COMMUNICATIONS TECHNICIAN O 3 & 2

BUREAU OF NAVAL PERSONNEL

NAVY TRAINING COURSE NAVPERS 10235-A

PREFACE

This book has been written to aid enlisted personnel of the United States Navy and Naval Reserve in preparing for advancement to the rates of Communications Technician, O Branch, 3 and 2.

Subjects with which Communications Technician personnel must be familiar and the skills to be acquired before qualifying for advancement are contained in the Manual of Qualifications for Advancement in Rating for Communications Technicians, Naval Security Group Instruction P002573.5 series. Personnel should check the currently effective edition of that instruction before beginning to study for advancement in rating.

Those who work in communications know how quickly procedures and equipment can change. Although this book was up to date when published and will be revised from time to time, between revisions some obsolescence may occur. For that reason, personnel should keep up to date on the latest publications and directives.

This Navy Training Course was prepared by the U. S. Naval Security Group Headquarters in cooperation with the Bureau of Naval Personnel.

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THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

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

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

WE SERVE WITH HONOR

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

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

Our responsibilities sober us; our adversities strengthen us.

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

THE FUTURE OF THE NAVY

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

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

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

Never have our opportunities and our responsibilities been greater.

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NAVY TRAINING COURSES

Introduction to Electronics, NavPers 10084

Basic Electricity, NavPers 10086-A

OTHER PUBLICATIONS

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Communication Instructions, General—ACP 121

Communication Instructions, Security—ACP 122

Communication Instructions, Teletypewriter (Teleprinter) Procedure—ACP 126

Communication Instructions, Tape Relay Procedure—ACP 127

Department of the Navy Security Manual for Classified Information, OPNAVINST 5510.1B

Naval Security Group Communications Manual, OPNAVINST P002561.1C

CRITICOMM Operating Instructions

CHAPTER 1

THE COMMUNICATIONS TECHNICIAN, O BRANCH

This training course is designed to help you meet the professional qualifications for advancement to Communications Technician, O Branch 3 & 2. The qualifications which were used as a guide in the preparation of this training course are those set forth in the Manual of Qualifications for Advancement in Rating for Communications Technicians, Naval Security Group Instruction P002573.5B. Changes in the qualifications subsequent to the Bravo edition are not reflected in the information contained in this publication.

The chapters following this introduction are designed to provide unclassified information concerning security, telecommunications, safety, radio wave propagation and electronic concepts, antennas, transmission lines, multicouplers, radio and teletypewriter equipment, and communication center administration and message handling procedures. Since this training course is unclassified, information pertaining to the more sensitive aspects of your specialty must be obtained from appropriate publications listed in the effective edition of Training Publications for Communications Technicians Examinations, Naval Security Group Instruction 002573.3.

The remainder of this chapter is concerned with the enlisted rating structure, the Communications Technician rating, requirements and procedures for advancement in rating, and references that will help you not only in working for advancement but also in performing your duties. Information is also given on how to make the best use of Navy training courses. Therefore, it is strongly recommended that you carefully study this first chapter before proceeding with an intensive study of the other chapters of this training course.

THE ENLISTED RATING STRUCTURE

In the present enlisted rating structure, two types of ratings will be of interest to you—general ratings and service ratings.

GENERAL RATINGS identify broad occupational fields of related duties and functions. Some general ratings include service ratings; others do not. Both Regular Navy and Naval Reserve personnel may hold general ratings.

SERVICE RATINGS identify subdivisions or specialties within a general rating. Although service ratings can exist at any petty officer level, they are most common at the PO3 and PO2 levels. Both Regular Navy and Naval Reserve personnel may hold service ratings.

THE COMMUNICATIONS TECHNICIAN RATING

Before and during World War II, the jobs now performed by Communications Technicians were done by men selected from several other ratings such as Radiomen, Yeomen, Electronic Technicians, and others. That group of personnel from the various ratings gradually was organized into one unit which is now called the Naval Security Group. Realizing that the work done by those persons assigned to the NAVSECGRU required special skills and training which were not available to each of the ratings then being utilized, the Navy established, in April 1948, the Communications Technician (CT) rating. CTs, together with specially designated officers and warrant officers, comprise the NAVSECGRU.

As the NAVSECGRU expanded and became responsible for a wide variety of technical programs, the need for specialization—even within the CT rating—became apparent. Consequently, six separate branches have evolved within the CT rating: the R or Collection Branch, the O or Communications Branch, the A or Administrative Branch, the M or Maintenance Branch, the T or Technical Branch, and the I or Interpretive Branch.

The CT rating is a general rating as defined in the foregoing section describing the enlisted rating structure; there are no service ratings within the CT rating. Separate professional qualifications for each of the six branches within the CT rating have been established. Although you are a part of the general CT rating, you will be examined for advancement on knowledge and skills applicable to your particular branch. Of course, you will also be expected to be proficient in subjects such as security and organization of the Naval Security Group, which are of equal importance to all CT branches.

The duty tours of CTs are varied and interesting. CT personnel may expect to utilize their special skills on board Navy ships, in aircraft, and at shore bases located throughout the world. Wherever you work, you will learn that other Navy personnel will be relying on the accuracy and efficiency of your work. Attention to small details is of utmost importance because the results of your work will be used at all levels of government. One small omission or careless error might start a chain of events which could, in addition to costing large sums of money, actually jeopardize the security of the nation.

LEADERSHIP

Many books about leadership have been published and more appear each year. Usually they present excellent definitions of complex characteristics, such as honor, initiative, and personal behavior. Most of them give interesting examples of the great leaders of the past and how those famous men applied those principles to themselves. Sometimes it seems difficult to relate all of that valuable information to ourselves personally.

As a petty officer, leadership certainly will concern you. As you advance in the CT rating, you will be placed in charge of more men and larger tasks. If you possess leadership ability, you will find respect, efficiency, and a fine working atmosphere wherever you go. If you have failed to train yourself in basic leadership principles, you will find only disappointment and perhaps even ridicule. Do yourself a most important favor at the start of your Navy career and begin to practice leadership now while you are still relatively free of the burdens of higher responsibility. You might one day be very much embarrassed to discover that leadership ability is not mysteriously acquired each time you sew on a new rating badge. Like any other skill, leadership must be studied and practiced. Following are a few basic guidelines for you to follow; whether or not you do so will probably determine your being a success in life or simply another "also-ran."

MILITARY ABILITY

No matter what a petty officer's technical specialty may be, he must understand and carry out his military duties. He must be able to take charge of a group of men and show and tell them how a job should be done. A petty officer should know what to do and how to do it when faced with matters of first aid, hygiene, damage control, fire prevention, and nuclear, biological, and chemical warfare. In short, he must accomplish his military duties and take care of his men. A petty officer's working relationship with others is of great importance to the success of his work and the mission of his activity. In your day-to-day working relationships, you will be required to cooperate with others. This is true not only within your own division but also with men in other divisions. Being able to get along is, at times, just as necessary as proficiency in performing your technical skills. The ability to get along with others is within itself a definite skill which can be developed in much the same manner as a technical skill.

PROFESSIONAL KNOWLEDGE

As a petty officer you should know your job at least as well as any of those persons working for you, and, if possible, better. Learn as much as you can about the operation of each piece of equipment in your working area. Be able to give honest instructions to your men about all phases of your work. To accomplish this you will probably have to seek answers and guidance from your seniors and will have to read manuals, instructions, and other material related to your work. You will be surprised how much your seniors will respect and appreciate your curiosity when you ask questions and show an interest in learning more about your job and more about the overall operations of your unit. Learn to use all available working aids. Try to know where you can find information on all phases of your job. Keep up with new techniques and equipment. Attempt to learn something new about your job every day. Be realistic and actually ask yourself, "Have I learned anything new today?" If not, you moved one step backwards on that particular day.

PERSONAL BEHAVIOR

Let your men see that you support your seniors just as much as you expect your men to support you. If your men hear you enforce what may be a disagreeable order from higher authority, they will understand the situation and show their respect by supporting your own orders to them. Share your men's problems. Avoid use of profanity and discourage its use among your men. Try to improve your speech and your manner of speaking directly to people. Be moderate in your personal habits. Readily admit you are in error when you make a mistake and do not try to bluff your way through a discussion. Bear in mind a most important rule of thumb in the skill of leadership: "Praise in public but reprimand in private."

MORAL BEHAVIOR

Providing moral guidance to your men is also the duty of the petty officer. The special emphasis placed on this phase of leadership is set forth in General Order Number 21, which directs you to observe the high standards of moral behavior and devotion to duty as set forth in Navy Regulations. Thus, you are required to set an example for those under your leadership by scrupulously observing all rules and regulations of the Navy, by indicating initiative and determination in accomplishing your work, by reflecting high moral standards in your behavior, and by ensuring that your men receive your full attention and supervision.

PERSONAL APPEARANCE

It is basic human nature for people to admire the man who is clean, neatly dressed, and carries himself well. Good personal appearance is easy to maintain and is also one of the most readily noted characteristics of the leader. Keep your uniforms as clean and neat as possible and wear them properly. Take a good honest look at yourself now and then, and take measures to improve your personal appearance when possible. Indulge in regular periods of physical exercise. You will not only feel better, but you will also be adding to your qualities as a leader. Develop a ready smile and present a cheerful appearance to your men when the going gets difficult.

ADVANCEMENT IN RATING

Some of the rewards of advancement in rating are easy to see. You receive more pay, your job assignments become more interesting and more challenging, you are regarded with greater respect by officers and enlisted personnel, and you enjoy the satisfaction of getting ahead in your chosen Navy career.

But the advantages of advancing in rating are not yours alone. The Navy also profits. Highly trained personnel are essential to the functioning of the Navy. By each advancement in rating, you increase your value to the Navy in two ways. First, you become more valuable as a technical specialist in your own rating. Second, you become more valuable as a person who can train others and thus make far-reaching contributions to the entire Navy.

HOW TO QUALIFY FOR ADVANCEMENT

What must you do to qualify for advancement? The requirements may change from time to time, but basically you must:

1. Complete a certain amount of time in your present grade.
2. Complete the required military and professional training courses.
3. Demonstrate your ability to perform all the PRACTICAL requirements for advancement by completing the Record of Practical Factors, NavPers 760.
4. Be recommended by your commanding officer, after the petty officers and officers supervising your work have indicated that they consider you capable of performing the duties of the next higher rate.
5. Demonstrate your KNOWLEDGE by passing a written examination on (a) military requirements and (b) professional qualifications.

Some of these general requirements may be modified in certain ways. Figure 1-1 gives a detailed view of the requirements for advancement of active duty personnel; figure 1-2 gives the information for inactive duty personnel.

ACTIVE DUTY ADVANCEMENT REQUIREMENTS

REQUIREMENTS *	E1 to E2	E2 to E3	E3 to E4	E4 to E5	E5 to E6	† E6 to E7	† E7 to E8	† E8 to E9
SERVICE	4 mos. service—or completion of recruit training.	6 mos. as E-2.	6 mos. as E-3.	12 mos. as E-4.	24 mos. as E-5.	36 mos. as E-6.	48 mos. as E-7. 8 of 11 years total service must be enlisted. Must be permanent appointment.	24 mos. as E-8. 10 of 13 years total service must be enlisted.
SCHOOL	Recruit Training.		Class A for PR3, DT3, PT3, AME 3, HM 3			Class B for AGCA, MUCA, MNCA.		
PRACTICAL FACTORS	Locally prepared check-offs.	Records of Practical Factors, NavPers 760, must be completed for E-3 and all PO advancements.						
PERFORMANCE TEST			Specified ratings must complete applicable performance tests before taking examinations.					
ENLISTED PERFORMANCE EVALUATION	As used by CO when approving advancement.		Counts toward performance factor credit in advancement multiple.					
EXAMINATIONS	Locally prepared tests.		Navy-wide examinations required for all PO advancements.				Navy-wide, selection board, and physical.	
NAVY TRAINING COURSE (INCLUDING MILITARY REQUIREMENTS)		Required for E-3 and all PO advancements unless waived because of school completion, but need not be repeated if identical course has already been completed. See NavPers 10052 (current edition).					Correspondence courses and recommended reading. See NavPers 10052 (current edition).	
AUTHORIZATION	Commanding Officer		U.S. Naval Examining Center			Bureau of Naval Personnel		
	TARS attached to the air program are advanced to fill vacancies and must be approved by CNARESTRA.							

* All advancements require commanding officer's recommendation.
† 2 years obligated service required.

Figure 1-1.—Active duty advancement requirements.

INACTIVE DUTY ADVANCEMENT REQUIREMENTS

REQUIREMENTS *		E1 to E2	E2 to E3	E3 to E4	E4 to E5	E5 to E6	E6 to E7	E8	E9
	FOR THESE DRILLS PER YEAR								
TOTAL TIME IN GRADE	48	6 mos.	6 mos.	15 mos.	18 mos.	24 mos.	36 mos.	48 mos.	24 mos.
	24	9 mos.	9 mos.	15 mos.	18 mos.	24 mos.	36 mos.	48 mos.	24 mos.
	NON-DRILLING	12 mos.	24 mos.	24 mos.	36 mos.	48 mos.	48 mos.		
DRILLS ATTENDED IN GRADE †	48	18	18	45	54	72	108	144	72
	24	16	16	27	32	42	64	85	32
TOTAL TRAINING DUTY IN GRADE †	48	14 days	14 days	14 days	14 days	28 days	42 days	56 days	28 days
	24	14 days	14 days	14 days	14 days	28 days	42 days	56 days	28 days
	NON-DRILLING	None	None	14 days	14 days	28 days	28 days		
PERFORMANCE TESTS				Specified ratings must complete applicable performance tests before taking examination.					
PRACTICAL FACTORS (INCLUDING MILITARY REQUIREMENTS)		Record of Practical Factors, NavPers 760, must be completed for all advancements.							
NAVY TRAINING COURSE (INCLUDING MILITARY REQUIREMENTS)		Completion of applicable course or courses must be entered in service record.							
EXAMINATION		Standard exams are used where available, otherwise locally prepared exams are used.						Standard EXAM, Selection Board, and Physical.	
AUTHORIZATION		District commandant or CNARESTRA					Bureau of Naval Personnel		

* Recommendation by commanding officer required for all advancements.
† Active duty periods moy be substituted for drills and training duty.

Figure 1-2.—Inactive duty advancement requirements.

Remember that the requirements for advancement can change. Check with your educational services officer to be sure that you know the current requirements.

Advancement in rating is not automatic. After you have met all the requirements, you are ELIGIBLE for advancement. You will actually be advanced in rating only if you meet all the requirements (including scoring high enough on the written examination) and if the quotas for your rating permit your advancement.

HOW TO PREPARE FOR ADVANCEMENT

What must you do to prepare for advancement in rating? You must study the qualifications for advancement, work on the practical factors, complete required Navy training courses, and study other material that is required for advancement in your rating. To prepare for advancement, you will need to be familiar with the (1) CT Quals Manual, (2) Record of Practical Factors, NavPers 760, (3) List of Training Publications for Communications Technicians Examinations, NAVSECGRU INSTRUCTION 002573.3, and (4) applicable Navy training courses. The following sections describe these publications and give you some practical suggestions on how to use them in preparing for advancement.

CT Quals Manual

The Manual of Qualifications for Advancement in Rating for Communications Technicians, NAVSECGRU INSTRUCTION P002573.5 (effective edition) states the minimum requirements for advancement to each rate within each branch. The manual is referred to as the CT Quals Manual. The qualifications, often called "quals," are of two general types: (1) professional or technical qualifications and (2) military requirements.

PROFESSIONAL QUALIFICATIONS are technical or professional requirements that are directly related to the work of each branch of the Communications Technician rating.

MILITARY REQUIREMENTS, which apply to all ratings rather than to any one particular rating, are contained in the effective edition of the Manual of Qualifications for Advancement in Rating, NavPers 18068 (with changes). Military requirements for advancement to third class and second class petty officer deal primarily with military conduct, naval organization, military conduct, naval organization, military justice, security, watch standing, and other subjects which are required of petty officers in all ratings.

Both the professional qualifications and the military requirements are divided into subject matter groups; each subject matter group is further divided into PRACTICAL FACTORS and KNOWLEDGE FACTORS. Practical factors are things you must be able to DO. Knowledge factors are things you must KNOW in order to perform the duties of your rating.

The professional qualifications for advancement in your rating are printed in the effective edition of the CT Quals Manual. Study these qualifications and the military requirements carefully. The written examinations for advancement in rating will contain questions relating to the practical factors and the knowledge factors of both the professional qualifications and the military requirements. If you are working for advancement to second class petty officer, remember that you may be examined on the qualifications for third class as well as those for second class petty officer.

At the time this training course was prepared, the effective edition of the CT Quals Manual was NAVSECGRUINST P002573.5B. However, the qualifications are changed more frequently than Navy training courses are revised. By the time you are studying this training course, some of the quals for your branch may have been changed. You should, therefore, check the effective edition of the CT Quals Manual to be certain that you have the latest information concerning your professional requirements.

Record of Practical Factors

Before you can take an examination for advancement in rating, there must be an entry in your service record to show that you have qualified in the practical factors for both the military requirements and the professional qualifications. A special form, the Record of Practical Factors, NavPers 760, is used to keep a record of your practical factor qualifications. This form lists all practical factors both military and professional. As you demonstrate your ability to perform each practical factor, be sure that entries are made in the DATE and INITIALS columns by your supervising officer.

When changes are made to the CT Quals Manual, revised forms of NavPers 760 are provided as required. Extra space is allowed on the form for entering additional practical factors which may be added to the CT Quals Manual. The form also provides space for recording demonstrated proficiency in skills which are within the general scope of the rating but which are not identified as minimum qualifications for advancement.

If you are transferred before you qualify in all practical factors, the NavPers 760 form should be forwarded with your service record to your next duty station. You can save yourself a lot of trouble by making sure that this form is inserted in your service record before you are transferred. If the form is not in your service record, you may be required to requalify in the practical factors which have already been checked off.

Study List

The List of Training Publications for Communications Technicians Examinations, NAVSECGRU INSTRUCTION 002573.3 (effective edition), is a very important publication when you are preparing for advancement in rating. This bibliography lists the Navy training courses and other reference material to be used by personnel studying for advancement in rating. Usually referred to simply as the Study List, this instruction is revised and issued periodically; each revision is indicated by a letter following the instruction number. When using the Study List, be sure that you have the most recent edition.

In the Study List, publications are listed by rate level. If you are working for advancement to third class, study the material listed for third class. If you are working for advancement to second class, study the material listed for second class, but remember that you are also responsible for the publications listed for the third class level.

Do not overlook Part I of the Study List, which lists publications pertaining to the military requirements for advancement. Personnel of ALL ratings must complete the mandatory military requirements for the appropriate rate level before they are eligible to take the examinations for advancement in rating. Part II of the Study List is also important because it lists the material which is common to all branches of the CT rating.

All references in the Study List, both recommended and mandatory, should be carefully studied. All references listed may be used as source material for the written examinations at appropriate rate levels. Although the Study List includes the majority of the material upon which examination questions are based, it is not intended to be an absolutely complete listing; other material pertinent to the qualifications may be used as source material for examination questions.

Navy Training Courses

There are two general types of Navy training courses. RATING COURSES are prepared for most enlisted ratings. A rating training course gives information that is directly related to the professional qualifications of one or more branches of the CT rating. SUBJECT MATTER COURSES or BASIC COURSES give information that may apply to more than one CT branch or more than one rating.

Navy training courses are revised from time to time in order to keep them up to date. The revision of a Navy training course is identified by a letter following the NavPers number. You can determine whether any particular copy of a Navy training course is the latest edition by checking the NavPers number and its letter suffix in the most recent edition of List of Training Manuals and Correspondence Courses, NavPers 10061. (NavPers 10061 is a catalog, revised semiannually, that lists all current training courses and correspondence courses.) You will find this catalog useful in planning your study program.

The following suggestions may help you to make the best use of this course and other publications when you are preparing for advancement in rating:

1. Study the military requirements and professional qualifications for your rating before you study the training course. Refer to the quals frequently as you study. Remember, you are studying the training course primarily to meet requirements set forth in the quals.

2. Set up a regular study plan. It will probably be easier for you to stick to a schedule if you plan to study at the same time each day. If possible, schedule your studying for a time of day when you will not have too many interruptions or distractions.

3. Before you begin to study any part of the training course intensively, become familiar

with the entire book. Read the preface and table of contents. Check through the index. Look at the appendixes. Thumb through the book without any particular plan, looking at the illustrations and reading bits here and there as you see things that interest you.

4. Look at the training course in more detail, to see how it is organized. Look at the table of contents again; then, chapter by chapter, read the introduction, the headings, and the subheadings. This will give you a pretty clear picture of the scope and content of the book. As you look through the book in this way, ask yourself some questions. What do I need to learn about this? How is this information related to information given in other chapters? How is this information related to the qualifications for advancement in rating?

5. When you have a general idea of what is in the training course and how it is organized, fill in the details by intensive study. In each study period, try to cover a complete unit—it may be a chapter, a section of a chapter, or a subsection. The amount of material that you can cover at one time will depend on how well you know the subject and the difficulty level of the material.

6. In studying any one unit, write down questions that occur to you. Many people find it helpful to make a written outline as they study; others simply write down the most important ideas.

7. As you study, relate the information in the training course to the knowledge you already have. When you read about a process, a skill, or a situation, try to see how this information ties in with your own experience.

8. When you have finished studying a unit, take time out to see what you have learned. Look back over your notes and questions. Maybe some of your questions have been answered, but perhaps you still have some that are not answered. Without looking at the training course, write down the main ideas that you have derived from studying a unit. Don't just quote the book. If you can't express the ideas in your own words, the chances are that you have not really mastered the information.

9. Enroll in enlisted correspondence courses associated with your path of advancement. Correspondence courses, based on Navy training courses or on other appropriate texts, are designed to broaden your field of knowledge.

10. Think of your future as you study Navy training courses. You are working for advancement to third or second class right now, but soon you will be working toward higher rates. Anything extra that you can learn now will help you both now and later.

SOURCES OF INFORMATION

One of the most useful things you can learn about a subject is how to find out more about it. No single publication can give you all the information you need to perform the duties of your rating. You should learn where to look for accurate, authoritative, up-to-date information on all subjects related to the military requirements for advancement and the professional qualifications of your rating.

Some of the publications described in this course are subject to change or revision from time to time, some at regular intervals, others as the need arises. When using any publication that is subject to change or revision, be sure that you have the latest edition. When using any publication that is kept current by means of changes, be sure you have a copy in which all official changes have been made. Studying cancelled or obsolete information will not help you to do your work or to advance in rating; it is likely to be a waste of time, and may even be seriously misleading.

CHAPTER 2

SECURITY

As a CT you will hear a great deal about the security of classified material. Most NAVSECGRU activities require all new arrivals to attend a security lecture. Further, every three months NAVSECGRU personnel must read and indicate that they understand several of the most important national laws and regulations such as the Espionage and Censorship Act. It might appear to you that there exists a large, secret organization which handles all the security matters of the NAVSECGRU. Actually, there is no such force of men. You as a CT provide your own security. There is no one to whom you can transfer your security job. The minute you become a CT, you take on the full responsibility for protecting all classified material and information with which you work.

Maintaining the security of classified material (assume that the term "classified material" includes classified information also) is not an extra job for the CT. It is really a basic part of your assignment just as is operating electronic equipment. Imagine how little your job would mean to the Navy if the classified material you handle were given no security protection.

Security is more than a matter of being careful; it requires both study and practice. Thorough understanding of this chapter will not provide full knowledge of all the finer points concerning security, but it will provide you a good fundamental background upon which security is built. As soon as possible you should become familiar with the following primary references for security information:

U. S. Naval Communications Instructions, DNC 5, Chapter 5

Communication Instructions Security, ACP 122

Navy Regulations, 1948, Chapter 15

Department of the Navy Security Manual for Classified Information, OPNAVINST 5510.1

United States Navy Physical Security Manual, OPNAVINST P5510.45

SECURITY CLEARANCES

Before a person can have access to classified material, his character and his past must be checked to the extent appropriate to the sensitivity of the material he will be handling. Following are the two basic qualifications which must be met:

1. He must be of unquestionable integrity, trustworthiness, and loyalty to the United States.
2. He must be of excellent character and of such habits and associations as to cast no doubt upon his discretion and good judgment in the handling of classified information.

TYPES OF INVESTIGATIONS

To determine whether an individual meets the criteria for a security clearance, two types of personnel security investigations are employed—the National Agency Check (NAC) and the Background Investigation (BI).

National Agency Check

A National Agency Check consists of the investigation of the records and files of a number of government agencies to determine if any derogatory information exists on the individual or on an organization to which he may have belonged.

Background Investigation

The Background Investigation is much more extensive than a National Agency Check. It is designed to develop information as to whether the access to classified information by the person being investigated is clearly consistent with the interests of national security. It inquires into the loyalty, integrity, and reputation of the individual. It consists of the following elements:

1. National Agency Check.
2. Verification of birth records.
3. Education, including verification of last school or college attended, checking school records, and interviewing people who knew the individual while at school.
4. Employment, including examination of records of present and past employment to determine period of service and efficiency record. Fellow employees are interviewed to determine character and reputation.
5. References, including interviews of those persons listed as references, plus others who may have knowledge of subject's background and activities.
6. Neighborhood investigation as deemed necessary to substantiate or disprove derogatory information.
7. Criminal records including police and law enforcement agency records in areas where individual has resided for substantial periods.
8. Military service, including length of service and type of discharge.
9. Associations which an individual may have had with foreigners or foreign organizations both in the U. S. and abroad.
10. Citizenship status.
11. Foreign travel. State Department and Central Intelligence Agency (CIA) records are checked to determine reasons for travel.
12. Credit record. Credit agencies and credit references are checked whenever necessary.

The Statement of Personal History, which must be submitted by all CTs, is the basic application from which a background investigation is accomplished. A Fingerprint Card must also be submitted. If the individual is married to or becomes married to an alien, an Alien Spouse Statement of Personal History is required. Each security clearance is reviewed approximately every five years. During the period between reviews, it is the responsibility of each CT to keep his Statement of Personal History current so that it reflects any changes to the information originally submitted. Failure to keep his record current could jeopardize his security clearance.

INTERIM CLEARANCE

A personnel security clearance is an administrative determination that an individual is eligible, from a security standpoint, for access to classified information of the same or lower category as the clearance being granted. Of the two types of clearances (interim and final), an interim clearance is granted as the result of a lesser investigative process and is a determination of temporary eligibility for access to classified information. Certain requirements, which vary with the classification category, must be met. These requirements are defined in chapter 15 of the Security Manual. An interim clearance is granted only when the delay in waiting for completion of the necessary steps for final clearance would be harmful to the national interest. Procedures to effect a final clearance are initiated simultaneously with the initiation of the procedures for an interim clearance.

FINAL CLEARANCE

A final clearance is granted when it has been determined that an individual is eligible, from a security standpoint, for access to classified information in the category of clearance being requested. To be eligible for a final clearance, an individual must meet the clearance criteria and full investigative requirements as set forth in chapter 15 of the Security Manual.

NAVSECGRU CLEARANCE

Satisfactory completion of the clearance prerequisites outlined earlier in this chapter will result, for CT personnel, in the issuance of a NAVSECGRU Top Secret Clearance, either final or interim. That clearance is granted by the Director, NAVSECGRU, who has been charged with the responsibility for security control of NAVSECGRU. The issuance of that clearance is the responsibility of the commanding officer of the activity to which the CT is attached. At those activities having a Special Security Officer (SSO)—specifically designated by the Director, NAVSECGRU—the SSO should be designated as the representative of the commanding officer for issuing NAVSECGRU Top Secret Clearances.

A NAVSECGRU Top Secret Clearance indicates that the individual is eligible, from a security viewpoint, for access to Top Secret and cryptographic information as well as to Special Intelligence material, a type of NAVSECGRU material which requires special handling.

A NAVSECGRU Top Secret Clearance may be suspended or cancelled at any time the individual fails to maintain the proper security qualifications. Further, the clearance can expire unless another security investigation is made within five years of the date of the latest investigation as indicated on the individual's Certificate of Clearance.

Suspension or cancellation of a NAVSECGRU Top Secret Clearance could result from an individual's being involved with any of the following activities:

1. Maintaining with a foreign national any relationship which the individual's commanding officer judges to be a potential security risk
2. Sexually perverted acts
3. Promiscuous heterosexual activity
4. Excessive drinking
5. Gambling
6. Excessive indebtedness
7. Flagrant disregard for established authority
8. Serious mental instability
9. Repeated security violations or poor security practices
10. Violations of military, criminal, or civil law
11. Subversive activities

CERTIFICATE OF CLEARANCE

Each clearance, final and interim, is evidenced by the issuance of a Certificate of Clearance. Certificates of clearance are made a matter of record and become a permanent part of an individual's service record.

Merely because an individual has been cleared for access to information of a certain classification category does not mean that he may have access to all classified information within that category. Classified information is made available to appropriately cleared personnel on a "need-to-know" basis.

NAVSECGRU INDOCTRINATION

After being granted either an interim or final security clearance, one final step must be accomplished before CT's can be granted access to NAVSECGRU classified material. That step is termed "indoctrination" and is accomplished by studying the security requirements concerning special NAVSECGRU material, and signing an oath that the requirements are understood and will be complied with. The recipient of an indoctrination is legally responsible for his security actions wherever he might go—in or out of the Navy. The indoctrination is administered at each NAVSECGRU activity by the Special Security Officer. You will do well to pay particular attention to the indoctrination process and to question your SSO about any matters which are not perfectly clear to you. Once the indoctrination is accepted, you are liable for fine or imprisonment or both should you willfully violate the provisions of that indoctrination.

SECURITY CLASSIFICATIONS

Classified material is official material which requires protection in the interests of national defense and which is classified for such purposes by responsible classifying authority. Three general categories of classification are authorized for such material. They are, in descending order of importance, Top Secret, Secret, and Confidential (including Confidential-Modified Handling Authorized).

After a CT is officially indoctrinated, the SSO will explain to him the use of a special handling system which supplements this classification system when applied to certain NAVSECGRU material.

TOP SECRET

The use of the classification Top Secret is limited to defense material or information which requires the highest degree of protection. It is applied only to information or material of which the defense aspect is paramount and which is of such a nature that its unauthorized disclosure could result in EXCEPTIONALLY GRAVE DAMAGE to the Nation, such as:

1. Leading to a definite break in diplomatic relations affecting the defense of the United States, an armed attack against the United States or its Allies, or war.
2. The compromise of military or defense plans, intelligence operations, or scientific or technological developments vital to the national defense.

SECRET

The use of the classification Secret is limited to defense information or material the unauthorized disclosure of which could result in SERIOUS DAMAGE to the Nation, such as:

1. Jeopardizing the international relations of the United States.

2. Endangering the effectiveness of a program or policy of vital importance to national defense.

3. Compromising important military or defense plans, or scientific or technological developments important to national defense.

4. Revealing important intelligence operations.

CONFIDENTIAL

Information or material classified Confidential is such that its unauthorized disclosure could be PREJUDICIAL TO THE DEFENSE INTERESTS of the Nation.

Certain types of Confidential information may be identified by the term Confidential-Modified Handling Authorized. This is material which, although falling in the group described by Confidential, has been designated by the originator for slightly lesser safeguards in stowage and transmission. This classification is assigned only after careful consideration of the content of the material and only for the purpose of making it more easily available to those who need to use it. Examples of this kind of material are textbooks, manuals, maps, and photographs whose content makes it permissible and desirable to use them for training purposes.

If you wish to understand more thoroughly the various categories of classified matter, you will find several examples of each type in the Security Manual, but the most important thing for you to learn at this time is that each category represents a degree of damage to the Nation that could result from letting the material get into the hands of unauthorized persons. The category also determines how the material shall be handled and the measures used for its protection.

RESTRICTED DATA

The term Restricted Data is not a category of classification but a special designator which is assigned because of the general subject of the information concerned. It is applied to all data concerning (1) the design, manufacture, or utilization of atomic weapons; (20 the production of special nuclear material; or (3) the use of special nuclear material in the production of energy—unless such data or materials have been declassified or removed from the category by the Atomic Energy Commission. Information marked Restricted Data is classified (Top Secret, Secret, or Confidential) according to the protection it should receive. It is declassified when the Atomic Energy Commission decides it may be published without undue risk to the defense and security of the Nation.

FOR OFFICIAL USE ONLY

Certain other official information, not included in the categories of classified matter and only briefly mentioned in the Security Manual, may also require protection in accordance with law and public interest. Such information, according to SECNAV INSTRUCTION 5570.2A, should be designated FOR OFFICIAL USE ONLY.

Among documents bearing the FOR OFFICIAL USE ONLY designation are certain personnel documents and tests and examinations of various kinds, such as those used for entrance on duty, classification, qualification, advancement, or promotion.

The FOR OFFICIAL USE ONLY designation is appropriately used for information relating to Department of Defense operations and activities such as bids from civilian firms on contracts, advance information on plans that should not be released until a later date, and other types of information which if generally disclosed would have an adverse effect on morale, efficiency, or discipline, or would give certain individuals an unfair advantage over others.

TYPES OF SECURITY

Thus far in this chapter you should have learned that security is an integral part of your assignment, that there are two primary types of security clearances, and that there are certain key differences among the categories of classification. The remainder of the chapter is devoted to a discussion of the types of security and the means of accomplishing each type.

Protection of classified material falls roughly into four broad categories:

1. Physical security
2. Personal censorship
3. Transmission security
4. Cryptographic security

PHYSICAL SECURITY

Physical security is the application of those measures designed to keep classified material

	VALUE
1. SHELTER	
None	0
Light structure, such as a quonset hut, which can be locked and barred	10
Heavy structure, such as masonry building	15
Commissioned ship	15
2. STOWAGE CONTAINER	
None	0
Any portable container	0
Wooden container, any type of lock	2
Metal container, key lock attached	5
Metal container, combination lock built in	15
Lightweight steel safe	20
Light vault	20
Heavy steel safe	30
Bank vault	40
3. GUARDING	
Unguarded	0
Military guard in general area	15
Military guard checks container every hour	20
Military guard checks container every 30 minutes	25
Military guard in attendance at container	35
No supporting guard force	0
Military supporting guard force	20
Aboard ship, in areas where only ship's company has access, or visitors are under constant escort	25
4. PROTECTIVE ALARM SYSTEM	
No alarm on container	0
System to detect opening of container	15
System to detect tampering with or opening of container	20
System to detect approach to, tampering with, or opening of container	30
No general area alarm	0
System to detect entry into general area	25
5. CONTROL OF PERSONNEL ACCESS TO CONTAINER WHEN CLOSED, AND TO CONTENTS WHEN OPEN	
System necessary but not in effect	−20
System not required	0
System in effect	5

31.3

Figure 2-1.—Table of numerical equivalents (simplified)

from coming into the possession of persons not authorized to have such information. This category includes even the viewing or hearing of classified information by unauthorized persons. Physical security is based upon two important requirements—proper stowage when not in use and proper handling on the part of every user.

Stowage

Classified material not in actual use by appropriately cleared personnel or under their direct observation should be stowed in a prescribed manner. Stowage facilities for Top Secret material must afford a greater degree of protection than for Secret. Similarly, the stowage requirements are higher for Secret material than for Confidential.

To provide a specific basis for establishing security protection for the various categories of classified material, a numerical evaluation for classified material in stowage has been developed. The system is covered in detail in chapter 6 of Department of the Navy Security

Manual for Classified Information and makes use of two tables:

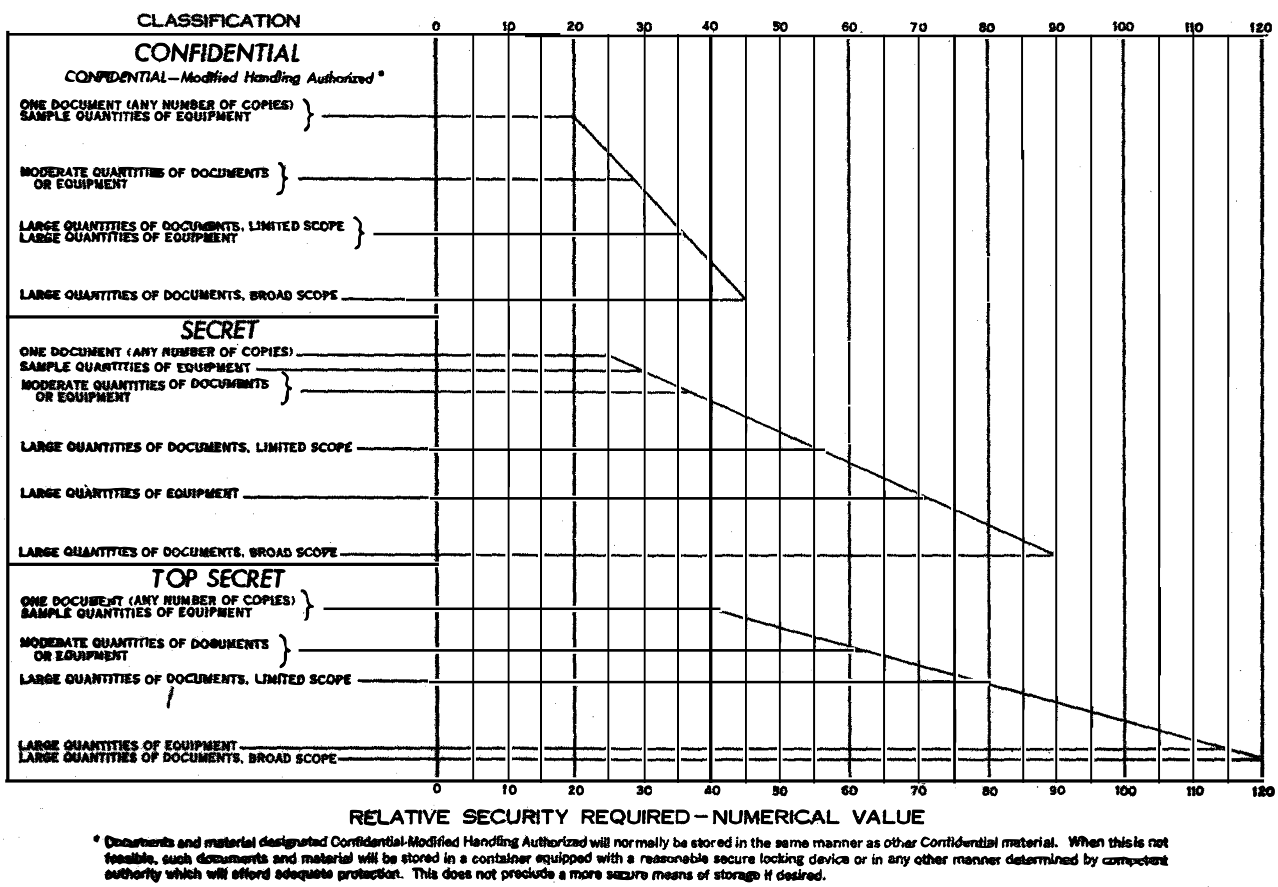
1. A table of numerical equivalents, (figure 2-1) which establishes numerical values for various items which individually or collectively may be incorporated in the stowage protection system.

2. An evaluation graph, (figure 2-2) which establishes minimum levels of required protection based on the classification and the strategic and intrinsic importance of material concerned.

Handling Precautions

In their daily work, most CT personnel will find themselves surrounded by classified material. Familiarity with such conditions must never deteriorate into laxness in physical security. When not in use, classified material should be returned to its proper safe file or storage container. Burn bags must be used for the disposal of all burnable classified material. Classified material must never be left exposed in an unattended working space. Furniture or equipment which is to be removed from spaces where classified matter is handled must be thoroughly inspected to insure that classified material is not inadvertently removed from the spaces.

Often it becomes necessary to admit into NAVSECGRU spaces uncleared maintenance personnel or other uncleared personnel. Appendix J of the Security Manual defines three types of security areas—exclusion, limited, and controlled. Refer to that appendix to determine the various restrictions applied to uncleared persons in relation to each of the three areas. When aware that uncleared persons are in the immediate vicinity, all cleared personnel should restrict their classified conversations to a minimum and never speak in a voice loud enough to be overheard by uncleared persons. In the



31.2

Figure 2-2.—Minimum levels of required protection.

event of a fire or other emergency, every precaution must be taken to prevent the loss or unauthorized disclosure of classified material.

PERSONAL CENSORSHIP

The most difficult category of security to accomplish is personal censorship. Each individual—through indiscreet or boastful conversation, thoughtless personal letters, and discussions involving classified information carried on in nonsecure spaces—is capable of doing grave damage to the security of our country. Personal discussion of official affairs with families or friends, or even careless talk while on duty in the presence of persons not authorized to receive certain information, is dangerous and must be avoided. There is only one safe policy for you to follow when off duty—say nothing about classified matter, or information, to anyone. There are few places where conversation cannot be overheard.

Through the very nature of your work, you will find yourself in possession of information known only to a small group. In order not to betray your trust, you must constantly be on guard against a slip of the tongue which might reveal information to those who have no need to know.

Official matters should not be discussed even with members of your own family or close friends in whom you have the greatest confidence. Although they might never knowingly reveal information given to them, they could disclose classified information without realizing they had done so. Your best bet is to decline to discuss official matters. If necessary, plead ignorance of the subject under discussion.

TRANSMISSION SECURITY

Classified material may be sent by a variety of methods. Within the requirements of precedence and security, the most appropriate means of transmission should be selected. The generally available means of transmission, in descending order of security are:

1. Messengers authorized to carry classified materials
2. U. S. registered mail
3. Approved wire circuits
4. Ordinary postal systems
5. Nonapproved wire circuits
6. Visual systems
7. Sound systems
8. Radio

Messenger

Classified matter is transmitted by messenger when security, not speed, is the paramount objective. The principal messenger agency for the Department of Defense is the Armed Forces Courier Service (ARFCOS), which is responsible for the safe transmittal of highly classified matter to military addressees and certain civilian agencies throughout the world. ARFCOS courier transfer stations are located at a number of places throughout the world. Every item of classified material sent via ARFCOS is in the physical custody and control of a commissioned officer courier from the time of entry into the system until the addressee or his authorized representative receipts for it. ARFCOS is not used to transmit classified material which is authorized to be sent by United States registered mail.

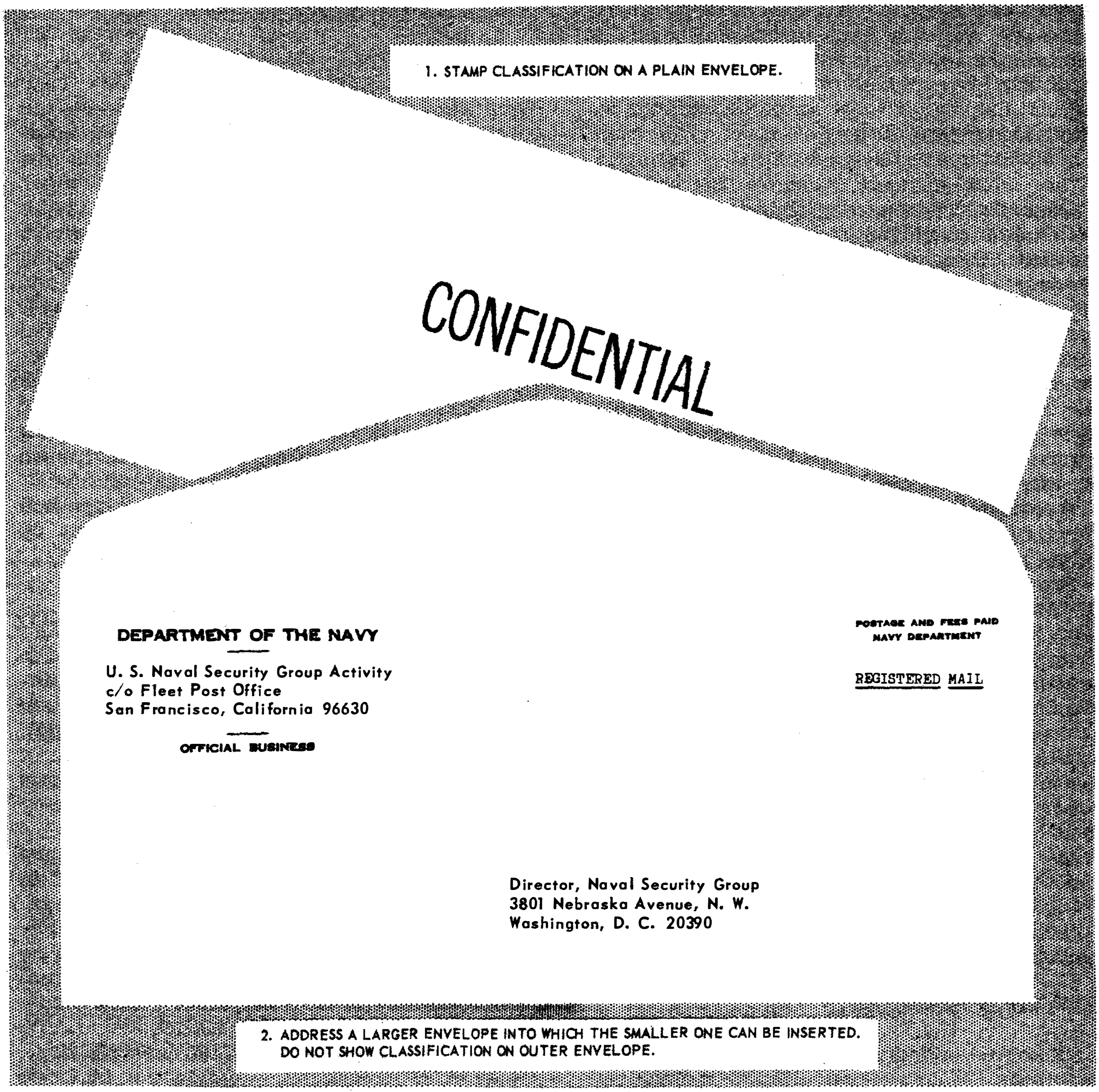
Mail

The United States Postal System is used to transmit both classified and unclassified material. However, the United States Postal System may not be used to transmit Top Secret material. Top Secret material is transmitted in one of three ways: direct personal contact of officials concerned, Armed Forces Courier Service, or electrical means in encrypted form.

Secret material may be transmitted by any of the means authorized for Top Secret, and in addition, U. S. registered mail may be used.

Confidential material may be transmitted by any of the means authorized for Secret, or by U.S. certified mail. Exceptions: Confidential cryptographic and cryptologic material, Confidential material of CENTO, NATO, and SEATO may not be transmitted by U. S. certified mail.

Material designated Confidential-Modified Handling Authorized may be transmitted by ordinary U. S. mail or electrically in unencrypted form over U. S. Government owned or leased land lines. When the originator is uncertain of the location of an addressee, as in the case of an afloat unit, U. S. registered mail must be used. The foregoing rules apply only within the continental United States. Chapter 7 of the Security Manual specifies the authorized methods of transmission of classified material outside the continental United States.



6.1

Figure 2-3.—Mailing classified material.

The great bulk of the Navy's administrative traffic is by mail, thus reserving circuits for operational traffic insofar as possible. Mailable classified material is double-wrapped, as shown in figure 2-3. Top Secret material is prepared in a similar manner but may not be sent through the mails.

Detailed procedures for transmission of cryptographic and registered material are contained in the current edition of the Registered Publications Manual, RPS-4.

Wire Circuits

There are two types of wire systems: APPROVED and NONAPPROVED. Such wire systems include telephone, telegraph, teletypewriter, and facsimile facilities.

An approved circuit is one designated by appropriate authority as suitable for transmission in the clear of messages classified no higher than Secret. Approved circuits usually lie entirely on military property.

A nonapproved circuit is one which does not lie entirely within military property, has a radio link, or for some other reason is not considered safe enough for transmission of traffic in the clear. Sending classified messages in the clear over a nonapproved wire, except as specified in the effective edition of ACP 122, is forbidden.

Telephone circuits are normally considered nonapproved and are not used to discuss classified data unless specifically designated as approved. Approved telephone circuits are equipped with security devices to minimize the possibility of tapping.

Tapping may often be discovered by physical examination or by transmission irregularities. Interception by induction, however, can escape detection completely. Supersensitive devices placed near the wire circuit will pick up sounds through a two-foot wall. Tiny microphones, hidden in telephone receivers, will pick up not only telephone conversations but also voices anywhere in the room.

Underwater cables are also liable to unauthorized interception, although they are more difficult to tap than landlines. Submarines are able to make successful interceptions through induction. The point where the cable emerges into shallow water is the most vulnerable.

Visual Systems

Ships often use visual communication systems in preference to radio because reception is limited to other vessels in the immediate vicinity of the transmitting vessel. Visual communication methods have varying degrees of security depending upon the distance at which they may be intercepted. During daylight hours, the relative descending order of security is: semaphore, directional flashing light, panels, flaghoist, pyrotechnics, and nondirectional flashing light. At night, the descending order is: infrared flashing light, directional flashing light, pyrotechnics, and nondirectional flashing light.

When utilizing flashing light systems, the aperture of the equipment should be kept as narrow as practicable, especially at night. Further, classified messages in plain language may be sent by visual systems only after careful consideration has been given to the necessity for sending it in plain language and to the possibility of interception by unauthorized persons.

Sound Systems

Whistles, sirens, foghorns, bells, and underwater sound devices are common types of sound systems. They are used by vessels to transmit emergency warning signals (air raid alerts, mine sighting, etc.) and for signals prescribed by the Rules of the Road. Sound systems have the same range limitations as visual methods and are less secure. Their use is largely restricted to maneuvering and emergency situations.

Radio

Radio, including all types of electro-magnetic radiations, is the least secure means of communication. A message sent by radio is susceptible to interception by anyone who has the necessary equipment and is within reception range. In addition to obtaining intelligence through cryptanalysis, an intercepting station may be able to fix the location of operating forces through use of direction finding equipment. The use of deceptive techniques can confuse and hamper communications. Traffic analysis can provide forecasts of the intentions of forces as well as information concerning their current activity.

Despite its shortcomings, radio is still the primary means of communication. It is fast, reliable, and often the only method of maintaining contact between distant and highly mobile units. A satisfactory degree of security can be obtained only by its proper and intelligent use.

Experience has proved that transmissions in the ultrahigh frequency (UHF), superhigh frequency (SHF), and extremely high frequency (EHF) ranges beyond line-of-sight distances are frequently noted. It is important that all users recognize the possibility of interception at distances far beyond the normal ranges. The increasing employment of "forward scatter" long-range communications, using VHF and high-powered transmitters, will greatly increase the usable range of VHF, thereby making it more susceptible to intercept by persons other than those intended to receive it.

RADIO SILENCE.—An effective, temporary defensive measure designed to prevent disclosure of intelligence through analysis of radio communications is the implementation of radio silence. When applied to the Navy, the procedure normally is better described as electromagnetic silence, since modern ships carry many other emitters of detectable radiations, such as radar and navigational devices. Electromagnetic silence (or radio silence) is normally imposed for the purpose of concealing the movements and location of military forces, such as a strike task force or an invasion force.

EMCON is the control of electromagnetic radiation for the purpose of reducing the likelihood of enemy interception of significant material during fleet operations. Within a fleet, this control is accomplished by imposing conditions, ranging from complete silence to unrestricted operations, on the transmitting equipment. The determining factor in the degree of silence imposed is the relationship of the frequency and the detectable range of electromagnetic signals.

IMITATIVE DECEPTION.—In imitative deception, an enemy may attempt to enter our communications nets and simulate our traffic in order to confuse and deceive our forces. The success of imitative deception depends largely on unsuspecting communication personnel who become lax in maintaining proper communications security. Several typical imitative deception techniques are listed below:

1. Remove a message from one circuit and introduce it on another circuit to waste time, create confusion, and produce service messages.
2. False plain language messages are sometimes originated to confuse an opposing force.
3. In hope of obtaining a direction finding bearing on a force which has implemented radio silence, an opposing force may transmit false, high-precedence messages which appear to require breaking of the radio silence.
4. One force may activate navigational beacons which imitate those of the opposing force in order to confuse aircraft which are attempting to home in on the valid beacon.

AUTHENTICATION.—The best defense against imitative deception is proper authentication. An authenticator is a letter, numeral, or group of letters or numerals sent before, in, or following a message to prove its authenticity. By correct use of authenticators, operators can distinguish between genuine and fraudulent transmissions.

CRYPTOSECURITY

Cryptosecurity is that type of security obtained by the proper use of either a cipher system or a code system. In cipher systems, cryptograms are produced by applying a cryptographic treatment to individual letters (sometimes to pairs of letters) of the plain text message. In code systems, cryptograms are produced by applying a cryptographic treatment to entire words, phrases, and sentences of the plain text message.

When required to use a cryptosystem, great caution must be taken to ensure that the system is used exactly as specified in the operating instructions, which vary with each cryptosystem. Consider the thought that your making an error in cryptosecurity would not only compromise the classified material which you intend to transmit but also all the other classified material transmitted by the hundreds of other persons who had used that same cryptosystem before.

Other countries are constantly and diligently studying our code and cipher systems in order to try to discover the keys to our many cryptographic systems. This technique is called cryptanalysis. Once it has been determined that there is a good possibility that one of our cryptosystems has been dangerously weakened by numerous instances of erroneous usage, that system must be cancelled and a new one issued to replace it—a process of tremendous cost, to say nothing about potential compromise of classified material.

EMERGENCY DESTRUCTION

In an emergency involving the danger of capture of classified material, the importance of starting destruction soon enough to insure completion cannot be overemphasized.

The consequences of such destruction, which later might be deemed to have been unnecessary, may be of little importance when measured against the consequences brought about by capture of the material. Every activity which holds classified material must have a prearranged simple and practical plan for the emergency destruction of that material. Usually, each person's responsibility in that plan is indicated on a Watch, Quarter and Station Bill. The importance of knowing how to accomplish emergency destruction is emphasized in chapter 6 of the Security Manual for Classified Information, which states in part, "Destruction plans of particular activities, therefore, will call for the exercise by personnel at all levels, of the highest degree of individual initiative practicable under the operative conditions of such activity, in preparing for and in actually commencing destruction required under the plan. Particular care will be taken to indoctrinate all personnel to insure their understanding that, in such emergencies and when required, they will initiate necessary destruction under the plan without waiting for specific orders."

The order in which classified material is to be destroyed under emergency conditions should be determined in advance and the material so marked and stored. The effective editions of both the Security Manual for Classified Information and Cryptographic Operations, KAG-1, offer directions about the priority of destruction. As a general rule, Top Secret cryptographic material always is destroyed first.

All NAVSECGRU activities periodically conduct emergency destruction drills. When a real emergency occurs, there will be no time for instruction and indoctrination. Below are listed a few of the most important points concerning emergency destruction.

1. As destruction is accomplished, a list or record should be kept of the material that has been destroyed. Informing higher authority of exactly which material has been destroyed is second in importance only to the actual destruction.

2. Personnel performing emergency destruction should possess clearances corresponding to the sensitivity of the material they are to destroy.

3. On board ship, it is permissible to jettison classified material in weighted perforated bags if the water is deep enough to preclude salvage.

4. Emergency destruction in an aircraft flying over or near hostile territory or water should be accomplished by shredding or smashing the material and dispensing it as completely as possible.

5. When destroying large volumes of burnable materials by fire, it is more efficient to utilize several small fires rather than one large fire.

6. Consider the use of chemical destruction material for large, bound, burnable material.

7. When time permits, use of chemical destruction material or acetylene torch on classified equipment is more effective than the smashing and dispersing method.

CHAPTER 3

TELECOMMUNICATION SYSTEMS

This chapter describes the communication systems of the Defense Communications Agency, the Navy, Army, Air Force and the major commercial telecommunication companies; and the work of the Federal Communications Commission—the agency that regulates electrical telecommunications within the U.S.

DEFENSE COMMUNICATIONS SYSTEM

The Defense Communications System (DCS) was established within the Department of Defense to provide a single communications system to meet all long-haul, point-to-point telecommunications requirements of the Department of Defense.

The DCS is comprised of all worldwide, long-haul, government-owned and leased point-to-point circuits, trunks, terminals, switching centers, control facilities, and tributaries of the military departments and other Department of Defense activities. In essence, the DCS combines into a single system those elements that make up the Navy's Naval Communications System, the Army's STARCOM, the Air Force's AIRCOM, and the DCS AUTOVON and AUTODIN. It does not, however, include tactical communications, fleet broadcasts, ship-to-shore, ship-to-ship, and air-ground systems.

The Navy, Army, and Air Force circuits that are part of DCS are discussed later in this chapter; therefore, only the DCS AUTOVON and AUTODIN systems are discussed here.

DCS AUTOVON AND AUTODIN

AUTOVON (Automatic Voice Network) is the basic general purpose switched voice network of the Defense Communications System. AUTOVON serves most major installations in CONUS and is extended to Alaska, Hawaii, and Panama. Further expansion is underway to include additional CONUS subscribers and other overseas areas.

AUTODIN (Automatic Digital Network) is a fully automatic digital data switching system managed by the Defense Communications Agency. AUTODIN provides store-and-forward and circuit-switching message service, to data and teletypewriter subscriber terminals and is capable of handling any type of information in digital form, including voice and graphics. The system consists of highspeed, electronic, solid-state switching centers, various types of data and teletypewriter subscriber terminals and the interconnecting transmission media.

The CONUS portion of AUTODIN is partially operational, with switching centers providing card, teletype, magnetic tape, and on-line computer transmission service to Navy, Army, Air Force, and other authorized users. These switching centers are leased, including subscriber terminal equipment from Western Union, as will be future additional centers and their associated terminals.

The overseas portion of AUTODIN, when fully operational, will consist of Automatic Store-and-Forward Digital Message Switching Centers located geographically to insure the availability of instantaneous world-wide communications for authorized users. The overseas centers will be Government owned, and will be maintained and operated by military personnel after one year of contractor operation and maintenance. The Navy will be responsible for the procurement of cryptographic equipment and of subscriber data terminals and modulators-demodulators (MODEMS) to satisfy overseas requirements.

The AUTODIN switching centers will be interconnected through a network of high-frequency radio channels, submarine cables, microwave and tropospheric channels, and a variety of wire lines. These circuits between switching centers will have the capability of operating at speeds equivalent to 60 to 6400 words per minute.

Switching Centers, both operational and planned, will have a high degree of reliability due to duplicate major units, uninterruptible power systems, and provisions for scheduled and unscheduled maintenance while the switching center is in operation. Once a message is accepted by a switching center, the probability of the message not being switched to its proper terminal is one in ten million messages.

Routing information, message formats, and operating procedures used in the switching centers are in accordance with ACP 117, ACP 121, ACP 127 and other applicable operating directives and practices.

The teletypewriter subscribers will be served by a controlled teletypewriter terminal which will automatically provide acknowledgement of end of message; transmission interruption; resumption of transmission of messages without rerun or intervention; rejection and cancellation of messages; message numbering; and verification of received message numbers.

AUTODIN is revolutionizing communications by reducing manual handling of messages to a minimum. In the future, message delivery times and delays will be measured in seconds rather than minutes and hours.

DEFENSE COMMUNICATIONS AGENCY

The Defense Communications Agency (DCA) was established by the Department of Defense to exercise operational and management direction of the Defense Communications System.

The DCA consists of a Director, a Deputy Director, a headquarters establishment, and other subordinate units, facilities, and activities as are established by or specifically assigned to the agency. Guidance to the Director, DCA is furnished by the Secretary of Defense or the Joint Chiefs of Staff by the authority and direction of SECDEF.

The Defense Communications Agency, in execution of its mission, is charged with specific responsibilities in operations, planning, engineering, programming, and research and development, all related to the Defense Communications System.

In order to exercise effective direction over the entire Defense Communications System, DCA has established and operates a control complex consisting of the Headquarters, 4 Area and 7 Regional Communications Operations Centers. However, the actual command, operation, and maintenance of the military stations within DCS rests with the service concerned.

Figure 3-1 shows the geographical locations of the DCA Operations Center Complex and the following paragraphs describe their functions.

DCA COMMUNICATIONS OPERATIONS CENTERS

The functions and tasks associated with the operations centers are to tabulate, assemble, store, and display information on current conditions of the components of the system; allocate channels and circuits to meet requirements of authorized users; and to perform continuous system analysis and such other tasks as are necessary. The principal objective of the operations center system is to assure the greatest possible responsiveness of the DCS to the needs of its users.

The communications operations centers receive and process performance date based on hourly and spot reports made by the various DCS reporting stations on networks, circuits, channels, and facilities of the DCS. These reports provide a knowledge of the status of the DCS at all times. The operations centers know of the traffic backlogs, if any; conditions of circuits; status of installed equipment at some 200 switching centers throughout the world; and the status of channels allocated to the various users. With this knowledge and that of alternate route capabilities between any two points, spare capacity, and radio propagation conditions, the operations centers restore elements and reallocate channels according to the needs and priorities of users.

DCA Headquarters Operations Center

The heart of the communications operations center complex is the DCA Headquarters Operations Center, located in Arlington, Va. In this automatic processing center, complete information on the communications traffic and system status throughout the world is processed and acted upon.

The Headquarters Operations Center consists of four major elements: input devices, a computer, displays, and control facilities. The

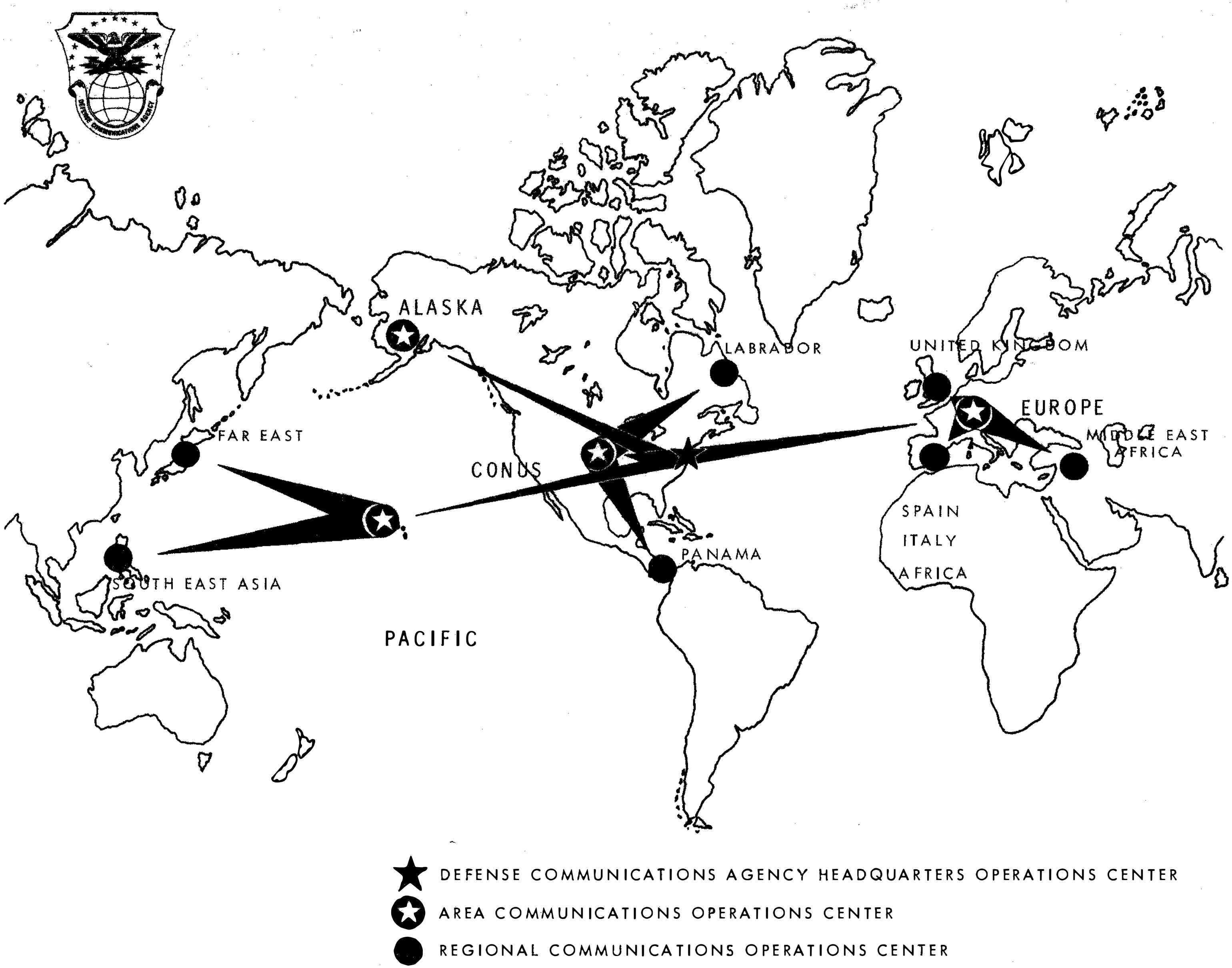


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Figure 3-1.—DCA Operations Center Complex.

input devices are standard teletypewriter machines used for the reception of status messages from the various reporting stations in the system. These status messages consist of data concerning the state of readiness of the circuits and facilities comprising the DCS, and include outage information, delays in transmission due to traffic backlogs, and important users affected by trouble in the system. Status information from teletypewriter messages is fed into an electronic computer previously programmed with a data base consisting of a detailed inventory of the resources and operating rules of the system. Current status information interacts on the data base in the computer to display automatically key information on electronic display boards. These displays reflect the current status of the system, showing whether conditions are good, marginal, or poor. One of the electronic display panels is an edge-lit map of the world, which shows the changing status of the major trunks and stations of the system.

Information presented on the display panels covers the full range of data required to analyze intelligently this world wide communications system. Included in this information are trunk status, assignment, and availability of individual circuits, station status, and the scope, priority, and quantity of message backlog. When the displays indicate the need for operational instructions to correct problem areas, the system supervisor issues instructions to the appropriate activity by telephone or teletypewriter message. The control area contains a series of operator consoles through which the watch supervisor can obtain and display additional detailed information from the computer to assist in decision making.

Area Communications Operations Centers

In addition to the DCA Headquarters Operations Center just described, there are four Area Communications Operations Centers. (Fig. 3-1). These operations centers are subordinate to the Headquarters Operations Center and report to it. They exercise operational control and supervision of DCS components in their geographical areas in the same manner that the headquarters covers the entire world.

The establishment of these Area Operations Centers provides control facilities that permit the DCS in their particular areas to be responsive to the changing needs of the area commanders. Although the headquarters center has extensive computer capability, the degree of automation for the Area Operations Centers is based chiefly on the requirements for day-to-day, close control.

Each of the four area centers is furnished teletypewriter and telephone circuits for status reporting, coordination and control, and administration.

Regional Communications Operations Centers

Subordinate to the Area Communications Operations Centers are 7 Regional Communications Operations Centers. (Fig. 3-1). Each Regional Center services the DCS activities within its own region and makes status reports to the cognizant Area Communications Operations Center.

U.S. NAVAL COMMUNICATIONS

The term Naval Communications is comprehensive, and is used to denote the whole of the communication undertaking throughout the Navy.

It refers to the concept of communicating and is not to be confused with the Naval Communication System (discussed later in this chapter) which is a world-wide network of communication channels that comprises only one part of the effort. Naval communications today is a giant and complex enterprise with thousands of round-the-clock operating personnel and many millions of dollars worth of equipment. It is a highly disciplined effort and the best of its kind in the world.

MISSION OF NAVAL COMMUNICATIONS

The mission of naval communications is to provide and maintain RELIABLE, SECURE, AND RAPID communications, based on war requirements adequate to meet the needs of naval command; to facilitate administration; to satisfy, as directed, JCS approved joint requirements; and to manage, operate and maintain facilities in the Defense Communication System (DCS) as assigned by JCS.

Naval communications is further pledged to assist in such disasters as floods, hurricanes, and earthquakes when normal communication facilities in the disaster area are out.

One of the principal functions of the Naval Security Group deals with SECURE communications. NAVSECGRU is assigned the job of providing the means of attaining security and acting as a watchdog over the entire communications system of the Navy. The NAVSECGRU is thus responsible for insuring that security regulations are observed and traffic handled in such a way as to reduce to a minimum the possibility of information falling into the hands of unauthorized persons.

POLICY OF NAVAL COMMUNICATIONS

The policy of naval communications is to—

1. Cooperate with the military services, Defense Communication Agency, and other departments and agencies of the U.S. Government and allied nations.
2. Encourage development of the amateur and commercial communication activities of the U.S. for the enhancement of their military value and for safeguarding the interests of the Nation.
3. Promote the safety of life at sea and in the air, maintain facilities for adequate communication with the U.S. merchant marine, aircraft over the sea, and appropriate U.S. and foreign communication stations.

ELEMENTS OF NAVAL COMMUNICATIONS

Naval communications has been organized into five major elements each of which has specific responsibilities contributing to the accomplishment of the overall mission. These major elements are:

1. Office of Naval Communications
2. Naval Security Group
3. Naval Communication System
4. Communication departments of activities of the shore establishment
5. Communication organizations of the operating forces

Office of Naval Communications

The office of Naval Communications (a part of the organization of the Chief of Naval Operations) is the headquarters of Naval communications and provides the communication coordination and planning for the entire Department of the Navy. The staff of the Director of Naval Communications (DNC) assists him in the execution of his responsibilities. The staff includes two deputy directors (one for communications and the other for Naval Security Group matters), five special assistants, and five divisions: plans and policy, programs, operations and readiness, administrative and personnel, and Navy radiofrequency spectrum. The work embraces radio and visual communications, landline systems, registered publications, and liaison with the other services and other Government agencies.

Naval Security Group

The Naval Security Group—the service cryptologic agency for the Department of the Navy—is a world-wide organization which performs cryptologic and related functions based upon requirements originated by or placed upon the Chief of Naval Operations. These functions consist of communication and electronic intelligence, operation of the Navy High Frequency Direction Finding (HFDF) nets, Communications Security, administration of the Registered Publications System, operation of the naval portion of the Armed Forces Courier Service and administration of the Naval Reserve Naval Security Group Program.

The Director NAVSECGRU (also designated Deputy DNC, NAVSECGRU) provides support to the component activities and detachments of the Naval Security Group in accordance with CNO directives which are normally issued via ACNO (COMM)/DNC. The staff functions for DIRNAVSECGRU are performed by NAVSECGRU Headquarters, located at the Naval Security Station, Washington, D.C.

To assist DIRNAVSECGRU in fulfilling his responsibilities, a senior NAVSECGRU officer is attached to the staff of each of the area naval commanders—CINCLANTFLT, CINCPACFLT, and CINCUSNAVEUR. These officers have the title of Director, NAVSECGRULANT, PAC, or EUR, as applicable; however, they function only as special assistants and coordinators for NAVSECGRU matters.

The functions of the Naval Security Group are carried out by independent activities, under a commanding officer, or by components, under an officer-in-charge, attached to naval communication facilities afloat or ashore. An example of a NAVSECGRU component attached to a naval communication facility is the NAVSECGRU Department of the NAVCOMMSTA Guam. Although the NAVSECGRU Department is under the military control of the CO NAVCOMMSTA, access to the NAVSECGRU spaces is limited to specifically authorized personnel.

Naval Communication System

The Naval Communication System is a fixed, integrated global communication network which forms the worldwide framework of naval communications. It is the means by which all other elements of naval communications are linked. The activities of the Naval Communication System manage, operate, and maintain facilities, equipments, devices, and systems necessary to provide requisite communications for the command, operational control and administration of the Department of the Navy afloat and ashore.

The staff functions necessary for the supervision, administration, and coordination of the activities and operations of the Naval Communications System are performed by the Naval Communication System Headquarters Activity located in the Washington D.C. area.

Communication Departments in the Shore Establishment

Activities of the Shore Establishment, such as naval bases, stations, air stations and facilities, and ammunition depots generally have a communication department which furnishes local or intra-activity communication services in support of the mission of the parent activity and serves as a link with the worldwide network of the Naval Communication System. The facilities and equipment used by these departments vary in accordance with the requirements of the activity concerned.

The communication department may be only a small communication center consisting of a message center and a cryptocenter. However, when required, the department may be expanded to provide for a tape relay station, wire and radio center, control center, radio transmitting and receiving facilities, and a visual signal station.

Communication Organization of the Operating Forces

Every communication organization of the Operating Forces is an integrated unit of command. The commanding officer or commander has direct control of communications through the ship or staff organization. The communication organization participates in the exercise of command by the transmission and reception of signals and messages.

All external communications are a function of either the communications or operations department of a ship. In a large ship the department will contain signal and radio divisions; in a small ship the divisions may be combined. The number, size, and arrangement of the communication spaces of a ship vary with the size and mission of the particular ship. In a large ship, the functions of the communication organization will be performed in the following spaces: message center, radio spaces, remote control facilities, cryptocenter, and visual signal spaces.

SHORE COMMUNICATION STATIONS

The component activities of the Naval Communication System are strategically located ashore throughout the world to provide complete radio coverage of the major portions of the earth's area. The Naval Communication System is comprised of three major types of activities—the NAVCOMMSTA, the NAVRADSTA, and the NAVCOMMU. These activities are linked to one another by point-to-point radio and landline circuits, and to the operating forces by broadcasts, ship-shore, and other special circuits.

The Naval Communication Station (NAVCOMMSTA)

The largest component in the System is the NAVCOMMSTA, of which the Navy has about 19 in strategic locations over the world.

The NAVCOMMSTA includes all communication facilities and equipment required to provide essential fleet support and fixed communication services for a specific area.

The principal communication functions and facilities usually provided by NAVCOMMSTAs are:

1. Facilities for fleet support, consisting of:
    a. Fleet and general broadcasts.
    b. Ship-shore radiotelegraph, radiotelephone, and radioteletypewriter circuits.
    c. Point-to-point wire and radio circuits.
    d. Interconnection with Army, Air Force, Federal Government Agency, and commercial communication systems.
2. Facilities for air operational support, including—
    a. Air-ground radiotelephone and radiotelegraph circuits.
    b. Monitoring circuits for navigational aids.

c. Weather intercept or reception.

d. Radio or wire circuits to air traffic control agencies.

3. Operation and maintenance of teletypewriter tape relay facilities.

4. Radio transmitting and receiving facilities.

5. Facsimile facilities.

6. Visual communication facilities.

In addition, NAVCOMMSTAs provide communication support facilities for the headquarters of naval district commandants, fleet or sea frontier commanders, and the commanders of naval bases, stations, or shipyards. Most NAVCOMMSTAs have facilities for issuing Registered Publications System publications. The specific missions assigned depend upon the role of the particular station in the Naval Communication System.

NAVCOMMSTAs are designated as major communication centers, minor communication centers, or tributaries.

Certain communication centers maintain fleet broadcasts, and usually have CW, RATT, and FAX components, for sending traffic to ships in their particular ocean areas. Ships in the Mediteranean, for example, receive traffic from NAVCOMMSTA Port Lyautey, Morocco. NAVCOMMSTA Washington transmits to ships in the Atlantic and Caribbean. All the major oceans of the world are covered in a similar manner. Some of the broadcasts may be inactivated at times, because of reduced operations in a certain ocean area, resulting in one broadcast area being extended temporarily to include another. For instance, the Honolulu broadcast area often is extended to include the Balboa area, and the San Francisco area is extended to include the Kodiak area.

Provisions are available so that a major communications center in a specific ocean may key the transmitters of one or more of the communication stations in the same area simultaneously with its own. This is called coronetting, and results in identical information being broadcast to these areas at the same time.

The RATT component of the broadcast may be utilized to disseminate classified as well as unclassified information to the fleet, in plain language copy, by using cryptographic devices at the sending and receiving ends. This is called a covered broadcast.

Certain major centers also send out a general broadcast of hydrographic information, weather forecasts, time signals, press news, and messages for Navy-controlled merchant ships. In addition, facilities are provided for ship-shore communication.

Most major communication centers are linked to each other by radio and/or landline circuits, and each maintains the circuits necessary for interconnection with tributaries and minor communication centers.

Minor communication centers serve areas where the traffic volume is not heavy enough to justify a major center. Most are located at such activities as naval air stations and supply and ammunition depots. They handle local communications and relay messages between tributary stations and the major center with which they are associated.

Each major and minor communication center maintains a tape relay station. Its function is to forward messages in tape form by means of the automatic or semiautomatic teletypewriter tape relay equipment (discussed later in this manual).

A recent addition to the tape relay system is the switching center, with fully automatic equipment for routing messages in tape form. Messages are handled within the switching center at a speed of 200 wpm, thereby speeding up teletypewriter communications while effecting a saving in operational personnel. Presently there are five automatic switching centers serving naval activities in the continental United States. They are at Washington, Norfolk, and Trenton, N.J. for service to east coast and midwestern activities, and San Diego and San Francisco for activities in the western area.

Tributaries are small stations serving particular commands. They differ from minor communication centers chiefly in that they perform no tape relay functions and generally handle less traffic. Tributaries are the points at which messages enter and leave the shore communication system, and may be compared with the subscriber in a telephone system. They send and receive messages, as necessary, to serve local command.

All the switching centers, tributaries and major and minor centers discussed, and the radio and landline circuits connecting them, form the Teletypewriter and Tape Relay Network. Teletypewriter (carried by wire or radio) is the means of transmission of all messages handled.

COMMUNICATION DEPARTMENT.—The typical NAVCOMMSTA is organized into eight departments, of which the communication department is by far the largest. It is headed by the communication officer, who has supervision over the personnel and work of the department. He serves as manager of the local communication program and determines its budgetary requirements. Some of his other duties are—

1. Formulating communication plans and directives.
2. Establishing an internal routing and filing system for messages.
3. Providing for physical security of messages and for monitoring facilities.
4. Supervising operation of the publications library by the RPS custodian of the command.
5. Supervising the training of communication personnel and cryptoboard members.
6. Ensuring proper operation and maintenance of electronic and visual communication equipment.

Within the communication department are the radio, traffic, material, and facilities divisions.

The radio division operates the radio stations of a NAVCOMMSTA. Normally, there are two such stations—a receiving branch and a transmitting branch. Each station is headed by a radio station officer.

The traffic division processes incoming and outgoing messages (including facsimile), enforces security, and maintains custody of RPS-distributed matter issued for station use. A traffic and circuit officer is division head. He is assisted by communication watch officers, cryptographers, and a custodian, whose duties are similar to their shipboard counterparts. The following officers may also be attached to this division: a relay station officer, to head the tape relay station; a communication security officer, responsible for monitoring radio circuits and developing communication security measures; and a facsimile officer, to plan and administer operation of facsimile facilities.

The material division is responsible for the physical functioning of wire circuits and for repair of electronic equipment. In charge are a landline officer and an electronics material officer.

The facilities division operates the visual station. (Inclusion of this division depends upon whether the NAVCOMMSTA is located where these facilities are required.) The visual station is operated by a signal officer who is in charge of receiving, transmitting, and relaying visual traffic to and from vessels in port or anchorage. His duties parallel those of the shipboard signal officer.

NAVAL SECURITY GROUP DEPARTMENT—You learned earlier that Naval Security Group functions are performed at NAVSECGRU headquarters, at area headquarters, at independent NAVSECGRU activities, by detachments, and by components located at NAVCOMMSTAs. When special functions, such as communication security, are performed at a NAVCOMMSTA, the operations are handled by a separate department—The Naval Security Group Department.

The Naval Security Group Department is organized in accordance with the particular size and mission of the operations. A typical NAVSECGRU Department includes the following divisions: Special Operations, Communication Security, Registered Publications (RPIO), and Courier (ARFCOS).

The Naval Radio Station (NAVRADSTA)

A naval radio station ordinarily is a component of a NAVCOMMSTA but may be located physically some distance from the NAVCOMMSTA. It is classified either a transmitting station or a receiving station, depending upon the function performed, and is so designated by the letter T or R added in parentheses. For example, NAVRADSTA (T) Lualualei, Oahu, is a component of NAVCOMMSTA Honolulu, Hawaii, but is located approximately 15 miles from the NAVCOMMSTA.

The Naval Communication Unit (NAVCOMMU)

Naval communication units are assigned limited or specialized missions, which may include some but not all of those assigned a NAVCOMMSTA. For this reason, the NAVCOMMU is much smaller in terms of personnel and facilities than the NAVCOMMSTA. NAVCOMMUs are identified by geographical location, as NAVCOMMU Seattle.

U. S. AIR FORCE COMMUNICATIONS

Air Force Communications (AIRCOM) is headed by the Director of Command Control and Communications. The Air Force Communications Service (AFCS) is responsible for the actual operation of AIRCOM and the elements within AIRCOM. In addition, AFCS develops and recommends practices and procedures for operating the entire system.

AIRCOM

AIRCOM is comprised of all communications circuits and facilities, both leased and government owned, employed by the Air Force for the transmission of intelligence to and between ground installations, air and aerospace vehicles.

To understand the significance of the term AIRCOM, you should understand that it is an intricate communication system composed of many integrated and related networks and facilities. The component networks, although operated independently and described separately here, still are part of AIRCOM.

The types of networks composing AIRCOM are functional and common user networks. For example, a common user network is one which is designed for common use of all Air Force orginizations and other authorized users. All types of messages are handled in a common user network, e.g. command, operational, logistics and administrative. AIRCOMNET and AIROPNET are the primary common-user networks of the Air Force. Functional networks are networks designed to handle a specific type traffic in a specified manner. Included in this category are the networks designed for the control of aircraft in flight and for the exchange of weather information. The USAF Air-Ground Network, Flight Service Interphone Network, major command networks, and the Weather teletype and Weather Facsimile Networks are functional type networks.

TACTICAL COMMUNICATIONS

Tactical communications within the Air Force is used mostly to handle the movement of aircraft. The different types of information needed for this purpose are handled on separate networks previously mentioned as functional networks. Air Force tactical communications is not a part of the DCS.

Air Operational Network

The Air Operational Network (AIROPNET) is a worldwide teletypewriter network interconnecting all Air Force bases having a requirement for handling aircraft movement traffic.

AIROPNET uses separate channels of the AIRCOMNET relay system, which will be discussed later in this chapter. It provides rapid communications between air traffic service facilities, flight service centers, transport control centers, and air operations agencies. The facilities of AIROPNET are also used by the other military services. AIROPNET is utilized for transmission of the following types of messages:

1. Aircraft emergency messages (distress, urgency, safety).
2. Air traffic control messages (arrival and departure requests/reports, changes in flight plans, etc.).
3. Messages originated by aircraft or by agencies having operational control of aircraft, which require immediate action and pertain to initiation, continuation, diversion or termination of a flight.
4. Transfer of radio guard.
5. Meteorological or Notice to Airmen (NOTAM) information of immediate concern to an aircraft awaiting departure or in flight.

Air-Ground Communications Network

The USAF Air-Ground Communications Network is a worldwide system that provides the link between ground stations and aircraft. Each air-ground station is a tributary of an AIRCOMNET/AIROPNET relay station. These air-ground stations are the air extensions of point-to-point circuits operated by the Air Force in AIRCOM. This network is available to all Air Force commands and is not intended as a primary network of any one command.

To meet requirements, chiefly in support of SAC and MATS, a number of air-ground stations are equipped with a patching capability. This facility permits direct electrical connection of air-ground voice channels into point-to-point landline or radio channels. By this means, the controlling agencies can be put in direct voice communications with their aircraft on a worldwide basis.

ADC Communications Networks

The purpose of Air Defense Command (ADC) Communications Networks is to provide communication support for the primary mission of the Air Defense Command/North American Air

Defense (ADC/NORAD). This mission encompasses detection, identification, interception, and destruction of enemy-manned air weapons.

The types of communication networks within the ADC, all of which are components of AIRCOM, are—

1. Surveillance Teletypewriter Network.
2. Alert Teletypewriter Network.
3. Command Teletypewriter Network.
4. Telephone Network.

ADC circuits also connect Army, Navy, and Canadian elements that are a part of the NORAD complex.

Seaward extensions of the ADC network are supplied on both the east and west coast of the United States. HF, VHF, and UHF radio is used for communications with picket ships, Airborne Early Warning aircraft, and control units in the air defense system.

Other Air Force Communication Networks

In addition to the communication networks already described, the Air Force has several other networks, detailed descriptions of which will not be given here. These include—

1. Flight Service Interphone Network.
2. Weather Teletypewriter and Facsimile Networks.
3. Air Materiel Command Networks.
4. Military Air Transport Service (MATS) Communications.
5. Strategic Air Command (SAC) Communications.
6. Tactical Air Command (TAC) Communications.

STRATEGIC COMMUNICATIONS

Strategic communications are generally long-haul, point-to-point, fixed station and transportable communications facilities. It usually supports or significantly affects national strategy.

Air Force Communications Network

The Air Force Communications Network (AIRCOMNET) is used for passing official teletypewriter traffic on a global scale. It is a common user network to which every Air Force installation has access if required. AIRCOMNET is the primary means of communications in the Air Force, handling the vast bulk of teletype traffic. AIRCOMNET employs major and minor relay stations completely interconnected by quality controlled wire and radio circuits. Each relay station serves assigned tributary stations within a given area and acts as Net Control Station (NCS) for those tributary stations. AIRCOMNET utilizes support facilities and allocated channels of AIRCOM. AFCS operates AIRCOMNET relay stations and some tributary stations and has overall supervision of the network.

AIRCOMNET can be divided into the CONUS portion and the overseas portion. The CONUS portion consists of five automatic switching centers, leased from Western Union, and numerous tributary stations. Two of the automatic switching centers are called gateway stations, because they work directly with overseas relay stations. Locations of these five relay stations are as follows:

Andrews AFB (near Washington, D.C.), Atlantic overseas gateway station.
McClellan AFB (near San Francisco), Pacific overseas gateway station.
Wright-Patterson AFB, Ohio.
Robins AFB, Georgia
Carswell AFB, Texas

The overseas portion consists of numerous strategically located automatic, semiautomatic and torn-tape relay stations which operate in conjunction with the CONUS portion of AIRCOMNET to provide rapid communications with all Air Force installations. AIRCOMNET is the Air Force portion of DCS. It is closely integrated with the systems of other services and agencies under the Department of Defense, and is operated in support of the Department of Defense and the Joint Chiefs of Staff (JCS).

ARMY COMMUNICATIONS

Army communications are operated by the Army Signal Corps and headed by the Chief, Communications-Electronics. His office is comparable to the Director, Naval Communications. His responsibilities to the Secretary of the Army and the Army Chief of Staff are equivalent to DNC's responsibilities to the Secretary of the Navy and Chief of Naval Operations.

STARCOM

The present Army communication system is known as STARCOM (Strategic Army Communication System). STARCOM is organized and operated to transmit and receive official messages and other traffic for the Department of Defense, Department of the Army, and other military departments and agencies of the Government.

STARCOM CONUS Portion

In the continental U.S. portion of STARCOM, there are three primary relay stations, located at Fort Detrick, Maryland, Fort Davis, California, and Fort Leavenworth, Kansas. These three relay stations complement one another's capabilities so that destruction or partial loss of one can immediately be compensated for by the other two.

The relay station at Fort Detrick is designated net control and exercises operational control over STARCOM. It is the largest automatic switching station in the system and can handle more than 275,000 messages a day. It has long distance radio, cable, and wire channels to provide teletypewriter, voice, data, and facsimile services throughout the United States and to vital overseas locations. Fort Detrick also serves as gateway station to Europe and the Caribbean, while Fort Davis is the gateway station to the Pacific and Far East.

In addition to these primary relay centers, relay stations are located at Seattle, New York, Atlanta, Fort Houston and Fort Bragg.

STARCOM Overseas Portion

The overseas portion of STARCOM is composed of a number of strategically located relay stations.

The location of these stations is dictated primarily by the worldwide deployment of troops. Multichannel teletypewriter circuits connect the Department of the Army COMMCEN in Washington with the Continental Army Headquarters and with each overseas command headquarters. Tributary circuits reach out to Army installations and other Government agencies as required. The facilities of the overseas portion consist of fixed point-to-point radio, wire, and cable circuits used with such equipment as single sideband, electronic time division multiplex, automatic and semiautomatic teletypewriter relay equipment, and high-speed tape reproduction equipment.

Most of the STARCOM system is under the management and operational control of the Strategic Communications Command (STRATCOM). STARCOM's long haul point-to-point system is part of the DCS.

THEATER COMMUNICATIONS

The Theater Area Communication System (TACS) is a high-capacity, high-quality, multimeans, multiaxis, integrated signal communications network. The circuits comprising the system extend forward from the theater rear boundary into the field army areas where they interconnect with field army area communications.

Signal Long Lines Command

The element of theater communications responsible for installation and operation of the TACS is the signal long lines command. Elements of this command are deployed throughout the theater of operations. Supply and maintenance support for these elements is provided by the logistics command in whose area the elements are located.

The signal long lines command consists of a headquarters and headquarters company plus construction and operating units as required, depending upon the mission and organization of the theater of operations, area of operations, plan of operations, troop composition and disposition, indigenous facilities, and enemy capabilities.

Field Army Communications System

The field army communications system is composed of field army area communications, communications of the subordinate corps, communications of the divisions and other communications facilities of units integral to the field army.

FIELD ARMY AREA COMMUNICATIONS.—Field army area communications is composed of area signal centers under centralized control, and interconnected with at least two other signal centers to provide alternate routing and to permit distribution of the traffic load.

Command signal centers are established to serve the echelons of field army headquarters. Each command signal center is connected with two or more area signal centers to provide alternate routing of circuits and flexibility of operations. In addition, command signal centers may be directly interconnected when availability of facilities, distance, and other factors permit.

To provide the field army access to the TACS, theater army signal control centers are located to interconnect readily with army area signal centers in the rear of the field army.

The field army messenger service is supervised and coordinated by the field army system control center for the systematic handling and expeditious delivery of messages, correspondence, and general distribution between the users of field army area communications. It consists of the messenger service provided by the army signal battalion and that provided by the signal combat area battalions, and is integrated with the signal messenger service provided by the corps and divisions.

ARMY CORPS COMMUNICATIONS.—The corps is essentially a tactical headquarters organized primarily to execute tactical combat operations, normally as part of the field army. It is not a fixed or permanent type of organization.

Army corps communications is installed, operated, and maintained by the corps signal battalion. It provides direct communications from corps headquarters to each division and from corps artillery headquarters to each division artillery headquarters and to each artillery group attached to the corps. This system, integrated with the field army area communications, provides a high degree of flexibility required in signal communications. The corps signal battalion is approximately 85 percent mobile.

COMMERCIAL COMMUNICATIONS SYSTEMS

The first transoceanic submarine cable was laid between Newfoundland and Ireland in 1858. This marked the beginning of international commerical telecommunications. Radiotelegraph service between the United States and England started in 1899. It was not until 1927, however, that the first international radiotelephone circuit was established between New York and London. Since that time, telephone and telegraph facilities have, of course, greatly expanded. Today, almost every country in the world is linked to another by such means.

TELECOMMUNICATIONS FACILITIES OF THE UNITED STATES

In the United States, the telecommunication facilities, and the industries supporting these facilities, are privately owned and operated.

Telephone

Telephone facilities are provided by the various operating subsidiaries of the American Telephone and Telegraph Company and approximately 5300 independently owned companies that are members of the Independent Telephone Association. The Bell Telephone Syetem, the name by which the AT&T is better known, operates about four-fifths of the more than 50 million telephones in the United States, making it the largest telephone system in the world.

Telegraph

Domestic telegraph service is furnished by the Western Union Telegraph Company. The Company also operates an international submarine cable network between the Unites States and Europe, the United States and certain islands in the Caribbean, and by relay over foreign company facilities to South America.

Teletypewriter

The Bell Telephone System and Western Union supply facilities for private line teletypewriter service to industry and to the military services. Western Union (along with AT&T, Mackay Radio, Commercial Cables, and RCA) operates a form of teletypewriter service to London, and also press news channels.

Radiotelephone

The AT&T operates the major facilities for overseas radiotelephone service. In certain overseas and foreign areas, RCA Communications, the Radio Corporation of Puerto Rico, and the Tropical Radio Telegraph Company provide radiotelephone service connecting with the AT&T in the United States.

Cable

Submarine cable facilities are provided by Western Union and two subsidiaries of the International Telephone and Telegraph Corporation

(IT&T). The IT&T cable companies are the Commercial Cable Company (operating in the North Atlantic to Europe), and the All America Cables and Radio Company (operating in the Caribbean and the Atlantic and Pacific Oceans to Central and South America).

International Landlines

International landlines are operated by AT&T and Western Union for telephone and telegraph service, respectively, to Canada and Mexico. Telephone service to Alaska is supplied by AT&T in the United States, via facilities of the Alberta Government Telephone Company and the Northwest Communications System in Canada, and on the Alaska Communications System (ACS) lines in Alaska. Many private industries, such as petroleum, railroad, airline, lumber, mining, shipping, operate private communication facilities. Some of these facilities are quite extensive and modern, such as the railroad communication systems and the microwave relay systems being installed along petroleum pipelines.

Radio Broadcast

The radio broadcast field is dominated by four major networks, and is supplemented by many regional networks for program relaying. Comprising the four major networks are the National Broadcasting Company, the Columbia Broadcasting System, the Mutual Broadcasting System, and the American Broadcasting Company. Member stations of these networks are supplied with program material over the facilities of the AT&T landlines. Television stations associated with these networks have the video portion of the program material relayed by coaxial cable and microwave relay systems; the audio portion is carried over the regular radio program networks.

BELL SYSTEM

Basically the Bell System is made up of the American Telephone and Telegraph Company and a group of 21 closely integrated associated telephone companies that own and operate telephone plants in their respective geographical territories. Each associated company therefore exists as a distinct corporate unit and is separated along territorial and functional lines. The associated companies are not controlled by the AT&T company but, like other associated companies, have a license contract arrangement with it. Included in the organization of the Bell System are the Western Electric Company, a manufacturing and supply organization, and the Bell Telephone Laboratories.

American Telephone and Telegraph Company

The AT&T performs an important interstate operating function through its Long Lines Department, which owns and operates long-distance lines interconnecting the 21 subsidiary operating companies. In addition, AT&T coordinates the entire enterprise by planning and advising the associated companies on all phases of the business through its staff of specialists.

Bell Telephone Laboratories

The Bell Telephone Laboratories is responsible for all fundamental research and development work of the Bell System. Laboratories are composed of four chief development and research groups. These groups work in close cooperation, and the majority of the products of the laboratories represent the work of all. The continued ability of the Bell System to provide high-quality service depends largely on this organization. It has been responsible for a number of new developments in the field of communications and electronics.

Western Electric Company

The manufacturing and supply unit of the Bell System is the Western Electric Company. Major functions of the company are manufacturing most of the apparatus and equipment, purchasing and distributing most of the supplies, and installing central office equipment. At supply houses located throughout the country, Western Electric maintains close supply sources for the operating companies. These facilities provide a ready reserve of materials in the event of disaster.

Through ownership of Western Electric, it is possible for the Bell System to control adherence to rigid specifications. Of great importance, also is the fact that a centralized supply source ensures the compatibility of the various systems. In large measure, Western Electric is responsible for the standardization and integration of the telephone network of this country.

Domestic Telephone Facilities

Supplying domestic telephone service is the Bell System's primary undertaking. The system, with its 21 operating companies, and through interconnecting arrangements with the independent telephone companies, furnishes domestic, local, and long-distance telephone service to over 50 million United States telephones. This concentration of telephones is greater than the rest of the world combined.

The Bell System has four methods for interconnecting our cities.

1. OPEN WIRE: A single pair of conductors is used to carry one voice channel; with multiplexing systems, 16 channels per pair.

2. MULTIPLE PAIR CABLE: Multiple copper paired conductors transmit voice circuits on the individual pairs, or up to 12 telephone channels per pair with multiplexing systems.

3. COAXIAL CABLE: Coaxial cable consists of a center conductor mounted within a concentric tube. The usual coaxial cable has eight of these tubes; six are for regular service, two for spares. The most recent design of voice-multiplex equipment enables each pair of tubes to handle 1800 two-way telephone circuits (one tube for each direction). A fully loaded coaxial cable will therefore handle 5400 two-way telephone circuits. Instead of the 1800 telephone circuits, each pair can be used to send two oppositely directed one-way TV channels and 600 telephone circuits. Thus three pairs would carry six one-way TV channels (three in each direction) plus 1800 telephone circuits, with two coaxials held as spares.

4. RADIO RELAY: Radio relay system require towers at regular intervals (about 30 miles) for relaying telephone, teletype, or television signals from city to city. Carrier waves are relayed from tower to tower by means of high-gain antennas, coupled with extremely reliable transmitters and receivers. Sensory units are included within each station to detect faulty circuits, to inform maintenance crews of failure, and to switch to standby equipment in case of outage. Radio relay stations will handle at least 12 one-way communication channels, servicing a total of 3000 telephone circuits or 10 one-way television channels. Spare channels are also provided for maintenance or emergency use.

Foreign Telephone Facilities

In addition to the telephone network covering the United States, telephone service is available to about 96 percent of the world's telephones through the overseas radiotelephone facilities of the Bell System. These facilities connect the United States with various parts of the world via radio channels originating at terminals near New York, Miami, and San Francisco. Connection is made with the Alaska Communication System of the Army at Seattle. Because the Bell System operates within the CONUS only, radiotelephone service is rendered in cooperation with the appropriate operating company in each of the countries served.

The long-haul international radiotelephone circuits of the world generally use single sideband transmission. This results in improved intelligibility with narrow carrier bandwidths. More than 90 percent of the Bell System's direct radiotelephone circuits operate with single sideband transmission.

Despite technical advances in electronics, the reliability of communications over long-distance high-frequency radiotelephone circuits still leaves much to be desired. This is particularly true of the paths from the United States to northern Europe, where magnetic storms sometimes interrupt communications to some countries for hours at a time. Consequently, a voice cable between the continents of American and Europe—under consideration for many years—has been constructed and placed in service.

Selection of the route was an important part of the construction plans for the North Atlantic telephone cable. Consideration of the many hazards led to the choice of a route from New York to Newfoundland to Scotland. It is the shortest practical route, is north of existing radiotelegraph cables, runs through a minimum of pack ice, and misses most of the trawling grounds. There are two cables, one for transmission in each direction. The main link is about 1800 miles long; overall length is 2250 miles. From Newfoundland to Nova Scotia the link runs underwater; but from Nova Scotia into Portland, Maine, it uses a conventional radio relay system.

The cable contains 36 voice circuits. To provide adequate communications, underwater repeaters are installed in the cable at intervals of about 40 miles. These repeaters have three low-power vacuum tubes that will operate for many years without attention. The cable itself is designed to last at least 20 years without attention.

Other underwater telephone cables in the Bell System include the Key West—Havana cable, two cables between the United States and Alaska, and the trans-Pacific cable connecting mainland

United States with Hawaii. This 2400-mile cable is similar in design and construction to the Atlantic and Alaskan cables. The twin-cable system is capable of carrying 36 simultaneous conversations, and is the first underwater cable to feature operator dialing. The Hawaiian cable system is capable of carrying 36 simultaneous operating between the mainland and Honolulu. This cable system is also used for teletypewriter service and for transmission of radio programs, but not television.

Private and Special Communication Facilities

The Bell System has an extensive network of private line telegraph facilities and TWX circuits. Most of the press wires and a large portion of the private line telegraph facilities of large business houses, brokers, and Government agencies are provided by the Bell System. Over 4000 TWX circuits and over 4,000,000 miles of private line telegraph circuits are now in service.

Among the special communication facilities of the Bell System are the mobile radiotelephone units. About half of these are private systems, and the balance connect to the regular commercial telephone network.

Other special communication facilities include marine radiotelephone service, available to ships on the high seas and small craft operating in coastal and harbor waters and in the Great Lakes.

The Bell System also has a nationwide network of video channels that serve the television broadcasting industry.

SECURITY AND MOBILIZATION PLANS

The entire communication industry is faced with the problems of providing interrupted service, despite natural or manmade disasters. One of the best methods of assuring reliable service is the diversification of circuits. In modern telephone facilities, diversification has been realized by building new routes. As the United States telephone networks spread, it became a simple matter to route circuits between any two points over separate lines. With the advent of possible nuclear bombing of large cities, it was realized that long-distance telephone facilities might be seriously disrupted. Bypass and express routes are now constructed to protect service from interruption.

Alternate switching facilities have been built to ensure that intercity telephone traffic is not wiped out completely if enemy attack or natural disaster occurs. Alternate switching centers, at considerable distance from the main switching centers, have been established to afford this protection. The Bell System offers relief for congested traffic situations in daily operations by use of this alternate routing. This is not a standby arrangement—it is working daily. In other words, a sizeable percentage of traffic in and out of a city is handled by dispersed offices every day. Consequently, in an emergency, no time would be required to put them into service.

The matter of bypassing cities is very important. The Bell System, with its many alternate routes, provides this capability. There are eight transcontinental routes. Of these, four are open wire; one is a cable equipped with the paired cable type of long haul carrier; another is of the coaxial cable type; and finally, two radio relay routes span the country from coast to coast.

As standby equipment the Bell System has available, throughout the country, approximately 100 radio systems that can be used in emergencies. They also may serve to bridge the gap that may have occurred in wire lines or cable as a result of disaster. Currently the Bell System is adding to its emergency radio facilities newly designed portable equipment. This equipment includes portable aluminum towers that can be erected within an hour at a location where circuits have been damaged.

Trained personnel with large stocks of material available to them are located in many locations. All the associated companies, as part of their regular service provision, have developed plans for restoration of essential service in emergencies.

WESTERN UNION TELEGRAPH COMPANY

The Western Union Telegraph Company started business in 1851, just 7 years after Samuel Morse sent the first telegram. The properties of over 500 other companies have been acquired by or merged with Western Union over the years.

Western Union provides service through over 2000 offices and 20,000 agencies over the Nation. In addition, Western Union owns, leases, and operates (or has arrangements with connecting companies for operating) a network of submarine cables. These cables make available communication for all of Western Europe, the Middle East, Cuba, and Central and South America.

The introduction of fixed and portable carrier telegraph terminals, electronic repeaters, microwave systems, modern terminal equipment, automatic switching centers, and other modern transmission equipment has led to highly reliable networks for public message services and private wire (leased line) systems. In recent years, Western Union's own staff of engineers and scientists pioneered in the development and installation of modern telegraph equipment. Nearly all the pole lines have been retired, and the manual relaying of messages has been eliminated. Western Union has 15 reperforator relay centers throughout the United States. By means of this high-speed switching system, telegrams are dispatched and relayed without manual retransmission.

Western Union owns over 4 million miles of carrier-equipped telegraph circuits, including 560,000 miles of microwave radio circuits. These channels are less subject to atmospheric disturbances than other radio circuits. All trunk circuits bypass major cities by approximately 30 miles so that the basic system will be little affected in the event of disaster.

Aside from telephone and messenger delivery of messages, Western Union provides large-volume users with direct teleprinter and facsimile connections. Teleprinter connections from patrons' offices direct to Western Union afford a rapid method of pickup and delivery. When the traffic volume warrants, patrons are provided with direct connections to automatic or semiautomatic reperforator switching centers. Approximately 20,000 customers are supplied with teleprinters. Western Union also furnishes a compact facsimile machine, called Desk-Fax, to 37,000 customers. Transmission is made directly from typed or handwritten copy, and reception is recorded on electrosensitive paper.

Telex, long used overseas and in Canada, was introduced in the United States by Western Union. This teleprinter direct dialing system is available in and between New York, Chicago, San Francisco, Los Angeles, and 21 other major cities in the United States, including Honolulu.

Commercial Departments

Western Union's Government Contract Sales Division handles the leasing of systems to Government and military organizations and the outright sale of equipment and engineering services to all organizations. A separate Private Wire Services department has cognizance over leasing systems to commercial companies.

Cable Facilities

Western Union's cable system is the largest of the North Atlantic cable facilities. Several of these cables are leased from the Anglo-American Telegraph Company of England on a long-term basis. The balance are owned by Western Union. These transoceanic facilities consist of seven cables between North America and Europe, with a total capacity of 1950 wpm; two cables to the Azores, with a capacity of 560 wpm; three to Cuba and the West Indies, of 2178 wpm capacity; and one to Barbados, with a capacity of 104 wpm in each direction. Western Union's submarine cable system totals about 26,600 miles.

FEDERAL COMMUNICATIONS COMMISSION

The Federal Communications Commission is the agency charged with regulating interstate and foreign commerce in communications by wire and radio. Jurisdiction of the FCC extends not only to private radio broadcasters and to common telecommunication carriers engaged in interstate and foreign commerce, but to communication activities of state and local governments as well.

The purposes of regulation by the FCC are (1) to make available to the people of the United States a rapid, efficient, nationwide, and worldwide wire and radio communication service with adequate facilities at reasonable charges; (2) for the national defense; and (3) for the purpose of promoting safety of life and property through the use of wire and radio communications.

