RADIOMAN 1 & C

BUREAU OF NAVAL PERSONNEL

RATE TRAINING MANUAL NAVPERS 10229—E

PREFACE

This book is written for Radiomen of the United States Navy and Naval Reserve who are studying for advancement to RM1 or RMC. Study of this text should be combined with practical experience, with review of other applicable Rate Training Manuals, and with a study of pertinent communication doctrinal and procedural publications and equipment technical manuals.

Those who work in communications know how fast procedures and equipment evolve, so you may find yourself working with equipment different from that described in this training manual.

This book is revised from time to time. Between revisions, some obsolescence may be unavoidable. For this reason it is suggested that the student with access to official communication publications use them as much as possible in his study.

As one of the Rate Training Manuals, Radioman 1 and C was prepared for the Bureau of Naval Personnel by the Training Publications Division, Naval Personnel Program Support Activity, and was reviewed by the U.S. Naval School, Radiomen, Class A and Class B, Bainbridge, Maryland; U. S. Naval School, Radiomen, Class A and Class B, San Diego, California; Naval Communications Command, Bailey's Crossroads, Virginia; and 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.

CONTENTS

CHAPTER 1

ADVANCEMENT

This Rate Training Manual is designed to help you meet the occupational qualifications for advancement to First Class and Chief Radioman. Chapters 2 through 12 of this training manual deal with the technical subject matter of the Radioman rating. The present chapter provides introductory information that will help you in preparing for advancement. It is strongly recommended that you study this chapter carefully before beginning intensive study of the chapters that follow.

REWARDS AND RESPONSIBILITIES

Advancement in rate brings both increased rewards and increased responsibilities. The time to start looking ahead and considering the rewards and the responsibilities of advancement is right now, while you are preparing for advancement to RM1 or RMC.

By this time, you are probably well aware of many of the advantages of advancement in rate: higher pay, greater prestige, more interesting and challenging work, and the satisfaction of getting ahead in your chosen career. By this time, also, you probably have discovered that one of the most enduring rewards of advancement is the personal satisfaction you find in developing your skills and increasing your knowledge.

The Navy also benefits by your advancement. Highly trained personnel are essential to the functioning of the Navy. By each advancement in rate, 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 supervise, lead, and train others and thus make far-reaching and long-lasting contributions to the Navy.

In large measure, the extent of your contribution to the Navy depends upon your willingness and ability to accept increasing responsibilities as you advance. When you assumed the duties of a RM3, you began to accept a certain amount of responsibility for the work of others. With each advancement in rate you accept an increasing responsibility in military matters and in matters relating to the occupational requirements of the Radioman rating.

You will find that your responsibilities for military leadership are about the same as those of petty officers in other ratings, because every petty officer is a military person as well as a technical specialist. Your responsibilities for technical leadership are special to your rating and are directly related to the nature of your work. The dual role of operating and maintaining a ship's communication system is a job of vital importance, and it's a teamwork job; it requires a special kind of leadership ability that can be developed only by personnel who have a high degree of technical competence and a deep sense of personal responsibility.

At this point, let's consider some of the broader aspects of your increasing responsibilities for military and technical leadership.

- Direction of Responsibility: Your responsibilities will extend upward as well as downward. Both officers and enlisted personnel will expect you to translate the general orders given by officers into detailed, practical, on-the-job language that can be understood and followed even by relatively inexperienced personnel. In dealing with your juniors, it is up to you to see that they perform their work properly. At the same time, you must be able to explain to officers any important needs or problems of the enlisted men.

- Extent of Responsibility: Even if you are lucky enough to have highly skilled and well-trained radio personnel, you still will find that training is necessary. For example, you will always be responsible for training lower rated men for advancement in rate. Also, some of your best workers may be transferred, and inexperienced or poorly trained personnel may be assigned to you, a particular job may call for skills that none of your personnel have. These problems and similar ones require you to be a training specialist who can conduct formal and informal training programs to qualify personnel for advancement and who can train individuals and groups in the effective execution of assigned tasks.

- Working with Others: As you advance to RM1 and then to RMC, you will find that many of your plans and decisions affect a large number of people, some of whom are not assigned to Radio Central and some of whom are not even in the operations/communication department. It becomes increasingly important, therefore, to understand the duties and responsibilities of personnel in other ratings. Every petty officer in the Navy is a technical specialist in his own field. Learn as much as you can about the work of other ratings, and plan your own work so that it will fit in with the overall mission of the organization.

As your responsibilities increase, your ability to communicate clearly and effectively must also increase. Several requirements must be met to satisfy this aspect of communications.

The basic requirement for effective communication is a knowledge of your own language. Use correct language in speaking and in writing. Remember that the basic purpose of all communication is understanding. To lead, supervise, and train others, you must be able to speak and write in such a way that others can understand exactly what you mean.

A second requirement for effective communication in the Navy is a sound knowledge of the Navy way of saying things. Some Navy terms have been standardized for the purpose of ensuring efficient communication. When a situation calls for the use of standard Navy terminology, use it.

Still another requirement for effective communication is precision in the use of technical terms. A command of the technical language of the Radioman rating will enable you to receive and convey information accurately and to exchange ideas with others. A person who does not understand the precise meaning of terms used in connection with the work of his own rating is at a disadvantage when he tries to read official publications relating to his work. He is also at a great disadvantage when he takes the written examinations for advancement in rate. You should always use technical terms correctly, but it is particularly important when you are dealing with lower rated men. Sloppiness in the use of technical terms is likely to be very confusing to an inexperienced man.

- Keeping up with New Developments: You are responsible for keeping up with new developments within the Navy. Practically everything in the Navy is subject to change and development–policies, procedures, equipment, publications, systems, and so on. As RM1, and even more importantly as RMC, you must make every effort to keep yourself informed about all changes and new developments that might affect your rating or your work.

Some changes will be called directly to your attention, but you will have to look for others. Try to develop a special kind of alertness for new information. Above all, keep an open mind on the subject of new radio and associated equipment. Openmindedness is especially important in the Radioman rating, because the Navy, in an effort to keep parallel with modern advances in communication development, is experimenting constantly with new and different high-speed communication devices. These new developments often call for changes in procedures in handling message traffic and sometimes for changes in a complete system.

RADIOMAN RATING

You have been a Radioman long enough to realize the importance of your rating to the Navy. Radiomen, along with Radarmen, Signalmen, and Electronics Technicians, are essential members of the operations department team. A former GNO, speaking of the operations department's task of providing external communications, operating the CIC, and repairing electronic equipment, assessed the significance of the operations department in these words:

> "The effectiveness of the many changes taking place in ships, in equipment, and in weapons rests more and more heavily upon the capability and output of the operations department. The men who man, maintain, and give effect to the components of the operations department exert a preponderant influence upon the quality of the ship's total capability."

In addition to see duty billets, Radiomen are assigned to shore duty at communication stations in the United States and at overseas bases. Radiomen are also assigned as instructors in Radiomen schools. Other important billets are at the Naval Examining Center, Great Lakes, where Radiomen assist in preparation of fleet-wide advancement examinations, and at the

Training Publications Division, Naval Personnel Program Support Activity, Washington, D.C., where Radiomen prepare and revise Rate Training Manuals and other training materials.

REQUIREMENTS FOR ADVANCEMENT

In general, to qualify for advancement you must–

1. Have a certain amount of time in grade.
2. Complete the required military and occupational training courses.
3. Demonstrate ability to perform all the practical requirements for advancement by completing the Record of Practical Factors, NavPers 1414/1 (formerly NavPers 760).
4. Be recommended by your commanding officer.
5. Demonstrate your knowledge by passing a written examination based on (a) the military requirements for advancement and (b) the occupational qualifications for advancement in the Radioman rating.

A recent addition to the requirements for advancement is a screening board for E-8/E-9 candidates. This board consists of at least three officers appointed by local commanding officers.

FINAL MULTIPLE

Advancement is not automatic. Meeting all the requirements makes you eligible for advancement but does not guarantee your advancement. The number of men in each rate and rating is controlled on a Navywide basis. Therefore, the number of men that may be advanced is limited by the number of vacancies that exist. When the number of men passing the examination exceeds the number of vacancies, some system must be applied to determine which men may be advanced and which ones may not. The "final multiple" system is used. It is a combination of three types of advancement systems: merit rating system, personnel testing system, and longevity (or seniority) system.

The Navy's system provides credit for performance, knowledge, and seniority, and although it cannot guarantee that any one person will be advanced, it does guarantee that all men within a particular rating will have equal advancement opportunity.

The following factors are considered in computing the final multiple:

Factor	Maximum Credit
Examination score	80
Performance factor (performance evaluation)	50
Length of service (years x 1)	20
Service in pay grade (years x 2)	20
Medals and awards	15
	185

All of the preceding information (except the examination score) is submitted to the Naval Examining Center with your examination answer sheet. After grading, the examination scores, for those passing, are added to the other factors to arrive at the final multiple. A precedence list, which is based on final multiples, is then prepared for each pay grade within each rating. Advancement authorizations are then issued, beginning at the top of the list, for the number of men needed to fill the existing vacancies.

KEEPING CURRENT ON ADVANCEMENT

Remember that the requirements for advancement may change from time to time. Check with your division officer or with your training officer to be sure you have the most recent requirements when you are preparing for advancement and when you are helping lower rated men to prepare for advancement.

To prepare for advancement, you should be familiar with (1) the military requirements and the occupational qualifications given in the Manual of Qualifications for Advancement in Rating, NavPers 18068B (with changes); (2) the Record of Practical Factors, NavPers 1414/1; (3) appropriate Rate Training Manuals and (4) any other material that may be required or recommended in the current edition of Training Publications for Advancement, NavPers 10052. These materials are discussed later in this chapter.

SCOPE OF THIS TRAINING MANUAL

Before studying any book, it is a good idea to know its purpose and the scope. Here are some pointers you should know about this training manual.

- It is designed to give you information on the occupational qualifications for advancement to RM1 and RMC.

- It must be satisfactorily completed before you can advance to RM1 or RMC, whether you are in the regular Navy or in the Naval Reserve.
- It is not designed to give you information on the military requirements for advancement to PO1 or CPO. Navy Training Courses that are specially prepared to give information on the military requirements are discussed in the section of this chapter that deals with sources of information.
- It is not designed to give you information that is related primarily to the qualifications for advancement to RM3 and RM2. Such information is given in Radioman 3 & 2, NavPers 10228.
- The occupational Radioman qualifications used as a guide in preparing this training manual are promulgated in change 3 the Quals Manual.

Because your major purpose in studying this training manual is to meet the qualifications for advancement to RM1 or RMC, it is urged that you obtain and study a set of the most recent Radioman quals.

- This training manual includes information that is related to both the knowledge factors and practical factors of qualification for advancement to RM1 and RMC. For developing skill in practical factors, though, remember that no training manual can take the place of actual on-the-job experience. The Record of Practical Factors, NavPers 1414/1 should be utilized, whenever possible, in conjunction with this training manual.
- Chapters 2 through 12 of this training manual deal with the occupational subject matter of the Radioman rating. Before studying these chapters, study the table of contents and note the arrangement of information. Information can be organized and presented in many different ways. You will find it helpful to get an overall view of the organization of this training manual before you start to study it.

SOURCES OF INFORMATION

It is of much importance for you to have an extensive knowledge of the references to consult for detailed, authoritative, up-to-date information on all subjects related to the military requirements and to the occupational qualifications of the Radioman rating.

A few of the publications discussed here 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 you have a copy in which all official changes have been entered.

BUPERS PUBLICATIONS

The BuPers publications described here include some that are absolutely basic for anyone seeking advancement. Others although nonessential, are extremely helpful.

Quals Manual: The Manual of Qualifications for Advancement in Rating, NavPers 18068B (with changes), gives the minimum requirements for advancement to each rate within each rating. The Quals Manual lists the military requirements applicable to all ratings and the occupational qualifications that are specific to each rating.

The Quals Manual is kept current by means of numbered changes. These changes are issued more frequently than most Rate Training Manuals can be revised; therefore, the training manuals cannot always reflect the latest qualifications for advancement. When preparing for advancement, you should always check the latest changes to be sure that you know the current requirements for advancement in your rating.

When studying the qualifications for advancement, remember these three helpful hints:

1. The quals are the minimum requirements for advancement to each rate within each rating. If you study more than the required minimum, you will of course have an advantage when you take the written examination for advancement in rate.
2. Each qual has a designated pay grades E-4, E-5, E-6, E-7, E-8, or E-9. You are responsible for meeting all quals specified for advancement to the pay grade to which you are seeking advancement in, as well as all quals specified for lower pay grades.
3. The written examinations for advancement to E-6 and above contain questions relating to the practical factors and the knowledge factors of both military/leadership requirements and occupational qualifications. Personnel preparing for advancement to E-4 or E-5 must pass a separate military/leadership examination before participation in the Navywide occupational examination. The military/leadership examinations for the E-4 and E-5 levels are given according to a schedule prescribed by the commanding officer. Candidates are re-

quired to pass the applicable military/leadership examination only once.

A special form known as the Record of Practical Factors, NavPers 1414/1, is used for recording the satisfactory completion of the practical factors, both military and occupational, listed in the Quals Manual. Either this form or its predecessor, NavPers 760, is available for each rating. The old form will continue to be used until supplies are exhausted. Whenever a person demonstrates his ability to perform a practical factor, appropriate entries must be made in the Date and Initials columns. As RM1 or RMC, you will often be required to check the practical factor performance of lower rated men and to report the results to your supervising officer. To facilitate recordkeeping, group records of practical factors are often maintained aboard ship. Entries from the group records must, of course, be transferred to each individual's Record of Practical Factors at appropriate intervals.

Because changes are made periodically to the Quals Manual, new forms of NavPers 1414/1 are provided when necessary. Extra space is allowed on the Record of Practical Factors for entering additional practical factors as they are published in changes to the Quals Manual. The Record of Practical Factors also provides space for recording demonstrated proficiency in skills that are within the general scope of the rating but are not identified as minimum qualifications for advancement. Keep this point in mind when you are training and supervising lower rated personnel. If a man demonstrates proficiency in some skill that is not listed in the Radioman quals but it falls within the general scope of the rating, report this fact to the supervising officer so that an appropriate entry can be made.

The Record of Practical Factors should be kept in each man's service record and should be forwarded with the service record to his next duty station. Each man should also keep a copy of the record for his own use.

NavPers 10052: Training Publications for Advancement, NavPers 10052, is an important publication for anyone preparing for advancement in rate. It lists required and recommended Rate Training Manuals and other reference material to be used by personnel working for advancement in rate. This publication is revised and issued once each year by the Bureau of Naval Personnel. Each revised edition is identified by a letter after the NavPers number. When using this publication, be sure you have the most recent edition.

The required and recommended references are listed by rate level in NavPers 10052. Remember that you are responsible for all references at lower rate levels, as well as those listed for the rate to which you are seeking advancement.

Rate Training Manuals that are marked with an asterisk (*) in NavPers 10052 are mandatory at the indicated rate levels. A mandatory training manual may be completed by (1) passing the appropriate Enlisted Correspondence Course based on the mandatory training manual (2) passing locally prepared tests based on the information given in the mandatory training manual or (3) in some instances successfully completing an appropriate Navy school.

Notice that all references listed in NavPers 10052, whether mandatory or recommended, may be used as source material for the written examinations, at the appropriate rate levels.

Rate Training Manuals: Rate Training Manuals are written for the specific purpose of helping personnel prepare for advancement. Some manuals are general in nature and are intended for use by more than one rating; others (such as this one) are specific to the particular rating.

Rate Training Manuals are revised from time to time to bring them up to date. The revision of a Rate Training Manual is identified by a letter after the NavPers number. You can tell whether a Rate Training Manual is the latest edition by checking the NavPers number and the letter after it in the most recent edition of the List of Training Manuals and Correspondence Courses, NavPers 10061 (revised).

Three Rate Training Manuals are specially prepared to present information on the military requirements for advancement. These manuals are—

Basic Military Requirements, NavPers 10054.

Military Requirements for Petty Officer 3 & 2, NavPers 10056.

Military Requirements for Petty Officer 1 & C, NavPers 10057.

Each of the military requirements manuals is mandatory at the indicated rate levels. In addition to giving information on the military requirements, these three books give a good deal of useful information on the enlisted rating structure; how to prepare for advancement; how to supervise, train, and lead other men;

and how to meet your increasing responsibilities as you advance in rate.

Some of the Rate Training Manuals that may be useful to you when you are preparing to meet the occupational qualifications for advancement to RM1 and RMC are discussed briefly in the following paragraphs. For a complete listing of Rate Training Manuals consult the effective edition of List of Training Manuals and Correspondence Courses, NavPers 10061.

Mathematics, Vol. 1, NavPers 10069 and Mathematics, Vol. 2, NavPers 10071 are two training manuals that may be helpful if you need to brush up on your mathematics. Volume 1, in particular contains basic information needed for using formulas and for making simple computations. Information in volume 2 is more advanced.

Radioman 3 & 2, NavPers 10228-E: Satisfactory completion of this training manual is required for advancement to RM3 and RM2. If you met their requirement by satisfactorily completing an earlier edition of Radioman 3 & 2, you should at least glance through the latest revision of the training manual. Much of the information given in this edition of Radioman 1 & C is based on the assumption that you are familiar with the contents of Radioman 3 & 2.

Correspondence Courses: Most Rate Training Manuals and Officer Texts are used as the basis for correspondence courses. Completion of a mandatory training course can be accomplished by passing the correspondence course that is based on the training manual. You will find it helpful to take other correspondence courses, as well as those that are based on mandatory training manuals.

Other BuPers Publications: Additional BuPers publications that you may find useful in connection with your responsibilities for leadership, supervision, and training include the Manual for Navy Instructors, NavPers 16103, and the Naval Training Bulletin, NavPers 14900 (published quarterly).

NAVSHIPS PUBLICATIONS

A number of publications issued by the Naval Ship Systems Command will be of interest to you. Although you do not need to know everything that is given in the publications mentioned here, you should have a general idea of where to find information in NavShips publications.

NavShips Technical Manual: The NavShips Technical Manual, NavShips 0901-000-0013 is the basic doctrine publication of the Naval Ship Systems Command. The Manual is kept up to date by means of quarterly changes. All copies of the Manual should have all changes made in them as soon as possible after they are received.

The following chapters of the NavShips Technical Manual, identified by number, are of particular importance to you.

Chapter	Title
9001	Publications and Plans
9004	Inspections, Records, and Reports
9670	Electronics
9690	Electrical Measuring and Test Instruments

Technical News: The Naval Ship Systems Command Technical News, a monthly technical publication, contains current unclassified information on the work and problems of NavShips and its field activities. The magazine is particularly useful because it presents information that supplements and clarifies articles in the NavShips Technical Manual, and because it contains data on new equipment, policies, and procedures.

Manufacturers' Technical Manuals: Manufacturers' technical manuals, furnished with most electronic units and many types of equipment, are valuable sources of information on operation, maintenance, and repair. Manufacturers' technical manuals for radio and associated equipment usually bear NavShips numbers.

Electronics Information Bulletin: The Electronics Information Bulletin, (EIB), NavShips 0967-001-5703 is a biweekly authoritative publication containing advance information on field changes, installation techniques, maintenance notes, beneficial suggestions, and technical manual distribution. A file of all EIBs should be kept available for handy reference.

Electronics Installation and Maintenance Book: The Electronics Installation and Maintenance Book (EIMB) (formerly EMB), NavShips 0967-000-0000 provides subordinate policies of chapter 9670 of the NavShips Technical Manual. The EIMB consists of several volumes covering each major electronic field.

TRAINING FILMS

Training films available to naval personnel are a valuable source of supplementary information on many technical subjects. Films that may be of interest are listed in the United States Navy Film Catalog, NavWeps 10-1-777, published in 1966. This catalog is now listed in the NavSup Forms and Publications Catalog. NavSup 2002, as NavAir 10-1-777. Supplements to the Film Catalog carry the number NavAir 10-1-777. The United States Navy Film Information Bulletin is promulgated monthly by the Naval Photographic Center and lists corrections, changes, obsolete films, new films, and other information pertinent to the Film Catalog.

When selecting a film, note its date of issue listed in the film catalog. As you know, procedures change; thus, some films become obsolete rapidly. If a film is obsolete only in part, it may sometimes be shown effectively if, before or during its showing, you carefully point out to trainees the procedures that have changed. For this reason, if you are showing a film to train other personnel, look at it in advance, if possible, so that you may spot material that may have become obsolete, and verify current procedures by looking them up in the appropriate sources before the formal showing.

ENLISTED CLASSIFICATION CODES

Special skills in the Navy are assigned a Navy Enlisted Classification (NEC) code. Depending upon your ship's type and mission, you probably will perform duties as a Radioman that require these specialized skills. Usually these NECs are acquired by attending a Navy training school and then on-the-job qualification. Primary NECs within the Radioman rating are as follows:

RM-2303	High Speed Radio Operator
RM-2304	Intermediate Radio Operator
RM-2305	Satellite Communication Terminal Operator
RM-2312	Radio Maintenanceman (B School)
RM-2314	Cryptographic Machines Repairman
RM-2318	Communication System Technical Operator
RM-2319	Communication System Technical Supervisor
RM-2333	Radio Equipment (Submarine) Maintenanceman
RM-2342 -2344	Teletype Repairman
RM-2372	Communication System Technician
RM-2392	Special Fixed Communication System Supervisor
RM-2393	Special Fixed Communication System Operator
RM-2395	Tropo-Scatter Equipment Operator

A complete listing and explanation of all NECs is given in the Manual of Enlisted Classification, NavPers 15105 (series), which is updated semiannually.

No attempt is made in this training manual to discuss extensively any special skills that are covered by NRCs.

CHAPTER 2

COMMUNICATION PLANNING

Communications is the link by which an operational commander directs his forces, receives instructions from his superiors, and keeps them informed of the local situation. It must, therefore, be a two-way street affording reliability, speed, and security needed for successful conclusion of any given task. Before this end can be attained, however, the ways and means by which it is to be accomplished should be made known. The communication annex of an operation order or operation plan conveys this knowledge.

As an RM1 or RMC you may or may not be involved in the actual writing of OpPlans or OpOrders, but it is imperative that you be able to use them effectively. It is with this objective in mind that we proceed in the following manner of covering the entire context and structual makeup of OpPlans and OpOrders.

Special coverage is given to the communication annex, with which you will be concerned primarily as leading Radioman.

Not all exercises will involve the use of OpOrders/OpPlans. In certain instances, when small exercises are conducted involving small numbers of participating units, the OTC/OCE will develop an operating instruction, which will include the communication portion of the exercise.

PLANNING

Before formulating the communication plan itself, some preliminary planning should be done to decide what information it should include. The communication planner must know, for instance, the following data.

- Task and purpose of the mission, so he can decide the types and quantity of circuits that are necessary.
- Types of ships, aircraft, and/or troops assigned, so he can determine the command and tactical radio nets that will be required.
- Type and amount of each unit's equipment, and number of Radiomen and their rates, so he can determine the type and number of circuits they can handle. To carry out the assigned task, he may need to ask for more equipment and personnel.
- Physical characteristics of operational area should be obtained, if possible, in order to know long-range circuit requirements and most suitable frequencies.

The foregoing requirements are but a few of many aspects that must be considered by the communication planner. When writing a communication plan, Naval Operational Planning, NWP 11(A) should be used as a guide.

BASIC OPERATIONS

In communication planning, three basic problem areas exist. They are flexibility in meeting command requirements, operating limitations, and protecting communications.

Flexibility

The commander of a naval operation organizes his forces principally to attain its objectives as effectively and efficiently as possible. Communications must provide him the means for directing and redirecting his forces so that he can take advantage of every favorable opportunity offered by the enemy and be able to meet any enemy threats. He should be able to reorganize his forces to do different jobs than those originally assigned, and communications must be equal to any situation.

As an example of the flexibility just described, if a certain task unit within a task force should be the anti-air warfare (AAW) unit, and the enemy made a full-scale submarine attack too large for the present antisubmarine (ASW) unit to handle, the commander might want to divert some ships from the AAW unit and put them under operational control of the ASW unit commander. For this changeover to take place smoothly and without complications, ships that are diverted must be able to shift without difficulty to ASW circuits. To meet this demand the communication plan should be flexible.

The task force commander must be in constant contact with his task group and task unit commanders. Also, task group and unit commanders must be in constant contact with their units and with individual ships. Ships within a unit must be in constant contact with each other.

All necessary circuits needed for the operation should be included in the communication plan, which must be arranged in such a manner that it can be easily read and understood. Too many circuits could cause confusion and tax communication facilities of participating ships and units. For these reasons care should be taken, when writing a communication plan, to meet the flexibility that a task force must have.

Operating Limitations

Communications must meet the demands of the task organization and contribute to its tactical effectiveness. Conversely, overall plans for the operation should be compatible with communications that can be provided. Three main areas that impose limitations on communications are: selection of radiofrequencies, availability of equipment, and availability of personnel.

Usually the choice of frequencies allocated to an operation is limited because of the constant heavy load placed on the frequency spectrum. From the allocated frequencies, the communication planner makes his selection on the basis of the purpose of the operation, geography of the area, seasonal and solar influences on frequency performance, and equipment available.

The communication planner should consider the capacity of each command in drafting its communication plan. Available information concerning equipment and personnel should, therefore, be aboard each command.

Although certain frequencies may be desirable for use, the planner must ensure that adequate equipment is available before he makes his selection. Because of time limitations, availability of equipment in a forward area, and space needed for installation, additional equipment may be out of the question.

Often, availability of communication personnel is limited. This limitation must be considered when the communication planner assigns circuits and makes guardship arrangements for individual commands.

Each command should organize its communication department so as to handle assigned workloads as efficiently as possible. Work capacity of the department and of individual personnel must be considered. When a command makes up its watch bill, care should be taken so that each position is filled by a qualified man. If training is needed to fill any positions, it should be inaugurated before commencing the operation.

IMPLEMENTATION PLANNING AT SHIPBOARD LEVEL

As leading Radioman you will have a definite role in planning and advising the communication officer in regard to implementing the communication annex of the OpPlan/OpOrder at the shipboard level. First of all, a shipboard CommPlan should be developed, utilizing the communication annex. The CommPlan development should take into consideration the following requirements:

1. Matching circuit requirements with available and appropriate equipments.
2. Calibration of all equipments to planned frequency usage.
3. Which circuits must be up and when, depending upon individual ship commitments.
4. Flexibility to allow for equipment failure.
5. All publications and devices that are required are readily available.
6. Establishment of a system for holding radio checks when implemented by the communication annex.
7. Assignment of key personnel so that they may be used to best advantage.

After the CommPlan has been approved by the communication officer, ensure that copies are provided to all communication personnel well in advance so that misunderstandings (if they exist) may be cleared up before the exercise.

Protecting Communications

Inasmuch as most communications of any operation are handled by radio circuits, protection of these circuits is a prime factor in planning. They must be protected against enemy interception or interference. Some methods used for these purposes are authentication, used to determine authenticity of a transmission; codes and ciphers to provide cryptosecurity; use of on-line cryptodevices that electronically encrypt and decrypt messages as they are transmitted and received; imposition of radio silence to shield movements of forces; and monitor communication circuits to analyze for intelligence information. The communication planner should see that necessary publications are available and that proper overall training is given to the force in communication security.

REQUIREMENTS

After preliminary planning is completed and all communication aspects and considerations are taken into account, the communication planner establishes requirements for the operation. From information gathered from various sources, he makes a preliminary outline for the communication plan. Data considered are capabilities and facilities of participating commands, estimates resulting from staff studies, and information received from Commander Naval Communications on facilities and services available within the Naval Communication System.

The outline for the communication plan should include four basic requirements. They are–

1. Command primary and secondary communications. From this requirement comes the primary and secondary command nets the commander uses to contact his own forces, commanders of other forces, and the command he is under.

2. Communications for logistic and other service and support activities. These circuits are for administrative and supply traffic to rear echelons and supporting activities.

3. Tactical communications. These circuits are used to interconnect various groups and units engaged in the same type of activity, such as anti-air warfare and shore bombardment.

4. Communication security. Provisions must be made for protecting communications discussed earlier.

From his outline and other information gathered, the planner can proceed to formulate the communication plan.

OPERATION ORDERS

Operation orders (OpOrders) are directives issued by naval commanders to subordinates for the purpose of effecting coordinated execution of an operation in the immediate or near future. These directives are prepared in accordance with a standard approved form, as set forth in NWP 11(A), Naval Operational Planning. Common understanding between individual services and, in larger aspect, between different Allied Nations is basic to successful combat. The approved format is designed to reduce to a minimum any areas of possible misunderstanding.

An operation order usually consists of a basic plan made up of the heading, body, and ending, and detailed procedures (in the form of enclosures) called annexes and appendixes as necessary. The basic plan is kept concise, and contains only those details necessary for a clear, overall picture of the operation. Annexes themselves may be brief or protracted. They often have appendixes and tabs to elaborate on the many details to be considered in a large and complicated tactical operation.

Among subjects that properly may be discussed in annexes are battle plans, search and rescue, communications, intelligence, logistics, anti-air warfare, and antisubmarine warfare. This list is not all-inclusive, however.

Amplifying information that is inappropriate for inclusion in the annex may be prepared as an appendix to the annex. In the same way, appendixes may be amplified by preparation of tabs to an appendix. Each one is given a name descriptive of its contents. Appendixes are listed at the end of the annex to which they belong. Tabs are listed at the end of their governing appendix.

DIFFERENCE BETWEEN OPERATION PLANS AND OPERATION ORDERS

An operation plan (OpPlan) is a directive for carrying out operations extending over a large geographical area and usually covering a considerable period of time. Ordinarily an OpPlan is based upon, and therefore restricted by, various appropriate assumptions. It is prepared well in advance of an impending operation, and includes information concerning the time it will become effective. This information may be included in the plan, or it may state merely that it will become effective when signaled by appropriate authority. The OpPlan is the instrument upon which subordinate commanders base directives to their commands covering specific tasks assigned.

An operation order (OpOrder) is prepared in a prescribed form, similar in most respects to an operation plan. It is issued by a commander to his subordinates to effect coordinated execution of a specific operation. It directs that the operation be carried out. No assumptions are included and, unless otherwise stated, the OpOrder is effective from the time and date signed.

Barely in peacetime–and only infrequently in wartime–is the shipboard communicator called on to use an operation plan, although much of his daily routine in handling messages and circuits is part of the communication plan. On the other hand, almost all coordinated operations experienced in the daily life of a sailor and carried out as the result of OpOrders.

HEADING

Figure 2-1 is a sample heading of an operation order. At the right, below the classification, is the title of the issuing headquarters. Omitted from the illustration is the copy number. It would be required on each copy of the directive if joint or combined operations were involved, or for plans and orders concerning only U. S. Navy forces if the document were classified higher than Confidential. Each copy would bear a different number, and a record of disposition must be maintained.

SECURITY CLASSIFICATION

Fourth Fleet
TG 47.5 and ComCarDiv 1
YORKTOWN (CVS 10), Flagship
Norfolk, Virginia
DTG 311200R, October 1969
Message Ref: 0059/69

Operation Order
ComCarDiv 1
No. 52-69

Time Zone: Use time zone plus 5 (ROMEO)
for operations.

50.2

Figure 2-1. –Operation order heading.

The issuing headquarters title is preceded by titles of higher echelons considered necessary to ensure proper identification. The name of the flagship (or headquarters, if on shore) must be included as shown. The geographical location of the issuing commander is listed; or, if at sea, latitude and longitude. The date-time group of the signature, including zone description, appears next. Unless stated to the contrary in paragraph 3x of the order, the DTG is the effective time of the order. A message reference number is the originator's serial number for identification. It is used for in-the-clear message acknowledgment of the order. A message reference number should contain no indication that it is associated with a plan or order.

Underlined words Operation Order appear to the left. This identifying title is sufficient when only one service takes part. If more than one service participates, such descriptive words as Joint Army-Navy Operation Order might be used.

Immediately below the directive designation is the short administrative title of the originator and the serial number of the directive. Each commander serializes his OpOrders consecutively throughout the calendar year.

Pertinent references, if applicable, are listed next; for example, REFERENCES: NWP 20, NWP 16. None were necessary in the example shown.

The time zone to be used in the operation is then included, as in figure 2-1.

BODY

The body of the OpOrder consists of the task organization, five numbered paragraphs, and acknowledgment instructions.

In the task organization listing, each paragraph is lettered alphabetically beginning with the small letter a. Each subdivision of the commander's entire force to be assigned a task is listed separately with its designated task name (Heavy Unit, Screen Unit, etc.), followed by the name of the ship or administrative title of the officer in command of the force, group, unit, or task element.

Because an individual ship often is assigned several different tasks to perform during various phases of an operation, it is common for a ship to be listed under several subheadings of the task organization.

Five Numbered Paragraphs

Paragraph 1 covers the situation. Here the commander sets forth only so much of the general situation as enables all his subordinates to understand the background of a planned operation. A history of preceding events is not desired. All information is brief and to the point. Paragraph 1 always contains three lettered subparagraphs (a, b, and c).

Subparagraph a relates to enemy forces. In a wartime situation, this topic reflects the best intelligence estimate of what the enemy has available. If information is so extensive that it is ineffective in this location, a separate annex may be written, including in the subparagraph a statement such as "See Annex______". When no information is available (as in peacetime), a statement to this effect is made; this section cannot be left blank.

Subparagraph b concerns friendly forces. It refers only to friendly forces not listed in the task organization. Information on friendly forces is always brief and restricted to data required for proper coordination of operations.

Subparagraph c is for listing attachments and detachments. Included here are any forces that will join or be detached from the force as the operation progresses; if none, this information is so stated. If a "Schedule of Events" annex contains this information, reference to that annex is sufficient. (To repeat, none of the three subparagraphs may be omitted or left blank.)

Paragraph 2 states the mission, which may have been assigned by higher authority or deduced from his instructions. In effect, paragraph 2 contains the most important information in the directive. Often it is the first item to be read by a subordinate upon receipt of the document. It consists of the task to be accomplished and the purpose for accomplishing it, separated by the phrase "in order to." By reading the mission paragraph, each subordinate should be able to understand what is to be done and why. No other place in the operation order gives such a concise statement of the intent of the operation.

Paragraph 3 is the execution paragraph. Opening with "This force will," it sets forth, in concise terms exactly what the overall organization is to accomplish.

In succeeding subparagraphs, beginning with letter a, tasks assigned to elements of the organization are prescribed in detail. Letters a, b, c, and so on, identify additional subparagraphs describing tasks assigned each unit of a force. An additional subparagraph, "Coordinating Instructions" follows, identified by letter x. Here are listed items of information to more than one task subdivision as well as instructions relating to security, cooperation, duration of events, and the like. If the directive is to become effective at some time or date besides the date-time group in the heading, this fact is stated in coordinating instructions.

Paragraph 4 is for administration and logistics. Necessary arrangements and procedures for accomplishing the mission are set forth in this paragraph. As elsewhere in the basic plan, it is permissible to refer to a logistics annex if one is appended; or, as often happens in comparatively small local training operations, refer simply to existing instructions.

Paragraph 5 is the command and signal paragraph. As used here, signal means communications. Contained in this paragraph are all special features of command. These features include designation of the officer second in command, and also the location of the commander and his second in command. Additionally, division of responsibility among various commanders is clarified, and the communication plan is described or, customarily, the communication annex is referenced. A complete annex and one or more appendixes are necessary—even for routine operations down to the division level of destroyer operations—because the problem of communications is so enormous and vital.

Acknowledgment instructions usually are included, but are not required. An acknowledgment means that the directive was received and is understood.

ENDING

The ending of the OpOrder includes the signature, list of annexes, distribution list, authentication, and security classification.

To make it effective, the directive requires the signature of the commander. It appears below the acknowledgment instructions, to the right side of the page, over his rank and command title. For OpOrders and OpPlans concerning United States Navy units only, operational and administrative titles are added. The commander signs the original OpOrder and each annex, appendix, and tab.

Task Organization:

a. 47.5.2	Heavy Unit		
	YORKTOWN (CVS 10)	RADM R. M. P. 1 CVS	
	PLATTE (AO 24)	CAPT E. C. R. 1 AO	
b. 47.5.3	Screen Unit		
	DesDiv 152	CDR B. D. W. 4 DD	
c. 47.5.4	Anti-Air Warfare, Coordination Unit		
	DesDiv 153	CDR W. C. M. 4 DD	

1. SITUATION. ComNavAirLant Notice 03360 of 16 February 1969 scheduled an opposed ASW/AAW coordination sortie on 4 November with ComCarDiv 1 as OCE and OTC. This OpOrder covers the conduct of the sortie.

a. Enemy Forces: None

b. Friendly Forces: None

c. Attachments and Detachments: None

2. MISSION. On 4 November 1969 conduct a combined opposed ASW/AAW coordinated sortie exercise from Narragansett Bay in order to train assigned units in antisubmarine warfare and AAW coordination.

3. EXECUTION. This force will conduct a combined opposed ASW/AAW coordination sortie exercise from Narragansett Bay on 4 November 1969

a. Heavy Unit - Sortie in accordance with Annexes ALFA and DELTA.

b. ASW Screen Unit - Sortie in accordance with Annexes ALFA and DELTA, and protect heavy unit from submarine and air attack.

c. Anti-Air Warfare Unit-Coordinate anti-air warfare of the sortie group in accordance with Annex GOLF.

x. Coordinating Instructions.

(1) This operation order is effective for planning on receipt and for operations commencing 4 November 1969.

(2) Search and rescue in accordance with CINCLANFLT OpOrder 1-65, NWP 37, NWIP 23-6, and Annex HOTEL. Submarine Search and Rescue Plan in accordance with COMSUBLANT OpPlan 27-65 (SUBMISS-SUBSUNK) and Annex HOTEL.

4. ADMINISTRATION and LOGISTICS. Administration and Logistics in accordance with existing instructions.

5. COMMAND and SIGNAL.

a. Communications in accordance with Annex CHARLIE.

b. Use zone time plus 5 (ROMEO).

c. Commander Carrier Division 1 in USS YORKTOWN (CVS 10) is OCE and OTC.

d. Commander Destroyer Squadron FIFTEEN in USS PUTNAM second in command.

Acknowledgment Instructions:

Units listed in Task Organization acknowledge receipt of this directive by message using message reference number.

50.3-.5

Figure 2-2.-Task organization and the five numbered paragraphs.

The security classification must appear on the top and bottom of each page of the directive. Below the signature are listed appended annexes, each designated by capital letters. Each appendix and tab to the various annexes are included in the list also.

A distribution list is inserted after the list of annexes. For comparatively short distribution lists, each addressee is listed as part of the basic plan. For longer lists (this practice is usual in all but the simplest directives), the distribution list may be a separate annex. The number of copies each addressee is to receive is indicated. If some addresses are to receive all but certain portions, the deleted part is so indicated. Administrative titles are used in the distribution list, because tactical titles might serve to compromise the directive as well as cause mailing delays.

COMMUNICATION ANNEX

In addition to paragraph 5 of the basic directive, the communication annex is the most important portion of the OpOrder for communication personnel. Purpose of the communication annex is to give information on communications deemed too extensive to be included in the basic operation order.

To provide uniformity, each communication annex of an operation order for U. S. Navy operations must be prefaced by a standard paragraph which reads: "Communications in accordance with effective edition of NWP 16 and appropriate Joint, Allied, and Navy Department publications."

In some instances an OpOrder/OpPlan may not include a communication annex, in which case reference is made to an existing ComOpPlan. When OpOrder/OpPlan does include a communication annex, however, the following applies.

Customarily, but not always, the communication annex is designated Annex C (fig. 2-3). The heading and ending of the annex are identical to those of the OpOrder. The numbering of paragraphs in the communication annex follows the numbering of related matters in NWP 16 that are to be amplified or modified.

In the communication annex for a combined operation, usually no reference is made to NWP 16 because not all Allied Nations have access to that publication.

The amount and type of information found in a communication annex depend on the purpose of the plan or order and on the mission of the command for which it is made.

Types of information that may be found in communication annexes are radio checks, call signs and address groups, frequency plans, distress communications, guardship lists, exercise communications, visual communications, authentication, and broadcast shifts. This list is not all-inclusive, however. Each of these headings is numbered according to the numbering of associated paragraphs in NWP 16.

Appendixes

An appendix amplifies portions of annex material much the same as an annex amplifies a basic directive.

Figure 2-4 is an example of Appendix I (Call Sign List) to Annex C of the OpOrder studied in this chapter. The heading and ending are the same as the annex it appends.

Column 1 lists commands within the task group. Columns 2 and 3 give the international call sign and voice call sign, respectively. These three columns are the only ones necessary in the call sign list. In this example columns 4 and 5 are added to give further information. Column 4 shows call letters of the ship occupied by various commanders. Column 5 lists the task group or task unit of which each command and ship is a part.

Any headings mentioned as being in the annex could be made into appendixes if sufficient information warrants.

Tabs

When necessary to amplify a portion of an appendix, a separate page is added as a tab. Appendix II (Frequency Plan), shown in figure 2-5, is broken down into tabs. Figure 2-6 is a condensed surface frequency plan designated Tab A. Possibly tab B (not shown) could be the aircraft frequency and channelization plan.

Numbering

Annexes are designated serially by capital letters; appendixes, serially by Roman numerals; and tabs, serially by capital letters. Thus, a tab might be referred to as Tab C to Appendix IV to Annex W. Pages of the basic directive are numbered serially starting with Arabic numeral 1; pages of annexes, serially

SECURITY CLASSIFICATION

Fourth Fleet
TG 47.5 and ComCarDiv 1
YORKTOWN (CVS 10), Flagship
Norfolk, Virginia
DTG 311200R, October 1969
Message Ref: 0059/69

Operation Order
ComCarDiv 1 No. 52-69

ANNEX CHARLIE

Communications

113. EFFECTIVENESS

1. Communications in accordance with NWP 16(A), and appropriate Joint, Allied, and Navy Department Publications. NWP 16(A) is effective throughout as applicable to the existing situstion unless modified or amplified by this Annex. The numbering of paragraphs herein follows the numbering of related material in NWP 16(A). The interpretation as to the applicability of a specific article is a function of the command concerned.

410. CALL SIGNS AND ADDRESS GROUPS

1. The call signs for CTG 47.5 and TG 47.5 are effective for use commencing 040600R.
2. Call signs will be those regularly assigned to participating units. (See Appendix I to this Annex.)

619. FREQUENCY PLAN

1. Radiofrequency plan is contained in Appendix II to this Annex.
2. Surface force frequency plan is contained in Tab A to Appendix II.
3. Aircraft frequency plan and channelization is contained in Tab B to Appendix II.

810. EMERGENCY, DISTRESS, AND COMBAT SCENE OF ACTION COMMUNICATIONS.

1. Distress communication guard assignments are prescribed in Appendix II of this Annex.
2. Ships or units not in company shall maintain a continuous split-phone guard on the distress frequencies prescribed.
3. Combat scene of action and ASW incident communications shall be as prescribed in Appendix II of this Annex.

R. M. P.
RADM, U. S. Navy
Commander Task Group 47.5 and
Commander Carrier Division ONE

Authenticated:

H. P. R.
LT, U. S. Navy
Staff Secretary

SECURITY CLASSIFICATION

50.9

Figure 2-3. —Communication annex.

SECURITY CLASSIFICATION

Fourth Fleet
TG 47.5 and ComCarDiv 1
YORKTOWN (CVS 10), Flagship
Norfolk, Virginia
DTG 311200R, October 1969
Message ref: 0065/69

Operation Order
ComCarDiv 1 No. 52-69

APPENDIX I TO ANNEX CHARLIE

CALL SIGN LIST

Command	Call Sign	Voice Call	Aboard	TG/TU
CTG 47.5	A5BC	JETSTREAM	NWKJ	
TG 47.5	C7FG	GLOBEMASTER		
CTU 47.5.2	B6DE	STARFIRE	NEJQ	
TU 47.5.2	D8HI	MOONGLOW		
CTU 47.5.3	E9JK	SUNFISH	NWKJ	
TU 47.5.3	FØLM	BLUESTAR		
CTU 47.5.4	G4NO	GREENSEA	NHXO	
TU 47.5.4	H3PQ	BROADSIDE		
COMCARDIV 1	XYAC	HIGHBROW	NWKJ	CTG 47.5
COMSERVRON 3	STCO	LIGHTSIDE	NEJQ	CTU 47.5.2
COMDESRON 15	DLHU	BEESTING	NHXO	CTU 47.5.4
COMDESDIV 152	XDBY	OVERBOARD	NHXO	TU 47.5.4
COMDESDIV 153	OSBR	CHANGEOVER	NTIR	TU 47.5.3
DUPONT (DD 941)	NTIR	PACEMAKER		TU 47.5.3
PUTNAM (DD 757)	NHXO	GOGETTER		TU 47.5.4
KEITH (DD 241)	NXDO	WANDERER		TU 47.5.3
HENLEY (DD 762)	NHXW	FASTENER		TU 47.5.3
AULT (DD 698)	NTWR	STICKPIN		TU 47.5.3
WALDRON (DD 699)	NTEX	FROGMAN		TU 47.5.4
HAYNSWORTH (DD 700)	NJTA	DRAGSTER		TU 47.5.4
JOHN W. WEEKS (DD 701)	NHEK	LOWBOY		TU 47.5.4
YORKTOWN (CVS 10)	NWKJ	HONEYCOMB		CTU 47.5.3
PLATTE (AO 24)	NEJQ	OILSLICK		TU 47.5.2

R. M. P.
RADM, U. S. Navy
Commander Task Group 47.5 and
Commander Carrier Division ONE

Authenticated:

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LT, U. S. Navy
Staff Secretary

SECURITY CLASSIFICATION

50.133

Figure 2-4.—Appendix I—call sign list.

SECURITY CLASSIFICATION

Fourth Fleet
TG 47.5 and ComCarDiv 1
YORKTOWN (CVS 10), Flagship
Norfolk, Virginia
DTG 311200R, October 1969
Message Ref: 0065/69

APPENDIX II TO ANNEX CHARLIE

FREQUENCY PLAN

1. All frequencies in accordance with JANAP 195(H) and as assigned by ComFourthFlt.

2. Frequency shifts as necessary controlled by the circuit net control station.

3. Surface frequency plan is contained in Tab A to this Appendix.

4. Aircraft frequency plan and channelization is contained in Tab B to this Appendix.

5. Radio checks will be conducted at 020800R, 031500R, and 040700R on all circuits in consecutive order.

R. M. P.
RADM, U. S. Navy
Commander Task Group 47.5 and
Commander Carrier Division ONE

Authenticated:

H. P. R.
LT, U. S. Navy
Staff Secretary

SECURITY CLASSIFICATION

50.134

Figure 2-5.—Appendix II—frequency plan.

SECURITY CLASSIFICATION

Fourth Fleet
TG 47.5 and ComCarDiv 1
Yorktown (CVS 10), Flagship
Norfolk, Virginia
DTG 31120R, October 1969
Message Ref 0059/69

Operation Order
ComCarDiv 1 No. 52-69

TAB A TO APPENDIX II TO ANNEX C

SURFACE FREQUENCY PLAN

Circuit	Use	Desig.	Freq.	Emission	CTG	Screen	Main body	AAW	Picket	Remarks
1	TF/TAC WARNING	C3.5A	318.6	V	N	X	X	X	X	Pickets may secure when in station
2	ASW OPS (SURFACE-AIR)	C3.7B	324.1	V	N	X	X	X	X	
3	TF/TG REPT (PRI CI)	C3.5F	345.8	V	N	X	X	X	X	
4 5 6	SAU SCREEN TAC PRI (A) SAU SCREEN TAC PRI (B) SAU SCREEN TAC PRI (C)	C3.15D C3.20L C3.5D	283.4 389.8 315.2	V		X				See Appendix IV
7	TF/TG OPS ADMIN	C3.5C	442	CW	N	L	L	L	L	Alt Air Safety Net, if required
8 9 10	SAU RPT CI (A) SAU RPT CI (B) SAU RPT CI (C)	C3.14A C3.14D C3.14J	148.68 134.46 158.04	V		X				See Appendix IV

X – Guard
N – Net Control
L – Listen

R.M.P.
Radm., U. S. Navy
Commander Task Group 47.5 and
Commander Carrier Division ONE

Authenticated:

H.P.R.
LT, U. S. Navy
Staff Secretary

SECURITY CLASSIFICATION

50.20

Figure 2-6. –Tab A, Appendix II–surface frequency plan.

by annex letter followed by page number, as C-2. Appendix pages are numbered by adding the Roman numeral in the appropriate place; for example, C-II-1 is page 1 of appendix II to Annex C. Tabs add the capital letter, as appropriate, after the Roman numeral.

