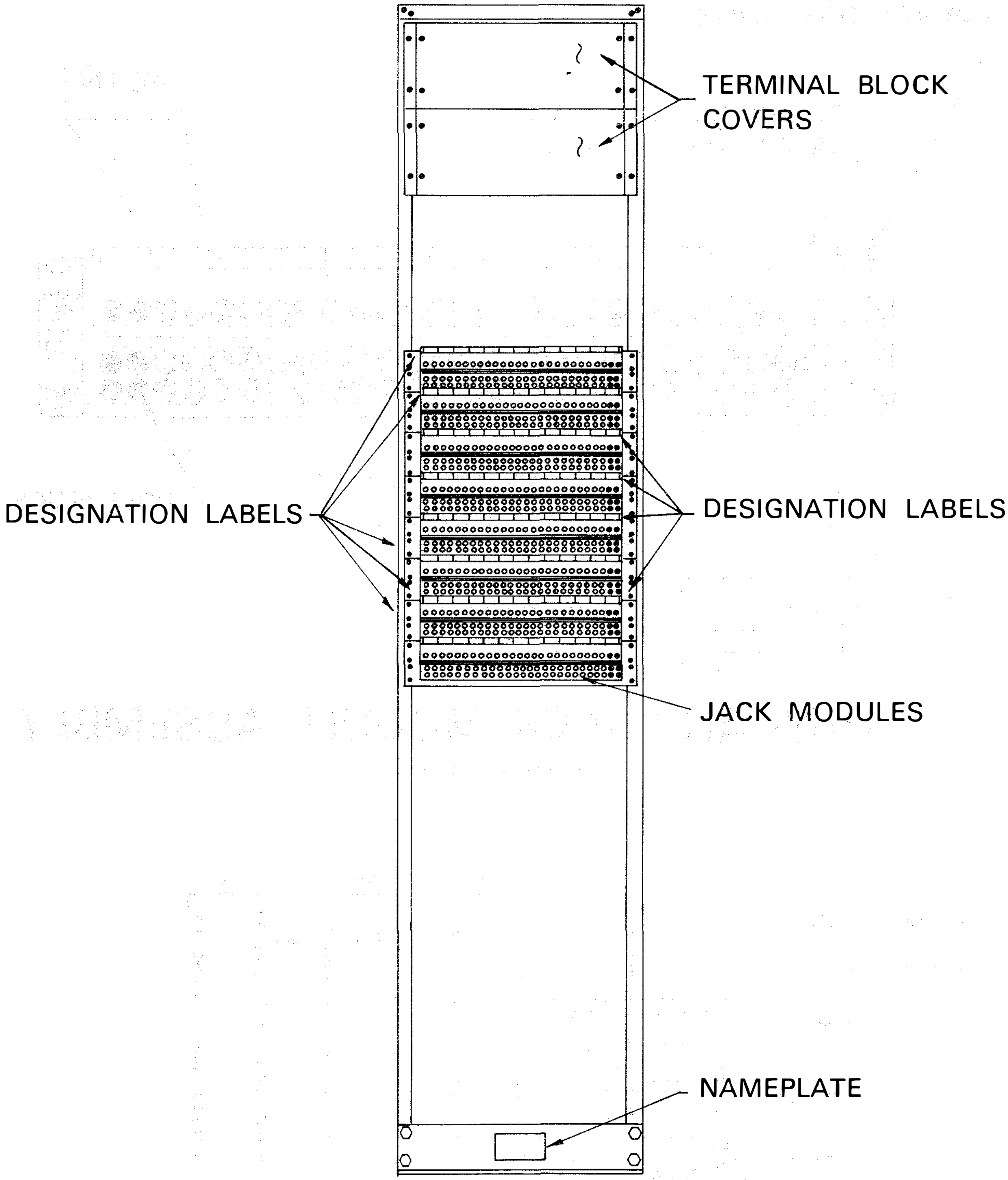
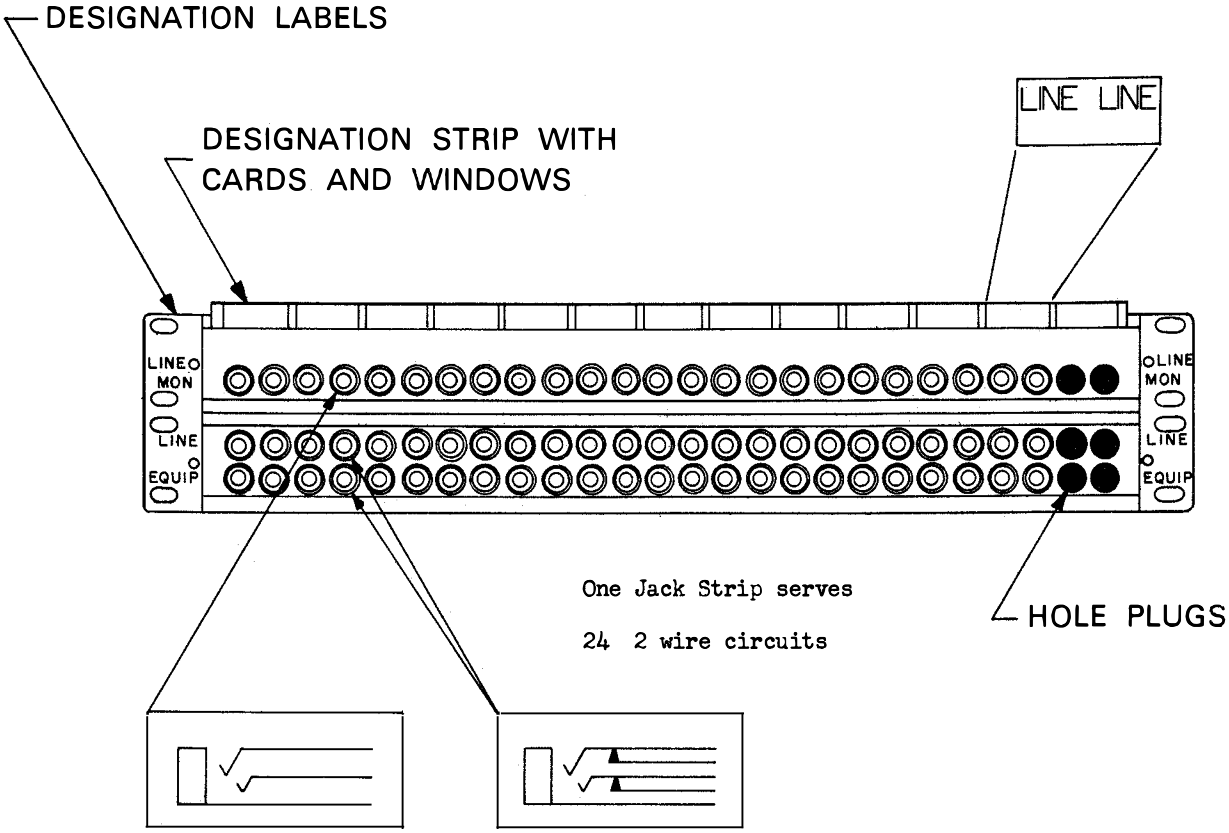


FIGURE VII-F-14. 2-WIRE PRIMARY VOICE FREQUENCY PATCH BAY



PRIMARY JACK MODULE ASSEMBLY

FIGURE VII-F-15.

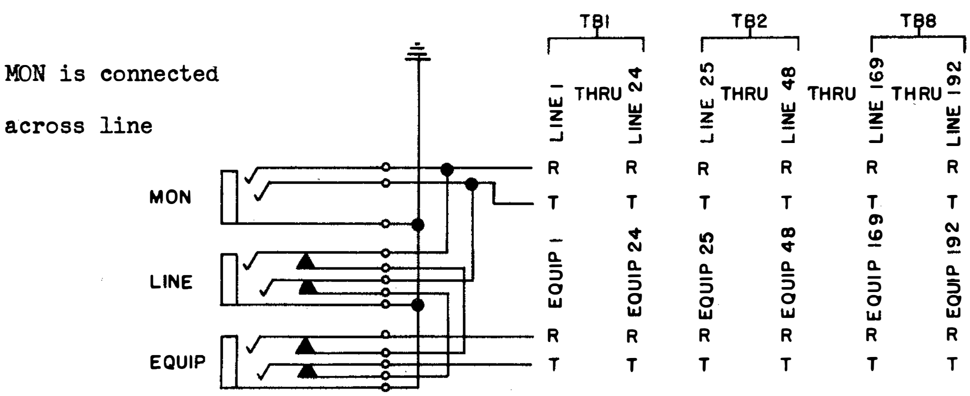


FIGURE VII-F-16.

PRI JACK WIRING SCHEMATIC

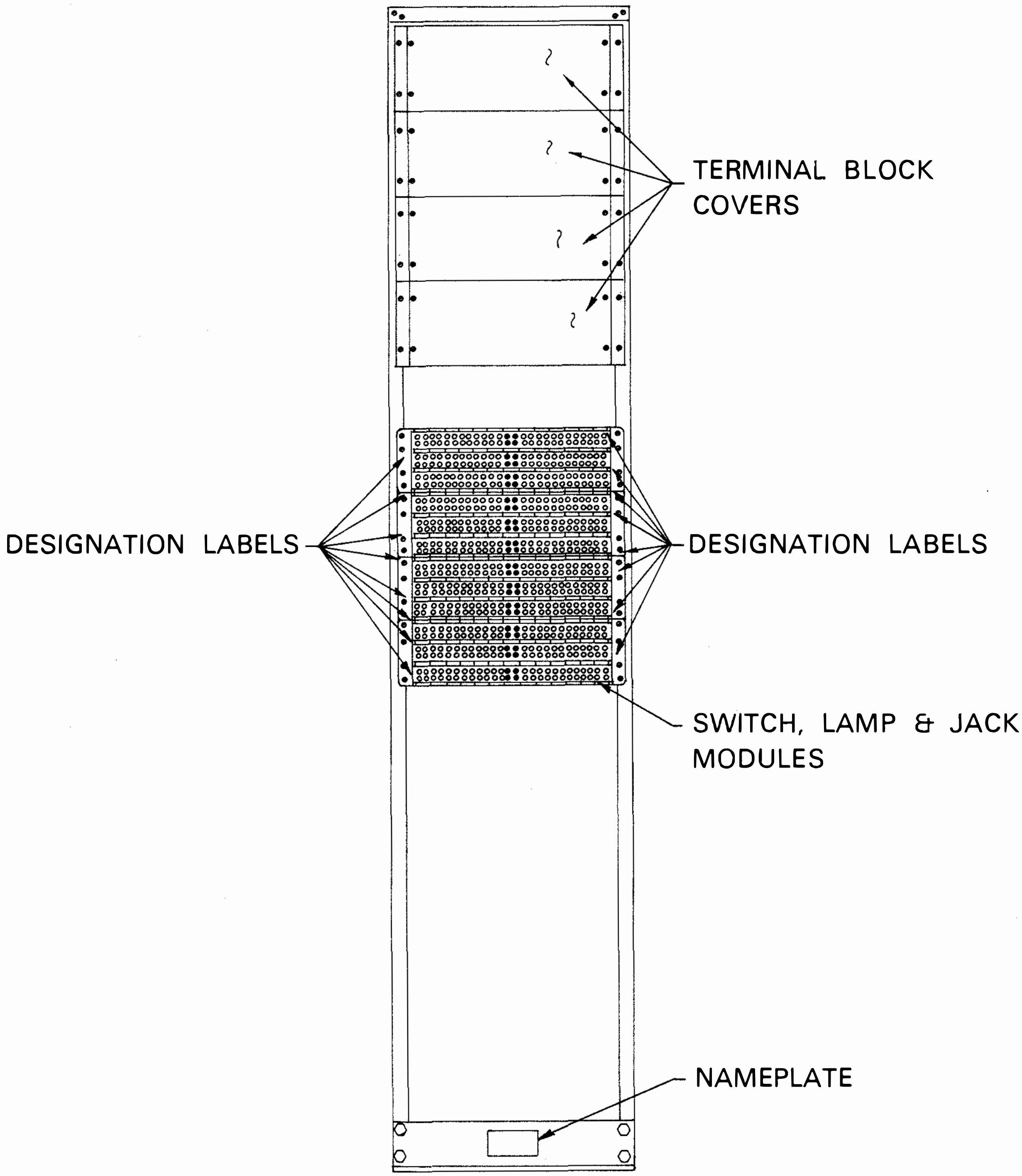


FIGURE VII-F-17. DC PATCH BAY,

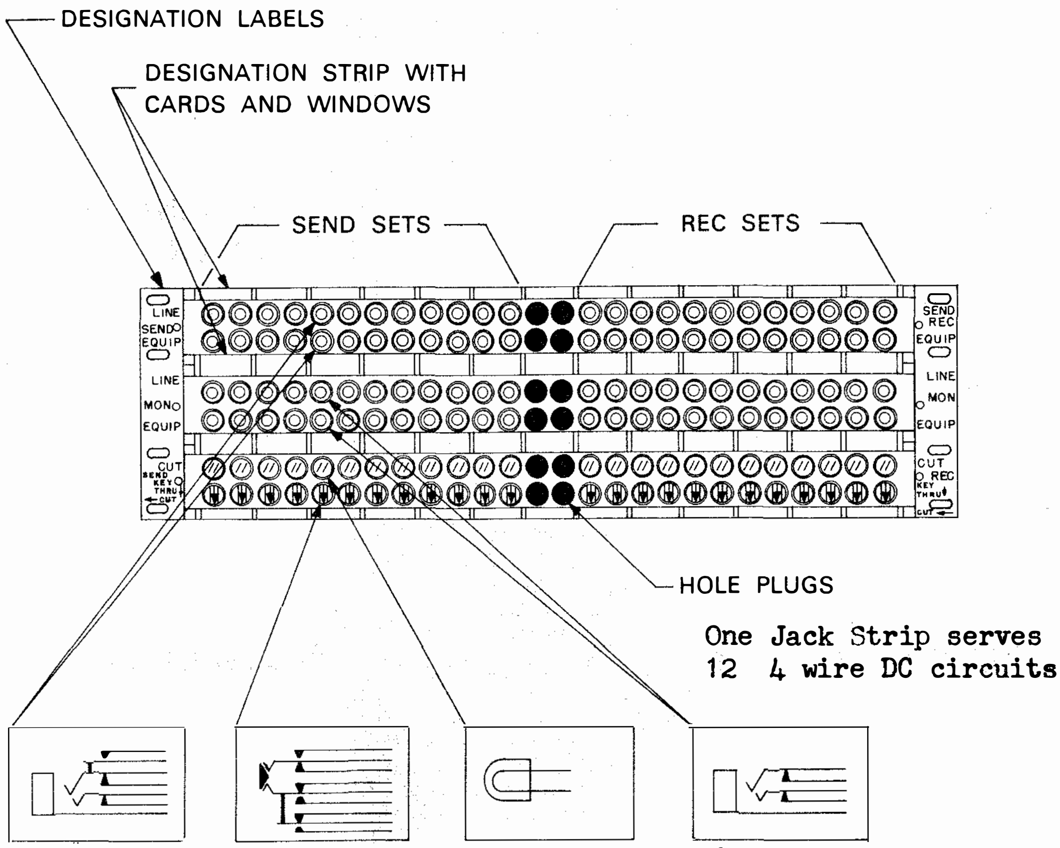


FIGURE VII-F-18. SWITCH, LAMP & JACK MODULE ASSEMBLY

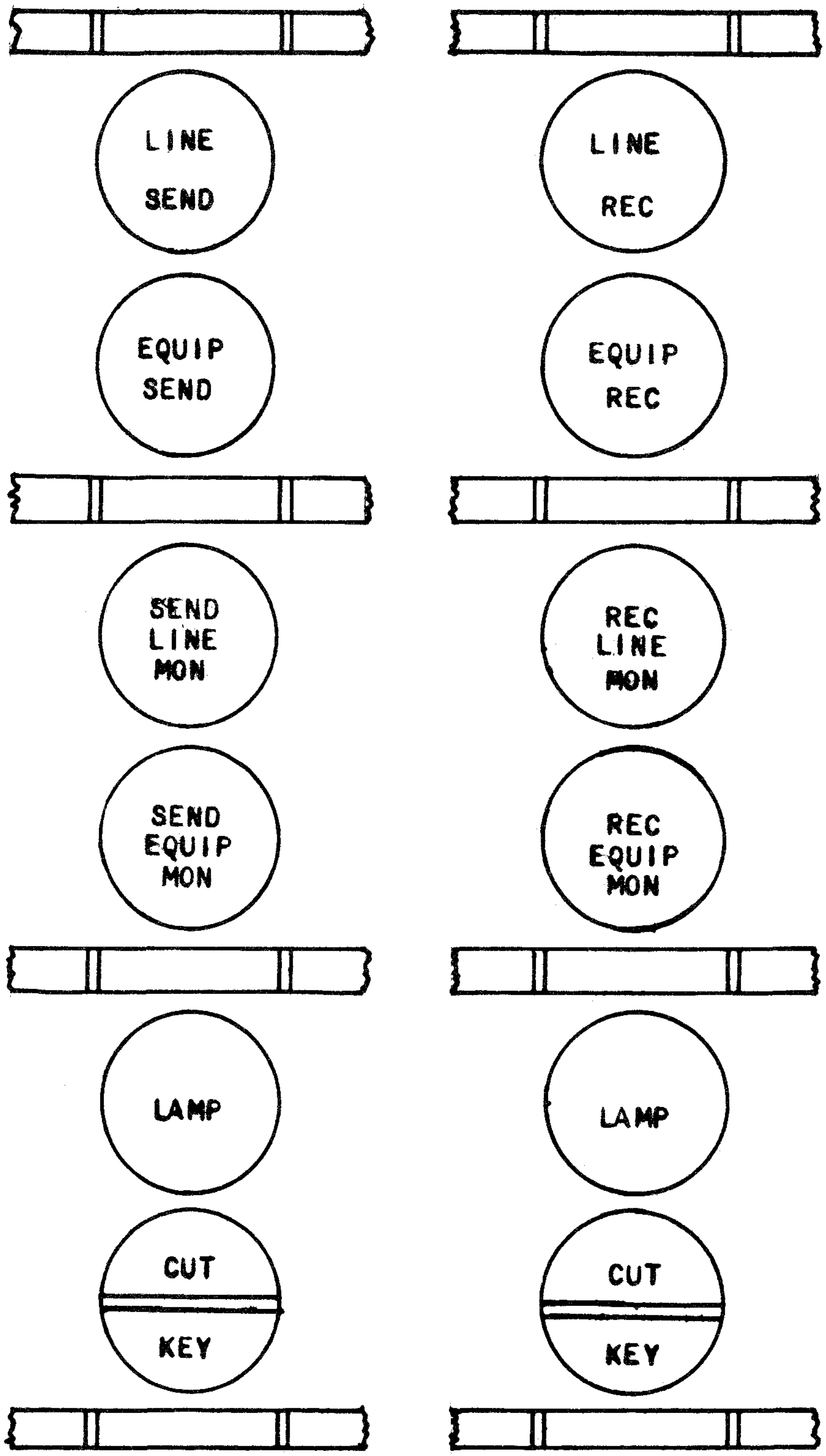


FIGURE VII-F-19. DC JACKS FOR ONE CIRCUIT (SEND AND RECEIVE)

G. COMBINED DISTRIBUTION FRAME - CDF:

There is a large degree of individuality in the layout of the distribution frames in each EE building, but they do have certain common characteristics:

1. There is only the one Combined Distribution Frame in each EE building.

2. All outside cables are terminated on the vertical side. These cables are normally protected; however, in a few instances, short cables are not.

3. Many sites have a terminal box mounted on a pole adjacent to the EE building. This "pole box" has a cable that is also terminated on a vertical.

4. The termination of all jacks (VF, CKT, PRI, and DC) appear on the horizontal side of the frame.

5. All equipment, SF units, attenuators, amplifiers, multiplex inputs and outputs, etc., appear on the vertical side of the frame.

6. Since the EE buildings were designed with a certain degree of planned expansion capability, there are often house cables terminated on pin blocks on the frame but not connected to any equipment. Sometimes they are wired to a plug-in module cage and the module capacity can be expanded by simply plugging in the additional modules. In other cases, such as attenuators and 4W terminating sets, it is necessary to "hard-wire" in the additional units in order to expand.

H. ORDER WIRE SYSTEMS:

Order wires are sole-user, dedicated circuits which are used for the operation and maintenance of the communications system. There are four different types of order wires found in the ICS.

Local Order Wires

Circuit Restoration

Express Voice Order Wires

Express Digital Order Wire

1. Local Order Wires:

There is a local order wire connecting the two terminals of each ICS radio system, LOS, scatter, or diffraction. These order wires are often called the "engineering channels", and as the name implies, they are used primarily for the engineering maintenance of the system. They are terminated in the radio and multiplex equipment room at several handy locations, usually at the end of a row of bays. Since each site usually has more than one system connecting it to other sites, the various local order wires are terminated on a jack strip and the maintenance man selects the desired one by merely inserting his headset plug in the proper jack.

2. Circuit Restoration Order Wires:

The primary users of the circuit restoration order wires are the technical controllers working at the patch panels. These order wires are usually terminated on "Lynch panels" mounted in the patch panel bays. The Lynch panel not only provides the capability to answer incoming calls and signal the other terminal by using the key switches, but it may also be used as a "cordless patch panel" to extend a call received over one order wire out onto another one.

As stated above, the purpose of these order wires is to provide communications for the technical controllers from one end of a circuit to the other. For this reason the allocation of circuit restoration order wires is not based necessarily on the number or size of links entering the site, but rather on the major terminals for circuits originating at this site. This is the same basis that is used for determining thru-group allocations, and it is not surprising to see a close correspondence between the thru-group plan and the circuit restoration order wire plan.

3. Express Voice Order Wires:

The express order wires found in the ICS represent a rather unique type of engineering channel. Equipment is provided at each IWCS site to permit selective signalling over the express order wire by dialing a two-digit number. One drawback to this system however, is that it is effectively a party line. Therefore, there have been six different express order wire networks established.

The first of these is the Major Technical Control Express Order Wire. This connects the technical control stations shown in the boxes in Figure VII-H-1. The other station in the network is the "SOC", the DCA/STRATCOM Operations Center located adjacent to the EE building at Tan Son Nhut. Figure VII-H-1 also shows the routing of this order wire circuit. It can be seen that it makes a complete loop that is open at the SOC. If something should happen to disable one of the links in this network, it would still be possible to contact all the stations by going around the loop the other way.

The other six express order wire networks are the Area Networks shown in Figure VII-H-2. The SOC is a member of each of these area networks. A major technical control is a member of two networks and will have two express order wire control panels, whereas a minor station will have only the one and the SOC will have seven (note, there is one for each direction of the major network).

The express order wires may be used only to call other stations in the same network. Therefore, Phu Bai would not be able to call Nha Trang or Cam Ranh Bay. Note, however, that the SOC can dial directly to call <u>any site</u>.

The primary purpose for the express order wire system is to provide communications for the SOC. These channels are intended primarily for system maintenance, control, and reporting of maintenance activities.

4. Express Digital Order Wires:

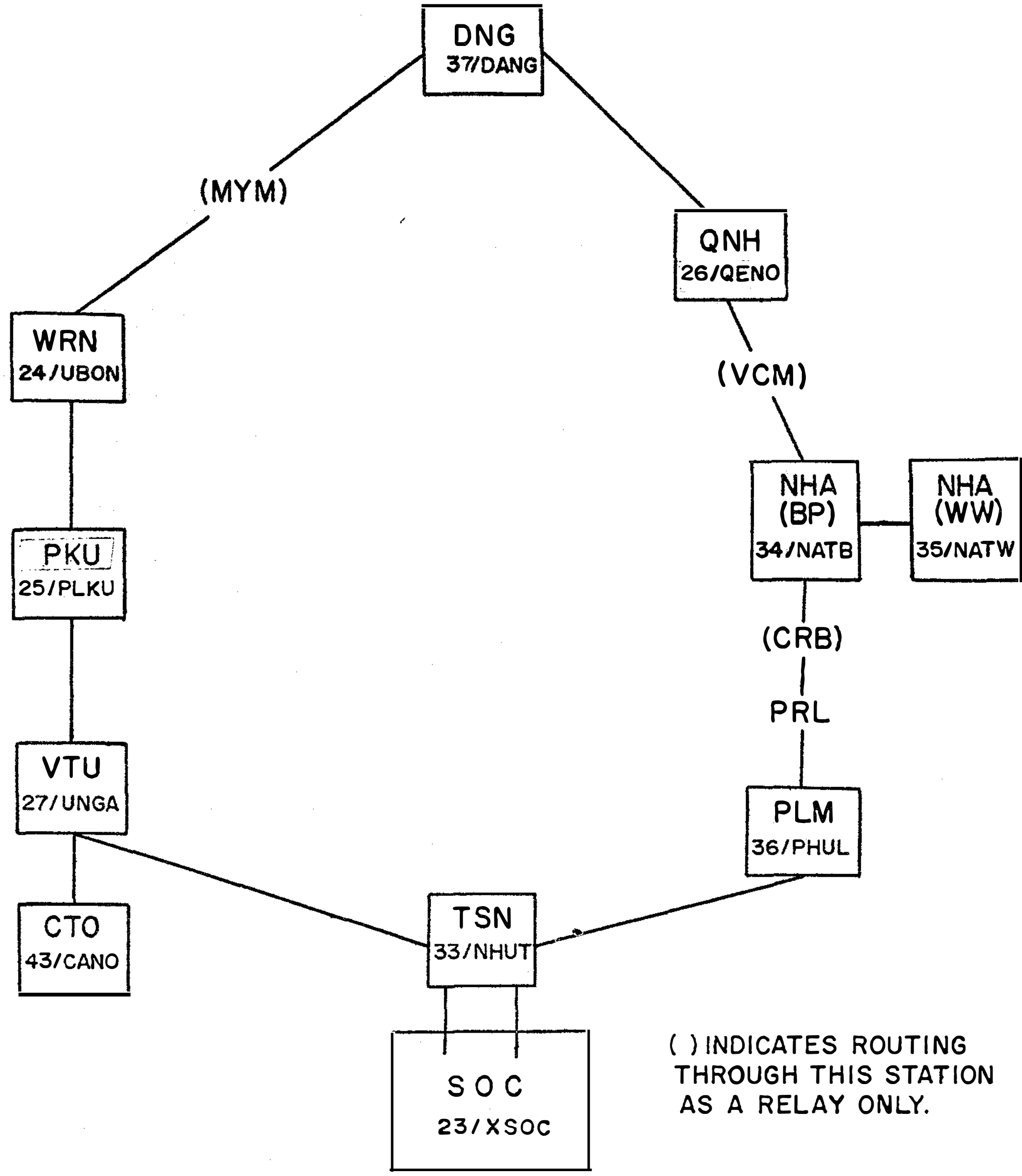
Associated with each voice express order wire system, there is also a selective-call digital order wire network which permits passing teletype traffic to a specific location. It operates in a manner similar to the voice system.

5. Routing of Order Wires:

Order wires are generally classified as either "in-band" or "out-of-band" according to whether they are routed over a standard voice channel of the voice multiplex equipment or over a "supervisory channel" derived in the frequencies below the multiplex message signal (i.e., below 60 kHz). The exact details of how this is accomplished are covered elsewhere.

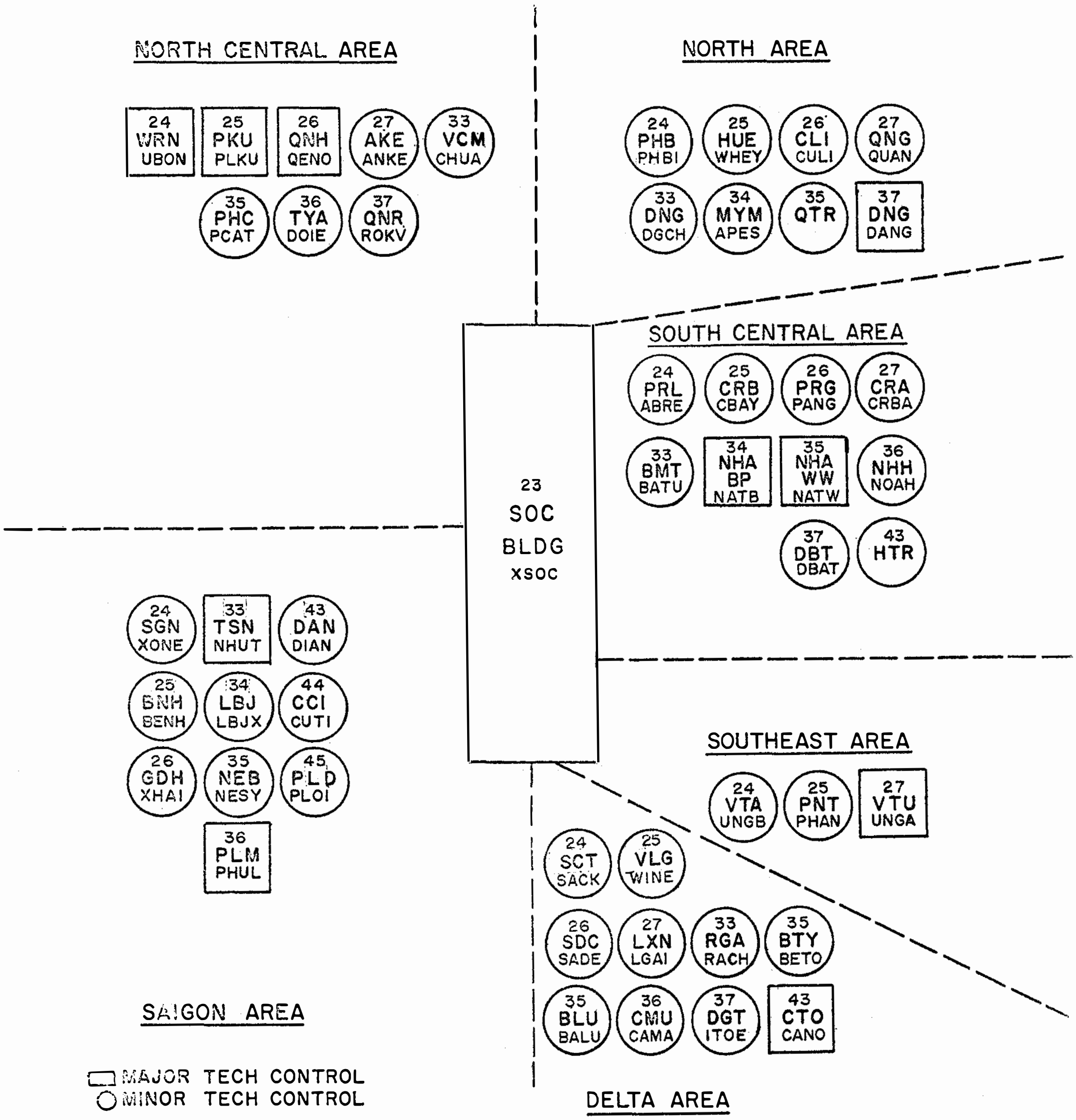
The four types of order wires discussed here are classified as:

In-Band:	Circuit Restoration Order Wires
Out-of-Band:	Local Order Wires
	Express Voice Order Wires
	Express Digital Order Wires



ROUTING OF MAJOR TECHNICAL CONTROL
EXPRESS ORDER WIRE
VOICE CALL CODE/DIGITAL CALL CODE

FIGURE VII-H-1



AREA EXPRESS ORDER WIRE SYSTEMS
VOICE CALL CODE/DIGITAL CALL CODE
FIGURE VII-H-2

I. REMOTE ALARM SYSTEM:

When you are out at an ICS site you might truly think that "Big Brother" is watching - and you would be correct, for the remote alarm system is transmitting detailed information about the status of your equipment to the DCA/STRATCOM Operation Center (SOC) at Tan Son Nhut. The system has been designed so that the occurrence of as many as 155 different conditions can be detected and transmitted to the SOC almost as quickly as the local personnel learn of them through the local alarm bells and trouble indicating lights.

When either a major or minor alarm occurs at a station, or an existing one is cleared, the SOC receives immediate notification. The personnel on duty at SOC may then interrogate the alarm transmitter at the remote site to obtain detailed information as to which of the 155 conditions exists. It should be pointed out again that all of this is accomplished with no action being taken by site personnel.

1. Major Alarm:

A major alarm is defined as the indication, local or remote, of the failure of a portion of the system that may result in a significant reduction in the quality and/or quantity of channels available for service.

This may be caused by the complete failure of:

a. Any power amplifier (indicated by low forward power)

b. Any exciter (indicated by low forward power)

c. Any receiver (indicated by received pilot failure or high noise).

d. Any baseband amplifier (indicated by baseband amplifier transfer).

e. Squelching of the radio baseband (indicated by operation)

f. Multiplex transmission path.

Or the occurrence of any of the five quality monitor alarms on the diffraction or troposcatter propagation mode paths, which are as follows:

a. Reduction of the received signal intensity beyond a pre-set limit (severe long term fading).

b. Variation in test tone level beyond pre-set limits.

c. Idle channel noise above pre-set limits.

d. Digital error rate beyond pre-set limits.

e. Transmitter loading above pre-set limits (over deviation).

Or the occurrence of a DC power system failure, which will result in an immediate or certain loss of DC power at the station in a short period of time as indicated by rectifier failure or a major power system fuse alarm.

2. Minor Alarm:

A minor alarm is defined as the indication, local or remote, of the failure of a portion of the system that may result in the loss of one portion of a redundant circuit that does not affect end-user service, or the various fuse alarms whose failure does not affect more than one voice channel.

3. Path Alarm:

A path is defined as the wide band transmission facility between adjacent stations, which includes the complete radio baseband made up of the radio equipment, antenna and transmission line equipment, and the propagation media between the adjacent stations.

A path failure alarm is defined as an indication of the complete failure at the station of:

(a) Both power amplifiers.

(b) Both exciters.

(c) All receivers.

(d) Both baseband amplifiers.

(e) Squelch relay panel operation on a particular path.

4. Summary Information:

Summary Alarm information is received at the SOC for all stations at all times. It indicates whether or not there has been a change of state, whether it is a major or minor alarm, and which path is affected (the system permits identifying up to 9 paths terminating at a single site).

5. Detailed Information:

When the operator receives a "Change of State" indication, he notes the summary information and then interrogates the site's alarm transmitter to provide detailed information about the alarm. The detailed information covers as many as 16 different alarms for a quadruple diversity troposcatter link to as few as 5 for a dual diversity line-of-sight microwave system without quality monitors or power amplifiers. Table VII-I-1 specifies the alarms covered for each type of system.

6. Automatic Performance and Quality Monitoring:

In addition to the equipment failure alarm, link performance parameters will be monitored and alarmed by a Link Performance and Channel Quality Monitoring System. The monitor is made up of two subsystems, a voice panel and a radio panel. The voice panel monitors and alarms the voice channel performance parameters of binary error rate, test tone stability, and idle channel noise. The radio panel monitors and alarms the radio performance parameters of baseband loading and received signal intensity.

One voice channel in the message multiplex, preferably the highest frequency or "top" channel, is required on each of the troposcatter and diffraction paths to monitor the idle channel noise, digital error rate, and test tone stability for the alarm system.

The voice panel is a full duplex terminal which utilizes a single multiplexed voice channel (300 to 3400) to transmit through the link and to monitor binary error rate, test tone stability, and idle channel noise. With the exception of the bit error rate, all performance parameters are continuously recorded on integral strip charts. The binary errors are displayed on a front panel totalizer counter. When the monitored parameters deviate beyond the adjustable preset degradation threshold, an alarm will be given and a visual display will be activated.

The radio panel will monitor, continuously record, and alarm baseband loading and received signal intensity. When the adjustable preset degradation threshold of a monitored parameter has been exceeded, an alarm will be given and a visual display will be activated.

Radio Panel:

Receive Signal Intensity

The voltage from the existing radio equipment signal intensity recorder is amplified and fed into the recorder. This recording chart's very low chart speed of 0.5 inches per hour will enable the operator to quickly observe performance over a 24 hour or longer period. The adjustable alarm threshold is set by a control on the front of the recorder. A time delay relay is used between the recorder and the alarm relay such that the threshold must be exceeded for thirty seconds before an alarm is indicated.

Baseband Loading:

The exciter output is monitored by this channel.

Voice Panel:

Idle Channel Noise

The test voice channel is essentially terminated at the transmit terminal with the exception of a single high amplitude stability, 100 wpm VFCT channel inserted at 3.145 kHz. The receive test channel modem filters out the VFCT channel and furnishes to the idle channel noise monitor circuit the channel noise between 300 Hz and 2.1 kHz. This is then amplified and its average value detected and applied to the recorder.

Test Tone Level:

The transmitted VFCT carrier is used for both the binary error rate and the test tone level stability measurement. The transmit terminal incorporates an automatic level control which stabilizes the VFCT carrier output to within several tenths of a db. In the receiver section, the VFCT signal is filtered and applied to both the binary error rate and the test tone level stability circuitry. The recorder contains a dual adjustable threshold circuit such that an alarm will be sounded for test tone levels which are either above or below the desired value.

Binary Error Rate:

The binary error rate monitor provides a true real-time measure of link error rates. The transmit section generates a known pseudo random binary pattern at a 75 baud rate which is used to key the VFCT tone keyer. In the receiver section, the VFCT signal is demodulated in a tone receiver and the binary output is applied to an automatic error detection system incorporating automatic bit rate and pattern synchronization.

7. Alarm Receiving Sites:

It was already pointed out that the SOC at Tan Son Nhut is a receiving and monitoring site for the remote alarm system. At the SOC, the alarm signal will activate indicators on both the control console and the wall display. In addition to the SOC, there are alarm receivers at Pleiku which display the alarm signal on a console only. Other than this, the operation is identical with that at the SOC.

Figures VII-K-1, 2, 3 are reference material on the alarm and performance monitor equipment.

	ALARM CONDITION	CONFIGURATIONS 1	2	3	4	5
1.	Power Amplifier #1 low forward power	x	x			
2.	" " #2 " " "	x	x			
3.	Exciter #1 low forward power	x	x	x	x	x
4.	" #2 " " "	x	x	x	x	x
5.	Receiver #1 received pilot failure or high noise	x	x	x	x	x
6.	" #2 " " " " " "	x	x	x	x	x
7.	" #3 " " " " " "	x				
8.	" #4 " " " " " "	x				
9.	Baseband failure	x	x	x	x	
10.	Multiplex major alarm	x	x	x	x	x
11.	Reduction in the received signal intensity beyond a pre-set limit (severe long term fading)	x	x	x		
12.	Variation in test tone beyond pre-set limit	x	x	x		
13.	Idle channel noise above pre-set limits	x	x	x		
14.	Digital error rate beyond pre-set limits	x	x	x		
15.	Transmitter loading above pre-set limits (over deviation)	x	x	x		

CONFIGURATIONS:

1. AN/FRC-39 or REL 2600 equipment, operating in quadruple diversity and equipped with quality monitors and power amplifiers,

2. REL 2600 equipment, operating in dual diversity and equipped with quality monitors and power amplifiers,

3. REL 2600 equipment, operating in dual diversity and equipped with quality monitors and not equipped with power amplifiers,

4. REL 2600 equipment, operating in dual diversity and not equipped with quality monitors or power amplifiers,

5. AN/FRC-109(V) equipment, operating in dual diversity and not equipped with quality monitors or power amplifiers.

TABLE VII-I-1 ALARMS ASSOCIATED WITH VARIOUS CONFIGURATIONS

Fault Indicators

REL FACT SHEET NO. 23

REL Fault Indicators provide instantaneous alarm, both visual and audible, of failures detected in the various components of its associated radio equipment. Installed in radio stations the units provide operators with an immediate indication that a fault has occured in the radio equipment.

Fault indicators may be located in the radio room or at some remote central position in a station. In addition, operational facilities allow further remoting by provision of additional relays in the equipment, in some cases.

RELradio equipment, for both line-of-sight and tropospheric scatter communications, is provided with dry contacts for critical and important functions. Should a fault occur, the contacts close and circuitry within the REL Fault Indicator enables the information to be centrally observed.

Normally, each Fault Indicator handles the faults for two receivers, one exciter and one power amplifier. Two Fault Indicators are provided for a quadruple diversity station, but it is possible for all faults to be displayed on one unit.

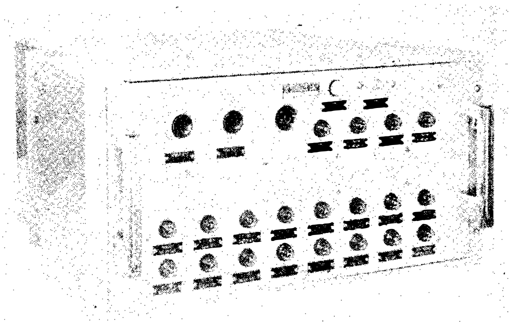
Fault Indicators may be used in all classes of REL radio designs: 2300, 2400, 2500 and 2600 Series equipments, encompassing 1, 10, 50 and 100 KW terminals. Each Fault Indicator is slightly different depending on the particular equipment configurations. If required, extra or spare positions may be supplied.

Generally, a Fault Indicator consists of three basic sub-units: a display panel for visual presentation which also carries a bell for audible warning, a component mounting panel which contains the relays and capacitors to permit visual signaling and a bell-ringing impulse, and a power supply containing the appropriate transformers and rectifiers to provide D.C. and A.C. voltages.

The Type 1099 Fault Indicator displayed is a compact unit used in conjunction with REL's 2600 Series of solid-state gear. In typical application, associated radio gear consists of one 10 KW power amplifier, an exciter and two receivers.

The Type 1099 Fault Indicator is housed in a cabinet-type enclosure for mounting on a 19-inch relay rack. The unit's overall dimensions are approximately 10-1/2 inches high by 21 inches wide by 20 inches deep.

The front panel contains 20 (amber) fault indicating lamps (including 2 spares), an alarm sounder, sounder and lamp reset pushbuttons, a power circuit breaker, and a (white) power indicating lamp. The drawer-type front-panel-and-chassis pulls out to allow access to all electrical components. Each fault indicating lamp is associated with a specific failure. When a failure occurs the associated lamp comes on, and the alarm sounder is actuated.



Compact Fault Indicator for Special 10 kw Terminals

TYPICAL SPECIFICATIONS FOR A 10 KW UNIT

INPUT VOLTAGE:	120 VAC±5%, 47 to 63 cps, single phase, 180 VA maximum
OPERATING TEMPERATURE:	0 to +45 degrees Centigrade
RELATIVE HUMIDITY:	0 to 100%
HEAT DISSIPATION: (to air)	650 BTU/HR

Four indicator lamps are associated with the Exciter, seven with the 10 KW Power Amplifier, three with the Power Amplifier Heat Exchanger, and three with the Receivers (whose similar fault indications are connected in parallel).

FIGURE VII-1-1

1072 Terminal Facilities Bay

REL's Type 1072 Terminal Facilities Bay constitutes a useful accessory to any tropospheric scatter system by providing a convenient interface between multiplex channeling equipment and the radio equipment. In addition, special patching facilities allow for the performance of most operational and maintenance testing. These include selecting, combining, terminating, and monitoring one link of a diversity system.

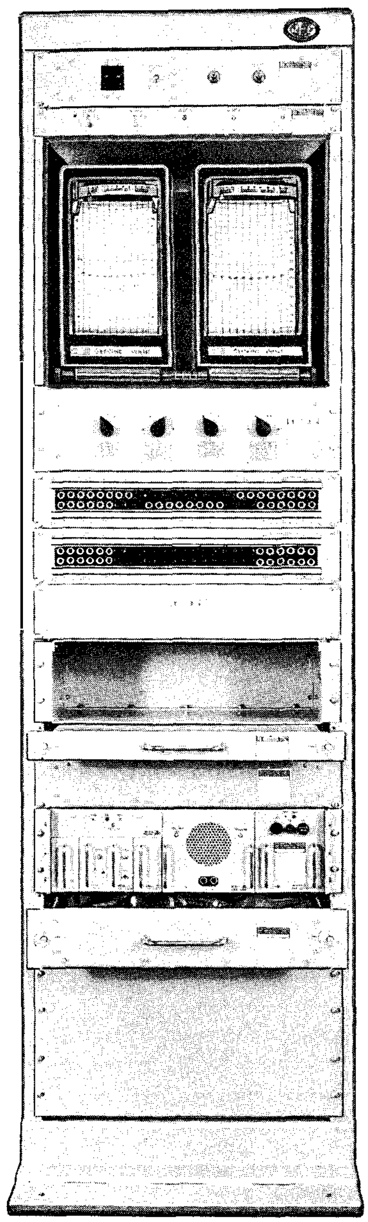
The terminal facility can be used in conjunction with a performance monitor to perform system checks or to provide a means of continuously monitoring the received signal strength.

Each terminal facility is slightly different depending upon the radio equipment such as the REL 2300, 2500, or 2600 series, type of multiplex used and desired test features. Any arrangement of facilities is available and the combination of equipment may be specifically built for each system.

The terminal facility may be comprised of any or all of the following units: Terminal Panel, RF patching Panel, Dual Recorder Panel, Modulation Patching Panel, Hybrid Interconnect Panel, Order Wire Assembly Panel, Line Amplifiers and Loop Converters. In addition to the above, a filing and writing shelf, drawer, test cords, head set and other accessories are provided.

Terminal Panel: This provides the control circuitry for the Order Wire assembly and Dual Recorder. Power switches with indicating lamps are provided for the main power circuitry.

RF Patching Panel: This provides points for RF sampling in the exciters, power amplifiers and receivers. This permits test conections to the system via this panel as well as providing monitoring facilities for the RF.



Dual Recorder Panel: This provides for the permanent record of received signal strength of an individual receiver and the combined signal strength. A time constant selector switch is available to permit 0.1, 1.0 or 10.00 second time constant. All REL receivers are provided with a signal strength recorder output jack.

Modulation Patching Panel: This provides for patching the exciter and receiver order wire and traffic basebands. Proper terminations are provided and measurements of levels may be made. Spare jacks are provided to allow special patching facilities as required in the field.

Hybrid Interconnect Panel: This provides the correct arrangement of hybrids to interconnect the carrier multiplex and order wire equipment to the exciters and receivers. Correct impedances are maintained.

Order Wire Assembly: This provides for voice communication over the radio service channel. Signalling is provided together with all filtering and bridging networks. A separate amplifier and loudspeaker is provided. A head set is included.

Line Amplifier: In those cases where the carrier multiplex and radio levels may not be compatible a transistorized line amplifier is provided. This is extremely linear with a very flat response. Normally, two such amplifiers are provided in one small panel.

Loop Converter: This provides for converting the transmitted RF signal to the received RF signal. This permits local loop testing of a complete system.

Overal dimensions of a fully equipped facility are: height -- 72 inches, width -- 21 inches, depth -- 18 1/2 inches, weight -- 480 pounds.

FIGURE VII-1-2.

Performance Monitors

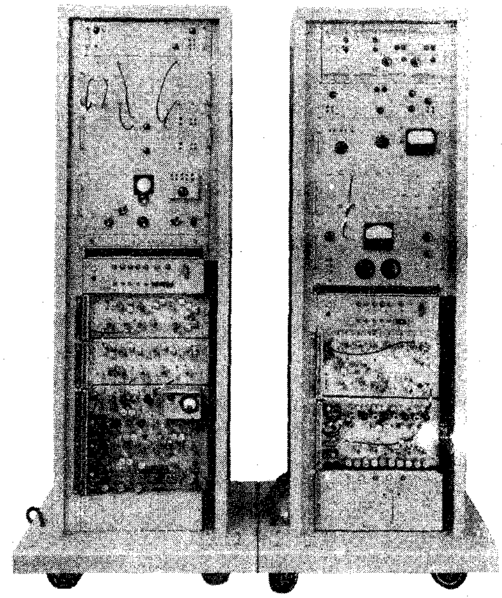
REL FACT SHEET NO. 12

REL Performance Monitors constitute completely integrated test facilities for checking the performance characteristics of tropospheric scatter radio systems. As a unique collection of special test equipment, Performance Monitors offer maximum flexibility for both in-service and out-of-service tests through self-contained substitution and measurement tests.

Mounted in standard relay rack cabinets in either one, two, or three bay configurations, REL Performance Monitors are optional customer items. Available in every series of REL tropo radio sets, they are specifically designed as to frequency requirements and channel capacity.

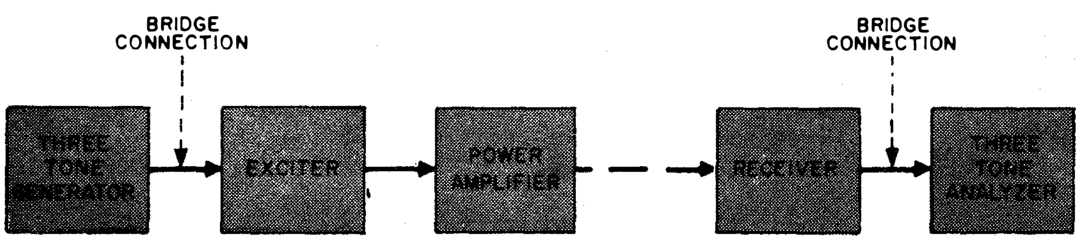
Performance Monitors serve two main functions by providing frequency conversion facilities and test facilities not normally available from standard test equipment. In everyday practical use, Performance Monitors are utilized for in-service-tests while tropo equipment is operating and carrying traffic, and in out-of-service tests when equipment has been removed from service and is not carrying traffic. Under these two basic categories, most prevalent testing consists of three tone intermodulation distortion tests and full baseband noise loading intermodulation distortion measurements, respectively.

Special test units provided by Performance Monitors for typical application consist in part of: Monitor Converters (convert transmitting RF signals to receiving RF signals or IF signals), Test Converters (convert IF signals to receiving RF signals), Three Tone Generators and

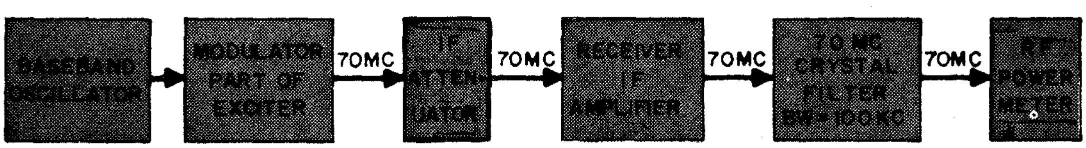


Typical Two Bay Configuration

Analyzers (permit intermodulation tests without interrupting service), Noise Generators for out-of-service intermodulation tests), Noise Analyzers (measure intermodulation at receiver output), Carrier Zero Test Receivers and Oscillators, High Frequency and Low Frequency Modulators, Demodulators, Baseband Oscillators (provice baseband frequency for modulation deviation test and frequency response level measurements), Baseband Voltmeters, 70 megacycle Attenuators, and Patching facilities.



Block Diagram Showing System Three Tone Intermodulation Measurement



Block Diagram Showing FM Deviation Measurement

FIGURE VII-1-3.

J. Test Equipment:

The variety and quantity of pieces of test equipment installed in a EE building is astounding. There are over 199 different types of test equipment in the ICS. The total quantity to be supplied for Phase I and II sites only is 4718. This is an average of 132 items per site - certainly a formidable capability.

However, test equipment that is malfunctioning or out of calibration is valueless and may create a great deal of trouble. The maintenance of the special types of equipment found in the ICS has been, and will surely continue to be, a problem. Calibration services are provided by Field Calibration Teams from Okinawa.

The proper and efficient operation of the ICS stations requires operating test equipment. Experience in the past indicates that this should be an area given close supervision.

K. ICS Power Systems:

If there is one feature of each ICS site that is not uniform for all sites, it is probably the primary ac power supply. There are several combinations found: some with all ICS generators, others having ICS generators only for emergency back-up, etc. The one feature that is common to all sites is the use of a dc system to power a portion of the equipment.

1. DC Equipment:

The 48 volt dc power source is furnished by several banks of high-capacity storage batteries which are continually on "floating charge" from the station rectifiers. The dc equipment is connected directly across the batteries; therefore, any interruption in the rectifier output will not affect the operation of the equipment. The equipment that is connected to the dc system is:

a. Microwave Radio Terminals.

b. Order Wire and Alarm Systems.

c. Voice Frequency Multiplex Terminals.

d. All Conditioning Equipment in the Technical Control Area.

2. AC Equipment:

As stated above, the primary ac source may be either ICS or some generator; however, all sites, except for those having no tropo terminals, have ICS emergency back-up generators which are installed and controlled so as to minimize power outages. The equipment that is ac powered is:

a. Tropo Radio Terminals.

b. Voice Frequency Carrier Telegraph Terminals.

c. Test Equipment.

d. Lighting (emergency lighting provided by battery units)

e. Air conditioning (not powered under emergency conditions).

3. Split-Bus Operation:

Where it has been possible to do so, the ac equipment has been installed on a "split bus" (Figure VII-K-1). The ac equipment is arranged so that redundant equipment, such as the two transmitters in a tropo terminal, is "split" between the two power buses. When one generator fails, the system is degraded, but not completely down while another generator is started. The other feature of the systems is the ability to combine the two buses if both generators on one bus fail.