The FCC is not a part of any Government department. It is a separate agency, created by an Act of Congress (the Communications Act of 1934), and reports directly to Congress. Formerly, jurisdiction over electrical communications was shared by the Commerce Department, Post Office Department, Interstate Commerce Commission, and (later) the Federal Radio Commission. With the Communications Act, all supervisory and regulatory functions were assigned to the FCC.

The FCC is administered by seven commissioners appointed by the President and subject to confirmation by the Senate. One of the commissioners is designated chairman by the President. Not more than four commissioners may be members of the same political party. Except for filling an unexpired term, the term of a commissioner is 7 years. The FCC organization chart is shown in figure 3-2.

In national and international communication matters, the FCC cooperates with various Government agencies, including the Department of Defense, Departments of State, Treasury, Interior, and Commerce, and other users of radio in the Federal establishment. It also cooperates with state regulatory commissions in matters of mutual interest.

The Communications Act applies to all the 50 states, Puerto Rico, and other U.S. possessions. Functioning within these areas, the FCC has 24 radio district offices, six suboffices, and one ship office. Also there are various monitoring stations and a field engineering laboratory. Field duties include monitoring and inspecting all classes of radio stations, examining radio operators, making various radio measurements and field intensity recordings, and conducting related investigations. In addition, there are three common carrier engineering field offices. (A common carrier is a company furnishing wire or radio communication to the public for hire, with the exception of broadcasters.) Broadcasting stations are not deemed common carriers, so the FCC does not regulate charges for program time. Even though the Commission monitors broadcasts, it has no power to censor radio or television programs.

Licensing

Only a limited number of radio transmissions can be on the air at the same time without causing interference, hence the Communications Act requires all non-Government radio operations to be licensed. Courts have held that radio transmission anywhere within the United States or its possessions calls for licensing both the transmitter and its operator.

Although FCC issues licenses to both operators and transmitting stations, the Commission collects no fee or charge of any kind in connection with this licensing. When the FCC issues a license, it first makes sure the license will serve the "public interest, convenience, or necessity." This is the standard that governs the granting of licenses. Because channels are limited and are a part of the public domain, it is important that they be entrusted to licensees who have a high sense of public responsibility. The license privilege is extended by the Communications Act to citizens of the United States only. It is denied to corporations wherein any officer or director is an alien, or if more than a fifth of the capital stock of the corporation is owned or voted by aliens or their representatives.

Monitoring

One of the important functions of the FCC is "policing the ether." This is done by field stations, which monitor transmissions to see that they are in accordance with treaties, laws, and regulations. There are 10 primary monitoring stations and 18 secondary monitoring stations. If necessary, mobile equipment can trace illegal operation or sources of interference. Monitoring stations also furnish emergency directions to Government and civil aircraft.

The Commission periodically inspects radio equipment on United States ocean vessels and on foreign ships calling at our ports. FCC ascertains that radiotelegraph installations comply with the International Convention for the Safety of Life at Sea, and the shipboard radio requirements of the Communications Act. About 14,000 such inspections are made each year.

FCC in Wartime

During World War II, the FCC cooperated with the Air Force in maintaining a constant vigil on the coasts, ready to close down radio transmissions that might furnish bearings for enemy aircraft. With the Office of Civilian Defense, it worked to guard vital communication facilities against sabotage. Also, the Board of War Communications, headed by the chairman of the FCC, coordinated communication activities for emergency purposes. The FCC established a foreign intelligence service to monitor foreign broadcasts for the military services and other Government agencies. Its own radio intelligence division policed the domestic ether and helped furnish bearings to our aircraft.

Emergency Broadcast System

In consonance with national civil defense and the Department of Defense, the Federal Communications Commission (FCC) has prepared plans for the emergency use of the facilities

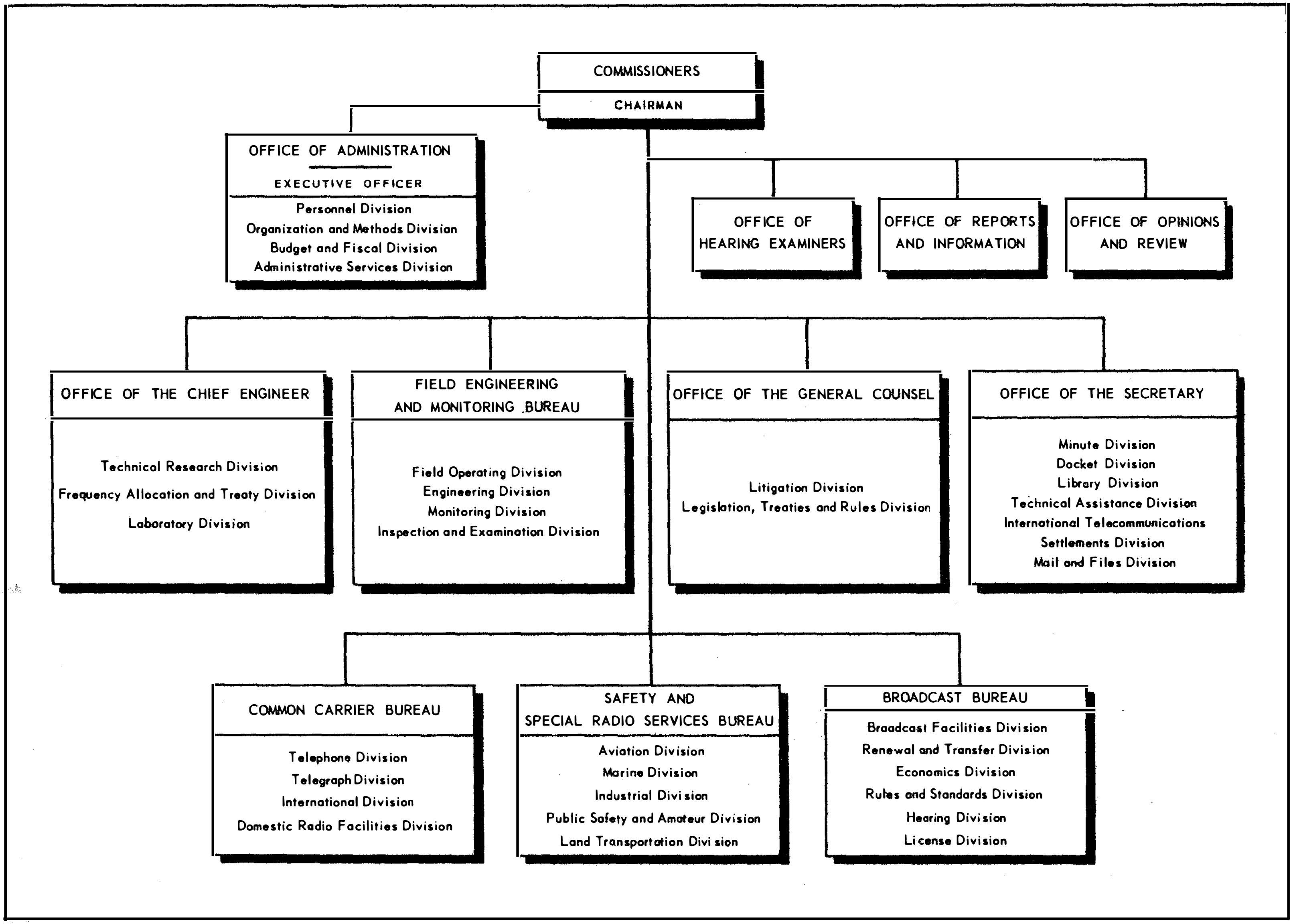

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Figure 3-2.—Organization of Federal Communications Commission.

subject to its jurisdiction. The "voice" of emergency communication facilities and systems—the final link to the public—is the Emergency Broadcast System (EBS).

The EBS consists of broadcast stations and interconnecting facilities which have been authorized by the FCC to operate in a controlled manner during a war, threat of war, state of public peril or disaster, or other national emergency. The EBS provides the President and the Federal Government, as well as State and local governments, with a means of communicating with the general public through non-government broadcast stations during a period of national emergency. The plan provides, insofar as possible, that every available facility be utilized to provide a continuity of service by the broadcast industry and FCC-licensed facilities of the communications industry of the nation. All official instructions concerning the plan are furnished to the stations through the offices of the FCC Field Liaison officers.

The EBS is activated by means of an Emergency Action Notification issued by an appropriate Federal Authority. Upon receipt of an Emergency Action Notification, all standard, commercial FM, and noncommercial educational FM broadcast stations with a transmitter output of over 10 watts, and television broadcast stations, including all such stations operating under equipment or program test authority, discontinue normal broadcasting, and only designated EBS radio stations continue in operation.

Tests involving transmission of the Emergency Action Notification Signal and test messages by standard, FM and television broadcast stations, are made once each week on an unscheduled basis between the hours of 0830 and local sunset. Results of these tests are forwarded to the Federal Communications Commission.

In summary, the major activities of the Federal Communications Commission are—

1. Allocating frequencies for all licensed radio stations.
2. Licensing and regulating radio services and radio operators.
3. Regulating common carriers engaged in interstate and foreign communication by wire or radio.
4. Promoting safety through the use of radio on land, sea, and in the air.
5. Encouraging more effective and widespread use of radio.
6. Utilizing its regulatory powers over wire and radio communications to aid the military effort.
7. Regulating Emergency Broadcast System Plan.

MILITARY USE OF COMMERCIAL FACILITIES

The Department of Defense has made the following statement regarding use of commercial facilities:

> It is impracticable to employ similar concepts and standards in assessing military and commercial communication requirements. In the development of commercial facilities, expected revenue must be a prime consideration. Military communications, on the other hand, as an essential element of command, must first satisfy military needs, with economy of force or funds an important but secondary consideration. As a result of this fundamental difference, it is impossible for the military to enunciate a policy which will, under all conditions, prescribe the specific degree to which it will utilize or depend on commercial communication facilities. It is incumbent on all military commanders, in compliance with the basic principle of economy of force, to make maximum possible use of all existing facilities available to them, including commercial service. Before reaching a decision to employ other than strictly military facilities, each commander, based on the conditions prevailing in his area, must weigh any advantages from the standpoint of economy against the resulting effect on military security and control, dependability of service, and the rapid flow of military messages. As general policy, therefore, it may be stated that the Military Services will, whenever practicable, utilize commercial facilities and service in the interest of economy of force or funds, provided that acceptable military standards of security control and service can be maintained.

Use of Commercial Facilities in the United States

During the early period in the development of national communication systems, it was necessary for the military services to construct and operate their own communication facilities. Today, however, extensive and dependable commercial communication networks cover the length and breadth of the United States. From the standpoint of security, the risk normally involved in partial military control of its communications has been considered as relatively low within the continental United States. This condition is a result of both the close working relationship that exists between the military services and the commercial communication organizations, and the existence of adequate laws to permit prompt Government operation and control if deemed advisable in the national interest.

Under these conditions, the construction and maintenance of completely separate communication systems within the United States for exclusive military use would entail an unjustifiable outlay of funds, manpower, and equipment. Military policy concerning use of commercial facilities in the continental U. S. may, therefore, be summarized as follows: Within the continental United States, the military services, in establishing communication networks for the purpose of interconnecting their various headquarters, installations, and activities, will, be lease or other contractual arrangement, utilize commercial facilities and services when available and feasible, except where unusual security or operational conditions are required. The terminal facilities, including communication centers and relay stations of these networks, will be operated and controlled by the military services.

Commercial Networks as a Source of Trained Personnel for Military Service

In peacetime, the military services can maintain only the nucleus of a wartime communication system. It is also known that the impact of a state of war or national emergency on military communication systems is instantaneous, and can be met only through immediate expansion of both trunkline and terminal facilities.

Modern communication facilities, although extremely efficient, require a comparatively long lead time in training operators and maintenancemen. Hence, in the critical period between the outbreak of hostilities and the time military training programs can meet overall demands, the commercial systems of the United States represent an important source of additional trained communication personnel for military service.

Legislation now exists whereby, in time of war or national emergency, the total telecommunication resources of the Nation can be placed at the disposal of the Government. To this end, the military services encourge the domestic communication systems of the United States to be as efficient and dependable as sound engineering, reasonable economy, and good operating practices will allow. Their capacity should reflect the ability to handle greatly increased wartime traffic volumes. Many alternate routings and types of facilities must be available, consistent with the ability of the commercial companies to realize a reasonable profit from their investments.

CHAPTER 4

SAFETY

SAFETY PRECAUTIONS REGARDING ELECTRICAL EQUIPMENT

Because of the possibility of injury to personnel, damage to material, and the danger of fire, all repair and maintenance work on electrical equipment should be performed only by duly authorized personnel. However, there are occasions when an operator is required to make routine adjustments to his equipment. Consequently, ALL personnel concerned with electronic equipment must be thoroughly familiar with proper safety practices outlined in Safety Precautions for Shore Activities, Nav SO P2455.

SAFETY DEVICES

Most electronic equipments utilizing high voltages have "built-in" devices which serve as safety features. As an example consider the conventional television receiver which is constructed in such a manner that it is necessary to disconnect the power cord from the chassis before removing the back panel. This serves as a simple but effective interlock switch. Safety devices such as interlocks, overload relays, and fuses should never be altered or disconnected except when making replacements. Safety or protective devices should never be changed or modified in any way without specific authorization. The interlock switch, which is ordinarily wired in series with the power-line leads to the power supply unit, is installed on the lid or door of the equipment case or enclosure in order to break the circuit when the lid or door is opened.

Fuses should be removed and replaced only after the circuit has been deenergized. When a fuse blows, it should be replaced only with a fuse of the same current and voltage ratings. When possible, the circuit should be carefully checked before making the replacement since the burned-out fuse is often the result of a faulty circuit. The covers of fuse boxes and junction boxes should be kept securely closed except when working on them.

HIGH-VOLTAGE PRECAUTIONS

No one should work alone on energized equipment. Tools and equipment containing metal parts should not be used in an area where any exposed electric wiring exists. Do not work on any type of electrical apparatus with wet hands or while wearing wet clothing, and do not wear loose or flapping clothing. Before working on electronic or electrical equipment, remove all rings, wristwatches, bracelets, badges suspended from chains, and similar metal items. Check clothing to be certain that it does not contain exposed zippers, metal buttons, or any type of metal fasteners.

PRECAUTIONS WITH CHEMICALS

Volatile liquids such as insulating varnish, lacquer, turpentine, and kerosene are dangerous when used near energized electronic or electrical equipment because of the possibility of igniting the fumes by sparks. When these liquids are used in spaces containing nonoperating equipment, be sure that there is sufficient ventilation to avoid an accumulation of fumes. Also make certain that all fumes are cleared before the equipment is energized.

The use of alcohol as a cleaning agent on electrical equipment should be avoided since it not only constitutes a fire hazard but also results in damage to many kinds of insulation. Neither should carbon tetrachloride be employed as a cleaning agent. Unlike alcohol, carbon tetrachloride does not create a fire hazard, but it is dangerous because of the injurious effects of breathing its vapor. Careless use of carbon tetrachloride can result in headache, dizziness, and nausea. If the fumes are inhaled in poorly ventilated spaces, the effect may be loss of consciousness or even death. Additionally, carbon tetrachloride forms an insulating film on the material to which it is applied. For these reasons, the use of carbon tetrachloride as a solvent or cleaner has been specifically prohibited in Navy maintenance operations. When cleaning electrical or electronic equipments or parts, always use an approved cleaning agent such as Dry Cleaning Solvent, Federal Specification P-S-661, observing proper safety precautions against fire and explosion. Since Dry Cleaning Solvent, P-S-661, is also injurious to certain types of insulation, make certain its use will not damage the insulating material.

SAFETY FROM FIRE

PREVENTING FIRES

General cleanliness of the work area and of electronic apparatus is essential for the prevention of electrical fires. Oil, grease, and carbon dust can be ignited by electrical arcing. Therefore, electrical and electronic equipment must be kept absolutely clean and free of all such deposits.

Wiping rags and other flammable waste material must always be placed in tightly closed metal containers, which must be emptied at the end of the day's work.

Containers holding paints, varnishes, cleaners, or any volatile solvents must be kept tightly closed when not in actual use. They must be stored in a separate building or in a fire-resistant room which is well ventilated and where they will not be exposed to excessive heat or to the direct rays of the sun.

FIREFIGHTING

In case of electrical fires, take the following steps:

1. Deenergize the circuit if possible.
2. Summon assistance from the appropriate fire fighting facility.
3. Attempt to control or extinguish the fire, using the correct type of fire extinguisher.
4. Report the fire to the appropriate authority.

For combating electrical fires, use a CO_2 (carbon dioxide) fire extinguisher and direct it toward the base of the flame. Carbon tetrachloride should never be used for firefighting since it changes to phosgene (a poisonous gas) upon contact with hot metal; even in open air, a hazardous condition is created. The use of foam type extinguishers or water to combat fires in energized electrical equipment is dangerous because foam and water are both electrically conductive and the danger of shock exists.

In cases of cable fires in which the inner layers of insulation, or insulation covered by armor, are burning, the only positive method of preventing the fire from running the length of the cable is to cut the cable and separate the two ends.

When selenium rectifiers burn out, fumes of selenium dioxide which are liberated cause an overpowering stench. The fumes are poisonous and should not be breathed. If such a rectifier burns out, immediately deenergize the equipment and ventilate the room. Allow the damaged rectifier to cool before attempting any repairs. If possible, move the equipment containing the burned-out rectifier out of doors. Do not touch or handle the defective rectifier while it is hot because the result could be a skin burn through which some of the selenium compound could be absorbed.

Fires involving wood, paper, cloth, or explosives should be fought with water. Because water works well on those substances, advantage is taken of its inexpensiveness, availability, and safety in handling.

A steady stream of water does not work in extinguishing fires involving substances like oil, gasoline, kerosene, or paint because these substances will float on top of the water and keep right on burning. Also, a stream of water will scatter the burning liquid and spread the fire. For this reason, foam or fog must be used in fighting such fires.

FIRST AID

ELECTRIC SHOCK

Electric shock is a jarring, shaking sensation resulting from the passage of an electric current through the body or a portion of the body. The victim usually feels that he has received a sudden blow; and if the voltage is sufficiently high, he may become unconscious. Severe burns may appear on the skin at the place of contact; muscular spasm can occur, causing the victim to clasp the apparatus or wire which caused the shock and to be unable to release it. Electric shock can kill its victim by stopping the heart, by stopping breathing, or both. It may sometimes damage nerve tissue resulting in a slow wasting away of muscles, a deterioration that may not become apparent until several weeks or months after the shock was received.

Treatment for Electric Shock

The following procedure is recommended for rescue and care of victims of electric shock:

1. Remove the victim from electrical contact at once, but DO NOT ENDANGER YOURSELF. Removal can be accomplished by (1) throwing the switch if it is nearby; (2) cutting the cable or wires to the apparatus, using an ax with a wooden handle while taking care to protect your eyes from the flash when the wires are severed; (3) using a dry stick, rope, leather belt, coat, blanket, or any other nonconductor of electricity.

2. Determine whether or not the victim is breathing. If the victim is NOT breathing, apply artificial respiration without delay, even though he may appear to be lifeless.

3. If the victim is breathing, keep him lying down in a comfortable position. Loosen the clothing about his neck, chest, and abdomen so that he can breathe freely. Protect him from exposure to cold, and watch him carefully.

4. Keep him from moving about. In cases of electric shock the heart is very weak; any sudden muscular effort or activity on the part of the patient may result in heart failure.

5. If the victim complains of thirst do not give him stimulants. A solution of one level teaspoon of salt and, if possible, 1/2 teaspoon of soda to a quart of water is most beneficial in this case. Give this solution in small amounts until the patient's thirst is satisifed and one or more pints have been given.

INJURIES FROM BURNS

Burns and scalds are caused by exposure to intense heat such as that generated by fire, bomb flash, hot solids, liquids, and gases, and by contact with electric current.

Burns are usually classified according to the depth of injury to the tissues. A burn which reddens the skin is called a first-degree burn. One which reddens and blisters the skin is called a second-degree burn. When the skin is destroyed and the tissues are actually charred, the injury is described as a third-degree burn.

It is easy to see that a deep burn (third-degree) is more serious than one which is not so deep. However, it is important to remember that the size of the burned area may be far more important than the depth of the burn. A first-degree or second-degree burn which covers a very large area of the body is almost always more serious than a small third-degree burn. A first-degree sunburn, for example, can cause death if a very large area of the body is involved.

It should be noted that burns and scalds are essentially the same type of heat injury. When the injury is caused by dry heat, it is called a burn; when it is caused by moist heat, it is referred to as a scald. Treatment is the same in both cases.

Treatment of Burns

The main dangers from burns are shock and infection. All first aid treatment for burns must be directed toward relieving the victim's pain, combating shock, and preventing infection.

Serious burns should be treated as follows:

1. Relieve the pain. Burns are painful, and the pain contributes to the severity of the shock. The immediate immersion in or application of clean, cold water (preferable ice-water) to the burned area has recently been found to be one of the most effective methods of instantly relieving pain caused by burns. A burn on a hand or arm or leg can best be treated by immersing the burned area in a bucket, or any other suitable container, or ice-water. Burns on parts of the body which cannot be immersed should be treated by applying ice-water compresses to the burned area. Ice cubes rolled in a wet towel makes an excellent compress for this purpose. When pain is no longer felt upon removal of the compress from the burn, or removal of the burned area from the water, this treatment may be discontinued; this may take as little as 30 minutes or as long as 5 hours. This method is so effective that it is gaining recognition as not only a first-aid measure for relieving pain, but as the sole treatment for some burns.

2. Treat for shock. Any person who has been badly burned must be immediately treated for shock. Serious shock always accompanies an extensive burn and is, in fact, the most dangerous consequence of the injury. Start the treatment for shock before making any attempt to treat the burn itself.

A seriously burned person has an overwhelming need for fluids, and the administration of liquids in such a case is an important part of the treatment. A solution of one level teaspoon of salt and 1/2 teaspoon soda in a quart of water is the recommended mixture for this purpose but warm sugar water, sweet tea, or fruit juices will suffice. This of course is contingent on the victim being conscious and able to swallow, and the absence of internal injuries.

3. Treat the burn. In cases of extensive burns, the first aid treatment depends upon the probable length of time which will elapse before the victim will receive medical aid. If you believe that a medical officer will be available within a period of about 3 hours, simply wrap the victim in a clean sheet (or whatever clean material is available), continue to treat him for shock, and do not attempt any treatment of the burn itself.

If more than 3 hours will elapse before the services of a medical officer can be obtained, you will need to dress the burn. First remove the victim's clothing around and over the burn, being careful not to cause further injury. If clothing sticks to the burn, do not attempt to pull it loose; instead, cut around the part which sticks, and leave it in place. If any material—such as wax, metal, tar, dirt or grease—adheres firmly to the burn, do not try to remove it. Do not allow absorbent cotton, powder, adhesive tape, or any other substance which might stick to the burn to come in contact with it. Never put iodine or any other antiseptic on a burn.

When you have cleared away as much of the clothing as you can, you should dress the burn. Cover the burn with a sterile battle dressing. If available, use sterile gauze in strips about 2 or 3 inches wide. Wrap the gauze strips smoothly and gently around the burned areas, and then cover with a roller bandage. The bandage must be tight, but it must not restrict circulation of the blood or interfere with breathing. A smooth, firm bandage greatly reduces the victim's pain. Once the bandage has been applied, it should not be disturbed. Leave it in place until the victim receives medical care.

Shock is the most immediate danger in burn injuries. The second danger which must be guarded against is infection. Second-degree and third-degree burns are, in effect, open wounds. At first the burned areas are probably sterile, because of the intense heat which caused the burn. Therefore, in handling and treating a person who has been burned, you must do everything possible to prevent contamination of the burn. Do not allow unsterile objects or materials to come in contact with the burn. Do not open any blisters. Contamination of the burn can cause serious (sometimes fatal) infections.

ARTIFICIAL RESPIRATION

A victim of electric shock who has stopped breathing is not necessarily dead, but he is in immediate, critical danger. The method by which a person can be saved after he has stopped breathing is called artificial respiration. The same methods of artificial respiration used for victims of electric shock can be used for drowning or gas asphyxiation cases.

The purpose of artificial respiration is to force air into and out of the lungs, in rhythmic alternation, until natural breathing is restored. Artificial respiration should be given only when natural breathing has been stopped; it must NOT be given to any person who is breathing naturally. Do not assume that a person's breathing has stopped merely because he is unconscious or because he has been rescued from contact with an electric circuit. Remember: DO NOT GIVE ARTIFICIAL RESPIRATION TO A PERSON WHO IS BREATHING NATURALLY. ALSO, NEVER GIVE MORPHINE TO AN UNCONSCIOUS PERSON OR A PERSON WHOSE BREATHING IS WEAK OR IRREGULAR.

If possible, send someone for a medical officer or a hospital corpsman; but don't go yourself if you are alone with the victim. Speed in beginning artificial respiration is essential in any case in which breathing has stopped. Every moment's delay cuts down the victim's chance of survival. Do not take time to move the victim to a more comfortable location unless he is in such a dangerous position that he must be moved in order to save his life.

If another person is present while artificial respiration is being given, he can be very helpful. Have him remove false teeth, chewing gum, or other matter from the victim's mouth; at the same time he can bring the victim's tongue forward. He can also loosen the clothing around the victim's neck, waist, and chest. If you are alone you will have to attend to these things before beginning artificial respiration.

Artificial respiration must be continued for at least 4 hours unless natural breathing is restored before that time or a medical officer declares the person dead. Some people have been saved after as much as 8 hours of artificial respiration.

The three most common methods of artificial respiration are the MOUTH-TO-MOUTH METHOD, the BACK-PRESSURE HIP-LIFT METHOD, and the BACK-PRESSURE ARM-LIFT METHOD. There are, of course, other methods which you may have previously learned. However, the National Academy of Sciences, the National Research Council, the American Red Cross, and the Armed Forces recommend the MOUTH-TO-MOUTH METHOD as the preferred and most effective method of providing artificial respiration. All other methods are considered alternate methods for use only when mouth-to-mouth resuscitation is not practicable.

Mouth-to-Mouth Method

The mouth-to-mouth method is particularly useful in cases of electric shock. Refer to figure 4-1 while learning the following six steps:

1. Place the victim on his back. Loosen collar and belt.

2. Clear the mouth of any foreign matter with your fingers or a cloth wrapped around your fingers.

3. Tilt the head back so the chin is pointing upward. With one hand push the jaw forward into a jutting-out position. Tilting the head and pushing the jaw forward should relieve obstruction of the airway. With the fingers of one hand, pinch the victim's nostrils shut to avoid any air leakage.

4. Take a deep breath. Place your mouth over the victim's mouth and breathe into him. The first blowing effort should determine whether or not any obstruction exists. Watch his chest which will rise only if his air passage is clear.

5. Remove your mouth, turn your head to one side, and listen for the return rush of air that indicates air exchange. Repeat the blowing effort about twelve times per minute.

6. If you are not getting air exchange, recheck the head and jaw position. If you still do not get air exchange, quickly turn the victim on his side and administer several blows between his shoulder blades in an effort to dislodge foreign matter. Again clean the mouth with your fingers.

Don't worry about germs when a life is at stake. Those who do not wish to come into direct contact with the victim may hold a cloth or handkerchief over the victim's mouth or nose and breathe through it. The cloth does not greatly affect the exchange of air.

The Navy now has available a plastic resuscitation tube which is to be a part of every first aid kit. Use of the plastic tube makes it easier to keep the victim's tongue from blocking the air passage, and avoids the necessity for direct oral contact between rescuer and victim.

Medical research has demonstrated conclusively that the mouth-to-mouth respiration technique is superior to all others in reviving a person whose breathing has stopped for any reason. The method is adaptable to a victim of any age. Everyone should be familiar with it.

Back-Pressure Hip-Lift Method

The back-pressure hip-lift method, shown in figure 4-2, is used in cases where it is necessary to give artificial respiration to a person who has been injured in the upper part of the body—chest, neck, shoulders, or arms. The hip-lift method is also useful in situations where lack of space makes it difficult or impossible to use the arm-lift method. The hip-lift method has the disadvantage of being somewhat harder on the operator.

The back-pressure hip-lift method requires the following steps:

1. Place the victim face down with one arm bent at the elbow and the other arm extended as shown in figure 4-2. Rest his head on his hand or forearm, with his face turned so that his nose and mouth are free for breathing. Clear his mouth of any objects or materials which might obstruct his breathing. At the same time bring his tongue forward so that it will not clog the air passage.

2. Kneel on one knee, and straddle the victim at the level of his hips. Place your hands on the middle of his back, just below the shoulder blades. Your fingers should be spread downward and outward, with your thumb tips just about touching. Be careful not to place your hands too high on his back; they should be below the shoulder blades.

3. With your arms held straight, rock forward slowly so that the weight of your body is gradually brought to bear upon the victim. Keep your elbows straight and yours arms almost vertical so that the pressure is exerted almost directly downward. Do not exert sudden pressure or any more pressure than is required to feel a firm resistance.

4. Release the pressure quickly by peeling your hands from the patient's back.

5. Now rock backward and let your hands come to rest on the victim's hips, well below

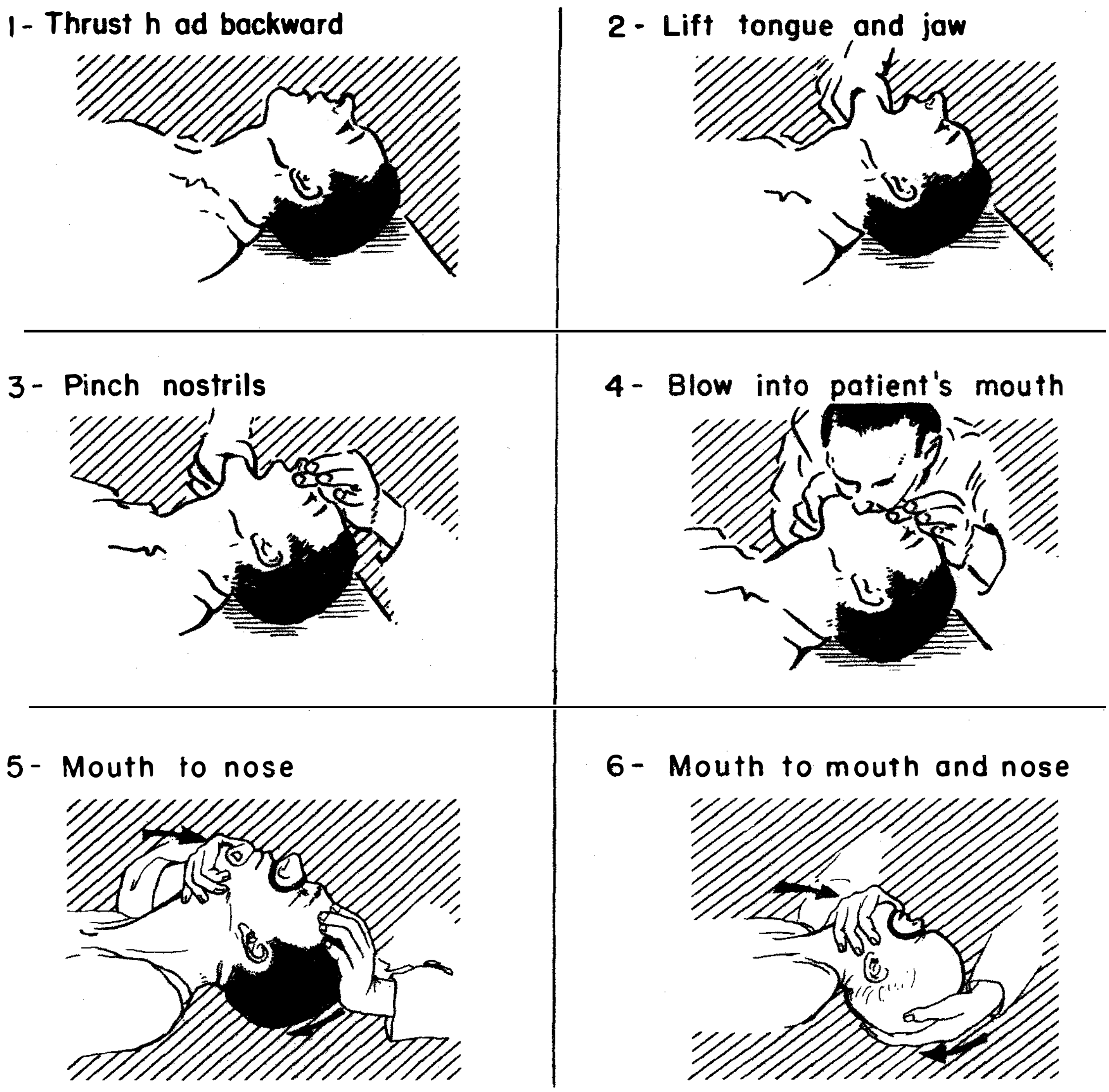

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Figure 4-1.—Mouth-to-mouth method of resuscitation.

his waist. Slip your fingers underneath his hip bones.

6. Lift the victim's hips 4 to 6 inches. The lifting allows the abdomen to sag downward and the diaphragm to descend. causing his chest to expand and fill with air. Then lower the victim's hips, and you have finished one full cycle.

The cycle should be performed approximately 12 times per minute. If a relief operator is available, he can come in one side and take over after one of the lift phases.

Back-Pressure Arm-Lift Method

The back-pressure arm-lift method of artificial respiration is shown in figure 4-3. This method requires the following steps:

1. Place the victim so that he is lying face down. If he is on a sloping surface, place him so that his head is slightly lower than his feet. Bend both his elbows and place one hand on the other, as shown in figure 4-3. Rest the victim's head on his hands, with his face turned to one side.

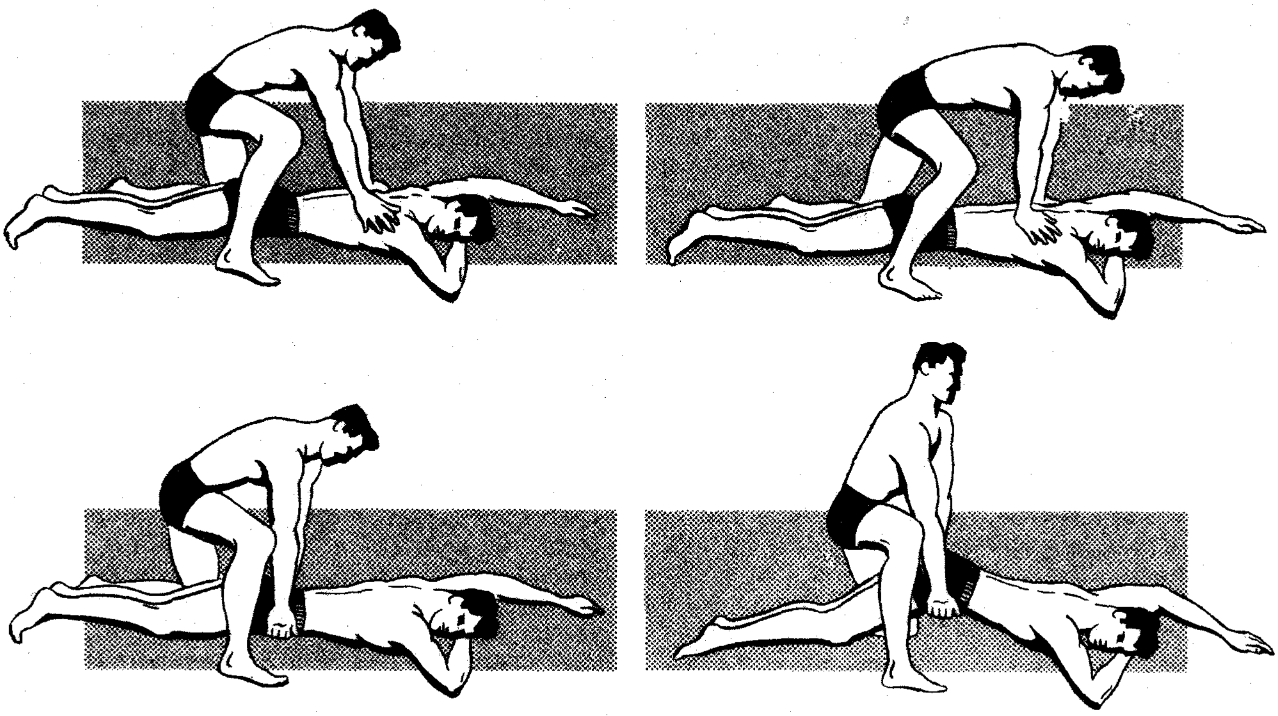

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Figure 4-2. —Back-pressure hip-lift method of resuscitation.

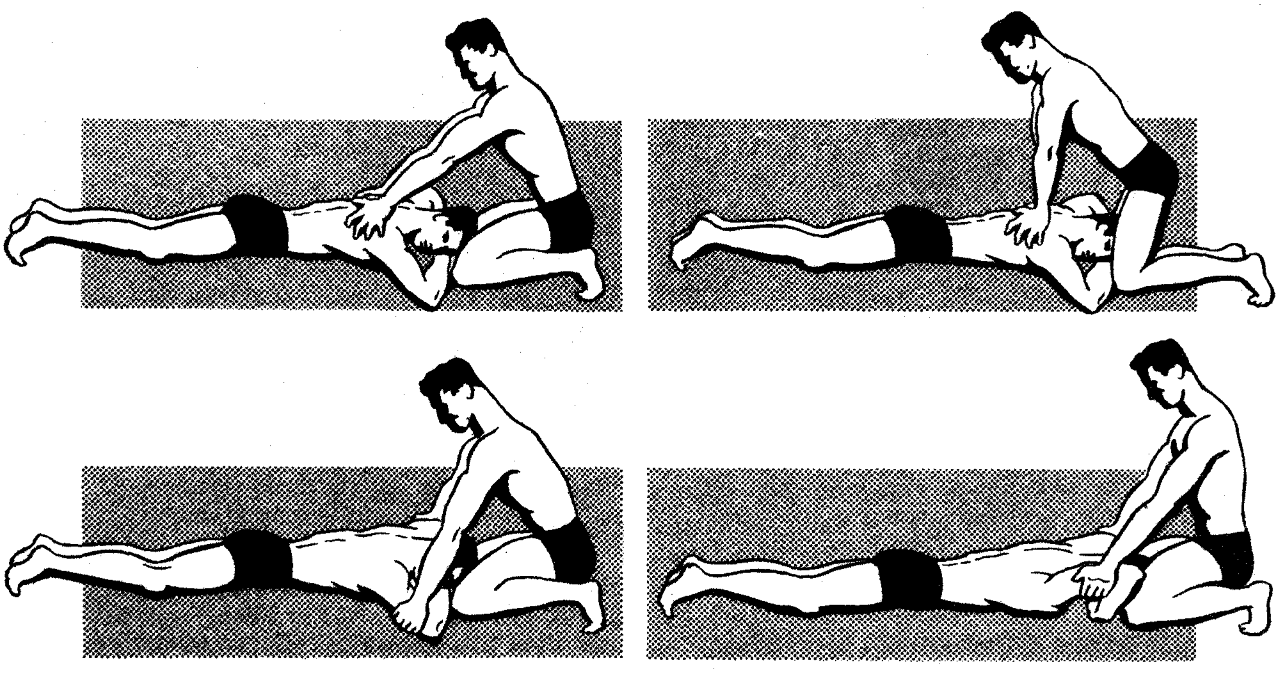

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Figure 4-3.—Back-pressure arm-lift method of resuscitation.

2. Kneel on one knee, facing the victim. (You can use either knee.) Place your knee close to his head. Place your other foot near his elbow. You may find it more comfortable to kneel on both knees; if you do this, place one knee on each side of the victim's head. Next, place your hands on the middle of his back, just below the shoulder blades, in such a position that your fingers are spread downward and outward, with thumb tips just about touching.

3. With your arms held straight, rock forward slowly so that the weight of your body is gradually brought to bear on the victim. This action will compress his chest and force air out of the lungs. Do not exert sudden pressure; do not place your hands too high on his back or on his shoulder blades.

4. Release the pressure quickly by peeling your hands from the victim's back.

5. Now rock backward, and allow your hands to come to rest on the victim's arms just above his elbows. As you swing backward, lift the victim's arms upward. The arm lift pulls on the victim's chest muscles, arches his back, releases the weight on his chest, and causes his chest to expand and fill with air. Then lower the victim's arms, and you have finished one full cycle.

Repeat this cycle approximately 12 times per minute (5 seconds per cycle). Follow the rhythm of: Rock forward and press, rock backward and lift. The pressing and lifting should take approximately equal periods of time; the release periods should be as short as possible.

Try to maintain a slow, easy rhythm—rocking forward on the back-pressure phase, rocking backward on the arm-lift phase. The rocking motion helps to maintain rhythm. Remember that a smooth rhythm is important in performing artificial respiration, but split-second timing is not essential.

Treatment During Recovery

When a person is regaining his breath, the bluish or pale appearance of his skin may be followed by a distinct flush of color. Then his muscles may begin to twitch and fingers scratch and clutch. Swallowing movements are sometimes the first sign of natural respiration; or the first attempt to breathe may be a faint catch of breath or a sigh. You must be very careful not to exert pressure when the victim is trying to get his first breath. If he begins to breathe on his own, adjust your timing to assist him. Do not hinder his efforts to breathe; instead, synchronize your efforts with his.

Keep the patient warm. Do not give any liquids until he is fully conscious. To avoid strain on his heart, the patient should be kept lying down and not allowed to stand or sit after he revives. Do not allow the patient to walk or otherwise exert himself. The slightest exertion at this point might easily cause death from heart failure. Get the patient under the care of a doctor as soon as possible.

Personnel in all rates and ratings, E-2 and above, are required to be able to administer artificial respiration. Detailed coverage of the Navy's standardized procedures for artificial respiration is given in the effective edition of Standard First Aid Training Course, NavPers 10081.

CHAPTER 5

REVIEW OF ELECTRONIC CONCEPTS

An understanding of the principles of electronics will help 0 Branch personnel to know how their equipment operates, what it is capable of doing, and when it is not operating properly. To use the complex equipment arrangements employed in modern communications, an operator must know more than how to push a button or turn a knob. For example, an operator may be required to use receivers, demodulators, demultiplexers, and automatic printers to receive and process a single complex communication signal. In some instances it may be necessary to connect individual equipments or components of individual equipments into the proper arrangement for processing the signal. It may be necessary to determine information concerning the type of modulation used and the quality of the received signal. Such a determination can be accomplished using panadapters, oscilloscopes, and other signal test equipment provided in a modern communication installation.

The subject of modulation of radio waves, the characteristics of radio transmission systems, and the function of specific types of equipment will be discussed later in this training course. The information presented in this chapter will provide a basis for understanding those subjects.

Electronics is the science and technology concerned with devices involving the emission, behavior, and effects of electrons in vacuums, gases, and semiconductors. It would be misleading to say that the study of electronics is an easy endeavor. However, it is not as mysterious and difficult as one might think, especially when only basic concepts are considered. In general, irrespective of the purpose to which they are used, electronic networks comprise not more than four fundamental components: (1) resistors, (2) inductors, (3) capacitors, and (4) control devices such as electron tubes and transistors. A review of the composition of matter and the structure of atoms and elements will make it easier to understand the function of current flow in electronic circuits.

THE ATOM

The idea that all matter is constructed of a great number of very small, separate particles called ATOMS dates back more than 2000 years to the Greeks. Many centuries passed before the study of matter proved that the basic idea of atomic structure was correct. At present there are over 100 known elements, the basic units of which are atoms. Most substances are composed of different combinations of atoms.

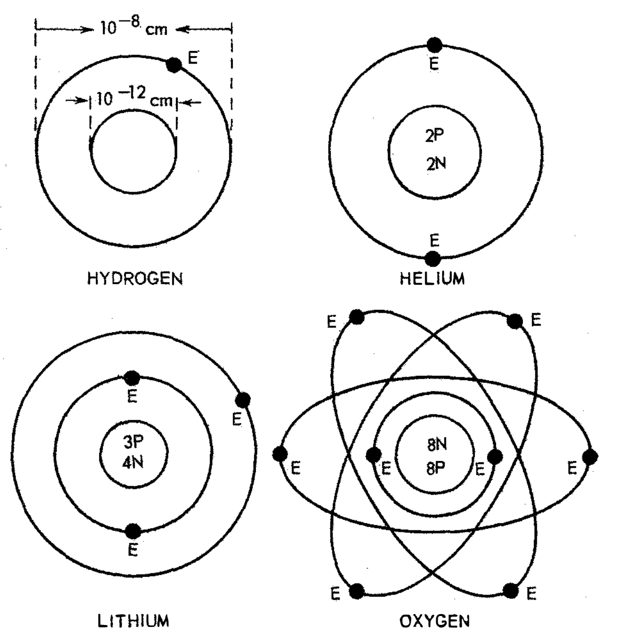
INTERNAL STRUCTURE OF THE ATOM

Modern theory not only pictures the atom as a fundamental building block of all matter, but also pictures all matter as being electrical in nature. It is not possible to determine the actual structure of the atom directly, but many facts of physics and chemistry can be explained by the Rutherford-Bohr theory concerning the atom.

An early concept of the structure of matter regarded the atom as composed of only two parts—ELECTRONS, each of which carries a definite negative charge; and PROTONS which are much heavier particles, each carrying a positive charge equal to the negative charge of the electron. However, research has indicated that the atom also contains uncharged particles, called NEUTRONS, each of which has about the same mass as the proton. More recent research has shown the existence of POSITRONS, other particles which have about the same mass as electrons. Additional subatomic particles are being studied. However, in the study of basic electronics, the electron is of primary concern—other subatomic particles are more appropriate to the study of advanced physics.

Figure 5-1 pictures diagrams of four simple atoms based on the Rutherford-Bohr theory that the atom consists of a dense central nucleus, protons and neutrons, with one or more much lighter particles, electrons, revolving about the nucleus in much the same way that the planets revolve around the sun.

The lightest and simplest atom, the hydrogen atom (figure 5-1A), has a single proton in the nucleus and a single orbital electron. Because hydrogen is the lightest element, an atom of hydrogen is said to have a mass of one. The next heavier atom, that of helium, has a mass of four relative to hydrogen and was originally expected to contain four protons. However, it was found that the helium atom has only two protons instead of the four expected. The remainder of its mass is attributed to two neutrons located in the nucleus of the atom. The more complex atoms contain more and more protons and neutrons in the nucleus, with a corresponding increase in the number of planetary electrons. The total number of positive and negative charges are equal in any uncharged or neutral atom. The



41.2

Figure 5-1.—Rutherford-Bohr models of simple atoms.

planetary electrons are arranged in orbits or shells of definite energy levels outside the nucleus.

The positron previously mentioned is formed only when high energy radiation strikes a nucleus. Because it has a short life, it is not found in electronic circuits as are electrons. Because the proton and neutron are about 1840 times as heavy as the electron, the mass of the atom is determined principally by the number of protons and neutrons in the nucleus.

In most materials some of the electrons are not tightly held in their orbits but are free to move from one atom to another. These are called FREE ELECTRONS. When free electrons are set in motion, they produce the flow of electric current. Materials known as electrical conductors contain many free electrons. The best known conductors are metals, carbon, and water. The most common metals in the order of conductivity are listed as follows, with silver taken as 100 percent:

Silver	100
Copper	96
Gold	67
Aluminum	60
Tungsten	30
Zinc	26
Nickel	21
Platinum	16
Iron	16
Tin	14
Lead	7
Mercury	2

MAGNETISM

A substance is said to be a magnet if it has the property of magnetism; that is, if it has the power to attract such substances as iron, steel, nickel, or cobalt, which are known as MAGNETIC MATERIALS. A piece of metal which is magnetized exhibits two points of maximum attraction—one at each end, with no attraction at its center. The points of maximum attraction are called MAGNETIC POLES.

A MAGNETIC FIELD, which exists around every magnet, consists of imaginary lines along which a MAGNETIC FORCE acts. These lines emanate from the north pole of the magnet and enter the south pole, returning to the north pole through the magnet itself, thus forming closed loops. The entire quantity of magnetic lines surrounding a magnet is called MAGNETIC FLUX. Flux in a magnetic circuit corresponds to current in an electric circuit. How readily flux flows through a magnetic circuit is a measure of that circuit's PERMEABILITY. High permeability indicates less resistance to the flow of flux.

A MAGNETIC CIRCUIT is a complete path through which magnetic lines of force may be established under the influence of a magnetizing force. A magnetic circuit is similar to an electric circuit, which is a complete path through which current is caused to flow under the influence of an electromotive force.

Magnets may be divided into three groups:

1. NATURAL MAGNETS. Found in the natural state in the form of a mineral called magnetite.
2. PERMANENT MAGNETS. Bars of hardened steel, or some form of alloy such as alnico, that have been permanently magnetized.
3. ELECTROMAGNETS. Composed of soft iron cores around which coils of insulated wire are wound. When an electric current flows through the coil, the core becomes magnetized. When the current ceases to flow, the core loses most of its magnetism. Permanent magnets and electromagnets are called ARTIFICIAL MAGNETS to distinguish them from natural magnets. Figure 5-2 pictures an artificial bar magnet and illustrates the magnetic field through and around the bar.

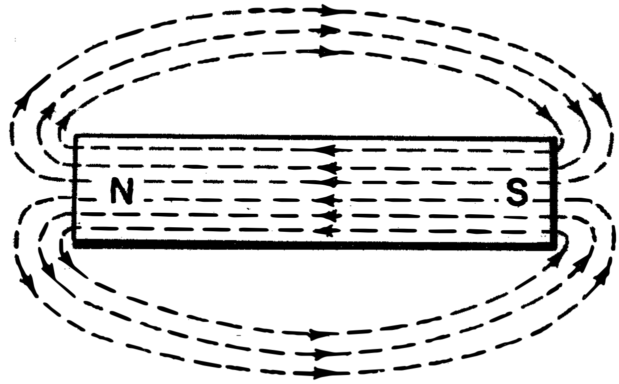
The reaction between magnetic poles is similar to that of electric charges in which opposite charges attract each other and like charges repel each other. Thus the laws of magnetic attraction and repulsion may be stated as follows:

1. LIKE magnetic poles REPEL each other.
2. UNLIKE magnetic poles ATTRACT each other.

ELECTROMAGNETISM

An interesting property of an electrical conductor is that current flowing through the conductor produces a magnetic field around the conductor as illustrated in figure 5-3A. That field is not a random one but is composed of magnetic lines of force which have a definite direction and strength.

If the conductor is wound into a coil, the magnetic lines of force will then tend to support each other and form a stronger magnetic field which will pass through the coil. When a metal rod or bar is placed inside the coil, as indicated in figure 5-3B, the bar or rod itself



41.4

Figure 5-2.—Magnetic field around a bar magnet.

becomes magnetized with a north and south pole. Thus, if the current through the coil reverses itself, the magnet will reverse its poles accordingly.

HYSTERESIS AND RESIDUAL MAGNETISM

HYSTERESIS is simply the tendency of the strength of induced magnetism (generally in an electromagnet) to lag behind the strength of the magnetizing force. Hysteresis is an important consideration in such operations as magnetic tape recording.

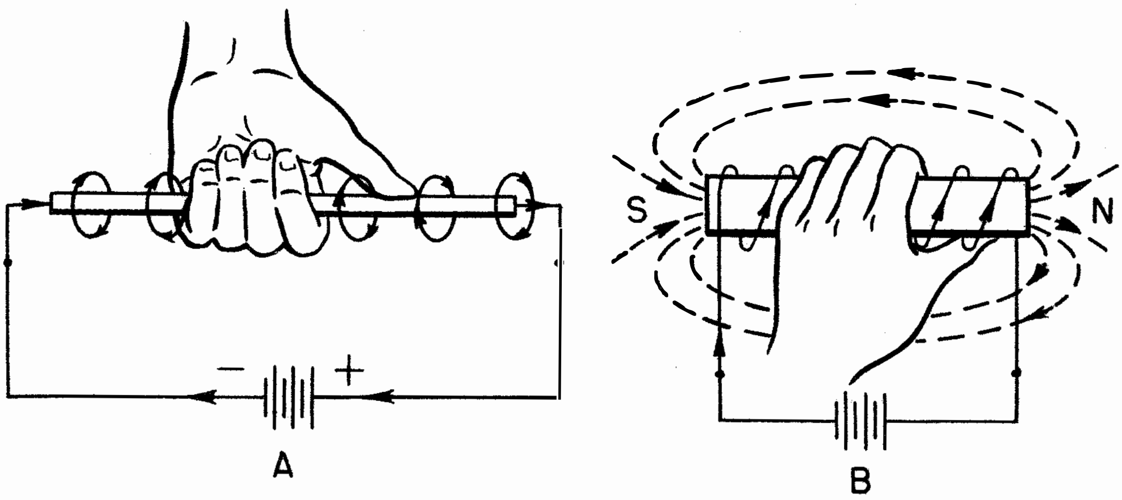
RESIDUAL MAGNETISM is an effect of hysteresis and is defined as that magnetism which remains in a magnet after the magnetizing force is removed. As in the case of hysteresis, residual magnetism is an important consideration in magnetic tape recording.

DIRECT-CURRENT ELECTRICITY

CURRENT FLOW

As previously stated, the atomic structure of some materials permits free electrons to move readily from one atom to another. The movement of electrons from atom to atom comprises electric current. In figure 5-4, notice that the electrons are moving in a particular direction. The movement is defined as the direction of current flow. Before further discussion of current flow, however, certain terms should be defined.

CONDUCTOR. A material composed of atoms whose electrons are easily moved from atom to atom. In general, all metals



41.6

Figure 5-3.—Magnetic fields; (A) around a single wire, (B) around a coil.

are conductors, with silver and copper being two of the best. SEMICONDUCTOR. A material which will conduct electric current but not as well as a material classified as a conductor. Carbon is an example of a semiconductor.

INSULATOR. A material which will not conduct significant amounts of electric current. Glass, rubber, paper, and mica are examples of insulators.

Determining the amount of current flow in a conductor is accomplished by measuring the number of electrons passing a given point in a specific amount of time. The practical unit of electric current, which is the AMPERE, is measured with an instrument called an AMMETER placed in a circuit in the manner shown in figure 5-5. Notice that the meter is connected so that the current must flow through the meter.

VOLTAGE

In order for current to flow through a conductor or an electric circuit, there must

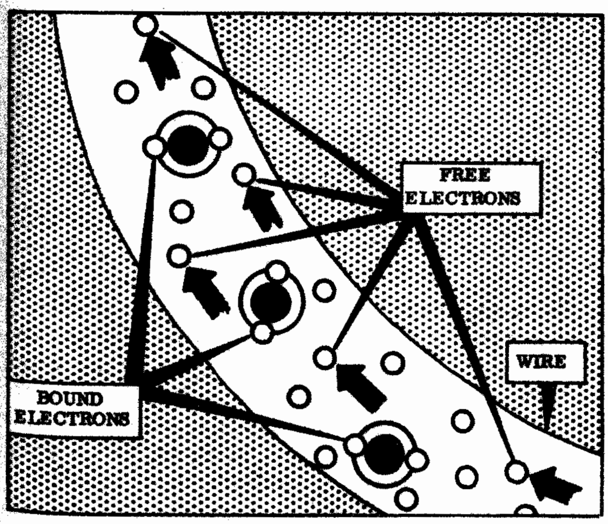


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Figure 5-4.—Current flow.

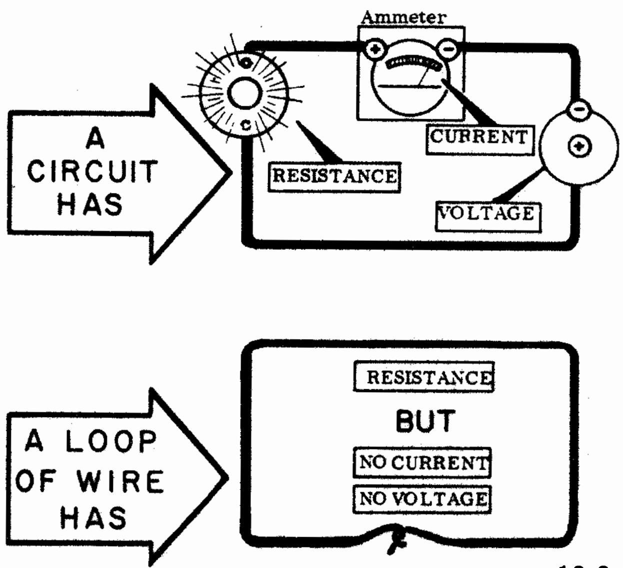

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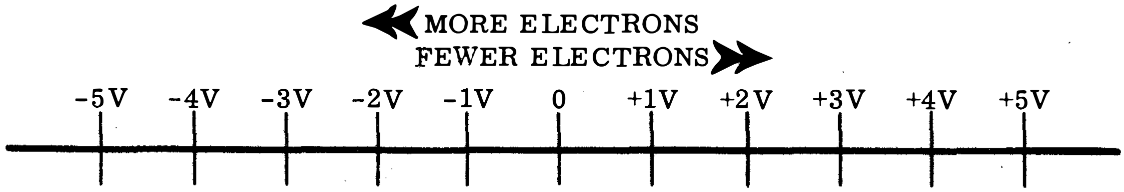
Figure 5-5.—Current in a circuit.



93.1

Figure 5-6.—Graphic display of relationship between differences in potential.

exist between the ends of the conductor or circuit some type of force to cause the electrons to move from atom to atom. This force is called ELECTROMOTIVE FORCE (EMF). The basic unit of EMF is the volt, named after the 19th century Italian physicist Alesandro Volta.

An EMF exists between any two points in a circuit having a difference in charge or potential. This EMF causes the current to flow toward the point having the lesser number of electrons (less negative charge). Figure 5-6 may help clarify this point. It can be seen that all charges to the left of zero are negative and all charges to the right of zero are positive. It is obvious that current will flow from a -5V potential to a +5V potential. However, since current will flow from any point to any less negative (more positive) point, current will also flow from -3V to -1V, -1V to +1V, +2V to +4V or any other combination having the same relationship. This explains the commonly held idea that current in a circuit flows from negative to positive.

The EMF in a circuit is measured by an instrument called a VOLTMETER. Measurement is accomplished by connecting the voltmeter across the points where the difference in potential is to be measured. Figure 5-7 shows a voltmeter properly connected for measuring the difference in potential across the two terminals of a light bulb.

RESISTANCE

Every material offers some resistance or opposition to the flow of electric current through it. A good conductor such as silver or copper offers very little resistance. In general, the amount of resistance in an electric circuit depends upon the physical size and type of materials which make up the components of the circuit. For example, the resistance of a copper wire varies directly with its length and inversely with its diameter; that is, the longer the wire, the greater the resistance; but the larger the diameter, the lower the resistance. Also, in most conductors the resistance increases as its temperature increases.

To make a circuit function properly, it is often necessary to control the amount of resistance in the circuit. This control is accomplished through the use of specially manufactured parts containing specific amounts of resistance. These parts are called RESISTORS, and the amount of resistance they present to current flow is measured in units called OHMS, named for a German physicist, George Simon Ohm. The instrument used to measure resistance is called an OHMMETER.

THE BASIC ELECTRIC CIRCUIT

Figure 5-8 is a drawing of a simple electric circuit showing a lamp connected to a power

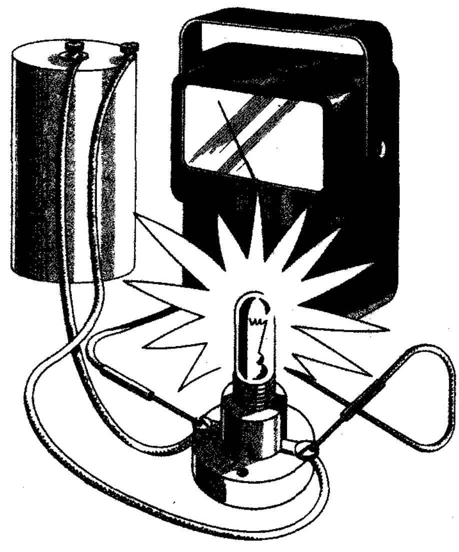


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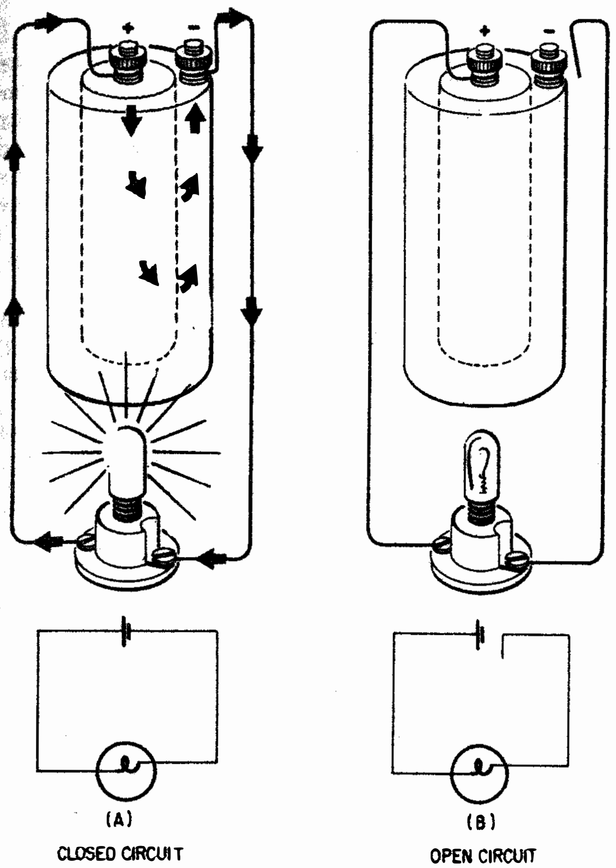
Figure 5-7.—Voltmeter connections.



13.13

Figure 5-8.—(A) Simple electric circuit (closed). (B) Simple electric circuit (open).

source, which in this case is a dry cell battery. As you learned in the first part of this chapter, whenever an electromotive force exists between components and they are linked by a conductor, current will flow from negative to less negative or positive. In the circuit shown, current will flow from the negative terminal of the battery, through the lamp, and return to the positive terminal of the battery as indicated by the arrows in figure 5-8.

As long as a difference in electron potential exists between the terminals of the battery and the path for the current is unbroken, current will flow. Unbroken current flow forms what is known as a CLOSED CIRCUIT. However, if the path is broken at any point, the circuit becomes an OPEN CIRCUIT, and no current flows. See figure 5-8B.

OHM'S LAW

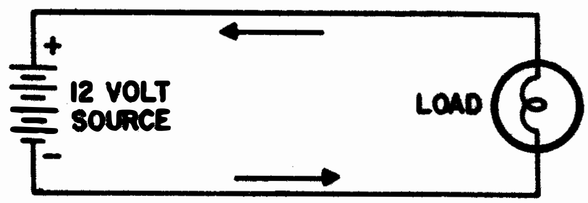
The VOLTAGE, CURRENT, and RESISTANCE in a d-c circuit, such as that shown in figure 5-9, can be computed by using OHM'S LAW, which is stated as follows:

THE VOLTAGE OR EMF EXISTING BETWEEN ANY TWO POINTS IN A D-C CIRCUIT IS EQUAL TO THE PRODUCT OF THE RESISTANCE OF THAT PART OF THE CIRCUIT AND THE CURRENT FLOWING IN THAT PART OF THE CIRCUIT. Expressed as an equation, the law becomes $E = I \times R$, where I is the current in amperes, E is the EMF in volts, and R is the resistance in ohms. For example, if the resistance of the load in figure 5-9 is 2 ohms and the current through the load is 6 amperes, the voltage can be computed as follows:

$E = I \times R$, or $E = 6 \times 2 = 12$ volts.

SERIES AND PARALLEL CIRCUITS

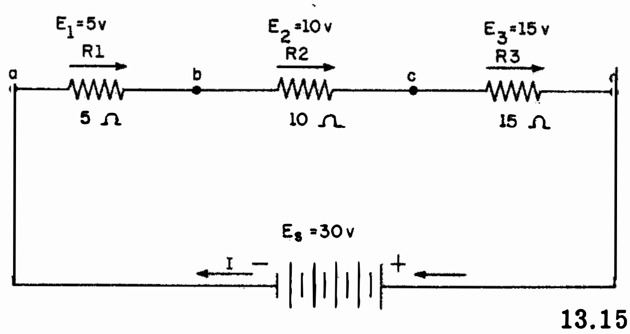
Two of the most common types of electric circuits are SERIES and PARALLEL circuits. If a circuit is arranged so that the electrons have only one possible path through the various parts, the circuit is a SERIES circuit. See



93.3

Figure 5-9.—Simple circuit.

figure 5-10. Notice that the voltage source E_s is 30 volts. Since there is only one path for current flow in the series circuit, the total current is the same in all parts of the circuit. By



13.15

Figure 5-10.—Series circuit.

applying Ohm's law the total current throughout the series circuit is derived by $I = \frac{E}{R} = \frac{30}{30} = 1$ ampere. The voltage drop for each individual resistor can be determined by multiplying the common current throughout the circuit by each individual value of resistance. The voltage drop for R_1 is derived by multiplying 5 ohms by 1 ampere = 5 volts. Voltage drop for R_2 and R_3 is derived in the same manner; that is, 10 and 15 volts respectively. Notice that the total voltage drop throughout the circuit is equal to the voltage source. The total resistance for any series circuit is determined by $R_t = R_1 = R_2 = R_3$.

A circuit having two or more paths for current flow is called a PARALLEL circuit. See figure 5-11. Notice that when the circuit separates into three branches the total current I_t separates, with the branches designated I_1, I_2, and I_3. The amount of current which flows through the individual branches is determined by the amount of resistance in each branch. For example, I_1 is equal to 6 amperes but I_3 is equal to 1 ampere because the first branch has only 5 ohms of resistance whereas the third branch has 30 ohms of resistance. Notice that the voltage drop across each branch of a parallel circuit is always equal to the source voltage. The total resistance for any parallel circuit is derived by $R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots\ldots}$

POWER

Power pertains to the rate at which work is being done. Work is done whenever a force causes motion. Previously, you found that voltage is electromotive force, and that voltage forces current to flow in a closed circuit. However, when voltage exists between two points, but current cannot flow, no work is done. When voltage causes electrons to move, work is done. The instantaneous RATE at which this work is done is called the electric power rate, and its measure is the watt.

A total amount of work may be done in different lengths of time. For example, a given number of electrons may be moved from one point to another in one second or in one hour, depending on the RATE at which they are moved. In both cases, total work done is the same. However, when the work is done in a short time, the wattage, or INSTANTANEOUS POWER RATE is greater than when the same amount of work is done over a longer period of time.

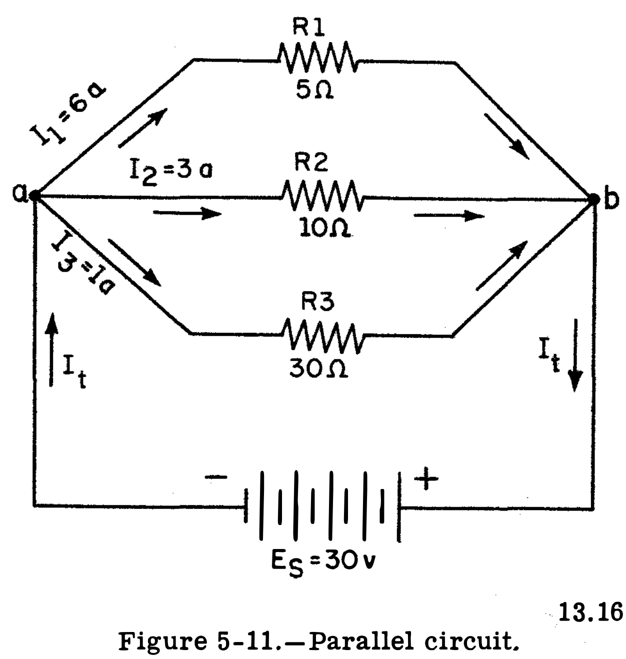
As stated, the basic unit of power is the WATT, and is equal to the product of the EMF in volts and the current in amperes. Thus power can be expressed by the equation P = IE. If you use Ohm's law, E = IR, and substitute this expression for E in the power equation, you find the relationship $P = I^2R$. Using Ohm's law to compute for current, $I = \frac{E}{R}$, you find that power can also be expressed as $P = \frac{E^2}{R}$. Consider the following examples:

1. What is the power required for a 110-volt light bulb which draws a current of 0.91 ampere?

   Substitute in the equation—

   P = EI = 110 x 0.91 = 100 watts

2. What is the power consumed by a 20-ohm load if the current through the load is 3 amperes?



13.16

Figure 5-11.—Parallel circuit.

Substitute in the equation—

$P = I^2R = (3)^2 \times 20 = 180$ watts

3. What is the power consumed by a 100-ohm device if the voltage across it is 50 volts?

Substitute in the equation—

$$P = \frac{E^2}{R} = \frac{(50)^2}{100} = 25 \text{ watts}$$

ALTERNATING-CURRENT ELECTRICITY

Direct current flow has been described as the movement of electrons from atom to atom along a conductor. The current flows out of the negative terminal of the source, through the load, and back to the positive terminal. The direction of current flow is always from a negative point to a less negative point or from a positive point to a more positive point. If the two terminals of the circuit are made alternately more and less negative, the current flow will repeatedly reverse, resulting in ALTERNATING CURRENT. The direction of flow changes periodically in a form known as sine-wave variation. The following discussion of the terms—sine wave, cycle, frequency, and period—will help you gain an understanding of alternating current.

SINE WAVE

The vertical projection of a ROTATING VECTOR may be used to represent the voltage at any instant. See figure 5-12. Vector E_m represents the maximum voltage induced in a conductor rotating at uniform speed in a 2-pole field. The vector is rotated counterclockwise through one complete revolution (360°). The point of the vector describes a circle. A line drawn from the point of the vector perpendicular to the horizontal diameter of the circle is the vertical projection of the vector at that instant.

The circle also describes the path of the conductor rotating in the bipolar field. The vertical projection of the vector represents the voltage generated in the conductor at any instant corresponding to the position of the rotating vector as indicated by angle theta (θ). Angle θ is the time-phase angle representing selected instants at which the generated voltage is plotted. The sine curve plotted at the right of the figure represents successive values of the a-c voltage induced in the conductor as it moves at uniform speed through the 2-pole field.

CYCLE

A CYCLE is defined as the variation of current or voltage from a starting point on the sine curve to a maximum value, back to zero, to a maximum value in the opposite direction, and back to a point on the curve that is identical to the starting point.

FREQUENCY

The number of cycles of alternating current or voltage that occur in one second is known as the FREQUENCY. A greater number of cycles per second means a higher frequency and thus less time for each cycle, as illustrated in figure 5-13. For example, on the time scale of one second shown in figure 5-13A, when the sine wave completes one cycle in one second, the frequency is one cycle per second. Notice in figure 5-13B that the waveform has much faster variations, with 4 complete cycles taking place in one second; therefore, the frequency is 4 cycles per second (cps).

PERIOD

The amount of time required for the completion of one cycle of a sine wave is known as the PERIOD of the wave. The symbol for period is T. For example, if a wave has a frequency of 60 cps, the time required for one cycle is $\frac{1}{60}$ of a second, or the period of the wave is $\frac{1}{60}$ of a second. The above explanation shows that the frequency and period of a wave are reciprocals of each other. The formulas for computing period and frequency are:

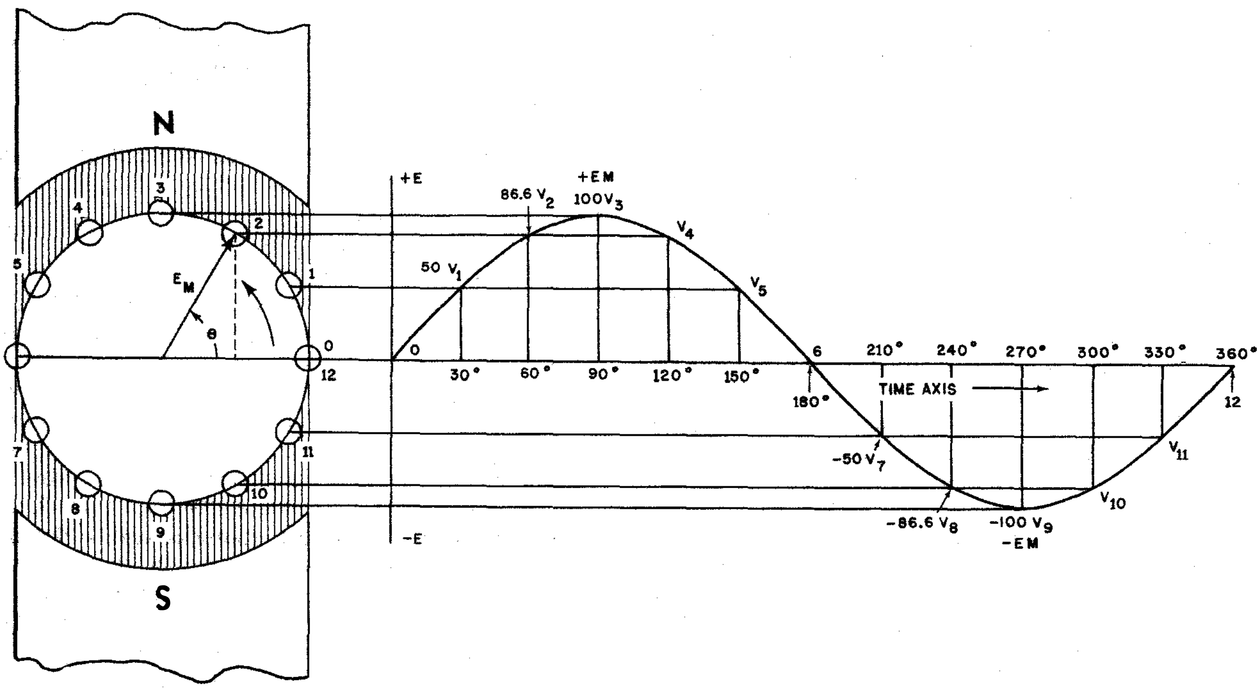
$$T(\text{seconds}) = \frac{1}{\text{Frequency (cps)}}$$

and

$$F(\text{cps}) = \frac{1}{T(\text{seconds})}$$

GENERATION OF ALTERNATING CURRENT

The basic method of generating alternating current is the use of mechanical generators which operate on the principle of magnetic induction whereby a conductor is moved through a magnetic field so that it cuts the magnetic lines of force causing an electromotive force to be induced in the conductor. This process, illustrated in figure 5-14 shows a suspended loop



41.19

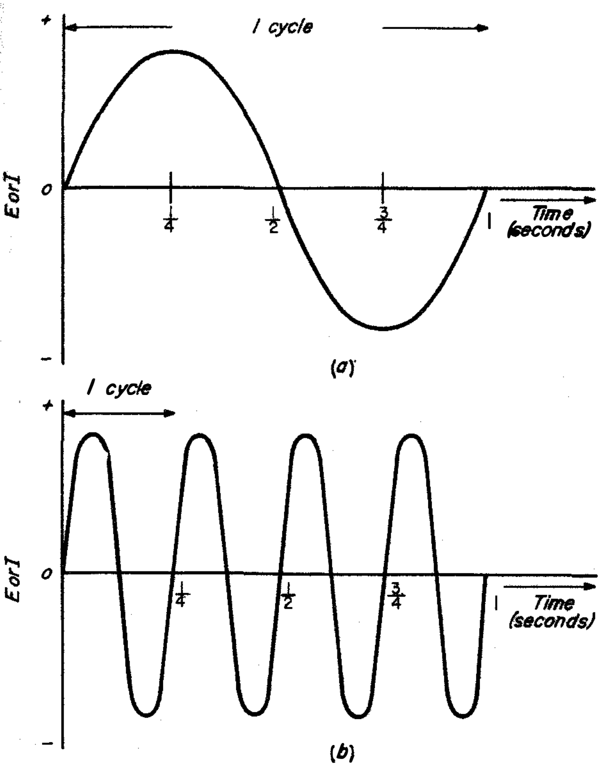
Figure 5-12.—Sine wave of voltage generated in a conductor as it is rotated at a uniform velocity in a two-pole field of constant strength.

of wire (a conductor) being rotated through the magnetic field between the poles of a permanent magnet.

For ease of explanation, the loop has been divided into a dark half and a light half. Notice that in part A, the dark half is moving parallel to the lines of force; therefore it is cutting none of these lines. The same is true of the light half moving in the opposite direction. Since the conductors are cutting no lines of force, no EMF is induced. As the loop rotates toward the position shown in part B, it cuts more and more lines of force because it is cutting more directly across the magnetic field as it approaches position B. At position B, the induced voltage is greater because the conductor is cutting directly across the field. As the loop continues to rotate towards position C, it cuts fewer and fewer lines of force; thus the induced voltage decreases from its peak value. Eventually the loop is once again moving in a plane parallel to the magnetic field and no voltage is induced. The loop has now been rotated through a half circle (180°) or one alternation. The sine curve shown in the lower part of figure 5-14 shows the induced voltage at every instant of rotation of the loop. Notice that this curve contains 360° or two alternations. Two alternations represent one complete cycle of rotation.

The direction of current flow during the rotation from (B) to (C), when a closed path is provided across the ends of the conductor loop, can be determined by using the LEFT-HAND RULE FOR GENERATORS. The left-hand rule is applied as follows: Extend the left hand so that the THUMB points in the direction of conductor movement, and the FORE-FINGER points in the direction of magnetic flux (north to south). By pointing the MIDDLE FINGER 90 degrees from the forefinger, it will point in the direction of current flow within the conductor.

Applying the left-hand rule to the dark half of the loop in part (B), you will find that the direction of current flow is as shown by the heavy arrow. Similarly, you can determine the direction of current flow through the light half of the loop. The two induced voltages add together to form one total e.m.f. When the loop is further rotated to the position shown in part (D), the action is reversed. The dark half is moving up instead of down, and the light half is moving down instead of up. By applying the left-hand



93.4

Figure 5-13.—Frequency of alternating current; (A) 1 cps, (B) 4 cps.

rule once again, you will find that the direction of the induced e.m.f. and its resulting current have reversed. The voltage builds up to maximum in this new direction, as shown by the sine-wave tracing. The loop finally returns to its original position (part E), at which point voltage is again zero. The wave of induced voltage has gone through one complete cycle.

If the loop is rotated at a steady rate, and if the strength of the magnetic field is uniform, the number of cycles per second and the voltage will remain at fixed values. Continuous rotation will produce a series of sine-wave voltage cycles, or in other words, an a-c voltage.

Phase Angle

Referring to figure 5-15, notice the comparisons of waves A and B. In this instance, sine wave B begins its cycle at a point of maximum voltage, and sine wave A begins at the point of zero value. Each has the same frequency. The complete cycle of wave B through 360° takes it to the maximum value from which it started, while wave A starts and finishes its cycle at zero. With respect to time, therefore, wave B is ahead of wave A in its value of generated voltage. The amount which it leads in time equals a one-quarter revolution (cycle) which is 90°. The angular difference is called the phase angle between waves B and A. In other words, wave B leads wave A by the phase angle of 90°.

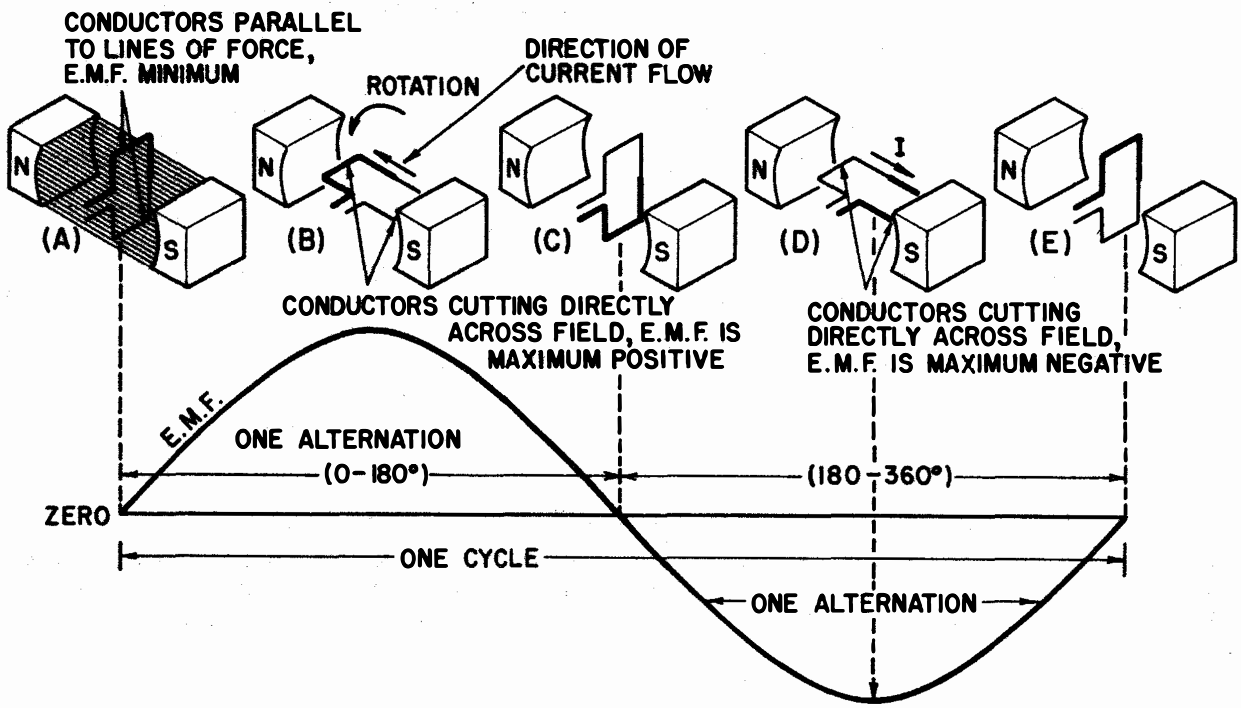
The 90° phase angle between waves B and A is maintained throughout the complete cycle and in all successive cycles, as long as both have the same frequency. Note that the phase angle for a wave can be specified only by comparison with another wave.

CAPACITANCE

In simple form, a capacitor (figure 5-16) consists of two parallel metal plates separated by an insulating material such as air, paper, oil, or mica. This insulating material is called a DIELECTRIC. When the plates are shorted to a ground point (figure 5-16A), no difference in potential exists across them; both plates have the same number of electrons evenly distributed on them. However, if the plates are connected to a battery (figure 5-16B), a transient flow of electrons takes place counterclockwise around the circuit and through the battery as the capacitor acquires a charge. Because of the battery EMF, electrons are removed from plate X and added to plate Y. Thus a voltage is built up across the plates as the capacitor is being charged. When the voltage across the plates equals the battery voltage, electron flow ceases because these two voltages are in opposition. Electrons cannot flow through the capacitor because the dielectric is a good insulator. A capacitor, therefore, cannot pass direct current. If, instead of a d-c battery, an a-c generator is placed across the capacitor, an a-c current will flow in the circuit around the capacitor because electrons travel through the circuit, from plate to plate, reversing direction just as the voltage across the capacitor reverses direction.

The standard unit of capacitance is the FARAD. Capacitance is usually designated by the letter C. Because the farad is too large for practical use, actual values of capacitance in circuits will usually be given in values of microfarads (10^{-6} farads) or micromicrofarads (10^{-12} farads).

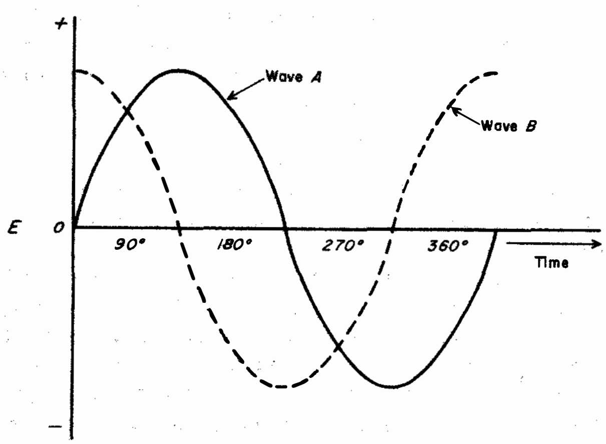
The ratio of the a-c voltage across the capacitor to the value of a-c current in the circuit is called CAPACITIVE REACTANCE. The value of capacitive reactance depends on two



93.5

Figure 5-14.—Basic alternating-current generator.

factors: the value of the capacitance and the frequency of the a-c source. When either capacitance or frequency is increased, the capacitive reactance decreases.



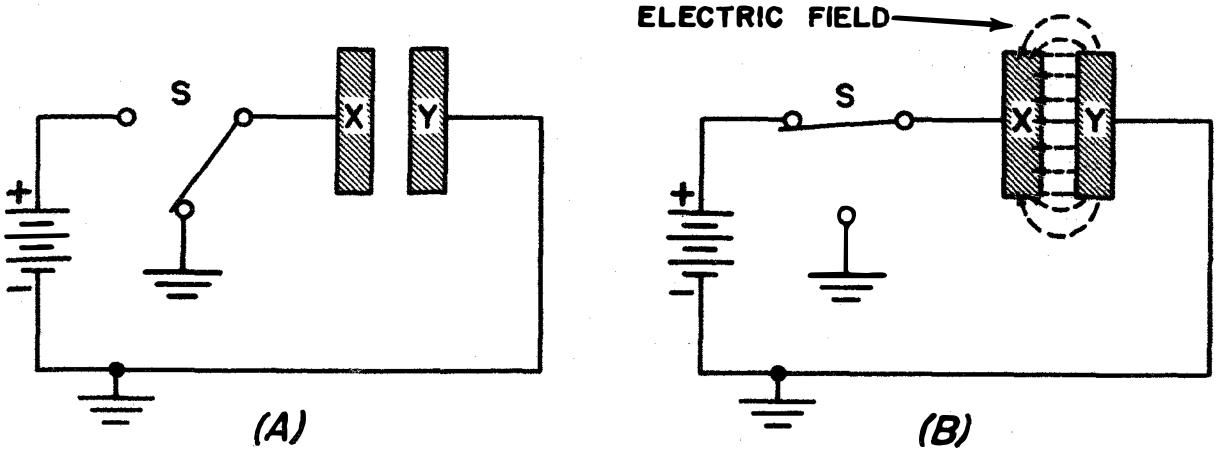
93.6

Figure 5-15.—Two sine-wave voltages 90° out of phase. Sine-wave voltage B leads voltage A by 90°.

INDUCTANCE

Whenever a conductor carries electric current, a magnetic field is formed around the conductor. The strength of the magnetic field is dependent on the value of current in the conductor; a large current results in a strong field. It should be noted that if an a-c current is present in the conductor, the resulting magnetic field will be constantly changing—increasing to a maximum value, decreasing to zero, increasing to a maximum value, decreasing, etc. If the conductor is wound to form a coil, the magnetic field inside the coil is much stronger than the magnetic field around a single conductor carrying the same amount of current. If a magnetic material, such as iron, is placed inside the coil, the magnetic field is much stronger than if the coil core were air. This principle is used in the construction of electromagnets.

A property associated with conductors and magnetic fields is INDUCTANCE. The principle of inductance is as follows: IF A CONDUCTOR IS MOVED IN SUCH A WAY THAT IT "CUTS" A MAGNETIC FIELD, A VOLTAGE



13.18

Figure 5-16.—Simple capacitor; (A) shorted (B) charged.

IS INDUCED ACROSS THE CONDUCTOR. The results are the same when a magnetic field moves in such a manner that it is cut by a stationary conductor.

The principle of inductance is of considerable importance when there are coils of wire in a-c circuits. Coils have the property of SELF-INDUCTANCE. When an a-c voltage is placed across the coil, the varying magnetic field resulting from the a-c current in the coil causes a voltage to be induced across the coil. The self-induced voltage always opposes the applied voltage and tries to prevent any change in the current flowing through the coil. Because of the property of self-inductance, coils are referred to as INDUCTORS. The practical unit of inductance for coils is the HENRY, which is a measure of how well a coil induces a voltage in itself under a standard condition.

When an a-c voltage is placed across a coil, the current is limited because the voltage induced in the coil opposes the applied a-c voltage. Therefore, a reactance associated with coils in a-c circuits can be defined in the same manner as for capacitors. The ratio of the a-c voltage across a coil to the value of a-c current through the coil is called the INDUCTIVE REACTANCE of the coil. Inductive reactance depends on the value of inductance of the coil and the frequency of the applied voltage. Reactance increases if either of the two quantities is increased.

Inductors find many uses in communication circuits. The tuning circuits of radio receivers all contain inductors which, because they are used for various purposes, are designated by names that actually describe their function; for example, r-f chokes and inductive filters.

IMPEDANCE

IMPEDANCE is the total opposition to the flow of alternating current in a circuit that contains resistance and reactance, both inductive and capacitive. This term is often used in dealing with antenna inputs, transmission lines, and coupling of electronic circuits—where there is a necessity for matching the impedances of circuits to obtain maximum efficiency. The symbol for impedance is the letter Z. The total impedance for any a-c circuit containing inductance (L), capacitance (C), and resistance (R), is derived by the formula

$$Z = \sqrt{R^2 + (X_L - X_C)^2},$$

where R is the total resistance, X_L is the inductive reactance, and X_C is the capacitive reactance.

Voltage, current, and impedance in a-c circuits are related by an $E = IZ$ relationship similar to the Ohm's law relationship, $E = IR$, for d-c circuits. However, a-c voltage, a-c current, and impedance are vector quantities which require special techniques for computation. They cannot be added, subtracted, multiplied, and divided in the algebraic manner used in d-c calculations. This principle is also true in combining resistances and reactances to calculate values of impedance.

RESONANCE

Capacitive reactance decreases as the frequency increases, and inductive reactance increases with frequency. Thus, for any combination of capacitive and inductive reactance, there is a frequency at which they are equal to each other. This condition of equal and opposite reactances in an a-c circuit is called RESONANCE. The frequency at which resonance occurs is known as the resonant frequency. A resonant circuit provides maximum voltage output at the resonant frequency as compared with the amount of output at any other frequency either above or below the resonant frequency. Resonance is accomplished by tuning a circuit; that is, by varying the inductance or capacitance until the circuit is resonant at the desired frequency. Figure 5-17 illustrates a circuit tuned to resonance at 1000 kc. Resonant circuits, commonly referred to as tuned circuits, are also used in filter circuits, as will be described in the next section of this chapter.

Series-Tuned Circuits

If a capacitor and an inductor are placed in series, the combination is known as a SERIES-TUNED CIRCUIT. THE CHARACTERISTIC OF A SERIES-TUNED CIRCUIT IS THAT, AT ITS RESONANT FREQUENCY, THE IMPEDANCE OF THE CIRCUIT IS MINIMUM. At this point it is important to consider what the effect would be if a series-tuned circuit were placed in series with a signal current. The series-tuned circuit would present an increasingly higher impedance to signals which are increasingly greater or less than the resonant frequency. In practical circuits, the impedance is usually low for a band of frequencies about the resonant frequency. Thus, the series-tuned circuit forms a basic bandpass filter—one which will pass only signal currents which are within a frequency band surrounding the resonant frequency of the series-tuned circuit.

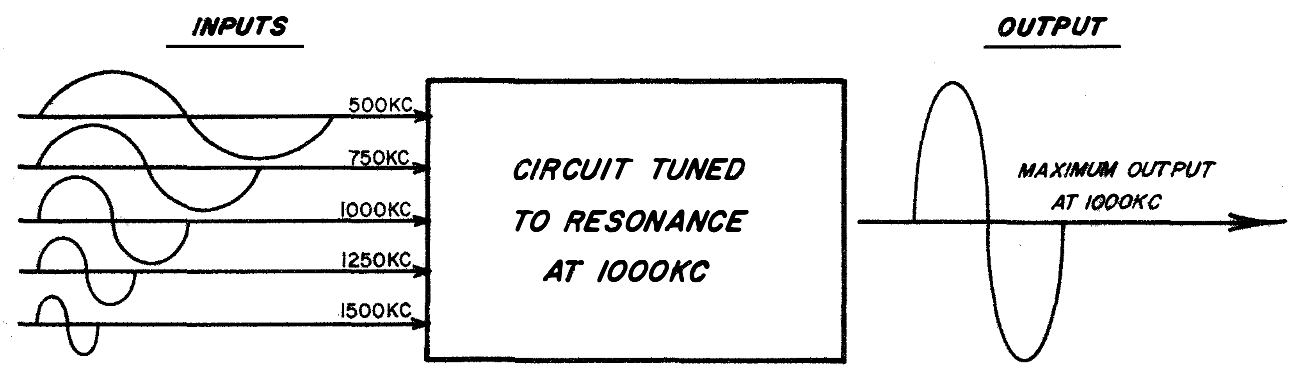
Parallel-Tuned Circuits

If a capacitor and inductor are placed in parallel, the combination is known as a PARALLEL-TUNED CIRCUIT. They are also commonly referred to as TANK CIRCUITS or simply TANKS.

THE CHARACTERISTIC OF A TANK CIRCUIT IS THAT, AT ITS RESONANT FREQUENCY, THE IMPEDANCE OF THE TANK IS MAXIMUM. As was true in series-tuned circuits, resonance occurs at the frequency where capacitive reactance is equal to the inductive reactance.

Signal currents which have a frequency not close to the resonant frequency will be confronted with only a very low impedance and will pass through the tank circuit. However, those signals which have frequencies near or at the resonant frequency of the tank will be opposed by a high impedance and will develop a large voltage across the tank.

Tank circuits find many applications in communications equipment. In most radio receivers, when the operator changes the setting of the tuning dial, he is actually changing the capacitance in one or more tank circuits in the receiver. Changing the capacitance changes the resonant frequency of the tuned circuits.



93.7

Figure 5-17.—Circuit tuned to resonance at 1000 kc.

FILTER CIRCUITS

An electric circuit can have currents and voltages of different frequencies. In many applications, where there are many different frequencies present, it may be desirable to separate them and to utilize only one specific frequency or one specific band of frequencies. In such cases, any of the several types of filters may be employed to accomplish the desired results. Typical filtering applications include separating radio frequencies from audio frequencies or vice versa and separating the components of a complex modulated radio signal. Some common types of filter circuits will be discussed in the following paragraphs.

LOW-PASS FILTERS

A low-pass filter allows the low-frequency components of an applied signal to pass while the high-frequency components are attenuated or reduced in the output. In order to obtain selective filtering, it is necessary to combine inductance and capacitance in such a manner that the desired results are obtained. Combining can be done because in all cases the inductive reactance increases with rising or increasing frequencies while the capacitive reactance decreases. Thus with the proper combination, a circuit can be made to operate at a predetermined frequency of attenuation or cutoff frequency, in which case frequencies below cutoff will be passed and frequencies above cutoff will be attenuated.

In the case illustrated in figure 5-18, the cutoff frequency is 15 kc; therefore all frequencies above this limit will be attenuated. Notice that the frequencies above 15 kc are called stop-band frequencies. All frequencies below 15 kc will be passed and are called pass-band frequencies. The sharpness of the cutoff depends upon the design of the circuit. In some applications it may be desirable to have a sharp cutoff, while in others a gradual attenuation is more desirable.

HIGH-PASS FILTERS

A high-pass filter passes all frequency components of an applied signal which are higher than the cutoff, and attenuates all frequency components below the cutoff frequency. Figure 5-19 illustrates the results obtained with a high-pass filter with a cutoff of 500 kc. Frequencies below 500 kc are attenuated and fall within the stop band, while frequencies above 500 kc will pass and are in the pass band of the filter. High-pass filters are designed with a combination of inductance and capacitance which will provide the desired characteristics.

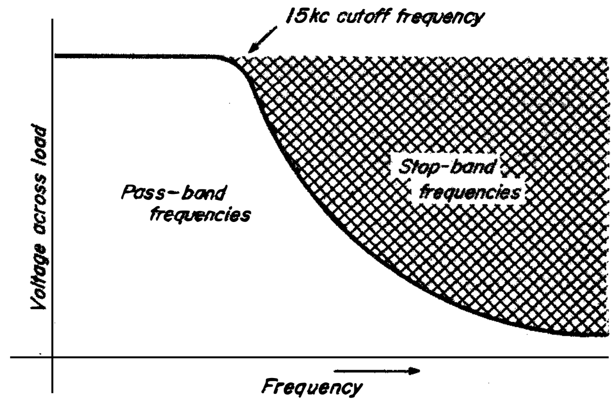


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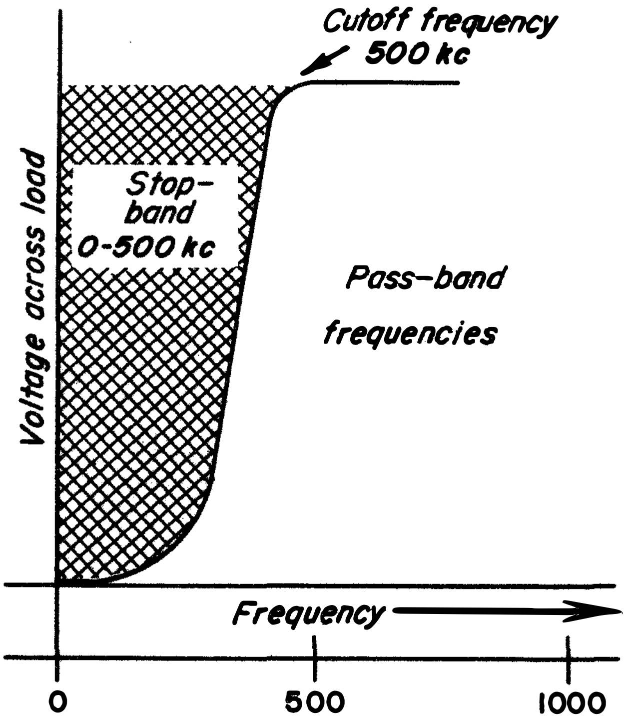
Figure 5-18.—Low-pass filter with cutoff at 15 kc.

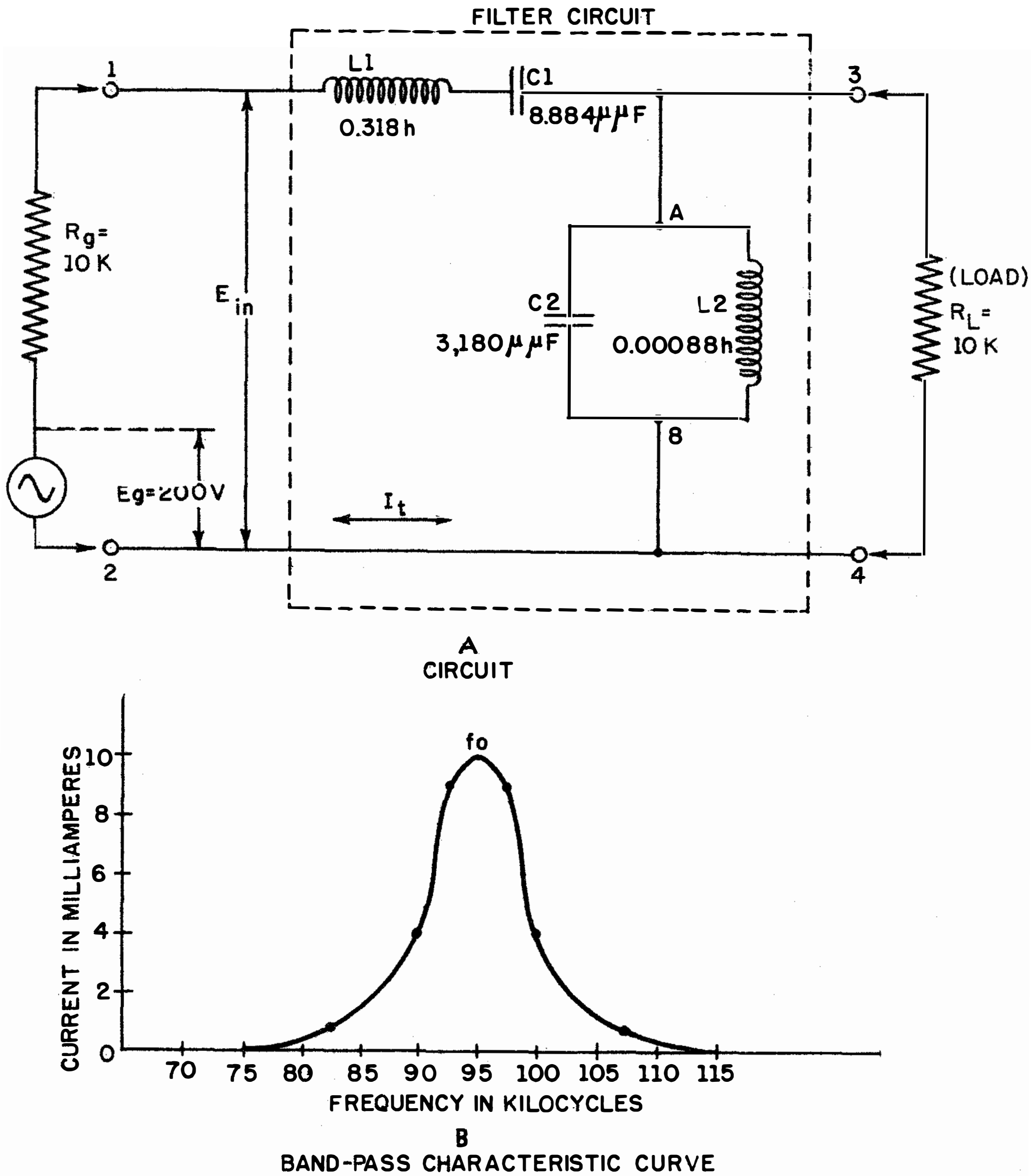


93.9

Figure 5-19.—High-pass filter with cutoff at 500 kc.

BAND-PASS FILTERS

The characteristic of a band-pass filter is that it attenuates all signal frequencies except a specific band of frequencies. In figure 5-20, which shows a typical band-pass filter circuit and its band-pass characteristic curve, the lower cutoff frequency is approximately 90 kc; the upper cutoff is approximately 100 kc. The band of frequencies between the cutoff frequencies is referred to as the pass band of the filter. The action of passing a band of frequencies and attenuating the frequencies above and below this band is accomplished by using



13.25

Figure 5-20.—Band-pass filter.

an appropriate combination of inductance and capacitance. Some band-pass filters are constructed in such a manner that the pass band is fixed. Others are constructed so that the values of electrical components (capacitors and/or inductors) can be varied, thereby making it possible to change the cutoff frequencies and shift the pass band over a range of frequencies.

ELECTRON TUBES

The electron tube is considered a primary factor in the rapid evolution of electronics to its present stage. It is one of the basic components of almost every piece of electronic equipment. Since most of your duties will be in connection with the use of radio and communication equipment, it should be apparent that a knowledge of the operating principles of electron tubes is important.

The electron tube is made up of a glass or metal shell which encloses several elements. These elements consist of the cathode, the plate, and sometimes one or more grids, depending on the use for which the tube is designed. There are many types and designations of electron tubes and they can be made to perform many functions. For example they can be made to (1) convert alternating current to direct current (RECTIFIERS), (2) amplify weak signals with minimum distortion (AMPLIFIERS), and (3) generate high frequencies (OSCILLATORS).

To understand how electron tubes work, it is first necessary to consider the phenomenon of electron emission. Certain metals exhibit the property that, when subjected to given conditions, electrons leave the surface of the metal. Liberation of electrons from the surface of a material is known as ELECTRON EMISSION. Electron emission due to high temperature is known as THERMIONIC EMISSION. Certain metals will give off electrons when subjected to light of prescribed characteristics. This effect is called PHOTOELECTRIC EMISSION. Electrons will leave the surface of many metals if the surface of the metal is bombarded with high velocity electrons from another source. This effect is known as SECONDARY EMISSION. There are several other methods of obtaining electron emission.

Thermionic emission is the basic principle of operation of nearly all electron tubes used in radio equipment. Only a few substances can be heated to the high temperatures that are required to produce satisfactory electron emission without melting. Tungsten, thoriated-tungsten, and oxide-coated emitters are the substances commonly used in electron tubes. As a general rule, the hotter the emitter, the greater the number of electrons emitted.

Electron tubes contain an element known as the cathode which emits electrons. The cathode may be heated in two ways—(1) directly and (2) indirectly. Figure 5-21 shows the two types of cathodes. The directly heated cathode receives its heat by passage of a current through a filament, which itself serves as the cathode. The indirectly heated cathode is a metal sleeve that surrounds the filament but is electrically insulated from it. The sleeve serves as the cathode emitter, receiving most of its heat by radiation.

DIODES

Electron tubes containing two elements, a cathode and a plate, are called DIODES. The plate collects electrons from the cathode and provides a connection to the external circuit.