DISTRIBUTION OF COMMUNICATION ANNEX

The distribution list is contained in annex Zulu of the directive. Although the communication plan is a supporting plan of the basic directive, it may be either bound with the basic directive or bound separately. In the latter instance, the communication annex may be, and frequently is, mailed separately, sometimes because of classification. It is also a common, desirable practice to provide additional copies of the communication annex. These extra copies make the information more widely available to the communication organization.

CHAPTER 3

COMMERCIAL TRAFFIC

Naval communications does not compete with privately owned and operated commercial communication companies. By terms of the Communication Act of 1934, however, the Navy is authorized to use its radio stations for reception and transmission of press messages and private commercial messages between ships, between ship and shore, and between shore stations and privately operated ships whenever privately owned and operated stations are incapable of meeting normal communication requirements.

Instructions contained in DNC 26 cover the handling by U.S. naval communications of all commercial communications, including official Government traffic involving tolls, and unofficial traffic involving and not involving tolls. These instructions are based upon the International Telecommunications Convention, Geneva, 1959, and the telegraph regulations (Geneva revision, 1958) annexed thereto; the Communication Act of 1934, as amended; rules and regulations of the Federal Communications Commission; and Western Union Telegraph Company tariff books.

COMMERCIAL TRAFFIC CLERK

Each Navy ship, station, or activity authorized to handle commercial traffic or to receive personal messages for transmission via naval communications has a commercial traffic clerk. He is designated in writing by the commanding officer. An experienced Radioman is selected for this task, although usually not the senior Radioman aboard.

The commerical traffic clerk handles all commercial traffic funds. He is not required to be bonded unless Commander, Naval Communications so directs. A summary of duties of the commercial traffic clerk follows.

1. Maintain a complete file of all commercial messages accepted for transmission.

2. Keep a complete file of all incoming commercial messages and all official Government messages, received from other sources than naval communications, for abstracting purposes.

3. Maintain and understand all instructions and materials concerned with handling commercial traffic, such as rate sheets, bulletins, publications, and forms.

4. Collect proper charges and safeguard funds collected and in his custody.

5. Prepare prescribed reports on time and forward them to the communication officer for review.

The commercial traffic clerk performs his duties under supervision of the communication officer. All reports or other correspondence addressed to the Commanding Officer, U. S. Navy Finance Center (Code FC), Washington, D. C., or to the Chief of Naval Operations (Commander, Naval Communications) are prepared for the commanding officer's signature.

WORD COUNT SYSTEMS

As a means of collecting fees for expense incurred when handling commercial communications, the Navy uses two systems of word count. Domestic word count applies to domestic messages and is based on domestic rules and regulations. International word count is used for radiotelegrams and international telegrams, and is based on international rules and regulations.

Domestic telegrams are messages originated at and addressed to points on shore within the continental United States, Canada, Mexico, Alaska, or Saint Pierre-Miquelon Islands, and transmitted in domestic form by wire or radio over all or part of its route.

A radiotelegram is a message originating in or intended for a mobile station, transmitted over all or part of its route by radio communication channels of the mobile service. International telegrams are messages originating at or destined to points except the continental United States, Canada, Mexico, Alaska, or Saint Pierre-Miquelon Islands. Both radiotelegrams and international telegrams are drafted in international form.

A detailed explanation of both word count systems is given in DNC 26, hence is not repeated here. Many examples in DNC 26 illustrate the rules effectively, showing how representative words and groups are counted differently according to their location in a message address, text, or signature.

COMMERICAL TRAFFIC FUNDS

The commandant of a naval district or commanding officer of a ship, station, or activity establishes the maximum amount of naval commercial traffic funds permitted to accumulate in the possession of the commercial traffic clerk. Unless approved by Commander, Naval Communications, however, this sum cannot exceed $100. Accumulated funds must be deposited at least weekly with the supply officer or disbursing officer. Only such amount is retained as is needed to make change.

When required for remittance, funds so deposited must be made available to the commercial traffic clerk by U.S. Treasury check, payable to the order of U.S. Navy Finance Center, Washington, D.C., or Western Union Telegraph Company, as appropriate.

Commercial traffic funds are kept separate and independent from other funds. Records are required to be inspected at least once a month by an auditing board. If practicable, this board includes as members the communication officer and supply officer. Their inspection includes verification of the cash balance and a complete audit of all accounts, including verification of rates used.

Reports of inspections are retained for 2 years if no irregularities are indicated. Original copies of records are subject to call by CNO (CNC) or Commanding Officer, NAVFINCEN Washington. Any report of inspection showing irregularity must be forwarded to NAVFINCEN Washington, via official channels, with endorsements to show what action, if any, has been taken or is recommended.

Whenever the commercial traffic clerk is relieved, a special inspection and audit must be made. The report is forwarded to NAVFINCEN Washington. If the commercial traffic clerk is relieved and no replacement is nominated immediately, commercial traffic funds are retained in custody of the supply officer or assistant for disbursing.

Neither the communication officer nor the naval postal clerk is authorized to handle commercial traffic funds.

Uses of Commercial Traffic Funds

Expenditures of commercial traffic funds are authorized for the following purposes:

1. Money order fees.
2. Postage (as necessary) to mail reports, or for mailing class D messages when originator requests delivery by mail.
3. Registration fees where the commanding officer determines that registered mail is necessary to protect or ensure delivery of the reports.
4. Refund of charges paid on non-Government messages when delivery cannot be made owing to causes not considered the responsibility of the sender.

An exchange-for-cash U.S. Treasury check may be used in preference to a money order. Use of these checks is a protection to the commercial traffic clerk, because, in case of loss, a second original can be issued without necessity of filling a bond.

All such expenditures of commercial traffic funds must be reported in detail on the statement of account form submitted with a message abstract.

Commercial traffic funds cannot be used for such purposes as taxi fare, messenger service, special delivery, or telephone toll calls.

ABSTRACT FORMS

The word "abstract" refers to the series of report forms used for tabulating, reporting, and accounting various categories of commercial traffic handled by naval communications. Three forms are utilized in reporting commercial traffic. Each one is illustrated and described later in this chapter. Following are the form numbers and titles, plus a brief rundown of classes of traffic reported on each form.

1. NavCompt Form 2132, U.S. naval communication service abstract (fig. 3-1): It is used for –

   a. All class D messages, including those by radiotelephone, originated by a naval ship.

   b. All class D messages received and delivered on board or relayed by a naval ship.

NAVCOMPT FORM 2132 (8-64)

U.S. NAVAL COMMUNICATIONS SERVICE ABSTRACT

NAVCOMPT 2101.2

NOTE: Report all messages sent and received including those to and from foreign stations. Submit the original report, two message copies, original and one copy of "Statement of Account," (NAVCOMPT FORM 2065) for personal messages and remittance payable to Commanding Officer, by the fifth of each month. For detailed instructions refer to DNC 26(A).

JOURNAL VOUCHER NO.

PAGE 1 OF 1 PAGES

NAME OF SHIP/STATION/ACTIVITY: USS OVERSEAS DD 123

FOR MONTH OF: SEPTEMBER

COMMUNICATIONS OFFICER (Signature): A. B. Cook / A. B. COOK LTJG, USN

COMMANDING OFFICER (Signature): D. E. Fairly / D. E. FAIRLY CDR, USN

SRS NO. (1)	DATE SENT (2)	DATE REC'D (3)	OFFICE OF ORIGIN (4)	ADDRESSEE (5)	DESTINATION (6)	TRANSMITTING DATA (Use call letters only) RECEIVED FROM (7)	SENT TO (8)	DO NOT USE (9)	NUMBER OF WORDS (10)	COASTAL OR SHIP STATION CHARGE (11)	TOLLS DUE CONNECTING CARRIER (12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	TOTAL AMOUNT DUE OR CASH REMITTED (20)	REMARKS OR EXTENSION (21)
1D	2		USS OVERSEAS	AMCON	CAIRO, EGYPT		SUK		10	1.33										
2D		4	CHRISTCHURCH N.Z.	COOK	U.S.S. OVERSEAS	NPM			14	1.83										
3D		5	AUCKLAND, N.Z.	WITTIG	U.S.S. OVERSEAS	ZLP			22	2.87										
4D	10		U.S.S. OVERSEAS	AMCON	AUCKLAND, N.Z.		ZLP		12	1.60										
									TOTAL	$										

50.134

Figure 3-1.—U.S. Naval communication service abstract, NavCompt Form 2132.

STATEMENT OF ACCOUNT
(NAVAL COMMUNICATIONS)
NAVCOMPT FORM 2065 (REV. 8-64)

NAVCOMPT 7210-1

REPORT FOR THE MONTH OF

TO: COMMANDING OFFICER, U.S. NAVY FINANCE CENTER (CODE FC), WASHINGTON, D.C. 20390

REPORTING ACTIVITY (SHIP OR STATION): U.S.S. OVERSEAS DD 123

DATE FORWARDED: 1 SEP. 69

INSTRUCTIONS

1. Forward in duplicate with remittance to Navy Finance Center, Washington, D.C. 20390 for Class "D" and Class "D" entitled to "E" privilege traffic.
2. Naval Commercial Traffic Funds shall be forwarded by exchange-for-cash U.S. Treasury check when possible.
3. For further instructions refer to DNC-26.

RECEIVED		AMOUNT		PAID OUT		AMOUNT	
CHARGES ON MESSAGES FILED DURING THE CURRENT MONTH		$ 23	15	REFUNDS			
FEDERAL TAX COLLECTED DURING THE CURRENT MONTH		1	05	MONTH	ERROR NOTICE REFERENCE NUMBER		
COLLECTIONS ON MESSAGES PREVIOUSLY REPORTED ON WHICH NO CHARGE OR A SHORT CHARGE WAS MADE						$	
MONTH	ERROR NOTICE REFERENCE NUMBER						
				REPLY PAID VOUCHER NUMBERS			
				REMITTANCE HEREWITH:		24	20
				CHECK OR MONEY ORDER NUMBER 384552			
				DATED 9/1/69			
				DRAWN ON			
TOTAL AMOUNT RECEIVED		$ 24	20	TOTAL AMOUNT PAID OUT		$ 24	20

TOTAL AMOUNT RECEIVED MUST EQUAL TOTAL AMOUNT PAID OUT

FOR USE BY REGIONAL ACCOUNTS OFFICE ONLY

I certify this is a true statement of all moneys received and disbursed by me this month for the Naval Commercial Traffic Fund of this command, Class "D" Traffic. There is forwarded herewith a remittance in the sum recorded on this form.

CERTIFICATION: *(Commercial Traffic Clerk)*
G. H. Isaly
G. H. Isaly RMI, USN
(Signature)

REVIEWED: *(Communications Officer)*
A. B. Cook
A. B. Cook LTJG, USN
(Signature)

FORWARDED: *(Commanding Officer)*
D. E. Fairly
D. E. Fairly CDR USN, USN
(Signature)

D-10504

50.18

Figure 3-2. –Statement of account, NavCompt Form 2065.

NAVCOMPT FORM 2067 (REV. 8-64)

U. S. NAVAL COMMUNICATION SERVICE

Abstract of Class "E" messages

NAVCOMPT 2101-1
SHEET NO. ONE

To: Commanding Officer, U.S. Navy Finance Center (Code FC), Washington, D.C. 20390

DURING MONTH OF: SEPTEMBER

NAME OF ACTIVITY	COMMUNICATIONS OFFICER (Signature)	COMMANDING OFFICER (Signature)
USS OVERSEAS DD123	A.B. Cook A. B. Cook LTJG USN	D.E. Fairly D. E. Fairly CDR, USN

SRS NO.	DATE	ADDRESSEE	DESTINATION	STATION SENT TO (Call Letters)	DO NOT USE	NO. WORDS	CREDIT TOLLS	CREDIT TAX	DR. CASH
5E	2	JONES	MOREHEAD CITY, N.C.	NSS		15	1.29		1.29
6E	10	TAYLOR	ELLWOOD CITY, PA.	NSS		10	1.08		1.08
7E	12	CUNNINGHAM	BERKLEY, W.VA.	NSS		8	1.13		1.13
8E	18	TURNER	WALTHAM, MASS.	NSS		12	1.29		1.29
									TOTALS		4.79	—	4.79

		TOLLS	TAX	DR. CASH
	TOTALS	4.79	—	4.79
	TOTALS BROUGHT FORWARD FROM SHEET NO.			
	GRAND TOTAL			4.79

CERTIFICATION (Commercial Traffic Clerk)

I certify this is a true statement of all moneys received and disbursed by me this month for the Naval Commercial Traffic Fund of this Command, CLASS "E" Traffic. There is forwarded herewith a remittance of $ 4.79

SIGNATURE: G.H. Isaly
G. H. Isaly

DATE: 1 SEP. 69

50.20

Figure 3-3. –Class E message abstract, NavCompt Form 2067.

c. All class D messages originated, received, forwarded, or delivered by a naval station or activity.

d. All class A and B messages (including official radiotelephone messages) transmitted by a naval ship direct to a domestic or foreign commercial shore radio station.

e. All class A and B messages received by a naval ship direct from a commercial shore radio station.

2. NavCompt Form 2065, statement of account (fig. 3-2): This form is required when forwarding remittances for class D private commercial messages, press messages, and radiophotos, and for class D messages entitled to class E privilege. It is not required for class E messages.

3. NavCompt Form 2067, abstract of class E messages (fig. 3-3): This form is used by both ships and shore stations originating class E messages involving tolls, and class D messages entitled to class E privilege.

Abstract forms and message copies comprising commercial traffic reports must be retained on file by the commercial traffic clerk for a period of 24 months.

SERIAL NUMBERS

For identification and accounting purposes, all commercial traffic handled by naval communications is assigned serial numbers. These numbers are known as SRS numbers. They are in addition to regular station serial numbers normally assigned. The SRS numbers are never transmitted with the message. They are written or typed on each commercial message and are listed on commercial abstract forms for identification and accounting.

Each commercial message handled (including paid service messages) must be assigned an SRS number by each ship or station participating in its disposition. As a result, the same message bears a different SRS number at each station handling it.

Additional information concerning specific uses of SRS numbers appears later in this chapter.

Naval communication stations and the Naval Station Guantanamo Bay assign SRS numbers consecutively up to 10,000. All other Navy activities and ships assign SRS numbers consecutively, on a monthly basis, commencing with number 1 each month.

A capital letter (called a suffix) is added to the SRS number to identify the class of commercial message reported. When service messages concerning a message are sent, they are given the SRS numbers of the message to which they refer, succeeded by letter "A" for the first service, "B" for the second, and so on. A group of suffix letters, together with an example of each, is given in the accompanying list.

Class of message	Suffix letter	Example
A	A	SRS 1A
B	B	SRS 2B
D (radiotelegram)	D	SRS 3D
D (press)	P	SRS 4P
D (radiophoto)	R	SRS 5R
D (entitled to class E privilege)	C	SRS 6C
E	E	SRS 7E
E (Christmas greetings)	H	SRS 7H
Service message		SRS 7EA

REPORT SYMBOLS

The Comptroller of the Navy has assigned NavCompt report symbols to commercial communication reports to aid in handling, auditing, and accounting for these reports. Report symbols consist of the word NavCompt followed by a number. For example, NavCompt 7210-1 is the Statement of Accounts report. Other report symbols are given in separate discussions of each message class. The appropriate report symbol must be placed on envelope or cover when forwarding commercial traffic reports. It should also appear on the abstract form itself. More than one report symbol may be used on one abstract form.

Responsibility for Reports

Commercial traffic reports are required whenever commercial messages involving tolls are handled by a ship or station during any calendar month. Monthly traffic reports, consisting of an abstract form, message copies, a remittance, and a statement of account, are mailed to the Commanding Officer, U.S. Navy Finance Center, Washington, D.C. Ships must mail their traffic reports by the 5th day of the month; shore stations by the 10th.

If a ship or station has not handled any class D or class E traffic during any calendar month, a negative report is not required. A statement is required, however, on the first line of the first class D or class E abstract submitted for any subsequent month; for example, "No class D (or E, as appropriate) traffic handled during the month(s) of ____________."

Class A and class B messages are refiled only by those shore stations and activities designated in ACP 117 U.S. Supp-1 as commercial refile activities. Their reports must be forwarded direct to CNO within 10 days after receipt and verification of the commercial communication carrier's refiled traffic billing. Negative reports to CNO are required of these stations for any month in which no class A or class B messages are refiled.

Considerable time may elapse before NAVFINCEN Washington is billed for commercial messages. In extreme cases concerning messages sent to foreign radio stations, involved international paperwork may take more than 1 year before NAVFINCEN Washington finally gets the bill. If NAVFINCEN Washington then finds that the message has not been reported, that office must check with the originating ship before payment can be made. This procedure takes additional time, and may be hard to do after so much time has elapsed. The originator's message files may have been disposed of already, for instance, and responsible personnel transferred, discharged, or retired, Thus, it is readily apparent that incorrect or incomplete reports can lead to complications.

Not all commercial traffic reports are sent to NAVFINCEN Washington. Later portions of this chapter explain which reports are sent to NAVFINCEN Washington and which ones go elsewhere.

COMMERCIAL ABSTRACTING

This section is devoted to a more detailed discussion of message classes and methods of commercial abstracting.

Of the five classes of messages, class C messages are not involved in commercial abstracting, thus they are not mentioned further.

CLASS A AND CLASS B MESSAGES

Class A and class B messages are official U. S. Government messages. Class A messages consist of official messages of the Department of Defense. Class B comprises official messages of U.S. Government departments and agencies except for Department of Defense messages. Both classes are treated together in this section because of similarities in handling, abstracting, and accounting.

Both class A and class B messages are prepared in joint form for transmission over military circuits. Detailed coverage of procedures for handling messages over military circuits are provided in Radioman 3 & 2.

Class B messages requiring commercial refile must always carry an accounting symbol to donate the Government department or agency responsible for payment of commercial charges. When filed with a domestic communication company, the accounting symbol is preceded by the Government indicator GOVT. This indicator appears as the first word in the address. In messages sent to or via foreign communication companies, the Government indicator is changed to US GOVT.

Handling Over Commercial Communication Systems

When it is necessary to file or refile a class A or class B message with a commercial communication company, the following rules apply.

1. When filed directly with a commercial communication company by an originator outside the continental United States, or destined to an addressee outside the U.S., messages are sent via the nearest U.S. military communication facility serving the area in which originated.
2. Provided either originator or addressee is not served by military communications, messages may be filed directly or refiled with Western Union without further transmission on military circuits. This rule applies when charges for delivery to an addressee are the same as (or less than) such charges for delivery from a designated commercial refile point.
3. When refiled by a shore station within the continental U. S. and addressed to a point in the United States, Canada, Mexico, Alaska, or Saint Pierre-Miquelon Islands, domestic form with domestic word count is used. The point of actual origin is added to the signature.
4. When refiled by a shore station in the continental U. S. and addressed to points outside the United States, Alaska, Canada, or Mexico, international form and word count are used. The point of refile is treated as the point of origin; point of actual origin is added to the signature.
5. When filed or refiled by a shore station outside the continental U. S., international form and word count are used. The point of file serves as point of origin, or point of refile is the point of origin, and point of actual origin is added to the signature.
6. When a message in joint form must be sent through a commercial communication system for further transmission by a military system, the message in joint form–complete with heading–is embodied in the text of the commercial message.
7. When transmitted direct by a Navy ship to a commercial shore radio station, international form and word count are used.

The following example shows the form for a GOVT NAVY message as transmitted by a ship to a shore station for refile with a commercial communication company.

```
NSS DE NMWW-
T-
R-291646Z-
FM USS GOODSHIP-
TO JOHN X DOE 1014 BEACHTREE LANE
   ERIE PA
NAVY GR12
BT
UNCLAS
YOUR LEAVE EXPIRES ON BOARD AT
   NORFOLK VA
0745 6 AUG 66
BT
K
```

The preceding message would be commercially refiled in the following form. (Chargeable words are underscored.)

CK 12 WASHINGTON DC 29 JULY 66 515PME
GOVT NAVY
JOHN Q DOE
1014 BEACHTREE LANE ERIE PA
<u>YOUR</u> <u>LEAVE</u> <u>EXPIRES</u> <u>ON</u> <u>BOARD</u> <u>AT</u> <u>NORFOLK</u> <u>VA</u>
<u>0745</u> <u>6</u> <u>AUG</u> <u>66</u>
COMMANDING OFFICER
USS GOODSHIP

Abstracting Class A and B Messages

Class A and B messages transmitted direct to a commercial shore radio station by a Navy ship must be reported on NavCompt Form 2132. (See fig. 3-1.) This monthly report, under symbol NavCompt 2101.2, must be forwarded to both CNO (OP-09B1C) and U.S. Navy Finance Center, Washington. Two copies of all messages are required with each report. No remittance is made; settlement of accounts is the responsibility of CNO/CNC. Reports from ships must be mailed by the 5th of the month after handling.

Incoming class A and B messages received by Navy ships direct from commercial shore radio stations are reported on NavCompt Form 2132. Other requirements are the same as for outgoing messages explained earlier.

Naval shore stations designated commercial refile activities in ACP 117, U.S. Supp-1 are required to submit monthly reports of all class B messages refiled with commercial communication companies. A speedletter report is made, and does not utilize any of the NavCompt forms mentioned previously.

Reports are mailed direct to the Chief of Naval Operations (OP-09B1C) within 10 days after receipt and verification of the commercial communication company's traffic billing. A speedletter report must contain the following information in the order indicated.

1. Report of class B messages.
2. Calendar month and year of report.
3. Inclusive class B message serial numbers reported.

The speedletter report must be accompanied by two copies of each message reported.

One copy must be in the military form in which received, arranged in SRS number order, on metal file fasteners, between cardboard covers, and in groups of 100 or fewer messages. Its cover must be labeled to indicate type of traffic, name of reporting station, and month and year of commercial refile.

The second copy of each message must be in the commercial form in which refiled, segregated into packets according to accounting symbols.

Both message copies must bear complete transmission data, and include the following information in the lower right corner:

1. SRS number (e.g., SRS 23B).
2. Accounting symbol (e.g., INT).
3. Commercial company and city where refiled (as Western Union, WASHDC).
4. Commercial service indicator (e.g., NL).
5. Commercial charges (e.g., $1.25).
6. Date and time of refile (as 011300Z/AUG).

Copies of service messages relating to commercially refiled class A and B messages must be forwarded with a copy of message to which they pertain.

Responsibility for Payment

A reporting activity does not collect toll charges nor send remittances when forwarding class A and B messages reports. In brief, payment for class A and B messages refiled with commercial communication companies is effected according to the ensuing explanation. For class A and B messages transmitted by Navy ships to commercial shore stations, CNO is responsible for settlement of accounts. Because bills submitted by commercial companies often contain amounts for other classes of messages, however, initial payment is made by NAVFINCEN Washington.

Charges for class B traffic are then billed to CNO by NAVFINCEN Washington. In turn, CNO bills other Government agencies responsible for originating their class A and B messages involving toll charges. Thus, naval communications is reimbursed for non-Navy messages handled.

Payment is handled differently for class A and B messages refiled with commercial companies by shore stations. Commercial communication companies bill a refile activity directly. The refile station verifies the monthly billing, certifies it as official U.S. Government traffic, and forwards the certified billing (with supporting message copies), for payment, to the local disbursing office of the NAVFINCEN serving the area in which refiling activity is located.

CLASS D MESSAGES

Class D messages are non-Government (private-commercial) messages handled by naval communications that were received or sent via commercial communication companies. Class D messages include–

1. Commercial (private) messages.
2. Commercial (private) messages entitled to class E privilege.
3. Press messages.
4. Radiophotos

Class D messages are always in commercial form. Handling of class D traffic by Navy ships and stations usually is suspended or curtailed in wartime.

Each category of class D messages is discussed in greater detail in the remainder of this section.

Commercial (Private) Messages

Any naval ship at sea, or in a port that has inadequate or unreliable commercial communication facilities, is authorized to file class D commercial (private) messages. This same authorization extends to overseas shore stations at locations where adequate and reliable commercial facilities do not exist.

Only three shore stations are presently authorized to handle commercial ship-to-shore and shore-to-ship traffic. These authorized shore stations are NavCommStas Balboa, Guam, and Kodiak.

In the following example of class D commercial messages in international form, chargeable words or groups are underscored. An explanation of component parts is given at the conclusion of this message example.

PCH DE NMWW NR1 INTL USS GOODSHIP/NMWW CK26
12 1430
BT MP BT
LOUIS COLBUS
69 EASTTHIRTYSIXST
NEWYORKCITY
BT
SELL TEN SHARES COMPTOMETER AND TWENTY SHARES PULLMAN BUY SIXTY SHARES MAGNAVOX ALL AT MARKET ADVISE TRANSACTION DATE
BT FORD COX AR NMWW K

After the call and station serial number in this example appears the international abbreviation INTL. Next is the office of origin, USS GOODSHIP, followed by her call sign. The check (CK26) consists of the number of chargeable words in the address, text, and signature. (Remember that chargeable words are underscored in this example.) In a commercial message such as this one, the date and local time of filing are always given in two numeral groups, with the date separated by a space from the four-digit hours and minutes group.

The message address contains the paid service indicator MP in addition to the name and address of the addressee. This particular paid service indicator (MP) means that the sender requests delivery of his message to the addressee in person-not by mail or telephone. More than a dozen different service indicators are authorized; DNC 26 carries the complete list. As shown in this message example, the paid service indicator is the first word of the address; it is counted as a chargeable word, and is included in the CK.

After the text is the sender's name, called the signature. Although it is not obligatory to transmit the signature, when transmitted it is chargeable and is separated from the text by the prosign BT. The prosign BT in this message example has many appearances. This prosign separates the preamble from the paid service indicator, paid service indicator from the rest of address, address from text, and text from signature. Prosign BT is never counted or charged in the CK.

Charges and Accounting

Charges to be collected from the sender by the commercial traffic clerk for class D messages include the following specific instances.

1. Charges that accrue to land radio stations.
2. Charges that accrue to the ship radio station.
3. Charges for service over landlines or cable, if any.
4. Relay charges of any intermediate land or mobile radio station.
5. Charges, if any, for special service requested by a sender.

Rate Requests

The International Telecommunications and Radio Conferences held at Geneva in 1959 authorized shipboard stations to make inquiry without cost to coastal stations concerning proper rates for messages for which they do not have necessary information. Because Navy ships are not issued commercial tariff books used for computing charges for class D messages, it is necessary to send a rate request (QSJ or service message) to determine charges on each message. Operating signal QSJ (preceded by $\overline{\text{INT}}$ for military usage, or followed by $\overline{\text{IMI}}$ when operating with commercial stations) means "What is the charge to be collected per word to ____________ including your internal telegraph charge?" As a reply QSJ means "The charge to be collected per word to ____________ including my internal telegraph charge is ____________ francs."

Examples of rate requests are not shown in DNC 26. Two examples are given here. The first one shows the procedure observed by Navy stations on point-to-point circuits. Transmissions from a Navy ship to a commercial shore station constitute the second example of a rate request.

In point-to-point circuit operation between military stations, the total charge for a message is given in United States dollars. Consider the following teletypewriter message, originated at Kwajalein and sent to Honolulu for commercial refile. Note how the operator added INT QSJ at the end of the message.

RR RBHPU
DE RBHPV ØØ9
KWAJALEIN CK13 15 Ø745
POLAROID CORP
CAMBRIDGEMASS
REFERENCE YOUR WIRE MARCH 3 DELAYED SHIPMENT
K6732 PERMISSIBLE
TRATEXCO. INT QSJ
15/1945Z

After computing charges, the operator at Honolulu replied with the following service message:

RR RBHPV
DE RBHPU 58
ZNR
R 152Ø31Z
BT
UNCLAS. YOUR ØØ9/15 Ø745 COML CHGS TWO DOLLARS FORTYSEVEN CENTS. NAVY CHGS SEVENTY-EIGHT CENTS. TOTAL PLUS TAX
BT
15/2Ø31Z

Accordingly, the commercial traffic clerk at Kwajalein collected the following charges from the sender:

Commercial charges	$2.47
Navy charges	.78
	3.25
10% tax	.33
Total	$3.58

A transmission by a shipboard operator to a foreign commercial shore station forms the second example of a rate request. Commercial charges in international communications are quoted per word in gold francs or centimes (100 centimes = 1 gold franc). The gold franc is an international monetary unit used by all member nations in the International Telecommunications Union. Rate of exchange with United States currency is 3 gold francs per U. S. dollar.

Assume that NHDY has a 10-word class D message for an addressee in Rotterdam. After establishing communications with foreign commercial station PCH, the Radioman transmits:

PCH DE NHDY QSJ ROTTERDAM $\overline{\text{IMI}}$ K

Station PCH replies:

NHDY DE PCH QSJ ROTTERDAM CC 4Ø LL 17.5 CTMS K

Station PCH's reply has the following meaning: CC (costal charge) represents charges that accrue to the land radio station; LL (landline) is the charge for service over landlines or cable; CTMS is an abbreviation for centimes.

According to the preceding explanation, charges for this message to Rotterdam are 57.5 centimes (40 + 17.5), or 0.575 franc, per word. For NHDY's message of 10 chargeable words, the total charge to be collected from the sender is 5.75 francs (0.575 x 10). This amount, converted to U. S. dollars at the 3 for 1 rate explained previously, would be $1.92 (5.75 francs ÷ 3).

An important point to remember when obtaining rate requests from commercial stations is to be sure that the operator includes all charges due his station: his station charge, plus any landline or cable charge, relay charge, or charges for special service requested by the sender. This remainder is mentioned here in discussing class D messages, but it applies as well to all classes of messages involving commercial refile. Operators sometimes fail to include all these charges in their QSJ, yet include them in their company's billing. This problem causes no end of difficulty to NAVFINCEN Washington in settling the account. It may test an operator's patience and tact in overcoming language barriers on a radiotelegraph circuit. That commercial charges are computed accurately in most instances attests to the ability and commonsense of radio operators, both Navy and commercial.

Copies of all QSJ exchanges must be forwarded to NAVFINCEN Washington, with the series of messages to which they pertain.

Abstracting Class D Messages

Class D messages are reported on NavCompt Form 2132. Whenever class D messages originate in own ship or station, money paid by senders must be forwarded with the abstract. The Treasury check or money order used for a remittance must be made payable to the U. S. Navy Finance Center, Washington, D.C. Actual transfer of funds between naval communications and commercial communication companies is made by NAVFINCEN Washington.

A complete class D message report consists of the–

1. Abstract (NavCompt Form 2132).
2. Copy of each class D message.
3. Statement of account, NavCompt Form 2065.
4. Remittance.

Special attention is directed to the necessity of reporting all class D messages handled (whether charges are involved or not), together with any QSJ or service message exchanges. Ships sometimes mistakenly fail to report class D messages received over Navy circuits. Failure to make these reports often results in financial loss to the Government. Such failure to make the required report of either sent or received messages usually causes needless correspondence and delay in settlement of accounts.

Message copies forwarded with an abstract must be legible and complete, including full transmission or receiving data. Duplicates must be retained in ship or station files for at least 12 months. Message copies forwarded and duplicates retained in files must show any discrepancies in counting chargeable words; an explanation of delays exceeding 1 hour between receipt and transmission in relaying, or between filing time and transmission time; charges collected, if any; and other pertinent information deemed appropriate.

In communications with naval or merchant ships, be sure to indicate the call sign, on both abstract and message copy, immediately after name of ship. A fraction bar (/) separates the ship's name and call sign.

Class D Messages Entitled to Class E Privilege

Occasionally, because of the location of addressees, naval personnel are unable to send a message in class E form, even though message contents comply in all respects with provisions for class E messages. In other words, the addressee will be at a geographical location other than the continental United States; for example, Hawaii, Puerto Rico, Panama, Japan, or Europe.

A category of messages known as "Private commercial message (class D) entitled to class E privilege," has been established with the view of making available to such personnel a modified version of class E message. Particular care must be taken in handling this category of message, and accounting for it, to ensure that it is not combined and reported with regular class E traffic.

Class D messages entitled to class E privilege are handled in international form as shown in the message example at the conclusion of this explanation. For identification purposes, each message carries the symbol COMLE as the first word of text; COMLE is counted and charged for as one word. Following is an example of a class D message entitled to class E privilege.

NSS DE NMWW –
T –
R – 271949Z
$\overline{\text{BT}}$
USS GOODSHIP/NMWW CK21 27 1500 $\overline{\text{BT}}$
MRS J V KELLY
CARIBE HILTON HOTEL
SAN JUAN PR
$\overline{\text{BT}}$
COMLE MOTHER AND I WILL MEET YOU THURSDAY IN CHICAGO $\overline{\text{BT}}$ JIM
$\overline{\text{BT}}$
K

Handling this type of message by naval communications is without charge. The sender, however, must pay charges incurred by commercial refile at San Juan. To determine the amount, the ship must send a rate request by

QSJ or service message. Charges must be ascertained and paid before transmission of class D message.

An exception to the foregoing rule applies in a class D message entitled to class E privilege destined to an addressee on the island of Oahu, Hawaii. Such a message is delivered by the refile activity at Honolulu by phone or other means not involving commercial refile. The message is written up and handled as a class E message free of toll charges and, as such, is not included in the commercial traffic report. This exception does not apply to messages destined to Hawaiian islands other than Oahu. Commercial refile is then required, resulting in toll charges, abstracting, and accounting.

Abstracting

Ships and stations originating class D messages entitled to class E privilege are required to submit monthly reports under report symbol NavCompt 2101-1 covering all messages originated. For this report, NavCompt Form 2067 is used.

Reports of class D messages entitled to class E privilege are comprised of the following forms:

1. Abstract, NavCompt Form 2067.
2. One copy of each message, showing complete transmission data. A related rate request (QSJ or service message) must be attached to the message.
3. Statement of Account, NavCompt Form 2065, in duplicate.
4. The remittance, made payable to U. S. Navy Finance Center, Washington, D. C.

An additional monthly report is required of shore stations effecting commercial refile of class D messages entitled to class E privilege. For this report, NavCompt Form 2132 is the proper form. If the shore station also handled "regular" class D traffic during the month, the two reports can be combined.

PRESS MESSAGES

In peacetime, the Navy frequently grants permission for duly accredited news reporters to go to sea in Navy ships for the purpose of reporting naval operations and activities. In such instances reporters usually are authorized to file press messages on board. The same privilege may be extended at isolated overseas bases where commercial communication facilities are unavailable.

Three examples of press messages illustrate the message form. The first example shows an international form press message from a Navy ship to a commercial shore station.

ZLB DE NMWW NR 1
INTL USS GOODSHIP/NMWW CK 145 16 1430 BT
PAGE 1/50 BT
PRESSE BT
YOMIURI PRESS TOKYO BT
(FIRST 46 WORDS OF PRESS TEXT WHICH, ADDED TO SERVICE INDICATOR AND 3 WORDS OF ADDRESS, MAKE 50 WORDS IN PAGE 1) BT
NR 1 USS GOODSHIP 1430 PRESS PAGE 2/50 BT (NEXT 50 WORDS OF PRESS TEXT) BT
NR 1 USS GOODSHIP 1430 PRESS PAGE 3/45 BT (REMAINING 44 WORDS OF PRESS TEXT AND ONE WORD OF SIGNATURE BT
TSUBOKAWA BT K

Note the page identification in the preceding message example. A radiotelegram of more than 50 words is transmitted in pages of 50 words. The page number is separated by a slant sign from the figure indicating numbers of words. Included in the first page are the paid service indicator, PRESSE (used only in international communications), and the in address. Each succeeding page is identified as in the example.

The next example shows a domestic/commercial form press message with Navy heading for transmission to a continental Navy shore station for refile with Western Union to an addressee in the continental United States.

NSS DE NMWW –
T –
R – 252130Z
BT
CK 95 DPR COLLECT USS GOODSHIP/ NMWW
25 JUL 1962 415PME VIA WESTERN UNION BT
DPR COLLECT
NEW YORK JOURNAL AMERICAN
220 SOUTH STREET NEW YORK BT
(PRESS MESSAGE TEXT) BT
TSUBOKAWA BT K

In the preceding press message the domestic service indicator DPR (day press rate) is used instead of the international indicator PRESSE (in the first example). Indicator DPR is for all press messages to or from a continental Navy activity and handled commercially by Western Union. As appropriate, DPR is followed by COLLECT, as in this example, or PAID.

The third example is of a press message for an addressee outside the continental United States transmitted to a Navy shore station. The message is in international form but has a Navy heading added for handling over Navy circuits.

NPM DE NMWW -
T -
P - 162045Z
BT
USS GOODSHIP/NMWW CK 145 16 1435
BT
PAGE 1/50 BT
PRESSE BT
(PRESS MESSAGE TEXT DIVIDED INTO
PAGES AS IN FIRST EXAMPLE) BT
TSUBOKAWA BT K

Abstracting Press Messages

Ships and stations handling press messages are required to submit monthly reports. Press messages are reported on NavCompt Form 2132.

The SRS serial numbers assigned to press messages use the suffix letter P after the number; for example, SRS 116P. Remember that SRS numbers are used for message identification in abstracting and accounting only. They are never transmitted.

Press message abstracts, accompanied by message copies and remittances, are forwarded to U.S. Navy Finance Center, Washington. Remittances are by Treasury check or money order, made payable to U. S. Navy Finance Center, Washington. Reports from ships are due in the mail by the 5th of the month after handling; from shore stations, by the 10th.

RADIOPHOTOS

Radiophoto transmission is between Navy facsimile units only. Exceptions to this rule must be authorized by CNO.

In addition to official Navy pictures and graphic material, including those for general distribution to news associations, Navy radiophoto services may be authorized for transmission of commercial pictures. Commercial pictures are of two classes: (1) those for general distribution to newspapers and news associations, and (2) exclusive commercial pictures filed by correspondents and addressed specifically to newspapers or news associations to which they are accredited.

Exclusive commercial pictures are the only ones for which the Navy charges for handling. Thus they are the only ones requiring abstracting and accounting.

Exclusive commercial pictures are abstracted in the same manner as press messages. They also are reported on the same NavCompt form. Abstracts forwarded to NAVFINCEN Washington should be mailed by the 5th of the month from ships, by the 10th from shore stations, and must be accompanied by a copy of each exclusive commercial picture transmitted and received.

For exclusive commercial pictures, SRS numbers are followed by the letter R; for example SRS 24R.

Normally, charges for exclusive commercial picture transmissions are not collected at the time of transmission. Accounting necessary for settlement of Navy charges due is performed by NAVFINCEN Washington. If the sender desires, however, charges may be collected in advance of transmission. In such an instance the remittance and statement of account are included in the report. The flat rate charge for a 7- by 9-inch glossy picture is $30.00.

CLASS E MESSAGES

Class E messages, as defined earlier in this chapter, are personal messages. Part of the leading Radioman's job is to restrict the routing of such messages so as to keep them personal. Subordinates should be instructed that under no circumstances are they allowed to divulge the contents of class E messages to any unauthorized person.

On board ship, incoming class E messages normally are received on the fleet broadcast. They are typed on a regular message form and routed only to the communication officer and addressee. Usually the addressee is called to the communication office to accept delivery. A personal message concerning death, serious illness, or injury is routed to the chaplain for delivery to the addressee. If the ship has no chaplain, the message is routed first to the captain or executive officer.

Class E messages are handled free of charge by naval communications. The only complication concerning class E messages is that most of them must be refiled with Western

Union because of the location of the addressee with respect to the sender. This procedure involves toll charges that must be paid by the sender, and accounting and abstracting by the commercial traffic clerk.

Class E messages were illustrated and described in Radioman 3 & 2. To narrow the present discussion, those class E messages that are free of toll charges are eliminated. In general, these toll-free messages are personal messages handled between ships, and from ship-to-shore, shore-to-ship, and shore-to-shore, when both originator and addressee are outside the continental United States and in the same ocean area. Outbound class E messages also are eliminated from this coverage. Outbound class E messages are originated in the United States and addressed to naval personnel aboard ships or overseas bases. The originator of such a message usually sends a Western Union telegram (he can also use mail) to one of four refile points for outbound class E messages. Depending on the location of the addressee, these refile points are NavCommSta San Francisco, Washington, Norfolk, or Newport. When an outbound class E message arrives at one of these refile stations, the sender already has paid Western Union for transmission from point of origin to refile point. The refile station places the message on an appropriate fleet broadcast or overseas circuit, for which there is no charge. No accounting or abstracting are necessary because the Navy handled no money whatsoever.

The foregoing treatment of class E messages is confined to those originating aboard ship or overseas bases addressed to persons within the United States. These inbound class E messages are subject to toll charges because the refile station must transfer them to Western Union for delivery to the addressee.

Naval communication activities authorized to receive and commercially refile class E messages with Western Union are –

NavSta Charleston
NavSta Key West
NavCommSta Newport
NavCommSta Norfolk
NAS Whidbey Island, Wash.
NavCommSta San Diego
NavCommSta San Francisco
NavCommSta Washington

All of the activities listed are authorized to refile class E messages from ships. Only the last two, San Francisco and Washington, can refile from overseas bases.

Abstracting Class E Messages

All ships and stations originating class E messages involving toll charges must submit monthly reports under report symbol NavCompt 2101-1. All reports are mailed to the Commanding Officer, U. S. Navy Finance Center, Washington, D. C. Ships must mail their class E traffic report by the 5th of the month after handling; shore stations, by the 10th.

Class E message reports consist of three items. They are–

1. Abstract, NavCompt Form 2067.
2. One copy of each class E message handled, showing complete transmission data.
3. Remittance necessary to cover commercial tolls of all class E messages reported.

Remittance must be in the form of exchange-for-cash U. S. Treasury check, U. S. postal money order, or American Express money order. (Cash, postage stamps, or personal checks are not allowed.)

Remittance covering class E messages addressed to the continental United States, and refiled for final delivery by Western Union Telegraph Company, must be made payable to Western Union Telegraph Company, Washington, D. C. Make sure that only those funds due Western Union Telegraph Company are included in the check or money order made payable to that company.

Details for Preparation

When filling in the class E abstract form, messages are arranged in groups according to shore stations to which messages were addressed for refile with Western Union. If there was a considerable volume of messages, a separate sheet must be used for each refile station. For reporting only a few messages, a single sheet will suffice, but be sure to leave a blank space of at least three lines to separate the groups of refile stations.

Copies of class E messages must be arranged and attached to the abstract form in the exact order of listing on the abstract. This requirement will probably cause SRS numbers to appear out of order, but cannot be avoided.

In listing messages on the abstract, use only the last name of addressees. City of destination can be abbreviated.

Be sure that only class E messages destined for refile with and final delivery by Western Union Telegraph Company are included in the class E message report.

Class E Rates

Rate tables for class E messages list toll charges applicable from each refile station to each state (except Alaska and Hawaii) and the District of Columbia. Rate tables are given in DNC 26; they are not repeated here.

In determining rates to be charged for class E messages, the following procedures are observed.

1. Count number of words to be charged. This count includes all words in text and all matter in the signature except name and rank of sender.
2. Consult schedule of rates for city at which message will be refiled with Western Union.
3. Applicable rate appears opposite listing of state in which destination of message is located. In these rate schedules, amount shown is the rate for a full-rate fast telegram of 15 words or less. A separate table is given for determining rates for each additional word above the 15-word minimum charge.
4. If message is to be sent as a day letter (deferred day service) or a night letter (overnight service), determine 15-word full rate as outlined in the preceding step, then refer to separate table of day letter and night letter rates. Its rates correspond to the full-rate charge determined previously. It should be noted that the minimum charge for a day letter or night letter is for 50 words, and that additional words in excess of that minimum are charged for in groups of five words–not by individual groups.

COASTAL HARBOR RADIOTELEPHONE SERVICE

Coastal harbor radiotelephone service is a two-way telephone communication service through a commercial land radiotelephone station between a naval vessel and any telephone on land. This service is provided to meet the needs of ships operating within a few hundred miles of the shore, and is known commercially as the coastal harbor service. Except for USNS contract operated vessels, naval vessels using this service are limited to calls originating on the ship. Calls normally are made collect in order to keep shipboard abstracting to a minimum. Incoming calls to the ship (except those necessary to complete shore-ship connection that involve some delay) are not accepted.

The coastal harbor radiotelephone service is authorized for passing official messages when appropriate. Any official message passed via this circuit requires release by an authorized releasing officer.

All U. S. Navy ships are authorized to use this service in peacetime unless otherwise directed by appropriate authority.

ARRANGEMENTS WITH TELEPHONE COMPANY FOR INITIATION OF SERVICE

Before using this service, a ship must establish an account with the telephone company representative nearest the home port assigned to the ship. The form letter shown in figure 3-4, when filled out, contains all the necessary data to establish a coastal harbor service account. Upon receipt of confirmation from the telephone company, use of the service may commence. Ships desiring to use the Hawaiian coastal ship-to-shore service must make local arrangements with the commercial manager, Hawaiian Telephone Company, Honolulu, Hawaii.

After the account is established, it covers service through all of the coastal harbor stations in the continental United States. No additional advice to other telephone company representatives is necessary.

In the event the ship is assigned to a new home port, a new form letter is sent to the telephone company representative nearest the new home port. A copy also is forwarded to the former representative. Paragraph 4 in the letter serves as authorization to cancel the old account.

Shipboard Arrangements

Shipboard arrangements for use of telephone service are handled by the communication officer. The communication officer or a person designated by him serves as the shipboard technical operator. He is responsible for all technical details incident to shipboard operation of equipment.

Rates for Service

The charge for service depends upon the location of the ship as well as the land telephone. The coastal waters are divided into rate areas, which are defined by latitude and longitude as shown in figure 3-5. Calls normally are made collect. Charges (toll plus 10 percent

____
(Date)

From: Commanding Officer, USS______________________________
To: ____

Subj: Coastal Harbor (and High Seas) Radiotelephone Service; request for establishment of account

1. It is desired that this vessel be registered as a subscriber to the Coastal Harbor (and High Seas) Radiotelephone Service.

2. The following data is submitted:

Name of Vessel: USS____________________

International Call Sign: ____________________

Assigned Home Port: ____________________

Billing Address: Communication Officer,

USS____________________

3. It is expected that calls will be placed within the next two weeks through the following coastal harbor stations (and/or high seas radiotelephone station) __________________________.

4. Previous account with representative for coastal harbor (and/or high seas radiotelephone) station at_______________to be terminated effective ____________________ 19______.

____
(The letter will be signed by Commanding Officer or his duly authorized representative by direction.)

Copy to:
(Type commander)

50.181

Figure 3-4.–Form letter for requesting establishment of coastal harbor and high seas radiotelephone service account.

Federal exise tax) on all calls must be collected when it is impractical to make the call collect. The marine operator will furnish the charges upon request.

Equipment

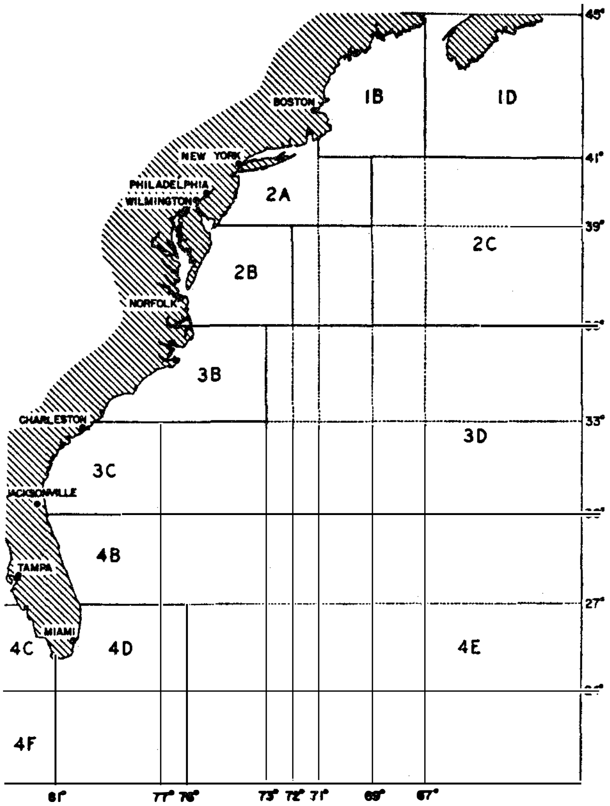
Transmitters: All standard Navy MF/HF transmitters designed for A3 (voice) emission are, if properly tuned and adjusted, adaptable to this service.

Receivers: All standard Navy MF/HF receivers designed for A3 reception are suitable for this service. Accurate tuning to the correct frequency is essential to ensure good service.