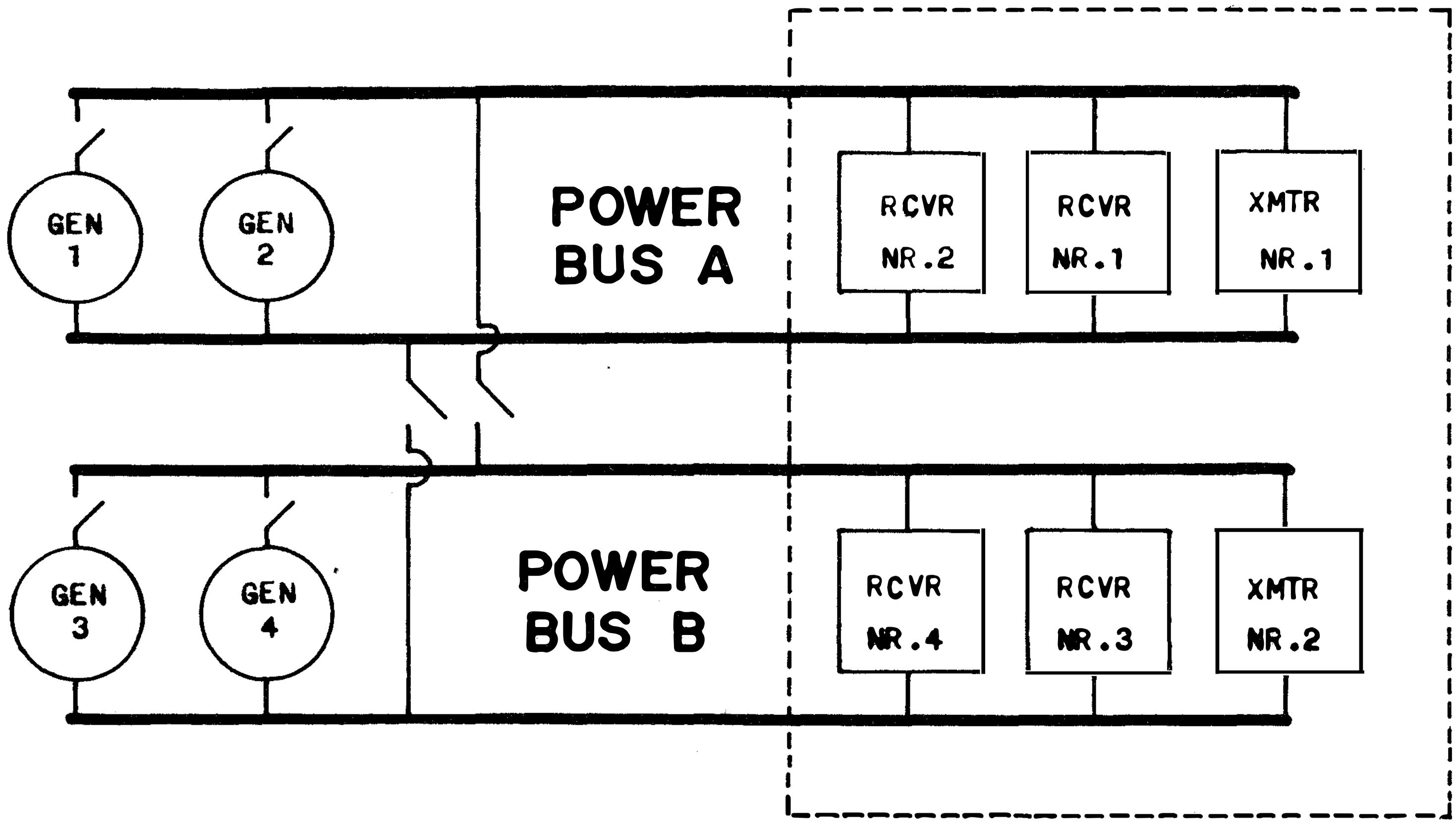


FIGURE VII-K-1 SPLIT-BUS OPERATION

VIII. TACTICAL EQUIPMENT

The primary reason for covering tactical equipment in this text is to provide the information required to properly interface it with the ICS fixed-plant facilities. For this reason, in the discussion of the tactical items, emphasis is placed on their interface specifications.

The following items of "tactical" or "transportable" equipment are covered:

Radio

AN/GRC-50

AN/TRC-24

AN/TRC-29

VF MUX

AN/TCC-3

AN/TCC-7

AN/TCC-13

VFCT

AN/TCC-20

AN/TCC-4

TH-5

Signalling

TA-182

Modified TA-182 (IWCS)

Technical Control

AN/MSQ-73

Circuit Control Facilities

SB-611/MRC

SB-675/MSC

Tropo Systems

AN/TRC-66

AN/TRC-90, AN/TRC-90B

AN/TRC-97, AN/TRC-97A

AN/TRC-129

AN/TRC-132

PCM (Pulse Code Modulation) Equipment

A. AN/GRC-50, RADIO SET

The AN/GRC-50 (V) is a transportable, VHF, radio set. It may be used with 4- 12-, or 24- channel TDM equipment to provide telephone, teletypewriter, data or facsimile circuits.

TECHNICAL CHARACTERISTICS:

Configurations:

AN/GRC-50 (V) 1: Low and high band.

AN/GRC-50 (V) 2: High band only.

AN/GRC-50 (V) 3: Low band only.

AN/GRC-50 (V) 4: High band only (has additional xmtr and rcrv).

AN/GRC-50 (V) 5: Low band only (has additional xmtr and rcvr).

Frequency range:

Low Band: 601.5-999.5 mHz (400 channel in 1.0 mHz steps).

High Band: 1350.5-1849.5 mHz (500 channel in 1.0 mHz steps).

Baseband: 240 kHz (250 to 240,000 Hz).

Input devices:

AN/TCC-3 (FDM); AN/TCC-7 (FDM); TD-202/U (TDM-PCM):

Planning range (KM): 40 to 48.

B. AN/TRC-24, RADIO SET

The AN/TRC-24 is a transportable, VHF-UHF radio set. Configurations of the AN/TRC-24 are normally used in conjunction with Terminals, Telephone AN/TCC-3 (4-channel) and AN/TCC-7 (12-channel).

TECHNICAL CHARACTERISTICS:

Frequency range:

A Band: 50 - 100 mHz (200 channel in 0.25 mHz steps).

B Band: 100 - 225 mHz (250 channel in 0.5 mHz steps).

C Band: 225 - 400 mHz (175 channel in 1.0 mHz steps).

D Band: 400 - 600 mHz (133 channel in 1.5 mHz steps).

F Band: 790 - 925 mHz (350 channel in 0.5 mHz steps).

J Band: 1,350 - 1,875 mHz (1,350 channel in 0.25 mHz steps).

Baseband:

68 kHz (250 to 68,000 Hz)

108 kHz (250 to 108,000 Hz, B Model only)

Input devices:

AN/TCC-3 (FDM); AN/TCC-7 (FDM).

Planning range (KM): 40 to 48.

C. AN/TRC-29, RADIO SET

The AN/TRC-29 is line-of-sight, VHF, Microwave terminal mounted in field transportable cases. The AN/TRC-29 is capable of handling the following signals:

Time Division Multiplex (TDM)

Frequency Division Multiplex (FDM)

Television

Radar

At the present time, here in Vietnam, the only multiplex equipment in use is the TDM terminal, AN/TCC-13; however, there are plans to use a special modulator to provide 4 wideband (50 kHz) secure voice channels over the AN/TRC-29.

TECHNICAL CHARACTERISTICS:

Frequency range:

1700 to 2400 mHz (27 RF channels, 25 mHz apart)

Baseband: 30 Hz to 4.5 mHz.

Baseband Input Requirements:

Impedance	50 ohm
Frequency	30 Hz to 4.5 dbm
Level	-3 to +7 dbm

Antenna;

Type	Horn fed Parabolic Reflector
Size	3 foot diameter
Gain	30 db

Planning range (km): 40 to 48.

D. AN/TCC-3, TELEPHONE CARRIER TERMINAL

The AN/TCC Telephone Carrier Terminal is effectively one third of and AN/TCC-7 Telephone Carrier Terminal; however, it provides only four (300-3,500 Hz) voice channels or one (16kHz) special service channel.

In addition to the four voice channels a separate voice orderwire, with 1600 Hz ringing facilities, is provided.

The interface requirements for the AN/TCC-3 are the same as those for the AN/TCC-7.

E. AN/TCC-7, TELEPHONE CARRIER TERMINAL

1. Purpose:

(1) The AN/TCC-7 system provides 12 telephone carrier channels over a single nonloaded spiral-four cable and/or radio links, such as AN/GRC-50 or AN/TRC-24, for distances up to 200 miles. Facilities are provided for replacement of all or a portion of the 12 telephone carrier channels by broad-band special service circuits in 3 frequency ranges. The communication channels available for simultaneous use are listed in the table below.

(2) An order wire circuit is provided in addition to the above listed communication circuits.

(3) The message channels (or the special service channels used in their place) are translated to a band of 12 to 60 khz for transmission over the cable or radio links. The order wire circuit operates in the VF (voice-frequency) range.

2. Technical Characteristics.

a. Message Channels.

Number	12
Frequency band	300 to 3,500 Hz
Impedance	600 ohms

Levels:

Operation	Input to AN/TCC-7 terminal	Output from AN/TCC-7 terminal	System net loss or gain
2-wire	0 db	-3 db	3 db loss
4-wire	-4 db	+1 db	5 db gain

NOTE: The level at any point in a system is defined as the gain (or loss) in db from some reference point to a point under consideration. In the AN/TCC-7 system, the 2-wire message channel transmitting input is the reference point (0db level)

b. Special Service Channels.

Level:

Frequency band kHz	No. of channels	Input to AN/TCC-7 terminal (db)	Output from AN/TCC-7 terminal (db)	Impedance (ohms)
4 to 20	3	0	0	600
12 to 60	1	0	-2	135
60 to 108	1	0	-5	135

c. Order Wire.

Frequency range	300 to 1,700 Hz
Signalling frequency	1,600 Hz
Transmitting level to cable	+20 db max
Transmitting level to radio	+10 db
2-wire extension to control board:	
Impedance	600 ohms
Transmitting level	0 db
Receiving level	12 db

3. Modulation Plan and Frequency Allocation

Although the AN/TCC-7 produces a 12-channel GROUP in the standard frequency band (60-108 khz), it does this in a manner somewhat different from that used in the AN/FCC-17. This two-step procedure can best to described by referring to Figure VIII-1. First, 4-channel SUB-GROUPS are formed in each of the three CHANNEL MODEMS. Then these 3 SUB-GROUPS are combined into one 12-channel GROUP in the standard GROUP frequency band 60-108 khz. Finally the GROUP is translated to the frequency range 12-60 khz and an order wire signal is added to produce the output signal.

Since the frequency ranges are identical (60-108 khz), the 12-channel of the AN/TCC-7 could be used as a thru-group on the AN/FCC-17; however, it would be necessary to have an AN/TCC-7 at the distant end to demodulate the signal because of the incompatibility of the inverted and erect channels. If the AN/FCC-17 channel multiplex was used, it would be possible to recover only every other channel, the even numbered ones.

F. AN/TCC-13, MULTIPLEXER SET

The AN/TCC-13 multiplexer in a pulse position modulation (PPM) terminal. It is the principle multiplexer used with the AN/TRC-29 radio set.

TECHNICAL CHARACTERISTICS:

Type of modulation	Pulse position
Type of multiplexing	Time division

Audio channel:

Band With	300 to 3500 Hz
Signalling	20 Hz on subscriber loops. Signal is transmitted over system by "blanking" the pulse for the channel ("drop-channel signalling")

2-wire operation:

Input level	0 dbm
Output level	-3 dbm

4-wire operation:

Input level	-4 dbm
Output level	0 dbm

Number of channels:

One AN/TCC-13 provides 23 audio channels; however, it is possible to "Slave" another AN/TCC-13 to the master to provide an additional 22 channels.

A major cause of excess noise in AN/TCC-13 (AN/TRC-29) systems here in Vietnam is excessively high input levels on the audio channels. Often, it has been found that the input level to a 4-wire channel has been set at 0 dbm. If this is done for all 45 channels, there is a significant decrease in the signal-to-noise ratio in each channel.

G. AN/TCC-4, AN/TCC-20, TELEGRAPH TERMINALS

1. GENERAL INFORMATION

The AN/TCC-24 and AN/TCC-20 provide high-speed (up to 100 wpm), half or full-duplex, frequency shift, carrier telegraph circuits within a voice frequency band of 300 - 3,100 Hz and over two-or four-wire circuits. The basic AN/TCC-4 provides an 8-channel system. Alternate arrangements of the equipment are described below. These terminals provide for either a voice frequency or a direct current type of loop circuit operation. The major components of the AN/TCC-4 are:

1 each Telegraph Modem TH-14/T (49 lbs)
2 each Telegraph Terminal Group TH-13/T (104 lbs)
2 each Telegraph Modem Assembly TH-15/T (82 lbs)

NOTE: The AN/TCC-20 is an AN/TCC-4 less the TH-14/T

2. TECHNICAL CHARACTERISTICS

Loop arrangements:

2w - vf - HDX;
4w - vf - FDX;
4w - dc - Neutral FDX;
4w - dc - TANDEM - Neutral FDX.

Loop signal:

Vf: Mark - - 1,325 Hz
Space - - 1,225 Hz

Dc: Mark - - 20 ma dc
Space - - 0 ma dc

Loop receiving sensitivity (vf): 0 dbm to -40 dbm.

Ringing in vf loop circuits:

20 Hz, 115v from terminal to loop;
20 Hz, 90v from loop to terminal.

Signalling in line circuits:

Channel space frequency operated two seconds minimum.

Break in one half-duplex operations:

Channel space frequency operated two seconds minimum.

Transmission level to line:

0 dbm (adjustable depending on number of channel).

3. Equipment Arrangements:

Channels req (HDX or FDX)	Transmission facility (Carrier channel or Physical wire line)	Components required
4	Four-wire	1 ea TH-13/T; 1 ea TH-15/T. (1 ea AN/TCC-20)
4	Two-wire	1 ea TH-13/T; 1 ea TH-15/T. (1 ea AN/TCC-20)
8	Four-wire	2 ea TH-13/T; 2 ea TH-15/T. (2 ea AN/TCC-20's)
8	Two-wire	1 ea TH-14/T; 2 ea TH-13/T; 2 ea TH-15/T. (1 ea AN/TCC-4)

12	Four-wire	2 ea TH-14/T; 3 ea TH-13/T; 3 ea TH-15/T. (one each AN/TCC-4 and one each AN/TCC-20)
16	Four-wire	1 ea TH-14/T; 4 ea TH-13/T; 4 ea TH-15/T. (two each AN/TCC-4's)

H. TH-5/TG, TELEGRAPH TERMINAL

Telegraph Terminal TH-5/TG is used between teletype stations to provide teletypewriter transmissions over facilities which will not pass direct current. For transmitting, the neutral Mark and Space signals from the teletypewriter are converted to 1325 and 1225 Hz, respectively. The received VF signals are reconverted to the corresponding neutral dc signals. The TH-5/TG also provides for connection of a local battery field telephone. Telephone and telegraph transmission, however, cannot be simultaneous without additional equipment (F98 filter).

Circuit Application:	Either 2-wire or 4-wire
Transmission Speed:	60, 75, or 100 wpm
Type of Modulation:	Frequency shift
Impedance (at 1000 Hz):	600 ohms input and output
Output level:	0 dbm ± 2
Sensitivity:	VF signals -50 dbm; ringing 90v, 20Hz
Jack Current:	14.85 to.15 ma send, 19 to 23 ma receive
Distortion:	5% maximum send and receive
Transmission Frequencies:	1325 ± 2 Hz Mark, 1225 ± 2 Hz Space, 20 Hz ring (break)

I. TA-182, CONVERTER, TELEGRAPH - TELEPHONE

The TA-182 is used to provide in-band signalling over the tactical carrier equipment. It combines the operation of two pieces of fixed-plant equipment into one unit, SF Unit and Ring-Down Converter.

The telephone signalling frequency of the TA-182 is 1600 Hz. It is to provide compatibility with the TA-182 that 1600 Hz SF Units were installed in the ICS ; however, the tone output of the standard TA-182 is so high that it over-drives the ICS signalling unit causing signalling problems. A modification program for the TA-182 has been initiated here in Vietnam to correct this problem (refer to Paragraph J).

TECHNICAL CHARACTERISTICS:

Frequency of telegraph signalling:	1,225 Hz
Frequency of telephone signalling:	1,600 Hz
Loop signal input:	20 Hz
20 Hz output level to line:	1000 volts
Output level to line:	0 dbm ±2 db
Receiver sensitivity on line side:	Low: -25 dbm; High: -45 dbm
Sensitivity on loop side:	25 volts

J. TA-182, (ICS MODIFIED)

The TA-182 has been modified for use on DCS circuits that traverse the ICS by lowering the output level of the 1600 Hz tone. This required merely changing three resistors in the unit. Aside from the output tone level, all other characteristics remained unchanged.

TECHNICAL CHARACTERISTICS:

Frequency of telegraph signalling:	1,225 Hz
Frequency of telephone signalling:	1,600 Hz
Loop signal input:	20 Hz
20 cps output level to loop:	100 volts
Output level to line:	-10 dbm ±2 db
Receiver sensitivity on line side:	Low: -25 dbm; High: -45 dbm
Sensitivity on loop side:	25 volts

Instructions have been issued by the USARV AC/S C-E to modify all TA-182's in Vietnam; however, there appear to still be a large number of unmodified units in use.

K. AN/MSQ-73, COMMUNICATIONS TECHNICAL CONTROL CENTER

1. Purpose. The AN/MSQ-73 technical control van is an air-transportable communications technical control center used to patch, monitor, and test voice and teletypewriter circuits. The floor plan of the van is shown in Figure VIII-2.

2. Voice Circuits. Voice circuits from telephone subscriber equipment telephone central offices, and multiplexer equipment can be interfaced at the technical control van. The Following equipments are examples of multiplexer sets which can be connected through the technical control van: AN/TCC-3, AN/TCC-7, AN/TCC-13, Collins MX-106 (used in transportable tropo systems), and Lenkurt 45BX3. The technical control provides equipments for 2-and 4-wire

20 Hz signalling, 2-and 4-wire E and M signalling and dial loop signalling. Interfacing equipment provides compatible operation for voice and ringing signals between 2-wire and 4-wire communication equipment. Examples of the typical modes of VF operation which may be interfaced are as follows:

a. Two-or four-wire ringdown to multiplexer
b. Two-wire E and M or dial to multiplexer
c. Multiplexer to multiplexer with compatible or incompatible signalling.

3. Teletypewriter Circuits. DC and voice-frequency (VF) teletypewriter circuits from single or multichannel lines can interface at the technical control van. DC teletypewriter signal converters are provided to interconnect 20 ma and 60 ma lines. Voice-frequency telegraph (VFTG) channel demodulators are provided to check any of the multiplexer channels by means of teletypewriter monitor and test equipment. A block diagram of the DC operation is shown in Figure VIII-3. DC patching and cross-connect arrangements are shown in Figure VIII-4.

4. Test Equipment. All lines and signals which are connected through the van can be checked by test equipment which is included as part of the van. Up to 12 channels of a multiplexer VFTG composite signal can be demodulated, tested and analyzed by the test equipment.

5. Circuit Capacity:

VF 4-wire	120 circuits
VF 2-wire	96 lines
DC teletype 4-wire	120 lines

6. Patching Levels: -2 dbm

7. Multiplexer channel signalling: 1600 Hz and 2600 Hz.

8. Equipment installed:

VF Attenuators	450
VF Amplifiers	150
Ringdown Converter	150
Hybrid 2W/4W Terminating Units	100
1600 Hz SF Units	75
2600 Hz SF Units	75
Loop to E&M Converter	10
DC Isolation Relays	30
Repeating Coils	30
Pulse Link Repeaters	78
Teletypewriter Site AN/FGC-69	1
Telegraph Terminal AN/FCC-19	1
Test Equipment	Assorted

L. SB-611/MRC, COMMUNICATIONS PATCHING PANEL

1. Purpose. The SB-611/MRC is an air-or vehicular-transportable circuit control facility which permits patching (routing and re-routing), testing in both directions, and monitoring telephone, vf and dc teletypewriter circuits.

2. Capabilities. The SB-611/MRC provides facilities for connection of forty-six 26-pair cables, two spare 26-pair cables, and eighteen field wire pairs. It contains facilities for terminating and patching 528 lines, and for terminating and switching 12 circuits. Twelve hybrids are provided for converting 2-wire circuits to 4-wire circuits. A functional diagram is shown in Figure VIII-5.

3. Major Components:

3-Bay Patch Panel	1
Manual Telephone Switchboard SB-22A/PT	1
Telegraph Terminal TH-5/TG	1
Telephone Set TA-312/PT	1
Teletypewriter Set TT-44/TG	1
Generator, Static Ringing TA-248/TT	1

M. SB-675/MSC, COMMUNICATIONS PATCHING PANEL

1. Purpose. The SB-675/MSC is an air-or vehicular-transportable circuit control facility which permits patching, testing and monitoring of telephone, vf and dc teletypewriter and system control (telephone and intercommunication) circuits.

2. Capabilities. The SB-675/MSC permits connection of thirty-six 26-pair cables and twenty-field wire pairs to the patching panel. Twelve of the field wire pairs appear on jacks on the patching panel, and twelve field wire pairs are terminated on line appearances on an SB-22/PT. A total of approximately 400 2-wire and 200 4-wire circuits may be patched. Hybrids are provided for converting 2-wire and 4-wire circuits. A functional diagram of the SB-675 is shown in Figure VIII-6.

3. Major Components:

3-Position Patch Panel	1
Manual Telephone Switchboard SB-22A/PT	1
Telegraph Terminal TH5/TG	1
Telephone Set TA-312/PT	3
Teletypewriter Set TT-4A/TG	1
Test Set TS-140/PCM*	1
Generator, Static Ringing TA-248/TT	1

*(Includes DB Meter ME-22A/PCM and Sig Gen SG-15A/PCM)

N. AN/TRC-66 RADIO SET

A tropospheric scatter and line of sight radio relay equipment capable of transmitting 60 voice channels over single hops up to approximately 100 nautical miles and tandem hops to system lengths of approximately 1000 miles. The radio set is packaged in equipment shelters capable of being transported by truck, cargo plane or helicopter. Power output 1 KW.

System uses the AN/FCC-17 multiplex terminal equipment.

O. AN/TRC-66A RADIO SET

A highly transportable tropospheric scatter ratio set capable of operating either as a single or dual line-of-sight terminal, line-of-sight relay or a quadruple diversity scatter terminal or relay. 60 channels. 1 KW maximum power output in the 4400 to 5000 MC frequency range. Transportable by land or air (including helicopter). 100 nautical mile single hops or 1000 nautical miles in tandem.

System uses the AN/FCC-17 multiplex terminal equipment.

P. AN/TRC-90, RADIO TERMINAL SET

1. General

The AN/TRC-90 series was developed from existing types of equipment; the MX-106 was a standard configuration of a 600 channel radiotelephone frequency division multiplexing terminal; the AN/TRC-80 terminal which was designed for a single speech plus circuit on a dual-diversity tropo system for use on missile ranges; and a modification of the Northern Radio Company (NRC)-235, which is a 16 channel voice frequency carrier telegraph (VFCT).

The TRC-90 is a dual-diversity (space) tropospheric scatter radio terminal with 24 voice frequency (vf) channels, 16 teletype (tty) channels, and a speech plus service channel.

The transmitter is a 1 kilowatt frequency modulated unit operated in the 4.4 to 5.0 gHz range with a 15 foot parabolic antenna which offers a nominal 45 db gain factor.

The two receivers are dual-conversion super-hetrodyne FM types operating in combining dual-diversity. The original receiver front ends have been changed from a three cavity to a four cavity preselector and a tunnel diode amplifier has been added resulting in better sensitivity, selectivity, and signal-to-noise ratio.

The multiplexing equipment (mux) is of the three step (channel), basegroup, and supergroup), 24 channel, frequency division multiplexing type utilizing the lower sideband in all modulation processes. There are two or four wire terminating options on all channels, though originally it was available only on Basegroup 4. There are no internal ringing facilities. Ringing is accomplished with externally wired TA-182 type converters. An order wire channel that is capable of simultaneous transmission and reception of voice or TTY signals is also available.

The voice frequency teletype terminal is a 16 channel frequency shift keying type. It has the keying line options of neutral 20 or 60 milliamperes (ma), or polar 20 or 30 ma with the battery being supplied by the VFCT or by an external source.

There is a 32RS1 single sideband transceiver included as an integral part of the van which is utilized to establish initial communications and for emergency purposes. The unit is a 4 channel crystal controlled pretuned device using 455 kHz lower sideband selection for transmit and receive functions. The operating range is 2 to 15 mHz with a 100 watt peak envelope power rating. A shelter mounted 32 foot vertical whip antenna is provided for the HF transceiver system.

Two air inflatable parabolic reflector antennas and transportable towers are stowed within the equipment shelter for transit, and the set can be transported by truck, helicopter, or fixed wing aircraft. A trailer mounted diesel engine ac power generator (PU-402/M) is used to supply 208 v at 15 kva primary power for the communication terminal. Radio Terminal Set AN/TRC-90 can be set up by a team of six trained men in approximately 6 hours after arrival at a suitable site location. Interior layout is shown in Figures VIII -7 and -8.

2. Technical Characteristics

Transmitter

Frequency Range:	4400 to 5000 mHz
Type of Transmission:	FM
Power Output:	1 kw

Radio Channels:	333 discrete transmit and receive channels in the 4400.8 to 4998.4 mHz band with 1.8 mHz channel separation.
Voice Channel Capacity:	One order wire channel, full duplex teletype or voice channel; or, one 4 kHz order wire channel and twelve 4 kHz voice channels with channel No. 12 normally utilized to handle 16 full duplex narrowband FSK teletype

channels (+42.5 Hz); or, one 4 kHz order wire channel and twenty-four 4 kHz voice channels with one of Them used to handle 16 teletype signals (modulation Plan shown in Figure VIII-9)

HF Capability:	One 100 watt SSB transceiver with 4 switch selected crystal controlled frequencies in the 2.5 to 12.0 mHz range.
Hybrids:	2-wire/4-wire termination units are provided for all channels.
DC Jacks:	Jacks for 16 TTY loops with one set jack and two looping jacks for each channel; jacks for AN/FGC-25X and loop current meter are provided.
Multiplexing:	FDM
Standard Channel Amplitude Frequency Response Terminal to Terminal (Channel Modem):	400 to 3000 Hz +1.0 db, -1.0 db 300 to 2400 Hz +1.0 db, -2.0 db
VF Termination Impedance:	
2 wire:	600 or 900 ohms
4 wire:	600 ohms
VF Levels Transmit:	
4 wire:	-16 dbm (-13 dbm available)
2 wire:	0 dbm
VF Levels Receive:	
4-wire:	+7 dbm (+24 dbm available)
2-wire	-3 dbm nominal
Signalling	Provided externally

Q. AN/TRC-90A, RADIO TERMINAL SET

1. General

There is no major difference in the radio frequency (rf) portion of this terminal. There has been a 2300 Hz signalling function added to the speech plus service channels. The front end of the receivers have again been changed to the four cavity tunnel diode, amplifier type. The antenna has been changed to a four section 10 foot parabolic dish type. The nominal gain of the antenna is 35 db.

The mux terminals are mounted in swing out racks which allows easier cleaning, maintenance, and faster troubleshooting. The jackfeilds have been changed to an 'in-line' configuration to make the operation simplier and faster. The ringing function is integrated into the terminal's termination unit with a 1600 over 20 Hz ringing mode.

The VFCT jackfield has an added Line Lift jack which facilitates troubleshooting and allows for altrouting around bad cable and/or bad equipment. A fuse has been added in all the direct current loops.

Pi filters have been added in the vf and dc signal entry pannels offering both protection and cable noise suppression.

The 32RS1 has been replaced by the battery operated AN/PRC-47 single sideband high frequency (2-12 mHz) transceiver.

The air conditioner has also been changed.

The two antennas are sectionalized metal parabolic reflectors 10 feet in diameter. Each antenna is mounted with its center 15 feet above the ground on a sectional tubular mast. (10-foot mast extension sets may be ordered separately if required). Bipolarized feedhorn permits using one of the antennas for transmission and reception simultaneously. 15-foot sections of low-loss flexible waveguide are provided.

2. Technical Characteristics:

The same as the AN/TRC-90 except that 1600/20 Hz signalling units are provided internally.

R. AN/TRC-90B, RADIO TERMINAL SET

The RF portion of this equipment has undergone some major changes. The Frequency Synthesizer, which is the operating frequency determining device, has been completely transistorized giving higher reliability, stability, and accuracy.

The receivers have the four cavity tunnel diode amplifier front ends as standard equipment. The IF has been increased from 8 to 10 mHz to allow for a broader baseband (more channels). The IF unit has also been transistorized and both receiver IFs are now incorporated into the single Dual IF Unit.

The FM modulator has been transistorized making it more compact, stable, and reliable.

The antenna is a 29 foot mesh 12 section parabolic with a nominal gain factor of 55 db.

The mux has several changes. The terminating and ringing facilities for each channel have been separated into two units. The option of 2600 or 1600 Hz is now available with either AC ring or an E&M line.

Redundant amplifiers have been added at the basegroup level, along with Basegroup Demod Regulators, which means more stability, higher reliability, and better channel signal-to-noise level.

The VFCT's unused diversity option on the receive side has been removed allowing a much more compact terminal. The keying on the even numbered channels has been 'inverted' to make the equipment compatable with the FGC-60, FGC-61, FGC-61A, FGC-61B, FCC-19, FCC-20 and several other VFCT's.

The 90B has an option of 24 or 48 vf channels and dual - or quad-diversity when integrated with another 90B or 129 van. The 48 channel operation is accomplished with one interconnecting cable and the changing of the Basegroup Carrier Selector for both of the basegroups in the auxiliary van and the setting of two mode switches in each van. The quad-diversity option requires two cables and the moving of the two receiver combiners from the Auxiliary van's Dual IF Unit to the FM Modulator in the Main van. Also the Diversity mode switch has to be set in the Main van.

S. AN/TRC-97/97A, TROPOSCATTER RADIO RELAY SET:

1. General

A completely solid state (except for klystron) transportable radio terminal providing tunable microwave. diffraction, or tropospheric scatter communications in the 4400 to 5000 mHz frequency range. Fully militarized and designed for full duplex multi-channel voice, data, or teletype. Output power: 1 KW for Tropo & 1 watt for line-of-sight. 12 or 24 VF channels available. 1300 RF channels in 432 kHz increments. 16 teletype channels on any one VF channel.

The set is transported on one M-37, 3/4 ton truck in an S-308 shelter.

2. System Characteristics:

	AN/TRC-97	AN/TRC-97A
Frequency Range	4400-5000MC	
Transmitter Power	1 Watt Exciter; 100-1000 Watts with P. A.	

	AN/TRC-97		AN/TRC-97A
Number of RF Channels		1200	
Diversity		Dual Space	
Modulation		FM	
Multiplex Type		FDM	
Multiplex Baseband	12-60 kHz		12-108 kHz
Voice Channels	12		24
Teletype Channels	16 (In any VF Channel)		16 (In any VF Channel)
Shelter Type	S-308		S-308
Shelter Weight	1655 lbs		1875 lbs
Trailer Type	M-101		M-101
Generator Set	Diesel Engine		Gas Turbine

3. Multiplexers:

VOICE: The voice channel multiplexer AN/GCC-5 combines 12, kHz nominal voice channels into one basic group at a line baseband frequency spectrum of 12-60 kHz for use in the AN/TRC-97. The AN/TRC-97A multiplexer, AN/GCC-6, stacks two 12 channel groups at a line baseband frequency spectrum of 12-108 kHz.

A patch panel is included for loop testing, monitoring and for teletype channel insertion and extraction in any voice channel.

The AN/TRC-97 Voice Multiplexer uses a twin sideband modulation plan while the AN/TRC-97A Multiplexer provides both inverted and twin sideband modulation plans either being selectable by an internal switch.

TELETYPE: The teletype multiplexer is compatible on the loop side with the TH-5/TG TTY converted and combines up to 16 TTY channels into a single voice channel frequency band.

MULTIPLEX CHARACTERISTICS

VOICE CHANNEL MULTIPLEXER	AN/TRC-97 AN/GCC-5	AN/TRC-97A AN/GCC-6
No. of Voice channels	12	24

Line Frequency Allocation	12 - 60 kHz	12 - 108 kHz
Modulation Plan	Twin	Inverted or Twin
Termination	2-wire or 4-wire	
Signalling	2600 Hz	
Levels:		
2-Wire		
Send	-0	
Rec	-6	
4-Wire		
Send	-16	
Rec	+7	

TELETYPE MULTIPLEXER

VF Transmit/Receive Terminal	
Mark Frequency	1325 Hz ± Hz
Space Frequency	1225 Hz ± Hz
Termination	2 Wire or 4 wire
FDM Sixteen Channel Group	
Channel Center Frequencies	425-2975 Hz in 170 Hz Increments
Frequency Deviation	± 42.5 Hz from each center freq.
Frequency Stability	± Hz
Data Rates	60,75, and 100 WPM

4. Antenna System:

The AN/TRC-97, 97A system uses dual space diversity for maximum propagation reliabilty. Two eight foot parabolic reflectors are normally used and 15 ft. parabolic dishes are available for more demanding requirements. In operation over wooded areas, horn antennas may be used for line-of-sight and diffraction paths. Dual polarized feedhorns are used interchangeably with all of the reflectors.

T. AN/TRC-129, RADIO TERMINAL SET

This van is the same as a 90B except the antenna is the 11 foot type as used with the 90A and the make of air conditioner has been changed.

1. Functional Description:

a. Radio Terminal Set AN/TRC-129 is a transportable, shelter-mounted radio terminal which provides full-duplex FM SHF communications with the capability of 24-4 kHz voice channels, 16 full-duplex narrow-band TTY channels, one 3 kHz telephone circuit and a teletypewriter both for service channel use. A separate auxiliary HF SSB transceiver is provided for communication during setup and installation. Tropospheric scatter propagation is the principal mode used by the main radio equipment; however, line-of-sight transmission may be used with reduced power output. 2W/4W and 20-cycle ringdown capabilities are available for all channels.

b. Each set has two receivers which use physically separated antennas in a dual space-diversity terminal configuration.

c. Two sets may be interconnected to provide the capability of operating as a quadruple (space-frequency or space-space) diversity terminal configuration.

NOTE: In quad diversity the voice multiplexing equipment of both shekters could be used to provide 48-channel capacity. However, only Radio Terminal Sets AN/TRC-90B (which are electrically similar to AN/TRC-129) have this capability since each shelter of the AN/TRC-90B uses two large 29-foot diameter antennas.

d. Relay station configurations can be set up using two or four sets for dual or quad diversity respectively.

2. Technical Characteristics:

a. General

(1) Range: Up to 160 KM (100 miles)

(2) Terminal Setup Time: About 4 hours using experienced 7 man team.

b. Transmitting and Receiving Systems.

(1) Frequency: 4.4 to 5.0 gHz

(2) Number of RF Channels Available: 333 channels at 1.8 mHz intervals.

(3) Power Output: 1000 watts FM (continuous duty cycle)

(4) Receiving System: Dual receiver in space diversity configuration using separated antennas.

(5) Receiver Bandwidths: Automatically variable from 4 mHz down to 200 kHz depending on signal strength.

(6) Antennas: Two sectionalized metal parabolic reflectors 10 feet in diameter. Each antenna is mounted with its center 15 feet above the ground on a sectional tubular mast. (10 foot mast extension set may be ordered separately if required). Bipolarized feedhorn permits using one of the antennas for transmission and reception simultaneously. 15 foot sections of low-loss flexible waveguide are provided.

NOTE: The above antenna system is identical with that used by Radio Terminal Set AN/TRC-90A.

c. Multiplexing System

(1) Synchronized frequency division carrier equipment is used to multiplex the 24 voice channels. In order to increase the overall reliability of the voice multiplexer, power supply units are paralleled, and all active circuits requiring DC power and affecting more than one channel are paralleled with standby units.

(2) The 16 teletype channels are narrow-band FSK Northern Radio Co. carrier multiplex equipment and are normally applied in place of voice channel 12.

U. <u>AN/TRC-132, RADIO TERMINAL SET</u>

Basically the RF equipment is the same as the 90B except it now has the equipment necessary for a quad-diversity option (two transmitters and four receivers) and 48 channel operation all in the one van. The VFCT has been deleted to give the needed space.

The 132 has the option, with <u>one van</u>, of operating as a 24 or 48 channel, dual - or quad-diversity system, or as two independant dual-diversity systems.

The van is equipped with through-grouping facilities so channels may be grouped through a relay station twelve at a time at the Basegroup level.

The single van may also act as a dual-diversity 24 channel through-group repeater with a 24 channel drop, or as a dual-diversity 48 channel Baseband repeater with a party line service channel in all options.

Two vans may be interconnected in any of several through group and channel drop configurations, or as a Baseband relay all of the options having the possibility of quad-diversity and a party line service channel.

The antennas are 29 foot parabolic reflectors.

All 48 channels are equipped with 2W/4W terminating units and options of 1600 or 2600 Hz with 20 Hz or E&M signalling.

V. SUMMARY OF INTERFACE CHARACTERICS AN/TRC-90, -90A, -90B, -129, -132

1. Voice Multiplex:

Equipment

All models	Collins MX-106 (Modulation Plan shown in Figure VIII-9)

Channels

-90	24
-90A	24
-90B	24
-129	24
-132	48

Levels - All models

2-wire:

Transmit	0 dbm
Receive	-3 dbm (nominal)

4-wire:

Transmit	-16 dbm (-13 dbm available)
Receive	+7 (+24 dbm available)

2. Teletype Multiplex:

The AN/TRC-132 has no VFCT capability

Equipment:

-90	Northern Radio NRC-235
-90A	Northern Radio NRC-235

-90B	Northern Radio NRC-235 modified
-129	Northern Radio NRC-235 modified

Type of System

-90	Diversity (old channels inverted)
-90A	Diversity (old channels inverted)
-90B	Non-diversity (compatible with) AN/FGC-60, -61, -61A, -61B,
-129	AN/FCC-19, -20, -25 and others)

3. Signalling

-90	None internal
-90A	20/1600 Hz only
-90B -129 -132	1600 and 2600 Hz SF Units; 20 Hz ringdown or E&M signalling

4. Terminating Units

All models have full capabilities for 2-wire or 4-wire terminating.

5. Antennas

-90	15 foot inflatable parabolic
-90A	11 foot sectional parabolic
-90B	29 foot mesh, 12-sectional parabolic
-129	11 foot sectional parabolic
-132	29 foot mesh, 12-section parabolic

6. Mode of Operation

-90	Dual-diversity (space only)
-90A	Dual-diversity (space only)
-90B -129	One van: Dual-diversity Two vans: Dual-diversity
-132	Quad-diversity

W. PULSE CODE MODULATION EQUIPMENT

Presently the AN/TCC-7 multiplex equipment used with the AN/GRC-50 radio system in RVN is being replaced by TDM-PCM equipment such as the TD-202/U and TD/352/U. These and other related items of PCM equipment are discussed below, following a brief introduction to PCM theory.

1. PCM Theory*:

Pulse code modulation (PCM) is a communication technique in which voice, data or facsimile signals are converted into a series of digital pulse codes. Each pulse code represents signal amplitude at a particular instant and a series of pulse codes represents a complete waveform. Since the transmitted signal is in digital form, it is less susceptible to noise and distortion buildup over long distance lines, and may be regenerated at repeaters along the route without introducing additional distortion.

In the PCM process (See Figure VIII-10), standard amplitude levels are assigned and are represented by digital codes. The incoming voice waveform is sampled at a high rate, and each sample is converted to a pulse at the closest standard amplitude, producing a pulse amplitude modulated (pam) waveform. The standard amplitude pulses developed are then measured and converted to a binary pulse code for transmission. The pulse codes are decoded at the receiving station and reconverted to a pam waveform, which is then demodulated to produce approximately the original waveform. As the sampling frequency is increased, the waveform generated at the receiver more accurately resembles the original waveform.

In the TD-352/U and TD-353/U, PCM multiplex units to be discussed below, the amplitude range of the incoming voice signals is divided into 64 levels which are then converted to 6-digit binary pulse codes. Companding (compression-expansion) circuits are used at the voice inputs to improve the fidelity of very high-level or very low-level signals. These circuits provide a non-linear amplification which compresses high-level signals to the amplitude range required for conversion to the 64-level range of the encoder and decoder, and expands very low-level signals to provide more accurate coding. The low-level signals must be expanded because they would cover only a few pulse code levels and would be more distorted than higher signals. A complimentary companding circuit is incorporated in the receiver circuits to restore the signals to their original levels after decoding and demodulating.

2. Purpose and use of PCM Equipment:

a. General: The TD-202/U, TD-203/U, TD-204/U TD-260/G, TD-352/U

* Reproduced from TM11-5805-367-12.

TD-353/U, and CV-1548/G Provide voice-frequency (vf) channel multiplexing-demultiplexing and telephone signal conversion in multichannel communication systems.

b. Multiplexer TD-202/U: This multiplexer is presently being utilized in RVN. It is a 12-or 24-channel, pcm, radio transmission interface unit. Its transmit section accepts time division multiplex (tdm) pcm outputs from one or two TD-352/U's, a TD204/U, or from another TD-202/U, and processes these outputs for radio transmission. The receive section accepts a pcm signal from a radio receiver, processes and retimes it, and extracts the order-wire signal.

c. Multiplexer TD-203/U: This multiplexer is a 48-or 96-channel pcm radio transmission interface unit which performs the same function described above for the TD-202/U, except it operates with the TD-353/U, TD-204/U, or another TD-203/U.

d. Multiplexer TD-204/U: This multiplexer is a 12-24-, or 48-channel pcm cable transmission interface unit. Its transmit section accepts tdm-pcm output signals from a TD-353/U, from one or two TD-352/U's, from another TD-204/U, a TD-203/U or a TD-202/U, and processes these signals for cable transmission. The receive pection accepts a pcm signal from the transmission cable, processes and retimes it. In addition, the TD-204/U provides power for up to 39 TD-206'/G's in the transmission cable, and contains an order wire facility.

e. Multiplexer TD-352/U: The TD-352/U converts 12 four-wire vf channels to a tdm-pcm signal in its transmit section and vice versa in its receive section. Two TD-352/U's are used with a TD-202/U or TD-204/U to provide a 24-channel capacity.

f. Multiplexer TD-353/U: This unit performs the same function described above for the TD-352/U, except it has a 48-channel capacity. Two TD-353/U's are used with a TD-203/U to provide a 96-channel system. One TD-353/U is used with one TD-204/U to provide a 48-channel capacity.

g. Restorer, Pulse Form TD-206/G: This unit is a two-way unattended repeater for pcm cable systems. It is installed at 1-mile intervals in the transmission cable to restore pcm pulse form and timing.

h. Converter, Telephone Signal CV-1548/G: The CV-1548/G provides telephone signal conversion and hybrid facilities for 12 multiplex channels. Each channel contains one way plug supervisor and ring down signalling conversion facilities, a hybrid for converting between 2-wire and 4-wire circuits, 4-wire straight through patching, and switching for selected combinations of these functions.

3. Technical Characteristics of PCM Equipment*:

a. TD-202/U and TD-203/U:

PCM input or output signal:

Impedance .... 91 ohms

Timing input or output signal:

Impedance .... 91 ohms

Radio input or output signal:

Impedance .... 51 ohms

Required radio bandwidth (at 3db point):

12-or 24-channel opn .... 240 kHz

48-or 96-channel opn .... 935 kHz

Order wire:

Impedance .... 600 ohms

Level (test tone) .... -4 dbm

b. TD-352/U and TD-353/U

Channel characteristics

Modulating bandwidth .... 300 to 3,500 Hz

Input for full modulation .... -4 dbm test tone

Output for full modulation .... -4 dbm (4-wire), +1dbm (2-wire), output is adjustable from -6 to +4dbm).

Input and output impedance .... 600 ohms (balanced)

PCM input or output signal:

Impedance .... 91 ohms

* Only equipment in use in RVN will be discussed

c. CV-1548/G

Operating modes (selected independently in each channel):

20 Hz signalling, 2-wire.

Plug supervision signalling, 2-wire (one-way)

from originator to terminator).

No signalling, 2-wire (hybrid only in use).

No signalling, 4-wire (channel patched straight through).

20 Hz signalling, 2-wire:

From subscriber ....20 Hz ringing voltage at 16 volts peak minimum.

To subscriber .... 20 Hz ringing voltage at 75 volts rms minimum (across four lines simultaneously).

Plug supervision signalling, 2-wire:

Opens or closes (T) tip and (R) ring lead circuit.

Multiplex terminal inputs, 4-wire (all signalling modes:

From multiplex terminal .... No tone or 1,600 Hz in-band tone between -25 and 0dbm.

To multiplex terminal .... No tone or 1,600 Hz in-band tone at - 15 dbm (adjustable ± db).

Channel characteristies (2-wire):

Insertion loss .... 4.5 db maximum (250 to 3,500 Hz)

Input and output impedance ..... 600 ohms (balanced to ground)

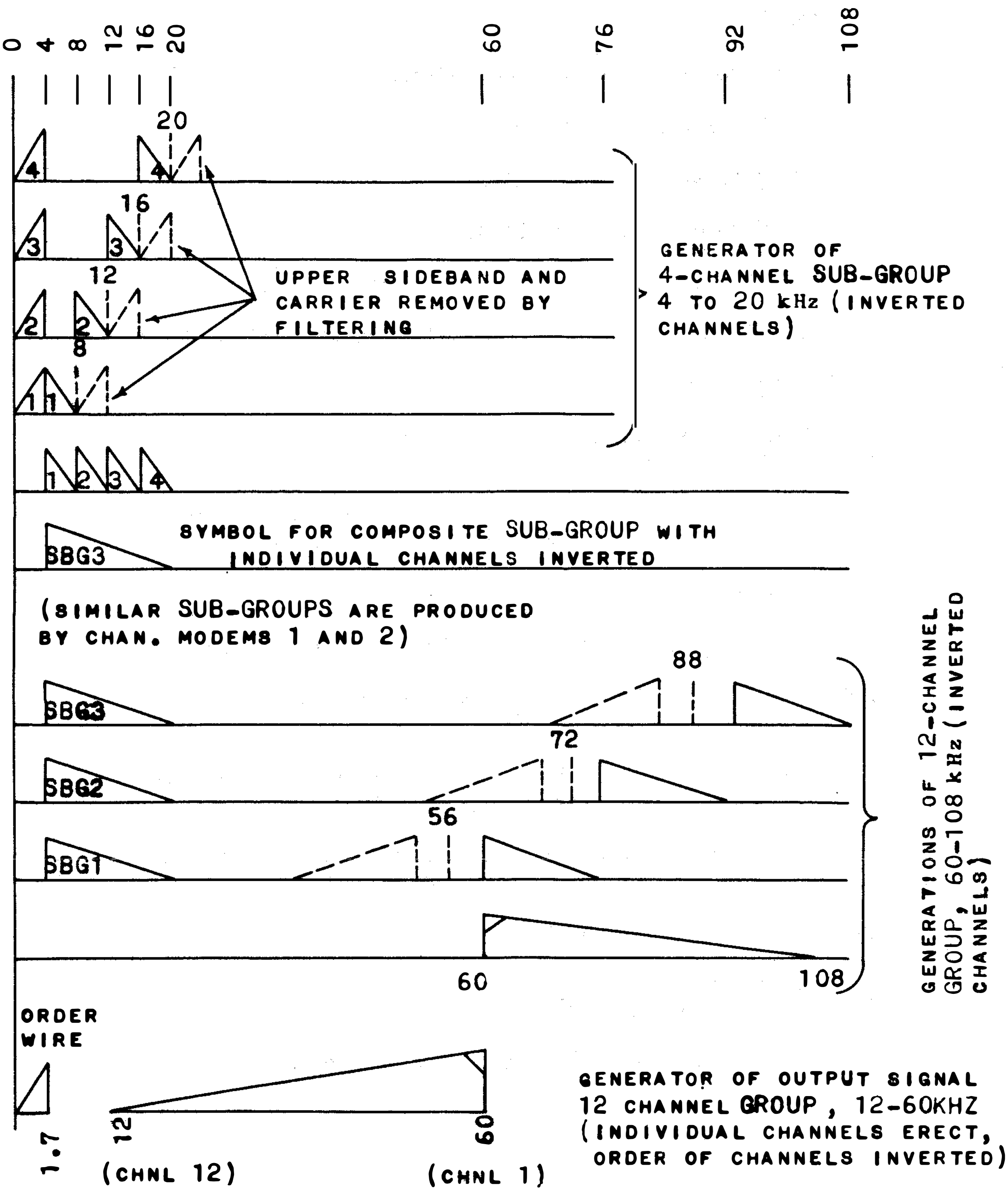
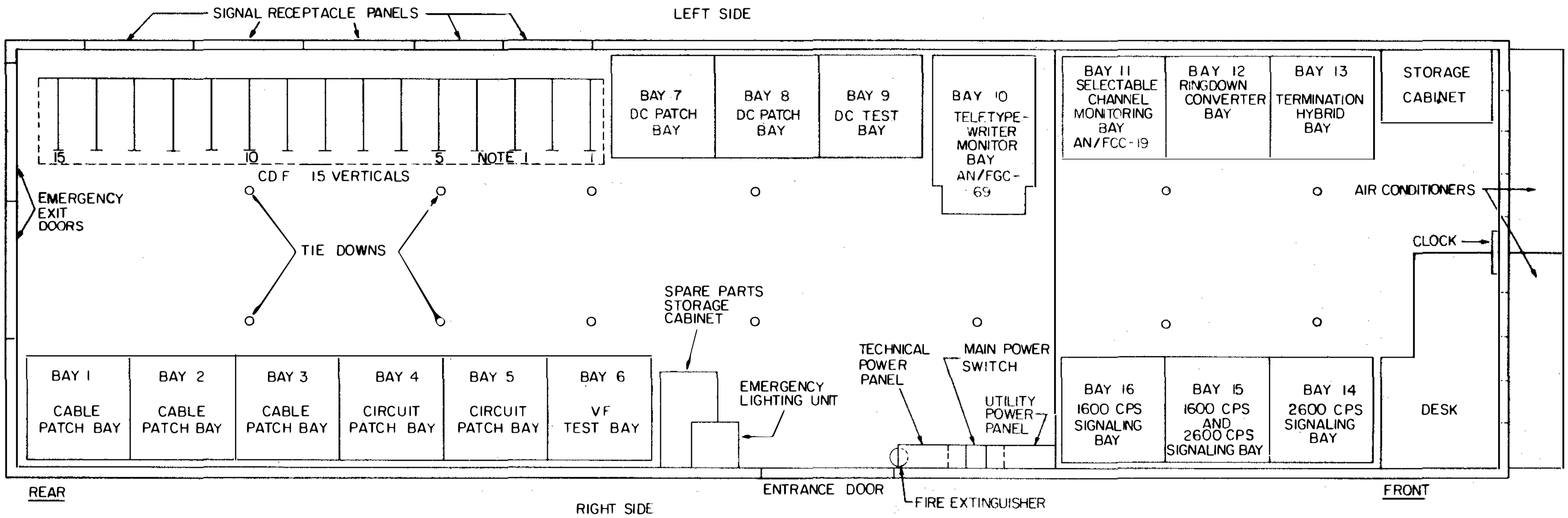


FIGURE VIII-1. MODULATION PLAN, AN/TCC-7



NOTES:

1. PROTECTOR BLOCKS INSTALLED ON VERTICALS 1 THRU 4 AND PART OF 5.

FIGURE VIII-2. AN/MSQ-73, TECHNICAL CONTROL VAN, FLOOR PLAN

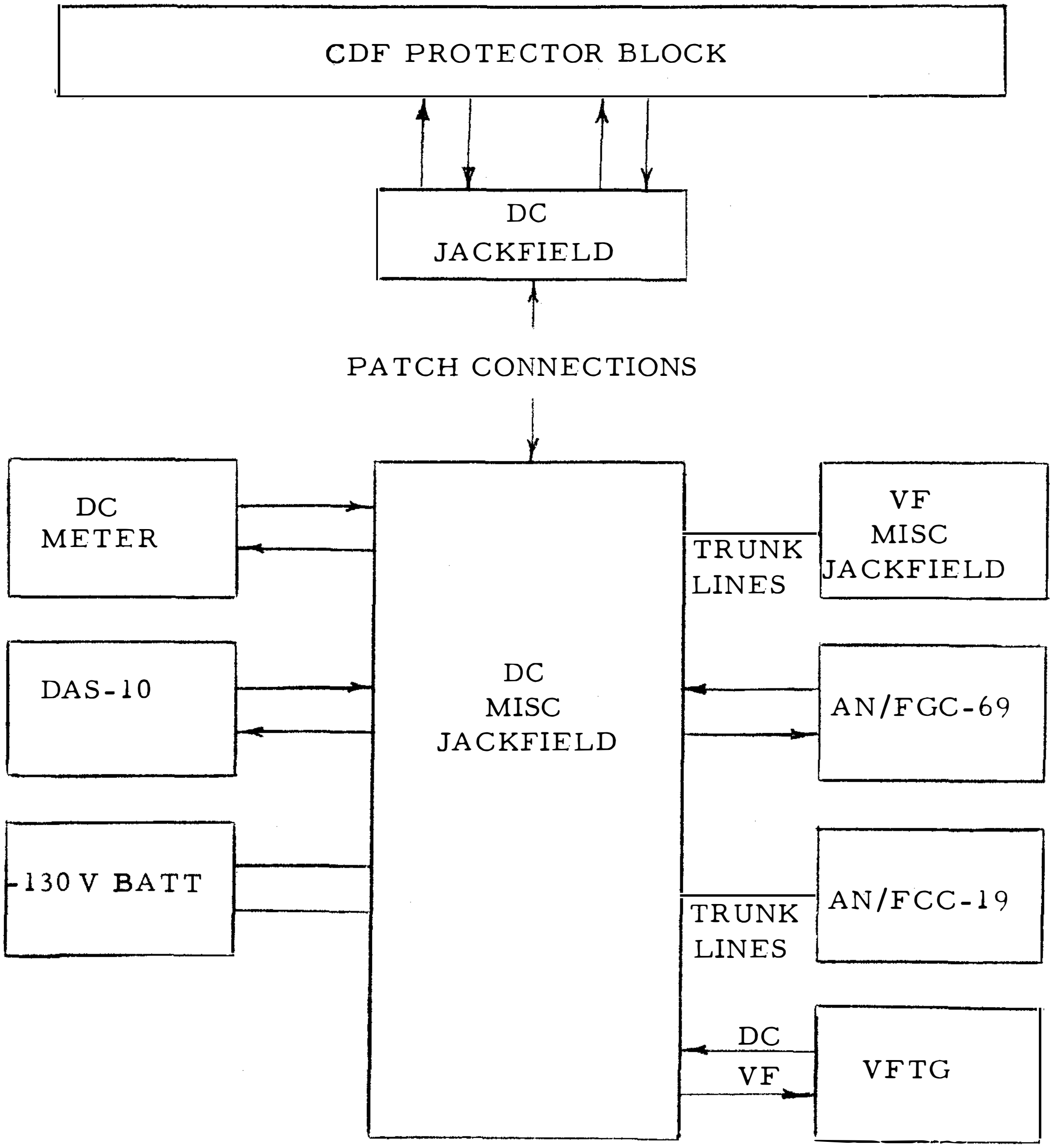


Figure VIII - 3. DC operation, block diagram.