In a circuit such as the one pictured in figure 5-22, the tube acts in the manner of a valve. Opening and closing of the valve occurs when the source of plate voltage changes from positive to negative. In figure 5-22, (A) shows the circuit of a diode used as a rectifier for changing alternating current to direct current, (B) represents the a-c voltage source which is impressed across the circuit, and (C) illustrates the current flowing in the plate and load circuit.

Alternating voltage is impressed on the plate, but a pulsating direct current flows to the load. (Pulsating direct current is defined as current with a single polarity but with varying amplitude.) The change from alternating current to direct current is due to the fact that, when the source voltage is negative (the negative portion of the a-c sine wave), no current flows because the plate is negative and will not attract electrons being emitted from the heated cathode. When the source voltage is positive (the positive portion of the a-c sine wave), the plate is positive and will attract electrons from the cathode, thus causing current to flow. The result is a current flow to the load during the positive half of the a-c source voltage as shown in figure 5-22. The pulsating direct current can be filtered to form a smooth direct current if required.

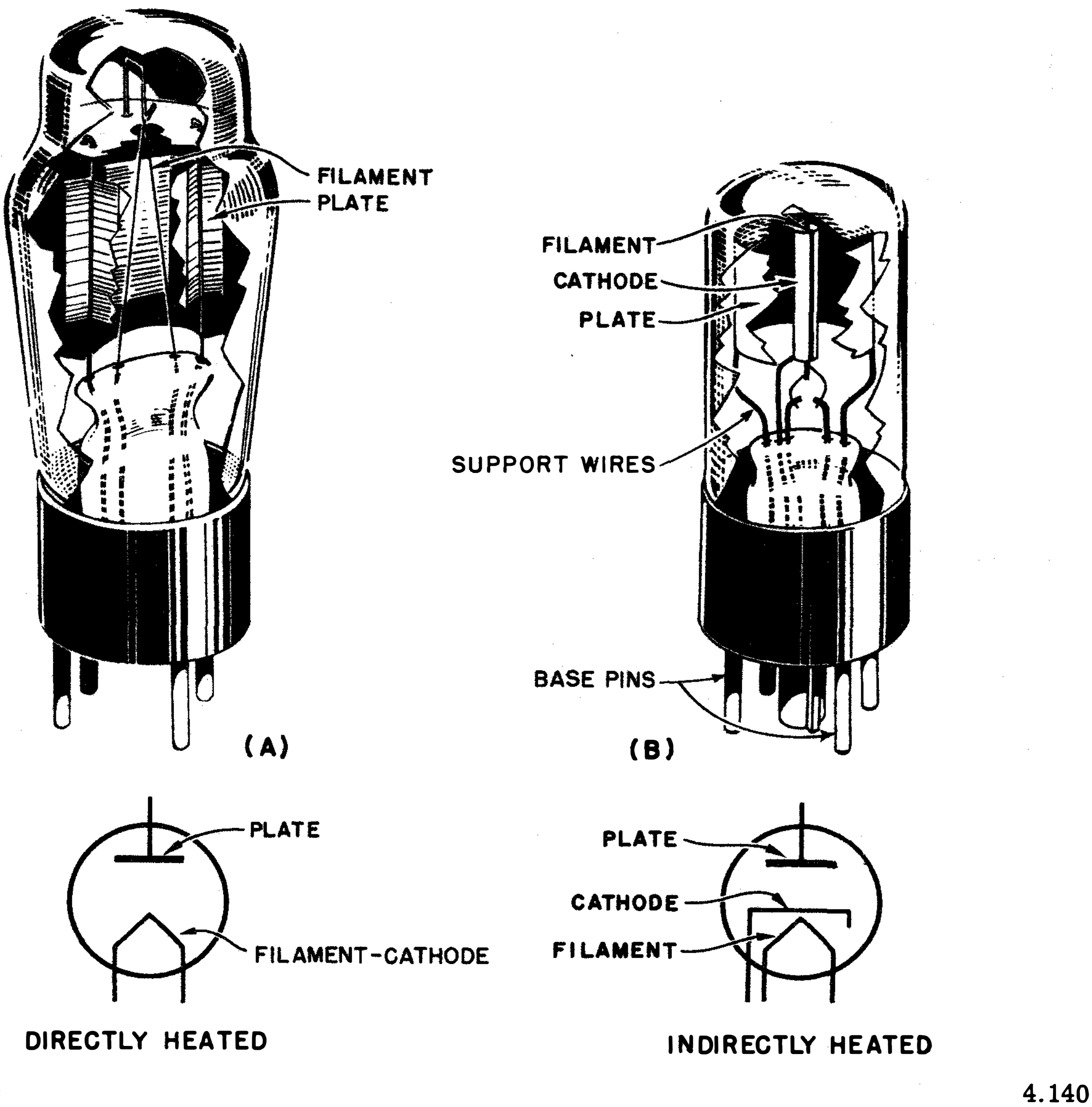


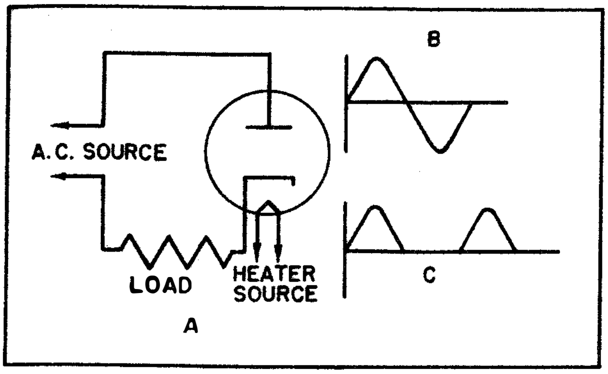
Figure 5-21.—Cutaway of 2-element tubes.

One of the most common uses of diode tubes is in power supplies, commonly called RECTIFIERS, where an a-c source voltage is converted to d-c voltage for operation of component circuits of electronic equipment. Another important use of diodes is in detector circuits of radio receivers. Functional descriptions of rectifier and detector circuits will be presented later in this chapter.

TRIODES

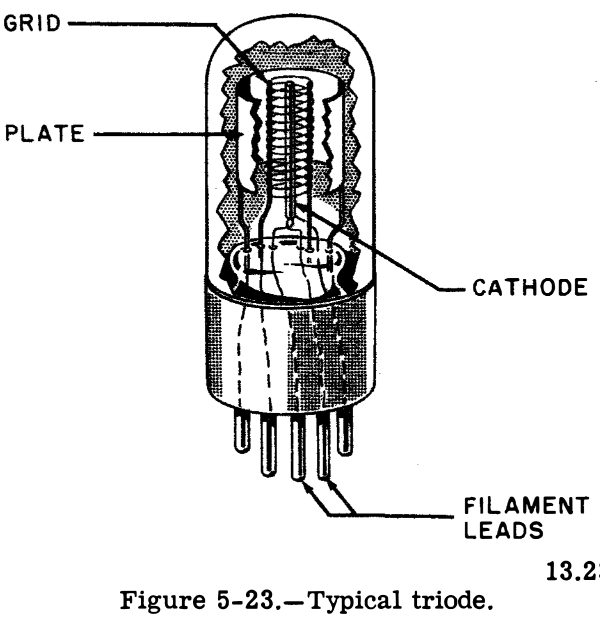
The triode or three-element electron tube is similar in construction to the diode except that a grid of fine wire is added between the plate and the cathode. Figure 5-23 shows the construction features of a typical triode.

The grid in a triode may be considered as an electronic control valve that regulates the flow of electrons through the tube and through the load in the plate circuit. This electron flow control is accomplished by varying the potential relationship of the grid to the cathode. If the grid potential is more negative than the cathode, no current will flow to the plate. On the other hand, making the grid potential more positive than the cathode will result in increased plate current flow. Since the grid is placed much



13.22
Figure 5-22.—Diode rectifier.

closer to the cathode than to the plate a small variation in grid-voltage input results in a relatively large variation in the output current (plate current). Thus the voltage applied to the grid is said to be amplified in the plate circuit. Figure 5-24 shows a triode amplifier and the difference in the signal of the grid at input and in the plate circuit: (A) shows the amplitude of the input voltage to the grid; (C) shows the amplitude of the signal after it has passed through circuit (B) and has been amplified by the action of the triode. A functional description of amplifiers will be presented later in this chapter.



13.23
Figure 5-23.—Typical triode.

MULTIELEMENT TUBES

Many desirable characteristics may be attained in electron tubes by the use of more than one grid. Multielement tubes include TETRODES which contain four elements—a plate, a cathode, and two grids.

PENTODES contain five elements—a plate, a cathode, and three grids. Other tubes containing as many as eight elements are available for certain applications. As you become more familiar with electronic equipment, you will notice that many multielement tubes are used, the pentode being one of the most common.

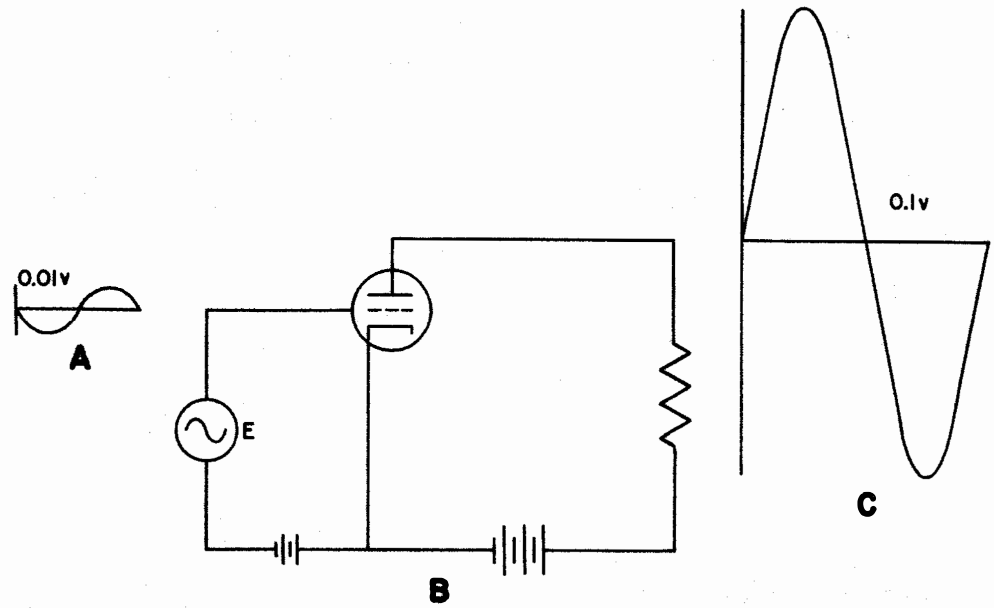
MULTIUNIT TUBES

To reduce the number of tubes in electronic circuits, the elements of two or more tubes frequently are placed within one envelope. Multiunit tubes generally are identified according to the way the individual types contained in the envelope would be identified if they were made as separate units. Thus, a multiunit tube may be identified as a duplex-diode, a diode-pentode, and diode-triode-pentode, and so forth. A number of multiunit tube diagrams are shown in figure 5-25.

CATHODE-RAY TUBES

The cathode-ray tube (CRT) is a special type of electron tube in which electrons emitted from the cathode are shaped into a narrow beam and accelerated to a high velocity before striking a phosphor-coated viewing screen. The screen fluoresces or glows at the point where the electron beam strikes, thus providing a means for producing visual presentations of waveforms of current and voltage. The CRT is used extensively in electronic test equipment and in receiving, transmitting, and terminal equipment employed in communications. For example, a CRT is used in test instruments such as oscilloscopes which provide waveform displays to check the operation of equipment. CRTS are also used as visual indicating devices for radar, direction finders, panoramic indicators, and other equipment.

Waveforms can be positioned on the viewing screen of a CRT so that they appear to be stationary because the electron beam repeatedly reproduces the pattern in the same spot on the screen as long as the horizontal motion of the electron beam is kept in step with the frequency of the signal fed to the CRT.



93.10

Figure 5-24.—Triode amplifier.

The length of time that the screen of a CRT glows or fluoresces, at the point where the electron beam strikes, depends on the material of the screen coating and is known as SCREEN PERSISTENCE. Some CRTs have longer persistence than others, depending on the purpose for which they are designed. For example, an oscilloscope designed for observing nonrepeating phenomena or periodic phenomena occurring at a low repetition rate requires a screen which will hold the image for a long time. In other uses, where the image changes rapidly, prolonged afterglow is a disadvantage because it may cause confusing presentations on the screen. Figure 5-26 shows the construction of one type of CRT.

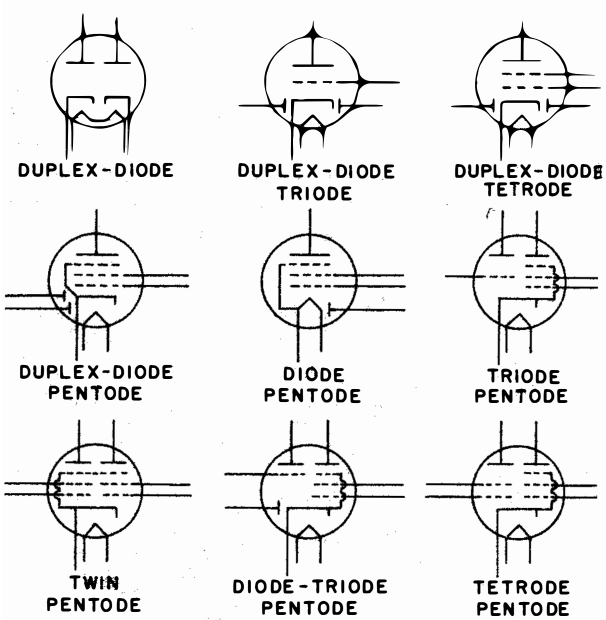


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Figure 5-25.—Schematic diagram of multiunit tubes.

SEMICONDUCTORS

Semiconductors are electronic components which have a wide application because they are capable of performing more efficiently many of

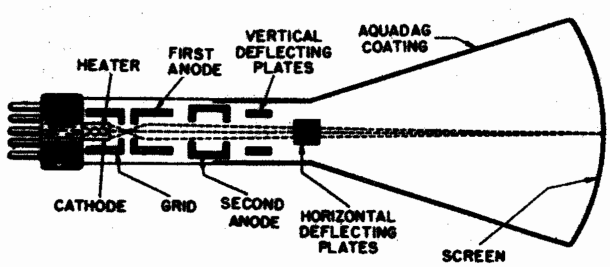

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Figure 5-26.—Electrostatic type of CRT.

the functions of electron tubes. The conductivity of a semiconductor is lower than that of a conductor but higher than that of an insulator. For example, a germanium crystal in its purest state acts as an insulator; but when a small amount of impurity such as arsenic is added to it, the crystal becomes a satisfactory conductor. Semiconductors operate on very low power compared to electron tubes and are very small in size. Therefore, they are ideal for use where space and power are limited, such as in missile guidance systems and in space vehicles. The most widely used semiconductor devices are semiconductor diodes and transistors.

SEMICONDUCTOR DIODES

A semiconductor diode is formed by taking a single crystal, such as germanium or silicon, and adding impurities. Diodes have wide application as rectifiers for converting alternating current to direct current. There are many types of diodes in use. They vary in size, the miniature type, hardly bigger than a pin head (used in computer and space vehicle circuitry), to large 500-ampere rectifiers used in power supplies. Figure 5-27 illustrates some of the various types of diodes.

TRANSISTORS

Although semiconductor diodes are useful as rectifiers, they cannot amplify signals. Three-element semiconductors (like three-element electron tubes) are needed to amplify a signal. Such semiconductors are called transistors. Like diodes, transistors have wide application in miniaturized circuits because they are small in size and operate on low power.

The most common cause of transistor and semiconductor diode failure is overheating due to inadequate ventilation or excessive current. Most transistorized equipment in use by the Navy is provided with forced air ventilation systems, and it is important that these systems operate properly. All ventilation filter screens must be kept clean and the air ducts kept free from obstructions.

BASIC ELECTRONIC CIRCUITS

There are basic electronic circuits—rectifiers, amplifiers, oscillators, modulators, and detectors—which are common to communications equipment. These basic circuits are used in transmitters, receivers, and terminal equipments. Although the CT operator is not required to learn the details of design and operation of these circuits, he will profit greatly by having a basic knowledge of the function of each.

RECTIFIERS

Rectifiers are used to change alternating current to direct current. Such circuits usually contain one or more diode electron tubes or diode semiconductors which function as illustrated in figure 5-22. The diodes thus used are often referred to as rectifiers. Since most communications equipment operates from a 60-cycle a-c line current, it is necessary to provide a rectifier to convert the a-c current to d-c current for the operation of such elements as the plates, screens and other grids of electron tubes. The majority of rectifier systems employing electron tubes utilize either high-vacuum or gas-filled tubes. The high-vacuum diode is most widely used as a power source for low-current applications. The hot-cathode mercury-vapor tube is widely used in high-current applications. The presence of mercury vapor in the tube envelope reduces the vacuum and results in low internal resistance, thus allowing a large amount of current to be drawn.

Rectifiers which do not employ the electron tube are known as dry-disk. Two of the more common types are the selenium and copper oxide rectifiers. Selenium rectifiers are used as plate-supply rectifiers in small receivers. Copper-oxide rectifiers have miscellaneous applications such as instrument rectifiers or bias-supply rectifiers in test equipment. Dry-disk

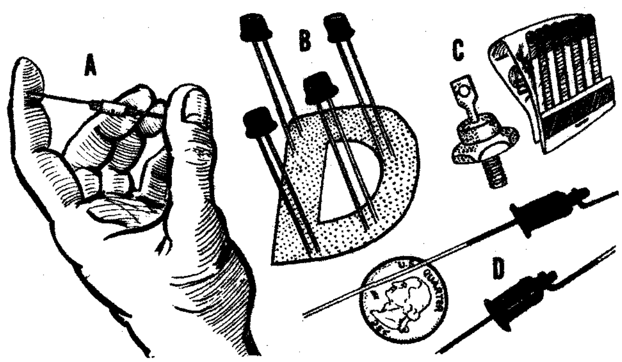

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Figure 5-27.—Types of diodes.

types have the advantage of not requiring heater current or warm-up time.

Half-Wave Rectifier

A half-wave rectifier is a device by means of which alternating current is changed into pulsating direct current by permitting current to flow through the device only during one-half of each cycle. In a diode, electrons are attracted to the plate when it is more positive than the cathode. When the plate becomes negative with respect to the cathode, electrons are repelled by it and no electron stream can flow in the tube. Therefore, a single diode may be used as a half-wave rectifier because electrons can flow in the tube during only the half of the cycle when the plate is positive relative to the cathode.

Full-Wave Rectifier

A full-wave rectifier is a device that has two or more elements so arranged that the current output flows in the same direction during each half-cycle of the a-c supply. Full-wave rectification may be accomplished by using two diodes in the same envelope (a dual diode). This type of rectification is widely used in large receivers and they are generally used in pairs for full-wave operation.

AMPLIFIERS

The function of amplifiers is to increase the amplitude of signal current or voltage. For example, the signal voltage picked up by a receiving antenna is too weak to be useful until it has been increased in amplitude. In this case, an amplifier circuit is used to increase the amplitude of the signal to many times its original value so that the signal may be demodulated and the intelligence recovered. Amplifiers are also used to increase small current signals to higher values in order to operate headphones, speakers, and other terminal equipments.

Another application of amplifiers is to increase the amplitude of signals which are to be transmitted through the atmosphere so that the signal will have sufficient strength to be propagated over great distances. Triode electron tubes and transistors are commonly used in amplifier circuits. The schematic diagram in figure 5-24 illustrates how a triode functions as an amplifier.

OSCILLATORS

Oscillators are actually sources of a-c voltage or current. Depending on its design, an oscillator may generate one specific frequency or may be adjustable to produce frequencies over a wide range. Most receivers contain an oscillator called the LOCAL OSCILLATOR or the VARIABLE FREQUENCY OSCILLATOR (VFO) which is used to produce a signal for heterodyning with the incoming r-f signal to obtain the INTERMEDIATE FREQUENCY (IF) of the receiver. Another common application in receivers is the BEAT FREQUENCY OSCILLATOR (BFO), which is a variable oscillator used to obtain the desired audio output frequency. There are many other applications for oscillators, including transmitters, signal generators, and other equipment.

MODULATORS

Modulators are special-purpose circuits used in radio transmitters. They have two inputs: (1) a high frequency a-c signal commonly referred to as the r-f carrier and (2) an intelligence signal such as voice, teletype, Morse, or pulse signals. Within the modulator, either the frequency or the amplitude of the r-f carrier is caused to vary in accordance with the intelligence signal, and the signal is then transmitted as a modulated r-f carrier. Amplitude modulation and frequency modulation are explained more fully in chapter 8.

DETECTORS

The process of detection is actually the process of demodulating a signal; that is, recovering the transmitted intelligence from the modulated signal. Circuits which accomplish this function are commonly referred to as detectors. Detector circuits are included in most radio receivers. The function of the detector is to act on a modulated carrier in such a way that the intelligence signal is separated from the carrier so that it can be amplified and processed through appropriate terminal equipment for reading the intelligence it conveys. Different techniques are required for detecting a-m and f-m signals. A detector designed for a-m signals must respond to variations in amplitude of the signal but not to variations in frequency. For f-m signals, the reverse is true; the detector must respond to variations in frequency but not to variations in amplitude.

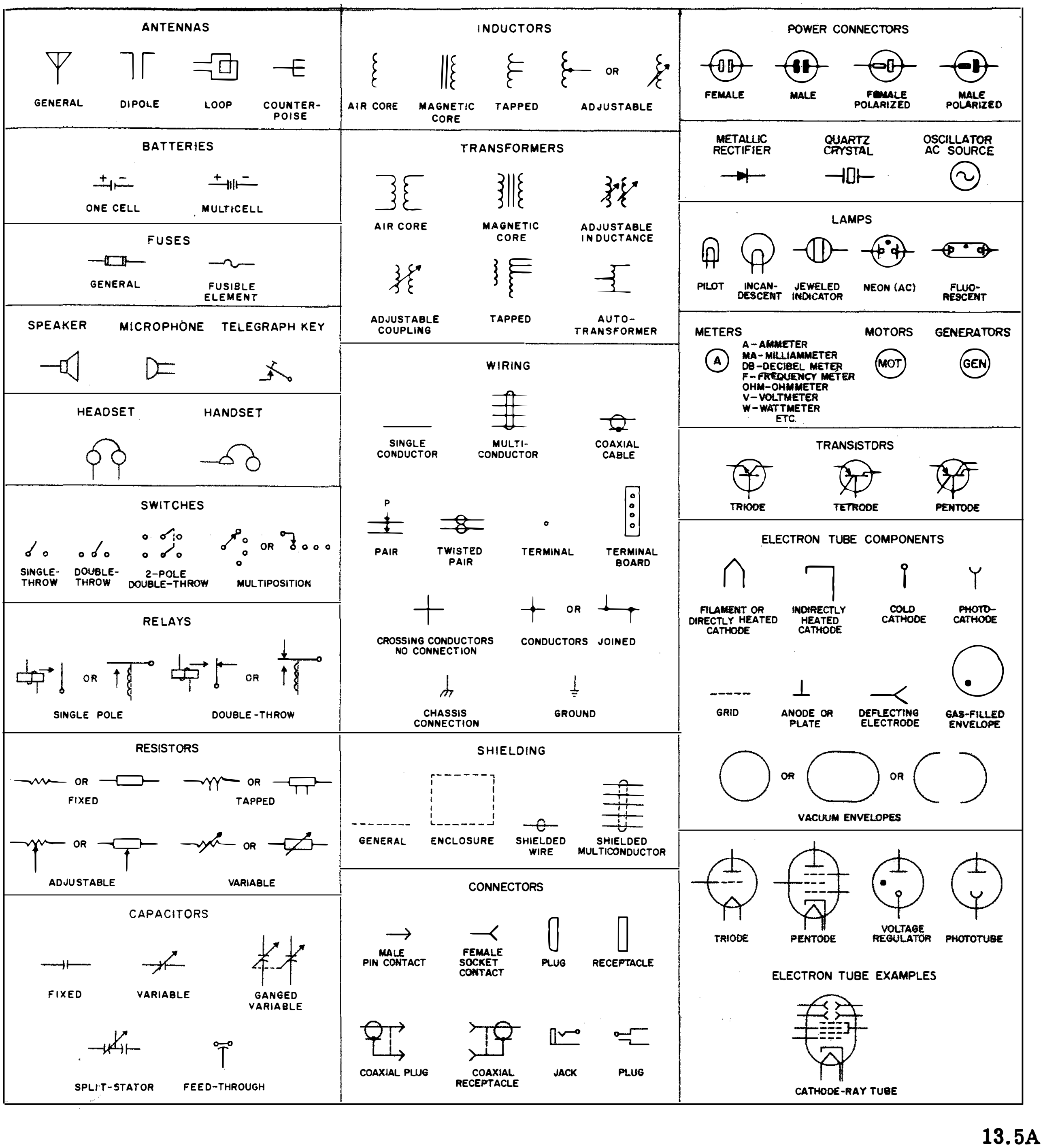

Figure 5-28.—Schematic symbols.

SCHEMATIC SYMBOLS

Electronic circuits in communications equipment are illustrated by schematic diagrams contained in equipment instruction manuals. It would be very difficult to show each circuit component as an actual picture, therefore a system of standard symbols is used, each symbol representing a particular type of circuit component. The most common symbols used are shown in figure 5-28. Knowledge of these symbols makes it possible for an operator not only to interpret the circuit diagrams as they are presented in equipment technical manuals but also to understand how the equipment functions.

ADDITIONAL READING

It must be noted that the information contained in this chapter is of a very basic nature. CT personnel desiring to further their knowledge in this area are encouraged to utilize the Navy Training Courses titled Basic Electricity and Basic Electronics.

CHAPTER 6

RADIO WAVE PROPAGATION

TERMS AND DEFINITIONS

In this discussion of radio wave propagation, a number of technical terms are used. To help you understand the material, the following list of terms and definitions is provided:

ANTENNA. A device used to radiate or receive radio waves.

ATMOSPHERE. The whole mass of air surrounding the earth, including the troposphere, stratosphere, and the ionosphere.

ATTENUATION. The decrease in signal strength of a radio wave with distance in the direction of propagation.

CONDUCTIVITY. A measure of the ability of a material to act as a path for electron flow. It is the opposite of resistivity and is expressed in mhos per meter.

CRITICAL FREQUENCY. The limiting frequency below which an electromagnetic wave is refracted back to earth by, and above which it penetrates through, an ionospheric layer at vertical incidence (straight up).

DECIBEL (DB). A term meaning one-tenth of a bel. The ratio of a change in power after attenuation or amplification.

DIFFRACTION. The bending of a radio wave into the region behind an obstacle.

DIRECT WAVE. A radio wave that is propagated directly through space from transmitter to receiving antenna.

DISTORTION. An undesired change in waveform.

FADING. The variation of radio signal strength at a radio receiver during the time of reception.

GIGACYCLE (gc). An expression denoting 10^9 cycles per second (1000 mc).

GROUND WAVE. A radio wave that travels close to the earth and reaches the receiving point without being refracted or acted upon by the ionosphere. The ground wave includes all components of a radio wave traveling over the earth except the sky (ionospheric) wave.

INCIDENT WAVES. A term denoting that portion of a radio wave which is about to strike a medium of different propagation characteristic which will result in that wave being refracted, reflected, diffracted, or scattered.

IONOSPHERE. The part of the earth's outer atmosphere where ions and electrons are present in quantities sufficient to affect the propagation of radio waves. The portion of the atmosphere above the stratosphere.

ISOTROPHIC ANTENNA (UNIPOLE). A hypothetical antenna equally radiating or receiving energy in all directions.

MAXIMUM USABLE FREQUENCY (MUF). The upper limit of the frequencies which can be used at a specified time for radio transmission between two points involving propagation by refraction from the regular ionized layers of the ionosphere. (Frequencies higher than the MUF may be transmitted by sporadic and scattered reflections.)

NOISE. Any extraneous electrical disturbance tending to interfere with the normal reception of a transmitted signal.

FREQUENCY OF OPTIMUM TRAFFIC (FOT). The most reliable frequency at a specified time for ionospheric propagation of a radio wave between two specified points.

LOWEST USABLE FREQUENCY (LUF). The LUF, based on the signal-to-noise ratio, varies as the power or the bandwidth is varied. An increase in power or a decrease in bandwidth will lower the LUF, and a decrease in power or an increase in bandwidth will raise the LUF. A small change in power will not materially effect the LUF.

REFLECTION. The phenomenon which, when a radio wave strikes a medium of different propagation characteristics (such as the earth or ionosphere), causes the wave to be returned into the original medium (ionosphere or the earth) with the angles of incidence and of reflection equal and lying in the same plane.

REFRACTION. The phenomenon which, when a radio wave leaves one medium such as the stratosphere and obliquely enters another medium such as the ionosphere, causes the wave to undergo a change of direction. Essentially, refraction is caused by a difference in wave velocity in the two propagation media.

SPACE WAVE. Often called the tropospheric wave. A radio wave that travels entirely through the earth's troposphere.

SKY WAVE. A radio wave that is propagated or acted upon by the ionosphere.

SUNSPOT NUMBERS. The number of dark irregularly shaped areas on the surface of the sun caused by violent solar eruptions. The spots are counted and then averaged over a period of time to obtain values which are expressed as "smooth sunspot numbers." These smooth sunspot numbers are used to predict the average sunspot activity over a period of time.

SURFACE WAVE. A radio wave that travels in contact with the surface of the earth.

STRATOSPHERE. The part of the earth's atmosphere between the troposphere and the ionosphere.

TROPOSPHERE. The lowest part of the earth's atmosphere. In this region, which extends from the surface of the earth to the stratosphere, temperature decreased with altitude, clouds form, and all weather phenomena take place.

GENERAL CHARACTERISTICS OF RADIO WAVES

Radio waves are a form of electromagnetic radiation similar to light and heat waves. They differ from the other radiations in the manner in which they are generated and detected, and in their frequency range which is from approximately 3 kc to 300 gc. The radio frequency spectrum is divided into various bands of frequencies as shown in the following table.

Table 6-1.—Radio Frequency Spectrum.

FREQUENCY	DESCRIPTION	ABBREVIATION
30gc-300gc	extremely high frequency	EHF
3gc-30gc	super high frequency	SHF
300mc-3gc	ultra high frequency	UHF
30mc-300mc	very high frequency	VHF
3mc-30mc	high frequency	HF
300kc-3mc	medium frequency	MF
30kc-300kc	low frequency	LF
3kc-30kc	very low frequency	VLF

Figure 6-1 shows the entire energy spectrum of which the radio spectrum is only a small part. Radio waves travel at the same velocity as light waves, which in free space have a speed of approximately 186,000 miles per second or 300,000,000 meters per second. The wavelength of a radio signal is the distance that the wave travels in one cycle, during which its electromagnetic or electrostatic displacements have a difference in phase of one complete period. Wavelength is also described as the distance from the crest of one wave to the crest of the next. The wavelength of any radio wave can be found by the formula: $\lambda = \frac{c}{f}$ where

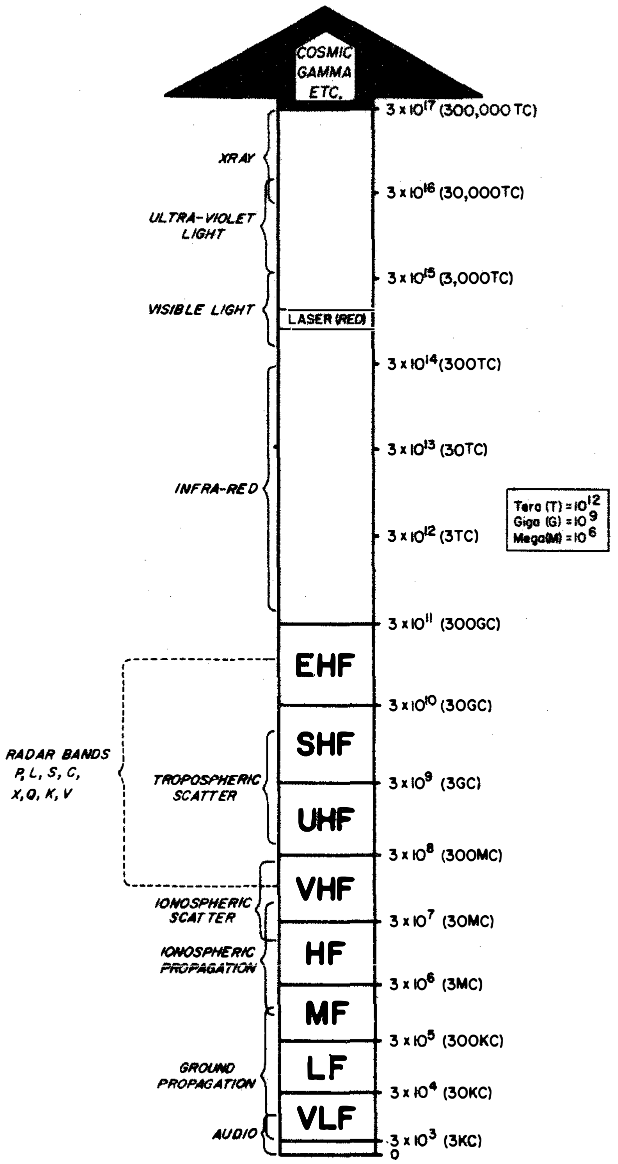

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Figure 6-1.—Energy spectrum.

λ is the wavelength, f the frequency in cycles, and c the constant velocity of light.

WAVE POLARIZATION

A radio wave consists of traveling electric and magnetic fields. The lines of force of these fields are perpendicular to each other and at right angles in a plane which is perpendicular to the direction of travel. The polarization of the radio wave is determined by the direction of the electric field of the wave with respect to earth. If the electric field is vertical (perpendicular) to the earth (figure 6-2) the wave is said to be vertically polarized. If the electric field is horizontal (parallel) to the earth, the wave is said to be horizontally polarized. Vertically positioned transmitting antennas radiate vertically polarized radio waves. Horizontal transmitting antennas radiate horizontally polarized radio waves.

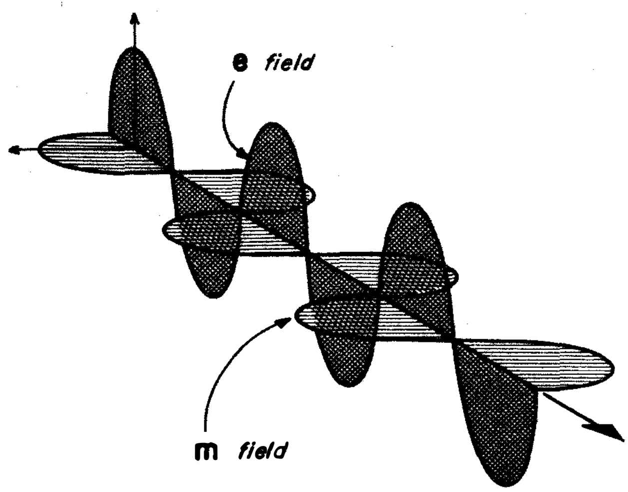

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Figure 6-2.—Instantaneous cross section of a radio wavefront.

REFLECTION, REFRACTION, AND DIFFRACTION OF RADIO WAVES

Reflection

Radio waves can be reflected, refracted, and diffracted in a manner similar to light and heat waves. They may be reflected from any sharply defined substances or objects of suitable characteristics and dimensions which are encountered in the medium of travel. The wave is not reflected from a single point on the reflector but rather from an area of its surface. The size of the area required for reflection depends on the wavelength and angle of incidence. When a wave is reflected from a plane (flat) surface, a phase shift occurs, as shown in figure 6-3. The amount of phase shift depends on the polarization of the wave and the angle of incidence.

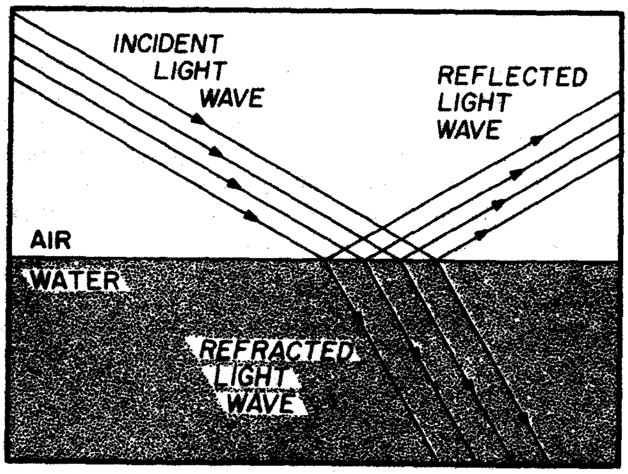

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Figure 6-3.—Reflection and refraction of a light beam.

Refraction

As in the case of light, a radio wave is bent when it moves from one medium into another in which the velocity of propagation is different from that of the first medium. The bending, which is called refraction, is always toward that medium in which the velocity is the least. If a wavefront is traveling obliquely from the earth and encounters a medium with a greater velocity of propagation, the part of the wavefront that first enters the new medium travels faster than parts of the wavefront which enter later. The difference in the rate of travel tends to swing the wavefront around or to refract it in such a manner that it is directed back to earth.

Diffraction

A radio wave is also bent when it passes the edge of an object. The bending, called diffraction, results in a change of direction of part of the energy from the line-of-sight path. This change makes it possible to receive energy at some distance below the summit of an obstruction or around its edges. A later section will show how, in the field of ground wave propagation, radio waves are diffracted beyond the earth's horizon. In certain cases, by using high power and very low frequencies, the waves can be made to encircle the earth by diffraction.

TYPES OF RADIO WAVES

The wave which is transmitted from an antenna can be considered to have two major components. One major component is the ground wave, which consists of two parts. One part travels along the ground and follows the curvature of the earth. This is the surface wave. The second part is the space wave, which is that part of the total radiation that undergoes refraction, reflection, or scattering from regions in the troposphere. The second major component is the sky (ionospheric) wave, which is radiated in an upward direction and returned to the earth at some distant location due to refraction or scattering from the ionosphere.

All types of waves are affected by the condition of the earth's surface or by one or more regions of the constantly changing atmosphere. However, for purposes of further discussion and in order to introduce fundamental concepts of propagation in a simple manner, we begin by considering the hypothetical properties of transmission in free space. The hypothetical transmission is between two antennas so isolated in space that no objects exert a measurable influence on the transmission.

TRANSMISSION IN FREE SPACE

There is a certain amount of attenuation or loss of energy even for radio signals transmitted in free space. This loss is due to the spreading of energy over a greater area as the transmission distance is increased. The loss is directly related to the frequency and transmission distance. The intensity of energy is the power per unit of area on the spherical wavefront. The relationship between intensity of energy and distance is illustrated in figure 6-4 which shows the pattern of radiated energy spreading directly with the square of the distance which results in the intensity of radiated energy decreasing inversely with the square of the distance from the isotropic antenna in free space. An isotropic antenna uniformly radiates energy in all directions or receives energy equally well from all directions.

Figure 6-4 illustrates the fact that free-space loss introduces a substantial attenuation in the transmitted signal. This is the basic loss which occurs for all types of radio transmissions. For line-of-sight circuits, where the conditions for free-space propagation are closely approximated, the total loss can be

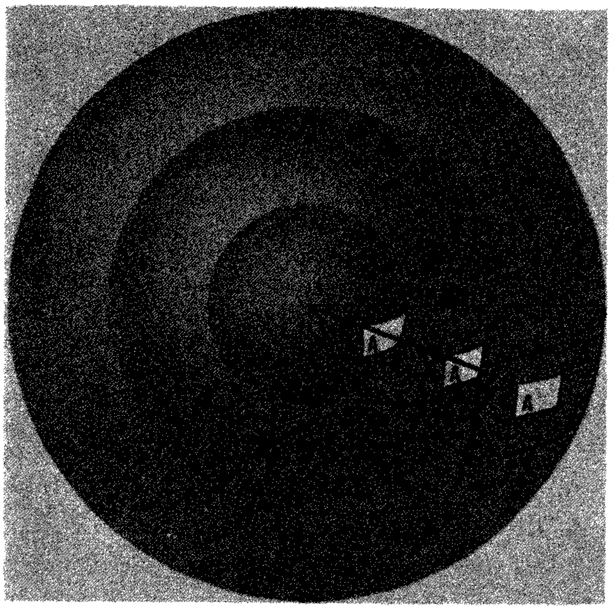

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Figure 6-4.—Free-space pattern of an isotropic antenna showing change in intensity of radiated energy with distance.

considered to be the free-space loss. However, for long distance communications, where either ground-wave, sky-wave, or scatter propagation is used, other losses are introduced by the effects of the earth and the atmosphere. Each of these losses must be added to the free-space loss to find the total attenuation of the transmitted signal.

THE SUN

The controlling body of our solar system, the sun, is a star whose dimensions cause it to be classified among stars as average in size, temperature, and brightness. Its proximity to the earth makes it appear to us as tremendously large and bright. A series of continuous atomic reactions, involving the elements of which the sun is composed, produces the heat and light waves that are received through the earth's atmosphere.

DIMENSIONS. The sun has a diameter of 864,000 miles and its average distance from the earth is 92 million miles.

DENSITY. The sun has a density of 1.41 times that of water.

DISTANCE IN TIME. Light waves from the surface of the sun reach the earth in slightly more than 8 minutes.

TEMPERATURE. The average solar temperature has been measured by several indirect methods which agree closely on a value of 6000 degrees centigrade or about 10,000 degrees Fahrenheit; however, the interior temperature of the sun is about 35,000,000 degrees Fahrenheit.

The radiating surface of the sun is called the photosphere (see figure 6-5). Just above that surface is the chromosphere which is a layer of solar atmosphere in a constant state of agitation as if stirred by spouting gases. The chromosphere is visible to the naked eye only at times of total solar eclipses, appearing then to be a pinkish-violet layer with great, swiftly moving spoutings. These spoutings, which project above the chromsphere's average level, are called prominences. With proper instruments the chromosphere can be seen or photographed whenever the sun is visible. Above the chromosphere is the corona, a bluish-violet light also visible to the naked eye only at times of total eclipse. The brighter parts of the corona can be studied with instruments whenever conditions are favorable. The corona surges millions of miles into space and is believed to be composed of atomic particles of iron, nickel, and calcium.

SUNSPOTS

Sunspots are dark irregularly shaped areas on the surface of the sun. Their diameter may reach several hundreds of thousands of miles. There is a direct relationship between sunspots and the corona. During low sunspot activity, the corona streamers will be much longer above the sun's equator than over its polar regions; during high sunspot activity, the corona streamers extend out evenly over the entire surface of the sun but to a much greater distance in space. It is believed that these sunspots and the associated high corona streamers are responsible for the cyclic variations in the ionization level of the ionosphere.

SHORT WAVE FADEOUT

Quite frequently violent sunspot activity produces effects in the earth's ionosphere called Short Wave Fadeout (SWF), formerly known as Sudden Ionospheric Disturbances.

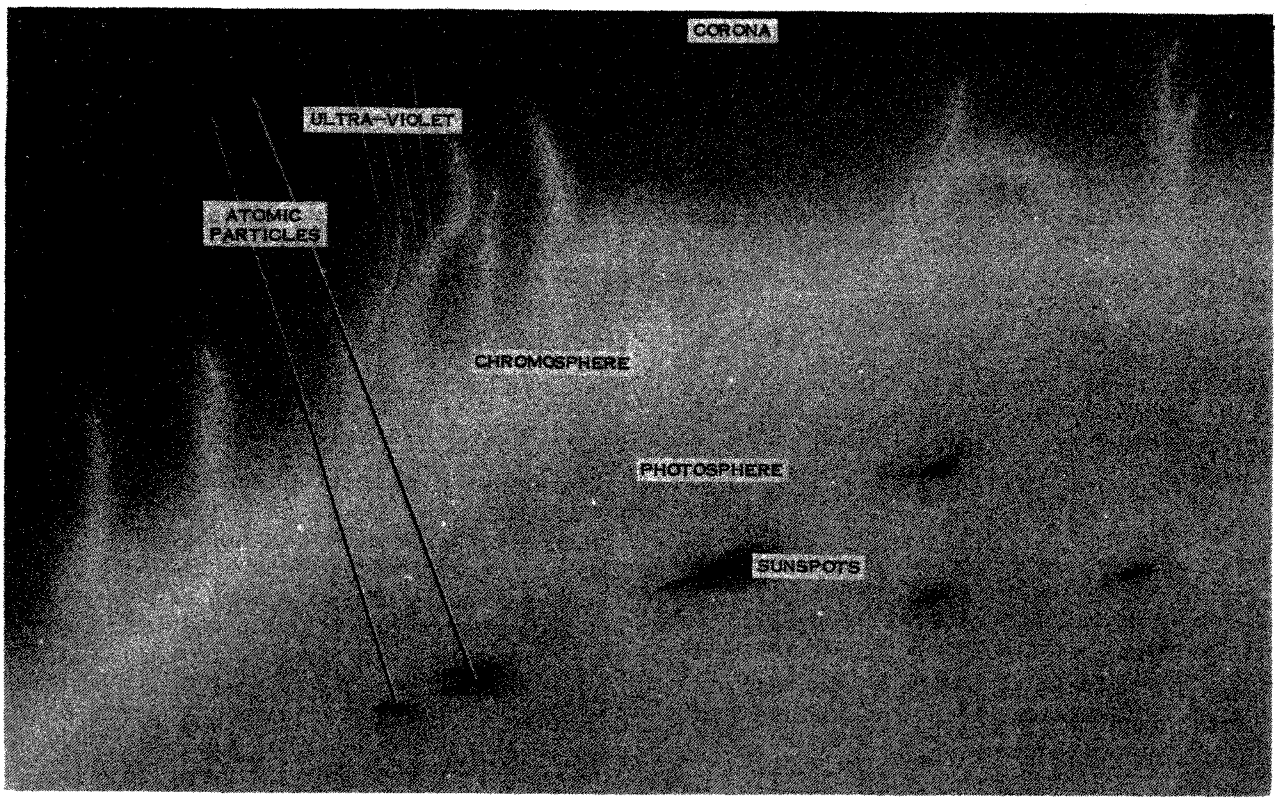

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Figure 6-5.—Composition of the sun.

During a SWF, "squirts" of abnormally strong ultra violet radiation cause the level of ionization in the lower part of the ionosphere to rise sharply. In these situations radio signals—especially those in the HF band—may be absorbed or refracted back to earth short of the intended receiving site. During SWF, the lower frequencies are absorbed first and recovered last. During SWF of low intensity, transmission may continue to be possible on the higher frequencies. SWF normally occurs only in the daylight hemisphere and is characterized by simultaneous fadeouts on a wide range of the useful high frequency band.

IONOSPHERIC PROPAGATION

A basic understanding of the ionosphere—what it is and how it is formed—is necessary in order to understand how it affects radio wave propagation. The following paragraphs provide a description of the ionosphere.

STRUCTURE OF THE IONOSPHERE

The ionosphere is the area of the atmosphere in which the gas atoms are charged by ultraviolet light from the sun and by meteor activity. These charged atoms are called ions; the process by which they are charged is called ionization.

Ionization occurs as follows. When a high-energy electromagnetic wave, such as ultraviolet light, hits an atom, it is capable of knocking an electron free of its parent atom. When this occurs, a positively charged atom, called a positive ion, remains in space along with the negatively charged free electron. The electron absorbs energy from the incident wave which frees it from its parent atom. The rate of ion and free electron formation depends upon the density of the atmosphere and the intensity of the ultraviolet light. As the ultraviolet light wave produces positive ions and negative free electrons, its intensity is decreased because of the absorption of energy by the free electrons. Therefore, the ionized region will tend to form in a layer for a given frequency of ultraviolet light. When the wave first hits the ionosphere, it has high energy, but the ionosphere is not dense at its highest altitudes; therefore, little ionization will occur. As the wave passes through the ionosphere, the density increases, but the energy level of the wave decreases. An ionized layer forms where the combined effect of ionospheric density and wave energy is maximum.

Since there are different ultraviolet wave frequencies, several ionized layers are formed, as shown in figure 6-6. Lower frequency ultraviolet waves tend to produce ionized layers at higher altitudes. The higher frequency ultraviolet waves tend to penetrate deeper into the ionosphere before producing appreciable ionization.

Ionospheric Layers

Figure 6-6 shows that there are four distinct layers of the ionosphere which are designated D, E, F1, and F2. The height, thickness, and intensity of ionization for each of the layers is measured by transmitting r-f pulses vertically into the ionosphere and then receiving the returned pulse. The echo time indicates height of the ionospheric layer; the strength of the received signal indicates thickness of the layer. When pulses of various r-f frequencies are transmitted, a frequency will be found above which the vertical wave will not be refracted back to earth. This frequency, called the critical frequency, indicates the extent of ionization. The higher the critical frequency, the greater the ionization. Since the ionospheric layers are caused chiefly by ultraviolet light emitted from the sun, their height and thickness change with the season and the time of day.

The D layer exists only in the daytime. Very little sky-wave refraction is obtained from this layer, and there is a pronounced absorption effect at frequencies below 2 mc. The E layer exists only during daylight hours at a height of about 55 to 85 miles. The F1 layer exists at a height between 85 and 155 miles during daylight hours. When the sun sets, the F1 layer merges with the next higher ionized layer, the F2 layer. The F2 layer is the most useful layer for sky-wave transmission because it exists during the night as well as the day. This layer occurs between 90 and 150 miles above the earth at night during all seasons. In the northern hemisphere, the F2 layer is somewhat higher in the summer than in the winter during the day, extending between 90 and 180 miles in altitude. The variation in height is accounted for by an increase in ultraviolet radiation which increases the height of the F2 layer and decreases its ion density during the summer. The reduction of ultraviolet radiation in the late afternoon causes the F2 layer to descend.

Besides the seasonal and daily changes in the ionosphere, other variations occur. There is a noted increase in ionization with an increase of sunspot activity. Sunspots produce vast amounts of ultraviolet energy; therefore the greater the number of sunspots, the greater the amount of ionization. Observers of solar activity over the past 100 years have confirmed that sunspot activity is cyclic, with the cycle repeating every 11.1 years. There are variations within this period and variations from one period to the next, all of which make it necessary to know the predicted sunspot number for a given time in order to determine the probability of obtaining efficient sky wave communication.

Sporadic E Layer

Another phenomenon associated with the ionosphere is the sporadic E layer which occurs roughly at the height of the E layer at irregular times and locations, both day and night. The critical frequency of the sporadic E layer may be much higher than that of the regular E layer, and successful refraction from the sporadic E layer may be effective at frequencies up to 60 mc.

REFRACTION IN THE IONOSPHERE

When a radio wave is transmitted into the ionosphere, the wave is refracted. The refraction, or bending, is caused by a change in velocity of the segments of the wavefront as it strikes the ionized layer at an oblique angle. The portion of the wavefront first striking the ionized layer undergoes bending while other portions of the wavefront which have not yet reached the ionized layer are still traveling in a straight line. The amount of bending depends upon the electron density of the ionized layer and the frequency of the transmitted wave. The effect of each of these factors is discussed in the following paragraphs.

Each ionized layer consists of a central region of relatively dense ionization which

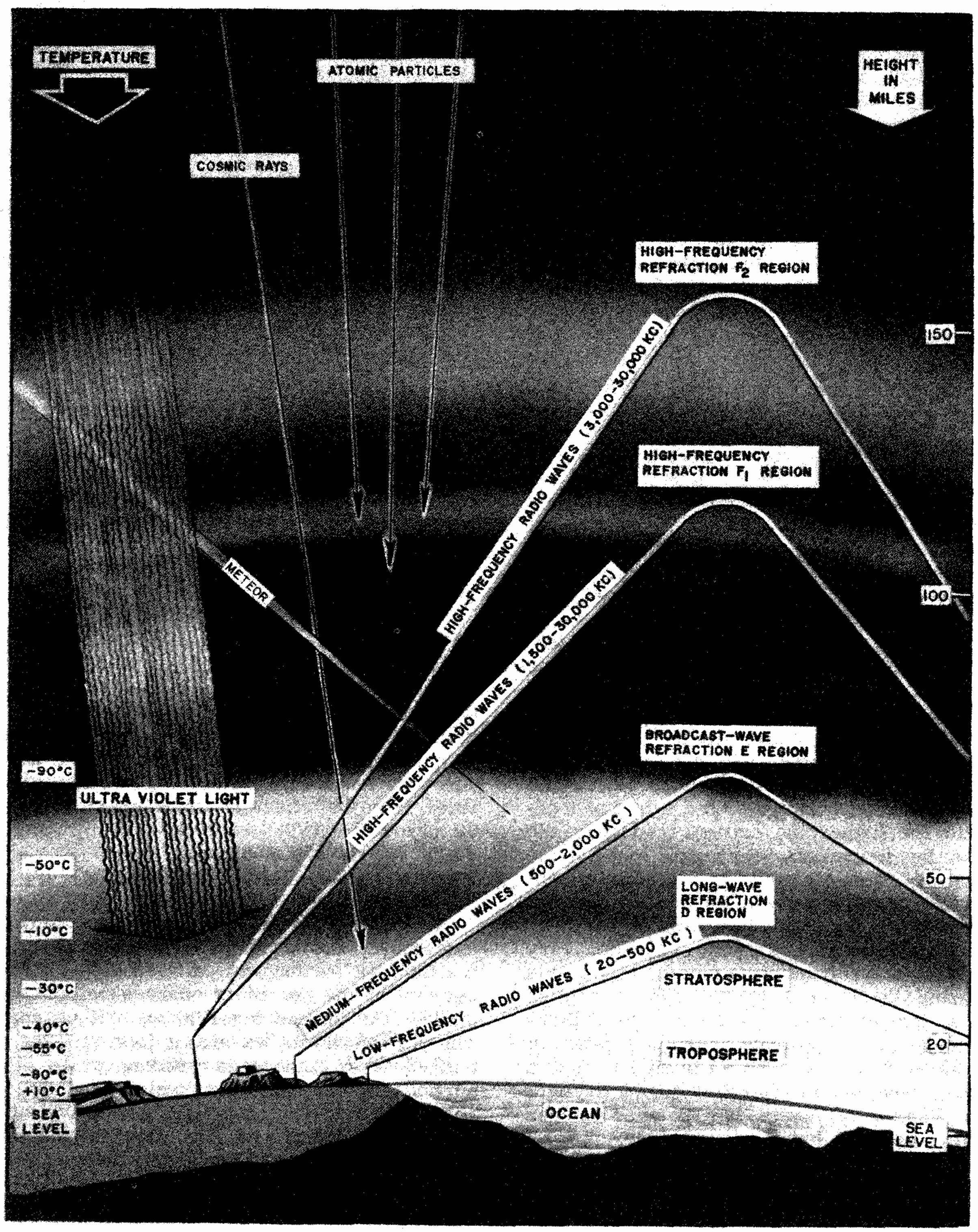

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Figure 6-6.—Composition of the earth's atmosphere.

tapers off in intensity both above and below the maximum region. As a wave passes into a layer of increasing ionization, the velocity of the upper part of the wave increases, causing the wave to bend back toward the earth. If the wave enters into a layer of decreasing ionization, the velocity of the upper part of the wave decreases, and the wave is bent away from the earth. The amount of bending in both cases depends upon both the variation in ionization and the height of the ionized layer. If the wave enters a thin, very highly ionized layer, the wave will be bent back so rapidly that it will appear to have been "reflected" instead of refracted back to earth. To reflect a radio wave, the highly ionized layer must be approximately no thicker than one wavelength of the incident wave. Since the ionized layers often are several miles thick, ionospheric "reflection" is more likely to occur at long wavelengths (low frequencies). The wave is bent (refracted) more slowly (as shown in figure 6-7) when there is a gradual change in the relationship between ionization density and increased height.

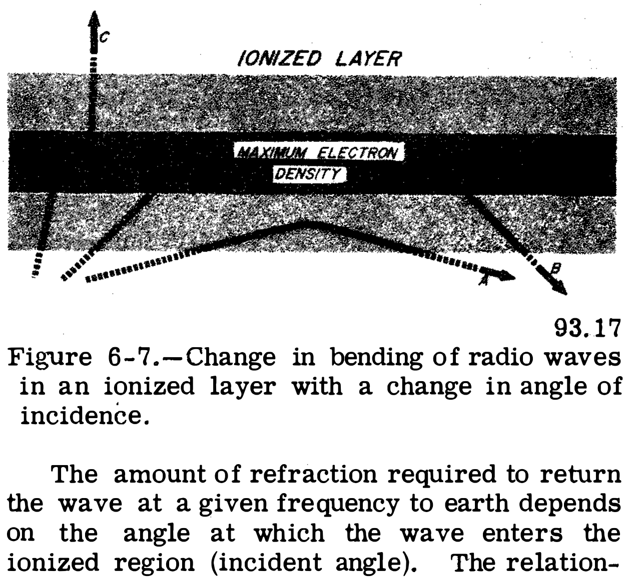

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Figure 6-7.—Change in bending of radio waves in an ionized layer with a change in angle of incidence.

The amount of refraction required to return the wave at a given frequency to earth depends on the angle at which the wave enters the ionized region (incident angle). The relationship is shown in figure 6-7 in which the radio waves of the same frequency are beamed toward the ionosphere at various angles. Because wave A approaches the ionized layer at a small angle, only a slight amount of bending is required to return it to earth. Because wave B approaches at a greater angle and penetrates deeper into the ionized layer, a longer path is required for bending it since the variation in density with height is more gradual. Because wave C approaches at almost vertical incidence, the ionized layer is unable to return it to earth.

If transmission is made at vertical incidence (straight up) and the frequency continues to increase, the lower frequencies will be returned to earth; but eventually a point will be reached where the signals are not returned. The highest frequency that will be returned from vertical incidence is called the critical frequency, which will vary with the seasons, time of day, or any other effects which cause the density of the ionosphere to change. The critical frequency is higher in the daytime than at night.

Maximum Usable Frequency

As the incident angle is lowered from the vertical, there is a corresponding increase in the frequency which will be returned to earth. The factors which determine the actual frequency to be used for a communication circuit are the height of the ionized layer used for refraction and the distance between the two ends of the circuit. The maximum frequency which will be refracted for a given distance of transmission is called the maximum usable frequency (MUF). The MUF is always higher than the critical frequency.

Frequency of Optimum Traffic

Experience has shown that the MUF may increase or decrease significantly, especially during daytime because of changes occuring in the ionosphere. Therefore, the frequency of optimum traffic (FOT), which is computed as 0.85 times the MUF, is used so that variations in the ionosphere will have less effect on the communication circuit. For example, the FOT of 10,000 kc (MUF) would be 8500 kc. Since the maximum usable frequency may be lowered by sudden variations in the ionosphere, radio signals of 10,000 kc may be absorbed or refracted back to earth short of the intended receiving site. However, by use of 8500 kc (FOT) communications would not be interrupted.

ABSORPTION IN THE IONOSPHERE

As the radio wave passes into the ionosphere, it loses some of its energy to the free electrons and ions. If those high-energy free electrons and ions do not collide with gas molecules of low energy, most of the energy lost by the radio wave is reconverted into electromagnetic energy, and the wave continues to be propagated with little change in intensity. However, if the high-energy free electrons and ions do collide with other particles, they dissipate the energy which they have acquired from the wave, resulting in absorption of the energy from the wave. Since absorption of energy is dependent upon collision of particles, the greater the density of the ionized layer, the greater the probability of collisions; therefore the greater the absorption. The highly dense D and E layers provide the greatest absorption for the ionospheric wave.

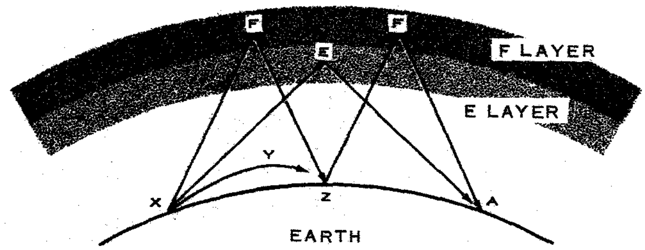
Because the amount of attenuation of the sky wave depends upon the density of the ionosphere which varies with seasonal and daily conditions, it is impossible to express a fixed relationship between distance and signal strength for ionospheric propagation. Under favorable conditions, only free-space attenuation will occur. Under certain conditions, the absorption of energy is so great that communicating over any distance beyond the line of sight is difficult. Sky-wave intensity varies from minute to minute, month to month, and year to year because of variations in the ionosphere.

FADING

Fading is the variation of radio signal strength at a radio receiver during the time of reception. Signals received over an ionospheric path may vary in intensity over short periods of time. There are three major reasons for fading. When the radio wave is refracted in the ionosphere or reflected from the earth's surface, random variations in polarization of the wave may occur, causing changes in the received signal level because of the inability of the antenna to receive polarization changes. Fading may also occur if the FOT is selected too close to the MUF. If this is the case, any slight change in the ionosphere might cause a change in signal strength or refract the wave far short of or beyond the intended receiving site. However, the major reason for fading on ionospheric circuits is caused by multipath propagation, which is next described.

Multipath Fading

Figure 6-8 shows the various paths a signal can travel between two sites in a typical circuit. One signal from the transmitter may follow the path XYZ, which is the basic ground wave. Another signal, which follows the path XEA, is refracted from the E layer and received at A, but not at Z. Still another path is XFZFA, which results from a greater angle of incidence and two refractions from the F layer. At point Z, the received signal is a combination



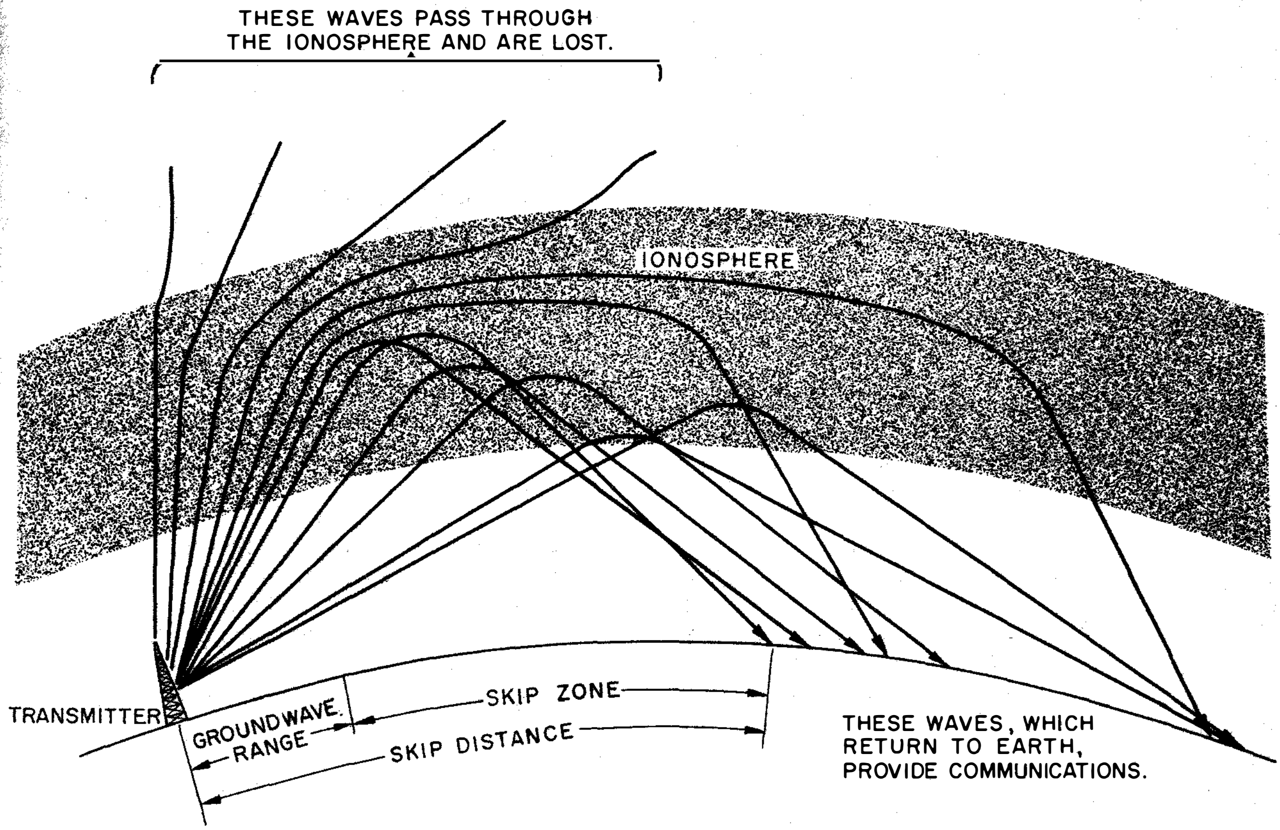
20.254
Figure 6-8.—Multipath transmission.

of the ground wave and the sky wave. If these two waves are received out of phase, they will produce a weak or fading signal. If they are received in phase, they will produce a stronger signal. Small alterations in the transmission path may change the phase relationship of the two signals, causing periodic fading. This same addition of signal components occurs at point A. At this point, the double-hop F layer signal may be in or out of phase with the signal arriving from the E layer.

SELECTIVE FADING.—Fading resulting from multipath propagation is variable with frequency since each frequency arrives at the receiving point via a different radio path. When a wide band of frequencies, such as multichannel single sideband, is transmitted, the frequencies in the sideband will vary in the amount (if any) of fading. This variation is called selective fading. When selective fading occurs, all frequencies within the envelope of the transmitted signal may not retain their original phases and relative amplitudes. This fading may cause severe distortion of the signal and limit the total bandwidth which can be transmitted.

SKY-WAVE TRANSMISSION PATHS

Figure 6-9 illustrates some of the many possible paths that radio waves of various



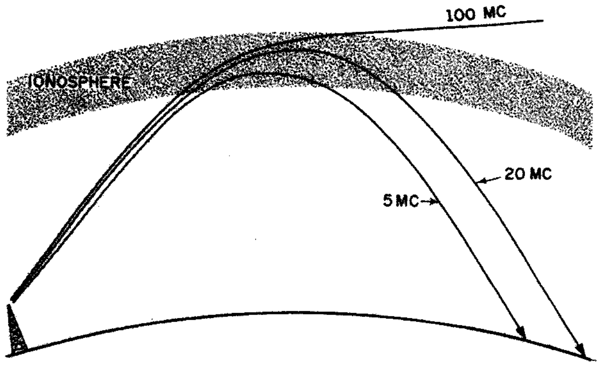
31.16

Figure 6-9.—Various sky-wave transmission paths.

frequencies may take between a transmitter and a receiver by refraction in the ionosphere. Note that some of the waves, which in this case are assumed to be of too high a frequency (30 mc and higher) for refraction by the ionized layer, pass on through and are lost in space. Other components of the wave, which are assumed to be of the correct frequency (below 30 mc) for refraction from the ionospheric layers, are returned to the earth; these waves provide communications. Note also that the skip distance is the distance from the transmitter to the nearest point at which the refracted waves return to earth. The skip zone and its relation to the ground wave are shown in Figure 6-9.

Note the distinction between the terms SKIP DISTANCE and SKIP ZONE. For each frequency at which refraction from an ionospheric layer takes place, there is a skip distance that depends on the degree of ionization present. The skip zone, on the other hand, depends on how far the ground wave extends from the transmitter and where the sky wave first returns to earth by refraction from an ionized layer. The skip zone is the zone between the end of the ground wave transmission and the point on the earth where the sky wave first returns from the ionosphere.

As noted previously in the discussion of the ionosphere, the higher the frequency of a wave, the less it is refracted by a given degree of ionization. Figure 6-10 shows three separate waves of different frequencies entering an ionospheric layer at the same angle. The 100-mc wave is not refracted sufficiently by the



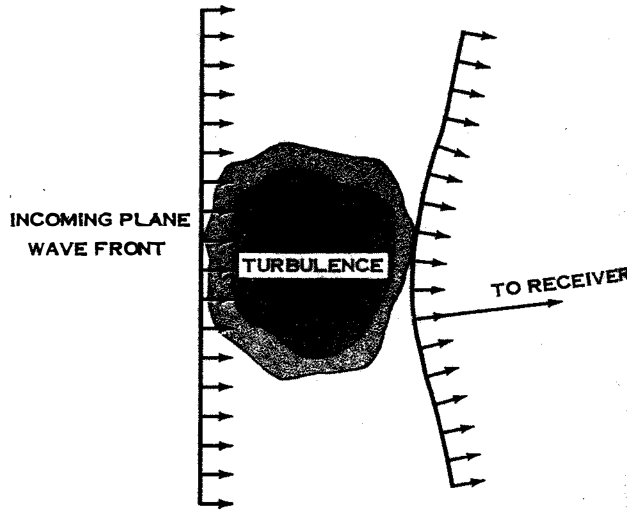
31.19
Figure 6-10.—Frequency versus distance for returned waves.

ionosphere and is not returned, but the 20-mc wave, refracted less than the 5-mc wave, returns at a greater distance from the transmitter.

IONOSPHERIC SCATTER

In explaining refraction and describing the ionosphere, it has been assumed that the density variation within a layer is gradual and uniform. This picture of the ionosphere provides a very satisfactory explanation for most radio wave phenomena associated with the ionosphere. However, there are also turbulent and irregular variations in the ion density of the ionosphere. These variations result in the scattering of the radio wave. In areas where scattering is quite predominant most of the year, point to point scatter communications can be accomplished by utilizing high-power transmitters. Figure 6-11 illustrates how scattering can occur. When a wavefront encounters a sudden change in ion density, irregular variations in the wavefront result. Scattering of radio energy by the ionosphere is similar to the scattering of light by small water droplets in a cloud or fog. When a beam of light shines through the mist, moving points of light are seen in the beam. These are caused by water droplets which scatter light to the observer.

Scattering takes place in the E layer region of the ionosphere. Under suitable conditions, this type of propagation may be used for low transmitting angles with frequencies as high as 100 mc. Ordinarily, radio waves with frequencies up to about 30 mc will pass directly through the E layers and be refracted from the F layer. However, the scattering process causes some of this energy to be returned from the E layer to the receiving antenna. Only a very small percentage of the total energy is returned. If the scattering region is within visible range of the transmitting and receiving antennas, the total loss is free-space loss, plus a scatter loss, which is dependent upon the size and strength of the irregular variation in the medium and the angular change in direction of the wavefront. This scatter loss is large—in the range of 60 to 100 or more db. Since the scatter loss is so large, this form of propagation requires the use of high-power transmitters and highly directional antennas.



93.18
Figure 6-11.—Variation in wavefront which results in scattering.

Signals received over ionospheric scatter circuits are quite weak, but do not show the extreme changes in signal level (fading) which sometimes occur with other types of propagation. In a daily cycle, the signal level reaches a minimum value at about 2000 local time. There is, however, no nighttime disappearance of the signal as in the case of regular E layer propagation which disappears shortly after sunset. There is also an annual cycle with minimum field strength or signal level during spring and fall. The received signal is also characterized by rapid, punctuated strong bursts of energy evidently associated with ionized meteor trails. (Meteor trails are treated in a later section.)

The principal factors which limit the utilization of ionospheric scatter are frequency and distance. The useful frequency range for ionospheric scatter extends from about 20 to 60 mc. The region in which the scattering occurs is fixed at an approximate height of 60 miles which determines the optimum range of distance, about 500 to 1100 miles.

GROUND-WAVE PROPAGATION

The ground wave is that part of the total radiated energy which is propagated at a low angle from the transmitting antenna and travels close to the earth. The ground wave includes components traveling in actual contact with the earth as well as components which travel directly from the transmitting antenna to the receiving antenna when the two antennas are high enough from the ground so that they can "see" each other. For purposes of discussion, ground waves are assumed not to be propagated via the ionosphere. The two components of a ground wave are the surface wave and the space wave.

SURFACE WAVE

A radio wave that travels in CONTACT with the earth's surface is called a surface wave. It is the type of wave which provides reception up to distances of 100 miles or more in the standard commercial broadcast band during the daytime. Because attenuation of this type of radio wave is very high, its intensity drops off rapidly with increased distance from the transmitter. A surface wave must be essentially vertically polarized because a horizontally polarized wave traveling in contact with the earth is completely attenuated only a short distance away from the transmitter. The transmitting and receiving antennas, therefore, must generate and receive vertically polarized waves if the surface wave is to be utilized to advantage. In general terms, this means that both antennas must be vertical.

Attenuation of the surface wave due to absorption depends upon the condition of the earth's surface and the transmitted frequency. Table 6-2 gives the relative conductivity of various earth surfaces. From this table, it is apparent that the best surface-wave transmission occurs over sea water and that the highest degree of attenuation is found over jungle areas. Attenuation over all types of terrain increases rapidly as the frequency is increased.

Table 6-2.—Relative conductivity.

Surface	Relative Conductivity
Sea water	Good
Flat, loamy soil	Fair
Large bodies of fresh water	Fair
Rocky terrain	Poor
Desert	Poor
Jungle	Unusable

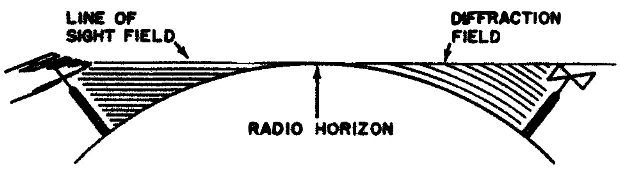
Extremely high losses make it impractical to use the surface wave for long-distance transmissions with frequencies above 1500 kc. However, by lowering the transmitting frequency into the VLF range and using very high-powered transmitters, the surface wave can be propagated great distances. High-powered VLF transmitters can provide coverage to naval units operating anywhere at sea. The phenomenon which permits propagation of surface waves far beyond the radio horizon is called diffraction, or the ability of a radio wave to bend around obstacles in its path. Thus, the Navy's extremely high-powered VLF transmitters are actually capable of transmitting surface wave signals around the earth.

SPACE WAVE

While the characteristics of the surface wave serve to explain propagation, along the earth's surface, of signals in the VLF to HF frequency ranges, they do not seem to apply to reception of higher frequencies within and slightly beyond the radio horizon. Such signals are considered to be propagated via the space wave.

Space waves travel close to but not in contact with the earth, directly from transmitting to receiving antenna. Consequently, the receiving antenna must be situated within the radio horizon of the transmitting antenna. Because radio waves are refracted or bent slightly even when propagated through the troposphere well below the ionosphere, the radio horizon is actually about four-thirds times the line-of-sight or natural horizon.

Figure 6-12 illustrates space-wave propagation of a low-powered VHF signal. Due to heavy absorption at frequencies above 1500 kc,



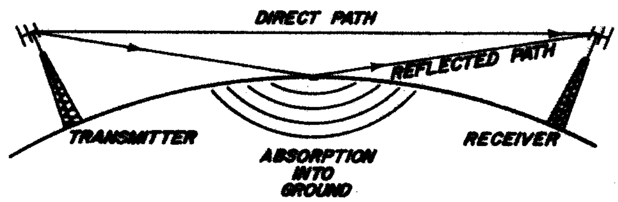
93.19

Figure 6-12.—Two regions in space-wave propagation.

surface-wave propagation could not be used to maintain such a circuit. However, because it is not in direct contact with the earth, the space wave is not attenuated greatly and will arrive at the receiving antenna with minimum loss of signal strength.

In figure 6-12, note the shaded area beyond the radio horizon of the transmitting antenna. Reception of the space-wave signal in this area is made possible because the space wave is diffracted over the surface of the earth. However, because space-wave signals are usually in the VHF and higher frequency bands and are transmitted using low power, their reception in the "diffraction zone" normally is limited to a few miles beyond the radio horizon. An exception to this rule is caused by the phenomenon called temperature inversion, which will be discussed in a later section.

Although space waves suffer little ground attenuation, they are susceptible to fading. Unless the space wave is transmitted by a highly directional, narrow-beam antenna, some of its energy may be directed obliquely towards the ground and subsequently be reflected towards the receiving antenna as illustrated in figure 6-13. That ground-reflected component of the space wave will undergo both a phase shift and partial absorption as it is reflected by the ground. Consequently, the signal which is finally received will be a combination of the direct space wave and the weaker, out-of-phase ground-reflected wave. This combination will cause the received signal to fade in varying degrees depending upon the phase



93.20

Figure 6-13.—Possible routes for ground waves.

difference of the two incoming waves. A phase difference of 180 degrees will produce almost complete fading.

WEATHER VERSUS PROPAGATION

Weather is one of the many factors affecting wave propagation. Because there are many ways in which weather may affect wave propagation, it is the purpose of this section to consider the various phenomena and to show their relationship to radio wave propagation.

Wind, air temperature, and water content of the air can combine in many ways, with different combinations causing radio signals to be heard hundreds of miles beyond their ordinary range or to be attenuated to a point where the signals may not be picked up over a normally satisfactory path. Unfortunately, no hard and fast rules may be given concerning the effects of weather on radio transmissions since the variables of weather are extremely complex and subject to frequent change. Any discussion of the effects of weather on radio must therefore be limited to general terms and will be so treated here.

PRECIPITATION ATTENUATION

Calculating the effect of weather on radio propagation would be comparatively simple if there were neither water nor water vapor in the atmosphere. However, some form of water (vapor, liquid, or solid) is always present in the atmosphere, even in arid regions and must be considered in all microwave calculations.

Rain

Attenuation due to raindrops is greater than attenuation due to other forms of water. Attenuation may be caused by absorption, whereby the raindrop, acting as a poor dielectric, absorbs power from the electromagnetic wave and dissipates the power by heat loss or by scattering. Raindrops will cause greater attenuation by scattering than by absorption at frequencies above 100 mc and at frequencies above 6 gc attenuation by raindrop scatter is quite pronounced.

Variation in raindrop size causes one of the difficulties in attempting to determine the attenuation by scattering. There is no uniformity of drop size in any rainfall; the droplets vary in diameter from less than one millimeter to five millimeters or more. As a general rule, the heaviest rate of rainfall is accompanied by the greatest drop size, and, therefore, the greatest attenuation.

Fog

As far as attenuation is concerned, fog may be considered another form of rain. Since fog remains suspended in the atmosphere, the attenuation to be expected is determined by the quantity of water per unit volume and by the size of the droplets. Attenuation due to fog is of minor importance at frequencies lower than 2 gc. Fog can cause serious attenuation by absorption, but only at frequencies above 2 gc.

Snow

Scattering due to snow is difficult to compute, owing to the irregularities of the flakes.

While information on the attenuating effect of snow is limited, it is probable that attenuation from snow is less than from rain falling at an equal rate. This assumption is borne out by the fact that the density of rain is eight times the density of snow. As a result, a rainfall of one inch per hour, for example, would have far more water per cubic meter of atmosphere than an equal snowfall.

Hail

Attenuation by hail is determined by the size of the stones and their density. Attenuation of electromagnetic waves by scattering due to hailstones is considerably less than by rain since ice has a lower index of refraction.

Sleet and Glaze

Sleet is defined meteorologically as very small pellets of ice, and as such has little effect on the electromagnetic wave in the frequency limits discussed in this chapter. Glaze, defined meteorologically as rain that freezes on contact with any object, may be safely treated as rain of equal drop size.

DUCTING

Unusual ranges of VHF and UHF signals are caused by abnormal atmospheric conditions a few miles above the earth. Normally, the warmest air is found near the surface of the water. The air gradually becomes cooler as altitude increases. Sometimes unusual situations develop where warm layers of air are found above cooler layers. This condition is known as TEMPERATURE INVERSION.

When a temperature inversion exists, the amount of refraction is different for the particles trapped within the boundaries from those outside them. These differences form channels or ducts that will conduct the radio waves many miles beyond the assumed normal range.

Sometimes these ducts are in contact with the water and may extend a few hundred feet into the air. At other times the duct will start at an elevation of between 500 and 1000 feet and extend an additional 500 to 1000 feet in the air.

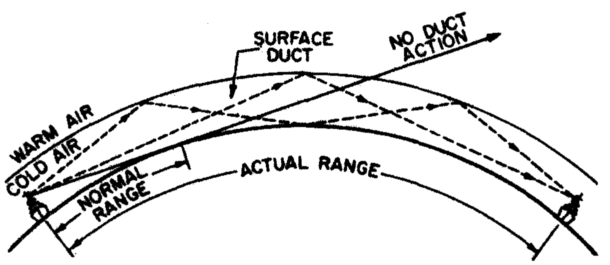
If an antenna extends into the duct or if the wave enters a duct after leaving an antenna, the transmission may be conducted a long distance. An example of this type of transmission of radio waves in ducts formed by temperature inversions is shown in figure 6-14.

With certain exceptions, ducts are formed over water where the following conditions are observed aboard ship:

1. A wind is blowing from land.
2. There is a stratum of quiet air.
3. There are clear skies, little wind, and high barometric conditions.
4. A cool breeze is blowing over warm open ocean, especially in the tropic areas and in the trade-wind belt.
5. Smoke, haze, or dust fails to rise, but spreads out horizontally.

TROPOSPHERIC SCATTER PROPAGATION

The foregoing sections of this chapter have provided a discussion of that portion of radiated energy which is acted upon by the ionosphere and returned to earth and also that portion of radiated energy which is propagated along the



20.255

Figure 6-14.—Duct effect in high-frequency transmissions.

earth's surface. In this section, consideration is given to that part of the total radiated energy which undergoes reflections and refractions in the troposphere.

CHARACTERISTICS OF THE TROPOSPHERE

The troposphere is the lowest region of the atmosphere, extending from the ground to a height of slightly over six miles. Virtually all weather phenomena occur in this region of the atmosphere. There is practically no ionization in the troposphere. Generally, the troposphere is characterized by a steady decrease of temperature and pressure with an increase in height.

Refraction of radio waves in the troposphere is a function of various meteorological variables. Because of the uneven heating of the earth's surface, the air in the troposphere is in constant motion. This motion causes small turbulences, or eddies, to be formed. These turbulences are quite similar to the whirlpools in a rapidly moving stream of water. The turbulence is most intense near the earth's surface and gradually diminishes with altitude.

For frequencies up to about 30 mc, radio wavelengths are large compared to the size of the turbulences; therefore, the turbulences have little effect on the transmitted signal. However, as the frequency is increased, these local turbulences become increasingly important because they are responsible for tropospheric scatter transmission

TROPOSPHERIC SCATTERING

When a wavefront passing through the troposphere encounters a turbulence, a small amount of energy is scattered away from the incident-wave. The scatter effect is the same as if each turbulence received the signal and reradiated it. Thus the effect is similar to the ionospheric scatter shown in figure 6-11. The total received signal is an accumulation of the energy received from each one of the turbulences.

The word "scatter" implies that the spreading of energy is equal in all directions; however, the direction of energy distribution in tropospheric scatter propagation differs only slightly from the direction of the path of the main wavefront. The scattering occurs chiefly in the forward direction; therefore the term "forward scatter" is sometimes used when talking about tropospheric scatter.

The magnitude of the received signal depends on the number of turbulences causing scatter in the desired direction and the direction and gain of the receiving antenna beam. This quantity or magnitude is called the scatter volume. The scatter volume and scatter angle are shown in figure 6-15. As the scatter angle is increased, the amount of received scattered energy decreases very rapidly.

The amount of received energy decreases as the height of the scatter volume is increased. There are two reasons for this: (1) scatter angle increases as height is increased; (2) the amount of turbulence decreases with height. As the circuit distance is increased, the height of the scatter volume must also be increased. Therefore, the received signal level decreases as the circuit distance is increased.

Since tropospheric scatter depends on turbulences in the atmosphere, changes in atmospheric conditions will affect the received signal level. Both daily and seasonal variations are noted. These changes are called long-term fading. In addition to long-term fading, the tropospheric scatter signal often is also characterized by very rapid fading which is caused by multipath propagation. The signals received at any one time are the sum of all the signals received from each of the turbulences in the volume. Since the turbulent condition is constantly changing, the path lengths and individual signal levels are also changing, resulting in a rapidly changing signal. Although the signal level is constantly changing, the average signal level is persistent, and no complete fade-out occurs.

Another characteristic of a tropospheric scatter signal is its relatively low power level. The scatter volume can be pictured as a relay station, located above the horizon, receiving the

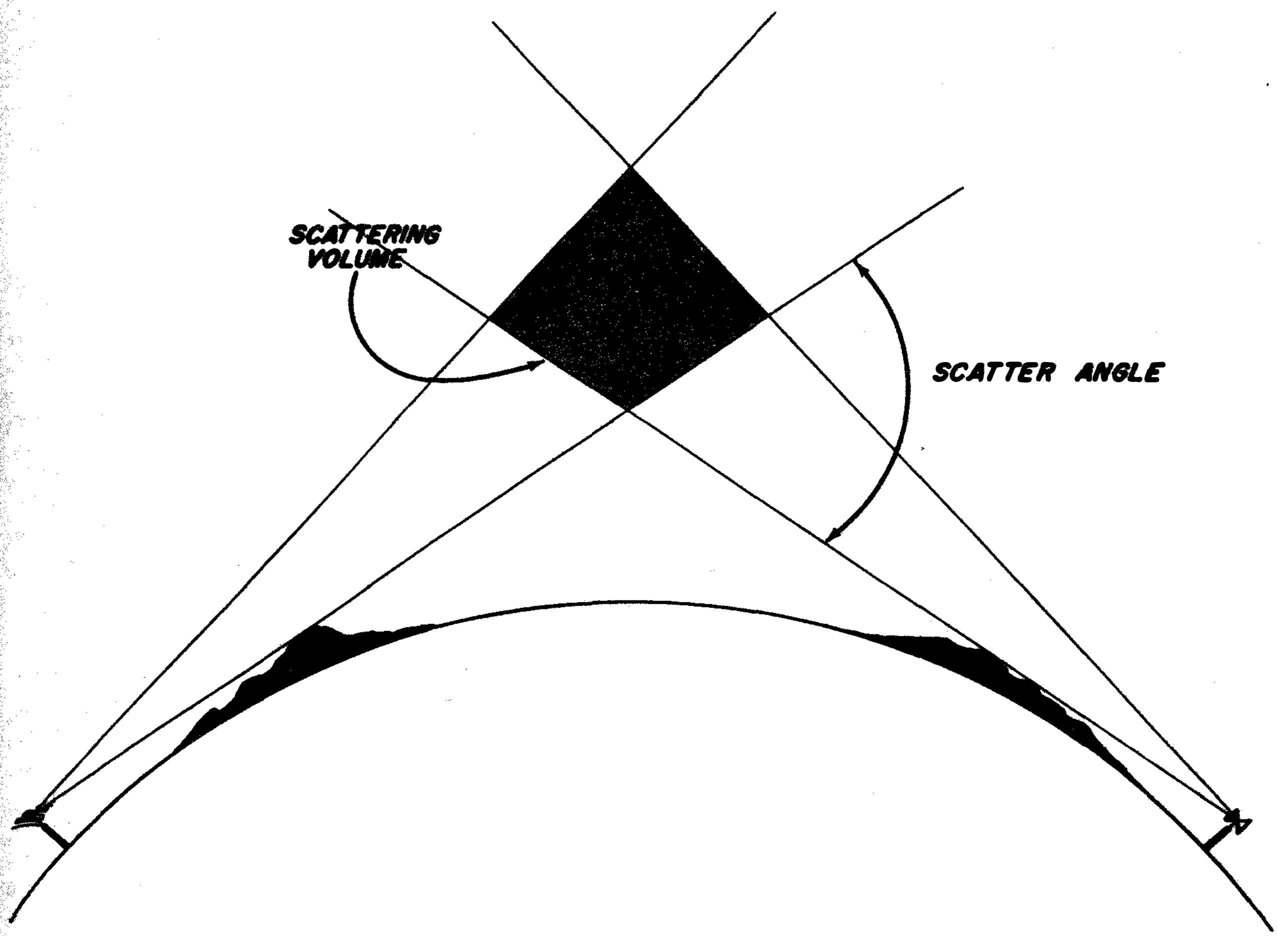


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Figure 6-15.—Geometry of tropospheric scattering.

transmitted energy and reradiating it to some point beyond the line-of-sight distance. Since most of the transmitted energy is not reradiated to the receiver, the efficiency is very low, and the signal level at the final receiver point is low. To compensate for the low efficiency in the scatter volume, the incident power must be high. This is accomplished by using high-power transmitters and high-gain antennas which concentrate the transmitted power into a beam, thus increasing the intensity of energy on each turbulence in the volume. The receiver must also be very sensitive to detect the low-level signals.

Several factors determine the frequency range most suitable for tropospheric scatter. For frequencies below 30 mc, the troposphere appears to be uniform, and scattering does not occur. Also, at these lower frequencies (longer wavelengths), it is difficult to construct the required high-gain antennas because of their large size. As the frequency is increased, the amount of scattering loss and the free-space loss increases. Above 10 gc, the wave is greatly affected by atmospheric conditions.

APPLICATION OF TROPOSPHERIC SCATTER

When a space wave (one part of the ground wave) is transmitted, it undergoes very little attenuation within line-of-sight distance. When the horizon is reached, the wave is diffracted and follows the earth's curvature. The rate of attenuation increases very rapidly for distances beyond the horizon, and signals in the diffraction field are extremely weak. Tropospheric scatter provides a usable signal at distances beyond the point where the diffraction field drops below a usable level. The scattered wave is able to reach beyond the diffraction field because of the height at which the scattering takes place. The tropospheric region, which contributes most strongly to the scatter field, lies near the midpoint of the circuit and just above the radio horizon of the antenna.

Tropospheric scatter propagation is used for point-to-point communications. A correctly designed tropospheric scatter circuit will provide highly reliable service for distances ranging from 50 miles to 500 miles. A tropospheric scatter circuit is not affected by ionospheric and auroral disturbances. The usable frequency range extends from approximately 100 mc to 10 gc.

METEOR-BURST PROPAGATION

Meteor-burst propagation can be considered in a separate category from ionospheric and tropospheric propagation. Basically, meteor-burst propagation is accomplished by bouncing a transmitted radio wave off the ion trail of a single meteor and back to earth.

Many hundreds of meteors enter the earth's atmosphere daily. Almost all of them disintegrate and vaporize because of the high heat which is caused by the friction of the meteor's passage through the earth's atmosphere. The heat vaporization causes the meteor to leave a trail of ionized particles behind it. Such trails can be thought of as cylindrical patterns of ionization. Initially, the cylinders are very small, but they expand quickly and within approximately one- or two-tenths of a second are absorbed by the surrounding atmosphere. The rates at which these meteor trails become available vary greatly, 120 per minute being a representative figure. The area of the atmosphere in which meteors ionize into trails is quite well defined between heights of 50 and 75 miles, or at approximately the lower part of the E layer.

The conditions for successful meteor-burst propagation are met by only about five percent of the meteors which enter the earth's atmosphere. Consequently, sensitive devices must continually monitor that portion of the ionosphere and "trigger" the transmitter only when a suitable meteor burst comes into a position appropriate for proper signal transmission. Thus a message transmitted by meteor-burst propagation usually is transmitted in a series of short bursts, each of which utilizes only one meteor trail. Communication links using meteor-burst propagation are normally limited to about 1000 miles. Frequencies suitable for this method of transmission are in the 6- to 100-mc range.

FREQUENCY CHARACTERISTICS

For all practical purposes it is convenient to classify radio waves into bands of frequencies. Each band of frequencies has similar propagation effects. However, any such classification must be of a general nature only since changes in propagation characteristics with changes in frequency are not sharply defined. Thus when an upper or lower limit of frequency is designated for a certain propagation effect, it does not mean that such an effect stops at those limits, but rather that it becomes negligible beyond such limits.

UPPER MF BAND

In the foregoing discussion of propagation, the upper MF band (the 1- to 4-mc region) received little attention since its role in communications is that of short haul (400 miles), reliable, point-to-point circuits. In general, the attenuation is so high as to make transmissions beyond 400 miles almost out of the question or at least so unreliable as to be considered of only secondary importance. Usually this band, because of the rather long antennas required, utilizes horizontal wire antennas where antenna space is unrestricted. In mobile application, whip antennas are used exclusively in this frequency range.

Sunspot activity ordinarily has only small effects in the 1- to 4-mc range. When sunspot activity is high, attenuation increases and circuit reliability decreases. However, when sunspot activity is low, the reliability of these circuits maintains a more uniform character since attenuation is reduced. The sunspot maximum experienced during 1958 constituted the highest peak in activity in the history of radio. The Solar Observatory at Zurich, Switzerland, which has been following the fluctuations in sunspot numbers since 1750, indicated that the 1958 peak was one of the highest ever observed.

Of particular interest now is the fact that this same cycle should take on its lowest value of sunspot activity during the 1964-65 time period. Best expert opinion predicts a situation during this period when the sunspot numbers will reach a new low for the history of radio. Smooth sunspot numbers as low as one or two are predicted as compared to the previous low (3 to 5) of the 1912-13 period. With the coming of the lower sunspot numbers during the next few years (optimum conditions occuring during the winter of 1965), increased propagation ranges will result in the 1- to 4-mc frequency range due to lower ionospheric absorption which will be present at that time. Communication ranges from 400 miles to 1200 miles should be possible during this period.

HF BAND

The range of frequencies designated as the HF band (3 to 30 mc) employs ionospheric propagation for long-range sky wave communication. The frequency characteristics and propagation effects were discussed earlier under ionospheric propagation.

VHF BAND

The VHF band (30 to 300 mc) is part of the oldest known frequency band of the entire radio spectrum; both Hertz and Marconi conducted their famous experiments in the region from 30 to 3000 mc. As a rule, ionospheric propagation is negligible in the VHF band and cannot be relied upon for propagation to great distances. However, irregular ionospheric refractions are possible (due to sporadic E variations) and can cause a signal in the lower part of the band to be propagated several hundred miles by the ionosphere. Propagation by way of the sporadic E layers is such that scattering or refraction decrease rapidly with an increase in frequency and becomes of little importance above 100 mc.

The most common path of propagation used at VHF frequencies is, therefore, through the troposphere and along the surface of the earth. Since the density of the earth's atmosphere normally decreases with altitude, radio waves are propagated by refraction along a curved path to a distance approximating four-thirds the earth's true horizon. In this frequency range, the radio horizon (four-thirds of the true horizon) is governed not only by refraction but by diffraction as well.

Diffraction plays a major role in the VHF band, depending upon the path over which the waves are propagated. The effect of obstacle gain, caused by diffraction of radio waves over a mountain ridge, was first discovered in this frequency range. Diffraction effects are primarily important with regard to irregular terrain which makes possible the reception of signals in the geometric shadow region of a hill or other intervening object. Generally the higher the frequency, the less the diffraction effects.

Atmospheric noise at these frequencies is fairly low and decreases with increasing frequency. Such noise usually originates only in local electrical storms. However, one of the more important sources of noise in this range is man-made noise such as that from ignition systems, diathermy machines, and X-ray equipment. In this range, receiver noise also begins to become prevalent, although considerable improvement in circuit design has made possible its reduction.

UHF BAND

Almost all the energy transmitted from point to point in the UHF band (300 to 3000 mc) is propagated through the earth's troposphere along a curved path. The refracted path may again be assumed to be a straight line path extending to distances of four-thirds times the true horizon. However, the transmission range may be extended several hundred miles further by means of tropospheric scatter propagation.

Ground reflections are still present at ultrahigh frequencies and can cause multipath fading due to destructive interference, although such reflections become of less importance at the higher frequencies of this band. However, a second type of multipath fading can occur when parts of the wave are refracted through other higher layers of the atmosphere and become bent sufficiently to return and combine with the wave received over a lower and more direct path.

At frequencies above 1000 mc, attenuation of the transmitted signal by trees or other vegetation can range anywhere from 12 to 46 db per mile. However, if the antennas are located to give first Fresnel zone (wave interference zone) clearance above the trees, such attenuation becomes negligible.

Atmospheric and man-made noise in this frequency band is extremely low, with the exception of ignition pulses which can become serious at times. Receiver noise is somewhat greater at these frequencies and increases with increasing frequency, thus calling for special receiving tubes and circuit design.

LOWER SHF BAND

At the frequencies of the lower SHF band (3 to 13 gc), transmission is generally limited to line-of-sight distances based on four-thirds the true horizon. Very little wave reflection will radiate from the earth at these frequencies. Instead, the earth will act as if it were made up of an infinite number of small mirrors, each reflecting the incident wave in a different direction. This phenomenon is sometimes called diffuse reflection. In addition, incident radiation will also be absorbed by the earth's vegetation. The amount of reflected energy from the earth's surface is small; consequently very little wave interference will occur from that source. However, multipath fading and refraction by several propagation paths through the atmosphere is important throughout the entire band. There is also a tendency for buildings and other man-made objects to cast sharp shadows at these frequencies and, if the surface of such objects is smooth, they will reflect the waves in a new direction.

Rain scattering and absorption can cause a serious loss of radiated power at the higher end of this frequency range. If the drop size is comparable to the wavelength of the propagated wave, a very substantial portion of the transmitted energy will be reradiated from the raindrop in a wide range of directions. This phenomenon, known as scattering, has an attenuating effect on radio waves, an effect somewhat like that of diffuse earth reflections. However, not all the energy incident upon a raindrop is reradiated; instead, it is virtually trapped or absorbed and converted into heat. If the drop size is comparatively small in relation to the wavelength, such losses are dependent only upon the volume of water in suspension and therefore are generally negligible.

The use of sharply beamed waves to overcome the losses due to atmospheric attenuation in this band conserves enough power to enable a few watts of directed power to be as effective at a distant receiver as many kilowatts of undirected power.

Receiver noise at these superhigh frequencies has a significant effect on the practical range of a receiving system. Special techniques—such as the use of crystal mixers, MASERS, transistors, and high frequency pumps—have been developed to minimize the noise by converting the received signal to a lower frequency before amplification.

SATELLITE COMMUNICATIONS

One of the new types of communications in the SHF band is satellite relay communications—a system of long range communications whereby shore-based transceiver sites communicate via satellite relay. One of the first successful attempts in this field of communications was Bell Laboratories' TELSTAR, so named by combining the words "telecommunication" and "star." The satellite was designed and developed to relay telephone, television, and telegraph messages across the Atlantic.

The SHF band is used in this field of communication for several reasons. This band is not affected by the ionosphere and is not subject to the sun's ionospheric storms and sudden ionospheric disturbances. Also the band has a low noise figure and is free of the crowded signal conditions in lower bands. Another advantage of using the superhigh frequencies is that the small antennas required for transmitting and receiving can be constructed of light material which adds little weight to the satellite.

The attenuation of the satellite's signal is essentially that of a wave traveling in free space; but because of the limited satellite weight and therefore limited transmitter power, the signal level is very low when it reaches earth. TELESTAR's transmitter power output is about two to three watts and the signal received at earth is about one trillionth of a watt. This low level of signal presented a difficult problem that had to be solved before the system could be put in operation.

The solution of this problem was greatly facilitated by the development of man-made rubies called MASERS and large horn-type receiving antennas which are used to amplify the weak signals several thousand times. Amplifying energy comes from the chromium atoms in the ruby which is operated at a very low temperature of minus 456 degrees Fahrenheit. The MASER, when operated in this manner, will amplify the weak signal without producing noise or amplifying adjacent interference. MASER is the short form of the

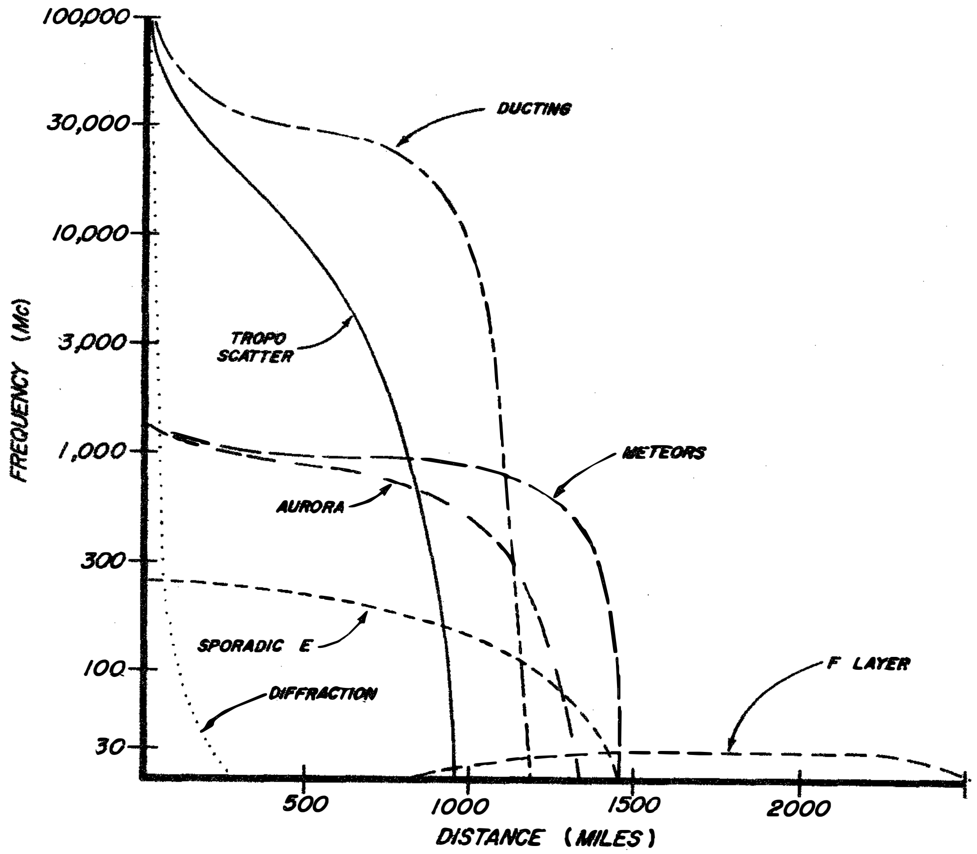


Figure 6-16.—Propagation ranges above 30 mc.

designation, Microwave Amplification by Stimulated Emission of Radiation.

The propagation path for this type of operation is direct line of sight and is usable in any direction except the first few degrees above the horizon. The tropospheric scatter angle must be passed before the signal level from the satellite is usable because of the high attenuation offered at low angles above the horizon.

LASER

The ever increasing need for more communications channels has resulted in new approaches to this communication problem. The optical LASER (Light Amplification by Stimulated Emission of Radiation) is one of the most recent and framatic developments in communications. The first LASER's were man-made rubies. It was found that under certain conditions a precisely shaped ruby when excited by electrical energy would emit a sharply defined red-light beam. With the ruby LASER, visible light in the red color spectrum (4×10^{14} cps) can be transmitted across considerable distances with high intensity, an extremely small beam, and with little loss of power. Further experiments have led to other types of LASER's and LASER producing devices.

The propagation properties of the LASER are the same as those for all visible light. The LASER beam can be reflected, refracted, and diffracted in the lower atmosphere (troposphere) in much the same way as any electromagnetic transmission above 13 gc. Rain, snow, and mist will have a great effect on transmission along the earth's surface by attenuation through diffraction and absorption.

LASERS have been modulated with frequencies as high as 11 gc producing a bandwidth wide enough to accommodate millions of communications channels.

Because of the small power losses in high-energy LASER beams traveling beyond the earth's troposphere, it is anticipated that a LASER with a small two- or three-inch initial beam could be used to communicate directly from the earth to Mars. Further research with LASERS undoubtedly will lead to many other applications.

PROPAGATION RANGES ABOVE 30 MC

The approximate ranges for radio transmissions propagated via various media at frequencies above 30 mc are illustrated in figure 6-16. The ranges given are calculated for average atmospheric conditions and will vary as conditions change.

It should be noted that the Aurora propagation phenomena will occur only during an ionospheric magnetic storm. Also, the ducting propagation phenomena will occur only during a temperature inversion which exists along the path between the transmitting and receiving ends of a circuit. For the other propagation media (troposcatter, diffraction, etc.), the ranges will exist most of the time under average conditions.

CHAPTER 7

ANTENNAS, TRANSMISSION LINES AND MULTICOUPLERS

Since operation of communication equipment over the entire range of the r-f spectrum requires many types of transmission lines, coupling devices, and antennas, it is essential that the operator know something about the basic types, their characteristics, and uses. Because the operator in most cases will have a choice of antennas, he must be able to select the one most suitable for the task at hand. In many cases, his ability to make or change connections can mean the difference between efficient and inefficient operation. In all cases he should be able to determine (1) whether or not his equipment is properly connected to the antenna best suited for his circuit, and (2) whether or not the antenna and connecting devices are operating properly. This chapter presents basic information which should be of assistance in making the most efficient use of antennas and associated equipment.

ANTENNAS

BASIC PRINCIPLES

An antenna is defined as a conductor or system of conductors which can be used to radiate or receive energy in the form of electromagnetic waves.