Microphones and remote radiotelephone units: Standard Navy model handsets, such as type CRV 51008A and 2592X, used in connection with remote radiophone units type CANG 23500 and CANU 23423, are satisfactory.

Push-to-talk, release-to-listen operation: This method is considered to be the most practical and satisfactory type of operation. However, this method offers difficulties to unpracticed users. It is anticipated that some instruction will be necessary.

Frequencies, station locations, and call signs are listed in the current edition of DNC 26.



50.182
Figure 3-5.—Coastal harbor stations and ocean rate areas, Atlantic Coast.

How To Place a Call

Assuming that the person desiring to place a call has made necessary arrangements with the communication officer, and that transmitting and receiving equipment has been properly adjusted and tuned to the desired shore station frequency, the following procedure is observed for placing and completing a call. The ship's technical operator will–

1. Listen to make certain that the circuit is not in use.

2. If the circuit is clear, call the marine operator by voice. If there is no immediate response, repeat the call after a short interval. Excessive testing, calling, and transmission of signals without identification are forbidden. Example:

"Norfolk Marine Operator, this is the USS Goodship."

3. When the telephone company marine operator responds, give the name of the ship, coastal rate area in which the ship is located, and the city and land telephone number desired. The marine operator should be requested to provide the time and charges when non-collect calls are made. Example:

"This is USS Goodship, rate area 2A, calling Minneapolis, Minnesota 336-1095 collect."

4. When the telephone company marine operator has recorded call details and made necessary connections, the circuit is ready for the person making the call. For best results, speak naturally and not too loudly. Also, wait until the other party has finished speaking before starting to talk.

5. Upon completion of the conversation, immediately advise the telephone company marine operator that the call is completed. Example:

"This is USS Goodship. Call completed."

HIGH SEAS RADIOTELEPHONE SERVICE

Ship radiotelephone service through high seas radiotelephone stations provides communication between a ship and a land telephone. Service is furnished through land radiotelephone stations WOO and WOY, New York, N.Y.; KMI, Oakland, Calif.; WOM, Miami, Fla.; and KQM, Kahuku, Oahu, Hawaii.

Authorization and availability of this service remain the same as for coastal harbor radiotelephone service. Because of the distance involved, however, the provision of service through these stations is subject to transmission, atmospheric, and other limitations.

Ordinarily, service to ships operating near the coast of the United States is furnished through coastal harbor radiotelephone stations established to provide radio communications over relatively short distances. It is contemplated that, in general, ship radiotelephone service through high seas radiotelephone stations will be used by ships operating beyond the normal range of these coastal harbor stations.

CONDITIONS UNDER WHICH SERVICE IS FURNISHED

The conditions under which high seas radiotelephone service is furnished are essentially the same as for coastal harbor stations. An exception is furnishing the station with a general approximation of the ships bearing on the shore station, in order to assist with selection of antenna.

Service Charge

Determination of service charge depends upon location of both the ship and the land telephone. The United States is divided into land rate areas by groups of states; the oceans are divided into ocean rate areas defined by latitude and longitude. Land and ocean rate areas are illustrated in DNC 26.

Billing of Service Charges

Normally, all calls are made collect. If it is impossible for all calls to be made collect, then the charges will be billed against the coastal harbor telephone service account of the ship.

Difference in Operating Procedures

The traffic procedures to be followed by ships in handling calls through high seas radiotelephone stations differ but slightly from handling calls through a coastal harbor station. The essential differences in dealing with calls are as follows:

1. After the radio circuit is established between the ship and the shore traffic operators, the details of all calls on hand are passed, together with any reports pertaining to calls carried forward from a previous contact period.
2. In dealing with a number of active calls, a definite order of precedence of one call over another should be followed. The basic order in the use of the circuits is that a call on which both parties are immediately available is completed before proceeding with new calls; otherwise, calls are dealt with in the order in which they were booked.
3. To facilitate identification of a particular call, where more than one call is active at the same time, the shore traffic operator assigns a serial number to each call.
4. In passing to the ship operator a call, report, or order that necessitates mention of a time of day, the shore traffic operator gives the time in terms of the shore station in all instances.

Frequencies

Operating frequencies for high seas radiotelephone stations are contained in DNC 26.

CHAPTER 4

COMMUNICATION CENTER MANAGEMENT AND ORGANIZATION

Advancement to First Class or Chief Radioman means an increase in authority, responsibility, and leadership—three factors of great importance. This chapter is concerned with the principles of personnel administration and office organization. Rather than set forth in detail the many aspects of communication office management, emphasis of the first section of this chapter is on the basic methods and principles that can be applied in any type of organization.

OPERATIONAL MANAGEMENT METHODS

Naval Communication System and facility managers require precise methods to properly evaluate specific portions of a communication system or an entire system. Such an evaluation provides a means for comparison of present and past performance of equipment and personnel, whereby any improvement or degradation can readily be observed. It also affords an expedient for comparison between types of facilities, as well as between individual facilities, so that weak areas become apparent and corrective action can be taken. This appraisal, in turn, forms the basis for determining operating standards and parameters. Such a continuing evaluation requires the collection of a mass of data, through a system of reports, from each communication section to all management levels.

EVALUATION OF PERFORMANCE

Evaluating the effectiveness of communications is the first consideration in management of a communication center. Overall capability must be examined closely, in relation to each function, so that standards of performance can be established and control elements determined. This selectiveness must include evaluation of the entire system by the highest level of command as well as estimation of each operational unit by the local chief in charge.

ESTABLISHING STANDARDS

Standards of performance must be established to provide a quality gage of the effectiveness of operations and service provided by communications against customer requirements and system capability. Standards must be established for instation functions as well as the overall system performance. After performance standards are established, the control elements and manner of control can be determined.

AREAS OF CONSIDERATION

The broad areas where establishment of performance standards are most important are in reliability, speed, security, and economy. These areas can be broken down into standards for instation operation, equipment, personnel, maintenance, supply, etc.

FLEXIBILITY OF STANDARDS

To obtain maximum utilization of resources without overcommitment, standards of performance capable of attainment must be established at realistic levels that are compatible with command requirements and within resource capability.

They must be sufficiently flexible to vary as operating conditions may dictate. Skill levels and the number of personnel assigned change constantly, the capability and status of equipment vary from time to time and place to place, and operating conditions change from one locale to another. For these reasons, communication system and facility managers must establish standards that are sufficiently flexible to permit adjustment according to local conditions.

MANAGEMENT CONTROL

In employing management control systems, it is advisable to set definite standards. For each control element selected, each level of the organization must establish a minimum standard for satisfactory performance and a goal for improvement. When performance falls below the minimum standard, it reaches the critical or unsatisfactory point where you (as leading Radioman) must take immediate steps to correct the situation. When a report of performance on a control element indicates a declining trend, it means the acceptable standard is not being maintained, and you must find the cause and take corrective action. As leading Radioman, you can evaluate the overall effect of your actions by observing progress toward achievement of the goal or improvement of performance.

RESPONSIBILITY OF MANAGEMENT

As leading Radioman, you must be aware of the need for progressively improving standards. All too often there is a tendency to rely extensively on past performance as a basis for setting the standards.

• Overcoming Resistance: The practice of relying on past performance as a basis for establishing performance standards is often sound, if nothing of proportionate significance creates a state of stagnancy or minimizes efforts to imporve performance. With an organized effort, however, conditions can be changed to improve performance. Moreover, if personnel responsible for better performance are permitted to participate in the organized effort, usually the problem of resistence to higher standards will not be encountered.

• Improving Conditions: Owing to the rapid growth and change in the character of communication systems, considerable managerial effort is devoted to improving reliability, speed, responsiveness, capability, flexibility, security, and economy. The essential approach to this type of problem can be summarized in a sequence to three stages:

1. Discovery of the problems, that is, what elements of the status quo need improving.
2. Diagnosis to determine what changes are needed to bring about the needed improvement.
3. Remedial action, that is, implementing the necessary changes.

• Accepting Responsibility: The foregoing recommendations seem deceptively simple. There is an awareness that changing the status quo requires effort, and that many supervisors and staff sections bear various portions of this responsibility. Responsibilities must be established in accordance with the organizational structure and must be clearly defined.

• Organizational Considerations: Leading Radiomen must also realize that the existing organizational structure may be a contributing factor to poor performance of personnel. In such instances, recommendations must be seriously considered for realignment of the organizational structure.

• Conservation of Personnel Resources: At all levels the communication facilities manager must be constantly aware of the need to conserve personnel resources. Conservation of personnel resources is accomplished by proper evaluation of personnel requirements, and also by the most effective utilization of available personnel through proper training and assignment.

GENERAL ADMINISTRATION

The efficiency and effectiveness with which the communication division functions reflect directly upon the ability of the senior supervisor to set up and manage an efficient organization.

It is the mark of a good supervisor that he retains an open mind to the need for change and makes necessary changes when they seem desirable. Before any plan of approach can be effective, however, the supervisor must have complete knowledge of the functions performed by the office. Not until he has a clear understanding of what is done and who does it can a rational course of action to the problem be initiated. Although the present organizational structure may satisfactorily fulfill the objectives of the division, a periodic review of the organization should be conducted to develop more efficient office methods, techniques, and routines. Acquisition of the latest equipment (a computer, for example) may necessitate a complete reevaluation and reorganization of the division workflow and the office layout. In order to plan properly, the leading Radioman must know–

1. What work is to be done.
2. When the work is to be performed.
3. How the work is to be accomplished.
4. Where the work is to be performed.
5. Who is responsible for performance of the work.
6. Why the work is to be performed.

PERSONNEL MANAGEMENT

Certain principles of good office management – otherwise known as organization – have been worked out by experts and tested by long experience. These principles apply just as well to the supervisor of the personnel office as they do to the head of the communication department. Knowledge of some of the basic organizational principles will be helpful as a guide and as a standard to measure individual concepts of office management. The basic principles usually recognized as requisites for office planning in a military organization are discussed in the topics that follow.

Duty Assignments

The first principle of organization is that every duty performed in the office must be assigned to someone. This requirement includes the obscure or once-in-a-while jobs as well as routine daily duties. Consideration must be given to dual assignments perpetuated by personnel losses or for reasons of leave, transfer, sickness, increased workload, and numerous other staffing contingencies.

Duty assignments emphasize the need for an effective on-the-job training program to maintain qualified replacements for all routine and important duties. Additionally, a thorough knowledge of workloads is required–both present and anticipated – for advanced staffing and manning factors.

Knowledge of Position

The second principle of organization is that as personnel are assigned a specific duty, they must understand clearly the responsibilities of the position. If duties require a combined effort from several people, the person ultimately responsible for the completion of the task must be specified. If the division is required to assign a petty officer to the security watch, a weekly or monthly watch list may be published to ensure that an individual petty officer (by name) is held responsible for standing a specific security watch. The purpose of such definite distinctions is to avoid the possibility of misunderstanding and overlapping of responsibilities. If necessary, any type of recurring task can be set up on a watch list basis, with each individual concerned initialing the list.

Awareness of Responsibility

The third principle is that the same responsibility should not be assigned to more than one person. Assignment of a responsibility must be specific. The simple task of making a guard mail run, for instance, should not be left to a group of radiomen assigned to the radio shack. One individual should be given the responsibility to ensure that a guard mail run is made daily. The need for clarity is obvious: Personnel may be transferred, they may be attending a security lecture, or they may be new to the section and not aware of the assigned responsibilities.

Authority With Responsibility

A fourth principle of organization, personnelwise, is matching responsibility with authority. This doctrine simply means that every supervisor should be given sufficient authority to complete the work for which he is held responsible. Prime examples of authority commensurate with responsibility are permitting the supervisor of a section to approve or disapprove special requests, to assign extra drills, or to recommend marks for consideration in assignment of semiannual performance evaluations.

Span of Control

A fifth principle concerns what is known as the span of control. By span of control is meant the number of men reporting to any one supervisor. The ability of an individual to directly control the work of his subordinates, and do it successfully, depends both on his own capabilities and experience and on the nature and complexity of the work. When the supervised activities are largely routine, the span of control is wide; as the work becomes more complex, the span narrows progressively. The leading Radioman, for example, has overall responsibility for the work, the spaces, and the personnel of the entire communication division. In this illustrative case, a sensible approach to the span of control would be to divide the division into sections, assign a petty officer to head each section, and make each of these petty officers responsible to the division head. In making this breakdown, you, as the leading Radioman, would give consideration to the number of personnel in the division and to the physical location of the various divisional elements. Through this division of effort, your span of control would be narrowed to the three petty officers, thus allowing you to concentrate on the more important aspects of office management and administration.

Fair Division of Work

Another organizational principle concerns fair division of the workload. A common malpractice, frequently done for expediency, is to delegate all the work to the most efficient personnel of the section. This action, in the first place, penalizes the men for being efficient. At the same time it tends to encourage the least proficient personnel to do less work and to lose interest in self-improvement through learning other jobs. Moreover, the efficient personnel may resent carrying the extra workload.

Uneven distribution of the workload ultimately results in a lack of competent replacement personnel. Inexperienced people not afforded the opportunity of on-the-job training cannot be relied upon to maintain the desired level of efficiency nor to replace competent personnel lost through transfer or other administrative action. To maintain a smooth workflow, therefore, all personnel must carry their share of the load.

Other Considerations

The principles just discussed do not constitute the complete list of considerations for good management practices. They do, however, represent the most frequently overlooked and misunderstood work assignment pitfalls.

OFFICE ARRANGEMENT

The physical location of the communication office probably would be determined by higher authority before commissioning the station. Furthermore, the amount of floorspace allotted to the various sections within the departments would be predetermined by competent engineers. After discussing the matter with the senior petty officers in his division, the division officer probably would determine the physical location of furniture and equipment.

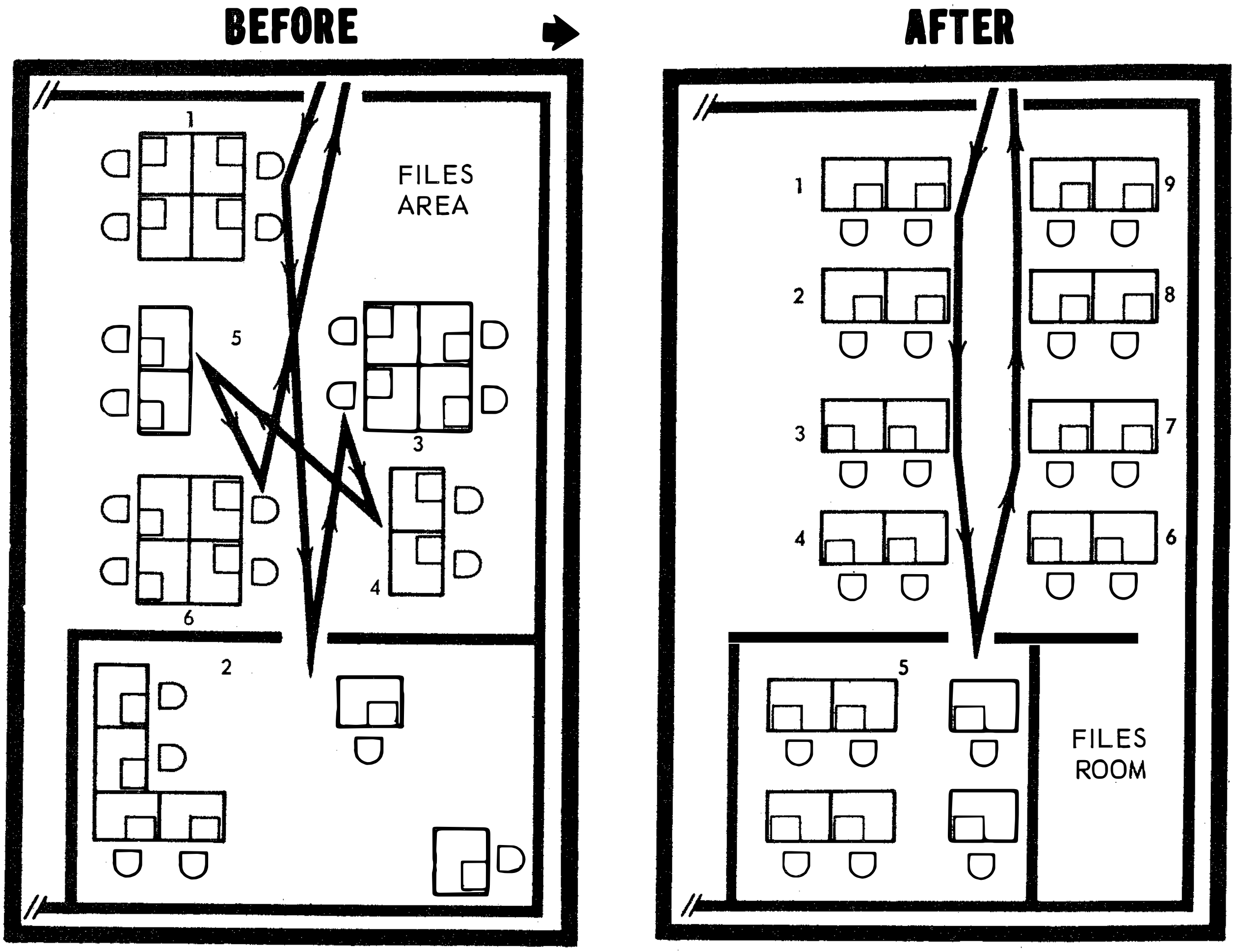
In planning the office layout, primary consideration must be given to the workflow and paperwork, the physical location of workspaces, and the internal communications of the division. Secondary factors to be considered are the number of personnel to be accommodated, safety standards, security of classified material, structural location of electrical outlets, and physical locations of bulkheads and passageways. The following discussion is concerned with the primary problems of office layout.

Workflow

Good workflow is a smooth movement of paperwork from one desk or clerk to another. Insofar as possible, the paperwork should flow in one direction through the various sections with no reversals or crisscrossing. (See fig. 4-1.) Placement of the communication files and the routing desk in different rooms would, for example, cause an uneven flow of paperwork, excessive walking, and unnecessary internal communications. The person responsible for incoming traffic should have the files physically located near enough for immediate access and reference to previous messages. The placement of related positions adjacent to each other reduces the distance, thus increasing the efficiency of the operations, and increasing the daily volume of work accomplished or completed. Workflow affects not only the placement of sections within the division, but also the location of desks, files, and other equipment. Once a steady workflow is attained, changes should not be allowed unless they represent an improvement over the previous system. Deviations from the approved method can cause uneven workflow, with resultant loss of time and motion as well as delays in completion of work assignments.

Physical Factors

The physical layout of workspaces should be reviewed whenever there is a change in the number of personnel or office procedures, whenever the volume of work increases or decreases, whenever new equipment is ordered or to be installed, whenever there is evidence of improper workflow, or whenever there is a change in allotted space. Before any physical movement of office equipment is attempted, it is good management practice to draw a scale model of the spaces available, outlining the placement of present and additional equipment in accordance with the concepts of good workflow. In this manner it is possible to evaluate in advance the tentative layout of the space and judge its probable effectiveness and efficiency.



52.11

Figure 4-1.—Communication space layout—existing and proposed.

Individual desks should be arranged so that the work can flow in one direction. If two men are working together on closely related assignments, their desks should be juxtapositioned. The modified office shown in figure 4-1 could well be a communication office showing the movement of a man checking a message in the files. The man moves from step 1 through 9, in that order. The proper workflow shown in the illustration could also represent the movement of correspondence or other paperwork within the division. As each step is completed, the finished product moves on to the next succeeding step, whether it be a man checking the files, or a message moving toward the supervisor for final checking. In the case of a message, it is unlikely that the work completed at the first desk must stop at each succeeding desk. In any event always remember that the office should have a physical arrangement that will facilitate the flow of work in one direction without crisscrossing or reversing.

In evaluating an office layout, you should consider—

1. Elimination of congestion in the office.
2. Better supervision of personnel.
3. Economical use of space.
4. Increased volume of work with decreasing number of employees.
5. Better appearance of office.

Internal Communications

A major portion of the workload of the communication office consists of receiving, distributing, and filing communications, reports, instructions, and records. What to do with each piece of correspondence or what action is required in each instance is another matter of concern. In order to have an efficient workflow, the supervisor must determine work procedures. Once decided, these procedures should be conveyed to the section, the department head, or other divisions by one of two types of communications—vertical or horizontal. Vertical communications are routed both downward and upward through the chain of command. Horizontal communications are routed to other divisions and departments.

Vertical communications can be formal or informal. In general, formal information consists of office procedures, watches, schedules, and job instructions or orders that are written. This type of information is passed to ensure wide dissemination, accuracy of information, avoid distortions, and to maintain a permanent record. At other times, informal information usually is passed orally. Informal messages provide guidance and instructions on work assignments.

Horizontal communications can be both formal or informal. Occasionally personnel holding parallel positions (e. g., two section supervisors) can reach a mutual understanding of a problem without referring it to a higher authority. Such informal discussion by persons who have an understanding of the matter materially simplifies the work of a complex organization. On the other hand, formal communications must be used when the subject matter requires official approval through the chain of command. Formal communications may be in the form of station instructions, station notices, administrative procedures, or station watch bills.

High Capacity Afloat Communications

The following example is a case study of what can be accomplished through information flow and management study. This particular study was conducted by the Harco Corporation of San Diego, California to be incorporated in the USS Constellation. The objective of the study was to streamline the information flow within the space constraints of the former installation, but with full freedom to rearrange the equipment and bulkheads within the complex as necessary.

The resulting information flow diagram is shown in figure 4-2. The diagram is simplicity itself, as is the actual system. In fact, the system is so simple that the natural reaction from most people is, "Why didn't we think of this sooner?" Some of the salient features are—

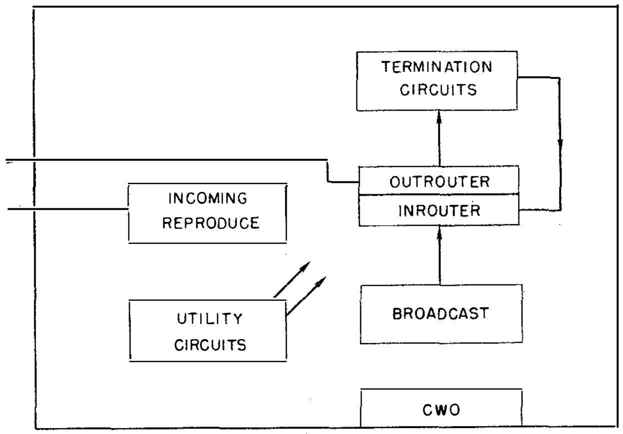


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Figure 4-2. —Afloat message center HICAPCOM.

1. Uninterrupted traffic flow from radio circuits to readers.
2. Short and distinct traffic flow lanes.
3. Rapid reproduction and distribution system.
4. The CWO is removed from the direct traffic flow line. His position is rather supervisory and "large view" as opposed to microscopic. He nevertheless performs traffic checking to assure quality control. In fact, five levels of quality controlscreening are provided in the system to ensure high quality copy and correct routing.
5. Minimum personnel are required to operate the system. The decrease in confusion normally associated with message processing centers allows greatly improved personnel efficiencies.
6. System simplicity permits rapid training of new personnel, because lines of flow are so clearly recognizable.

Similar efficiency improvements have been effected in the circuit control (radio) division required to feed this giant message center. Receivers have been clustered together, as have transmitters and ancillary equipment. Once again, consolidation of like functions has resulted in more effective personnel utilization and less operator fatigue.

The system depicted can handle, with relative ease, 2500 messages a day—and has done so—with excellent quality copy provided by the high capacity and highly reliable Masterfax/ Ditto reproduction system. All this production is accomplished with far fewer men in the message center flow, with greater speeds in processing, and with virtually no message backlogs, even at peak periods.

The one remaining element worth noting is the internal distribution system designed by the Constellation in the summer of 1966, and since adapted by other ships. It is called the "case" routing system. Again, it is quite simple.

Case 1–General interest messages are given broad internal distribution (general messages, full ship evolutions).

Case 2–Basically operational traffic of interest to only the operations oriented group (operational plans, operational reports.)

Case 3–Messages of interest only to one or two shipboard subscribers (milstrips (supply), Hydros (operations)).

Case 3 requires considerable expansion, of course, to ensure that the spectrum of delivery matches the spectrum of interest on the ship. On the Constellation a 6-page routing guide was designed by department heads working in concert. This guide very accurately reflects the interests of the shipboard subscribers. Naturally, such a routing guide is not a static document, and is constantly undergoing refinements. A case routing system such as that used by the Constellation requires a considerable amount of department head and command forbearance and patience during the growing period. Once past the initial trauma, however, the system pays handsome dividends for the entire unit.

This case routing system, then, is one method of processing high volumes of traffic with a minimum of personnel; confusion, and writer-to-reader times.

What of the future? Embellishments of the fundamental design should include optical scanning devices to read drafters' messages, computer aided routing, circuit control, quality control monitors, ionospheric sounders, satellite communications, and automatic distribution from reproduction device to reader. The only limit is the imagination of the reader and the very real limitations of his pocketbook.

TRAINING YOUR STAFF

In training communication personnel, the first responsibility is to see that each man understands how to perform routing duties. Any noticeable deficiencies in the ability of personnel to accomplish routine tasks or in the quality of completed work are indicators that your training program should be reviewed. Training and supervision go hand in hand. It is the leading Radioman's responsibility to provide the men with pertinent Navy training material and the supplementary manuals needed to enhance their professional knowledge. Further, new methods of operation may require new skills of variations in current techniques and procedures, which can be provided only through training. If personnel lack the skills required for immediate application toward the accomplishment of a specific task, therefore, you should provide the space, the equipment, and the time for on-the-job training. Adopt the principle that every billet is a stage for a more responsible one. If applied to your own career as well as those of your men, this principle encourages continued study and efforts to improve. Although many training aids and training programs provided are available from the Bureau of Naval Personnel, the major portion of on-the-job training is the responsibility of the immediate supervisor. Supervisors must be familiar with training methods and thoroughly study all training requirements before undertaking any instruction. Lesson outlines should be prepared well in advance of the training in order to determine subject matter, length of instruction, sequence of materials, and training aids and equipment.

One method of instruction, the 4-step method, usually is applicable in all teaching situations, particularly those encountered in offices or in classroom teaching. The series of steps should be followed regardless of how simple or complex the subject matter. In this method of instruction the lesson progression has a definite sequence.

Step I–Preparation: Put the trainee at ease. Do not stress the difficulty of the job, and tell him he will have plenty of time to learn. State the details of the job, and find out what he already knows about it. Show the relation of past experience or skills to his new job. Interest the trainee in wanting to learn the job. If the training is manual in nature, involving equipment, see that he learns the proper physical stance or position.

Step II – Presentation: Illustrate one important step at a time. Stress each key point. Instruct clearly, completely, and patiently, but no more than the trainee can master in one training session.

Step III – Application: Have the trainee do the job, and correct any errors he makes. Have the trainee explain each key point to you as he does the job again. Continue instructions until the trainee masters the operation.

Step IV – Followup: Put the trainee on his own, but designate the person to whom he can go for help. Check his work frequently, and encourage questions. Taper off extra instruction and close followup.

JOB ROTATION

Although it is customary to assign routine matters to specific personnel so that you know whom to hold responsible for getting the job done, it also is a good management principle to rotate men occasionally in various jobs. Rotation of personnel is useful in two ways: It shows the men how each job contributes to the general function of the office, and it prevents the routine from breaking down when a keyman is detached. Transfers, leave, and sickness all cause frequent changes in the number of assigned personnel. It is necessary, therefore, to be prepared for unforeseen contingencies by keeping your personnel trained to replace one another.

SUPERVISION

It has been pointed out that to be an effective supervisor, one must know both the good and bad qualities of his men, and he must clearly understand the functions the office performs. To put it another way, a good supervisor must know what is going on in his office. Only in that way will he know his job. Too many senior petty officers make the mistake of thinking that once they have assigned a job, they can forget it. At various times this philosophy may be true. For efficient workflow, however, the supervisor should ascertain which men can be relied on to proceed on their own and which men need close supervision or additional training.

By conscientious effort, supervisors can often prevent mistakes or incorrect procedures before they materialize. Being on the alert for bad habits, communicating with clarity (both upward and downward), or simply knowing what is going on, has an invigorating effect on office atmosphere.

CRITICISM AND PRAISE

In addition to the increased responsibility accepted with promotions, supervisory personnel must judge the quality of completed work. In doing so, it may be necessary to criticize unsatisfactory work or praise a man for exceptional work.

Critical comments should always be reserved until all the facts are determined. At times, personnel may have had a valid reason for following a particular method of approach. Insofar as possible, delay making any comment until an informal discussion has been scheduled with the man in private. An informal discussion tends to take the pressure off the man and encourages him to discuss his failures, or (conversely) his methods of increasing his efficiency. During the discussion, to point out things that are wrong may not only be discouraging, but may cause him to continue defending his methods. It is preferable, therefore, to discuss his better aspects, and eventually let the conversation shift to the negative aspects, which you desire to change. Use constructive criticism whenever possible. This tactic means not only to point out why a certain piece of work is unsatisfactory but also to explain how the quality can be improved. If criticism is necessary, be sure it is correct.

As with criticism, it is also an art to praise and encourage personnel. Praise, or recognition of a job well done, is one of the best means of motivating a section. If you want the best efforts from your men, let each individual know that his efforts play an important part in the overall mission of the division. This tribute is simply a just reward for a job well done. Just as individual recognition by name to the division officer helps build morale among personnel, so does public commendation. Practice some restraint, though; overdoing it results in praise losing its value. Do not repeatedly pat a man on the back because he is doing his job well. The enlisted evaluation report is the place for this recognition.

COMMUNICATION CENTER ORGANIZATION

To become a Radioman First or Chief, you must be willing to assume the additional responsibilities and authority that go along with the prestige and extra pay of your rate. In many instances you will be the leading petty officer in your division. As such, you must familiarize yourself with the communication organization and how to place men to best advantage in positions to handle all kinds of situations.

The existing organizational pattern in the United States Navy, ashore and afloat, is an outgrowth of many years of experience, both in time of peace and in war. Established on the "chain of command" principle, its primary objective is effectiveness in battle. Details of a communication organization vary according to ship types, but the basic structure remains the same. Officers and petty officers in the chain have certain administrative duties they must perform. Each category has clearly defined obligations regarding leadership of personnel, upkeep of material, and readiness of his ship for battle.

OPERATIONS DEPARTMENT ORGANIZATION

When a ship does not have a communication department, communications becomes an integral part of the operations department organization. In addition to familiarizing yourself with the communication organization, as already suggested, you must also familiarize yourself with the makeup of the operations department. The operations officer heads up the department. He normally has several assistants. The communication officer and the assigned division officers are the ones you will be working for. From time to time they will assign you tasks requiring a thorough knowledge of the entire ship's administrative command structure as well as the departmental organization. The next three illustrations will help give you a better understanding of the operations department and how it fits into the shipboard administrative organization.

Figure 4-3 typifies a "universal" type of administrative organization, and therefore is not representative of a particular ship. All departments of a typical ship are included; the relationship of each department in the overall administrative organization is shown. Notice especially that the operations department is responsible for these functions: preparation of operation plans and operational training schedules; visual and electronic search intelligence; operational evaluation; combat information; operational control of airborne aircraft; and electronic countermeasures. Additionally, the operations department has cognizance over radio and visual communications; issuance control of RPS-distributed publications; photointelligence; and repair of assigned electronic equipment. Normally, the head of the operations department has several assistants.

Figure 4-4 shows how a communication department for a cruiser may be set up.

A typical departmental organization for destroyers is diagramed in figure 4-5. Because of the limited number of officers available, there is much doubling of duties aboard most destroyers. The executive officer, for example, may also be navigator; the engineer officer may perform the duties of main propulsion assistant; and the communication officer may double as division officer and RPS custodian. Aboard a large ship, having a communication department, the communication officer has several assistants: radio officer, C-R division officer, assistant communication officer, signal officer, C-S division officer, and custodian. In a small ship you will likely be assigned duties that would be performed by officers of a larger ship.

Operations Officer

You already know that on small ships, the communication division is part of the operations department—one of the major command departments aboard ship. As head of the department, the operations officer is responsible to the commanding officer for the prompt performance of the numerous duties and activities assigned to the communication division, CIC division, electronics repair division, and (on some ship types) the photographic division and meteorology (aerology) division.

The operations officer usually prepares sections of the ships organization and regulations manual that are applicable to the department. Departmental instructions, which supplement information in the ship's organization and regulations manual, are also prepared by him.

Communication Officer

The communication officer directs the communication organization. When it is not a separate department, he is answerable to the operations officer for its effectiveness.

He must be familiar with operation plans and operation orders (covered in chapter 3), particularly sections relating to communications. From the OpPlan or OpOrd he must organize, write, and distribute the ship's communication plan.

On larger ships, the communication officer usually is assigned several assistants, some of whom have collateral duties. A description of the assistants follows on page 49.

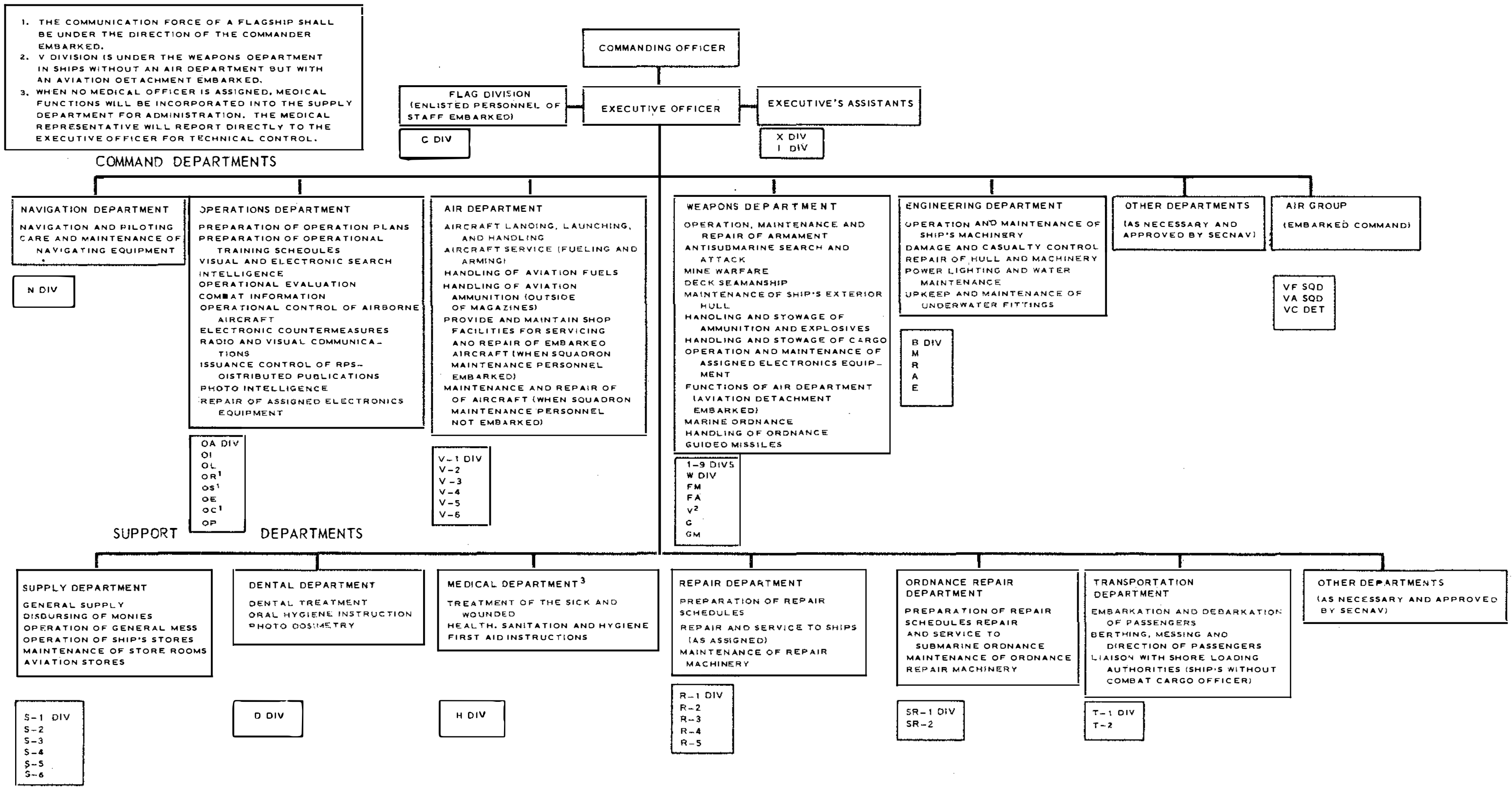

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Figure 4-3. —Administrative organization.

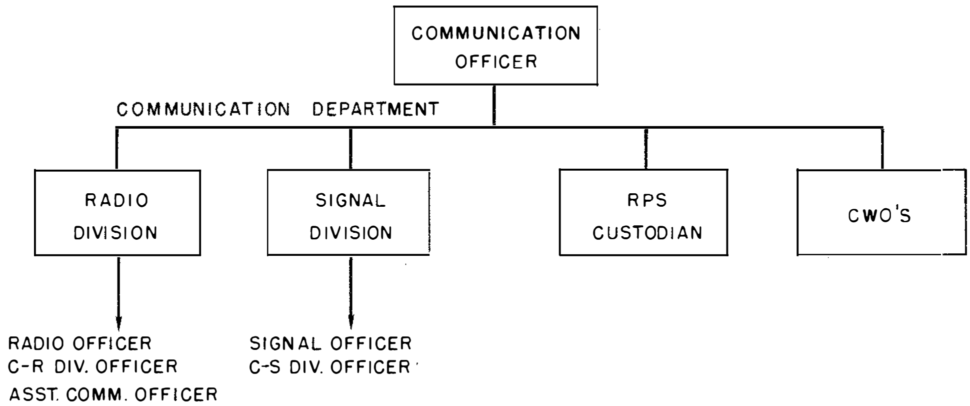

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Figure 4-4. –Communication department organization.

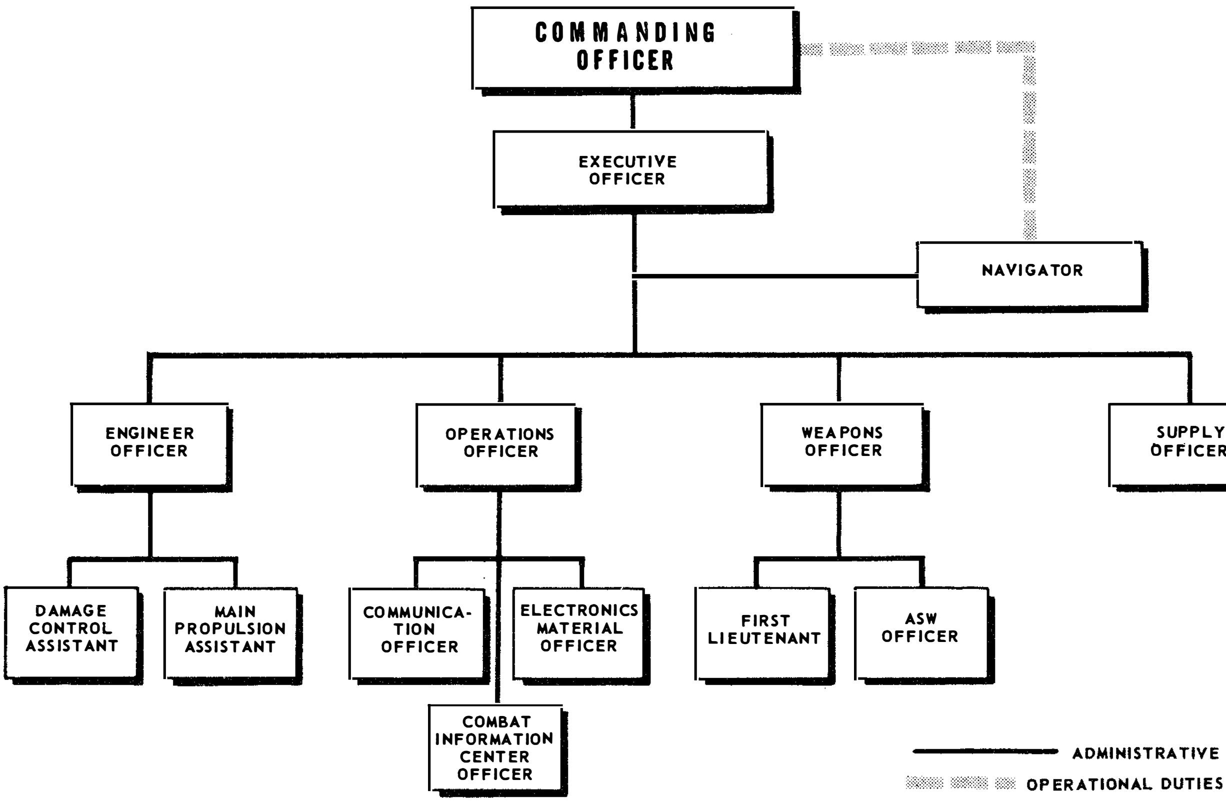

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Figure 4-5. –Departmental organization for destroyers.

Radio officer: The radio officer is responsible for the operation, care, and maintenance of the radio equipment. He usually directs the Radiomen (O-R division). It is his duty to organize and supervise his division in such a manner as to assure accurate, secure, and rapid handling of radio communications.

Signal officer: The signal officer is responsible for the proper operation and maintenance of the ship's visual signaling apparatus. He is in charge of the signal force (O-S division) personnel, supervises their training and watch standing, and takes command of them during maneuvers, tactical drills, general quarters, getting underway, and coming to anchor.

Custodian: The custodian, sometimes called the registered publications officer or RPS officer, is responsible to the commanding officer for the maintenance of a complete, up-to-date, and corrected allowance of registered and nonregistered publications issued by CNO. He is liable for drawing, stowing, correcting, inventorying, and issuing these publications aboard ship.

Division officer: Depending on the size of the ship, the communication officer may also be the O-R/O-C division officer. When this additional designation happens, you, as leading Radioman, will be required to assist in the general administration of communication enlisted personnel. Thus, it is to your advantage to review the duties of the O-R division officer. Don't get the mistaken idea that because you are the leading Radioman your work pertains only to radio and radio watches. Actually, your job includes running the division, assuming responsibility for compartment maintenance, cleanliness of spaces, and so on. Even if the communication officer does not serve as O-R division officer, the officer who does head the O-R division and the division's assigned personnel and material normally works with the communication officer in organizing the communication team and will delegate considerable work to you.

In some ships (again depending on size) the RM1 or RMC may be required to act as junior division officer. He assists the division officer in coordinating and administering the division, and helps prepare bills. At the same time he must develop a thorough understanding of the division's functions, and must know all about the directives governing its operations, and equipment assigned to the division.

Responsibilities of the division officer and his assistants, the petty officers, are required by Navy Regulations. Those requirements specify that he must train his men "in their duties and in the duties to which they may succeed, and shall encourage them to qualify for advancement and to improve their education."

One of the first duties of a division officer is to ensure that initial personnel assignments are properly made and that each man can be identified with a billet assignment shown on the watch, quarter, and station bill. To accomplish this primary duty assignment, observance of the following 6-step process is recommended:

1. Assign men to three sections under section leaders as shown in figure 4-6, maintaining rates and numbers of men in each section

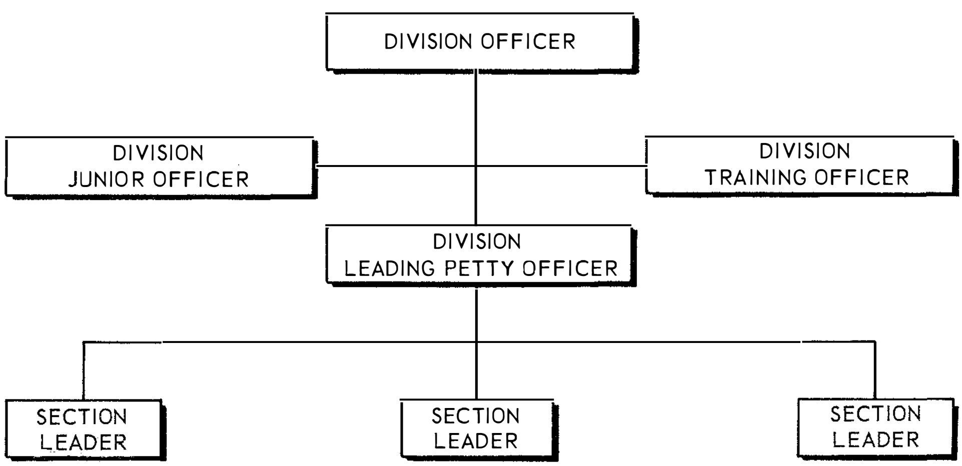

Figure 4-6. —Typical division organization.

as nearly equal as possible to conform to the personnel assignment bill. (The personnel assignment bill is contained in the battle bill. Its purpose is to set policy for assigning officers and men to billets in the various departments of a ship.)

2. Arrange the rates in each section in order of seniority from top to bottom. Watches, liberty, and duties normally are assigned on the basis of the 3-section makeup of the division, but is subject to change when workload increases or decreases.

3. Make a list of division responsibilities given in the ship's organization and regulations manual, and indicate the number of men required for each station of duty–such as special sea detail, replenishment at sea, rescue and assistance, rescue of survivors, emergency assistance, landing party, visit and search–and whether men must be assigned from each section.

4. Assign men of the required rating or ability, from appropriate sections, to each station and duty listed in step 3.

5. Fill out the watch, quarter, and station bill by applying assignments made in steps 2 and 4. Post completed bill to inform personnel of their stations and duties.

6. Assign men to watches and special duties not included in ship's organization bills, and post the watch and duty lists.

Secondary division officer duties and responsibilities are as follows:

1. Schedule and conduct training for personnel assigned to the division. Be sure that phases of division training include indoctrination of new personnel; preparation for advancement in rating, including correspondence courses that cover both military and professional subjects; individual instruction and drills in shipboard duties; team training to fulfill operation requirements of the division; and individual training through USAFI courses.

2. Initiate enlisted performance evaluation sheets for personnel of his division.

3. Maintain a division notebook containing–
   a. Personnel data cards.
   b. Training program data.
   c. Space and equipment responsibility log.
   d. Watch and battle stations required to be manned.
   e. Other information that may be useful for ready reference and for the orientation of any officer relieving the division officer.

4. Assume responsibility for all forms, reports, and correspondence originated or maintained by his division.

5. Establish and maintain a division organization manual and other directives necessary for the administration of his division.

6. Make recommendations to his department head for personnel transfers and changes in the division allowance.

7. Ensure that prescribed lectures on security are conducted and that security measures are strictly observed by personnel of his division.

8. Forward requests for leave, liberty, and special privileges (with recommendations).

9. Conduct periodic inspections, exercises, and musters to evaluate performance and discipline of his division and initiate disciplinary action, when deemed necessary, in accordance with the Uniform Code of Military Justice and other regulatory directives.

Communication training officer: If enough officers are available, one may be designated the communication training officer. Otherwise, this assignment doubtless will go to the junior division officer or the leading Radioman. Whoever serves in this capacity is responsible for organizing, instituting, and coordinating all individual and team training for all officers and enlisted personnel attached. Briefly, but more specifically, the communication training officer–

1. Develops and administers a long-range training program.

2. Coordinates communication training with the operations department through the operations training assistant and the O-R division officer.

3. Recommends to the communication officer changes and improvements in the training program.

4. Reports directly to the communication officer, basing his reports on information furnished him by the communication assistant training officer and other personnel assigned to training tasks.

Section leaders: In the Navy, individuals are specially trained. As they become experienced and capable, they are placed in positions of responsibility. You can see in figure 4-6 that the top man in each section is the section leader. Section leaders are important links in the chain of command. For this reason, they should not be chosen at random nor just because they wear hashmarks.

The main obligation of the section leader is to assist the senior Radioman (as necessary) in briefing, instructing, and training men so that the division's work will be completed successfully. Next in importance is to look after the welfare of his men. In general, section leaders serve as watch supervisors.

As leading Radioman, you should not attempt to carry the entire load yourself. Utilize your section leaders and petty officers to the fullest extent. You should consider yourself as the "cement" that holds the division together–not as the "keystone" of the entire division. Constantly search for better ways to execute certain evolutions. Ask for recommendations or comments from your section leaders and personnel in the division.

Division police petty officer: Excluding CPOs, most ships have a petty officer from each division assigned as division police officer (PPO). In port the duty section leader takes over as division PPO outside normal working hours.