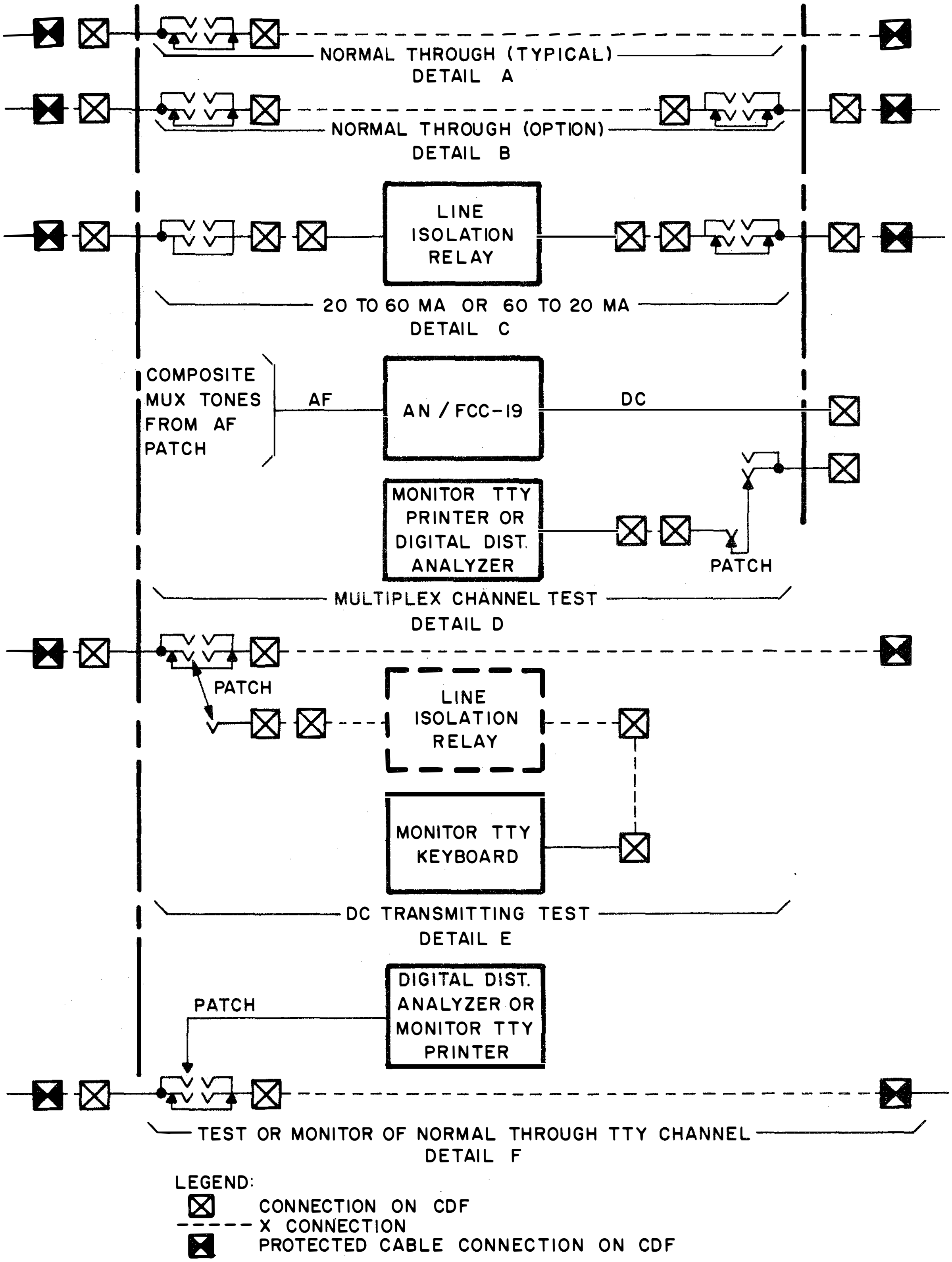


Figure VIII - 4. Dc patching and cross-connect arrangements.

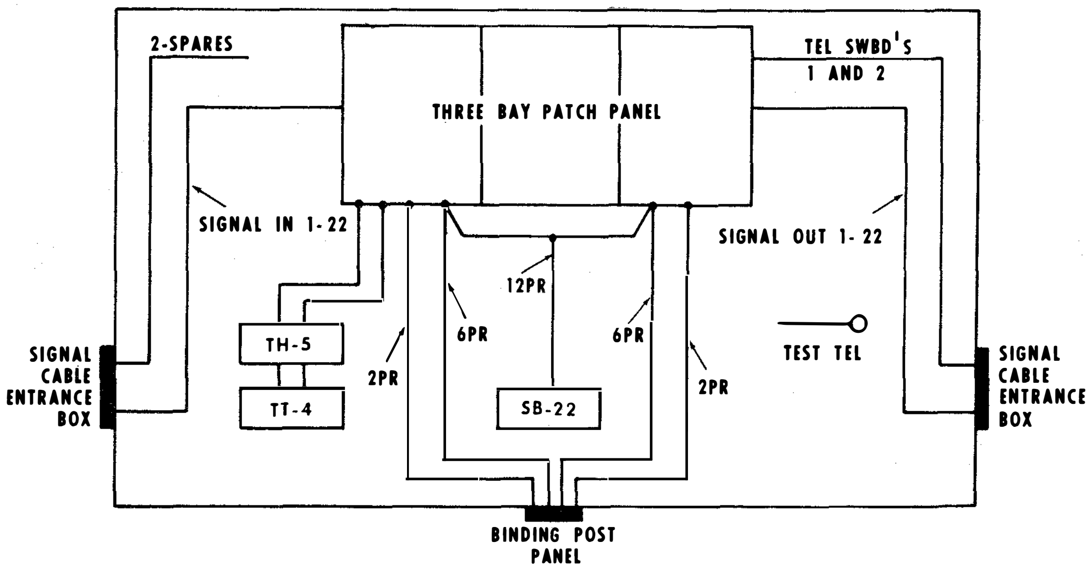


Figure VIII-5 Functional Diagram SB-611/MRC

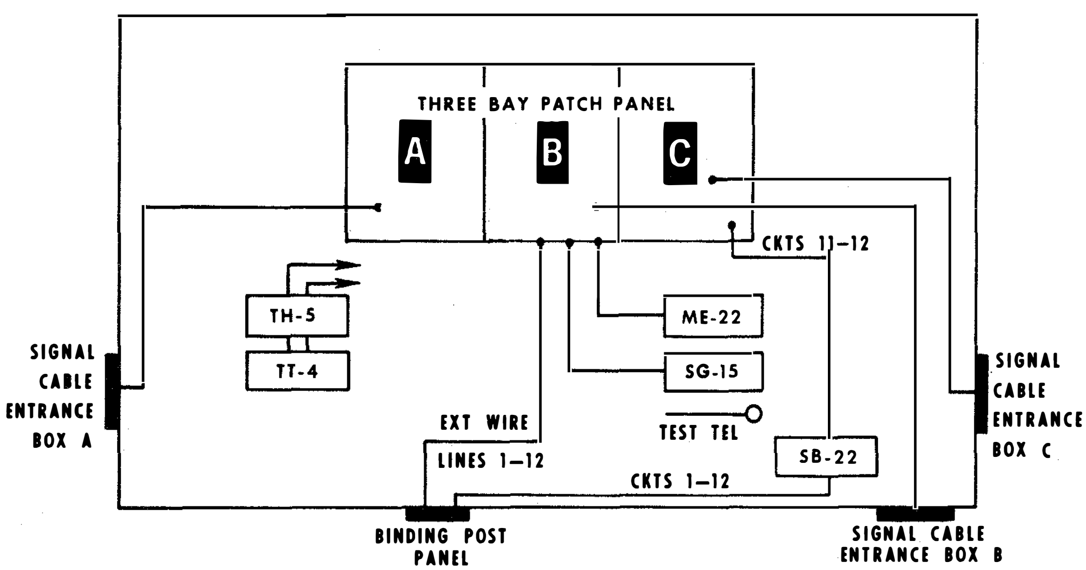


Figure VIII-6 Functional Diagram SB-675/MSC

LEGEND:

1. POWER DISTRIBUTION PANEL
2. SIGNAL ENTRANCE PANEL
3. DC PATCH PANEL
4. LOOP PAD PANEL
5. TTY MONITOR PANEL
6. 32 FOOT WHIP ANTENNA
7. ANTENNA COUPLER 180V-1
8. AIR CONDITIONING UNIT
9. VFCT TERMINAL TYPE 235
10. VOICE MULTIPLEX CARRIER MX-106
11. VOICE MULTIPLEX CARRIER MX-106
12. STORAGE AREA SPACE KLYSTRON AND HF ANTENNA BASE
13. AUDIO PATCH PANEL
14. STORAGE DRAWERS IF ASSEMBLY, 12/24 CHANNEL MODULES

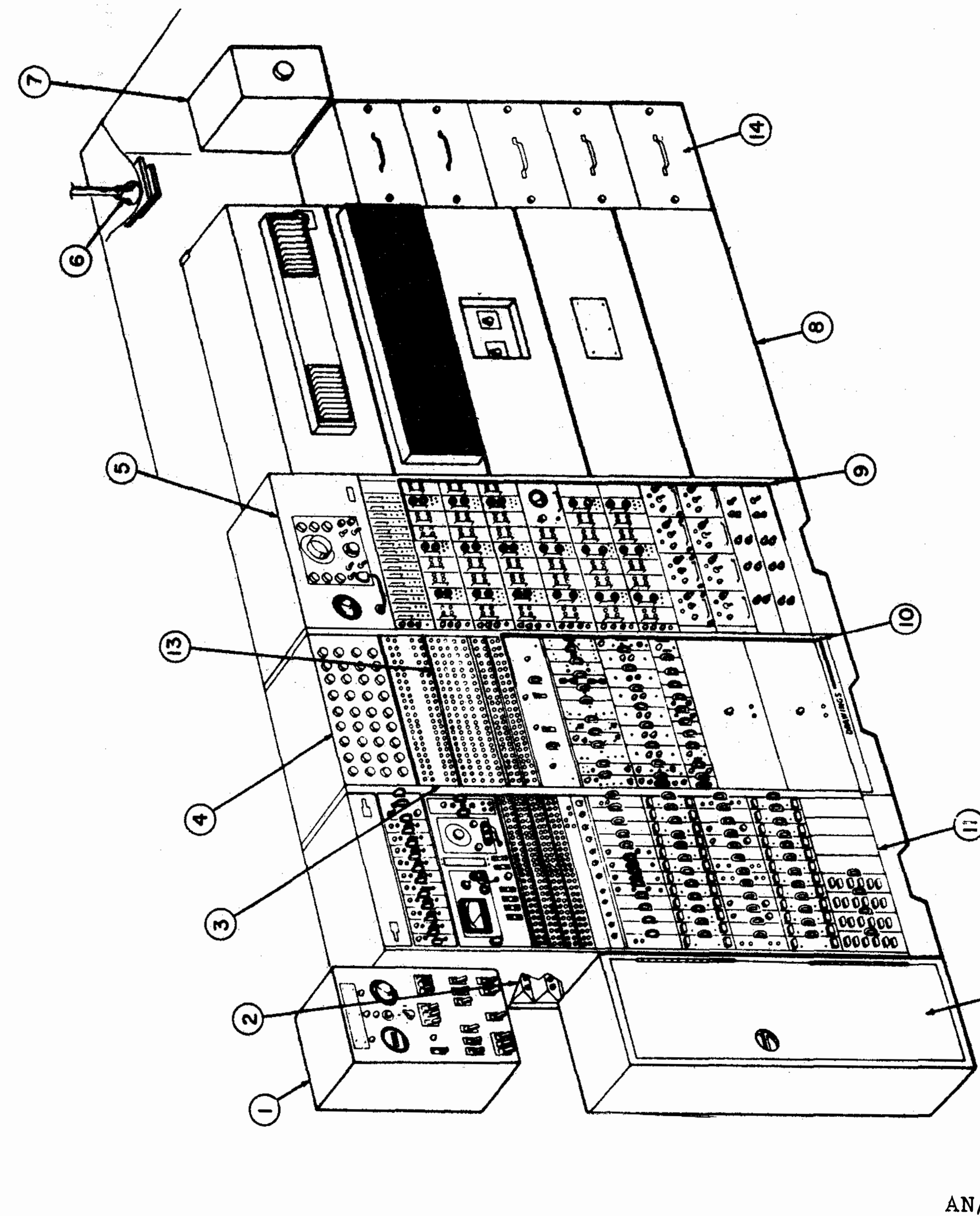
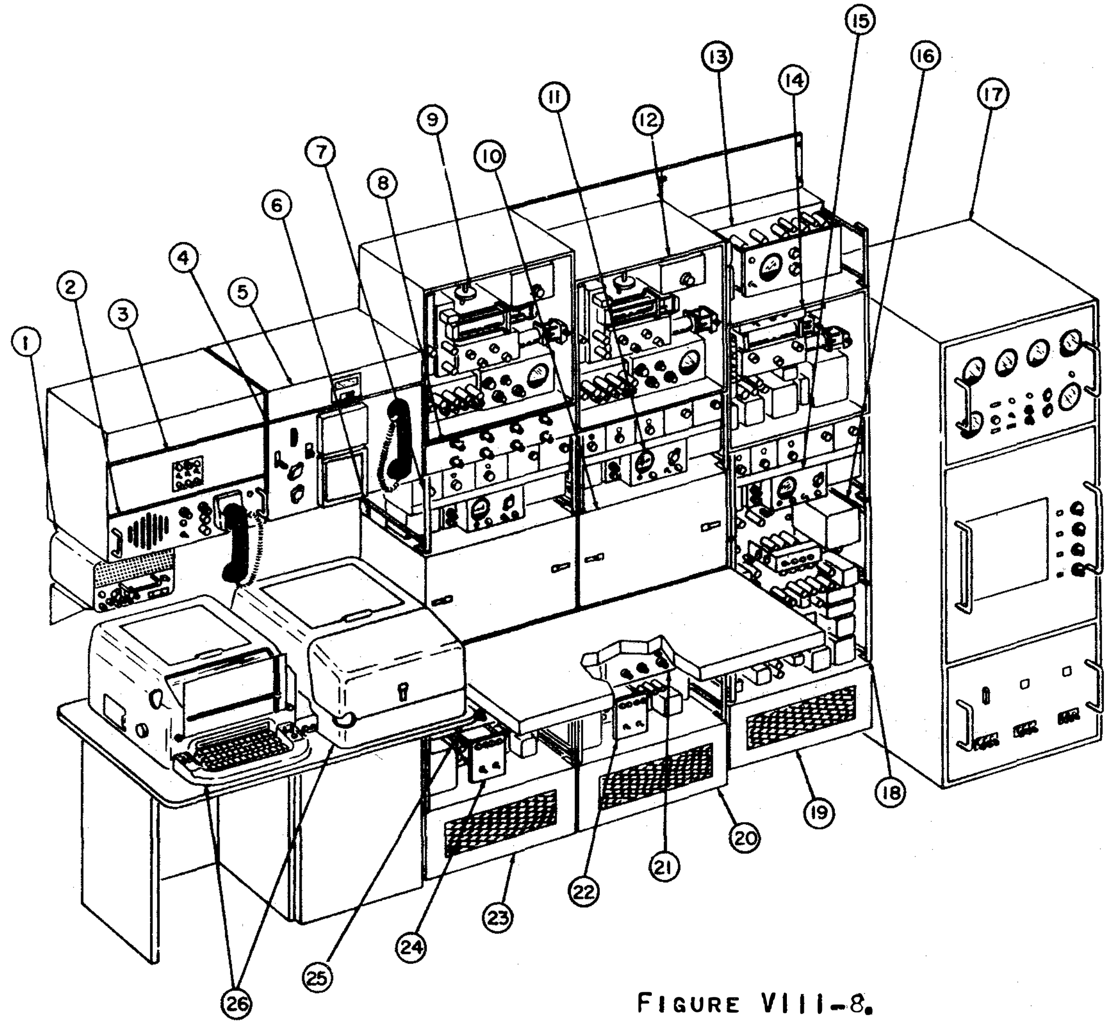


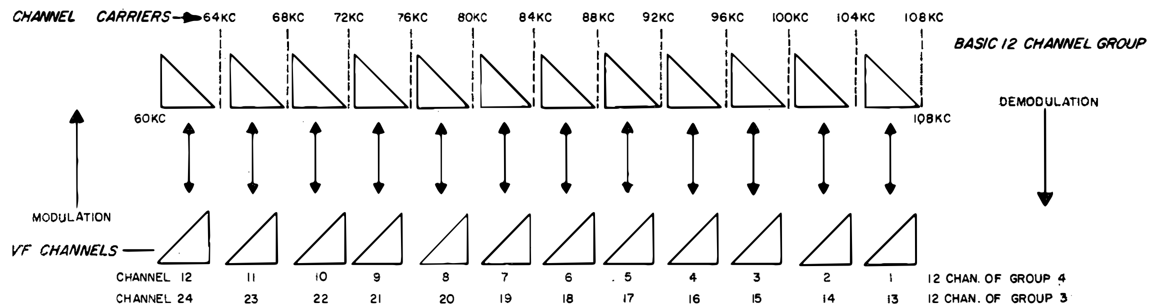
FIGURE VIII-7.
AN/TRC-90 SHELTER, LEFT WALL INSTALLATION



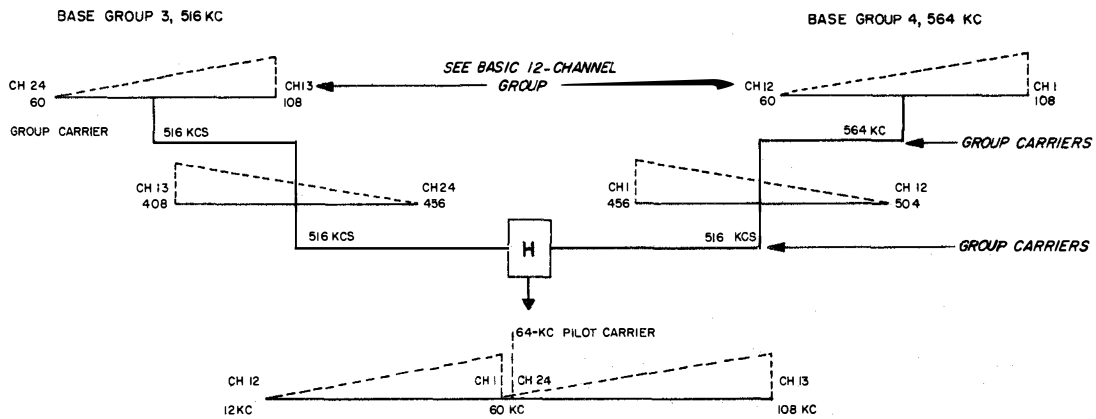
LEGEND:

1	TELEGRAPH TERMINAL TH-5/TG
2	VOICE MONITOR ASSEMBLY 159C-1
3	POWER SUPPLY (TRANSCEIVER 32RS-1F)
4	TRANSCEIVER 32 RS- 1F
5	ACCESSORY PANEL (32RS-1F)
6	IF AMPLIFIER Q50-2A1
7	FREQUENCY SYNTHESIZER 708E-2A
8	70-MC PATCH PANEL
9	SHF AMPLIFIER-CONVERTER Q50-8
10	IF AMPLIFIER Q50-2A1
11	FREQUENCY SYNTHESIZER 708E-2A
12	SHF AMPLIFIER-CONVERTER Q50-8
13	DEVIATION AND LEVEL MONITOR 900B-1
14	SHF AMPLIFIER CONVERTER T310-6
15	FREQUENCY SYNTHESIZER 708E-2A
16	MODULATOR-MULTIPLIER T310-1A
17	POWER AMPLIFIER 240F-4B
18	SERVICE CHANNEL AMPLIFIER 397B-2A
19	BLOWER ASSEMBLY 199G-7
20	BLOWER ASSEMBLY 199G-7
21	POWER SUPPLY Q50-4A
22	POWER SUPPLY Q50-4A
23	BLOWER ASSEMBLY 199G-7
24	POWER SUPPLY Q50-4A
25	POWER SUPPLY Q50-3A
26	TELEPRINTER SET AN/FGC-25X

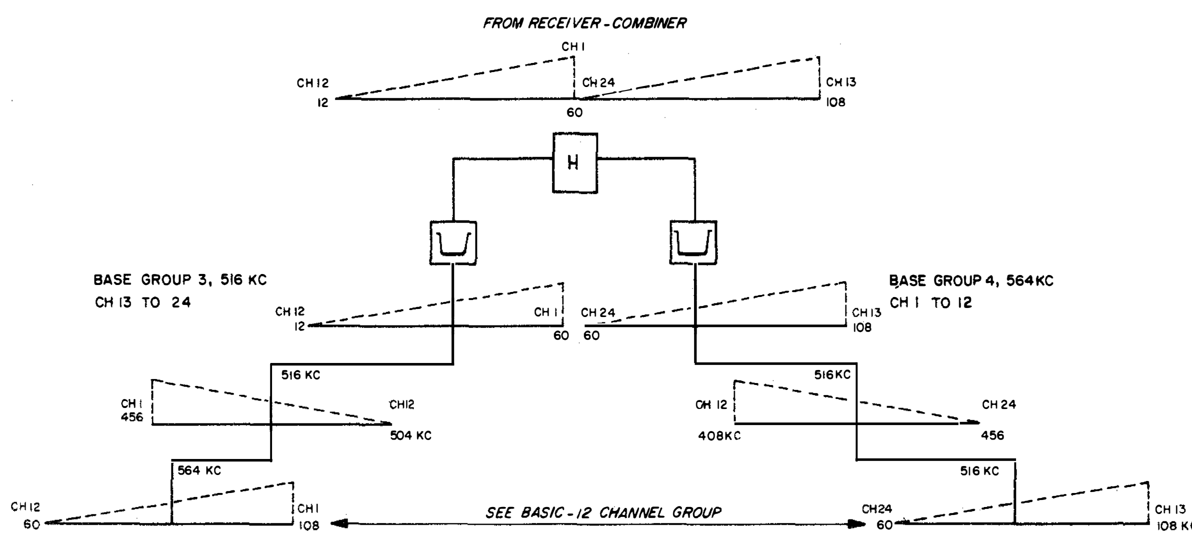
FIGURE VIII-8.
AN/TRC-90 SHELTER, RIGHT WALL INSTALLATION



VF CHANNEL MODULATION AND DEMODULATION PLAN



MULTIPLEX MODULATION PLAN



MODULATION PLAN DEMULTIPLEX

AN/TRC-90 MODULATION PLAN

FIGURE VIII-9.

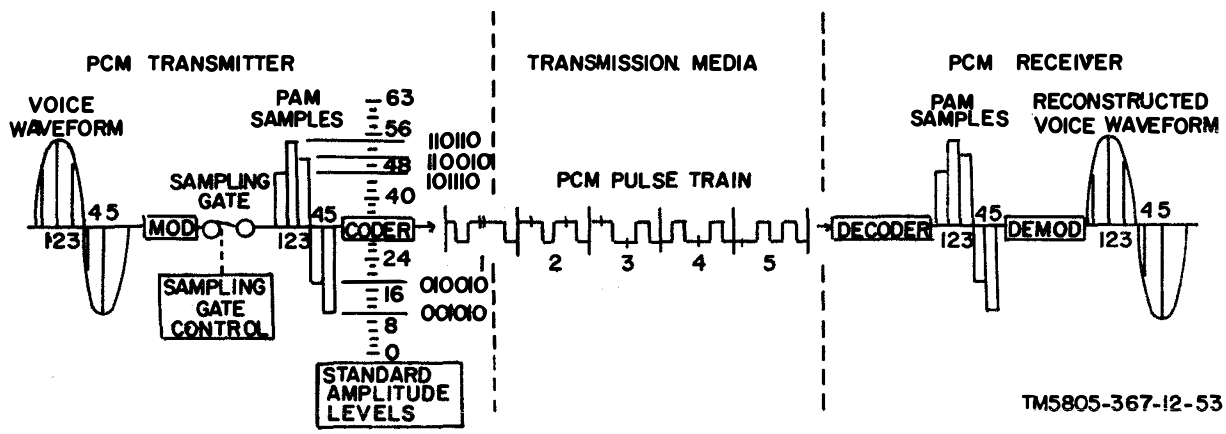


Figure VIII-10 The PCM Process

IX. INTERFACE PROBLEMS

If the most common problem in communication in Vietnam had to be chosen, there is little doubt that is would be "interface". There are in Vietnam a wide assortment of various types of equipments that were not designed to work together. The problem is to integrate them into a unified system that will provide efficient and quality service. Primarily, these problems have occurred when we attempted to combine "tactical" and "fixed-plant" equipment into a common system. There are several points of basic incompatability between these two. There are also some incombatabilities between various pieces of tactical equipment; however, these do not concern the ICS directly. A final group of interface problems that do concern the ICS are those occurring when fixed-plant equipments of two different manufactures are interconnected.

The examples discussed on the following pages are some of the interface problems that have been identified and solved. They should not cause any trouble in the future; however, the solution to these examples may suggest ideas and techniques for overcoming future problems. Of course, there are always "those that don't get the word the first time" and maybe these discussions will save them some needless work. Unfortunately, dissemination of this information heretofore has been quite limited.

A. LEVELS INTERFACE WITH TRANSPORTABLE EQUIPMENT:

The problem of properly interfacing levels with the transportable equipment is a relatively easy one to solve on paper, but in practice several complications arise.

1. Transportable systems have been terminated in three different configurations in the ICS technical controls. If the system is very important and is a major link in the SEAWBS, all channels of the system are terminated on primary jacks, VF jacks and circuit jacks with amplifiers between primary and VF jacks to provide standard + 7, - 16 levels at the VF patch appearance. Figure IX-A-1 illustrates this type of termination.

Some TCG's do not have enough amplifiers and or primary jacks to terminate per Figure IX-A-1. In this case transportable systems will terminate on the VF patch bay at non standard levels and may have no primary patch appearance.

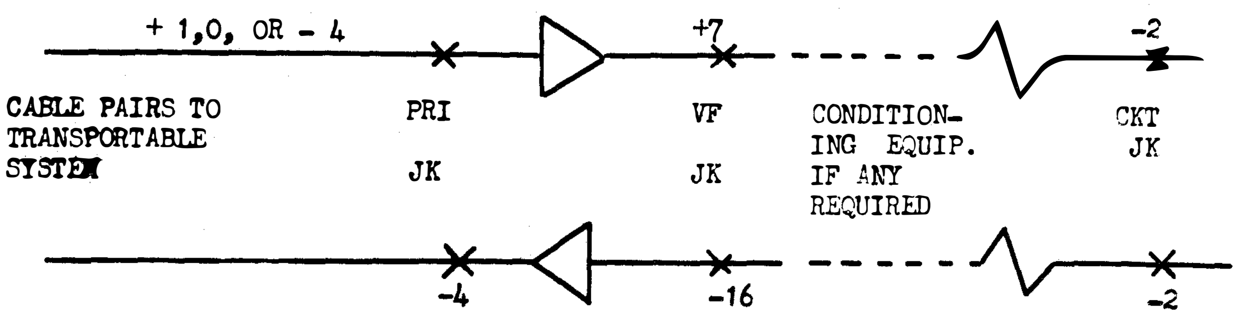


Figure IX-A-1 Transportable termination

If the transportable system is not considered of sufficient significance to warrant treatment discussed above, individual channels are terminated in the ICS TCG on primary jacks as required.

2. System terminated per Figure IX-A-1 provide compatable patching levels to ICS or other transportable systems so terminated, but some caution is necessary when patching channels at the primary patch or the VF patch, if amps are not provided, because transportable system channel levels are non-standard and not always the same. The levels for the two most common transportable multiplexers and for the PCM (pulse code modulation) equipment being introduced in RVN are given below:

	AN/TCC-7	AN/TCC-13	PCM
4-W Receive	+ 1	0	- 4
4-W Send	- 4	- 4	- 4

3. The other problem that appears with transportable equipment is that the levels often vary widely. When this happens and a signal comes in considerably "hotter" than it should be, it can cause distortion and noise in the entire GROUP. When this does occur, the technical control is instructed to ask the subscriber to correct his levels; but, if he fails to do this, then a limiter will be placed across his circuit at the - 2 dbm point (CKT PATCH PANEL). Limiters can cause some distortion, so prior to placing them on a circuit the controller will attempt to correct the problem by notifying the subscriber. However, in any event, one subscriber must not be allowed to degrade the service provided to others.

B. INCOMPATIBLE SIGNALLING FREQUENCIES AND LEVELS:

1. Frequencies:

One interface problem commonly encountered is a difference in signalling frequencies. The ICS uses the DCA standard of 2600 Hz, the TA-182 signalling unit uses 1600 Hz. It was for this reason that 1600 Hz SF units were installed in the ICS technical controls. However, there are still some situations in which both signalling frequencies must be used on different parts of the same circuit. In this case it is necessary to interface the two signalling frequencies at some intermediate station having both types of SF units. This conversion interface is presently accomplished by using only the ICS SF units but, after Phase 3, a pulse link repeater will be utilized (refer Fig. VI-C-3 and VI-D-9).

2. Levels:

The normal output power levels of the Collins 1600 Hz SF unit are - 22 dbm or 6 db below the level of the standard 1000 Hz test tone which is - 16 dbm at the output of the SF unit (Figure IX-B-1).

The standard TA-182 Signal Converter generates a 1600 Hz tone at 0 dbm. Since the reference tone level is 0 dbm at this point, the 1600 Hz level is 0 db with respect to the reference.

a. Problem: When the TA-182 converters were first used with the Collins 1600 Hz units, it was noted that the SF unit would not function properly. It was found that the 1600 Hz tone generated by the TA-182 was received at such a high power level at the SF unit that the SF unit would not operate the ringdown converter. This is better explained by Figure IX-B-1.

b. Solution: Two actions were taken to correct this problem:

(1) A program was initiated to modify all TA-182's in Vietnam to have an output level of - 10 dbm.

(2) The circuits using 1600 Hz signalling are engineered so as to have the three possible 1600 Hz tone power levels centered within the sensitivity range of the SF unit (Figure IV-B-2).

A comparison of the standard circuit layout and the modified one, illustrates how this was accomplished (Figure IX-B-3). Experience has shown that there are still <u>some unmodified</u> TA-182's, and it is absolutely necessary to take them into consideration when engineering the circuit. Therefore, the configuration shown in Figure IX-B-3b is now the standard for all circuits specifying <u>1600</u> Hz signalling.

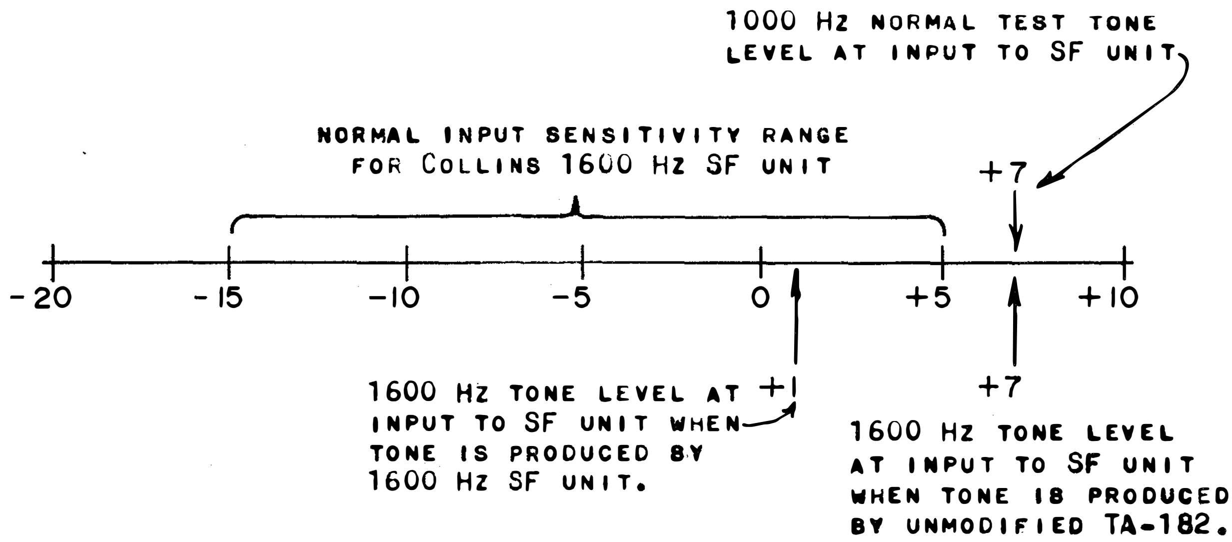


FIGURE IX-B-1 POWER LEVEL AT INPUT TO SF UNIT; STANDARD RECEIVE LEVEL OF +7 DBM

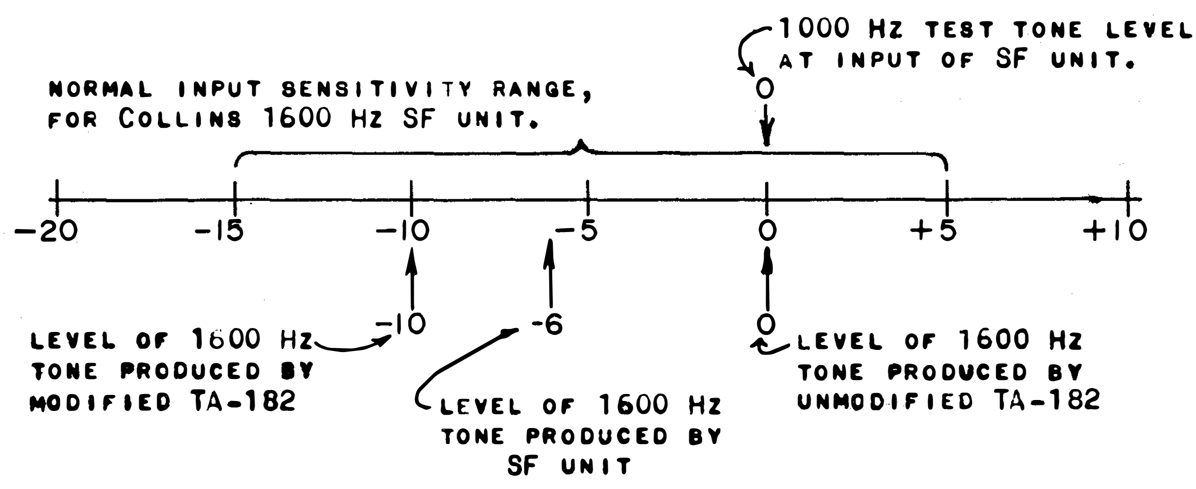
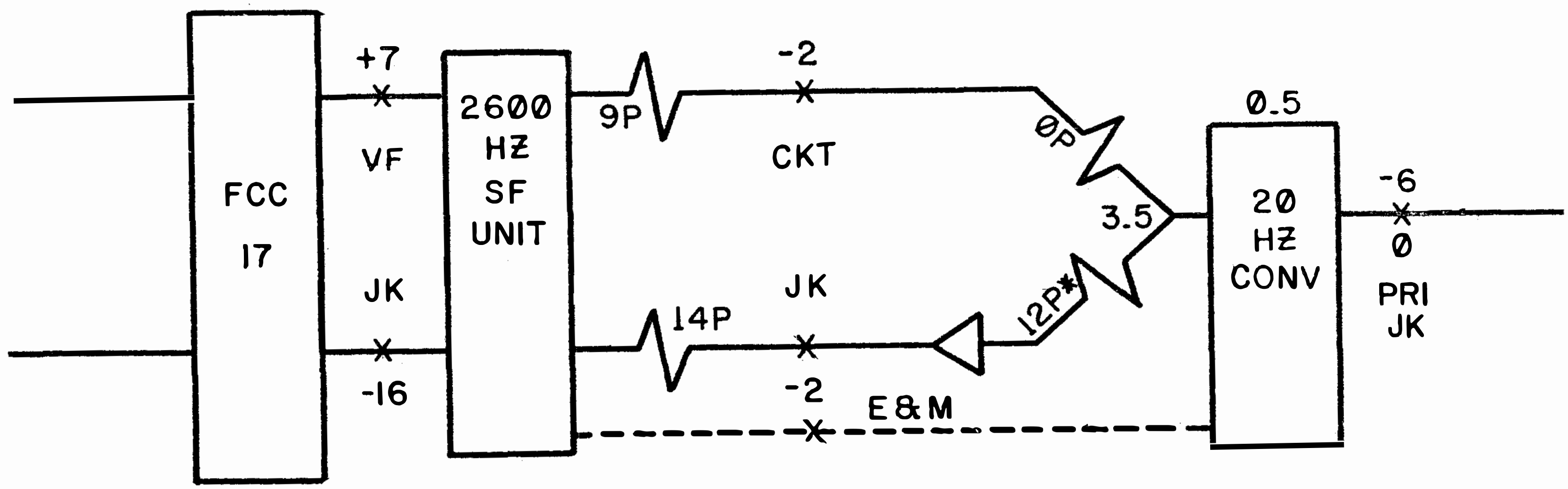
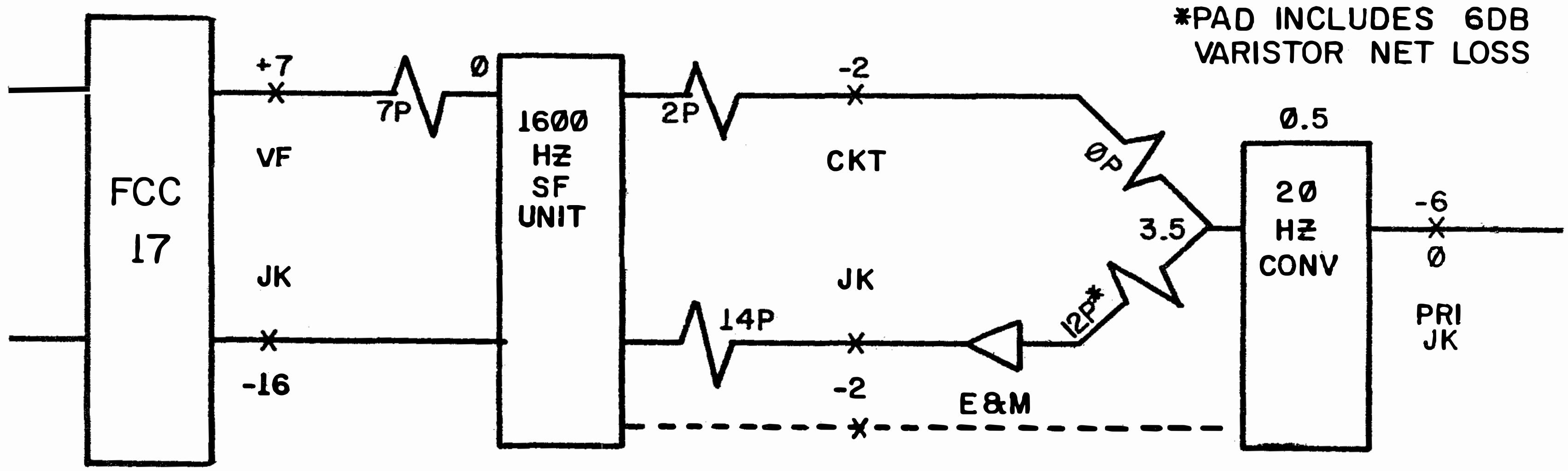


FIGURE IX-B-2 POWER LEVELS AT INPUT TO SF UNIT; MODIFIED RECEIVE LEVEL OF 0 DBM.



A. 2600 Hz Signalling Configuration With Standard Test Tone Levels



B. 1600 Hz Signalling Configuration With Standard Test Tone Levels

Figure IX-B-3 Comparison of 2600 and 1600 Hz Signalling Circuits

C. The Problem Of Too Many Grounds.

A memorandum prepared by MR. Frank Shufford is reproduced below. Mr. Shufford, a Philco-Ford tech-rep, was formerly a member of the ICS Cutover Commitee.

SCCVRG-PO 7 April 1967

MEMORANDUM FOR RECORD (Mr. Shufford)

SUBJECT: Investigation of Tiger DCO-Long Binh Dial Trunk Malfunction by F. M. Shufford and Jack Bowdoin

1. References:

a. Collins Instruction Book-subject: "ICS Signal and Ringdown Converter Equipment", dated March 1966.

b. Collins Dwg 762-9768-Schematic diagram SF Sig. unit 20D3-1MX. Also Block Diagram Fig 2. (Part of Ref a).

2. Background: On or about 20 February 1967, 6 dial-to-dial trunks were established between Tiger DCO (MACV-I) and Long Binh TTC-28 dial van. Upon establishment, an irregularity in operation was noted as follows: When calls were **placed from Long Binh to Saigon no "ringback" or "busy" tones** were heard by the calling party. These tones originate in the Tiger DCO equipment and are transmitted back to the calling telephone over the normal trunk voice path. The condition came and went at various times but appeared to follow no set pattern. The trunk functioned normally in the reverse direction.

3. Problem:

a. Investigation quickly determined that the immediate cause of the malfunction lay in the Collins 20D3-1MX 2600 Hz SF unit in the IWCS Technical Control Facility. The circuit within the SF unit which normally controls the termination across the 4W/TX voice path was not removing the termination during the "busy" or "off-hook" trunk condition. During normal operation in the "off hook" or "dialing" condition this control circuit releases the cut-off relay, removing the termination across the transmit voice path. This was not being done, but the specific cause was not immediately apparent.

b. During the course of the investigation attention was called to an undesirable situation existing between the station grounding systems of IWCS and Tiger DCO. Measurements made between the grounds showed negligible D. C. resistance and voltage but an A. C. voltage component in the order of 14-16 volts maximum. This voltage appeared at the M lead terminal on each S. F. unit associated with a Tiger dial trunk equipment. By analyzing the effect of this A. C. voltage at the M lead terminal on the S. F. unit operation, it was demonstrated that the normal operation of the cut-off relay could be directly affected through the "cut-off relay pulsing circuit". This circuit appears to be sensitive to unwanted A. C. voltages as its operation is based on the charge and discharge of capacitors. Tests indicated that the presence of 14-16 volts A. C. on the M lead would block the release of the relay. As this voltage was decreased, normal operation was restored. It was found, however, that this voltage must be reduced to approximately a maximum of 2 volts before completely reliable operation could be expected. This unwanted A. C. ground potential appeared to be the specific cause of the S.F. unit malfunction.

3. Action taken: The first experimental action taken to reduce this ground potential was to tie the ICS ground bus to the DCO ground bus with #6 wire. This reduced the M lead potential to about 8 volts which was still excessive for reliable relay operation. The #6 wire was next replaced with a #3/0 wire. This reduced the M lead potential to approximately 0.2 volts and, also, reduced greatly the transient currents visible on the scope. This action appeared to clear the trouble, and all trunks now functioned normally.

4. Source of A. C. Ground Potential: The basic source of this high A. C. ground potential was obviously a condition peculiar to the MACV I Compound. There are 3 entirely separate grounding systems within a radius of 100 feet; ICS ground, DCO ground, and power generator ground. None of these were physically tied together. The A.C. power system, located immediately adjacent to both ICS and the DCO, consists of 4-100 KW generators using a 3-phase, Y connected, 208-120 volt, distribution system. This furnishes power to both ICS and the DCO. Although no ground resistance tests have been made, with the extreme seasonal soil dryness, it may be assumed that one or more of these ground arrays may have appreciable resistance, and that any phase load unbalance could cause a current flow through the power neutral ground system. With the battery rectifiers of both ICS and the DCO operating from the same power source, appreciable ground potential could exist between the 3 ground arrays. This appears to have been the basic problem.

5. Conclusions: The sensitivity of the cut-off relay pulsing circuit in the Collins S.F. unit to A.C. voltage on the M lead may very well be a problem at other ICS sites. This could be encountered wherever dial trunks are used. This circuit characteristic of the Collins S.F. unit has apparently heretofore gone unnoticed. The tolerance of this circuit to A.C. voltage has not been experimentally established except from the MACV I tests where it appeared to be less than 2 volts for reliable operation. At locations where the 2 ground systems are adjacent and can be physically tied together, this should present no great problem; but at widely separated sites, other measures would be required. It is impossible at this point to predict the extent to which this problem may be encountered as the dial trunk program is activated. At sites where DX signalling units

will be required to extend the E&M leads beyond the 25 ohm limit no problem should arise as the DX units effectively isolate the ground system.

6. Recommendations: The following general and specific recommendations are made:

a. Where physically possible, tie all ICS, DCO, and power ground systems together.

b. Use DX signal lead extension where required.

c. Place channel terminating equipment (S.F. units, hybrids etc) in DCOs if necessary.

d. Use isolation relays in the M lead.

e. Give careful attention to the design and installation of grounding systems for both ICS and DCOs. Ground system design in RVN should take into account the peculiar condition existing during the lengthy dry reason when soil moisture may decrease to such an extent that special ground construction may be required to maintain the ground resistance within acceptable limits. A desireable by-product of increased quality of grounding systems could be a reduction in circuit noise of various kinds.

s/F. M. Shuford, Eng
t/F. M. Shuford, Eng
Networks Branch

ED. Note:

It should be noted that this problem again appeared during the activation of dial trunks terminating at Bien Hoa DCO in November 1967. In this instance SF unit malfunctions occured with an AC ground potential of 0.2 Volt. This situation was alleviated by the use of the Collins M lead applique unit discussed in Long Lines Technical Control Standards and Practices.

D. FIXED-PLANT -- TACTICAL VFCT INTERFACE:

The problem that immediately comes to mind when fixed-plant and tactical teletype terminals are mentioned is the difference in the loop currents, 60 ma and 20 ma respectively. This problem is easily solved by dc isolation relays. The point of interest here is the interface on the composite audio tone side. The use of fixed-plant equipment on one end of a tone-pack trunk and tactical equipment on the other has been necessary on several occasions due to the limited availability of fixed-plant terminals.

An examination of the appropriate references discloses that both the fixed-plant and the tactical teletype carrier systems make use of the same 32 basic tones, 2 for each channel, to transmit marks and spaces. The lowest frequency pair has a mean value of 425 Hz and subsequent pairs are separated by 170 Hz. The two tones actually transmitted are 42.5 Hz above and below the mean values (see Table IX-1).

Fixed-plant terminals are basically four wire systems, and each channel transmits and receives using the same two tones. The 16 channels in a standard system such as the AN/FCC-19 or the AN/FGC-60 are numbered sequentially from the 425 Hz channel to the 2975 Hz channel.

The tactical terminals, AN/TCC-4, -20, were designed to be capable of either four-wire or two-wire operation. In two-wire operation, it would be impractical to use the same frequencies for both transmitting and receiving; therefore, each channel MODEM of the AN/TCC-4, -20, uses one set of tones for transmitting and one set for receiving. The exact ones used by each channel are selected by the setting of several switches.

The incompatibility is: a teletype machine connected to channel 5 of the fixed-plant terminal might be transmitting to channel 7 of the AN/TCC -4 but receiving from channel 11. Needless to say, CHAOS could easily occur. In fact, many of the more pessimistic said it would never work. The solution decribed below has permitted highly efficient operation with no problems attributable to the frequency interface.

SOLUTION:

The channel MODEMS of the AN/TCC-4 are integral units, and it is not possible to physically separate the TRANSMIT and RECEIVE positions of the channel. However, the TRANSMIT and RECEIVE circuitry in the AN/FCC -19 and AN/FGC-60 are completely separate; and further, each individual TRANSMIT tone keyer and RECEIVER tone converter is a plug-in module that may be inserted in any channel position in the transmit and receive sections respectively. By rearranging the fixed-plant modules, it is possible to establish a tone-pack that operates in all respects as if the two terminals were identical. Table IX-2 shows the rearrangement of modules necessary if the AN/TCC-4 is set up as prescribed on the table. For less than 16 channels, only a portion of the table is used.

Mean Value, Hz	Actual Tones Transmitted, Hz	Mean Value, Hz	Actual Tones Transmitted, Hz
425	382.5	1785	1742.5
	467.5		1827.5
595	552.5	1955	1912.5
	637.5		1997.5
765	722.5	2125	2082.5
	807.5		2167.5
935	892.5	2295	2252.5
	977.5		2337.5
1105	1062.5	2465	2422.5
	1147.5		2507.5
1275	1232.5	2635	2592.5
	1317.5		2677.5
1445	1402.5	2805	2762.5
	1487.5		2847.5
1615	1572.5	2975	2932.5
	1657.5		3017.5

TABLE IX-1 VOICE FREQUENCY CARRIER TELETYPE TONES

Tactical terminal AN/TCC-4			Fixed-Plant Terminal		Tactical Terminal AN/TCC-4			Fixed-Plant Terminal	
Chnl Nr.	Mean Transmit Tone, Hz	Mean Receive Tone, Hz	Conv Chnl Nr.	Keyer Chnl Nr.	Chnl Nr.	Mean Transmit Tone, Hz	Mean Receive Tone, Hz	Conv Chnl Nr.	Keyer Chnl Nr.
1	2975	595	16	2	9	425	2805	1	15
2	2635	935	14	4	10	765	2465	3	13
3	2295	1275	12	6	11	1105	2125	5	11
4	1955	1615	10	8	12	1445	1785	7	9
5	2805	425	15	1	13	594	2975	2	16
6	2465	765	13	3	14	935	2635	4	14
7	2125	1105	11	5	15	1275	2295	6	12
8	1785	1445	9	7	16	1615	1955	8	10

Note: The AN/TCC-4 is arranged as in Fig 15 of TM 11-5805-250-10. The four stacks are lettered A, B, C, D, left to right. The channels are numbered left to right, top to bottom, in each stack. Switch Settings are given in the table below.

Panel	Switch Designation	Stack A	Stack B	Stack C	Stack D
TH-14	Line Send Freq	HI	None Used	LO	None Used
AM-683	Send Frequency	LO	HI	LO	HI
	Channels	16	16	16	16
	Line	4W	4W	4W	4W
TH-17	Send Frequency	LO	HI	LO	HI
TH-16	Send Frequency	LO	HI	LO	HI

TABLE IX -2

SOLUTION FOR FIXED-PLANT AND TACTICAL
VOICE FREQUENCY CARRIER TELETYPE INTERFACE

E. IDLE LINE TERMINATION:

1. Problem:

Proper termination of idle lines has not previously been a matter of concern to the "tactical communicator" for two reasons:

a. It is not too critical on systems limited to 12 channels.

b. Tactical equipment provides no capability for doing so.

In Vietnam, the switching or interconnecting of telephone common user trunk circuits (normally 4-wire) to subscribers and/or to other trunks is accomplished via 2-wire switchboards (with the exception of Saigon Overseas Board). This 2-wire switching introduces a transmission loss of several db at each switching location due to the 2w/4w terminating set (hybrid), drop cable, and switchboard losses. To maintain a relatively stable circuit and prevent the introduction of spurious oscillation (singing) and unwanted and excessive noise in the 4-wire section, it is necessary to maintain a high degree of electrical isolation or loss between the transmit and receive paths at the point where they come together, the hybrid coil in the 2w/4w terminating set. Due to the construction of the hybrid coil the degree of 4-wire path separation is also directly a measure of the degree of balance or impedance matching between the 2-wire line (subscriber) and the 2-wire balancing network of the hybrid coil. Since the network is fixed at a standard impedance of 600 ohms the variable factor is the impedance of the 2-wire line and around this the entire circuit balance problem revolves.

The essence of the problem lies in the fact that the various tactical switchboards generally in use now in Vietnam were not basically designed to maintain a high degree of balance or impedance matching with a fixed plant system such as ICS.

The problem has two basic parts:

a. To provide, in the circuit drop, an optimum impedance whose function will be mainly to match the 600 ohm fixed impedance of the 2-wire balancing network in the hybrid coil, thus assuring a maximum hybrid balance and separation of the send and receive paths of the 4-w section (Figure IX-E-1)

b. To provide at the same time an optimum condition with no subscriber connected (Figure IX-E-2).

2. Equipment Used:

The basic equipment most generally used in Vietnam are the SB-86/P switchboard, the TA-223/TTC and TA-226/TTC trunk relays which in various configurations, are used in the MTC-1, MTC-9 and TTC-7 manual switchboards.