If an antenna is fed a radio frequency current from a transmitter, it will radiate electromagnetic waves into space. If an antenna is placed in the path of an electromagnetic wave traveling through space, a radio frequency current will be induced in the antenna. The induced current is used as the input to a receiver; thus some type of antenna is necessary to either radiate or receive electromagnetic waves. However, before further discussion, it will be helpful to review and discuss four terms commonly associated with antennas.

Wavelength

The physical length of an antenna is often referred to in wavelengths. Such terms as quarter-wave, half-wave, and full-wave are used extensively. Wavelength (LAMBDA) is usually expressed in meters and is defined as the velocity of a radio wave in free space divided by the frequency of the wave. The symbol for LAMBDA is λ .

Since the velocity of an electromagnetic wave in free space is considered to be 300 million meters per second, the formula for computing wavelength is expressed as:

$$\text{Wavelength in meters} = \frac{300{,}000{,}000}{\text{Frequency in cycles per second}}$$

If wavelength in meters is known, frequency in cycles per second can be determined by the following formula:

$$\text{Frequency in cycles per second} = \frac{3000{,}000{,}000}{\text{Wavelength in meters}}$$

For example, to compute the length of a full wave antenna for use on 10,000 kc proceed as follows:

$$\frac{300{,}000{,}000}{10{,}000{,}000} = 30 \text{ meters, or, since}$$

$$1 \text{ meter} = 3.28 \text{ feet}$$

$$30 \times 3.28 = 98.4 \text{ feet}$$

If half-wave or quarter-wave antenna values are desired, simply divide the result by 2 or 4.

Polarization

Radio wave polarization is an important consideration with respect to antennas. In general, the following rules apply. Vertical radiating antennas radiate vertically polarized waves which are received best by vertical antennas. Horizontal radiating antennas radiate horizontally polarized waves which are received best by horizontal antennas. Figure 7-1 shows both vertical and horizontal polarization of waves.

Directivity

All antennas are directional to some extent (except for a hypothetical unipole). This statement means that an antenna used for transmitting will radiate most of its energy in certain directions; an antenna used for receiving will best receive signals from certain directions. The directional characteristics of an antenna are determined to a great extent by its design and the position in which it is installed. Thus certain directional qualities are associated with each type of antenna. Special tests are usually conducted to determine the characteristics of an antenna when it is designed; then the characteristics are plotted on a chart. (See figure 7-2). The information shown on the charts can be used to determine the best operational use for an antenna. An operator should be able to interpret and use these charts if they are available.

The directivity of an antenna is often referred to in terms of "beamwidth" which refers to the width of the directive lobes expressed in degrees of azimuth.

The following three terms are used to describe general directional qualities of an antenna:

OMNIDIRECTIONAL. Receives or radiates equally well in all directions except off the ends

BIDIRECTIONAL. Receives or radiates efficiently in two directions; for example, North and South or East and West

UNIDIRECTIONAL. Receives or radiates efficiently in only one direction

Frequency Coverage

Frequency coverage refers to the bandwidth in the r-f spectrum in which an antenna will

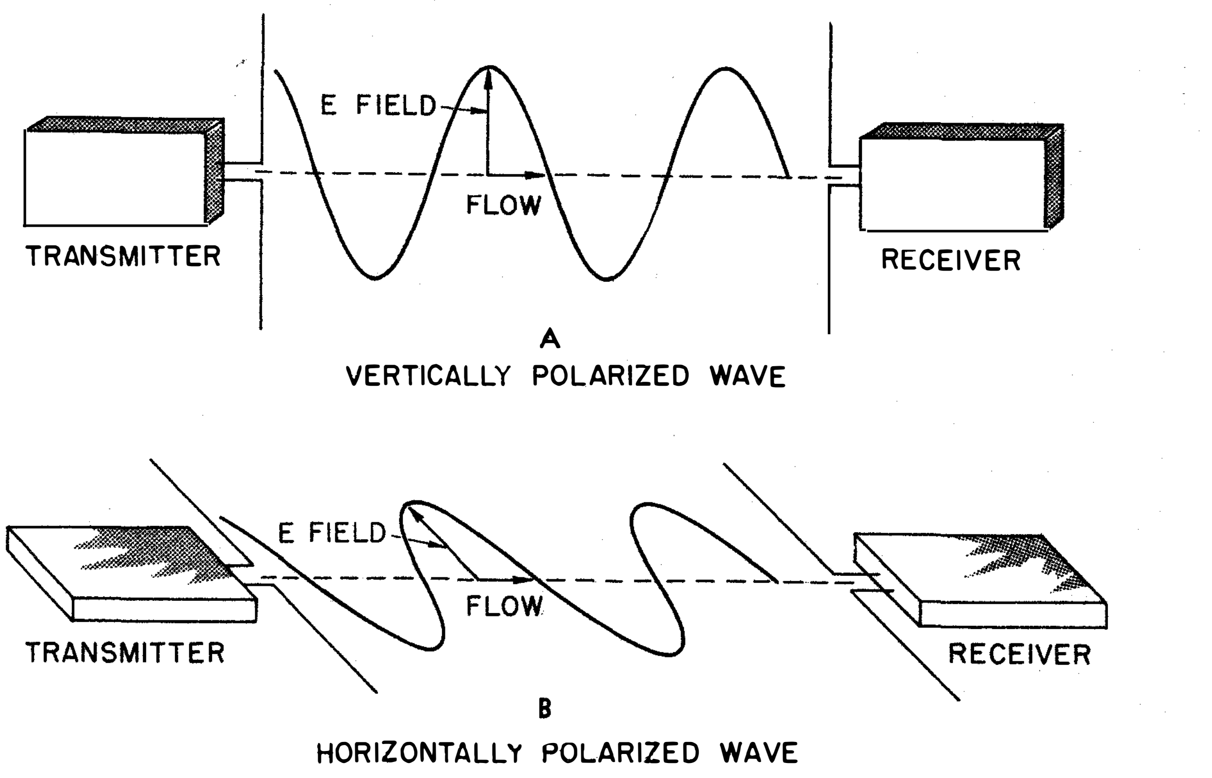
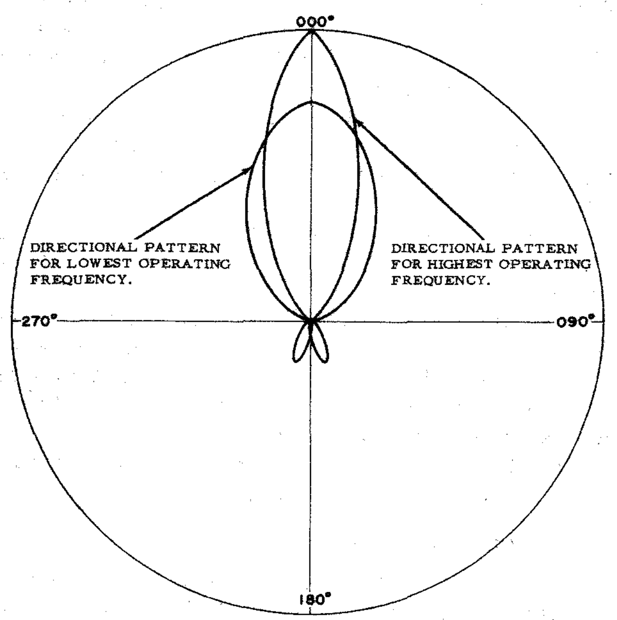


Figure 7-1.—Vertical and Horizontal polarization.



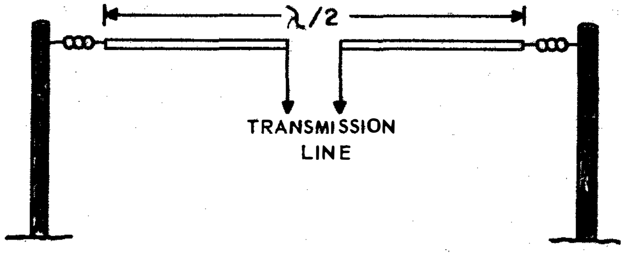
13.33
Figure 7-2.—Plot of directional characteristics of an antenna.

receive or radiate efficiently. Because some antennas operate efficiently over a wide frequency range, they are referred to as "broadband" antennas. Others operate efficiently over a very narrow frequency band; the basic half-wave and quarter-wave antennas are examples of this type.

BASIC TYPES OF ANTENNAS

Half-Wave

A basic form of antenna with a length of one-half wavelength or a multiple thereof is known as a dipole or Hertz antenna. (See figure 7-3.) This type of antenna will not function efficiently unless its length is one-half wavelength (or a multiple thereof) of the frequency to be radiated or received. Therefore, this antenna is not suitable when a wide range of frequencies is to be used. A distinguishing feature of a dipole antenna is that it need not be connected to the ground as are other antennas which will be described later. At low frequencies, half-wave antennas are rather long; therefore they are used primarily at shore installations where there is sufficient room. They can be connected to transmission lines either in the center or at the

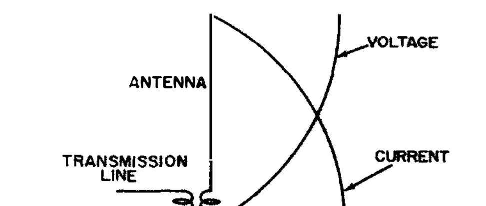


13.34
Figure 7-3.—Half-wave (Hertz) antenna.

ends and can be installed in either a vertical or horizontal position. The half-wave antenna is sometimes referred to by other terms which indicate its shape or electrical characteristics, such as doublet, end-fed, center-fed, etc.

Quarter-Wave

A grounded antenna which is one-fourth wavelength, or any odd multiple thereof, of the frequency to be radiated or received is known as a Marconi antenna. (See figure 7-4.) Notice that the transmission lines are connected between the bottom of the antenna and the ground. Although the antenna itself is only a quarter wavelength, the earth acts as another quarter-wave antenna—the image antenna shown in figure 7-4. Half-wave operation is obtained by aid of this image. This type of antenna can be used on planes and ships where the plane's fuselage



13.35
Figure 7-4.—Marconi antenna and waveforms of current and voltage.

or the ship's hull provides the image antenna. It is often practical to use a quarter-wave antenna where space is a problem.

There are many variations of the quarter- and the half-wave antenna as well as many different types designed for special use throughout the range of the radio frequency spectrum. They are often used as components of more complex antennas. Combinations of elements, electrically connected and physically spaced in the proper manner, can be used to obtain many desirable features. Such combinations of elements are called ARRAYS.

COMMON ANTENNA CONFIGURATIONS

Rhombic

The rhombic, an antenna frequently used at Naval Security Group receiver sites, consists essentially of four long wires, positioned in a diamond shape so that the major lobes are aligned in a common direction. The rhombics used at receiver sites are generally the terminated, unidirectional type. See figure 7-5. Because of its directive radiation pattern (fig. 7-5) the terminated rhombic is very useful for point-to-point communications.

The length of the rhombic legs determines its lowest efficient operating frequency. A rhombic may be used with good results over a frequency range ratio of 3 to 1. For best results, each leg should be at least two wavelengths at the lowest operating frequency. If, for example, the lowest desired operating frequency is 3000 kc, each of the four legs should be at least 656 feet long. If an antenna is two wavelengths at 3000 kc, it will be a greater number of wavelengths at a higher frequency; and the lobe position with relation to the leg axis will change. The change in lobe position with change in frequency means that the alignment of the lobes in a common direction will be more effective at some frequencies than at others.

The azimuth directivity patterns in figure 7-6 show the major lobe and the minor lobes for a typical frequency of a rhombic. Note that the antenna receives signals with fair ability in the directions favored by the minor lobes. Note also that there are spots between lobes where the sensitivity of the antenna falls to almost zero.

If an antenna patchboard bears a label that an antenna is a 000-degree rhombic, it means that the rhombic connected to that patch socket has the center of its major lobe oriented at 000 degrees. There is no indication of the width of that major lobe, and no bearings of the minor lobes and nulls are given.

An operator must keep directivity patterns in mind when selecting a rhombic antenna. For example, imagine that figure 7-6 is the directivity pattern for two rhombic antennas which are

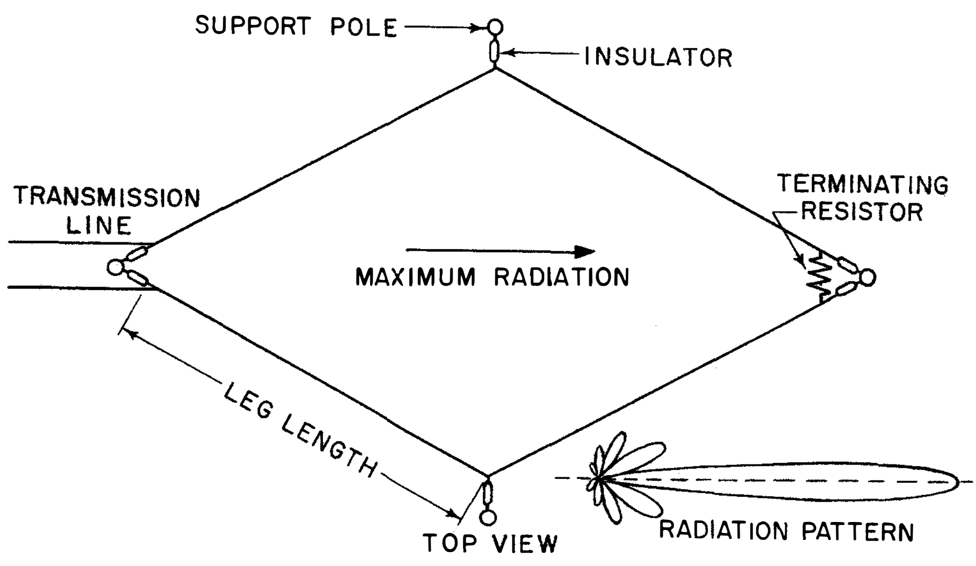


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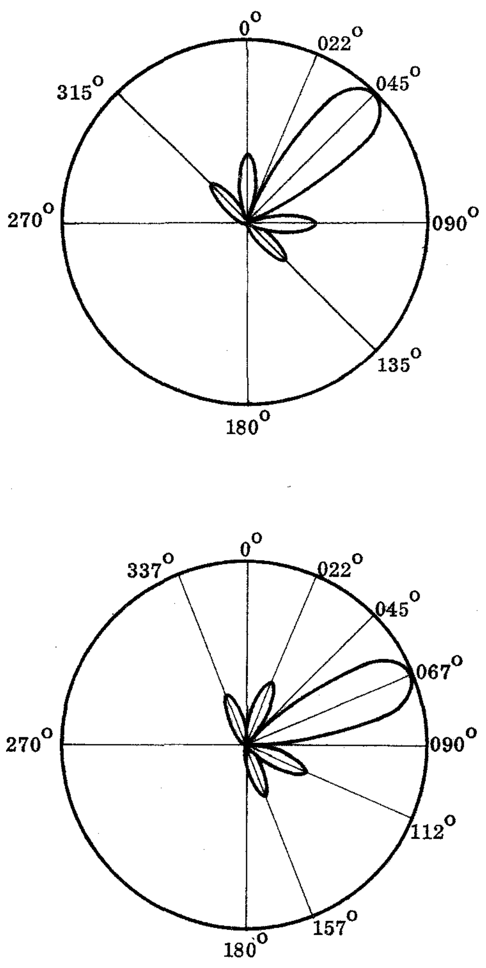
Figure 7-5.—Typical rhombic antenna.

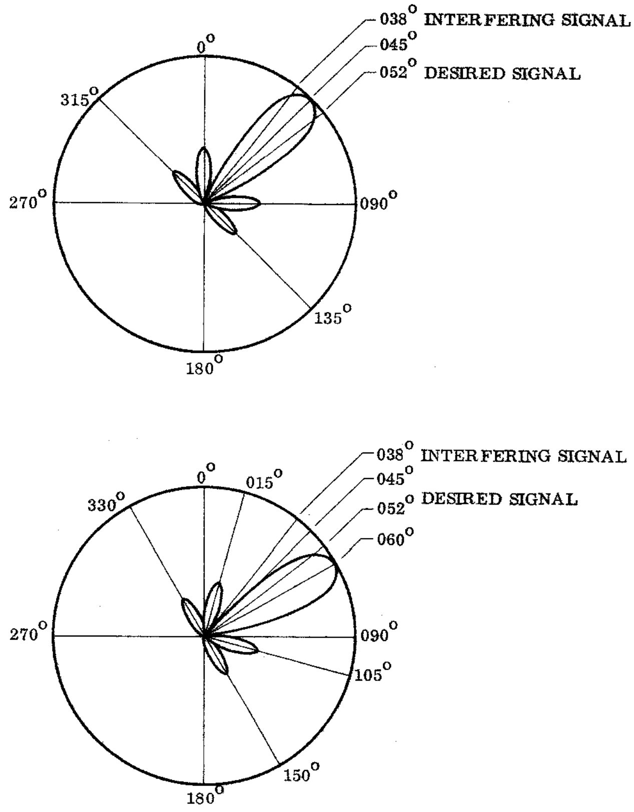


34.4

Figure 7-6.—Directivity patterns of two rhombic antennas.

available to an operator in copying a transmitting station bearing 022 degrees from the receiver site. The operator has available for use one rhombic at 045 degrees and one rhombic at 067 degrees. It would be incorrect for the operator to assume that the 045-degree antenna, the antenna with its major lobe closest to the desired direction, would be the better of the two antennas for reception of the transmitted signal. Note from the two polar diagrams that the 045 antenna has a sharp and definite null at 022 degrees, whereas the 067 antenna has a minor lobe that peaks at 022 degrees. The ability of the 067-degree antenna to receive the 022-degree signal will be much greater than the 045-degree antenna because of the positioning of the minor lobe of the former and the null of the latter.

The null points of an antenna can be used by an alert operator to attenuate unwanted interfering signals. Referring to figure 7-7, assume that an operator is copying a signal on 052 degrees using a directional antenna oriented at 045 degrees. The operator is encountering severe interference from a signal that is bearing 038 degrees from the receiver site. Note that both these signals are within the major lobe receiving plot of the 045 antenna. If the operator shifts to a 060 antenna, the desired signal will still be within the major lobe area of the antenna, but the interfering signal will be greatly reduced in strength because it is positioned in the null point in the directivity pattern of the 060-degree antenna. Proper choice of receiving antennas can often reduce the level of an interfering



34.5

Figure 7-7.—Using nulls to attenuate interfering signals.

signal to the point where copy of an otherwise uncopiable signal is possible.

The relative position of the minor lobes of an antenna is related to the wavelength of the antenna. Therefore, with an antenna of fixed dimensions, changing frequency will shift the relative positions of the minor lobes and the nulls. The major lobe, although it may narrow or broaden with change in frequency, will remain at the same bearing throughout the operating frequency range of the antenna. An operator in selecting an antenna for the strongest signal of the transmitting station, or the best antenna to attenuate an interfering signal, must experiment with several antennas oriented in the general desired direction. The best method of choosing the proper antenna is to listen to the transmitting station while changing antennas.

Multi-Wire Rhombic

A rhombic antenna will improve in performance if more than a single wire is used to form each leg. By using three wires (see figure 7-8) to form each leg and connecting all of them at both ends to a common point, but spacing them vertically 5 to 7 feet apart at the side poles, an improved antenna known as a "curtain rhombic" is formed. Advantages of the multi-wire or curtain rhombic over the single-wire rhombic are: (1) the impedance of the antenna is held at a more constant value over a given range of frequencies, (2) the value of impedance is reduced somewhat so that a better impedance match to an ordinary two-wire line is possible, (3) the signal-to-noise ratio will be improved, (4) there will be a slight increase in signal gain, and (5) there will also be a reduction in interference caused by rain (precipitation static).

Sleeve Antenna

The sleeve antenna, a high-frequency antenna, is capable of operating over a wide range of frequencies as a broad-band antenna. Originally it was developed to fill the need for a versatile antenna at shore stations, but it has been modified for shipboard use also. Figure 7-9 is a shore station version of a sleeve antenna. The shipboard sleeve antenna is shown in figure 7-10.

Sleeve antennas are especially helpful in reducing the total number of conventional narrow-band antennas that otherwise would be required to meet the requirements of shore stations. By using multicouplers (discussed later in this chapter) one sleeve antenna can serve several receivers operating over a wide range of frequencies. This feature also makes the sleeve antenna ideal for small antenna sites.

Wire Antennas

For some applications ashore, especially in VLF and LF transmissions, it is practical to use an antenna that is simply a long wire with one end connected to the equipment. A long-wire antenna will usually be stretched between poles in such a manner that the wire is essentially parallel to the surface of the earth. (See figure 7-11). Long single-wire antennas are constructed several wavelengths long; in some cases in the VLF band, the antenna may extend several miles. If a long-wire antenna is five or more wavelengths, the antenna will be quite

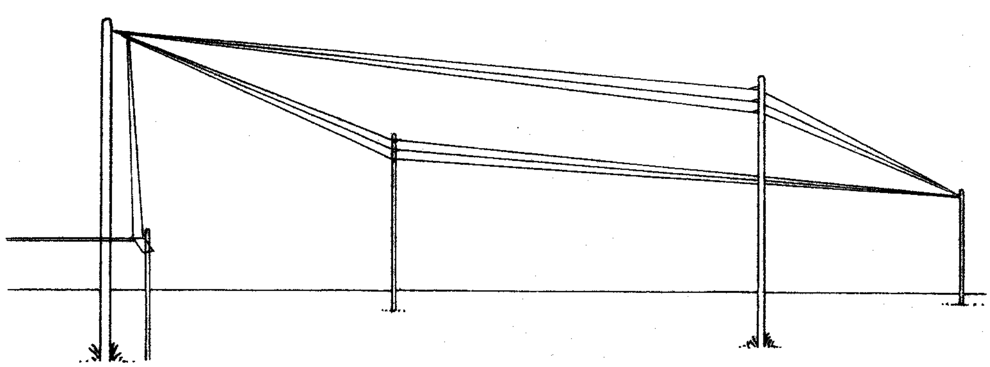


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Figure 7-8.—Three-wire rhombic antenna.

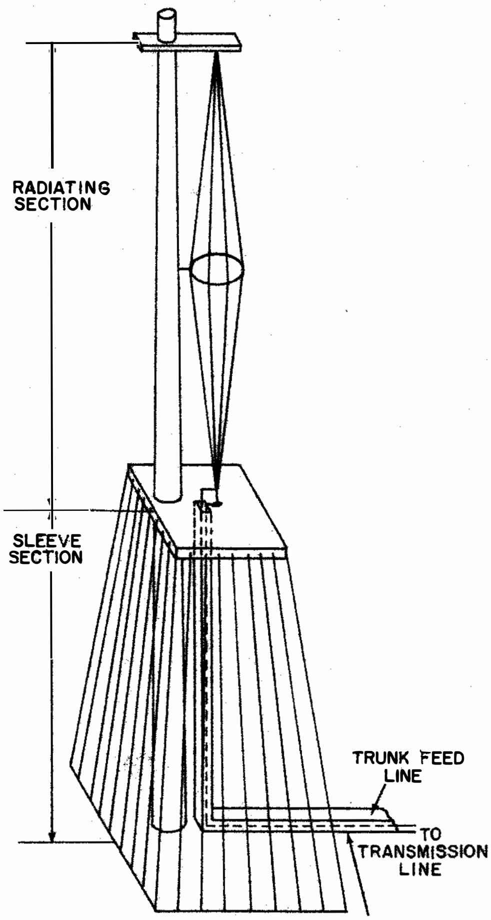

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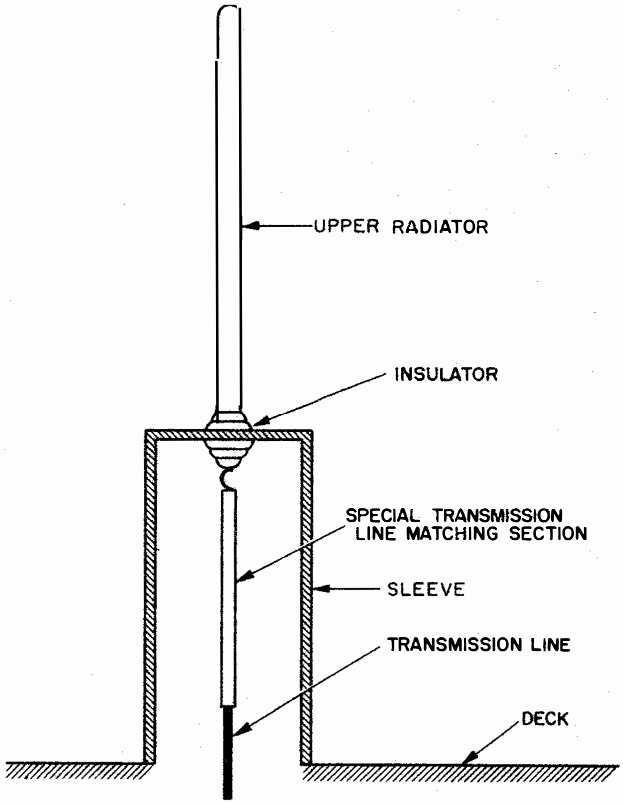
Figure 7-9.—Sleeve antenna (shore station).



25.217
Figure 7-10.—Sleeve antenna (shipboard).

directional along its axis. The longer the antenna in wavelengths, the more directional it will be along its axis.

Wire antennas are installed on board ship for medium- and high-frequency coverage. Normally, they are not cut for a given frequency. Instead, a wire rope is strung either vertically or horizontally from a yardarm (or the mast itself) to outriggers, another mast, or to the superstructure. If used for transmitting, the wire antenna is tuned electrically to the desired frequency.

Much larger wire is used for shipboard antennas than for land installations. The larger wire is less likely to break under the strain of shipboard vibrations and, in addition, can be stretched tighter to avoid sagging in hot weather. The wire is twisted and stranded for additional strength.

The metal rings, antenna knife switches, antenna hardware, and accessories associated with transmitting antennas are painted red. Hardware and accessories used with receiving antennas are painted blue. This color scheme is a safety precaution in that it shows at a glance, whether an antenna is used for radiating or receiving.

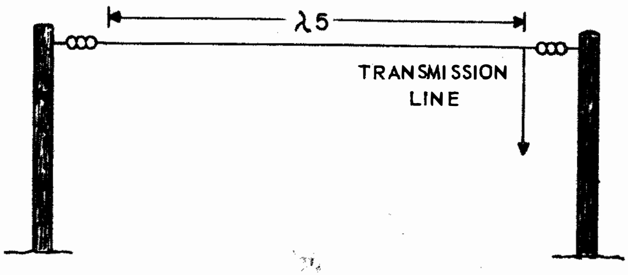


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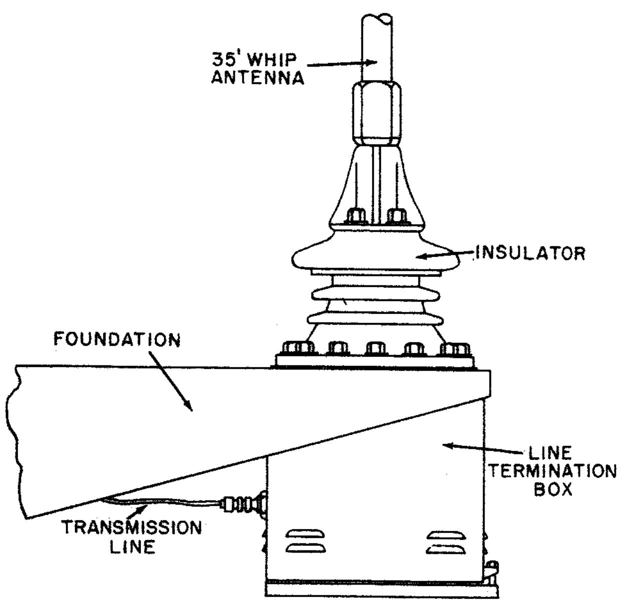
Figure 7-11.—Long-wire antenna.

Whip Antennas

Whip-type antennas have replaced many wire antennas aboard ship because they are essentially self supporting, may be deck-mounted, or mounted on brackets on the stacks or superstructure (fig. 7-12). The physical characteristics of tiltable whips for use along the edges of aircraft carrier flight decks and retractable whips for use aboard submarines are two more advantages of the whip antenna for shipboard use.



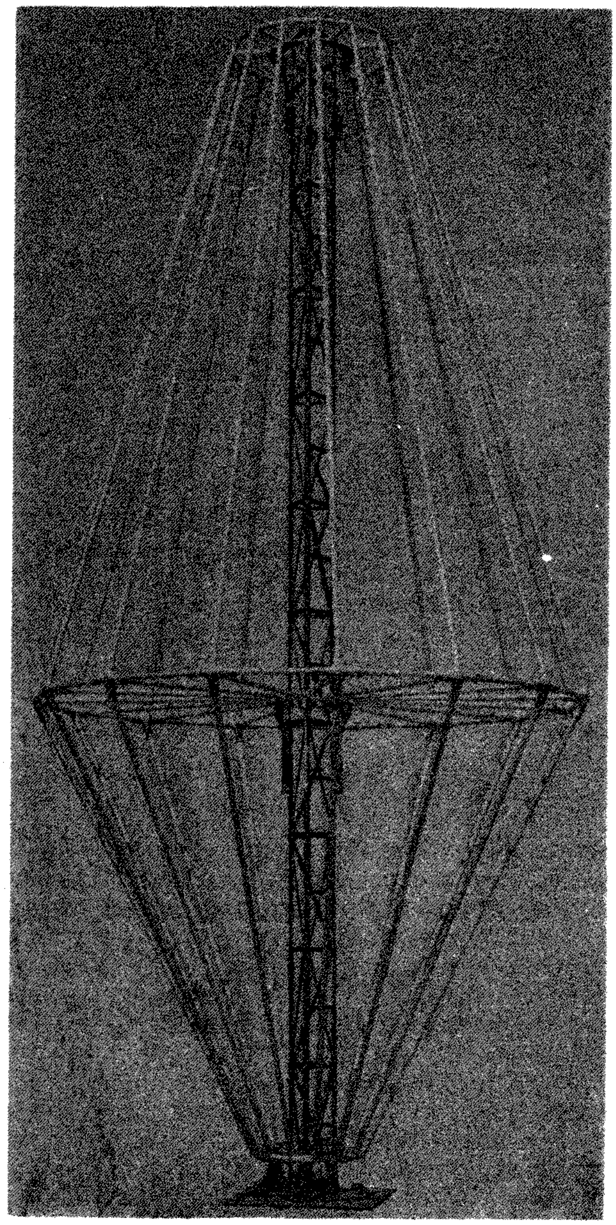
1.47
Figure 7-12.—Whip antenna.

One disadvantage of whip antennas aboard ship is that space limitations usually prohibit the installation of antennas that are long enough to be resonant at the low and medium frequencies. This lack of proper length results in decreased radiation because less wire is carrying the high current that produces radiation. One method of compensating for antennas that are physically short is to add an inductance (called a loading coil) at the base of the antenna. Inductance has the effect of increasing the antenna's electrical length. If the antenna must be used over a wide frequency range, a large variable capacitor is placed in series with the loading coil. The capacitor has the effect of shortening the antenna. The combination of the loading coil and the capacitor permits the antenna to be tuned to resonance over a wider frequency range.

Because of their physical length, whip antennas are also useful with portable and mobile communications equipment; e.g., walkie-talkies and police cars.

Conical Monopole Antenna

Another broad-band antenna that is used extensively is the conical monopole shown in figure 7-13. Like the sleeve antenna, it is used both ashore and aboard ship.

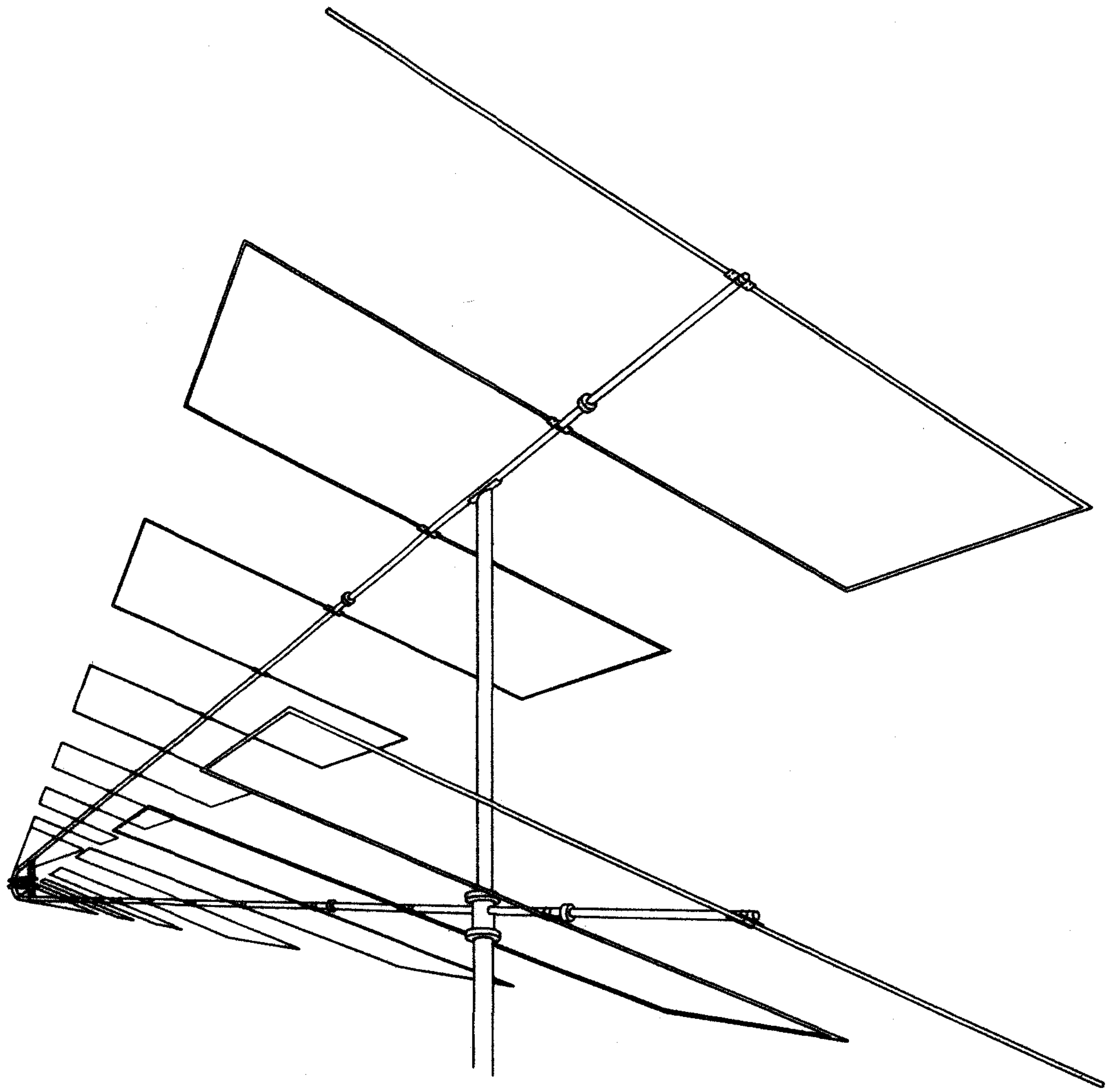


25.214
Figure 7-13.—Conical monopole antenna.

When operating at frequencies near the lower limit of the high-frequency band, the conical radiates in much the same manner as a regular vertical antenna. At the higher frequencies the lower cone section radiates, and the effect of the top section is to push the signal out at a low angle. The low angle of radiation causes the skywave to return to the earth at great distances from the antenna. Hence, the conical monopole antenna is well suited for long-distance communication in the high-frequency range.

Log-Periodic Antenna

A requirement has existed in the HF and VHF bands, as well as other frequency bands, for an antenna which will operate over an extremely wide frequency range. Recently, types of LOGARITHMICALLY PERIODIC ANTENNAS (LPA) have been developed. These antennas are of a general class whose structure (figure 7-14) is such that the directivity pattern will vary periodically with the logarithm of the frequency. If the variations over one period are small, and



93.26

Figure 7-14.—Log-periodic antenna.

continue to be small for all periods, the result will be an extremely broad-band antenna.

Figure 7-14 shows a typical LPA designed for extremely broad-band, VHF communications. The radiation patterns and impedance characteristics are essentially independent of frequency. An LPA is unidirectional and will provide an average gain of 8 db over a frequency range in a ratio of approximately 10 to 1. A typical frequency range would be from 30-300 mc, where the low frequency limit of the antenna occurs when the longest transverse element is approximately one-half wavelength. The high frequency limit is obtained when the shortest transverse element is approximately one-quarter wavelength. The LPA can be mounted on steel towers or utility poles that incorporate rotating mechanisms and is particularly useful where antenna area is limited. A rotating LPA is known as an RLPA.

OTHER TYPES OF ANTENNAS

Dummy Antennas

Under radio silence conditions, placing a carrier on the air during transmitter tuning would give an enemy the opportunity to take direction-finding bearings and determine the location of the ship.

Even though radio silence is not imposed, DNC 5 directs that transmitters be tuned by methods that do not require radiation from the antenna, in order to minimize interference to other stations using the circuit.

One way to tune a transmitter without causing unwanted radiation is through use of previously determined and recorded calibration settings for the tuning controls.

Another method is the use of a dummy antenna. Dummy antennas (called dummy loads) have resistors that dissipate the r-f energy in the form of heat and prevent radiation by the transmitter during the tuning operation.

One model, typical of most dummy loads, is the DA-91/U (fig. 7-15), which can be used with transmitters up to 500 watts. It is enclosed in a metal case that has fins to increase its air-cooled surface area. The dummy load, instead of the antenna, is connected to the output of the transmitter, and the normal transmitter tuning procedure is followed.

Some Navy Transmitters, such as the AN/WRT-2, have built-in dummy antennas. This arrangement permits connection of either the dummy antenna or the actual antenna by simply throwing a switch.

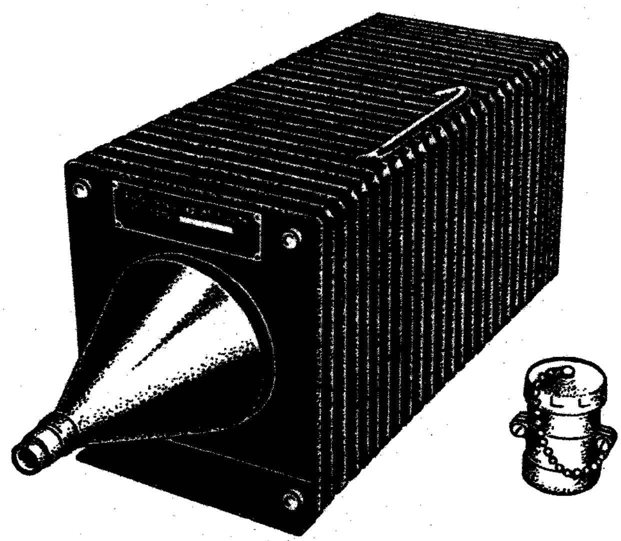


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Figure 7-15.—Dummy antenna, DA 91/U.

Emergency Antennas

Loss or damage to an antenna from heavy seas, violent winds, or enemy action may cause serious disruption of communications. Sections of a whip antenna may be carried away, insulators may be damaged, or a wire antenna may snap loose from its moorings, or break. If loss or damage should happen when all available equipment is needed, you may have to rig an emergency antenna (or at least assist) to restore communications on a temporary basis until the regular antenna can be repaired.

The simplest emergency antenna consists of a length of wire rope to which a high-voltage insulator is attached to one end and a heavy alligator clip or lug is soldered to the other. The end with the insulator is hoisted to the nearest structure and secured. The end with the alligator clip (or lug) is attached to the equipment transmission line. To radiate effectively, the antenna must be sufficiently clear of all grounded objects.

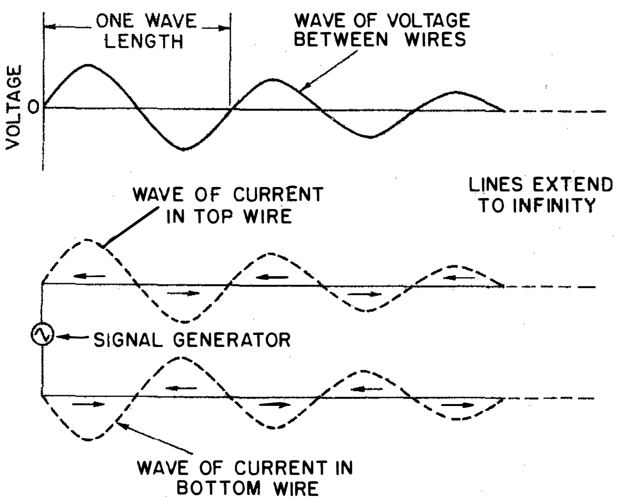
TRANSMISSION LINES

Two basic elements in every receiving system are the antenna and the receiver. In most instances the two elements are physically separated. A third element is required—a transmission line to carry the energy from antenna to the receiver. Efficient coupling between the antenna and the receiver is necessary to minimize loss of energy.

There are some losses associated with every type of transmission line. Any loss is undesirable because it tends to reduce the signal-to-noise ratio. Losses can be reduced to a certain extent by keeping the lines as short as possible; however, reducing the length of a transmission line does not minimize all losses. If there is a mismatch between the electrical characteristics of an antenna and a transmission line, a phenomenon called STANDING WAVES develops.

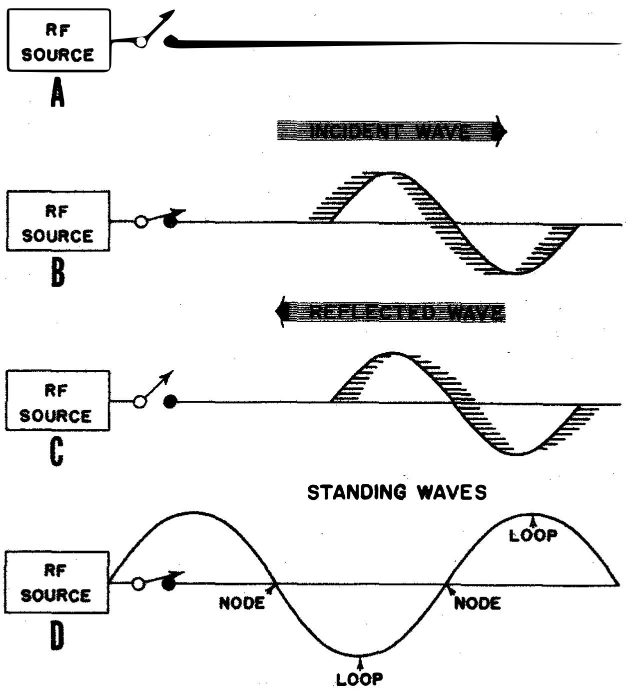
TRAVELING AND STANDING WAVES

Assume that a source of r-f energy is connected to an infinitely long conductor. (See figure 7-16) A current with its associated field



20.225
Figure 7-16.—Traveling waves of current and voltage on a line of infinite length.

begins to move down the length of that conductor in the form of waves of energy. As the line is of infinite length, the waves of energy continue to travel in the direction indicated. The energy moving in this manner is appropriately referred to as TRAVELING WAVES. Actually, the amplitude of the traveling waves is reduced as the wave moves away from the r-f source. This is true because the conductor has resistance which absorbs some of the energy as it travels. In practice, there is no such thing as an infinitely long line; however, it is possible to design the transmission line so that, to the traveling waves, it "appears" to be infinitely long. Now assume that a conductor of finite length is connected through a switch to an r-f generator. (See figure 7-17A.)



93.24
Figure 7-17.—Standing waves on a conductor.

If the switch is closed for a time equal to the period of the wave of energy and then opened, one cycle of energy is sent down the line to the far end. (See figure 7-17B.) This wave is called the incident wave. When the energy reaches the end of the conductor, it can go no farther because there is no path for current flow beyond this point. As a result, the energy stops abruptly, and the magnetic fields associated with the energy then collapse. The collapsing fields induce a voltage which causes current to flow back toward the r-f source. Thus, a reflected wave is caused to move back along the conductor. (See figure 7-17C.)

If the switch connecting the r-f source to the conductor is kept closed, then a condition exists in which energy is traveling in opposite directions at the same time. If the incident waves and the reflected waves are added together, the result is a wave that does not travel. Such waves are called STANDING WAVES. The points of maximum standing-wave amplitude are called LOOPS while the points of zero standing-wave amplitude are called NODES. (See figure 7-17D).

Although standing waves on electrical conductors are not visible, it is possible to see standing waves in mechanical systems. By tying one end of a line to an upright stanchion or post (see figure 7-18) and by moving the other end of the line up and down one time, a mechanical wave is sent down the line toward the tied end. When the mechanical wave reaches the tied end of the line, the wave reverses its direction and travels back toward the untied end. If the loose or untied end of the line is moved up and down rapidly and at the right frequency, standing waves will be seen. Sections of the line will oscillate violently while other sections hardly move at all. Those sections of the line where maximum movement occurs are the loops of the standing waves; those portions where little or no movement occurs are the nodes of the standing waves. These waves have been produced by mechanical waves moving in opposite directions through a single conductor.

To understand how standing waves are eliminated in a finite transmission line it is necessary to understand CHARACTERISTIC IMPEDANCE.

CHARACTERISTIC IMPEDANCE

In a conventional circuit which contains inductors and capacitors, the inductance and capacitance are present in very definite quantities or "lumps". In an r-f transmission line, however, these quantities are distributed throughout the length of the entire line and cannot be separated from each other.

The characteristic impedance of a transmission line having infinite length is the impedance in ohms at the operating frequency, presented

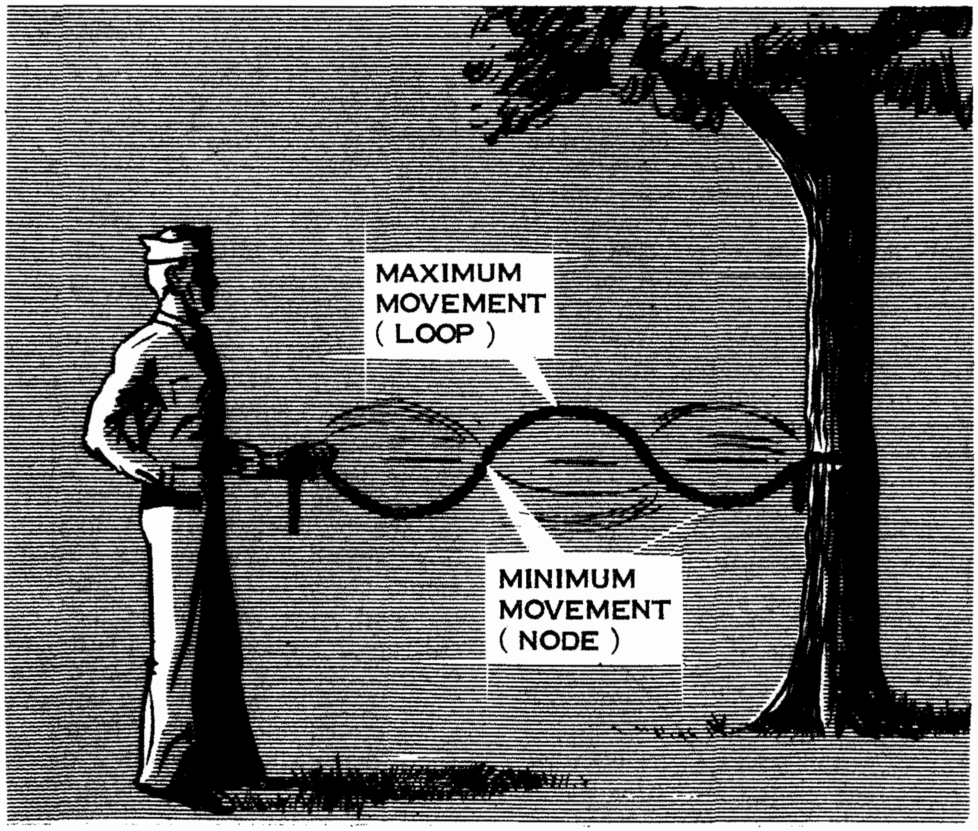


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Figure 7-18.—Standing waves on a line.

by the line to the source feeding the line. Knowledge of the characteristic impedance across the input of an infinite line can be put to very valuable use. As was shown in the preceding section on standing waves, there are no standing waves present on an infinite line. ANY LENGTH OF LINE CAN BE MADE TO APPEAR LIKE AN INFINITE LINE IF IT IS TERMINATED IN ITS CHARACTERISTIC IMPEDANCE. Devices used for this purpose are called MATCHING DEVICES. Some matching devices provide external controls so that an operator can check the STANDING WAVE RATIO (SWR) or the VOLTAGE STANDING WAVE RATIO (VSWR). By adjusting external controls on the device, the operator can keep the standing wave ratio at a minimum value, thus providing maximum efficiency.

NONRESONANT LINES

A nonresonant line can be defined as a line which has no standing waves of current and voltage. Such a line is terminated in its characteristic impedance. Because there are no reflections, all of the energy passed along the line is absorbed by the load (receiver or antenna as the case may be), except for the small amount of energy dissipated by the line. The voltage and current waves are traveling waves that move in phase with each other from the source to the load.

On lines carrying radio frequencies, the characteristic impedance is almost always pure resistance. Therefore, it is customary to say that a nonresonant line is terminated in a resistive load equal to its characteristic impedance.

RESONANT LINES

A resonant transmission line is one which has standing waves of current and voltage. The line is not terminated in its characteristic impedance; therefore, reflections are present.

A resonant line, like a tuned circuit, is resonant at some particular frequency. The resonant line will present to its source of energy a high or a low resistive impedance at multiples of a quarter-wavelength. Whether the impedance is high or low at these points depends on whether the line is short- or open-circuited at the output end. At points that are not exact multiples of a quarter-wavelength, the line acts as a capacitor or an inductor.

TYPES OF TRANSMISSION LINES

Parallel Two-Wire Line

Two conductors, running side by side with insulating spacers to keep them separated and parallel form a parallel two-wire line. They are easy to construct, have good operating efficiency, and are economical. The principal disadvantage of this type of line is that it has high radiation losses and therefore cannot be used at the higher frequencies in the vicinity of metal objects. They are most often used in applications involving frequencies in the HF band and below. One notable exception is the two-wire ribbon-type line which has VHF applications. You will recognize this as the familiar antenna lead-in wire used for most television sets. Refer to figure 7-19 for diagrams of each type of transmission line discussed in this section.

Twisted Pair

The twisted pair, as the name implies, consists of two insulated wires twisted to form a flexible line without the use of spacers. This type line is generally used for low-frequency applications over very short distances. It is not suitable for use at the higher frequencies because of the high losses incurred. Its chief advantages are that it is easy to construct, it is economical, and it may be used where more efficient lines would not be feasible because of mechanical considerations.

Shielded Pair

The shielded pair consists of two parallel conductors separated from each other and surrounded by an insulating dielectric material. The conductors are contained within a copper-braid tubing which acts as a shield for them. This type line is normally used for applications in the HF band and below. Its primary advantage is that the shield prevents radiation from the lines and prevents pickup of undesired radiations. The principal advantage of the shielded pair is that the two conductors are balanced to ground; that is, the capacitance between each conductor and ground is uniform the entire length of the line, and the wires are shielded against pickup of stray fields. This balance is effected by the grounded shield that surrounds the conductors at a uniform spacing throughout their length.

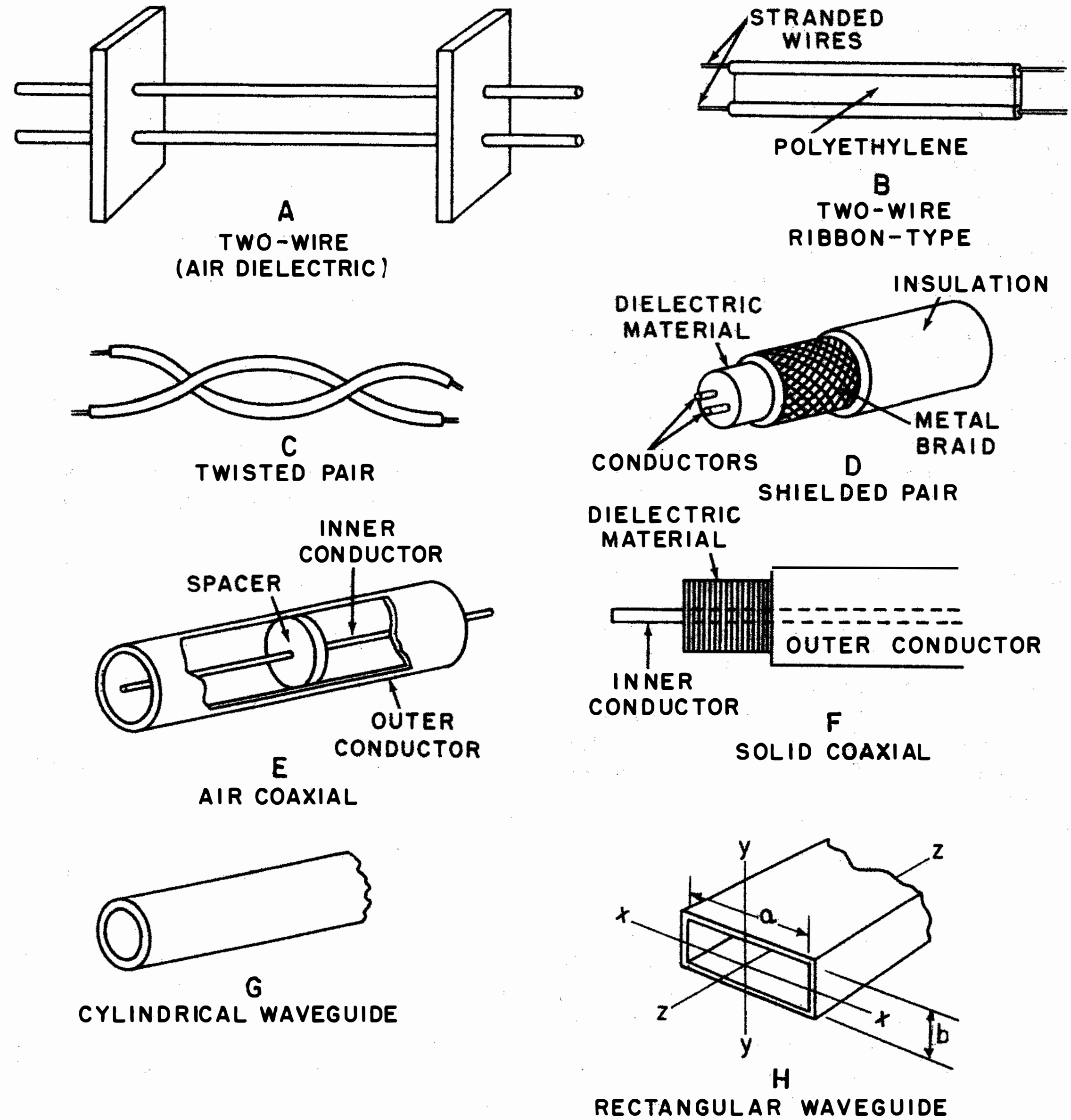

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Figure 7-19.—Types of transmission lines.

Coaxial Lines

There are two general types of coaxial lines: one uses air as a dielectric between the two wires; the other uses a solid insulating dielectric. One conductor (usually the outer) is grounded to eliminate radiation. Coaxial lines operate efficiently for frequencies up to approximately 1500 mc.

AIR COAXIAL.—The air coaxial line consists of a wire mounted inside of, and coaxially with, a tubular outer conductor. In some cases the inner conductor also is tubular. The inner conductor is insulated from the outer conductor by insulating spacers or beads at regular intervals. The spacers are made of pyrex, polystyrene, or some other material possessing good insulating qualities and having low loss at high frequencies. The chief advantage of the air coaxial line, which makes it practical for operation at ultrahigh frequencies, is its ability to keep down radiation losses. In the two-wire parallel line the electric and magnetic fields extend into space for relatively great distances and tend to cause radiation losses and noise pickup from other lines. In a coaxial line, however, no electric or magnetic fields extend beyond the outside conductor. They are confined to the space between the two conductors. Thus, the coaxial line is a perfectly shielded line. The disadvantages of such a line are: (1) it is expensive; (2) at extremely high frequencies, its practical length is limited because of the considerable loss that occurs; and (3) it must be kept dry in order to prevent excessive leakage between the conductors. To prevent condensation of moisture, the line may be filled with dry nitrogen gas at pressures ranging from 3 to 35 pounds per square inch above normal atmospheric pressure.

SOLID COAXIAL.—The solid coaxial line is probably the most commonly used type of transmission line. It consists of a center conductor surrounded by a tubular outer conductor. A solid dielectric material insulates the two conductors from each other. This type of line is suitable for use up to frequencies in the lower portion of the UHF band. At higher frequencies they become less efficient due to high losses incurred in the insulating material.

Waveguide

The term "waveguide," as used in connection with transmission lines, refers to a hollow metal tube which may be either circular or rectangular in cross section. The waveguide is a very effective conductor at frequencies in the UHF band and above. Just as a speaking tube prevents voice waves from spreading and from becoming weaker, a waveguide channels

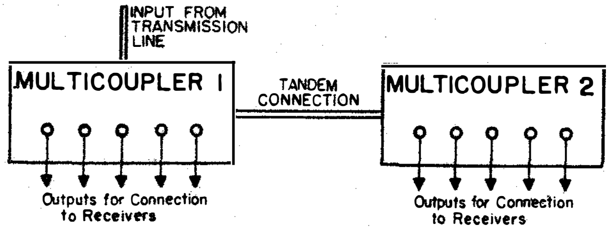

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Figure 7-20.—Multicouplers connected in tandem.

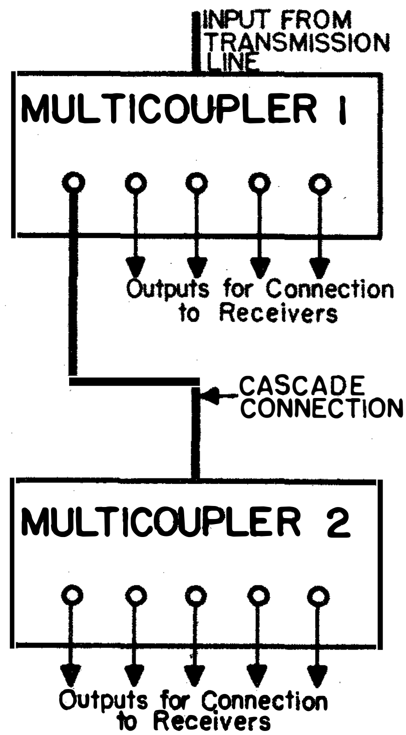

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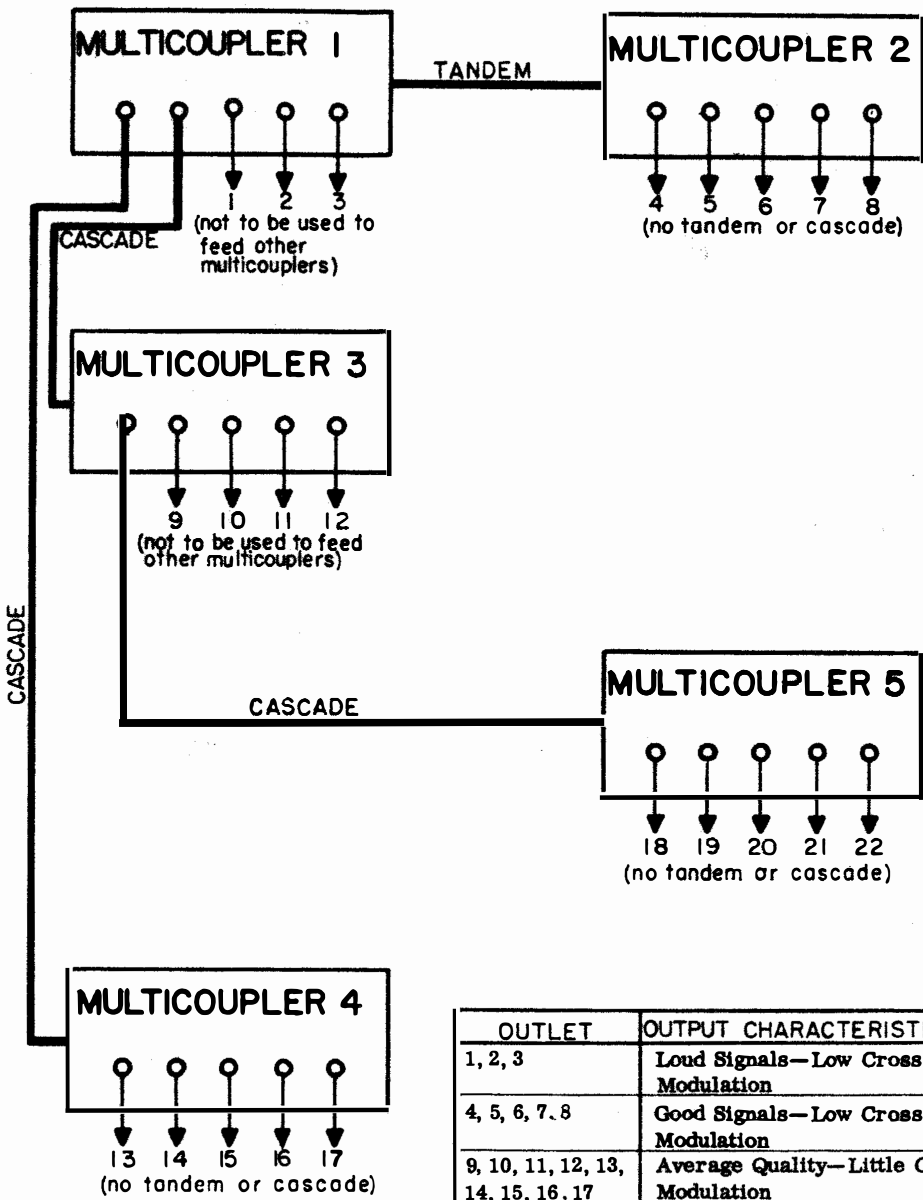
Figure 7-21.—Multicouplers connected in cascade.

the electromagnetic waves, reducing attenuation and preventing radiation until the waves are delivered to its end. Waveguides are widely used as transmission lines in modern radars. The physical dimensions of a waveguide are predetermined by the wavelengths of the frequencies which are to be conducted. Waveguides are not used for the lower frequencies because they would be too large for practical applications.

MULTICOUPLERS

Optimum performance of communication receivers can be achieved only by connecting the individual receivers to separate antennas. Because of the increasing number of receivers installed at each communications site, it is impractical, if not impossible, to provide a separate antenna for each receiving system. One satisfactory approach to the problem has been the development of multicouplers.

Multicouplers are devices used extensively at receiving sites to allow several receivers to operate simultaneously from one antenna. They



OUTLET	OUTPUT CHARACTERISTICS
1, 2, 3	Loud Signals—Low Cross Modulation
4, 5, 6, 7, 8	Good Signals—Low Cross Modulation
9, 10, 11, 12, 13, 14, 15, 16, 17	Average Quality—Little Cross Modulation
18, 19, 20, 21, 22	Compromised Quality but satisfactory for some signals

13.49

Figure 7-22.—Multicoupler connections showing graduated quality of outputs.

are designed to provide the best possible coupling between antennas and receivers and at the same time isolate the receivers from each other. There is some loss of signal quality in multicouplers, and interference between receivers can not be completely overcome. ("Signal quality" is a term used to describe the overall usefulness of a signal and encompasses such properties as signal-to-noise ratio and distortion.) In some cases it is necessary to bypass multicouplers and use only one receiver with an antenna. Such cases exist when there are several signals operating on or near the same frequency and when complex modulation systems are used. Multicouplers also are usually designed to operate efficiently over a fixed frequency range and to have a relatively sharp cutoff above and below this range. Therefore it is important to know the operating frequency range of multicouplers in order to use them efficiently.

Multicouplers can be connected so that a large number of receivers can be fed from a single antenna. The two types of connections are known as TANDEM and CASCADE connections.

A TANDEM connection is one in which multicouplers are connected in series, using a special connection provided for this purpose. Figure 7-20 shows a tandem connection.

A CASCADE connection is one in which a normal output of one multicoupler is used as the input to second multicoupler. See figure 7-21 for an illustration of a cascade connection.

One important consideration regarding the use of tandem and cascade connections is that, as additional connections are added, there is a gradual decrease in the quality of the outputs. Because received signals are of various strengths and qualities, receiving facilities of higher capabilities are required for weak signals. Thus it is necessary to limit the number of receivers used with one antenna. If tandem or cascade multicoupler connections are properly made, a graduated quality of outputs can be obtained and used. Figure 7-22 shows an arrangement which might be used. Note that multicoupler number 1 provides the highest quality outputs, with multicouplers 2, 3, 4, and 5 providing outputs of lowering quality as additional connections are added.

CHAPTER 8

RADIO COMMUNICATION EQUIPMENT

A well-rounded knowledge of present-day communication equipments is essential to the CT "O brancher" if he is to be efficient in performing all duties to which he is assigned. Communication equipment today is becoming increasingly more complex and although the "O brancher" is not required to qualify as a specialist in electronics, he must be familiar with the designating systems, principles of operation, and capabilities of the equipment he operates.

EQUIPMENT DESIGNATING SYSTEMS

A nameplate on the front of each item of electronic equipment carries a group of letters and numbers to identify the equipment. This group is assigned in accordance with either the Joint Electronics Type Designation System (commonly called AN nomenclature system) or the Navy Model System, depending upon the relative age of the equipment. Most new electronic equipment procured for the Navy, Army, Air Force, Marine Corps, and Coast Guard is assigned model letters under the Joint Electronics Type Designation System.

JOINT ELECTRONICS TYPE DESIGNATION SYSTEM

The first two letters of the Joint Electronics Type Designation System are AN. This is the system indicator. It does not mean that all the services use the equipment, but only that the type number was assigned under the AN system. The AN is followed by a slant sign and three identifying letters. The letters to the right of the slant sign are very important, for they give a brief description of the equipment:

FIRST LETTER—Where installed; whether designed for use in aircraft, submarine, surface craft, shore station, etc.

SECOND LETTER—Type of equipment; radio, radar, sonar, visual, etc.

THIRD LETTER—Purpose of the equipment; communications, direction-finding, receiving, transmitting, etc.

The three equipment indicator letters are followed by the model number, and the model number may be followed by additional letters to indicate a modification of the original equipment.

For an example, take the equipment designation AN/FRT-39. The AN is the system indicator. A glance at table 8-1 gives us the meaning of the equipment indicator letters:

F—Fixed
R—Radio.
T—Transmitting.

The figure 39 is the model number.

NAVY MODEL SYSTEM

The AN nomenclature system was adopted by the Navy in 1946, but you may still find equipment marked and identified by the older Navy Model System.

The assignment of Navy model letters to electronic equipment depends on the primary function of the equipment, such as receiving, transmitting, direction-finding, etc. In this system only the first letter (in a few instances, the first two letters) indicates the basic purpose of the equipment. The remaining letters were assigned in alphabetical sequence as newer equipments were designed. Some first letters you will find on equipment nameplates are:

D—Radio direction-finding
FS—Frequency shift keying.
L—Precision calibrating (such as frequency meters).
R—Radio receiving.

Table 8-1.—Equipment Indicator Letters, a Nomenclature System.

1st letter (designed installation classes)	2d letter (type of equipment)	3d letter (purpose)
INSTALLATION	TYPE OF EQUIPMENT	PURPOSE
A—Airborne (installed and operated in aircraft). B—Underwater mobile, submarine. C—Air transportable (inactivated). D—Pilotless carrier. F—Fixed. G—Ground, general ground use. K—Amphibious. M—Ground, mobile (installed as operating unit in a vehicle which has no function besides transporting the equipment). P—Pack or portable (animal or man). S—Water surface craft. T—Ground, transportable. U—General utility (includes two or more general installation classes, airborne, shipboard, and ground). V—Ground, vehicular (installed in vehicle designed for functions other than carrying electronic equipment, etc., such as tanks). W—Water surface and underwater.	A—Invisible light, heat radiation. B—Pigeon. C—Carrier. D—Radiac. E—Nupac (nuclear protection and control). F—Photographic. G—Telegraph or teletype. I—Interphone and public address J—Electromechanical (not otherwise covered). K—Telemetering. L—Countermeasures. M—Meteorological. N—Sound in air. P—Radar. Q—Sonar and underwater sound. R—Radio. S—Special types, magnetic, etc., or combinations of types. T—Telephone (wire). V—Visual and visible light. W—Armament (peculiar to armament, not otherwise covered). X—Facsimile or television. Y—Data Processing.	A—Auxiliary assemblies (not complete operating sets). B—Bombing. C—Communications (receiving and transmitting). D—Direction finder and/or reconnaissance. E—Ejection and/or release. G—Fire control or searchlight H—Recording and/or reproducing (graphic, meteorological, and sound). K—Computing. L—Searchlight control (inactivated; use G). M—Maintenance and test assemblies (including tools). N—Navigational aids (including altimeters, beacons, compasses, racons, depth sounding, approach, and landing). P—Reproducing (inactivated). Q—Special, or combination of purposes. R—Receiving, passive detecting. S—Detecting and/or range and bearing. T—Transmitting. W—Control. X—Identification and recognition.

T—Radio transmitting (includes combination transmitting and receiving).

In the list you can see that the letter R means radio receiving. The first receiver designated under the system was RA, RB the second, and so on. When the alphabet was exhausted, 3-letter designators were used. For example, RAA followed RZ, then RAB followed RAA; RAZ was followed by RBA, and so on.

Numbers following the model letters indicate a modification of the equipment or the award of a new manufacturer's contract.

Although the Navy model letter system of equipment identification no longer is in primary use, you will find some equipments under this system of comparatively recent design and manufacture—for example, the model R-390/URR receiver.

TRANSMITTERS

The purpose of a radio transmitter is to produce radiofrequency energy, and, with its amplifiers and antenna, to radiate a useful signal.

The most common types of transmitters used by the NAVSECGRU are treated later in this chapter following a discussion of the theory of operation of radio transmitters.

The general plan for all transmitters can be seen in figure 8-1.

Every transmitter has an oscillator that generates a steady flow of radiofrequency energy. The oscillator may be the self-excited type, which originates the signal in electron tubes and associated circuits. Or it may be of the crystal type, which uses, in conjunction with an electron tube, a quartz crystal cut to vibrate at a certain frequency when electrically energized. In either type, voltage and current delivered by the oscillator are very feeble, and both must be amplified many times to be radiated any distance.

The buffer stage is a voltage amplifier that increases the amplitude of the oscillator signal to a level that will drive the power amplifier. Voltage delivered by the buffer varies with the type of transmitter, but it may be hundreds or thousands of volts.

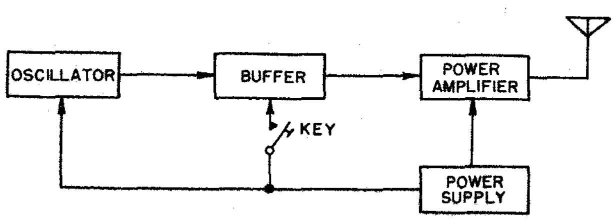


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Figure 8-1.—Stages of a typical transmitter.

The buffer serves two other purposes, one of which is to isolate the oscillator from the amplifier stages. Without the buffer, changes in the amplifier due to keying or variations in source voltage would vary the load on the oscillator and cause it to change frequency. It may also be a frequency multiplier, as we will see later.

The final stage of a transmitter is the power amplifier. Power is the product of current times voltage, and in the power amplifier a large amount of r-f current is made available for radiation by the antenna.

The power amplifier of a high-power transmitter may require far more driving power than can be supplied by an oscillator and its buffer stage. One or more low-power intermediate amplifiers may be required between the buffer and the final amplifier that feeds the antenna. The main difference between many low- and high-power transmitters is in the number of intermediate power-amplifying stages that are used.

In the block diagram of figure 8-2, the input and output powers are given for each stage of a typical medium-frequency transmitter. It is shown that the power output of a transmitter can be increased by adding amplifier stages capable of delivering the power required.

HARMONICS AND FREQUENCY MULTIPLICATION

The term harmonics is sometimes loosely used to designate unwanted radiations caused by imperfections in the transmitting equipment, but this is not entirely accurate. True harmonics are always exact multiples of the basic or fundamental frequency generated by the oscillator, and are created in the vacuum tubes and their associated circuits. Even harmonics are two, four, six, eight, etc., times the fundamental; odd harmonics are three, five, seven, nine, etc., times the fundamental. If an oscillator has a fundamental frequency of 2500 kc, harmonically related frequencies are—

5000	2d harmonic
7500	3d harmonic
10,000	4th harmonic
12,500	5th harmonic

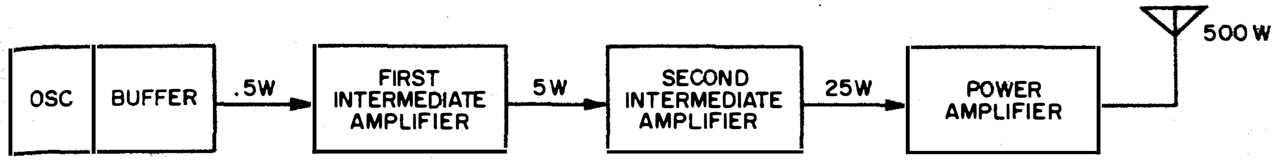

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Figure 8-2.—Intermediate amplifiers increase transmitter power.

The series ascends indefinitely until the intensity is too weak to be detected. In general, the energy in frequencies above the third harmonic is too weak to be significant.

It is difficult to design and build a stable oscillator for high frequencies; and, if a crystal is used to control a high-frequency oscillator, it must be ground so thin that it might crack while vibrating. These transmitters therefore have oscillators operating at comparatively low frequencies, sometimes as low as one-hundredth of the output frequency. The oscillator frequency is raised to the required output frequency by passing it through one or more frequency multipliers. Frequency multipliers are special power amplifiers that multiply the input frequency. The stages that multiply the frequency by two are called doublers; those that multiply by three are triplers; and those multiplying by four are quadruplers.

The main difference between many low-frequency and high-frequency transmitters is in the number of frequency-multiplying stages used. Figure 8-3 shows the block diagram of a typical Navy VHF/UHF transmitter. The oscillator in this transmitter is tunable from 18.75 mc to 33.33 mc. The multiplier stages increase the frequency by a factor of 12 by multiplying successively by 2, 2, and 3.

In high-power, high-frequency transmitters, one or more intermediate amplifiers may be used between the last frequency multiplier and the final power amplifier.

TRANSMISSION OF INFORMATION BY RADIO

Because the high-frequency output from the radiofrequency (r-f) section of a transmitter is constant in frequency and amplitude, it does not convey any intelligence by itself. This output is called the CARRIER WAVE, or simply the CARRIER, and information to be transmitted is added to it. The process of adding or superimposing information on the carrier is called MODULATION.

Modulation is accomplished by combining another (modulating) signal with the carrier. This is done in such a manner as to cause the output to vary in frequency or in amplitude according to the current or voltage variations of the modulating signal. The modulating signal usually is of a much lower frequency than the carrier.

AMPLITUDE MODULATION

If the modulating frequency is impressed on the r-f output to vary its amplitude, it is called amplitude modulation (abbreviated a-m).

Figure 8-4 is a block diagram of an a-m radiotelephone transmitter, showing the waveforms for the various stages. The top row of blocks indicates the r-f section. The next row of blocks shows the a-f section; and the lower block points out the power supply, which provides all d-c voltages to the transmitter.

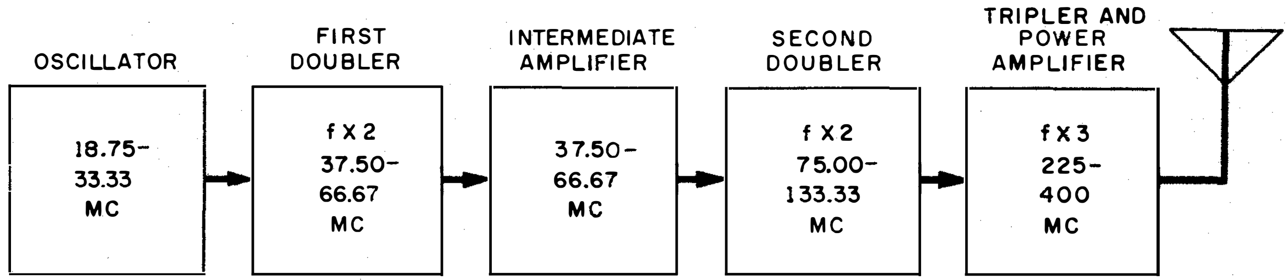

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Figure 8-3.—Frequency-multiplying stages of typical VHF/UHF transmitter.

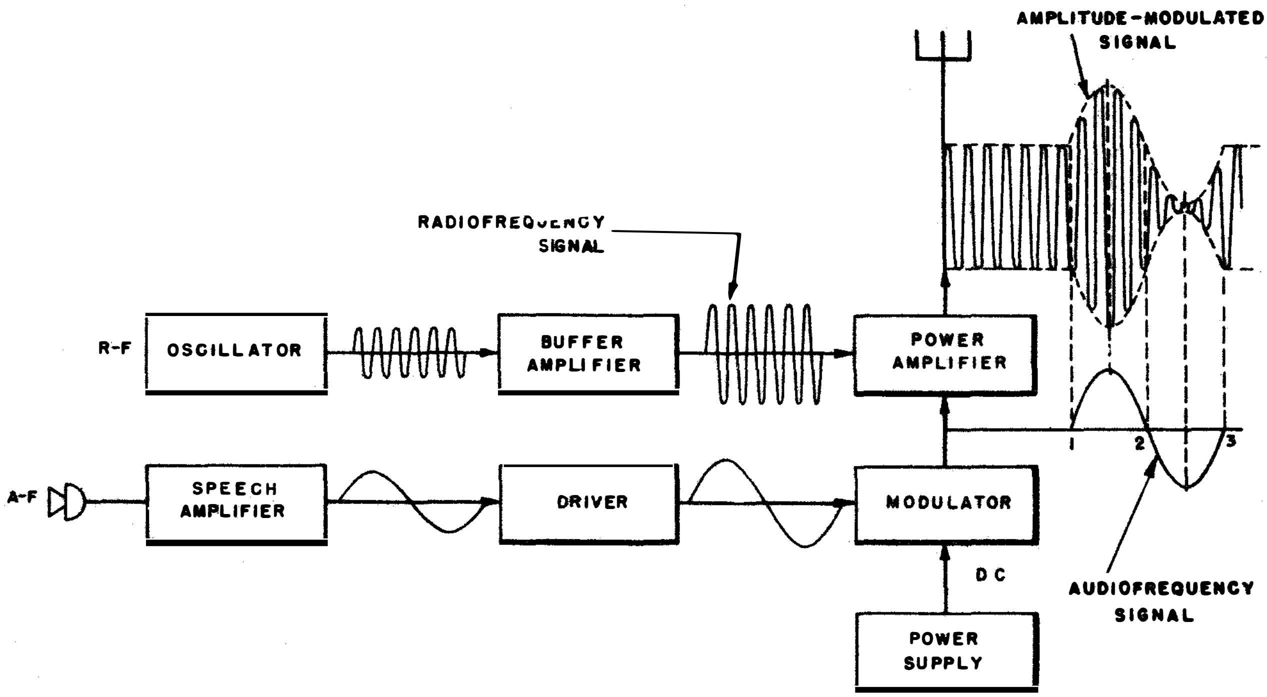

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Figure 8-4.—An a-m radiotelephone transmitter.

The r-f section (explained previously), generates the high-frequency carrier radiated by the antenna.

The audiofrequency (a-f) section includes a speech amplifier that receives considerably less than 1 volt of a-f signal from the microphone and builds it up to several volts at the input to the driver stage. The driver stage is made up of power amplifiers that convert the signal into a relatively large voltage and appreciable current at the input to the modulator. The modulation transformer is capable of handling considerable audio power. Its output is fed to the final r-f power amplifier in such a way as to alternately add to and subtract from the plate voltage of the power amplifier.

The result of the modulation is that the amplitude of the r-f field at the antenna is increased gradually during the time the a-f output is increasing the r-f power and decreased gradually during the time the a-f output is decreasing the r-f power.

In other words, during the positive alternation of the audio signal (between point 1 and point 2 in figure 8-4), the amplitude of the r-f output wave is increased, and during the negative alternation (between point 2 and point 3) it is decreased. Amplitude modulation consists of varying the amplitude of the r-f antenna current (and r-f output wave) gradually over the relatively long a-f cycle. Thus, the r-f field strength is alternately increased and decreased in accordance with the a-f signal and at the a-f rate.

Modulation may be accomplished by several methods, but the two most important to you are plate modulation and grid modulation. When modulation takes place in the plate circuit of the power amplifier it is said to be HIGH-LEVEL MODULATION. If the modulation is injected at the grid of the power amplifier (or at any point of lower voltage than the plate of the power amplifier, regardless of the stage) it is called LOW-LEVEL MODULATION. High-level modulation is more efficient, but low-level modulation requires less power. Navy transmitters employ high-level modulation except in single-sideband transmitters where the high plate voltages make it impractical, and when weight is an important consideration, as it is in aircraft and portable equipment.

FREQUENCY MODULATION AND PHASE MODULATION

Besides its amplitude, the carrier wave has two other characteristics that can be varied to produce an intelligence-carrying signal. These are its frequency and its phase. The process of varying the frequency in accordance with the audiofrequencies of voice or music is called frequency modulation (f-m), and the process of varying the phase is phase modulation (p-m). These two types of modulation are closely related. When f-m is used, the phase of the carrier wave is indirectly affected. Similarly, when p-m is used, the carrier frequency is affected.

The primary advantages of f-m are improved fidelity and increased freedom from static. Because of these qualities, it is of considerable use in commercial broadcasting, but its shortcomings—frequency extravagance, short range on available frequencies, and others—have severely limited its naval communication applications. The Navy has, however, found f-m satisfactory for other purposes, among them altimeters and some radars.

SIDEBANDS AND BANDWIDTH

When an r-f carrier is modulated by a single audio note, two additional frequencies are produced. One is the upper frequency, which equals the sum of the frequency of the carrier and the frequency of the audio note. The other frequency is the lower one, which equals the difference between the frequencies of the carrier and the audio note. The one higher than the carrier frequency is the UPPER SIDE FREQUENCY; the one lower than the carrier frequency is the LOWER SIDE FREQUENCY. When the modulating signal is made up of complex tones, as in speech or music, each individual frequency component of the modulating signal produces its own upper and lower side frequencies. These side frequencies occupy a band of frequencies lying between the carrier frequency, plus and minus the lowest modulating frequency, and the carrier frequency plus and minus the highest modulating frequency. The bands of frequencies containing the side frequencies are called SIDEBANDS. The sideband that includes the sum of the carrier and the modulating frequencies is known as the UPPER SIDEBAND (USB). The band containing the difference of the carrier and the modulating frequencies is known as the LOWER SIDEBAND (LSB). The space a carrier and its associated sidebands occupy in a frequency spectrum is called a channel. The width of the channel (called BANDWIDTH) is equal to twice the highest modulating frequency. For example, if a 5000-kc carrier is modulated by a band of frequencies ranging from 200 to 5000 cycles (0.2 to 5 kc), the upper sideband extends from 5000.2 to 5005 kc, and the lower sideband extends from 4999.8 to 4995 kc. The bandwidth is then 4995 to 5005, or 10 kc. The bandwidth is twice the value of the highest modulating frequency, which is 5 kc. This is illustrated in figure 8-5.

SINGLE SIDEBAND

A mode of radio emission that has become increasingly important to the communicator is single sideband (SSB). Single sideband is not a new term in the history of communications. It has been used extensively by the shore communication system for many years. The congestion in the medium- and high-frequency bands and recent developments that have reduced the physical sizes of equipments have given a new impetus to the advantages of using SSB in fleet communications.

Following is a brief introduction to the technique of SSB.

In our study of sidebands, we learned that modulation of the carrier produces a complex signal consisting of three individual waves: the original carrier, plus two identical sidebands, each carrying the same intelligence. Naturally, this appears to be an uneconomical means of transmission. By eliminating the carrier and one of the sidebands, the same intelligence can be transmitted at a saving in power and frequency bandwidth.

Suppressed Carrier

In SSB, the carrier itself is suppressed (or eliminated) at the transmitter, so that sideband frequencies are produced but the carrier is reduced to a minimum. This is usually the most

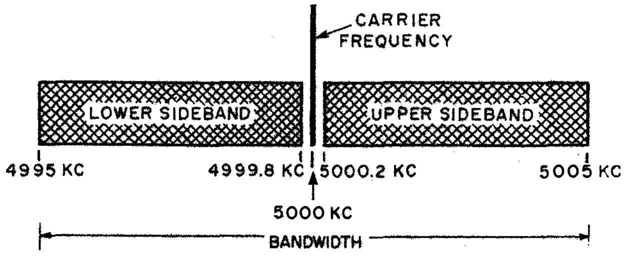

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Figure 8-5.—Sidebands produced by amplitude modulation.

difficult or troublesome aspect in understanding SSB suppressed carrier. In single sideband suppressed carrier, there is no carrier present in the transmitted signal. It is eliminated after modulation is accomplished, and reinserted at the receiver for the demodulation process. All the radiofrequency energy appearing at the transmitter output is concentrated in the sideband energy or "talk power."

After eliminating the carrier, the upper and lower sidebands remain. If, however, one of the two sidebands is filtered out before it reaches the power amplifier stage of the transmitter, the same intelligence can be transmitted on the remaining sideband. All the power is then transmitted in one sideband, instead of being divided between the carrier and both sidebands as in conventional a-m. This amounts to an increase in power for the wanted sideband. Equally important, the bandwidth required for SSB voice circuits is approximately half that needed for conventional a-m. (See fig. 8-6.)

SSB Advantages

The advantages of single sideband over conventional amplitude modulation are numerous, but only a few of the main ones are presented in the following paragraphs.

MINIMIZATION OF DISTORTION.—In conventional a-m, the two sidebands and the carrier must arrive at the receiver with the same phase relationship as they had when transmitted. If

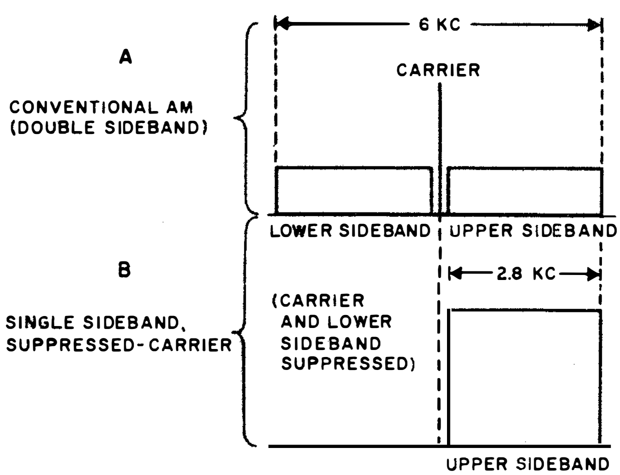

Figure 8-6.—Comparison of bandwidths of conventional a-m and SSB voice channels.

they are not received in phase (usually because of multipath skywave propagation conditions), the signal heard is fuzzy, distorted, and possibly quite loud. (You may have heard the report "Loud but distorted.") This occurs because one sideband experiences a slight phase shift and cancels a portion of the other sideband, resulting in distortion and loss of intelligibility. Fading or slight phase shift of the carrier can produce similar results. With the suppressed-carrier type of SSB, however, these problems are minimized because only one sideband and no carrier is transmitted.

INCREASED EFFECTIVE POWER—In a conventional a-m system, approximately one-half of the transmitter's power goes into the carrier, and the remaining one-half is divided equally between the two sidebands. With the suppressed-carrier SSB system, virtually all of the transmitter's power goes into the single sideband that carries the useful intelligence. This more efficient utilization of power gives the SSB voice circuit a much greater distance range than that of a normal a-m voice circuit.

PROVISION FOR DOUBLE THE NUMBER OF CHANNELS.—In the system of SSB suppressed carrier, the number of voice channels utilizing the same frequency in the radio spectrum is doubled. These two channels are referred to as the upper and lower sidebands. With the scarcity of frequencies available for new assignments in the spectrum, particularly in the 2- to 30-mc range, this is an important advantage in fleet communications.

REDUCTION OF INTERFERENCE.—In voice systems employing conventional amplitude modulation, the carrier of the transmitting station remains on the air as long as the microphone button is depressed. If an additional station transmits while the carrier of the other station is on, squeals and howls result. They are caused by the heterodyning of two or more signals transmitting at the same time. In SSB, as soon as the individual stops speaking into the microphone, talk power in the remaining, or single, sideband leaves the air. Even though two stations may transmit at the same time, it may be possible for a receiving station to read through the interfering station the same way we are able to listen to more than one conversation at the same time around the mess table.

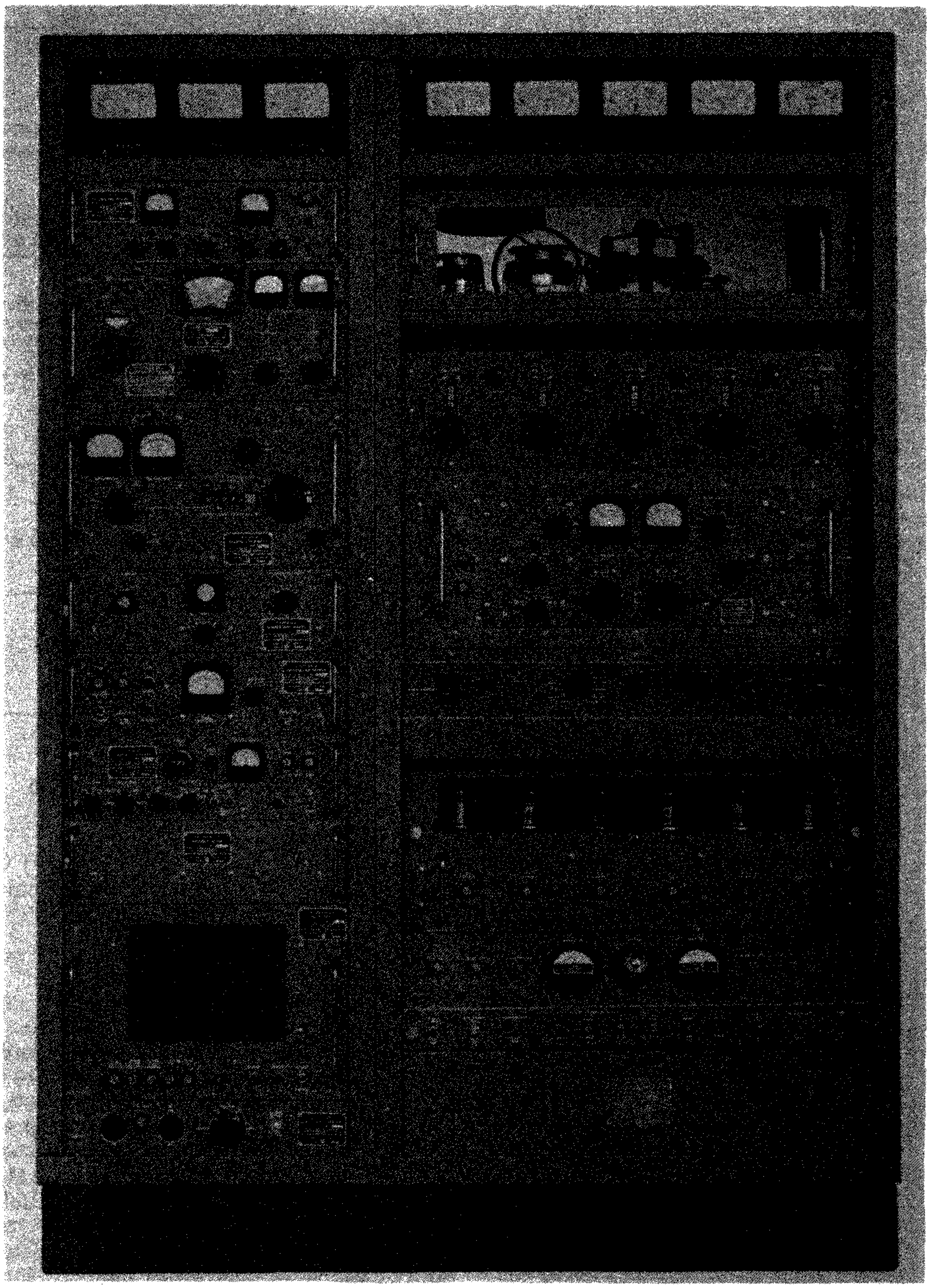

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Figure 8-7.—Radio Transmitter Set AN/FRT-39

REPRESENTATIVE TRANSMITTERS

AN/FRT-39

The radio transmitter set AN/FRT-39 (figure 8-7) is a general purpose radio communications transmitter capable of providing 10,000 watts peak envelope power output throughout a frequency range of 2 to 28 mc. The principle function of the equipment is to provide long range communications from shore-to-ship or point-to-point by the single-sideband type of operation. The equipment may also be used for the following types of transmission:

(1) CW (keyed carrier)
(2) Frequency-Shift Carrier
(3) Single-Sideband Suppressed Carrier
(4) Double-Sideband Suppressed Carrier
(5) Independent Sideband (separate intelligence)
(6) Single- or Double-Sideband (with carrier)

The AN/FRT-39 is constructed in two basic sections, the main frame and the auxiliary frame. The main frame is located to the right of the auxiliary frame and houses the power amplifier, the intermediate power amplifier, the main power supply, and high voltage section, the power amplifier loading and tuning controls, the relay and indicator control panels, and the meter panel. The auxiliary frame houses all of the sideband exciter equipment, exciter power supply equipment, and other control equipment for the various modes of operation.

AN/URC-32

One of the Navy's most versatile modern communication equipments is the AN/URC-32 (fig. 8-8). It is a transceiver operating in the 2- to 30-mc high-frequency range, with a transmitter peak envelope power of 500 watts.

A transceiver, as you know, uses part of the same electronic circuitry for both transmitting and receiving, hence cannot transmit and receive simultaneously.

The AN/URC-32 is designed chiefly for single-sideband transmission, and for reception on either the upper or lower sidebands, or on both sidebands simultaneously, with separate audio and i-f channels for each sideband. In addition to single-sideband operation, provisions are included for a-m (carrier reinserted), CW, or FSK operation.

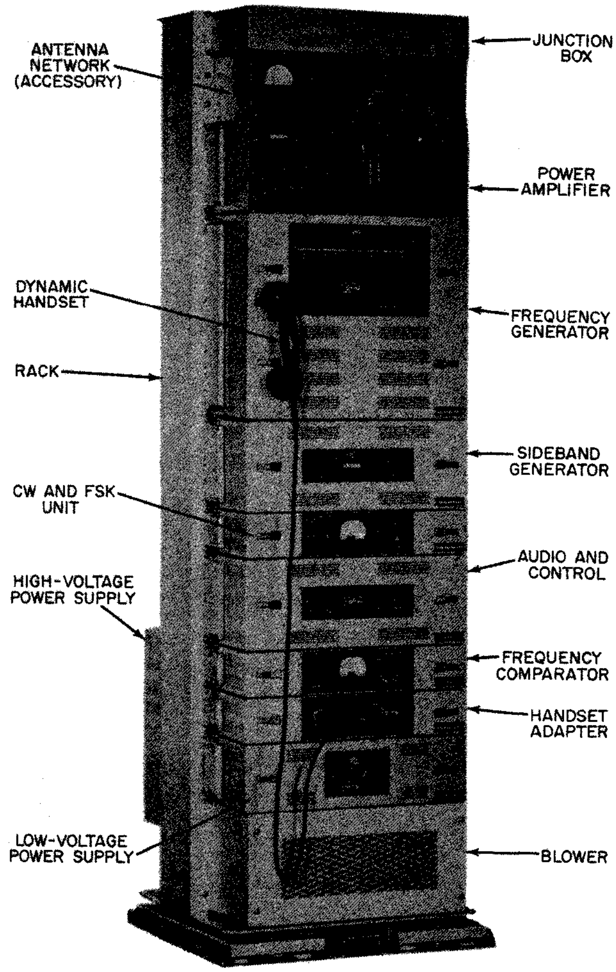

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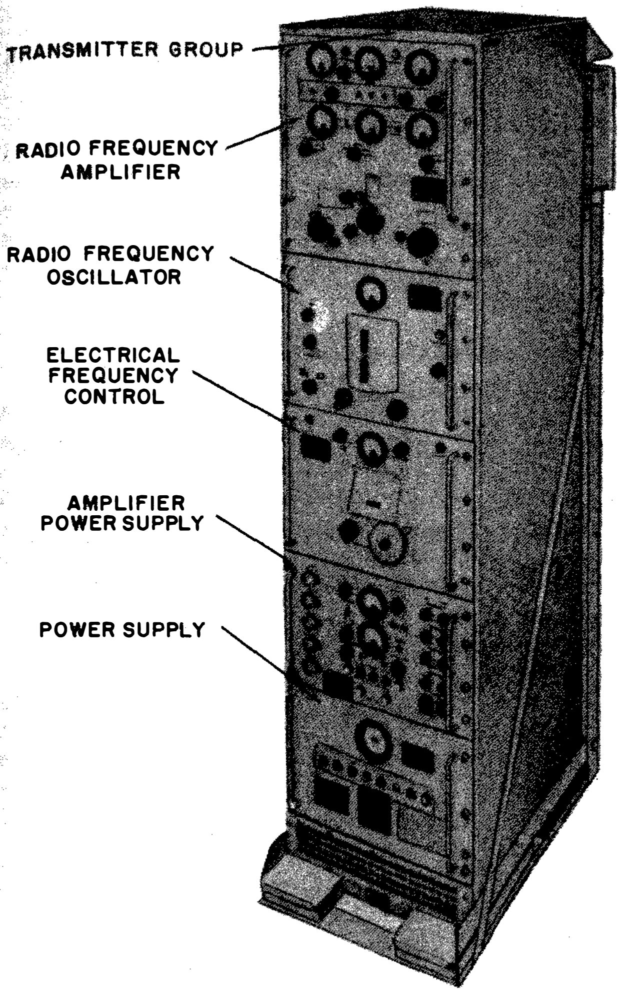
Figure 8-8.—Single-sideband transceiver AN/URC-32

AN/WRT-2

The AN/WRT-2 (fig. 8-9) is a modern HF transmitter used in surface ships and submarines. It covers the frequency range of 2 to 30 mc. The AN/WRT-2 transmitter has an output power of 500 watts on CW, frequency-shift RATT and FAX, and conventional AM radiotelephone. It has an output power of 1000 watts when transmitting single sideband. It may also be used for transmitting separate intelligence on each independent sideband. A built-in dummy load permits off-the-air tuning under radio silence conditions.



32.278
Figure 8-9.—Radio transmitter AN/WRT-2.

Lifeboat Transmitter AN/CRT-3

Radio transmitter AN/CRT-3, popularly known as the "Gibson girl," is a rugged emergency transmitter carried aboard ships and aircraft for use in lifeboats and rafts. It is shown in figure 8-10. No receiving equipment is included.

The transmitter operates on the international distress frequency, 500 kc, and the survival craft communication frequency, 8364 kc.

The complete radio transmitter, including the power supply, is contained in an aluminum cabinet that is airtight and waterproof. The cabinet is shaped to fit between the operator's legs and it has a strap for securing it in the operating position.

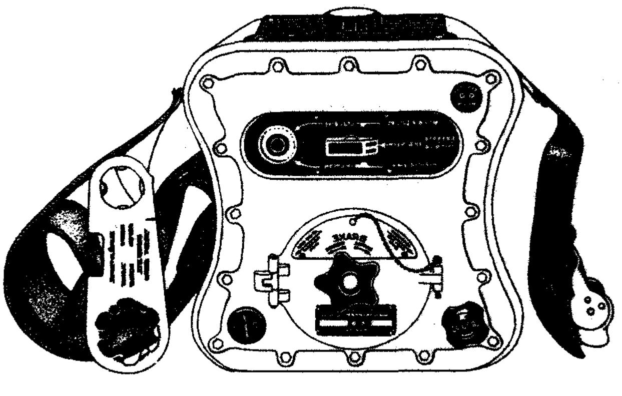


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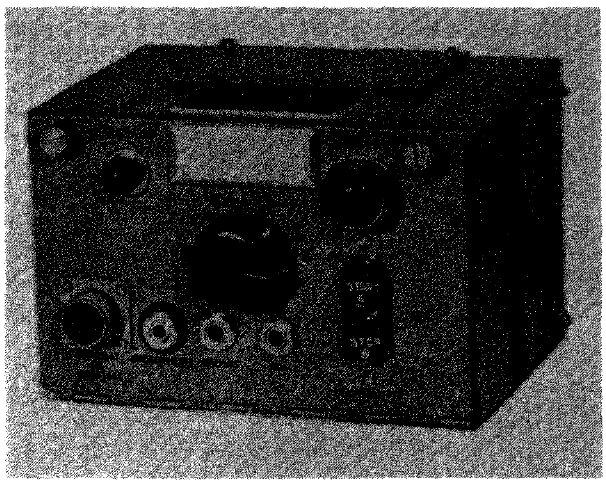
Figure 8-10.—Emergency lifeboat transmitter AN/CRT-3

REMOTE CONTROL UNIT

To operate a transmitter from a remote location requires a remote-control unit. A typical remote-control unit, commonly called RPU (radiophone unit), is type C-1138A/UR shown in figure 8-11. This unit contains a start-stop switch for turning the transmitter on or off, jacks for connecting a handset or chestset, microphone, headphones, or telegraph key, a volume control for the headphones, and indicator lamps for transmitter-on and carrier-on indications.



7.40.2A
Figure 8-11.—Radiophone unit (RPU).

RECEIVERS

Receivers perform the function of intercepting a tiny part of the radio wave radiated by transmitters and of recovering the information contained in it.

FUNCTIONS OF RECEIVERS

Radio receivers must perform the following six functions (fig. 8-12):

1. Signal interception.
2. Signal selection.
3. Radiofrequency amplification.
4. Detection.
5. Audiofrequency amplification.
6. Sound reproduction.

These six functions are sufficient for a-m reception, but for CW reception an additional circuit (shown by dotted lines, fig. 8-12), called a beat-frequency oscillator, is required.

Signal Interception

The receiving antenna intercepts a small portion of the passing radio waves. The signal voltage extracted by receiving antennas is only a few microvolts, sufficient for subsequent amplification as long as the noise energy intercepted by the antenna is substantially less than this.

Signal Selection

Some means must be provided to select the desired signal from all r-f carriers intercepted by the antenna. This selection is made by tuned circuits that pass only their resonant frequency (frequency to which the receiver is tuned) and reject other frequencies. Thus the receiver is able to differentiate between the desired signal frequency and all other frequencies.

Radiofrequency Amplification

The weak signals intercepted by the antenna usually must be amplified considerably before the intelligence contained in them can be recovered. One or more r-f amplifiers serve to increase the signal to the required level. A tuned circuit in each r-f amplifier makes sure that only the desired signal is amplified.

Detection (Demodulation)

If the signal is amplitude-modulated, the original intelligence must be recovered from it by separating the modulation signal from the r-f carrier. The circuit that separates the audiofrequency signal variations from the r-f carrier is called the detector or demodulator.