In general, personnel assigned as division PPOs serve for 3 months. When appointed to or relieved from such duties, they must check in and out with the chief master at arms. If possible, the division PPO should be relieved from other divisional duties during his tour of duty as PPO.

The division PPO and the duty section leader (when he is the acting PPO) must–

1. Maintain discipline and cleanliness at all times in their divisional compartments.
2. Conduct division reveille daily and report to the chief master at arms office: "Division turned out and bunks triced up."
3. Hold divisional authorized late sleeper reveille in accordance with ship's routine, reporting: "Up all late sleepers."
4. Ensure that all loose clothing found adrift in divisional compartments is turned in to the lucky bag.
5. Instruct and supervise compartment cleaners in the proper method of cleaning the compartment and the heads for which they are responsible.
6. Act as division mail petty officer and collect divisional mail in accordance with ship policy.
7. Perform the duties of division liberty card petty officer, and have liberty cards available for the division 1/2 hour before liberty time, ascertaining that each man is in proper uniform prior to issuing his card.
8. At designated times, make certain that the compartment is swept down and trash disposed of properly, and make required reports.
9. Sound taps in divisional spaces and report to the master at arms office: "Division turned in."
10. Pick up and issue early meal passes.
11. Within the division, enforce compliance with orders for "Sweepers," "Smoking lamp," "Knock off all games," etc.
12. Perform any other police duties directed by the division leading petty officer, division officer, and chief master at arms.

ORGANIZING COMMUNICATION CENTER

The communication team should be so organized that the ship is enabled to carry out most effectively her specific and contingent tasks. Responsibility for discharging these tasks is assigned by the ship's organization book and battle bill, which show how each department is affected. When the communication organization is based on peacetime allowances and is called upon to perform wartime evolutions, undoubtedly certain personnel must be shifted from one billet to another so as to conduct prescribed exercises or duties.

The two topics that follow discuss some of the sources of information for setting up a communication center for all conditions of readiness. You will find that these informational guides also are advantageous to you in your capacity as leader and instructor of the men in your division, because, as leading Radioman you will–

1. Serve as assistant to the communication officer in the general administration of communication enlisted personnel.
2. Plan, organize, schedule, and supervise training programs.
3. Plan facilities and organize personnel for communication operations for all conditions of readiness.
4. Supervise and train personnel in operating interrelationships as a communication team. Bear in mind, too, that often you may be required to write part or perhaps all of the material for the sources cited.

Besides the individual ship communication doctrine, certain bills and instructions are other sources of information that should be consulted as guides when setting up a communication center and assigning personnel to various billets. A description of the general content of some of the more widely used bills and instructions follows.

Operational bills: Operational bills are concerned with special sea detail, replenishment at sea, rescue and assistance, landing, party, visit and search, and boarding and prize crews.

Emergency bills: Emergency bills are applicable for a general emergency (e.g., fire bill, collision bill, and man overboard bill).

NOTE: Usually, the operational bills and emergency bills are contained in the ship's organization and regulations manual.

Training bill: The training bill—a schedule and outline of training for a particular group—should be in writing and should meet the requirements of Navy Regulations, CinClantFlt and CinCPacFlt instructions, type commander instructions, and any instructions promulgated by the various Nayy bureaus that apply directly to communication training. To make certain that personnel are given an orderly training program, this bill is implemented by lesson plans and records.

Destruction bill: The destruction bill should be complete and sufficiently detailed so that no essential evolutions or functions are overlooked. The Department of the Navy Security Manual for Classified Information provides the necessary information required in the bill. Make sure that your destruction bill covers the following points: (1) Definite procedures set forth in detail for carrying out destruction in shallow water and deep water; (2) order of priority of destruction; (3) provisions for destruction of classified and unclassified equipment clearly outlined (category of equipment listed); (4) provisions for destruction of classified publications and accountability for their destruction; (5) determine that the necessary destruction devices are available and properly stowed in communication spaces; and (6) see that the watch, quarter, and station bill provides personnel by billet or job classification to carry out provisions of the destruction bill.

Instructions and notices: Instructions and notices are issued frequently. They are serially numbered department or division directives. Instructions are directives of a continuing or permanent nature. A notice is effective for only a short time.

STAFFS AFLOAT

When a flag is embarked in a ship, efficient operation demands consolidation of staff and flagship communication operational personnel. The staff communication officer assumes direct authority over this team, prescribing watches, message-handling procedures, and other details to maintain effective communications. He is also responsible for providing the commanding officer of the flagship with appropriate communication services.

While the flag is embarked, the ship's communication officer will be assigned additional duty in the staff and assist the flag communication officer in fulfilling his responsibility. He is the contact officer for matters pertaining to handling ship or staff message traffic. Care must be exercised to maintain the communication organization and files of the flagship intact so that, when the embarked staff moves, the ship's communication organization can resume operations.

STAFFS ASHORE

Communication services to shore-based staffs vary substantially, depending on the volume and nature of traffic, operational requirements of the organization, and availability of communication support. Communication requirements, therefore, are discussed only in general terms here.

A staff with a small traffic volume and no special terminal requirements may receive communication support in the form of over-the-counter service from the message center of another conveniently located organization. A staff that conducts an operations control center may require a communication center with a wide assortment of facilities to meet its requirements. These facilities include AUTODIN access, AUTOVON drops, weather nets or other dedicated systems, and operating positions for direct control of ship/shore and air/ground circuits. Such a large organization may operate its own radio facilities, or it may receive services from another organization or a communication station or unit.

CHAPTER 5

U.S. COMMUNICATION SYSTEMS

This chapter is designed to show how the Naval Communication System links its various ships and stations in order to provide a continuous flow of information from the smallest unit at sea to major commands ashore.

NATIONAL COMMUNICATIONS SYSTEM

RM2 E074

The objective of the National Communications System (NCS) is to provide all necessary communications for the President and the Federal Government—at all times and under all conditions. Such conditions may conceivably range from a normal situation to national emergencies and international crises, including nuclear attack. The system is developed and operated so as to be responsive to a variety of needs of national command authorities. It must be capable of meeting priority requirements under all emergencies. To obtain survivability of essential communications in all circumstances, the system must possess necessary combinations of hardness, mobility, and circuit redundancy.

The Secretary of Defense is executive agent for the NCS. It encompasses assets of the Department of Defense, State, Federal Aviation Agency, National Aeronautics and Space Administration, and Federal telecommunications system managed by General Services Administration. The NCS has designed and is continually improving the necessary technical and procedural standards and establishing the necessary degree of interconnection required to integrate its several elements. Such assets as just mentioned are thus ensured of being utilized effectively to serve national needs in emergencies.

DEFENSE COMMUNICATIONS

The Defense Communications System (DCS) is under the operational and management direction of the Defense Communications Agency (DCA). It is an agency of the Department of Defense (DOD). Within the DCS the chain of command is from the Secretary of Defense, through the Joint Chiefs of Staff (JCS), to the Director, DCA.

The Defense Communications System comprises all worldwide, long-haul, Government-owned and -leased, point-to-point circuits, terminals, control facilities, and tributaries of the three military departments, as well as other Department of Defense activities.

The DCS combines into a single system selected communication elements of the Army, Navy, and Air Force, as well as the DCS Automatic Voice Network (AUTOVON) and Automatic Digital Network (AUTODON) Systems.

DCA ORGANIZATION

A significant reorganization of Defense Communications Agency headquarters, announced in November 1966, affected primarily the Defense Communications System Directorate and the Communications Satellite Project Officer. The latter office was integrated into the Defense Communications System. In turn, the former four directorates of the DCS were reorganized into three offices: Plans and Policy, Program Implementation, and Operations, each office is under a flag or general officer. Basic functions of the three offices are listed in figure 5-1, which indicates the new setup within the DCS.

A prime reason for the reorganization was to include as part of the DCS satellite circuitry as the new element of communications rapidly becomes operational. In effect, satellites are becoming a normal rather than a special mode of communications thus, affording one more method of providing DCS long-haul circuitry. (Satellites are discussed later in this chapter.)

Second in importance (in the DCA reorganization) was the necessity for strengthening the program management elements of DCS. Program Management Offices were established

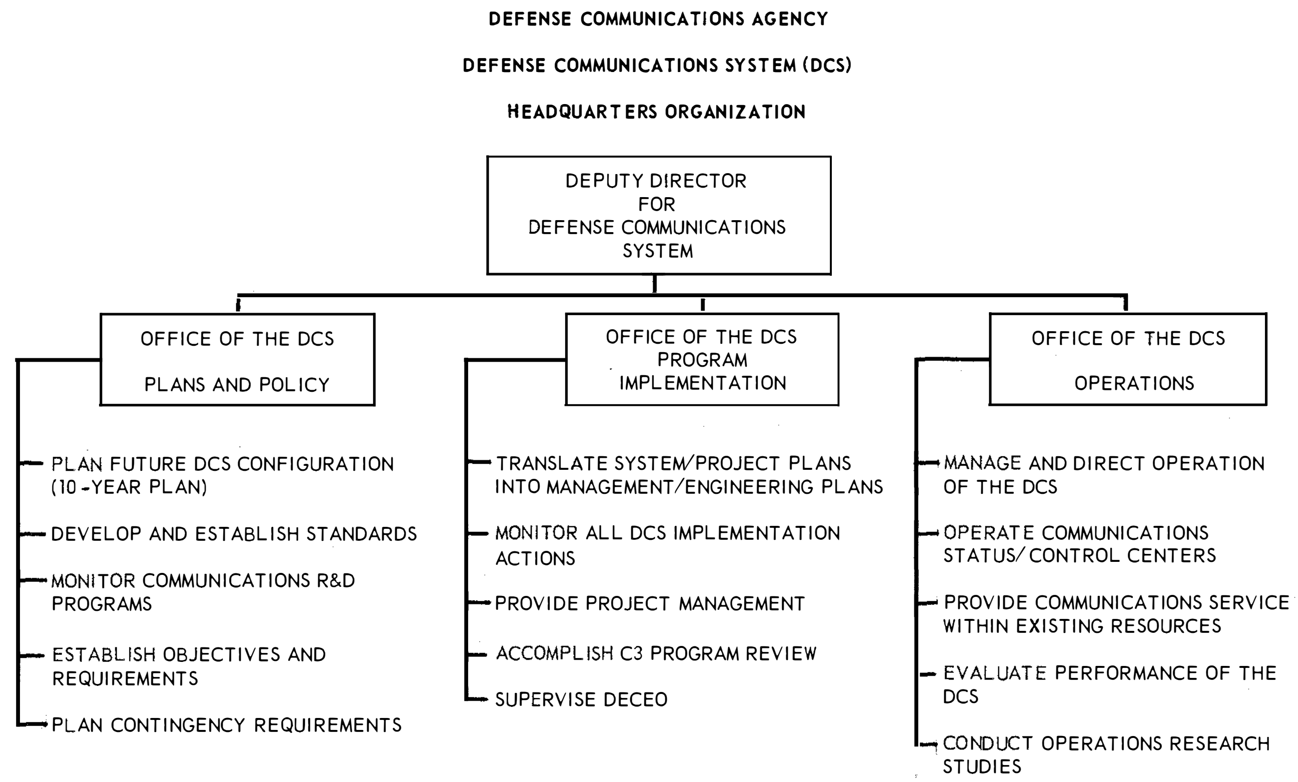

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Figure 5-1.—DCS organization structure.

under the Assistant Director for Program Implementation. Five program managers serve as a single focal point in implementing the principal DCS program: the Defense Special Security Communications System (DSSCS), Autovon, Autodin, Autosevocom, and Satellite Communications (SATCOM). A sixth program manager closely monitors implementation of various DCS programs, such as transmission upgrading and high-frequency improvements. The Assistant Director for Program Implementation also functions as the Chief of the Defense Communications Engineering Officer (DECEO). In turn, the DECEO organization is strengthened by the addition of engineering billets previously in the DCS staff, including those in the former CSPO. A feature of this reorganization places major emphasis a single focal on implementing all major programs.

Another facet of the organization is the centralization of the requirements function in a division under the Assistant Director for Plans and Policy. Requirements are processed and reacted on first by the operators, if a capability exists; if not, through the planning and implementation cycle.

In summary, this new reorganization places the DCS directorate in a position to logically plan for the future, monitor the implementation of current programs, and carry out the day-to-day operational direction of the Defense Communications System under three clearly defined offices, each directly responsible to the Deputy Director for Defense Communications System.

DEFENSE COMMUNICATIONS AGENCY

The Defense Communications Agency (DCA) has operational direction over the Defense Communication System. This direction is set up by policy coordination with the commanders of each military service and by operational coordination with the communication headquarters of each service.

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 by the Joint Chiefs of Staff, by authority and direction of the Secretary of Defense.

The DCA operates a communication control complex consisting of a requisite number of operational control centers. The objective of this complex is to accomplish the mission of the DCA. The mission of the DCA is to-

- Ensure that the Defense Communications System (DCS), as established, will be improved so as to meet the long-haul, point-to-point, telecommunication requirements of the Department of Defense and other governmental agencies as directed.
- Provide technical support to the National Military Command System.
- Be the strong focal point for continuing integration of space and ground elements of the communications satellite systems to meet DOD requirements.

Defense Communications Agency Operations Center

The Defense Communications Agency Operations Center exercises operational direction over all elements of the DCS through Area Communications Operations Centers. See figure 5-2. It provides communication status information as required by the Joint Chiefs of Staff. The Operations Center maintains and displays the status of the worldwide DCS.

Internally it consists of four major elements. These elements are input devices, a computer, displays, and control facilities. Input devices are standard teletypewriter machines used for the reception of Operational immediate status messages from various reporting stations in the system. These status messages consist of information concerning the state of readiness of circuits and facilities comprising the DCS. Such messages include outage information, delays in transmission resulting from traffic backlogs, and important users affected by trouble in the system. Status information from teletypewriter messages is fed into an electronic computer previously programed with a data base source and operating rules. 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. It is 8 feet high and 15 feet long. This panel shows the changing status of the system's major trunks and stations.

Information presented on display panels covers the full range of data required to analyze intelligently this worldwide communications system. Included in this information are trunk status, assignment, and availability of individual circuits, station status, and the scope, priority, and quality of message backlog. When displays indicate a need for operational instructions to correct problem areas, the system supervisor issues instructions by telephone or teletypewriter message to the appropriate activity. The control area contains a series of operator consoles. Through these operator consoles 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 operations Centers, there are four Defense Area Communications Operations Centers. These control centers are subordinate to the Control Center and report to it. They exercise operational direction and supervision of DCS components in the geographical areas in the same manner that the Control Centers control the entire world.

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

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

Regional Communications Operations Centers. - Subordinate to Area Communications Operations Centers are eight Regional Communications Operations Centers. These area Centers take care of the DCS within its own region, according to its needs, and makes status reports to the appropriate Area Communications Operations Center. The type and amount of automatic teletype and computer circuits and equipment depend on the needs of each particular region.

Circuit Control

Each military service has command of-and is responsible for-operation and maintenance of its stations within the DCS. Each DCS station operates under the circuit direction of a designated communication operations center.

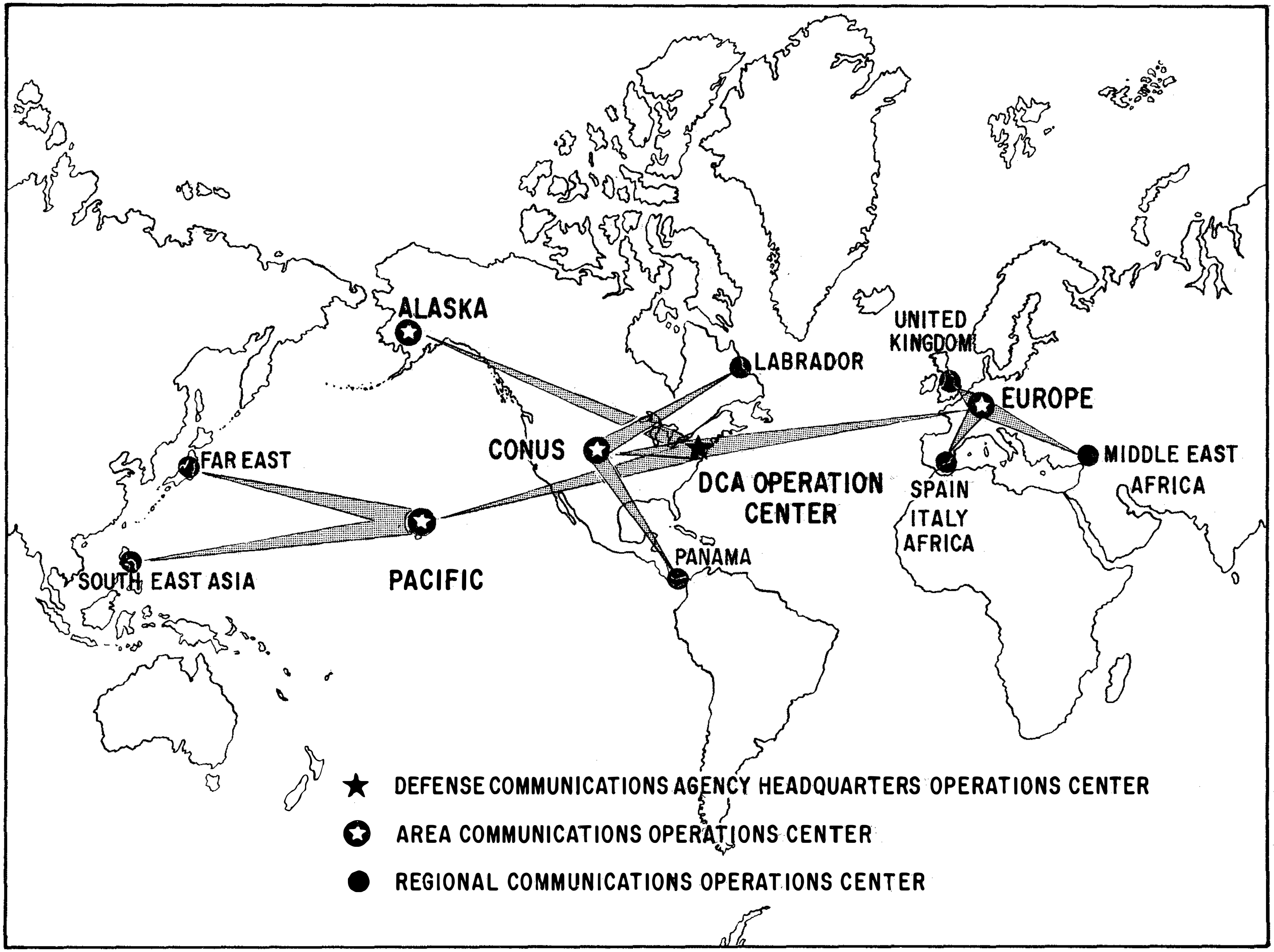

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Figure 5-2. –Defense Communication Agency Operations Center Complex.

Circuit control and operation are the responsibility of each relay station. Most relay stations usually have the necessary information for alt-routing or setting up new circuits. They normally handle these procedures without requesting help from DCA operations centers. If a relay station requires assistance in alt-routing a circuit or message traffic, it can call on the designated operations center for requisit data. The operations center supplies the information, but the relay station ensures that proper connections are made. If required by the local station, the operations center also provides coordination with distant stations.

Each communication operations center, in exercising operational direction of subordinate DCS stations, issues message or telephone instructions when required. These messages direct actions or request additional information calling for operational responsiveness of the DCS station. Normally, these messages require direct and immediate action by technical or traffic control elements of the DCS station. Messages entailing operational direction are referred to as operational direction messages (ODMs). These messages are identified by the month in which originated, and are numbered serially from 010001Z commencing January of each year. To illustrate, DCA-Pacific ODM 4-112 means that the message was originated in April and is the 112th ODM of the year. Operational direction messages are released only by the system control officer on duty in the operations center.

Each communication operations center functions in its area as a central source for technical and operational data on the DCS and the service it provides. Military commanders, DCS stations, DCS users, and local commercial communication companies must coordinate communication problems with the center in order to furnish the most effective communication service.

The chief of each Defense Operations Communications Complex (DOCC) must make arrangements to furnish to senior military commanders served by this center the latest available communication status. Current status, warning, and long-term performance information on stations, facilities, networks, and the like, are provided, as required, to the military departments for fulfillment of their responsibilities.

The chief of each area center must ensure that the following functions are accomplished within his assigned area. Coordination functions indicated by an asterisk (*) may be performed by certain communication activities designated by the area center chiefs.

*DCS circuit coordination;
*DCS facility coordination;
*DCS network coordination;
DCS technical control;
DCS traffic control.

Effective control of each circuit, trunk, and facility of the DCS is achieved only if responsibility for each facet of the operation is clearly understood by all personnel concerned. To ensure better understanding, both the DCAOC and each DCA area center are encouraged to develop plans for exercising control of each facility, trunk, and circuit in the DCS within their assigned responsibility. They also must distribute extracts to appropriate communication activities.

DCS Reporting Station Reports

Status information is required so that Director, DCA can maintain current information on circuits, channels, and resources of DCS.

An individual DCS reporting guide is prepared by the appropriate operations center for each DCS reporting and reported-on station. These guides contain only such information as pertains to preparing status reports by a reporting station.

A reporting station is a DCS station required to submit status reports in a prescribed format and accomplish other specific functions.

A reported-on station is a communication facility designated to have status reports submitted on it by a reporting station. Reports concerning these stations are put in the same form as though the reported-on station submitted the report.

Automatic data processing techniques are the basis for producing reporting guides. Information in the reporting guide is also programed in the computer. Information from status reports is fed into the computer, then is compared against information from the reporting guide programed previously. Any differences in the status of circuits and message traffic loads are shown automatically on the display panels.

Reports by DCS reporting stations for DCS operational direction are of two different forms: automated format and narrative form. These fall into five categories. A description of various formats and categories follows.

Automated format: An automated format is required on specified information so that the Automatic Control Operation Center (ACOC) automatic processing system can accept data to be used for operational direction and management of DCS.

Narrative form: The narrative form is used independently of automated format reports or to supplement them. Information submitted in this form is not processed by the computers. Voice reports follow the general format for the narrative form.

Regular reports: Regular reports are automated format reports of DCS performance that do not require special reports. Narrative remarks may be added. A regular report is required only when reportable information was not submitted by any other report category, and then at such intervals as to preclude the information being unreported for more than 4 hours. An exception to this rule is the regular formatted report required at the end of each radio day.

Special reports: Special reports are automated format or narrative reports of DCS status are called special reports. They are required when facility or user service outage or restoral in special categories (normally related to restoration priority) is experienced. A special report is required when transmission paths supporting one or more priority 1 circuits sustain an outage, and it becomes apparent to the reporting station that circuit continuity cannot be restored within 10 minutes. The same requirement applies to any outage of circuits in this priority group, if the fact of outage is known but the cause and its location are unidentified.

Emergency report: Emergency reports are narrative reports of communication disruptions resulting from malicious interference with communications. An emergency report is required in the following circumstances: (1) when any physical damage or threat of damage occurs as a result of violence or warfare; (2) instances of sabotage or attempted sabotage to communication facilities; and (3) jamming or suspected jamming of electronic devices.

Recapitulation report: A recapitulation report (recap) summarizes the current status of station, and is submitted upon request of a Defense Operations Control Center (DOCC) element. A recapitulation report is a complete summary of present status of a reporting/reported-on station in automated format. It provides for summary correction to suspend erroneous status indications at the ACOC. It is not a substitute, however, for internal corrections at the ACOC. Current outages or allocations, which began on the previous radio day, are reported as beginning at 0001Z of the current radio day.

Correction report: A correction report is a corrected version of a previously submitted automated format report. A correction report is submitted by a DCS reporting station upon request of cognizant DOCC element or upon discovery of a factual error in an earlier automated format.

AUTOVON

The DCS automatic voice network (Autovon) offers rapid, direct interconnection of Department of Defense and certain other Government installations. Some overseas areas are now connected into the Continental United States (CONUS) automatic system. As facilities become available, other overseas areas will be connected. The Autovon is intended to be a single, worldwide, general-purpose, direct dialing system. Its goal is to complete connections between two prearranged points, anywhere in the world, in about 2 seconds, and to complete regular connections with pushbutton speed. Eventually, this facility is expected to be able to switch every type of information transfer, including voice transmission, teletypewriter, or other data.

Several installations, comparable in function to commercial telephone exchanges, constitute the Autovon switch, or simply a switch. Within individual areas exist local command, control, and administrative voice communication systems. These systems can be connected into the worldwide Autovon through manually operated telephone switchboards, or automatic dial exchanges by provision of direct in or out dialing capabilities.

A naval station telephone system may be connected into the Autovon by its local private branch exchange (PBX) or private automatic branch exchange (PABX). In this instance the PBX or PABX would be considered the Autovon subscriber. Some offices and facilities may have direct access to the Autovon system, hence would be individual Autovon subscribers.

Normal Service

Normal Autovon service provides a capability for subscribers to call other subscribers on a

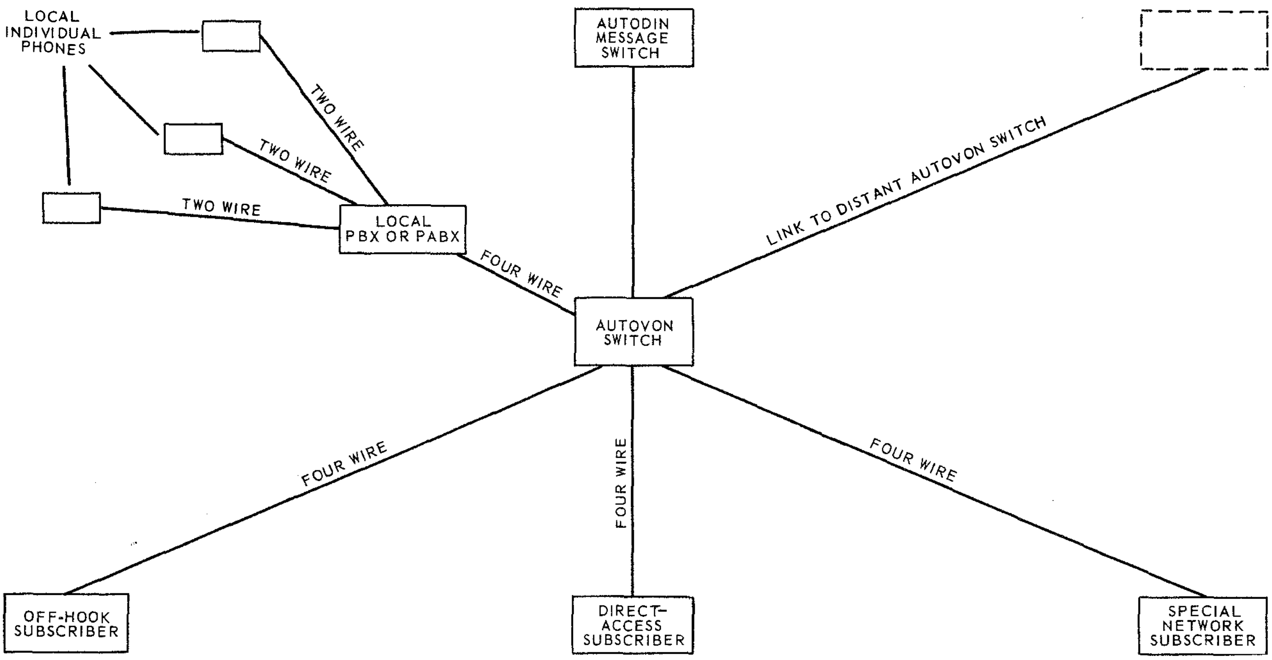

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Figure 5-3.–Area Autovon switch and subscribers.

worldwide basis for day-to-day nonpreemptive traffic. Depending on the type of service provided in each locality, this service may be accomplished by either direct dialing or through a local operator. Where users of this type of service require priority calls to be made, they must place the call with their local operator or the Autovon dial service assistance (DSA) Operator.

Most military installations are provided connection to the general-purpose Autovon through their local PBX or PABX. These local systems are two-wire systems. Inasmuch as Autovon is a four-wire system, its terminal equipment must be four-wire also. Where such equipment as two-wire local switchboards are to be interconnected, four-wire/two-wire conversion equipment is used. Figure S-3 shows a local exchange and how it might be connected to the area Autovon switch.

Besides general-purpose Autovon service provided through local PBX, certain selected subscribers are authorized direct four-wire access to the general-purpose network through pushbutton four-wire telephone sets (fig. 5-4) installed in their offices. These subscribers can be supplied up to four classes of priority. Each level of priority can preempt any lower levels. A four-wire subscriber may employ any level of precedence he desires up to and including the highest level he is authorized. The precedence desired by a four-wire subscriber is selected by pushing one of four buttons on his set.

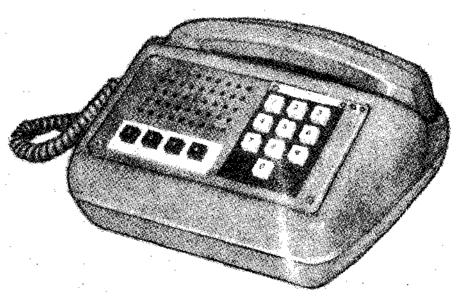

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Figure 5-4.–Type AE-023 four-wire subset.

Table 5-1. –Joint Uniform Telephone Communications Precedence System

Precedence designators are for joint use and specify the relative order in which telephone calls should be handled based on the importance (content) of the call.

Numerical Category:	1
Designator:	**FLASH**
Application:	Flash precedence is reserved for alerts, warnings, or other emergency actions having immediate bearing on National, command, or area security. Examples: Presidential use; announcement of an alert; opening of hostilities; land, air, or sea catastrophies; intelligence reports on matters leading to enemy attack; potential or actual nuclear accident or incident; implementation of services unilateral emergency actions procedures, etc.
Numerical Category:	2
Designator:	**IMMEDIATE**
Application:	Immediate precedence is reserved for vital communication (1) having an immediate operational effect on tactical operations; (2) which directly concern safety or rescue operations; or (3) which affect the intelligence community operational role. Examples: Initial vital reports of damage due to enemy action; land, sea, or air reports which must be completed from vehicles in motion such as operational mission aircraft; intelligence reports on vital actions in progress; natural disaster or widespread damage; emergency weather reports having an immediate bearing on mission in progress; emergency use for circuit restoration, use by tactical command posts for passing immediate operational traffic, etc.
Numerical Category:	3
Designator:	**PRIORITY**
Application:	Priority precedence is reserved for calls which require prompt completion for National defense and security, the successful conduct of war, or to safeguard life or property, which do not require higher precedence. Examples: Reports of priority land, sea, or air movement; administrative, intelligence, operational, or logistic activity calls requiring priority action; calls that would have a serious impact on military, administrative, intelligence, operational, or logistic activities if handled as a ROUTINE call. Normally, PRIORITY will be the highest precedence which may be assigned to administrative matters for which speed of handling is of paramount importance.
Numerical Category:	4
Designator:	**ROUTINE**
Application:	Routine precedence is reserved for all other official communications.

Notes:

1. Calls of any precedence may be preempted by the application of the FLASH OVERRIDE capability available to: (1) the President of the U.S., the Secretary of Defense, and the Joint Chiefs of Staff; (2) Commanders of Unified and Specified Commands when declaring either Defense Condition One or Defense Emergency; and (3) CINCNORAD when declaring either Defense Condition One or Air Defense Emergency.
2. Precedence designators FLASH through PRIORITY will be given preemption rights in the order of listing.

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Joint Uniform Telephone Communications Priority System

Precedence designations in table 5-1 are directed for joint use. These precedence designations indicate the relative order in which a telephone call of one designation should be handled in respect to all others.

Special Networks

Within the Autovon, different types of special networks can be provided. They may afford privacy of service, within a specified community of interest, so that only participants are able to communicate on the network without interference from the general-purpose network.

Off-Hook Service

Certain command and control needs and other operational requirements are met by provision of automatic off-hook (hot-line) preemptive service. When the telephone instrument is lifted off its cradle, it is connected immediately to a predesignated telephone instrument at the distant installation. Only a preset instrument is activated, because these instruments cannot be utilized for any other purpose.

Conferences

Conferences can be provided on either a preset or random basis. A preset conference is initiated by the originator to an operator at a preset conference console. An operator keys in the preset codes of a preselected group of subscribers. These codes are translated into a predetermined number of outgoing codes. A call is thereby established to each distant switch indicated. A random conference occurs when an originator desires to call a conference of other subscribers not in a preselected group. This type of conference is accomplished through a PBX operator. If the originator is a four-wire subscriber, a random conference can be made through a dial service assistance (DSA) operator.

AUTODIN NETWORK

The Autodin network is a worldwide, high-speed, common-user data communication system. It is operated for and managed by the Defense Communications Agency to provide message service for the Department of Defense and other Government agencies.

The system is designed to link approximately 3500 Navy, Air Force, Army, and defense installations in an automatic chain. Eventually it will replace all manual data relay centers and all torn-tape relay centers.

The Autodin is a computer-controlled, electronic, completely secure system designed to function as an integral part of the worldwide complex of the DCA. Specifically, the Autodin network is intended to provide–

- Direct user-to-user service.
- Store and forward message service.
- Compatibility of media, codes, speeds, and formats.
- Automatic error detection and correction.
- Message processing by assigned precedence.
- Maximum security.
- Automatic alternate routing.

The system was first conceived in 1958 by a special U. S. Air Force planning group. Its activation as a replacement for several manual data networks was completed in early 1963. Upon its official activation, the network with its five automatic electronic switching centers (AESC) was adopted by the DCA as the nucleus of a planned worldwide automatic digital network. Since that time the system has expanded to include all services and has been extended overseas.

At present 9 Autodin facilities are located in the United States, and 12 facilities and planned or under construction overseas. The facility at NAVCOMMSTA Honolulu will be the third designated as under the control of the U. S. Navy. The others are located at Albany, Ga., and Syracuse, N. Y.

The DCS automatic digital integrated network is a fully automatic digital data switching system. This network provides store-and-forward and circuit-switching message service to data and teletypewriter subscriber terminals. It is capable of handling any type of information in digital form, including voice and graphics. The system consists of high-speed, electronic, solid state switching centers, various types of data and teletypewriter subscriber terminals, and interconnecting transmission media.

Administrative and logistic traffic from afloat units will enter the Autodin system at Navy Communication stations and units, which will be provided direct access to the nearest Autodin switching center.

Interconnection of Autodin switching centers is through a network of high-frequency radio channels, submarine cables, microwave and tropospheric channels, and a variety of wire line. These transmission media are provided from existing DCS transmission resources, automatic voice network (Autovon), and from commercial communication facilities. At least one alternate route is provided for each trunk. Activation of this alternate path is controlled from the Autodin supervisory position. All d-c digital signals are converted to suitable analog signals by modulators-demodulators (MODEMS) before they are transmitted over interconnecting trunks.

Backbone of the Autodin system is the automatic digital message switching center (ADMSC), which is self-supporting. It includes an automatic digital message switch, technical control facility, power generator and distribution equipment, a timing source cryptographic and cryptoancillary equipment, and maintenance facilities.

Basic functions of the ADMSC are to accept, store, and retransmit digital messages from one location to another, automatically detect and correct errors, and accomplish alternate routing. For locations requiring real-time service, CONUS switching centers provide automatic circuit switching (direct user-to-user) services.

Each switching center has a high degree of reliability resulting from duplicate major units, which can be activated with a minimum of disruption to service. A standby communication data processor is provided at each center and is automatically tested for on-line use at regular intervals.

Once a message is accepted in the ADMSC, it is checked automatically for valid control characters. Thus, probability of a message not being switched to its proper terminal is 1 in 10 million messages.

Circuits that terminate in ADMSCs can operate at rates of 45.5, 75, 150, 300, 600, 1200 2400, and 4800 bits per second. These units are equivalent to 60 to 6400 words per minute.

Routing information, message formats, and operating procedures utilized in the ADMSC are in accordance with ACP 121, JANAP 128, and other applicable operating directives and practices.

Any traffic classified higher than the security clearance of its intended destination(s) is not delivered by the ADMSC. Such messages are intercepted automatically at the last center, and the originator is informed of a nondelivery resulting from a security mismatch.

Another special feature of the ADMSC is the provision of incoming and outgoing journals. These message journals store and present synoptic information on each message, sufficient to identify it, to record how the message was procured, and to determine where and when it was sent to an outgoing line. Journal information is retained in inactive storage for up to 30 days. Sufficient active storage is maintained for a period determined by operating requirements. Current status of the ADMSC can be checked at any moment by obtaining a printout of exactly how many messages, by precedence and designation, are in the center.

Each overseas ADMSC is capable of recognizing and routing 300 single routing indicators for local tributaries terminating in the center, 200 collective routing indicators, and routing indicators for 300 other switching centers. Service to four types of terminal stations, for example, is provided by CONUS Autodin. These four types are—

- Low-speed compound terminals (12 cards or 200 teletype wpm).
- High-speed compound terminal (100 cards or 200 teletype wpm).
- Magnetic tape terminal (3400 baud).
- Computer interfaces (21 to 2400 baud).

Teletypewriter subscribers are served by a controlled teletypewriter terminal. It provides the following functions:

- Automatic acknowledgment of end of message.
- Automatic transmission interruption.)
- Automatic resumption of transmission of messages without rerun or intervention.
- Automatic rejection and cancellation of messages.
- Automatic message numbering.
- Automatic verification of received message numbers.

By reducing manual handling of messages to a minimum, Autodin is revolutionizing communications. In the future, message delivery times and delays anywhere in the world will be measured in seconds instead of minutes and hours.

NAVY COMMUNICATIONS

Navy communication systems are in a continual state of change. Newer and better types of equipment constantly are being developed and introduced. Accordingly, newer communication systems equipment can be put to use effectively. Because of constant changes it is necessary to keep communications flexible in order to provide a speedier and more reliable type of communications for the forces and activities they serve.

RADIO

Until comparatively recently, the term "radio communications" brought to mind one of two or even three types of circuits: telegraphy, or c-w as it is commonly called by communicators, using the ever-reliable Morse code; a-m voice communications, for short-haul voice circuits; and possibly teletypewriter communications. Anyone passing a radio shack heard the familiar sound of Morse code; a Radiomansitting at an operating position with a pair of earphones on his head was a common sight.

Communications has come a long way since then--no longer is Morse code a familiar sound; it has been replaced by teletypewriter clatter and the buzz of Radiomen handling an ever-increasing volume of message traffic. Instead of talking about telegraph keys and earphones, a Radioman now speaks of TDs, reperfs, and teletype channels. Although CW circuits have been pushed to the background in favor of single-sideband circuits, microwave, and even satellite circuits, they still are in use today, and at times afford the most reliable means of communications.

SINGLE-SIDEBAND TRANSMISSION

Single-sideband (SSB) transmission is the most common link used today. It is being applied to many circuits that previously operated on amplitude modulation. Many UHF circuits are expected to utilize SSB in the near future. Chapter 9 tells what SSB is and the theory of operation. This chapter discusses where it is utilized and the methods of operation.

SSB Voice Circuits

Single-sideband communications are rapidly replacing many voice circuits that have been using amplitude modulation.

The high command net (HICOM) uses SSB as a means of communication between fleet commanders, and by fleet commanders with their subordinates and adjacent commands.

Whenever special voice circuits are necessary, either between shore activities or ships and shore activities, SSB is selected because it is less susceptible to atmospheric interference than is amplitude modulation. Often, SSB is used for voice order-wire circuits between NavCommStas.

The, UHF circuits are starting to use SSB as the means of transmission. Moreover, SSB circuits are being adapted to existing UHF equipment. Other applications of UHF SSB circuits, besides voice circuits, are discussed in a later chapter.

SSB Teletype Circuits

With few exceptions, SSB is used on all existing long-haul teletype circuits. It is also used on ship-shore circuits, as well as ship-ship teletype circuits. Most of these systems are now covered circuits; that is, an electronic cryptodevice on both ends of the circuit automatically encrypts and decrypts message traffic. These devices are used on ship-ship, ship-shore, point-to-point, and broadcast circuits.

SHIP-SHIP SSB TELETYPE CIRCUITS.—Although ship-ship SSB teletype circuits are not in wide use, they will be used more often as equipment becomes available. Their main application is for task force or task group nets or several ships in company. By using this type of net, ships can send their outgoing messages to a guardship from which traffic can be relayed ashore. This procedure saves manpower, circuit time, prevents individual ships from overcrowding ship-shore circuits, and saves usage of the frequency spectrum. Depending on the number and types of ships in company, the guard can be shifted to other ships from time to time. A major advantage of these circuits is that electronic cryptodevices can be used so that classified messages can be sent without need for manual encryption. These circuits are used for incoming as well as outgoing traffic, and they can use either HF or UHF.

SHIP-SHORE SSB TELETYPE CIRCUITS.–Many ships handle enough message traffic that a continuous ship-shore teletype circuit is justified. Depending on traffic load, these circuits can be from one to four teletype channels on one SSB circuit. If the traffic load warrants more than one teletype channel, usually time division multiplex (MUX) or frequency division multiplex equipment is used. This equipment handles up to four incoming and four outgoing channels. One channel normally is used as an order-wire circuit for handling operator-to-operator procedure messages and for making frequency

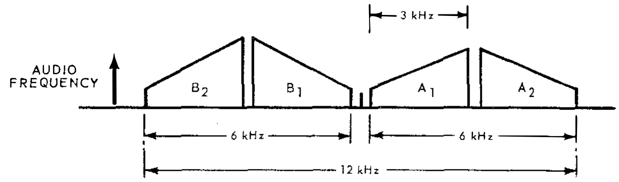

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Figure 5-5.—Radiofrequency—ISB channel and frequency bandwidth.

changes when necessary. Three remaining channels are available for handling official message traffic.

POINT-TO-POINT TELETYPE CIRCUITS.—Most point-to-point long-haul circuits between naval communication stations need more channels than SSB can provide. To compensate for the deficiency, independent sideband (ISB) transmission is used. It is similar to SSB. In ISB, instead of suppressing the carrier and filtering out a sideband, only the carrier is suppressed. Both sidebands are used, and are split into two 3-kHz audio channels, as shown in figures 5-5. Each audio channel may carry different intelligence.

By using frequency division multiplex equipment, 16 teletype channels can be put into each of the 3-kHz audio channels, giving a possible total of 64 teletype channels on one ISB circuit. Usually, only one or two audio channels are used for teletype. Other channels are available for voice and/or facsimile, depending on the needs of participating stations.

MICROWAVE TRANSMISSION

Microwave is a line-of-sight radio transmission system. Line-of-sight systems are made up of one or more links having a clear path between antennas at the ends of a link. Usually frequencies used are above 900 mHz. In the Naval Communication System, three equipments currently in use are the UQ, operating between 1700 and 1850 mHz; AN/FRC-37 system, operating between 1700 and 2400 mHz; and AN/FRC-84 system, operating between 7125 and 7750 mHz. Wideband transmission, suitable for 24 to 600 voice channels, has been obtained by proper system planning.

At frequencies mentioned, wavelengths become short, and propagation of the r-f energy becomes remarkably similar to that of light

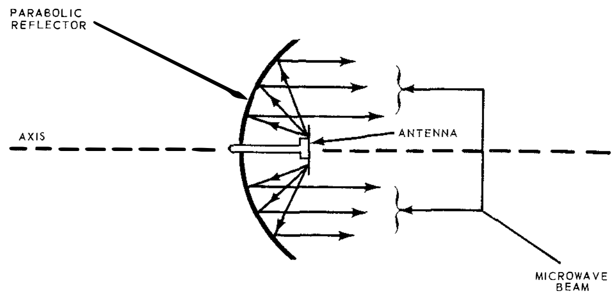

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Figure 5-6. —Microwave antenna.

energy. It thus is practicable at microwave frequencies to use high-gain antennas that resemble reflectors used in searchlights. These antennas concentrate energy into a narrow beam in the same manner as light energy. With the beam directed in the desired direction, it can be seen that a much larger signal arrives at the receiving antenna than would happen with a nondirectional antenna. Figure 5-6 depicts a parabolic antenna that is used for transmission and reception of microwave electromagnetic energy.

Terrain determines the length of a single link. In actual practice, transmit and receive antennas can be separated by a slightly greater distance than the actual horizon-to-horizon line-of-sight distance, due to refraction of the microwave-beam by the atmosphere. Most systems are composed of links of 30 miles or less, except where especially favorable sites can be found. Repeater stations may be used to connect one link to another to form long chains, thereby setting up long paths for many voice channels where needed. Chains of more than 40 links, for example, cross the United States carrying voice, teletype and television signals.

Microwave links are often used for carrying signals from a portion of a naval communication station to another; from and to the transmitter and receiver sites to the main station, for example.

Microwave radio link systems have the advantage of greater flexibility, economy of operation, and almost complete independence over weather conditions. They have excellent reliability (over 99 percent), extremely wide information-carrying bandwidth, good resistance to interference, and low power requirements. Limitations are that they require a relatively large portion of the frequency spectrum, and are effective at only a short range.

Usually microwave radio is used where large channel capacity is required, links are relatively short, and where it is more difficult or costly to install cable.

SCATTER TRANSMISSION

Forward propagation scatter transmission is a point-to-point method of HF or UHF radio communications. It permits reliable multichannel telephone, teletype, and data transmission out to a range of 400 miles.

Two types of scatter systems that have been used are ionospheric and tropospheric. Because of greater capacity and reliability, only the tropospheric system is now being used.

Forward propagation ionospheric scatter (FPIS), a system using HF range, utilizes SSB or ISB. A transmitted signal is beamed at the ionosphere where it is scattered in a forward direction. A receiving antenna is beamed at the same point in space to receive the signal. Because of its limited bandwidth, relatively high-power requirements, and crowded HF spectrum, this system is not used extensively.

Forward Propagation Tropospheric Scatter (FPTS)

Numerous communication networks now in operation, extending for thousands of miles, utilize "tropo" terminals with hops of 300 miles or more. These relay hops are accomplished by using both transmitting and receiving equipment and antennas at each terminal. At the initial transmitting point, many separate telephone conversations and teletype circuits are combined into a single radio signal. A feedhorn on a tower beams the signal out toward the horizon, and thus is similar to a huge, precisely aimed searchlight. A minute reflected portion of the signal is picked up by a parabolic receiving antenna well over the horizon. There it is reamplified and sent on its way again, if necessary, for another leap over the horizon toward its destination at the other end of the circuit.

Tropo has many advantages over other methods of long-distance communications. Besides greater economy in areas where construction and maintenance present problems, it is relatively free of atmospheric interferences that affect other transmission methods.

Tropospheric scatter transmission operates in the UHF band, using f-m transmission. The troposphere is the lowest area of the atmosphere, extending from the ground to a height of approximately 6 miles. Above this area are the stratosphere and the ionosphere.

Almost all weather phenomena occur in the tropospheric area. The troposphere itself is made of various layers similar to the entire atmosphere. Within the troposphere, these layers are sharply defined, differing in temperature and moisture content. Because these layers are shifting constantly, the refractive index for any one area of the troposphere changes. Boundaries between layers act as reflecting surfaces. The present theory is that the phenomenon of refraction and reflection within the troposphere makes possible the scatter system of transmission. Part of a radio signal beamed upward through the troposphere goes through a complex series of partial refraction and reflection, causing most of the energy to be scattered in all directions and become partially diffused. Figure 5-7 shows how this refraction/reflection change might take place.

A receiving antenna, beamed at the same point in the troposphere as the transmitting antenna, picks up enough transmitted energy to make it useful. For any particular transmitter power and a given antenna size, an average received signal depends on beam (scatter) angle, distance between stations, frequency used, and weather conditions at the midpoint of the radio path (fig. 5-8).

To obtain optimum results, high-power transmitters are used, and antennas range in size from 8 feet in diameter for mobile use to 120 feet for fixed installations. Output power, size of antenna, and frequency used depend on the type of circuit desired.

Scatter angle influences the amount of received signal. Better reception is obtained when scatter angle is kept to a minimum. The takeoff angle of transmitter and receiver antennas is made as low as permissible by local terrain and general geographical location.