The design of the SB-86/P (TA-207 Jackfield) and the TA-223 trunk relay equipment is such that when the circuit is "idle" with no connection established, the switchboard presents an open circuit toward the carrier hybrid causing a maximum unbalance condition. The TA-226/TTC Circuit presents a repeating coil termination of 600 ohm impedance to the carrier channel and will not be discussed further (Figure IX-E-3)

3. Solution:

To alleviate the above condition, it is standard industry practice to provide a termination at the switchboard which will, during the idle circuit condition, approximate the 600 ohm hybrid net thus maintaining maximum return loss and 4-w section stability. This termination should drop out automatically when a connection is made at the switchboard. These terminations are not standard equipment on tactical switchboards.

4. Action Taken:

This problem, for SEA at least, was recognized as far back as September 1965, when ECOM was tasked by the Army to develop field modification kits for placing Idle Line Termination on all tactical switchboards in SEA. This resulted in the development and provision of 2 types of ILT kits, one for the TA-223 relay circuit and the other for the SB-86 switchboard. A large number of kits were built and received in Vietnam during April 1966.

The design of these kits is shown in Figure IX-E-4 Note that in the SB-86 the termination remains bridged across the line even when in use; therefore, a compromise terminating impedance had to be used.

5. Comments:

On DCA Circuit Layout Records the notation is found "Switchboard provides idle line termination". When the technical control discovers that other channels on a system are being distorted because of high noise levels or "singing" on a common user trunk, it might be advisable to check that the idle line termination has been installed properly.

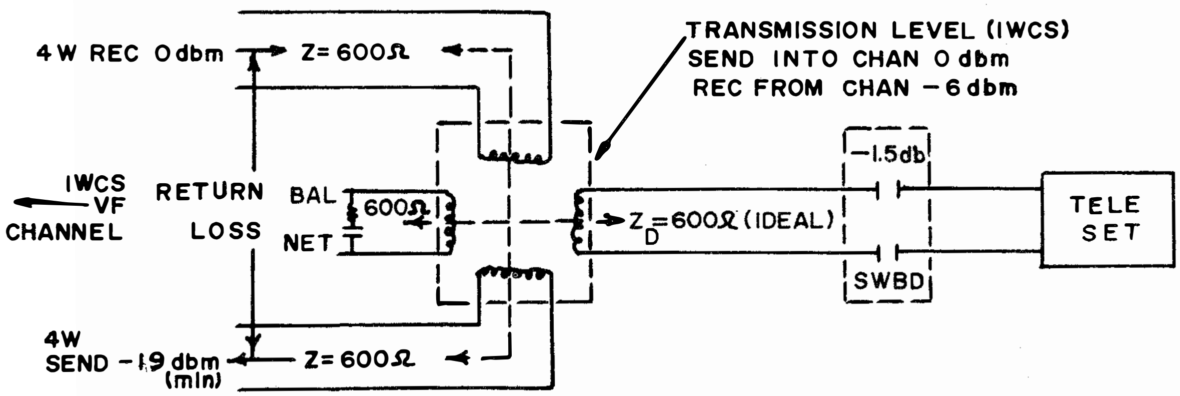
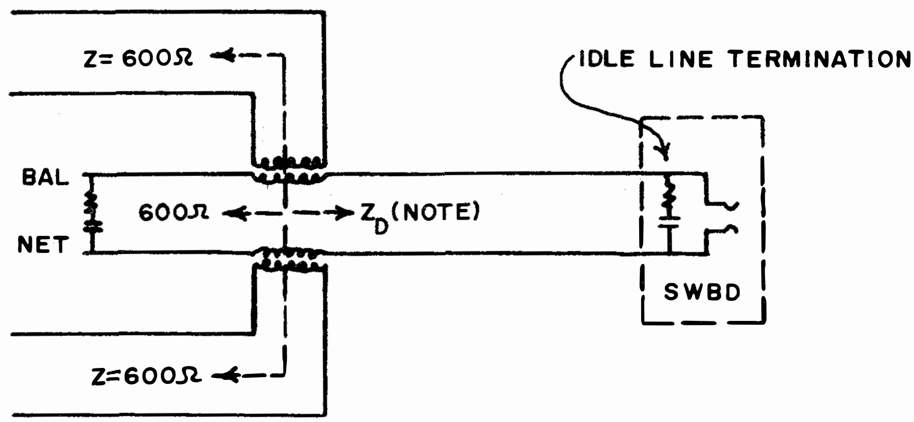


FIGURE IX-E-1 CIRCUIT CONDITION: WITH TERMINAL CALL ESTABLISHED



NOTE: IN THE IDLE CONDITION, IMPEDANCE AT THIS POINT IS 600Ω. IN PRACTICE, Z_D IS SELDOM 600Ω, BUT IS DETERMINED BY CHARACTERISTIC Z OF TRUNK CABLE AND THE TERMINATION. THIS SHOULD APPROXIMATE 600Ω FOR OPTIMUM DROP BALANCE. THE BALANCING NETWORK IS SLIGHTLY ADJUSTABLE.

FIGURE IX-E-2 CIRCUIT CONDITION: IDLE(NO CORD UP AT SWBD)

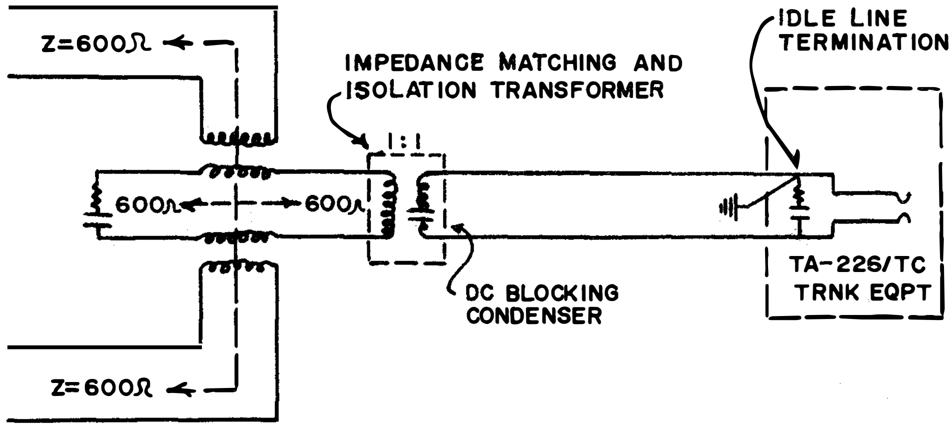
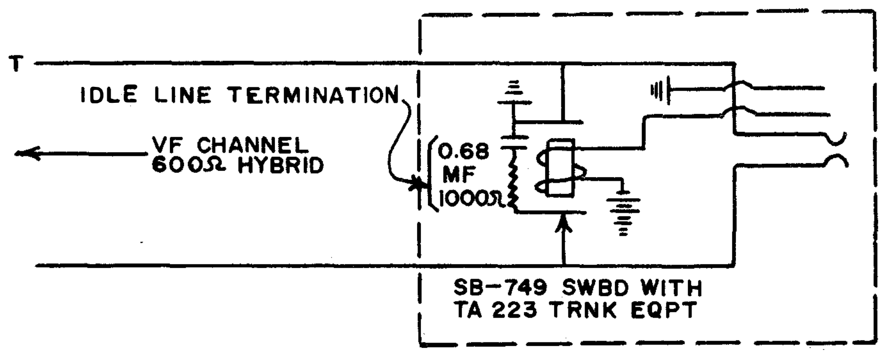
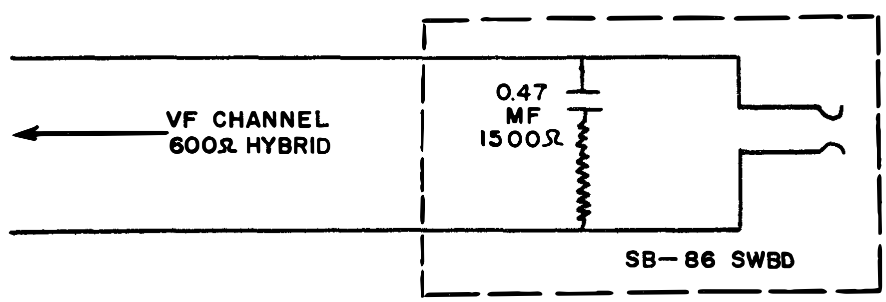


FIGURE IX-E-3 TRUNK EQUIPPED WITH TA226/TTC RELAY EQUIPMENT. CIRCUIT CONDITION: IDLE



A. TA 223 TRUNK RELAY EQUIPMENT. (TERMINATION WILL DROP OUT WHEN OPERATOR INSERTS PLUG)



B. SB-86 SWITCHBOARD. (TERMINATION WILL NOT DROP OUT WHEN OPERATOR INSERTS PLUG.)

FIGURE IX-E-4 IDLE LINE TERMINATION KIT DETAILS

F. ICS INTERFACE TO AN/TCC-13:

The AN/TCC-13 multiplex set, used with the AN/TRC-29 microwave terminal, has a built-in 20 Hz signalling capability which does not make use of a VF signalling tone. If an ICS circuit is to be extended over the AN/TCC-13 and the AN/TCC-13 is to provide the 20 Hz at the distant end, then the signalling interface between the ICS and the AN/TCC-13 must be at 20 Hz. Also, good engineering dictates that the interface be a 4-wire connection. This requires the use of 2 ringdown converters as shown in Figure IX-F-1.

When this was done with several circuits at Nha Trang, it was discovered that the signalling would not function properly on several of the circuits.

1. Problem:

When the AN/TCC-13 generated a 20 Hz signal, the transmit RD Converter reacted in an unusual manner. This was observed by listening to the SF unit tone on the line. The 2600 Hz tone was interrupted 20 times a second and these short bursts of tone were not long enough to actuate the SF unit at the distant end.

2. Cause:

It has not yet been possible to determine the exact cause of this behavior.

3. Quick-Fix (Not the solution):

An immediate solution was found to be reversing the 4W RCV leads from the AN/TCC-13. Both arrangements resulted in the tone being interrupted 20 times a second, but one arrangement produced a longer burst at the end of the signal and this long burst was enough to operate the SF unit at the distant end.

4. Comment:

Typical of many "little" interface problems.

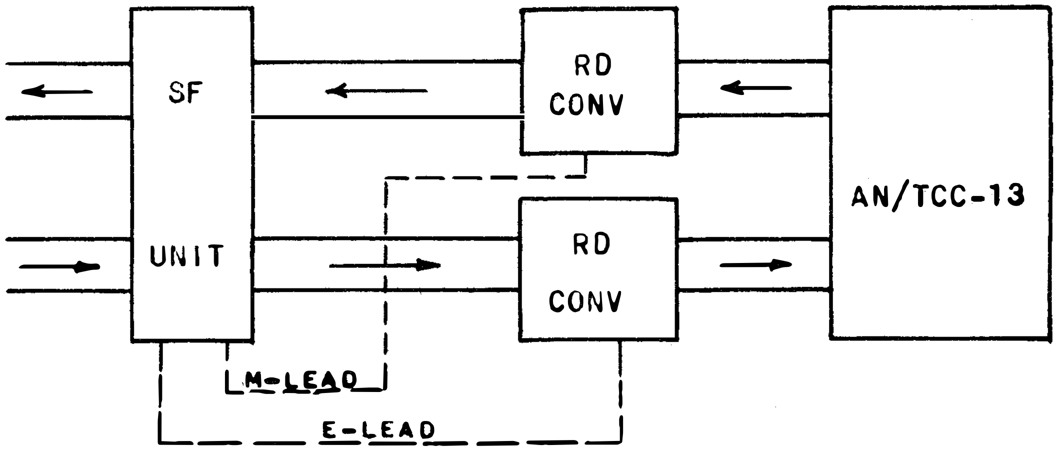


FIGURE IX-F1 ICS -AN/TCC-13 SIGNALLING INTERFACE

G. A TYPICAL SIGNALLING INTERFACE PROBLEM:

A memorandum prepared by Mr. C.W. Holley is reproduced below. Mr. Holley, of Page C&I, was assigned to work with Networks Branch as a member of the ICS Cutover Commitee.

SCCVRG-PO-NW 24 February 1968

MEMORANDUM FOR RECORD (Mr. Holley)

SUBJECT: Signalling toward a WECO 302A key telephone system.

1. Background:

At Phu Cat the Air Force radar approach control station is equipped with a WECO 302A KTS (key telephone system). This particular 302A installation would not accept 20Hz ringing from the Phu Cat ICS EE building. Signalling the other direction gave no difficulty since the 302A sends 20HZ toward the ICS ringdown converter. Investigation by Mr Dermako, Phu Cat M&O supervisor, and T/Sgt Hoffsmith at the radar approach control revealed the fact that the 302A requires a dry loop closure from the ring down converter to signal incoming.

2. Solution to Problem:

The modification to the Collins 20E1-MX AC ringdown converter to provide the dry loop is very simple, but is most conveniently done to certain converters depending on their location in the bay.

Figure IX-G-1 illustrates the routing of the 20HZ supply bus on the back of the ring down converter bay.

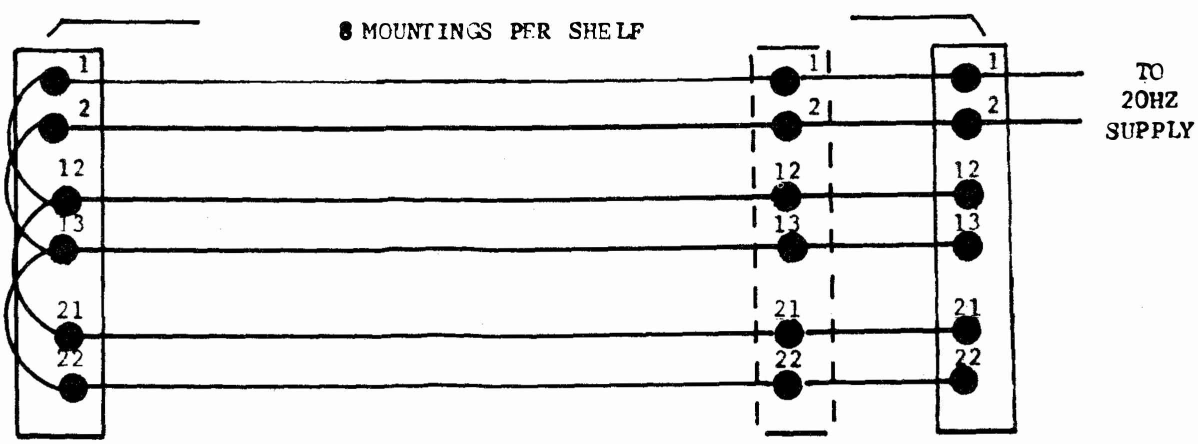


Figure IX - G - I 20 HZ Bus On Back Of Ring Down Converter Mountings.

The modification consists of replacing the 20HZ with a 600 ohm resistor. Lift the 20HZ bus from punchings 12-13 or 21-22 and solder a 600 ohm resistor across the punchings (12-13 or 21-22).

Look again at Figure IX-9 and it is obvious that the neatest job can be done on the bottom two converters on the far right. These will be converters 2 and 3, 26 and 27, 50 and 51 etc. Add 24 to get the number of the next two. There are 24 converters per shelf.

It is possible that the next 302A installation that crops up will be equipped to both send and receive 20HZ signals. WECO provides ring down trunk circuits for other types of KTS's (they call them key telephone unit, KTU) and future 302A's may be so equipped. Each installation will have to be thoroughly examined before modifying the ICS converter. If at all possible, avoid the modification; of course, modification may be necessary in order to provide service.

X. DC CIRCUITS AND PATCH PANELS

DC circuits (teletype) always seem to cause much more trouble than voice circuits do. Conceptually, dc circuits are no more difficult to understand, but they are certainly "merciless" compared to audio circuits. Many mistakes can be made in either the engineering or the installation of an audio circuit, and yet it will still operate, although the performance will be degraded. For dc circuits, almost <u>any</u> error is enough to cause <u>complete</u> failure.

The purpose of this chapter is to give only a <u>brief</u> introduction to the subject. Some of the common types of circuits will be described, common terms will be defined, and a few interface situations will be illustrated. A detailed discussion of the activation and restoration of dc circuits can be found in RCG LL TCG S&P.

A. ICS VOICE FREQUENCY CARRIER TELETYPE (VFCT) TERMINALS:

The fixed-plant ICS teletype carrier terminals provide both SEND and RECEIVE battery <u>internally</u>. This means that a subscriber's teletype equipment may be connected directly to the channel terminals (Figure X-1). The exact value of the "loop current" is adjusted on the loop current power supply bay or the terminal itself. Some of the terminals have the capability to operate with either 60 ma or 20 ma loop current by merely changing one switch. However, to completely remove the internal line battery from the circuit usually requires <u>internal wiring changes</u>(this is the case for the ICS AN/FCC-25 and AN/FCC-19 telegraph terminals).

There are often several built-in options available for loop current; however, efficient technical control operation dictates that there be one standard option used for all systems appearing on the dc patch panels. If this is not done, the patching capability is greatly reduced and testing of circuits becomes quite slow since each type requires different test configurations.

The standard for ICS VFCT terminals is:

1. DC 60 ma neutral negative signal (positive battery is ground).

2. Battery provided internally on both SEND <u>and</u> RECEIVE loops.

B. TYPES OF CIRCUITS:

1. Full-duplex:

A full-duplex circuit provides simultaneous two-way service between the two subscribers (Figure X-2)

2. Half-duplex:

The half-duplex circuit provides transmission in only one direction at a time. It is common practice to connect the SEND and REC equipment in series to provide "reversible" service (Figure X-3).

3. Multipoint:

The multipoint circuit is extremely popular in Vietnam. A four-subscriber system is shown in Figure X-4. Note that the SEND and REC equipment at each subscriber station has been connected in series to operate half-duplex. Would it be possible to have a full-duplex multipoint? Obviously not since there are not separate transmit and receive paths. Another point to note in Figure X-4 is the fact that there is only one closed path for the dc signal through all the equipment. The presence of more than one closed path, unless they are properly "isolated" (i.e., electrically separated), usually results in an inoperative circuit.

C. ICS DC PATCH PANELS:

The complete circuitry for the ICS DC Patch is quite complicated and a complete explanation would be of little value here. However, the important features of the dc jacks and cut keys should be understood. There are two types of jacks - "looping or monitor jacks" and "set jacks".

1. Monitor or Looping Jacks:

In order to monitor a teletype circuit the dc signal must pass through the monitor equipment. Note in Figures X-5 and 6 that the MON jacks are placed in series in the line. Also, note that the patch cord should be connected to the monitor equipment before the plug is inserted into the MON jacks or an open line condition will result. There are usually two MON jacks so that the circuit on either side of the set jacks can be checked separately.

2. Set Jacks:

Set Jacks are provided to disconnect the LINE and EQUIP sides of the circuit while still providing closed loops and proper battery conditions on each side(Figures X-5 and 6). When the LINE jack is used, the patch cord is connected to the VFCT terminal and "marking" or "hold" battery is supplied to the subscriber. When the EQUIPMENT jack is used the patch cord is connected to the subscriber's equipment, and the VFCT terminal has a complete loop through the closed jack contacts to ground.

Note in Figure X-5, showing the RECEIVE jacks, that the "rings" on both loop jacks are grounded. The same is true for the SEND jacks (Figure X-6). Since the battery is on the R (ring) lead of the SEND terminal, this lead can not be grounded. The normal full-duplex connection is shown in Figure X-6. Note that the R lead of the SEND circuit bypasses the ICS dc jacks. A close and detailed analysis will show that this is necessary for proper operation of the patch board.

3. Cut keys:

Operating the CUT KEYS on the DC Patch Panel causes the equipment and terminal loops to be separated, and each loop is closed individually with the proper battery condition. The effect obtained is the same as if shorted plugs were inserted in both the LINE and EQUIP jacks. There are separate CUT KEYS on the SEND and RECEIVE sides of the circuit. A light on the jack field indicates a CUT KEY has been turned.

D. ICS THROUGH - STATION CONNECTION:

The through-station connection is quite simple (Figure X-7). It is used to extend an incoming VFCT channel out over another system. Because of the arrangement of the battery supplies in the ICS VFCT terminals, it is not possible to make the connection directly as shown in Figure X-7. In fact the only connections made are shown in Figure X-8.

E. ISOLATION RELAYS:

The isolation relay was described earlier in Section VI-C-8. In the discussion below on some of the uses of isolation relays, only the basic input and output windings will be considered (Figure X-9). It is assumed that the bias winding has been adjusted for proper operation.

1. Fixed-plant and Tactical VFCT DC Interface:

A very common use of isolation relays here in Vietnam is interfacing 60 ma fixed-plant terminal with the 20 ma tactical equipment, AN/TCC-4,-20. The tactical equipment has only one loop current value possible, 20 ma, and battery is provided internally just as with the fixed plant equipment. Since both ICS fixed-plant terminals and 20 ma tactical equipment supply battery it is necessary to isolate these two current supplies. The resulting interface is obtained by creating separate loops for the 20 ma and 60 ma currents (Figure X-10).

2. Subscriber Provides Battery:

Often the subscriber wishes to provide his own loop battery. This is often done in large comcenters to facilitate in-station testing and trouble-shooting. This creates a problem similiar to that discussed in paragraph 1 above, since there should be only one battery in each loop. The obvious answer is to create two loops as on the RECEIVE side in Figure X-11. However, because of the arrangement of the battery supply and the ground in the SEND side of the terminal equipment, an isolation relay is not necessary if one side of the SEND circuit is connected to the ground of the VFCT terminal.

3. Half-duplex Circuit:

When the subscriber's send and receive equipment is placed in series as in Figure X-3, a problem arises since the SEND and RECEIVE portions of the terminal can not be placed in the same loop. Again the solution is an isolation relay inserted as shown in Figure X-12. The subscriber's loop current is provided by the SEND side of the VFCT terminal. The isolation relay is installed so as to permit:

a. The RECEIVE tone converter to control the current in the subscriber loop.

b. The subscriber's transmitting equipment to control the current in the loop to the SEND tone keyer.

Note that the VFCT channel still operates in the full-duplex mode.

4. The Problem of Low Subscriber Current:

Occasionally here in Vietnam the situation depicted in Figure X-13 is encountered. The shunt losses in wet cable and bad splices are so great that the subscriber does not receive enough loop current for his machines to operate properly. The obvious answer is to put in more current at the terminal; however, there is a limit as to how much current can go through the VFCT equipment without causing damage. Again, isolation relays provide the answer (Figure X-14). Additional battery supplies which can provide the higher current required are available in the loop power supply bays.

F. ICS MULTIPOINT CIRCUITS:

Multipoint teletype circuits are very common in Vietnam, and because of the many links involved and the number of isolation relays used to connect these links, they are the cause of a great deal of trouble. Two types of multipoint circuits possible in the ICS are discussed below.

1. Hub Multipoint:

The hub arrangement shown in Figure X-15 is the desired configuration for multipoints in the ICS The equipment connections at the hub station are shown in Figure X-16. Figure X-16 is for a four-spoke hub system with a subscriber at the hub. It can easily be expanded to more spokes by adding two isolation relays for each new VFCT channel. Note however, there may be only one center or "hub" station.

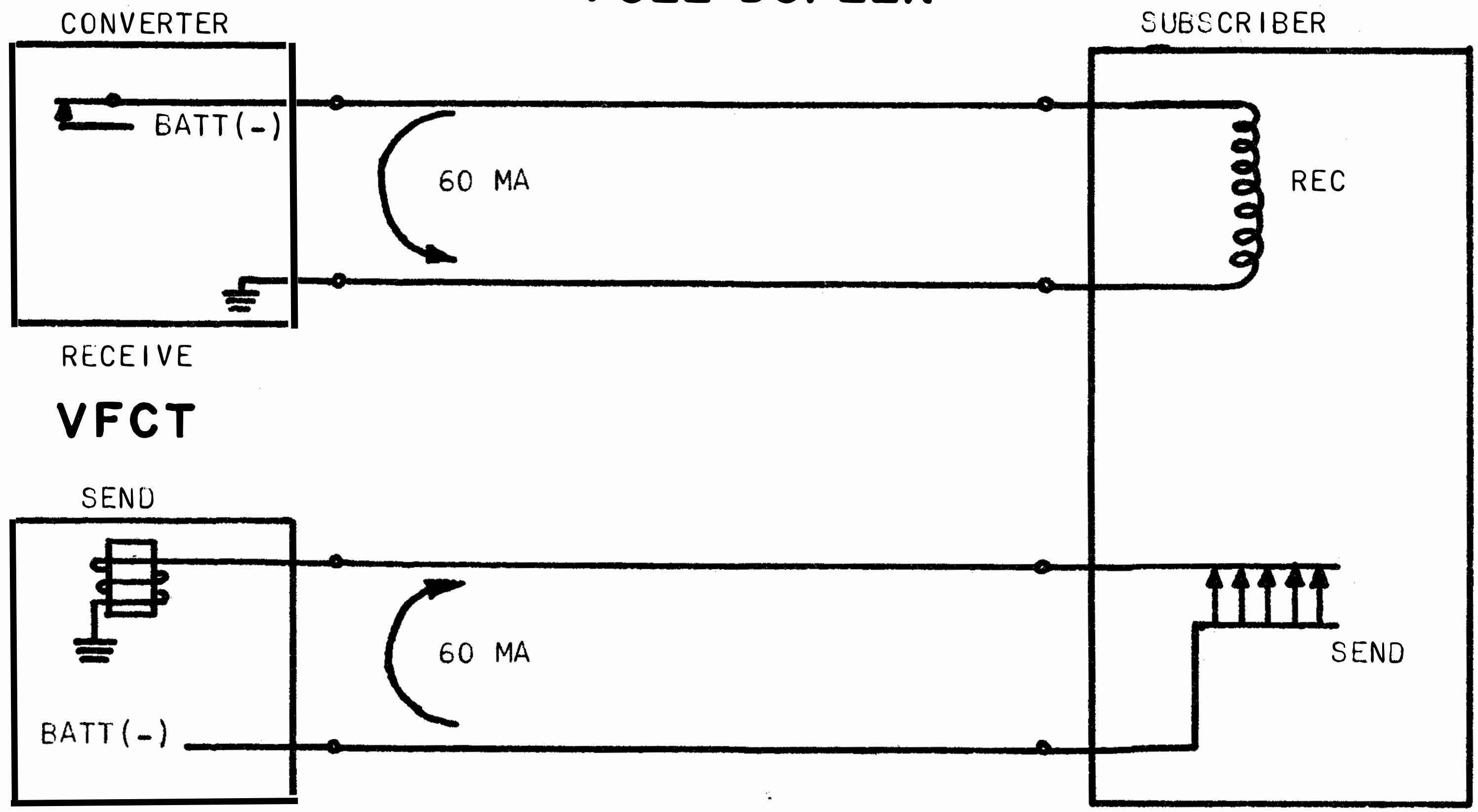
2. Half-duplex Multipoint:

The network configuration for the half-duplex multipoint is shown in Figure X-17. This configuration allows more than one "multipoint" station; however, it is not recommended for the ICS since it requires a large amount of equipment and is more difficult to adjust properly. The equipment connections for a multipointing station are shown in Figure X-18. This configuration is also expanded by adding two isolation relays for each additional VFCT terminal, and it may have as many "multipoint" stations as desired.

G. MULTIPLE DROPS:

Often it is desired to have more than one dc subscriber on a circuit at a terminal. This is only possible with half-duplex circuits. If the sum of the loop resistance to all subscribers is not too great, this service can be provided by connecting additional stations in the half-duplex loop (Figure X-19). If the total loop resistance of all loops is too high, then separate loops must be established using isolation relays (Figure X-20).

FULL-DUPLEX



ICS BATTERY
SEND & RECEIVE

FIGURE X-1 ICS VFCT CHANNEL CONNECTED
(FULL-DUPLEX)

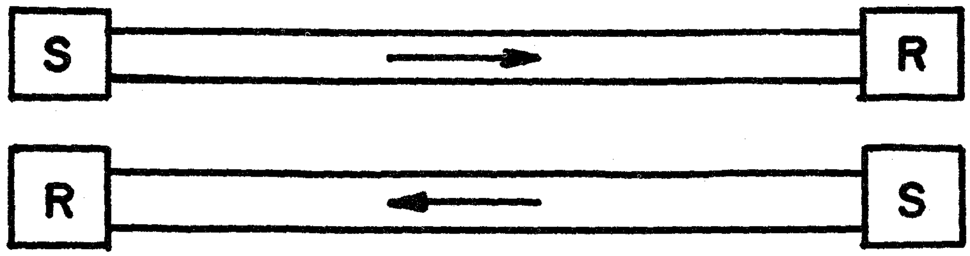


FIGURE X-2 FULL-DUPLEX CIRCUIT

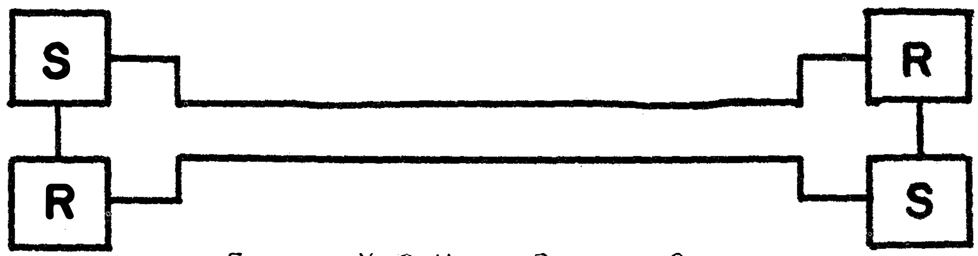


FIGURE X-3 HALF-DUPLEX CIRCUIT

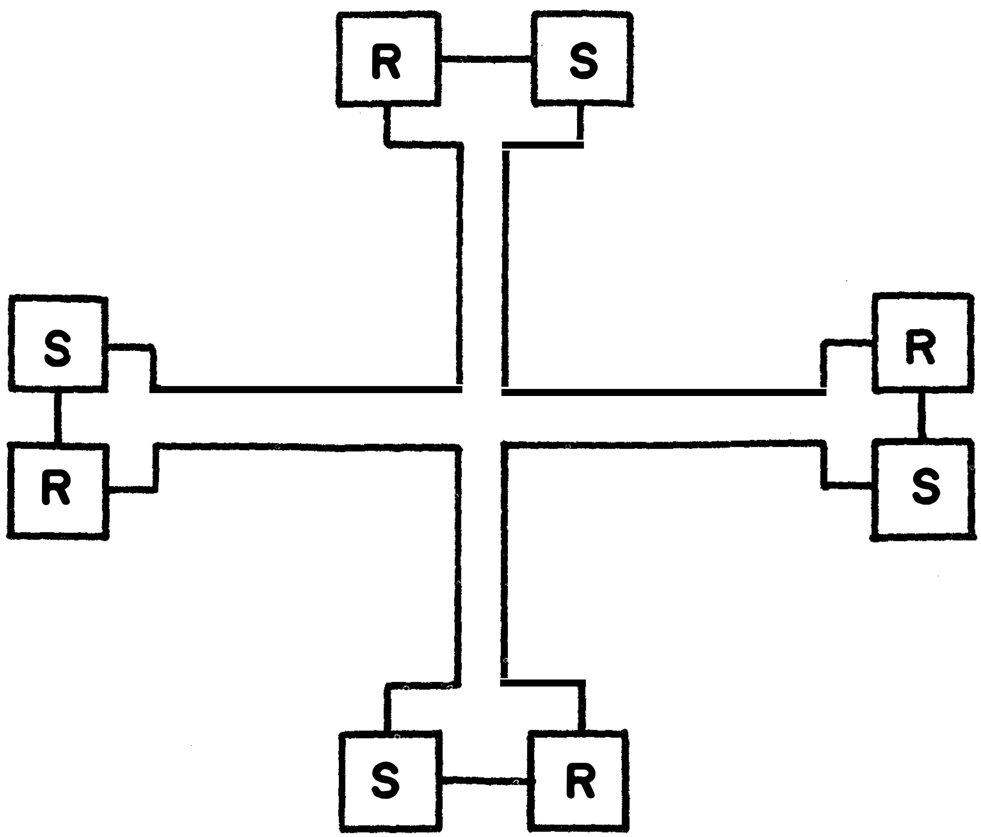


FIGURE X-4 MULTIPOINT CIRCUIT

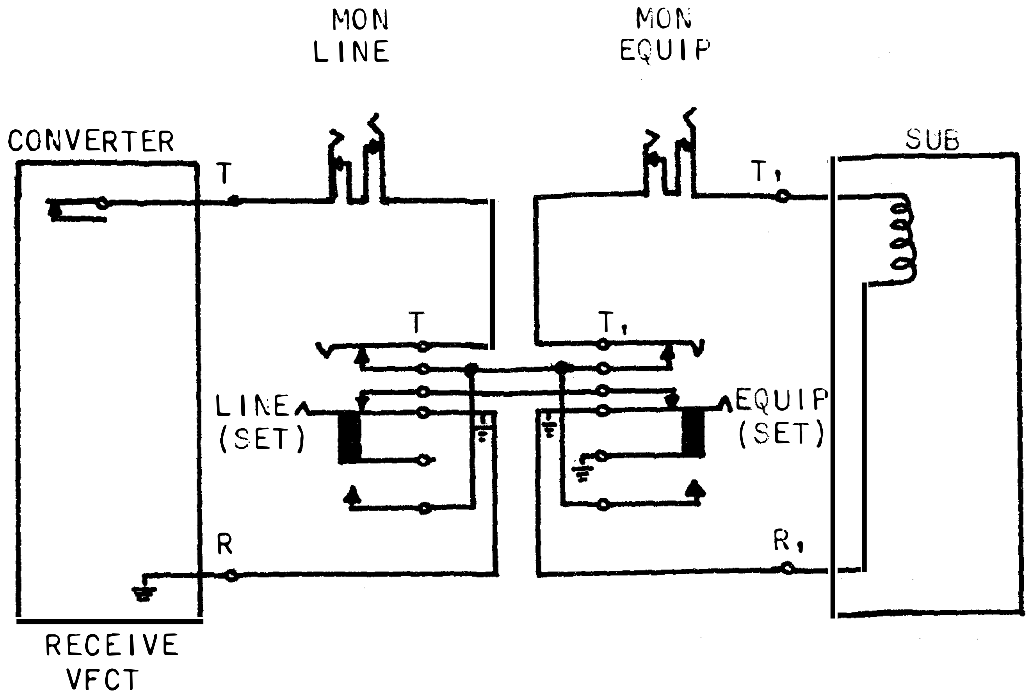


FIGURE X-5 SIMPLIFIED ICS DC RECEIVE JACKS,
(FULL-DUPLEX CONNECTION)

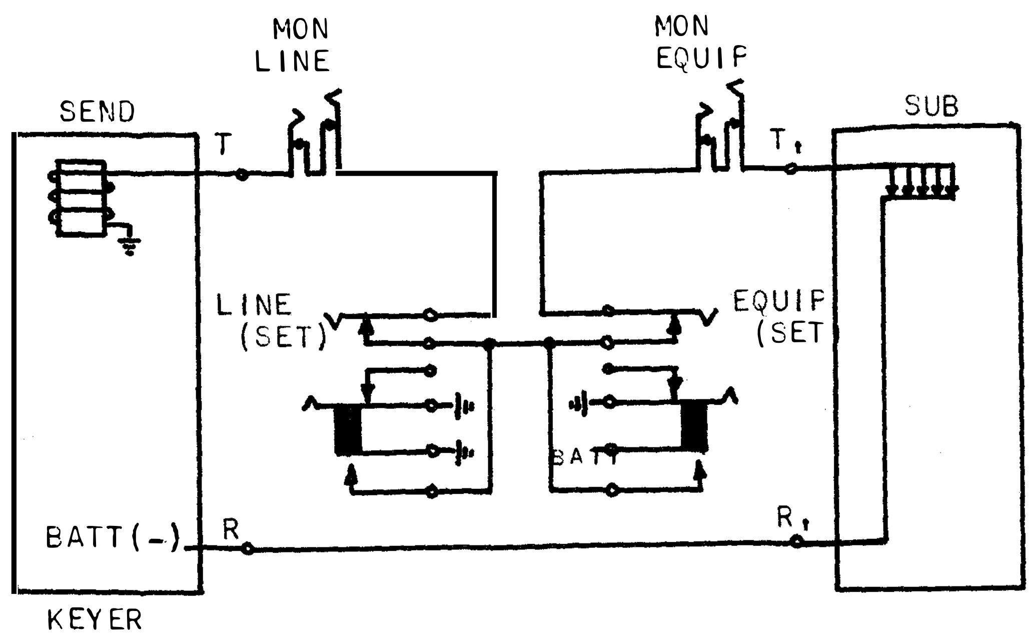


FIGURE X-6 SIMPLIFIED ICS DC SEND JACKS,
(FULL-DUPLEX CONNECTION)

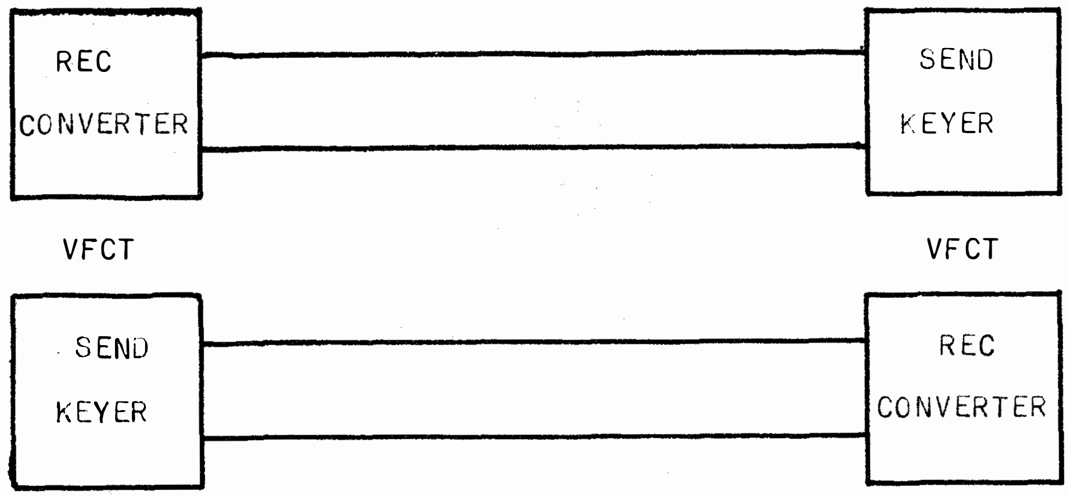


FIGURE X-7 THROUGH-STATION CONNECTION

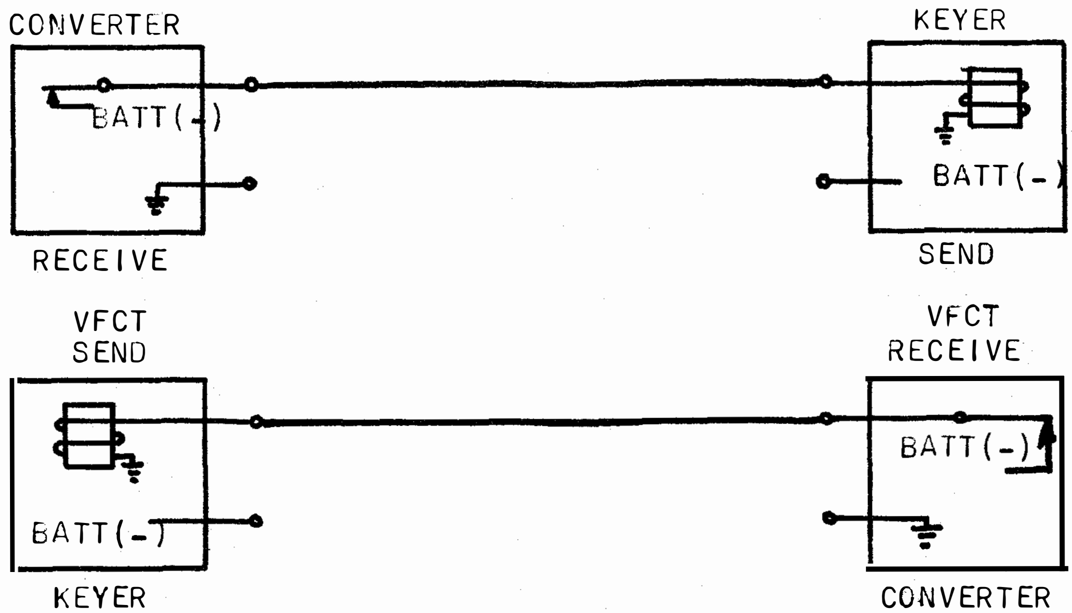


FIGURE X-8 ICS THROUGH-STATION CONNECTION

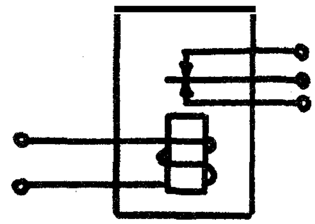


Figure X-9 Basic Isolation Relay

TACTICAL INTERFACE

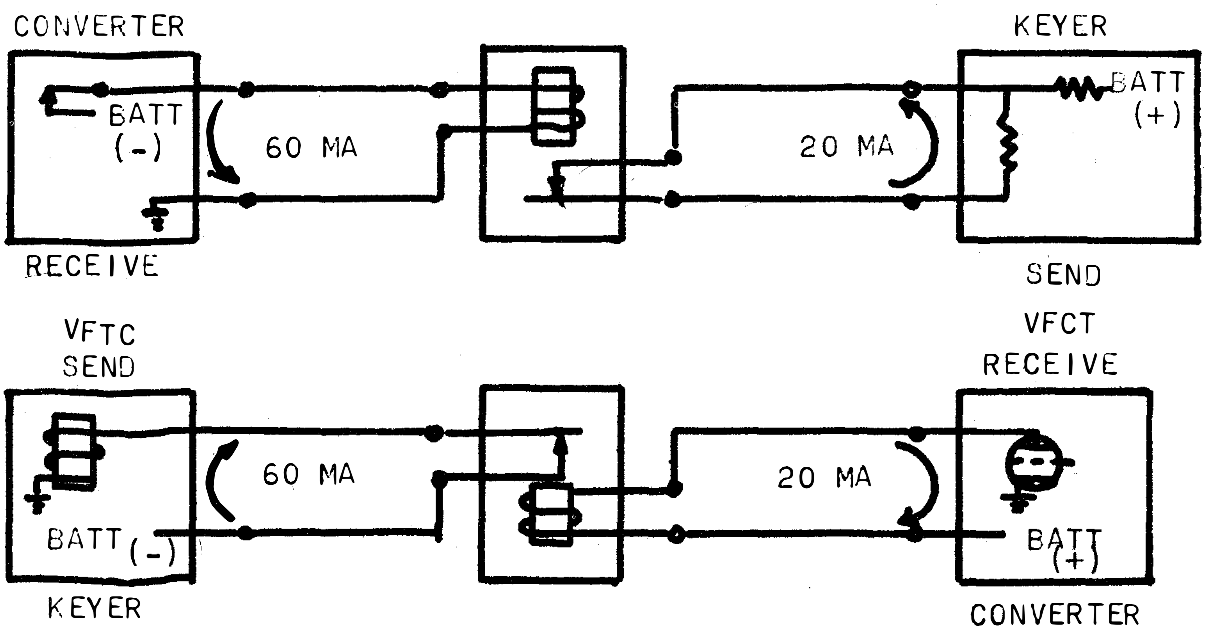


Figure X-10 Fixed-Plant And Tactical VFCT Interface

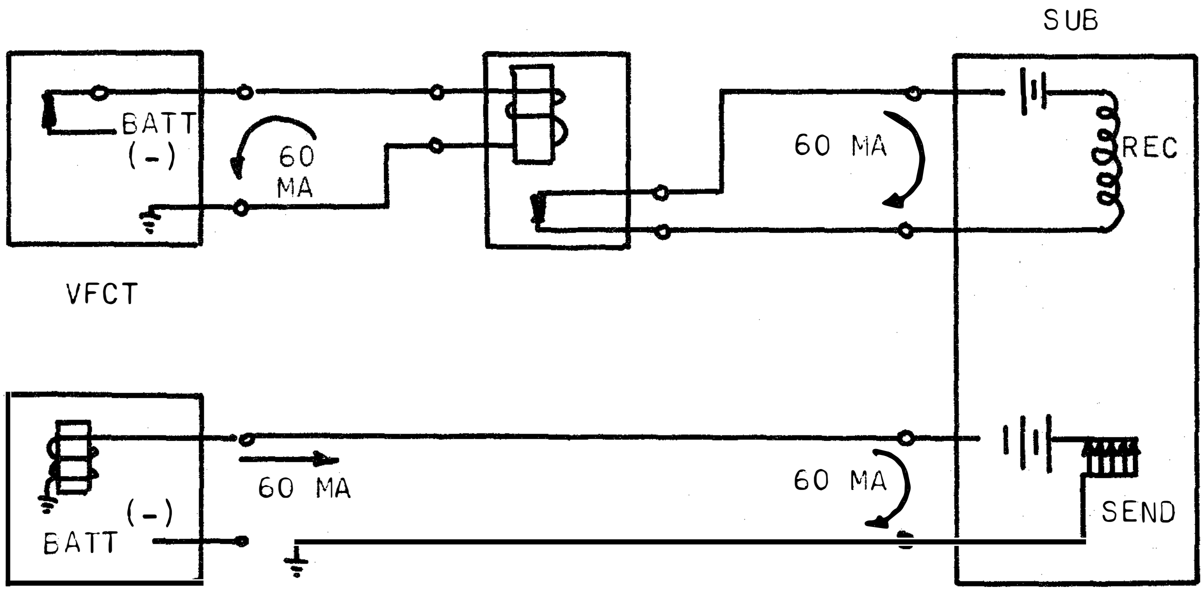


FIGURE X-11 SUBSCRIBER PROVIDING BATTERY

(FULL DUPLEX)

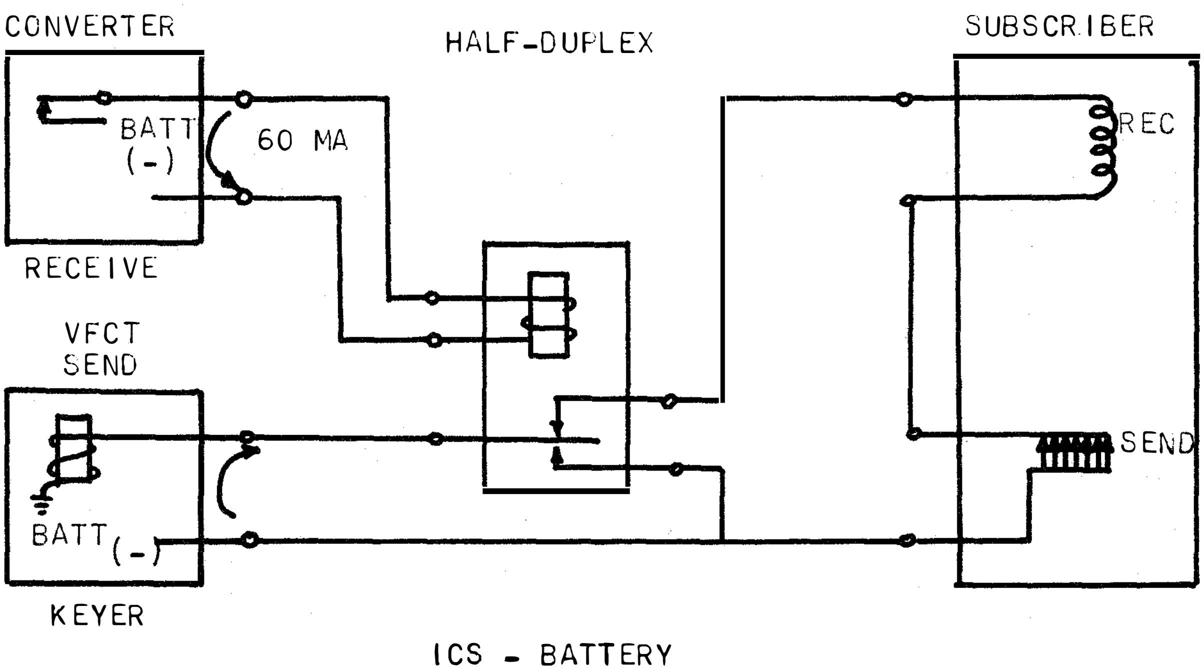


FIGURE X-12 HALF-DUPLEX CONNECTION TO ICS VFCT TERMINAL

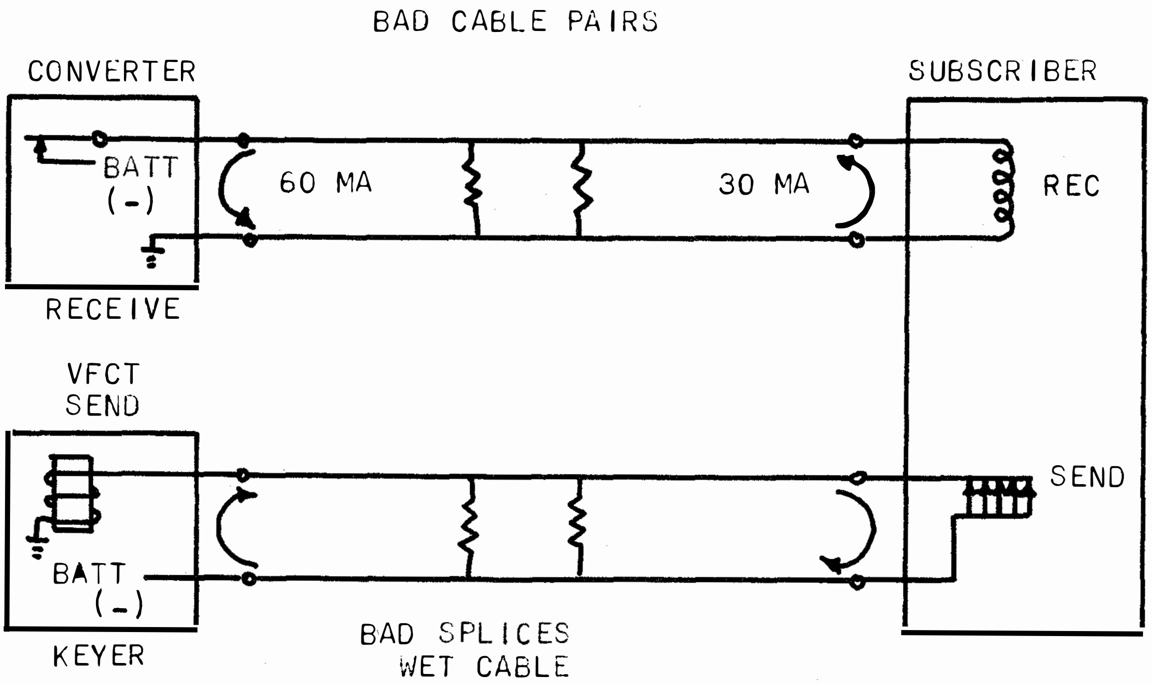


FIGURE X-13 LOW SUBSCRIBER CURRENT

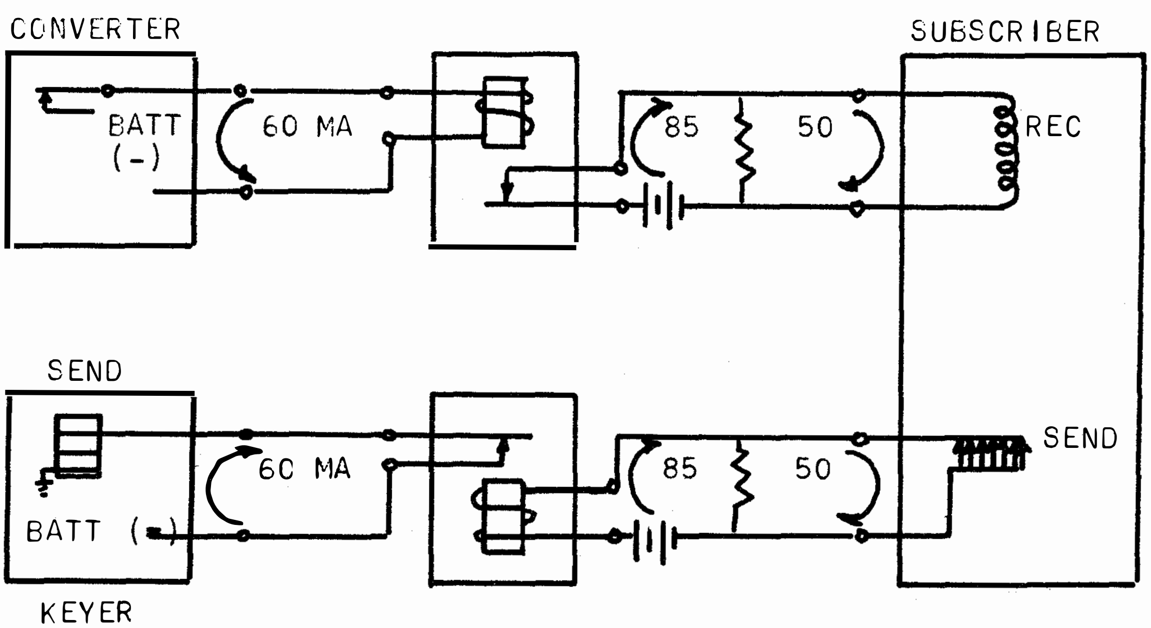
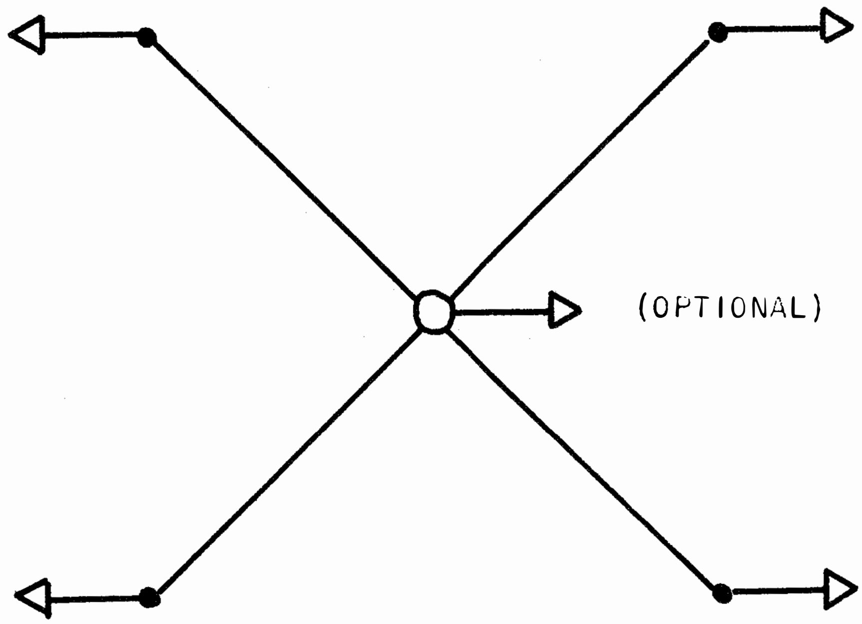


FIGURE X-14 SOLUTION TO LOW SUBSCRIBER CURRENT



LEGEND:

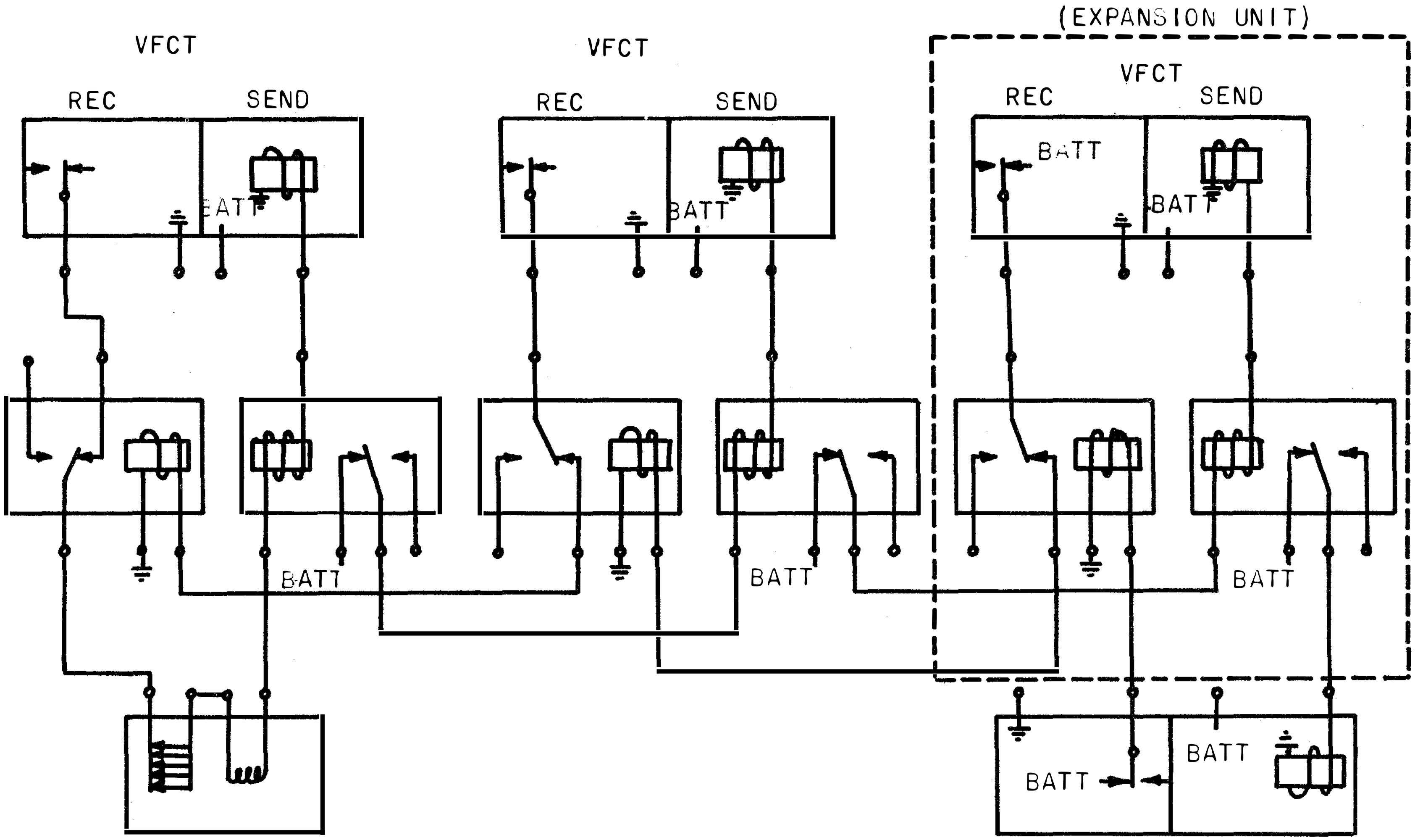
HUB STATION

TERMINAL STATION

SUBSCRIBER

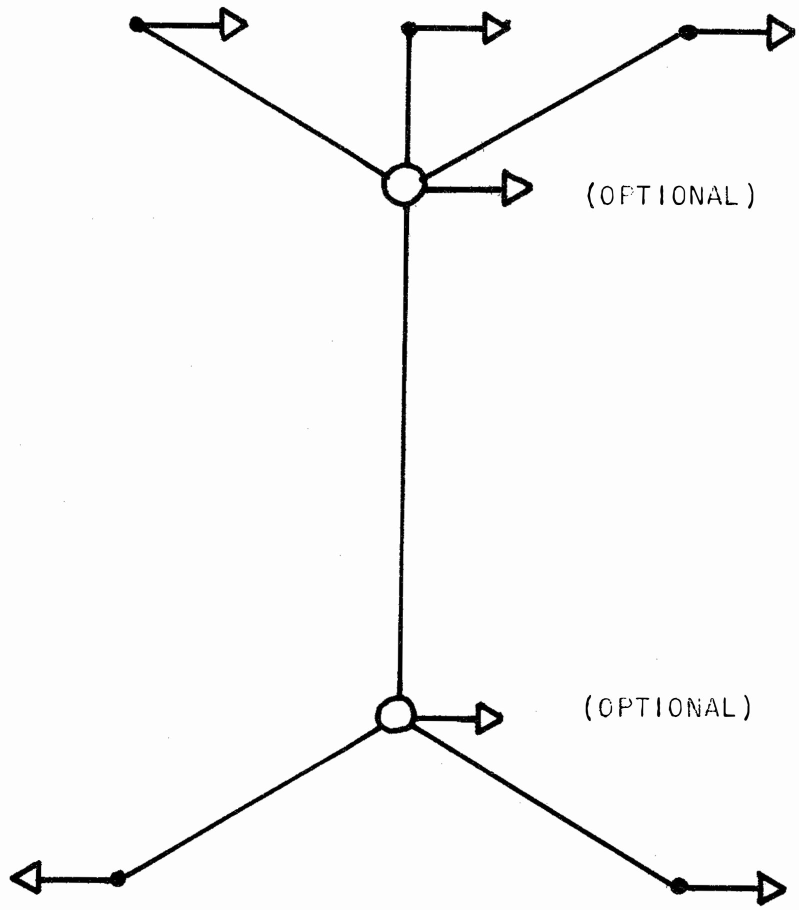
NOTES: SUBSCRIBER EQUIPMENT AT LOCATION OTHER THAN THE HUB STATION IS WIRED FDX BUT OPERATES HDX.