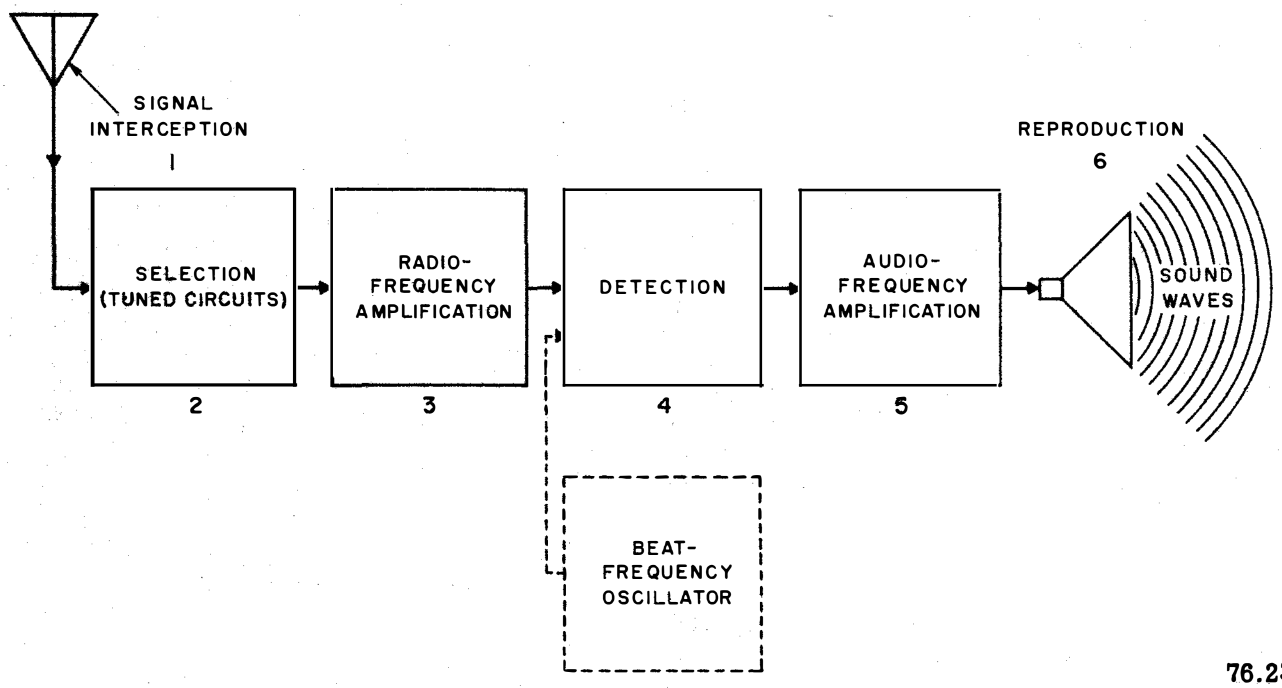


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Figure 8-12.—Essentials of radio reception.

Most detectors do not operate well at very low signal levels, and this is one of the reasons why r-f amplification is required ahead of the detector.

In CW (radiotelegraphy) reception, a beat-frequency oscillator (bfo) is used in the receiver circuit. The bfo provides an r-f signal that beats or heterodynes against the frequency injected into the detector. The resultant frequency is a low-level audiofrequency.

Audiofrequency Amplification

The signal frequency in the output of the detector generally is too weak to operate a headset or loudspeaker. One or more stages of a-f amplification are therefore required to strengthen the audio output of the detector to a level sufficient to operate the headset or loudspeaker.

Sound Reproduction

The amplified a-f signal is applied to the headset or loudspeaker that translates the electrical a-f variations into corresponding sound waves. For a-m, the sound output of the speaker is a close replica of the original audio sounds at the transmitter. For CW, the sound is a tone the frequency of which depends upon the frequency of the beat-frequency oscillator. This tone is heard whenever the key is depressed at the transmitter, and, consequently, it reproduces the interruptions of the r-f carrier in accordance with the Morse code.

FIELD STRENGTH

The amount of voltage induced in an antenna depends upon the length of the antenna and the strength of the carrier wave at that point. The carrier wave, strongest when it leaves the transmitting antenna, is attenuated (weakened) as it travels until its energy level, called field strength, is too weak to be received. The amount of voltage induced in an antenna depends on the length of the antenna as well as upon the field strength of the signal.

SENSITIVITY

The sensitivity of a receiver is a measure of how well it can amplify weak signals. Communication receivers are highly sensitive and can operate on far weaker signals than a home radio.

In an area of strong local interference, a receiver needs a strong signal to give good reception. If the local interference has a field strength of 100 microvolts per meter, a signal strength of from 500 to 1000 microvolts per meter is required to drown the noise. The same receiver, free of local interference, may give good reception on a signal strength of 10 microvolts per meter. It is hard to state the exact minimum field strength needed to operate a receiver satisfactorily, but many sets under ideal conditions can function on a signal strength of from 1 to 3 microvolts per meter. To bring such a signal to an audible level requires an amplification of many millions of times.

SELECTIVITY

Selectivity is the ability of a receiver to respond to one particular signal and to reject all others. A very selective receiver is said to tune sharply.

Some types of receivers are more selective than others. A radiotelephone communication receiver tunes more sharply than a commercial broadcast receiver, and a CW communication receiver is even more selective. You can compare the three tuning curves in figure 8-13.

You will remember the analysis of amplitude modulation treated earlier in this chapter. It showed how the intelligence transmitted was contained in the sideband frequencies.

Carrier waves from commercial broadcast stations contain sideband frequencies that extend 5 kc on either side of the carrier frequency. If a station is transmitting on 1140 kc, the complete carrier wave contains frequencies from

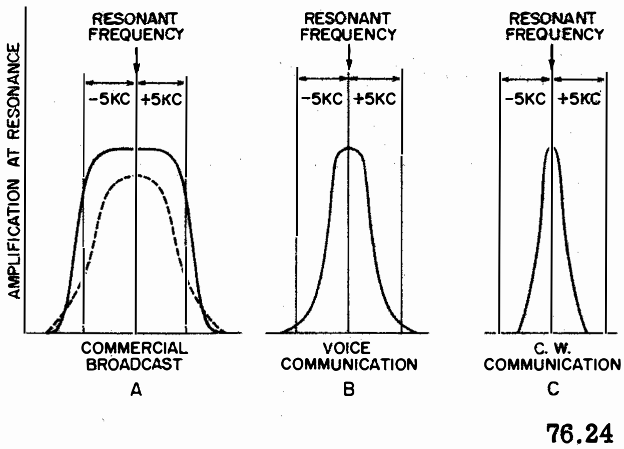

Figure 8-13.—Tuning curves of three types of radio receivers.

1135 to 1145. If a receiver tunes too sharply, some of the sideband frequencies are lost, with a corresponding sacrifice of fidelity. The commercial broadcast receiver tuning curve shown in figure 8-13 is OPTIMUM— "at its best." The top is broad and flat and the sides are steep. Actually, most a-m broadcast receivers have tuning curves resembling the broken line, and many frequency components of voice and music contained in the signal are not reproduced by the set.

Although sharp tuning in a home radio would make for poor listening, it is desirable for military sets for the sake of frequency economy and reduction of interference. Radiotelephone messages can be sent on frequencies that extend only 2 kc on either side of the carrier frequency. The voice may sound unnatural, like a voice on the telephone, but it can be understood.

The CW sets tune so sharply that, unless an operator is careful, he can turn his dial through the signal without even hearing it.

TYPES OF RECEIVERS

The two major types of communication receivers are the TUNED RADIOFREQUENCY (TRF) and the SUPERHETERODYNE. A few years ago there were a considerable number of TRF receivers in use by the U. S. Navy. There are still a few today; however, the vast majority of communication receivers are of the superheterodyne type and this is the type with which a CT O brancher is primarily concerned.

Tuned Radiofrequency Receiver

In the TRF receiver all radiofrequency amplification takes place at the frequency of the incoming signal, and all tuned circuits must be adjusted to this frequency. For this reason the TRF receiver has several disadvantages. It is difficult to get uniform amplification of the r-f stages over the entire frequency range of the receiver. At the higher frequencies the sensitivity of the receiver is reduced. The most serious drawback of the TRF receiver is that the selectivity of the tuned circuits cannot be kept uniform over the frequency range, the selectivity decreasing at the high end of the frequency band.

Superheterodyne Receiver

The difficulties of the TRF receiver are overcome to a large degree in the superheterodyne receiver by conversion of the signal frequency to a lower intermediate frequency (i-f). Regardless of the frequency of the received signal, the signal with its audio modulation is always converted to this fixed intermediate frequency. Then it can be amplified in a fixed-frequency i-f amplifier. This amplifier has much higher and more uniform amplification and selectivity over the tuning range of the receiver than is possible with the TRF amplifier. Summing up, the superheterodyne receiver is superior to the TRF receiver because it is more selective, has higher amplification, and more uniform selectivity and sensitivity. In addition to these advantages it has fewer variable-tuned circuits, and the receiver can more easily be made to cover more frequency bands. For these reasons, superheterodynes have replaced TRF receivers for practically all uses.

The basic stages for a-m superheterodyne reception are shown in figure 8-14 in the order in which a signal passes through the receiver. The illustration also shows the changes in waveshape of the signal as it passes through the receiver. The operation of the superheterodyne receiver for the reception of a-m signals is as follows:

1. Modulated r-f signals from many transmitters are intercepted by the antenna. They are fed to the first stage of the receiver, which is a variable-tuned r-f amplifier.
2. The desired r-f signal is selected by the tuning circuit of the r-f amplifier. This signal is amplified, and all other signals are rejected to some degree.
3. The amplified r-f signal is coupled to the mixer stage, where it is combined with the output of the local oscillator. In this process of heterodyning (mixing), two new frequencies are produced. One is equal to the sum of the incoming signal and the local oscillator; the other equals the difference between the incoming signal and the local oscillator frequencies. Most receivers are designed with selective circuits to reject the sum frequency; the difference frequency is used as the intermediate frequency (i-f). It contains the same modulation as the original r-f signal.
4. The i-f signal is amplified in the fixed-tuned i-f amplifier stages and is coupled to the detector.
5. The detector stage removes the audio modulation contained in the i-f signal and filters out the i-f carrier, which no longer is needed.

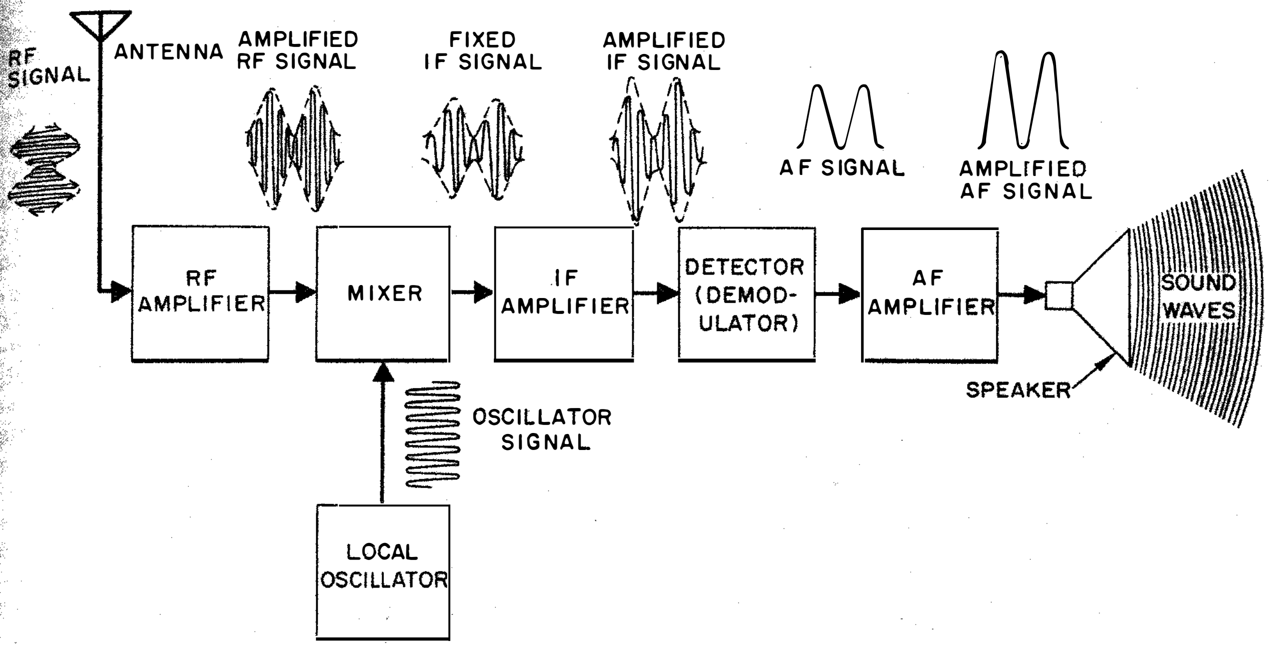

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Figure 8-14.—Superheterodyne receiver, showing signal waveshape.

6. The resulting audio signal is amplified to the level required by the loudspeaker.

7. The electrical audio variations are converted into the corresponding sound waves by the loudspeaker (or headphones).

REPRESENTATIVE RECEIVERS

R-390A/URR

Radio receiver R-390A/URR (fig. 8-15) is a modern, high-performance, exceptionally stable superheterodyne receiver for both shipboard and shore station use. It will receive CW, MCW, a-m radiotelephone, frequency-shift RATT and FAX, and SSB signals within the frequency range from 500 kc to 32 mc.

The tuning knob turns a complex arrangement of gears and shafts to indicate the frequency to which the receiver is tuned on a very accurate counter-type indicator that resembles the mileage counter on an automobile dashboard. The dial is calibrated in kilocycles, and the frequency-reading accuracy of this tuning dial permits use of the receiver as an accurate frequency meter. The calibration of the receiver is accurate to within 300 cps.

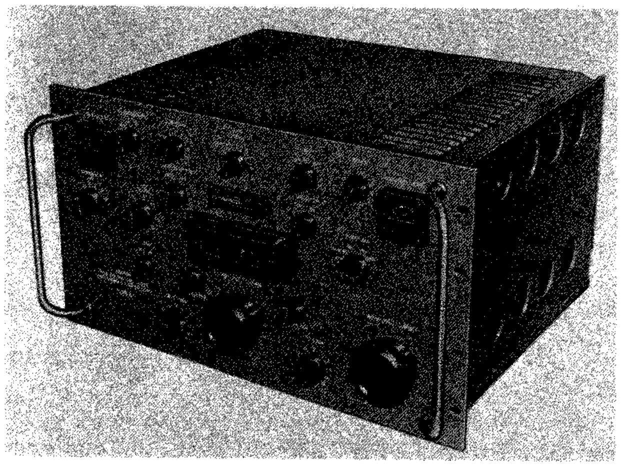

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Figure 8-15.—Radio receiver R-390A/URR.

AN/FRR-60(V)

The AN/FRR-60(V) (figure 8-16) is a general purpose Diversity Radio Receiver system designed to cover the frequency range of 2 to 32

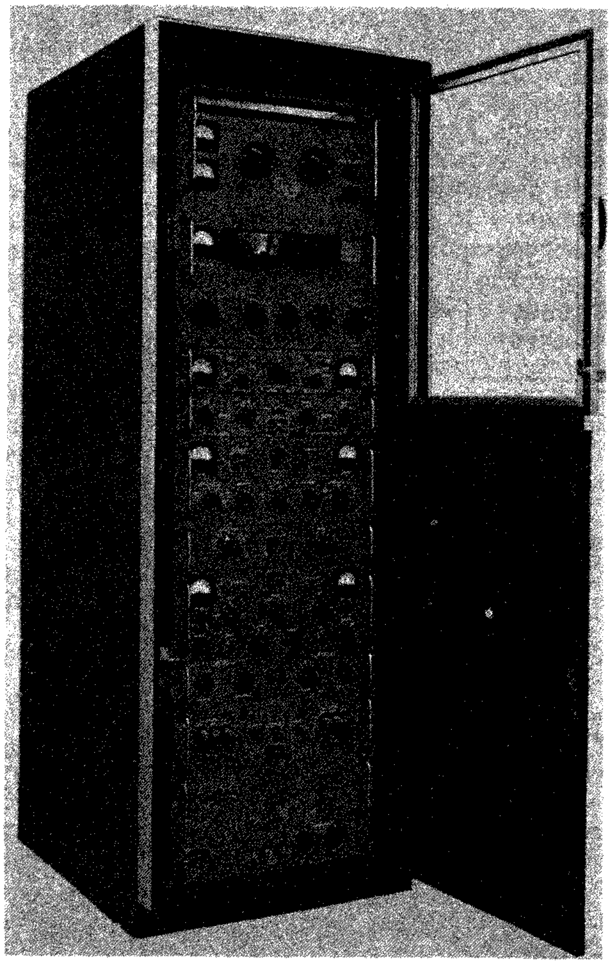

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Figure 8-16.—Diversity Radio Receiver AN/FRR-60(V)

mc. The equipment is capable of reception in the following modes of operation:

(1) SSB (suppressed carrier)
(2) SSB (with carrier)
(3) DSB (suppressed carrier)
(4) DSB (with carrier)
(5) FSK
(6) FAX
(7) CW
(8) MCW
(9) Pulse modulation
(10) Phase modulation

The 2 to 32 mc range covered by the AN/FRR-60(V) is divided into eight continuous bands. Continuous coverage is provided in either synthesized (controling the receiver VFO with an external frequency standard) or non-synthesized type of operation. In the synthesized type of operation a frequency standard output is provided over the entire frequency range of the receiver in 100 cycle steps. One complete AN/FRR-60 by itself can only be operated in nondiversity; however, when two complete AN/FRR-60's are operated together and their AGC lines are interconnected, the equipment may be operated in either space-diversity or frequency-diversity. In space-diversity operation the two receiver antenna inputs are connected to separate antennas which are spaced several wavelengths apart. In frequency-diversity operation the two receiver antenna inputs are connected to the same antenna but the two receivers are operated on separate frequencies which are being transmitted simultaneously with identical intelligence. Both types of diversity operation are designed to overcome the difficulties encountered in long-range communications which are due to fading.

The AN/FRR-60(V) comprises various modular units mounted in a single rack, and is used in fixed-station or mobile communications systems.

A forced-air cooling system using electric blowers is incorporated within the equipment cabinet. Washable air filters are used to filter out external dust.

SWITCHBOARDS

Control panels which utilize switches instead of plugs and patch cords are called switchboards. The use of switchboards allows spare and/or normal equipment and lines to be interchanged or interconnected without resorting to physical rewiring.

Two common switchboards which CT O personnel will encounter are the Receiver Transfer Switchboard, type SB 82/SRR, and the Transmitter Transfer Switchboard, type SB-83/SRT. These switchboards feature unitized construction and increased flexibility.

RECEIVER TRANSFER SWITCHBOARD

Receiver Transfer Switchboard, type SB-82/SRR, is shown in figure 8-17. The receiver switchboard has five vertical rows of ten double-pole, single-throw (ON-OFF) switches that are continously rotatable in either direction.

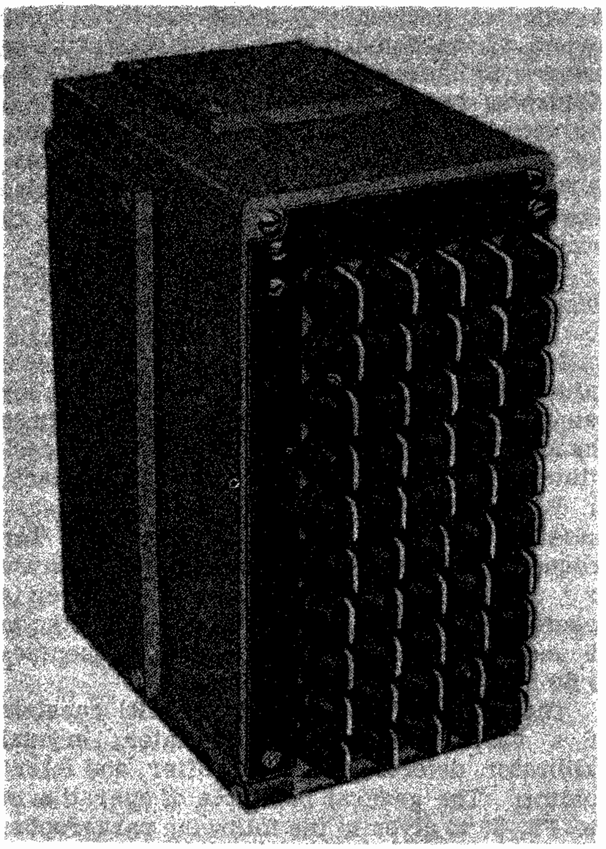

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Figure 8-17.—External view of the Receiver Transfer Switchboard, type SB-82/SRR.

One side of each switch within a vertical row is wired in parallel with the same sides of the other nine switches within that row. Similarly, the other side of each switch is wired in parallel horizontally with the corresponding sides of each of the other four switches in a horizontal row. This method of connecting the switches permits a high degree of flexibility.

The audio output from five radio receivers, connected to the five vertical rows of switches, may be fed to any or all of the remote stations by closing the proper switch or switches.

The knob of each switch is marked with a heavy white line to provide visual indication of the communication setup. In general, there are more remote stations than radio receivers, hence the switchboards are normally mounted in a vertical position (as in fig. 8-17). This arrangement permits the outputs from five receivers to be fed to the five vertical rows and up to ten remote stations to be fed from the ten horizontal rows of switches. Switchboards are always installed with the knobs in the OFF position when the white line is vertical. To further standardize all installations, receivers are always connected to the vertical rows of switches, and remote stations are always connected to the horizontal rows.

Identification of the receivers and remote stations is engraved on the laminated bakelite label strips fastened along the top and left edges of the panel front.

It should be noted that only the receiver audio output circuit is connected to the switchboard. Transmitter transfer switchboards, however, handle several other types of circuits in addition to audio circuits.

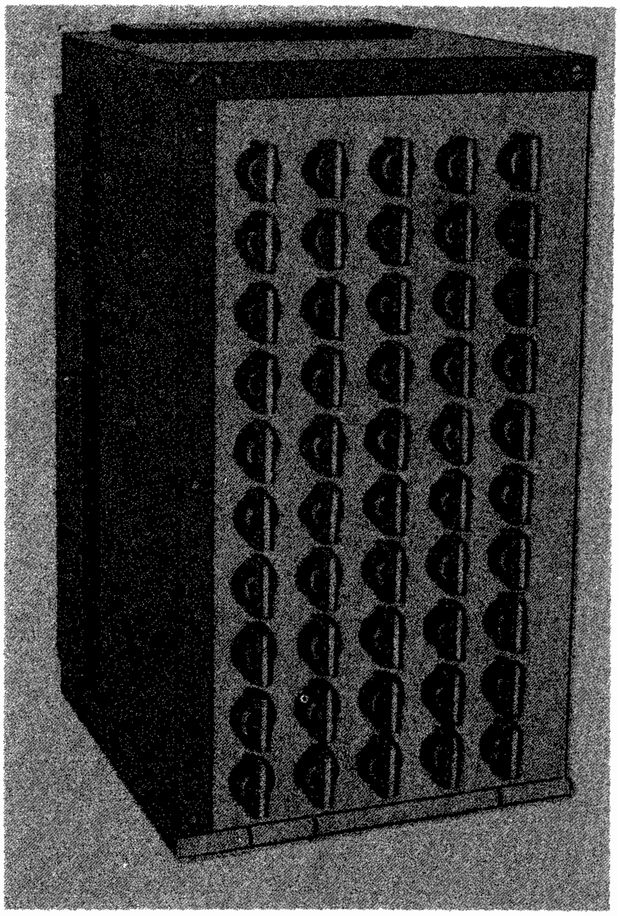

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Figure 8-18.—External view of the Transmitter Transfer Switchboard, type SB-83/SRT.

TRANSMITTER TRANSFER SWITCHBOARD

Transmitter Transfer Switchboard, type SB-83/SRT, is shown in figure 8-18. The same parallel wiring of the switches is used as in the receiver switchboard.

The transmitter switchboard has five vertical rows of ten 12-pole, single-throw switches continously rotatable in either direction. Radio transmitters are wired to the five vertical rows and remote stations are connected to the ten horizontal rows. Switches are OFF when the white lines on the knobs are vertical.

A mechanical interlock arrangement prevents additional switches in each horizontal row from being closed when any one of the five switches in that row has been closed already. This arrangement prevents serious damage that is certain to result from two or more transmitters feeding a single remote station at the same time. Although the mechanical interlock will prevent closing a second switch in a horizontal row after one switch has been closed, it will not prevent two switches from being turned at the same time. In other words, by using both hands, you could make the mistake of turning two switches in a horizontal row at the same time, connecting two transmitters to the same remote unit, and damaging the transmitters. One foolproof way to prevent turning more than one switch at a time is to do all transmitter switching with only one hand.

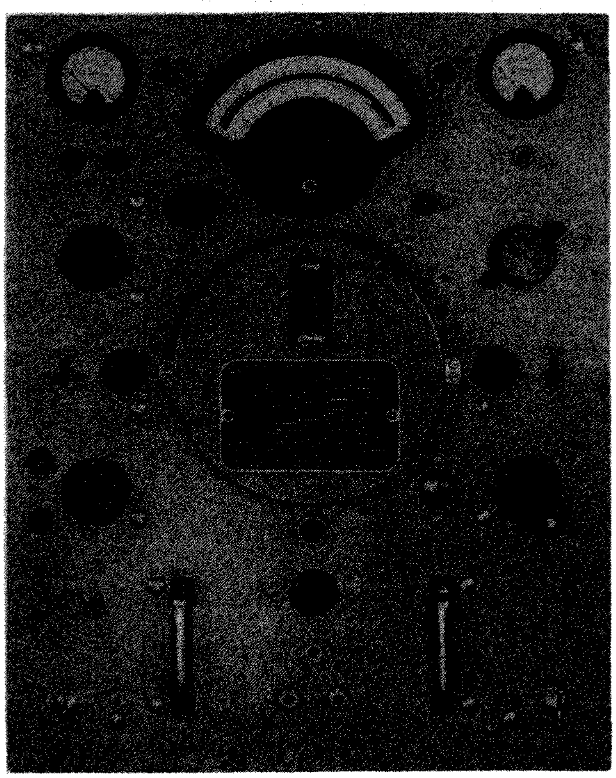

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Figure 8-19.—FR-36 frequency meter.

FR-36 FREQUENCY METER

Modern receivers have very good reset values; that is, an ability to be reset to the same frequency value when the dial has been changed. However, where requirements necessitate setting a receiver exactly on frequency, or determining the exact frequency of a transmission, a frequency meter must be used. The frequency meter FR-36 (fig. 8-19) is accurate to $\pm$ 0.003 percent or $\pm$ 50 cycles, whichever is greater, within the frequency range of 160 kc to 15 mc. By harmonic extension, frequencies to 60 mc may also be measured.

The model FR-36 (formerly LR) consists of a variable frequency oscillator, crystal calibrator, detector-audio amplifier, and interpolator. The general principle of operation of the FR-36 is given in the following paragraphs.

The internal 100-kc crystal oscillator provides a marker or calibrator signal every 100 kc over the tuning range of the frequency meter. The signal from the variable frequency oscillator and the signal from the 100-kilocycle calibrator are detected and the amplified beat note is used to adjust the VFO dial to agree with the dial at a 100-kc point on the scale. Marker signals at 10-kc and 20-kc points are available from a multivibrator. A driven multivibrator is an oscillator, oscillating at a submultiple of the frequency of the crystal oscillator. Using the 100-kc crystal standard and the 10- or 20-kc multivibrator, the dial of the VFO can be set to any frequency that is a multiple of 10 kc; for example, 7000 kc, 7020 kc, and 7010 kc could be set exactly on frequency by zero beating the signals from the 100-kc crystal oscillator, the 20-kc multivibrator, or the 10-kc multivibrator, respectively. Interpolation enables the user of the frequency meter to set frequencies between any two calibration oscillator markers. A dial scale for interpolation is provided on the FR-36; however, it is seldom used because the FR-36 includes an electronic interpolator. As the dial of the VFO is moved from zero beat at one of the calibrator marker points, a meter reads the audio beat frequency directly in divisions of a kilocycle. This audio beat frequency is the amount the internal variable frequency oscillator differs from the frequency of the 10-, 20-, or 100-kc standard. A simplified procedure for setting up the FR-36 on a frequency of 8252 would be as follows:

1. Set band switch to proper band.
2. Set dial to 8200 kc.
3. Turn on 100-kc calibrator and adjust compensator for zero beat in phones.
4. Adjust FR-36 to 8250 as indicated on direct reading dial.
5. Turn on 10-kc oscillator.
6. Zero beat variable frequency oscillator.
7. Turn dial higher in frequency until interpolation meter reads 2 kc.

The FR-36 is now set on 8252 kc. Note that the steps move progressively closer to the desired frequency: to proper band, to nearest 100-kc point, to nearest 10-kc point, and to two kc higher than the 10-kc checkpoint.

The FR-36 frequency meter does not literally measure a frequency. The FR-36 uses an accurately calibrated variable frequency oscillator that can be set to any selected frequency within its tuning range. The tuning controls of this variable frequency oscillator are checked against an internal crystal standard which furnishes marker signals of high accuracy.

CHAPTER 9

TELETYPEWRITER

The teletypewriter is little more than an electrically operated typewriter. The prefix "tele" means "at a distance." Coupled with the word "typewriter" it forms a word meaning "typewriting at a distance." By operating a keyboard similar to that of a typewriter, signals are produced that print characters in page form, called hard copy.

The characters appear at both sending and receiving stations. In this way, one teletypewriter will actuate as many machines as may be connected together. An operator transmitting from New York to Boston will have his message repeated in Boston, letter by letter, virtually as soon as it is formed in New York. The same will apply at all receiving stations that tie into the network. One commonly used machine is the model 28 page teletypewriter, also called the model 28 printer, a machine widely used by both military and commercial communication systems.

MODEL 28 TELETYPEWRITERS

Model 28 is a manufacturer's designation applied to a complete line of teletypewriter equipments. Compared with some of the older models the components of the model 28 series feature smaller size, lighter weight, increased speeds, quieter operation, and less maintenance. They are also better suited for shipboard use under severe conditions of roll, vibration, and shock.

One of the more common Model 28 series teletypewriters is the AN/UGC-6.

TELETYPEWRITER MODEL AN/UGC-6

Model AN/UGC-6 teletypewriter, shown in figure 9-1, is an electromechanical apparatus for sending and receiving both printed and tape-perforated messages.

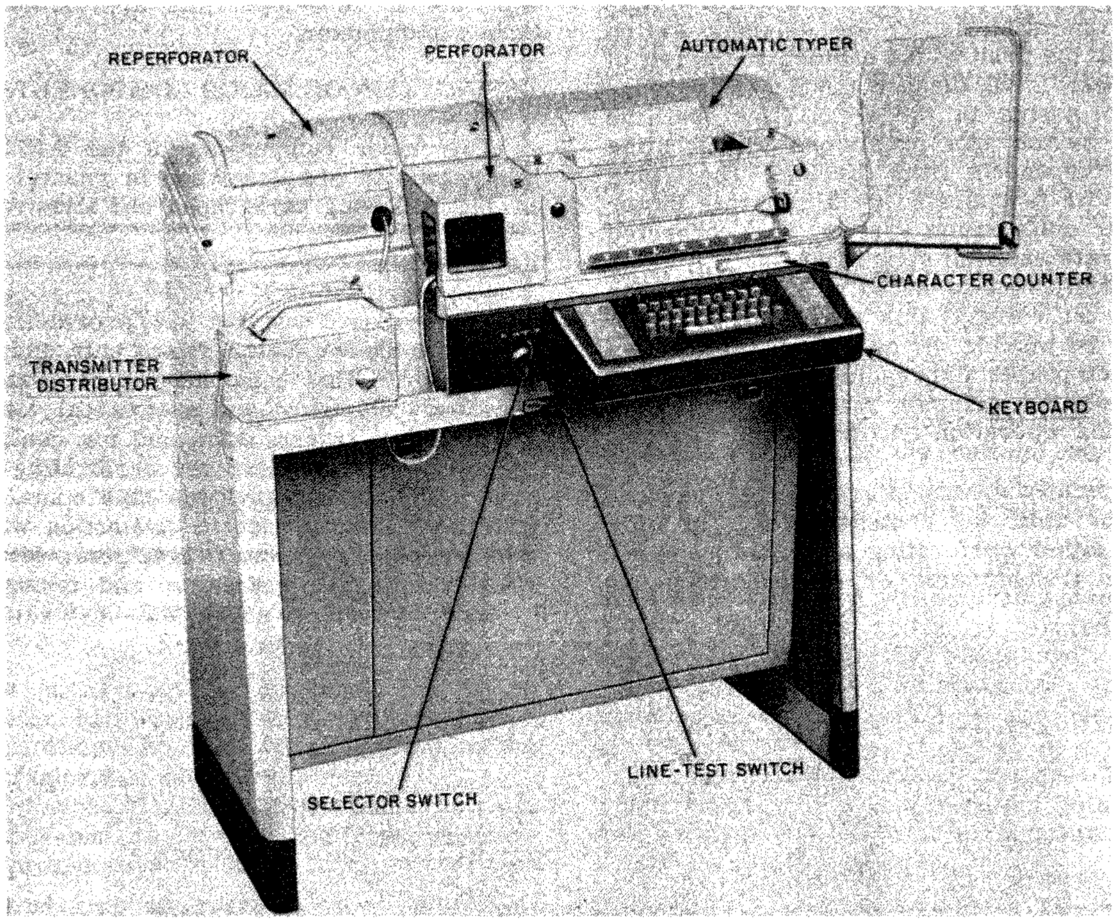
Although discussion in this chapter is confined principally to the AN/UGC-6, the reader should understand the similarity between this and other models in the series. For example, the essential difference between AN/UGC-6 and AN/UGC-5 is that the latter does not include the typing reperforator. The AN/UGC-7 differs from AN/UGC-6 in that it has a weather keyboard (certain keytops include aerological weather symbols instead of standard communication symbols). The type box in the typing unit and the typewheel in the typing perforator also have weather symbols to match the keyboard. Like the AN/UGC-5, the AN/UGC-7 does not have a reperforator. Model AN/UGC-8 is like the AN/UGC-7, except that the typing reperforator is included.

As you can see, the equipment nomenclature is changed as a result of changes in the basic components. Additional nomenclature changes, moreover, depend upon the type of a-c motor installed. The AN/UGC-6, for instance, has synchronous a-c motors. With series governed motors (required for some installations), the model designation is changed to AN/UGC-6X. A detailed description of the AN designator system is contained in chapter 8.

The AN/UGC-6 teletypewriter was selected for presentation in this chapter because it contains all the components for a complete message originating and receiving center, and because it is being installed in quantity at shore stations and aboard fleet units.

PURPOSE OF THE EQUIPMENT

Model AN/UGC-6 teletypewriter is a versatile communication equipment. It receives messages electrically from the signal line and prints them on page size copy paper. In addition, it can receive messages and record them on tape in both perforated and printed form. With page-printed monitoring, the teletypewriter electrically transmits messages that are originated either by perforated tape or keyboard operation.



31.29A

Figure 9-1.—Model AN/UGC-6 teletypewriter.

It mechanically prepares perforated and printed tape for separate transmission with or without simultaneous electrical transmission and page-printed monitoring.

Transmission between stations is accomplished electrically by use of the five-unit start-stop code.

The fundamental operating speed of the equipment is 60 wpm. Speeds of 75 wpm or 100 wpm can be attained by installing different gear sets. The trend today is toward the higher operating speed of 100 wpm.

The teletypewriter set is composed of the following components: a cabinet mounting, a power distribution panel, a keyboard, a typing unit, a typing perforator, a transmitter distributor, an auxiliary power distribution panel, and a typing reperforator.

In operation, the components are linked together by electrical or mechanical connections to offer a wide range of possibilities for sending, receiving, or storing teletypewriter messages. All equipment components are housed in the cabinet. Electrical connections between components are routed through the power distribution panels. Transmission signals are initiated through the keyboard or the transmitter distributor. Signals are received and local transmission can be monitored on the typing unit. The typing perforator and typing reperforator are devices for preparing tapes on which locally initiated or incoming teletypewriter messages can be stored for future transmission through the transmitter distributor.

The keyboard, typing perforator, typing unit, and transmitter distributor are operated by the motor mounted on the keyboard. Selection of these components for either individual or simultaneous operation is by the selector switch located at the front of the cabinet, to the left of the keyboard. All these components are connected in series in the signal line, but the selector switch has provisions for shunting various components from the line. The typing reperforator is operated by a separate motor and power distribution system. It is connected to a separate external signal line.

The equipment is wired at the factory for operation on a signal line current of 35 milliamperes. By making wiring changes in the power distribution panels and readjusting the armature springs on the selector magnets, it can be adapted for operation on other values of line current.

Page-printed messages are typed on standard size paper rolls 8 1/2 inches wide. The tape used for either perforating and printing messages for transmission or for recording incoming messages is 11/16 inch wide. It is supplied in 1000-foot rolls approximately 8 inches in diameter.

DESCRIPTION OF MAJOR COMPONENTS

The major components of the AN/UGC-6 teletypewriter are described in greater detail in the following paragraphs and illustrations.

Keyboard Unit

The keyboard unit (fig. 9-2) provides a foundation for the a-c motor, typing unit, and typing perforator. This component incorporates the necessary electrical and mechanical elements for message transmission and for controlling the mechanical printing and perforating of the tape. It also supports the tape container, a character counter used in connection with the typing perforator, intermediate gears for operating the signal generator and typing unit,

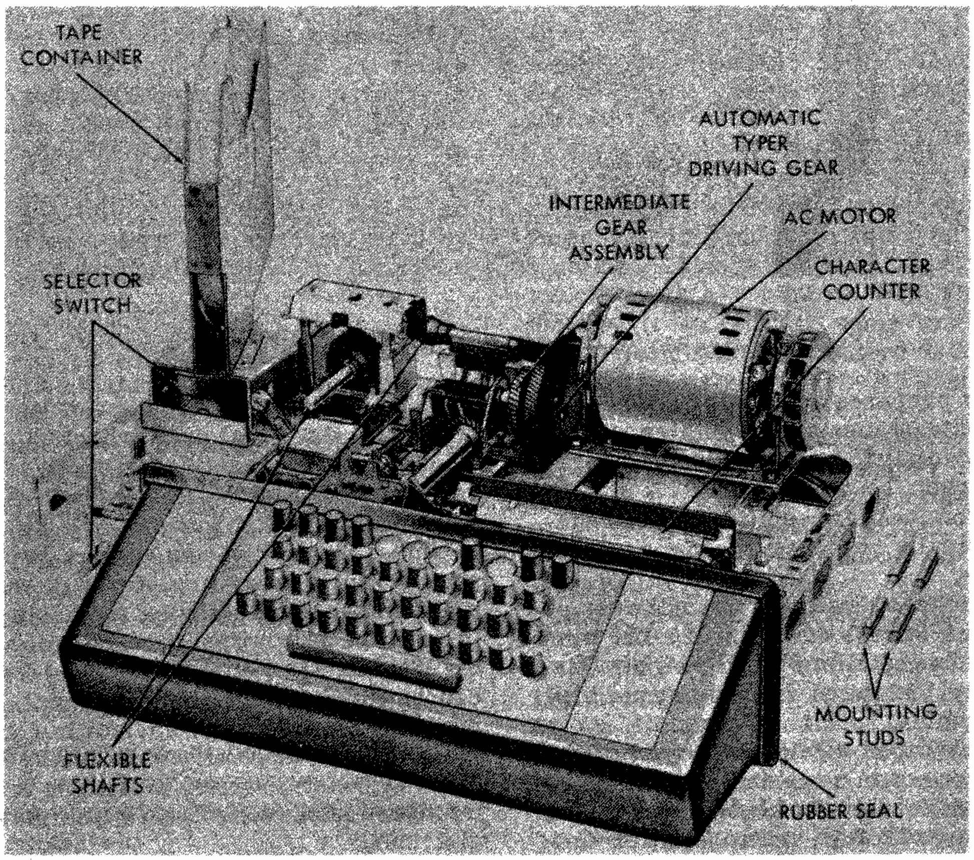


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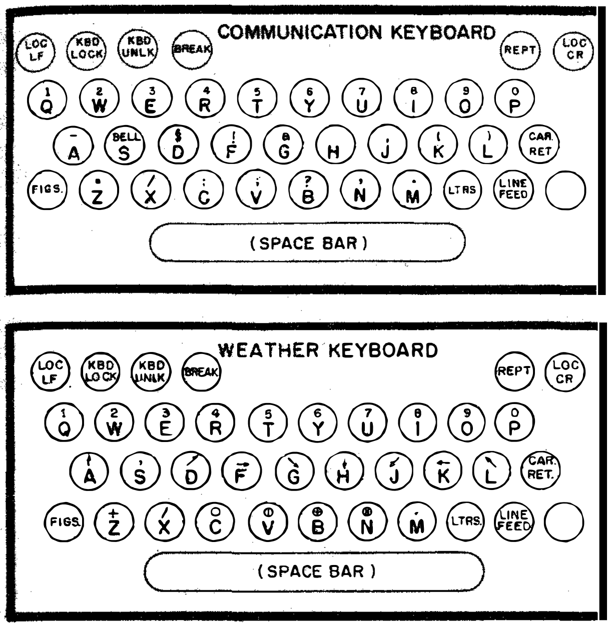
Figure 9-2.—Teletypewriter keyboard unit.



31.23

Figure 9-3.—Two types of teletypewriter keyboards.

flexible connections for operating the typing perforator and transmitter distributor, and a three-position selector switch for choosing the mode of operation of the equipment.

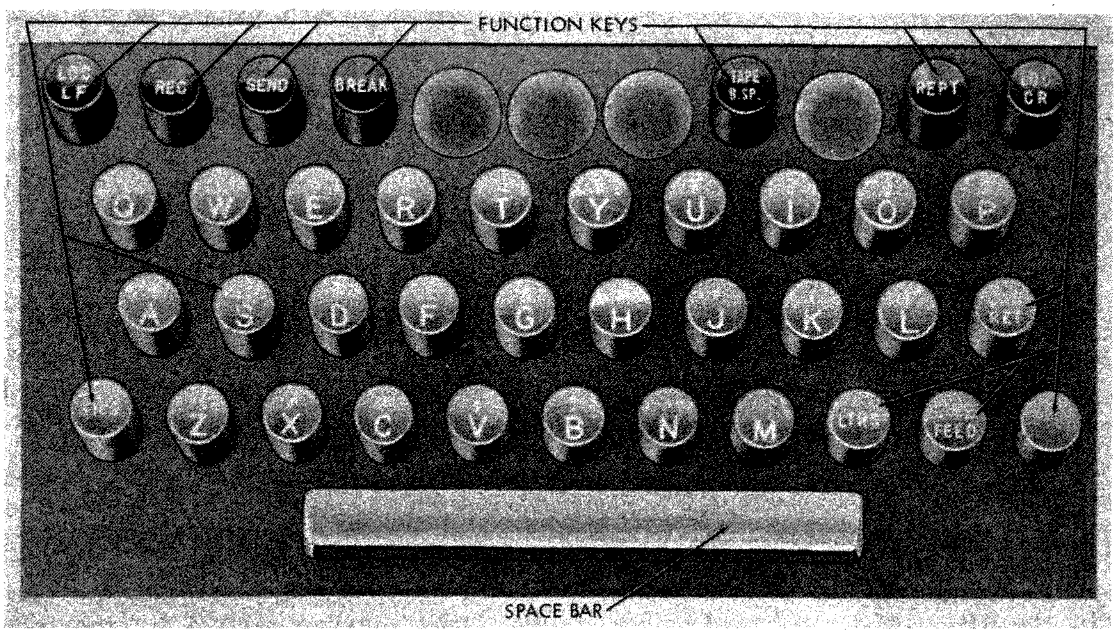
The keyboard mounts in the cabinet on rails of a shock-mounted cradle. The front of the keyboard protrudes from the cabinet and is fitted with a rubber seal for a silencing effect. Mechanical power for activating the keyboard is derived from the a-c motor through intermediate drive gears and the typing unit or the typing perforator, depending on the selected mode of the three-position switch.

The model 28 printer series is equipped with either of two types of keyboards: communication or weather. The communication keyboard contains letters and punctuation marks common to the standard typewriter, and the weather keyboard provides necessary symbols for transmission of weather data. Similarities and differences in the two keyboards are illustrated in figure 9-3. Observe that the lowercase characters are the same, and that letters of the alphabet appear in the same positions. The difference lies in the uppercase of the bottom two rows. A trained operator can use either the communication or weather keyboard without loss of speed or efficiency.

Figure 9-4 is an illustration of the communication keyboard with emphasis placed on the function keys. The action performed by the function keys is described as follows:

1. SPACE BAR—The space bar, located at the front of the keyboard, is used to send spaces (as between words).

2. CAR RET (carriage return)—The carriage return key is used to return both the type box carriage and the printing carriage to the left to start a new line of typing.



50.93

Figure 9-4.—AN/UGC-6 keyboard.

3. LINE FEED—When depressed, this key causes the paper to feed upward one or two spaces depending upon the position of the single-double line feed lever located on the typing unit.

4. FIGS (figures)—The figures key is pressed to condition the machine for printing figures, punctuation marks, or other uppercase characters.

5. LTRS (letters)—The letters key is used to condition the machine for printing the letters (lowercase) characters.

6. BELL—Operation of the BELL key (which is uppercase action of the S key) causes a signal bell to ring locally and at distant stations.

7. BLANK (unlabeled key in bottom row)—Depressing the blank key twice (effective in either uppercase or lowercase) locks all keyboards in the circuit and renders them inoperative by setting up the receive condition. Restoration to the send condition is accomplished, under individual circumstances, through operation of the KBD UNLK key by the operator desiring to send from his keyboard. (KBD LOCK and KBD UNLK, when installed, will be located in spaces available in the center of the function key row).

8. BREAK—To stop (break) another station's sending, depress the BREAK key for about 3 seconds. This causes the KBD LOCK key to drop and lock keyboards on both sending and receiving machines. After a break it is necessary to operate the KBD UNLK key to free the keyboard for sending.

9. REPT (repeat)—To repeat a character, depress the character key and the REPT key. The character will be repeated automatically at line speed as long as both keys are held down.

The four keys described next perform their functions only on the machine on which the key is operated (referred to as "local machine"), without affecting any other machine on the line.

10. LOC LF (local line feed)—To feed the paper up in the local machine, depress the LOC LF key, which feeds the paper up automatically and rapidly as long as it is held down. This key is for use in locally feeding up paper to tear off a message not fed up far enough by the transmitting station. It also is used when inserting a new supply of paper in the machine.

11. KBD LOCK (keyboard lock)—To lock the keyboard on the local machine, depress the KBD LOCK key. The keyboard is now inoperative until released by the KBD UNLK (keyboard unlock) key. The KBD LOCK key also drops automatically when the power switch is turned OFF, when the BREAK key is operated, or when a break is received.

12. KBD UNLK (keyboard unlock)—To unlock the keyboard on the local machine, depress the KBD UNLK key. This action raises the KBD LOCK key, making the keyboard operative. Operate this key after turning on the power switch and after sending or receiving a BREAK.

13. LOC CR (local carriage return)—To return the type box to the left margin on the local machine, depress the LOC CR key. This key is for use in omission of carriage return at the end of a transmission from another station.

Typing Unit

The typing unit used in the AN/UGC-6 teletypewriter is pictured in figures 9-5 and 9-6. The typing unit incorporates the necessary electrical and mechanical elements to translate the signaling code combinations into mechanical actions that print the messages and perform functions incidental thereto.

Code signals are applied to a two-coil selector magnet that interprets the signals and controls the motion involved in typing a character or performing a required function. A range finder is provided for orienting the selector unit to the received signal.

The a-c motor (mounted on the keyboard unit) is geared to the main shaft of the typing unit, which, in turn, extends motion to the keyboard mechanism. The typing and various functional sections of the typing unit are activated by individual clutches that completely disengage at the termination of each operating cycle and thus reduce the motor load to a minimum during idling.

The paper roll is mounted at the top rear of the typing unit. The paper feeds around the platen that rotates but does not move horizontally.

Type pallets are arranged in a small type box (fig. 9-7), which is detached easily for cleaning or replacement. In operation, the type box moves across the paper and presents the proper type pallets to the printing hammer, which drives the pallets and inked ribbon against the paper to print the characters. Combined automatic carriage return and line feed features operate to return the carriage if overprinting occurs at the end of a line.

As each character is printed the inked ribbon feeds from one spool to the other reversing automatically when the ribbon reverse lever is tripped by the small rivet at each end of the ribbon. The ribbon mechanism is shown in figures 9-8 and 9-9.

Printing is produced by the type box, which contains the characters and symbols shown on the key tops. Operation of keys and spacebar moves the type box across the platen from left to right. On each key stroke the type box is moved into position for the printing hammer to strike the proper type pallet, printing the character on the paper. Operation of the CAR RET key returns the type box to the left margin, and operation of the LINE FEED key moves the paper up to the next line.

The force of the printing blow is controlled by the printing spring adjusting bracket, which is set for the individual service requirement according to number of carbon copies required. Notch 1 is for one to three copies, and notch 2 for four or five copies. If copies are either too light or too dark, the force of the printing blow can be adjusted by moving the printing spring adjusting bracket, taking care not to make the printing blow any heavier than necessary to produce satisfactory copies.

Type pallets are arranged in four rows. (See figure 9-7.) The type box moves up and down in selecting the row in which each character to be printed is located. Lowercase characters are in the left half of the box and uppercase characters are in the right half. The type box moves left and right on shifting and unshifting operations, rather than in the familiar up-and-down motion of carriage shifting on the typewriter and older teletypewriters. This combined vertical and horizontal motion brings the character to be printed into line with the printing hammer. There are two pointers on the type box, (see figure 9-5) the LTRS pointer on the left and

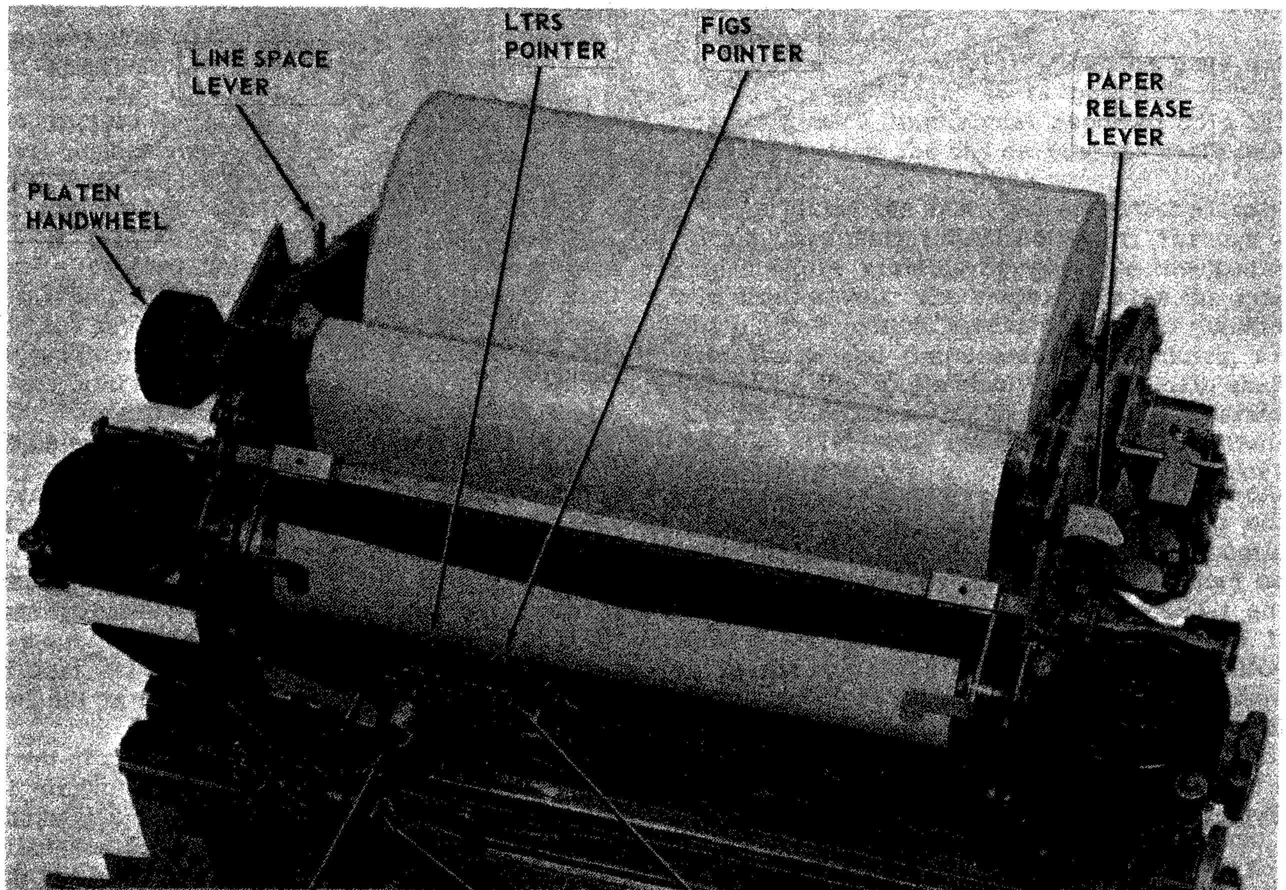


Figure 9-5.—AN/UGC-6 typing unit. 1.218

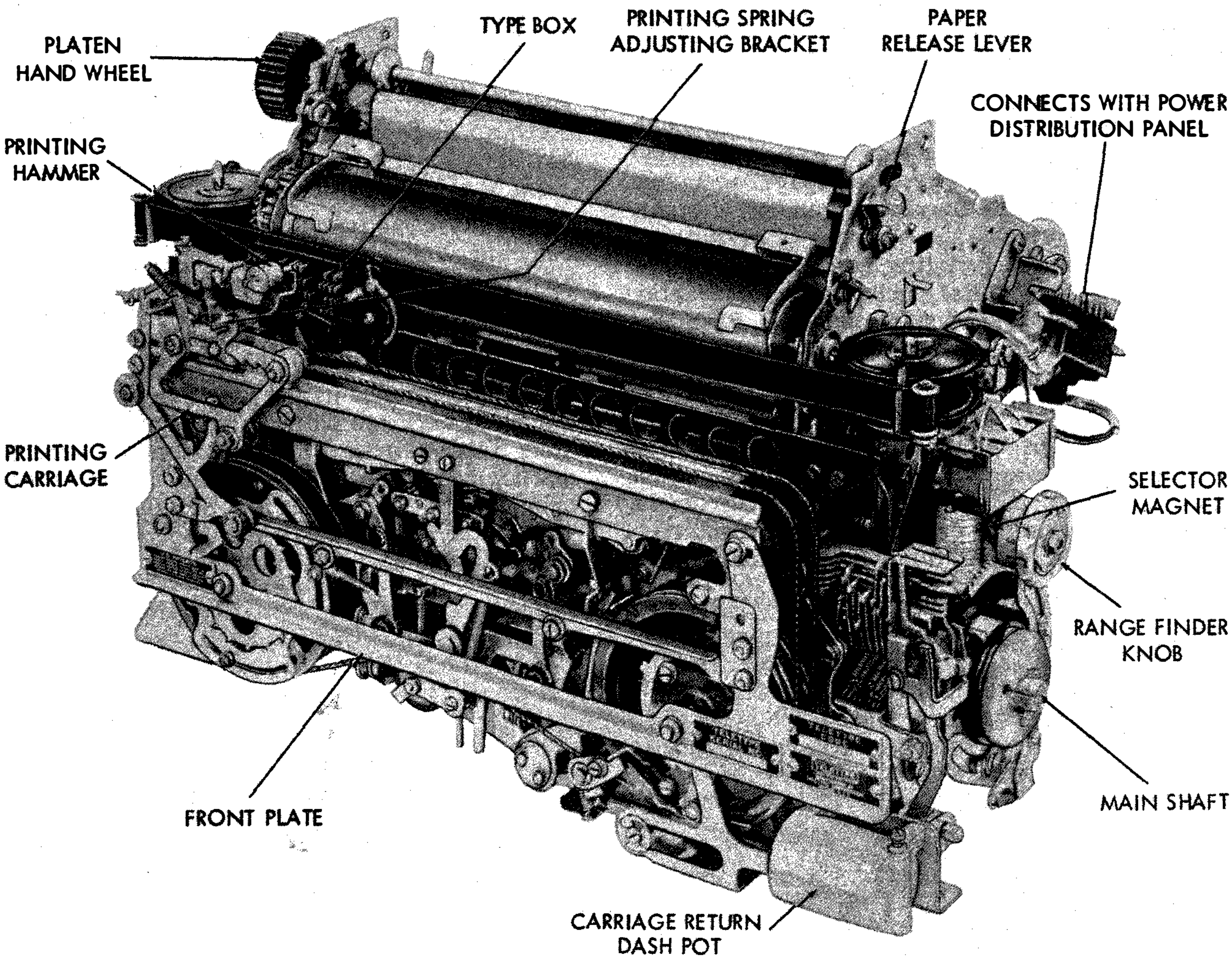


Figure 9-6.—Typing Unit (front view). 50.94

the FIGS pointer on the right. When typing stops, the pointer at which the printing hammer is aimed indicates where the next character will be printed. If the printing hammer is aimed at the LTRS pointer, the type box is in lowercase. If the printing hammer is aimed at the FIGS pointer, the type box is in uppercase. An operation shifting the type box to uppercase or lowercase moves the corresponding pointer to the typing location.

Typing Perforator

Tape preparation, by operation of the keyboard, is accomplished by the typing perforator (figure 9-10 and 9-11). This perforator is controlled by mechanical linkages on the keyboard. The tape produced by the perforator is a transmissible, five-level, chadless, perforated tape with printed characters corresponding to the perforated code.

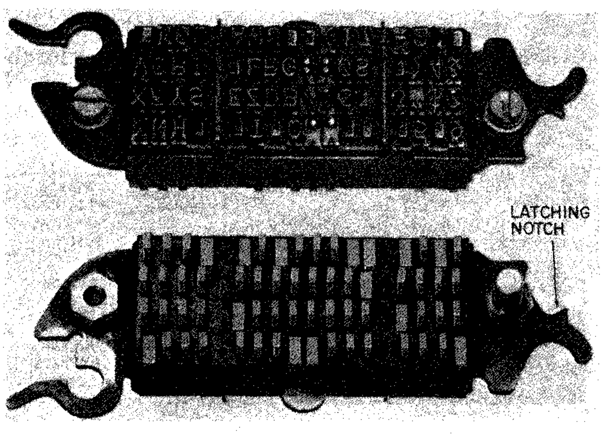
The typing perforator, mounted on the left front corner of the keyboard, is powered through flexible connections and a jack shaft by the a-c motor mounted on the keyboard. Its tape is supplied from a container mounted at the left rear corner of the keyboard.

With the keyboard selector switch in the K (keyboard) position, the typing perforator is inoperative. (See figure 9-12.) In K-T (keyboard-tape) position, the selector switch manually engages linkages between the keyboard and the perforator to permit preparation of perforated and typed tape simultaneously with signal line transmission. With the switch in T (tape) position, operation of the keyboard results in perforator operation independent of the signal line.

Printing on the tape is accomplished by a typewheel. Some typewheels are bakelite, others are plastic. The typewheel character arrangement is pictured in figure 9-13, in which the wheel's cylindrical surface is shown rolled out into a plane. There are 16 longitudinal rows, each made up of 4 characters numbered 0 to 3 from front to rear. The surface is divided in 2 sections, a letters and a figures section. Each section contains 8 rows. The fifth row counterclockwise from the division line in both sections is numbered 0. Four rows in one direction from 0 are numbered 1 to 4 and designated as counterclockwise rows. Three rows in the other direction, numbered 1 to 3, are designated as clockwise rows. The terms clockwise and counterclockwise refer to the direction of rotation of the wheel to select the rows—not to their position on the wheel.

The typewheel is controlled by mechanical arrangements in the keyboard. Axial and rotary positioning mechanisms select the proper characters by moving the typewheel. The printing mechanism includes a hammer for driving the tape and inked ribbon against the typewheel to imprint the selected characters.

A perforating mechanism steps the tape, rolls in feed holes, and perforates chadless code holes corresponding to the code selected in the keyboard. Printing and perforating occur simultaneously at the punch block, but the characters are printed six spaces to the right of the corresponding code combinations. The tape thus produced has the same printing/perforating relationship as printed chadless tape produced



31.28
Figure 9-7.—Type Box, front and back.

by older models of teletypewriters. The typewheel is retracted at the end of each operation, so that the last printed character is visible to the operator.

Typing Reperforator

The typing reperforator is similar to the typing perforator already described, with identical subassemblies for the typing and perforating mechanisms. (See fig. 9-14.) Because the reperforator is not controlled by the keyboard but receives messages from an incoming signal line instead, it has a selector unit. The typing reperforator is mounted on a special base and is powered by a separate a-c motor and an auxiliary power distribution panel, both of which are unrelated to other components of the teletypewriter.

The location of the reperforator in the cabinet is at the top left, above and behind the transmitter distributor.

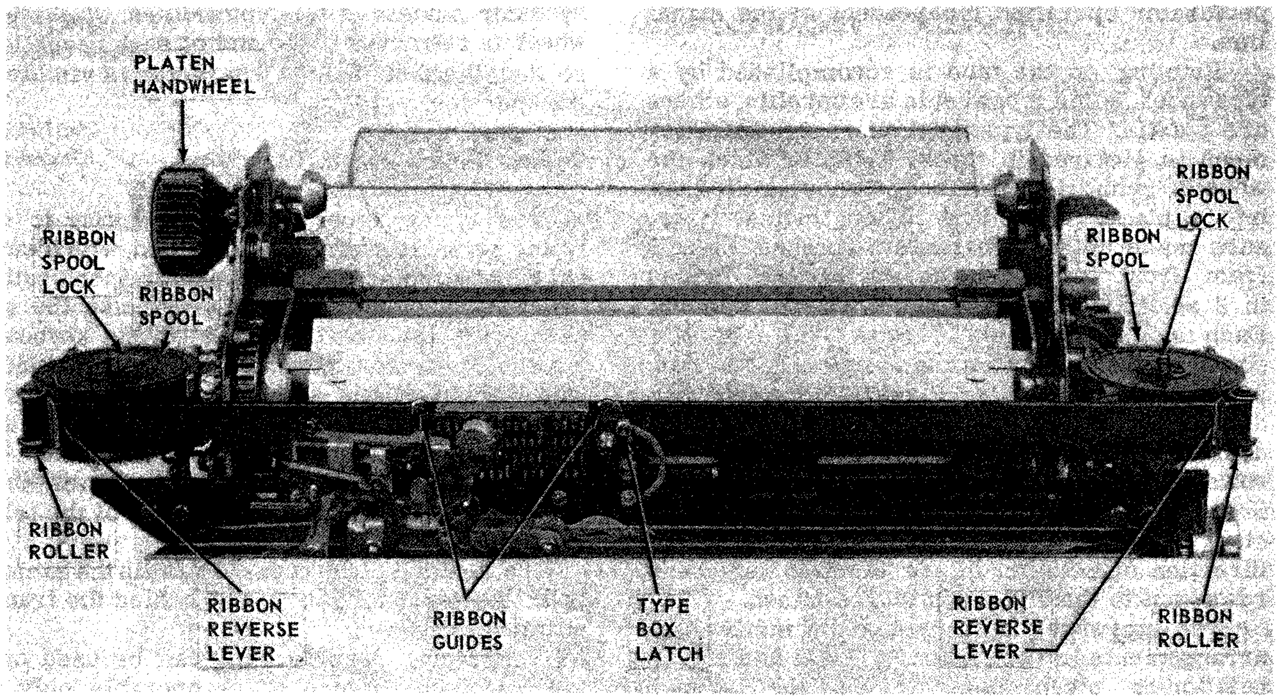
The typing reperforator can be used only for receiving. Hence it is operable only in response to a line signal received on a different line from the one serving the basic teletypewriter.

Energizing the main power switch (located on the base unit) starts the motor. Through an intermediate variable speed drive mechanism and timing belt, the motor rotates the main shaft. Two clutch mechanisms, the function cam-clutch and the selector cam-clutch, are driven by the continuously rotating main shaft. The function cam-clutch mechanism operates both the perforating and the typing mechanisms. These are identical to corresponding features of the typing perforator. The selector cam-clutch operates a selector. In response to signal code combinations, this selector sets up mechanical arrangements that control the perforator and typing mechanisms.

Like the typing unit, the typing reperforator is wired for operation on 35-ma line current, but can be converted for operation on other line current values.

Although the reperforator is equipped with the same backspace mechanism found on the typing perforator, it is inoperable because it is not wired to any operating circuit or key.

Additional features of the reperforator that are not common to the perforator are the signal bell and switch, low tape alarm and switch, the mechanical variable speed drive mechanism,



1.222

Figure 9-8.—Ribbon inserted.

a noninterfering blank tapefeed-out mechanism, and a tape threading handwheel.

Typing Reperforator Base

The typing reperforator base unit is shown in figure 9-15. It provides a foundation for the typing reperforator and the a-c motor, and incorporates a number of electrical and mechanical accessories. It is mounted above and behind the transmitter distributor and is fastened to the transmitter distributor base and to the rear rail of the cradle at the left side of the cabinet.

The base has a line fuse and electrical facilities for interconnection of the typing reperforator and its auxiliary power distribution panel. A variable speed drive mechanism affords three manually selected optional gear ratios for operation at 60, 75, or 100 wpm. The base also has a tape container equipped with a low tape alarm switch.

Transmitter Distributor

The transmitter distributor (fig. 9-16) is mounted on its own base in front of the cabinet on the left side. It is a mechanical tape reader used to convert messages on standard five-level chadless or fully perforated tapes to signaling code combinations for transmission on a telegraph channel.

A main shaft, powered by flexible shaft connections from the keyboard motor through an intermediate gear and shaft on the transmitter distributor base unit, operates a cam-clutch assembly. The cam-clutch, through the main bail, drives a transfer and signal generating mechanism and a tape feed wheel. The clutch is released by a clutch trip magnet.

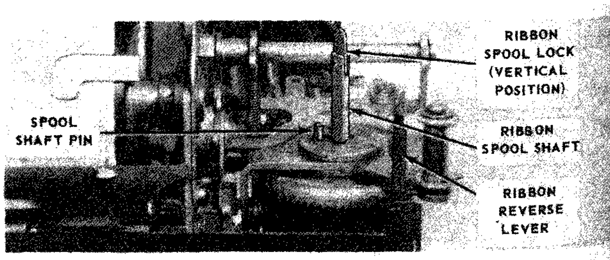


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Figure 9-9.—Ribbon spool mechanism.

The unit includes a start-stop switch in which are incorporated tight-tape, shut-off, and free-wheeling tape feed features. A second switch shuts off the transmitter distributor automatically when tape runs out. Electrical requirements are supplied from the power distribution panel through a connector on the base. Transmission speed is 60, 75, or 100 wpm, depending on the optional gear ratios selected.

Motors

Two types of motors can be used with the Model 28 series equipments: synchronous and governed. (See figure 9-17 and 9-18.) Previously, it was explained that the AN/UGC-6 uses synchronous motors. The installation of governed motors changes the model designation to AN/UGC-6X. The a-c synchronous motor is used in installations that have 60-cycle power with good frequency stability. Frequency stability is extremely important because the correct speed of the synchronous motor depends on a precise 60-cycle power source. Aboard ships and stations where the a-c power supply has poor frequency stability the teletypewriters are equipped with governed motors.

Two a-c motors (either synchronous or governed) are required with each AN/UGC-6 teletypewriter, one mounted on the keyboard unit (figure 9-2) and the other on the typing reperforator base (figure 9-15).

Cabinet

A sheet metal cabinet (figure 9-19) houses all the components of the teletypewriter. The upper portion holds the keyboard, typing unit, typing perforator, transmitter distributor and its base, power distribution panel, and the typing reperforator and its base. The auxiliary power distribution panel for the typing reperforator is housed in a rack in the lower part of the cabinet.

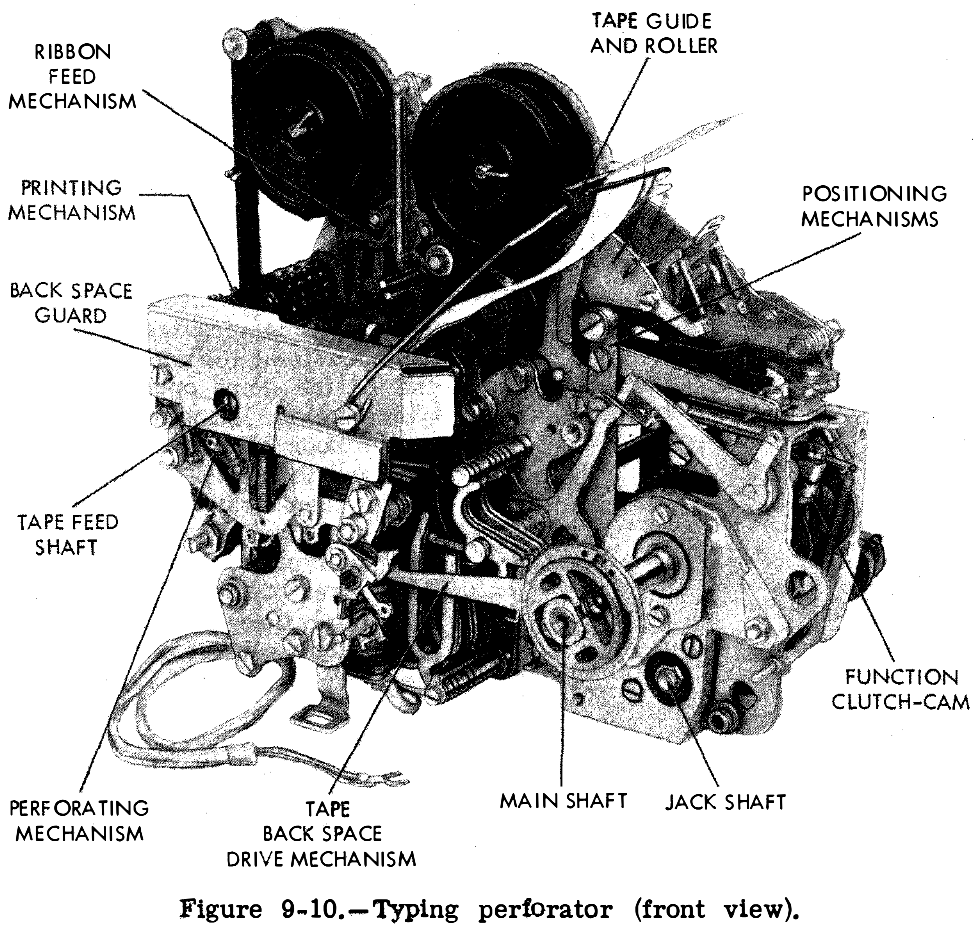

Figure 9-10.—Typing perforator (front view).

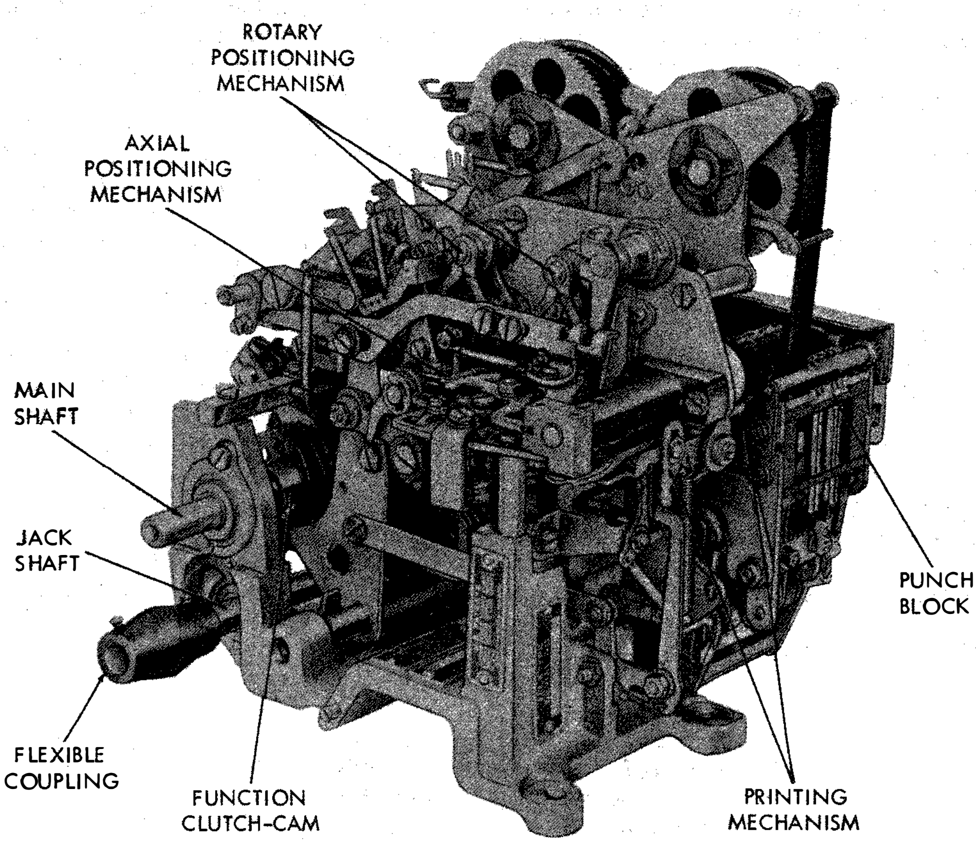

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Figure 9-11.—Typing perforator (rear view).

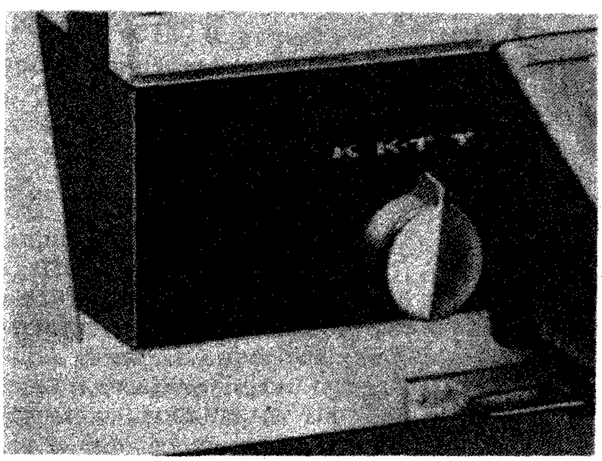

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Figure 9-12.—Selector switch.

A dome, extending completely across the cabinet, is hinged at the rear and latched at both sides. It is partially raised by two torsion bars when the latches are released. Small doors in the dome provide access to components without raising the dome. A door at the top right end of the dome opens above the rear of the typing unit for changing paper. A window in front of the door affords a view of the platen, type box, and the line being typed. The rear of the window is a straightedge for tearing off printed copy. The window can be opened for straightening the paper or changing ribbon. A dome door in the center of the cabinet is for reloading the perforator tape container. A hinged part of the front of the cabinet can be raised for access to the perforator. When closed, this part has two windows for viewing the perforated tape. The window at the left serves as a tape cutoff guide. A door at the left of the dome provides access to the typing reperforator.

The dome is wired to include a 6-volt copy and indicator lamp circuit. Associated with this circuit is a transformer and a three-position toggle switch accessible in the center of the cabinet dome when the right dome door is open. Also mounted in the dome are a lamp for illuminating tape copy in the perforator, two lamps for the typing unit copy paper, and a margin indicator or end-of-line lamp.

Terminal boards, on which all wiring terminates, are located across the back panel of the cabinet.

The shelf separating the upper portion from the lower part of the cabinet serves as a mount for most of the components. A signal bell is located on the bottom side of the shelf. An electrical noise suppressor, incoming signal and power lines, and a cradle assembly are mounted on the top side of the shelf. The cradle rests on vibration mounts. A switch lever, for controlling the power switch on the power distribution panel, extends under the cradle and protrudes at the right of the keyboard. A similar lever for controlling the line test key is positioned at the left of the keyboard.

OPERATING THE AN/UGC-6

Power is applied to the AN/UGC-6 by a switch located on the front of the cabinet, slightly below and to the right of the keyboard. Rotating the switch so that the pointer is pointed up energizes the equipment, except for the reperforator, which is controlled by its own power switch.

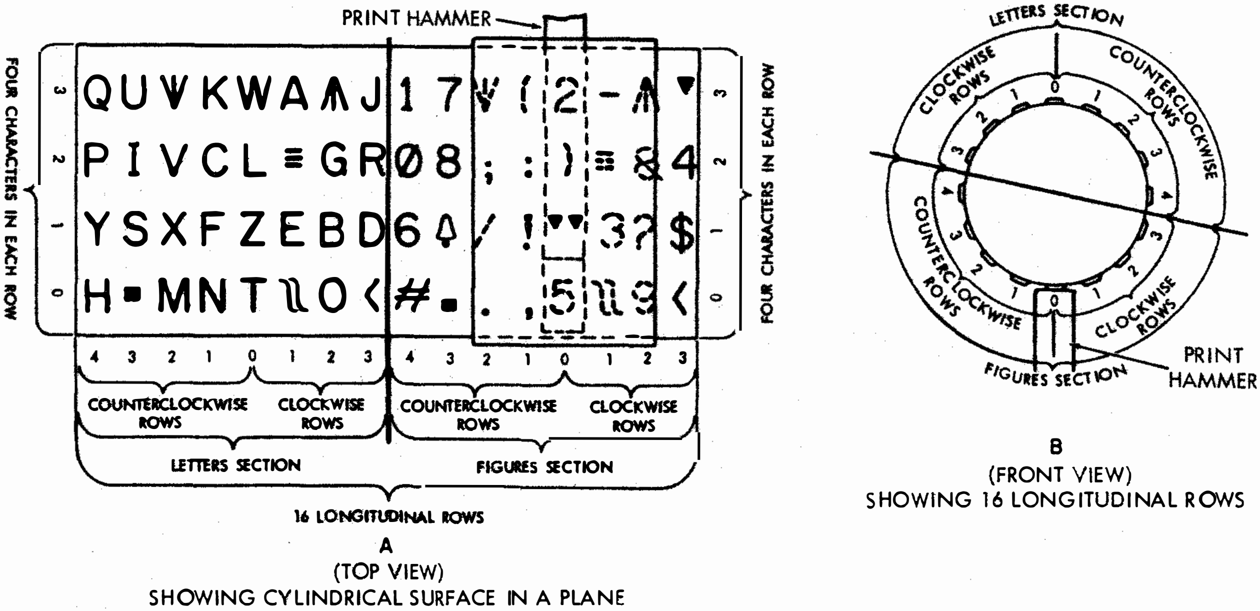
After applying power, but before operating the set, ascertain that the line-test switch (figure 9-12) is in the desired position. The switch must be in the lower (LINE) position to connect the teletypewriter to distant stations. In the upper (TEST) position, the equipment is connected to a local test circuit (if wired), and no intelligence is sent to the signal line. This, of course, does not affect the reperforator, which is connected to its own external line.

With power applied and the line-test switch in the LINE position, select the desired mode of operation with the three-position selector switch (figure 9-12). From left to right, the three positions of the switch are keyboard (K), keyboard and tape (K-T), and tape (T).

Keyboard Mode of Operation

To transmit a message directly to the line as you are typing it, rotate the selector switch to the K position. Depress and hold down the BREAK key for approximately 2 seconds to lock out all keyboards in the circuit, and then depress the SEND (KBD UNLK) key to unlock your keyboard. The typing unit monitors your transmission, providing you with a printed copy of the message.

In the keyboard mode of operation, the typing perforator is mechanically isolated from the keyboard, and the character counter mechanism



50.100

Figure 9-13.—Typewheel character arrangement.

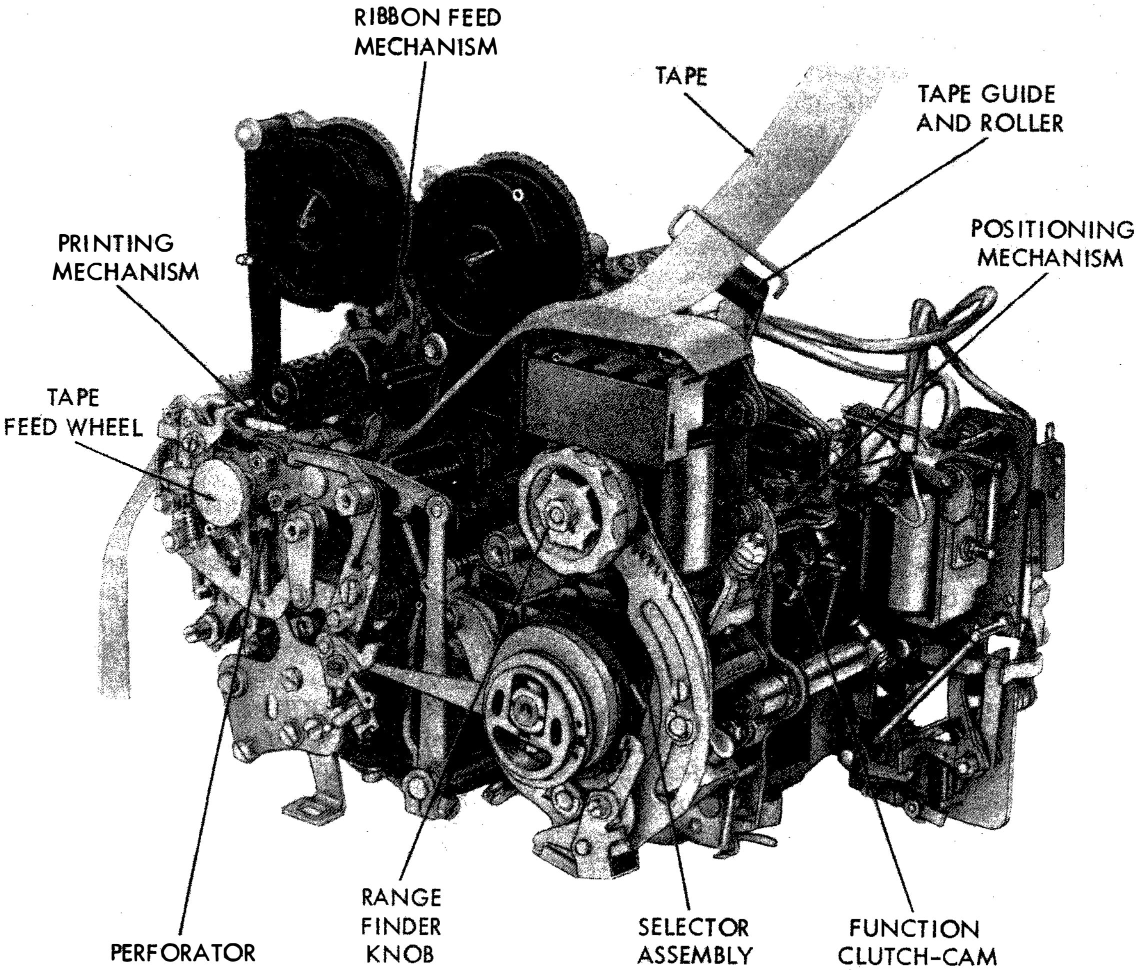


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Figure 9-14.—Typing reperforator (front view).

does not function. The transmitter distributor circuits also are inoperable.

Keyboard-Tape Mode of Operation

Keyboard operation in the keyboard-tape (K-T) mode is the same as when in the keyboard mode, except that typed, perforated tape is prepared simultaneously by the typing perforator. This mode is particularly useful when a message must be transmitted on more than one circuit. You can transmit the message on one circuit while preparing a tape for transmission on the other circuits.

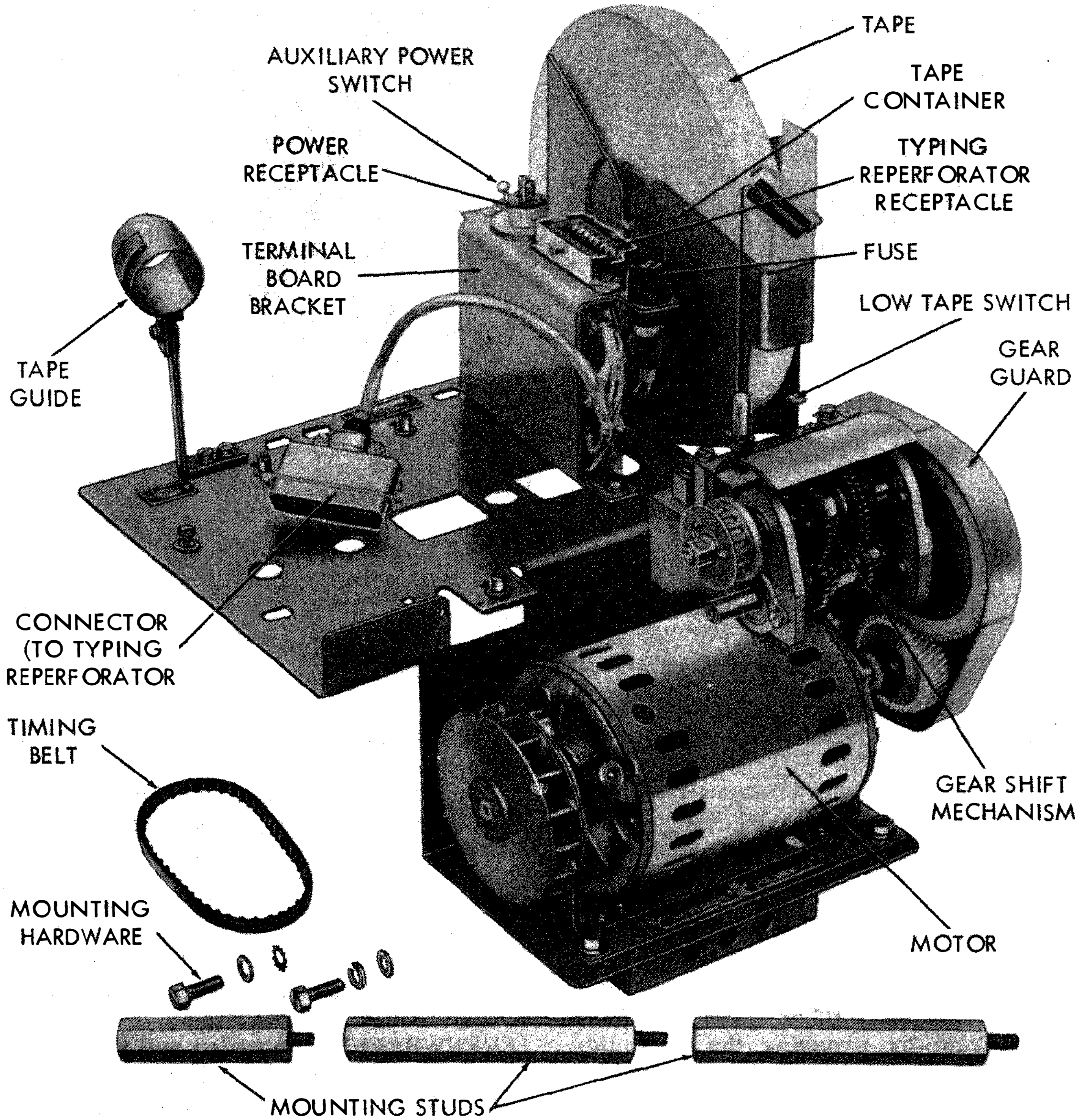
With the line-test switch in the TEST position, you can utilize this mode of operation to prepare tape for later transmission and, at the same time, to obtain a page copy of the transmission as it will appear when sent on the circuit. Care must be exercised in using this method, however, because you can neither send nor receive messages during the period the machine is disconnected from the circuit.

When the selector switch is in the K-T position, the character counter moves one unit to the right with each character and spacing operation recorded on the tape. The transmitter distributor also is operable.

Tape Mode of Operation

When the selector switch is in the T position, the keyboard and perforator are isolated from the other units. This permits you to prepare tape for transmission while transmitting messages via the transmitter distributor, or receiving messages on the printer. You type no page copy in this position, so watch the character counter to make certain that you do not type too many characters for the length of the line. As pointed out previously, the counter registers each spacing character. Nonprinting functions, such as FIGS, LTRS, LF, and CAR RET, are not registered.

To correct an error when punching tape, depress the TAPE B. SP. key to move the tape back, one space at a time, until the first wrong code is over the perforating pins of the punch block. Press the LTRS key as many times as you have backspaced to change the incorrect codes to LTRS codes. Because it is the only character having all five perforations, the LTRS code will obliterate any other character code on the tape. This is called "lettering out" an error. After lettering out the incorrect portion, retype that part of the message. The error will not appear on the page copy when the tape is sent. The characters still are registered on the counter, however. Therefore, when the counter indicates that you have reached the end of the line, you still may type as many characters as you lettered out.



50.103

Figure 9-15.—Typing reperforator base.

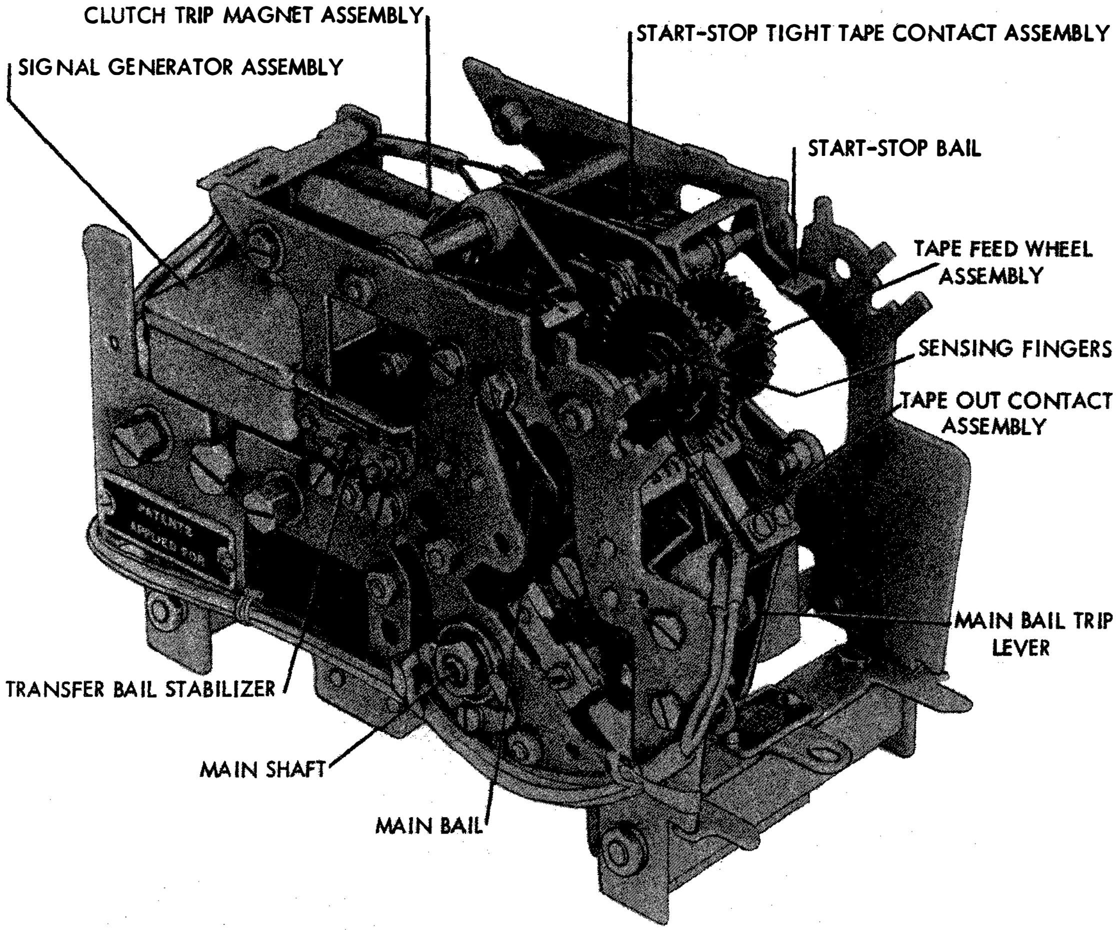


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Figure 9-16.—Transmitter distributor (cover plate, top plate, and tape guide plate removed).

Using the Transmitter Distributor

The transmitter distributor (commonly called the TD) is operable only in the K-T and T modes of operation, and then only when the SEND key is depressed. In the following discussion of the TD, assume that the selector switch is in either the K-T or T position and that the SEND KEY IS DEPRESSED.

To place a tape in the TD, move the start-stop lever to the center (OFF) position. Release the tape lid by pressing the tape lid release button. Place the tape in the tape guide in such a manner that its feed holes engage the feed wheel with the portion of the tape having two perforations toward the rear of the TD. Insert printed tape so that the printed, chad side is up. If nontyped chadless tape is used, position the tape so that the open side of the hinged chads is to the top. With fully perforated (chad) nontyped tape, you must be careful to feed the tape from the beginning. Reversing the tape results in a garbled transmission. While holding the tape firmly in place on the feed wheel, press down on the tape retaining lid until its latch is caught. Move the start-stop lever to the left (FREEWHEELING) position and manually adjust the tape so that the first character to be transmitted is located over the sensing pins. Figure 9-20 shows the path of the tape through the TD.

To transmit from the tape, operate the start-stop lever on the TD to the extreme right (ON) position. If the tape is inserted in the TD correctly, it feeds over the sensing pins, and the message is transmitted to the signal line.

ADDITIONAL MODEL 28 UNITS

The design and function of the individual units in the model 28 line of teletypewriters remain basically the same, but the AN nomenclature assigned the units when they are employed separately (or in combinations such as found in the AN/UGC-6) usually is changed. Often, simply changing the style or type of cabinet in which a unit is enclosed causes a change in nomenclature. For example, when the keyboard and typing unit comprising the TT-48/UG teletypewriter (figure 9-21) are placed in the cabinet shown in figure 9-22, they become the TT-69/UG teletypewriter set. The latter set is designed for installation aboard ship.

TYPING REPERFORATOR TT-192/UG

The typing reperforator shown in figure 9-23 is designated TT-192/UG. Basically, it is the same as the one described as a component of the AN/UGC-6. It serves the same purpose and functions in the same manner. Because of space limitations, however, most shipboard installations of the TT-192/UG do not include the table shown in the illustration.

Normally, the reperforator's wiring is terminated in a patch panel (described later in this chapter) so that it can be patched or connected into any teletype circuit wired through the panel. By patching the reperforator into a circuit, a tape copy of each message is obtained, and messages requiring further processing in tape form need not be retyped by the operator.

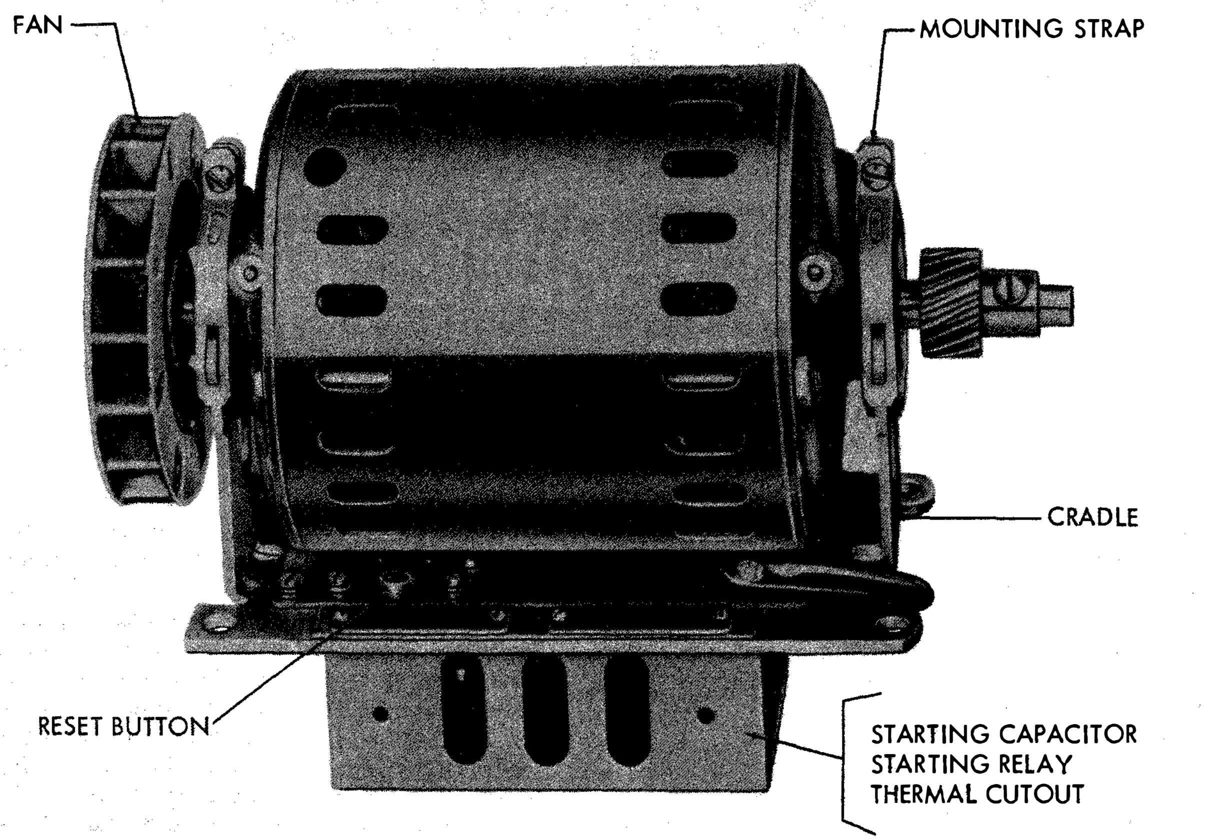
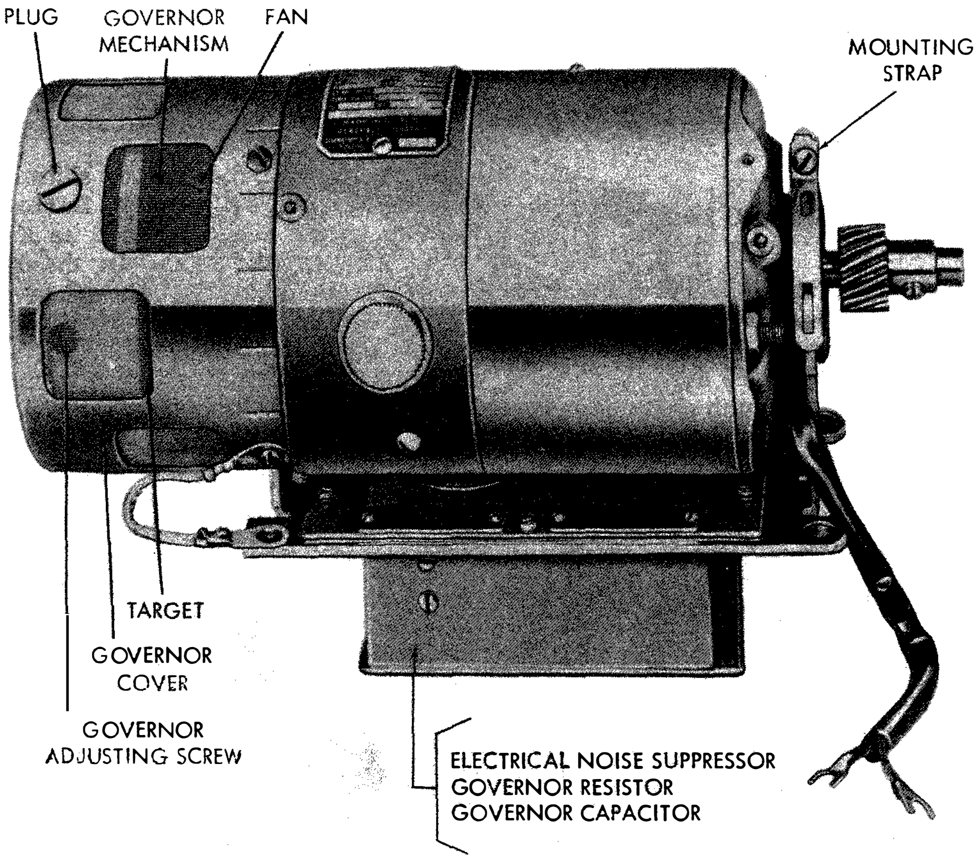


Figure 9-17.—A-C synchronous motor.



50.110

Figure 9-18.—A-C governed motor.

SEND/RECEIVE TYPING REPERFORATOR TT-253/UG

Because of its versatility and compactness, the TT-253/UG send/receive typing reperforator (figure 9-24) is installed aboard ship in large numbers. In addition to its usefulness as a regular reperforator, the set can be utilized to prepare tape for transmission and to send and receive messages in the same manner as the larger, page-printing teletypewriter sets. Its use for sending and receiving messages is, of course, restricted to situations where a page copy is not required.

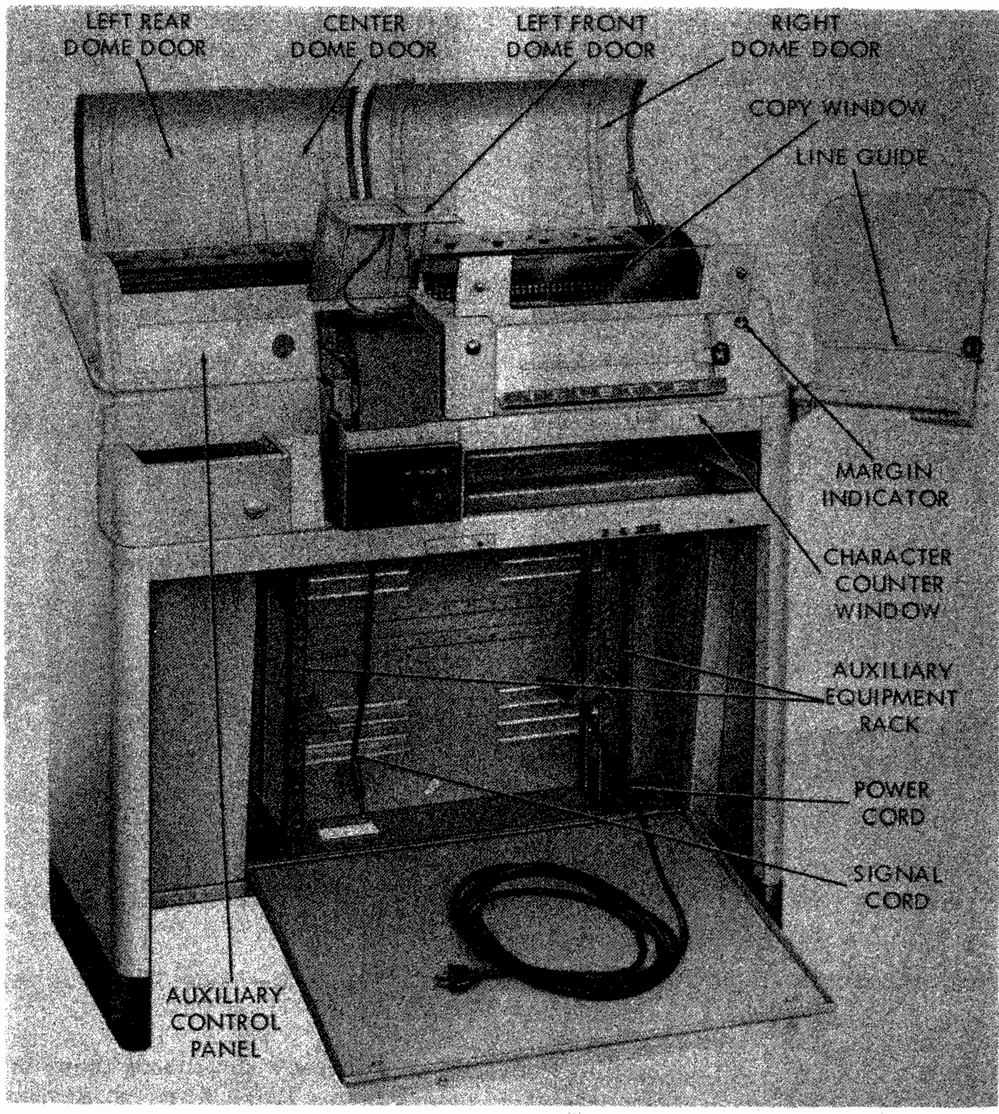
TRANSMITTER DISTRIBUTOR TT-187/UG

With the addition of its own motor, the transmitter distributor described as a part of the AN/UGC-6 console becomes the TT-187/UG shown in figure 9-25. The unit is self-contained and can be mounted in any convenient space that is large enough to accommodate its base.

PACKAGE EQUIPMENTS

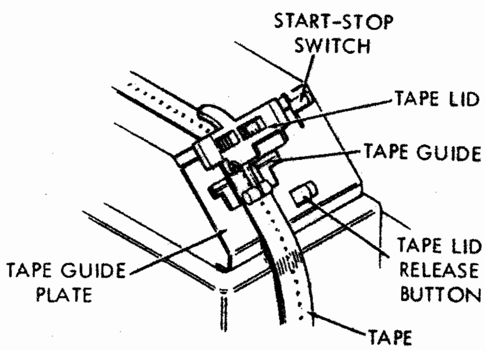
The volume of teletypewriter traffic relayed by NAVCOMMSTAs and many of the smaller shore stations has led to the development of tape relay equipment that requires a minimum of operator attention. The AN/FGC-59 Teletypewriter Set is an example of the type of equipment used in semi-automatic tape relay centers. The AN/FGC-59 consists of three groups; the TT308 Receiving Group, the TT309 Monitor Group, and the TT310 Transmitter Group.