The received signal of scattered energy varies extensively, causing conditions of fast and slow fading. Fast fading, caused by multipath transmission, exists for short intervals. Slow fading usually extends over several hours and is brought about by changes in refractive properties of the troposphere. Seasonal variation in signal strength also is experienced. Received signal level is lower during the worst month of the winter season, and higher during the best month of the summer season. Another factor is that communication paths in tropical

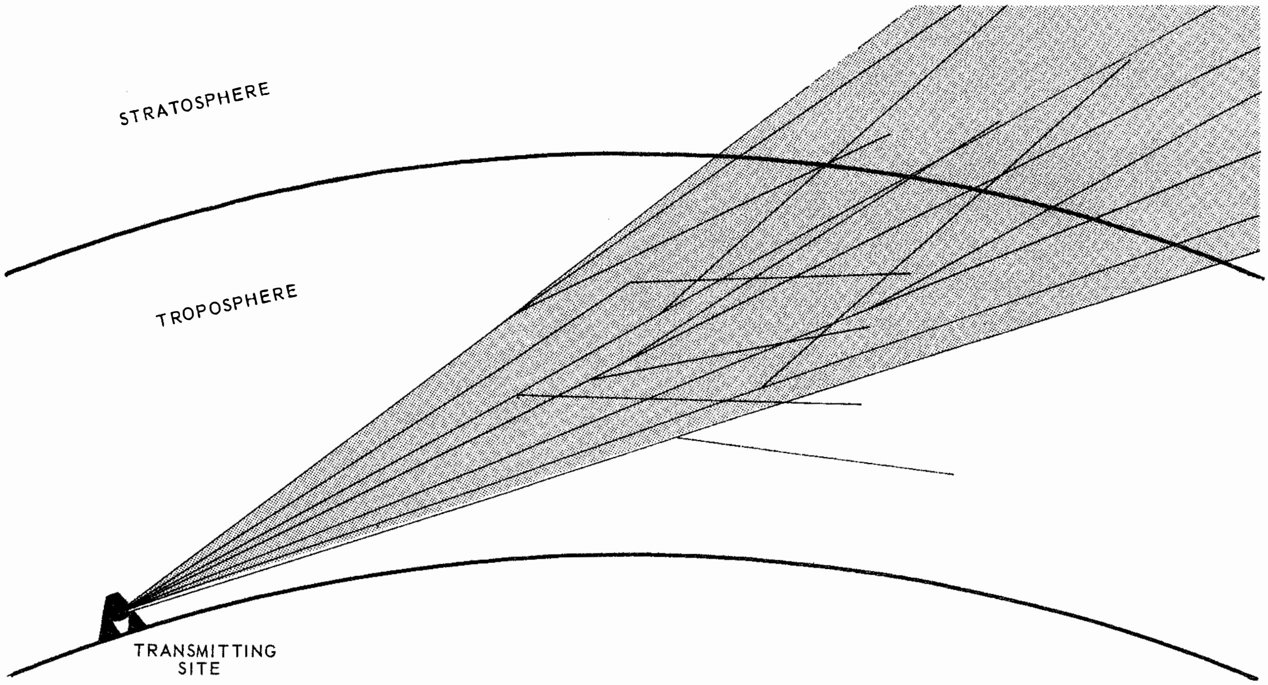

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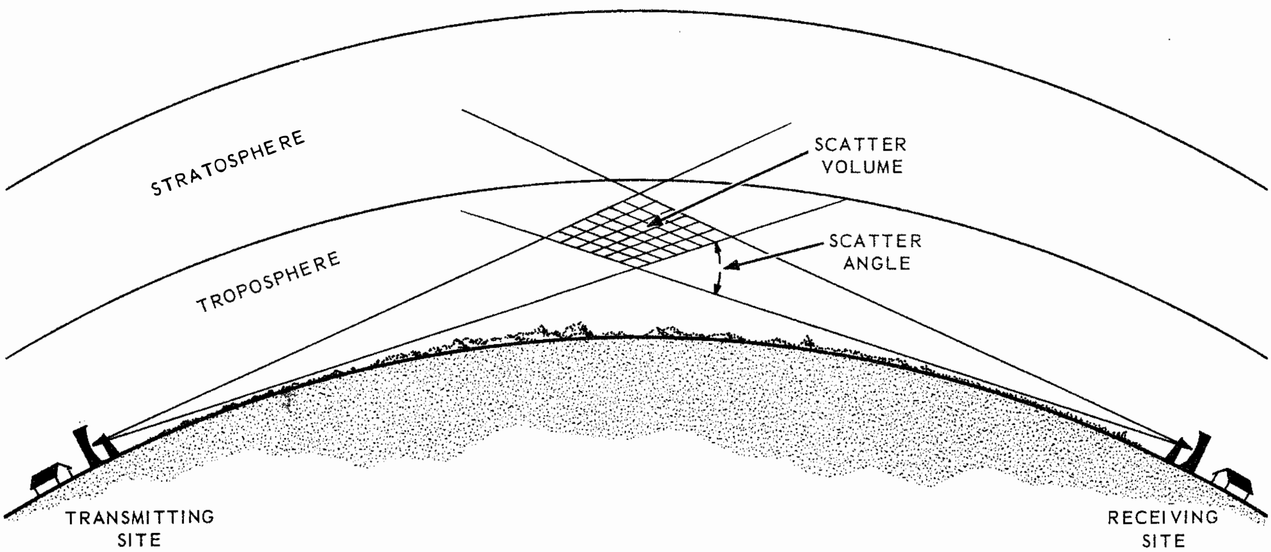
Figure 5-7. –Scattered radio signal. Shaded area is a beamed signal. Lines within the beam show a simplified idea of how the signal is partially refracted and reflected.



50.148

Figure 5-8. –Scatter propagation.

or temperate zones are somewhat better in yearly average signal level than are paths in higher latitudes.

To obtain a steady signal, energy combined from a number of fluctuating signals is used in a diversity system. Some or all of the following methods are used to obtain a steady signal over different paths that fade and vary independently.

- Space diversity: Receiving antennas separated by 50 wavelengths or more at the signal frequency. (Usually a separation of 10 to 200 feet is sufficient.)
- Frequency diversity: Transmission on different frequencies fades independently, even when transmitted and received through the same antennas.
- Angle diversity: Two feedhorns produce two beams from the same reflector at slightly different angles. This arrangement results in two paths based on illuminating different scatter volumes in the troposphere.

The number of channels that can be transmitted over a given link depends on the degree of distortion the particular circuit can accept. For links that are part of long-haul telephone systems, distortion must be held to a minimum. Typical tropospheric scatter link capacities are given in the accompanying list.

Distance	No. voice channels
0-100 miles	To 252
100-200 miles	To 132
200-300 miles	To 72
Over 300 miles	12-24 (quality usually limited)

NAVAL SATELLITE COMMUNICATIONS

The U. S. Navy has continued to develop and improve all modes of ship-to-ship and ship-to-shore communications, using all available frequencies, from the very low frequency (VLF) band with wavelengths of several miles, to the super high frequency (SHF) band with wavelengths of only a few centimeters. Extremely long-range communications became possible on lower frequencies, but the airwaves soon became jammed; demand had exceeded the spectrum supply. The higher frequencies were less crowded, but were restricted by their characteristics to line-of-sight ranges; they were of no value for long-range communications until after the satellite communications followed the moon relay project from 1954 to 1963.

Even with satellite communications, the problems of the fleet were far from solved. The pioneer satellites of 5 years ago provided a relatively weak signal strength, which required large and complex antenna systems to receive their signals. Locating and tracking the tiny rotating pinpoints 20,000 miles above proved difficult, especially when tracking was done from a violently rocking mobile platform such as a ship at sea. The thought of adding a 30- or 40-feet antenna to the already cluttered superstructure taxed the imagination of naval designers. The first shipboard satellite terminal, located on board USNS Kingsport, had a 30-foot-diameter antenna, enclosed in a 53-foot radome, mounted on the after part of the ship.

The shipboard satellite antenna system has taken advantage of advances in electronics to become smaller and more efficient. Still operators of shipboard systems are faced with the problem of the superstructure blocking the line of sight while a satellite is being tracked, particularly during ship maneuvers.

The problems of tracking were not minimized until July 1963. Then, an entirely new satellite, developed by the National Aeronautics and Space Administration (NASA) and Hughes Aircraft, was launched successfully and placed in an inclined synchronous earth orbit; this was SYNCOM II. Excellent performance was obtained from the SYNCOM repeater, and in August 1964, SYNCOM III was launched and placed in a true equatorial synchronous orbit.

In an orbit such as that of SYNCOM III at an altitude of approximately 19,000 nautical miles, the time of orbit is exactly 24 hours. Such an orbit naturally causes the satellite to appear stationary over the same spot on earth, because both the earth and the satellite are rotating at the same radial velocity or speed. The first terminal strictly for use with SYNCOM III was installed on board the USS Canberra (CAG 2) in December 1964. The first ship-to-ship communications via satellite relay were accomplished on 10 January 1965 between Canberra and Kingsport. Shortly thereafter the second SYNCOM terminal was installed on board USS Midway, and on 16 February 1965 Canberra and Midway conducted the first satellite communications between two combatant ships at a distance of 6000 nautical miles.

In 1964 the decision was made to proceed with the initial communications satellite project (IDCSP). In June 1966 a multiple satellite launch was accomplished, putting 7 slow-moving or near-synchronous satellites in orbit approximately 18,000 nautical miles above the equator. These satellites gave almost complete coverage of the earth's surface between 70° N and 70° S. With the success of the IDCSP have come further multiple satellite launchings, placing a total of 19 near-synchronous satellites in orbit.

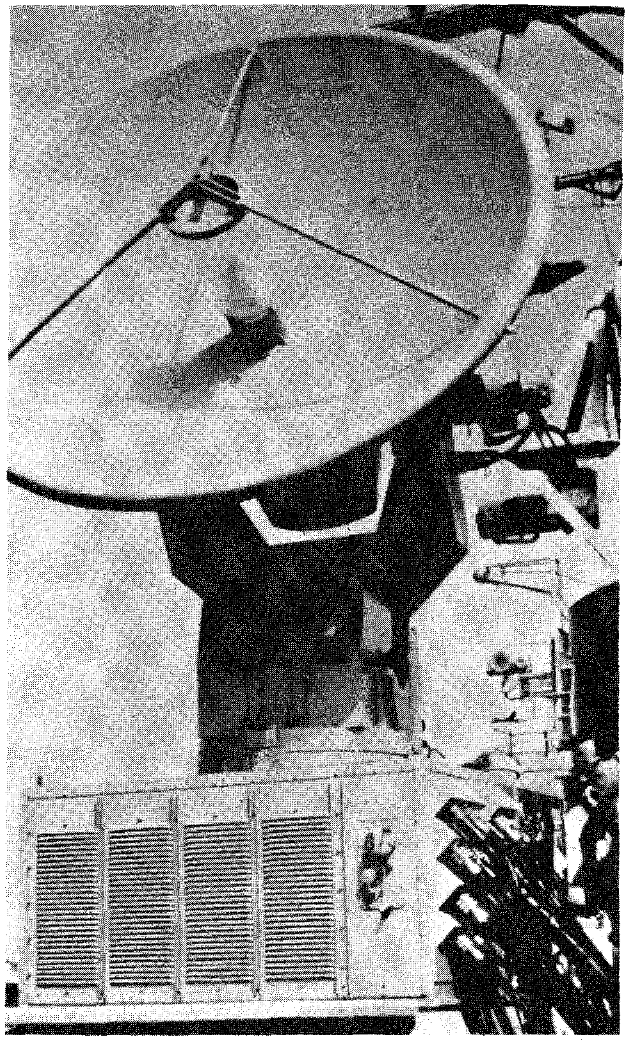
The Navy is also participating fully in the Lincoln Lab experimental UHF satellite program, known as LODUS or LES-5, which includes seven terminals located on ships, submarines, aircraft, and ashore. The LODUS program is a forerunner of the tactical satellite communications program (TACSATCOM), which includes six types of UHF mobile terminals: a one-man receive pack, team pack terminal, 1/4-ton vehicular (jeep) terminal 1 1/4-ton shelter mounted terminal, 2 1/2-ton shelter-mounted terminal, and an airborne terminal.

Because of the numerous restrictions on antenna size, power, and location, naval satellite communications still are in a stage of development and testing. The U. S. Navy now has several ships and shore stations operating with SYNCOM, IDCSP, and LODUS, and anticipates extensive operational use of satellite communications in the near future, especially when more shipboard terminals are installed.

The present shipboard satellite terminals include the SSC-2, with a 6-foot parabolic antenna utilizing SHF and designed for use with SYNCOM, and the SSC-3, also with a 6-foot SHF parabolic antenna (fig. 5-9), designed for use with the IDCSP. The SSC-2 and the SSC-3 utilize different frequencies and therefore are not compatible. The high cost of equipment conversion does not make it practical to convert the SSC-2 for purposes of compatibility. The SSC-3 is a lighter and more versatile terminal than the SSC-2. Shore link terminals compatible with the SSC-3 for ship-to-shore communications are TSC-54, with an antenna consisting of four 10-foot reflectors, the MSC-46, with a 40-foot parabolic dish antenna, and the FSC-9, with a 60-foot parabolic dish.

With modifications, the SSC-3 and the TSC-54 can be utilized with the tactical satellite communications program.

Integration of communications via satellite into the existing Naval Communication System will be accomplished by applying existing procedures where practicable, with adaptions as required. Communications via satellite will augment existing communications as part of the overall system for the command and control of naval forces. Satellite communications will not replace existing means of radio communications, because there will continue to be many operational requirements and applications for circuits in all radiofrequency ranges. Satellite communications, however, will improve Navy strategic and tactical communications.



50.185

Figure 5-9. –Six-foot SHF parabolic antenna for SSC-3 satellite tracking–shipboard installation.

Tests of the SSC-3 satellite communications terminal installed in the Providence, as well as many other tests conducted to date, have shown that satellite communications will significantly increase the Navy's communications capability, furnishing another means of helping to handle the ever-increasing volume of message traffic. The procurement and development of shipboard terminals is the Navy's responsibility in the current triservice satellite effort.

Initial installation, because of price, will be limited to fleet flagships, carriers, command ships, and communication ships. Hopefully, further development work will lead to reduction in size, weight, and cost.

The current equipment, instead of being integrated into the ships, is self-contained for easy installation and removal, so that when the ship returns from deployment, the terminal may be removed and then installed in another ship about to deploy.

When satellite communications are well established and Navy ships have need for permanent terminals, a new type will be integrated into the ship and will be fully compatible with other electronic equipment. With this eventuality, the number of conventional transmitters and receivers aboard ship can be reduced, thus eliminating portions of the maze of antennas, which today interfere with each other and reduce the effectiveness of shipboard communications. This development will result in better communications in all frequency bands; more capacity for reliable, long-range communications; and overall reduction in shipboard space and weight needed for communication equipment.

NORATS

On-call radiotelephone is a ship/shore radiotelephone service that is provided through the Navy operational radio and telephone switchboard (NORATS), installed at NavCommStas throughout the world. It provides an interface between afloat voice radiotelephone circuitry and government-owned and/or Government-leased telephone systems. The NORATS is operational at most NavCommStas and NavCommUs using existing assets to support NORATS. This facility is used for official telephone calls only.

FOLLOW-THE-FLEET CONCEPT

Because of security classification, a discussion of the follow-the-fleet concept cannot be included in this publication. The topic is considered of prime importance to Radiomen, however, and it is suggested that the current edition of DNC 5 be referred to for proper coverage on this system.

CHAPTER 6

PRINCIPLES OF READING SCHEMATIC DIAGRAMS

A picture is worth a thousand words. Man has used pictures as a means of communication for many years. If an engineer designed a simple electronic device, for example, it would be difficult to convey his idea to the person who is to fabricate the object without a drawing to show the shape, size, and location of the components.

Drawing or sketching is the universal language used by engineers, technicians, and skilled craftsmen. Whether a drawing is made freehand or with the use of drawing instruments, it is needed to convey all necessary information to the individual who will fabricate and assemble the object, whether it be a building, ship, aircraft, or an electronic device. If many people participate in the fabrication of the object, copies should be made of the original drawing or tracing so that all persons who need to know will have the same information.

Drawings or schematics not only are used as plans to fabricate and assemble objects, but they also may be used to illustrate how machines, ships, aircraft, and so on are operated, maintained, repaired, or lubricated.

Reading electronic schematics is similar to reading any other type of drawing or print. They may even be equated to road maps. A basic difference is that, in general, electronic schematics are more complex and have more components (such as various types of tubes and resistors) than do most other types of prints or drawings.

It is customary to show electrical and electronic components and their interconnecting wires by using schematic drawings. Wiring diagrams also are used, but not so widely as schematics.

UNIT TERMS USED IN ELECTRICITY

A review of the unit terms used in electricity is given in this section of the chapter. It is essential that the student have a thorough understanding of these terms so that he can properly (and easily) interpret schematic diagrams, block diagrams, and service block diagrams.

The more knowledge you have of electrical and electronic theories, the easier it will be for you to read electronic diagrams and schematics. If you feel that you are weak in these areas, you should review Basic Electricity, NavPers 10086 and Basic Electronics, NavPers 10087.

COULOMBS

No one has ever seen an electron and probably never will. To simplify the job of counting them, individual electrons are grouped together into a large electronic unit—the coulomb—much like grouping grains of sugar into a larger unit, such as the pound.

You probably never troubled to count the grains in 1 pound of sugar, but some one did calculate the number of electrons in 1 coulomb. He found that it contained 6.3 billion billion electrons. That quantity is 63 with 17 zeroes after it, which adds up to a lot of electrons.

AMPERES

When 1 coulomb of electricity passes a point in 1 second, 1 ampere of electricity is flowing. Thus, 1 ampere is to electrical flow as 1 gallon-per-minute is to water flow. In other words, we are dealing with the rate of flow.

One-half coulomb per second is 1/2 ampere; 1/1000 coulomb is 1/1000 ampere or 1 milliampere (abbreviated ma).

In radio work, the most-used unit of current is the milliampere. With receiving circuits, the range is from 1 or 2 to about 50 ma. With transmitters, the current flow will range upwards of several hundred milliamperes.

VOLTS

Volume of current is not always the same. It varies directly with the size of the charge.

Work is required to move electrons and create a charge, consequently the size of the charge may be expressed in units of work necessary to move the charge.

The volt is the unit used to express the amount of work done to create a charge. One volt of charge is created when 1 joule of work is expended in moving 1 coulomb.

JOULES

The joule is the term used to express the absolute unit of work or energy applied. In this application, 1 joule is equal to approximately 0.7375 foot-pound.

A volt, however, actually expresses more than the degree of charge. When you accumulate a surplus of electrons, a reserve of potential energy is created. Thus, 1 volt may also be used as an expression of the potential energy of an object.

VOLTAGES ARE DIFFERENCES IN POTENTIALS

Because it is possible to create an electrical charge by either adding or removing electrons, the energy of two points is not expressed in actual potentials but in differences of potential.

When you say an object has a potential of 200 volts, you actually are expressing the difference in the potentials of two points.

Zero Potential

All objects have some potential, but it is common practice to designate some point as zero potential. In a radio, zero potential is usually the frame or chassis of the set. When you say the plate of a vacuum tube is positive 200 volts, therefore, you are only stating that the plate is 200 volts more positive than is the chassis.

The rate of current flow is influenced by the magnitude of the difference between the two charges. If the difference between the charges is small, for example, the rate of flow will be low. If the difference is large, the rate of flow will be large.

Negative Potentials

Besides positive potentials, there are negative potentials also. Although the chassis of a radio is given as zero potential, it is possible for certain parts of a receiver or transmitter to be at a lower potential than is the chassis. These parts are said to have negative potentials.

You will find the grids of vacuum tubes rated as -5, -10, -50, or -75 volts. This expression means that the grids of the tubes are at a lower positive potential than the chassis by 5, 10, 50, or 75 volts. Don't let a negative potential fool you. There is just as much wallop between -200 volts and the chassis as between +200 volts and the chassis.

Voltages Are Relative

Voltages are relative. Point A in figure 6-1 is given as -200 volts in comparison to the chassis. Point B, on the other hand, is 200 volts more positive than is the chassis. You may say, therefore, that point B is 400 volts more positive than point A. Reversing the expression, point A is 400 volts negative in respect to B.

How about point C? It is 100 volts positive in respect to the chassis, but 100 volts more negative than point B. In respect to A, point C is 300 volts positive.

Point D is 50 volts negative in respect to the chassis, but 150 volts positive in respect to point A. Thus, point D is also 150 volts more negative than C, and 250 volts more negative than B.

All these potentials (voltages) are measured in relation to the potential of the chassis. When you state the voltage of an element, therefore, remember that what you state is true only in respect to, or relative to, another point.

Here is a little statement to remember: Electrons flow toward the more positive potential. Even if all potentials are negative, the electrons move from the most negative toward the least negative potential. The higher the voltage and the greater the potential difference, the greater is the flow of electrons.

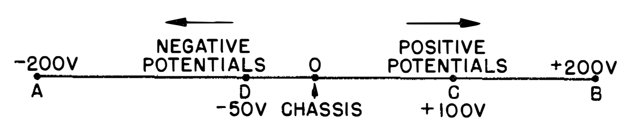


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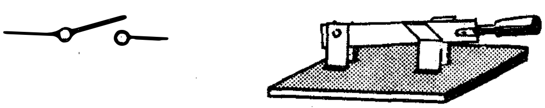
Figure 6-1. –Relative potentials.

INFLUENCING FACTORS

Now that we have covered the essentials of electricity, we will move into the components, their influencing factors, and their symbols. In drawing electronic schematics it would be difficult and time-consuming to represent each component as an actual picture. Instead, standard symbols are used to represent parts and components. The symbols are universal and are readily understood throughout the world.

Before you try to interpret electronic schematics and diagrams, you should become familiar with some of the electronic symbols and their influencing factors on the circuit. A few of the more common electrical and electronic symbols are explained in the following paragraphs and are illustrated as cited.

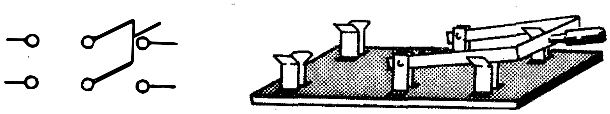
A simple single-pole, single-throw knife switch is shown in figure 6-2. It makes and breaks a connection for one line, and only at one point. The symbol shows two small circles indicating contact points and a straight line indicating the movable throw switch.



13.5.1G

Figure 6-2.—Single-pole, single throw switch.

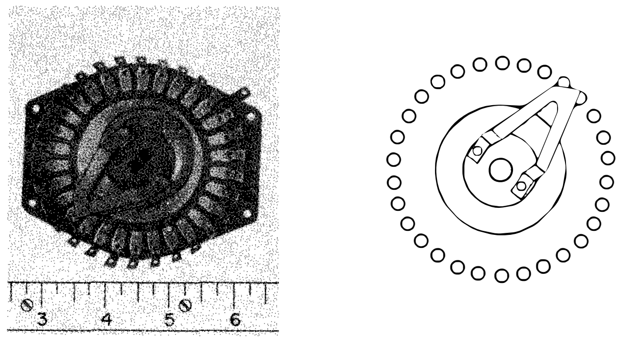
Figure 6-3 illustrates a double-pole, double-throw switch. It is similar to the single-throw switch, except that it has two blade switches mechanically connected, and can make and break contact in two different positions.



13.5.1K

Figure 6–3.—Double-pole, double-throw switch.

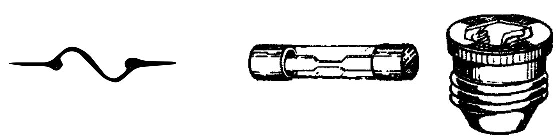
A wafer switch is shown in figure 6-4. The symbol indicates a 3-pole, 3-circuit switch with two nonshorting and one shorting moving contact.



65.75

Figure 6-4.—Wafer switch.

Two types of fuses are illustrated in figure 6-5. There are many types of fuses but they all have the same function: to protect a circuit from overloading. The two types of fuses shown are the cartridge type and the screwed plug type. When a circuit draws too much current, a metal wire or strip within the fuse melts, interrupting the flow of current. Note that the symbol is the same regardless of fuse type.



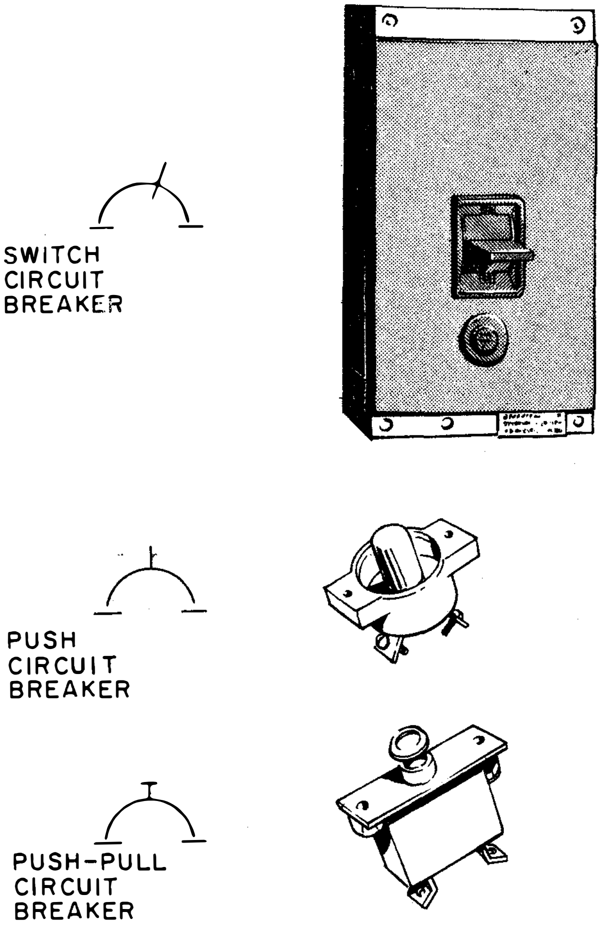
13.5.2D

Figure 6-5.—Fuses.

Circuit breakers perform the same function as fuses. Instead of melting, however, they merely open the contacts, thereby interrupting the flow of current. Three types of circuit breakers and their symbols are shown in figure 6-6.

RESISTORS

One of the most common electronic components is the resistor. A resistor opposes the flow of electrons. Thus far, only the voltage has been given as a factor influencing the rate



13. 5. 2ABC
Figure 6-6. –Circuit breakers.

of flow of electrons. In some substances–such as glass, rubber, and cotton–resistance is great enough to stop the flow completely. Three types of resistors and their symbols are illustrated in figure 6-7.

Figure 6-8 illustrates the potentiometer and its symbol. A potentiometer is a variable resistor commonly used as a volume control for radios and television sets.

A rheostat and its symbol are shown in figure 6-9. A rheostat is another form of a variable resistor. It is similar in construction to a potentiometer. A rheostat is almost always wire-wound, whereas a potentiometer can be either of wire or carbon. A rheostat normally is used as a resistor in a lighting system to vary the light intensity.

CAPACITORS

Three types of capacitors and their symbols are illustrated in figure 6-10. Capacitors are devices used to store or release electrons as they are needed in the circuit.

TYPES OF COILS

Figure 6-11 illustrates two types of inductors and their symbols. One is an air core, coil type, and the other is an iron core, usually referred to as a "choke." Inductors are used to smooth out variations in current flow.

Two types of transformers and their symbols are shown in figure 6-12. Transformers are used to step a-c voltage up or down, or to transfer a-c voltage from the primary to the secondary.

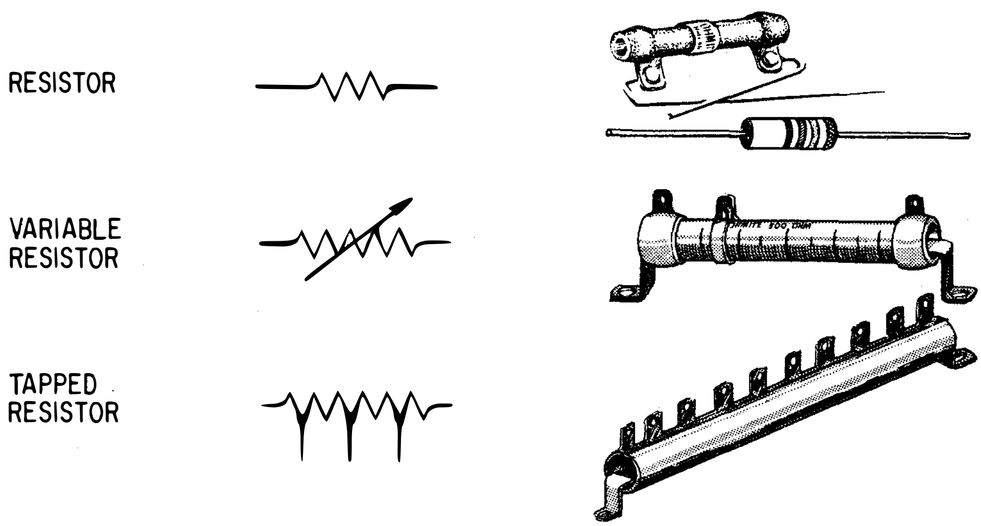
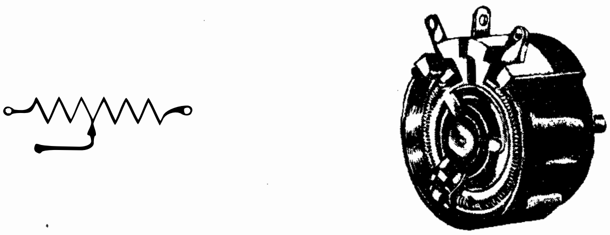


Figure 6-7. –Resistors.

13. 5. 4AB



13.5.4D
Figure 6-8. –Potentiometer.

13.5.4E
Figure 6-9. –Rheostat.

FIXED

VARIABLE

GANGED

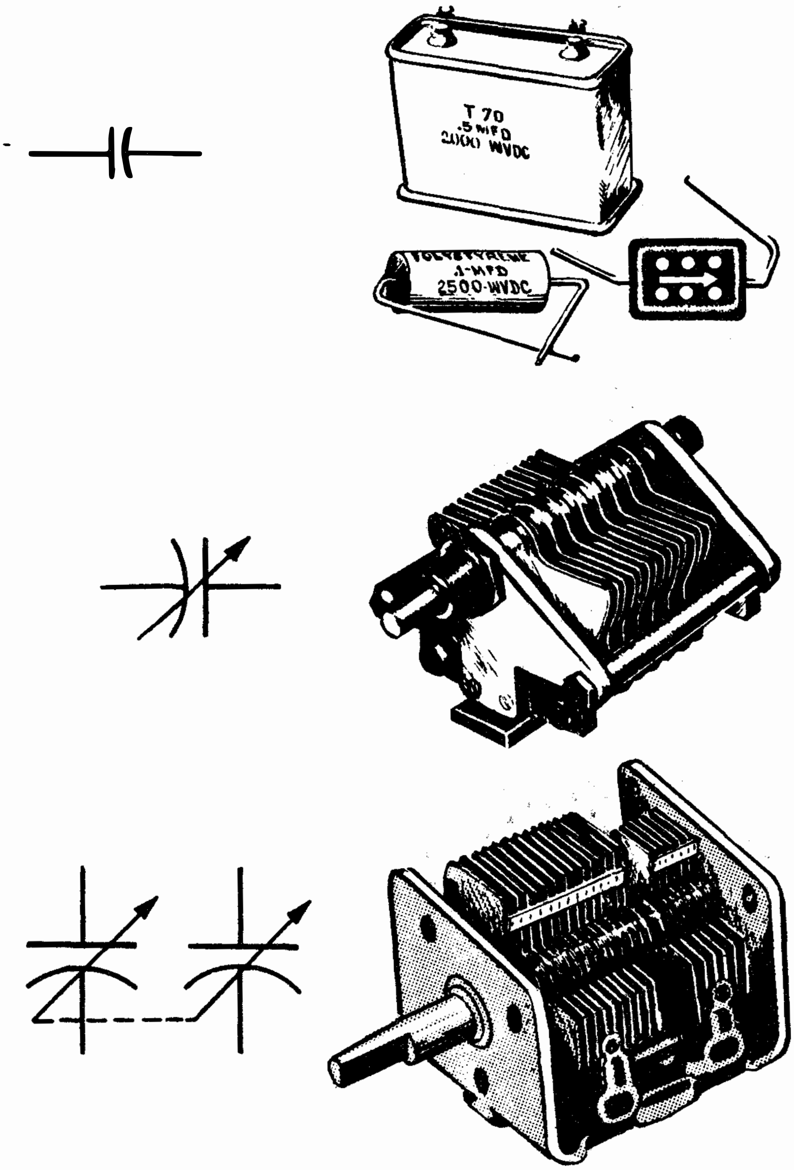


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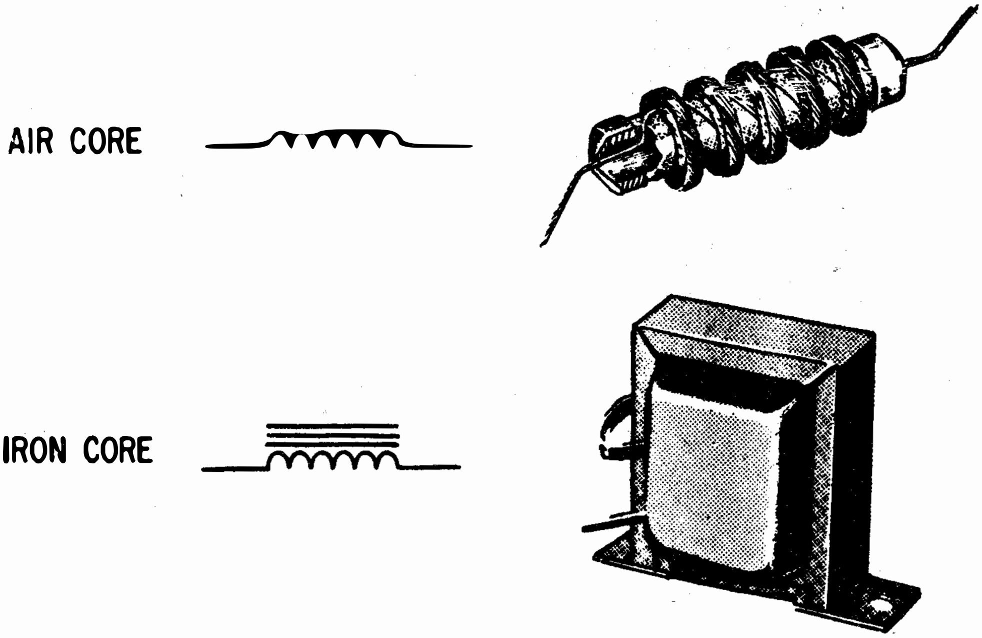
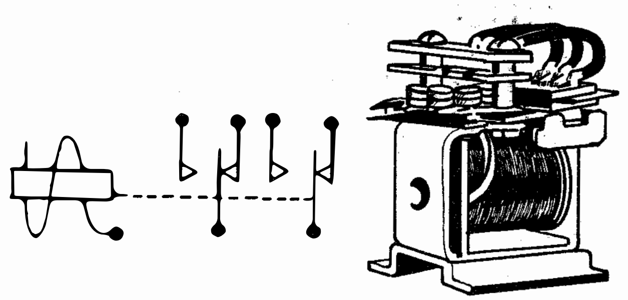
Figure 6-10. –Capacitors.



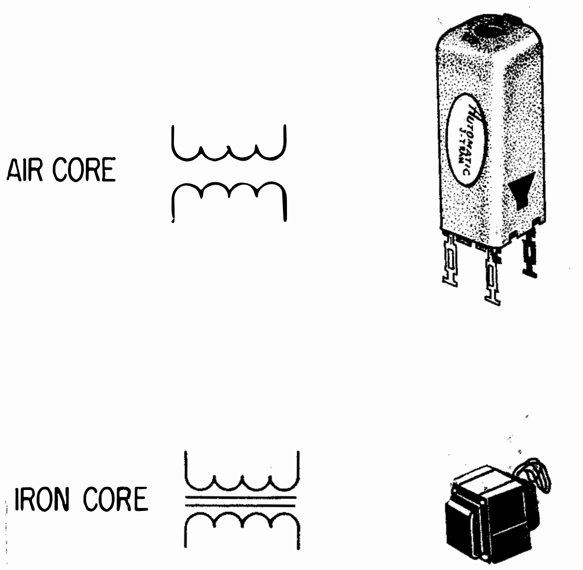
13. 5. 5

Figure 6-11. –Inductors.



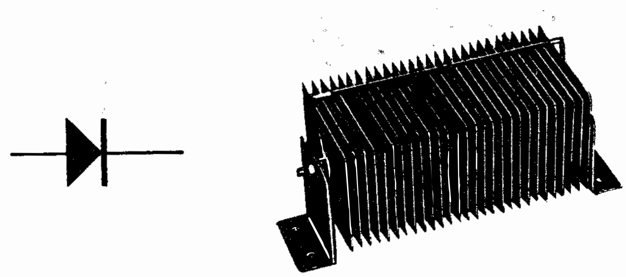
13. 5. 6C

Figure 6-13. –Relay coil with contacts.



13. 5. 6A

Figure 6-12. –Transformers.

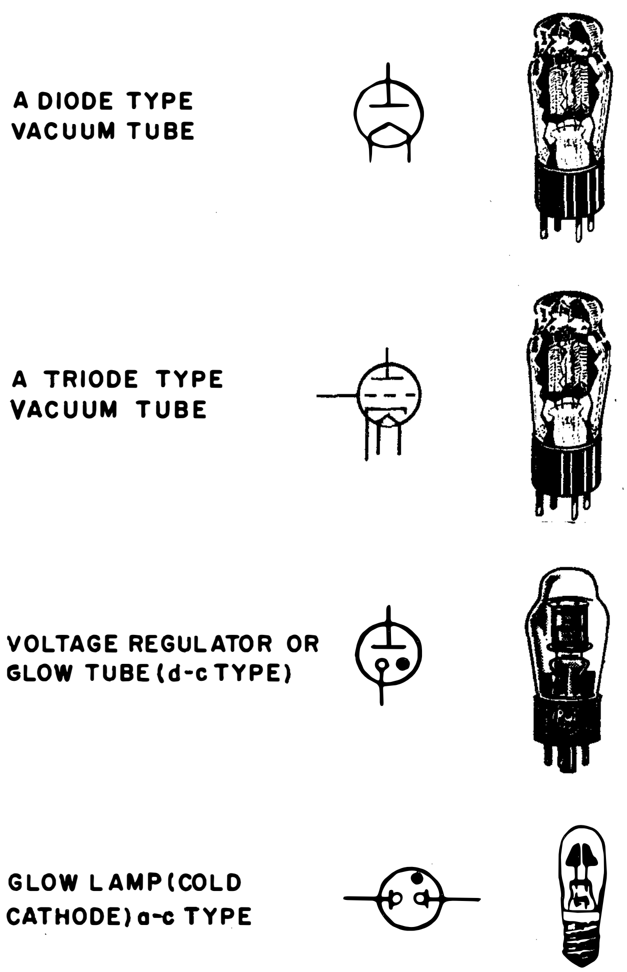


13. 5. 3

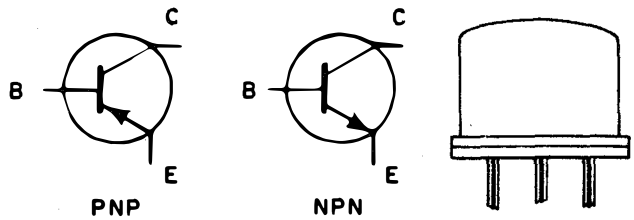
Figure 6-14. –Metallic rectifier.

Figure 6-13 illustrates a relay coil (with contacts) and its symbol. A relay is an electromagnetic switching device energized by a coil through which an electric current flows, causing its core to act as an electromagnet. A familiar example of an electromagnet is a low-voltage wall thermostat for a furnace or heating plant for a home; the thermostat contains a switch that is actuated by a bimetallic element. The bimetallic element is affected by temperature changes within a room. In turn, any change in temperature actuates the relay.

Figure 6-14 shows a metallic rectifier and its symbol. Rectifiers are used in radio and television to convert a-c line voltage to d-c voltage.



4.140:13.23
Figure 6-15.—Vacuum types, and gas-filled tubes.



12.194:1.288.1
Figure 6-16.—Transistors.

Four of the many types of tubes are seen in figure 6-15. Symbols with black dots within the circle indicate that the tube is gas filled. Other symbols have no black dots within the circle and indicate that the tube is a vacuum tube.

Illustrated in figure 6-16 are two types of transistors, the PMP and the NPN. Note that the difference in the symbols is the direction in which the arrowhead is pointing. Transistors can be used in practically all applications for which tubes are used. Transistors, however, being small, and having particular characteristics, are used in equipment in which specific demands must be met.

Figure 6-17 illustrates the symbols used for ground and wire connections, and several of the more common types of equipment and their symbols used in communications. All of you are familiar with headphones, microphones, loudspeakers, and wires and ground connections; they need no explanation.

ELECTRONIC DRAWINGS (DIAGRAMS)

Now that you are familiar with a few common electronic symbols, you are ready to identify them with electronic prints.

Figure 6-18 shows a drawing of radio set AN/URR-13B. The illustration shows you how the set looks, but tells you nothing of how it is wired or operated. Figures 6-18 through 6-22, together, give you a complete picture of the set and its components. Figures 6-23A and B represent a wiring diagram of the AN/URR-13B. A wiring diagram is necessary to specify the component parts and their locations and to show wiring details. For servicing or troubleshooting, schematic drawings are most widely used. A partial schematic of the AN/URR-13B is shown in figure 6-24.

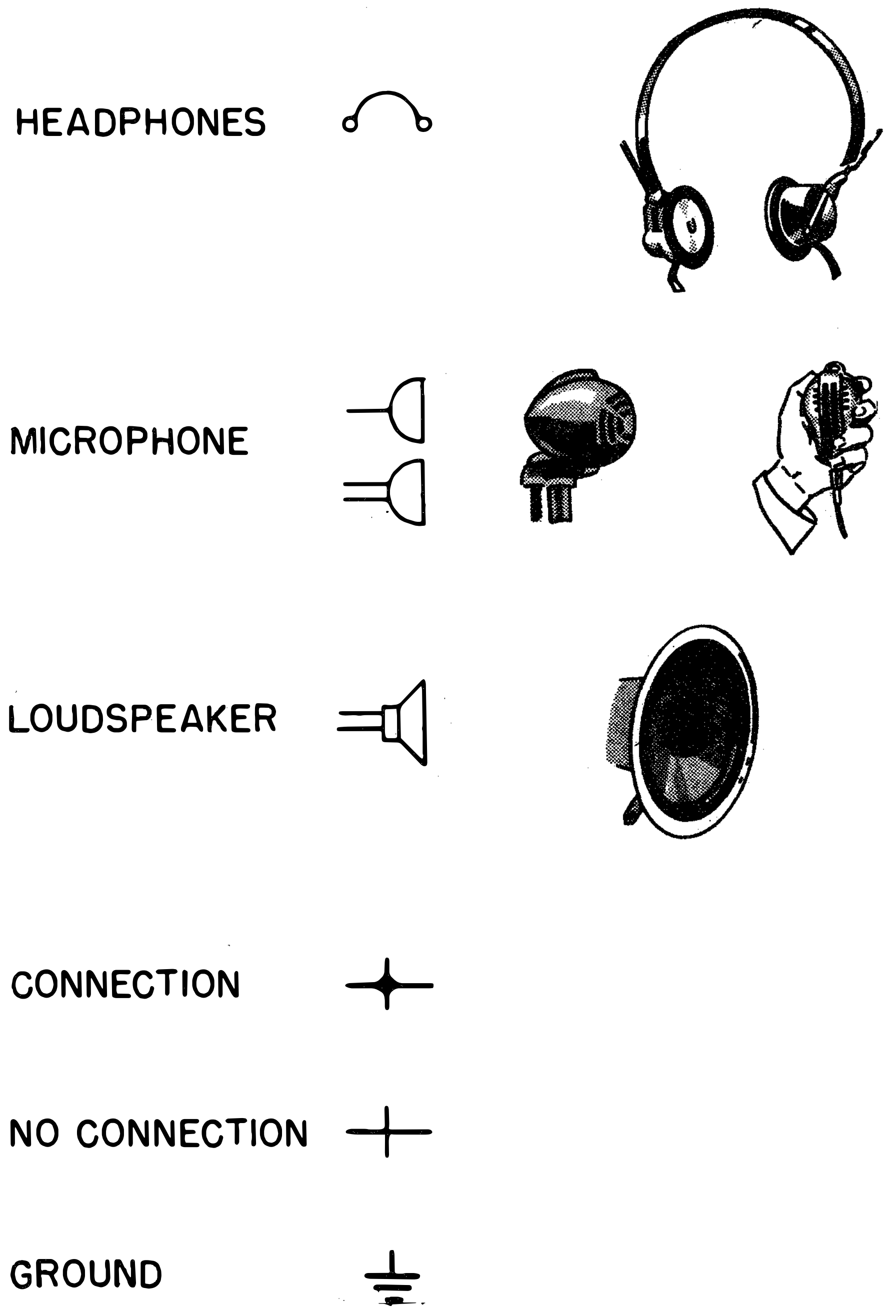


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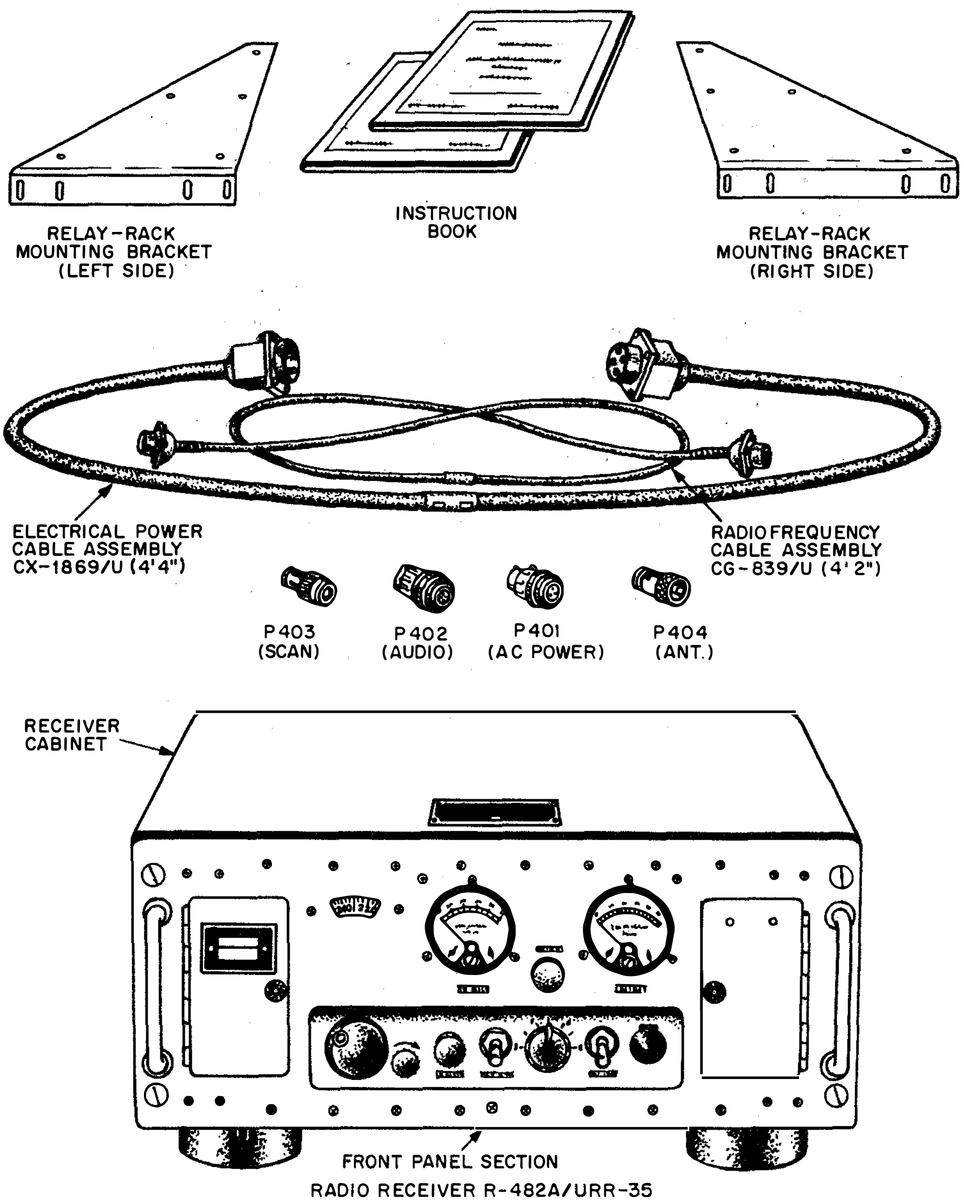
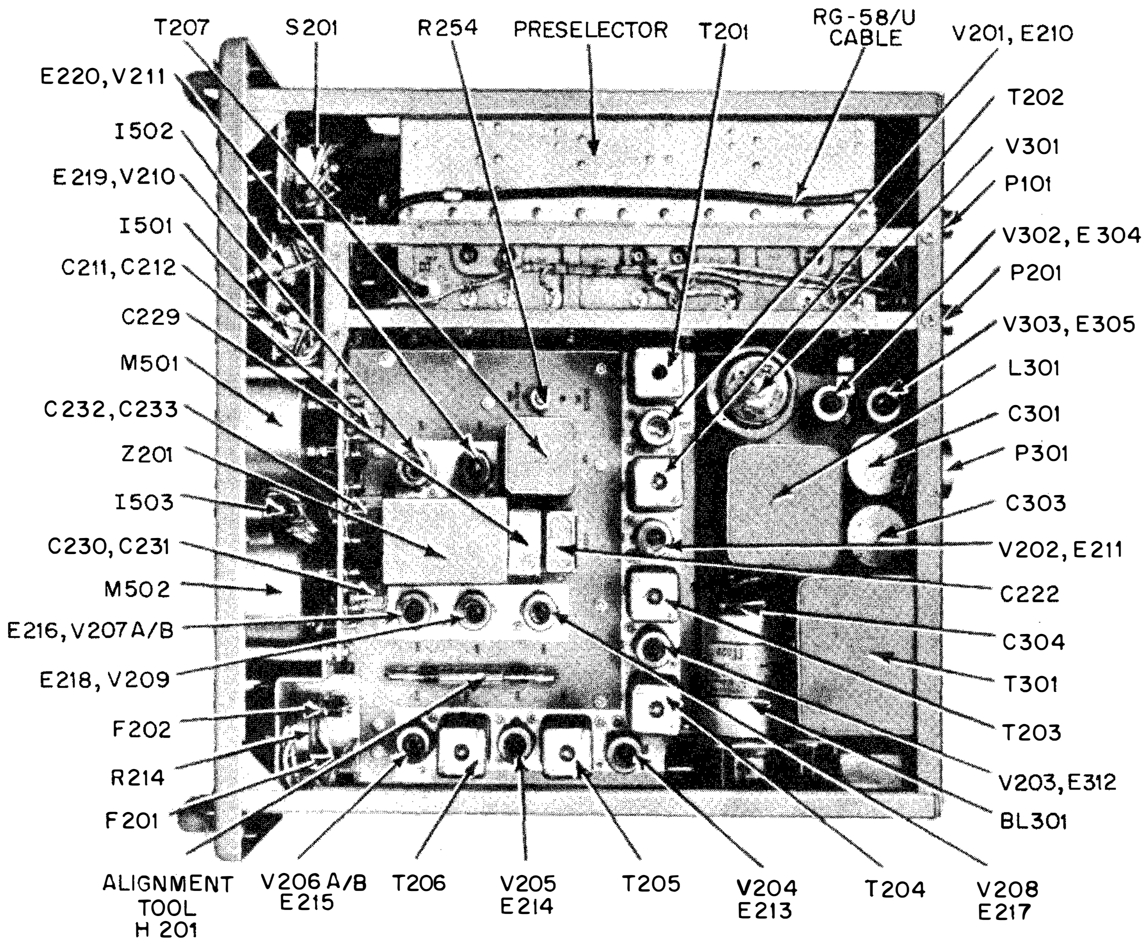
Figure 6-17.—Symbols and illustrations of ground, wire connections, and some common communication accessories.