FIGURE X-15 HUB MULTIPOINT, NETWORK CONFIGURATION



NOTE: ALL RELAYS ARE SHOWN IN NORMAL IDLE POSITION; "MARK" OR "HOLD"

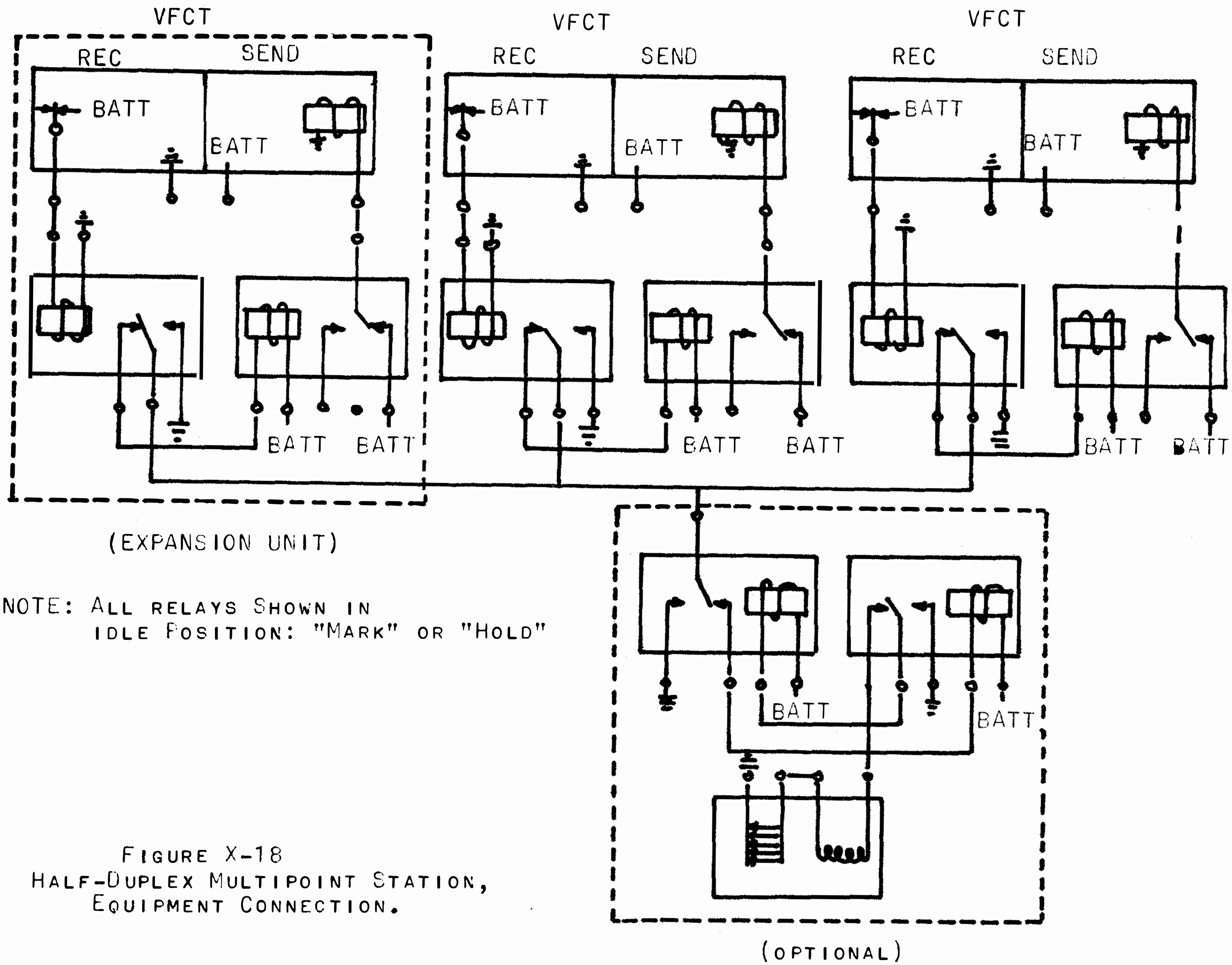
FIGURE X-16 HUB STATION CONNECTIONS



LEGEND: ○ MULTIPOINTING STATION
● TERMINAL STATION
▷ SUBSCRIBER

NOTES: SUBSCRIBER EQUIPMENT WIRED HDX.

FIGURE X-17 HALF-DUPLEX MULTIPOINT, NETWORK CONFIGURATION.



NOTE: ALL RELAYS SHOWN IN
IDLE POSITION: "MARK" OR "HOLD"

FIGURE X-18
HALF-DUPLEX MULTIPOINT STATION,
EQUIPMENT CONNECTION.

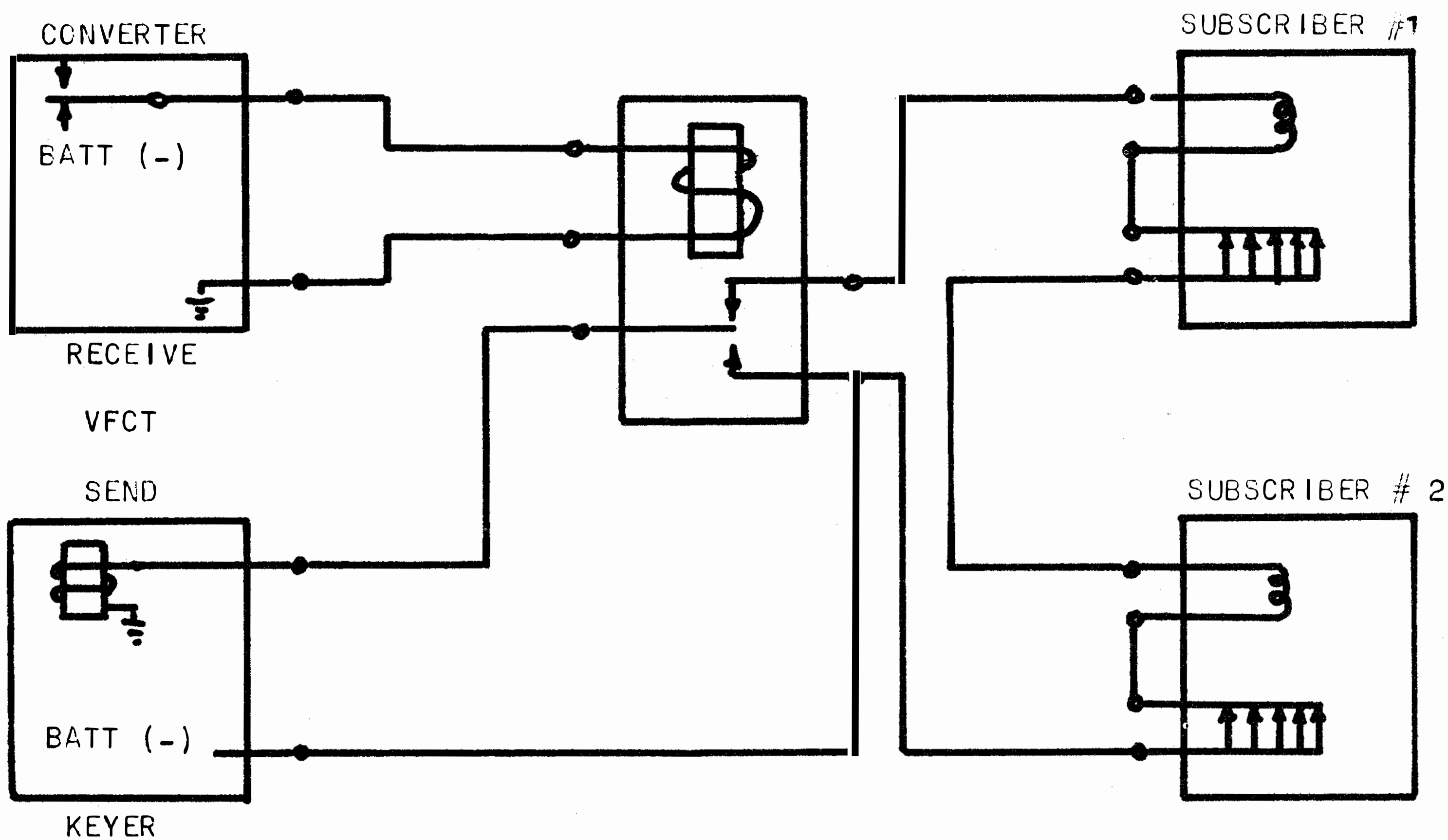


FIGURE X-19 HALF-DUPLEX CIRCUIT, MULTIPLE DROP, COMMON LOOP

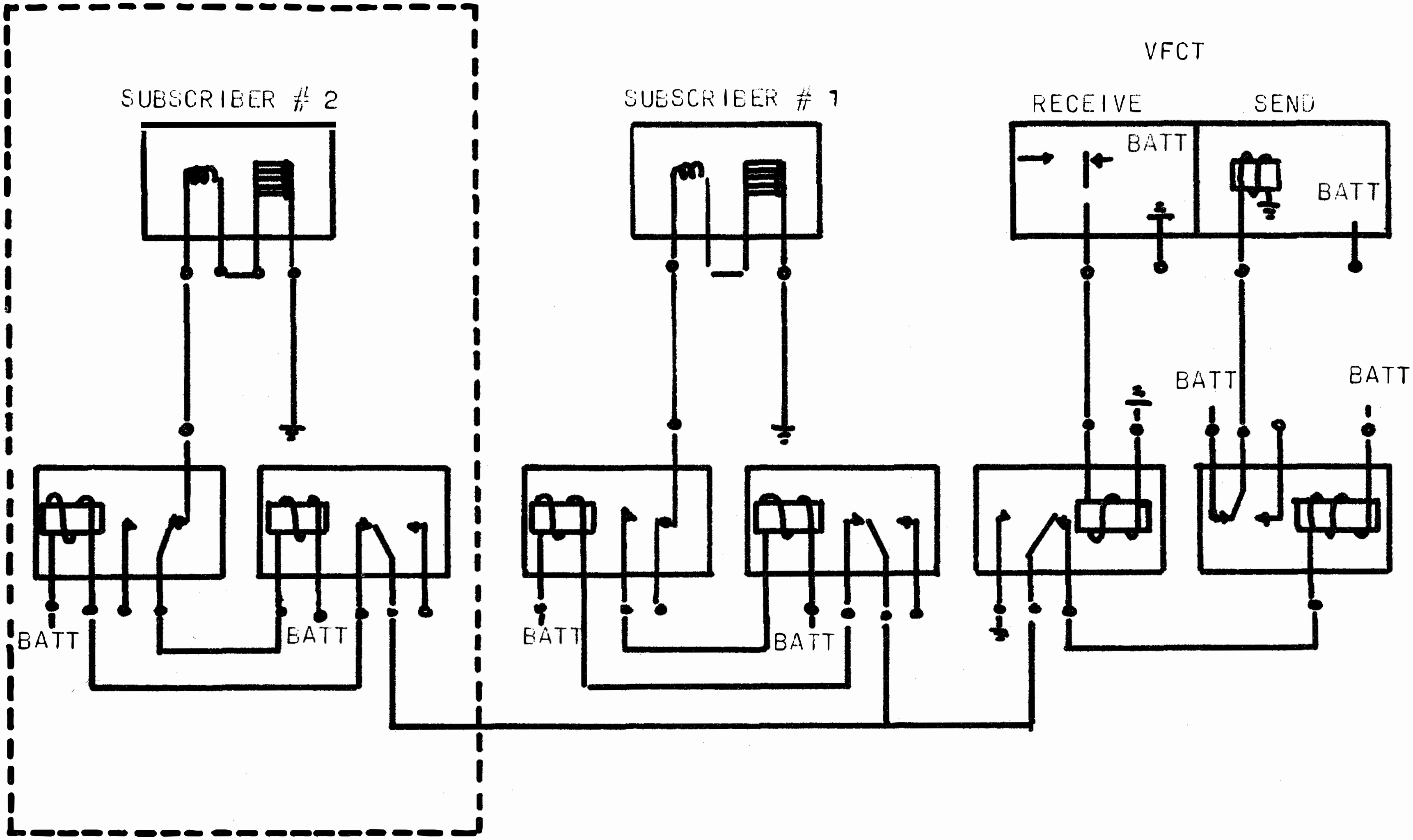


Figure X-20 Half-Duplex Circuit, Multiple Drops, Separate Loops

XI. CIRCUIT ACTIONS

Complete details on circuit activations and realignment are given in the RCG Long Lines Technical Control Standards and Practices:

ITEM NR	TITLE
0201	Circuit Activation Documents
0211	Standard Activation Procedure
0212	AUTOSEVCOM Circuit Conditioning
0221	Engineering Changes to ICS Circuits
0231	Expedited Circuit Activation
0241	Standard Circuit Configuration

XII. SYSTEM CONTROL PROCEDURES, REPORTS, AND RECORDS

In order to operate smoothly and efficiently in a system of the size and complexity of the ICS, established control procedures must be strictly followed, and the reports and records required to support these procedures must be completed in a timely and accurate manner. A brief summary of control procedures, reports, and records utilized is presented in this chapter to provide you with a few key points about this aspect of the ICS.

The first step for every individual concerned with the control of the ICS is to read and understand these basic references:

DCAC 310-70-1 DCS Technical Control
DCAC 310-55-1 Operational Directional Manual of the DCS
RCG LL TCG S&P

Within these references you can find the information you need or you will be referred to another applicable document. As always, there is still room for improvement, especially in a system as new as the ICS; thus you, the operators of the system, are encouraged to come forward with your suggestions as to improvements that can be made.

A. CONTROL PROCEDURES:

You will find that the control procedures governing the ICS differ only slightly from those utilized for the SEAWBS, and the DCS in general. These modifications generally involve the area of circuit actions (see Chapter XI for further detailed references) and are the results of adapting a fixed station system to the ever-changing combat environment we operate in.

1. DCA Procedures:

The control procedures utilized by DCA-SAM are clearly described in DCA directives and circulars, in particular the two noted above. The management role of DCA is executed in part by the allocation of resources (routing of circuits by assignment of channels) and scheduling of circuit actions. The scheduling of actions is closely coordinated with Engineering Branch, Regional Communications Group so that the workload on any one technical control can be regulated. Circuit routing (channel assignment) is solely a DCA function. DCS-SAM also exercises a certain degree of "technical control" over the ICS, as well as the entire SEAWBS, by preparing and issuing TSO's. The final, and perhaps the most important, aspect of DCA management control is the monitoring of the operational status of the system as well as individual circuits.

One of the most effective control procedures used is the appointment of a Coordinating Technical Control for each circuit. The Coordinating Control is specificed by DCA in paragraph 2a of the TSO. It is the responsibility of that technical control to coordinate and report on that circuit from the time of issuance of the activation TSO to the completion of the deactivation TSO. This pinpointing of circuit responsibility goes a long way towards increasing the efficiency of the ICS.

2. Regional Communications Group Procedures:

The RCG LL TCG S&P provides a single source for locating RCG directives setting forth policy and guidance that is not included in other applicable documents or regulations. Individual S&P items are used as the media to standardize operational procedures within RCG.

The assignment of individual items of ICS conditioning equipment is controlled entirely by Regional Communications Group. The Circuit Engineering Section of Engineering Branch, RCG, makes the exact equipment assignment for each ICS circuit as engineered by DCA. These equipment assignments are transmitted to the sites by TTY message. It is essential that these assignments be exactly followed and any changes necessary due to faulty equipment, double assignments, etc, be closely coordinated with Engineering Branch before activating the circuit.

B. REPORTS:

An essential component of any control procedure is an effective "feedback" mechanism that provides accurate and timely information concerning system performance. The primary form that feeback takes in the ICS is the "55-1" report. These reports on activations, deactivations, outages, restorations, alt-routes implemented and exceptions, are vital to both DCA and Regional Communications Group. You should set a goal of perfection in "55-1" reporting procedures and settle for nothing less.

1. DCA Reports:

The principle guide to DCA reporting requirements and formats is DCA Circular 310-55-1, "Operational Direction of the Defense Communications System (DCS)". In fact, nearly all DCA reports fall into the category of "55-1" reports. DCAC 310-55-1 is of such importance that every DCS station should have at least two copies, one of which should be readily accessible to the personnel preparing and submitting the reports. Each DCS station should also have a copy of the DCA-SAM , DCAC 310-55-1 Training Guide, published in October 1967, by that agency to facilitate understanding of DCAC 310-55-1. DTD September 1969 DCAC 310-55-1 supps Dtd 22 December 1969.

It would be impractical to have every DCS station report directly to the DCA operations center. The procedure followed is to designate some large, centrally located stations as reporting stations. All other stations, (those being reported on) submit their reports to the reporting stations for further transmission to the DCA operations center. The method of transmitting these reports to DCA is by use of dedicated teletype circuits directly to the operations center.

At the present time all but one of the reporting stations are operated by the Regional Communications Group. The reporting stations as of 16 April 1970 are:

Tan Son Nhut	Nha Trang
Da Nang	Can Tho
Phu Bai	Pleiku
Long Binh	Vung Chua Mountain (operated by 21st Signal Group)

The following types of DCA "55-1" reports are of primary interest to the operators of the ICS.

a. Activation, realignment, and deactivation of circuit trunk groups, and systems.

b. Activation and deactivation of "on-call" circuits and patches.

c. Exception reports on non-completion of TSO action.

d. Reroute and pre-emption action.

e. Outage reports of circuits, trunk groups and systems.

2. Regional Communications Group Reports:

RCG utilizes the "55-1" reports submitted by the technical control to DCA in basically the same manner as that agency does. The requirements for all reports submitted to RCG are based on the need for operational information and for the supervision of circuit activations and realignments. In addition to the "55-1" reports, there are other reports, whose formats and submission requirements are contained in RCG LL TCG S&P.

a. Required reports on TSO status: It has been found much more efficient, and requiring less effort to all concerned, if all inquiries regarding ICS circuit actions are made to the Circuit Control Section, Engineering Branch, RCG. However, in order to answer these inquiries, the Circuit Control Section requires accurate and timely reports on the status of DCA TSO's.

C. RECORDS:

1. DCA Records:

The reference for DCA records in DCA Circular 310-70-1 "DCS Technical Control, Vol II Procedure 11. The DCA records that must be maintained in the ICS technical control are:

a. Station Log

b. Circuit Layout Record (CLR)

c. Trunk Layout Records (TLR)

d. (1441 cards) TSO

2. Regional Communications Group Records:

a. Circuit History File (Ref: S&P Item Nr. 0820-01): This S&P prescribes the manner in which the CLR's, TLR's, and TSO will be filed.

b. Equipment Utilization Records (Ref: S&P Item Nr. 0820-01): Each Technical Control must maintain records on the utilization of all conditioning equipment. Periodically, these records will be compared to the records maintained by Engineering Branch, RCG and the discrepancies adjusted.

c. Performance Records (S&P Item to be issued): Each ICS Technical Control will keep statistical data on circuits, channels, groups or supergroups as to efficiency, outages, reasons for outages, and corrective actions. These records will be kept a minimum of 6 months for possible analysis.

XIII. SECURE VOICE SYSTEMS

A. HISTORY:

There has always been a need in the military for private or secure communications. Special couriers, intricate codes, cyphers, and false messages were but a few of the means used by the armies of the past to obtain secure communications. This need for secure communications still exists.

Both teletype and telephone services can be made secure. Security is usually achieved by making the transmitted information indecipherable to the enemy. This is normally done by encrypting the information, transmitting it, and then deciphering the information at the receiving end.

B. THEORY OF SECURE VOICE TRANSMISSION:

Human speech is transmitted through the air as a series of compressions and rarefactions of air pressure. These can be represented as a continuous waveform composed of frequencies from 20 to 20,000 Hz. Only frequencies between 300 to 3,000 Hz are required, however, to reproduce good intelligible speech. A normal telephone converts speech waves into electrical audio frequency waveforms, transmits them, and then reconverts them to speech-waves at the distant end. If carrier systems are utilized, the audio waves are modulated to a new frequency for transmission, but the waves are still continuous.

A means to scramble or encrypt the voice information must be utilized if secure voice is to be achieved. It is difficult to encrypt a continuous waveform and then accurately decipher it at the distant end. It is less difficult to encrypt and then decipher a series of discrete pulses. This is what secure voice equipment actually does. The original continuous audio wave form is first converted to a series of discrete pulses and then the discrete pulses are scrambled according to a prearranged code. At the distant end, the pulses are de-scrambled and reconverted to audio frequencies.

To represent audio wave forms as a series of discrete pulses the audio wave amplitude is first sampled at frequent intervals. Each sample is represented by a discrete pulse code representing the amplitude of the sampled wave. The quality of the reproduction is closely related to the sampling rate. Within certain limits, a high sampling rate will produce a more accurate representation of the audio wave since the sample intervals are much closer together. High sample rates imply narrow discrete pulses. Unfortunately, the bandwidth required to pass narrow pulses is greater than that required to pass wide pulses. Thus, the quality of a secure voice circuit is directly related to its transmission path bandwidth.

Both narrowband (3 kHz) and wideband (50 kHz) secure voice equipments are used in Vietnam. The narrowband equipment is designed to pass over standard 3 kHz telephone circuits. The 3 kHz bandwidth limits the pulse rate, however, so that speech quality is poorer than normal telephone quality. Wideband secure voice equipment is designed for use on short, specially dedicated wideband circuit paths. Excellent speech quality is achieved with wideband equipment.

Both wideband and narrowband equipment must be synchronized with each other. Without synchronization, the receiving equipment will be unable to correctly decipher the pulses and severe distortion or garble will result. Great care must be exercised to insure that accidental disconnects, mis-patches, and path noise and level shifts are minimized. Each can cause the secure voice equipment to lose synchronization. Loss of synchronization requires that the circuit must be re-established and re-synchronized before secure voice communications can be continued. Since all secure voice circuits in Vietnam pass extremely high priority traffic, every effort must be made to avoid even momentary disruptions.

C. SECURE VOICE SYSTEM IN VIETNAM

AUTOSEVOCOM (Automatic Secure Voice Communications) is an automatically switched secure voice communications system currently being installed on a world-wide basis. AUTOSEVOCOM, Phase I, is now being installed in Vietnam. A non-automatic secure voice system, TALK QUICK, is currently in operation in Vietnam providing an interim AUTOSEVOCOM capability. Future expansions of the secure voice system in Vietnam will be referred to as AUTOSEVOCOM rather than TALK QUICK.

The secure voice system presently consists of the following: (Figure XIII-1)

a. A secure voice access console (SEVAC)

b. An automatic dial exchange, AN/FTC - 31

c. Narrowband (3kc) and wideband (50kc) subscriber terminals with trunk connections to a switchboard

(SEVAC) provides the interface between the wideband and narrowband subscribers. AN/FTC-31 subscribers (AUTOSEVOCOM) have a dial capability to other AN/FTC-31 subscribers, but must use the operator at a manual switch for access to non-AN/FTC-31 subscribers.

Narrowband trunks are terminated at the Phu Lam overseas switchboard (JOSS) to provide access into the Pacific area secure voice network. Access to this network allows connection to secure voice subscribers worldwide.

These narrowband trunks are high priority (1D), specially conditioned circuits to support secure voice traffic. Any changes to the circuit routing requires extensive tests and reconditioning of the circuits. Specific instructions have been given technical controls on the proper test of secure voice circuits. When the circuit is idle, a 2600 Hz tone at the proper level is normally sufficient to indicate that the circuit is operating properly. The 2600 Hz supervision tone should be 20 db below standard test tone levels listed on the CIR Card. Circuits should not be tested with operational traffic being passed. Any interruption of the signal or significant change in levels will cause the subscriber terminal to go into an alarm conditon. Temporarily bridging the circuit will indicate if traffic is being passed. A rushing sound is heard in the headset.

Signal Company (AUTOSEVOCOM) organic to the Regional Communications Group has responsibility for operation and maintenance of the Army portion of the secure voice system in Vietnam and operation of the Network Coordination Station (NECOS). The NECOS was organized to provide a single point of contact for trouble reporting in Southeast Asia.

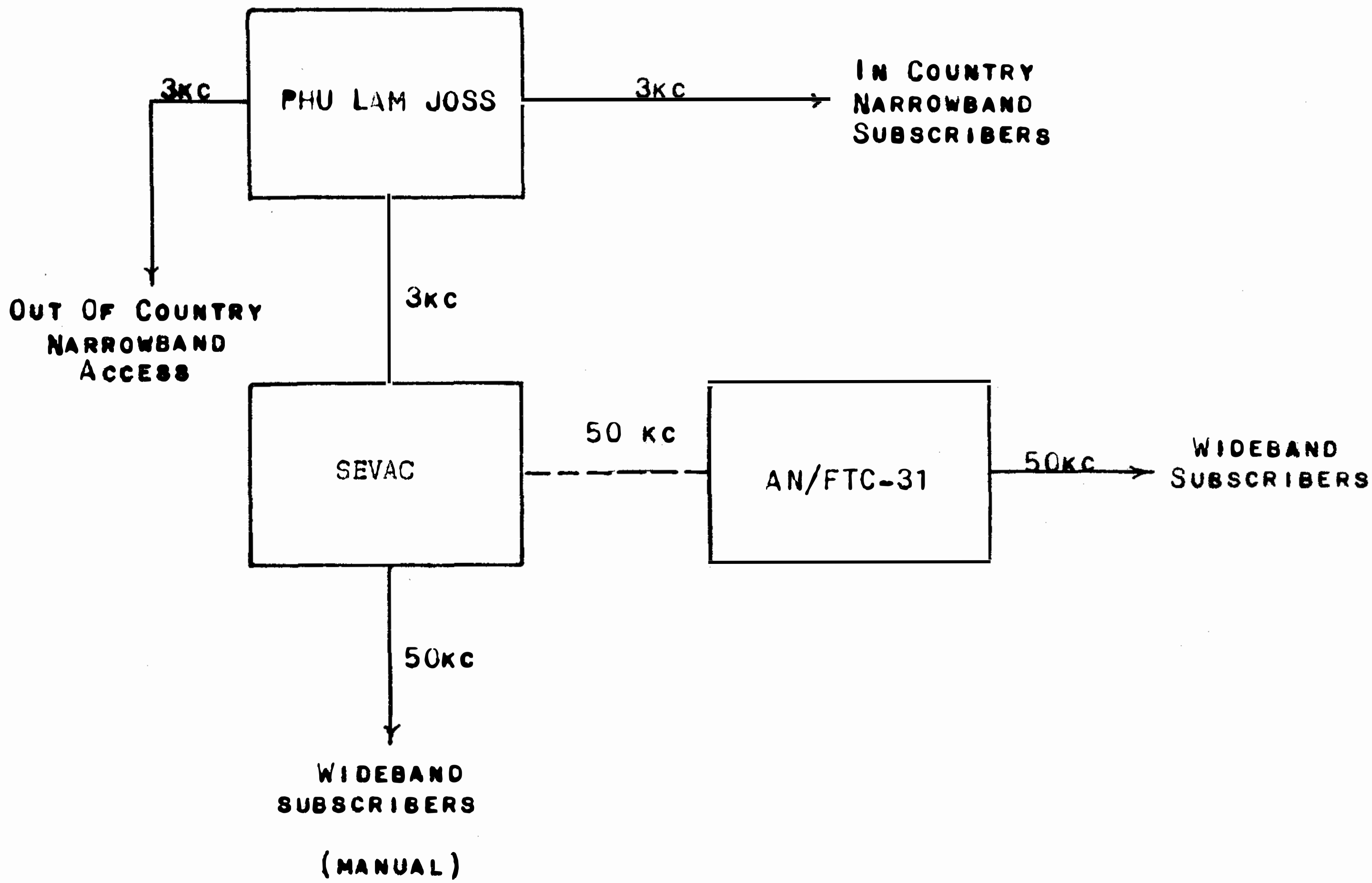


Figure XIII-1 Secure Voice System

XIV. DATA SYSTEMS IN VIETNAM

A. AUTOMATIC DIGITAL NETWORK (AUTODIN):

During the summer of 1962 the Secretary of Defense directed that the DCS be a single intergrated automatic switched communications system comprised of an Automatic Digital Network (AUTODIN) and an Automatic Voice Network (AUTOVON). This system upgrade improves the overall effectiveness of the DCS by increasing the responsiveness, flexibility, survivability and economy of communications through the use of automatic switching techniques.

The AUTODIN in CONUS consist of nine interconnected Automatic Switching Centers (ASC's), their associated subscriber terminals, and appropriate DCS transmission facilities. Overseas, the network consits of ten Automatic Digital Message Switching Centers (ADMSC's), their associated subscriber terminals, relays, and appropriate DCS transmission facilities. Each ADMSC is interconnected with adjacent ADMSC's and connects with CONUS AUTODIN through designated gateway stations.

High traffic volume/high priority subscribers such as manual data, DCS teletypewriter relays and AUTODIN subscribers are directly connected over full-time circuits into the AUTODIN Switching Ceneters.

Two overseas switches are located in Vietnam; one ADMSC at Phu Lam and one ADMSC at Nha Trang. USA Regional Communications Group operates both of these switches. The Phu Lam switch was activated on 25 March 1968. The Nha Trang switch was activated 25 April 1968. The AUTODIN configuration for the Pacific area is shown in Figure XIV-1.

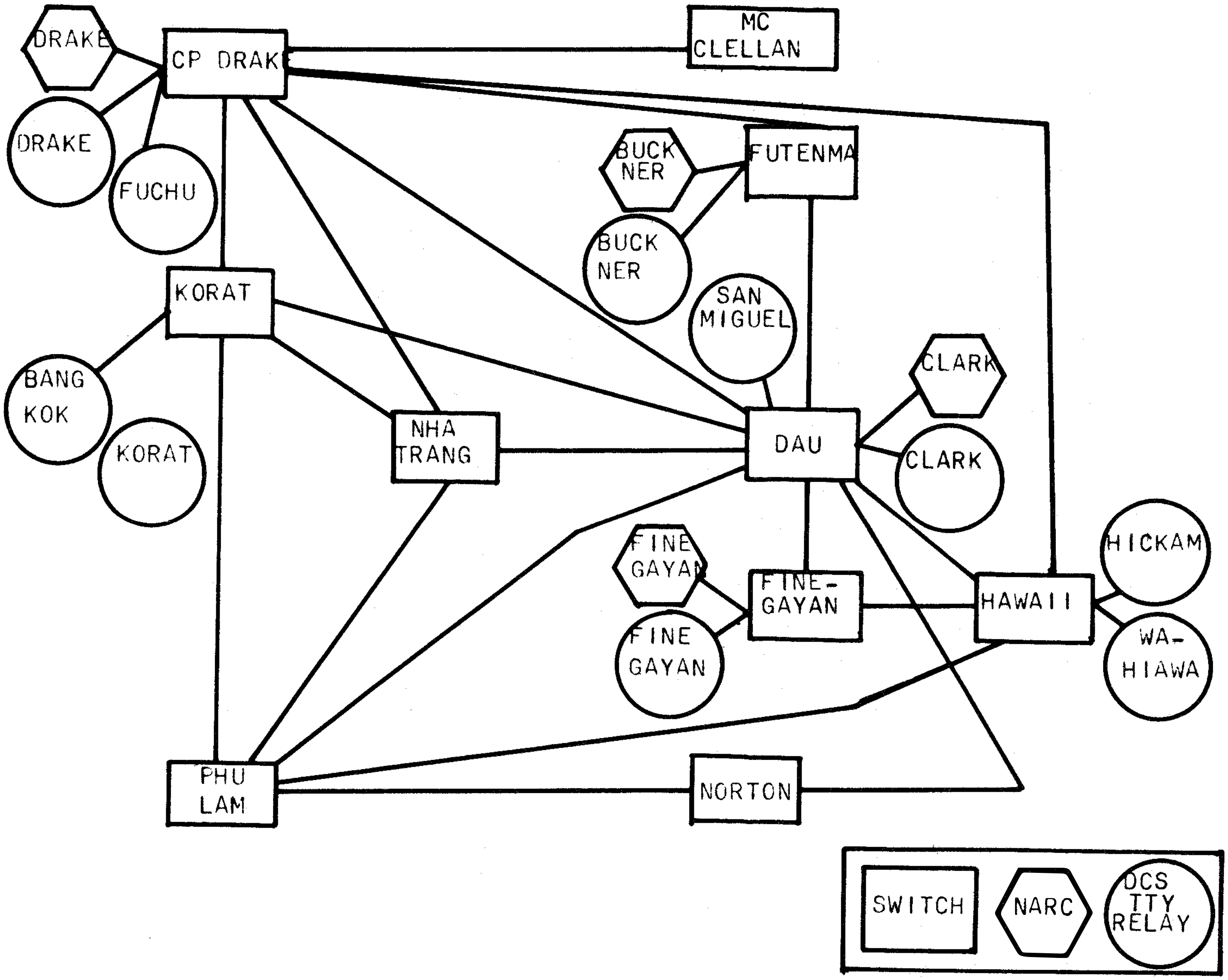
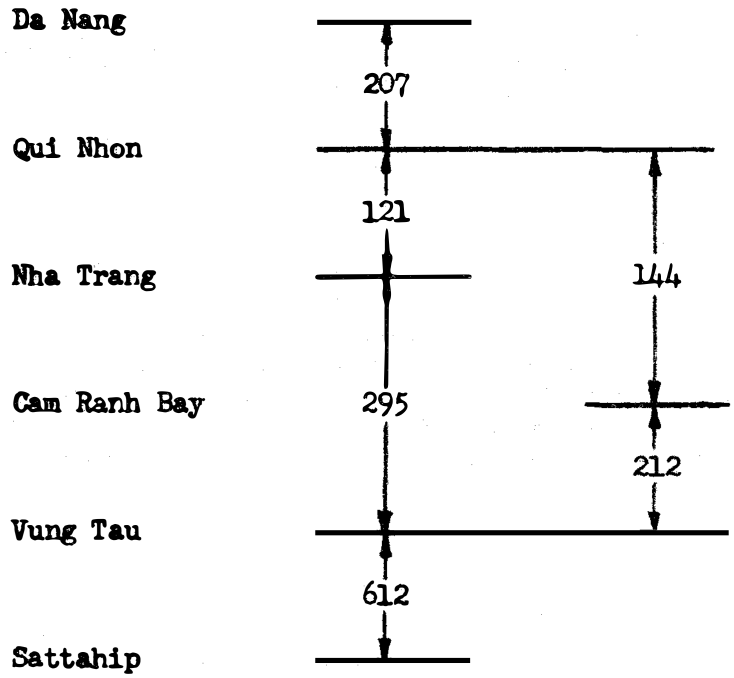


FIGURE XIV-1 AUTODIN OVERSEAS-PACIFIC NETWORK

XV. 439L CABLE SYSTEM

Since the 439L undersea cable system is such an important link in the long lines systems here in Vietnam, it is helpful and interesting to know a few of its features and capabilities.

A. CABLE LENGTHS (NAUTICAL MILES):



B. CABLE SIZE:

The basic cable is a dielectric filled 5/8" coaxial cable. The sea portion of the cable uses single armored cable with a total diameter of 2". On the portion from the sea splice up to the beach, double armored cable is used, and from the beach to the cable terminal, it is again single-armored.

C. CHANNEL CAPACITY:

60 each 4 kHz voice channels are provided. Approximately 25% of these can be used for VFCT tone packs (loading limitation). The cable terminals break down the 60-channel SUPERGROUP into five 12-channel GROUPS; however, the terminals do not have channel MODEM equipment. There is one 12-channel MODEM at each terminal of each link which is primarily for test purposes only. The channel MODEMs used for general purposes are in the ICS buildings. There is a voice order wire for terminal-to-terminal communications.

D. TRANSMISSION PLAN:

Since this is physically only a two-wire system, the transmission in oposite direction must be separated in frequency. This is accomplished by having the "B" terminal transmit in the standard SUPERGROUP 2 frequency band (312-522 kHz) and the "A" terminal transmits in the band from 24-264 kHz. The 96 kHz pilot tone is transmitted from the "A" terminal to the "B" terminal.

E. REPEATERS:

There are active repeaters placed in the cable every 16.8 nautical miles. These are tube-type units powered by direct current supplied by the terminals. The repeaters are bidirectional, separating the two directions of transmission with appropriate filters.

F. CABLE POWER FEED:

The submarine cable derives all of its power from the shore station. Depending on the length of the section, either one or both terminals will supply DC current to the cable. The cable center conductor is used to convey all of the DC power. The salt water and earth itself being the return path to the feeding station. The repeaters draw their power between the center conductor and the return path. The important feature of the power feed is a constant current of 426 milliamperes. This may require a very high voltage, for example, the terminal voltage is 1850 volts on the Vung Tau - Sattahip link which is fed from both terminals.

G. COMPANIES INVOLVED:

Engineered by: Page Communications Engineers

Installed by: Under Sea Cable Corporation

Cable manufactured by: Simplex

Terminals and repeaters manufactured by: Felten and Guilleaume of Germany

H. ICS INTERCONNECTION:

Under Modification Number 6 to the Area 1 ICS contract, LOS microwave links were installed between each cable terminal in Vietnam and the nearby ICS terminal. These are AN/FRC-109 systems, operated and maintained by Regional Communications Group.

XVI. Satellite Communications

In the field of Military Communications, reliability and high quality are of major importance. One of the latest techniques used, that of communication by satellite relay, promises both of these features plus a long distance capability with relative ease of establishment.

Until December 1967 there were two satellite programs being implemented in RVN. The first program was the Synchronous Communications (SYNCON) Satellite program, using two satellite relays in synchronous orbit. Five transportable ground terminals were in operation carrying communications across the Pacific to the U.S. One of these terminals was in RVN and utilized an AN/MSC-44 located at Ba Queo. It was taken out of traffic in December 1967.

The second program, the Initial Defense Communications Satellite Program (IDCSP), remains in use and provides an operational system (IDCSS) capable of global communications via a belt of satellite relays circling the earth above the equator. The satellites were carried as a package into final orbit by a TITAN III-C rocket. A trans-stage was then used to accelerate the package while the satellites were sequentially ejected. In this way, a different velocity and orbital period was imparted to each of the nineteen satellites enabling a slow, random dispersion. The satellites are in near synchronous orbit at an altitude of 18,200 miles, randomly dispersed around the globe. A given ground terminal "sees" the satellites continually drifting into, through, and out of his field of visibility; thus any two or more satellite ground terminals having mutual satellite visibility can communicate. The maximum power output of the IDCSP satellites is two point five (2.5) watts with a bandwidth of 20 mHz. An experimental satellite was launched on 2 July 1967 that has an increased power output of approximately 16 watts. Because of the omnidirectional antennas on the satellites, the ground terminals must have extremely sensitive receivers. This sensitivity is achieved through the use of supercooled parametric amplifiers. The parametric amplifiers are cooled with liquid helium to a temperature of -245 degrees centigrade. Three (3) ground terminals were initially deployed to sites located in West Germany, Hawaii, and the Phillippines. The initial terminals have been supplemented by eight (8) additional AN/MSC-46 terminals, two of which are located in RVN, one (1) at Ba Queo (see figures 1 and 2) and one (1) at Nha Trang. The Ba Queo circuits terminate at Phu Lam and Kunia, Hawaii; the Nha Trang circuits terminate at GUAM.

The AN/MSC-46 terminals have a capacity of twelve (12) four (4) kHz VF Channels. The transmit frequency is preset within the range of 7.9 to 8.4 gHz with an output power of up to 10 Kw. The receive range is from 7.25 to 7.75 gHz.

The operational control of the IDCSS is the Satellite Communications Control Facility (SCCF) colocated with the Defense Communications Agency Operations Center in Arlington, Virginia. The SCCF is responsible for overall system control and assigns schedules and satellites to link terminals for subscriber use. The satellite circuits are tied into the Integrated Wideband Communications System (IWCS), here in Vietnam, and are used to provide service throughout the world. Presently the satellite circuits are used for out-of-country communications through the Hawaii and GUAM ground terminals, where they can be routed over an undersea cable to destinations in CONUS and points beyond. The alternate route is a direct path from Vietnam to Camp Roberts, California; however, due to the transmit-receive angles involved the circuits on this path are of lesser quality.

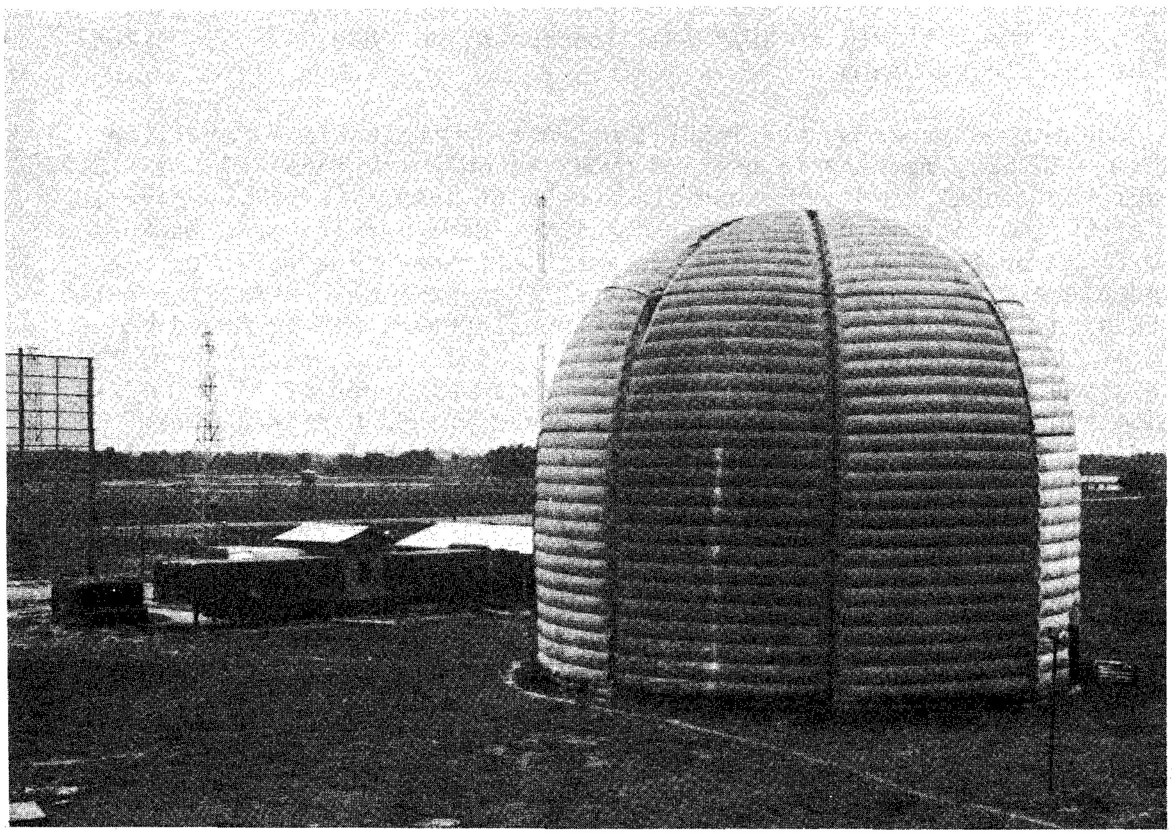


Figure XVI - 1 Ba Queo Satellite Terminal

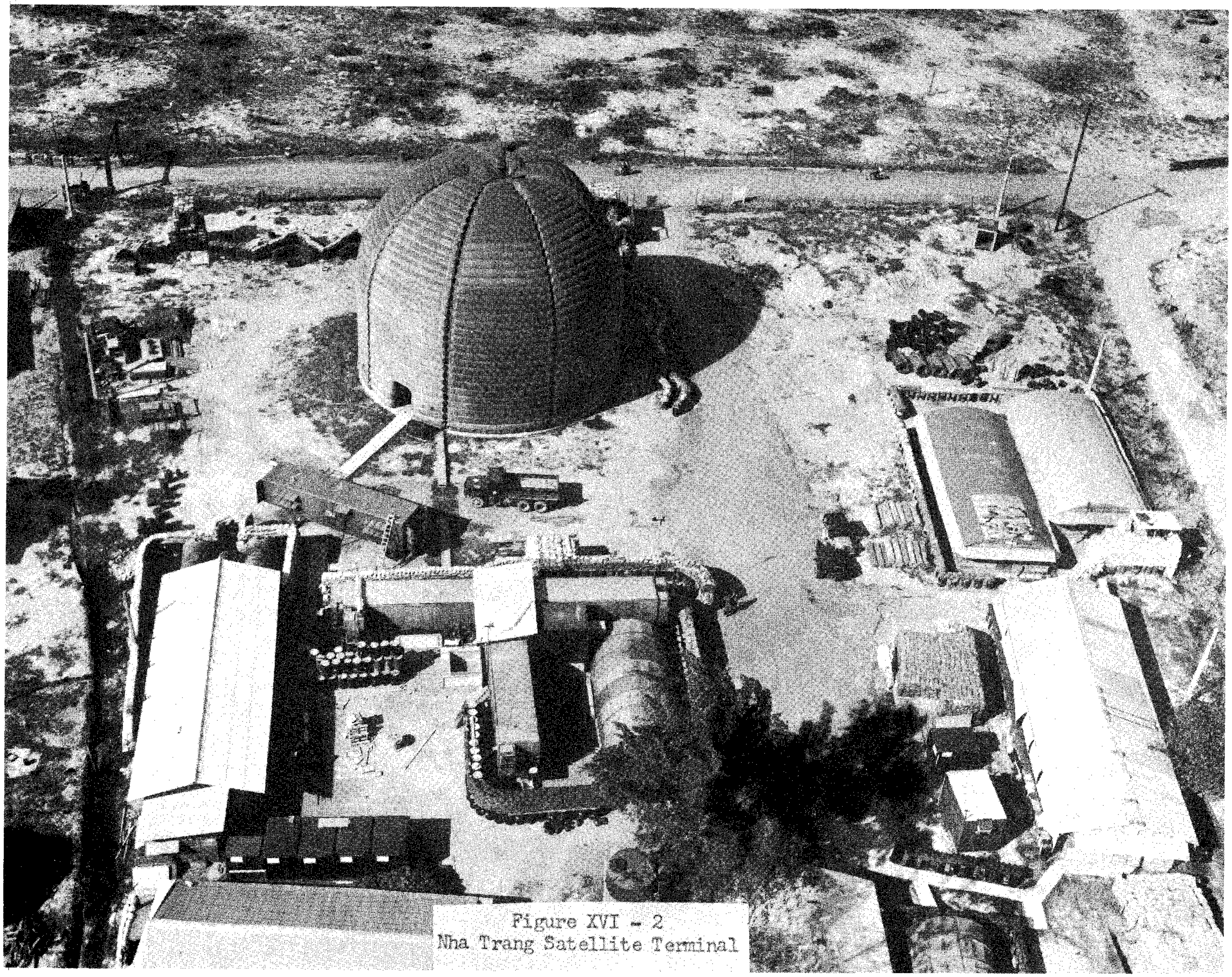


Figure XVI - 2
Nha Trang Satellite Terminal

XVII. ICS QUALITY ASSURANCE AND OPERATIONAL EVALUATIONS

A. GENERAL:

The ICS quality assurance program is conducted in accordance with the references listed in paragraph B. The purpose of this program is to insure that the ICS performance is of the highest quality possible.