In figure 9-26 are receiving banks or console packages, which house several typing reperforators for use on incoming lines in torn-tape relay centers. The operator logs each incoming



50.113

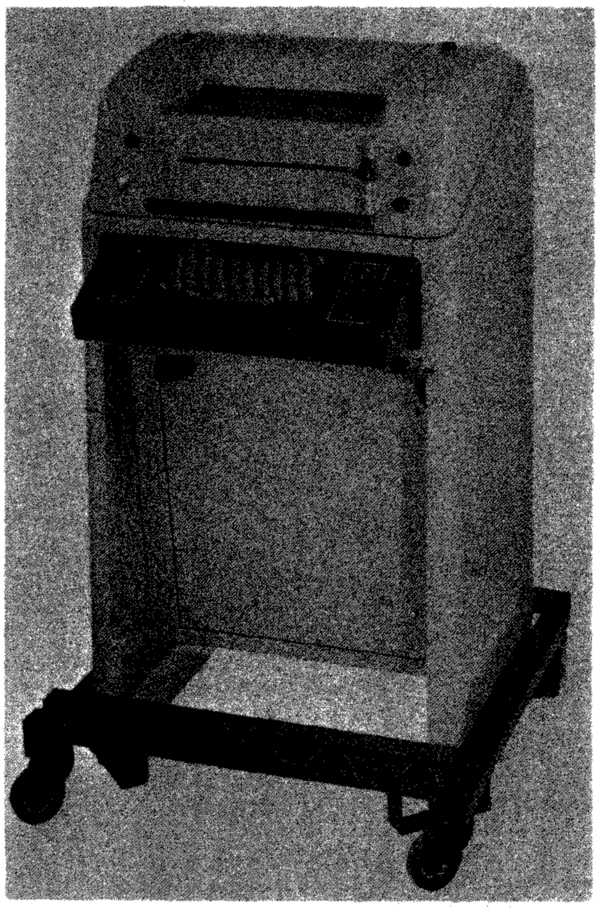
Figure 9-19.—AN/UGC-6 teletypewriter cabinet.



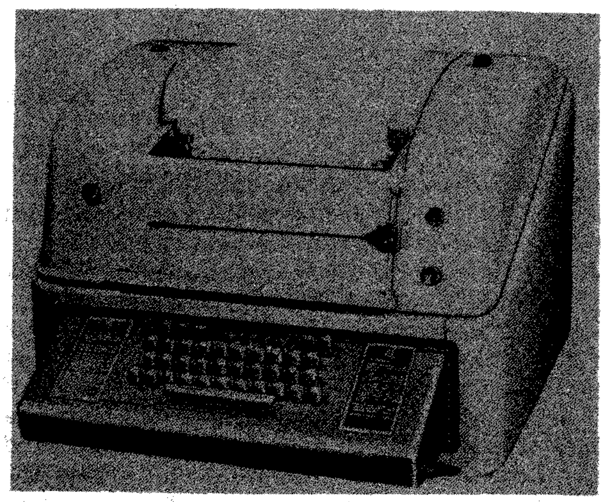
1.210

Figure 9-20.—Path of tape in transmitter distributor.

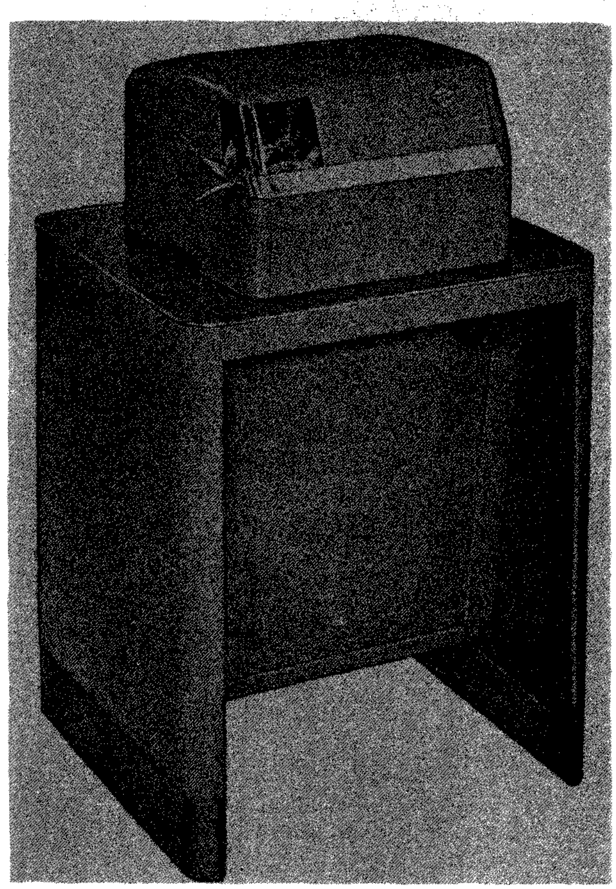
message, tears it off at the end of the message, and determines the proper outgoing circuit from the routing indicators on the tape. He then hand-carries each tape to the appropriate sending bank of automatic transmitter distributors (figure 9-27) and inserts it in the appropriate circuit tape grid (visible at tops of sending banks). The tape grid—sometimes called a washboard because of a certain similarity of appearance—is simply a place where tapes can remain during the period they are awaiting retransmission. They are stowed from top down in order of precedence. Other operators in attendance at the sending bank remove waiting tapes from the grid in order



1.217
Figure 9-21.—Teletypewriter TT-48/UG.



76.35
Figure 9-22.—Teletypewriter TT-69/UG.



50.114
Figure 9-23.—Model 28 typing reperforator set TT-192/UG.

of precedence and insert them in the TDs. A numbering TD applies a sequential channel number to each message, thus keeping a record of traffic relayed over each channel.

If duplicate copies of relayed traffic are required for the files, monitoring equipment (figure 9-28) is used. This is a group of typing reperforators that produces duplicates of tapes undergoing transmission on the sending bank, and winds the monitor tapes on reels suitable for stowage. The monitoring equipment also duplicates the channelnumber for each message, providing a means of reference if the message should be needed in the future.

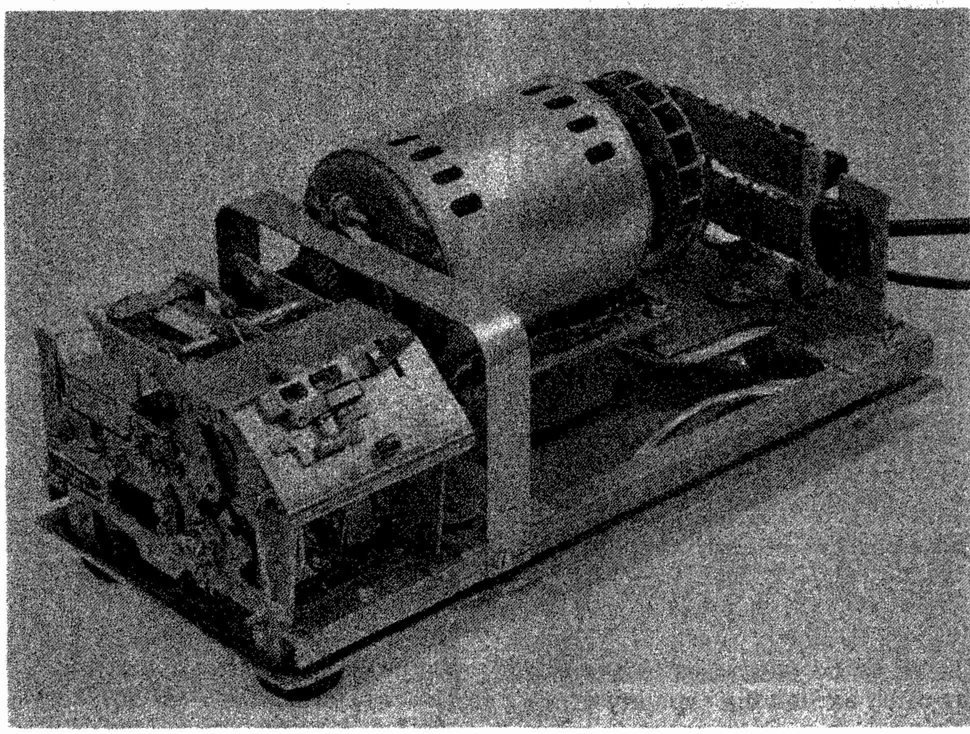
FULLY AUTOMATIC RELAY EQUIPMENT

High-speed automatic relay centers are equipped with the very latest model 28

50.116

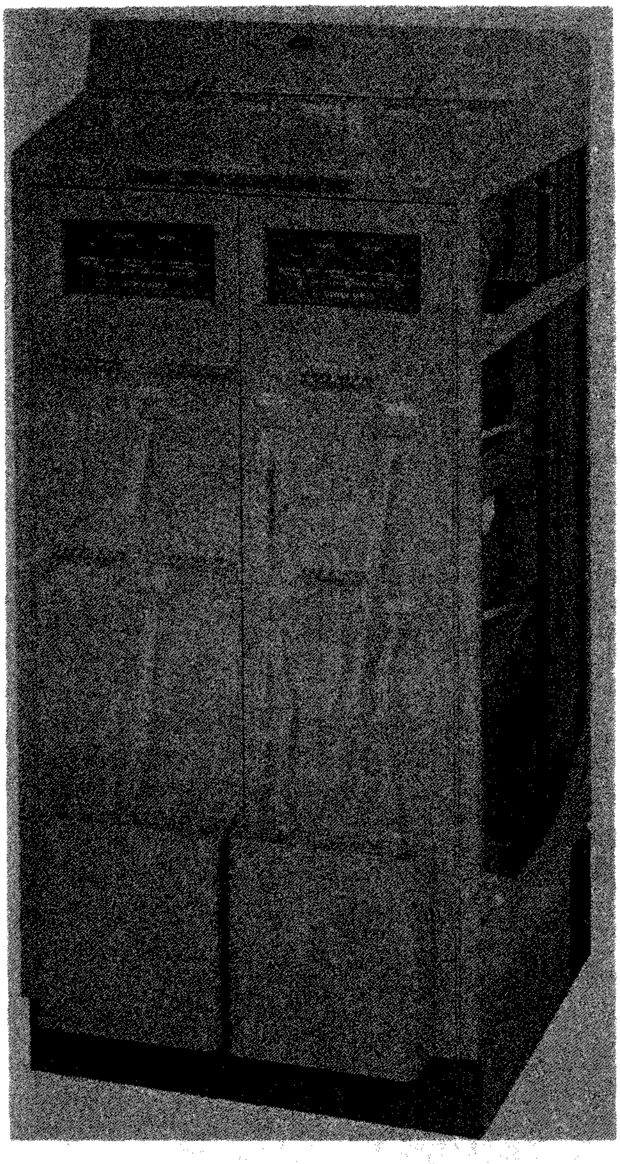
Figure 9-24.—Send/receive typing reperforator TT-253/UG.

teletypewriter components. The transmitter distributors and reperforators are enclosed in cabinets that also contain the operating controls. The Teletype Model 28 Reperforator Transmitter Group AN/FGC-51 (figure 9-29) is basically a mechanical relay or storing device for printing telegraph intelligence. The group provides for fully automatic perforation, storage, and retransmission of an entire message on tape. There are two reperforator-transmitters in each incoming cabinet. They slide out of the cabinet for easy replacement in event of failure. The reperforator-transmitters operate at a cross-office speed of 200 wpm. Therefore, messages are relayed from the incoming line cabinets to the outgoing line cabinets in a matter of seconds. When necessary, a third machine can be assigned to an outgoing circuit, to which high-precedence messages can be switched. The equipment is designed to "recognize" high-precedence tapes; a message in this "priority" machine causes its transmitter to take control of the line as soon as any message in progress is transmitted. The



50.118

Figure 9-25.—Transmitter distributor TT-187/UG (covers removed).



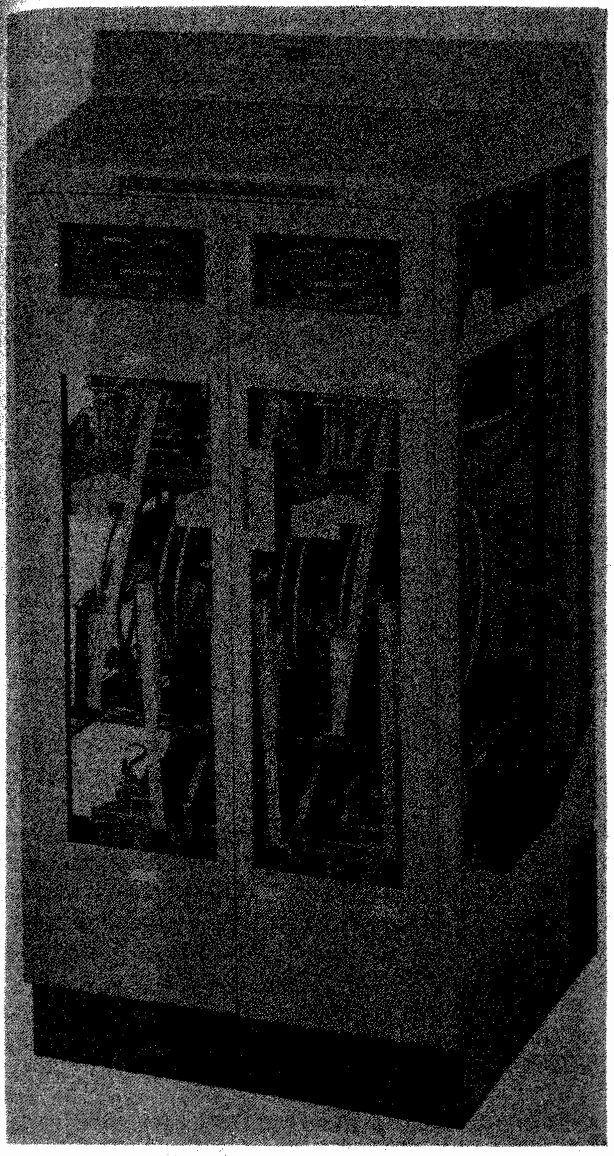
1.369
Figure 9-26.—TT308 of AN/FGC-59; Typing Reperforator Receiving Group.

transmitter retains control until it has processed all urgent messages awaiting transmission. Only then does control revert to the two regular machines.

Traffic volumes to be delivered to a given destination may often exceed the capacity of one outgoing-line channel. In such an event as many as 10 machines and 10 line channels may be shifted to serve a single destination.

All lines are duplex circuits; that is, any station can transmit a message to the relay center at the same time it is receiving a message. Each tributary station normally has two

1.367
Figure 9-27.—TT310 of AN/FGC-59; Transmitter Group.



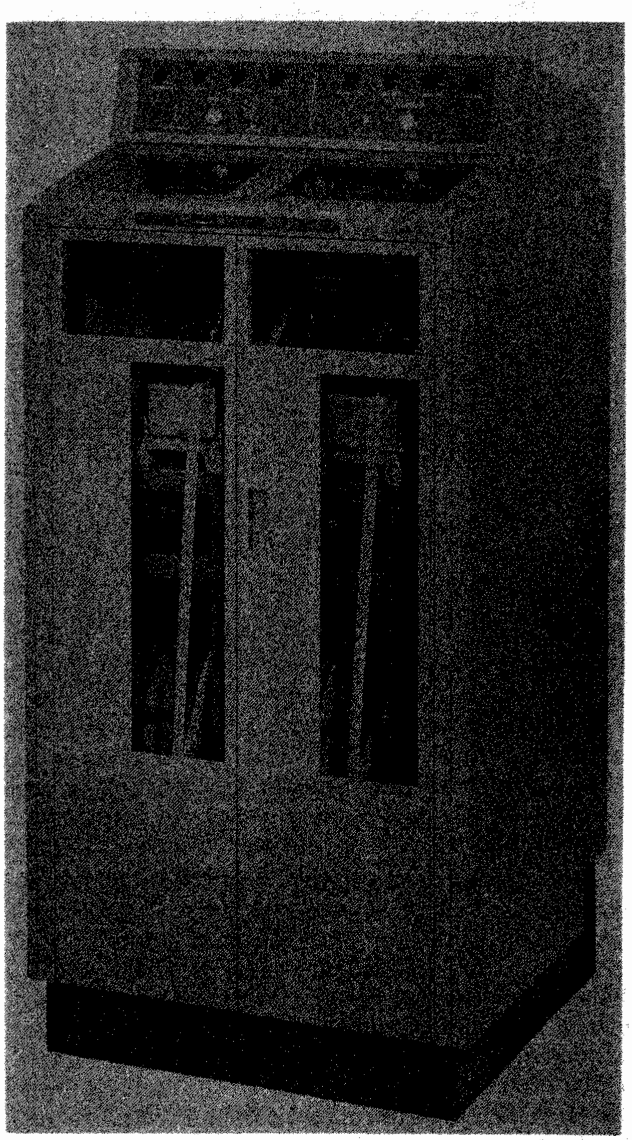
1.368
Figure 9-28.—TT309 of AN/FGC-59; Typing Reperforator Monitor Group.

teletypewriters; one is a sending machine and the other a receiving-only teletypewriter.

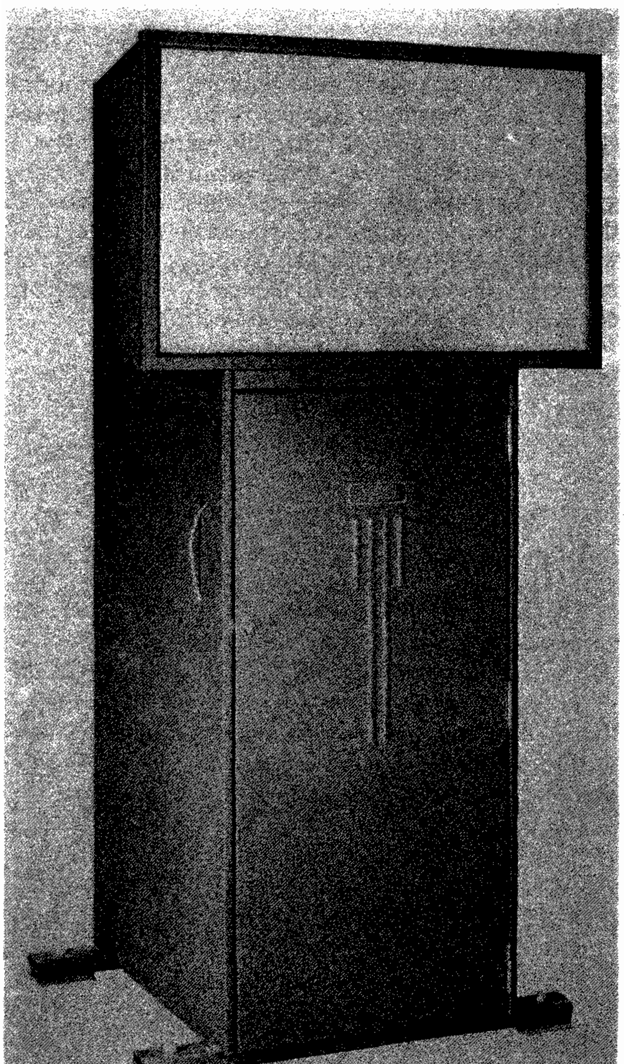
Automatic relay centers are manned by very few operators, compared with semiautomatic torn-tape relay stations. Improperly prepared or garbled message tapes are routed automatically to the intercept position for operator action. Correctly prepared messages enter and leave the relay center untouched by human operators.

TELETYPEWRITER PROJECTOR UNIT TT-71/UG

The Teletypew ter projector unit model TT-71/UG shown in figure 9-30, enables teletypewriter messages and information from distant stations to be read simultaneously by groups of persons. Projector units are used in the pilot ready rooms aboard carriers, teletypewriter conference rooms, or on orderwire and special circuits which require operators to constantly be aware of circuit condition .



1.366
Figure 9-29.—AN/FGC-51 Reperforator Transmitter Group.



31.34
Figure 9-30.—Teletypewriter projector unit model TT-71.

The typing unit (figure 9-5) mounted in the projector cabinet is used to print out the incoming information. This information is printed on a roll of transparent cellophane instead of the normal teletype paper. An optical lens system with a 1000-watt lamp enlarges the image of the teletypewriter message and projects it onto a tilted mirror at the top rear of the cabinet from where it is reflected onto the translucent screen. The message is visible along the lower edge of the screen as it is being printed. With each successive line feed the message advances upward on the screen one line at a time and finally moves out of view at the top. A tape typing unit provides a permanent typewritten record of transmissions in the projector unit, but at most installations this feature is not used because a page copy from an additional printer patched into the same circuit has been found to provide a more readable and more convenient file copy.

The projector unit uses an ordinary teletypewriter ribbon. The cellophane roll is changed exactly as you would install a roll of paper in an ordinary printer, except that the loose end must be started on an automatic take-up spool. The optical unit is easily focused and does not often need refocusing.

The screen size limits the length of the typing line to approximately half the normal line length. You must remember this whenever you are typing material to be received on the projector unit. At most installations, the printer or perforating teletypewriter used for punching tapes for the projector has the end-of-line warning light and bell adjusted to warn you of this shortened line length.

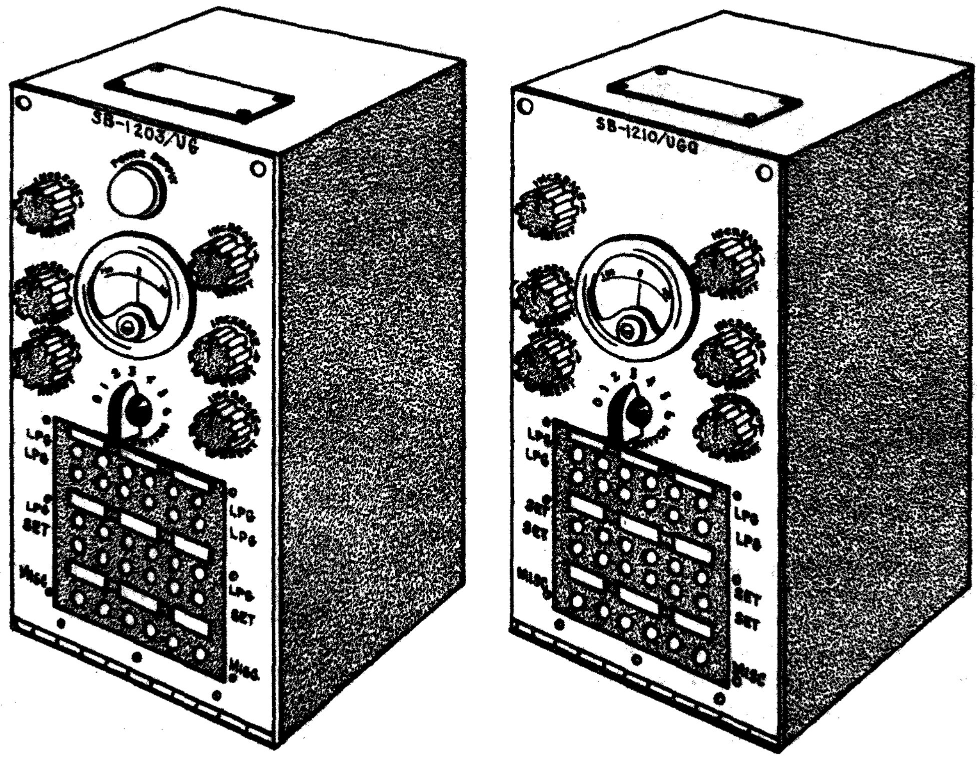
ASSOCIATED TERMINAL EQUIPMENT

Teletypewriter communication systems require other associated equipment in addition to the teletypewriters just discussed. Radio transmitters and receivers, such as those studied in chapter 8, are required for radioteletypewriter transmission and reception. Likewise, communication personnel must be acquainted with patch panels and other equipment us in communications.

PATCH PANELS, SB-1203/UG and SB-1210/UGQ

Teletype panels SB-1203/UG and SB-1210/UGQ shown in figure 9-31 are used for interconnection and transfer of teletypewriter equipment aboard ship with various radio adapters, such as frequency shift keyers and converters. The SB-1210/UGQ is intended for use with cryptographic devices, whereas the SB-1203/UG is a general-purpose panel.

Each of the panels contains six channels, with each channel comprising a looping series circuit of looping jacks, set jacks, and a rheostat for adjusting line current. The number of looping and set jacks in each channel varies with the panel model. Each panel includes a meter and rotary selector switch for measuring the line current in any channel. There are six



70.79

Figure 9-31.—Teletype patch panels SB-1203/UG and SB-1210/UGQ.

miscellaneous jacks to which may be connected any teletypewriter equipment not regularly assigned to a channel.

To operate either of the the teletype panels:

1. Turn all line current rheostats counterclockwise to increase circuit resistance to maximum value.

2. Turn on the local line current supply at the rectifier unit and at the distribution panel (not shown in the illustration). The green indicator light on the model SB-1203/UG panel will come on.

3. If the desired teletype equipment is wired in the same looping channel as the radio adapter (keyer or converter) to be used, no patch cords are required.

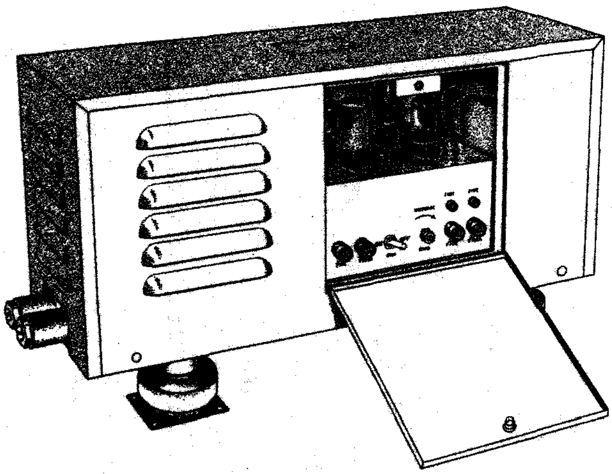
4. Turn the meter selector switch to the desired channel and adjust the corresponding rheostat to give a line current indication of 60 milliamperes.

5. If the desired teletypewriter (for example, in channel 1) is not wired in the same looping channel as the keyer or converter to be used (for example, channel 3), insert one end of a molded patch cord (supplied with panel) in the set jack in channel 1, and the other end in either one of the two looping jacks in channel 3.

In any switching operation between the various plugs and jacks of a teletype panel, remember to never pull the patch plug from the machine (set) jack before first removing the other end of the cord plug from the loop jack. Pulling the plug from the set jack first will open-circuit the channel and cause all teletype messages in the channel to be interrupted. The proper procedure is to take the plug out of the looping jack first, and to insert it last. This action maintains closed-circuit operation of all channels in the panel at all times.

RECTIFIER POWER SUPPLY

Although teletypewriter motors operate on alternating current, a source of direct current is always required for the signal circuit carrying the start-stop code intelligence. Figure 9-32 shows one model rectifier power supply installed aboard ship to rectify alternating current, changing it to d-c for the operation of teletypewriters and converters. This rectifier furnishes a power



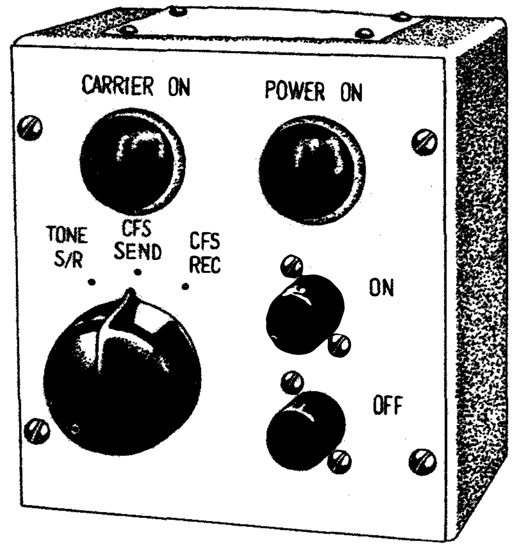
31.33
Figure 9-32.—Rectifier power supply for teletypewriter operation.

output of 120 volts d-c at 1.0 ampere, which is enough to supply many teletypewriters operating simultaneously. The on-off switch, fuses, and voltage adjusting control are accessible through a door in the front of the cabinet.

TRANSMITTER TELETYPEWRITER CONTROL UNIT

Another piece of equipment used with teletypewriter installations aboard ship is the control unit shown in figure 9-33. This unit is mounted close to the teletypewriter keyboard and permits remote control of the radio transmitter. It has a transmitter power on-off switch, a power-on indicator lamp, a carrier-on indicator lamp, and a 3-position rotary selector switch.

The TONE S/R switch position is used for both sending and receiving when using tone-shift keyer/converter. When using carrier-frequency shift mode of operation, the operator must switch to CFS SEND position for transmitting, and to CFS REC position for receiving.



1.244.1
Figure 9-33.—Transmitter teletypewriter control unit.

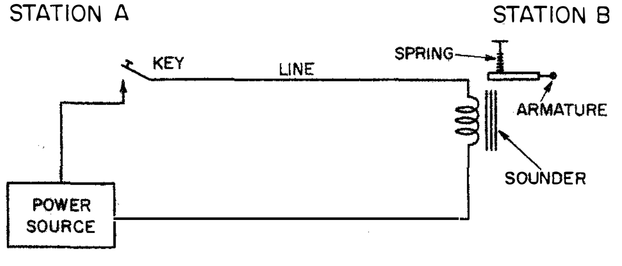
CHAPTER 10

BASIC TELETYPEWRITER CIRCUITS

To see how intelligence is sent over teletypewriter, one of the simpler devices for electrical communications—the manual telegraph circuit—is first considered. This circuit, shown in figure 10-1, includes a telegraph key, a source of power (battery), a sounder, and a movable sounder armature. If the key is closed, current flows through the circuit and the armature is attracted to the sounder by magnetism. When the key is opened, the armature is retracted by a spring. With these two electrical conditions of the circuit—closed and open—it is possible, by means of a code, to transmit intelligence. These two conditions of the circuit may be thought of as MARKING and SPACING. Remember: marking occurs when the circuit is closed and a current flows; spacing occurs when it is open and no current flows.

If the key at station A is replaced by a transmitting teletypewriter and the sounder arrangement at station B is replaced by a receiving teletypewriter, the basic teletypewriter circuit shown in figure 10-2 is formed.

When a teletypewriter circuit operates on current and no-current, as in figure 10-1, it is called a NEUTRAL circuit. This type is generally used to operate teletypewriters, although the Navy's machines often operate on a line condition called POLAR OPERATION. This refers to the system whereby marking signals are formed by current impulses of one polarity and spacing signals by current impulses of equal magnitude but opposite polarity. The majority of the machines which the CT O brancher will operate use the POLAR system.



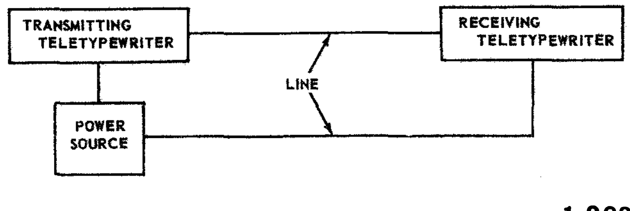
1.196
Figure 10-1.—A manual telegraph circuit.

THE TELETYPEWRITER SIGNAL CODE

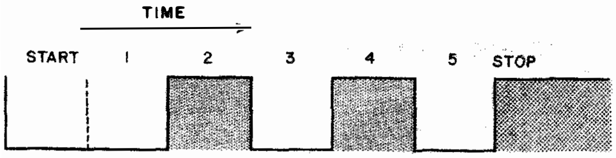
If a teletypewriter signal could be drawn on paper, it would resemble figure 10-3. This is the code combination for the letter R. Shaded areas show intervals during which the circuit is closed (marking), and the blank areas show the intervals during which the circuit is open (spacing). There are a total of seven units in the signal. Five of these are numbered, and are called INTELLIGENCE units. The first and last units of the signal are labeled START and STOP. They are named after their functions: the first starts the signal and last stops it. These are a part of every teletypewriter; the START unit is always spacing and the STOP unit is always marking. This method of teletypewriter communication—the so-called START-STOP method—gets its name from these units.

The start-stop method keeps teletypewriter machines and signals in synchronization with each other. With this method the selecting mechanism in the receiving machine comes to a complete stop after each character.

Examine figure 10-3 again. This is theoretically a perfect signal. The time between each unit remains the same during its transmission



1.200
Figure 10-2.—Simple teletypewriter circuit.



1.197

Figure 10-3.—Mark and space signals in the teletypewriter character R.

and the shift from mark to space (and vice versa) is called a TRANSITION. A transition occurs at the beginning and end of each unit when it shifts from mark to space or space to mark and there will be only 2, 4, or 6 transitions for each character.

When figuring time duration of a signal character no allowance for transition time is made as the transition is instantaneous and is considered to have zero time duration. The time duration for each unit is measured in milliseconds. The uniform lengthening and shortening of each unit determines the MODULATION RATE (signaling speed).

BAUDS AND WORDS-PER-MINUTE

There are two methods of referring to teletype modulation rate. These are in words-per-minute (WPM) or in bauds (bauds per second). Heretofore most discussions of teletypewriter speed have been in terms of how many words-per-minute are transmitted. Now a more technically accurate term "baud" is being used.

The baud is officially designated as the unit of modulation rate. One baud corresponds to a rate of 1 unit interval per second. Hence, to find the modulation rate of a signal in bauds, the figure 1 is divided by the time duration of the shortest unit interval present in the signal. For example, 22 milliseconds (.022) is the time interval of the shortest unit in the 7-unit code at 65 words-per-minute. To find the number of bauds corresponding to 65 WPM, we divide 1 by .022. Rounding off the results of our division, we arrive at the figure 45.5, which is the baud equivalent of 65 WPM. Each increase in WPM will correspondingly decrease the signal unit time interval.

Conversion formulas for baud operations are as follows:

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

$$\text{WPM} = \frac{\text{Baud}}{\text{Unit code} \times 0.1}$$

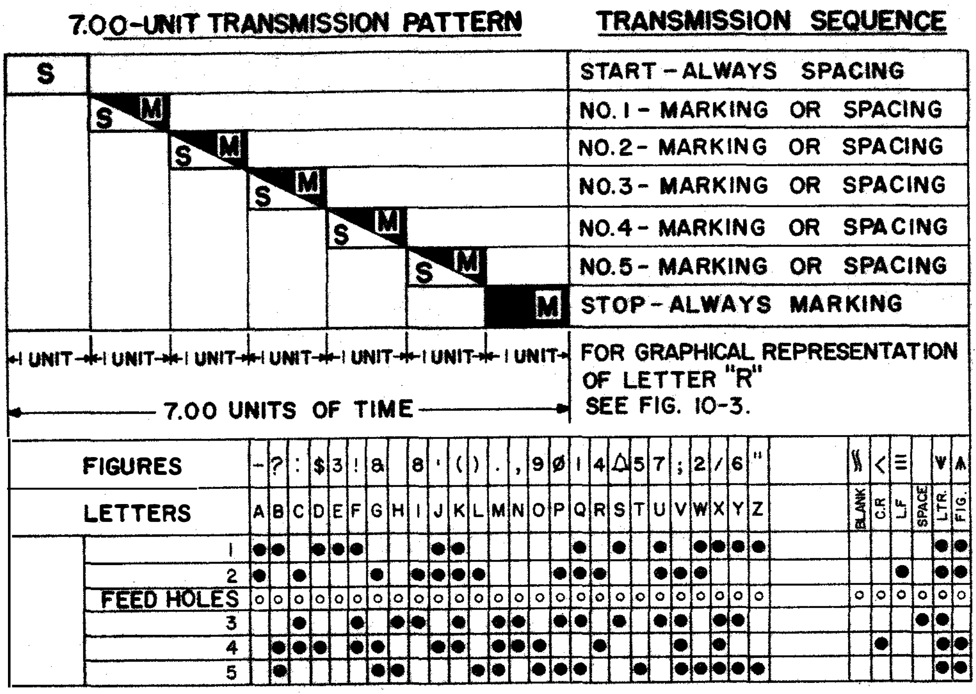
The unit code for most U. S. Navy systems is a 7-unit code with each unit having equal time duration; however, you may find a circuit operating with the stop unit of greater duration, the most common of which is the 7.42-unit system. The 7-unit code, operating at 107 WPM, has a unit duration of 13.3 milliseconds. Also, the 7.42-unit code has a unit duration of 13.3 milliseconds, however the stop unit has a duration of 19 milliseconds.

TRANSMITTING INTELLIGENCE

Different characters are transmitted from the keyboard by an automatic process that selects various combinations of marking and spacing in the 5 intelligence units (fig. 10-4). When you come to tape reading, you will see that the mark and space units match the holes and blank spaces on the tape. This is because holes in the tape allow the transmitter distributor pins to rise, sending a marking pulse. No holes mean no pulses—that is, spacing intervals. The machine, without benefit of tape perforations, automatically takes care of start and stop elements.

A total of 32 combinations can be obtained from the five intelligence units, but by using upper and lower case the number of characters obtainable is nearly doubled. When a teletypewriter printing mechanism has been shifted to upper case as a result of having received a FIGS shift character, all succeeding characters received prior to a LTRS shift character will print in upper case—as numerals and punctuation marks. The machine does not, however, make such double use of all 32 possible combinations, since six are used for the functions of carriage return, line feed, figures shift, letters shift, space, and for one normally unused blank key. This leaves 26 of the 32 that can be employed in both upper and lower case. When the six special functions are added, the total is 58, which is the number of characters and functions that can be sent from a teletypewriter keyboard or a prepared teletype tape.

Rapid communication systems utilize the automatic relay equipment which require messages to be prepared on tape. It is important then that the operator be familiar with the types of tape he may work with and also know how to read the teletype code from a tape in case the characters are not printed on the tape because of a printing malfunction.



50.89:1.198

Figure 10-4.—A teletypewriter signal code.

TELETYPE TAPE

Rapid communication systems utilize automatic relay equipment which require the messages to be prepared on paper tape. There are two types of teletype tape which may be found in most communication centers. The first type is the fully perforated, or CHAD, tape (figure 10-5A). (CHAD is the confetti—small paper disks—which is the residue resulting from the perforations). On CHAD tape the teletypewriter code is completely perforated, and the remaining surface will not accept legible printing.

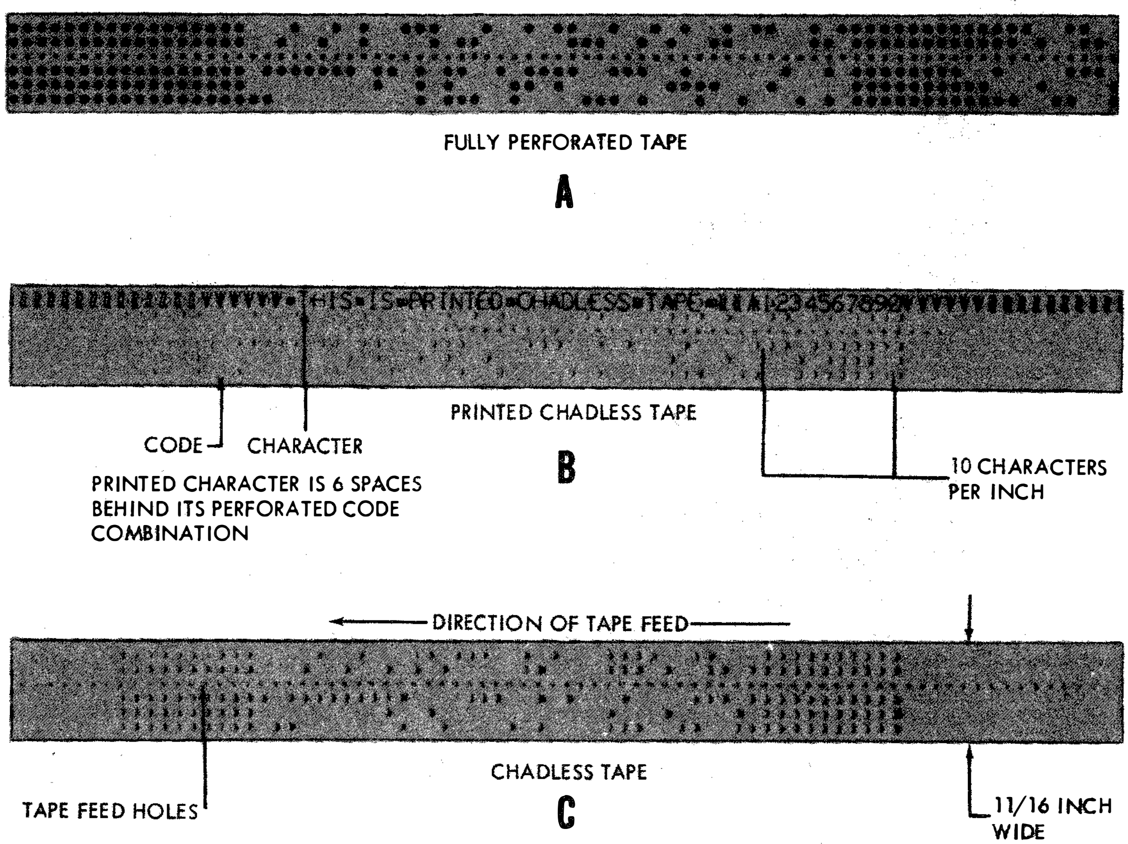
The other type of tape, only partially perforated, is called CHADLESS. There is, however, more than one type of chadless tape. Figure 10-5B illustrates printed chadless tape which is produced by the newer model perforators and carries the printed message, in addition to the perforations. Older models produced a chadless tape in which the lower case characters were printed on the top edge of the tape, while the upper case characters were printed on the bottom edge of the tape. The improvement in the newer tape is self-evident.

Physical and mechanical considerations make it impractical for the perforations and the printing to occur at the same point on the tape. Therefore, the printed character always lags the corresponding perforation by six spaces. For example, as shown in figure 10-5B, if the letter T is the first letter of a message, the perforation (in position 5) appears first, then six spaces to the right the letter T is printed on the upper edge of the tape.

The partial perforations of chadless tape remain hinged to provide enough surface for the printed word, which eliminates the need for reading the perforations, at the same time permitting the transmitter-distributor sensing pins to penetrate the perforations and transmit the message.

Another type of chadless tape has the partial perforations, but differs from the previously discussed chadless tape in that it does not have the printed characters (figure 10-5C).

Obviously, the perforated tapes that have been discussed thus far have advantages, one over the other, as well as disadvantages. For example, the primary advantage of chad tape is that the complete perforations permit more positive



1.206

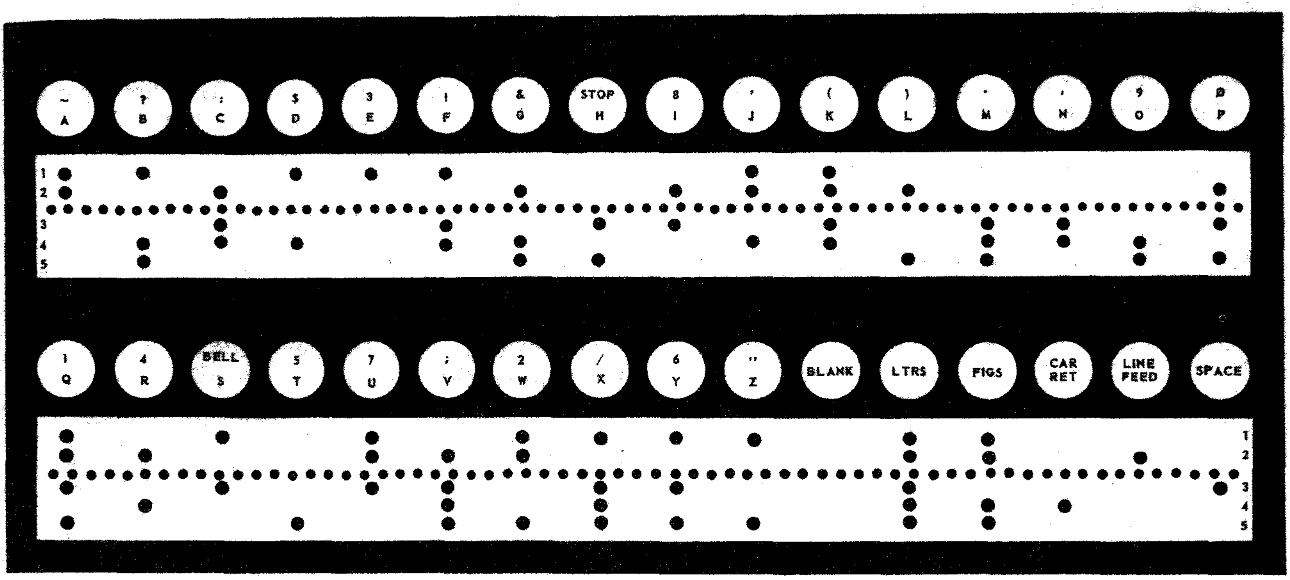
Figure 10-5.—Chad and chadless tape.

sensing, thus reducing the possibility of error. The disadvantage, on the other hand, is the problem created by the chad itself (the residue resulting from the perforations). It is difficult, if not impossible, to keep the chad out of the electrical contacts and the mechanical components, and results in frequent equipment failures and an increase in maintenance problems.

Printed chadless tape overcomes the problems created by the chad, and of course the printing on the tape permits more rapid reading and handling. When used with present equipment and at current speeds, printed chadless tape presents no particular problems. However, when viewed from the standpoint of the extremely high-speed operations envisaged for future communications, the printed chadless tape must be ruled out because of the mechanical limitations of the printing mechanism. Chadless tape provides the communication community with a tape which eliminates the undesirable aspects of both chad and printed chadless tape.

TAPE READING

In order to read perforated tape, you must understand arrangement of code positions. The code is a five-unit mark-space signaling code arranged vertically on the tape, from the No. 1 position at the top to the No. 5 position at the bottom. A hole is a mark; no hole is a space. Between the second and third positions is a tape feed perforation (TRACK) that is smaller than the code perforation (see fig. 10-6). This smaller perforation fits over the tape feed wheel that moves the tape through the transmitter-distributor, and is NOT a part of the code. The upper side of chad tape usually has a slight roughness made by the hole-punching pins. Read the tape with this side uppermost. Use the track



31.38

Figure 10-6. —The 5-unit teletypewriter code.

as a visual guide. Remember, no more than two perforations will appear above the track, nor more than three below. In figure 10-6 the positions are numbered from 1 to 5. This is for study purposes: don't expect these numbers to appear on an actual tape.

The LTRS character contains perforations in all five positions and the BLANK character has no perforations. All other characters are formed by specific combinations of perforations. For instance, A is 1—2, B is 1—4—5, and C is 2—3—4.

Read the perforations in lowercase until a FIGS character appears. Following a FIGS character read the tape as uppercase until a LTRS character appears, after which read as lowercase again. On circuits on which machines unshift on spacing, read characters in lowercase following the space.

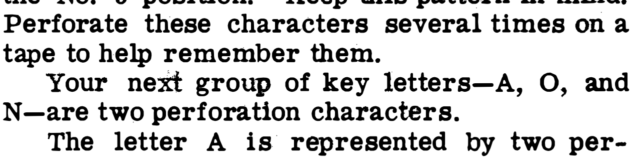
Memorize the upper and lowercase characters that correspond to specific combinations of perforations. Perforate strips of tape and read the characters you have memorized. Association of memory and eye will help you recognize characters quickly and increase reading speed.

The discussion and illustrations following provide a study plan for learning the code. Begin by learning the 1-HOLE characters: E, LF, SPACE, CAR RET, and T (see figure 10-7). Letter E is perforated in the No. 1 position, and the remainder of the positions are blank. LINE FEED is one perforation in the No. 2 position—and so forth, down to T, which is perforated in the No. 5 position. Keep this pattern in mind. Perforate these characters several times on a tape to help remember them.

Your next group of key letters—A, O, and N—are two perforation characters.

The letter A is represented by two perforations above the track. This pattern—two perforations above the track—is also characteristic of U, J, and W. In the same way O is common to M, G, and B, in that they all have perforations in positions 4 and 5. The final letter of this series is N which you read up for C and F, with common perforations in positions 3 and 4.

With this much information mastered, get plenty of practice before learning more letters. Perforate a tape with these characters and, as your reading improves, mix them to make the reading more difficult. Emphasize ACCURACY, not speed. If you haven't the opportunity to work with a perforator, draw the codes on 3 x 5



31.39

Figure 10-7. —The 1-hole codes: E, LF, SPACE, CAR RET, and T.

cards (with answers on back) and scramble them.

You can learn three more sets of letters by using the track line as a guide. Read letter I (one hole above and one below the track line) and retain it as a reference point for reading D or Z (See figure 10-8). Learn R and use it to read L; learn Y and read P.

Eight letters that you can master by remembering them as opposites are Q and X, V and K, H and S, E and T.

Two keys you will use a great deal are LTRS and FIGS, which shift your machine into lower-case and upper case. The LTRS code is easy to recognize because it is the only one with five perforations. The FIGS code resembles it in that there are two perforations above the track, and two below, with only the No. 3 position blank.

SIGNAL DISTORTION

An ideal teletypewriter circuit reproduces signals at the receiving end exactly as they are impressed at the sending end. Unfortunately, this seldom happens under actual operating conditions, for signal units have a way of lengthening and shortening as they travel. This lengthening and shortening of marks and spaces occurring during transmission reduces the quality of the signal, and is called distortion.

Four fundamental types of distortion adversely affect fidelity of teletypewriter signals.

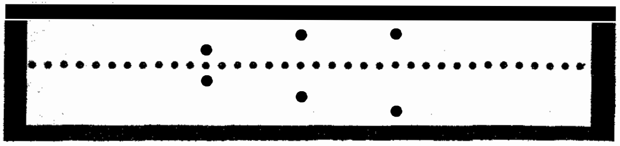
1. Bias distortion is the uniform lengthening or shortening of the mark or space elements, one at the expense of the other. This means that the total time for one mark and one space never changes; only the length of the mark or space element changes. If the mark is lengthened, the space is shortened by the amount the mark is lengthened. Bias distortion may be caused by maladjusted teletypewriter line relays, detuned receivers, or a drift in frequency of either the transmitter or receiver.

2. Fortuitous distortion is the random displacement, splitting, or breaking up of the mark and space elements. It is caused by cross-talk interference between circuits, atmospheric noise, power line induction, poorly soldered connections, lightning storms, dirty keying contacts, and such similar disturbances.

3. End distortion is the uniform displacement of mark-to-space signal transitions with no significant effect on space-to-mark transitions. It is caused by the combination of resistance, inductance, and capacitance in the circuit.

4. Characteristic distortion is a repetitive displacement or disruption peculiar to specific portions of the signal. It normally is caused by maladjusted or dirty contacts of the sending equipment. It differs from fortuitous distortion in that it is repetitive instead of random. An example would be the repeated splitting of the third code element of a teletypewriter signal.

Equipment used for recognition and identification of signal distortion in communication centers is described in the following paragraphs.



31.43

Figure 10-8.—I, D, and Z.

TELETYPE DISTORTION ANALYZER

There is an ever increasing need for more rigid radio teletypewriter transmission quality control in the operations of communication systems facilities. In the past there has been a tendency toward more rigid tolerances in equipment manufacture, with only normal emphasis on the maintenance of rigid control of equality of transmission in the operating system. The trend toward higher transmission speeds, and the introduction of new modes of operation in the system, have not only emphasized the need for better quality control, but have caused most of the equipment formerly used for analysis of signals to be obsolete, or at least inadequate. The first step toward improvement in the quality of transmission is the analysis of signals. Only by the analysis of signals can it be determined what is necessary to improve the quality, or check on actions to determine whether or not they actually produce an improvement. The AN/GGM Teletype Test Set is considered capable of meeting these requirements for signal analysis for all teletypewriter systems presently in use, and in addition can be readily adapted to any new modulation rates up to 600 baud. There are other equipments in use for signal analysis at the various communication stations but the principles described in the AN/GGM are similar.

The design philosophy of the AN/GGM-1 is based on a modular concept and consists of the following plug-in units.

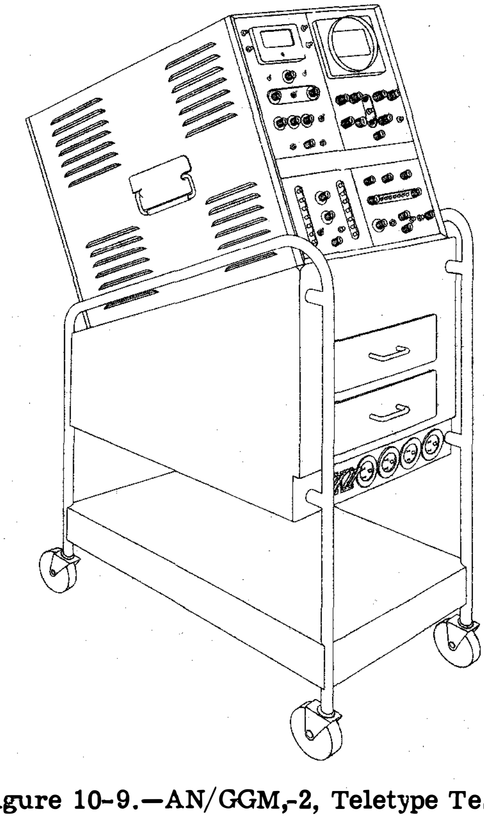
Name	Military Nomenclature
Digital Distortion Analyzer	TS-1512/GGM
Test Pattern Generator	SG-431/GGM
Oscilloscope	OS-119/GGM
Time Base Generator	SG-430/GGM
Power Supply	PP-2971/GGM

The AN/GGM-1 equipments are mounted in a standard 19" wide rack for fixed station use. The same equipments mounted in an equipment cart for movement around the communications center has been designated the AN/GGM-2. (See figure 10-9.)

Digital Distortion Analyzer, TS-1512/GGM

The Digital Distortion Analyzer, TS-1512 (figure 10-10) is a teletypewriter test set that provides an entirely new approach to the art of signal distortion analysis. By the use of digital computer techniques and solid-state devices, the TS-1512 provides a degree of long-term accuracy and reliability not possible with conventional test equipment.

The front-panel controls of the TS-1512 permit the analysis of every transition and



1.322
Figure 10-9.—AN/GGM-2, Teletype Test Set.

every element of the character—either individually or combined. There is no type of distortion that can escape measurement on the meter.

This unit is as accurate with present synchronous systems as with the start/stop teletype signal and will accommodate any speed up to 600 baud. The timing signals are provided by the SG-430 Time Base Generator. The SG-430 permits the addition or change to any modulation rate by replacing a plug-in printed circuit card. In this manner, additional modulation rates can be accommodated, as the station requirements demand, with no change in the TS-1512.

Because distortion measurements are displayed on the large front-panel meter, the need for interpretation of the display, by the operator, is eliminated. The untrained operator need only record the reading on the meter.

Test Pattern Generator, SG-431/GGM

The Test Pattern Generator, SG-431, (figure 10-11) is a solid-state test pattern generator that transmits the "Quick Brown Fox" test message, repeated characters, or reversals. The test patterns may be transmitted with zero distortion or with any amount of distortion from 0 to 49%, in steps of 1%.

Spacing bias, marking bias, or switch bias may be transmitted at all baud rates with an overall accuracy within 2%.

The SG-431 transmits an 80 character test sentence. The last seven characters, after the "fox" sentence are optional and may be conveniently programmed into the unit in the field (station call letters, etc.)

Oscilloscope, OS-119/GGM

The Oscilloscope, OS-119 (figure 10-12) is specially designed for viewing data/radio teletypewriter signals. It provides an automatic means of viewing radio teletypewriter signals, while traffic is being transmitted, by selecting a single character and blanking the characters that follow.

By presenting the selected character on a five-inch long-persistence cathode-ray screen, the oscilloscope permits the operator to view the signal on working circuits with an accuracy and clarity not possible with ordinary oscilloscopes. The OS-119 Oscilloscope has its own self-contained power supply.

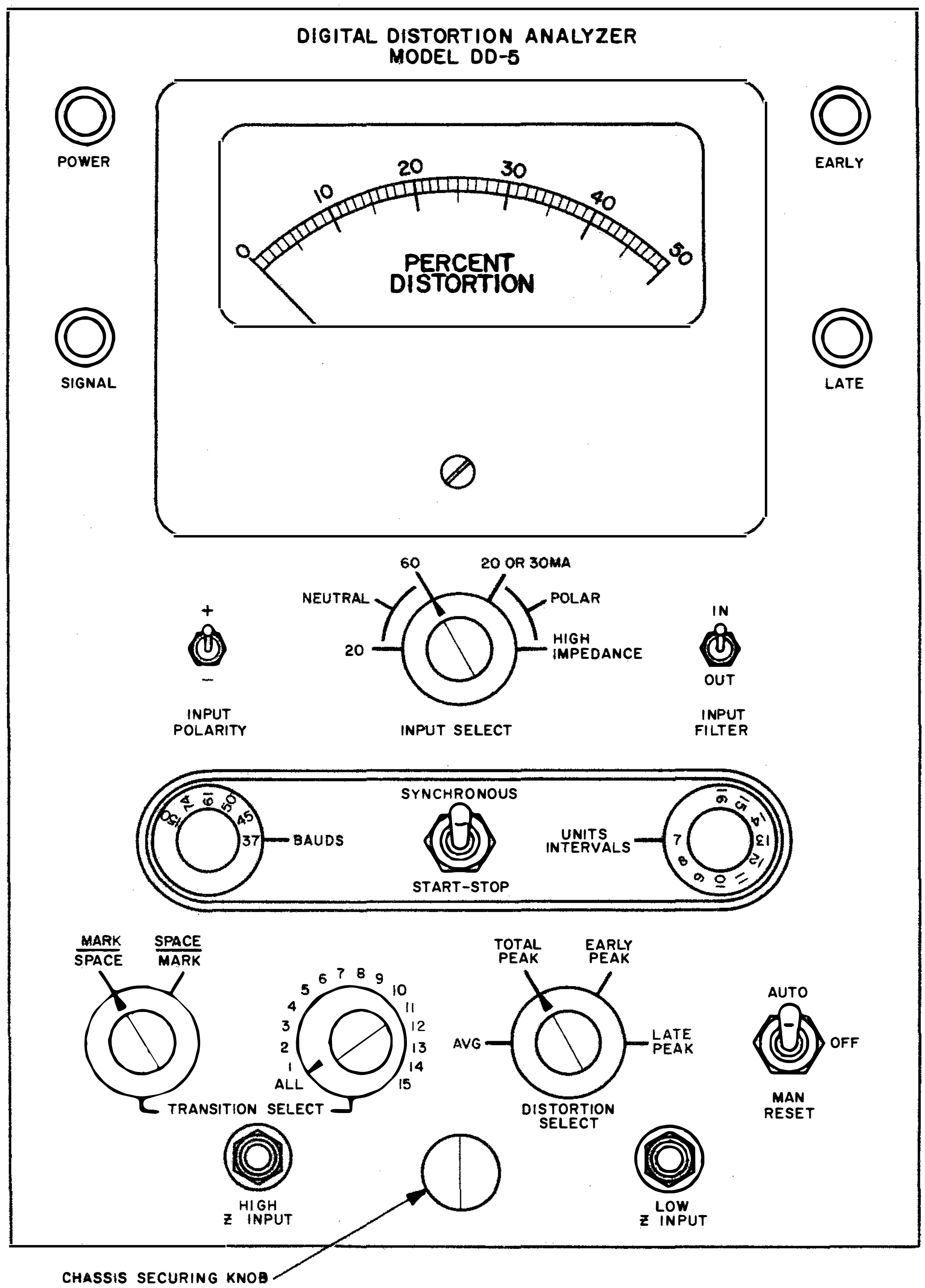


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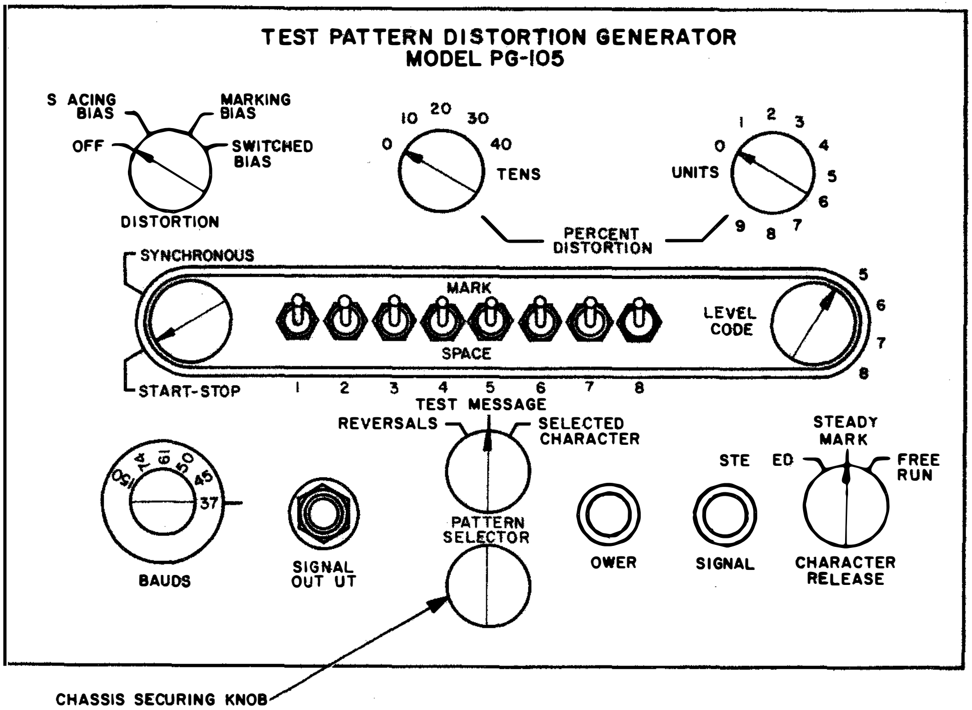
Figure 10-10. —TS-1512/GGM, Digital Distortion Analyzer.



1.324

Figure 10-11.—SG-431/GGM, Test Pattern Generator.

Time Base Generator, SG-430/GGM

The Time Base Generator, SG-430 (figure 10-13) provides timing signals to the TS-1512 Test Set and SG-431 Test Pattern Distortion Generator for all baud rates. The SG-430 provides up to twelve crystal-controlled transistor oscillators with a stability of 1 part in 10,000 per day.

Power Supply, PP-2971/GGM

The Power Supply, PP-2971 (figure 10-14) supplies all power required for the TS-1512 Test Set and SG-431 Test Pattern Distortion Generator and the SG-430 Time Base Generator.

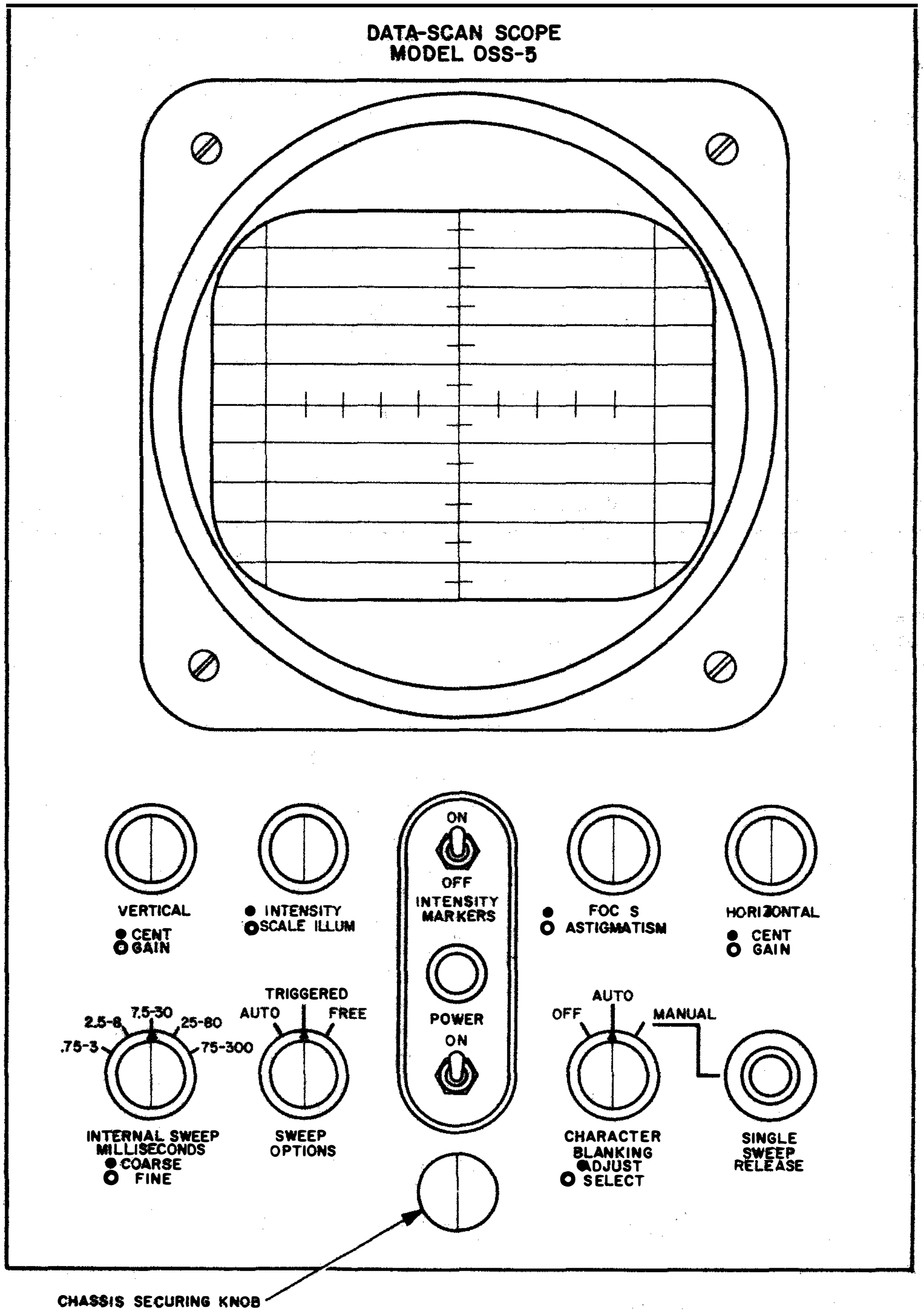
ORIENTATION RANGEFINDER

Every teletypewriter has an ORIENTATION RANGEFINDER. By means of the rangefinder scale, the operator can set the machine at the range of best signal reception. Low equipment range indicates only a lowered operating margin. It does not clearly indicate whether the cause is distortion or a badly adjusted teletypwriter.

Refer again to figure 10-3, illustrating the signal for the letter R. Each unit or element is perfect in every respect. To print the letter R, the selector mechanism could be set to operate on any 20-percent portion of each unit, and perfect copy would result. Under actual conditions, a signal is never this perfect, nor is a teletypewriter expected to operate over the entire range of the rangefinder scale. Rarely will more than 70 percent of the scale be usable by the selecting mechanism. This means that the selection point of the rangefinder scale must be positioned so that the best portion of the element will be used by the selecting mechanism.

The rangefinder in figure 10-15 is located on the right side of Model 28 series page printers and at the right front of Model 28 series reperforators. In this type of rangefinder, the range scale is moved by rotating the rangefinder knob. The indicator mark on the rangefinder plate is the reference point for reading the scale. Points on the scale—0 to 120—divide the first unit of the signal only, not the entire signal. Since all other intelligence units of the signal follow at equal time intervals, the adjusting of the rangefinder amounts to an adjustment or orientation of the entire signal at the start pulse.

To determine the range limits, the finder is adjusted at the two extreme positions—at the lower and the upper end of the scale. In each



1.325

Figure 10-12.—OS-110/GGM, Oscilloscope.

case observations are made of the typed record and a reading is taken when about one error is typed per line of copy. This means about one error in 69 characters. Orientation ranges on properly adjusted teletypewriters for different degrees of signal distortion are as follows:

	Points
Very little distortion	80
Moderate distortion.	60-70
Average distortion.	50
Large distortion	Less than 40

The orientation range limits, with practically perfect signals and a teletypewriter in good condition, should be 15 and 95. In this case, best operating results will be obtained when the finder arm of the receiving teletypewriter is set at the midpoint (55) of this range.

Actually, the orientation range is determined twice: First, range of the machine (local range) is determined, then range of machine when connected to the line (line range) is determined. Set the rangefinder at the midpoint average of the two ranges.

The orientiation range is obtained locally by using keyboard signals or running a test tape through the transmitter-distributor. Normally, the letters R and Y are used since they give a complete reversal of impulses. R is S-M-S-M-S and Y is M-S-M-S-M. (Other characters, such as S and G, can be selected which would also give a complete reversal of impulses.) If the range is not less than about 70 points (from about 20 to 90 on the scale) it may be assumed that the machine is satisfactory.

The difference between the range determined by local test, and the corresponding range obtained when receiving signals over a line, represents the reduction in margin due to signal distortion. The reduction is a direct measure of total signal distortion. This shows the line range limits to be 20 and 70 on the scale. The line range represents a reduction of local range limits by 5 points on the lower end and 25 on the upper.

The manner in which typed errors occur in the neighborhood of the orientation limits may give indication of the nature of the distortion. If limits are fairly definite—the copy changes from good to bad when the rangefinder is moved only a small distance—bias, or distortion due to speed variations or faulty apparatus, is present. If there is a CERTAIN range at each limit over which CERTAIN characters are consistently in error, this is due to characteristic distortion. If limits are not definite—that is, there is a range over which errors occur, and errors do not occur consistently on certain characters—this is an indication of fortuitous distortion. As a general rule, characteristic

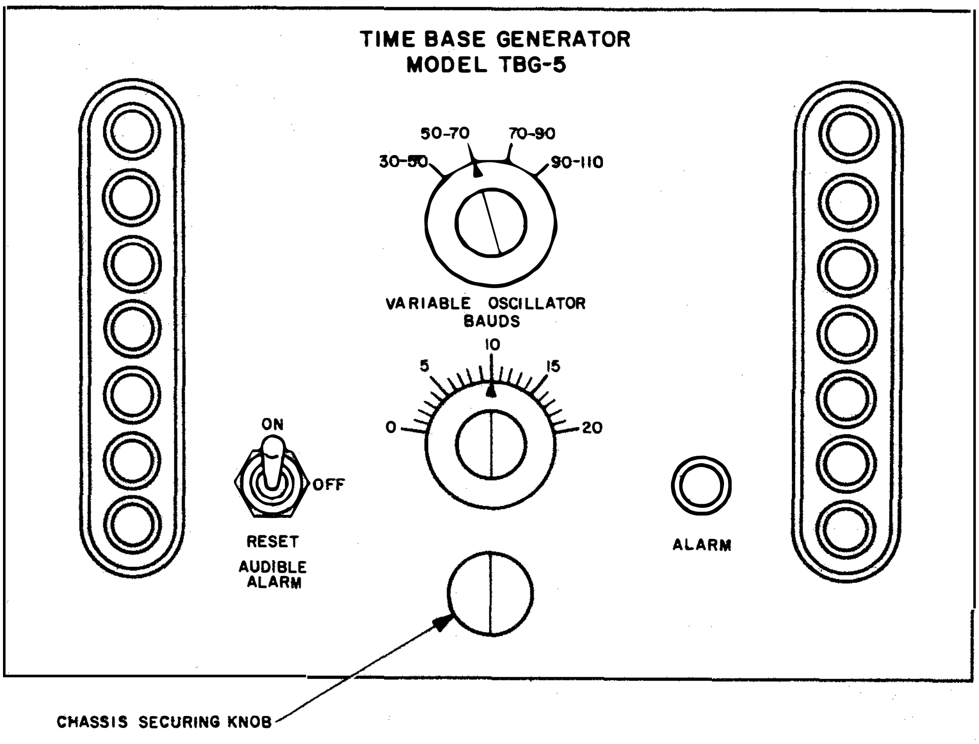


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Figure 10-13.—SG-430/GGM, Time Base Generator.

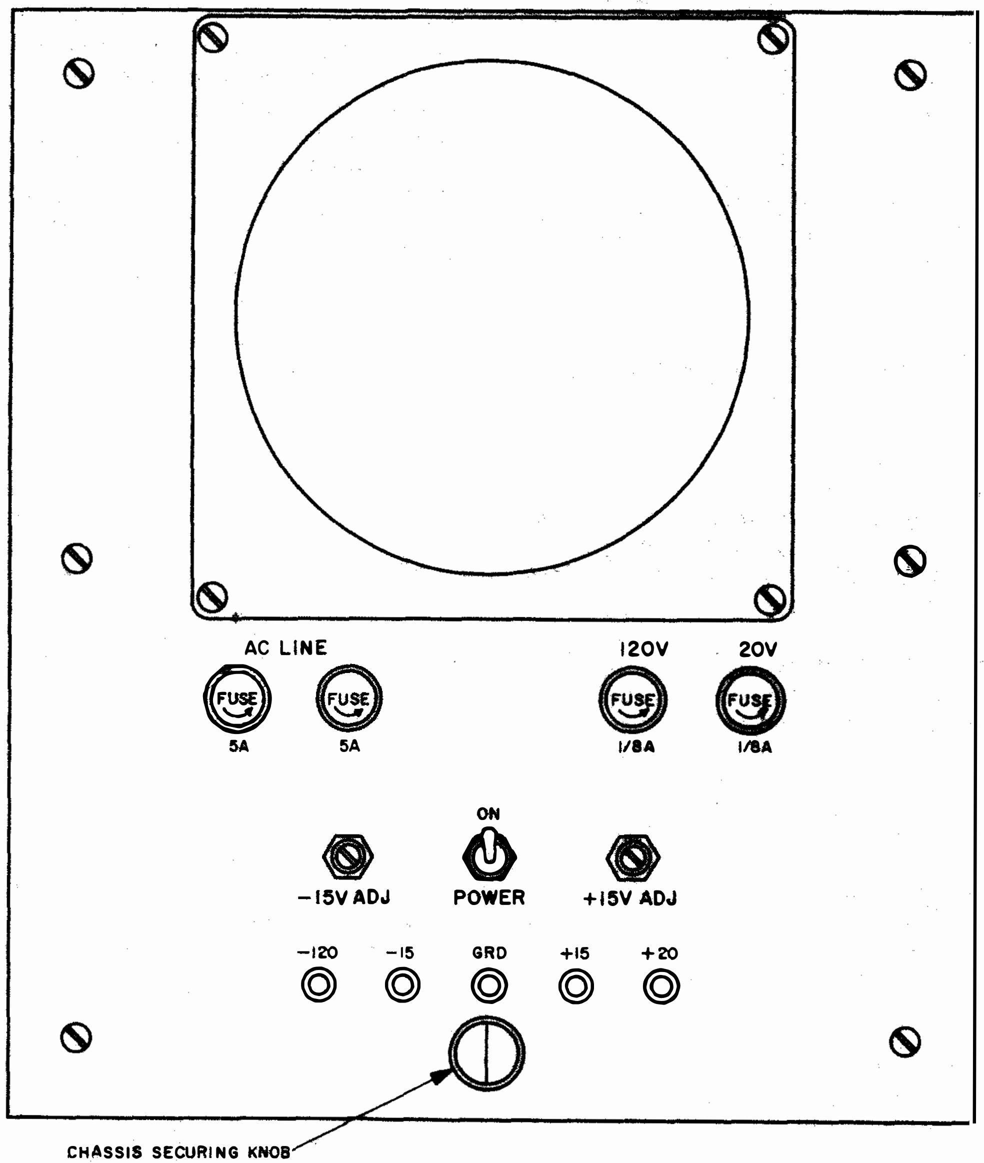

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Figure 10-14.—PP-2971, Power Supply.

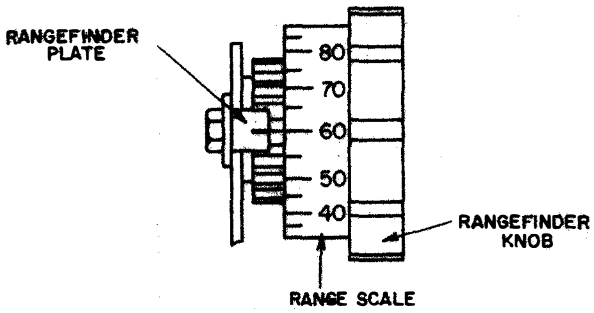
and fortuitous distortion cause reduction of the range at both limits. On the other hand, bias affects one range more than the other. Marking bias reduces the upper range limit, and spacing bias reduces the lower range limit.

Maintenance men sometimes test distortion tolerance of a teletypewriter by applying predistorted signals. This predistortion ranges from zero to 40 percent. A well-adjusted machine will type correctly when signals from a test set are distorted as much as 35 percent.

Rangefinding a teletypewriter is not an everyday occurrence. Unless something goes wrong with the circuit, rangefinding is performed only during maintenance periods. When rangefinding is necessary, care must be taken that the machine is in good adjustment, and range limits are read accurately.

CIRCUIT TYPES

The word "circuit" is used in two senses in the communicator's work. First, in the electrical sense: a continuous conductor for the



1.202

Figure 10-15.—Model 28 series orientation rangefinder.

flow of electrons; second, in the communication sense: a path between two or more points, capable of providing one or more channels for the transmission of intelligence. In the discussion of teletypewriter operation, the emphasis is on the communication sense of the word.

A duplex circuit is a radio or landline circuit which permits communication between stations in both directions at the same time. You may sometimes hear it called "full duplex," which means the same time.

A half-duplex circuit is a single electrical path used for transmitting information from one station to another. The circuit has no provision for the exchange of information, but may comprise any number of receiving stations. Each station receives only or transmits only, depending on its intended function. The fleet broadcast is an example of a half-duplex circuit.

A simplex circuit, embracing features of both the duplex and half-duplex type circuits, consists of a single electrical path over which two or more stations may exchange information. Any station may transmit and receive, but not simultaneously.

DIVERSITY RECEPTION

Because of fading and interference over long distances, diversity reception is used. In space diversity two receivers are tuned to the same frequency but the receiving antennas are spaced more than one wavelength apart. Because of the required spacing between antennas, space diversity is generally limited to shore station use. In frequency diversity the two receivers are tuned to separate frequency-shift carriers (of different frequencies), which are simultaneously carrying the same mark-space characters. The output of each receiver is connected to its associated frequency-shift converter, which converts the frequency shifts characters into d-c pulses. These mark-space pulses are fed to another unit called a comparator where an automatic circuit selects and uses the better of the two signals to control the teletypewriter. Frequency diversity is commonly used aboard ship for copying the fleet broadcasts, which are keyed simultaneously on several frequencies.

The next section describes the converter and comparator used for diversity reception.

FREQUENCY-SHIFT CONVERTER-COMPARATOR GROUP AN/URA-8B

The frequency-shift converter-comparator group AN/URA-8B, shown in figure 10-16, comprises two frequency-shift converters (top and bottom units), and one comparator (middle unit). It provides an important link at the receiving end of the frequency-shift radioteletypewriter system.

Any standard Navy receiver may be used to translate the frequency-shifted r-f signals from the transmitter into audio tones by means of its beat frequency oscillator. From this process, the r-f carrier shift becomes an audiofrequency shift that is patched into the converter unit of the AN/URA-8B. The converter changes these frequency-shifted audio signals into d-c mark-space pulses for operation of the teletypewriter. This method of communication utilizes the noise-reduction advantages of frequency modulation for long-distance RATT reception.

Either converter unit of the AN/URA-8B can be operated in a single-receiver FSK receiving system or can be used together in combination with two receivers and a single teletypewriter to provide a diversity receiving system. The diversity system makes use of the principles of space-diversity or frequency-diversity reception to eliminate severe signal fading over long transmission distances.

In space-diversity operation, two receivers are tuned to the same r-f carrier frequency, but their receiving antennas are spaced more than one wavelength apart. The advantage of this method of reception is that maximum fading of a given carrier frequency usually does not coincide in time at points so separated. The audio output of each receiver is applied to a separate converter.

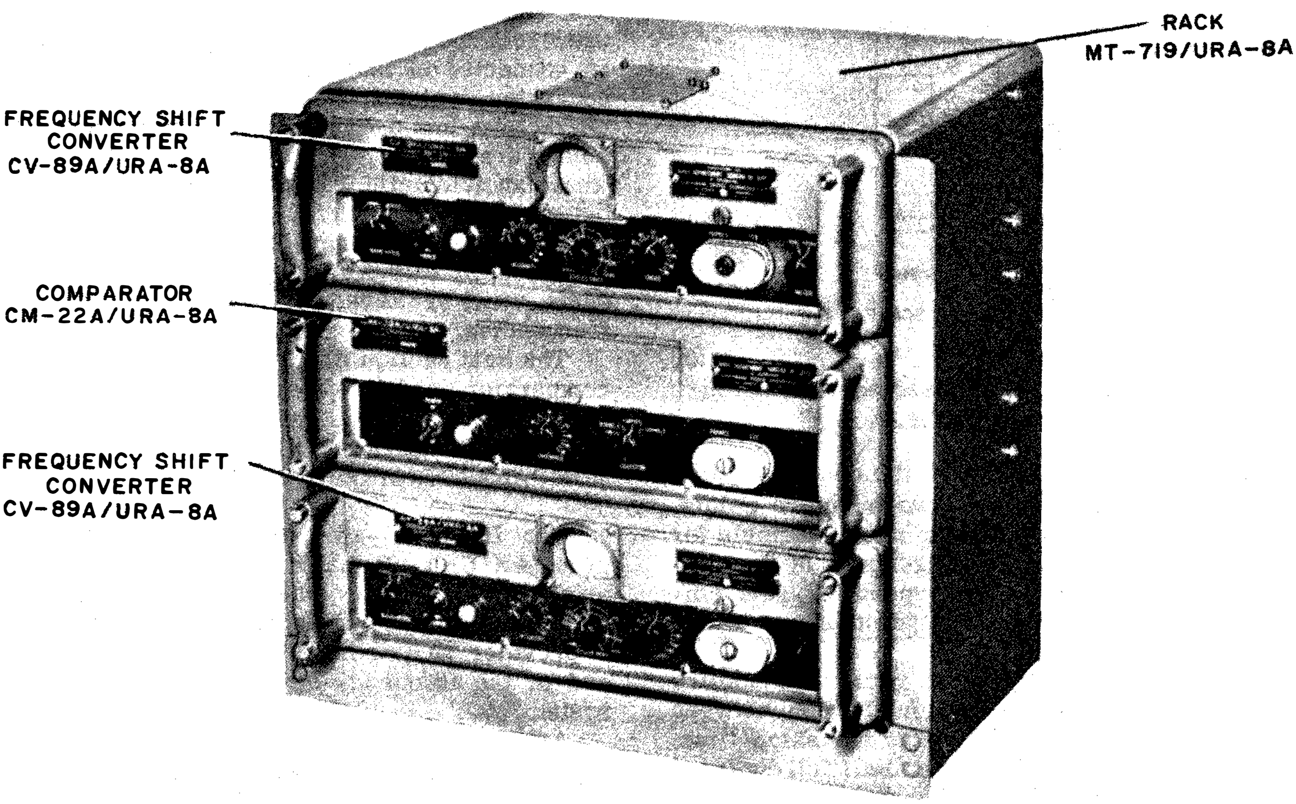


Figure 10-16.—Frequency-shift converter-comparator group AN/URA-8B.

In frequency-diversity operation, two receivers are tuned to different r-f carrier frequencies from two transmitters keyed simultaneously with the same mark-space modulation. The audio output of each receiver is applied to a separate converter. The advantage of this method of reception is that maximum fading of two different carrier frequencies seldom occurs at the same time in a given location. This method is common aboard ship, where space limitations do not allow sufficient antenna separation for effective space-diversity reception.

In either method of diversity reception, the audio outputs of two radio receivers are patched to the two converters. The d-c signals from the discriminator circuits of the two converters are compared in the mark-space selector of the comparator unit, which automatically selects the better mark and the better space pulse for each character. The output of the comparator is patched to the teletypewriter.

The frequency shift employed in the converters may be as little as 10 cps or as much as 1000 cps frequency separation between mark and space signals. This scope of frequency shifts is divided into two ranges called narrow shift (10 to 200 cps) and wide shift (200 to 1000 cps). A frequency shift of 850 cycles is commonly used in Navy radioteletypewriter channels.

COMPARATOR-CONVERTER GROUP AN/URA-17

Comparator-Converter Group AN/URA-17 (fig. 10-17) is a completely transistorized equipment designed to perform the same functions in the frequency-shift RATT receiving system as the AN/URA-8B, just described.

The AN/URA-17 consists of two identical converter units, one of which is shown in figure 10-18. Each converter has its own comparator circuitry. This achieves a considerable reduction in size from model AN/URA-8B, wherein the comparator occupied a separate chassis. The physical size of the AN/URA-17 is further reduced through use of semiconductors and printed circuit boards. The complete equipment is less than half the size of the AN/URA-8B.

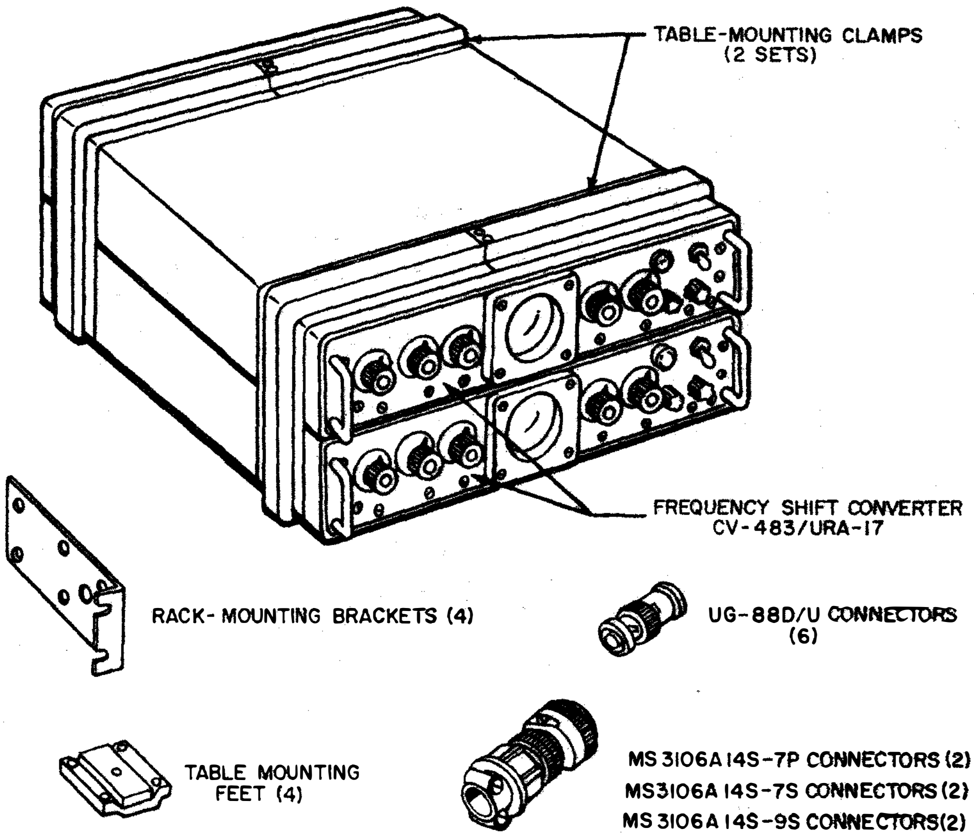


Figure 10-17.—Comparator-converter group AN/URA-17.

The comparator-converter can be operated with two radio receivers in either space-diversity or frequency-diversity receiving systems. When conditions do not require diversity operation, each converter can be used separately with a single receiver for reception of frequency-shift RATT signals. In this latter usage, the two converters can be operated in two independent communication circuits.

For diversity operation, the function switch (fig. 10-18) on both converters must be placed in the diversity position. The teletypewriter may be connected to either converter.

Operation of the converters and comparator is relatively simple. Proper tuning of the receivers is of the utmost importance. The operator should understand that the comparator passes only the stronger of the two mark or space pulses, including any noise present in the stronger pulse. Each converter has a small monitor oscilloscope which gives a visual indication of the receiver tuning. The scope patterns for correct and incorrect tuning are shown in figure 10-19.

RADIOTELETYPE SYSTEMS

You learned in your study of amplitude modulation that whenever a carrier is modulated, two sideband frequencies are produced that carry the intelligence present in the audiofrequency. Only one sideband is necessary for transmission of the signal, and a transmitter in which the carrier has been suppressed may be used to send a separate message on each of the sidebands. The messages from the two audio channels are made to modulate the same carrier, but modulation takes place in different modulators.

The output of the two modulators contain sidebands formed by heterodyning the individual audio signals with a common carrier suppressed in the output. The filters remove the lower sideband from one modulator output and the upper sideband from the other. Thus, each of the two

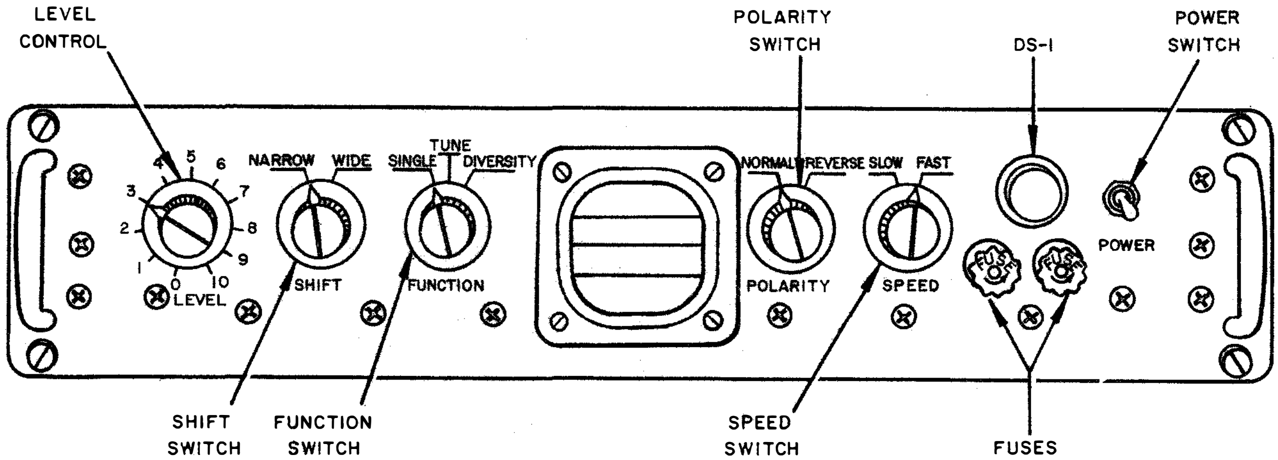


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Figure 10-18.—AN/URA-17 frequency-shift converter, front panel controls.

sidebands conveys a separate message and may be used as a separate channel. At the receiving end, the carrier frequency is reinserted and the intelligence recovered.

As used in the Naval Communication System, multichannels of teletype are transmitted on one sideband of each SSB circuit through a frequency multiplexing system. Frequency multiplexing is a process for including multiple sets of transmissions on a single bandwidth by crowding, or "stacking" the individual frequencies.

To give added range to landline transmissions, repeaters are inserted in the line to renew the strength of weak signals as they pass through the wire. Repeaters are of two kinds. First, there is the "straight" repeater, which strengthens (amplifies) the signal just as it is received. Unfortunately, this type also amplifies any interference the signal may have picked up along the wire.

The other repeater is the "regenerative" type. It builds, or regenerates, an entirely new signal from one that is worn out or distorted, and eliminates the interference. Both types of line repeaters retransmit signals automatically, using a local source of power. They may be placed at the end of the line (terminal) or at an intermediate point along the line.

Repeaters cannot be used with RATT transmissions. Radioteletype is further handicapped by the same atmospheric disturbances that sometimes hamper radiotelegraph communications. Although RATT transmits on radio waves instead of wires, the basic terminal equipments are the same as those used in landline teletype operation. The difference is that radioteletype requires transmitters and receivers to send and receive signals.

Let us now see how the various pieces of equipment—teletypewriters, keyers, converters, receivers, and transmitters—are combined into complete radioteletype systems. The Navy uses two basic radioteletype systems. One, the TONE-MODULATED SYSTEM is similar to the familiar AM radio. The other, the CARRIER-FREQUENCY SHIFT SYSTEM is similar to the standard FM radio. The two systems are shown integrated in figure 10-20.

The page printer or transmitter distributor sends out a continuity of direct-current on-and-off pulses (timed intervals of current and no-current). These intervals are mark and space impulses, and various combinations represent the various characters being transmitted.

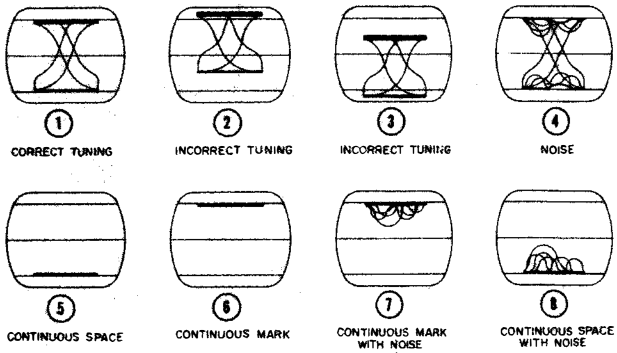

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Figure 10-19.—Monitor oscilloscope patterns for frequency-shift converter.

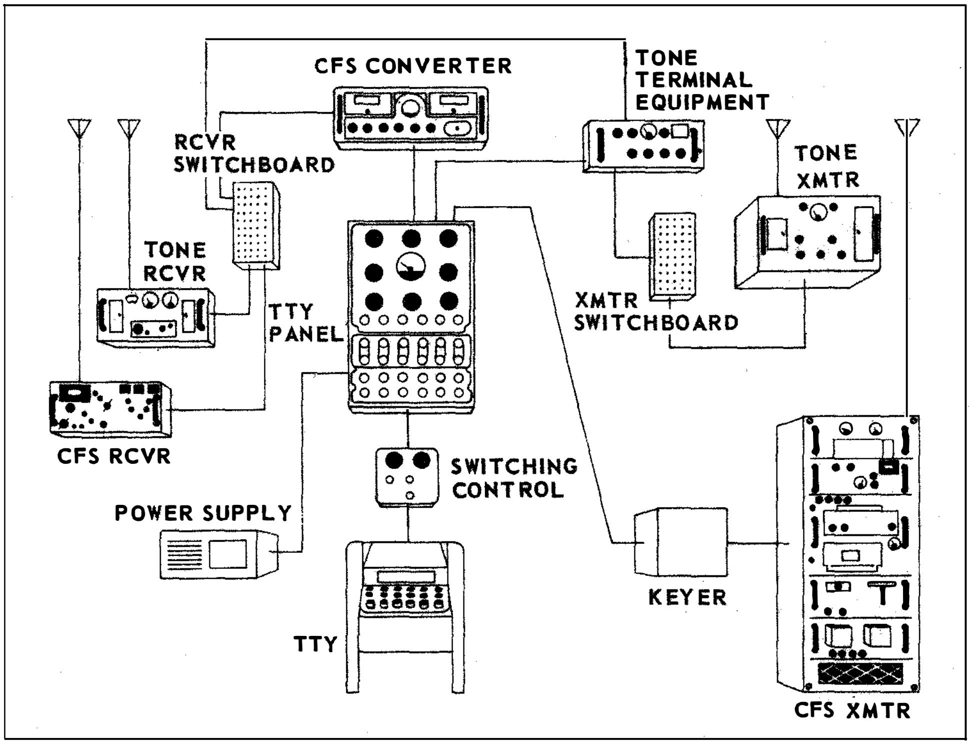

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Figure 10-20.—Basic RATT transmit-receive systems.

When two teletypewriters are wire-connected, the exchange of intelligence between them is direct. But when the teletypewriters are not joined by wire, operation is more complex. Direct-current mark and space intervals cannot be sent through the air.

The gap between the machines must be bridged by radio. To bridge the gap, a radio transmitter and receiver are needed. The transmitter produces a radiofrequency carrier wave to carry the mark and space intelligence. Also, a device such as a KEYER is needed to change the d-c pulses from the teletypewriter into corresponding mark and space modulation for the carrier wave in the transmitter. The radio receiver and a CONVERTER are required to change the radiofrequency signal back to d-c pulses.

Figure 10-21 shows a modulated carrier wave with audio tone impulses impressed on the radiofrequency carrier wave, with corresponding d-c mark and space signals.

Figure 10-22 shows a carrier-frequency shift wave which increases and decreases to denote mark and space d-c impulses.

In the operations shown in figures 10-21 and 10-22, the d-c teletypewriter signal that can travel only by wire becomes, through the medium of a tone terminal or keyer unit, either a tone-modulated signal or a carrier-frequency shift signal for radio carrier wave transmission.

TONE-MODULATED SYSTEM

Tone-Modulated Systems use the process of amplitude modulation to change the d-c mark and space impulses into audio electrical impulses. Conversion to the audio tones is

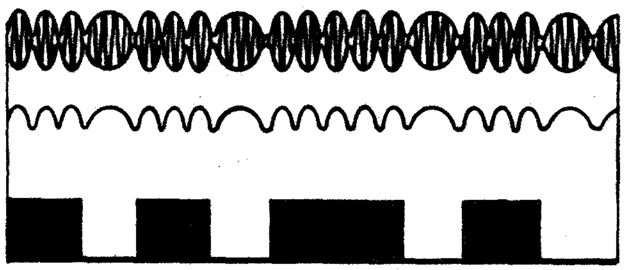

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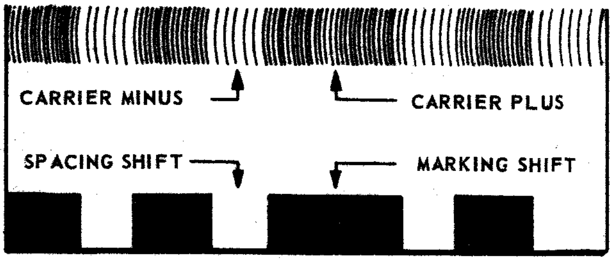
Figure 10-21. — Modulated carrier wave with corresponding audio tone for mark and space electrical impulses.



1.227
Figure 10-22.—Frequency of the carrier wave increases and decreases corresponding to mark and space impulses.

accomplished by an audio oscillator in the tone converter, which operates at 700 cycles for a mark impulse and at 500 cycles for a space impulse. The rapid varying of the tone according to the characters transmitted from the teletype equipment is impressed on a carrier wave in the transmitter. Figure 10-23 illustrates a basic tone-modulated system.

At the receiver site the signal is received with the carrier and audio signal impressed together. The receiver filters the audio signal from the carrier, this process of separating the impressed signal is known as detection or demodulation.

CARRIER-FREQUENCY SHIFT SYSTEM

For Frequency-Shift Systems, a keyer in the transmitter provides a source of radiofrequency excitation which can be shifted above or below the assigned frequency corresponding to the mark or space required to transmit the teletype characters. The amount of this frequency-shift deviation of the keyer is adjustable over a range of from 0 to 1000 cycles per second. Normally the keyer is adjusted for an 850 cycle shift, 425 cycles above the assigned frequency and 425 cycles below. A marking impulse will be 425 cycles above the operating frequency and a spacing impulse will appear 425 cycles below. Figure 10-24 illustrates a basic frequency shift system.

MULTIPLEX SYSTEMS

The number of communication circuits in operation throughout any given area is increasing constantly; as a result the radiofrequency spectrum is rapidly becoming saturated to such an extent that radio frequencies are not readily available for the establishment of new circuits. These required increases have been met in part by conversion of teletypewriter operation to 100 WPM and are being met still further by conversion to multiplex systems.

The primary purpose of a multiplex system is to increase the message-handling capacity of teletypewriter channels and the transmitters and receivers associated with them. This is accomplished by the simultaneous transmission of several messages over a common channel.

Multiplexing can be accomplished in either of two methods. Frequency-division multiplexing, for example, employs a number of tone channels slightly displaced in frequency. Each tone channel carries the signals from a separate teletypewriter circuit and modulates a common carrier frequency. Time-division multiplexing, on the other hand, divides the time duration of a standard start-stop signal into a number of equal intervals and allots each interval to a separate teletypewriter circuit. Thus, the start-stop signals are, in effect, compressed in time for transmission. Receiving equipment at a distant station accepts the multiplex signals, converts them to start-stop signals (in effect, expands them in time), and distributes them in the proper order to a corresponding number of circuits.

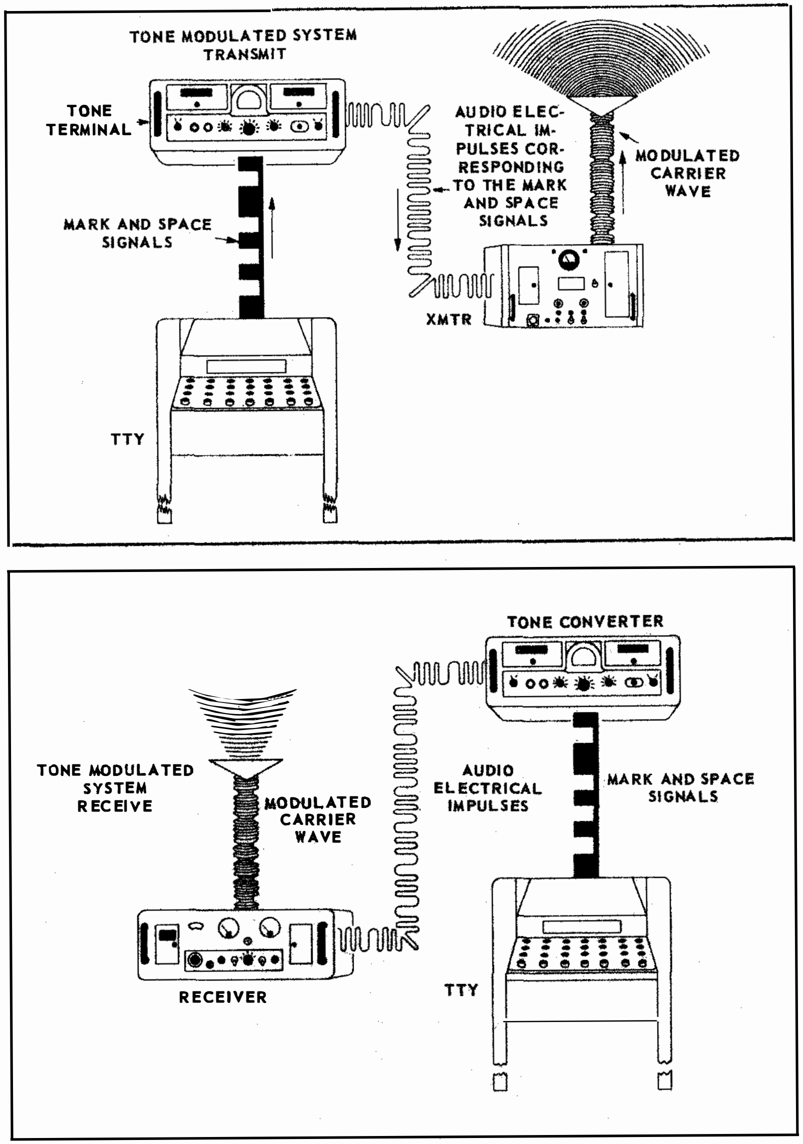
The Navy currently has only a limited number of multiplex equipments installed aboard ship. They are models AN/FGC-5 and AN/UGC-1, both of which use the time-division method of multiplexing. Both the AN/FGC-5 and AN/UGC-1 are send-receive terminal sets used for teletypewriter communications over long-range, high-frequency radio circuits. They are operationally compatible.

The AN/FGC-60 is used by the Navy between large communication centers to support the demand for handling high traffic volumes. The AN/FGC-60(V) will be discussed later in this chapter.