32.58

Figure 6-18. -Radio receiving set AN/URR-13B, complete.



32.43

Figure 6-19.–Top view of chassis of radio receiving set.

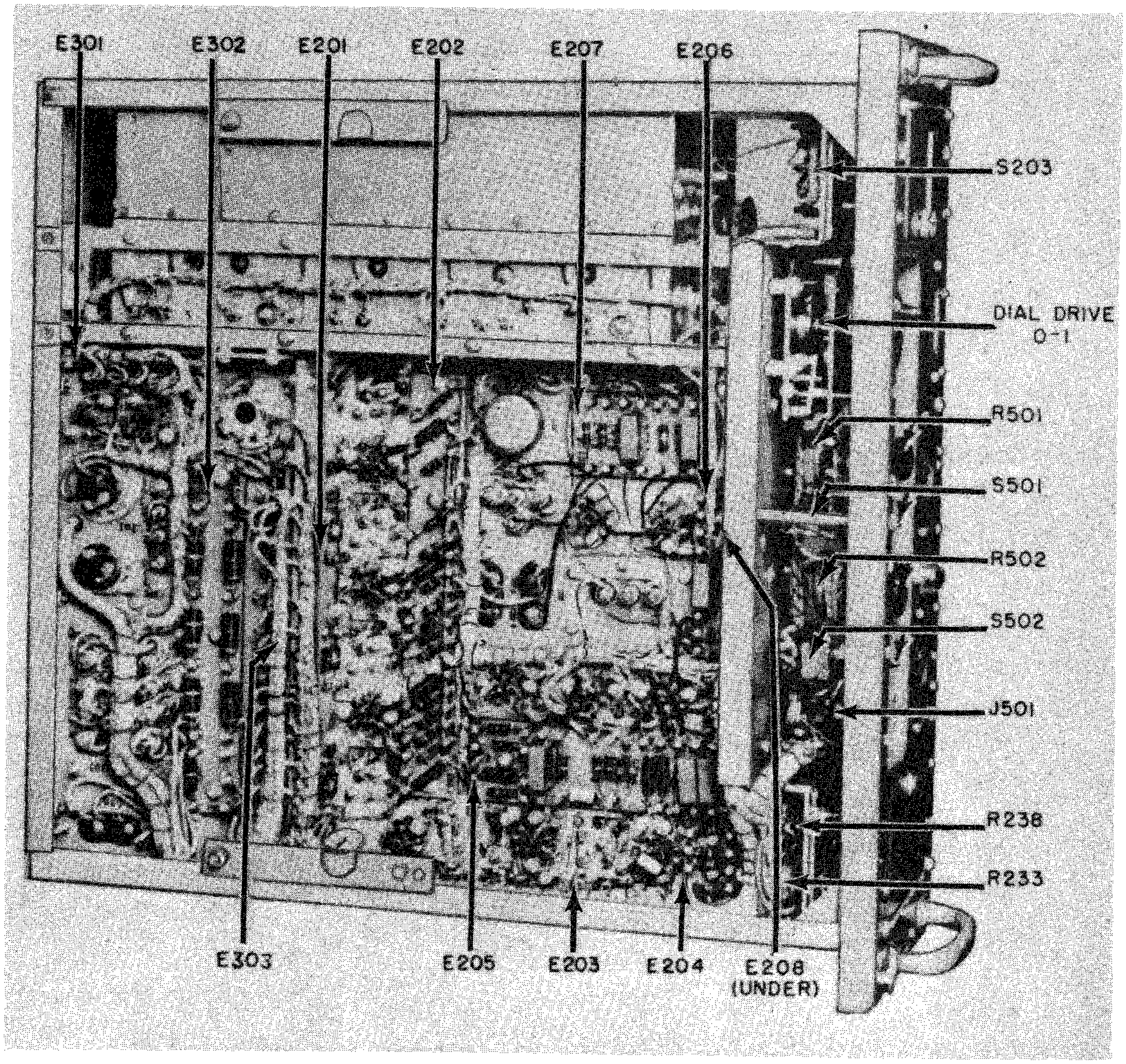


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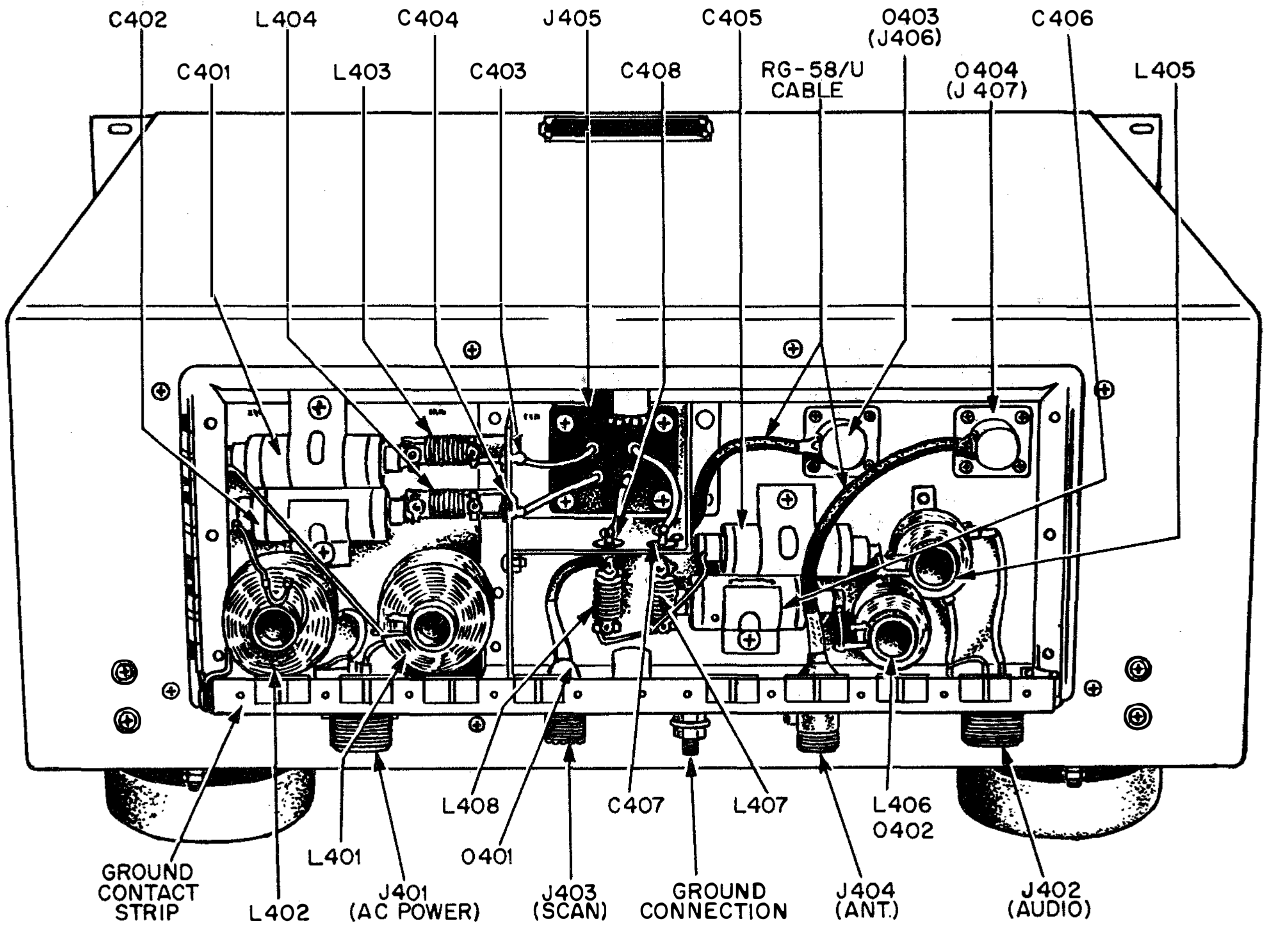
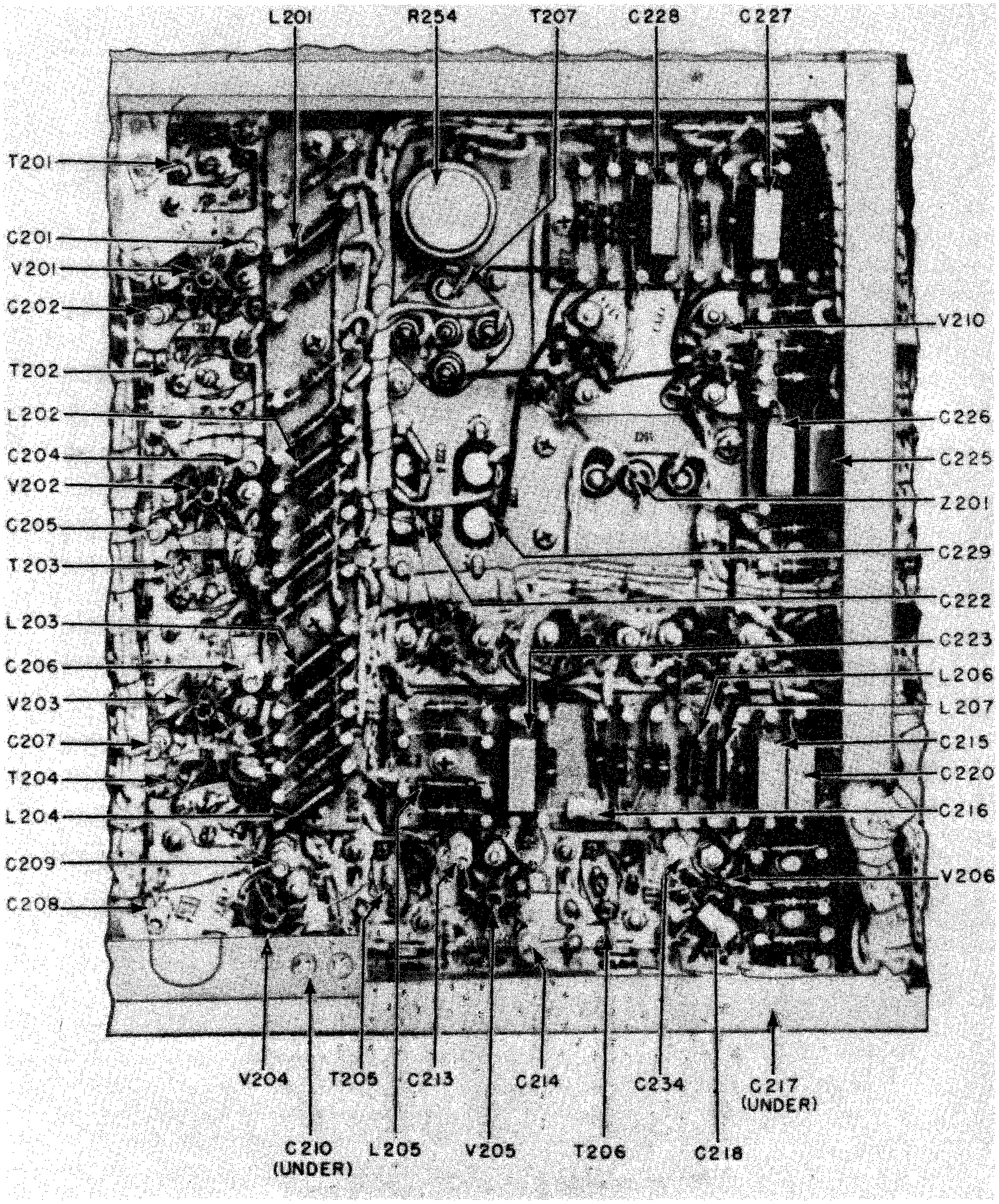
Figure 6-20. –Bottom view of chassis of radio receiving set.



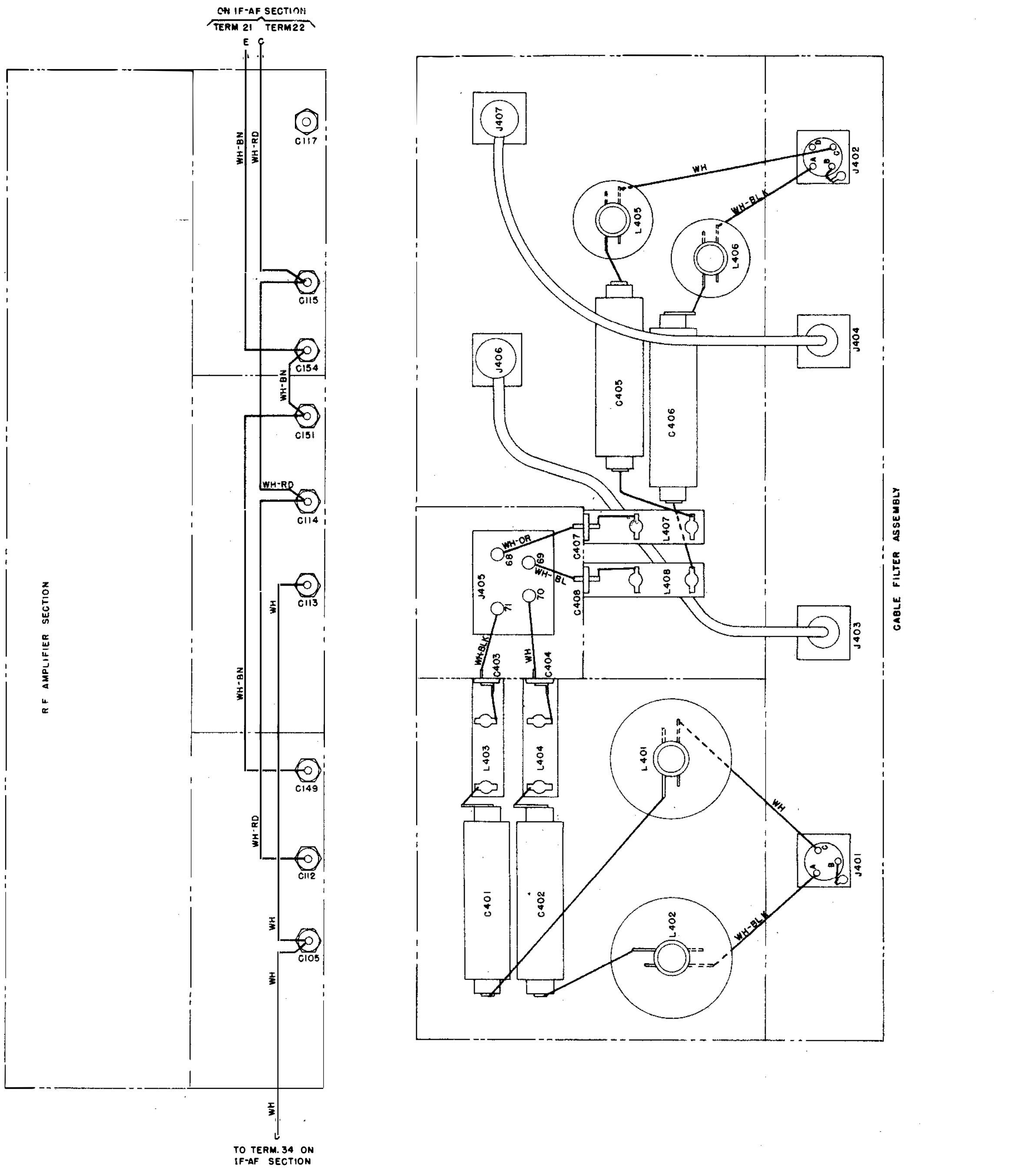
32.44

Figure 6-21.–Rear view of chassis, showing band suppression filter.



65.76

Figure 6-22. - Underside of radio receiving set.

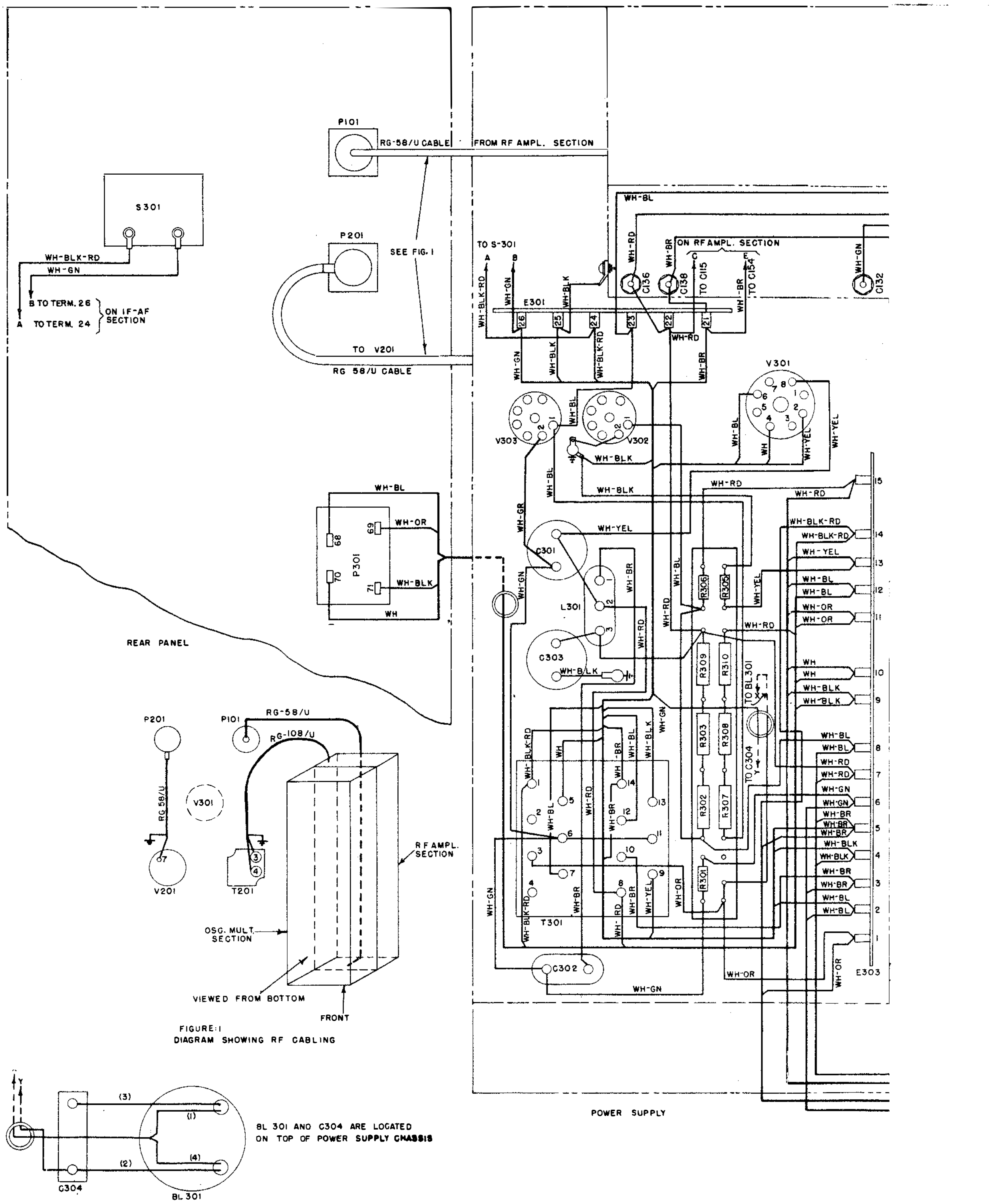


NOTES

1. ALL HOOK UP WIRES TO BE #20-7/.0126 STRANOING, 1000 V. INSULATED PER. JAN-C-76 SRIR. (RAYON BRAID OUTER COVERING).
2. "SW" INDICATES #20-7/.0126 STRANDING, 1000V. INSULATED, SHIELDED PER. FRS-19821-1.
3. ALL UNMARKED JUMPERS ARE #20 SOLID BARE TINNED COPPER WIRE PER ASTM-B33-46.
4. "JS" INDICATES A JUMPER PER NOTE #3 WITH A #20 FIBERGLASS SLEEVING, DOUBLE SATURATED PER IRVINGTON VARNISH INSULATING COMPANY OR EQUAL.
5. REFER TO DWG. FRD-20324-14 FOR INTERNAL WIRING OF RF AMPLIFIER AND OSCILLATOR MULT. SECTIONS.
6. "STP" INDICATES #20-7/.0126 STRANDING, 1000V. INSULATED, SHIELDED TWISTED PAIR PER FRS-19822-1.

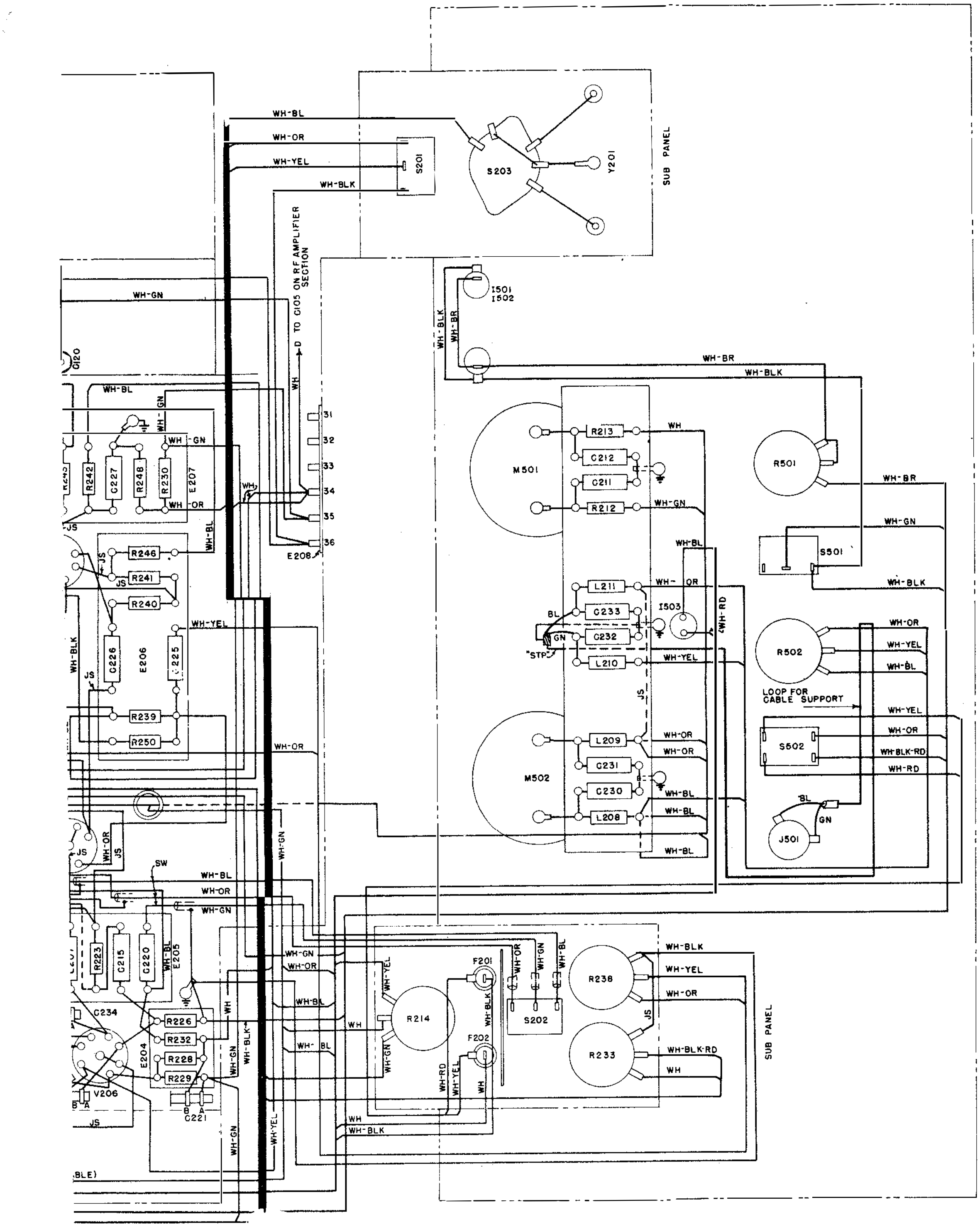
65.77.3

Figure 6-23A.–Band suppression filter.



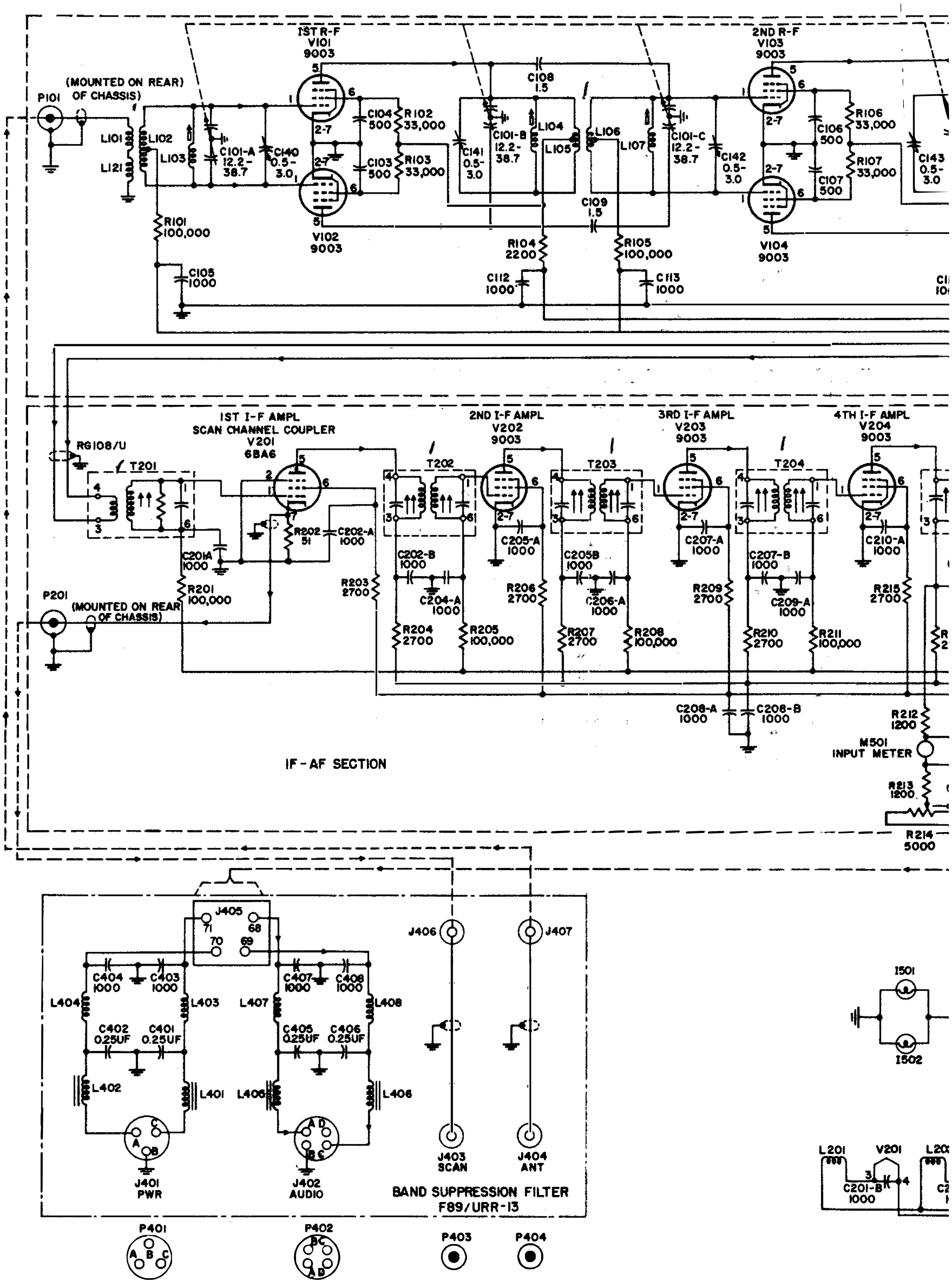
65.77.1

Figure 6-23B.—Wiring diagram of receiver chassis.



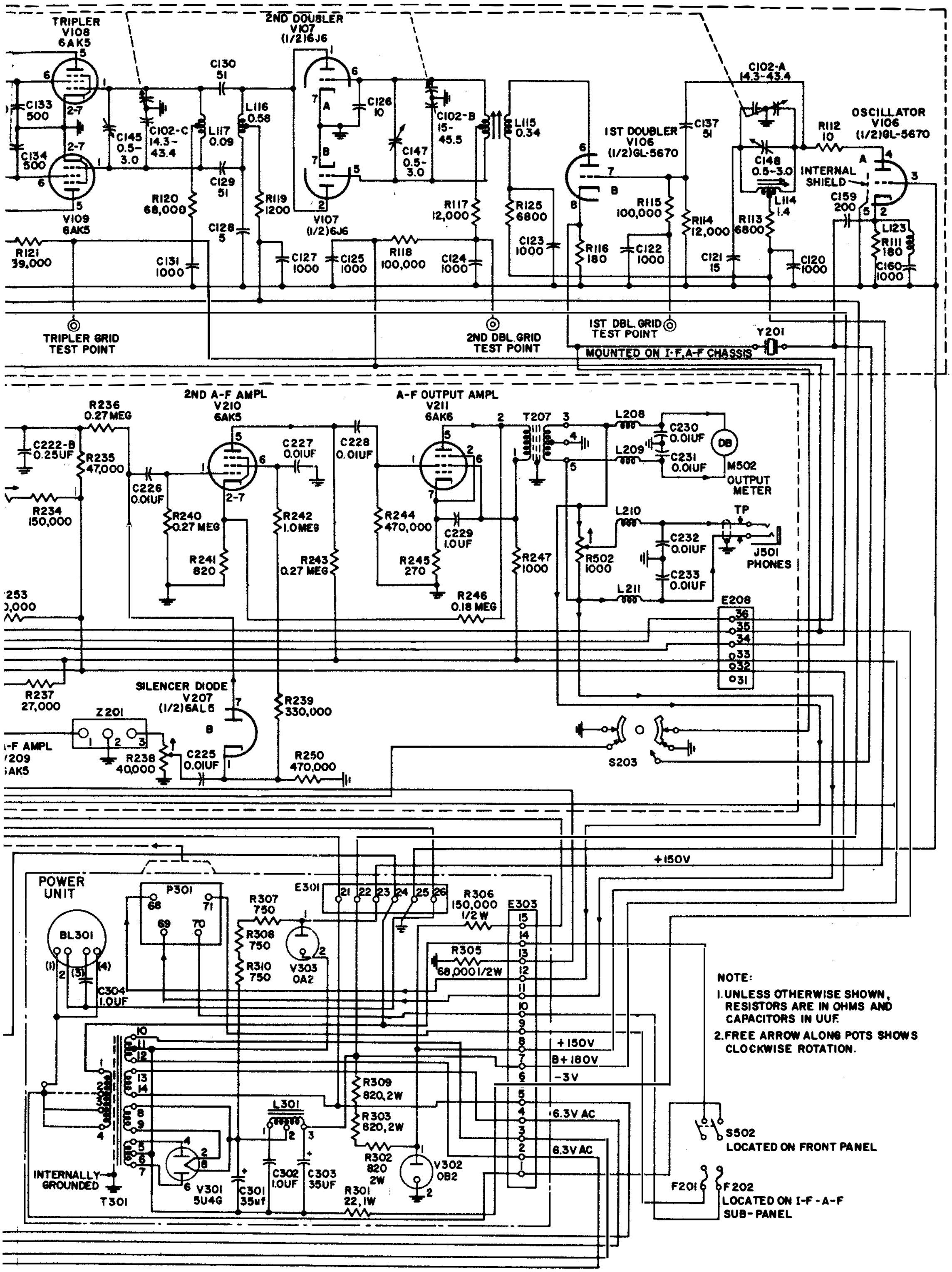
65.77.2

Figure 6-23B.–Wiring diagram of receiver chassis–con't.



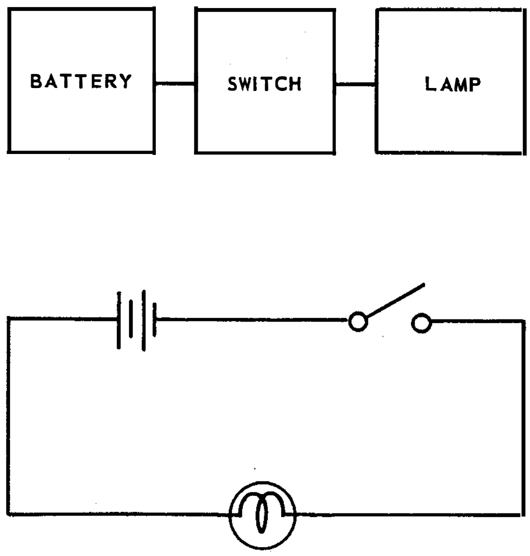
65.78.1

Figure 6-24. –Overall schematic of radio receiver set.



65.78.2

Figure 6-24.-Overall schematic of radio receiver set-con't.



65.79

Figure 6-25. –A simple block diagram and schematic.

The purpose of illustrating the receiving set, the wiring diagrams, and the schematic, is to help you to visualize and locate the components and wirings within the set. It is suggested that you keep referring to these illustrations as you read the diagram and the schematic.

BLOCK DIAGRAM

Block diagrams are drawings used extensively in the field of electricity and electronics. In general, they show the interrelationships of various components and circuits, as well as the overall operation of the equipment.

For a simple example of an electrical block diagram and schematic, refer to figure 6-25. This block diagram illustrates a battery (input) as your first block; a simple switch as the second block; and an electric lamp in the final block (output).

SERVICE BLOCK DIAGRAM

Illustrated in figure 6-26 is a block diagram of the AN/URR-13B radio receiver set. This diagram is much more complex than figure 6-25, but the reading technique is the same. At the extreme left in figure 6-26, dashed lines enclose the preselector unit. Within this enclosure are the controls. The antenna leads into the first radiofrequency (r-f) amplifier; the signal then goes to the second amplifier to the mixer; at the same time the flow is from the oscillator to the first doubler, to the second doubler, to the tripler, to the mixer; the flow continues on down the line as indicated by the arrows. After the fifty intermediate-frequency (i-f) amplifier, the arrow continues to the second detector and also to the automatic volume control (a-v-c) rectifier, which in turn leads back to the other amplifiers, mixer, and the scan channel coupler. This signal path merely indicates that this part automatically keeps the equipment settings operating properly by absorbing any electron fluctuations that may alter the preset volume. To read the block diagram completely, continue reading from left to right to the last block.

SCHEMATICS (ELECTRONIC)

Schematic prints follow a general arrangement. In most instances the input is placed at the upper left corner of the print, and the paths usually are arranged in rows going from left to right and top to bottom. Normally, you should start at the input and trace the individual circuits, in much the same manner as you follow a line in a book.

In reading schematic prints, analyze each circuit, forming a mental picture of the function of that circuit and follow it to its termination point in the print. Keep reading through each stage of the circuit until it reaches its final output. (If you were tracing a television circuit, the termination point would be the

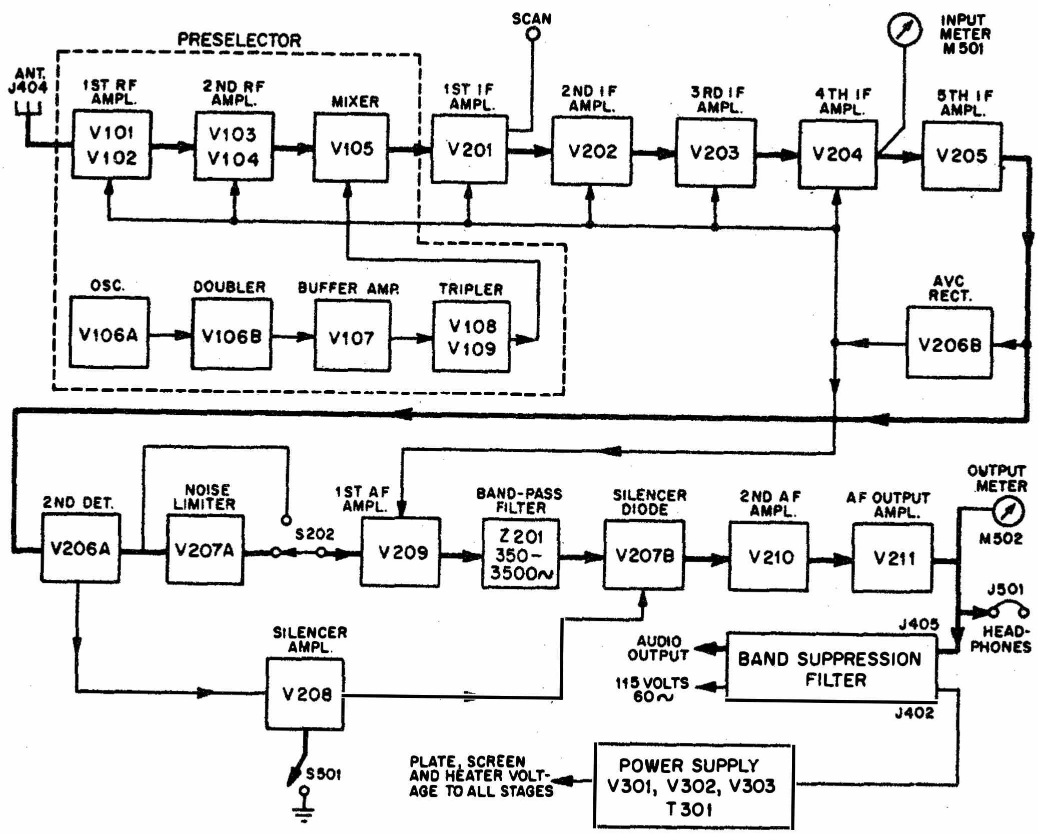


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Figure 6-26.–Block diagram of radio receiver set.

picture tube and speaker. In a radio, the termination point would be the speaker.)

Refer to figures 6-21 and 6-22. Figure 6-21 shows a band suppression filter. The wiring diagram in figure 6-23A also represents the band suppression filter. Now locate the components and read the schematic (fig. 6-24) of this filter. The schematic drawing of this filter is shown at the extreme lower left of figure 6-24. By studying each of these diagrams, you can learn to visualize the components and the wiring connection of the schematic and wiring diagram.

SUMMARY

Many of you studying this chapter may think that reading electronic prints is complicated. In reality it is not; most of your misunderstanding probably stems from the fact that you are not familiar enough with the field of electricity and electronics. As your knowledge of these related fields grows, your ability to read electronic schematics will also grow.

CHAPTER 7

VHF/UHF COMMUNICATION PRINCIPLES

The increase in congestion of the communication channels below 30 MHz and the special advantages of shorter wavelenghts in the very-high and ultrahigh-frequency bands have led to increasing use of these parts of the r-f spectrum.

The upper limit for radio signals that can be returned effectively to the surface of the earth by the ionosphere is about 30 MHz. Therefore, 30 MHz was chosen as the low-frequency limit of the VHF band. This 30-MHz dividing line is not an abrupt one, because there is no abrupt change in the ability of the ionosphere to return the r-f waves to earth as the frequency is increased. Ionospheric changes take place over a region of the frequency spectrum with its center at about 30 MHz. The band of frequencies affected by ionospheric changes may occasionally move higher or lower by considerable amounts.

The 300-MHz dividing line between the VHF and UHF bands and the 3000-MHz upper limit of the UHF band likewise are more or less arbitrary and are agreed upon for convenience. Again, these dividing lines are not abrupt. The limits should be thought of as transition regions, centering on those frequencies.

It must be understood that the behavior of radio waves at VHF/UHF frequencies differs from lower frequencies, and the differences are extremely important. For this reason, this chapter furnishes information on the fundamental differences of radio waves in this frequency range and the reasons for the differences.

Communication equipments below 225 MHz in the VHF range are no longer used extensively aboard ship, because most tactical voice circuits now operate in the UHF band. Limited installations of VHF equipment are retained principally for communication with allied forces who have not yet converted to UHF equipments.

Transmitters and receivers installed in Navy ships cover only parts of the VHF and UHF bands. The VHF equipments, described later in this chapter, cover the range of frequencies from 115 to 156 MHz. Shipboard UHF transmitters and receivers are designed for 225- to 400-MHz operation. Although this frequency range includes the upper portion of the VHF band, the equipments commonly are called and referred to in this chapter as UHF equipments.

The distributed properties of inductance, capacitance, and resistance associated with any conductor are discussed also, because their effects must be understood before the action of radio circuits at these frequencies can be comprehended. In particular, the effects of the distributed properties of inductance, capacitance, and resistance in the connecting leads in radio circuits are presented. These effects are the principal reason for the physical differences between equipment operating in this frequency range and the more familiar circuits used at lower frequencies.

It also is necessary to understand the changes that occur in the behavior of lumped-property components, such as inductors, capacitors, and resistors, when they are operated in the VHF/UHF region. The differences in design of components meant for operation in these frequency bands are compared with the more familiar lower frequency components.

The remainder of the chapter describes some of the latest types of UHF equipments in current use throughout the fleet. The older types, such as the TEDs and REDs, are not discussed in this chapter.

SPECIAL ADVANTAGES OF SHORTER WAVELENGTHS

At 30 MHz and above, the ionosphere does not return radio waves to the surface of the earth very effectively, except under rather unusual conditions. Effective range of radio communication in these frequency bands is thus limited to points not far beyond the optical horizon, as seen from the transmitting antenna. At first this limitation was considered serious, because most of the emphasis was on long-distance communication, far beyond the horizon. It soon was realized, however, that the shorter wavelengths could be used for covering relatively local areas. This capability freed some additional lower frequencies for long-distance communication.

Because propagation of the shorter radio waves does not normally reach points on the surface of the earth beyond the horizon, stations can operate on the same assigned frequency without interference, if they are separated far enough geographically. This separation provides reliable short-range communication and is widely used in naval operations at sea, for convoy communications, and for communications between ships and aircraft. A more recent use of this portion of the spectrum, extending its use to long-range communications, has come about as a result of the satellite communication program.

A second effect of the decrease in wavelength as the frequency is increased is related to the phenomenon of radio wave reflection. All electromagnetic waves, such as radio, light, and heat, can be reflected, but how well they are reflected depends on a number of different factors.

One factor is the relationship between the length of the wave and the physical size of the reflecting object. Another factor directly related to wavelength is the physical size of the equipment used to generate the r-f energy, and the antenna needed to radiate it effectively. Both of these factors can be made smaller in direct proportion as the wavelength is made shorter. A half-wave antenna for a station operating in the broadcast band requires a tower hundreds of feet high, for example; but at 500 MHz, an aluminum rod 30 cm (11.8 inches) long is sufficient. Obviously, equipment for the shorter wavelengths can be made smaller and more compact because of this relationship between physical size and wavelength.

DISTRIBUTED PROPERTIES

Distributed properties may be defined as the inductance, capacitance, and resistance uniformly spread along each unit length of any circuit element, plus the inductance and capacitance existing from each conductor to ground and to other objects. A 1/4-inch rod of copper, 4 inches long, placed in free space where no outside influence could act upon it, for example, would be found to possess small but definite values of inductance, capacitance, and resistance. If the conductor were cut in two, each part would possess exactly half the values previously found. In other words, the distributed properties are uniform so long as the conductor itself remains uniform in cross-sectional size, shape, and conductivity, and where no external influences exist. If the conductor is not uniform, the distributed properties still exist, but their distribution is not uniform.

When a conductor is placed in an actual circuit, it possesses these self-contained distributed properties, and may or may not possess additional distributed properties caused by its proximity to ground and to other conductors in the circuit. Distributed properties exist in all conductors and conducting surfaces, even in the leads and other parts of the lumped-property circuit elements (capacitors, coils, resistors), which are manufactured to provide definite amounts of the properties. When used in practical circuits at VHF/UHF frequencies, however, the distributed properties of inductance, capacitance, and resistance in a given conductor actually are not fixed amounts or constants, but slowly change in value as the frequency changes.

At frequencies below 30 MHz, it is practicable to ignore distributed, or stray, circuit properties, except in circuits such as resonant sections of transmission lines or antennas. Above 30 MHz, the effects of distributed properties upon practical circuits can no longer be neglected, because of the relationship between the physical size of the circuit components and the wavelengths. At 3 MHz, for instance, 1 wavelength is 100 meters long, in comparison with which a 6-inch length of wire is very short. When the wavelength becomes relatively short, as the frequency increases, it becomes physically impossible to scale down the parts of the electronic circuit and keep them small in relationship to wavelength. Even where such a size reduction is possible, the power-handling ability of the circuit is reduced in proportion. As a result, much of the usefulness of the device is lost.

When the operating frequency increases, the various losses that lower circuit efficiency increase, and make it desirable to use circuit arrangements and elements that have lower built-in losses. So far it has been found impossible to construct lumped-property elements that are pure and do not contain small distributed values of the other two properties. As the working frequency increases, the effects of the unwanted distributed properties cause increased losses, with the result that the efficiency drops. In circuits having distributed properties, losses are lower than in the same circuits constructed of lumped-property elements, because it is possible to use conductors of proper size and shape to minimize r-f resistance and because the dielectric is usually air. Better circuit stability and efficiency are achieved as a result of using the distributed properties.