Regional Communications Group and the Defense Communications Agency-Southeast Asia Mainland provide independent teams which perform periodic quality assurance and operational evaluation inspections on technical control, tropospheric scatter radio and microwave radio facilities. ACOC, 1st Signal Brigade, alsl has a team which performs periodic quality assurance inspections and technical control evaluations.

B. REFERENCES:

DCAN 210-0-1	DCA Numbered Publications
DCAC 310-55-1	Operational Direction Manual
DCAC 310-70-1	Technical Control Procedures (4 Volumes)
DCAC 300-175-9	DCS Circuit Operating Standards
DCAN 330-10-1	Communications-Electronics Terms
DCAN 330-175-1	Engineering-Installation Standards
ACP 131 (B)	Communications Instructions Operating Signals

Regional Communications Group Long Lines Technical Control Standards and Practices

1st Signal Brigade Standing Signal Instructions

C. PROCEDURES:

1. The prime element of any quality assurance program is the support of the operating station. Without this support, such a program can hardly be successful. For this reason it is imperative that site commanders vigorously implement the detailed quality assurance directives contained in RCG LL TCG S&P and DCA publications. Questions concerning specific quality assurance procedures not covered in these should be referred to Quality Assurance Branch, Hqs, RCG.

2. ACOC and Regional Communications Group quality assurance teams will periodically visit all ICS technical controls. The purpose of these visits is to provide CG, 1st Signal Brigade and CO, RCG with information as to the effectivdness of the on-site implementation of the quality assurance program.

3. The DCA-SAM team periodically visits the DCS technical controls and the major relay stations. This team performs operational evaluation inspections. Reports of these inspections are forwarded by Chief, DCA-SAM to MACV J-6. A check-list of Technical Control Quality Assurance and Operational evaluation is reproduced on the following pages.

TECH CONTROL QUALITY ASSURANCE/OPERATIONAL EVALUATION

CHECKLIST

1. Publications, Forms, Reporting.

a. Are current editions (with posted changes) of the following publications held by the Tech Control Facility?

IDENTIFICATION	TITLE	YES	NO
DCAN 210-0-1	DCA Numbered Publications	___	___
DCAC 330-10-1	Communications-Electronic Terms	___	___
DCAC 330-175-9	DCS Circuit Operating Standards	___	___
DCAC 310-55-1	Operational Direction Manual	___	___
DCAC 310-70-1	Tech Control Procedures	___	___
ACP 131	Communications Instructions-Operating Signals	___	___
DCAC 330-175-1	Engineering-Installation Standards	___	___

b. Are all documents relative to classified operational matters (restoral plans, etc) available to personnel whose duties require them?

c. Is a separate reporting section authorized for DCAC 310-55-1 actions?

d. Does in-station SOP ensure accuracy and timeliness of DCAC 310-55-1 reports?

e. Are procedures for reporting trunk and circuit status and backlog conditions adequate?

f. Are the following DD forms listed in DCAC 310-70-1 (or suitable substitutes) being used by the facility:

	YES	NO
Master Station Log (para 11-2):	___	___
Analysis of Channel Operation Form, DD 1440 (para 11-40:	___	___
Circuit Record Form, DD 1441 (para 11-9):	___	___
Quality Control Log (para 11-10):	___	___
Circuit Layout Record (para 11-12) (prepared by DCA-SAM):	___	___
Tech Control Communications Work Order Form, DD 1445:	___	___
Quality Control Circuit Test Schedule (para 4-3B):	___	___
Quality Control Equipment Test Schedule (para 4-3C):	___	___

2. Procedures.

a. Review station SOP for completeness in meeting DCS standards with particular attention to the following:

(1) Are schedules for periodic testing posted and followed to insute circuits meet DCS standards?	___	___
(2) Are procedures prescribed for each emergency action involving:		
(a) System failure:	___	___
(b) Power failure:	___	___
(c) Air conditioning failure:	___	___
(d) Cable failure:	___	___
(e) Jamming:	___	___
(f) Interference:	___	___
(g) Natural disaster:	___	___
(h) Enemy attack:	___	___
b. Do circuit records list coordination points or contacts to correct circuit/system problems?	___	___
c. Are circuit outage records maintained?	___	___
d. Are controllers familiar with plans for rerouting circuits and trunks for which the facility is responsible?	___	___

YES NO

e. Are pre-planned reroutes available for circuits with a restoration priority of one and two? ___ ___

f. Are listings maintained indicating restoration priorities for each circuits? ___ ___

g. Are circuits preempted in accordance with restoration priorities? ___ ___

h.. Are "down circuits" returned to service in accordance with established restoration priority? ___ ___

3. Facilities (refer to general information sheet prepared by Facility OIC).

a. Is equipment adequate to meet exising and known future requirements? ___ ___

b. Are operational coordination and inter-communication facilities between tech control and associated locations adequate? ___ ___

c. Is adequate test equipment available to perform telegraph distortion measurements? ___ ___

d. Has test equipment been calibrated as required by MILDERS? ___ ___

e. Is test equipment properly maintained and serviced? ___ ___

f. Has appropriate action been taken by the facility to obtain needed items of test equipment? ___ ___

g. Are circuit patching facilities adequate? ___ ___

4. Operations. Observe the following (DCAC 310-70-1):

a. Are controllers familiar with DCA directives and their availability? ___ ___

b. Are controllers familiar with restoration procedures? ___ ___

c. Are DCS circuits assigned to the proper channels as specified by CEO? ___ ___

d. Are non-DCS circuits assigned to DCS systems? ___ ___

YES NO

e. Does the controller cooperate and coordinate with distant stations and with other components within the station? ____ ____

f. Is the subscriber notified of circuit restoration? ____ ____

g. Are DCS users being informed of their responsibilities as prescribed in para 3800, DCAC 310-55-1? ____ ____

h. Is there an effective on-the-job training program? ____ ____

i. Is there a Daily Notice program in effect? ____ ____

j. Has any attempt been made to implement a technical controller exchange program with connecting stations? (DCAC 300-210-1) ____ ____

5. General Comments:

a. Do tech controllers exhibit a sense of urgency in maintaining reliable communications? ____ ____

b. What is the attitude toward DCA reporting in accordance with DCAC 310-55-1? ______________________________

____

____

c. Is there a shortage (below authorized manning levels) of trained tech control personnel which degrades the quality of DCS control actions? ____ ____

XVIII. MISCELLANEOUS TOPICS

A. TELEPHONE SIGNALLING - By C. W. Holley, Page Engineer.

1. General:

The first telephone transmitted and received voice intelligence only, and that not very well. As its ability to transmit voice was improved, it was soon apparent that a means of attracting the attention of the called party was necessary. The small battery which supplied current to the telephone set's transmitter did not transmit current to the line connecting the two telephone sets, so it could not be used to signal the other end. A separate source of signalling energy was necessary and the hand powered 16-20 Hz, 85-90 volt AC generator has proven to be a good solution. The same system is used in the TA-312 field telephone, and Western Electric still manufactures such magneto tel sets.

Let's stop for a minute and translate some of the words used so far into telephone language. The battery which supplies current to the telephone transmitter is called TALK BATTERY. The hand-cranked ringing generator is called a MAG (short for magneto). A telephone is frequently called a TEL SET. A tel set with a mag is called a MAG SET.

We have already mentioned voice transmission and signalling. A telephone system is designed to transmit and receive only those two types of intelligence. We will not consider signalling in it's broadest sense; ie, data, telegraph, etc., but we will consider only: attention getting, selecting, and supervisory signals.

2. Attention getting signals:

The 20 Hz, 85 volt energy generated by the calling party with a mag tel set is transmitted over the line to the distant tel set and causes a bell to ring. The bell is called a RINGER. Figure 1 depicts a highly simplified mag tel set telephone circuit.

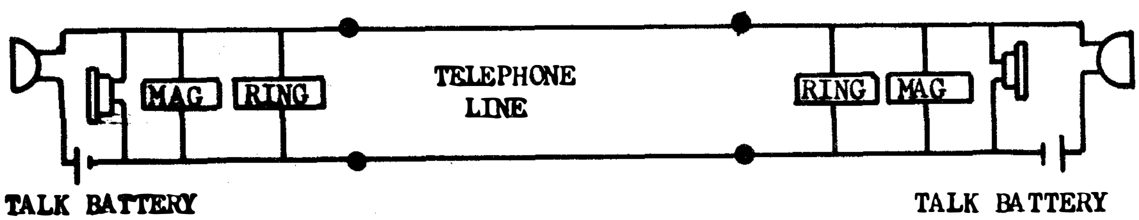


Figure XVIII - 1 Simplified Telephone Circuit

Such tel sets are also called LOCAL BATTERY tel sets because the talk battery is located "locally", in the case of the tel set. A COMMON BATTERY tel set gets its talk battery from a centrally located, large capacity battery which may supply talk battery to thousands of tel sets. Thus we can say the battery is "common" to many tel sets.

Figures 2 and 3 depict respectively local and common battery telephone circuits.

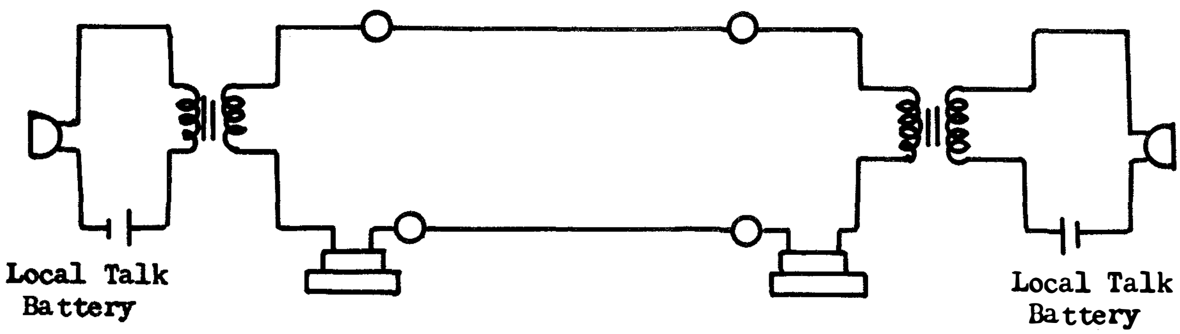


Figure XVIII - 2 Local Battery Circuit

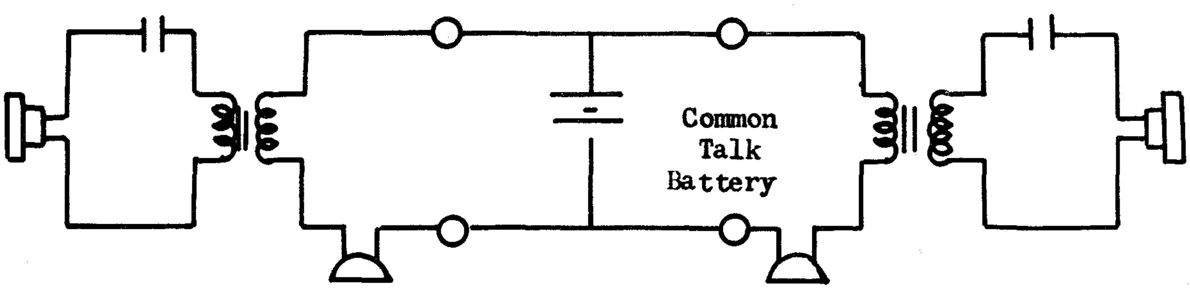


Figure XVIII - 3 Simplified Common Battery Circuit

Ringers and generators are not shown - we want to emphasize the difference in talk battery source. Both local and common battery tel sets are equipped with a switch called a HOOKSWITCH which operates to close the talk battery circuit through the transmitter when the telephone is lifted off its hook or cradle.

Let's now discuss common battery signalling in detail. The common battery supplies current for the tel set transmitter. This current can be passed through a relay winding and provide a signal function. Figure 4 is a more detailed schematic of a common battery circuit's relay configuration.

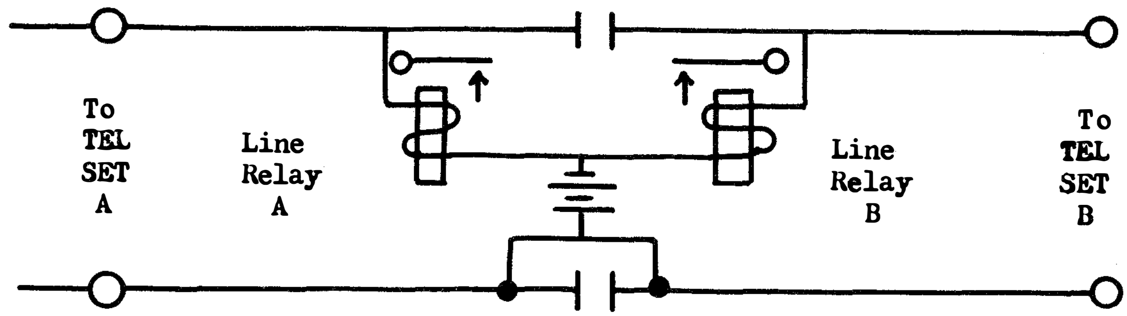


Figure XVIII - 4 Use of Relays in Common Battery Circuit

When tel set A calls tel set B, current flows from the common battery through winding of line relay A, over the line through the transmitter of tel set A and back over the line to the common battery. Thus tel set A has talk battery (current) and line relay A operates. The contacts of line relay A cause a relay to operate which imposes 20 Hz signalling toward tel set B. When tel set B answers, his transmitter receiver talk battery through a cut-off relay winding which operates and cuts off the 20 Hz. The two can then talk. The operation of the line relay can also be used to signal a switchboard by lighting a lamp.

Here's some more telephone language. When a tel set is picked up preparatory to making a call, it is said to GO OFF HOOK or to be OFF HOOK. When a tel set user hangs up the tel set, it is said to GO ON HOOK or to be ON HOOK. The line from the common battery consists of two wires called a PAIR. If in a cable, a CABLE PAIR. The two wires are referred to as a LOOP. When the tel set is ON HOOK, it is an OPEN LOOP. When the tel set is OFF HOOK, it is a CLOSED LOOP. The two wires of a pair are called the TIP (T) and the RING (R). This terminology is a carry-over from manual switchboards. A switchboard plug has three conducting elements as shown in Figure 5.

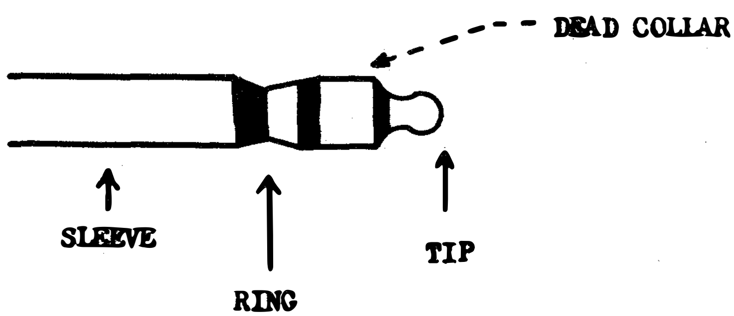


Figure XVIII-5 Conducting Elements of a Switchboad Plug.

The T of the plug is connected to the pair tip conductor and the R to the pair ring conductor. The sleeve (S) lead is used for local circuit control functions. Common battery is installed with its positive terminal grounded and is represented schematically as shown in Figure 6.

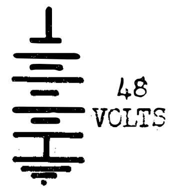


Figure XVIII - 6 Battery Installation

Normally the R conductor of the telephone pair or loop is connected to negative battery and T to ground.

So far we have discussed two types of signalling: Local battery and common battery. In our discussion we have considered telephone circuits using only two tel sets. Local battery signalling is usually referred to as 20 Hz SIGNALLING, though Hz is a word used to replace the old word cycle/sec and you'll also hear it called 20 CYCLE SIGNALLING. Its use is not restricted to local battery systems, though that is its origin. Common battery signalling is also called LOOP SIGNALLING or WET-DRY SIGNALLING. A loop is wet when one of its conductors is normally connected to battery and the other to ground. A DRY LOOP has neither battery nor ground standing on it.

We can now refine our terminology further by saying that there have been two types of signalling discussed so far: 20 Hertz and LOOP. Here are some simple block diagrams illustrating "attention getting" signalling (combinations of LOOP and 20 Hertz).

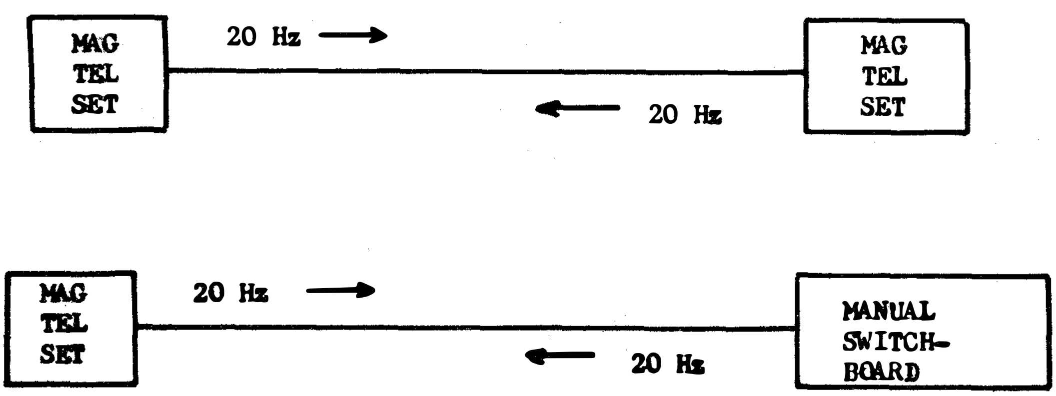


Figure XVIII - 7A Attention Getting Signalling

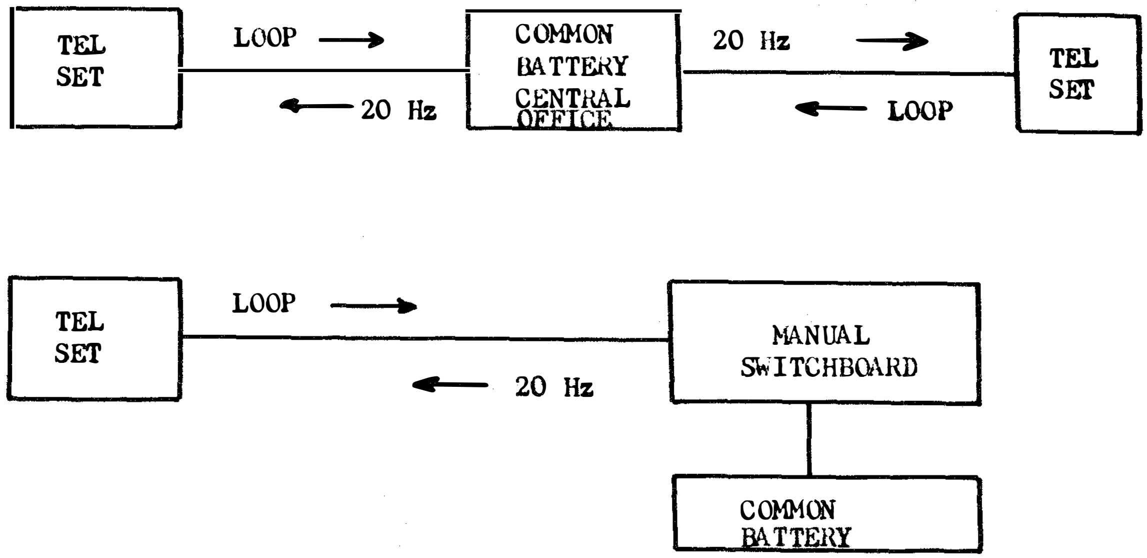


Figure XVIII - 7B Attention Getting Signalling

3. Selecting signals:

Now let's consider selecting signals, sometimes called address signalling. Twenty Hz is still used to provide semi-selectivity on subscriber lines with three or more parties. Twenty Hz is passed to either the T or R of the line in "code groups" of 1, 2, 3, 4 or 5 (that's about the limit) spurts of ringing current. The tel set ringers are connected to either T or R to ground, five ringers to T and five to R as shown in Figure 8.

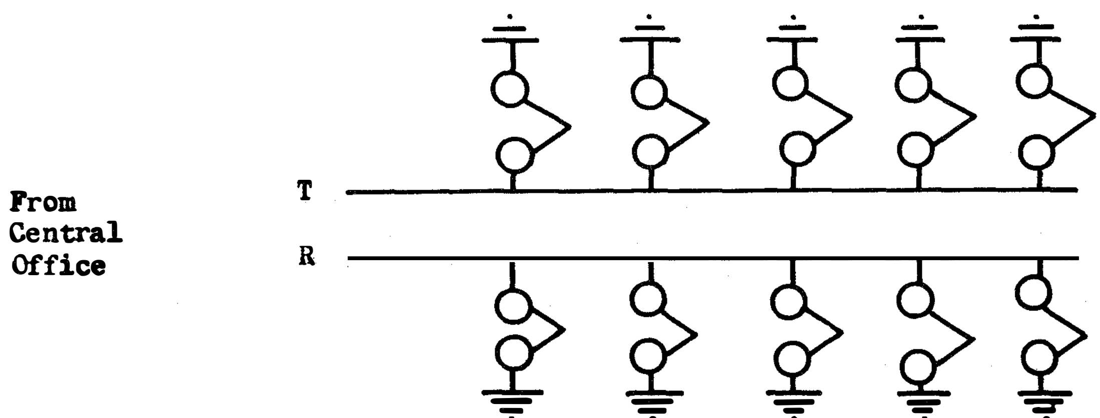


Figure XVIII - 8 Semi- Selectivity

Of course everyone hears 4 rings besides their own, thus semi-selectivity ie; they don't hear 10 rings.

Full-selectivity can be provided with only two parties on the line:

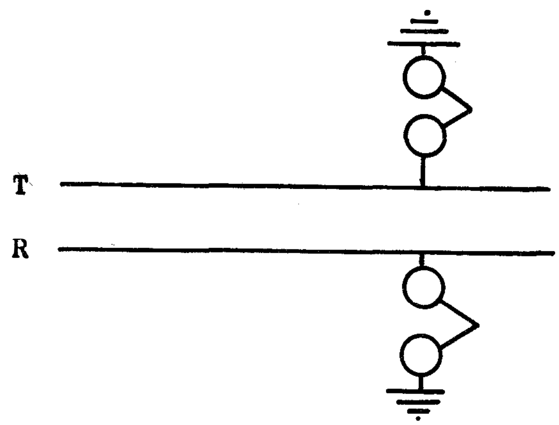


Figure XVIII - 9 Full-Selectivity

Neither party hears the others ring, thus full-selectivity. One party is called the TIP PARTY, ringer wired T to grd, and the other of course, the RING PARTY. If the ringer is wired one side to ground, it is called GROUNDED RINGING. If the ringer is wired across the line (ie, across T & R), it is called METALLIC RINGING.

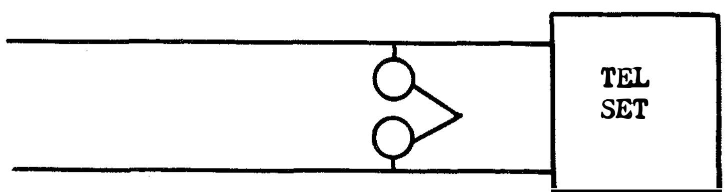


Figure XVIII - 10 Metallic Ringing

Another method of providing fully selective ringing involves the generation of different ring current frequencies and frequency selective ringers in the tel sets. Such a system is not widely used and semi-selective ringing is gradually disappearing. More people can now afford a private line and the commercial systems would much rather sell a single party line (it is called a One Spot) than a four party, or Four Spot.

Twenty Hz selective signalling is sometimes applied to private lines. The term PRIVATE LINE as used here means a line to which no one but the buyer of the private line service has access. They are sometimes called LEASES or LEASED LINES. Twenty Hz selective signalling applied to this type of service requires a trunk circuit at the customer location that responds to 20 Hz and differentiates between 1, 2, 3 or more rings, then in turn rings or buzzes the proper tel set. This system is not used to any great extent. It requires a degree of skill of the calling party that most users will not take the effort to learn and they blame the consequent failure on the telephone company.

Selective loop signalling usually consists of DIAL PULSES made by the dial on the tel set. When a telephone is picked up (goes off hook), the hook switch closes the loop to the common battery central office, places the dial contacts in the loop, and operates the line relay in the central office. A clearer picture of the circuitry is given in Figure II.

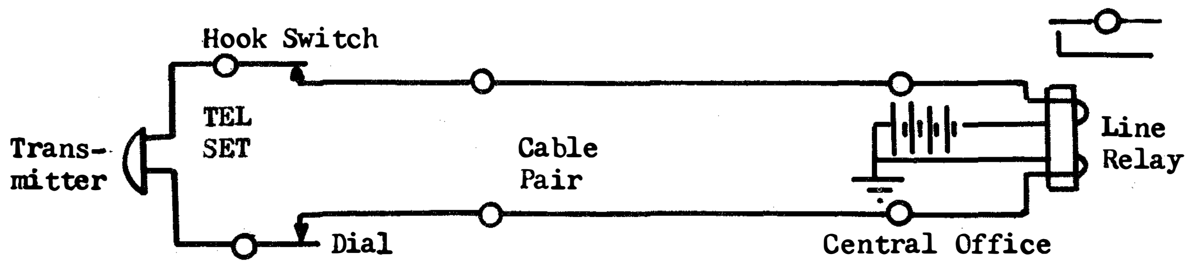


Figure XVIII - 11 Dial Circuit

The closed contacts of the line relay cause many things to happen in the central office and eventually your line is located by the switching equipment and it sends dial tone to your tel set. Now you can dial. If you dial say a 6, you will cause the dial contacts to open and close 6 times, causing the current in the loop to cease and flow 6 times. Or you've created 6 DIAL PULSES like this:

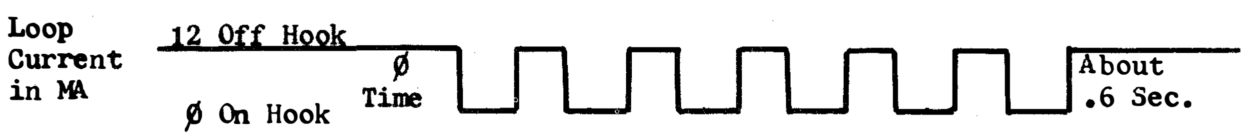


Figure XVIII - 12 Dial Pulse Train

The common battery central office switching equipment absorbs the dial pulses and if you send it a legitimate number of proper pulses, it will ring the party you want - if that line is not busy or out of order.

4. Supervisory Signals:

Supervisory signals, or just supervision, are control or call monitoring signals. Some supervision functions are:

a. Cord lamp supervision: After you have placed a call through a manual switchboard and want to talk to the operator you can "recall" the operator by "jiggling" the hookswitch. This of course opens and closes the loop and causes the switchboard cord lamp in use on your call to flash on and off advising the operator you want assistance. After you have completed your call and hang up, the loop goes open, or on hook, and the cord lamp is lighted steadily indicating to the operator you have completed the call. Switchboard operators can recall each other by "ringing back" on an established trunk connection. The process is rather complicated, but the ring signal causes the distant cord lamp to flash until the operator opens his talk key on that cord circuit.

b. Coin collect supervision: When the called party answers a call placed from a dial coin telephone, or COIN BOX, the loop closure causes the battery and ground in the central office to be reversed which indicates to the coin telephone trunk circuit than coin collect rather than coin return battery must be sent to the coin box after the caller hangs up. The same battery reversal takes place on all answered calls and is used also to operate registers or counters associated with a "message" service (A service that permits so many calls a month for a flat fee then so much more money for each additional call). The same reversal is also used to provide cord lamp supervision to an operator who has dialed a number, perhaps from a distant city.

Dial speed is adjusted to satisfy the type of switching equipment in the central office, 10 to 12 pulses per second. Note that the "longer" the loop, the greater its resistance and the lower the loop current. Beyond a certain distance, measured in ohms not miles, special "long line" equipment is necessary.

5. Development of Long Distance Signalling:

So far we've considered signalling over short distances. When 20 Hz or loop signals are required to be transmitted, say 100 miles, special equipment is necessary. 20 Hz can be transmitted over a cable pair for about 30-35 miles without special equipment, but beyond that distance, the signal must be REPEATED. (At the end of a 30 mile trip the 20 Hz signal operates an INTERMEDIATE RINGER which sends fresh 20 Hz from a local generator on to the next ringer, etc.). Loop signals can be transmitted for somewhat less than 1000 ohms and still be intelligable to a central office. One thousand ohms loop resistance equals about six miles of 22GA CABLE and about 11 miles of 19GA CABLE. Loop resistance is the resistance out on one wire and back on the other wire of the pair. Beyond approximately 1000 ohms, sensitive LONG LINE EQUIPMENT or PULSE REPEATERS are necessary. Long line equipment (sometimes called long haul) can handle loops as long as 5000 ohms. Pulse repeaters will not necessarily handle loops of over 1000 ohms, but do absorb the weak pulses, reshape them, make fresh pulses and send them on. If is not economical to transmit 20 Hz or loop signals from city to city because of the extra equipment required. Both ringing and dial signals can be efficiently transmitted over long distances by changing the 20 Hz or loop signal to a form more suitable to transmission over modern telephone circuits.

Let's examine briefly the historical development of long distance signal transmission. Some of the older systems are still in use. 20 Hz signalling was not well suited for use on "long distance" or "toll" cables because the cables carried many telegraph (TGH) circuits riding along on the same cable pair with a voice circuit. This was accomplished by a SIMPLEX (SX) or COMPOSITE (CX) circuit. It was common practice to transmit 60 word per minute (60 speed) teletypewriter signals on the SX or CX facility.

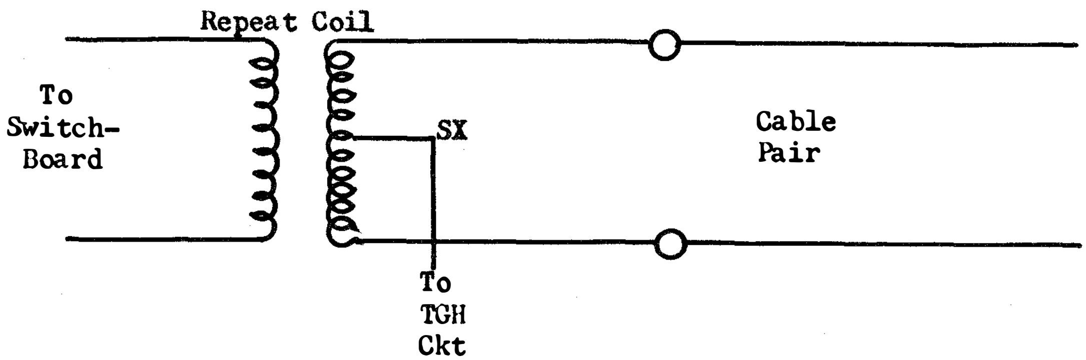


Figure XVIII - 13 Simplex Circuit

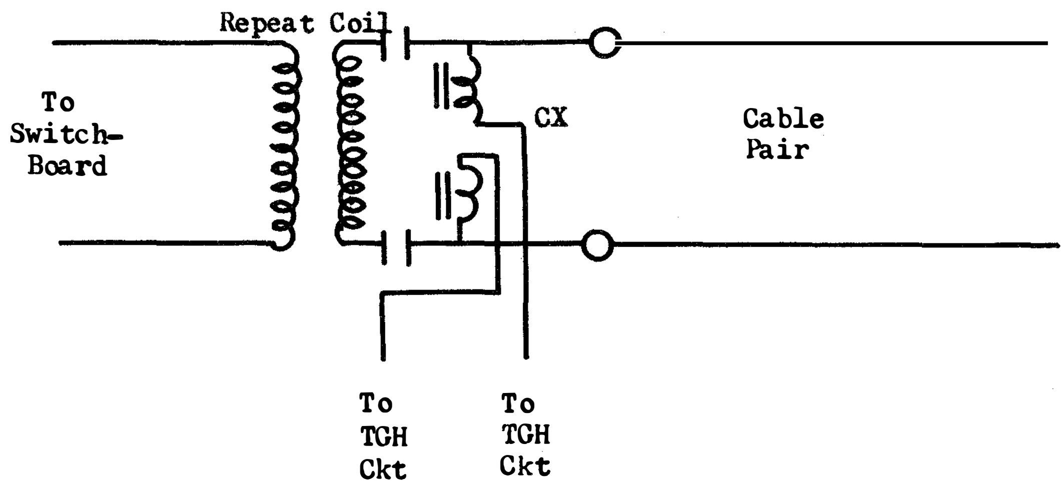


Figure XVIII - 14 Composite Signalling

60 word per minute teletypewriter signals are very close to 20 Hz, and thus if 20 Hz ringing signals were used on such a circuit, it would interfere with the teletypewriter signal. For this reason 135 Hz ringing was developed and widely used until about 10-15 years ago. The trouble with 135 Hz ringing was the necessity to bypass it around a voice frequency repeater (amplifier). 135 Hz is too low a frequency for voice frequency amplifiers (normally used on telephone circuits) to pass. So the next development was 1000/20 ringing

(1000 Hz modulated at 20 Hz). 1000 Hz passes through a VF (voice frequency) repeater, but must be modulated because the ringer receiver circuit at the far end could otherwise be "talked off" (operated) by 1000 Hz voice energy. 135 Hz signalling is practically a thing of the past and the Bell System is now phasing out 1000/20 signalling.

The technique of transmitting signals over relatively long distances leaned heavily on telegraph practices initially. Ringing, dial and supervisory signals are changed by a TRUNK CIRCUIT to direct current signals which can be transmitted over a cable telegraph facility (TF). Some early trunk circuits used positive and negative 130 volt telegraph battery as a source of signal current, but modern trunk and signal circuits use negative 48 volts.

6. Present Day Long Distance Signalling:

Present practice utilizes a dial or ringdown trunk circuit with E and M leads. The E and M leads are the signal leads that connect the trunk circuit to a signal circuit. The M lead transmits and the E lead receives. The M lead usually transmits battery (-48V) and ground toward the signal circuit. The E lead usually receives ground and open from the signal circuit.

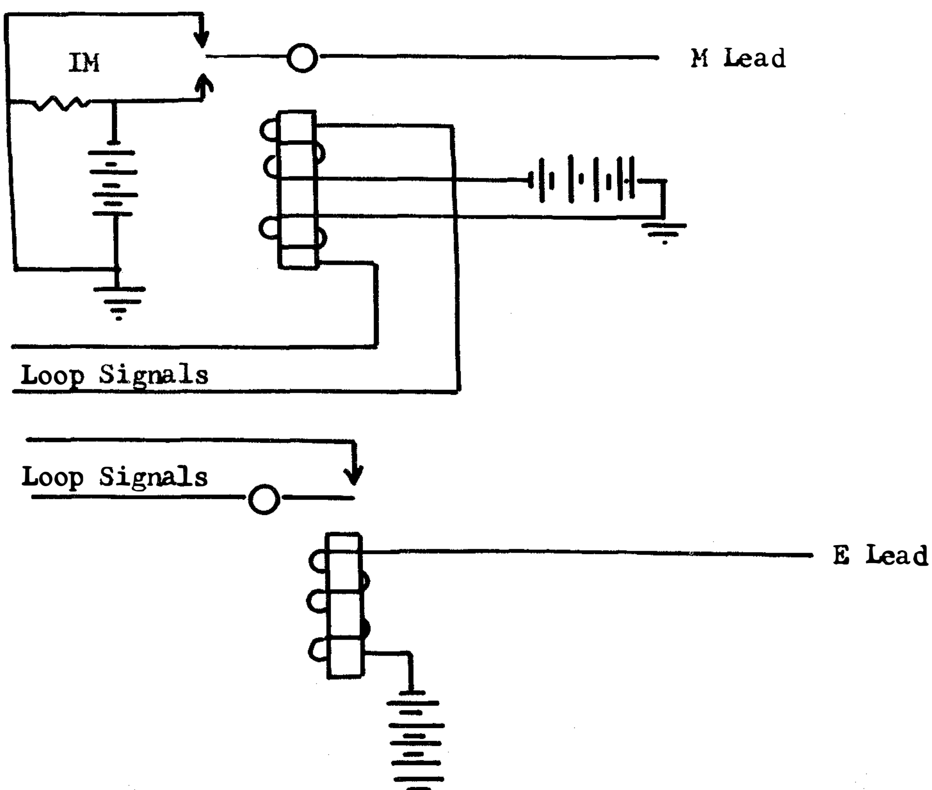


Figure XVIII - 15 E-M Lead

Part of a trunk circuit is shown in Figure 15. The upper relay is called a pole changer and converts the loop signal current in its winding to ground-battery signals toward the signal circuit. The lower relay takes open-ground signals from the signal circuit and changes them to loop signals. No trunk circuit is quite this simple, and thus the schematic drawing in Figure 15 is very elementary. E and M lead signals can be any of our three basic types:

a. Ringing (attention getting)

b. Dialing

c. Supervision

Trunk circuit E-M leads are wired to signal circuit E-M leads. The signal circuit can be one of several types:

a. Composite

b. Single frequency

c. E-M lead extension

d. Multi - frequency

Let's discuss each of these in detail:

(1) Composite signal circuit: Basically this circuit is a full

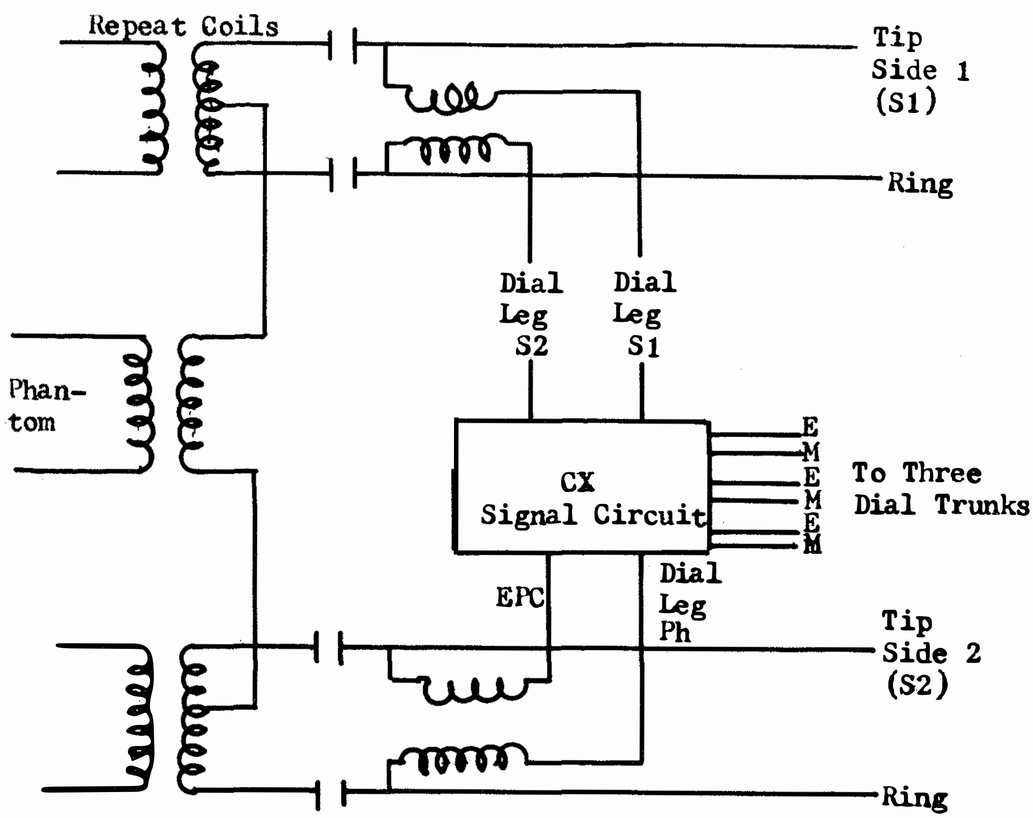


Figure XVIII - 16 Composite Signal Circuit duplex telegraph circuit. The usual arrangement consists of CX signal circuits in groups of three - side 1, side 2, and phantom to work on a quadded cable group, two pair, three circuits, side 1, side 2, phantom. The four wires of the cable group provide 3 signal legs and an EPC, earth potential compensation leg. This type of signalling is now used to serve towns so small that carrier facilities are not economically feasible in view of existing cable plant capabilities.

(2) Single frequency signalling: Most American cities of any size have cable carrier or microwave facilities serving them. The single frequency signal system was designed to operate on a carrier channel. The signal set is wired into the circuit like this - one on each end of the circuit (IWCS configuration is shown):

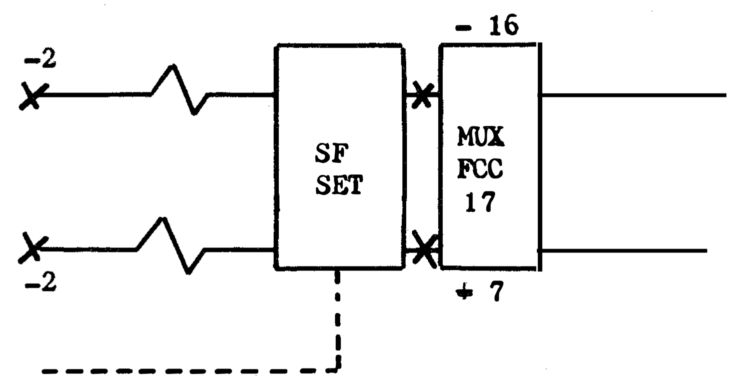


Figure XVIII - 17 Single-Frequency Signalling

The SF set changes the DC signal on the M lead to tone signals on the carrier line. The tone received by an SF set is changed to a DC signal on the E lead. Some 1600 Hz SF sets are still in use, but 2600 Hz is much more common. You will frequently hear the expressions ON HOOK, OFF HOOK, TONE ON, TONE OFF, etc., used in connection with SF signals. The table below gives conditions of equality for ON and OFF HOOK:

CONDITION	M	TONE	E
ON HOOK	GROUND	ON	OPEN
OFF HOOK	BATT	OFF	GROUND

Figure XVIII - 18 Standard Conditions

These conditions are not always the case in the ICS system. In ICS the following is true for ring down circuits only:

CONDITION	M	TONE	E
ON HOOK	GROUND	ON	GROUND
OFF HOOK	OPEN	OFF	OPEN

Figure XVIII - 19 ICS Conditions

ICS ring down converter and SF set options were selected to permit this E lead condition, which in turn permits wiring SF sets back to back without pulse link repeaters (refer to Paragraph 4, Section D, Chapter VI). Back to back wiring is shown below:

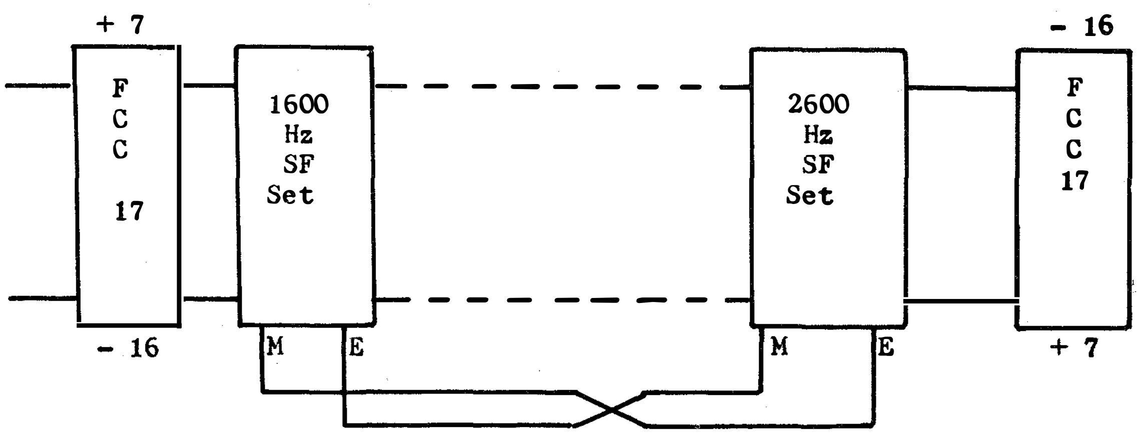


Figure XVIII - 20 SF Units Back-to-Back

3. E-M extension (also called DX signalling): E and M leads cannot normally be extended from the signal circuit to the trunk circuit for any appreciable distance. DCA and the Bell System require that maximum resistance of E or M lead be 25 ohms. Sometimes the signal circuit is located a long distance from the trunk circuit. To extend signalling in such a case requires an EMX (Bell terminology) or DX circuit to extend the E-M leads. The extended signal leads are connected to the cable pair, which also carries the voice energy, through A-B leads on a repeat coil (Figure 21).

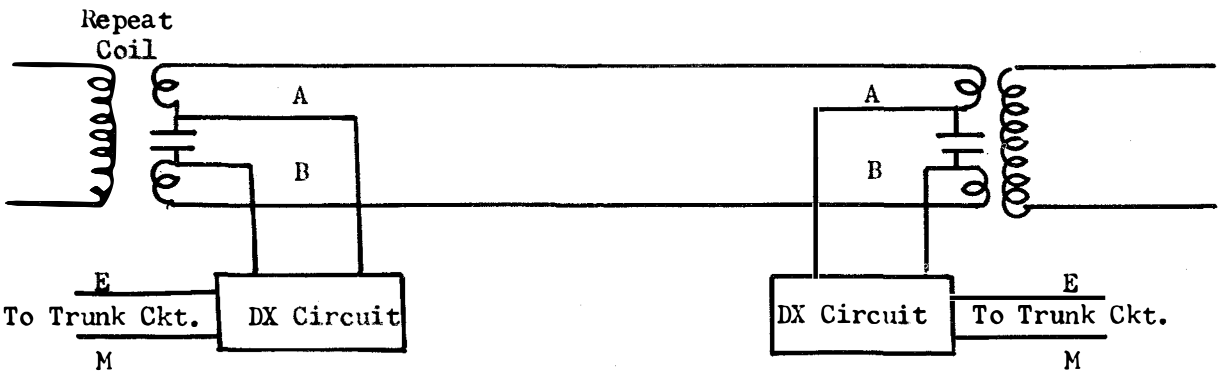


Figure XVIII - 21 E-M Extension Using Repeat Coil

or through A-B leads on a hybrid (4 wire term set) as shown below.

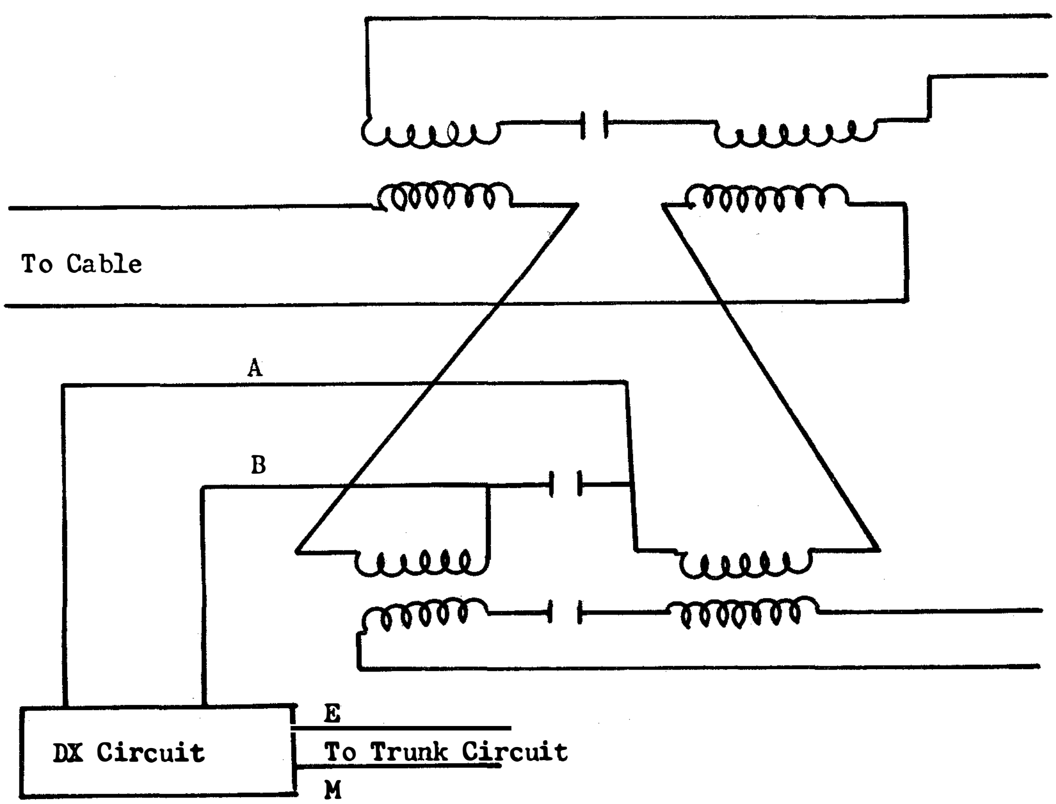


Figure XVIII - 22 E-M Extension Using Hybrid

(4) Multi-frequency signalling: A multi-frequency (MF) trunk circuit changes DC dial signals to tone signals. Two tones are transmitted for each digit and the trunk circuit at the other end changes the tone combinations to DC signals which can be used by the dial switching system.

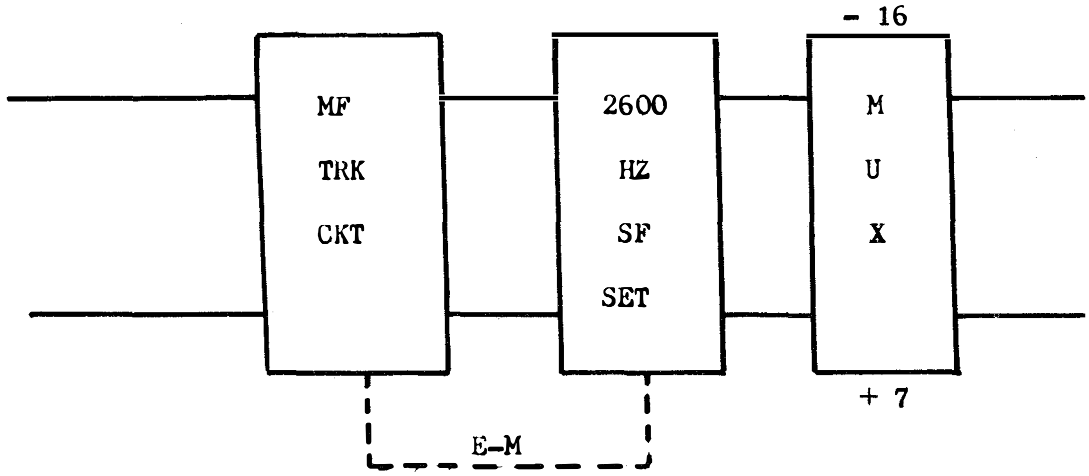


Figure 23: Multi-Frequency Signaling

Note that MF trunk requires a SF signal set, but only to transmit and receive ringing and supervisory signals.

B. SIGNALLING OVER TELEPHONE TRUNKS.

Signaling provides the means for operating and supervising a telephone communications system; it establishes connections, announces incoming calls, reports the fact that a line is busy. The functions of signaling are indeed most vital to the basic operation of the telephone plant.

Trunk signaling involves many considerations that are quite different from the basic techniques employed in signaling over a subscriber loop. This article reviews some of these considerations and describes the major techniques used to transmit signaling information over physical and carrier-derived trunk circuits.

Without signaling, a telephone system cannot operate. Even the simplest system, such as two local battery telephones connected by field wire, requires some means for the users to attract one another's attention when they want to talk. In early telephone systems, users simply cranked a hand magneto which caused a bell to ring at the subscriber station or a flag to drop at a switchboard. Over the years, signaling systems have had to keep pace with the advances made in telephone switching and transmission systems. The increasing complexity of the worldwide telephone plant has had a tremendous influence on the evolution of signaling techniques, from the simple hand cranked magneto to the many techniques employed today.