TRANSISTOR MULTIPLEX SET AN/UGC-1

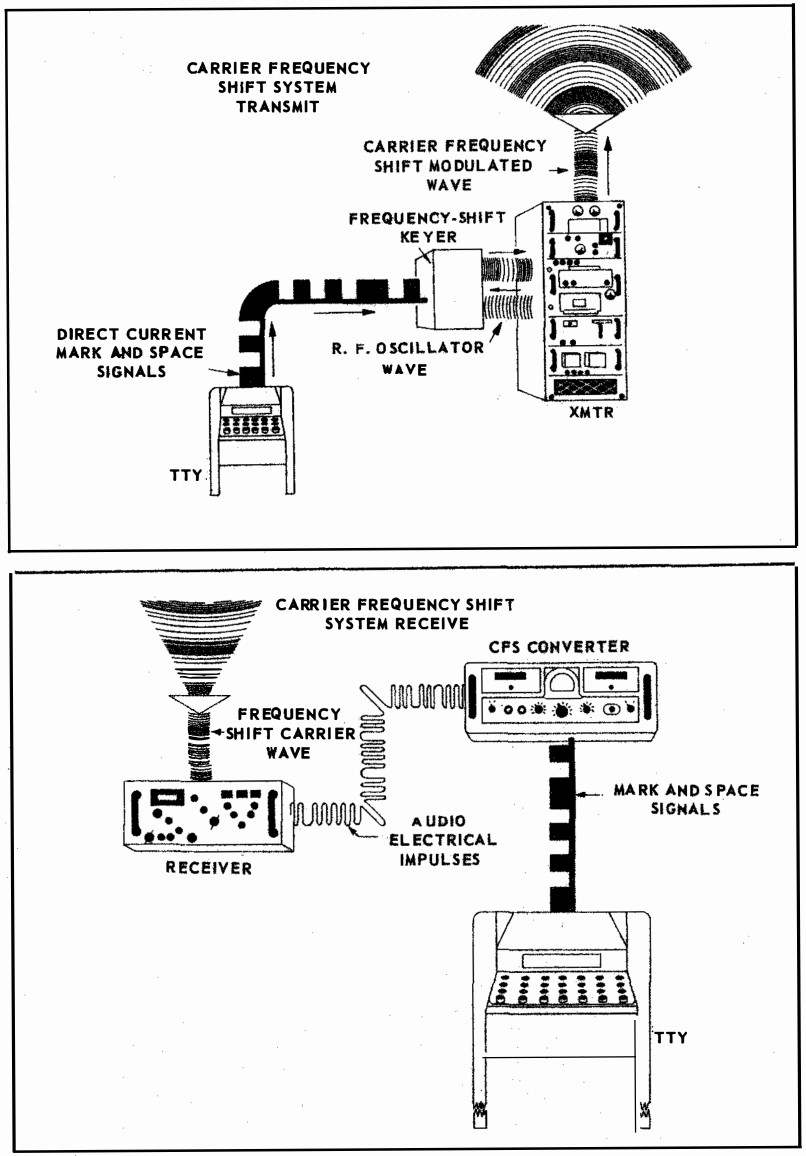
Model AN/UGC-1 transistor multiplex set consists of three functional equipment groups. These are the transmitting group, receiving group, and the power supply group. They are illustrated in figure 10-25.

The transmitting group accepts teletypewriter signals from two, three, or four separate circuits and assembles them in sequential order



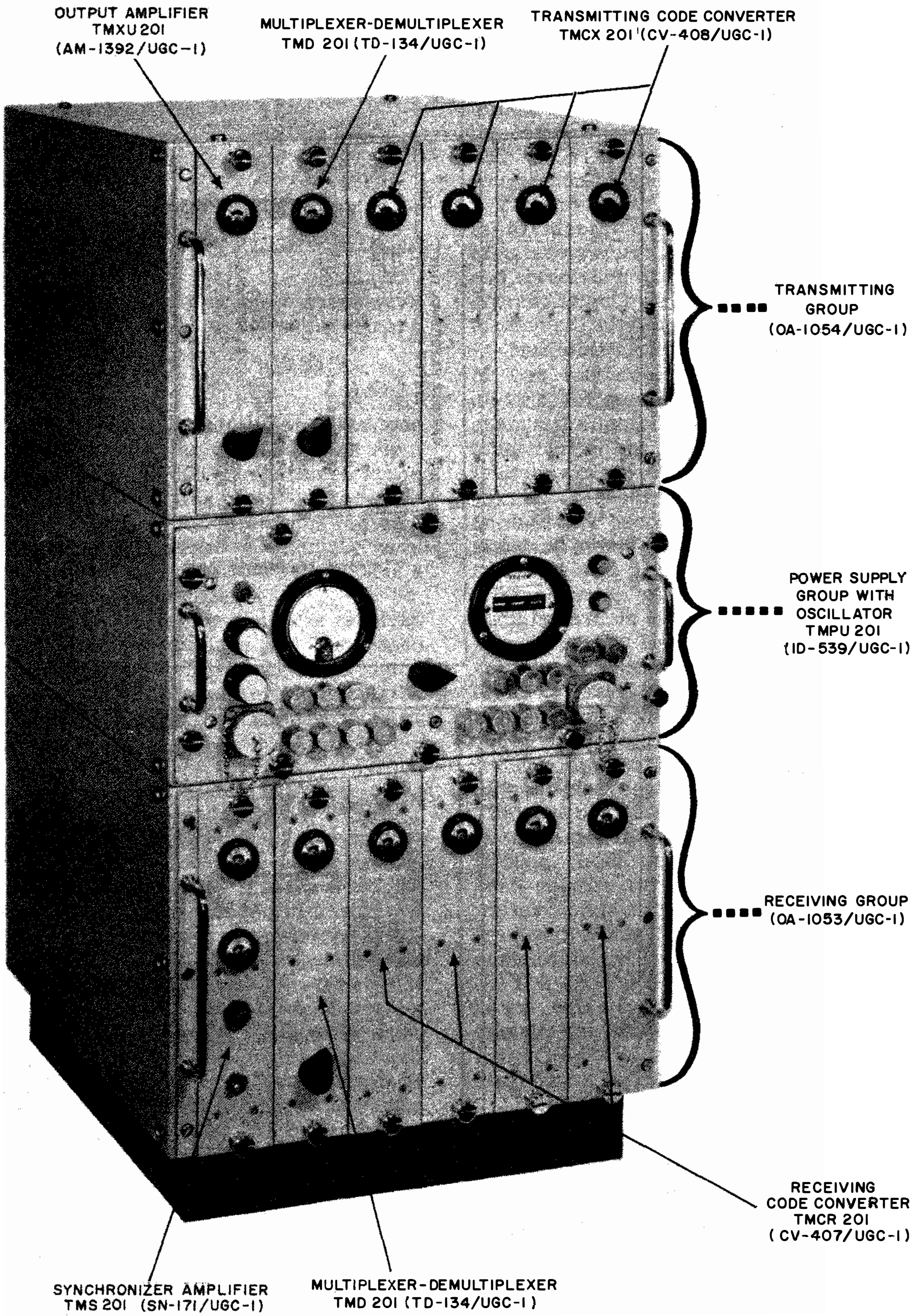
1.230:.231

Figure 10-23. —Basic tone-modulated system.



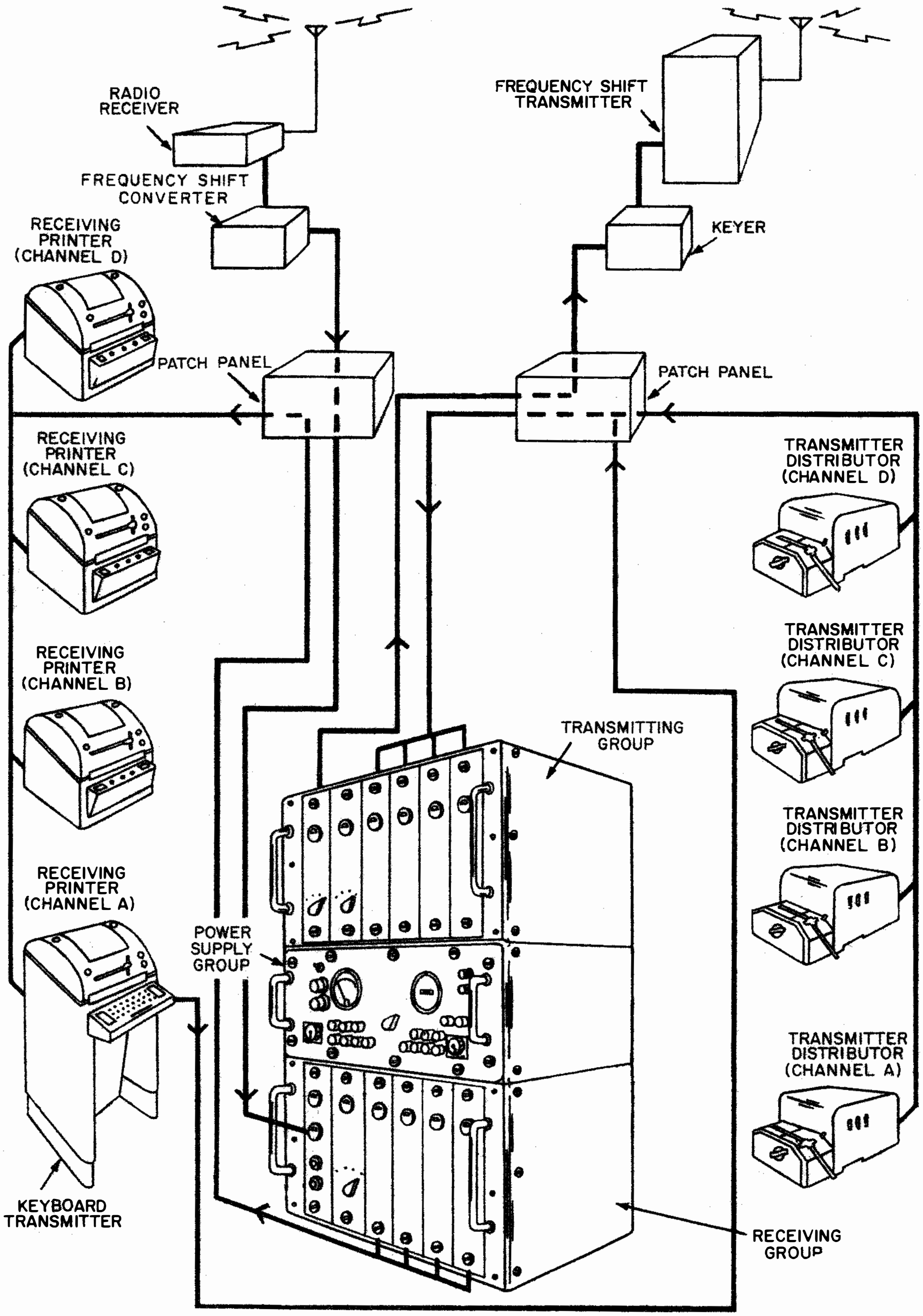
1.228:.229

Figure 10-24. —Basic carrier frequency-shift system.



31.37

Figure 10-25.—Transistor multiplex set AN/UGC-1.



50.83

Figure 10-26.—Typical multiplex send-receive station.

for multiplex transmission over a single radio circuit.

The receiving group accepts multiplex signals from the distant station, converts them to start-stop form, and distributes them to two, three, or four separate teletypewriter circuits.

The power supply group provides the necessary voltages and a frequency standard for both the transmitting and receiving groups.

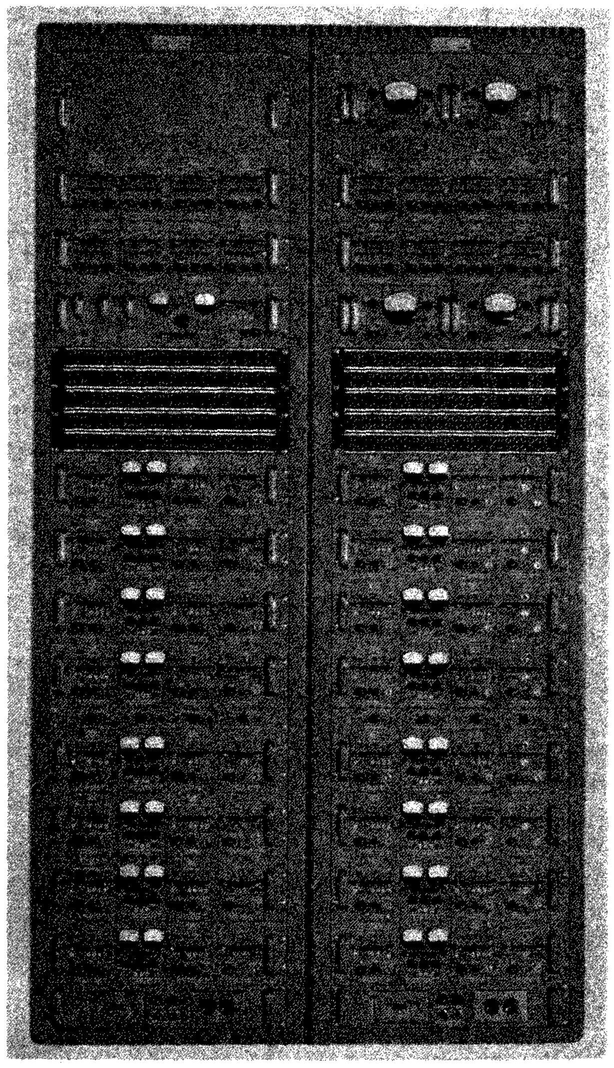
A schematic representation of a multiplex send-receive installation is shown in figure 10-26. The frequency-shift transmitter, the keyer, the radio receiver, the demodulator (converter), the patch panels, and the teletypewriter equipments are included to show the complete send-receive system.

At the send side of the multiplex station, four teletypewriter tape transmitters simultaneously send four messages to respective transmitting code converters (identified in fig. 10-25) in the transmitting group. The code converters translate these signals, which are in sequential form, into 6-wire parallel form. The start and stop elements of the signals are discarded and a sixth element is added. The multiplexer-demultiplexer unit of the transmitting group sweeps over the outputs of the code converters, channel by channel, and picks up, in turn, a complete signal character from each converter. By varying the pulse-division ratio, the equipment can be switched to operate with two, three, or four teletypewriter circuits (designated channels A, B, C, and D in figure 10-26). The teletypewriter equipment can be operating at speeds of 60, 75, or 100 WPM, but the speed must be the same for each channel. The output of the transmitting group is fed through the patch panel and keyer to the radio transmitter, where the frequency-shifted multiplex signal is placed on the air.

At the receiving station, the multiplex signals from the radio receiver are patched to the synchronizer-amplifier in the receiving group of the AN/UGC-1. This unit amplifies the signals and sends inverted and normal versions to the multiplexer-demultiplexer. The latter unit performs functions complementary to the multiplexing in the transmitting group. It separates the multiplex signals into 6-wire parallel signals, and, as it sweeps over the input wiring of the receiving code converters, it applies, channel by channel, the proper signals to the proper converters. The sixth pulse of the parallel signals, which is used only to recognize the presence of bona fide blank transmission, is dropped. The start and stop elements are added, and d-c teletypewriter code signals are sent at the proper speed to the four receiving teletypewriters.

FREQUENCY-DIVISION MULTIPLEX SYSTEM AN/FGC-60(V)

The AN/FGC-60(V) Diversity Telegraph Terminal (fig. 10-27) is intended for use on long distance communication links. The terminal



1.358
Figure 10-27.—AN/FGC-60(V), Frequency Division Multiplex.

provides for the transmission and reception of a number of independent telegraph channels which are simultaneously conveyed over one audio circuit.

The AN/FGC-60(V) is a fully transistorized 16-channel transmit and dual diversity receive frequency-division multiplex system further capable of expanding to 64 channels. All the channels can be individually operated and utilize the audiofrequency shift keyed method of signaling.

Structurally, all basic units within the cabinets are of modular type, designed for high reliability and simplicity of operation.

While the AN/FGC-60(V) system in its standard configuration provides for 100-WPM telegraph channels, the modular structure of the system makes it readily adaptable to other forms of communications. A simple change of plug-in submodules permits change of frequency assignment, frequency shift, and maximum channel speed.

CHAPTER 11

THE MESSAGE

A message is a thought or idea expressed briefly in plain or cryptic language and prepared in a form suitable for transmission by any means of communication. This chapter will describe various types and classes of messages that a communicator will handle. Special communication systems will vary slightly, depending on the mission being accomplished.

CLASSES OF MESSAGES

There are five classes of messages: A, B, C, D, and E. Classes A, B, and C are Government messages; D and E are non-Government, or private messages. The purpose of this classification system is to aid administration and accounting.

By far the largest volume of traffic handled by the Navy is class A, consisting of official messages and replies thereto originated by the Department of Defense (including the U. S. Coast Guard when operating as part of the Navy).

Class B consists of official messages of U. S. Government departments and agencies other than the Department of Defense. (U. S. Coast Guard is included under class B except when operating as a part of the Navy).

Class C consists of broadcast traffic in special forms, available to ships of all nationalities. Class C messages are concerned with special services, such as hydrographic data, weather, and time.

Class D's are private messages for which the Navy collects tolls. The group includes radio-telegrams and press messages sent by correspondents aboard ship.

Class E messages are personal messages to and from naval personnel, handled free of charge over naval circuits. Charges are collected from the sender only when a commercial communication company, such as Western Union, will handle the message over part of its route. For example, suppose your ship is in the Atlantic and has a class E message addressed to a man at a naval air station in Cuba. Your ship transmits the message to Radio Washington, which relays it via San Juan, P.R., to a station at Guantanamo Bay, Cuba, that effects delivery to the naval air station. The message never leaves Navy channels and the originator pays nothing. But if the message were addressed to Louisville, Ky., Western Union would handle it out of Washington and the ship would collect tolls from the originator for the distance between Washington and Louisville. Your ship would forward the money to the Navy Finance Center for payment to Western Union in accordance with instructions found in the effective edition of DNC 26.

The class E message privilege is primarily for purposes of morale. It affords naval personnel at sea a means of communication regarding urgent personal matters without incurring prohibitive expense. It is not available between points on shore within the United States. In general, the privilege is used sparingly. Subjects ordinarily acceptable for transmittal or delivery are matters of grave personal concern, such as the serious illness of a close relative, birth announcements, important nonrecurring business communications, matters of life and death, and occasional greetings on important anniversaries. Not acceptable are trivial or frivolous messages, those of unnecessary length, and ordinary congratulations.

TYPES OF MESSAGES

Most messages have at least one addressee responsible for taking action on the contents and for originating any necessary reply. Other addressees with an official concern in the subject of the message, but who do not have the primary responsibility for acting on it, receive the message for information. Do not be confused by the term "information addressee." Even though an information addressee usually is concerned only indirectly with a message, very frequently he must take action of some nature within his own command. Some messages have only information addressees.

Messages may be divided into types, according to the way they are addressed, as—

1. Single-address;
2. Multiple-address;
3. Book;
4. General.

A single-address message is sent to one addressee only.

A multiple-address message is sent to two or more addressees, each of whom is informed of the others. Each addressee must be designated either as action or information.

A book message is sent to two or more addressees, and is of such a nature that no addressee needs to know who the others are—although each addressee is informed whether he receives the message for action or for information.

The station sending a book message divides addressees into groups according to the relay stations serving them. A separate message is prepared and transmitted to each relay station; the message is changed only to drop addressees that are the concern of some other station. Upon receiving a book message, a relay station may further reduce the number of addressees by repeating the process or by making up single address messages for each of its tributaries addressed. Because many book messages are intended for dozens of addressees, and because some addressees may require delivery by Western Union or commercial teletypewriter services, substantial time and expense are saved by the shortened headings.

A general message has a wide standard distribution. General messages are of many types, each of which carries an identifying title and is intended for a certain standard set of addressees. (See table 11-1.) All messages of a given general message title are numbered serially through the calendar year; for example, ALNAV 12-63, signifying the twelfth ALNAV sent during 1963.

You will see other general messages with titles not listed in table 11-1. These are originated by the Joint Chiefs of Staff, sea frontier commanders, commandants of naval districts, and fleet, force, and ship type commanders to publish information within their respective commands.

Maintenance of general message files is often part of a communicator's duties. General messages are grouped according to type, and are filed in order of serial numbers. Copies of general messages are kept in the general message file until cancelled or superseded.

SPECIAL-PURPOSE MESSAGES

A number of messages are named for the purpose they serve. They usually contain reports or information of a recurring nature and may follow a specific format. A few of the more common types of special-purpose messages follow.

CONTACT AND AMPLIFYING REPORTS

A contact report is a message reporting the first contact with an enemy force. Speed of handling such a message is of utmost importance. Contact reports take priority over every other type of traffic handled by naval communications.

An amplifying report follows up a contact report. It contains further information about the enemy force, such as number, type, position, course, speed, and distribution. A contact report may be followed by many amplifying reports as information becomes available and the enemy shows his intentions. It is often possible to transmit some amplifying data with the contact report.

MOVEMENT REPORTS

The Navy has hundreds of fleet units always on the move. It is necessary both to command and to efficient administration to have an up-to-the-hour knowledge of the location of every vessel. This large-scale change-of-address work is carried on by the movement report system.

The controlling agency of the entire movement report system is the movement report control center at Washington, D. C. (MRCC WASHDC). For reporting purposes the world is divided into five zones, of which only four presently are assigned. Each zone is controlled by a movement report center (MRC). Each zone is further subdivided into areas controlled by movement report offices (MROs). An MRC

Table 11-1.—General Messages.

Originator	Title of series	Description
JCS	ALMILACT	Messages for distribution to all US activities world-wide which use military communications. For the imposition of MINIMIZE or for the promulgation of other instructions or information which have world-wide application.
	CONUSACT	Content same as ALMILACT, distribution and application to Continental US Activities only.
	JAFPUB	Messages for distribution to all US holders of JANAP/ACP's served by US military communications. For the promulgation of supplements and corrections to JANAP/ACP's.
SECNAV	ALNAV	Messages intended for wide distribution throughout the entire Naval Establishment, including the Marine Corps. They deal with administrative matters, such as fiscal policies, changes in personnel allowances, legislation affecting the Navy, promotions of officers, etc.
	NAVACT	Similar in content to ALNAV, but of no interest to the Marine Corps.
	ALNAVSTA	Administrative information requiring wide dissemination to the shore establishment of the Navy — including shore-based elements of the operating forces — and to the Marine Corps.
	ALSTACON and ALSTAOUT.	Similar to the above but of interest, respectively, to activities inside and activities outside the continental United States.
CNO	NAVOP	Similar in content to ALNAV but distribution list does not include attaches, missions, observers, or minor shore activities.
	ALCOM	Usually used for, but not restricted to, promulgation of communication information throughout the Navy.
	ALCOMLANT and ALCOMPAC.	Subdivisions of the ALCOM series for, respectively, Atlantic-Mediterranean areas Pacific area.

Table 11-1.—General Messages—Continued

Originator	Title of series	Description
CNO (Cont'd)	FLTOP.	Messages concerning fleet units and their operational commanders.
	MERCAST.	The merchant ship equivalent to an ALNAV. Distribution includes ships guarding MERCAST (merchant ship broadcast) schedules, naval port control and naval control of shipping officers, and MSTS commands.
CINCPAC	JANAFPAC.	Messages pertaining to the Pacific commands on matters of joint interest.
CINCPACFLT	ALPACFLT.	Messages for general distribution to commands under CINCPACFLT.
	MERCASTPAC.	The merchant ship equivalent to an ALPACFLT.
Commandant, Marine Corps.	ALMAR	Messages for general dissemination to all Marine Corps activities.
	ALMARCON	Messages for Marine Corps activities within the continental United States.
CINCLANTFLT	ALLANTFLT.	Messages for general distribution to commands under CINCLANTFLT.
	MERCASTLANT.	The merchant ship equivalent to an ALLANTFLT.
Communications Electronics Directorate/ Joint Staff.	ALJAP	Promulgates to holders information pertaining to CED/JS-adopted publications when rapid delivery to all branches of the armed forces is required.
Commandant, Coast Guard.	ALCOAST	Messages for general dissemination within the Coast Guard. The Coast Guard equivalent of ALNAV.
	ALDIST	Provide Coast Guard district commanders with policy instructions and other information.
Commander, MSTS	ALMSTS.	Messages for all MSTS commands and offices.

receives information on movements all over the world, but MROs have information only on movements in their own areas of responsibility.

Before getting underway, a ship sends a movement report message stating the time of departure, destination, route, speed of advance, and any other information the ship may be directed to furnish. The message enters the movement report system through the MRO or MRC controlling the area the ship is presently in. It then is the responsibility of the MRO or MRC to relay the information to military and civilian activities that have an official interest in the location of the vessel. Included are such activities as supply centers, fleet post offices, fleet broadcast stations, and the customs authorities.

Movement report messages are prepared in accordance with the movement report supplement to NWIP 10-1.

HYDRO MESSAGES

The U. S. Navy Oceanographic Office originates messages concerning navigation warnings. These messages are given wide distribution on special hydrographic broadcasts and may be rebroadcast on the Navy's fleet broadcast. There are two subdivisions of HYDRO messages. HYDROLANTS contain navigational information relating to the Atlantic, Mediterranean, and Indian Oceans. HYDROPACS furnish such information for the Pacific Ocean areas.

NOTICES TO AIRMEN

Notices to airmen (NOTAMs) are originated by military activities and civil agencies concerned with the safety of aircraft. NOTAMs are composed of data relating to aerological facilities, services, and hazards.

Q MESSAGES

The classified portions of the navigational warning systems of Allied Nations are known as Q messages. They contain information affecting navigation that an enemy would find difficult to obtain on his own. Do not confuse Q messages with Q signals, which are explained later in this chapter.

ALL SHIPS PRESENT MESSAGES

All ships present messages are for ships within a specified area. They are originated by the senior officer present afloat (SOPA), and relate to such matters as storms, port security regulations, and local liberty policy. The SOPA prescribes local instructions governing the initiation, transmission, and relay of all ships present messages.

MINIMIZE MESSAGES

In an emergency—either actual or simulated—it may be necessary to reduce message and telephone traffic to prevent delay in handling vital messages. This reduction in traffic is accomplished by promulgation (usually by message) of the word MINIMIZE, which has the following meaning: "It is now mandatory that normal message and telephone traffic be reduced drastically in order that vital messages connected with the situation indicated shall not be delayed." The message ordering MINIMIZE consists of the word MINIMIZE followed by the scope (area affected) and the reason, and the duration of its imposition (when known).

Messages imposing MINIMIZE must be brought to the immediate attention of the communication officer.

Detailed instructions on traffic handling during MINIMIZE are contained in ACP 121.

RED CROSS MESSAGES

The American Red Cross is permitted free use of naval communication facilities for sending and receiving messages regarding emergency welfare in the interest of armed forces personnel. Red Cross messages are handled as class B messages and normally are in plain text.

The Red Cross messages you are most likely to see concern personal hardship, or death or serious illness of relatives of naval personnel. Every command should have specific instructions for handling these messages in the local SOP.

When emergencies or disasters occur involving Red Cross relief work, Red Cross messages may be handled over naval circuits whether they are in the interest of armed forces personnel or not.

Red Cross messages normally are not accepted for transmission unless delivery can be effected entirely by naval communications.

STATION AND ADDRESS DESIGNATORS

Station and address designators are formed of combinations of characters or pronounceable words for use in message headings to identify originators and addressees. The four kinds of station and address designators are call signs, address groups, routing indicators, and plain launguage address designators.

CALL SIGNS

Call signs are letters, letter-number combinations, or one or more pronounceable words which identify some communications activity and are used chiefly for establishing and maintaining communications. They are used in both civil and military communications. Call signs are of several categories, with some calls belonging to more than one category. They are described in the ensuing eight topics.

International Call Signs

International call signs are assigned to radio stations of all countries—civil and military, afloat and ashore—according to international agreement. The first letter or first two letters of an international call indicate the nationality of the station. The United States has the first half of the A block (through ALZ) and all of the K, W, and N blocks. The United States reserves A calls for the Army and Air Force. The K and W blocks are assigned to commercial and private stations, merchant ships, and others. The N block is only for use by the Navy, Marine Corps, and Coast Guard.

Naval shore communication stations have three-letter N calls. If necessary, these calls may be expanded by adding numerical suffixes. Thus, additional call signs are provided for radio transmitting and receiving facilities located remotely from the parent station. Examples are the following:

NAM . . . NAVCOMMSTA Norfolk.
NAM1 . . . Headquarters, CINCLANTFLT, Norfolk.
NAM2 . . . Naval Shipyard, Norfolk.

The call signs for fixed and land radio stations are listed in ACP 100 (Allied Call Sign and Address Group System - Instructions and Assignments) and U. S. Supplement 1 thereto.

International call signs assigned to U. S. naval vessels are four-letter N calls, which are to be used unencrypted only. They have no security value, hence they are utilized for all nonmilitary international communications. Example:

NWBJ . . . . USS Renshaw (DD 499).

International call signs for USN, USMC, and USCG aircraft are composed of the service designator N, NM, or NC, respectively, followed by the last four digits of the serial or bureau number of the aircraft.

Military Call Signs

Most ships of the Allied Nations are assigned military call signs in addition to their international call signs. From the miltary call signs are derived the encrypted call signs for CW and RATT communications. Likewise, military call signs form the basis for both encrypted and unencrypted call signs for voice communications. They are never used in their basic form to address messages. Consequently, military call signs are assigned only to ships capable of encrypting call signs. Both international and military call signs are listed in ACP 113 (Call Sign Book for Ships).

Indefinite Call Signs

Indifinite call signs represent no specified facility, command, authority, or unit, but may represent any one or any group of these. Examples:

NERK . . . . . . (To) any or all U. S. Navy ships(s).
NA through NZ . (From) any U. S. Navy ship
NQO. . . . . Any or all U. S. Navy shore radio station(s).

Indefinite call signs are used in codress message headings to conceal the identity of originators and addressees. In such instances this information is placed in the encrypted text.

The call NQO might be sent by a ship unable to raise a particular shore station. Any Navy shore station hearing the transmission would answer and accept the traffic.

Collective Call Signs

Collective Call signs pertain to two or more facilities, commands, or units, Examples:

NATA . . . . . . All U. S. Navy ships coyping this broadcast.
NIMK . . . . . . All U. S. submarines coyping this broadcast.

Net Call Signs

Net call signs represent all stations within a net. (A net is a group of stations in direct communication with each other on a common channel.) Examples:

NQN . . . . All U. S. Navy radio stations in the

Pacific guarding the ship-shore high-frequency calling series.

OVERWORK . . All U. S. Navy stations on this (radio-telephone) circuit.

Tactical Call Signs

Tactical call signs, with the exception of task organization and aircraft call signs, are limited in application. They normally are used in tactical communications only, to identify tactical commands or communication facilities. Tactical call signs are four element, combination letter-number call signs. They are listed in ACP 110, Tactical Call Sign Book with supplements, and ACP 112, Task Organization Call Sign Book.

Voice Call Signs

Voice call signs are words or combinations of words—such as SUNSHINE or HIGH HAT—limited to radiotelephone communications. Call signs in JANAP 119, Joint Voice Call Sign Book, are only for tactical circuits. On ship-shore administrative circuits, phonetically spelled international call signs are given as ships' voice calls. Under certain conditions, ships' names are used as voice call signs on local harbor circuits.

Visual Call Signs

Visual call signs are groups of letters, numerals, special flags and pennants, or combinations of any of these, for use in visual communications. They are listed in ACP 118.

ADDRESS GROUPS

Address groups are four-letter groups assigned to represent a command, activity, or unit. They are used mainly in the message address, although, in military communications, they can be used in the same manner as call signs to establish and maintain communications. In general, call signs and address groups are used by the Navy in exactly the same way. Address groups never start with the letter N, hence they are easily distinquished from naval radio call signs. Unlike international call signs, address groups follow no distinctive pattern. For example, you learned the difference in call signs for naval ships and shore radio stations. In address groups, however, the arrangement of the four letters conveys no significance whatsoever.

All commands afloat (except individual ships) are assigned address groups. Shore-based commands, authorities, or activities not served by their own communications facilities are also assigned address groups. For example, (1) senior commands and commanders ashore, such as the Secretaries of Defense and of the Navy, bureaus and offices of the Navy Department, and district commandants; (2) fleet, type, or force commanders ashore; (3) elements of operating forces permanently ashore who are in frequent communication with forces afloat; and (4) elements of the shore establishment (such as weather centrals) having a need for direct addressing and receipt of the messages.

Among other uses, address groups facilitate delivery of messages when a communication center serves so many activities that its own call sign is insufficient to identify the addressee.

Address groups are contained in ACP 100 and its U. S. Supplement 1.

Address groups, like call signs, are divided into types. They are individual activity, collective, conjunctive and geographic address groups, address indicating groups, and special operating groups.

Individual Activity Address Groups

Individual activity address groups are representative of a single command or unit, either afloat or ashore. Examples:

DTCI - - - - - COMPHIBLANT.
SSMW - - - - CNO.

Collective Address Groups

Collective address groups represent two or more commands, authorities, activities, units, or combinations of these. Included in the group are the commander and his subordinate commanders. Examples:

DSWN - - - - - DESRON 16.
AMGK - - - - - SIXTHFLT.

Conjunctive Address Groups

You must remember that conjunctive address groups have incomplete meanings. It is always necessary to complete the meaning by the addition of other address groups denoting a specific command or location. It is for this reason that conjunctive address groups are used only with one or more other address groups. The conjunctive address group XZKW, for example, means "All ships present at __________." This particular group must be followed by a geographic address group to complete the meaning.

Geographic Address Groups

Geographic address groups are the equivalent of geographic locations or areas, and are always preceded by conjunctive address groups. Assuming the geographic address group for Newport, R. I., to be DEXL, all ships present at Newport would be addressed XZKW DEXL.

Address Indicating Groups

Address indicating groups (AIGs) represent a specific set of action and/or information addressees. The originator may or may not be included. The purpose of AIGs is to increase the speed of traffic handling. They shorten the message address by providing a single address group to represent a number of addressees, thus eliminating individual designators for each addressee. For example, BIOQ is an AIG used to address air defense messages originated by COMEASTSEAFRON to 24 action addressees and 37 information addressees. By using a single AIG, 61 call signs and address groups are eliminated from the heading of the message.

Special Operating Groups

Special operating groups (SOGs) are utilized for passing special instructions in message headings. They are four-letter groups that are identical in appearance to address groups. Special operating groups are not used by the Navy unless specifically authorized by CNO. When they are authorized, they must always be encrypted. A list of the SOGs, together with their meanings, is in ACP 100.

ROUTING INDICATORS

Routing indicators are groups of letters whose purpose is to identify stations in a teletypewriter tape relay network. Depending upon the type of station, routing indicators vary in length from four to seven letters. It is easy to distinguish routing indicators from call signs or address groups because routing indicators always begin with either the letter R or U. Routing indicators are never encrypted. A complete discussion of routing indicators and their usage in teletypewriter tape relay operation is included in chapter 12.

PLAIN LANGUAGE ADDRESS DESIGNATORS

Plain language address designators are the official, abbreviated or short titles of commands or activities, used instead of call signs or address groups in the headings of messages. Some abbreviated titles are written as single words; others have conjunctive titles and g ographical locations. Examples:

BUSHIPS
NAVCOMMSTA GUAM
COMSERVLANT
COMSERVRON EIGHT

Plain language address designators are widely used in unclassified messages originated and addressed within the shore establishment.

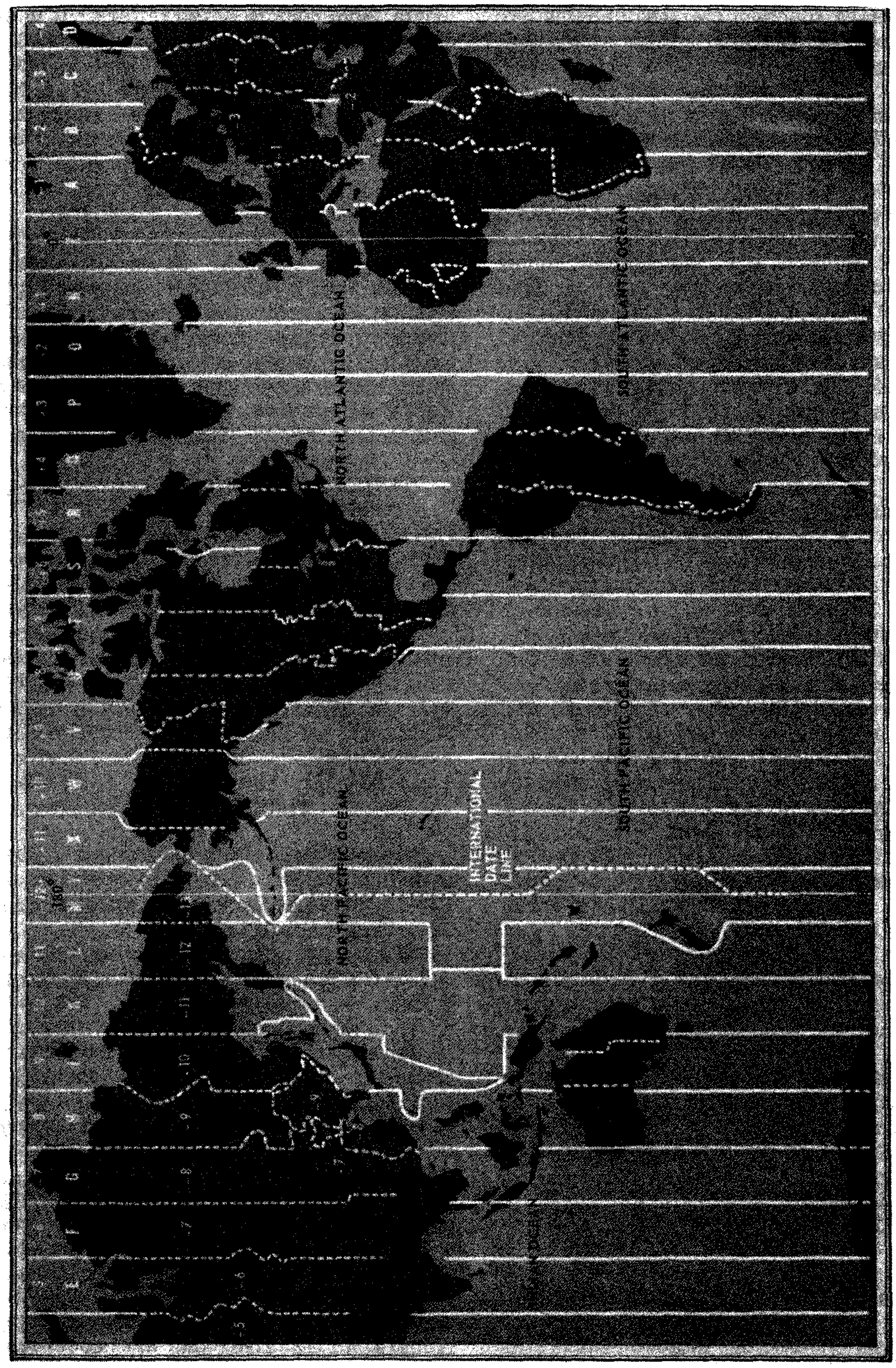
When using plain language headings some authorities and commands must be addressed in messages by short title only. The authorities and commands requiring mandatory use of their short titles are listed in ACP 121(D) US SUPP(B)-1 ANNEX (A).

TIME IN MESSAGES

For reckoning time, the surface of the earth is divided into 24 zones, each extending through 15° longitude. Each zone differs by 1 hour from the zone next to it.

The initial time zone lies between 7-1/2°E. and 7-1/2°W. of zero meridian, which passes through the twon of Greenwich, England. The time in this zone—zone zero—is call GMT (Greenwich mean time). You may hear some oldtimers call it GCT (Greenwich civil time); both names mean the same. Each zone, in turn, is indicated by the number that represents the difference between the local zone time and Greenwich mean time.

Zones lying in east longitude from zone zero are numbered from 1 to 12 and are designated minus, becaus for each of them the zone number must be subtracted from local time to obtain Greenwich mean time. Zones lying in west longitud from the zero zone are numbered from 1 to 12 also, but are specified plus,



13.76

Figure 11-1.—Time zone chart of the world.

because the zone number must be added to local zone time to obtain GMT. In addition to the time zone number, each zone is further designated by letter. Letters A through M (J omitted) indicate minus zones; N through Y, plus zones. (See fig. 11-1.) The designating letter for GMT is Z.

The 12th zone is divided by the 180th meridian, the minus half lying east longitude and the plus half in west longitude. This meridian is the international date line, where each worldwide day begins and ends. A westbound ship crossing the line loses a day, whereas an eastbound ships gains a day.

The number of a zone, prefixed by a plus or a minus sign, constitutes the zone description. Often zones crossing land areas are modified to agree with boundaries of countries or regions using corresponding time.

The approved method of expressing time in the 24-hour system is with the hours and minutes expressed as a four-digit group. The first two figures of the group denote the hour and the second two the minutes. Thus 6:30 a.m. becomes 0630; noon is 1200; and 6:30 p.m. is 1830. Midnight is expressed as 0000—never as 2400—and 1 minute past midnight becomes 0001. The time designation 1327Z shows that it is 27 minutes past 1:00 p.m., GMT. Numbers are prefixed to the time to indicate the day of the month; in other words, to form a date-time group (DTG). The DTG 171327Z means the 17th day of the current month plus the time in GMT. Dates from the 1st to the 9th of the month are preceded by the numeral 0.

A date-time group is assigned to a message by the message center at the time the message is prepared for transmission. For standardization, the time expressed by a date-time group normally is GMT. The date-time group in a message heading serves two purposes: It indicates the time of origin of the message, and it provides an easy means of referring to the message.

In addition to the external DTG, an encrypted message has a DTG buried within the text. This internal DTG is called the true date-time group (TDTG) and is inserted by the cryptocenter. The TDTG is used when referring to a message that has been encrypted.

The DTG assigned to a general message always has a slant sign (/) and additional digits added to the DTG. The additional digits represent the general message sequential serial number. Example: 102347Z/35.

Local time is sometimes used to indicate date and time in the text of a message, but must be accompanied by the zone designating letter—as in 170812Q. When local time is referred to frequently in the text, the suffix may be omitted if a covering expression is used, such as ALL TIMES QUEBEC.

The time conversion table (table 11-2) is useful for converting time in one zone to time in any other zone. Vertical columns indicate the time zones. Zone Z is GMT. Time in each successive zone to the right of zone Z is 1 hour later, and to the left of zone Z is 1 hour earlier. Time in each successive shaded area to the right is 1 day (24 hours) later; to the left it is 1 day (24 hours) earlier. For example, to calculate the time in zone U when it is 0500 hours in zone I, proceed as follows: Find 0500 in column I and locate the time (1200) in the corresponding line in column U. Inasmuch as 1200 is not in the shaded area, the time is 1200 hours yesterday.

PRECEDENCE

Precedence is an important concept in naval communications. To communication personnel, it indicates the relative order in which a message must be handled and delivered. To the addressees, precedence shows the relative order in which the contents are to be noted. Precedence is assigned by the originator on the basis of message content and how soon the addressee must have it. No message is assigned a precedence higher than that required to ensure that it reaches all addressees on time.

Multiple-address messages having both action and information addressees are often assigned two precedences, called dual precedence. One precedence is for the action addressees, and a lower precedence is for information addressees.

Use of higher precedences is limited to certain types of urgent traffic, and standards for handling each precedence are prescribed by DNC. The rules governing precedence are set forth in table 11-3.

In addition to the precedences given in table 11-3, precedences of EMERGENCY and DEFERRED are assigned messages originated by NATO and other Allied Nations. Messages introduced into U.S. Military Communications Systems carrying an EMERGENCY (Y) precedence are handled before IMMEDIATE and after FLASH messages of the United States. Messages

	Y +12	X +11	W +10	V +9	U +8	T +7	S +6	R +5	Q +4	P +3	O +2	N +1	Z 0	A −1	B −2	C −3	D −4	E −5	F −6	G −7	H −8	I −9	K −10	L −11	M −12	
PREVIOUS DAY	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	SAME DAY
	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	
	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	
	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	
	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	
	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	
	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	
SAME DAY	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	NEXT DAY
	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	
	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	
	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	
	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	
	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	
	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	
	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	
	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	
	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	
	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	
	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	
	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	
	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	
	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	
	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	
	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	

Table 11-2.—Time conversion table.

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carrying a DEFERRED (M) precedence are handled after ROUTINE messages of the United States.

PROSIGNS

Procedure signs, or prosigns, are letters or combinations of letters that convey in short, standard form certain frequently sent orders, instructions, requests, reports, and the like, relating to communications. In radiotelegraphy, an overscore means that the prosign is sent as one character, that is, without the normal pause between the letters. Overscores are ignored in teletypewriter work.

Although some prosigns seem to be abbreviations of their assigned meanings, prosigns are never referred to as abbreviations. Prosign $\overline{\text{IMI}}$, used internationally for many years by military radio operators, means "repeat." Some veteran operators would have you believe that $\overline{\text{IMI}}$ derived from the words "I missed it."

Following is a complete list of authorized prosigns. Memorize them now. It may be helpful to prepare a number of small cards, with the prosign on the front and its meaning on the back. Use the cards for self-drill.

1. Precedence prosigns:
   - Z . . . . FLASH.
   - O . . . . IMMEDIATE.
   - P . . . . PRIORITY.
   - R . . . . ROUTINE.
2. Prosigns that identify portions of a transmission:
   - AA . . . . All after.
   - AB . . . . All before.
   - WA . . . . Word after.
   - WB . . . . Word before
3. Ending prosigns:
   - K . . . . Go ahead; or, this is the end of my transmission to you and a response is necessary.
   - $\overline{\text{AR}}$ . . . . End of transmission; no receipt required.
4. Pause prosigns:
   - $\overline{\text{AS}}$ . . . . I must pause for a few seconds.
   - $\overline{\text{AS}}$ AR . . . . . I must pause longer than a few seconds; will call you back.
5. Separation prosigns:
   - $\overline{\text{BT}}$ . . . . Break. (Separates text of message from heading and ending.)
   - II (written in messages as a short dash) . . . . . . Separative sign. (Used to separate parts of the message heading.

Not to be used as punctuation to represent a hyphen or dash in message texts.)

6. Prosigns always followed by one or more call signs and/or address groups:

DE . . . . From (in call).
FM . . . . Originator's sign.
TO . . . . The addressee designations immediately following are addressed for action.
INFO . . . . . . The addressee designations immediately following are addressed for information.
XMT . . . . . . Exempt. (Used to exempt addressees from a collective call or address.)

7. Prosigns used in transmission instructions of a message:

T . . . . Transmit this message to all addressees or to the addressee designations immediately following.
G . . . . Repeat this entire transmission back to me exactly as received.
F . . . . Do not answer.

8. Group count prosigns:

GR plus numerals. Group count
GRNC The groups in this message have not been counted.

9. Prosigns used with the executive method:

$\overline{\text{IX}}$ . . . . Action on the message or signal that follows is to be carried out upon receipt of "Execute."
$\overline{\text{IX}}$ plus 5-second dash . . . . . . "Execute"—carry out the purport of the message or signal to which this applies.

10. General:

$\overline{\text{AA}}$ . . . . Unknown station.
B . . . . More to follow.
C . . . . Correct
EEEEEEEE . . . . . . Error.
EEEEEEEE $\overline{\text{AR}}$ . . . This transmission is in error. Disregard it.
$\overline{\text{HM}}$ $\overline{\text{HM}}$ $\overline{\text{HM}}$ . . . . . . Emergency silence sign.
$\overline{\text{IMI}}$ . . . . Repeat
$\overline{\text{INT}}$ . . . . Interrogative.
J . . . . Verify with originator and repeat.
NR . . . . Station serial number.
R . . . . I received your last transmission satisfactorily.
CFN . . . . Confirmatory material to follow. (Used teletypewriter operation only.)

OPERATING SIGNALS

Radio operators and teletypists frequently exchange routine advice and operating information, and occasionally relay emergency communication instructions or reports to other ships and stations and to aircraft. Traffic of this nature is transmitted in condensed standard form by means of operating signals consisting of three-letter groups beginning with Q or Z. These signals—of which there are several hundred—represent words, phrases, or complete sentences, and are a form of shorthand, eliminating time-consuming plain language transmissions. The Q signals are employed in both military and civil communications, and are understood by ships and shore stations of any nationality. The Z signals are for use only in the United States and Allied military communications, and represent meanings not found in the Q code. Both Q and Z signals can be used together, when necessary, in military communications. Operating signals are published in ACP 131. It has decode sections for both Q and Z signals, indexed alphabetically, and an encode section tabbed by subject matter.

Operating signals are prescribed for every form of electrical telecommunication except radiotelephone. Instead of using the customary operating signals, the radiotelephone operator transmits operating information in brief spoken phrases. An exception is made to this rule when a message containing an operating signal is relayed by radiotelephone; then the operator transmits the group phonetically.

Many operating signals may be used in either of two ways—as a question or as a statement.

Table 11-3.—Precedence of Messages.

Pro-sign	Desig-nation	Definition and use	Handling requirements
Z	FLASH	FLASH precedence is reserved for initial enemy contact messages or operational combat messages of extreme urgency. Brevity is mandatory. Examples: (1) Initial enemy contact reports. (2) Messages recalling or diverting friendly aircraft about to bomb targets unexpectedly occupied by friendly forces; or messages taking emergency action to prevent conflict between friendly forces. (3) Warnings of imminent large-scale attacks. (4) Extremely urgent intelligence messages. (5) Messages containing major strategic decisions of great urgency.	FLASH messages are hand-carried, processed, transmitted, and delivered in the order received and ahead of all other messages. Messages of lower precedence will be interrupted on all circuits involved until handling of the FLASH message is completed. Time standard: Not fixed. Handled as fast as humanly possible with an objective of less than 10 minutes.
O	IMMEDIATE	IMMEDIATE is the precedence reserved for messages relating to situations that gravely affect the security of national/allied forces or populace, and require immediate delivery to the addressee(s). Examples: (1) Amplifying reports of initial enemy contact. (2) Reports of unusual major movements of military forces of foreign powers in time of peace or strained relations. (3) Messages that report enemy counterattack or request or cancel additional support. (4) Attack orders to commit a force in reserve without delay. (5) Messages concerning logistical support of special weapons when essential to sustain operations. (6) Reports of widespread civil disturbance. (7) Reports or warnings of grave natural disaster (earthquake, flood, storm, etc). (8) Requests for, or directions concerning, distress assistance. (9) Urgent intelligence messages.	IMMEDIATE messages are processed, transmitted, and delivered in the order received and ahead of all messages of lower precedence. If possible, messages of lower precedence will be interrupted on all circuits involved until the handling of the IMMEDIATE message is completed. Time standard: 30 minutes to 1 hour.

Table 11-3. —Precedence of Messages—Continued

Pro-sign	Designation	Definition and use	Handling Requirements
P	PRIORITY	PRIORITY is the precedence reserved for messages that require expeditious action by the addressee(s) and/or furnish essential information for the conduct of operations in progress when ROUTINE precedence will not suffice. Examples: (1) Situation reports on position of front where attack is impending or where fire or air support will soon be placed. (2) Orders to aircraft formations or units to coincide with ground or naval operations. (3) Aircraft movement reports (messages relating to requests for news of aircraft in flight, flight plans, or cancellation messages to prevent unnecessary search/rescue action). (4) Messages concerning immediate movement of naval, air, and ground forces.	PRIORITY messages are processed, transmitted, and delivered in the order received and ahead of all messages of ROUTINE precedence. ROUTINE messages being transmitted should not be interrupted unless they are extra long and a very substantial portion remains to be transmitted. PRIORITY messages should be delivered immediately upon receipt at the addressee destination. When commercial refile is required, the commercial precedence that most nearly corresponds with PRIORITY is used. Time standard: 1 to 6 hours.
R	ROUTINE	ROUTINE is the precedence to use for all types of messages that justify transmission by rapid means unless of sufficient urgency to require a higher precedence. Examples: (1) Messages concerning normal peacetime military operations, programs, and projects. (2) Messages concerning stabilized tactical operations. (3) Operational plans concerning projected operations. (4) Periodic or consolidated intelligence reports. (5) Troop movement messages, except when time factors dictate use of a higher precedence. (6) Supply and equipment requisition and movement messages, except when time factors dictate use of a higher precedence. (7) Administrative, logistic, and personnel matters.	ROUTINE messages are processed, transmitted, and delivered in the order received and after all messages of a higher precedence. When commercial refile is required, the lowest commercial precedence is used. ROUTINE messages received during nonduty hours at the addressee destination may be held for morning delivery unless specifically prohibited by the command concerned. Time standard: 3 hours—start of business following day.

The prosign $\overline{\text{INT}}$ before the signal places it in the form of a question. Example: USS Epperson (DD 719) asks USS Renshaw (DD 499): NWBJ DE NTGT $\overline{\text{INT}}$ QRU K, meaning "Have you anything for me?"

Renshaw replies: NTGT DE NWBJ QRU $\overline{\text{AR}}$, meaning "I have nothing for you."

When communicating with nonmilitary stations, the prosign $\overline{\text{IMI}}$, after the Q signal, is employed instead of $\overline{\text{INT}}$ ahead of the Q signal to give an interrogatory meaning.

Some signals must be accompanied by a numeral suffix that completes, amplifies, or varies the basic meaning. Example: A teletypewriter operator checks circuit operation with the query $\overline{\text{INT}}$ ZBK, meaning "Are you receiving my traffic clear?" The receiving station has a choice of replies: ZBK1 means "I am receiving your traffic clear," or ZBK2, "I am receiving your traffic garbled."

Many operating signals contain blank portions in their meanings that are filled in to convey specific information. To illustrate, $\overline{\text{INT}}$ ZRE means "On what frequency do you hear me best?" In ACP 131 the declaratory meaning listed for ZRE is "I hear you best on________kc (mc)." The operator fills in the necessary information thus: NTGT DE NWBJ ZRE 8578, which means "I hear you best on 8578 kc."

Other signals, in their meanings, have blanks enclosed in parentheses. Filling in such a blank is optional. For example, INT ZHA neans "Shall I decrease frequency very slightly (or____kc) to clear interference?" The operator receiving the signal $\overline{\text{INT}}$ ZHA without the frequency added knows it means "Shall I decrease frequency very slightly?"

During wartime, operating signals often are encrypted, especially those revealing—

1. Special frequencies.
2. Cryptographic data.
3. The organization of networks.
4. Ship movements (estimated times of arrival, departure, and kindred data).

Unless they are encrypted, operating signals possess no security and must be regarded as the equivalent of plain language. Remember that the Q code is used internationally, and speaks of "telegrams" whereas a U. S. Navy communicator would say "messages."

ORIGINATOR, DRAFTER, AND RELEASING OFFICER

The originator of a message is the COMMAND by whose authority the message is sent. The drafter—normally a division officer or department head—is the person who actually composes the message, assigns the precedence and classification. The releasing officer authorizes transmission of the message for and in the name of the originator (the command). Ordinarily the commanding officer is the releasing officer, however he may delegate releasing authority to specifically designated officers to increase efficiency of the command.

A communicator charged with accepting locally originated messages must know who has releasing authority, and should check every message for the releasing officer's signature.

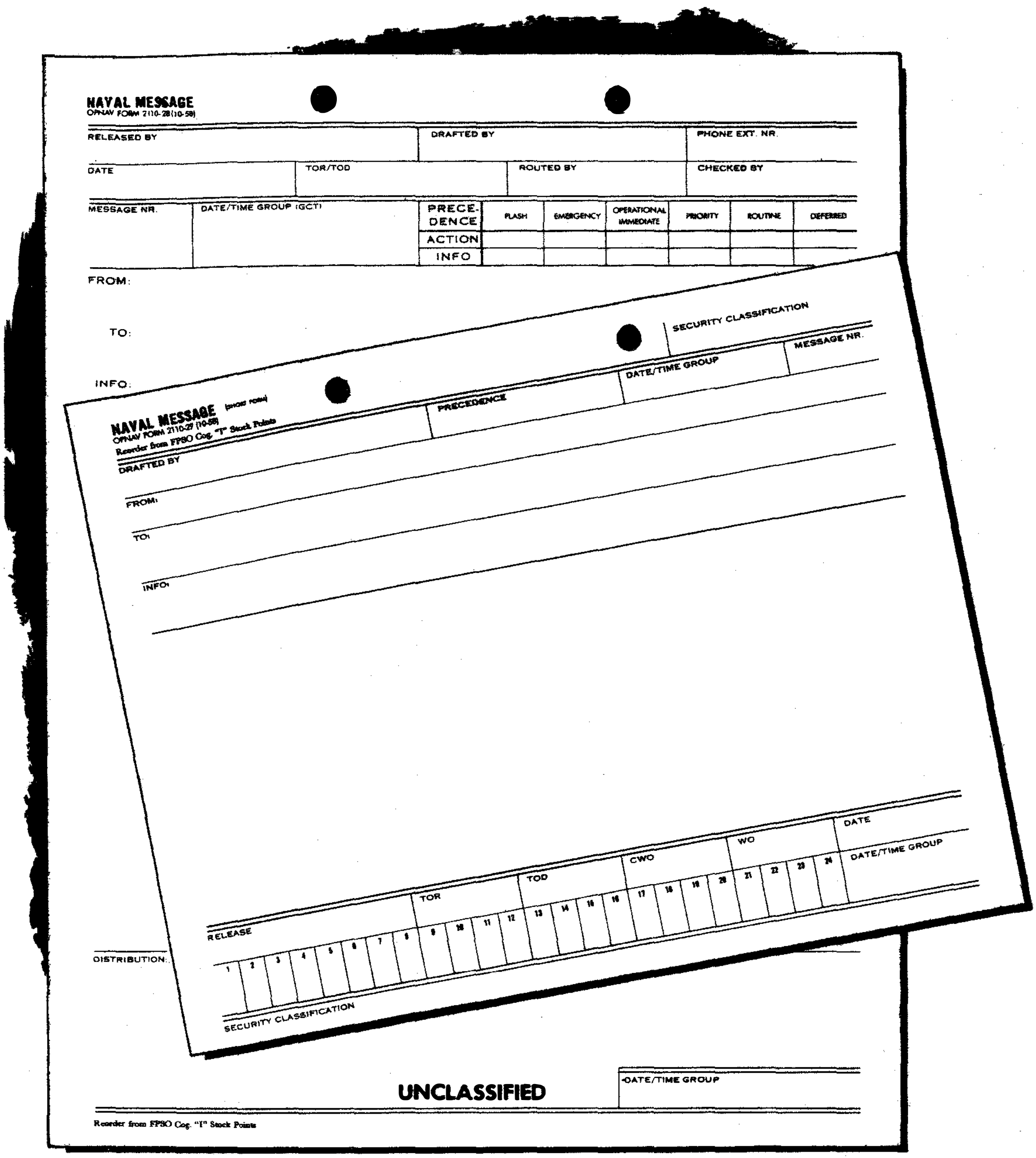
THE MESSAGE BLANK

Because commands vary widely in specific message handling procedures and systems of internal routing, there is no mandatory Navy-wide message blank. Each command devises a message blank to suit its individual requirements. Some shore communication centers use message blanks for both incoming and outgoing messages; other stations may use the blanks for outgoing messages and "run-off" incoming messages on plain paper by duplicating machine. As previously implied, each communication center must decide what procedure best suits its particular needs.

Figure 11-2 illustrates two typical message blanks which can be used for both incoming and outgoing messages. The dual purpose is evident by the TOR/TOD section. On incoming messages the circuit operator indicates the time of receipt (TOR); on outgoing he indicates the time of delivery (TOD). While one example is marked UNCLASSIFIED at the botton, blanks are also available with any of the security classifications preprinted. In addition to the appropriate marking, some commands use a paper color code to emphasize the various security classifications.

On outgoing messages, most sections of the message blank are completed by the drafter. After selecting the blank with the appropriate classification, he will complete the following sections: DRAFTED BY; PHONE EXT NR; DATE; PRECEDENCE; ADDRESS (FROM, TO, and INFO if appropriate); and TEXT.

When the drafter has finished composing the message, he must have it released before it goes to the communication center. All drafters know to whom the commanding officer has delegated the authority to release messages. The


NAVAL MESSAGE
OPNAV FORM 2110-28 (10-58)
RELEASED BY | DRAFTED BY | PHONE EXT. NR.
DATE | TOR/TOD | ROUTED BY | CHECKED BY
MESSAGE NR. | DATE/TIME GROUP (GCT) | PRECEDENCE | FLASH | EMERGENCY | OPERATIONAL IMMEDIATE | PRIORITY | ROUTINE | DEFERRED
ACTION
INFO
FROM:
TO:
INFO:
DISTRIBUTION:
UNCLASSIFIED
DATE/TIME GROUP
Reorder from FPSO Cog. "I" Stock Points

NAVAL MESSAGE (short form)
OPNAV FORM 2110-27 (10-58)
Reorder from FPSO Cog. "I" Stock Points
SECURITY CLASSIFICATION
DATE/TIME GROUP | MESSAGE NR.
PRECEDENCE
DRAFTED BY
FROM:
TO:
INFO:
RELEASE | TOR | TOD | CWO | WO | DATE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
DATE/TIME GROUP
SECURITY CLASSIFICATION

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Figure 11-2.—Two typical Message blank forms

releasing officer's signature should be typewritten in the block marked "RELEASED BY," and the block must be signed so that responsible communication center personnel can check the signature for authenticity. A sample signature list of all releasing officers is maintained by the communication center in order to check signatures. Because the releasing officer is held responsible for the correctness of the message, he has authority to change any portion of it before sending it on to the communication center, where the remaining sections of the blank are completed.

BASIC MESSAGE FORMAT

With a few exceptions, military messages sent by electrical telecommunications are arranged according to a standard joint form

Table 11-4. —Message Format.

Parts	Components	Elements	Format line	Contents
H		Handling instructions.	1	Not used in radiotelephone and radiotelegraph.
	Beginning procedure	a. Call	2 3	Station(s) called; prosign XMT (exempt) andexempted calls. Prosign DE (from) and designation of station calling.
E		b. Transmission identification. c. Transmission instructions.	4	Station serial number. Prosign T (relay); G (repeat this transmission back to me exactly as received); F (do not answer); operating signals; calls signs, address groups, plain language.
A	Preamble	a. Precedence; date-time group; message instructions.	5	Precedence prosign; date-time group and zone suffix; operating signals; prosign $\overline{IX}$ (execute to follow).
D	Address	a. Originator's sign; originator.	6	Prosign FM (originator of this message is); originator's designation expressed as call sign, address group, or plain language.
I		b. Action addressee sign; action addressee(s).	7	Prosign TO; action addressee designation(s) expressed as call signs, address groups, address indicating groups, or plain language.
N		c. Information addressee sign; information addressee.	8	Prosign INFO (this message addressed for information to); information addressee designation(s) expressed as call signs, address groups, or plain language.

Table 11-4 Message Format (continued)

Parts	Components	Elements	Format line	Contents
		d. Exempted addressee sign; exempted addressee(s).	9	Prosign XMT; exempted addressee designation(s) expressed as call signs, address groups, or plain language.
G	Prefix	a. Accounting information; group count; SVC.	10	Accounting symbol; group count; SVC (this is a service message).
SEPARATION			11	Prosign $\overline{BT}$ (break).
TEXT	Text	a. Subject matter . .	12	Internal instructions; basic idea of originator.
SEPARATION			13	Prosign $\overline{BT}$.
ENDING	Ending procedure	a. Time group	14	Hours and minutes expressed in digits and zone suffix, when appropriate.
		b. Final in-	15	Prosigns B (more to follow); $\overline{AS}$ (I must pause); C (I am about to correct a transmission error in some foregoing part of this message); operating signals.
		c. Ending sign	16	Prosign K (go ahead and transmit), or $\overline{AR}$ (end of transmission).

called the basic message format. The form is substantially the same whether the message goes by radiotelegraph, radiotelephone, manual teletypewriter, or by automatic tape equipment. The format exists in four versions, one of which is adapted to the special requirements of each of these primary transmission media. Here we will study the radiotelegraph message format, the one of first and most immediate importance to the Radioman. You will read about the other formats in later chapters, but if you learn the one given here you will have little trouble understanding any message.

All messages in joint form have three parts: HEADING, TEXT, and ENDING. (Of the three the most complex is the heading, which often uses as many as 10 of the format's 16 lines.) Heading, text, and ending are divided into COMPONENTS. Each component, in turn, contains one or more ELEMENTS. From left to right, in table 11-4 the message is divided into its parts, components, and elements. The heading, for example, consists of the following components: beginning procedure, preamble, address, and prefix. Elements of the beginning procedure (see "Elements" column) consist of the call, transmission identification, and transmission instructions. Contents of the call are station(s) called, prosign XMT and exempted calls (if required), and the prosign DE and designation of calling station.

It is well to consider each item in the heading separately, for each has a special meaning and its relative position is significant. Prosigns, call signs, address groups, and other contents that make up a typical heading must always appear in the order specified for the means of transmission.

It should be understood that there is no relationship between format lines and typed or handwritten lines. Format line 12, for example, is the text of the message and may consist of many written lines.

The form of the message and its transmission requirements dictate which components, elements, and contents will be used in the heading. Format line 1 is used only in teletypewriter and tape relay work, but is omitted in radiotelephone and radiotelegraph. The abbreviated plaindress heading (discussed later) may omit any or all of the following: precedence, DTG, and group count. Many messages not in abbreviated plaindress omit such elements as transmission instructions, information addressee data, and final instructions because there is no occasion for them. The messages themselves are, for this reason, much simpler than the basic message format, which must provide for everything. You seldom see a message with every format line, and you may never see one that used all the contents. But remember that the sequence actually appearing in any one message must be in accordance with the proper message format.

It is impossible in a training course such as this to show you how to construct headings to meet every eventuality. Your chief or supervisor has handled thousands of messages, and can explain a greater variety of message examples for you. Make it your rule to read every message you handle. Take a good look through the message files in your ship or station. Doctrinal communication publications, which are available on the job, provide you with valid, up-to-date sources of operational communication information.

PLAIN LANGUAGE TEXT

A standard textual format is prescribed for plain language messages. The format is designed to make maximum use of the capabilities of teletypewriter equipment, thereby eliminating much of the processing formerly required for incoming messages. It also decreases the originator's preparation time and the addressee's comprehension time.

Exempt from the standard format are messages with very short texts, such as tactical messages, and messages employing a firmly established format, such as standard "reporting type" messages that use letters of the alphabet to indicate a prearranged subject matter. For messages received for relay by other means than tape relay system, the communication center accepting the message is responsible for assuring that the elements are in proper sequence before relaying. If all of the elements are required, they must appear in the following order:

1. Classification or the abbreviation UNCLAS.
2. Special handling designations such as CRYPTOSECURITY, EXCLUSIVE, (*) EYES ONLY, (*) - identity of nations or activity(ies), etc.
3. Codeword, code name, project/operation designations such as PROJECT HANDCLASP, OPERATION PAJAMA GAME, etc.
4. Originator's CITE NR. such as AFOAC 1033, SVC 10/3, etc.
5. Message distribution instructions other than the type described above in 2. Examples are: FOR CAPT SMITH, FOR ELECTRONICS OFFICER, FROM VADM SMITH TO ALL HANDS, etc.
6. Subject line such as SUBMARINE TRAINING, BILLET REQUIREMENTS, etc.
7. References
8. TEXT
    a. Paragraphs are numbered.
    b. Subparagraphs are indented and lettered or numbered as appropriate.
    c. In a one-paragraph message, any subparagraphs are lettered.
    d. If a message is classified, proper downgrading/declassification markings are included at the end of the text.

Following is an example of a message employing most of the elements of the standard text format.

CONFIDENTIAL NOFORN
COMTWELVE PASS TO FADM SMITH
REVISED CONFERENCE SCHEDULE
A. MY 091700Z
B. COMTHIRTEEN 131530Z
1. REQUEST DESIGNATED COMMITTEE
2. AGENDA
   A. ADD "LOGISTICS OF PROJECT."
   B. DELETE "POSSIBLE LOCATION FACILITIES."
3. CNO ITINERARY, 19 AUG, TIMES UNIFORM:

ETA	ETD	LOCATION
ORIG	1300	NAS SEATTLE
1515	1800	NAS ALAMEDA
2300	TERM	CHICAGO-OHARE

GP 4

If a message does not require all of the elements, the format is adjusted accordingly by omitting the nonessential elements. Certain other exceptions are allowed when using the standard format.

The subject line may be omitted if it necessitates that an otherwise unclassified message be classified, noticeably increases the length of what would be a brief message, or increases commercial charge when the message is addressed to activities served by commercial communication facilities.

If a short message consists of only one paragraph, the paragraph is not numbered; and when there is only one reference, the reference identification is included in the body of the paragraph. For example:

UNCLAS
YOUR 100915Z. BUDGET APPROVED SUBJECT CNO CONCURRENCE

The number of characters and spaces on each teletypewriter line is limited to 69.

MESSAGE PARTS THAT MAY NOT BE CHANGED

Certain portions of a message are fixed by the originator and may not be changed by anyone else. This rule is necessary to ensure the reliability of communications. No one knows better than the originator what the message should say, to whom it should be delivered, or what precedence it should carry. Changes in these message parts are forbidden: (1) preamble, (2) address, (3) prefix, and (4) text.

MESSAGES BETWEEN COMMUNICATION PERSONNEL

Supervisory wires, procedure messages, and service messages between communication personnel are for the purpose of expediting the handling of message traffic. All three types of these messages make maximum use of prosigns and operating signals to shorten message length and transmission time. Although supervisory wires, procedure messages, and service messages are in everyday usage in handling messages, you are likely to hear friendly argument among communicators about their differences.

SUPERVISORY WIRES

Supervisory wires are the means of correcting traffic-handling errors in teletypewriter tape relay operation. You can recognize them easily, because they invariably are addressed to the supervisor (SUPVR) of the called station.

PROCEDURE MESSAGES

Procedure messages request and provide corrections, verifications, and/or repetitions. The text of a procedure message contains only prosigns, operating signals, address designations, identification of messages or parts of messages, and any necessary amplifying data. A procedure message may contain any of the components shown in the basic format, except that the break prosign (BT) is used only if the DTG is included. The DTG, in turn, is employed only when it is necessary to show time of origin, or when further references may be made to the procedure message.

SERVICE MESSAGES

Service messages pertain to any phase of traffic handling (including requesting and giving corrections and repetitions of messages), communication facilities, or circuit conditions. Most service messages are concerned with the handling of messages. Less frequently they deal with communication facilities or circuit conditions, which accounts for the occasional confusion between procedure messages and service messages. The majority of both types are used to obtain corrections and repetitions of messages or parts of messages. Service messages, however, are prepared and transmitted as regular messages, and normally contain all the necessary format lines, including The DTG and $\overline{BT}$. They may even be encrypted, but in an encrypted service message, you cannot recognize it as a service—purposely so, for security reasons. It is identified as a service message only within the encrypted text. You can recognize plain language service messages easily by one or more of the following:

1. Reference to another service message;
2. The abbreviation SVC in the prefix or as the first word of the text;
3. That it is addressed specifically to a communication center.

In teletypewriter tape relay operations, if the tributary station is not in direct communication with any station but its own relay station, service messages are used when necessary to question the originating station about a message.

FORMS OF MESSAGES

A military message may be drawn up in any one of the following forms: plaindress, abbreviated plaindress, or codress.

PLAINDRESS

A plaindress message has originator and addressee designations in the heading. Unless the call serves as the address, the message contains all the components (but not necessarily the elements) prescribed by the message format—with one exception: The prefix may be omitted. All foregoing examples of radiotelegraph messages are in plaindress form. Call signs and address groups in plaindress messages may be encrypted for a degree of security.

ABBREVIATED PLAINDRESS

Operational requirements for speed of handling—of contact reports, for example—may dictate the abbreviation of plaindress message headings. At such times, any or all of the following may be omitted from the heading: precedence, date, DTG, and group count.

CODRESS

Codress is an encrypted message form in which originator and addressee designations (as well as additional passing instructions, if any) are buried in the encrypted text. Codress is a valuable security device in that it conceals the identity of units and prevents an enemy from making inferences from originator-addressee patterns.

BASEGRAM SYSTEM

The basegram system of delivery is for general messages of insufficient operational importance to warrant immediate delivery to ships by the fleet broadcast method. Originators of general messages decide which messages may be designated basegrams. The purpose of basegram delivery is to keep the fleet broadcast free for operational traffic. Strategically located shore stations, acting as basegram delivery authorities, furnish copies of basegrams to ships in ports from which U. S. Navy ships normally operate.

Basegrams and all other general messages are delivered by teletypewriter throughout the shore communications system. Broadcast stations, although they receive basegrams by rapid means, normally do not broadcast the actual basegrams. Instead, they originate and broadcast a procedure message, indicating that the general message is being delivered as a basegram. The operating signal ZFO (Message ________________ is being delivered as a basegram) is transmitted, along with the message identification. Example:

```
WR NR 34Ø4
R 11Ø254Z
FM NSS
TO NERK
BT
UNCLAS
ZFO ALNAV 1Ø192ØZ/Ø5
BT
AR
```

Broadcast stations are permitted to send basegrams on the fleet broadcast if all other traffic is cleared and free circuit time exists.

All ships are required to keep a general message receipt log. Usually, a standard ledger-type book is used for this purpose, with columns ruled and labeled to indicate the general messages that were received and the basegrams for which only the procedure messages (ZFOs) were received. The ZFO procedure message is always placed in the appropriate general message file until it is replaced by the actual general message basegrams.

Aboard ship, your communications chief may send you ashore to pick up basegrams as soon as you arrive in port, at frequent intervals while in port, and immediately before getting underway. Be sure to take along the general message logbook, because the basegram office has no other way of knowing which general messages your ship lacks.

When you obtain copies of basegrams from the basegram office, you will notice the word BASEGRAM near the beginning of the text. Additionally, the message heading bears the operating signal ZFP, meaning BASEGRAM, following the DTG.

Upon receipt, basegrams are written up and routed the same as any other general message.

CHAPTER 12

HANDLING MESSAGES

The purpose of this chapter is to describe procedures employed by communicators handling and processing messages for delivery by manual, semiautomatic, or fully automatic systems, referred to in this chapter collectively as TAPE RELAY.

The attainment of reliability, speed, and security depends, to a large extent, upon how well the assigned personnel do their job. It is essential that they be well trained, follow operating procedures, and understand their responsibilities. Adherence to prescribed operating procedure is mandatory. Unauthorized departure from the prescribed operating doctrine invariably creates confusion, reduces reliability and speed, and may lead to a security violation.

ORGANIZATION FOR TRAFFIC HANDLING

To accomplish its assigned mission in accordance with current directives the Naval Communication System is planned, engineered, and operated so that activities of the system are organized into one or more of the following operational components centrally controlled at any geographical area by the communications center. Figure 12-1 represents a large communications center with all components illustrated. The operational components of a communications center are:

(1) Facilities Control: Operates and maintains the radio and landline facilities to and from the receiver and transmitter sites, patching facilities, terminal equipment and measuring equipment to check all lines and circuits.

(2) Message Center: Accepts and prepares messages for transmission, receives and delivers incoming messages, maintains files of all traffic handled, and originates all services required for handling messages in their area of responsibility.

(3) Cryptocenter: Handles all classified messages transmitted or received by on or off-line means. Makes internal distribution of classified traffic.

(4) Fleet Center: Delivers messages to mobile units via broadcast methods, receives and relays incoming messages from mobile units.

(5) DCS Relay Center: Handles messages via the DCS tape relay network for further relay via automatic or semi-automatic facilities. Maintains a monitor section for the purpose of obtaining and making reruns and retransmissions.

(6) Wire Room: Operates the unprotected and unclassified circuits either radio or landline. These circuits may be the commercial circuits or ship-to-shore circuits.

(7) Graphics Center: Facsimile facilities are located in this area.

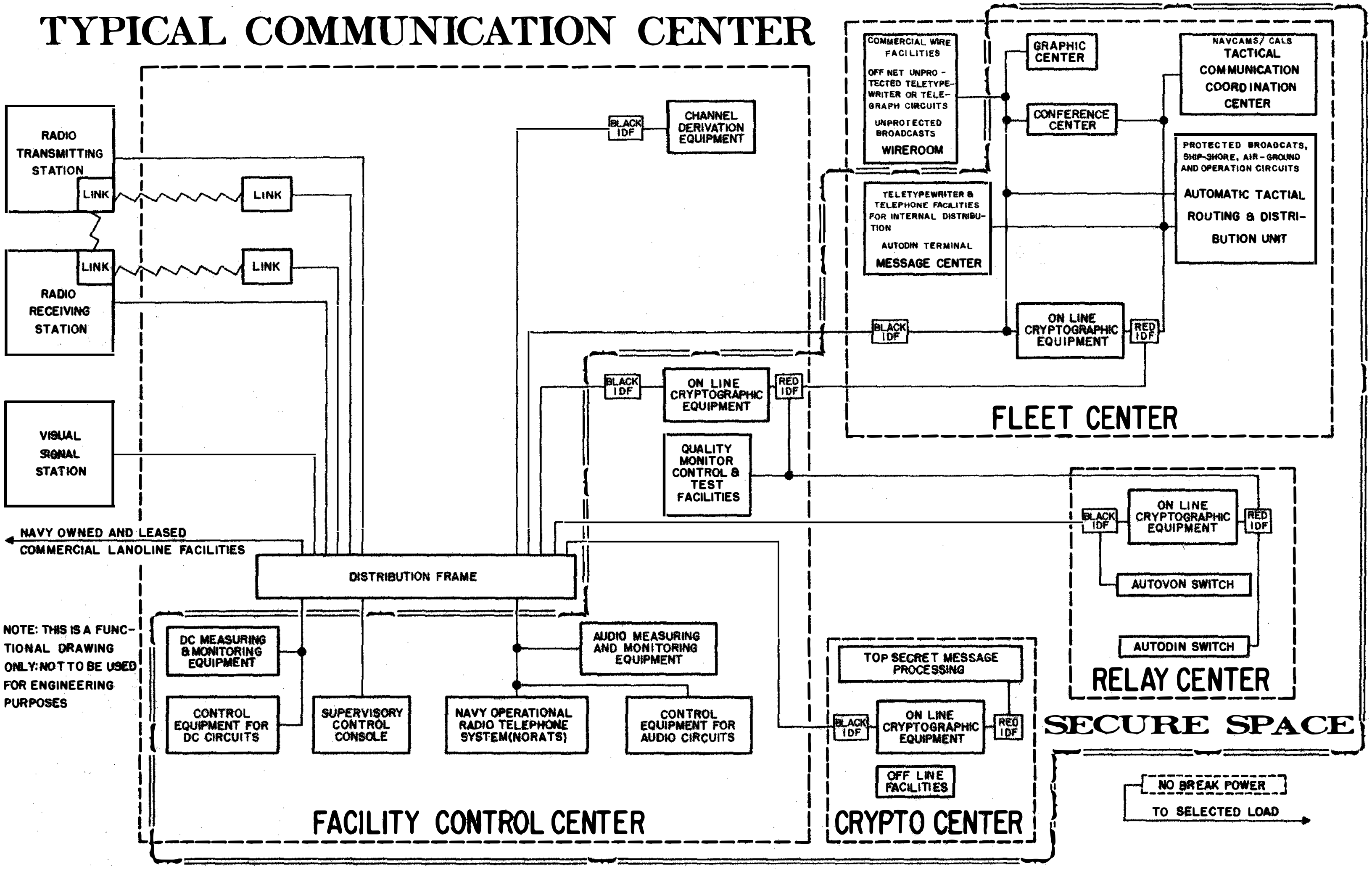
(8) Visual Signal Facilities: Sends and receives messages by any of the visual means.

(9) Transmitter Facilities: Provides the capabilities for transmitting by radio means to distant units and stations.

(10) Receiver Facilities: Provides capabilities to receive incoming signals and patching facilities to deliver the signal to the main distribution frame in the communications center.

AUTOMATIC RELAY

The automatic switching equipment installed in relay stations is designed to relay only those message tapes that meet certain requirements. In certain critical portions of an incoming tape, the equipment senses each character (letter and function) to determine the message routes and to guard against nondelivery resulting from garbles or improper character sequence. Any deviation from prescribed procedure, including omission or insertion of machine functions, results in a rejected message.



76.2

Figure 12-1.—Typical Communication Center.

Messages rejected by the equipment are shunted to a miscellaneous intercept position for service action. When rejections occur, delay is inevitable and, depending upon the traffic load and number of rejects, the delay may amount to hours.

You must bear in mind that automatic relay stations are manned by very few operators. If your message is not punched correctly and the precedence is lower than IMMEDIATE, the relay station does not reprocess and correct it for you. Your station is notified by service message to transmit a correctly prepared tape, and you will have to retransmit the message. It is most important, therefore, that you learn and always use the correct teletypewriter procedure.

Even if a tributary station does not work directly into an automatic relay station, the messages enter the automatic system if there are addressees in the continental United States.

The sequences of letter, numeral, and machine function characters required for automatic system operation are shown in message examples later in this chapter.

TORN TAPE RELAY

Torn tape relay is a term derived from the manner in which message tapes are processed at a semiautomatic relay station. At such stations, incoming message tapes are received on a reperforator, torn from the reperforator by the operator, and hand-carried to the outgoing circuit. Hence, torn tape relay means that the tape actually is torn at the receiving machine, and is transferred to the outgoing machine by hand.

An operator at a torn tape relay station usually is assigned to operate several circuits in the immediate vicinity of one another. He is responsible for all traffic passed over these circuits; maintains a separate message log for each circuit; screens all messages for obvious errors or garbles; makes certain that messages given him for transmission are transmitted on the circuit indicated; and disposes of incoming messages in accordance with the practices of his particular station.

Except for a slight difference in format line 1, the message format for torn tape relay is identical to the format for automatic relay. We will discuss this difference when we take up the message format.

MESSAGE ROUTING

The Defense Communications System employs the tape relay method of traffic relay whereby messages are received and routed to their destination in teletypewriter tape form by means of automatic or semi-automatic relay equipment. Tapes are routed by means of routing indicators which are directional in character. These indicators are constructed and assigned in accordance with a definite plan. Tapes are routed in accordance with a routing doctrine, whereby the traffic flow over various circuits or channels and the responsibilities of the relay stations concerned are in accord with a specific prearranged plan. The various circuits or channels, equipment, procedures and routing indicators are engineered and coordinated with the system in such a manner that full benefits may be realized from the advantages, flexibilities, and speed of service of automatic or semi-automatic relay equipment. This method of traffic handling is designed to reduce in-station processing time to a minimum.

ROUTING INDICATORS

In order to move tape relay traffic efficiently from one point to another, each station in a teletypewriter network is designated by a routing indicator. An indicator is made up of a group from four to seven letters, following a specific pattern, to indicate the nation's specific network to which the station belongs, its geographic area and whether it is a major, minor, or tributary station.

Construction

Routing indicators are distinguished easily from call signs and address groups because the first letter of a routing indicator is always either the letter R or U. These letters, in that order, show whether the message will be handled by the worldwide communication network or will travel over a net serving some local area. Messages with routing indicators beginning with the letter U do not enter the worldwide system. Routing indicators are not encrypted for transmission security purposes.

The second letter identifies the communication system of each country. Those of the United States and its Allied Nations are as follows:

A—Australia;
B—British Commonwealth (less Canada);

C—Canada;
U—United States;
X—NATO.

The third letter indicates the geographical location in which a station is located or from which it is served. There are 15 such areas. Following is a list of the letters used to designate each.

A—Eastern Asiatic area, including Japan and Korea;
C—Central United States;
M—Southwest Pacific area, including the Philippines and Marianas;
Y—Australian-New Zealand area;
K—Alaskan-Aleutian area;
H—Central Pacific area, centered on the Hawaiian Islands;
W—Western United States and Canada; Mexico;
E—Eastern United States and Canada; Greenland;
L—South American and Caribbean areas;
D—British Isles and Iceland;
F—European area;
T—Northwest African area;
Q—East African, Arabian, Turkish, and Iranian areas;
V—South African area below equator;
S—Western Asian area, including India.

Zone boundaries are laid out according to latitude and longitude; but, despite area boundaries, a tributary must carry the same area designator as the parent relay station, regardless of location. For example, although in a different zone area, the Naval Air Station in Olathe, Kansas (C zone) is assigned a routing indicator from major relay Trenton, N.J. (E zone.

Fourth and subsequent letters (except for any special suffixes) designate relay and tributary stations. Four-letter indicators designate major relay stations. The fourth letter does not distinguish between the two, however.

Following are breakdowns of the routing indicators for (1) major relay station, RUMG, and (2) major relay station, RUAT.

R—Worldwide network;
U—U. S. facility;
M—Southwest Pacific;
G—Major relay station (Guam Mariana Islands).

R—Worldwide network;
U—U. S. facility;
A—Eastern Asia;
T—Major relay station (Yokosuka, Japan).

Routing indicators containing four letters mean a major relay station. These four-letter indicators form the basis for every routing indicator in the tape relay network. If you learn the geographical location of the relay stations and their routing indicators, you will have no trouble routing or relaying messages.

Fifth and subsequent letters of a routing indicator designate a minor relay station or a tributary of some major relay station. You will have to look it up to know which one it is. A minor relay station always has a five—or six-letter routing indicator, the first four letters of which are identical to the indicator of the major station into which it feeds. The minor relay station RUKAG at Adak, Alaska, for example, feeds into the major relay station RUKA, Kodiak.

Routing indicators simplify message handling in semiautomatic relay systems because operating personnel do not need to look up locations of distant addressees to relay the message properly. Assume that NAS Patuxent River originates a message addressed to NAS Guantanamo Bay—served by the tributary station RULAGB.

The first relay point is Washington (relay station is located in Cheltenham, Md.), where the message is received in the automatic relay center but must be transferred to the semiautomatic relay section that handles overseas traffic. An operator in the semiautomatic relay station, seeing that the routing indicator begins with the letters RULA, knows that the message goes to the major relay station at San Juan, P.R., and forwards it to RULA through the facilities of RULB. At San Juan, RULA, the operator knows that the next letter, G, designates the minor relay center at Guantanamo Bay. At Guantanamo, RULAG, the operator knows that the last letter, B, designates the Naval Air Station, and forwards the message to that tributary.

Special Suffixes

The letter C, and all two-letter combinations CA through CZ, are reserved for suffixes to routing indicators. Additionally, the two-letter combinations SO, SU, and SX are used as routing indicator suffixes by the U. S. Air Force only. There is a prescribed meaning for each suffix. Suffixes aid routing of tapes for processing purposes or localized action by the relay station or any of its supplementary sections or facilities. A list of suffixes and their meanings follows. Those authorized for Navy use are so indicated in ACP 117 CAN-U. S. SUPP-1.

C—Local delivery or refile in page form is required.
CF—Section accomplishing delivery by broadcast methods.
CI—Section coordinating routing information.
CM—Section preparing tape copies for retransmission.
CN—Electrical conference facility or section.
CR—Cryptocenter.
CS—Section dealing with service messages.
CT—Section effecting delivery by telephone.
CU—Section using tape relay for delivery to commercial carriers.
CW—Section relaying by radiotelegraph.
CX—Section using tape relay for refile to activities served by teletypewriter exchange systems.

Following are two examples of suffixes as used with the routing indicator of the COMMCEN Washington, D. C. (RUEC).

RUECC—Message center, COMMCEN Washington,
RUECCR—Cryptocenter, COMMCEN Washington.

PUBLICATIONS

Publications of principal importance to operators are the effective editions of ACP 127 (with United States supplement), and ACP 117 (with Canadian and United States supplements). Tape relay procedure is dealt with in ACP 127. Routing indicators are listed in ACP 117.

Supplements actually are separate publications, issued by the individual Allied countries, that amplify (or expand) the basic publications. For example, ACP 127 U.S. SUPP-1 prescribes operating procedures that are peculiar to the United States tape relay networks. In ACP 117 CAN-U. S. SUPP-1 (a Joint supplement) are listed the routing indicators of the teletypewriter stations belonging to the United States and to Canada. The ACP 117 U. S. SUPP-1 contains instructions for routing U.S.-originated messages to military and nonmilitary activities that are not assigned a routing indicator in the CAN-U. S. SUPP-1.

At the larger shore COMMCENs, the routing indicator book would literally be "worn out" in a short time through constant usage. For that reason, most of the busier message centers ashore transfer the routing information from ACP 117 to cardboard strips, which are held in metal frames supported by revolving stands called spindles. Routing spindles are practically indestructible and provide speedier access to the current routing information. They also provide more space for entering the frequent routing indicator changes than is available on a fixed, printed page.

MACHINE FUNCTIONS

Machine functions are of the utmost importance in teletypewriter operation. Because some functions do not show up on the printed page copy of the message, you may wonder why it is necessary to use them at all. Remember that messages are relayed in tape form; machine functions play an important part in efficient operation of the tape relay system.

An explanation of the machine functions and the rules for their use are given in the ensuing six topics.

SHIFT (FIGS) AND UNSHIFT (LTRS)

Teletypewriter machines, owned or leased for use in naval communications, shift from uppercase characters (figures) to lowercase characters (letters) only when the LTRS key is pressed. Many naval messages, however, are delivered to some addressees by the commercial Teletypewriter Exchange Service (TWX). The TWX machines shift automatically from uppercase to lowercase characters whenever the SPACE BAR is pressed, in addition to shifting when the LTRS key is pressed. To ensure that this unshift-on-space feature does not result in errors, the following rules must be complied with when transmitting by direct keyboard or punching tape on either a TWX or Navy—owned or—leased teletypewriter.

1. Always press the LTRS key to shift from uppercase to lowercase (disregarding the unshift-on-space feature of TWX machines). Example:

35784 (SPACE) (LTRS) TRY MAKE

This procedure has no adverse effect on either a TWX or Navy machine. Failure to follow this procedure would result in the following error:

a. Transmitted on TWX machine:
35784 TRY MAKE
b. As received on Navy machine:
35784 546 .-(3

2. Always press the FIGS key to shift from lowercase to uppercase, and also after the space before each group of figures or uppercase characters in a series. Example:
35784 (SPACE) (FIGS) 27896 ...

The procedure in step 2 has no adverse effect on either a TWX machine or on a Navy machine. This rule applies whether direct keyboard transmission or tape perforation is used. Failure to follow this practice would result in the following error:

a. Transmitted on Navy machine:
35784 (SPACE) 27896
b. As received on TWX machine:
35784 (SPACE) WUIOY

CARRIAGE RETURN (CR)

The carriage return function resets the machine to the left margin of the paper. As a special precaution to make sure that the carriages return on all machines properly, the operator presses the CR key twice at the end of each line. Regardless of your own typing speed when punching a message tape, the message is transmitted on circuits running at 60, 75, or 100 words per minute. At these high speeds, the carriage does not have enough time to return to the left margin on a single CR function. As a result, the next character will print while the carriage is still moving toward the left. Always press the CR key twice at the end of each line.

LINE FEED (LF)

The line feed function advances the paper on the page. You will note that the normal end-of-line functions include only one LF. At the end of the message, however, eight LF functions are used to provide more space between messages on the printed page.

BELL SIGNAL

The bell signal attracts the attention of the receiving operator. It precedes the precedence prosign in the routing line (format line 2) in FLASH messages.

On most teletypewriters the bell signal rings when the uppercase S key is pressed. Some equipments, though, particularly those used in the Canadian tape relay network, have the bell on the uppercase J key. Consequently, correct procedure requires the bell signal to be transmitted as follows:

(FIGS) JJJJJSSSSS (LTRS)

SPACE (SP)

The space function advances the carriage without printing any character on the page. It is used throughout the message for spacing between prosigns, routing indicators, words or groups, and the like.

BLANK (BL)

Pressing the blank key has no effect on the page copy of a message, but it advances blank tape through the punch block of the teletypewriter perforator. The blank function is required in the operation of certain cryptosystems, but has no application in relay procedure. Do not substitute BLs for LTRS functions.

MESSAGE ALIGNMENT

Message alignment is essential so that the receiving teletypewriter can print a legible page copy of the message. The alignment procedure given here is for your guidance when preparing message tapes for transmission. Functions that usually are inserted by the automatic channel numbering unit are not included here, but are discussed in the next topic.

Machine functions that are a part of the message alignment must appear in the specified sequence. Otherwise, the message is rejected at the first automatic relay station along its route.

All messages must be preceded by five spaces, two carriage returns, and one line feed. The transmission must begin with the five spaces. Any tape feedout functions preceding the five spaces are not transmitted.

The functions at the end of each line of a message are two carriage returns and one line feed. An exception is when the end of the line is also the end of a page of a long message. Then, the end-of-line functions are two carriage returns and four line feeds.

End-of-message functions are two carriage returns, eight line feeds, the letter N repeated four times, and 12 letters (functions). (The BL key is not used in lieu of LTRS, and any tape feedout in excess of 12 LTRS is removed before the message is transmitted.)

Separation between groups within any given line of a message is one space, except in the text of tabulated messages (presented later in the message examples). Spacing between routing indicators in the routing line is particularly important because the routing indicators are sensed by the automatic switching equipment when it is determining message routes.

The lines of a teletypewriter message are limited to 69 characters, including spaces.

MESSAGE IDENTIFICATION

Aside from the DTG and any message identifying numbers (called cite numbers) in the text, the numbers assigned a message for identification purposes are of two types. They are station serial numbers and channel numbers. A filing time may also be used to identify a referenced message.

STATION SERIAL NUMBERS

Teletypewriter messages are assigned station serial numbers by the station originating (punching) the messages. Messages are numbered consecutively for a 24-hour period, beginning at ØØØ1Z each day.

The station serial number is a permanent means of message identification, and it remains the same regardless of whether the message is destined for one or many addressees. Communication activities that have occasion to refer to the message (to obtain repetitions, for example) cite the station serial number of the message as part of their identifying data. The station serial number is also referenced for in-station accountability of the message.

When a station has more than one preparing position, a separate set of serial numbers is used for each position. In such instances, a letter designator is added to the station serial number to identify the position used to type the message. The letter appears following the station serial number. Letter A usually is assigned the first position. The next is designated B, the next C, and so on. For example, the station serial number 1Ø7B indicates a message prepared on position B of a teletypewriter station.

CHANNEL NUMBERS

Another name for channel numbers is transmission identification (TI). You will see and hear both terms used interchangeably.

To provide a means of keeping a constant check on traffic between stations, a channel number is required in the heading of every message. The channel number ensures that no message is lost or unaccounted for. Each station relaying a message adds its channel number to the head of the message. The station receiving the message checks this channel number against its record of transmissions received from that station. The number of transmissions received and the number in the message heading must agree. Such a check on traffic is known as "protecting the continuity of service." Understand: A message carries the same station serial number all the way, but receives a new channel number at each relaying station.

Equipment that automatically sends transmission identification ahead of each message is the most satisfactory means of performing the identification function. When automatic number equipment is unavailable, transmission identification is prepared in tape form in such a way that a tab containing identification for one transmission can be detached from a roll and be transmitted ahead of each message. As a last resort, transmission identification is incorporated directly into each message as it is being prepared for transmission.

Transmission identification for messages transmitted directly into fully automatic relay stations consists of the following: (1) the letter V; (2) the start of message indicator ZCZC; (3) the three-letter station and channel designators; (4) one figures shift; (5) a channel serial number; and (6) one letters shift. Example: VZCZCABC(FIGS)Ø31(LTRS).

The preceding example is explained in this manner: Letter V is required to ensure that the first character of intelligence is not lost or garbled. The start of message indicator (abbreviated SOM) activates the automatic switching equipment at the relay station. (The SOM must appear once (and only once) in each transmission introduced directly into an automatic relay station.) Letters ABC are the station (AB) and the channel (C) designators of the station making the transmission. The figures shift is operated once to shift the equipment from lowercase to receive the channel serial (Ø31). Then, the letters shift is operated once to bring the equipment back to the lower-case position.

A slightly different form of transmission identification applies in messages transmitted directly into torn tape relay stations. It consists of (1) letters VV; (2) three space functions; (3) the three-letter station and channel designators; (4) a figures shift; (5) a channel serial number; and (6) a letters shift. Example: VV(3 SPACES)ABC(FIGS)Ø31(LTRS).

The explanation of the foregoing example is the same as that for the automatic system, except that the characters VV(3 SPACES) replace the start of message indicator. This substitution is made because the ZCZC serves no purpose unless automatic switching equipment is used.

FILING TIME

The filing time for messages is the time a message is received by the communications center ready for transmission. The filing time in tape relay messages is shown as a Julian date, immediately followed by hours and minutes expressed in Greenwich time without a zone suffix. A Julian date is a chronological date in which days of the year are numbered in sequence, i.e., the first day of the year is ØØ1, the second ØØ2, the last day of the year 365 (366 in leap year). A message received in a communications center on 8 January at 1645Z would have a filing time of ØØ81645 and a message received on 1 February at 1645Z would have a filing time of Ø321645.

TAPE RELAY MESSAGE FORMAT

Messages transmitted over tape relay circuits must be prepared in the message format shown in table 12-1. The 15 format lines are explained briefly in the table, and are amplified in the following paragraphs:.

LINE 1: Because format line 1 contains the message transmission identification, its construction varies with the type of relay station into which you are transmitting. If you are transmitting into an automatic station, this line must include the start of message indicator (ZCZC).

The security prosigns referred to in the Contents column of table 12-1 are not used by the United States. Hence, they are not discussed in this text. (Consult ACP 127 U. S. SUPP-1.) Pilots are explained under a separate topic later in this chapter.

LINE 2: Tape preparation usually begins with line 2, the routing line. It consists of the precedence prosign (repeated) and the routing indicators of stations called, that is, stations to which the message is routed for final delivery. To avoid misroutes, the routing line must be prepared with special care.

In multiple-call messages, all routing indicators associated with a single relay station are grouped together in the routing line. They are not intermingled indiscriminately. If a called station serves more than one addressee in the message, the station's routing indicator need appear only once in line 2.

When dual precedence is used, only the higher precedence appears in the routing line. If a dual precedence of FLASH and a lower precedence are assigned to a multiple-address message, and the message requires using more than nine routing indicators in line 2, the originating station makes two separate transmissions. One transmission goes to the action addressees, and the other is sent to the information addressees. You must remember: When the FLASH precedence prosign is transmitted in the routing line, it is preceded by the bell signal.

LINE 3: Line 3 consists of the prosign DE, the routing indicator of the station preparing the message for transmission, the station serial number, and the filing time shown as Julian date and Greenwich time without zone suffix.

It is essential that the prosign DE follow immediately the two CRs and one LF at the end of the routing line (line 2). The automatic relay equipment is designed to stop seeking outgoing channels upon receipt of the letter D at the beginning of line 3.

LINE 4: The operating signals, ZNR (for unclassified messages) and ZYN (for classified messages), shall be transmitted as the first component of format line 4. The appropriate operating signal will always be followed by a classification character repeated five times. The classification characters are U for unclassified, E for unclassified EFTO, C for confidential, S for secret, and T for top secret. The classification character X for clear will be used for classified messages which must be transmitted unencrypted in urgent situations.

When necessary, transmission instructions denoting transmission responsibility are included in line 4. Such instructions are employed only when essential to ensure delivery of the message. They are not used when stations called are automatic guard for the addressees, nor when delivery responsibility is indicated in the address portion of the message.

LINES 5 AND 6: See table 12-1 for explanation of format lines 5 and 6.

LINE 7: Line 7 is the action addressee line. It commences with the prosign TO and contains the address designations of commands' or activities that are to take action on the message. Addressees normally are designated by plain language. But, as you will see in the message examples that follow this section, there are certain instances when the addressees are designated by both plain language and call signs or address groups.

Delivery responsibility is indicated by preceding each address designation with the routing indicator of the station responsible for delivery to that addressee. An exception to this is when the addressees are designated by a collective address designator or an address indicating group. Then, it is not necessary to precede the designator with routing indicators. When a single station is responsible for delivery to all addressees represented by a collective address designator, however, that station's routing indicator precedes the designator.

When delivery to an addressee is accomplished by other means than a particular transmission, the operating signal ZEN is used in place of a routing indicator. A slant sign separates the routing indicator (or ZEN) from the address designation.

LINE 8: The explanation of line 8 is the same as line 7, except that line 8 pertains to information addressees.

LINE 9: When necessary to exempt one or more addressees from a collective address designation appearing in lines 7 or 8, line 9 is utilized. Line 9 consists of the prosign XMT and the designator(s) of commands or activities exempted from the collective address designation.

LINE 10: In tape relay procedure, line 10 (group count) is included only when the text of the message consists of encrypted groups. An accounting symbol is used to indicate financial responsibility only when the message requires commercial refile. (Complete instructions concerning accounting symbols are contained in ACP 127 U.S. SUPP-1.)

LINE 11: The prosign $\overline{BT}$ appears in line 11. It separates the text from the message heading.

LINE 12: Line 12 is the text of the message. The first word of all plain language text messages must be either the abbreviation UNCLAS, the word CLEAR, or the security classification of the message. The abbreviation UNCLAS indicates that the message is unclassified. CLEAR indicates that the message is classified, but that the originator has authorized its transmission over nonapproved circuits. The abbreviation UNCLAS and the word CLEAR are sent as one word, but a space is transmitted between each letter of the security classification of a classified message. For example, SECRET is sent as S E C R E T.

LINE 13: The prosign BT appears in line 13. It separates the text from the message ending.

LINE 14: Line 14 is not used in tape relay procedure.

LINE 15: Occasionally, an error in the text of a message is undetected until the message is nearly completed. Instead of canceling the transmission (or destroying the tape) and starting the message again, the error is corrected in line 15. The correction consists of the prosign C, followed by the correct version of the error.

The end-of-message functions are a part of line 15. They follow any necessary corrections, and consist of two carriage returns, eight line feeds, the letter N repeated four times, and 12 letters functions. The end-of-message functions must be in the exact order indicated.

TAPE RELAY MESSAGE EXAMPLES

The message examples shown in the remainder of this chapter are for illustrative purposes only; they do not necessarily reflect actual routing indicator, call sign, or address group assignments. The format of the examples, however, gives the proper sequence of the message elements and of line functions used. End-of-line and end-of-message functions are in parentheses. The messages are prepared as they would appear when reproduced on a page printer set for single line feed.

PLAINDRESS MESSAGE

A plaindress message carriers the originator and addressee designations in the message

Table 12-1.—Message Format.

Parts	Components	Format line	Elements	Contents	Explanation*/
HEADING	PROCEDURE	1	Handling instructions.	Transmission identification. Security warning prosign (when used). Pilot - Pilots contain: Repeated precedence prosign**/. Routing indicator(s). Prosigns, operating signals and address designations***/ as required.	Always contains transmission identification (which includes the "start of message indicator" when necessary); also contains pilot(s) as required to convey specific message-handling instructions.
		2	Called station(s).	Repeated precedence prosign**/. Routing indicator(s) of station(s) responsible for delivery or refile.	Basic routing line. If message is dual-precedence, only the higher precedence is shown in this line.
		3	Calling station and filing time.	Prosign DE. Routing indicator of station preparing message for transmission. Station serial number. Filing time.	Filing time is the date and time the message was filed with the communication center.
		4	Transmission instructions.	Security warning operating signal. Classification character repeated 5 times. Prosign T. Other operating signals. Special operating group(s) (SOGs). Address designator(s). Routing indicator(s).	Indicates specific transmission responsibility not apparent in other components of the message heading. Not to be used unless necessary. Plain language address designators are not permitted in codress messages.
	PREAMBLE	5	Precedence; date-time group; message instructions.	Precedence prosign(s). Date-time group and zone suffix (Z indicating Greenwich mean time). Operating signal(s).	In dual precedence, both prosigns are shown separated by a space. Operating signals are used only when required to convey message-handling instructions.

Table 12-1.—Message Format—Continued

Parts	Components	Format line	Elements	Contents	Explanation*/
	ADDRESS	6	Originator.	Prosign FM. Originator's designation.	Message originator is indicated by plain language, routing indicator, address group, or call sign.
		7	Action addressee(s).	Prosign TO. Routing indicator(s). Operating signal. Address designation(s).	Action addressees are indicated by plain language, routing indicator(s), address group(s), or call sign(s). In multiple-address messages, when addressees are listed individually, each address designation must be on a separate line and may be preceded either by the operating signal ZEN (meaning delivered by other means) or by the routing indicator of the station responsible for delivery. Such use is mandatory on all joint and combined messages.
		8	Information addressee(s).	Prosign INFO. Routing indicator(s). Operating signal(s). Address designator(s).	Same as for line 7, except that line 8 pertains to information addressee(s).
		9	Exempted addressee(s).	Prosign XMT, Address designator(s).	Used only when a collective address deignation is used in line 7 or 8 and an indication of the addressee(s) exempted from the collective address is required.

Table 12-1.—Message Format—Continued

Parts	Components	Format line	Elements	Contents	Explanation*/
	PREFIX	10	Accounting information: group count.	Accounting symbol (when required). Group count prosign GR. Group count.	The group count prosign and group count must be used only when the text consists of countable encrypted groups.
SEPARATION		11	. . . .	Prosign BT.	
TEXT	. . . .	12	Classification; internal instructions; thought or idea expressed by originator (in that order).	. . . .	See ACP 121 series.
SEPARATION		13	. . . .	Prosign BT.	
ENDING	PROCEDURE	14	Confirmation.	. . . .	Not used in tape relay operation.
	. . . .	15	Correction.	Prosign C. Other prosigns, operating signals, and plain language as required.	
			End-of-message functions.	2CR, 8LF, 4Ns, 12LTRS	The 4Ns in this sequence are the end-of-message indicator.

*/ Included only when required for clarity.