DISTRIBUTED INDUCTANCE

The term "distributed inductance" refers to the self-inductance distributed along the length of any sort of conductor, whether it is or is not meant to act as an inductor. Inductance is the property of a conductor that tends to oppose any change of electron flow through the conductor. Inductance reveals itself only when current is varying in the conductor; a back emf (electromotive force) is induced in a direction that tends to oppose the change in current flow. It is apparent that even a very short section of straight wire possesses self-inductance. The conductor does not have to be wire, however; it can be any conductor of any shape or size.

Usually, the actual amount of self-inductance is small, but its effect becomes important at frequencies above 30 MHz. The effect may be desirable or unwanted, but it cannot be ignored. A complex equation is needed to find the actual value of self-inductance, but the important point here is that the value depends directly on the number of lines of flux surrounding the conductor. Self-inductance is highest at the center of any conductor carrying alternating current, and tapers off toward the outside surface. This phenomenon is the cause of skin effect (explained later).

Undesirable Effects

The property of distributed inductance can cause serious r-f losses if leads and connecting linkages are not kept as short as possible. Figure 7-1 demonstrates how this loss takes place. The plate tank circuit (part A) is designed to operate at a frequency of 4 MHz. The inductor is connected to the tube plate by a 4-inch length of No. 20 wire having a self-inductance of approximately 0.1 microhenry (uh). Ignoring loading and other factors, calculation

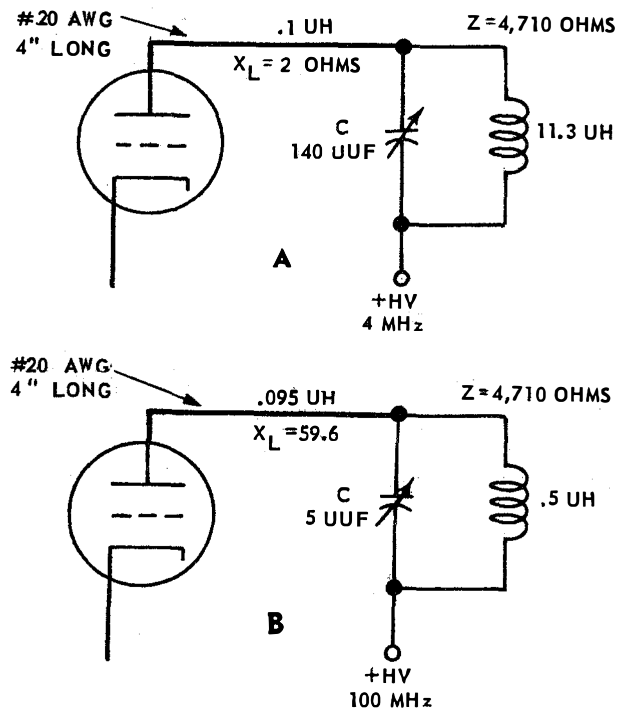

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Figure 7-1. —Effect of distributed inductance at higher frequencies.

shows that the resistive impedance offered by the tank circuit at resonance is 4710 ohms, whereas the inductive reactance ($X_L = 2\pi fL$) of the connecting wire is approximately 2 ohms, and is so small in proportion to 4710 ohms that it can be neglected at this low frequency.

When the operating frequency is raised to 100 MHz (part B, fig. 7-1), the inductance of the tank coil must be reduced to resonate at the higher frequency. At 100 MHz, the self-inductance has decreased slightly and, if the tube-plate lead remains 4 inches long, its inductive reactance is 59.6 ohms. The resistive impedance of the tank circuit still is 4710 ohms at resonance and, therefore, a voltage-divider effect occurs, which prevents the entire r-f signal output of the tube from being impressed across the tank circuit and results in a loss of gain. Moreover, the introduction of an inductive component causes a phase lag that is undesirable in certain applications. At higher frequencies, the effect becomes even more pronounced, introducing larger losses.

Desirable Effects

In certain circuits, a condition of series or parallel resonance is desired. To achieve this condition, the property of distributed inductance, distributed capacitance, or a combination of both, may be used. To provide a bypass for signal voltages from the low-impedance end of an i-f tank circuit back to the cathode of the tube, for example, a series-resonant circuit offers the lowest impedance path. When the intermediate frequency is above 30 MHz, it is possible to get the effect of series resonance by cutting the leads of the capacitor to lengths offering the necessary series inductance. This effect is shown in parts A and B of figure 7-2. Note that the capacitance is lumped, but the inductance is the distributed inductance of the capacitor leads. The signal voltage sees a certain value of each property, regardless of whether the properties are lumped, distributed, or any combination thereof.

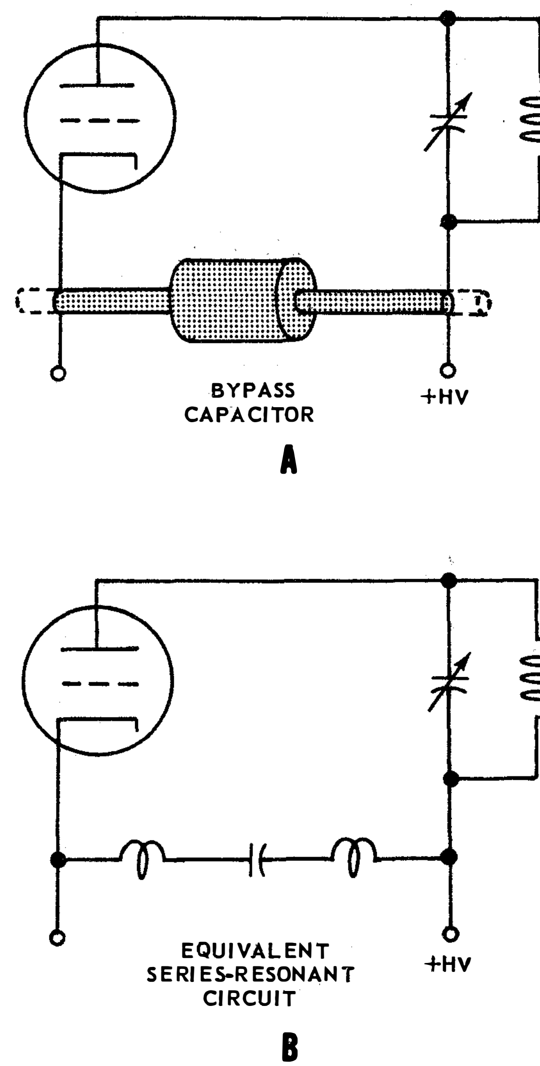

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Figure 7-2. -Series resonance; lumped capacitance and distributed inductance.

Inductive Coupling

When a conductor carrying alternating current runs sufficiently close to another conductor, its magnetic field induces an electromotive force in the second conductor, causing a current to flow. This combination is the effect of mutual inductance.

Usually, the study of mutual inductance and coupling at lower frequencies is restricted to coils and transformers. Above 30 MHz, however, the effect of coupling between two conductors–even, two straight pieces of wire–becomes important. The amount of coupling or mutual reactance between two inductors increases as the frequency is increased, if the physical relationship remains the same.

Some effects of coupling between distributed inductances are undesirable. If the grid and plate leads of a single-tube amplifier stage are permitted to run close to each other, for instance, signal energy from the plate circuit may be coupled back to the grid, causing either regeneration or degeneration. Distributed capacitance also is present. Only the inductive coupling effect is considered at this time, though. As another example, a current-carrying wire may be too near a tube shield, inducing an emf that causes current to flow in the shield. This current flow through the shield is a power loss that can be supplied only from the current-carrying wire.

When inductive coupling causes circuit imbalance or power loss, it usually is spoken of as stray coupling. The amount or degree of coupling depends directly on the relative positions of the conductors as well as their distance from each other. Figure 7-3 shows the effect of physical position on the degree of coupling. In view A, the coupling is loose, inasmuch as the leads are crossing at right angles, and the least mutual inductance results. The coupling between the wires in parts B and C increases because of the greater amount of mutual inductance Practical circuits are laid out with the shortest possible leads, well separated from one another and distant from

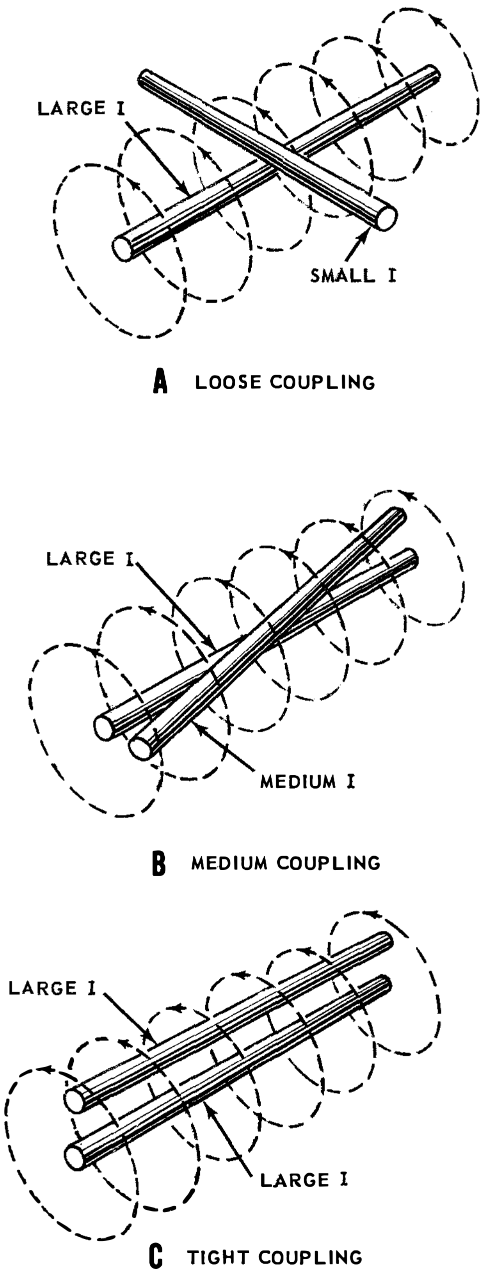

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Figure 7-3.—Coupling effects at higher frequencies.

the chassis and shields. If two wires must cross, they should cross at right angles, because in this manner the smallest mutual inductance results.

DISTRIBUTED CAPACITANCE

The term "distributed capacitance" refers to the capacitance between any point on a conductor and all surrounding objects. Capacitance exists between any two points that are at different electrical potentials. This capacitance exists whether the points of different potential are in different conductors or in the same conductor. Although the self-capacitance of a conductor is of relatively little importance, except in special circuits, the effect of the capacitance between two conductors must be taken into consideration at VHF/UHF frequencies. Distributed capacitance exists between the parts of circuit elements and the electrodes of vacuum tubes, as well as between leads and switch contacts.

The actual value of distributed capacitance changes only slightly with frequency, but the reactance changes greatly. The formula for capacitive reactance ($X_c = \frac{1}{2\pi fC}$) shows that if the value of capacitance remains the same, increasing the frequency causes the capacitive reactance to decrease. A small value of distributed capacitance at the lower frequencies, therefore, offers a high reactance to the flow of a-c, but at VHF frequencies it offers a lower reactance. This effect often is undesirable when it occurs accidentally between two conductors in a circuit, but may be used deliberately to achieve series or parallel resonance in resonant line sections. The losses in distributed capacitance are lower than those in lumped capacitors because the dielectric is usually air instead of a solid, and because the r-f resistance and distributed inductance values are smaller.

Undesirable Effects

An example of the manner in which distributed capacitance may upset the proper operation of a circuit is shown in figure 7-4. Assume that C_d represents a distributed, or stray, capacitance of 1 mmf appearing between ground and the lead from the coupling capacitor to the grid of tube V2. The stray capacitance C_d effectively shunts the 5000-ohm grid impedance Z_g. If an r-f signal at a frequency of 2 MHz is traveling from the tank circuit of V1 to the grid of V2, the 1-mmf distributed capacitance offers a capacitive reactance of 79,618

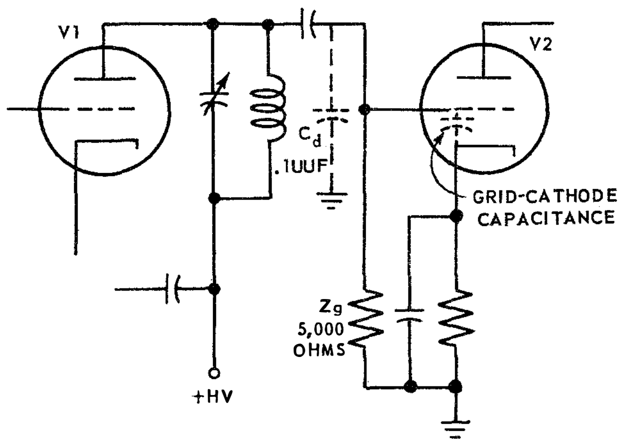

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Figure 7-4.-Effect of distributed capacitance at higher frequencies.

ohms to the signal. This value is so high in relation to Z_g that its effect is negligible at this frequency and similar low frequencies. If, however, a 100-MHz signal voltage is coming from the tank circuit of V1, the same 1-mmf stray capacitance offers only 1592 ohms of capacitive reactance. Now, the signal voltage sees a relatively low-impedance path across the stray capacitance, offering less than one-third the opposition of the grid impedance Z_g. Therefore, more than two-thirds of the signal voltage is shunted across this path and is lost. If the frequency of the signal voltage is increased to 400 MHz, the reactance drops to 398 ohms, and only a small amount of the signal voltage reaches the grid impedance.

To keep the stray capacitance at a minimum, whenever possible, the circuit wiring is kept well spaced with short leads that run at right angles to one another.

Desirable Effects

For certain applications, such as i-f amplification, a parallel LC (inductance-capacitance) circuit, resonant at a single frequency, is useful. A simple way of achieving this resonance is to wind a coil in such a manner that the total distributed capacitance is used to make the coil self-resonant at the desired frequency.

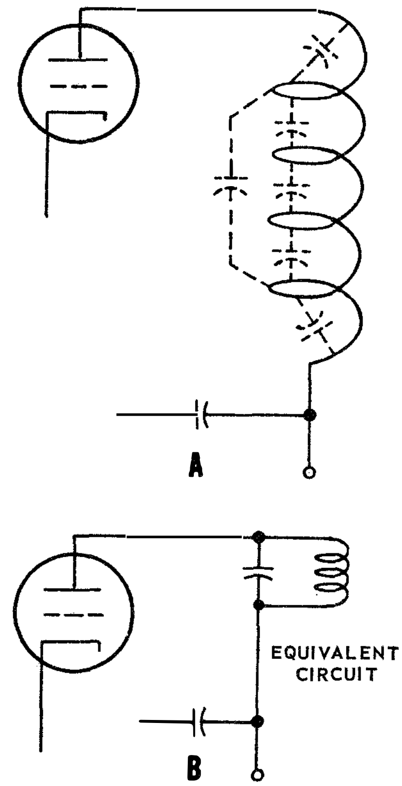

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Figure 7-5.-Parallel resonance; lumped inductance and distributed capacitance.

Part A of figure 7-5 shows the distributed capacitance that exists because of the difference of potential between adjacent turns of any coil. The sum of these small values is shown in part B as an effective value of capacitance in parallel with the lumped inductance of the coil. Although most inductors are wound to minimize the distributed capacitance some are designed to offer the necessary capacitance to provide a desired LC ratio. This design offers an advantage because the response of the tuned circuit can be made sharper than would be possible with lumped-property coils and capacitors.

DISTRIBUTED RESISTANCE

The term "distributed resistance" seldom is used, because it is necessary to distinguish between the resistance offered to d-c and low-frequency a-c and the resistance offered to r-f currents at the higher frequencies.

Depending on the conductivity of the metal or alloy, all conductors have d-c resistance.

It is distributed uniformly along conductors that are uniform in cross-sectional area, shape, and conductivity. Resistance to r-f, however, is caused by d-c resistance plus the effect of self-inductance, which is greater at the center of a conductor than at the surface. At the lower frequencies, this self-inductance has little effect on the flow of current because the values of inductive reactance are extremely small. As the operating frequency increases, the inductive reactance at the center of the conductor becomes higher, and the current seeks the lower reactance path toward the surface, resulting in a current distribution that is not uniform.

Tendency of the current to flow on or near the surface of a conductor is called skin effect. As the frequency increases, less current flows in the center of the conductor and more flows on the surface. The result is that more current is forced through less conductor, with higher losses and more heating. Because the center of the conductor is not carrying current, the effect is the same as using a smaller conductor. The r-f resistance at VHF frequencies can amount to several times the d-c resistance of the same conductor.

Minimizing Skin Effect

Skin effect takes place regardless of the shape of the conductor, but it causes less r-f resistance in conductors having rectangular cross sections than in those that are circular, like common wire. Flat copper strip is sometimes used, but this method is more costly and does not work easily. Another means of reducing skin effect is the use of hollow or tubular conductors.

Litz wire, as it commonly is called, is made up of many strands of very fine enameled wire woven together. The current is divided among the strands, and the skin effect on any single conductor is extremely small. Litz wire is comparatively expensive, hence it is not widely used.

Probably the best method of avoiding losses from r-f resistance is by silverplating the conductors. This method does not eliminate skin effect, but takes advantage of it. When the plated conductor carries r-f, skin effect takes place as usual. Now, however, the current is flowing in the silverplating, which has less d-c resistance than ordinary conductors; therefore, the r-f resistance is reduced considerably. In practice, plating is expensive, limiting its use.

The most common means of reducing r-f resistance is to use a hollow conductor or one of larger diameter. Again, this method does not eliminate skin effect. The depth to which the current penetrates is affected only by the frequency and the conductor material. When the diameter is increased, consequently, the current layer has the same thickness but more cross-sectional area in which to flow, reducing the effective r-f resistance.

LUMPED-PROPERTY COMPONENTS

A lumped-property component is an electronic part in which a definite amount of capacitance, inductance, or resistance exists, usually with relatively little of either of the other properties present. Capacitors, coils, and resistors used in radio equipment operating at frequencies below 30 MHz are, in general, lumped-property components.

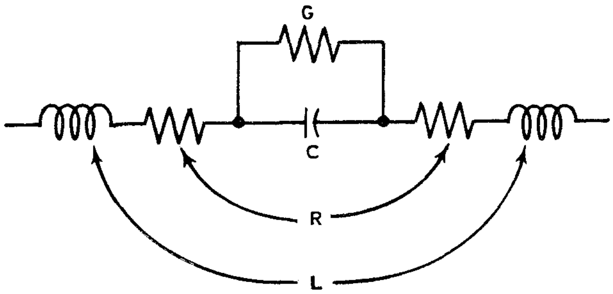
As the frequency of operation is raised, the electrical loss in lumped-property components increases, until a frequency is reached where this increasing loss cannot be tolerated. The increased loss is actually a combination of three distinct effects—dielectric loss, r-f resistance loss, and radiation loss.

Loss in even the best dielectric materials increases with frequency, because a definite amount of applied electrical energy is lost in each cycle, and the more cycles that occur in a unit of time, the more heat is generated in the dielectric. The r-f resistance loss also increases with increasing frequency, because of skin effect.

Radiation loss occurs in any r-f circuit because of direct radiation from the parts. This loss usually is negligible, so long as the circuit is not more than about 1/10 of a wavelength in any physical dimension. With increasing frequency, however, it becomes impossible to scale down the components in physical size in proportion to the decreasing wavelength, thus radiation losses increase. The addition of r-f shielding around the circuit also causes energy to be lost in heating the shield, rather than by radiation.

CAPACITORS

All capacitors, of any size, type, or construction, have characteristics that cause them to behave in a way unlike the theoretical ideal capacitor, which would have pure capacitance but no inductance or resistance. Practical capacitors actually have some series inductance because of their leads and internal metallic foil plates. This inductance is actually in series with the capacitance as shown in the approximate equivalent circuit of figure 7-6, where C



50.63

Figure 7-6. —Equivalent high-frequency circuit of a capacitor.

represents the actual capacitance, L the inductance of each lead, and R the effective r-f series resistance of the leads and foils. Losses in the dielectric are represented by the shunt conductance, C. Below 10 MHz, dielectric losses are seldom serious, even in ordinary paper capacitors, and in high-quality mica and ceramic units it has no serious effects at the highest frequencies.

Because capacitors have a small but significant amount of inductance in series with the actual capacitance, there is a resonant frequency at which the reactances of the inductance and capacitance become equal and cancel each other. The reactance becomes capacitive below series resonance, and grows larger as the frequency decreases. The opposite effect takes place above resonance, where the reactance is inductive, and grows larger with increasing frequency.

The common types of electrolytic, mica, paper, and ceramic capacitors are subject to increasing losses as the operating frequency is increased. In electrolytic capacitors, these losses and the inductance of the leads and internal foil strips that form the plates make them practically ineffective as capacitors at frequencies above a few megahertz. Even in equipment operating below 30 MHz, electrolytic capacitors usually are shunted with a suitable value of paper or mica capacitor, which bypasses the higher frequency currents around the electrolytic unit.

Paper capacitors also are subject to serious losses as the frequency is raised, but not to so severe an extent as in electrolytic units. The series inductance of paper units is large, and causes them to become series-resonant at frequencies ranging from 1 to 10 MHz, depending on the capacitance and lead length.

Mica capacitors, because of their lower losses and smaller series inductance, have an extended range of usefulness. Average types become series-resonant at frequencies from 10 to 100 MHz, depending on the capacitance value and lead length.

Ceramic capacitors are a more recent development and have improved properties in certain respects. Their losses are lower than those of mica units, and their design permits a much lower series inductance. As a result, their series resonance may be as high as 400 or 500 MHz, which, together with their stability and low losses, makes them preferred in many VHF/UHF applications.

Improvements in Capacitors

Changes in the materials and design of capacitors have been made to adapt them for more effective performance at frequencies above 30 MHz. In general, because capacitors do not behave as capacitors above their own resonant frequency, most of the improvements have been made with a view to raising the resonant frequency. The greatest improvement results from the development of ceramic materials that made possible ceramic-dielectric capacitors with only two plates, compared with the many interleaved foils necessary in paper and mica units. Ceramics also made possible capacitors with various temperature coefficients, which can be used to improve the stability of critical circuits.

Various ceramic materials, such as barium and strontium titanates, have been found to have high dielectric constants and good dielectric strength. By plating or firing silver electrodes directly on thin plates of this dielectric material, air and moisture are prevented from getting between the plates of the capacitor. This method results in greatly improved stability. By varying the mixture of the ceramics, the temperature coefficient of the capacitor can be made negative, zero, or positive, as desired. Ceramic capacitors then can be used to compensate for frequency drift caused by changes in other components with changes in temperature. Skin effect is reduced by using short, heavy leads. Moreover, losses caused by surface leakage and humidity are minimized by sealing the surface with baked silicon lacquer. A similar process of plating or coating the silver electrode on mica also has been developed for the manufacture of mica capacitors, with considerable improvement in their stability and high-frequency performance.

INDUCTORS

All inductors have some distributed capacitance between turns, which appears as a small capacitance in parallel to the external circuit. When the applied frequency is increased to a point where the distributed capacitance of the coil resonates with the inductance, a new effect appears. The coil becomes a parallel-resonant circuit (fig. 7-7) to the external circuit connected to its terminals. The resistance in this equivalent circuit represents the losses incurred in practical coils. This self-resonant characteristic is used in many applications in VHF/UHF receivers. The inductor is made to resonate with its own self-capacitance, plus the tube input and stray circuit capacitance. This action eliminates the need for a separate tuning capacitor and also provides the highest possible inductance-capacitance ratio, the largest load impedance, and the greatest stage gain.

Self-resonant inductors often are used in the i-f amplifiers of communication receivers. If adjustable tuning is required, it is accomplished by varying the inductance either by a switching arrangement or with an adjustable core (slug) of iron-dust-impregnated plastic.

In transmitter circuits, the inductor must handle considerable power without serious heating. This requirement calls for a coil of larger physical size, and usually makes the use of iron-powder cores impractical because such cores tend to saturate magnetically, and lose efficiency as the power level increases. Transmitting inductors thus are usually of the air-wound, self-supporting type.

RESISTORS

The effects of increasing frequency on the performance of some types of resistors are such that the resistors cannot be used efficiently at frequencies of 30 MHz and upward. Wire-wound resistors that are used at low frequencies become useless above this range because of unavoidable inductance and capacitance, which introduce unwanted reactive or resonant effects. Therefore, composition resistors made of finely divided carbon in a suitable binder are most commonly used in this frequency range.

For practical purposes, the simple equivalent circuit shown in figure 7-8 illustrates the effective impedance of a composition resistor at high frequencies. This equivalent circuit normally is used in the design of VHF and UHF circuits. The reciprocal of the conductance is R_p and is referred to as the parallel resistance. The total effective capacitance, C, is caused by the capacitance between the leads and the effect of distributed capacitance.

Resistors made by depositing a thin layer of pure, finely divided carbon or a carbon-boron mixture on the surface of a ceramic or glass tube provide improved performance characteristics at all frequencies, particularly in stability. They also show less change in impedance with increasing frequency.

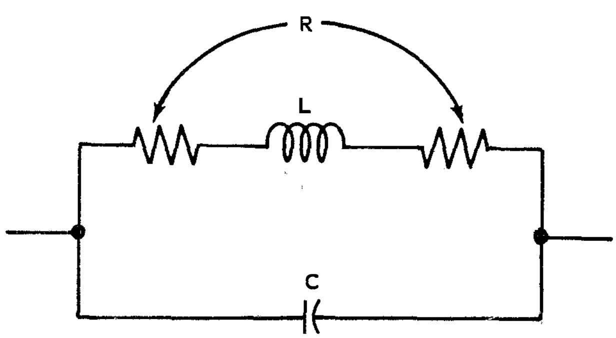


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Figure 7-7. –Equivalent circuit for inductor at high frequencies.

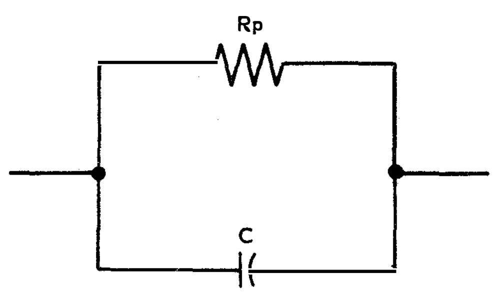

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Figure 7-8. –Equivalent circuit for composition resistor at high frequencies.

VHF EFFECTS ON TUBES

Although the basic principles of vacuum-tube operation are unchanged, certain factors that can be disregarded in tube operation below 30 MHz become important at higher frequencies. The inductances of the electrode leads and the capacitances between electrodes are minute, but at higher frequencies their reactances become significant. Additionally, electrons do not travel instantaneously from the cathode to the plate, but require a transit time. This delay causes an in-phase grid current to flow, even though the grid is negativė, and results in a loading effect across the input that reduces overall gain in all classes of tube operation.

Skin effect in the electrodes and electrode leads causes the r-f resistance to increase with frequency. Dielectric losses in the insulating electrode supports are increased, and some power is lost by direct radiation from the electrodes and their leads. The effect of these factors is to cause tube efficiency to become progressively lower as the operating frequency is increased. A tube operated as an amplifier at 50 MHz, for example, gives less output for a given signal input than at 5 MHz, even if the external circuits are equally efficient at both frequencies. Because these losses increase with frequency, there is a practical upper frequency limit beyond which the tube is not useful as an amplifier. If the same tube is operated as an oscillator, the high-frequency limit of operation will be about two-thirds to three-fourths that of the limit as an amplifier, because the tube can no longer supply sufficient output to make up the increased losses and still provide a useful putput signal. These effects always are present in a vacuum tube, no matter what the operating frequency; but, as the frequency is raised, the effects increase and become so large that they place an effective upper limit on useful operation. Although it is unnecessary to learn new operating principles, it is important to understand how and why these previously disregarded characteristics become major limitations at frequencies above 30 MHz.

As the wavelength is made shorter, it becomes comparable in length to the physical length and spacing of tube electrodes and leads. The apparent solution to this difficulty is to scale down the entire tube structure. There is a practical limit to this method, however, governed by the power-handling capacity that is required. New tube designs have been developed that successfully overcome one or more of the limitations without requiring such a drastic size reduction that mass-production methods of manufacture become impractical.

INTERELECTRODE CAPACITANCE AND LEAD INDUCTANCE

Inasmuch as any two points between which a difference of potential can exist are said to have capacitance, a small but significant value of capacitance must exist between any element of an electron tube and each of the other elements. Additional capacitances exist between the leads, particularly in those tubes in which the leads are brought out through a common stem to the base. When the tube is operating with normal applied voltages, the effective capacitances between electrodes differ from the capacitances when the cathode is not emitting. These differences are caused partly by expansion of the parts when the tube heats and partly by the electron stream.

When the tube is cold, the dielectric between electrodes is mostly vacuum. In operation, however, this vacuum is partially filled with a stream of electrons, resulting in a change in the dielectric constant. Naturally, this dielectric constant changes with variations in the electron stream. The capacitance values are measurable, and are listed in tube characteristics tables.

Because any conductor possesses self-inductance, the internal leads to the tube elements, as well as the elements themselves and the tube pins, have some inductance. Within a tube operating above 30 MHz, for example, circuit calculations must take into consideration the effective values of inductance. This inductance is in series with the plate, grid, and cathode. Although the actual inductance of a lead usually is small, the reactance offered at frequencies of several hundred megahertz becomes appreciable.

TRANSIT TIME

Transit time is the length of time required for an electron to travel from the cathode to the plate in an electron tube. When the frequency is increased, the time of 1 cycle is shortened progressively, and the transit time can become a definite portion of the cycle. During this part of the cycle, the applied signal on the grid may go from positive to negative, or from an increasing value to a decreasing value. The flow of electrons past the control grid causes a current to be induced in the grid that may flow into or out of the grid, depending on the relative grid voltage. This grid current flow absorbs power from the input signal, even though the grid is always negative; it has the same effect as if a shunt resistance and a shunt capacitance were connected across the grid and cathode of the tube. The loss of signal energy brought about in this manner is the most important effect of transit time. This energy loss increases as the frequency increases.

REDUCING TRANSIT TIME EFFECTS

Transit time effects can be minimized by scaling down tube dimensions and increasing operating voltages. Miniaturization is utilized widely. Amplifiers designed for use above 30 MHz usually have close interelectrode spacing. Many transmitting tube types are small in proportion to their power ratings, and require cooling by forced-air draft.

Where close spacing is utilized, the cathode-to-grid distance is of particular importance. Preventing the electrons from leaking from cathode to plate around the ends of the control-grid supports is also of consequence, because such leakage would result in increased transit times.

Screen-grid tube types have naturally shorter transit times than triodes and are used in many VHF/UHF equipments to reduce transit time effects.

MISCELLANEOUS EFFECTS

Other effects on electron tubes at VHF/UHF frequencies are caused by grid gas current, grid emission, and heat radiation.

Even a well-manufactured vacuum tube always has some molecules of gas, because it is impossible to produce a perfect vacuum. When electrons collide with these molecules, positive ions are created and are attracted to the negative control grid. This action causes a grid current to flow when the grid is negative. The grid current thus produced is small, but it has the effect of making the grid less negative, which is undesirable in view of the effects of input resistance in this frequency range.

Any metal emits electrons if heated sufficiently, although some metals are much more efficient in this respect than others. In scaled-down tubes suitable for use at frequencies higher than 30 MHz, the grid is subjected to heating by the nearness of the cathode as well as by the in-phase grid currents. Some electrons strike the grid even though it is negative, causing the possibility of secondary emission. As a result, there is likely to be both primary and secondary emission from the grid, which adds to the space charge and is undesirable because it varies erratically. This effect can be reduced by plating the grid with a metal that does not emit electrons easily. Gold is particularly effective and is used where the type of operation is critical enough to warrant the expense. Another method, somewhat less effective, is spraying the grid with finely powdered boron carbide.

The radiation of heat from the plates of air-cooled tubes becomes a factor of importance because the tube efficiency is reduced as the frequency is raised. For a given power input, a reduction of efficiency causes higher plate dissipation. This increased action means that the input power must be reduced to keep the plate dissipation from going above the rated value and causing serious overheating. When the input power is decreased, however, the useful output power drops.

The most common method of improving the thermal radiation of the tube plate consists of coating the plate with finely divided carbon. The resultant dull-black surface is about 60 percent more efficient as a heat radiator than is polished metal.

UHF TRANSMITTER-RECEIVER AN/GRC-27A

The AN/GRC-27 and AN/GRC-27A transceivers are UHF transmitter-receiver sets, covering frequencies from 225 to 400 MHz. The AN/GRC-27 is the shore station equipment, whereas AN/GRC-27A is the shipboard installation. Primarily, the AN/GRC-27A is used for UHF radiotelephone communication between ships, from ship to shore, and from ship to aircraft. It also has an MCW capability and, like the model TED, is used with the model AN/SGC-1A tone-shift keyer/converter for UHF radioteletypewriter communications. The AN/GRC-27A is operationally compatible for net operation with other radio sets in the UHF band, such as the TED transmitter and the AN/URR-13 and AN/URR-35 receivers.

The TED transmitter and its companion receiver, the AN/URR-13 (commonly called the

RED), have been in service for many years. They are adequately covered in the current edition of RM 3&2, hence they are not discussed in this chapter.

Current shipboard installations of the AN/GRC-27A include all ships of the destroyer escort class and larger. The AN/GRC-27A occupies considerably more space than does the TED with its companion receiver. The transmitter section of the AN/GRC-27A features an output power of 100 watts, compared with 15 watts for the TED transmitter. Additionally, the AN/GRC-27A has other features, such as automatic tuning and channel selection. These characteristics are described and illustrated in the following topic.

GENERAL DESCRIPTION

The AN/GRC-27A comprises a transmitter, receiver, modulator-power supply, distribution panel, control radio set, and the mounting rack.

The transmitter normally generates a radiofrequency carrier in a range from 225.0 to 399.9 MHz, with a nominal power output of 100 watts over this range. The transmitter has 3 crystal-controlled oscillators (frequency generators), which employ a total of 38 crystals. The combination and multiplication (synthesizing) of these 38 crystal frequencies make it possible to produce 1750 frequencies spaced at 100-kHz intervals from 225.0 to 399.9 MHz. Any 10 of these 1750 frequencies can be preset manually by a series of selector switch dials (calibrated in megahertz) in 100-kHz increments. Any 1 of these 10 frequencies (channels) can be selected automatically, either locally or from a remote station. Automatic selection of a preset channel is accomplished in 2 to 7 seconds by a combined autopositioner drive system and a servosystem.

The modulator-power supply provides the transmitter with all necessary operating and control voltages, and supplies amplitude modulation power (either voice or MCW tone) for the transmitter. The transmitter output includes both upper and lower sidebands generated when the carrier is amplitude-modulated.

The receiver normally operates on any 1 of 1750 frequencies, spaced at 1-kHz intervals from 225.0 to 399.9 MHz. The receiver employs a triple conversion superheterodyne system using crystal-controlled oscillators. There are a total of 38 crystals in a synthesizer system. Any 10 channels of the 1750 frequencies can be preset manually. Moreover, any 1 of the 10 channels can be selected automatically, either locally or from a remote station.

Automatic channel selection in the receiver is accomplished by a frequency selector and autopositioner system similar to that in the transmitter. A motor-driven system of gear trains operates the various crystal switches and tuning mechanisms to permit rapid change of operating frequency. Here again, channels are shifted automatically in 2 to 7 seconds.

The receiver is designed for use with directional or omnidirectional antennas having a characteristic impedance of 52 ohms. Audio output circuits for operation of loudspeakers and for operation into telephone lines are built into the receiver. A special output circuit for direction-finding applications is provided also. The receiver is equipped with automatic volume control, automatic noise limiter, and carrier-operated squelch circuits.

The preset channels for the transmitter or the receiver are selected by operating a channel selector switch on the front panel of the respective units or by telephone-type dials on associated radio set control facilities.

The radio set control unit adapts the control circuits of the AN/GRC-27A to the standard 12-wire shipboard remote control system. The control unit provides for the control of power for Radio Set AN/GRC-27A, starting and stopping the modulator-power supply, automatic channel selection in the transmitter and receiver, local or remote control of the transmitter, and squelch adjustment for the receiver.

AN/SRC-20 AND -21 UHF TRANSCEIVERS

Radio Sets AN/SRC-20 and AN/SRC-21, shown in figures 7-9 and 7-10 are designed for shipboard or fixed station operation. These sets provide amplitude modulation (AM) and modulated continuous wave (MCW) on any of 1750 channels spaced 0.1 MHz apart in the 225-MHz to 399.9-MHz range. Of the 1750 channels, 19 can be preset. Complete control, including the selection of preset channels, can be exercised from up to a maximum of 4 remote control points. Additionally, circuits are incorporated that permit the connection of two sets for two-way automatic retransmission.

The AN/SRC-20 radio set is composed of radiofrequency amplifier AM-1565/URC, radio set AN/URC-9, and radio set control C-3866/

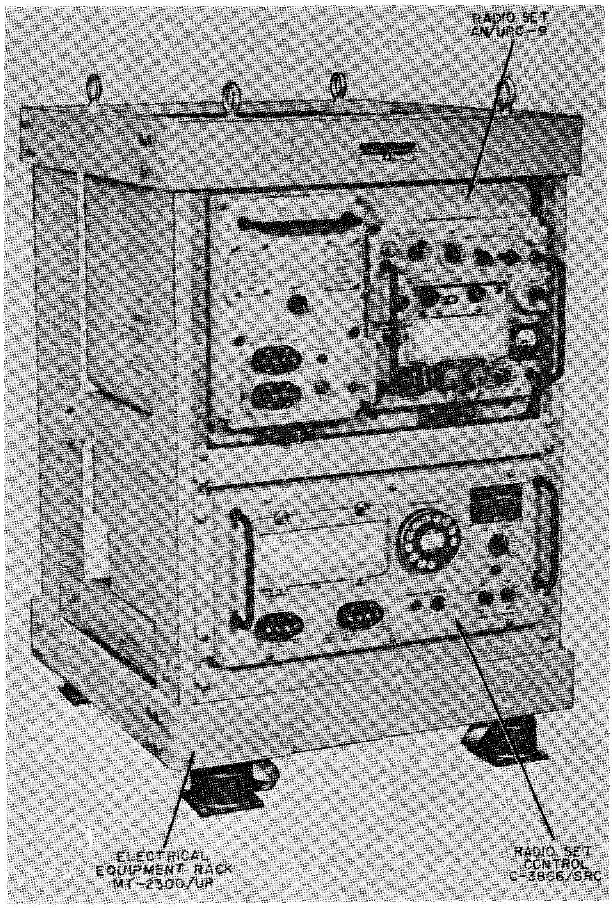

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Figure 7-9. –Radio set AN/SRC-21.

SRC. The AN/SRC-21 radio set is composed of the latter two units only.

The sets have three modes of operation: normal, retransmit, and tone. Provision is made for operation with broadband equipment in the normal and retransmit modes. The preset channels can be dialed directly on the radio control set or any 1 of up to 4 remote control units. The minimum carrier output of the AN/SRC-20 is 100 watts, with modulation capability of 80 percent. For the AN/SRC-21 the minimum carrier output is 16 watts, with a modulation capability of 80 percent.

RADIOFREQUENCY AMPLIFIER AM-1565/URC

The AM-1565/URC radiofrequency amplifier, a linear UHF amplifier, operates class AB1. The amplifier supplies a minimum of 100 watts of radiated power over a frequency range of 225.0 to 399.9 MHz. The r-f amplifier is continuously tunable over the frequency range. A dial calibrated in frequency and a logarithmically calibrated dial are provided to allow presetting of channels. Radiofrequency excitation is controlled automatically by an attenuator that compensates for variation in the exciter output of the AN/URC-9.

The AM-1565/URC is composed of the following functional groups: power amplifier, servoamplifier, drive control regulator, power supply, autopositioner, and the front panel.

The signal from the AN/URC-9 passes through a variable attenuator to the r-f amplifier. After amplification, the signal passes through a directional coupler (used to monitor forward and reverse antenna power) and a low-pass filter (used to minimize harmonic radiation) to the antenna.

During receive, the signal passes from the antenna to the input of the AN/URC-9.

The drive regulator circuits, in conjunction with the ferrite attenuator and front panel controls, compensate for variations in exciter output and drive requirement over the frequency range. This allowance is made by sensing the voltage output of the r-f amplifier, or a manual control, to change the r-f conducting properties of the variable attenuator.

Automatic tuning of the r-f amplifier is performed by a servosystem together with the autopositioner and preset channel potentiometers. The autopositioner, operated by front panel control, forms an unbalanced a-c bridge between the preset potentiometer of the desired channel and the servo circuits. As the servosystem seeks the new null position, the servomotor drives shorting contact rings in the resonant cavities of the r-f amplifiers until proper cavity length is obtained. The servo uses a rate generator feedback system to prevent hunting and oscillation.

RADIO SET AN/URC-9

The AN/URC-9 radio set is a triple-conversion superheterodyne transceiver, which can send and receive amplitude-modulated (A3) and MCW (A2) signals.

During normal receive, the signal from the antenna passes through the AM-1565/URC unit in the AN/SRC-20. In the AN/SRC-21, the signal goes direct to the r-f and PA assembly, where the signal is amplified and mixed with a frequency (injected by the frequency multiplier oscillator) to obtain a difference frequency in the 20.0 to 29.9 MHz range. This latter signal is passed to the first amplifier, where it is amplified. The resulting signal is mixed with a signal in the range of 17 to 26 MHz from the crystal-controlled oscillator in the first i-f amplifier. The difference frequency, in the range of 3.0 to 3.9 MHz, is passed to the second i-f amplifier, where it is mixed with the third injection frequency in the same range but a difference of 500 kHz. This signal is applied through a 500-kHz filter to the third i-f amplifier. The third frequency is always 500 kHz. The resulting signal is demodulated, passed through a noise limiter, again amplified, and applied to the audioamplifier and modulator assembly. The audio signal is then amplified and sent to the local and remote headsets.

During normal transmit, the push-to-talk switch on the microphone operates relay circuitry. This circuitry grounds the key line from the AM-1565/URC and switches particular circuits in the RT-581/URC-9, allowing the set to operate as a transmitter.

Operation in the retransmission mode requires interconnection of two sets, because a transceiver cannot transmit and receive concurrently. When two sets are connected in this manner, the reception of a signal of the proper level causes the alternate set to operate as a transmitter. This interchange is done by connecting the squelch circuitry to operate when a carrier is received. When a signal is received on one set, it is used to modulate the transmitter output of the alternate set. The audio signal appears at the headsets of the first set. An audio sidetone appears at the headsets of the alternate set.

Frequency Selection

Information is transferred electrically from the channel selector switch to the frequency selector subassembly. There, it is converted to mechanical tuning information for tuning the various oscillators and amplifiers in the radio set. Five accurately positioned tuning shafts, driven by the frequency selector, automatically tune the set to the desired frequency. This process requires from 1 to 5 seconds; the exact time depends upon the sequence of frequency selection.

RADIO SET CONTROL C-3866/SR

The C-3866/SRC radio set control enables a radio operator to select any 1 of the 19 preset radio channels remotely. It contains a front panel telephone-type dial and the relays necessary to operate an internal stepping relay for channel selection. For setting the squelch level of each radio channel, 19 squelch level potentiometers are available. A local-remote transfer switch controls functions to the remote stations.

To dial any radio channel higher than channel 10, the operator must first dial the letter A, then dial the last digit in the channel number. To dial channel 14, for example, dial A and then the number 4.

VHF TRANSMITTER

It was explained earlier in this chapter that shipboard communications in the VHF range are no longer used as extensively as in the UHF band. Reduction in usage has resulted in rather limited VHF installations in the active fleets. One shipboard VHF transmitter, the AN/URT-7, is described briefly here.

VHF TRANSMITTER AN/URT-7

Radio transmitter AN/URT-7 functions the same as the transmitters of the model TED series, except that the AN/URT-7 operates in the 115- to 156-MHz range. In many instances, the component sizes and schematic nomenclatures are identical.

Because the operating frequency range of the AN/URT-7 is lower than that of the model TED series, fewer frequency multiplier stages are needed in the r-f chassis of the AN/URT-7. In the AN/URT-7, one doubler stage and one tripler stage are used to yield a total frequency multiplication of 6. In the model TED transmitters, two doubler stages and one tripler stage produce a total multiplication of 12 times the oscillator frequency. In all other respects, the AN/URT-7 and the transmitters of the model TED series closely resemble each other.

VHF RECEIVERS

Two models of VHF receivers currently are used aboard ship. They are the AN/URR-21 and the AN/URR-27. Of these two, the AN/URR-27 is installed in greater quantity and is described first in the following discussion.

VHF RECEIVER AN/URR-27

Radio Receiving Set AN/URR-27 (fig. 7-11) provides for reception of amplitude-modulated

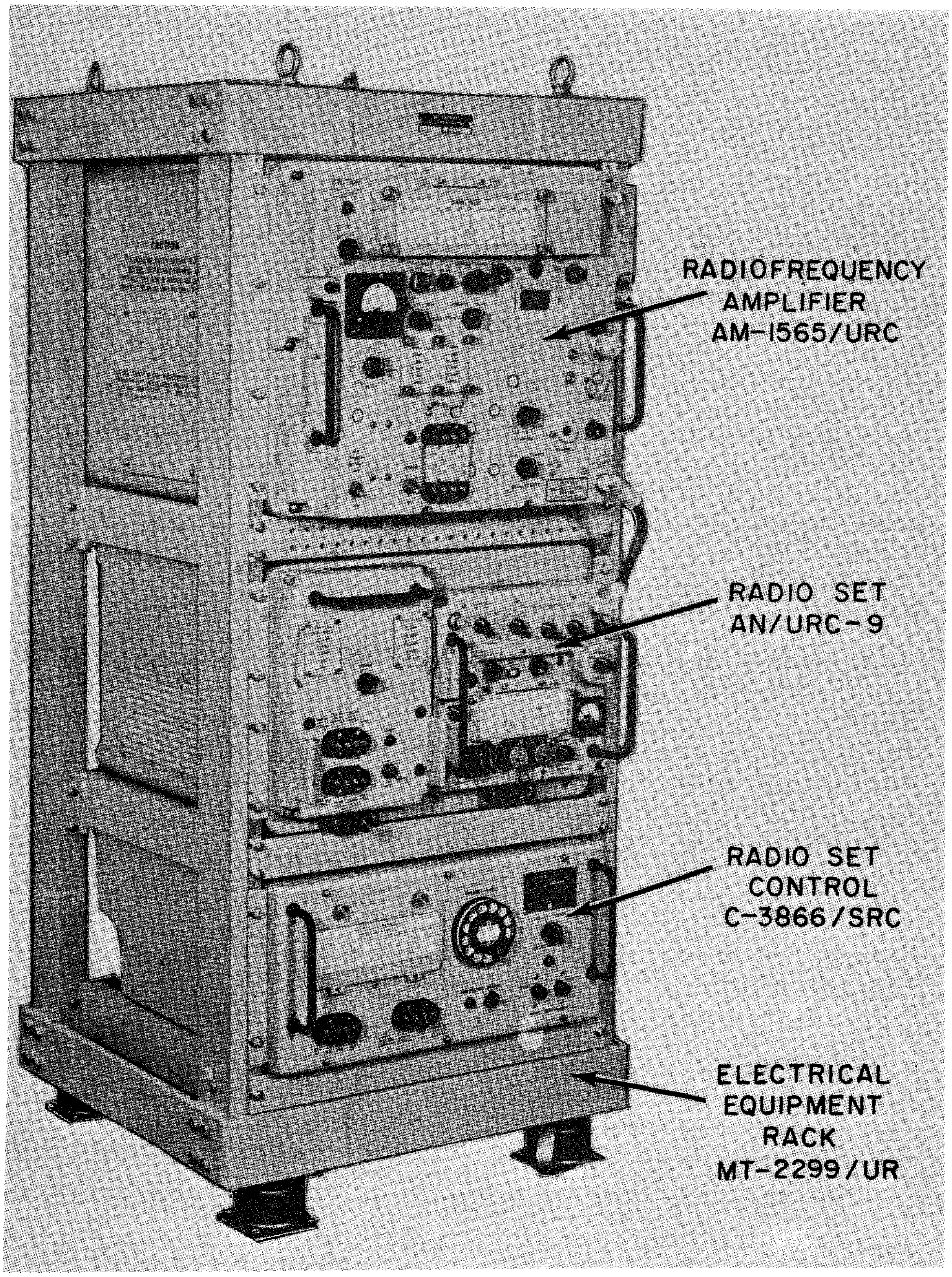

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Figure 7-10. –Radio set AN/SRC-20.