Many different signaling methods have evolved during the transition from one type of switching office or transmission system to another. Today's telephone plant includes various types of local exchange and toll switching offices, such as manual, step-by-step, panel, crossbar, and the modern electronic switching offices. In addition, there are many types of open-wire, cable and microwave radio transmission systems interconnecting the various switching offices.

Signaling Functions

There are a multitude of signaling functions that must be transmitted between the various manual and dial switching offices. These include functions whereby people must communicate with machines, machines must communicate with other machines, and machines must communicate with people.

The major functions can be somewhat arbitrarily classified as *ringing, supervisory,* and *address* (or dialing). Ringing signals are used to operate a visible or audible alarm to alert someone of an incoming call. Supervisory signals are used to convey information regarding switchhook conditions (on-hook or off-hook) at either end of a telephone circuit. Address signals convey dialing or digital information which is necessary to establish the desired connection.

In subscriber loops, supervisory and address signals are accomplished by means of direct current, while alternating current is used for ringing. Direct current signaling is also used on short-haul trunks between switching offices. However, such methods are not adequate for signaling on longer trunks, such as inter-toll, or on trunks derived from carrier or multiplex systems. As a result, various alternating current signaling systems have been developed for use over long-haul v-f and carrier-derived trunks.

Ringdown Trunks

In certain trunks, especially those interconnecting manual offices, it is necessary to transmit a ringing current to signal the switchboard operators. This type of signaling is known as *ringdown.* The ringing alternating current used in subscriber loops is at a frequency of 20 Hz. This same frequency is also used in certain short-haul trunks. On trunks equipped with composite telegraph, 20-Hz ringing cannot be used because of interference. In these circuits, a signaling frequency of 135 Hz is used. Neither of these frequencies, however, is suitable for long trunks because voice-frequency repeaters cannot pass them. Consequently, a 1000-Hz signaling tone, well within the v-f amplifier passband, has been adopted for use on longer circuits. To prevent voice signals from falsely operating the signaling equipment, the 1000-Hz tone is interrupted (modulated) at a 20-Hz rate.

Address Signals

Probably the most important and the most complicated signaling function is address or dialing. This function directs the operation of the switching equipment in the automatic offices. Consequently, the evolution of the various switching systems has brought about changes in address signaling techniques. Address signals originate at the telephone dial and consist of a train of dc pulses corresponding to the number dialed. Modern "touch calling" systems, which use keys or pushbuttons instead of a dial, employ tones at different frequencies rather than dc pulses.

In the step-by-step systems, the switching equipment responds directly to the dc pulses. However, in panel and crossbar systems, the switches cannot be controlled directly by the dial pulses. Consequently, these systems require a device known as a *sender* which stores the dial pulses and then controls the movement of the switches.

There are four basic methods commonly used to transmit address or dialing signals for use by the various switching offices. These are known as *dial pulsing, revertive pulsing, panel call indicator (PCI) pulsing,* and *multifrequency (MF) pulsing.*

Dial pulsing is the earliest and most commonly used method of transmitting address information — the numerical value of each digit is represented by the number of pulses in a train (ten pulses

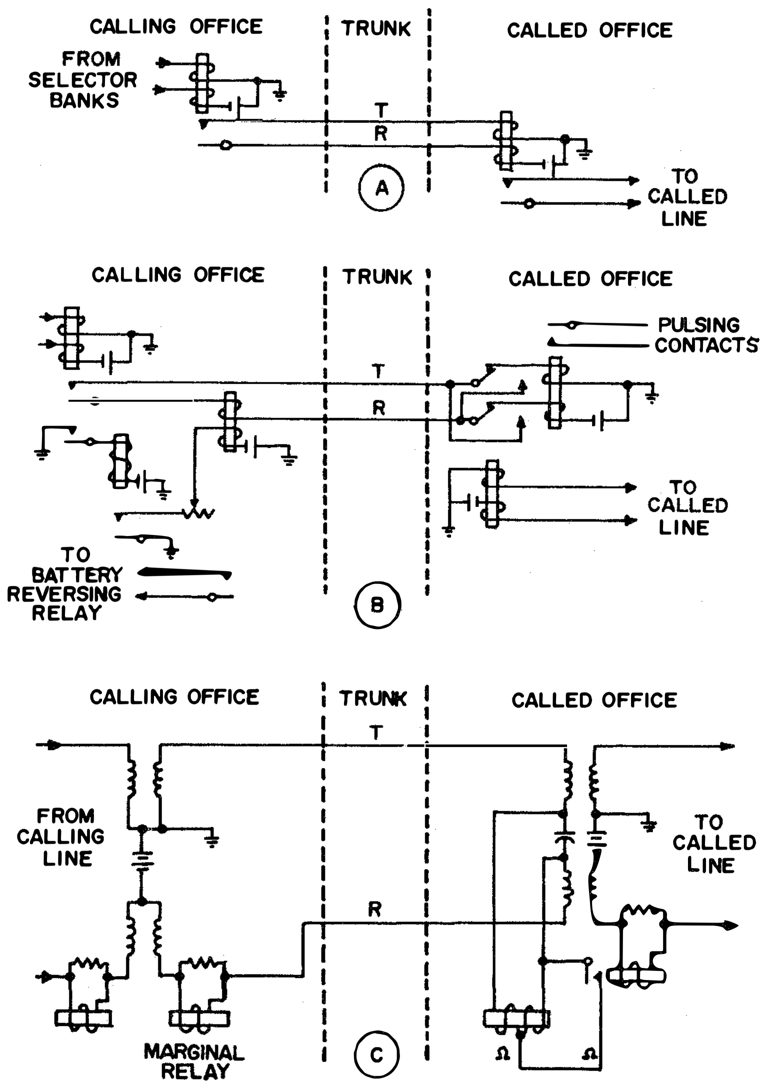


Figure 1. Loop signaling is accomplished by altering the flow of current in the trunk conductors. Three methods used to accomplish loop signaling are: (A) wet-dry, *(B)* reverse battery, *and (C)* high-low.

represents 0). Dial pulsing is used in all types of switching offices.

Revertive pulsing was originally developed for use in panel switching offices. In this type of pulsing, the address pulses are not transmitted by the originating office. When a call is made, a loop to the distant office is closed. This starts the movement of a panel selector switch at the distant office. As the selecting wipers pass each terminal, a commutator transmits pulses back to the sender at the originating office. When the proper number of these *revertive* pulses, corresponding to the called number, are received by the sender, a signal is sent back to the distant end to stop the movement of the selector. Revertive pulsing is used in certain crossbar offices as well as panel offices.

Panel call indicator (PCI) pulsing is a method of transmitting address signals between a dial office and a manual office. This technique converts pulses received from a dial office to lamp indications which appear on a switchboard. The switchboard operator then connects the incoming call to the called number and rings the subscriber.

Multifrequency (MF) pulsing is the newest method of transmitting address pulses between switching offices. Digital information is transmitted in the form of short tone bursts. Six signaling frequencies are used, each digit being represented by a combination of two of the six frequencies. The signaling frequencies fall within the speech band and are simply processed through the trunk in the same manner as speech signals. (A different form of multifrequency pulsing has recently been introduced to subscriber loop circuits through the use of telephones with pushbuttons instead of the conventional dial.)

Historically, signaling systems designed to transmit supervisory and address information have evolved from simple dc systems operating over 2-wire short-haul interoffice trunks, to complicated ac systems operating over multichannel carrier and microwave transmission systems. Today, there are essentially two fundamental techniques used to derive signaling paths on trunk circuits. The first of these is known as *loop signaling*. This technique requires a dc loop, and is the method used in all subscriber loops and in most short-haul 2-wire trunks. The second signaling technique, known as *E & M*, is used with both ac and dc signaling systems on 2-wire or 4-wire physical trunk circuits, and on carrier-derived trunk circuits. This type of signaling is standard for use in all intertoll trunks.

Loop Signaling

Loop signaling is the simplest of the two, and is used in certain exchange trunks, short-haul toll-connecting trunks, and one-way dialing toll trunks, where 2-wire voice-frequency circuits are employed. The dc signaling current flows over the same conductors used for voice transmission.

This type of signaling is accomplished by simply interrupting the condition of a dc voltage applied to the line to transmit both supervisory signals and dialing information. The range of loop signaling is usually limited to about 25 miles because of the dc resistance of the conductors.

There are three methods currently used to apply loop signaling to a 2-wire voice-frequency trunk: *wet-dry, reverse battery,* and *high-low.* (See Figure 1.)

In the wet-dry method, signaling information is indicated by the presence (wet) or absence (dry) of a battery and ground condition on the line at the called end of the trunk. Normally in the wet condition, the battery is placed on the ring conductor and ground on the tip conductor.

As its name implies, reverse-battery loop signaling is accomplished by reversing the polarity of the battery on the line to indicate supervisory conditions. For one condition, battery is on the ring conductor and ground on the tip conductor. The opposite supervisory condition is indicated by reversing the polarity of the battery, thus causing a polar relay to operate or release at the distant end of the trunk. This is the most prominent type of loop signaling used between exchange offices. To increase the operating range of reverse-battery loop signaling, batteries are sometimes placed at both ends of the circuit, in series. This variation of reverse-battery operation is called *battery and ground* signaling.

The third method, high-low, is used principally for supervisory signaling within a central office or from an automatic to a manual office. This type of signaling employs a marginal relay. During on-hook condition, a high resistance is placed in the loop. For off-hook, the resistance in the loop is reduced to a low value allowing more current to flow, and thereby causing the marginal relay to operate.

E & M Signaling

As mentioned previously, loop signaling is limited to trunks of about 25 miles in length. Also, such systems do not provide simultaneous signaling in both directions. In order to overcome these limitations, and especially to extend the dialing range of telephones, another type of signaling was developed.

This method of signaling employs two leads to connect the signaling equipment to the trunk circuit. These two leads are designated E and M, respectively. The name for the two leads was probably acquired from designations appearing in early drawings for this type of signaling circuit. The M lead transmits battery or ground signals to the distant end of the circuits, while incoming signals are received on the E lead as either a ground or open condition. Thus, the M lead reflects conditions at the near end of the circuit while the E lead reflects conditions at the far end.

There are several methods of deriving an E and M circuit to permit signaling between offices on a dc basis. These arrangements are known as simplex (SX), composite (CX), and duplex (DX). A simplex signaling circuit is obtained by means of a center-tap coil placed at both ends of the voice-frequency trunk circuit, as shown in Figure 2A. Signaling currents flow in both directions through the coils and, therefore, do not induce any interfering voltages into the voice channel. Conversely, voice currents do not flow through the simplex conductors (or legs) extending from the center tap of the coils. Since the two trunk conductors provide a parallel path for the signaling current, the dc resistance is approximately one-fourth of that presented to a loop-signaling arrangement over the same trunk. Thus, the dc signaling range is extended considerably. However, simplexing has certain disadvantages and has been largely superseded by the duplex arrangement.

In the composite method, a filter is used at each end of the trunk to separate the signaling current from the speech signals. The filter is called a *composite set.* Two composite signaling paths can be obtained from the two conductors of a v-f trunk and four can be obtained from a phantom circuit arrangement. This type of signaling, shown in Figure 2B, is used typically

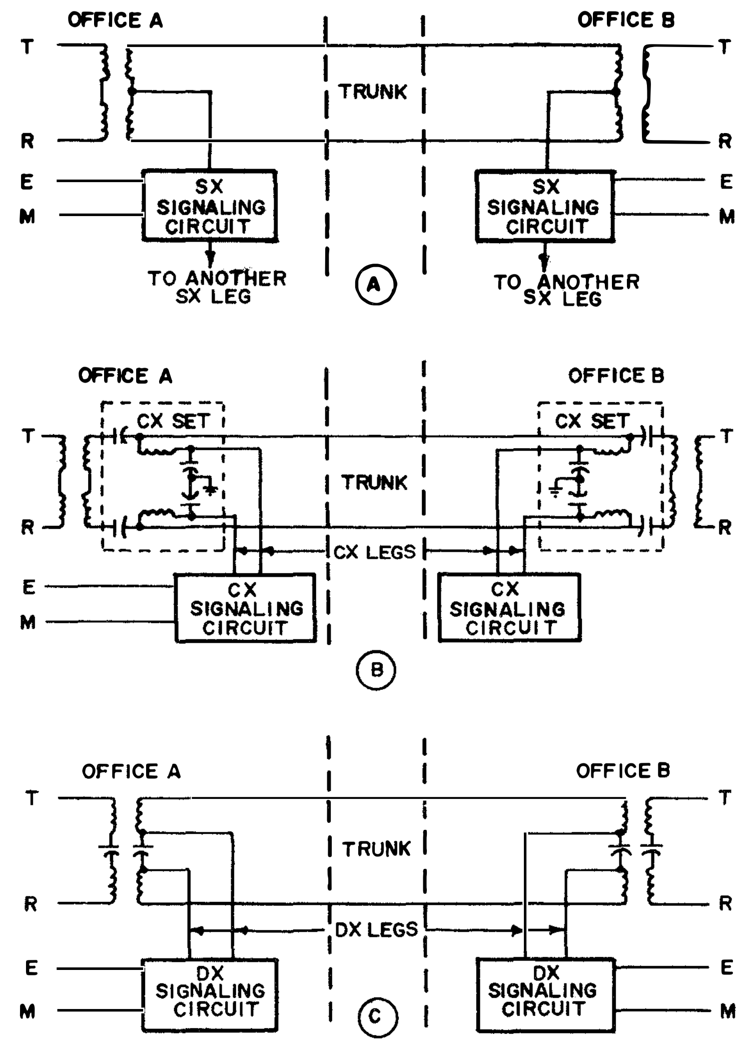


Figure 2. There are a number of different circuit arrangements designed for E & M signaling over telephone trunks. The three most prominent d-c arrangements are: (A) simplex, *(B)* composite, *and (C)* duplex.

on trunks derived from quadded cable where the conductors are arranged in phantom groups.

The duplex signaling arrangement, like the composite method, uses one conductor of the v-f circuit for signaling on a ground return basis, and the other conductor for ground potential compensation. Ground potential compensation is required because of the inherent instability of ground-return circuits. The composite set or filter, however, is not used with the duplex circuit. Instead, the signaling circuit is connected to the trunk pairs by means of a center-tap transformer and a capacitor, as shown in Figure 2C. This signaling arrangement is used primarily in paired cable trunks.

AC Signaling

The dc signaling systems described thus far are limited to relatively short v-f trunks containing a dc path. These systems are not suitable for use on long v-f trunks employing repeaters, or for carrier or multiplex trunk circuits because a dc path is not available. As a result, ac signaling systems had to be developed for use over the more modern exchange trunks and on the longer toll-connecting and intertoll trunks, especially where carrier is used.

The ac signaling systems use frequencies within the voice-frequency range so that the signals can be transmitted directly over the same path used for voice transmission. These ac systems usually employ E and M leads to connect the signaling circuit to the trunk. If the signaling frequency falls within the band used for speech transmission (typically 300 to 3400 Hz) the system is referred to as an *in-band* system. If the signaling frequency falls outside the speech band, the system is called an *out-of-band* system.

The ac systems must process the dc supervisory and address signals received from the switching office and convert them into ac signals for transmission over the trunk circuit. At the other end of the trunk, the ac signals must be converted back to dc signals before being applied to the switching equipment. Only one signaling frequency is required on 4-wire trunks. However, on 2-wire trunks two frequencies are required, one for each direction of transmission.

Early ac signaling systems used a frequency of 1600 hertz. On 2-wire trunks, 1600 hertz was used for one direction and 2000 hertz for the opposite direction. Later in-band systems used a frequency of 2600 hertz, with a second frequency of 2400 hertz for use with 2-wire trunks. The ac signaling frequencies easily pass through the same path used for voice transmission, and are amplified in repeaters in the same manner as speech signals. These so-called single-frequency (SF) signaling systems are used to transmit both supervisory signals and address or dial pulses. Multifrequency (MF) address pulsing, described previously, uses tones that are already in the voice band, so they do not require additional processing before being transmitted over a long-haul or carrier-derived trunk.

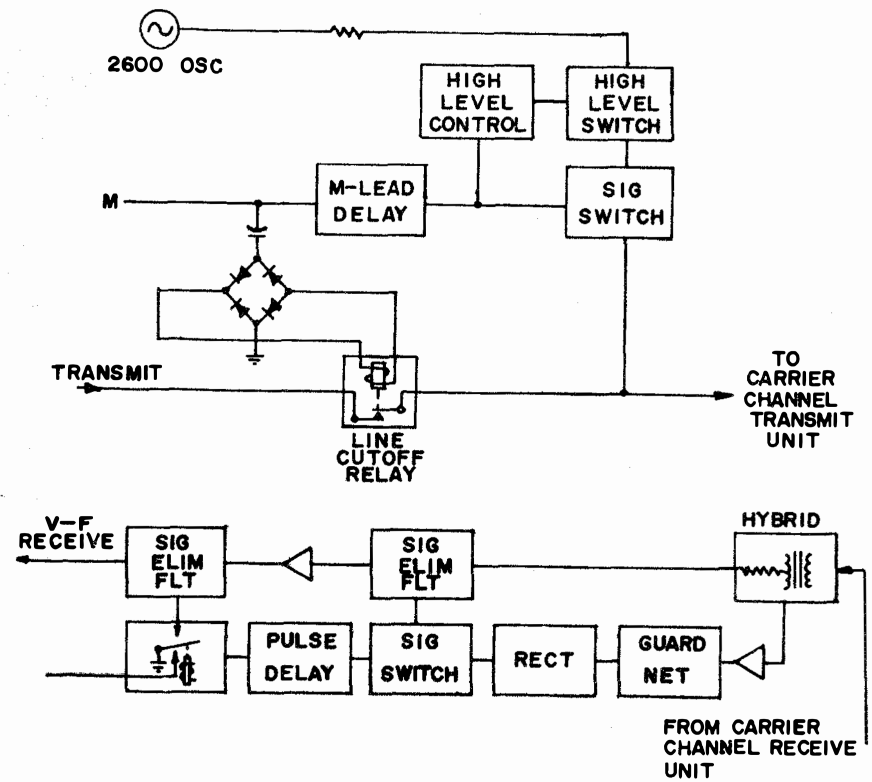


Figure 3. Simplified block diagram of a 2600-hz in-band signaling circuit applied to transmit channel and receive channel of a carrier system.

Signaling Over Carrier Channels

All trunk circuits equipped with carrier or multiplex equipment require some type of ac system for signaling. There are many different carrier signaling systems in use today employing either an in-band or out-of-band signaling frequency.

The most prevalent type of carrier signaling is accomplished with in-band frequencies. In-band signaling systems have an advantage over out-of-band systems in that they do not require extra bandwidth — the signals are passed directly through the voice channel. Another advantage is that signaling equipment is required only at the terminal stations of a trunk made up of several tandem links. Also, the in-band signaling system can be made a part of the office switching equipment rather than the particular carrier system, thus making it easier to patch trunk circuits to different carrier transmission systems.

The main disadvantage to in-band systems is that the signaling tones lie within the speech band. This leads to the possibility of speech energy at the signaling frequency "talking down" the signaling; that is, falsely operating the signaling equipment with speech energy. Protection against "talkdown" can be accomplished by using a time delay or guard circuit in the signaling system. By introducing a delay, the signaling circuit can be made insensitive to most voice energy or transient noise at the signaling frequency.

Additional protection is obtained by properly selecting the in-band signaling frequencies. Generally, it is desirable to use the highest possible frequency that will pass through the voice channel. Speech energy declines rapidly at the higher frequencies, thereby reducing the chances of "talkdown".

Most of the older voice-frequency telephone circuits use filters with an upper frequency cutoff of about 2800 hertz. For this reason, the most commonly used frequency for SF in-band supervisory and address signaling is 2600 hertz. In-band carrier signaling systems can be adapted for use with either loop signaling or E & M signaling arrangements.

Following the development of economical short-haul carrier systems, the need arose for inexpensive methods of signaling. This need resulted in the development of various out-of-band signaling systems. Out-of-band signaling equipment is generally less expensive than in-band equipment and also permits signaling during speech transmission, thus permitting extra functions such as regulation to be performed. Since the signaling frequency is outside of the speech band, there is no need for complicated guard circuits to prevent talkdown.

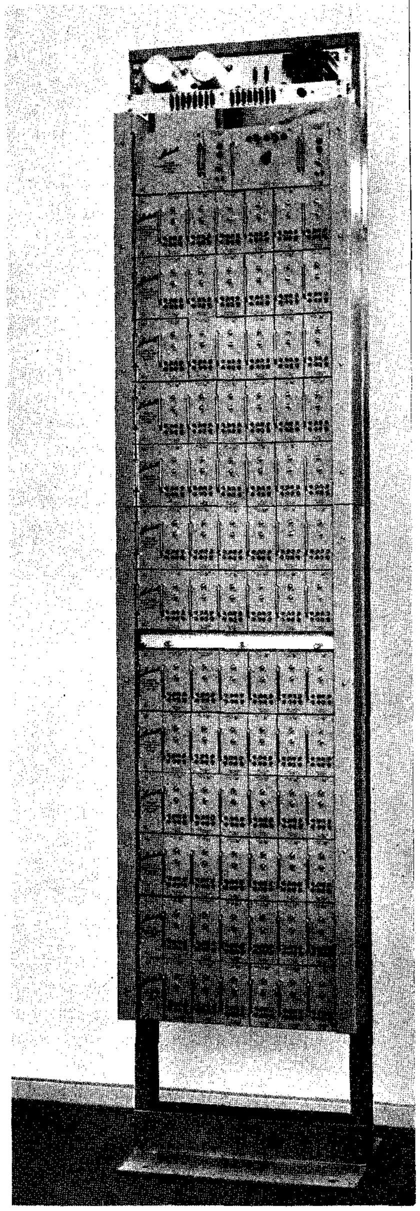


Figure 4. Photograph of typical in-band signaling units used with carrier systems. One signaling unit is required for each carrier channel. Many types of signaling units are required to accommodate the many different methods of signaling.

With out-of-band signaling, voice channel filters are designed with an upper cutoff frequency well below the top edge of the channel. This leaves the top portion of the channel passband available for transmitting out-of-band signaling tones. The most prevalent frequencies used for out-of-band signaling are 3700 hertz, which is standard throughout the Bell System, and 3825 hertz, which is recommended by the International Telegraph and Telephone Consultative Committee (CCITT) for use in international circuits.

Unfortunately, out-of-band signaling has certain disadvantages which tend to limit its use. Out-of-band signaling equipment has to be built-in to the carrier channel equipment and cannot be separated as in the case of in-band signaling equipment. This condition prevents randomly patching the circuit to other trunks.

Also, out-of-band signaling requires some sort of dc repeater at the end of each link of a multi-link trunk. As the signal passes from one link to another, the signal pulses must be detected and then made to operate a relay. The relay, in turn, keys the signaling equipment in the succeeding link. Thus, signaling equipment is required at both ends of each link in the trunk.

Another economical type of signaling, using time division multiplexing techniques, is used in Lenkurt's 81A exchange trunk carrier system. This unique method provides signaling for all 24 voice channels of the system using one common signaling channel. Each voice channel is assigned a specific time slot for signaling, and all 24 slots are scanned 500 times per second. The resulting signaling frequency modulates a pilot in the carrier system that is also used for slope regulation.

Although out-of-band and time division multiplex signaling techniques may be more economical for certain short-haul trunks, they lack the flexibility and other advantages offered by in-band signaling systems, especially when applied to long-haul trunks. As a result, single-frequency (SF) in-band signaling for supervisory functions and multifrequency (MF) pulsing for address functions have become the standard methods of signaling in modern interoffice, toll-connecting, and intertoll trunks.

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C. DB AND OTHER LOGARITHMIC UNITS. *

Dealing with very large and very small numbers is often necessary in the telecommunications industry. For example, the frequency of a typical microwave radio is 12,000,000,000 cycles per second. Or, the power represented in conversational speech is measured at about 1/100,000,000,000 watts/cm². These are obviously unwieldy terms.

Powers of Ten

However, there are various methods of handling them conveniently. Expressing numbers as *powers of ten* is a first step to simplicity. We know that $10 \times 10 = 100$, and can be written 10^2. Likewise, $10 \times 10 \times 10 = 1000$, or 10^3. By definition, the exponent 3 means that the number 10 is used as a multiplier 3 times. 12,000,000,000 cycles per second then becomes 12×10^9 cycles per second (or 12 GHz).

Note that $10^1 = 10$; $10^0 = 1$. Numbers smaller than 1 also can be treated using powers of ten. By definition, 10^{-1} is the same as $1/10^1$, or simply 1/10. In this way, the power rating for conversational speech mentioned previously can be written 10^{-11} watts/cm².

When discussing two relative values, it is sometimes convenient to use the term *orders of magnitude.* This is only another way of expressing powers of ten. That is, one order of magnitude (10^1) is 10 times as much; two orders of magnitude (10^2) is 100 times as much. Simple division indicates that a plane flying 1000 miles per hour is 100 times faster than a horse traveling at 10 miles per hour. It could be said that the plane is two orders of magnitude faster than the horse. Notice that orders of magnitude are really concerned with the exponent of the number. If a number is 1000 times greater than another, $1000 = 10^3$, or *three* orders of magnitude greater.

Logarithms

All of the figures in these examples have had the same "base" number of 10. If we treat the exponent of the base number separately, another useful shorthand is achieved, called *logarithms.* In $100 = 10^2$, the logarithm of 100 is 2. That is, the common logarithm (abbreviated Log_{10}) of a number is the power to which the base 10 must be raised to produce the number. The written form is $\log_{10} 100 = 2$. In practice the subscript $_{10}$ is usually eliminated when referring to common logs. Another log system used in mathematics has a base number of 2.718, and is written $\log_e$ or ln.

The use of logarithms is advantageous in many forms of complicated calculations. Remember that to multiply like numbers, it is only necessary to *add* their exponents ($10^2 \times 10^3 = 10^5$); to divide, *subtract* exponents ($10^5 \div 10^3 = 10^2$). Logarithms are used in the same way. Multiplications and divisions involving large numbers may be carried out by adding or subtracting the corresponding logs and then converting back. In fact, any series of events involving multiplication or division, if expressed logarithmically, may be handled by simple addition and subtraction. This is particularly valuable in the telecommunications industry, where a variety of measurements are necessary to describe the properties of a signal as it passes through the system. Voltages, currents, and powers are measured, noise identified, and losses assessed. These are all made much easier by the use of the logarithmic system.

Decibels

The basic unit of measure in communications is the *decibel,* derived from the less practical unit, the bel, named in honor of Alexander Graham Bell. A *deci*bel is a tenth of a bel.

DECIBELS	POWER RATIO
1	1.259
2	1.585
3	1.995
4	2.512
5	3.162
6	3.981
7	5.012
8	6.310
9	7.943
10	10.0
20	100.0
30	1000.0
40	10,000.0

Figure 1. The Relationship Between Decibels and Power Ratios.

Early experimentation proved that a listener cannot give a reliable estimate of the absolute loudness of a sound. But he can distinguish between the loudness of two *different* sounds. However, the ear's sensitivity to a change in sound power follows a logarithmic rather than a linear scale, and the decibel has become the unit of measure of this change. A difference of 1 decibel, abbreviated dB, in the power supplied to a listening device produces approximately the smallest change in volume of sound which the normal ear can detect. The relationship between any two power values can be calculated in decibels as:

$$dB = 10 \log \frac{P_1}{P_2}$$

where

P_1 is the larger power

It should be emphasized that a given number of decibels is always the relationship between two powers, and not an absolute power value by itself (Figure 1). For example, the gain in an amplifier, or the attenuation of a pad, can be expressed in decibels without knowledge of the input or output power of the device.

dBm

Frequently, it is convenient to represent absolute power with a logarithmic unit. One milliwatt is generally accepted as the standard reference for such purposes in the telephone industry, and signal powers can be written as being so many dB above or below this reference power. When this is done, the unit becomes dBm, in the expression:

$$dBm = 10 \log \frac{P_1}{P_2}$$

where

$$P_2 = 1 \text{ milliwatt}$$

By adding a definite reference point, dBm becomes a measurement of absolute power, rather than just a ratio, and can readily be converted to watts. 10 dBm indicates a signal 10 times greater than 1 milliwatt, or 10 milliwatts; 20 dBm is 100 times greater than 1 milliwatt, or 100 milliwatts. A 30 dBm sig-

* Reproduced from "The Lenkurt Demodulator" April 1966, Vol. 15, No. 4, with the permission of Lenkurt Electric Co, Inc. San Carlos, California.

nal applied to an amplifier with 10 dB gain will result in a 40 dBm output. Or, a standard test tone (0 dBm) will be measured as −15 dBm after passing through an attenuator of 15 dB.

It is important to note at this point that most meters used in the telephone industry are calibrated for measurements of voltage appearing across a 600-ohm termination (standard transmission line impedance). If the circuit to be measured is of a different impedance than that for which the meter is calibrated, the indicated power level will be wrong, and a correction factor must be taken into account. The relationship is:

$$dB\ (corrected) = dB\ (indicated) + 10 \log \frac{600\ ohms}{circuit\ impedance}$$

For example, a +6 dB reading across a 500-ohm line is calculated:

$$\begin{aligned} dB &= 6 + 10 \log \frac{600}{500} \\ &= 6 + 10 \log 1.2 \\ &= 6 + 0.792 \\ &= 6.792\ dB \end{aligned}$$

Level Point

In most telephone systems the toll switchboard is defined as the zero transmission level point (0 TLP), and the levels of both signal and noise at other parts of the system are usually referred to that point. A point in the transmission system where a signal has experienced 16 dB attenuation relative to the toll switchboard is known as the −16 dB level point. Note that *level* used this way is purely relative and has nothing to do with actual power — a signal of any power will be down 16 dB at the −16 dB level point. When a standard test tone is transmitted over the circuit, its power in dBm at any point is numerically equal to the level in dB at that point.

dBm0

Another term, dBm0, is used to refer measured power back to the zero transmission level point, and has useful significance in system planning. Measurements adjusted to dBm0 indicate what the power would have been had it been measured at the zero transmission level point. For example, a tone measured at the −16 dB level point with a meter reading of +8 dBm, is equal to +24 dBm0.

D. TELEGRAPH TRANSMISSION OVER VF MULTIPLEX SYSTEMS:

Telegraph systems provide a means of transmitting information using electrical pulses which conform to a preestablished code. In earlier days, telegraph messages were transmitted by hand-operated *keys* using the familiar Morse code. Modern telegraph systems, however, use electromechanical machines, called teleprinters, page printers, or tape printers, that employ some type of machine code.

Conventional telegraph machines use the standard 5-level Baudot code and normally operate at transmission speeds of 60, 75, and 100 words per minute, at pulse rates of 45, 57, and 75 bits per second, respectively. A new 7-bit code called ASCII (American Standard Code for Information Interchange) was recently developed and is expected to find wide application in data processing systems as well as for message processing. Telegraph systems currently using the new ASCII code have added an eighth bit to provide a parity check, thus making it an 8-level code. The new 4-row keyboard teleprinters designed to handle the new code operate at a transmission speed of 100 words per minute with a pulse rate of 110 bits per second. These various telegraph machines provide a printed copy of the message or a punched tape which is then used to operate a printer.

Telegraph machine signals consist of a sequence of current and no-current pulses of equal length, known as *mark* and *space*, respectively. Using the 5-level Baudot code, for example, the letter A is indicated by a signal of mark-mark-space-space-space. Before these dc telegraph signals can be transmitted over standard voice frequency communication channels, they must be converted to ac tones. There are two basic methods used to convert the dc loop pulses to tones suitable for transmission over a voice-frequency multiplex channel. These are amplitude modulation, and frequency modulation.

In both AM and FM telegraph multiplex systems, a tone oscillator, in each transmitting channel, is used to provide the necessary voice-frequency carrier. Frequency division is the type of multiplexing ordinarily used and so the carrier frequency in each channel is different.

Amplitude Modulation

Amplitude modulation methods are historically related to direct-current telegraphy. In dc telegraph, a battery or other source of direct current is keyed on and off. At the receiving end, the signals are detected by some sort of magnetic device. In AM, the process is similar except that a tone oscillator is keyed on or off to indicate mark and space conditions and, for this reason, is sometimes referred to as on-off modulation.

This method has several disadvantages. It does not use bandwidth efficiently, since two sidebands of the carrier are produced and, unlike single-sideband voice communications methods, the carrier and one sideband cannot be completely eliminated and still do a satisfactory job.

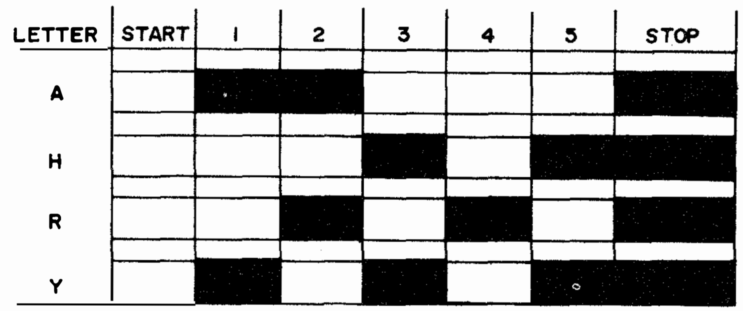
Sidebands are produced when the modulating wave causes the carrier to change from one value or state to another. In voice communications, the modulating waveform is continuous, thus causing modulation products (sidebands) to be formed continuously. If the carrier and one sideband are eliminated, the other sideband remains to convey the modulating intelligence.

In telegraphy, where on-off pulses are the modulating signal, modulation products are formed only during the transition from "on" to "off," and from "off" to "on." These modulation products are transients whose bandwidth is a function of the keying or switching rate. Except when a pulse is started or ended, no modulation products can appear in the transmission path. Thus, it would be impossible to continuously transmit a steady mark or space.

The information-carrying characteristic of an AM signal is its amplitude. For this reason, AM is particularly vulnerable to impulse noise and changes in transmission level. Impulse noise is particularly disturbing. Noise pulses caused by electrical storms, switching transients, and similar disturbances, may equal or exceed the information pulses in amplitude and duration. Under severe conditions, impulse noise may completely obliterate an AM information pulse.

Frequency Modulation

In FM systems, the carrier frequency is shifted in one direction for a mark condition and the opposite direction for a space condition. A *diode keyer* in the tuned circuit of the tone oscillator changes the circuit resonance so as to shift the tone back and forth between



POSITION OF CODE PULSES

	START	1	2	3	4	5	STOP
60 SPEED	22	22	22	22	22	22	31
75 SPEED	18	18	18	18	18	18	25
100 SPEED	13.5	13.5	13.5	13.5	13.5	13.5	19

PULSE DURATION IN MILLISECONDS

Figure 1. Examples of the 5-level Baudot code for the letters A, H, R, and Y, including pulse lengths for the three standard telegraph speeds. Mark pulses are shown in color while space pulses are shown in white.

the two frequencies. Such frequency shifting does not occur instantaneously, however. The inherent resonance of the tuned circuit causes the resulting waveform to change smoothly from one frequency to the other. The amount of shift is the same for both directions and varies from about ± 30 to 42.5 Hz depending upon the operating speed of the telegraph equipment. This type of modulation is also referred to as frequency-shift keying (FSK).

Since the mark and space signals are represented by different frequencies of equal strength, amplitude variations have no effect on the signal unless the signal has the same or less amplitude than the noise. This contrasts strongly with amplitude modulation where a mark is represented by the presence of the carrier and a space is represented by the absence of the carrier. Level changes due to fading, noise, and other interference have a strong effect on AM signals. FM systems can tolerate level changes of about 40 to 50 dB, and are about 12 dB less sensitive to impulse noise than AM systems.

Bandwidth

The bandwidth required for a voice frequency multiplex telegraph channel depends on such things as the code pulse rate, noise, filter attenuation to adjacent channels, and whether or not both sidebands are transmitted (AM systems). A bandwidth of 120 Hz is usually satisfactory for 5-level code telegraph signals at speeds up to 100 words per minute for both FM and double-sideband AM systems. The usual bandwidth for 8-level coded telegraph signals is 170 Hz.

Since the required bandwidth is much smaller than that required for speech signals, a normal 3-kHz voice band can be divided by frequency division multiplexing into sub-bands or channels each capable of transmitting a telegraph signal. Approximately 18 channels can be obtained with 170 Hz spacing, while up to 26 channels can be obtained with 120 Hz spacing. This means that up to 18 or 26 voice-frequency multiplexed telegraph signals can be transmitted simultaneously over a single voice channel.

Telegraph Loops

The circuit between the telegraph machine and the multiplex terminal is called a *loop* circuit. Each telegraph loop is made up of two legs which are the conductors (full metallic or ground return) between the terminal points of the loop. In half-duplex operation, the same loop is used for sending and receiving. However, full-duplex operation, which permits simultaneous transmission in both directions, requires both a sending and a receiving loop.

Because of differences in applications and because of the variations in lengths, any one of a number of circuit arrangements may be employed in telegraph loops.

Neutral Loops

One of the simplest and most direct circuit arrangements is the *neutral* or *open-and-close* loop, illustrated in Figure 4(A). The neutral loop requires a battery only at the central office, and the difference between mark and space is determined by whether or not current is flowing in the loop.

When the printer is sending, closing of the printer contacts closes the loop circuit and the current flowing in the loop applies a potential to the multiplex-channel keying circuit. In the receiving direction, the carrier frequencies are applied to a discriminator. In the discriminator, the two frequencies that are used to transmit the marking and spacing conditions are separated and are rectified to obtain dc for operation of the polar receiving relay. The contacts of this relay open or close the receiving neutral loop to reproduce the transmitted character at the receiving printer.

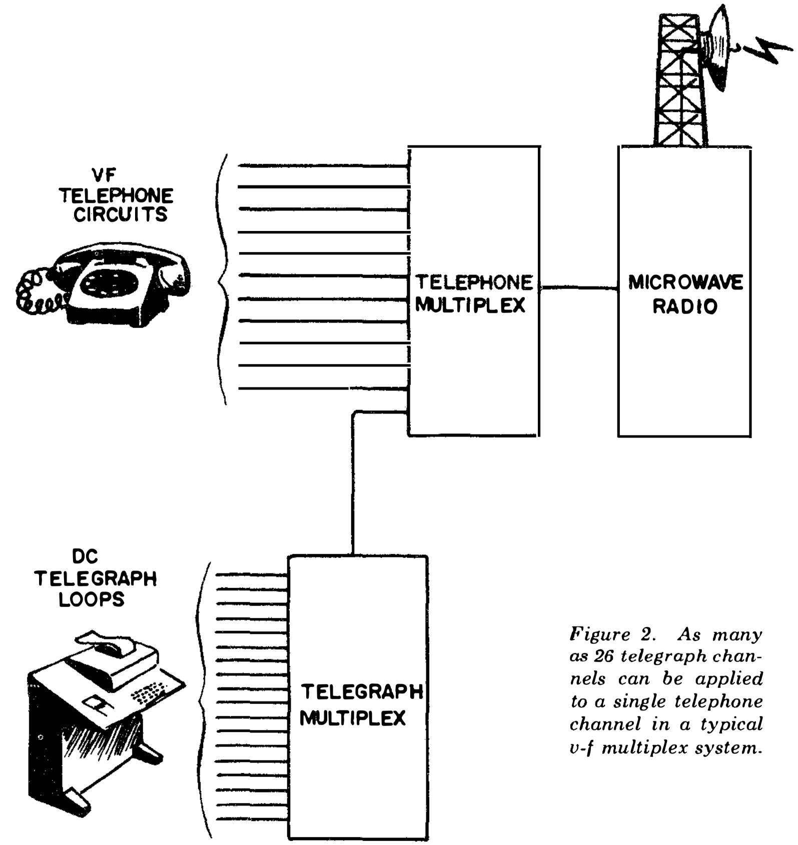


Figure 2. As many as 26 telegraph channels can be applied to a single telephone channel in a typical v-f multiplex system.

Balanced Loop

While neutral loops offer the advantage of simplicity, they are restricted to the shorter loops in which either leakage or the distributed capacity of the path does not severely affect the signal. To reduce these problems a balanced loop (also called effective polar loop) may be used. An example is shown in Figure 4(B).

A balanced loop is similar to a neutral loop in that the difference between mark and space is determined by whether or not current flows in the loop. However, the balanced loop differs

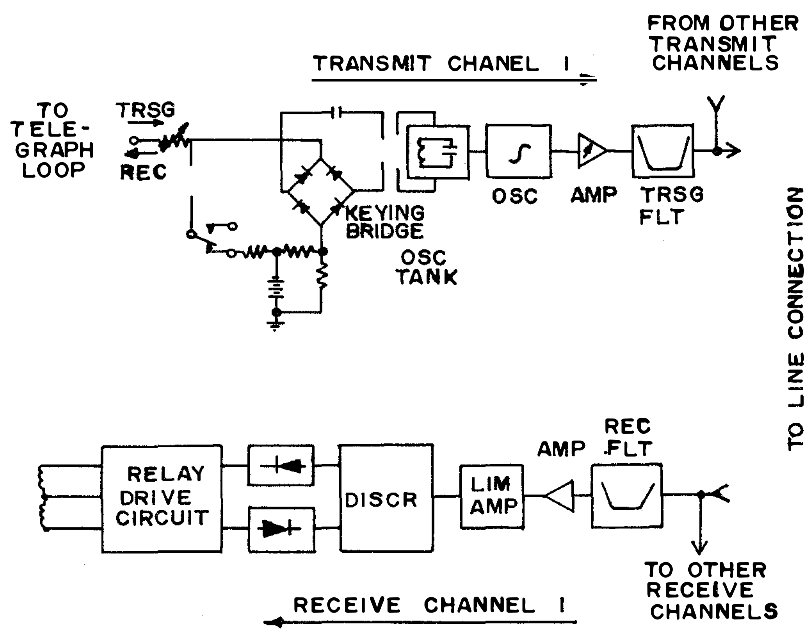


Figure 3. Simplified schematic diagram of telegraph multiplex terminal operating into a half-duplex neutral loop.

from the neutral loop in that a battery potential is applied at the printer location as well as at the central office. The printer battery, in conjunction with the battery potential applied to the marking contact, applies a higher potential to the loop. The increased potential improves the rise time of the marking pulse which tends to increase the length of the pulse. In addition, the increase in potential permits operation over longer loops.

When a spacing signal is received, application of equal potentials to both ends of the loop discharges the line more rapidly than simply opening the loop, resulting in an improvement of the pulse shape. Adjustments can be made in battery potentials to eliminate bias in the loop as required for changing conditions in the loop.

Polar Loop

The most effective transmission method commonly employed is called polar operation. In this case equal currents of opposite polarity are used for the marking and spacing conditions. In addition to the two voltages, this method requires the use of a polar relay in which the direction of current flow in a winding causes the relay to operate to either the marking or spacing position. Since printers normally oper-

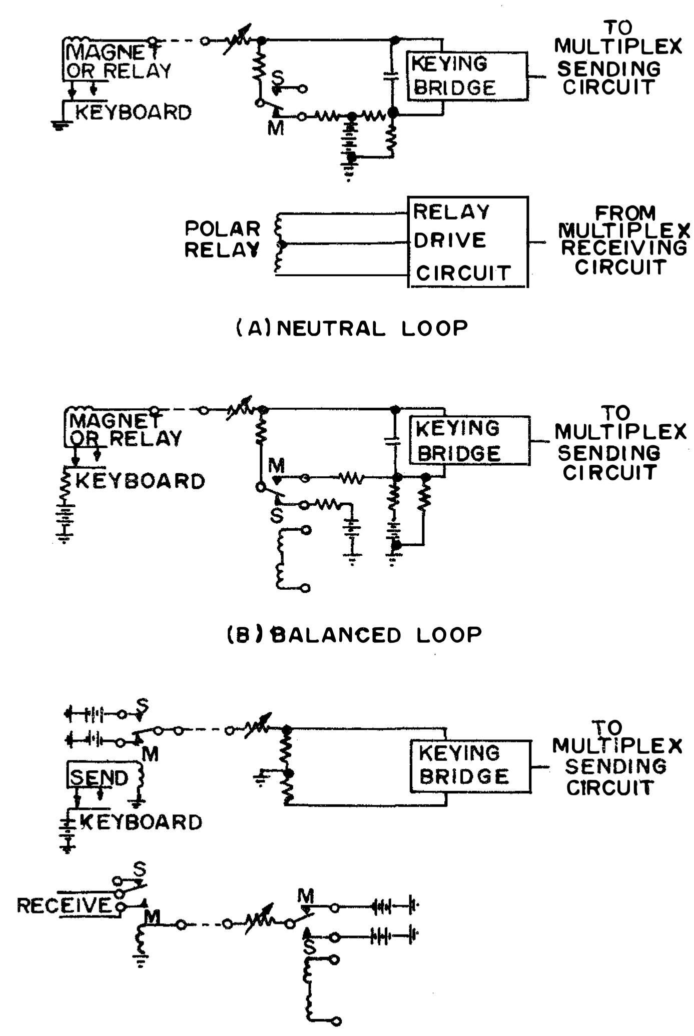


Figure 4. Three types of basic telegraph loop circuits. (A) neutral, (B) balanced, and (C) two-path polar.

ate only from on and off signals, a relay is usually required at the printer location. An example of a polar loop is shown in Figure 4(C). Where battery potentials are the same, the loop characteristics do not change between the sending of a mark or space signal, and if the relay is properly adjusted, the mark and space signals are equal and no bias is obtained.

However, because of the requirement for two batteries, the method is normally only used in transmission from the office to the subscriber, and either neutral or effective polar transmission is used in transmitting from the subscriber to the office.

Break Feature

In a half-duplex loop it is sometimes necessary for the operator at the receiving printer to interrupt the sending printer. This requirement led to the use of an additional relay in the telegraph loop, called the break relay, arranged to accomplish this purpose. The receiving operator may interrupt by opening his loop.

When the receiving loop is opened (effective spacing condition) signals received from the distant terminal are applied to the local-terminal keying circuit, but are inverted. The combination of the retransmitted signals with the original signal causes a continuous spacing signal condition at the sending terminal. When this occurs, the sending operator knows that the receiving operator wishes to interrupt.

Hub Operation

In some telegraph applications, it is occasionally desirable to connect a number of telegraph circuits together in such a way that telegraph signals originating in one circuit are transmitted to all other interconnecting circuits. A method of doing this is through a *hub* board. In this arrangement the dc sides of the multiplex channels are connected together on a high impedance basis. Thus, only a small amount of current is required.

Battery potentials of ±130 volts are required in the hub equipment unit. The hub is supplied with a +130 volt potential through the hub potentiometer. The hub circuitry is such that in the normal marking condition the hub voltage is +60 volts.

The changes in current that result from one circuit sending a space signal into the hub changes the hub potential from +60 volts for marking to −30 volts for spacing. When applied to the sending portion of the remaining channels, these potentials effect simultaneous transmission of the desired signal condition. Three telegraph circuits are interconnected in the simplified diagram of a hub shown in Figure 5. Each circuit is connected to a multiplex channel through a hub-equipment unit.

Hubs may be operated either half or full duplex as with normal telegraph loops. Like the normal telegraph loop, it is sometimes necessary on half-duplex hubs for a receiving operator to break in.

Interruption is accomplished as in the normal loop by a receiving operator sending a spacing signal into the hub. The circuit is arranged so that the hub potential drops to −60 volts when two or more machines are sending spacing signals into the hub. This low potential causes all machines to go to spacing, including the original sending machine, and the sending operator then knows that someone wants to interrupt.

Channel Loading

When transmitting several telegraph tones over a voice frequency channel of a multiplex system, great care must be exercised in establishing the levels at which the signals are applied. Multiplex telegraph signals have greater average power than voice signals. If the power handling capability of the multiplex system amplifiers is exceeded, intermodulation products from the telegraph tones have far greater interfering effect on other channels than do voice signals.

For this reason, a standard signal level is usually specified for voice frequency telegraph signals transmitted over multiplex voice channels. This level is conservative, and is based on the loading effect produced by the maximum number of telegraph channels that can be handled by the voice channel. A common standard per-channel level is −21 dBm at the zero transmission level point. For most applications,

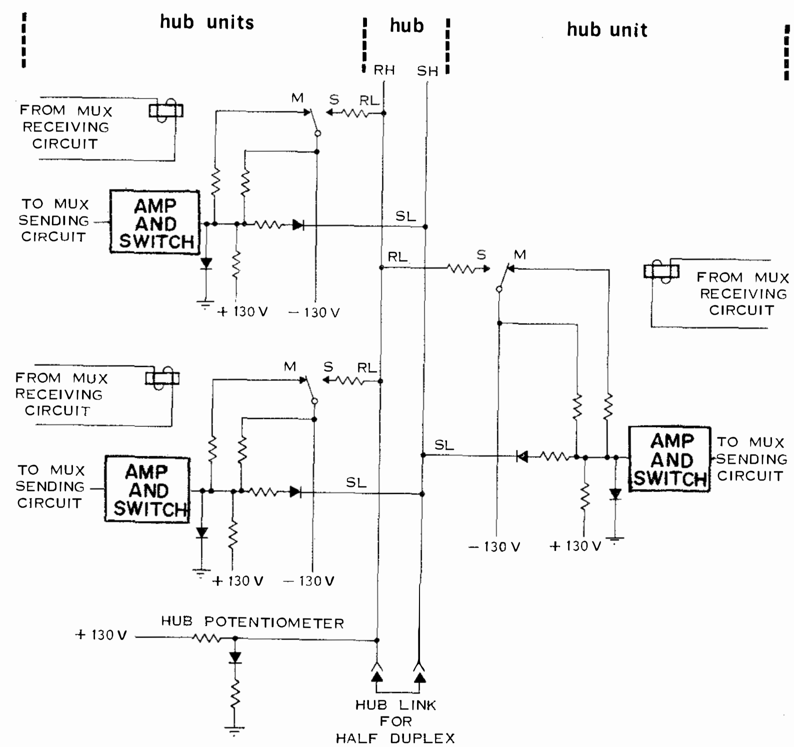


Figure 5. Hub operation, showing three multiplex telegraph channels interconnected on the d-c loop side.

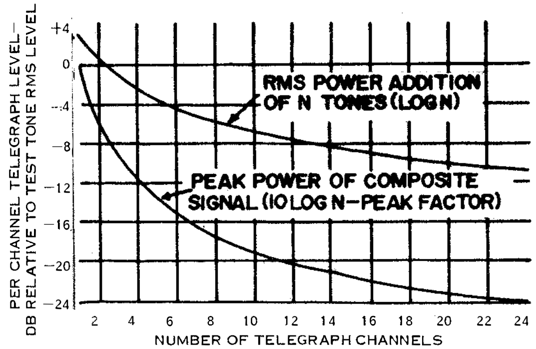


Figure 6. Theoretical maximum transmission levels for various numbers of telegraph tones transmitted over a multiplex voice channel.

this level is high enough to provide good service over a voice frequency multiplex channel.

However, in applications where the maximum telegraph channel capacity is not used, it may be desirable to increase the level of each telegraph tone in order to improve the signal-to-noise ratio. The increased level is a function of the number of telegraph tones to be transmitted.

In calculating the loading effect, peak power must be used, since distortion will occur if the peak power exceeds the load handling capacity of the multiplex equipment. When telegraph signals are applied to a single voice frequency channel of a multiplex system, the permissible peak power is normally +3 dBm at the zero transmission level point. This value is assumed in the following discussion.

For a single telegraph channel, the calculation of peak power is straightforward. A sine wave is normally assumed. Peak voltage of a sine wave is 1.4 times the rms value of the wave, or 3 dB greater in power than the rms power value. When only one telegraph channel is involved, the level of the telegraph tone may be equal to the level of the normal test tone, since both signals are sine waves.

As the number of telegraph channels increases, the peak power that the composite waveform may reach also increases. Since there is a possibility that this value can become quite high for a large number of tones, a *peak factor* is used. This peak factor is based on the statistical probability that the peak power of a complex wave will almost never add up in such a way as to exceed the sum of the rms value of the wave and the peak factor. For a single tone, the peak factor is 3 dB. Peak factor increases as the number of channels is increased, reaching a maximum of 13 dB for approximately 20 channels.

As an example, assume that ten telegraph channels are to be applied to voice frequency multiplex channel normally adjusted to a −16 dBm test tone level. In this example, peak power should not exceed −13 dBm. Each telegraph channel transmitting level must be lower than −13 dBm by the sum of the combined power of the ten tones (rms power addition) and the peak factor.

First, the combined tone level is calculated by taking ten times the logarithm of the number of channels (10 log 10 = 10 dB). Adding a 12-dB peak factor to this 10-dB level gives a peak value 22 dB above a single channel peak. The per-channel transmitting power is then obtained by subtracting the 22-dB peak level from the maximum permissible level (−13 dBm minus 22 dB = −35 dBm). Similar calculations may be made for different numbers of telegraph channels. Figure 6 shows how the telegraph tone levels must be reduced as the number of channels increases. It is important to note that these calculations yield *theoretical* maximum levels for telegraph tones and pertain to the loading of a *single* voice channel in a multiplex system.

Conclusion

The transmission facilities provided by telephone communications systems constitute a vast network which is capable of interconnecting locations almost anywhere in the world. Although these facilities are made up in many forms and have different types of transmission media, they do have one very important thing in common — the standard voice frequency channel, which has a useful bandwidth of about 3 kHz.

While this vast network of multiplexed telephone channels was designed primarily to handle speech signals, the circuits can be used to transmit other forms of information such as telegraph. The techniques of modulation and multiplexing provide a practical means of converting the dc telegraph signals to ac tones suitable for transmission over telephone circuits.

Through the use of frequency division multiplexing, as many as 26 narrow-band voice frequency telegraph channels can be derived within a single 3 kHz telephone channel.

Such efficient use of a single telephone channel is a tremendous asset in view of the present growth of machine communication to process business information.