**/ If message is dual-precedence, only the higher precedence is shown in this line.

***/ Plain language designators are not permitted in codress messages.

heading. The message text may be plain language or encrypted. A group count is not required for plain language, but an encrypted message always carries a numerical group count.

As explained earlier, in line 7 the addressees of messages normally are designated in plain language. Intra-Navy messages, however—those originated by and addressed to commands and activities served entirely by Navy-operated stations—destined for mobile units, such as ships and commands afloat, must indicate the mobile units by their call signs or address groups and by their plan language designations. You must remember that the foregoing method of addressing messages applies only to messages handled within the tape relay system. It does not affect the addressing of messages sent via CW (which are addressed by call signs/address groups), nor those sent via manual RATT.

In addition, the only call signs/address groups authorized for use with their plain language equivalents are those assigned to U. S. Navy, Marine Corps, and Coast Guard units.

Single-Address

Following is a plaindress version of a single-address message destined for a mobile unit (ship).

```
Format
 line

     (5 SPACES 2CR LF)
 2   PP RUHPC                      (2CR LF)
 3   DE RUHPB 85 Ø97Ø841           (2CR LF)
 4   ZNY SSSSS                     (2CR LF)
 5   P Ø1Ø837Z                     (2CR LF)
 6   FM CINCPACFLT                 (2CR LF)
 7   TO RUHPC/NWBJ/USS             (2CR LF)
     RENSHAW
11   BT                            (2CR LF)
12   S E C R E T                   (2CR LF)
     1. THIS                       (2CR LF)
     SINGLE-ADDRESS MSG IS
     PREPARED IN FORMAT            (2CR LF)
     PRESCRIBED FOR INTRA-         (2CR LF)
     NAVY MSGS ADDRESSED           (2CR LF)
     TO MOBILE UNITS.              (2CR LF)
     2. TRANSMISSION IN-           (2CR LF)
     STRUCTIONS ARE UN-            (2CR LF)
     NECESSARY BECAUSE             (2CR LF)
     DELIVERY RESPONSIBLE          (2CR LF)
     IS INDICATED IN AD-           (2CR LF)
     DRESS OF MSG.                 (2CR LF)
     3. NOTE UTILIZATION           (2CR LF)
     OF LINE 15 TO CORRECT         (2CR LF)
     AN ASSUMED ERROR              (2CR LF)
13   BT                            (2CR LF)
15   C WA THIS                     (2CR 8LF)
     SINGLE-ADDRESS                (2CR 8LF)
     NNNN                          (12LTRS)
```

Multiple-Address

A multiple-address message intra-Navy form appears in the next example. Plain language address designators are employed because all the addressees are stationary commands, and are a part of the tape relay network.

```
Format
 line

     (5 SPACES 2CR LF)
 2   RR RUHPB RUHPC RUATA          (2CR LF)
     RUWSPG                        (2CR LF)
 3   DE RUECW 115A 23Ø15Ø5         (2CR LF)
 4   ZNR UUUUU                     (2CR LF)
 5   R 3Ø1455Z                     (2CR LF)
 6   FM CNO                        (2CR LF)
 7   TO RUHPB/CINCPACFLT           (2CR LF)
 8   INFO RUHPC/                   (2CR LF)
     COMHAWSEAFRON                 (2CR LF)
     RUATA/FOMFAIR-                (2CR LF)
     WESTPAC                       (2CR LF)
     RUWSPG/                       (2CR LF)
     COMWESTSEAFRON                (2CR LF)
11   BT                            (2CR LF)
12   UNCLAS                        (2CR LF)
     1. INCLUSION OF CALL          (2CR LF)
     SIGNS/ADDRESS GROUPS          (2CR LF)
     IN ADDRESS UNNECES-           (2CR LF)
     SARY. ADDEES NOT              (2CR LF)
     MOBILE UNITS                  (2CR LF)
13   BT                            (2CR 8LF)
15   NNNN                          (12LTRS)
```

A message received via CW, R/T, or manual RATT must be prepared in tape relay format before it can be introduced into the tape relay network. This preparation is made by the station introducing the message into the network. (It is called the refile station.)

Assume that a refile station receives an unclassified message via radiotelegraph. Prior to tape preparation, the station must (1) insert routing indicators in format lines 7 and 8, (2) convert the heading to authorized plain language address designators, and (3) retain the call signs/address groups for mobile addressees. These follow the routing indicators and precede the plain language designators.

The following exemplifies a message prepared in tape relay format after it is received by radiotelegraph.

Format line		
	(5 SPACES 2CR LF)	
2	PP RUCKCF RUCKHC	(2CR LF)
	RUEGNE	(2CR LF)
3	DE RUECC Ø55 1Ø91542	(2CR LF)
4	ZNR UUUUU	(2CR LF)
5	P R Ø91428Z	(2CR LF)
6	FM USS TUCKER	(2CR LF)
7	TO RUCKCF/SQBC/	(2CR LF)
	COMDESRON 12	(2CR LF)
8	INFO ZEN/COMDESDIV 121	(2CR LF)
	RUCKHC/CINCLANTFLT	(2CR LF)
	RUEGNE/COMCRUDE-	(2CR LF)
	SLANT	(2CR LF)
	RUCKCF/E5TT/CTF 14Ø	(2CR LF)
11	BT	(2CR LF)
12	UNCLAS	(2CR LF)
	1. PLAIN LANGUAGE TEXT.	(2CR LF)
13	2. NOTE USE OF ZEN TO	(2CR LF)
	INDICATE MSG DLVD BY	(2CR LF)
	OTHER MEANS TO COM-	(2CR LF)
	DESDIV 121.	(2CR LF)
	3. NOTE USE OF DUAL	(2CR LF)
	PRECEDENCE.	(2CR LF)
	A. ONLY HIGHER PRE-	(2CR LF)
	CEDENCE APPEARS IN	(2CR LF)
	ROUTING LINE. BOTH	(2CR LF)
	APPEAR IN LINE 5.	(2CR LF)
13	BT	(2CR 8LF)
15	NNNN	(12LTRS)

As indicated in the preceding example, RUCKCF has delivery responsibility for two addressees via fleet broadcast. If the message is transmitted on the RATT broadcast, routing indicators and call signs normally are not removed. But if the message is sent on the CW broadcast, routing indicators and call signs must be removed by RUCKCF. In other words, only the plain language address designators appear in the heading, and these are separated from each other by the separative sign.

JOINT AND COMBINED FORM

Messages originated by or addressed to activities served by Army or Air Force tape relay networks must be in joint form. If addressees are served by teletypewriter systems belonging to other countries, the message format is called the combined form. The formats of joint and combined forms are almost identical. These forms differ slightly from the intra-Navy form, however.

In the intra-Navy message form, routing indicators are used in the address of both single- and multiple-address messages to denote delivery responsibility. In the joint and combined forms, routing indicators are used for this purpose only in multiple-address messages. Similarly, call signs and address groups are mixed with plain language to designate addressees of joint and intra-Navy messages but such mixtures are never permissible in combined form messages. The address must consist of either all plain language designators or all call signs and address groups.

Abbreviated Plaindress

Operational requirements for speed of message handling may sometimes require abbreviations of plaindress message headings. In such instances, any or all of the following elements may be omitted from the message heading: precedence, date, date-time group, and group count.

Most plaindress messages originated for intra-Navy delivery omit the group count (format line 10). In this instance, absence of the group count does not, in itself, place a message in abbreviated plaindress form. (This is an exception to the definition of the abbreviated plaindress form.) Only in encrypted messages are numerical group counts required for messages originated within the Navy system.

Abbreviated plaindress form is employed widely in radiotelephone, radiotelegraph, and manual teletypewriter procedures. It is used rarely, if ever, in tape relay procedure.

Codress Messages

A codress message is an encrypted message that has the designations of the originator and addressees (and any internal passing instructions) in the encrypted text. Accordingly, the address components (format lines 6, 7, 8, and

9) are omitted. Codress is a valuable security device, because it conceals the identity of units and prevents an enemy from making inferences from originator-addressee patterns.

Transmission instructions are required in the heading of codress messages when the station (or stations) called in line 2 is to deliver or refile the message without decrypting it. If the station is to decrypt the message, as well as refile it, the station's routing indicator must appear following the prosign T in line 4. An example of a codress message follows.

Format line		
	(5 SPACES 2CR LF)	
2	OO RUCKHCR RUECK	(2CR LF)
3	DE RUTPC 42C 1151Ø4Ø	(2CR LF)
4	ZNR UUUUU	(2CR LF)
	RUECK T RUECK XYPT	(2CR LF)
5	O 121Ø37Z	(2CR LF)
10	GR97	(2CR LF)
11	BT	(2CR LF)
12	(Ninety-seven groups,	(2CR LF)
	ten groups to a line.)	(2CR LF)
13	BT	(2CR 8LF)
15	NNNN	(12 LTRS)

ROUTING LINE SEGREGATION

The automatic relay system uses a method of routing multiple-call tapes (messages having two or more routing indicators in the routing line) known as routing line segregation. This means that routing indicators in the routing line are segregated or distributed in accordance with the desired transmission channel in the switching process. Under this method, only the routing indicators applicable to a particular transmission appear in the routing line. Messages received at a station that has further relay responsibility contain only the routing indicators for which that station has relay responsibility.

Routing line segregation does not affect the tape preparation at the originating station; it is accomplished at the relay stations. At the automatic relay stations, the relay equipment segregates the routing indicators automatically according to the required transmission path.

In order to make the semiautomatic relay system compatible with the fully automatic system, relay stations that are not connected directly to the automatic system must also perform routing line segregation on all relayed messages. Semiautomatic relay stations require an operator using special routing segregation equipment to perform the routing line segregation.

This procedure results in decreased transmission time for onward relay of the message, and the message arrives at each terminal station with only that station's routing indicator in the routing line.

PUNCTUATION

Message drafters try to word their messages clearly without using punctuation. Occasionally, though, punctuation is essential for clarity. In such instances, punctuation marks (or symbols) are used in preference to spelling out the desired punctuation.

All of the punctuation marks and symbols on U. S. military teletypewriter keyboards are authorized for use in U. S. networks. Only those marks and symbols listed in table 12-2, however, may be used in messages that have other routing indicators besides the United States in format line 2.

Table 12-2.—Punctuation Used in Allied Messages

Punctuation	Abbreviation	Symbol
Period	PD	.
Hyphen	---	-
Parentheses	PAREN	( )
Slant sign	SLANT	/
Colon	CLN	:
Comma	CMM	,
Question mark	QUES	?
Quotation marks	QUOTE UNQUOTE	" "
Apostrophe	---	'

TABULATED MESSAGES

The ability to handle information in tabulated form is one of the many advantages of teletypewriter equipment. If a message is received for transmission in tabulated form, it normally should be transmitted in that form. In some instances the headings of the columns require more space than the data in the column. When this happens, use more than one line for the headings. (Compare the form of the headings in the examples of incorrect and correct methods.) Another point: Keep your columns as close as possible to the left margin, to reduce the total transmission time.

In the first example, each dot represents the transmission of a space, which requires as much circuit time as transmitting a character. In the second example (the correct way), the same information is transmitted at a considerable saving of circuit time.

1. Example of incorrect method:

```
   STOCK REPORT AND REQUIREMENTS

        CAT  QUANTITY
ITEM    NO   ON HAND  ARTICLE  REQUIRED

1 . . 268423 . . . 1ØØ . . . CYL RINGS . . . .  3ØØ
2 . .  93846 . . .  39 . . . MUFFLERS. . . . .  5Ø
3 . . 624364 . . .  28 . . . MAGNETOS. . . . .  2Ø
4 . .  34256 . . . 3ØØ . . . WRIST PINS. . . . 3ØØ
5 . .  19432 . . . 14Ø . . . VALVES . . . . . . 5ØØ
6 . .  43264 . . .  42 . . . CARBURETORS . .  5Ø
```

2. Example of correct method:

STOCK REPORT AND REQUIREMENTS

ITEM	CAT NO	QNTY ON HAND	ARTICLE	REQUIRED
1	268423	1ØØ	CYL RINGS	3ØØ
2	93846	39	MUFFLERS	5Ø
3	624364	28	MAGNETOS	2Ø
4	34256	3ØØ	WRIST PINS	3ØØ
5	19432	14Ø	VALVES	5ØØ
6	43264	42	CARBURETORS	5Ø

MULTIPLE-PAGE MESSAGES

Most message centers ashore serve several addressees. To provide the addressees with sufficient copies of each message, the messages are run off on a duplicating machine. Usually, the paper used in duplicating the messages is standard letter-size paper on which approximately 20 lines can be typewritten. To facilitate the duplication process, messages containing more than 12 lines of text are divided into pages by the operator preparing them for transmission.

The first page of a multiple-page message contains the heading and the first 10 lines of text. Each succeeding page contains 20 lines of text, with the exception of the last page, which may have fewer. No more than five pages may be sent in any one transmission.

The second and succeeding pages carry a page identification line above the first line of text. This page identification line gives the page number, the originating station's routing indicator, the station serial number of the message, and, if the text is plain language, the security classification or the abbreviation UNCLAS. Page identification is not included in the group count of those messages for which a group count is required.

In the following example of the proper way to page a message, note that necessary corrections are made at the end of each page, and that the pages are separated from each other by 4LF functions.

```
(5 SPACES 2CR LF)                         (2CR LF)
RR RUWSPG RUHPB                           (2CR LF)
DE RUECW 43B 1591123                      (2CR LF)
ZNR UUUUU                                 (2CR LF)
R Ø8Ø951Z                                 (2CR LF)
FM CNO                                    (2CR LF)
TO RUWSPG/COMWESTSEAFRON                  (2CR LF)
RUHPB/CINCPACFLT                          (2CR LF)
BT                                        (2CR LF)
UNCLAS                                    (2CR LF)
(Ten lines of plain language text         (2CR LF)
on page.)                                 (2CR LF)
C LINE 6 WA LANDING POINT               (2CR 4 LF)

PAGE 2 RUECW 43B UNCLAS                   (2CR LF)
(Twenty lines of plain language text.)  (2CR 4 LF)
(Note: Pages 3 and 4 appear as shown for
      page 2.)

PAGE 5 RUECW 43B UNCLAS                   (2CR LF)
(Remaining lines of text.)                (2CR LF)
BT                                        (2CR LF)
C PAGE 3 LINE 2 WA BEACH ALL            (2CR 8 LF)
NNNN                                      (12LTRS)
```

Paging rules do not apply to statistical and meteorological (weather) messages that are intended for processing by computers. Messages of this type that exceed 100 lines, however, are divided into transmission sections, which are discussed in the next topic.

LONG MESSAGES

Messages that exceed five teletypewriter pages are transmitted in sections. This procedure prevents prolonged circuit tieups that could result in delaying more important traffic. By breaking the longer messages into sections, higher precedence messages can be sent between sections without appreciable delay.

At a convenient point within the limits of five pages, the text of a long message is separated into sections. Normally, the separation is at the end of a sentence or a cryptopart. (Long encrypted messages have cryptoparts.) Each section then is numbered, and the section number is inserted on a separate line at the beginning of the text. If the text is plain language, the section number follows the security classification or the abbreviation UNCLAS. For example, when a message is divided into two sections, the first section is identified as SECTION 1 of 2, and the second as FINAL SECTION of 2.

In long encrypted messages, when a transmission section commences with a new cryptopart, the designation of the cryptopart follows the designation of the transmission section.

Transmission sections of a long message have exactly the same heading, except that station serial numbers change with section. Each section bears the same date-time group and filing time. A group count, if used, applies only to the section it accompanies. Transmission section and page identifications are not included in the group count. The cryptopart identification is included.

Here is a message handled in two transmission sections:

(5 SPACES 2CR LF)	
RR RUHPB RUWSPG RUMGB	(2CR LF)
DE RUECW 1Ø5A 1692Ø15	(2CR LF)
ZNR UUUUU	(2CR LF)
R 181912Z	(2CR LF)
FM CNO	(2CR LF)
TO RUHPB/CINPACFLT	(2CR LF)
INFO RUWSPG/COMWESTSEAFRON	(2CR LF)
RUMGB/COMARIANAS	(2CR LF)
BT	(2CR LF)
UNCLAS	(2CR LF)
SECTION 1 OF 2	(2CR LF)
(Plain language text includes	(2CR LF)
90 teletypewriter lines in this	(2CR LF)
section, paged as required.)	(2CR LF)
BT	(2CR 8LF)
NNNN	(12LTRS)

(5 SPACES 2CR LF)	
RR RUHPB RUWSPG RUMGB	(2CR LF)
DE RUECH 1Ø6A 1692Ø15	(2CR LF)
SNR UUUUU	(2CR LF)
R 181912Z	(2CR LF)
FM CNO	(2CR LF)
TO RUHPB/CINCPAFLT	(2CR LF)
INFO RUWSPG/	(2CR LF)
COMWESTSEAFRON	(2CR LF)
RUMGB/COMARIANAS	(2CR LF)
BT	(2CR LF)
UNCLAS	(2CR LF)
FINAL SECTION OF 2	(2CR LF)
(This transmission section	(2CR LF)
contains the remainder of the	2CR LF)
text, paged as required.)	(2CR LF)
BT	(2CR 8LF)
NNNN	(12LTRS)

CORRECTING ERRORS

Even the best operators sometimes make mistakes. There are definite procedures for correcting mistakes, depending on whether they occur in tape preparation or while you are sending direct from a keyboard.

You learned in chapter 10 how to erase or letter out errors in tape by backspacing and striking the LTRS key as many times as necessary to obliterate the error. This is the method used to correct errors in tape preparation, except when they occur in format lines 1, 2, 3, and 4. Errors in the first four format lines cannot be corrected; you must discard the tape with the error in it and prepare a new one. The main reason for this rule is that even one extra LTRS function in any of the first four format lines results in rejection of the tape at the first automatic relay station.

Another special rule applies to correcting errors in the security classification of a plain language message. When such errors occur, you must backspace and obliterate the entire classification. Then, start anew with the first letter of the classification.

When transmitting from the keyboard, you cannot correct mistakes that occur in the message heading, nor in the security classification when it is the first word of the text. You must cancel the transmission and again send the message from its beginning. To cancel the transmission, send 2CR, 1LF, 1LTRS, and prosigns E E E E E E E E AR, followed by your station's routing indicator and the usual end-of-message functions. In tape relay procedure the error prosign is exactly 8 Es—no more, no less—with a space between each E.

To correct a mistake in the text of the message (other than one in the security classification), send 1 LTRS, 8 Es, repeat the last word sent correctly, and continue with the correct version of the text. For example, assume you are transmitting the words IN ACCORDANCE WITH PREVIOUS INSTRUCTIONS and make a mistake in the word "previous." Correct it as follows: IN ACCORDANCE WITH PREVX E E E E E E E E WITH PREVIOUS INSTRUCTIONS. The error prosign is transmitted immediately after the error occurs. Transmission resumes with the last word or group sent correctly.

If the text is transmitted before you discover an error in it, make the correction on the line following the prosign BT. Use of the prosign C for this purpose was shown in earlier message examples. Errors in a multiple-page message, which were not corrected by 8 Es or the lettering-out method, are corrected at the bottom of each page by means of the prosign C. If the error is not noticed before starting another page, the error is corrected at the end of the last page.

HIGH-PRECEDENCE TAPES

Messages of FLASH precedence are given special handling over tape relay circuits. When the tape is prepared at the originating station, the repeated precedence prosign in line 2 is preceded by the bell signal so that succeeding stations have audible warning that a high-precedence message is coming in. Example:

(FIGS)JJJJSSSSS(LTRS)ZZ RUHPB RUWSC
DE RUATC 58A Ø322310
Z Ø12312Z
(Etc.)

Notice that the precedence prosign appears in lines 2 and 4, just as in any other message, but the bell signal is used only in line 2.

In semiautomatic relay stations, high-precedence tapes receive hand-to-hand processing. The receiving operator immediately notifies the supervisor when a high-precedence tape is being received. The supervisor sees that the tape is taken immediately to the proper outgoing circuits and sent out. A receipt must be transmitted to the station from which the message was received, and a receipt obtained from every station to which the message is relayed.

The equipment in automatic relay stations is designed to "recognize" IMMEDIATE as well as FLASH messages. Upon receipt of the repeated prosigns ZZ or OO at the beginning of the routing line, the director component of the switching equipment seeks an immediate connection with the proper outgoing circuits instead of waiting for the four Ns at the end of the message. As a further aid to high-speed relay of high-precedence messages, the busiest circuits usually are provided with an additional receiving unit for use exclusively with high-precedence messages.

The system of station-to-station receipts used by semiautomatic relay stations for FLASH messages is not practical in the fully automatic system because messages enter and leave the relay station unseen and untouched by human operators. For this reason, receipts for FLASH messages are handled as follows:

1. Messages originated and addressed entirely within the automatic relay network require a receipt from the addressee to the originator.

2. Messages originated by a station within the automatic network and addressed to stations outside the automatic network require a receipt from the station transferring the message from the automatic network (called gateway refile station) to the originator. All messages transmitted outside the automatic network must be receipted for, station-to-station.

3. Messages originated outside the automatic network and destined for addresses within the automatic network are receipted for station-to-station from originator to the gateway refile station. No receipt is required of such messages after entry into the automatic relay network, unless an acknowledgment was requested.

MISSENT AND MISROUTED MESSAGES

Occasionally you will receive a message that was delivered to your office through error. Whenever this happens, remember that every office is responsible for delivering EVERY message received, even though it was transmitted through error.

Messages transmitted through error are classed in two groups: MISSENT and MISROUTED. A missent message has the correct routing indicator, but the relay station transmitted it over the wrong circuit. The message may have carried Asmara's indicator RUQA, for example, but was transmitted over the RUFR circuit to Naples.

Misrouted messages bear the wrong indicators, either through error when assigned by the punching station, from mechanical trouble in the system, or from the tape-cutter's typing mistake.

If you should receive two copies of a multiple-address message, and the second is not marked SUSPECTED DUPLICATE, you must assume that one of the other addresses did not receive his copy. You must notify the relay station from which you received the duplicate message, explaining the situation. The relay station then checks its monitor rolls to make sure that all addressees received a copy of the message in question.

The procedure for forwarding a misrouted message is treated in detail in the discussion of reroute pilot tapes.

PILOT TAPES

A pilot indicates that, for some reason, a particular message requires special handling over relay circuits. The pilot is considered to be format line 1 of the message. Here are four important types of pilots.

Pilot	Abbreviation	Associated operating signal
1. Subject to correction.	SUBCOR	ZDG
2. Corrected copy.	CORCY	ZEL
3. Suspected duplicate transmission.	SUSDUPE	ZFD
4. Rerouted message.	- - - -	ZOV

SUBCOR PILOT

When a relay operator finds a garbled or mutilated tape of PRIORITY or lower precedence, the tape usually is not relayed until a good copy is available. If waiting for a good copy would delay the message unreasonably, or if the message is of higher precedence than PRIORITY, it is forwarded immediately, subject to correction. The station releasing a message subject to correction is responsible for seeing that a good tape is transmitted as soon as possible as a corrected copy.

In the following example, a message from the Far East, addressed to Washington, is received garbled at the relay station in Honolulu, and is forwarded SUBCOR.

(TI) (5 SPACES 2CR LF)	(2CR LF)
OO RUECN	(2CR LF)
ZNR UUUUU ZDG RUHP	(2CR LF)
VV (3 SPACES)MGA19ØVV	(2CR LF)
(3 SPACES)ATA1Ø5	(2CR LF)
OO RUECN	(2CR LF)
DE RUATH 93 31119Ø1	(2CR LF)
ZNR UUUUU	(2CR LF)
O 18191ØZ	(2CR LF)
FM CONMAVFORJAPAN	(2CR LF)
TO RUECN/DIRNAVSECGRU	(2CR LF)
BT	(2CR LF)
(Text garbled but still useful.) (Etc.)	(Etc.)

CORCY PILOT

When a relay station forwards a SUBCOR message, as in the foregoing example, it is that station's responsibility to obtain a good tape and forward it to the station to which the SUBCOR was sent. The next example shows the pilot used by RUHP in forwarding the corrected copy of the preceding message.

(TI) (5 SPACES 2CR LF)	
OO RUECN	(2CR LF)
ZNR ZEL RUHP	(2CR LF)
VV (3 SPACES)MGA19ØVV	(2CR LF)
(3 SPACES)ATA1Ø5	(2CR LF)
OO RUECN	(2CR LF)
DE RUATH 93 31119Ø1	(2CR LF)
....Etc....	(Etc.)

SUSDUPE PILOT

When a station has no conclusive evidence that a tape was transmitted, but suspects that it was, the message is forwarded as a suspected duplicate. In such instances, the station called is responsible for preventing duplicate deliveries to the addressee. Example:

(TI) (5 SPACES 2CR LF)	
PP RULAGB	(2CR LF)
ZFD RULA	(2CR LF)
PP RULAT RULAC RULAGB	(2CR LF)
DE RUECH 48A 2141158	(2CR LF)
P 111213Z	(2CR LF)
(Etc.)	(Etc.)

REROUTE PILOT

As you learned in the previous section, a misrouted message bears an incorrect routing indicator. Because a misroute is handled differently, do not confuse this type of message with the missent message, which bears the correct routing indicator but inadvertently is sent to the wrong station. The misrouted message must be forwarded with a pilot, whereas the missent message is forwarded without alteration.

The station detecting a misroute is responsible for taking corrective routing action. (In some instances the station detecting a misroute is a relay station; in others, the tributary station to which the message was misrouted.) Corrective routing action consists of preparing a pilot containing the message precedence (repeated), the correct routing indicator of the station to effect delivery, the operating signal ZNR or ZNY and the repeated classification Character, the operating signal ZOV followed by the routing indicator of the station preparing the pilot. Transmission instructions are used only in multiple-addressed messages, and then only when absolutely necessary to effect delivery of the message.

In the following example, assume that relay station RUHP receives a message for further relay, and discovers a misroute in it. An operator at RUHP prepares a reroute pilot tape, prefixes it to the original tape (as received), and relays the message to the correct station.

(TI) (5 SPACES 2CR LF)	
RR RUHPF	(2CR LF)
ZNR UUUUU ZOV RUHP	(2CR LF)
VV (3 SPACES)UATØ98	(2CR LF)
RR RUHPB RUHPE	(2CR LF)
DE RUATA 43 3ØØØ759	(2CR LF)
ZNR UUUUU	(2CR LF)
R Ø8Ø923Z	(2CR LF)
FM NAS ATSUGI	(2CR LF)
TO RUHPB/CINCPACFLT	(2CR LF)
INFO RUHPE/COMBARPAC	(2CR LF)
BT	(2CR LF)
(Etc.)	(Etc.)

After rerouting the message, RUHP transmits a service message to RUATA (station originating the misrouted message), pointing out the incorrect routing and indicating the corrective action taken. This procedure is an important part of the reroute process. It brings the routing error to the attention of the station at fault, and helps prevent future misroutes.

TWX SYSTEM

The TWX is a commercial teletypewriter system owned and operated by the various telephone companies. Its services are available to anyone on much the same basis as the telephone. Any businessman may have TWX installed in his office. Charges are made as for phone service—so much for the use of the equipment and so much for each call, based on time and distance.

DCA uses TWX as an extension of the teletype relay system. The TWX serves outlying stations that do not send or receive enough traffic to warrant the cost of circuits and equipment that would make them a part of a relay network.

A message to an activity served by TWX is forwarded to the station nearest its destination and there is refiled into the TWX network. This method results in considerable savings because the long-haul portion of such traffic is then handled over DCA-leased lines and the only extra cost is for the short-distance transmission from the refile station. The routing indicator given in ACP 117 for an activity served by TWX is the basic indicator of the relay station or tributary station that will effect transfer of traffic, with the suffix CX added. For instance, the routing indicator for the Naval Propellant Plant at Indian Head, Md. is listed as RUECCX, which indicates that the message would be sent to the TWX section of RUECC COMMCEN in Washington, and there refiled by TWX for delivery to Indian Head. Keep in mind that any time you have a message to an activity whose routing indicator ends in CX, there are commercial charges for final delivery.

When a message is received for TWX refile, the operator finds the TWX number in the directory. When he has the number, he calls the local TWX operator, states the number he wants, and then stands by until he receives a GA (go ahead) from the distant station.

Assume that RUECCX receives a message for refile to the Naval Propellant Plant at Indian Head. This is the way it came in:

VZCZCCCB395CDAØ78	(5 SPACES 2CR LF)
RR RUECCX	(2CR LF)
DE RUECD 21B 3111412	(2CR LF)
ZNR UUUUU	(2CR LF)
R 111533Z	(2CR LF)
FM BUWEPS	(2CR LF)
TO RUECCX/NPP INDIAN HEAD	(2CR LF)
NAVY	(2CR LF)
BT	(2CR LF)
(Etc.)	(Etc.)

In the following procedure for delivery by TWX, the TWX operator answers as soon as the RUECC operator turns on his machine. Example:

Transmission	Explanation
GA PLS	TWX operator answers "Go ahead, please."
INDIAN HEAD MD 241	RUECC operator gives number he wants.
MIN PLS	TWX operator says "Stand by a minute please," then makes the circuit connection.
INDIAN HEAD	TWX operator calls Naval Propellant Plant, Indian Head, Md.
GA PLS	Naval Propellant Plant, Indian Head, answers (At this point, the switchboard operator drops off line.)
RUECC 3, etc.	RUECC transmits message.
END (bell signal)	Sent by RUECC operator at end of message or end of last message, if more than one is transmitted.
R NR3	Operator at Indian Head receipts for message. Both the RUECC and Indian Head operators turn off machines, and the TWX operator disconnects circuit.

COMMERCIAL MESSAGES

Official messages to commercial activities are sent over DCA circuits to the message center nearest the addressee. If the message center is near enough, delivery may be made by telephone or by other appropriate means. Otherwise, it must be given to a commercial communication company for final delivery.

Here are two messages addressed to commercial activities. The first message has two commercial addressees; the second has one naval addressee and one commercial addressee. Note that the form is the same for both messages. An accounting symbol is always required in format line 10. Example 1:

```
VZCACCDA198                      (5 SPACES 2CR LF)
RR RUEGCU                                 (2CR LF)
DE RUECD 43A Ø261Ø15                      (2CR LF)
ZNR UUUUU                                 (2CR LF)
R 261235Z                                 (2CR LF)
FM BUSHIPS                                (2CR LF)
TO RUEGCU/TELETYPE CORP                   (2CR LF)
41ØØ FULLERTON                            (2CR LF)
AVE CHGO                                  (2CR LF)
RUEGCU/COLLINS RADIO CO                   (2CR LF)
CEDAR RAPIDS IOWA                         (2CR LF)
NAVY                                      (2CR LF)
BT                                        (2CR LF)
UNCLAS                                    (2CR LF)
THIS IS AN EXAMPLE OF A                   (2CR LF)
MULTIPLE ADDRESS MSG                      (2CR LF)
FOR COMMERCIAL ADDEES                     (2CR LF)
ONLY CMM ROUTED TO                        (2CR LF)
AUTHORIZED REFILE POINT                   (2CR LF)
NEAREST ADDEES                            (2CR LF)
BT                                       (2CR 8LF)
NNNN                                     (12 LTRS)
```

Example 2:

```
VZCZCCDB312 (5 SPACES 2CR LF)
RR RUCKDY RUWPLC                          (2CR LF)
DE RUECD 296B Ø271759                     (2CR LF)
ZNR UUUUU                                 (2CR LF)
R 272331Z                                 (2CR LF)
FM BUWEPS                                 (2CR LF)
TO RUCKDY/NAVSHIPYD NORVA                 (2CR LF)
RUWPLC/CONSOLIDATED                       (2CR LF)
VULTEE ACFT                               (2CR LF)
CORP POMONA                               (2CR LF)
NAVY                                      (2CR LF)
BT                                        (2CR LF)
UNCLAS                                    (2CR LF)
THIS IS AN EXAMPLE OF A                   (2CR LF)
MULTIPLE ADDRESS MSG                      (2CR LF)
FOR A NAVAL AND A                         (2CR LF)
COMMERCIAL ADDEE, ROUTED                  (2CR LF)
BY NTX FOR DELIVERY TO                    (2CR LF)
NAVAL ADDEE AND TO NEAREST                (2CR LF)
POINT OF COMMERCIAL                       (2CR LF)
REFILE FOR DELIVERY TO                    (2CR LF)
COMMERCIAL ADDEE                          (2CR LF)
BT                                       (2CR 8LF)
NNNN                                     (12 LTRS)
```

CLASS E MESSAGES

Class E messages originated by ships were discussed in chapter 11. The class E privilege also is extended to personnel at all overseas naval stations served by naval communications. Such messages are handled as plaindress, single-address messages to points of refile in the continental United States. Although many shore stations on both coasts are authorized to refile class E messages from ships at sea, those originating at overseas shore stations are refiled at the circuit entry points at Washington and San Francisco. Following is an example of a class E message in relay form.

```
(TI) (5 SPACES 2CR LF)
RR RUECC                              (2CR LF)
DE RULAC 125A 222Ø913                 (2CR LF)
ZNR UUUUU                             (2CR LF)
R 141227Z                             (2CR LF)
FM NAVCOMMSTA SAN JUAN                (2CR LF)
TO RUECC/NAVCOMMSTA WASHDC            (2CR LF)
BT                                    (2CR LF)
MSG CK18 COMLF JOHN D                 (2CR LF)
NICHOLAS 33Ø8                         (2CR LF)
SENATOR AVE SE DISTRICT               (2CR LF)
HEIGHTS MD                            (2CR LF)

JOYCE AND KIDS ARRIVING               (2CR LF)
IDLEWILD 123Ø AM                      (2CR LF)
OCT 15 PAA FLT 2Ø6 MEET IF            (2CR LF)
POSSIBLE                              (2CR LF)
MARK VECELLIO NAVCOMMSTA              (2CR LF)
SAN JUAN                              (2CR LF)
BT                                    (2CR 8LF)
NNNN                                  (12 LTRS)
```

READDRESSING

The procedure for readdressing messages is the same as for readdressing radiotelegraph messages. That is, all procedure lines preceding line 5 (preamble) of the original heading are deleted, and a supplementary heading is inserted in front of the original preamble. The supplementary heading is separated from the remaining portion of the original heading by a line feed function.

Assume that on receipt of this message, COMFIVE wishes to readdress it for INFO to NTC Bainbridge, Md.

```
(TI) (5 SPACES 2CR LF)
PP RUECW RUCKC RUWSPG                 (2CR LF)
DE RUHPB 123C Ø64Ø821                 (2CR LF)
ZNR UUUUU                             (2CR LF)
P 15Ø911Z                             (2CR LF)
FM CINCPACFLT                         (2CR LF)
TO RUECW/CNO                          (2CR LF)
RUCKC/COMFIVE                         (2CR LF)
RUWSPG/COMWESTSEAFRON                 (2CR LF)
BT                                    (2CR LF)
UNCLAS                                (2CR LF)
(Plain language text.)                (2CR LF)
BT                                    (2CR 8LF)
NNNN                                  (12 LTRS)
```

The next example is the message as readdressed. Notice that COMFIVE has changed the precedence in the supplementary heading. Selection of the precedence and the decision whether the message is to be readdressed for action or information are responsibilities of the readdressing activity. When readdressing a message for intra-navy delivery the routing indicators in the address and the delivery operating signal ZEN may be removed, for a readdressal in Joint or Combined form all format lines from line 5 must not be changed.

```
(TI) (5 SPACES 2CR LF)
RR RUECTAJ                            (2CR LF)
DE RUCKC 34 Ø461334                   (2CR LF)
ZNR UUUUU                             (2CR LF)
R 151452Z                             (2CR LF)
FM COMFIVE                            (2CR LF)
INFO RUECTAJ/NTC BAIN                 (2CR LF)
P 15Ø911Z                             (2CR LF)
FM CINCPACFLT                         (2CR LF)
TO CNO                                (2CR LF)
COMFIVE                               (2CR LF)
COMWESTSEAFRON                        (2CR LF)
BT                                    (2CR LF)
UNCLAS                                (2CR LF)
(Plain language text.)                (2CR LF)
BT                                    (2CR 8LF)
NNNN                                  (12 LTRS)
```

SERVICE MESSAGES

Service messages are short, concise, messages between communication personnel used to expedite the handling of messages. Usually service messages concern transmissions originated at, addressed to, or refiled by a station, although they may pertain to any phase of traffic handling, communication facilities, or circuit condition.

Plain language service messages are prepared in abbreviated plaindress format. The degree of abbreviation depends upon whether the service messages must be relayed. If two stations are directly connected, service messages consist of only format lines 1, 2, 3 (less station serial number), 4 (when required), and 12. Service messages requiring relay contain all format lines except lines 5, 6, and 10. Lines 7 and 8 are used only when it is necessary to show action and information addressees, at which time addressees are designated by routing indicators. Service messages requiring commercial refile must show the complete address, including accounting data in format line 10.

The text of all service messages begins with the security classification or the abbreviation UNCLAS. Then follows the abbreviation SVC, which, in turn, may be followed by a reference number. When reference numbers are used, they are assigned consecutively on a monthly basis, commencing with the first and ending on the last calendar day of each month. This numbering method provides an additional means of referring to a particular service message.

Following is an example of an abbreviated service message between directly connected relay stations, requesting retransmission of a garbled tape.

(TI) (5 SPACES 2CR LF)	
RR RUEP	(CR LF)
DE RUCA 3Ø21421	(2CR LF)
ZNR UUUUU	(2CR LF)
UNCLAS SVC EUC128 RPT	(2CR 8LF)
EUC 128 ZES2	(2CR 8LF)
NNNN	(12 LTRS)

A normal, single-address service message between tributary stations in the continental United States (CONUS) is shown in the next example. (In the CONUS, a tributary station receiving a garbled message requests retransmission (rerun) from the station originating the message. Outside the CONUS, a tributary station receiving a garbled message from a relay station requests retransmission from the relay station.)

(TI) (5 SPACES 2CR LF)	
RR RUEPDA	(2CR LF)
DE RUEPPD 29 3Ø7Ø643	(2CR LF)
ZNR UUUUU	(2CR LF)
BT	(2CR LF)
UNCLAS SVC RUEPDA 15A	(2CR LF)
Ø7/Ø5Ø5Z Ø7Ø445Z	(2CR LF)
ZES2	(2CR LF)
BT	(2CR 8LF)
NNNN	(12 LTRS)

TRACER PROCEEDINGS

Naval communications prides itself on reliability, but no communication system is absolutely perfect. For this reason there must be some provision for tracing messages that are lost or meet unreasonable delay. Tracers answer three questions: Was the message actually lost? Who lost it? Why was it lost?

Tracers are sent to protect the dependability of communications—not to serve as a basis for disciplinary action. They warn the station at fault that its internal message-handling procedures may need reexamination.

Tracing a message is nothing more than checking from station to station to find where the failure occurred. The proceedings leading to transmission of a service message tracer differ, however, depending upon whether the message in question is a nondelivery, a suspected nondelivery, or an excessively delayed delivery. Detailed procedures for each of these circumstances are prescribed in the effective edition of ACP 127.

For purposes of our discussion of tracer proceedings, assume that a known (not suspected) nondelivery occurs. In such instances, tracer proceedings start with the originator of the message, either on his own initiative or at the request of the addressee who did not receive the message. Tracer action is not authorized after 30 days from the date of the message being traced.

The first step the originator takes is either to cancel or retransmit the original message to the addressee not receiving it. If the message is retransmitted, the operating signal ZFG is transmitted immediately following the DTG in the original message heading. (Operating signal ZFG means "This message is an exact duplicate of a message previously transmitted.")

After retransmitting the message, a service message tracer is drafted and sent to the first relay station concerned with the original message. The relay station, after assuring that the message was not mishandled at that station, forwards the tracer to the next relay station for action, and to the originating station for information. This procedure continues on a station-to-station basis until the cause for the lost message is determined and reported to the originating station.

To illustrate a message being traced from originator to addressee, assume a message originated by RUEAHQ was lost en route to the addressee at RUFPBW. After retransmitting the original message to RUFPBW as an exact duplicate, RUEAHQ originates and transmits the following tracer to the service desk of the first relay station handling the original message.

```
(TI) (5 SPACES 2CR LF)
RR RUEASU                          (2CR LF)
DE RUEAHZ 25A Ø5615ØØ              (2CR LF)
ZNR UUUUU                          (2CR LF)
UNCLAS SVC RUEAHQ 1Ø4C             (2CR LF)
Ø55Ø8ØØ 24Ø75ØZ                    (2CR LF)
ZDE2 RUFPBW/HQ USAFE               (2CR LF)
ZDQ RUEA HQB115                    (2CR LF)
24Ø9ØØZ                            (2CR 8LF)
NNNN                               (12 LTRS)
```

(The meaning of the operating signals used in the text of the tracer are: ZDE2—Message ___ undelivered. Advise disposition. ZDQ—Message ___ was relayed to ___ by ___ at ___.)

On receipt of the tracer, RUEASU checks its handling of the original message and finds that the message was forwarded to RUFP. Tracer action continues with RUEASU sending the following to RUFPSU (service desk of relay station RUFP) and RUEAHQ.

```
(TI) (5 SPACES 2CR LF)
RR RUFPSU RUEAHQ                   (2CR LF)
DE RUEASU 75A Ø561625              (2CR LF)
ZNR UUUUU                          (2CR LF)
TO RUFPSU                          (2CR LF)
INFO RUEAHQ                        (2CR LF)
BT                                 (2CR LF)
UNCLAS SVC RUEAHQ 104C             (2CR LF)
Ø55Ø8ØØ 24Ø75ØZ                    (2CR LF)
ZDE2 RUFPBW/HQ USAFE ZDQ           (2CR LF)
RUFP JNB185                        (2CR LF)
24Ø955Z                            (2CR LF)
BT                                 (2CR 8LF)
NNNN                               (12 LTRS)
```

On receipt of the foregoing tracer, RUFPSU checks its station monitors and finds that the questioned message was sent to RUFPBW for delivery to the addressee. Accordingly, RUFPSU sends this tracer:

```
(TI) (5 SPACES 2CR LF)
RR RUFPBW RUEAHQ                   (2CR LF)
DE RUFPSU 1Ø9 Ø5617Ø5              (2CR LF)
ZNR UUUUU                          (2CR LF)
TO RUFPBW                          (2CR LF)
INFO RUEAHQ                        (2CR LF)
BT                                 (2CR LF)
UNCLAS SVC RUEAHQ 1Ø4C             (2CR LF)
Ø55Ø8ØØ 24Ø75ØZ                    (2CR LF)
ZDE2 RUFPBW/HQ USAFE ZDQ           (2CR LF)
RUFPBW BWA234                      (2CR LF)
241ØØØZ                            (2CR LF)
BT                                 (2CR 8LF)
NNNN                               (12 LTRS)
```

As seen in the preceding examples, the original message was traced from the originating station to the station serving the addressee. After a thorough search of its files and records, RUFPBW discovers that the original transmission of the questioned message was received garbled and was filed without a good copy being obtained. That station must accept responsibility for the nondelivery. It does so in the following report to the originator of the message.

```
(TI) (5 SPACES 2CR LF)
RR RUEAHQ RUFPSU                   (2CR LF)
DE RUFPBW 223B Ø561915             (2CR LF)
ZNR UUUUU                          (2CR LF)
TO RUEAHQ                          (2CR LF)
INFO RUFPSU                        (2CR LF)
BT                                 (2CR LF)
UNCLAS SVC ZUI RUEAHQ              (2CR LF)
1Ø4C Ø55Ø8ØØ                       (2CR LF)
24Ø75ØZ ZDE2 RUFPBW/HQ             (2CR LF)
USAFE RECEIVED                     (2CR LF)
ZBK2. THISTA FAILED TO             (2CR LF)
INITIATE ZDK                       (2CR LF)
REQUEST. CORRECTIVE ACTION         (2CR LF)
TAKEN                              (2CR LF)
BT                                 (2CR 8LF)
NNNN                               (12 LTRS)
```

ENSURING CONTINUITY OF TRAFFIC

Except for FLASH messages, station-to-station receipts are not employed in the tape relay system. The responsibility for continuity of received messages rests with the station receiving the traffic. The receiving station ensures that a tape is received under each channel number and that numbers are not duplicated or omitted.

When no transmission is received over a circuit or channel for a period of 30 minutes (this interval may be increased to 60 minutes at the discretion of the relay station on channels to its tributaries), the receiving station originates a service message (called a channel check) to the transmitting station. The channel check is assigned a precedence of IMMEDIATE, and is in the following form:

(TI) (5 SPACES 2CR LF)	
OO RUHPB	(2CR LF)
DE RUHPC 11316Ø5	(2CR LF)
ZNR UUUUU	(2CR LF)
UNCLAS SVC ZID PBA113	(2CR 8LF)
NNNN	(12 LTRS)

(The channel number following the operating signal ZID indicates the channel number of the last message received from RUHPB on that channel.)

Station RUHPB checks the channel number of the last message transmitted to RUHPC on the channel indicated, and if it agrees with the number in the channel check, RUHPB transmits:

(TI) (5 SPACES 2CR LF)	
OO RUHPC	(2CR LF)
DE RUHPB 11316Ø7	(2CR LF)
ZNR UUUUU	(2CR LF)
UNCLAS SVC ZIC PBA113	(2CR 8LF)
NNNN	(12 LTRS)

If the message reported as last received does not correspond to that sent last, RUHPB takes whatever action is necessary to establish contact with RUHPC, and retransmits the missing message(s).

At tributary stations, if no traffic is received for a period of 30 minutes (or 60 minutes if so directed), the tributary originates and transmits a channel check addressed to its own station. The following example is such a channel check.

(TI) (5 SPACES 2CR LF)	
OO RUHPB	(2CR LF)
DE RUHPB	(2CR LF)
ZNR UUUUU	(2CR LF)
UNCLAS SVC CHANNEL CHECK	(2CR LF)
RYRYRYRY	(2CR LF)
ABCDEFGHIJKLMNOPQRSTUV	(2CR 8LF)
WXZY 123456789Ø	(2CR 8LF)
NNNN	(12 LTRS)

The preceding message, routed in its own station, indicates to the tributary a satisfactory circuit condition if it is received promptly from the relay station and the channel number agrees with the received message log. If it is not returned over the receive channel within a reasonable length of time, then circuit trouble should be suspected, and the condition of the circuit should be investigated by maintenance personnel.

CHANGING CHANNEL NUMBER SEQUENCE

Channel number sequences are changed as near to 0001Z daily as practicable. Because of having many circuits on which the numbers must be changed, relay stations usually commence resetting their outgoing channel numbers to 001 at approximately 2330Z daily.

Upon receipt of channel number 001 from the relay station, tributary stations reset their numbers to 001. Then they originate a service message to the relay station, stating the last number received for that day and listing any messages awaiting rerun. This service message is sent under channel number 001 for the new day.

In the following example, station RUECD sends the final number comparison for the old day and informs RUEC that retransmission of a message still is pending.

(TI) (5 SPACES 2CR LF)	
RR RUEC	(2CR LF)
DE RUECD 212ØØØ2	(2CR LF)
ZNR UUUUU	(2CR LF)
UNCLAS SVC ZID ECA164	(2CR LF)
AWAITING ZDK ECA137	(2CR 8LF)
NNNN	(12 LTRS)

The same procedure is observed on circuits between relay stations, except that on multichannel circuits one service message usually suffices for reporting all circuits. Example:

(TI) (5 SPACES 2CR LF)	
RR RUEC	(2CR LF)
DE RUWS 212ØØØ2	(2CR LF)
ZNR UUUUU	(2CR LF)
UNCLAS SVC ZID ECA558	(2CR LF)
ECB62Ø ECC459 ECD7ØØ	(2CR 8LF)
NNNN	(12 LTRS)

MANUAL TELETYPEWRITER PROCEDURE

Manual teletypewriter procedure is used on teletypewriter circuits that are not part of the tape relay network—on ship-ship and ship-shore

RATT circuits, for example. The procedure, contained in the effective edition of ACP 126, presents little difficulty for the operator versed in radiotelegraph procedure. The two are closely related, and the message formats are essentially the same. Because of this similarity, the message format for manual teletypewriter messages is not given here.

The rules concerning calling and answering, repetitions, corrections, use of ending prosigns, and the like, in manual teletypewriter procedure are the same as in radiotelegraph procedure.

CHAPTER 13

COMMUNICATION CENTER ADMINISTRATION

Maintaining accurate records and observing good message-handling practices contribute toward an efficient communication organization. The importance of well-kept files and of cooperation by the various watch sections to keep them that way cannot be overemphasized. You should be able to locate any message in 1 or 2 minutes. Inaccurate files mean delays in processing traffic, some of which may be operational in nature and of high precedence. A large shore station may file messages at the rate of 50,000 or more a month. Hence, it is easy to see that a misfiled message often means a lost message.

In this chapter you will learn what some of these records are and how they are used. Bear in mind, however, that different stations may do things in different ways. There is no "one" way to log a message, for example, nor is there just "one" message blank form. Here we discuss mostly those practices and procedures that have become, through regulation or custom, fairly well standardized.

MESSAGE FILES AND LOGS

Copies of every message handled by a ship or station is placed in one or more files. Some of the files are maintained by all ships and stations, but others are optional and are maintained only to fill the need of a particular ship or station.

When it is necessary to remove a message from a file for any reason a FILLER must be inserted in place of the message. The filler should list the DTG, the originator of the message, the name of the person removing the message and information as to where the message may be located. Blank fillers prepared on colored paper will reduce preparation time and the colored paper will help when refiling the message.

Table 13-1 summarizes the types of message files commonly used. Those marked with an asterisk (*) are required for all ships and stations; the remainder are optional. Following the table is a brief explanation of each type of file.

COMMUNICATION CIRCUIT LOGS

A communication log is a continuous record of everything that happens on a communication net. There are different logs for each type of net, but basic rules governing logs apply to all types.

It is never permissible to erase an entry in any communication log. Any necessary changes must be made by drawing a single line through the original entry and indicating the changed version next to the original entry. The operator making the change initials all such changes. It is desirable for a log to be as neat as possible. It is absolutely necessary that it be complete and accurate. Because you will be primarily concerned with the teletypewriter log, it will be the only one discussed here.

The teletypewriter log may consist either of page copy or perforated tape. Page copy may be wound on a continuous roll, or it can be cut into pages for insertion into a more accessible file. Perforated tape is wound on a reel. The reel type of log is inconvenient for reference because of the necessity for unwinding and rewinding the reel each time there is a need to search for a particular transmission.

Some stations are equipped with automatic time clocks which stamp the time on perforated tape and page copies of messages. At stations not equipped with automatic time stamping devices, the operator must enter the time on incoming tapes or page copy at least once every 30 minutes.

Table 13-1.— Summary of Message Files.

File	Contents	Disposition
*Communication center file.	A copy of every message addressed to or originated by the command. Filed chronologically by DTG. Classified messages are filed by encrypted version, or by filler or dummy.	Messages incident to distress or disaster: destroy when 3 years old. Messages involved in any claim or complaint: destroy when 2 years old, or when complaint or claim is settled, if earlier. Messages of historical or continuing interest: retain. All other messages: destroy when 1 year old.
*Cryptocenter file.	The edited plain language version of each classified message addressed to or originated by the command. Filed by DTG. This file may be subdivided as necessary, in order to comply with stowage requirements for classified matter. In effect, the cryptocenter file is the classified version of the communication center file.	Same as communication center file.
*Radio station file.	Radio circuit copy of each nontactical message received, addressed to, transmitted, or relayed by radio. Filed in DTG order.	Destroy when 6 months old.
*Visual station file.	Copy of each nontactical message received, addressed to, transmitted, or relayed by visual means.	Destroy when 6 months old.
*General message file.	A copy of each general message addressed to the command, segregated by type (ALNAVs, ALCOMs, etc.). Filed according to serial numbers.	Destroy when canceled or superseded.
*Broadcast file.	Messages received by broadcast method.	Two months old, for ships over 1000 tons. One month old, for ships 1000 tons or under.
Tickler file.	Messages awaiting reply or acknowledgment.	Reply or acknowledgment is sent or received.
"Rough" file.	Originator's rough drafts.	Destroy with regular file copy.
Press file.	Copy of daily press, as distributed.	Destroy when no longer of interest.
Awaiting signature file.	Messages awaiting signature by one or more information officers.	Given to information officer when signed for.
Box or 24-hour file.	Messages received since previous midnight (GMT).	Place in regular files.

Teletypewriter logs may be destroyed after 6 months unless they relate to distress or disaster, in which case they must be kept for 3 years. This disposal schedule does not apply to tape relay stations. Relay stations are authorized to destroy monitor tapes or page copies of incoming messages after 24 hours; relay monitor reels or page copies of outgoing messages are retained for 60 days.

COMMUNICATION CENTER AND CRYPTOCENTER FILES

The communication center file contains a copy of every message addressed to or originated by the command. It does not matter whether the messages were sent plain or encrypted, or by radio, visual, mail, or other means. All are filed together in DTG order. Classified messages are filed in either of two ways: in encrypted form, or by dummy or filler. A dummy or filler is a form showing only the heading of the message. The communication center file may be subdivided into incoming and outgoing sections.

Plain language translations of classified messages are stowed in the cryptocenter file. Top Secret messages are stowed separately. Messages of other classifications usually are filed together.

If you do not know the file location of a message you need, check the communication center file. If the message is unclassified, you will find it there. If the message is classified, there will be an encrypted or dummy version, indicating that the message is in the cryptocenter file.

Messages in the communication center and cryptocenter files bear the signatures or initials of the drafter, releasing officer, communication watch officer, operator, persons to whom the message was routed, and such other information as may be required by the local command.

For convenience of stowing, filing and referencing, the communication center file may be combined with the station files described in the next topic.

STATION FILES

The radio station file contains copies of messages handled by the command via radio. It includes a copy of each nontactical message received, transmitted, or relayed by the radio facilities of the ship or station. The copies must bear the operator's servicing endorsements. They are filed in chronological order by DTG, and the file may be combined with the communication center file.

The visual station file is a chronological record of all nontactical traffic handled by the command by visual means. It is identical in purpose and description to the radio station file.

GENERAL MESSAGE FILE

The general message file is a record of all general messages addressed to the command. Normally, the file is subdivided by type of general message, and each type is filed in serial number order. (Types of general messages are discussed in chapter 11.)

General message files are given the security classification of the highest classified message contained in the files. For convenience of access and stowage, the files may be segregated by security classification, with appropriate cross-references, and the classified portion filed in the cryptocenter or other secure place.

BROADCAST FILE

Ships copying broadcasts are required to have complete broadcast files. Messages actually addressed to the ship are written up on message books for local delivery, and after processing, copies are placed in the communication center and radio station files. The messages, as they are received on the broadcast, are filed in serial number order in the broadcast file. The broadcast file usually is maintained on a monthly basis because the serial numbers run consecutively and start with number 1 the first day of each month.

When a ship moves from one broadcast area to another, it shifts the broadcast guard accordingly. As a result, more than one broadcast is guarded during the month. A notation is made in the file showing the station from which each broadcast was received, and the inclusive serial numbers of messages from each station.

TICKLER FILE

The tickler is a temporary file of copies of messages requiring a reply. It usually is kept on a clipboard near the CWO's desk.

Assume that your station just received a BuMed message bearing DTG 081704Z. It reads:

REPORT QUANTITY PLASMA ABOARD IN EXCESS NORMAL REQUIREMENTS NEXT THREE MONTHS.

The BuMed message is routed to the medical officer for action, and a copy (flimsy) goes into the incoming section of the tickler file. The tickler copy is removed when the medical officer prepares a reply.

If the station sends a message requiring a reply from another command, a copy goes into the outgoing section of the tickler, and is removed when the reply is received. If the message requires replies from several addressees, the outgoing section of the tickler will tell you who has or has not answered.

ROUGH FILE

Sometimes the drafter of a message says something different from what he meant to say, or leaves out something he meant to put in. The rough file consists of originators' rough drafts, and is the communicator's evidence if an originator thinks his message did not go out as he wrote it. Some ships file these copies separately; others staple them to smooth copies in one of the permanent files.

At most shore communication centers, the originator's rough draft never enters the shack. Clerical personnel in the originator's office smooth-type outgoing messages and deliver them to the message center properly released and ready to go.

PRESS FILE

Aboard ship, an important source of news is press broadcasts. Press material is copied by CW or RATT, then duplicated and distributed throughout the ship. One copy is placed in the press file to be retained until no longer timely. One of the commanding officer's responsibilities is to keep himself informed of current events, with particular emphasis on the international situation and on happenings in countries the ship is scheduled to visit. For this reason, a duplicate press file sometimes is maintained for the captain's use.

Press news transmitted on general broadcasts is purchased by the Navy from the press associations with the provision that it will not be placed in competition with normal newspaper outlets and commercial subscribers. Where disclosure to unauthorized persons is a possibility, particularly at shore activities outside the United States, all copies of press should be marked: FOR OFFICIAL USE ONLY. DESTROY AFTER IT HAS SERVED ITS PURPOSE. THIS PRESS MUST NOT FALL INTO UNAUTHORIZED HANDS.

AWAITING SIGNATURE FILE

Information officers usually do not need to see a message as promptly as the action officer. If an information officer is asleep or is not on board, his copy is placed in the awaiting signature file, to be signed for when he awakens or returns. The file is kept near the CWO's desk, or on the messenger's clipboard.

BOX OR 24-HOUR FILE

For convenience in locating current traffic, many message centers keep a box file for temporary stowage of messages. The box has 24 pigeonholes numbered by the hour. Copies of all messages received are stowed temporarily in the appropriate pigeonhole by DTG. A message with DTG 132146Z, for instance, goes in the 21 slot. Each day the messages are cleared from the box file and filed permanently. If the amount of traffic justifies it, separate boxes may be maintained for incoming and outgoing messages.

DISPOSAL OF FILES

Stowage space often is a problem, both ashore and afloat. The larger shore communication centers solve the problem of stowage space for message files by reproducing the files on microfilm. Aboard ship, stowage space for message files nearly always is inadequate. Inasmuch as there is rarely occasion to refer to a message more than a few weeks old, DNC 5 (effective edition) authorizes destruction of sections of the files after a certain period of time elapses. Except for messages pertaining to distress and those of legal or historical interest, the communication center and cryptocenter files are destroyed after 1 year, as indicated in table 13-1. About the first of July, for example, the files for June of the previous year are destroyed. Methods of destruction, such as burning and pulping, are described in Chapter 6 of the Security Manual for Classified Information, OPNAVINST 5510.1B.

General messages must be retained until they are canceled or superseded. Certain general messages (ALNAV, ALNAVSTA, ALSTACON, ALSTAOUT, NAVACT, and NAVOP) are incorporated into the Navy Directives System and are canceled by a superseding message, by a cancellation date indicated in the message text, or automatically after 90 days. Other general messages are incorporated into Registered Publication Memoranda (RPM) and Communications Security Publication Memoranda (CSPM) and are considered canceled when thus published. General messages not incorporated into RPM, CSPM, or the Navy Directives System, and which remain effective at the end of the year, are listed as effective in the first general message of that series for the new calendar year.

When destroying the Broadcast file a record of destruction should be made. In many commands this is mandatory.

INCOMING MESSAGES

With certain exceptions, all communications traffic addressed to a station is processed through the message center. You will recognize an inverse parallel between the processing of outgoing messages and the following typical steps through which an incoming message is processed:

1. On arrival of the message in the message center, one of the communicators translates the call signs and address groups in the heading. The CWO checks the message and marks action and information officers. It is given to the communication clerk, who makes a smooth and as many copies as are required. These are passed back to the CWO.
2. The CWO checks the message again and gives it to the messenger, retaining at least one copy until completion of delivery.
3. The messenger delivers the traffic to action and then to information officers, who receipt by initialing the original message. The captain, executive officer, and communication officer receive copies of all messages, and for this reason often maintain file boards on which their copies are placed. At a large activity, handling a great volume of traffic, each office may have its own messenger who makes regular "pickups" at the message center; under such circumstances, initialing information copies is seldom required.
4. After distributing all copies and obtaining initials, the messenger returns the initialed original to the message center. There the CWO checks it for completeness of delivery. This master copy becomes a permanent part of the communication center file, and the circuit copy is placed in the radio station file.

INTERNAL ROUTING AFLOAT

Although the captain has the overall responsibility for taking any action required by a message, he seldom is indicated as the action officer. Customarily, a message is routed for action to the department head who has direct responsibility for the subject matter of the message. The captain (or the executive officer), receiving a copy of all messages, then ensures that the action officer takes the required action.

A message is routed for information to officers who have an indirect interest in its subject matter.

Call signs and address groups in the heading of a message do not indicate who aboard is to receive the message either for action or for information. The CWO must read the text and decide who is principally responsible and who is officially interested. Some incoming messages are borderline cases; that is, more than one department must take some kind of action. The CWO must decide upon the one action officer, keeping in mind that the officer with the GREATER interest in the subject matter is routed action.

It is important that the proper number of copies of a message be made. An underrouted message may result in delay, overshadowing the inconvenience of making additional copies. The other extreme—preparing a copy for everyone who might have even a remote interest in the message—is just as bad; it would take too much time and often circulate classified information too widely.

An example of internal routing afloat may be helpful. Refer to the incoming message shown in figure 13-1. The routing ("A" for action, "I" for information) is given on the following page.

INTERNAL ROUTING ASHORE

The principles of internal routing are practically the same everywhere, but routing at a shore station often presents difficulties because of traffic volume and the number and diversity of activities the station may serve. For some activities, the station may not route at all, but only make delivery in accordance with address groups. Actual routing to action and information officers in such an instance is a function of the addressee. For other activities the station

Block	Assigned to	Routing	Explanation
1	Commanding officer	I	Receives all messages. Responsible for everything that goes on in his command and, therefore, necessarily must be informed of everything.
2	Executive officer	I	Receives all messages. In charge of administering the ship, hence must also be informed of everything.
3	Operations officer	A	Acts in matters relating to the ability of the ship to carry out her assigned mission.
4	Communication officer	I	Receives all messages, for two reasons: to check for errors, and to be informed if questions arise.
6	Navigator	I	Plots storms and gales; must determine bearing and distance of ship from gale; plots diversionary route, if necessary.
7	Weapons officer	I	Must see that exposed ordnance equipment is covered properly.
8	Engineer officer	I	Responsible for damage control and ship's stability. Must ballast as necessary and be prepared to strike topside weights below; must take precautions against water damage to engineroom power panels; must see that shaft alleys, workshops, and storerooms are ready for heavy weather.
9	Meteorological officer	I	Receives all messages concerning weather. Must advise command in matters relating to his specialty: anticipated storm track, probable state of sea, etc.
10	Supply officer	I	Must see that galley, messhalls, storerooms, and other spaces assigned his division are rigged for heavy weather; may have to revise his menus to provide food that can be served when the seas are high.
12	Medical officer	I	Must see that bedridden patients are subjected to a minimum of discomfort caused by roll and pitch of the ship, and that the sick bay, medical storerooms, and other spaces are secure from heavy weather.
14	First lieutenant	I	Must see that ground tackle is secured, if not required; that rafts, boats, and other gear on the weather decks are secure from damage.
24	OOD	I	Responsible for safety of the ship during period of his watch. (A message routed "OOD" is seen by all OODs).

makes internal routing; but the messages usually go to offices, divisions, or sections—not to individuals—for action and information.

In addition to the action/information internal routing commonly used everywhere, another routing symbol, COGNIZANCE (abbreviated

NAVAL MESSAGE (SHORT FORM)
OPNAV FORM 2110-29 (10-58)
Reorder from FPSO Cog. "I" Stock Points

SECURITY CLASSIFICATION: UNCLASSIFIED

DRAFTED BY	PRECEDENCE	DATE/TIME GROUP	MESSAGE NR.
	IMMEDIATE	11Ø4Ø3Z	31

FROM:

FLEAWEACEN WASHDC

TO:

ALL SHIPS COPYING THIS BROADCAST

INFO:

COMEASTSEAFRON / FLEWEAFAC NORVA / FLEWEAFAC MIAMI

UNCLAS

11Ø4ØØZ GALE WARNING. BETWEEN FORTY TWO AND FORTY FIVE NORTH FROM THIRTY FIVE WEST TO EUROPEAN COAST. WIND WESTERLY TWENTY FIVE TO THIRTY FIVE KNOTS

WR NR3365 WU/JN

RELEASE	TOR	TOD	CWO	WO	DATE
	11/Ø417Z				11 OCT 64

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	DATE/TIME GROUP
I	I	A	I		I	I	I	I	I		I		I										I	11Ø4Ø3Z

SECURITY CLASSIFICATION
UNCLASSIFIED

Figure 13.1.—Incoming message. 31.47

COG), is in use at many of the large shore message centers. It is used instead of action routing on messages addressed to the command for information. The office that has primary cognizance over the subject matter contained in the message is routed COG. It is responsible for taking any action that may be required within the command, including checking to see that the CWO's routing for information includes distribution of copies to other activities that might need the information.

Many stations, especially the larger ones, maintain a routing file based on subject matter of messages. The file consists of cards showing the activities interested in each subject for action and for information.

Messengers from each activity make several trips daily to the communication center to pick up their activity's incoming traffic and to deliver outgoing messages for transmittal. Delivery to some activities may be made by direct teletypewriter drop rather than by messenger.

Final responsibility for routing rests with the CWO, even though an enlisted assistant performs the work. Some CWOs do the routing themselves, using an operator for clerical assistance. Others delegate the work of routing, but check its accuracy before delivery is made. At small stations, both ashore and afloat, it is not unusual for a First or Chief to act as CWO and to assume responsibility not only for routing but also for supervising the watch.

OUTGOING MESSAGES

Typically, an outgoing message is processed according to these steps:

1. After determining that a message is necessary, the drafter prepares it, assigns appropriate classification and precedence, and sends it to the releasing officer.

2. The releasing officer checks the message for content, procedence, classification, brevity, and clarity, making any changes he sees fit. If he thinks the message unnecessary, or that it can go by slower means, he returns it to the drafter. If he approves the message, or approves it with changes, he signs it and sends it to the message center.

3. As soon as the message arrives in the message center, the time of file (TOF) is stamped or penciled on it. The CWO then logs the message in the outgoing message log, which contains the same general type of information as the incoming message log. The CWO determines that all addressees hold copies of any referenced messages listed in the message being processed, or that the references are marked with the abbreviation NOTAL, which the originator uses to indicate that the referenced messages were "not to, nor needed by, all addressees." The CWO also must ascertain that the classification of the message is in accord with the requirements for unclassified references to classified messages. Primarily, these checks are the responsibility of the message drafter, but they are double-checked by the CWO or one of his assistants.

4. The originator's draft is given to the communication clerk, who makes file and routing copies. On some ships, the originator indicates internal routing for an outgoing message. On others, the CWO performs this duty and routes an outgoing message just as he would in incoming message.

5. If the message is classified, the CWO prepares it for encryption and sends it into the cryptocenter. The encrypted version is passed back to the CWO, who drafts a heading, places it on the encrypted copy, and sends it to the watch supervisor in the radio room for transmission. If the message is unclassified, it is unnecessary, of course, to route it through the cryptocenter.

6. In the radio room the message is placed on the air. The time of delivery, accepting station, frequency, and operator's sign are noted on the face of the form, and the message is returned temporarily to the message center for completion of the CWO's outgoing message log.

7. The originator's draft goes into the rough file. The original encrypted copy, if any, goes to the radio supervisor for the radio station files. A filler, dummy, or encrypted copy goes into the communication center files. A plain language copy goes in the proper section of the cryptocenter file. If the message is plain language, a copy goes in the radio station file, as before, and another in the communication center file.

RELEASING SIGNATURE

Before you accept any outgoing message for transmission, be certain that it is released properly. You will find the signature of the releasing officer on the face of the message. The authority to release messages is vested in the commanding officer, but for sake of convenience the authority often is delegated.

Shore stations maintain a signature file of releasing officers. This file is used in much the same way as a bank's signature file of depositors. Each local command or activity served by the station submits a signature card for every officer authorized to release messages. Besides signatures, the cards also carry information regarding any limitations on the officer's releasing authority. An officer may, for example, be authorized to release messages to shore activities, but not those addressed to forces afloat. When an outgoing message is received over the counter, the releasing officer's signature is compared with that on his card. If he is authorized to release messages of that type and classification, the message is accepted.

REFERENCES

Many messages refer directly to a previous incoming or outgoing message. It saves bother for everyone if half a dozen officers do not need to telephone the message center to have previous references taken from the files and read to them. Accordingly, if there is a reference in an incoming message, look up the referenced message and show identifying extracts across the face of the routed copies. The same applies to outgoings. It is unnecessary to copy the reference in its entirety, but quote enough so that action and information officers get the gist of it. There are two additional reasons why you must check references in outgoing messages. First, checking references assures accuracy. Second, it is a security measure; unclassified replies to certain types of classified messages are forbidden.

THE COMMUNICATIONS DIVISION

Specific duties of personnel assigned to communications divisions or departments vary according to the size, location, and mission of the ship or station. Detailed instructions for each position in the communications center should be written up in the division's Standing Operating Procedures (SOP). Normally communications divisions are arranged in the following order:

1. Division Head: Communications Officer
2. Communications Chief: Leading or senior petty officer in the division
3. Communications Watch Officers: CWO assigned to each watch section
4. Watch Supervisors: Leading or senior petty officer on watch
5. Operators: Number of operators to a watch will depend on the work load and availability of personnel.

COMMUNICATIONS OFFICER

The communications officer is responsible through the local chain of command to the commanding officer or the officer in charge, for effecting reliable, secure, and rapid communications. He is also responsible for the physical security of all communications spaces, and the performance of the personnel in carrying out the commands mission.

COMMUNICATIONS WATCH OFFICER

The communications watch officer under the communications officer is responsible for the delivery of incoming and outgoing traffic. He must be kept aware at all time of conditions which may affect the secure and rapid delivery of traffic. At some stations the job of the CWO is assumed by the watch supervisor.

COMMUNICATIONS CHIEF

The communications chief (CommChief) is responsible to the CommOfficer to ensure that all instructions are carried out and to supervise the overall operation and training of personnel in the division. He prepares and drafts routine reports required by current directives. At some small stations the job of CommChief may be filled by a 1st or 2nd class petty officer.

WATCH SUPERVISORS

The supervisor is responsible for the conduct of his watch, the proper handling of all traffic passing into and through the CommCenter and the equipment in operation.

OPERATORS

While on watch operators are responsible to the supervisor. An operator has the responsibility of keeping his supervisor informed of all conditions in his area relating to high precedence traffic, equipment malfunctioning and any situation he does not fully understand.

CORRECTIONS TO PUBLICATIONS

One of your jobs as a CT3 or CT2 is to help keep your communication publications up to date. All communication publications, particularly the call sign, address group, and routing indicator books, frequently undergo necessary changes. The custodian (or technical publications librarian) is responsible for the prompt and accurate entry of all changes and corrections to publications. Usually, he issues the changes and corrections to the CommChief for the publications held in communication spaces. The CommChief then assigns the work to his men through the watch supervisors. On some ships and stations, each man is assigned his share of the publications to keep up and is responsible only for those assigned to him. Other activities assign the correcting job to any men available at the time the work needs to be done.

Corrections to publications are issued in four ways: errata, changes, memoranda, and messages. An errata is a correction, usually mimeographed, distributed with a publication or change to a publication at the time of its initial distribution. Errata are for the purpose of correcting defects that may affect the status or accountability of a publication, or to amend serious errors in the text that may lead to misinterpretation.

A change to a publication is itself a serially numbered publication, and may consist of pen-and-ink corrections, cutout corrections, or new pages to amend or add to the contents of a basic publication. Changes are numbered consecutively (change No. 1, No. 2, etc.).

Memorandum corrections are of two kinds: Registered Publication Memorandum Corrections (RPMC) for corrections to RPS-distributed publications, and Navy Memorandum Corrections (NMC) for publications distributed by the Forms and Publications Supply Office of the Navy supply system. Memorandum corrections are used when time does not permit the preparation of a serially numbered change. The RPMCs and NMCs are numbered serially, using a system of two numbers separated by a slant sign. The figure before the slant sign indicates the number of the NMC (or RPMC), and the numbers run consecutively for the life of the basic publication. The figure after the slant sign indicates the change that will confirm the material contained in the NMC or RPMC. For example, NMC 2/1 to ACP 113 is the second NMC issued to ACP 113 and will be confirmed by a forthcoming change No. 1.

Message corrections to publications are issued by ALCOM general message (or ALCOMLANT, ALCOMPAC when appropriate). Message corrections are used only when it is absolutely necessary to disseminate the correction by rapid means.

Entering corrections in publications is of such importance that it warrants your most careful attention. Here are some general rules for entering corrections:

1. Read and understand the specific instructions contained in the correction before you begin the actual entry.
2. For pen-and-ink corrections, use green ink or any dark ink except red. Red ink is not visible under the red night lights used aboard ship.
3. Type lengthy pen-and-ink corrections on a separate slip of paper, then paste the paper on the page.
4. When cutouts are provided, use them in preference to pen-and-ink corrections.
5. Cutouts should be cemented flat on the page with rubber cement or mucilage. (Rubber cement or mucilage is more satisfactory than cellophane tape because the tape often sticks pages together or may tear pages if its removal is attempted.) If there is insufficient room on the page to insert cutouts, they may be attached to the inner (binding) edge of the page as flaps.
6. Delete, in ink, all subject matter superseded by a cutout before adding the cutout. This method prevents using the superseded material if the cutout becomes detached.
7. Because a correction entered in one section of a publication often affects another section, such as the index, make certain that the corrections are entered in all applicable sections.
8. After entering pen-and-ink or cutout corrections, note on the margin, opposite the line containing the correction, the identification of the correction, as NMC 1/2, ALCOM 3, etc.
9. Upon completion of the entry of any change affecting page numbers, and before destroying any superseded pages, make a page check of the publication.
10. After entering the correction, fill in the information required by the "Record of Changes" page in the front of the publication. This page provides spaces for the correction number and its date, the entry date, your signature and rate, and the name or your ship or station.

TIME SYNCHRONIZATION

It is the responsibility of the communications center to have all clocks set accurately. One of the easiest and most accurate means is to set the clocks with radio station WWV or WWVH.

RADIO STATION WWV

The technical radio services broadcast by radio station WWV, located at WASHDC, include:

1. Standard radiofrequencies. Six frequencies are broadcast continuously, day and night—2.5, 5, 10, 15, 20, and 25 mc.
2. Time announcements.
3. Standard time intervals.
4. Two standard audiofrequencies, 440 and 600 cycles per second, alternated each 5 minutes.
5. Radio propagation disturbance warning notices for the North Atlantic area.

When you tune in WWV you will hear the audiofrequency of 440 or 600 cycles as a steady tone. Superimposed on the tone is a series of clocklike ticks. You can determine time and intervals of time to the finest degree through

(1) regular interruptions of the audiofrequency, (2) regular interruptions of the ticking, and (3) Morse code and voice time announcements.

The audiofrequencies are interrupted at exactly 2 minutes before the hour and resumed exactly on the hour and each 5 minutes thereafter. Each 5-minute period therefore consists of 3 minutes of tone and 2 minutes of no tone around the clock. You can see that, by listening, an operator is given exact time intervals of 2 minutes, 3 minutes, and 5 minutes.

The time in GMT is broadcast in telegraphic code each 5 minutes, and is followed by a voice announcement of the eastern standard time. These transmissions are made near the end of the 2-minute period when the audiofrequency is off, and refer to the time it will be when the audiofrequency, or tone, returns. For example, just before 1655Z, or 11:55 a.m. eastern standard time, you will hear 1655 in Morse code followed by a voice: "This is radio station WWV; when the tone returns it will be 11:55 a.m. eastern standard time; 11:55 a.m." If you were correcting the message center clock, you would preset hour, minute, and second hands to exactly 1655 while the announcements were going on; you would start the clock the instant the tone resumed.

The ticking is a pulse on the carrier frequency of 0.005-second duration, which occurs at intervals of precisely 1 second.

Radio propagation disturbance warnings are notices that tell users of radio transmission paths over the North Atlantic the condition of the ionosphere at the time of the announcement, and also how good or how bad communication conditions are expected to be for the next 12 hours. They are prepared four times daily and are sent at 19.5 and 49.5 minutes past the hour. Report of current conditions is made by one of the letters N, U, and W, signifying normal, unsettled, or disturbed, respectively. A digit is the forecast of expected quality of transmitting conditions on a scale of 1 (impossible) to 9 (excellent), as in the accompanying table.

Digit (forecast)	Propagation condition	Letter (current)
1	Impossible	W
2	Very poor	W
3	Poor	W
4	Fair to poor	W
5	Fair	U
6	Fair to good	N
7	Good	N
8	Very good	N
9	Excellent	N

If, for example, propagation conditions at time of forecast are normal, but are expected to be only "fair to poor" within the next 12 hours, the forecast notice would be broadcast as N4 in Morse code, sent five times: N4 N4 N4 N4 N4.

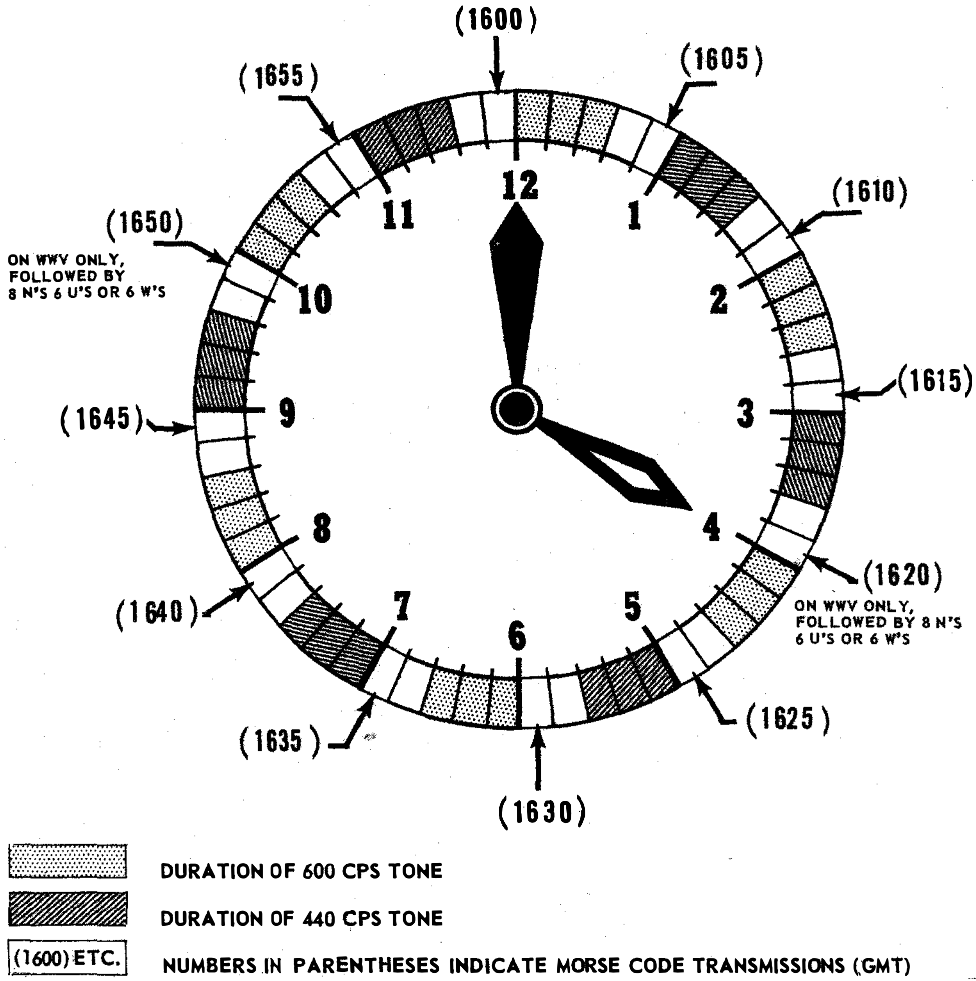
RADIO STATION WWVH

Station WWVH, on the island of Maui, Hawaii, is WWV's sister station serving the Pacific. Station WWVH broadcasts on three radiofrequencies—5, 10, and 15 mc. Reports indicate that station WWVH may be usefully received at many locations not served by station WWV and that simultaneous reception of WWV and WWVH does not interfere with ordinary use of the standard frequencies and time signals. Except for propagation warnings, services are the same as those offered by WWV, but schedules are somewhat different. Further information about both stations may be found in Radio Navigational Aids, H.O. Pubs. 117A and 117B.

Figure 13-2 shows the structure of WWV and WWVH signals.

TRAINING AND STUDY

As a supervisor of a watch, it is your responsibility to train your men to become more proficient in their duties. During a normal watch, you are presented with an untold number of opportunities for on-the-job training. Conditions permitting, each shift in frequency or change in equipment can be utilized to train one or more of your men. Many outgoing messages can be used in a similar manner. Take advantage of these opportunities, because both you and your men benefit from them. You benefit by having a sharper watch section that requires less of your time in doublechecking their work; they benefit by increasing their advancement opportunities. In the ACPs and other publications



76.40

Figure 13-2.—Structure of WWV and WWVH signals.

available, you and your men have at your fingertips all of the doctrinal communications information required for advancement from Seaman to Master Chief Petty Officer. Take advantage of them!

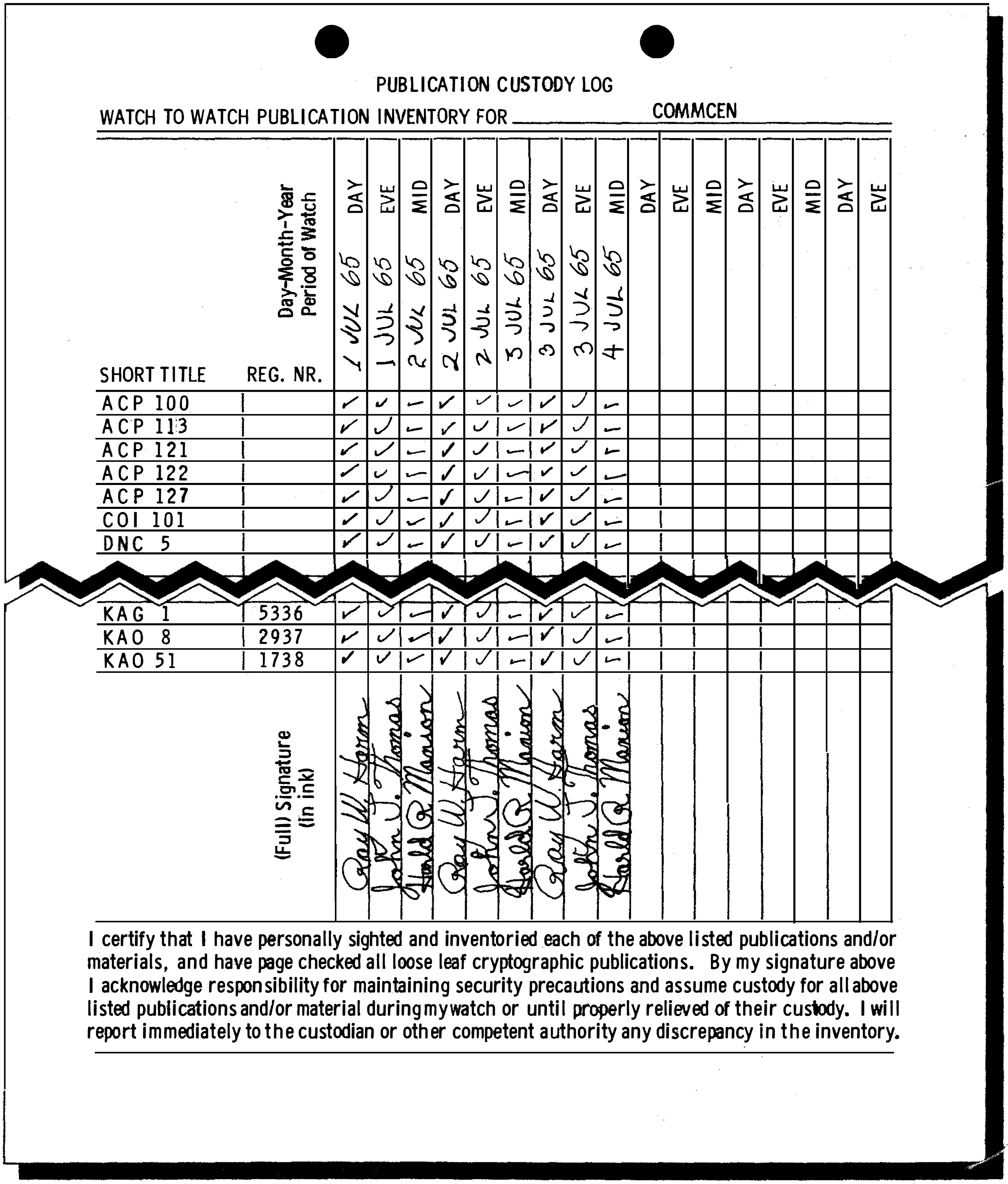
WATCH SUPERVISOR'S LOG

Usually, ships and commands that handle a large volume of traffic and maintain a large number of circuits require the watch supervisor to keep a log. The supervisor's log is a running record of the happenings during his watch. It contains such data as circuit outages, equipment failures, frequency shifts, off-frequency reports, traffic backlogs, security violations, and unusual circumstances that occur. Entries are made only when warranted. They are not required at specific time intervals.

The supervisor's log is particularly useful as background information when turning the watch over to a relieving supervisor.

PUBLICATION CUSTODY LOG

The watch supervisor is personally accountable for official publications used by his section. In order to provide effective control, ships and shore stations use publication custody logs for recording the watch-to-watch inventory. No standard form for this log is available, so you may see many different log forms. The publication custody log shown in figure 13-3 can be modified to satisfy any requirement. The log



PUBLICATION CUSTODY LOG

WATCH TO WATCH PUBLICATION INVENTORY FOR COMMCEN

SHORT TITLE	REG. NR.	DAY	EVE	MID	DAY	EVE	MID	DAY	EVE	MID	DAY	EVE	MID	DAY	EVE	MID	DAY	EVE
	Day-Month-Year Period of Watch	1 JUL 65	1 JUL 65	2 JUL 65	2 JUL 65	2 JUL 65	3 JUL 65	3 JUL 65	3 JUL 65	4 JUL 65								
ACP 100		✓	✓	✓	✓	✓	✓	✓	✓	✓								
ACP 113		✓	✓	✓	✓	✓	✓	✓	✓	✓								
ACP 121		✓	✓	✓	✓	✓	✓	✓	✓	✓								
ACP 122		✓	✓	✓	✓	✓	✓	✓	✓	✓								
ACP 127		✓	✓	✓	✓	✓	✓	✓	✓	✓								
COI 101		✓	✓	✓	✓	✓	✓	✓	✓	✓								
DNC 5		✓	✓	✓	✓	✓	✓	✓	✓	✓								
KAG 1	5336	✓	✓	✓	✓	✓	✓	✓	✓	✓								
KAO 8	2937	✓	✓	✓	✓	✓	✓	✓	✓	✓								
KAO 51	1738	✓	✓	✓	✓	✓	✓	✓	✓	✓								
	(Full) Signature (in ink)	Ray W. Harm	John J. Thomas	Harold R. Manion	Ray W. Harm	John J. Thomas	Harold R. Manion	Ray W. Harm	John J. Thomas	Harold R. Manion								

I certify that I have personally sighted and inventoried each of the above listed publications and/or materials, and have page checked all loose leaf cryptographic publications. By my signature above I acknowledge responsibility for maintaining security precautions and assume custody for all above listed publications and/or material during my watch or until properly relieved of their custody. I will report immediately to the custodian or other competent authority any discrepancy in the inventory.

31.58

Figure 13-3.—Publication Custody Log.

lists all publications in use in a particular space. At the change of watch, the supervisor and his relief sight every publication, and the relief signs the log. By doing so, he says, in effect, that the publications are actually present and that he holds himself responsible for them. Always sight every publication for which you sign. If you fail to do so, you leave yourself open to king-size troubles.

SOME QUESTIONS FOR SUPERVISORS

Following is a list of questions worth asking yourself every time you stand your watch.

1. Does handling of traffic meet Navy requirements for reliability, security, and speed?
2. Are regulations for handling and stowing classified matter observed in the spaces for which you are responsible?
3. Are all logs and files kept properly?
4. Does all wastepaper go into the burn bag?
5. Are unauthorized personnel kept out of the communication spaces?
6. Are encrypted call signs broken rapidly and accurately?
7. Do all operators in your watch section understand communication procedures and authentication?
8. Can all your operators tune every transmitter aboard? Can all use a frequency meter?
9. Are frequency meters calibrated weekly against radio station WWV?
10. Is all your equipment operative? If not, is something being done to put it in working order?
11. Are safety precautions and warning posters displayed?
12. In a sudden electrical accident, would every man on your watch know what to do?
13. Do you know what condition of radio silence exists, and under what circumstances and by whose authority it may be broken?
14. Do you know what channels and frequencies are in use for every purpose? What standby frequencies are available?

CHAPTER 14

MAINTENANCE

Equipment maintenance is a broad field of endeavor. Maintenance includes both measures to reduce or eliminate failures and prolong the useful life of the equipment (preventive maintenance) and measures taken to correct damage incurred through long use, accident, or other causes (repair, also called corrective maintenance).

The subdivisions of electronics maintenance are defined as follows:

Operational maintenance consists normally of inspection, cleaning, servicing, preservation, lubrication, and adjustment, as required, and may also consist of minor parts replacement not requiring high technical skill or internal equipment alignment. Operational maintenance on communication-electronic equipment is the responsibility of the operator.

Technical maintenance usually is limited to maintenance consisting of replacement of unserviceable parts, subassemblies, or assemblies and the alignment, testing, and internal adjustment of equipment. Technical maintenance customarily is done by personnel specifically trained for the equipment.

Tender/yard maintenance is maintenance that requires a major overhaul or complete rebuilding of parts and assemblies. Maintenance beyond the capacity of ship or station forces is performed by tenders or by naval or private shipyards and industrial managers or by contractors responsible to the maintenance yard.

The trend in recent years is toward increased maintenance responsibilities for operators. Although the line is not always clearly drawn between operational and technical maintenance, and there may be certain exceptions, it is the intent of the Bureau of Ships that operational maintenance be done by the operational ratings and technical maintenance by the technical ratings. The duties of the two ratings are summarized as follows:

1. Operational ratings—operational use, manipulation, and operational maintenance of electronic equipment associated with the technical specialties of the rating, and such portions of preventive maintenance as do not require realignment after accomplishment.
2. Technical ratings—manipulation, technical and tender/yard maintenance, repair of electronic equipment, and preventive maintenance that requires realignment after accomplishment.

PLANNED MAINTENANCE

To overcome weaknesses in local maintenance programs, the Bureau of Ships instituted the POMSEE program. The expression POMSEE stands for Performance, Operation, and Maintenance Standards for Electronic Equipment. The POMSEE consists of two publications. They are the Performance Standards Sheet and the Maintenance Standards Books.

The POMSEE program is presently being revised and incorporated into the Planned Maintenance System, which comprises maintenance of all types of equipment (hull, machinery, and the like). Main features of the present POMSEE program will be carried into the new program. Instead of employing Maintenance Standards Books, however, the System utilizes Maintenance Requirement Cards (MRCs) for the detailed guidance of personnel performing a specific preventive maintenance task on a particular item of equipment. Accompanying the MRCs are forms for scheduling the preventive maintenance and for recording the results. Decriptions of the MRCs and the various scheduling forms are contained in OpNav Instruction 4700.18.

EQUIPMENT TECHNICAL MANUAL

Two copies of the equipment technical manual are supplied with each new equipment. The technical manual contains the usual front matter (table of contents, for example), an index, and 6 sections entitled as follows: (1) General information, (2) Installation, (3) Operation, (4) Troubleshooting, (5) Maintenance, and (6) Parts list.

Section 3—Operation—is the section of most concern to you. It contains a description of the equipment's controls, tuning adjustments, and operating procedures. Always study this section before attempting to tune or operate any equipment with which you are unfamiliar. It also is a good idea to read section 1, which contains a general description of the equipment and its capabilities.

ELECTRONIC EQUIPMENT OPERATIONAL TIME LOGS

Another important source of equipment performance data is the Electronic Equipment Operational Time Log, NavShips 4855 (5-61), shown in figure 14-1. This log, maintained by the equipment operator, is a record of the periods of time an equipment actually is energized during a given month. At the end of each month, a copy of the log is forwarded to BuShips. There, it is used for evaluating equipment reliability and failure/replacement reports, and for other maintenance programing. It also keeps BuShips informed of the number of equipments actually in use.

Detailed instructions for completing and forwarding the Electronic Equipment Operational Time Logs are printed on the front and rear covers of each pad of forms. You can contribute toward better and more reliable equipment by carefully following these instructions.

Logs are required only for selected equipments, and these are listed periodically in the Electronics Information Bulletin.

MAINTAINING AIR FILTERS

The cleaning of air filters is exceedingly important for the proper operation of electronic equipment. The lack of proper servicing (cleaning or replacing) of air filters causes an enormous amount of trouble. For some reason (perhaps their importance is not fully recognized), air filters often are neglected or disregarded until excessive heating causes a breakdown of the equipment.

Forced air cooling, which circulates a large volume of air throughout the equipment cabinets, to maintain constant temperature, is used in modern transmitters, receivers, and converters, and in many types of on-line cryptographic units. The air is filtered to keep dust and other foreign particles out of the equipment. If the filters are efficient, they remove most of this foreign material from the air that passes through them. Eventually, accumulated dust and dirt clogs the filter and prevents the air from moving through. The result is that the equipment gets too hot and may be ruined.

An analysis of the failures of parts in electronic equipment indicates that the majority of failures can be traced to excessive heat caused by dirty air filters. On the basis of this alone, it would appear that the maintenance man can reduce his workload substantially by ensuring that air filters are serviced properly.

TROUBLESHOOTING

Any troubleshooting job you are required to do should be performed in the following order:

1. Analyze the trouble.
2. Detect and isolate the fault.
3. Correct the fault and test your work.

In troubleshooting, as in most other matters, there is no substitute for commonsense. A mistake made by most beginners is to remove units from the equipment unnecessarily. The first thing to do is to determine if the equipment in question is actually faulty. Very often a preliminary check of the system discloses a faulty remote control box, frayed or broken wiring, and, in some instances, improper operating procedure—especially with new equipment. Occasionally, you will find an absence of power to the unit to be the cause of the trouble.

If there is an absence of power, you can assume temporarily that the set may be all right, and start checking the power source. The first and most important step is to check the condition of fuses and circuit breakers. Their condition determines your next move. If a circuit breaker is tripped or a fuse blown, power should be turned off immediately, because this indicates a circuit malfunction, and power should not be reapplied until the malfunction is

ELECTRONIC EQUIPMENT OPERATIONAL TIME LOG
NAVSHIPS 4855

SUBMIT MONTHLY FOR EACH APPLICABLE EQUIPMENT WHETHER IN USE OR NOT IN USE

1. MONTH	YEAR	2. DESIGNATION OF SHIP OR STATION
6	65	USNAVCOMMSTA., ADAK ALASKA

3. EQUIPMENT MODEL TYPE DESIGNATION	4. EQUIP. SERIAL NO.
AN/UGC-1	64

COMPLETE THIS SECTION IF EQUIPMENT HAS TIME METER(S)

READ DATA ON COVER	5. FILAMENT OR ELAPSED TIME METER READINGS		6. LEAVE BLANK	7. HIGH VOLTAGE (PLATE) TIME METER READINGS		8. LEAVE BLANK	9. NO. OF OPERATIONAL FAILURES THIS MO.
	1st DAY OF MO.	LAST DAY OF MO.		1st DAY OF MO.	LAST DAY OF MO.		

COMPLETE THIS SECTION IF EQUIPMENT DOES NOT HAVE TIME METER(S)

10. DAY OF MONTH	11. STANDBY		12. LEAVE BLANK	13. FULLY ENERGIZED		14. LEAVE BLANK	15. CHECK (✓) IF OPR. FAIL. OCCURRED
	TIME ON	TIME OFF		TIME ON	TIME OFF		
1	N/A			1500			
5					1800		✓
5				1900			
18					1427		

DO NOT WRITE BELOW THIS LINE — CONTINUE ON REVERSE SIDE IF NECESSARY

SRA-2

15.3

Figure 14-1.—Electronic Equipment Operational Time Log, NavShips 4855.

corrected. If a short, ground, or overload condition is not indicated, continue to take power readings at the circuit checkpoints. The most common faults that interrupt power through a circuit are broken wiring, loose terminal or plug connections, faulty relays, and faulty switches. Be alert for these conditions when checking the successive points along a circuit.

Assure yourself that the equipment in question actually is faulty before beginning any wholesale removal of components.

VISUAL INSPECTION

The visible condition of a unit is usually the first detail to check in any process of troubleshooting. If certain parts obviously are not in proper condition, correct these faults before going any further in your tests. Such conditions include parts burned, loose from mounting, disconnected, dented, or any other obviously improper condition.

Crude as it may seem, your nose can be a good pinpointing device for certain troubles. A part that overheats usually gives off an odor that is readily detectable, and sometimes can be located by the combined use of eyes and nose only. Of course, location of a burned part does not necessarily reveal the cause of the trouble. In determining the cause of the trouble, it usually is necessary to refer to the equipment technical manuals. These manuals will be your constant reference when performing maintenance on electronic equipment.

The technical manual for a particular piece of equipment contains a detailed explanation of the theory of operation of each circuit in the unit. Also it has innumerable block diagrams, wiring diagrams, and schematic drawings of each circuit. It gives the location of test points and the readings that should be found on them, and it shows what voltage, resistance, and (sometimes) what waveshapes appear on each pin of every vacuum tube. The technical manual also contains directions for troubleshooting.

CLEANING ELECTRONIC EQUIPMENT

All electronic equipment should be cleaned, not just for appearance, but to assure good performance. Be sure to secure the power to the equipment before starting any kind of cleaning. The safest and best method of cleaning inside transmitters and receivers is to use a vacuum cleaner with a nonmetallic hose. A small typewriter brush is handy for getting dust out of congested areas where the vacuum cleaner will not reach. A hand bellows can be used for blowing out dust particles, but is not as satisfactory as the vacuum cleaner because of the likelihood of blowing dust into inaccessible spaces.

Steel wool or emery in any form mustnot be used on electronic equipment. Sandpaper and files are to be used only on competent advice, or not at all.

Use of chemicals and their necessary safety precautions were discussed in chapter 4.

TELETYPEWRITERS

The most important consideration in maintenance of teletypewriter equipment is proper lubrication and cleaning of the machines. Lubrication does not mean drenching the teletypewriter with oil or swabbing it with grease. Too much lubricant will, in a short time, collect dust and grit and oil-soak the wiring. A machine in this condition will be subjected to excessive wear and deterioration of insulation. Such machines are a fire hazard as well as a source of constant trouble.

It is important that you understand your cleaning and lubricating responsibilities. At some stations the operators are not required to clean or lubricate equipment. These duties are assigned to the station's maintenance force. On small stations or on some ships, however, it may be necessary for the operator to clean and lubricate. You should not attempt the job alone until you have done it several times under supervision of an experienced hand. Even so, be sure to consult references that give exact lubrication specifications.

Before beginning to clean or lubricate a machine, be sure that you ALWAYS DISCONNECT THE POWER.

At this point, you must consult the equipment technical manual for instructions in disassembling the equipment into its major units (such as removing the printing unit from its base).

After you have the equipment broken down, begin by wiping all old grease, oil, and dirt from the machine. Use a clean, dry piece of cheesecloth or other lint-free cloth for wiping. The cloth may be wrapped around a screwdriver or stick to reach points not readily accessible. Take care not to disturb springs or adjustments. Troubles frequently develop as a result of careless cleaning.

If a cleaner (solvent) is used to remove hardened grease, be sure that any unit on which you use it is not allowed to stand more than 1 hour before grease or oil is applied to the cleaned surfaces to avoid any chance of rusting or pitting of unprotected metal surfaces. A good cleaning mixture is kerosene and SAE-10 oil. This mixture leaves a rust-preventing residue of light oil on the metal. NEVER use a paraffin base oil, for it leaves the parts gummy and results in sluggish action of moving parts.

Do not use cleaning fluid on the model 28 type box. Remove the type box from the machine and clean the type with a dry typewriter brush or soft cloth. Should it be necessary to disassemble the type box, be careful not to lose the small springs that are inside the box.

Clean key caps with a cloth slightly moistened with water; do not use solvent.

After a thorough cleaning, the equipment is ready for lubrication. Here, again, you will have to consult the technical manual for explicit instructions on points to lubricate and the type and quantity of lubricant to use.

In general, Teletype KS-7470 oil and type MIL-C-3278 grease are used to lubricate teletypewriter equipment. The grease is applied to wearing surfaces, gears, and heavy moving parts, and the oil is applied to bearings and small moving parts. All springs, wicks, and felt washers must be saturated thoroughly in oil.

When lubricating, exercise special caution to prevent any oil or grease from getting between the armatures and the pole pieces of the magnets. Electrical contacts must be kept free of oil or grease.

A teletypewriter must be lubricated more frequently as the operating speed increases. Thus, a machine geared for an operating speed of 100 wpm requires lubrication more often than one operating at 60 wpm. Here is the recommended lubrication schedule:

Operating Speed (words per minute)	Lubricating Interval (whichever occurs first)
60	3000 hours or 1 year
75	2400 hours or 9 months
100	1500 hours or 6 months

Regarding the lubricating interval, an important point to remember is the expression "whichever occurs first." To illustrate, a machine in continuous use at 100 wpm accumulates 1500 operating hours in only 2 months. For machines used occasionally or intermittently, you need a log to keep track of the total operating hours. The Electronic Equipment Operational Time Log, described earlier in this chapter, is used for this purpose.

TYPEWRITERS

A typewriter that is used with care will give many years of service. Typewriter manufacturers claim that the modern typewriter never really wears out if it is not abused. The fact is that with ordinary careful use, and with regular cleaning and adjustment, typewriters can be counted on for at least 10 years of satisfactory service.

A typewriter should be brushed out by the operator at the end of each day. Type should be cleaned often with one of the various cleaners available for the purpose. Nothing looks worse than messages written up for delivery with letters such as o and e filled in because of dirt-clogged type keys. Any commercial type cleaner procured by the Navy is satisfactory. Put out your cigarette before you start.

Eraser waste must be cleaned away often if the typewriter is to stay in good condition. It can be removed with a long-handled brush. The best way to prevent accumulation of rubber crumbs is to move the carriage far enough to left or right that the point of erasure is not over keys or other mechanical parts of the typewriter. The waste then will drop on your desk from where it can be brushed away.

The cylinder and rollers should be cleaned occasionally with alcohol. This prevents their leaving streaks of dirt on paper inserted in the typewriter. In this connection, it is best to use only one typewriter in the office for cutting and correcting stencils; otherwise the rollers of all your typewriter will become coated with wax from the stencils.

The typewriter should be oiled occasionally, but do it carefully. Apply oil only at friction points, and don't use too much. When finished, wipe away excess oil; otherwise, it will drip on other parts and in time form a gummy mass with dust and eraser crumbs. Keep oil from getting on rubber parts, the ribbon, and any place in the machine where it might stain the paper.

Keep your typewriter covered when not in use. No matter how clean the office, a certain amount of dust is always in the air. When the machine is uncovered for long periods, dirt gets into the moving parts of your machine and causes wear.

TELETYPE MAINTENANCE SCHOOLS

The Navy has two excellent Teletype Maintenance training schools, one at Norfolk, the other at San Diego. These schools graduate qualified teletypewriter repairmen, able to identify, locate, and repair quickly any type of trouble the equipment may develop. If you have not attended one of these schools, you should try to do so at your earliest opportunity.

In substance, the course of instruction covers—

1. General description and theory of operation.
2. Adjustments and lubrication.
3. Troubleshooting.

During the description and theory of operation phase of the course (called electrical and mechanical orientation), the student learns the electrical circuits and each mechanical train of parts. This includes memorizing the correct name of each part, what furnishes the power to move it, and the direction it moves.

In the adjustments phase of the course, trains of parts are thrown out of adjustment by the instructor, and the student makes the correct adjustments as directed in the technical manual. One by one, each train of parts is maladjusted by the instructor and corrected by the student until the trainer makes every adjustment in each component of the entire machine. This practical experience of learning-by doing is quite effective and cannot be duplicated in any other way.

The troubleshooting phase of the teletype maintenance course is just what the name implies. The instructor introduces troubles into the equipment (while the student is out of the room), and the student is required to locate and correct these troubles. This procedure tests not only the repairman's knowledge of the equipment, but also his ability to diagnose trouble.

In the performance of the teletypewriter repairman's practical work, proficiency comes with practice and experience, for which no training manual, however helpful, can be an adequate substitute.

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