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E. LOADING*:

1. Limiting:

An important engineering consideration in the design of a multiplex system, particularly one to be used over great distances, is that of limiting. Where a large number of channels are multiplexed, total average signal power may be considerable. If the channels are used to transmit speech conversations, the range of power may be extremely large -- as much as 70 db.

In order to obtain the best signal-to-noise performance from both the multiplex system and the transmission medium, it is desirable to operate the system at the highest signal level that can be handled by the equipment without excessive distortion. If the range of signal power is too great, because too many loud talkers are using the system simultaneously, for instance, the system will overload during periods of peak use, with the result that intermodulation distortion and noise will be excessive. If modulation levels are reduced to prevent this, there will be many periods when the signal level will be far too low, and background noise becomes predominant.

One way of overcoming this difficulty is to restrict the range of signal levels applied to the system. This may be accomplished by some sort of peak limiting or by automatic gain control at the transmitter. This permits the transmitted signal level to be relatively constant regardless of the range of input signal levels. Refer to Paragraph 14, Section C, Chapter VI (Limiters).

2. Intermodulation Distortion:

Intermodulation distortion occurs when traffic is so great as to overload the amplifiers or exceed the design rating of the modulators and associated circuit elements. Present day multiplex systems carry many voice-frequency channels that are handled by common amplifiers, modulators, and demodulators which are not perfectly linear.

In the case of a single channel, modulation products resulting from nonlinearities are directly related to the power and frequency of the signal applied to the channel and appear as distortion of the signal. In multiplex systems, however, the case is entirely different. Most modulation products appearing in any given channel are unrelated to the signal applied to that channel. At higher multiplex frequencies, modulation products from any one channel may be distributed over many other channel allocations. Thus, instead of distorting only the impressed signal, the entire multiplex system overloads, resulting in background noise and crosstalk that increases as the system load becomes greater. In some cases, crosstalk may even be intelligible. In larger systems, however, most distortion appears only as random noise which reduces the signal-to-noise ratio.

Distortion increases significantly when large signal voltage peaks drive some element in the system beyond its region of linear operation.

* From "Multiplexing" by Maurice E. Cookson and Ewell M. Thompson. Reproduced by permission of Lenkurt Electric Co., Inc., San Carlos, California.

In the case of amplifiers employing negative feedback, there is only a slight increase in distortion and intermodulation products as signal level increases, until the amplifier "break" point is reached. In vacuum tubes this point is reached when grid current begins to flow or plate current cut-off occurs, while in transistors this occurs when the saturation or cut-off point is exceeded. Accordingly, distortion increases very rapidly with signal voltage after the break point is reached.

3. Speech Loading:

Speech signals are more complicated than telegraph tones and data signals. Each signal consists of a variety of frequencies and a great range of amplitudes.

In telephone multiplex systems, many factors influence the load on the system. Some of the more important include speech habits of the telephone user, hourly variations in system use, the psychological effect on the speaker of the circuit quality, and the technical characteristics of the subscriber's equipment and local telephone plant.

By using statistical methods of computing load, it is possible to provide a multiplex system that will not overload except during the very busiest periods. Telephone company practice has been to design communication systems for a "break" point of 1 percent of the busiest period. Thus, for the busiest hour, overload may occur during 36 seconds (1 percent of 3,600 seconds). Since this total time is distributed throughout the entire period as a number of brief moments of possible audible disturbance, the net effect on a individual conversation is negligible.

4. Telegraph and Data Loading:

The channel capacity and transmission levels for multiplex systems are stated in terms of voice circuits, referenced to the rms value of a test tone (usually 1000 Hz). Because of their narrow bandwidth, however, up to about 26 ordinary telegraph or data signals can be applied to a single voice channel of a multiplex system. Since these multiple-tone signals have a greater average power than a voice signal, a loading factor must be considered.

In calculating the loading effect of a multiple-tone signal, peak power is used. As the number of telegraph or data signals is increased, the potential peak power level that the composite signal may reach also increases, even though the rms level is held constant by lowering the level of the individual tones. To avoid the possibility of peak overloading, the peak factor is used when calculating the maximum permissible level of multitone signals applied to a single voice channel. The absolute peak factor is expressed mathematically as:

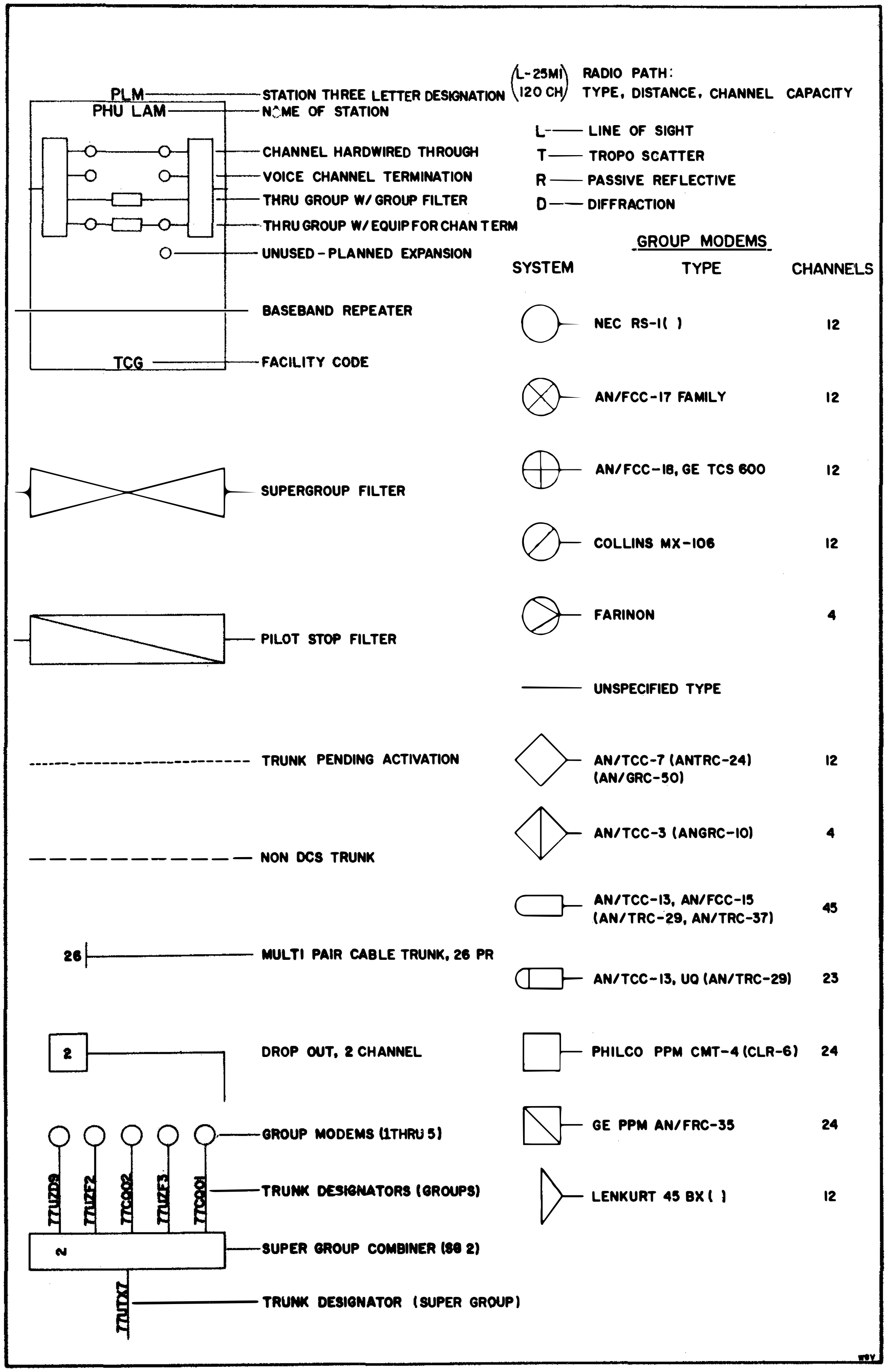
$$\text{Absolute Peak Factor (in db)} = 3 + 10 \log N$$

N - number of single tones

Thus, for a single tone, the absolute peak factor is 3 db. Since the absolute peak factor can become quite high, it is not practical to build high density multiplex systems that are completely free from the possibility of peak overloading. In practice, it is more common to express the peak factor as the statistical probability that the peak power of a composite signal will exceed the sum of the rms value of the signal and the peak factor a given percentage of the time, usually 1 percent of the busiest hour.

XIX. REFERENCE MATERIAL

A. SYMBOLS USED ON SEAWBS TRUNK DIAGRAMS:



B. DCA DESIGNATION CODES:

DCA Designation Codes are alpha-numeric codes assigned by DCA to identify all DCS trunks and circuits. The following information is correct as of 1 Jan 1970 However, changes in these codes occur quite often; consult an up-to-date copy of DCAC 310-65-1 for latest changes.

1. Trunk Designation Codes - a six position alpha-numeric code is assigned to each trunk. In addition, each group which traverses more than one trunk (i.e. it is through-grouped) will have a Trunk Designation Code. VFCT's (Voice Frequency Carrier Telegraph or "Tone Packs") will have a Trunk Designation Code and also a CCSD, the CCSD identifying the voice frequency circuit which the VFCT traverses.

a. First Position-identifies the DCA geographic region in which the "from" end of the trunk is located, using the following codes:

1. USA and Central and South America

2. Canada and Greenland

3 Great Britain and Scandinavia

4 European Mainland

5 West Africa

6 Middle East and East Africa

7 Western Pacific

8 Eastern Pacific

9 Alaska

b. Second Position-identifies the DCA geographic region in which the "to" end of the trunk is located using the same code as the first digit.

c. Third Position-this indicates the agency (s) providing the trunk:

A - Trunks owned by NCS agencies not specifically listed herein; e.g., Dept of State, DTS - NASA - GSA, etc.

B - Department of the Navy

C - Joint Army/Air Force

D - Commercially leased by DCA

E - Joint Navy/Air Force

F - Joint Army/Navy

G - Joint NCS Agencies owned trunks e.g., between DoD/FAA, DoD/Department of State, etc. This code used when the trunk is being provided jointly between two NCS operating agencies. (DoD being an NCS operating agency)

H - Commercially leased by NCS agencies, other than DoD, not specifically listed herein.

I - Allied Government provided - to be used for those trunks provided solely by allied governments, owned or leased.

J - Department of the Air Force

K - Commercially leased by DoD agencies, other than those specifically listed herein; e.g. DSA, NSA DASA, DIA, etc.

L - FAA

M - Trunks owned by DoD agencies not specifically listed.

N - Commercially leased by Department of State

O - Joint U.S. and Allied Government provided- to be used for those trunks which are provided by the U.S. and any Allied Government

P - Commercially leased by GSA

Q - Commercially leased by Diplomatic Telecommunications System

R - Commercially leased by FAA

S - Commercially leased by NASA

T - Commercially leased by FAA

U - Department of Army

V - Commercially leased by Army

W - Commercially leased by Air Force

X - Commercially leased by Air Force

Y - Commercially leased by Army

Z - Commercially leased by Navy

d. Fourth Position-identifies the type of trunk:

A - Single or multichannel HF radio other than single side band including Continuous Wave (CW) transmission

B - Sideband (HF) single or multichannel

C - Unassigned

D - AUTODIN in - Plant Cable Mode I

E - AUTODIN in - Plant Cable Mode V

F - AUTODIN in Plant Equipment

G - Unassigned

H - UHF/VHF Line of Sight Radio

I - Unassigned

J - Unassigned

K - Landline Cable (including open wire)

L - Landline Cable

M - Microwave

N - Group frequency spectrum without channel modems

O - Unassigned

P - Landline Cable

Q - Submarine Cable

R - Landline Cable

S - Satellite Relay

T - Forward Propagation Tropospheric Scatter (FPTS)

U - Supergroup frequency spectrum without group or channel modems

V - Voice Channel package preempteable for Wideband service

W - Unassigned

X - VFCT System not provided via HF systems

Y - VFCT provided via HF or combination HF, wideband

Z - Composite System (nonsimiliar media)

e. Fifth and Sixth Positions-alpha-numeric combination assigned DCA to identify the particular trunk.

Following is an example of a trunk designator code:

7	7	U	T	47
GEOGRAPHIC AREA	GEOGRAPHIC AREA	AGENCY PROVIDING TRUNK	TYPE OF TRUNK	DCA NUMBER

The numbers indicate that the trunk is provided by the Army and is on a tropospheric scatter system. Both ends of the trunk are in the Western Pacific Area and DCA has assigned number 47 to it.

2. Command Communications Service Designator (CCSD). - an eight position alpha-numeric code assigned to each voice frequency circuit.

a. First Position-identifies the agency requiring the circuit:

A - Department of State

B - Department of the Navy

C - National Command Authority, (JCS) Command and Control

D - Department of Defense-Defense Communications Agency

E - Not Assigned

F - NCS - Minor Operating Agencies

G - General Service Administration (GSA)

H - Diplomatic Telecommunication System

I - Allied Government - For circuits required by allied governments provided over some DCS facilities

J - Department of the Air Force

K - Not assigned

L - Federal Aviation Agency

M - National Aeronautics and Space Administration

N - Other DoD Agencies (not listed); e.g. DIA, NSA, DSA, DASA, PDMS, etc.

O - Host country - for all circuits required by any country who is host to the United States

P - Other U.S. Departments, Agencies, Commissions or commercial companies (Govt or non-Govt not listed); e.g., Department of Justice, requirments by commercial companies etc.

Q - Not assigned

R - Commander in Chief's (CINC) Command and Control Circuits

S - Not assigned

T - Treaty Organization; e.g. NATO, or SEATO

U - Department of the Army

V - Not assigned

W - Not assigned

X - Not assigned

Y - Not assigned

Z - Not assigned

b. Second and Third Positions-this identifies the DCS network. A partial listing follows (complete listing is found in DCA 310-65-1).

AG - Federal Aviation Agency
BP - Naval Special Administrative and Logistics Network
BD - Fleet Broadcast Access Network
CA - Air Force Air Defense Command Network
CC - PACAF Air Defense Network

CF - PACFLT Command and Control
DD - DCA Operations Network
DF - Navy Direction Finding Network
DI - Special Intelligence Communications Network
DR - Army Security Agency
DS - Diplomatic Telecommunications System
EA - Air Force Security Service
FO - Fleet Operations Control Network
GU - US Coast Guard
JE - SAC Teletypewriter Network
JG - SAG Telephone Network
JP - Pacific Command Joint Network
KK - Army Command and Control Network
KL - Keying Lines
KV - Army Aviation Network
MC - US Marine Corps
MV - US Military Assistance Network
NK - Information Dissemination
NS - Navy Security Group
OO - Order Wire
PC - AF Command Net
PP - Army Continuity of Operations Network
PS - Commercial Press Services
QA - MAC Teletype Communications Network
QE - Weather, TTY, Civil, FAA
QG - Weather, TTY, DCS/USAF
QI - Weather FAX (Civil, US Weather Bureau)
QJ - Weather FAX DCS/USAF
QM - MAC Operational System Network
RF - PACAF Command and Control Network
RS - Armed Forces Radio and TV Service and Stars and
Stripes Network
SO - Spare Channel
SP - Spare Patch/Interconnect
TF - Department of State
FE - Army, Air Force, Navy Temporary
TX - VFCT Trunk
TZ - AFTAC Data Network
UA - Common User Teletype Writer Service
UB - Common User Voice Service
UD - Secure Voice
UL - DCS Digital Data Network
UM - Special Purpose Network
UO - Air Force Air Operations Network
UW - Inter-Departmental Dial Telephone Network
WX - Navy Weather Network
YA - Fleet Ship-Shore Access Network
ZM - Military Air Traffic Control & Flight Facilities
Network

c. Fourth Position-indicates the type of service and speed of the circuit:

A Teletype service other than DCS switched networks

B AUTOVON Access Line

C AUTOVON Interswithc Trunk

D Data other than DCS switched networks

E AUTODIN Access Line

F SEVOCOM/AUTODIN Interswitch Trunk

G SEVOCOM/AUTOSEVCOM Access Line

H AUTOSEVCOM Interswitch Trunk

I Voice Channel Package preemptable by Wideband Service

J Facsimile other than DCS switched network

K CW

L DSSCS Access Line

M DSSCS Interswitch trunk both automatic and manual switches

N AUTOSEVOCOM subscriber to an AUTOVON switch

P Not assigned

Q AUTODIN Interchange Circuits between AUTODIN and other switched networks except AUTOVON

R Alternate Voice Record other than DCS switched networks

S Video other than DCS switched networks

T Telemetery other than DCS switched networks

U Telephoto other than DCS switched networks

V Voice other than DCS switched networks

W DC signaling other than DCS switched networks

X VFCT

Y Audio signaling

Z Not assigned

d. Fifth, Sixth, Seventh and Eight Positions:

These are assigned by DCA to identify the particular circuit. The O and I will not be used in the circuit numbers.

Following is an example of a CCSD:

J	UA	C	KAZ9
AGENCY REQUIRING CIRCUIT	DCS NETWORK	TYPE OF SERVICE AND CENTER SPEED	DCA IDENTIFICATION

The above CCSD indicates that this is an Air Force circuit on the DCS Teletypewriter network. It is a 100 wpm circuit and is identified by KAZ9.

The DCA identification code normally will tell you nothing about certain types of circuits:

1 - - -	CRITICOM circuit
P A - -	Temporary circuit
6 - - -	Audio path VFCT

C. 3-LETTER GEOGRAPHICAL DESIGNATION CODES:

The geographical designation codes are formulated by DCA for the purpose of abbreviating the names of places where there are DCS terminals or facilities.

ADA	Ap Dangia	CMI	Chiang Mai, TH
AGU	Aguinaldo, PI	CMU	Ca Mau (Cau Mau)
AKE	An Khe	CPD	Camp Drake, JA
ALI	Aliamanu, HI	CPH	CP Holloway
ALX	Alexandria, VA	CPS	CP Smith,HI
ARL	Arlington, VA	CPZ	CP Zama, JA
ARW	Andrews, MD	CRA	Cam Ranh AB
ASN	Anderson, AFB, GU	CRB	Cam Ranh Bay
ATO	An Thoi	CRO	Cheo Reo
BAD	Ba Di	CSF	CMDR 7th Fleet
BAQ	Ba Queo	CTO	Can Tho
BGK	Bung Kan, TH	DAN	Di An
BKK	Bangkok, TH	DAU	Dau, PI
BKN	Bang Khen, TH	DAV	Davis, CA
BLU	Bac Lieu	DBT	Dong Ba Thin
BMT	Ban Me Thuot	DCH	Duc Hoa
BNH	Bien Hoa	DGG	Duong Dong
BNL	Bien Loi	DGH	Dong Ha
BOL	Bao Loc	DGM	Dragon Mt
BPA	Bang Pla, TH	DGN	Da Nang North
BPG	Bang Ping, TH	DGT	Dong Tam
BRA	Baria	DGP	Dong Phuoc
BSA	Base-A Phu Mu, TH	DGW	Da Nang West
BTY	Binh Thuy	DLT	Dalat
CBP	Cubi Point, PI	DMG	Don Muang, TH
CCI	Cu Chi	DMY	Duc My
CCK	Ching Chuan Kang,TW	DNE	Da Nang East
CHI	Chitose, JA	DNG	Da Nang
CHL	Chu Lai	DBT	Dong Ba Thin North
CHO	Chachoensao, TH'	DPO	Duc Pho
CLK	Clark, AB, PI	ELT	El Toro CA
CLN	Cholon	FIN	Finegayan, GU
CLR	Cu Lao RE	FMH	FM Hill, PI
CLT	Cheltenham MD	FMM	Ft Monmount, NJ
FDT	Ft Detrick, MD	MKD	Mukdahan, TH
FTM	Ft Deade, MD	MTH	My Tho
FTS	Ft Shafter, HI	MYM	Monkey Mt
FUC	Fuchu, JA	NBE	Nha Be
GDH	Gia Dinh	NHA	Nha Trang
GIA	Gia Nghia	NHH	Ninh Hoa
GNH	Green Hill, TH	NIC	Nichols, PI
GUA	Agana, GU	NPN	Nakhon Phanom, TH
HAN	Hoi An	NTN	Nha Trang North
NAZ	Hanza, RK	OAK	Oakland, CA

HEL	Helemano
HIK	Hickam, AFB, HI
HNI	Ho Nai
HNL	Honolulu, HI
HNW	Hoi An West
HQN	Hon Quan
HTR	Hon Tre Island
HUE	Hue
CJM	CP John Hay, PI
JUZ	Juzon Mt, TW
KAD	Kadena, RK
KAU	Kauai, HI
KCA	Kanchanaburi, TH
KHK	Khon Kaen, TH
KKG	Khanh Hugn
KKT	Koke Kathiem, TH
KLT	Klong Touey
KNE	Kaneohe, HI
KPT	Kingsport, HI
KRT	Korat, TH
KSH	Khe Sanh
KTM	Kon Tum
LBM	Lang Bian Mt
LBN	Long Binh
LKE	Lai Khe
LMS	Lam Son
LNN	Long Thanh North
LNT	Loeng Nak Tha, TH
LOS	Los Angeles, CA
LPB	Lop Buri, TH
LPG	Lam Pang,TH
LTH	Long Thanh
LXN	Long Xuyen
MAN	Manila, PI
MBM	Marble Mt
MCC	McClellan AFB, CA
SGA	Saigon Old AEB
SGB	Saigon New AEB
SGN	Saigon
SGY	Sangley Pt, PI
SHP	Sattahip, TH
SKN	Sakon Nakhon, TH
SMG	San Miguel, PI
SOB	Sobe, RK
SRA	Siracha, TH
STK	Stockton, CA
TAE	Taegu, KS
TAI	Tainan, TW
TAN	Tuy Hoa North
PGN	Pentagon, US
PHB	Phu Bai
PHC	Phu Cat
PHE	Phu Hiep
PHT	Phu Tai
PKN	Pleiku North
PKO	Phu Khieo, TH
PKU	Pleiku
PLM	Phu Lam
PLO	Phu Loi
PMU	Phu Mu, TH
PNS	Phanom Sarakham, TH
PNT	Phan Thiet
PRG	Phan Rang
PRL	Pr' Line
PSL	Phitsanulok, TH
PSW	Peshawar, PK
PTH	Phu Thanh
PTY	Pattaya, TH
PVN	Phuoc Vinh
PYK	Phon Yang Kham, TH
QNC	Qui Nhon Capitol
QNG	Quang Ngai
QNH	Qui Nhon
QTR	Quang Tri
RDP	Ritidian Pt
QTA	Quang Tri AB
RGA	Rach Gia
RIT	Santa Rita, PI
RIB	Robbins
SAC	Sacramento, CA
SGE	Song Be
SCH	Schofield, Bks, HI
SCT	Soc Trang
SDC	Sadec
SEO	Seoul, KS
TRI	Trai Mat Mt
TSN	Tan Son Nhut
TSP	Trang Sup
TYA	Tuy Hoa AB
TYH	Tuy Hoa
TYN	Tao Yuan
UBN	Ubon, TH
UDN	Udorn, TH
UPT	U-Tapao, TH
VCM	Vung Chua Mt
VLG	Vinh Long
VNT	Vientiane, LA
VTA	Vung Tau AB

TBU	Tobaru, RK
TCH	Tachikawa
TKL	Takhli, TH
TKO	Tokyo, JA
TKY	Tam Ky
TMH	Tung Manhomek, TH
TMH	Tay Ninh
TNW	Tay Ninh West
TPI	Taipie, TW
VTU	Vung Tau
WAH	Wahiawa, HI
WAS	Washingon DC, US
WKE	Wake Island, US
WRN	Warin, TH
WRP	Wright Pat AFB, OH
XNL	Xa Loc Ninh
YOK	Yokota AB, JA
YUK	Yokosuka, JA
ZUK	Itazuki, JA

D. USER TERMINAL AND ENROUTE FACILITY CODES:

The terminal and facility codes are formulated by DCA for the purpose of abbreviating the type of DCS terminal or facility. These codes are most frequently used in conjunction with the geographical designation codes.

The following terminal and facility codes are a few of the more common ones that a technical controller will encounter. A more complete list is given in DCAC 310-65-1.

CODE	DESCRIPTION
AAV	Army Aviation Terminal
ACA	Army Communications Center
ACF	Fwd Air Control Post
ACG	American Consulate General
ACO	American Consulate
ACP	Air Component Command Post
AEB	American Embassy
AER	Aeronautical Station
AFB	Air Force Base
AFC	Air Force Communications Center
AFD	Air Force Communications Service
AFL	Air Field
AFN	Armed Forces Network
AGN	Naval Advisory Group
ALO	Air Liaison Center
AMA	Air Movement Information Section
AOB	Army Overseas Switchboard
AOC	Air Force Overseas Relay Center
ASC	Air Support Op Cen/Dasc or Asoc
ASF	Advisor Special Forces
ATC	Air Route Traffic Control Center
AVN	Army of Vietnam
BBD	Base Post Camp Station Switchboard
BCA	Communications Office
BCC	Navy Communications Center
BCO	Base Communications Center
BFC	Navy Facilities Control
BOP	Base Operations
BOR	On-Line Relay Facility
CBC	Construction Battalion Center
CCC	Command Communications Control Center
CCF	CRITICOMM Technical Control Facility
CCO	CRITICOMM Operations
CCT	Communications Center
CIN	Combat Intell Center
CKA	Communications Squadron

CODE	DESCRIPTION
COC	Command/Combat Operations Center
COM	Commercial Switchboard
COV	Comm Opns Van
CPA	Command Post
CRC	Control Reporting Point (Cmd & Control)
CRP	Control Reporting Post
CSU	AUTODIN Automatic Relay Ckt Sw Unit
CTC	Commercial Cable/Radio Carr Tech Cont Fac
CTP	Circuit Tie Point
CXR	Cable Radio Carrier Tech Cont Fac
CXX	Cable Radio Carrier Tech Cont WO DEMOD
CXL	Cable Carrier Sys at Tech Control
DAC	Defense Communications Agency Area
---	Operations Center
DAR	Dept of Army
DCA	Defense Communications Agency Operations
---	Center
DCO	Division Communications Office
DCR	Defense Communications Agency Regional
---	Operations Center
DIS	Dispatch
DOD	Dept of Defense
DPA	DCS AUTODIN Computer Terminal
DPC	DCS AUTODIN General Purpose Terminal
DPE	DCS AUTODIN Magnetic Tape Terminal
DRA	DCS AUTODIN Manual Relay
DRC	DCS AUTODIN Automatic Relay
DTC	AUTODIN Auto Relay Tech Control
DTE	Dial Telephone Exchange
ENG	Corps of Engineers
ESO	Electronic Supply Office
FAC	Forward Air Controller
FAX	Facisimile Center
FCA	Federal Communications Commission
FCM	Marine Facilities Control
FFH	Field Forces Command Hq
FFO	Flight Following Office
FOC	Fighter Opns Center
FPA	Forward Propagation Ionosphere Scatter Bldg
FRP	Field Representative Far East
FSB	FTS Switchboard
FSF	FTS Class 4 Terminal Switch
FSH	FTS Class 3 Switching Facility
FSI	FTS Class 1 Switching Facility
FST	FTS Class 2 Switching Facility
FWC	Fleet Weather Control

CODE	DESCRIPTION
FWF	Fleet Weather Facility
GBA	Global Communications Bldg
GCA	Ground Controlled Approach
GWC	Global Weather Center
JCC	Joint Communications Center
FCR	Joint CRITICOMM Relay Center
JGS	Joint General Staff
JOC	Joint Operations Centers
LCC	Communications Long Lines Central Control
MAG	Military Assistance Advisory Group
MAR	MARS (Army)
MAS	Marine Corps Air Station
MAW	Marine Aircraft Wing
MCB	Marine Corps Base
MCC	Army Message Center
MCD	Air Force Message Center
MCE	Navy Message Center
MCF	Message Center Facility
MCH	Movement Report Control Center
MCO	Main Control Center
MCP	USMC CMD Post or Opns Cen
MCR	Master Control Center Station
MCS	Main Control Station (Radio Relay or Wire)
MDF	Main Distribution Frame
MFC	Military Flight Service Center (MFSC)
MFU	Missile Fire Unit
MRA	Army Minor Relay Station
MRB	Air Force Minor Relay Station
MRC	Navy Minor Relay Station
MRP	Movement Report Center
MRS	Microwave Repeater Site
MSU	AUTODIN Auto Relay Msg Sw Unit
MXA	Mobile Radio
NAF	Naval Air Facility
NAS	Naval Air Station
NBA	Naval Base
NCF	Naval Communication Facility
NCS	Naval Communication Station
NCU	Naval Communication Unit
NEL	Naval Electronic Laboratory
NFA	Naval Facility
NHQ	Naval Communications Systems Hq
NIC	Naval Information Center
NOB	Naval Operating Base
NRA	Naval Radar
NRD	Naval Radio Office
NVN	Vietnamese Naval Terminal

CODE	DESCRIPTION
NYA	Fleet Action Control
OCA	Operations Center
OCN	Overseas Connection
OPA	Operations Bldg
OPF	Operations Office
OPV	Operations Van
OSA	Overseas Supply Agency (Army)
OSS	Overseas Switchboard
POC	CINC Pacific Operations Center
PRF	Peripheral Site
PRS	Army Manor Primary Relay Station
PRT	Air Force Major Primary Relay Station
PRU	Navy Major Primary Relay Station
PSB	Press Switchboard
PYO	Public Information Office
RAC	Naval River Assault Center
RAN	Radio Vietnam
RAP	RAPCOM
RAS	Radar Site
RAT	Radar Air Traffic Control Center
RCC	Rescue Coordination Center
RCE	Army Receiver Station
RCO	Remote Communications Outlet
RCV	Air Force Receiver Station
RCW	Navy Redeiver Station
RFA	Reports Center
RLT	Radio Terminal (W/O Tech Control)
RMA	Radio Room
RNA	Operations Radio Naval Air Station
RNZ	Royal New Zealand Navy Message Center
ROC	Reconnaissance Operations Center
ROK	Korean Forces Command
RRC	Remote Control Center
RRF	Regional Relay Facility
RRS	Radio Relay Station
RSA	Radio Site
RSE	Receiver Site
RVN	Republic Of Vietnam
SAC	SAC Headquarters
SAR	Sea - Air - Rescue Unit
SBA	SAC Composite Bldg
SBK	Switchboard, Korean
SBL	Signal Building
SBU	Switchboard, Army
SCA	AUTOVON Switching Facilities
SCC	SAC Communications Center

CODE	DESCRIPTION
SCP	SAC Command Post
SDP	Signal Depot
SDT	SCAN Data Terminal
SIG	Signal Corps
SOC	Squadron Operations Center
SPI	Spintcom Realy/Terminal
SSA	Signal Supply Agency
SSO	Special Security Office
STC	Staff Communications Office
STE	Satellite Control Center
STO	Satellite Operations Center
STT	SAC Tech Control
SWB	Switchboard
SWC	Switching Center other than AUTOVON
SWF	MATS Switchboard
SYT	SYNCOM Terminal (Def Sat Comm Sys
---	Earth Terminal)
TAC	Tactical Air Control Center
TBD	Command Switchboard
TBS	Tributary Station
TBX	Air Force Tributary Station
TBZ	Navy Tributary Station
TB2	Telephone Swbd (Tact)
TB3	Telephone Swbd (Tact)
TCA	Traffic Control Agency
TCC	Transport Control Center
TCF	Air Force Technical Control Facility
TCG	Army Facilities Control (STARCOM)
TCL	Technical Control
TCM	Tech Control Fac - Limited Capability
TCT	Comm Center/Term (Tact)
TCU	Traffic Control Unit
TC2	Comm Center/Term (Tact)
TGX	Tech Control Fac without DEMOD Capability
THA	Cdr Tactical Air Command (TAC)
TIC	Technical Intelligence Cenger
TIP	DCS/Tactical Interface Point
TOC	Tactical Operations Center
TMC	Transport Movement Center
TMT	Transportable MW/Tropo/VHF Fac
---	(W/Tech Control)
TRS	Transmitter Site
TSM	Telephone Toll Sw (Manual)
TTC	Transportation Traffic Coordinator
TTF	Telecom Terminal Facility
TUC	Command Post/Op Cen (Tact)
TUN	Transportation Unit
TWR	Control Tower

CODE	DESCRIPTION
TXL	Army Transmitter Station
TXM	Air Force Transmitter Station
TXO	Navy Transmitter Station
UTS	Unattended Transceiver Site
VAF	Vietnamese Air Force
WFC	Weather Forecast Center
WOA	Wing Communications Office
WOC	Wing Operations Center
WRC	Weather Relay Center
WSA	Weather Station
WSS	Wing Command Post
YAA	Subscriber (NCMC) to AUTOVON
YAB	Data (NCMC SSB) to AUTOVON
YAC	Voice (NCMC SSB) to AUTOVON
YBD	Combat Center Primary Data
YBG	Combat Center PBX Access
YBJ	Combat Center Receiving Voice Alert (DC)
YBK	Combat Center Commander Conf.
ZAR	American Red Cross

E. ICS NUMERICAL SITE DESIGNATIONS

SITE NO.	SITE NAME	SITE NO	SITE NAME
09	Ubon/Warin	51	Qui Nhon Cable Terminal
11	Vung Tau	61(16WW)	Nha Trang (Wet Wash Area)
12	Pleiku	62	Quang Tri
13	Phu Bai	63	Hon Tre Island
14	Da Nang	64	Monkey Mountain
15	Qui Nhon	65	Vung Chua Mountain
16(16BP)	Nha Trang(Back Porch Area)	66	New MACV (Gia Dinh)
		67	Hong Cong Mountain
17	Phu Lam		
18	Tan Son Nhut	69	Da Nang East
19	Bien Hoa		
23	Pr'Line	71	Phu Cat
24	Cam Ranh Bay	72	Ninh Hoa
25	Vung Tau Air Base	73	Dong Ba Thin
26	Can Tho	74	Dong Tam
27	Hue	75	Long Binh
28	Chu Lai	77	Di An
29	Phan Thiet	78	Cu Chi
30	MACV 1	79	Phu Loi
33	Tuy Hoa	81	Vinh Long
34	New American Embassy	82	Sa Dec
35	Phan Rang	83	Long Xuyen
36	Cam Ranh Bay Air Base		
39	Quang Ngai	85	Rach Gia
40	Soc Trang	86	Binh Thy
41	Da Nang Cable Term.	87	Korat SOC
42	Cam Ranh Cable Term.	88	Tan Son Nhut SOC
44	Vung Tau Cable Term.	89	Bac Lieu
45	Ban Me Thuot	90	Ca Mau
47	An Khe	92	Qui Nhon ROK
50	Sattahip Cable Terminal		

Non-diversity Systems		425	595	765	935	1105	1275	1445	1615	1785	1955	2125	2295	2465	2635	2805	3230
AN/FCC-3,-7,-8 (Note 1)		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
AN/FCC-19,-25,FGC-60		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
NRC-235					1	2	3	4	5	6	7	8	9	10	11	12	
AN/TCC-4 Term "A" (2W)	SEND									8	4	7	3	6	2	5	1
	RECV	5	1	6	2	7	3	8	4								
AN/TCC-4 Term "A" (4W)	SEND	9	13	10	14	11	15	12	16	8	4	7	3	6	2	5	1
	RECV	5	1	6	2	7	3	8	4	12	16	11	15	10	14	9	13
AN/TCC-20 Term "A"	SEND		1		2		3		4								
	RECV	1		2		3		4									
Diversity: All even numbered channels are inverted (Mark freq. below center freq.)																	
AN/FGC-29,-61,-61A		2	4	6	8	10	12	14	16	1	3	5	7	9	11	13	15

INTERNAL BATTERY CAPABILITIES

	neut	polar	rec	snd
AN/FCC-3	60ma 20ma	30ma	x	
AN/FCC-7	60ma 20ma	30ma	x	
AN/FCC-8	60ma 20ma	30ma 30ma	x	
AN/FCC-19	60ma	20ma		
AN/FCC-25	60ma	20ma		
AN/FGC-29	60ma		x	x
AN/FGC-60	60ma		x	x
AN/FG -61	60ma 20ma		x	x
AN/FGC-61A	60ma 20ma		x	x
NRC-235	60ma		x	
AN/TCC-4	20ma		x	x
AN/TCC-20	20ma		x	x
TH-5	20ma		x	x

TH-5 Center freq 1275 Hz, shift ± 50Hz

Note 1: The FCC-3 contains only channels 1 thru 8 plus an additional four (4) wideband channels which are not compatible with any other system presently in use. The center frequencies of these additional channels are;

9-1955 (+ 85Hz) — 11-2805(± 85Hz)
10-2380 (± 85 Hz) — 12-3220 (± 85 Hz)

The first 8 channels of 2 each FCC-3's will form a 16 channel system utilizing channel converters provided. The Fcc-8 contains only channels one thru eight. The FCC-7 contains channels one thru eight and channel converters which may be used with an FCC-8 to form a 16 channel system.

Note 2: All channels shift ± 42.5 Hz unless otherwise indicated.

G. GLOSSARY OF COMMUNICATIONS TERMS:

NOTE: A move complete list given in DCAC 310-70-1 Vol IV, Glossary.

ACU (Automatic Calling Unit): Unit capable of establishing a circuit connection upon input of a digital calling from an attached processor.

Alternate Routing: A secondary or backup circuit path; used if the normal routing is not possible (circuit failures or backlogs)

Amplitude: The strength or magnitude of an electrical signal, usually expressed as voltage or power.

Amplitude Modulation: Variation of a carrier signal's strength (voltage and/or current), as a function of an information signal.

Analog Signal: A non-discrete or continuous signal, the variations of which represent meaningful information.

Answerback: The response of a data set or terminal to remote control signals.

ASR (Automatic Send-Receive): A telegraphic terminal incorporating keyboard, page printer, paper tape reader and punch, and a shunt box capable of automatic control functions.

Asynchronous Transmission (Also called start/stop): Transmission in which each intelligent character or byte is individually synchronized with a start signal.

Attenuation: Reduction in the strength, or power, of a transmitted signal, through circuit losses.

Audio Frequency: A frequency within the range of human hearing (approximately 15 to 20,000 Hz).

Autodin (Automatic Digital Network): The data-handling portion of the military communications system.

Automatic Switching: Directs the transfer of traffic from incoming to outgoing circuits without manual intervention.

Backporch: Original long lines tropospheric scatter system in Vietnam.

Back to Back: A direct connection from the vf drop of one carrier to another, to enable a subscriber to check his equipment by receiving his own transmission. Also known as a "Loop Back".

Bandwidth: The difference in Hertz between high-and low-frequency cut-off points.

Baseband: The band of frequencies occupied by transmitted and received signals at the interface between the wire or radio transmission and multiplex equipment.

Baud: Unit of modulation rate. One baud is one unit interval per second; it is the reciprocal of the duration in seconds of the unit interval.

Baudot Code: 5-bit telegraphic signalling code, incorporating two shifts (figures/letters) which provide 64 combinations: 52 data characters, which are identical in each shift. When transmitted, 1-bit start and 1.42 bit stop intervals are added, giving 7.42-bit effective character length.

Bit: Contracting of "Binary Digit", the smallest unit of information, which is dual-state (one or zero, on or off, mark or space).

Bit Rate: Transmission speed, usually synonymous with "bits per second".

Broadband Circuit, Channel: High bandwidth channel, using microwave or coaxial transmission facilities.

Broadcast: Transmission to a number of receiving locations simultaneously.

Byte: A data character.

Cable: One or more conductors, insulated within a protective covering.

Calling Sequence: A unique series of digits which establishes a circuit connecting to one station.

Carrier: A continuous frequency, capable of being modulated, or impressed with a second (information-carrying) signal.

Carrier System: A system of combining more than one carrier frequency for simultaneous occupancy of a channel, and subsequently separating the component signals.

CCSD: See Command Communications Services Designator.

CDF: See Combined Distribution Frame.

Central (Exchange): Switching facilities to allow interconnecting of circuits from various routes.

CEO: See Circuit Engineering Order.

Channel: Electrical Circuit

Character: A digit, letter, or special symbol (data); or unique function (control).

Circuit (or Channel): A continuous path for electrical transmission between two or more terminal points; may be a physical (wire) link, a radio link, or a combination.

Circuit Engineering Order: DCA authorization to activate, change, or discontinue a circuit or trunk.

Circuit Layout Record (CLR): The engineering record of an individual circuit. Contains a detailed engineering sketch of the circuit and narrative descriptive data.

CLR: See Circuit Layout Record.

Circuit Switching: The process of establishing an electrical connection between two channels to allow transmission.

Coaxial Cable: Two-conductor set, in which one conductor encircles and shields the other; provides better signal-to-noise and bandwidth characteristics than parallel-wire or twisted pairs.

Code: A set of unique bit combinations assigned to represent characters.

Combined Distribution Frame (CDF): A distribution frame used to terminate both lines entering and leaving a station and intra-station wiring. See Sect G, Chapter VII.

Command Communications Services Designator (CCSD): An eight digit alpha numeric code used to identify DCS circuits.

Common Carrier: A company with a vested interest in providing communications services to the public.

Common Control: In switching, a system wherein signalling is accepted from the calling subscriber and the desired connection is subsequently established in the switch.

Communication: The transfer of information between separate points.

Conditioning Equipment: Equipment necessary to match transmission levels, impedances, etc. of a circuit.

Conductor: A metallic signal path (usually wire).

Cps: Cycles per second (obsolete). See Hertz.

Cross-Talk: Interference between adjacent communications channels.

Cut-Off: The point of degradation, due to attenuation and/or distortion at which a signal becomes unusuable.

Cutover: Term used to refer to circuit activations or realignments.

Cycle: One complete oscillation (360 phase rotation) of a signal.

Data: Information in the form of a code.

Db: (Decibel) A logarithmic expression of ratio. It is equal to ten times the logarithm to the base ten of the ratio of two power levels.

dbm: Power level in decibels with reference to a power of 1 milliwatt

dbm0: Power in dbm (referred to a point of zero relativity transmission level.)

DCA: Defense Communications Agency. A DOD agency which manages the long distance communications of the US Armed Forces.

DCAC: Defense Communications Agency Circular.

DCA-PAC: Defense Communications Agency Pacific, located in Hawaii. A subordinate command of DCA, responsible for the entire Pacific area, including Southeast Asia.

DCA-SAM: Defense Communications Agency-Southeast Asia Mainland. A subordinate command of DCA-PAC responsible for Southeast Asia Mainland. Located at Tan Son Nhut.

DCO: Dial Central Office

DCS: Defense Communications System. Long distance communications system operated by DCA.

DCS Reporting Station: A DCS station that submits reports to DCA in accordance with DCAC 310-55-1.

DCS Reported on Station: A DCS station that submits reports to a DCS Reporting Station to be submitted to DCA in accordance with DCAC 310-55-1.

DCS Station: A communications facility operated by a U. S. Military Department through which or to which DCS circuits are connected.

DDD (Direct Distance Dialing): Dial-up connection, without operator assistance, to a point outside the user's local service area.

Demodulation: The process of recovering intelligence (data) from a carrier signal; the reverse of modulation.

Dial-up: Establishment of a line connection by dialing a sequence of digits.

Digital Signal: A discrete, or discontinuous signal; one whose various states are discrete intervals apart.

Display: Visual representation of data.

Distortion: Non-linear variation of the different components of a signal.

Diversity: Method of transmission and/or reception designed to reduce the effects of fading.

Duplex Circuit, Channel: Capable of simultaneous transmission in both directions.

EE Bldg: Electrical Equipment Building consisting of 2 rooms, an RF room and a Technical Control room.

EOM (End of Message): A unique character, or sequence of characters, always used to terminate a message.

Encoder: A device to alter the amount or format of information.

Exchange: Centralized circuit switching equipment.

Exchange Service: Interconnection, through switching, of two or more customer's communications equipment.

Extended Area Service: An exchange service which covers more than the local service area.

FAX: Facsimile, transmission of images by a process of scanning and reconstruction.

FCC (Federal Communications Commission): U. S. Agency responsible for regulation of interstate communications services.

Fieldata: A standardized military data transmission code, 7-data plus 1-parity bits.

FIGS: "figures" shift, in a dual-case code.

Four-Wire Circuit, Channel: Two-way circuit, with separate pairs for each direction of transmission.

Foreign Exchange Service: Connection of a telephone to an exchange not normally serving the customer's location.

Frequency: Rate of signal oscillation, in Hertz.

Frequency Modulation: Variation of a carrier signal's frequency, as a function of an information signal.

Frequency Domain: A way of representing electrical signals in which amplitude is indicated with respect to frequency.

Full Duplex: A channel property whereby information can be transmitted in both directions independently and simultaneously.

GROUP: A multichannel system subdivision. Normally comprised of 12 voice channels (multiplexed) and occupying the frequency band 60-108 kHz.

Half-duplex Circuit, Channel: Capable of transmission in two directions, but not both simultaneously.

Hard Copy: A machine-printed document.

Header: The first part of a message, containing all necessary routing information.

Heavy Tropo: Tropo facilities of 10kw or more, 30-120 ft parabolic antennas, and equipped to handle 24 or more voice frequency channels by use of multiplex equipment.

Hertz (Hz): One complete positive and negative alternation of an alternating current. One Hertz is one cycle per second (cps)-the term Hertz is preferred. One kHz is 1000 Hz, one mHz is 1,000,000 Hz, etc.

Home Loop: Data path, allowing off-line use of terminal components.

ICS : Integrated Communications System. Replaces the term IWCS

In-Line: Processing in order of receipt, without prior grouping or sorting, of transactions.

In-Plant System: A system whose parts, including remote-terminals, are all situated in one building or localized area.

Interface: The common boundary, or physical connection, between two devices or systems interconnecting.

IWCS: Integrated Wideband Communications System. Wideband communications network serving Southeast Asia. Replaced by the term ICS

Kilohertz: One thousand Hertz.

KSR (Keyboard Send-Receive): Telegraphic terminal with keyboard and page printer.

Light Tropo: Tropo facilities of less than 10kw and handling 12-24 voice channels.

Link: A portion of a communications circuit; a channel, or designed to be connected in tandem with other channels or circuits; a radio path between two points.

Line Loop: Data path, in a terminal, connected to transmission facilities.

Line Switching: See Circuit Switching.

Local Distribution System: Portion of the SEAWBS providing subscriber access to long lines systems.

Local Loop: The circuit connecting a subscriber to a central exchange.

Long Lines Systems: Portion of SEAWBS that connects designated nodal points with fixed plant, high capacity, multichannel tropospheric scatter, microwave or cable carrier systems.

Loop: A single message circuit from a switching center and/or individual message distribution point to the terminals of an end instrument.

Major Alarm: A signal indicating serious trouble in a communications system.

Mark (As opposed to Space): Telegraphic term for one of two possible signals on a circuit; normal, or closed-circuit, condition is "marking".

Master Station: A terminal having selection control of all other terminals on a multipoint circuit.

Medium: The physical entity through which electrical energy is transmitted.

Medium Tropo: Tropo facilities of 10 kw and handling 24 voice channels.

Megahertz: One million hertz.

Message: A sequence of words or symbols which is complete in itself; typically consists of header, text and EOM.

Message Routing: The process of selecting the correct circuit path for a message.

Message Switching: The process of receiving, temporarily storing and forwarding a message, by a central location.

Microwave: Super-high radio frequency; nominally, 1,000 to 300,000 megahertz.

Minor Alarm: A signal indicating a fault in a communications system which has not degraded traffic handling capability.

Mod/Demod, Modem: Abbreviations for modulator/demodulator.

Modulation: A process for varying one or more characteristics (frequency, amplitude, phase) of a carrier signal with an information signal.

Multiple-Address (Message): A message to be delivered to more than one location.

Multiplexing: The process of sharing one facility among several users by time and/or space division.

Multipoint, Multistation: A circuit having multiple stations connected.

Networks: A system of connected points; as, terminals connected by communications channels and some form of exchange.

Nodal Point: A location to which several stations are connected by communications channels.

Noise: An undesired signal.

ODM: See Operations Directive Message.

Off-Line: Not connected to the transmission facility (line).

On-call Circuit: A circuit activated only on request of the user.

On-Line: Directly connected to a central processor.

Operations Directive Message (ODM): DCA message directing action or requesting additional information involving operational responsiveness of the DCS.

Parallel Transmission: Simultaneous transmission of the bits making up a character or byte, either over separate channels or on different carrier frequencies on one channel.

Perforator: A manually operated or directed paper tape punch.

Phase Modulation: Control of the phase, or timing, of a carrier signal by an information signal.

Pre-emption: Seizure of a circuit to restore a higher priority circuit

Priority Indicators: Group of characters which indicate the relative urgency of a message.

Pulse Modulation: Transmission of information by modulation of a pulsed, or intermittent, carrier; pulse width, count, phase, and/or amplitude may be the varied characteristic.

Relay Center: A message exchange point between circuits.

Remote: A terminal located at some distance from a central system.

Repeater: A device used to regenerate signals on a communications circuit.

Reperforator: A line-operated paper tape punch.

Reroute: To substitute a channel or channels when original channel or channels fail.

Restoration: Re-establishment of communications service.

Restoration Priority: An alpha-numberical designation establishing a means of determination of the order of circuit restoration.

RO (Receive Only): A telegraphic terminal with receiving circuits and a page printer.

ROTR (Receive Only Typing Reperforator): A telegraph terminal with a receiving tape punch which also prints characters directly on the tape.

Routing: Assignment of a message to the proper circuit to reach an addressee.

Routing Indicator: An address in a message header, showing the destination circuit or terminal.

RT (Reperforating Transmitter): Telegraphic terminal incorporating a paper tape punch (receive) and reader (transmit).

SEAWBS: Southeast Asia Wideband System.

Selection: Addressing terminal and/or components on a Selective Calling Circuit.

Selective Calling: The ability to address one, or a selected group, of multiple terminals on a circuit.

Semiautomatic Switching: Transfer of traffic from incoming to outgoing circuits under operator control (usually push-button).

Side Band: In a modulated carrier, those frequency components above and below the carrier frequency, which contain the information being transmitted.

Signal: Information in the form of electrical power.

Signal-to-Noise Ratio: Relative power of signal to the noise in a channel.

Simplex Circuit, Channel: One-way transmission, not capable of being reversed.

Single-Address(Message): A message to be delivered to only one location.

Single Sideband: Transmission technique in which the carrier and one sideband are suppressed; used to conserve power, since one sideband contains all the information which was impressed on the carrier originally.

Space (As opposed to Mark): Telegraphic term for one of two possible signals on a circuit; transferred, or open-circuit, condition is "spacing".

Space Division: In switching, a method whereby switching is accomplished by the provision of separate physical paths.

Start-Stop: Asynchronous transmission.

Station: An installation where electrical communications are originated and/or terminated.

Sub-Voice Circuit, Channel: A circuit with narrow bandwidth, usually 200 baud or less; may be a subdivision of a voice circuit.

Supergroup: A multiplex division, having normally 60 channels of a wideband path (five, 12 channels GROUPS) and occupying the frequency band, 312-552 kHz.

Supervision: Information provided to control the provision of service by a switching system. This includes, for example the "off-hook" or demand-for-service signal.

Switch: A means of directing information from one channel to another, as desired, under local or remote control.

Switching Center: A location which terminates multiple circuits and is capable of transferring traffic between them; may be automatic, semi-automatic, or torn-tape.

Synchronous Transmission: Continuous bit-stream transmission, with no start-of-character identification.

Terminal: Any device capable of sending and/or receiving information over a communication channel.

Terminal Facility: A communications facility where channels may be tested, rerouted or terminated.

Text: The information portion of a message.

Through-Grouping: The interconnection of a wideband GROUP (12 channels, mux) from one radio trunk to another either by use of filters or switching.

Tie-Line: A leased channel, usually voice-grade.

Time Division Switching: Switching accomplished through the multiplexing of several channels onto a time-shared path with time association of the channels to be connected.

Time Domain: A way of representing electrical signals in which amplitude is indicated with respect to time.

Tone pack: See Voice Frequency Carrier Telegraph.

Torn-Tape Switching: Manual transfer of punched tape from incoming circuits to outgoing circuits.

Touch-Tone: Circuit connection technique utilizing a set of frequencies, instead of pulses, to represent digits; pushbuttons are used for input, instead of a dial mechanism.

Traffic: Data or messages in a communications system.

Transceiver: A terminal capable of both transmitting and receiving traffic.

Transmission: The electrical transfer of information between two points.

Trunk: A single or multi-channel communications medium between two terminal facilities.

Trunk Designator: Six position alpha numeric code indentifying a trunk.

TTY: Abbreviation for teletype, often used to mean telegraphic.

Turnaround Time: The time necessary to reverse the direction of a half-duplex circuit, data set and/or terminal.

Two-Wire Circuit, Channel: Single pair transmission path, capable of operation in one direction at a time; may be simplex or half-duplex.

TWX (Teletypewriter Exchange Service): AT&T's switched network for interconnecting teletypewriter subscribers, in U. S. and Canada.

UHF (Ultra-High Frequency): A radio signal in the range of 300 - 3,000 megahertz.

VFCT: See Voice Frequency Carrier Telegraph

Video: An electrical signal capable of representing television or a channel capable of transmitting television (nominally about five megahertz of bandwidth).

Voice Circuit, Channel: A circuit with sufficient bandwidth to permit transmission of intelligible speech as an analog signal.

Voice Frequency Carrier Telegraph (VFCT): A number of teletype signals that are converted to one composite tone in the voice frequency range.

Wet Wash: Undersea cable system between Nha Trang and Clark AFB, Philippines. Extended to Saigon by an AN/MRC-85 system.

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