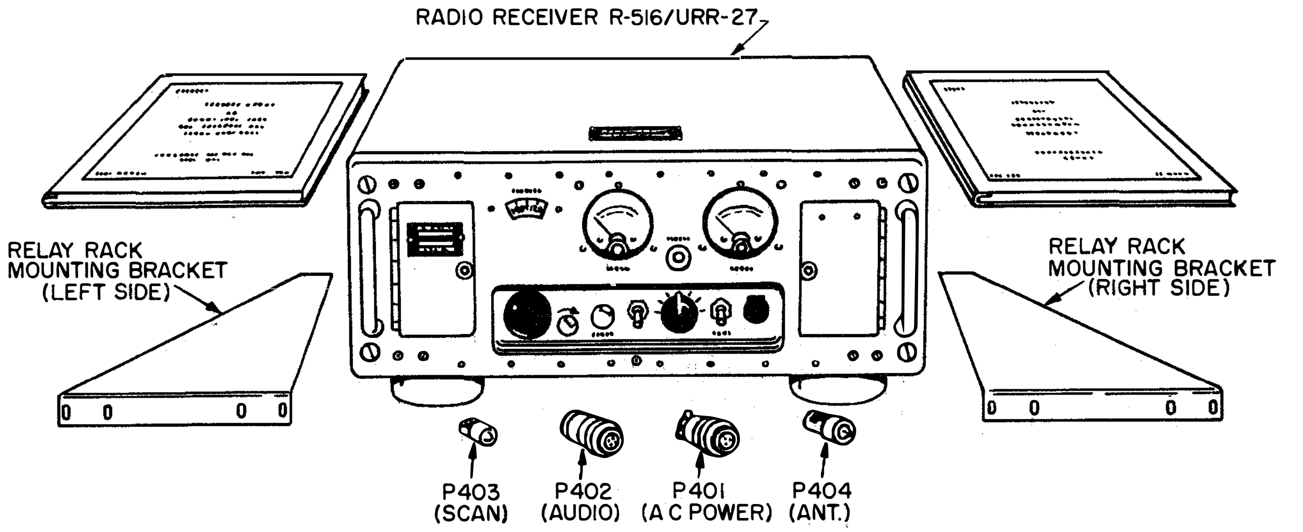

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Figure 7-11.–Radio receiving set AN/URR-27 complete, including radio receiver R-516/URR-27, brackets, plugs, and instruction books.

voice and MCW transmission in the 105- to 190-MHz frequency range. Note that this range of frequencies slightly exceeds that of the VHF transmitters, which cover a band from 115 to 156 MHz. This extra coverage, above and below the transmitter frequency range, has no practical worth, thus it is of little use.

The AN/URR-27 is a superheterodyne receiver. It is designed primarily for operation as a pretuned, single-channel, crystal-controlled receiver. Continuously variable manual tuning is also available. A single tuning control is used for tuning to any frequency for either crystal-controlled or manual tuning operation. Either of these two methods of operation may be selected by means of the CRYSTAL-MANUAL switch on the front panel.

The receiver has a built-in power supply, which can be adjusted to operate from 110- , 115- , or 120-volt, 50- to 60-hertz, single-phase power sources. The audio output and power source input connections to the receiver are filtered to limit possible radiofrequency interference.

Equipment Arrangement

The circuit components are grouped, on a functional basis, into five major sections: the preselector, IF/AF, power supply, cable filtering, and front panel sections. The first three sections are assembled within the chassis frame. The front panel section is attached to the front of this frame. The cable filtering section is mounted against the rear wall of the cabinet. The preselector section consists of the r-f amplifier-converter and the oscillator-multiplier subsections. The ganged tuning capacitors in the two subsections are geared together through a common dial drive assembly. This action permits tuning the receiver by means of a single front panel tuning control.

All primary operating controls and the meters are mounted on the front panel. The crystal, the fuses, and those controls requiring only periodic change for operational adjustment are in panel compartments accessible through hinged doors at the right and left sides of the front panel. The panel-mounted controls are located as shown in figure 7-12. Trimmer adjustment controls are accessible when the chassis assembly is removed from the cabinet.

Cable connections for antenna, power input, and audio output are made to connectors on the underside of the cable filtering section attached to the rear of the cabinet.

VHF RECEIVER AN/URR-21

Radio Receiving Set Model AN/URR-21 (fig. 7-13) provides reception of amplitude-modulated voice radiotelephone signals in the range 115 to

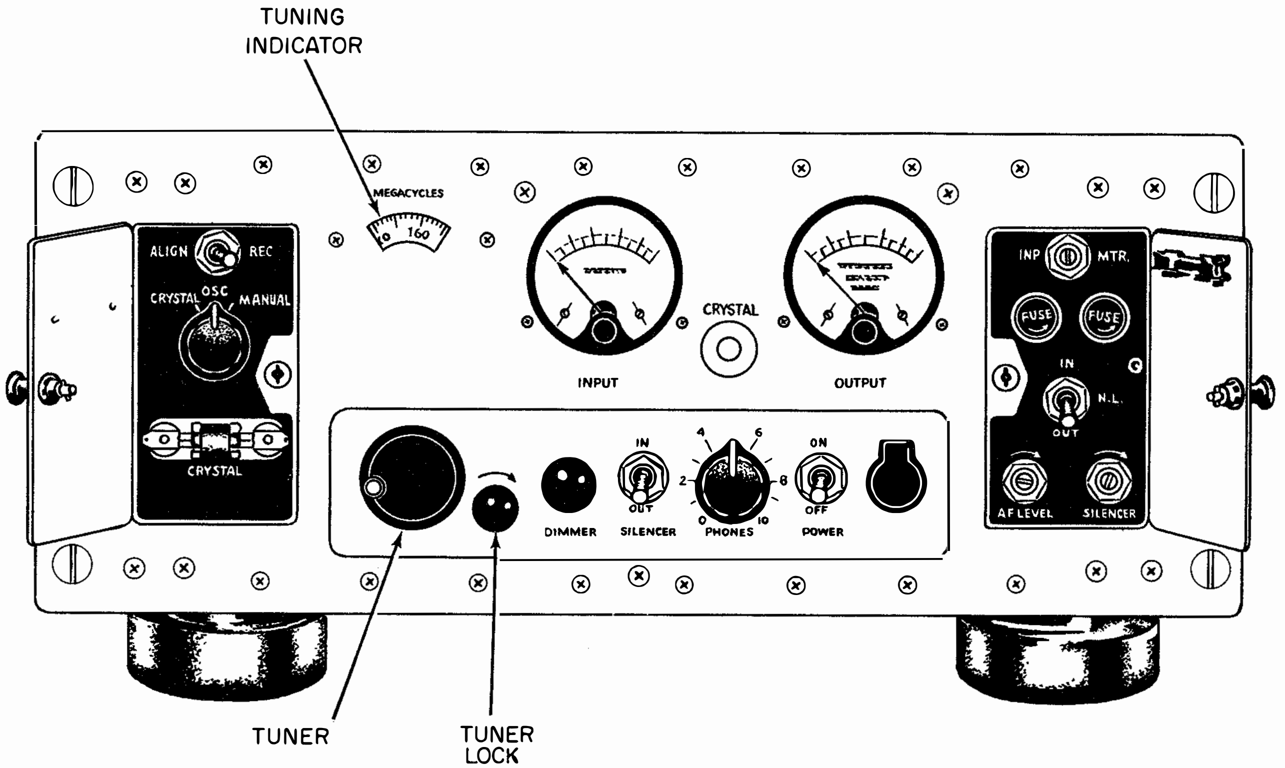

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Figure 7-12.—Front panel, doors open.

156 MHz. The receiver operates on the superheterodyne principle. However, the addition of crystal control, additional i-f amplification, and squelch circuit minimizes drift over long operating periods, increases signal sensitivity, and provides quiet operation.

The receiver accommodates four quickly selectable preset crystal channels in conjunction with an r-f amplifier to produce a 12-MHz intermediate frequency that is amplified and detected in conventional manner. Special features, in addition to crystal-controlled operation, include a front panel dial detent mechanism for rapid selection of channels, high stability, and continuous tuning of all r-f circuits by means of a single dial mechanism. The dial detent mechanism permits setting the dial to any one of four positions corresponding to the four crystal-controlled channels. The detent mechanism is continuously adjustable so that any four channels within the tuning range may be used.

Description of Units

The AN/URR-21 receiver consists of three functional units: a preselector, IF/AF amplifier, and the power supply unit. These three chassis are bolted together and slide into the cabinet as a single unit.

The preselector chassis contains all of the r-f circuit elements from the antenna through the primary of the first i-f transformer. Circuits contained in the preselector unit are an antenna input stage, one r-f amplifier, a crystal oscillator, two frequency tripler stages, a mixer, and the primary of the first i-f transformer. Crystals for the four operating channels are mounted in sockets on top of the chassis. They are shielded by a removable metal cover.

The IF/AF amplifier chassis consists of the intermediate-frequency amplifier, its asso-

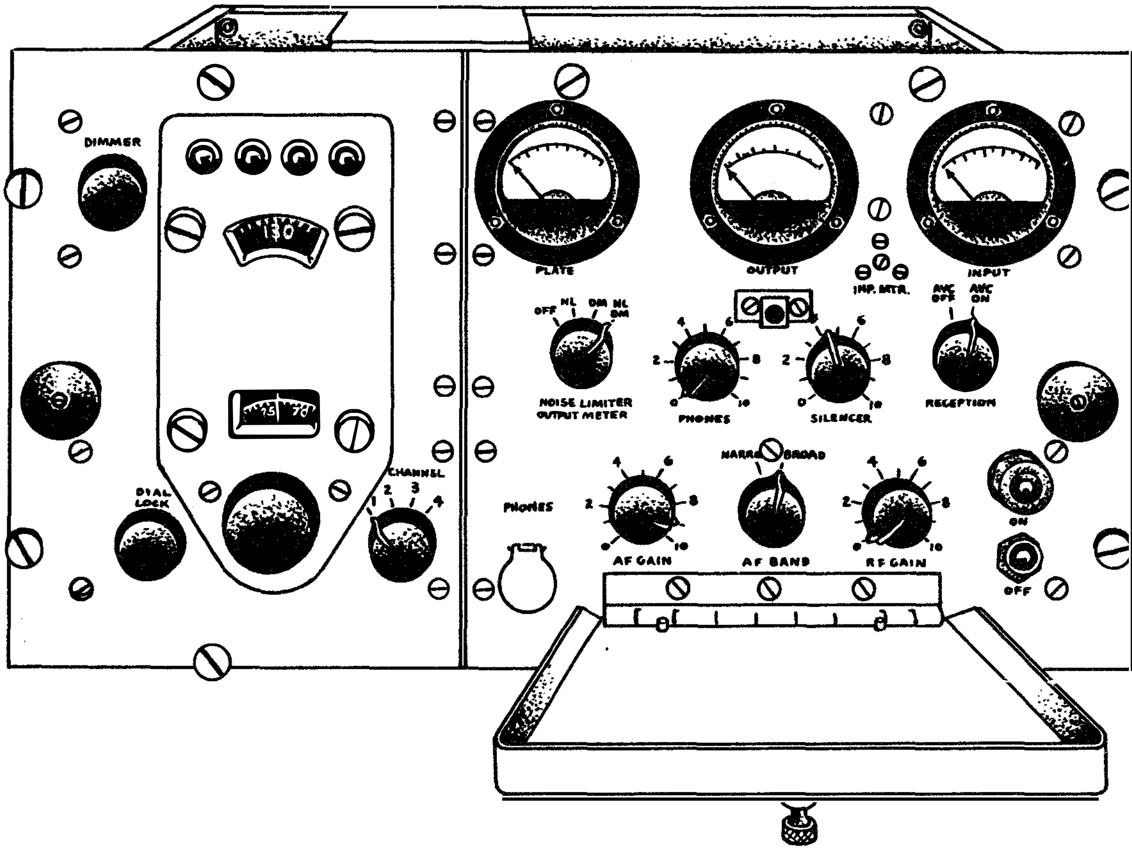

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Figure 7-13.–Radio receiver R-432A/URR-21, knob cover down.

ciated detection and control circuits, and the audiofrequency amplifier. The controls and meters for these circuits are mounted on the front panel. Because of the large number of i-f stages in this unit, it was necessary to arrange all wiring and components for a minimum of common coupling, either through proximity of parts or through ground circuits. In order to mount most of the resistors and capacitors on terminal strips, two large terminal boards with uninsulated leads are arranged for minimum coupling and the most direct connections possible under the circumstances.

The chassis for the power supply unit contains all the components for furnishing power to the receiver. On its top are mounted the power transformer, filter chokes, filter capacitors, and rectifier and regulator tubes. The fuses and the receptacles for power input, antenna, and audio output are mounted on the rear. The line filter is mounted underneath the chassis on a small terminal board.

CHAPTER 8

COMMUNICATION EQUIPMENT PREVENTIVE MAINTENANCE

To properly implement the PMS, each ship must plan for training her own personnel in preventive procedures. Ideally, such training should be in the form of lectures or classroom work, supplemented by on-the-job training, i.e., correcting actual deficiencies.

Many senior petty officers prefer to do the work themselves and relegate their men to fetching tools; or, at best, merely permit the men to watch the proceedings. This procedure may be good for the equipment, and it may save time for the present, but it perpetrates an insidious practice that will bear fruit in recurring deficiencies as soon as the skillful, knowledgeable petty officers are transferred. Hence, it behooves the leading Radioman to formulate plans and practices that guarantee a continuing supply of well-trained preventive maintenance men.

FILTERS

One way to keep a preventive maintenance program moving is to make frequent inspections. Such inspections may well be most effective if they are not scheduled regularly but come as a surprise.

An inspection will be most effective if the leading Radioman has some knowledge of the basic principles of preventive maintenance of electronic equipment, and if he knows what kinds of maintenance are most likely to be neglected or overlooked. More detailed information on maintenance may be obtained from the manufacturers' technical manuals furnished with the equipment and from various NavShips directives.

Cleanliness of equipment is frequently an important indication of the general condition of equipment. When making an inspection, the leading Radioman should check for cleanliness of equipment and all areas around, behind, and under cabinets and consoles. Dust should not be tolerated. It can seriously affect the functioning of any equipment.

PURPOSE OF FILTERS

Air filters must be maintained in accordance with manufacturers' instructions and NavShips directives. The importance of maintaining air filters must be emphasized. Electronic equipment that uses a great deal of power or has high ambient temperatures must be cooled. For this purpose, air cooling normally is employed. Air filters are necessary to remove dust and other foreign particles from the air before it flows over the hot equipment.

Air filters must be checked frequently and cleaned or replaced as necessary. Lack of proper servicing can cause considerable trouble. For some reason—perhaps because filters are hard to locate, or perhaps because their importance is not fully recognized—air filters often are neglected until excessive heating results in equipment breakdown.

Another hazard in connection with air filters is that any loose material—dust, dirt, pieces of paper, and so forth—may be sucked up against the air filter and thus cut off the flow of cooling air. This hazard can be controlled only by insisting on a high standard of housekeeping in all spaces that house electronic equipment. Loose gear should never be permitted. Lockers or other suitable storage places should be provided for all materials that must be kept in such spaces. To illustrate the point, it might be noted that pieces of paper that find their way under cabinets, as well as garments laid across cabinet tops, have been known to block air filters and cause damage to electronic equipment.

By inspecting a few air filters himself, or at least requiring that they be inspected in his presence, the leading Radioman may cause communication personnel to take an increased interest in servicing all air filters. Damage resulting from clogged or dirty air filters is too expensive to be tolerated.

Lubrication

Lubrication is required for all moving mechanical parts of electronic equipment. Incorrect lubrication (or total failure to lubricate) can be extremely expensive. At least one instance has been reported in which failure to use 30¢ worth of grease resulted in an antenna repair bill of $30,000.

Improper lubrication of one part of an equipment can lead to a sequence of troubles. If moving parts of a direction-finding antenna assembly, for example, are not lubricated properly, a bearing may freeze. The bearing is replaceable; but, before need for replacement becomes evident, a burned-out motor, stripped gears, or other troubles may occur. The final result could be failure to accomplish the ship's mission.

On the other hand, overlubrication can cause trouble. With equipment used infrequently, grease can pack in so tightly around a shaft that the shaft cannot move. A motor saturated with grease may burn out. Moreover, the wrong type of lubricant may lead to overheating and unnecessary wear.

Indicator Lights

Indicator lights on electronic equipment should be checked when equipment is being inspected. Some indicator lights are rather hard to get at, and there is a common tendency to postpone replacing a burned-out light. Although a burned-out light may be a trivial defect in itself, it may be an indication of generally poor preventive maintenance.

ELECTROMAGNETIC INTERFERENCE

Electromagnetic interference (EMI) is defined as any undesired radiated or conducted electrical perturbation that degrades the proper operation of electrical or electronic equipment. This interpretation takes into account a broader spectrum than the previous term, radiofrequency interference (RFI), which dealt only with the r-f portion of the frequency spectrum. The causes and effects of EMI are almost as numerous as the types of electrical and electronic equipment in naval shipboard use. Leading Radiomen, therefore, should be aware of its existence and possible causes.

A number of separate and distinct causes of EMI contribute to the total reception problem. The prime contributors to the overall interference problem are undesired receiver r-f intermodulation, transmitter cross modulation, nonlinear junctions, harmonics, and co-channel adjacent channel interference.

Harmonics are covered in RM 3&2 and co-channel adjacent channel interference is covered in Chapter 9 and therefore will not be discussed further in this chapter.

R-F INTERMODULATION

Radiofrequency intermodulation is an occurrence wherein two or more electromagnetic signals mix in a nonlinear element or device to produce discrete signals at new frequencies, which are the sums and/or difference of the original signals or their harmonics. The nonlinear element can be receiver circuitry, transmitter output stages, or the environment (nonlinear junctions) in which these equipments operate.

Receiver nonlinear elements are the r-f stages and detector mixers. Intermodulation can occur in either of these circuits or through a combination of both. In naval shipboard installations where transmitters and receivers are local, this problem can be exemplified by the saturation of a receiver front end by nearby transmitters. In such instances, the receiver r-f amplifier tubes are driven to operate in the nonlinear region of tube amplification, thus enabling all signals present in the receiver bandpass and circuitry to mix and produce intermodulation product. The tendency of nearby transmitters to overload receiver circuits is a common one in shipboard high-frequency systems, however, the resulting r-f interference can be reduced to an acceptable level by the physical separation of transmitter/receiver panels, shielding of panels/compartments, good maintenance practices, and circuit filters.

A second contributor to the overall problem of r-f intermodulation is the inability to provide the level of isolation of the transmitter/receiver antennas necessary to minimize antenna coupling while maintaining effective antenna patterns, therefore, it is necessary to provide the receiving system with frequency selective filters to attenuate saturating transmitting frequencies. This use of filters also serves to improve receiver overload protection and eliminates most of the undesirable intermodulation products that are created by mixing in the receiver.

CROSS MODULATION

In a transmitter, the device that contributes most to the production of intermodulation products is the output power amplifier stage. Signals present on the transmitter antenna, which reach the plate circuits of the transmitter amplifier tubes, through the various shipboard non-linear junctions, can intermodulate with its high-level signal and produce discrete, spurious signals.

Although well below the level of the usual in-band odd-order intermodulation products, these transmitter-generated products are of sufficient amplitude to interfere with reception by the ships receivers. This phenomenon is commonly referred to as transmitter cross modulation.

Multi-Couplers

Basically, multicoupler need arises from limitation in the number of antennas that may successfully be sited in the shipboard environment. As the number of transmitting antennas is increased on a given hull, both pattern and impedance degradation occur as the mutual coupling between antennas increases. This fact leads the antenna designer to the solution of optimizing both the pattern and the impedance performance of a limited number of broadband antennas.

To gain an appreciation of the vastness of the intermodulation problem, computations were made that relate the number of generated frequencies to the number of transmitted frequencies as a function of frequency order. By calculation, 10 transmitters radiating will generate possibly 100 second order products, 800 third order products, 4000 fourth order products, and 15,000 fifth order products. Thus, if the ship environment had characteristics that contained all nonlinear orders up through the fifth, a total of approximately 20,000 discrete frequency products could be generated from the original 10 fundamental transmitter frequencies.

NONLINEAR JUNCTIONS

At this point you may be asking yourself: "Just what can be done about the EMI problem?"

The shipboard environment possesses all the necessary elements required to produce a harmonic generating and mixing system. The elements are present in the complex ship structures, appendages, and other objects that are found in the topside areas in which intense r-f fields are present. The r-f signal produces standing waves on portions of the structures, and, if a corroded joint or oxidized fastening exists, rectification occurs to some extent. Intermodulation products created by the nonlinear junctions existing in the ship structures are commonly called the "rusty bolt" effect.

The rusty bolt effect can be reduced considerably by a combination of good design and maintenance practices. A primary electronic design consideration is to make the topside areas a single conducting structure, devoid of miscellaneous obstructions such as stanchions, metal or pipe-rack holders, metal storage bins and cabinets, metal spare parts boxes, booms, vehicles, and all metallic objects not absolutely essential to ship operation. These considerations ensure an effective ground plane for the antennas and also tend to keep induced hull currents and voltages at the same potential. Required appendages such as rigging, lifelines, handrails, stanchions, and ladders, which are exposed to the weather elements, should be constructed of suitable nonmetallic materials, where applicable. Nonmetallic materials are impervious to r-f voltages and, in general, to the rigors of weather corrosion. Where structures must be metallic, permanent joints should be welded or brazed to keep the structure at hull potential. If flexibility of the joint is required, a good bonding strap must be installed across the joint. These items should be checked during shipyard repairs or modifications. Hull and superstructure maintenance should be aimed at keeping the hull and structures free of corrosion formations and loose joints. A program should be set up to ensure periodic cleaning of antenna insulators. This aspect of maintenance is extremely important in the reduction of electromagnetic interference, because a ship is exposed to saltwater, one of the most corrosive environments known.

ANTENNA MAINTENANCE

Antennas, of necessity, are located in the most exposed locations possible aboard ship. This placement makes for radiation or reception efficiency, but it complicates proper maintenance. Because personnel have a natural reluctance to climb masts or stacks, the antenna system occasionally is neglected until a major casualty develops.

The major enemies of the antenna system are corrosion, caused by salt spray or stack gases, and paint on insulators.

Constant whipping of all types of antennas, caused by the wind or ship motion, contributes to broken strands, parted couplings, and broken mounting brackets.

Aside from collecting moisture, enclosed trunk transmission lines seldom give trouble. For proper maintenance, they require little more than periodic cleaning.

At frequent intervals wire antennas should be lowered and inspected for signs of deterioration, particularly at clamps and where they connect to trunk or transmission lines. Nicks and kinks should be avoided, because the wire will be weakened at these points. It is a good policy to wire-brush antennas, while they are down, to remove soot and salt deposits. Signs of weak or broken strands can also be detected at this time. Insulated-type receiving antennas should be wiped rather than wire-brushed. Whip-type antennas are usually hollow and have a tendency to collect moisture inside. A small hole should be drilled near the base of these antennas to permit moisture to drain out. Whips while down, should be inspected for rust spots or loose sections. Mounting straps and standoff insulators should be checked carefully for cracks, breaking, or deterioration as well as for cleanliness.

Dipole antennas usually have one pole grounded; the other pole is connected to the inner conductor of the coaxial transmission line. Any insulators on the dipole should be carefully cleaned of any paint, salt, or soot deposits. Care should be taken to avoid damaging glazed surfaces of insulators. The mechanical condition of dipoles should also be checked for loose mountings, rust spots, and the like.

After each cleaning, all antenna fittings, such as insulator ring bolts, shackles, turnbuckles, and any other topside antenna fittings, should be coated with corrosion preventive compounds. Satisfactory corrosion preventive compounds that are available include Hard-Film Corrosion Preventive (standard Navy Stock Number G52-C3094-50) and Gun Slushing Compound, Grade B (standard Navy Stock Number W14-C-113).

Shipboard antenna systems, including transmission lines and associated wiring, as well as interunit wiring and connecting cables, form an important weak link in the electronic installation, which many personnel tend to neglect in their preventive maintenance schedules. Many complaints of poor sensitivity on the part of a radio receiver or lack of range from a transmitter have been traced frequently to some minor defect in the antenna or transmission line. Often, instability and noise are caused by loose cable couplings or poor equipment bonding.

ANTENNA LEAKAGE RESISTANCE

Aside from actual physical damage, the most common fault in the antenna system is low resistance to ground. Moisture in trunks or coax, dirty insulators, and coax dielectric breakdown all cause varying degrees of shunting resistance, and must be guarded against if maximum system efficiency is to be expected.

The most convenient test of an antenna system is by means of high-voltage, high-resistance ohmmeter or megger. The megger uses a high voltage (roughly 500 volts) which often is sufficient to break down and thus reveal any weak spots in the insulation. Before proceeding with the test, the antenna should be inspected for any intentional d-c shorts or receiver protective devices.

After disconnecting protective devices, intentional shorts, and equipment from the antenna, proceed as follows:

1. Connect ground lead of megger to the hull.
2. Connect high side or line connection of the megger to the inner conductor of the transmission line. It may be convenient to fabricate a suitable plug to match coaxial fittings for test purposes.
3. Measure and record the indicated resistance.

Theoretically, any antenna transmission line system should read infinity on the megger, but this reading is not always possible to obtain. Abrupt changes in the weather, high humidity, or other natural causes often result in low readings. It is safe to say that any antenna reading under 100 megohms to ground, for several successive daily readings, should be investigated. Often, insulation resistance may be raised by cleaning the insulators or couplings. The coaxial cables and other cables and fittings used to connect the equipment should also be tested. A check of continuity of the antenna system should be made periodically.

For insulation resistance, the following values are suggested:

1. A resistance of 200 megohms (or more) to ground indicates an antenna in good condition.
2. A resistance of 5 to 200 megohms to ground indicates the insulators need cleaning.
3. A resistance of less than 5 megohms to ground indicates an immediate and urgent need for locating the leak in the antenna and taking necessary steps to restore the system to its original condition.

PAINTING ANTENNAS

All transmitting and receiving antenna hardware and accessories, antenna framework, and dipoles should be inspected quarterly. Antenna apparatus installed directly abaft the stack should be inspected monthly. The gases and high temperature in the vicinity of the stacks tend to dry out and crack the paint, accelerating corrosion.

When the extent of the damage warrants only a touchup job and there is an indication of corrosion, the surrounding area should be entirely cleaned of old paint, soot, rust, and the like. One coat of wash primer pretreatment (formula No. 117 for metals) should then be applied to improve adherence of the primer and paint. One coat of zinc-chromate primer and no fewer than two coats of outside haze-gray No. 27 should follow the wash primer pretreatment. Brass dipoles need not be coated with zinc-chromate primer. Because of their conductivity, metallic paints should never be used.

The foregoing procedure applies also when the extent of damage indicates complete repainting. When just the finish coat is damaged, and there is no indication of corrosion, one or two coats of the outside haze-gray paint should be applied after the proper cleaning.

All or part of the metal rings, antenna transfer switches (outside only), other hardware, and accessories associated with transmitting antennas should be painted with red enamel as a finish coat. Hardware and accessories used with receiving antennas should be painted with blue enamel as a finish coat.

Paint, varnish, shellac, or grease must not be applied to any portion of insulating material forming a part of the antenna system, nor to the antenna bus, nor to the metallic portion of any insulator in contact with the antenna bus.

RECEIVING ANTENNAS ABOARD SHIP

The best receiver on the market cannot operate efficiently without an antenna. Antennas have the unpredictable characteristic of operating better at some frequencies than others, depending on the position of the antenna to adjacent metal bulkheads, masts, rigging, and gun barrels. An antenna may operate fine while a ship is on one course, but, when she changes course, the antenna efficiency may drop to practically nothing. With these thoughts in mind, the operator must check constantly to ascertain that he is getting the best reception. He accomplishes this check by changing antennas when he notices that the carrier meter or input meter has decreased from its normal position.

GENERAL ANTENNA MAINTENANCE

One preventive action the shipboard operator can take is to maintain his antennas properly and keep them clean. Shipboard antennas, due to gunnery and other limitations on the ship, are not the best antennas for reception, but preventive maintenance will keep them in operable condition. Normally this care entails more effort than the average Radioman uses in cleaning insulators. Following are a few suggestions for RM and ET rates to observe in order to keep the antenna system in tip-top condition.

1. Remember that the antenna system consists of everything from the outboard or top insulator to the antenna input of the receiver. Included are all insulators, junction boxes, static drain resistors, coaxial cables, all connections, patch cords for receiver antenna patch panel, multicouplers and coaxial cables to the individual receivers, and antenna jack on the receiver.
2. Insulator cleaning is a must, and the time between cleaning the lower insulators depends on the type of ship, the tempo of operations, and the area of operation.
3. Junction boxes usually hold a resistor that drains off static electricity from antennas. These boxes should be opened and inspected at least every 6 months. The resistor should be measured and inspected to ascertain if it is the proper size and in good condition. All connections within the box should be inspected critically to make sure they are in good shape and well soldered. The gasket on the box should be inspected and replaced, if necessary, then it

should be well sealed. All bolts or screws should be replaced and tightened to prevent water or salt spray from entering the junction box.

4. While the junction box is open and the static resistor is out of the circuit, the coaxial line from the antenna patch panel should be checked thoroughly. Remember, this line takes the signal from the antenna to the receiver. With the static resistor removed from the circuit, the circuit should be meggered from the radio central end of the coaxial cable, and the reading should be in the high megohm range. This reading will show if the antenna and the center conductor of the coaxial cable are free from ground. (This method does not prove that all hidden junction boxes have continuity through them.) Now ground the antenna near the junction box and, with an ohmmeter, check for continuity to ground from the center conductor of that particular antenna outlet on the receiver antenna patch panel in radio central or wherever the antenna appears inside the ship. The reading should be very close to 1 or 2 ohms. Remove the short, and again megger for short to ground. This reading should be approximately 40 to 50 megohms or higher. If this reading is not obtained, it is possible that the coaxial line must be replaced.

5. The filter board receiver antenna patch panel on the AN/SRA-12 should be tested in accordance with the equipment technical manual for proper operation of the filters. On a more frequent basis, the isolation resistors for the antenna outputs should be checked with an ohmmeter. It is common for these resistors to be completely opened because they are burned out. Remember that R-390 receivers place a short across their antenna input when the receiver is placed in either standby or calibrate mode. This short will affect all other receivers on the AN/SRA-12 type of receiver patch panel.

6. Remove the antenna from the receiver, and megger the coaxial line from the receiver antenna patch panel to determine that the coaxial cable has high resistance between inner and outer conductors. Check for continuity by shorting one end of the coaxial cable and checking with an ohmmeter for a very low resistance of 0 to 1 ohm. Inspect the antenna jack on the receiver for tightness, and then reinsert the antenna into the receiver.

The preceding 6 recommendations constitute a lot of work, but will eliminate hours of fighting to receive some frequencies that should be loud and clear. Often poor reception is blamed on shore transmitters, when it actually is the result of poor antenna maintenance. Normally junction boxes, coaxial cables, and hardware need inspection only once every 6 months. Insulators should be cleaned once a week or more frequently.

The foregoing procedure applies to transmitting antennas when checking insulators and hardware. On high-frequency antennas, insulator cleaning and maintenance is relatively simple. On UHF receivers it usually is necessary to break open watertight connections high on the mast. It is recommended that these connections be checked only once a year. After that, rely on VSWR readings taken on three frequencies on the range of the equipment tied to a particular antenna. The three frequencies should be as close as possible to the top frequency, the middle frequency, and the lowest frequency. Sometimes breaking open the watertight fitting on the coaxial cable does more harm than good.

When meggering transmitting antennas, remember that dry salt is an insulator and the salt deposit will not become conductive until it becomes dampened. For this reason, the antennas should be meggered early in the morning while the morning dew is present.

During operations at sea the salt deposit on insulators continues to build up. Thus, it is not always possible to close down transmitters long enough to clean insulators effectively. Advantage can be taken of the basic principle that the salt deposit becomes more conductive as it increases in thickness. Another principle is that sea water is a relatively poor conductor, especially when it is in a thin film. Based on these principles, an alternate procedure of shutting down transmitters and using a firehose as a salt water washdown can be effective in reducing the salt deposits on antennas and insulators.

SAFETY PRECAUTIONS WHILE WORKING ON ANTENNAS

Chapter 9670 of the Naval Ships Technical Manual calls for the following precautions to be observed when working on antennas.

1. Personnel shall not be permitted to go aloft while antennas are energized by electronic equipment except by means of ladders and landings rendered safe by grounded hand rails or similar structures unless it is definitely determined in advance by suitable tests

that no danger exists. This will prevent casualty resulting from involuntary relaxation of the hands which might occur if a spark is drawn from a charged piece of metal or section of rigging. The spark itself might be quite harmless. The voltages, or resonant circuits, set up in a ship's structure or section of rigging will cause shock to personnel or produce open sparks when contact is broken, or when momentarily in contact with a metallic object. Personnel of the deck force or others working on rigging shall be warned regarding the hazards which may exist and the precautions to be observed. Safety belts shall be employed when working aloft to guard against falls.

2. The above precautions should be observed when other antennas in the immediate vicinity are energized by electronic transmitters unless it is definitely known that no danger exists. Other antennas may be interpreted to mean any antennas on board another ship moored alongside or across the pier or at a nearby shore station.

3. There is serious danger to man aloft from falls caused by radar or other antennas which rotate or swing through horizontal or vertical arcs. Motor switches controlling the motion of radar antennas shall be tagged and locked open before men are allowed aloft within dangerous proximity to such antennas. It also must be borne in mind that deenergizing main supply circuits by opening supply switches, circuit breakers, or circuit switches will not necessarily disable all circuits in a given piece of equipment. A source of danger that often has been neglected or ignored, sometimes with tragic results, is the inputs to electronic equipment from other sources, such as synchros, remote control circuits, and the like. For example, turning off the antenna safety switch will disable the antenna, but it may not turn off the antenna synchro voltages from the ship compass or stable elements. Moreover, the rescue of a victim shocked by the power input from a remote source often is hampered because of the time required to determine the source of power and turn it off.

4. No non-Navy radio should be connected to a shipboard antenna. Many cases of burned-out receiver antenna coils have been a result of someone connecting a commercial receiver to a ship receiving antenna. By this means, it is possible to put the ship antenna at 120 volts above ground, thus creating a threat to someone's life and a hazard to equipment. The placement of a capacitor in series with the commercial antenna will not prevent the voltage from reaching the shipboard antenna because an a-c voltage is involved. Also, commercial receivers are likely to radiate and thus create an interference problem.

STACK GAS WARNING

Personnel servicing equipment aloft are further cautioned to guard against the poisonous effects of smoke pipe gases. Besides smoke particles and noxious fumes, stack gases also contain carbon monoxide. Although the possibility is remote that this gas would build up to high concentrations in the open, the results of prolonged exposure to even small concentrations can be lethal. Stack gases sometimes give no warning and can cause illness, loss of consciousness, or even death as a result of a fall from the mast. To prevent personnel from being overcome by these gases, certain precautions should be observed.

1. Warning signs should be posted and located so that they are in full view of personnel required to service equipment. It is recommended that one sign be located below, near the access ladder, and another aloft at the servicing platform.

2. Oxygen breathing apparatus should be used. Because of its small size and weight, the type-B oxygen breathing apparatus, NavShips No. S-23-B 69855 is best suited for this work. Personnel who are required to service equipment aloft in the vicinity of stack gases and who are unfamiliar with oxygen breathing equipment should be instructed in its use by trained personnel.

3. As a further precaution. a telephone chest or throat microphone set should be worn for communication with others in the working party. The working party should always include at least one man (stationed below) who is required to wear his phones and stand watch on the sound-powered telephone circuit as long as a man is working aloft.

4. Make sure to obtain all necessary equipment before going aloft.

SAFETY PRECAUTIONS FOR MAST WORKERS

A safety belt should be worn at all times by mast workers. The safety belt should be of the approved type, and should be tested periodically for its rated load. These belts should be attached to a strong permanent support, preferably the mast itself. A tool belt should be worn, and care should be taken to prevent tools from falling. It is recommended that all handtools be tied to the belt with a length of wire or string of sufficient length to permit ease in working. Wherever possible, work should be done from a scaffold or working platform. If a small job is to be performed on the mast, it may be found that the use of a "bosun's chair" is a safer and more economical method than construction of a scaffold.

TELETYPEWRITER PREVENTIVE MAINTENANCE

Use of the equipment technical manual is required for proper preventive maintenance on teletypewriters. The scope of the information contained in the technical manual is indicated in ensuing topics.

Preventive maintenance is applied for the purpose of detecting and correcting troubles before they develop to the point of interference with satisfactory operation of the teletypewriter equipment. Proper lubrication–but not overlubrication–is an important preventive maintenance measure. When work on equipment is necessary, use care to avoid introducing trouble.

A thorough visual inspection of equipment during periodic checks may uncover conditions that could possibly cause trouble later. Appearance of oxidized (red) metal dust adjacent to any bearing surface indicates insufficient lubrication. Adjustable clearances of working parts should be observed also.

A visual examination should be accompanied by a manual test. Connections at terminal boards should be checked for tightness. Vibrations sometimes loosen these connections just enough to give intermittent troubles that are difficult to locate. Nuts and screws that lock adjustable features should be observed carefully for looseness, and should be tightened if necessary. While cleaning the units, care should be exercised to avoid damage or distortion to delicate springs that might weaken their tension. Electrical contact points should be kept free and clear of dirt, oil, corrosion, or pitting. Check that operating clearance is maintained when a contact is cleaned.

LUBRICATION

More than 60 pictures and diagrams in the equipment technical manual illustrate lubrication points of the AN/UGC-6 teletypewriter. In addition to points to be lubricated, technical manual pictures show the type and quantity of lubrication to use. A new teletypewriter should be lubricated before it is placed in service for the first time. After a few weeks in service, relubricate to make certain that all points are lubricated adequately.

Lubrication Schedule

A teletypewriter must be lubricated more frequently as operating speed increases. Thus, a machine geared for 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 lubrication interval, an important point to remember is the words "whichever occurs first." To illustrate, a machine in continuous use at 100 wpm will accumulate 1500 operating hours in only 2 months. For machines used occasionally or intermittently, some kind of log is needed to keep track of total operating hours. The electronic equipment operational time log (NavShips 4855), described and illustrated in a later chapter of this training course, is used for this purpose.

Oil and Grease

For normal or high temperatures (above 41°F.), apply KS-7470 oil at all locations where the need for oil is indicated. For lower temperatures, dilute the KS-7470 oil with kerosene (half and half). Use type MIL-G-3278 grease on all surfaces (except motor bearings) where grease is prescribed. Apply two drops of KS-7470 oil to motor bearings every 4 months. If the motor is disassembled at any time, repack bearings with MIL-G-3278 grease.

All springs, wicks, and felt oilers should be saturated. Friction surfaces of all moving parts should be lubricated thoroughly. Overlubrication, which permits oil or grease to drip or be thrown on other parts, must be avoided.

Electrical contact surfaces must be kept free of oil. Take special precaution to prevent any oil or grease from accumulating between armatures and pole pieces of selector magnets, transmitter distributor clutch magnets, tape back-space magnets, or tape feedout magnets.

Apply a thick film of grease to all gears and to the spacing clutch reset cam plate. When gear changes are made, such as changing from 60-wpm to 100-wpm operations, lubricate replacement gears at the time the change is made.

Lubrication Charts

For visual identification, lubrication instructions are keyed to a photograph of the equipment. The first digit is a hyphenated numeral corresponding to the figure number in which the photograph is found. The second part of the key is a letter to indicate the reference point on that photograph. For example, 5-2(A) is a lubrication instruction for a part shown photographically in figure 5-2 and a point (A) on that illustration.

Specific lubricant requirements and the amount of lubricant are indicated on the chart in accordance with the following code.

0 apply 1 drop of KS-7470 oil.
02 apply 2 drops of KS-7470 oil.
03 apply 3 drops of KS-7470 oil.
020 apply 20 drops of KS-7470 oil.
SAT saturate (felt oilers, washers, wicks) with KS-7470 oil.
G apply thin film of MIL-G-3278 grease.

In addition to routine lubrication intervals, relubrication is necessary whenever parts of assemblies are removed and reassembled, or when handling the equipment for adjustment purposes may have removed some or all of the lubricant.

OPERATOR'S EMERGENCY MAINTENANCE

Even though some teletype operators may have received no maintenance training, they can be authorized to perform emergency maintenance to the extent of replacing fuses and lamps.

Fuses

Power circuits of the AN/UGC-6 teletypewriter are protected by two cartridge-type fuses. The main fuse for the basic equipment is on the right end of the power distribution panel under the cabinet dome behind the keyboard. A separate fuse for power circuits of the typing reperforator is located on the terminal board bracket to the left of the printing unit on the typing reperforator base. Fuse location and symptoms of failure are summarized in the accompanying tables.

Lamp Replacement

Four bayonet-type lamps for the AN/UGC-6 teletypewriter are located beneath the cabinet dome. Maintenance and copy illumination lamps are 6-volt lamps in a circuit supplied by a transformer at the rear of the cabinet. These lamps are installed on either side of the right front dome door and above the typing perforator (three lamps) and the margin indicator or end-of-line lamp (one lamp) at the extreme right of the dome. All lamps are accessible when the dome is raised. The accompanying lamp replacement data table gives the location and electrical characteristics of lamps.

TELETYPE MAINTENANCE SCHOOLS

All corrective maintenance to teletype equipment normally will be performed by a qualified teletype repairman, NEC 2342. The Navy has two Teletype Maintenance Schools, one at Norfolk, the other at San Diego. These schools graduate qualified teletypewriter repairmen who are able to identify, locate, and repair quickly any type of trouble that may develop in the equipment. If you never have attended one of these schools, endeavor 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, and (3) troubleshooting.

In the performance of the teletypewriter repairmen's practical work, proficiency comes with practice and experience, for which no training manual, however helpful, can be an adequate substitute.

Symptoms of Fuse Failure

Maintenance lamps	Keyboard motor	Reperforator motor	Blown fuse	Value (amps)	Comments
Out	Off	Operating	F800	6.25	In power distribution panel.
On	Operating	Off	F2300	4	On typing reperforator base.

WARNING: Never replace a fuse with one of higher rating except in emergency or battle condition when continued operation of equipment is more important than possible damage.

If a fuse burns out immediately after replacement, do not replace a second fuse until the cause is corrected.

Fuse Location

Reference designation symbol	Location	Protects	Amps.	Volts
F800	In power distribution panel	Main a-c supply	6.25	250
F2300	On typing reperforator base	Reperforator a-c supply	4	250

Lamp Replacement Data

Reference designation symbol	Function	Location	Volts	Watts	Amps.	Base
I4250	Maintenance and copy illumination	Left of right front cabinet dome door.	6-8	6	1.14	Bayonet, double contact
I4251	. . . do . . .	Right of right front cabinet dome door.	. do.	. do .	. do .	Do.
I4252	. . . do . . .	Left front door of cabinet dome.	. do .	. do .	. do .	Do.
I4350	. . . do . . .	Right front end of cabinet dome.	. do .	. do .	. do .	Do.

CHAPTER 9

SINGLE-SIDEBAND COMMUNICATION PRINCIPLES

Because single sideband is becoming increasingly important in Navy applications, it is necessary that Navy Radiomen acquire an understanding of the basic principles of operation. If the Radioman understands the principles of operation, he will experience little difficulty in utilizing the instruction books or technical manuals of single-sideband equipment. An alert Radioman will make every effort to keep abreast of advances in the field.

It is, of course, impossible to give complete coverage of this subject in a single chapter. Some references that will be of value to the RM are included in the Electronics Information Bulletin.

It is the purpose of this chapter to present, first of all, the advantages of single-sideband (SSB) communications and equipment and to point out the difference between SSB and the conventional system of amplitude-modulation communications utilizing both sidebands and the carrier. Some of the important problems in SSB communications are discussed next. After the problems is a discussion of the various methods of single-sideband generation and the commonly used types of filters and linear amplifiers.

In order to approach the subject of equipment operation in the simplest and most logical manner, a functional block diagram of a widely used single-sideband transceiver is given. The diagram is accompanied by a discussion of the functions performed in each of the blocks.

A simplified circuit diagram of the equipment is included next. The various circuits are analyzed to better acquaint the Radioman with circuit operation. The actual circuit diagram, including the various switching functions, is included in the instruction book provided by the equipment manufacturer.

ADVANTAGES OF SINGLE-SIDEBAND COMMUNICATIONS

A comparison of the frequency and power relationships between single-sideband transmission and conventional a-m transmission is illustrated in figure 9-1. The SSB system is illustrated in part A of the diagram. Only one sideband, peak envelope power (PEP) of 50 watts, is needed to transmit intelligence. None of the power is contained in the carrier or in the upper sideband. Although the lower sideband is transmitted, the upper sideband could have been transmitted just as easily. In some systems both sidebands may be utilized independently.

In the familiar a-m system of communication (fig. 9-1, part B), the radiated signal includes the carrier and an upper and a lower sideband frequency for each frequency in the modulating signal. If a 1-MHz carrier is modulated by a 1-kHz tone, for example, the radiated signal will include the 1-MHz carrier, the lower sideband frequency (1 MHz - 1 kHz = 999 kHz), and the upper sideband frequency (1 MHz + 1 kHz= 1001 kHz). If the modulating signal contains many frequencies, there will be, of course, many frequencies in the sidebands. In this system of transmission, none of the transmitted intelligence is contained in the carrier. All of the power put into the carrier is therefore wasted, insofar as transmitting intelligence is concerned. Likewise, because duplicate information is contained in each of the two sidebands, the intelligence content of the transmitted signal could be recovered from one sideband only.

In a conventional a-m system, where both sidebands and the carrier are transmitted, the power in the sidebands is dependent upon the amount of modulation. For 100 percent modulation the power in the sidebands is equal to half that in the carrier. Thus, a conventional a-m transmitter with carrier power of 100 watts will have 50 watts in the sidebands (25 watts in the upper sideband and 25 watts in the lower sideband) at 100 percent modulation, making the total power transmitted 150 watts (fig. 9-1, part B). It can be seen, then, that two-thirds of the total radiated power in a conventional a-m system (assuming 100 percent modulation) is in the carrier and is therefore not useful in conveying intelligence.

When the r-f signal is demodulated in the conventional a-m system, the audio output is a combination of the upper and lower sidebands. In this conventional type of detection (known as coherent detection), the audio output is proportional to the power contained in the two sidebands.

In a single-sideband system, only one sideband is transmitted. The audio output of the SSB receiver, therefore, is proportional to the power contained in the one sideband.

It now becomes apparent that, under ideal propagating conditions, an SSB transmitter and an a-m transmitter will perform equally (same signal-to-noise ratio) if the total sideband power of the two transmitters is equal. Considering the relationship between sideband power and carrier power in conventional a-m system, it is evident that, under ideal propagating conditions, an SSB transmitter will perform as well as an a-m transmitter of twice the carrier power rating. Thus, a single-sideband transmitter rated at 50 watts will produce the same signal intelligence level at a receiver as a conventional a-m transmitter rated at 100 watts of carrier power. (See fig. 9-1.)

A comparison between the SSB power and the a-m power, which can be radiated from an antenna of given dimension, is even more significant. If an antenna is chosen which will radiate 400 watts of peak envelope power (PEP), the a-m transmitter which may be used with this antenna must be rated at no more than 100 watts. This statement is true because the PEP of the a-m signal at 100 percent modulation is four times the carrier power. A single sideband transmitter rated at 400 watts of PEP, all of which is sideband power, may be used with this same antenna, as compared with the 50 watts of sideband power (25 watts in each sideband) obtained from the a-m transmitter with a 100-watt carrier rating.

As propagating conditions become less than ideal, the SSB system will show an even greater advantage over an a-m system. An a-m transmission is subject to deterioration under poor propagation conditions because, to realize perfect reception, all three components of the transmitted signal (the upper sideband, the lower sideband, and the carrier) must be received exactly as transmitted. Because there is only one component in the transmitted signal of an SSB system, an improvement of from 0 to 9 db will be realized under various conditions of propagation, when the total sideband power in SSB is equal to that in amplitude modulation (fig. 9-2).

Note that under average conditions, the SSB system shows about a 3-db advantage over the a-m system. In other words, in normal use, an SSB transmitter rated at 100 watts (PEP) will give equal performance with an a-m transmitter rated at 200-watts carrier power.

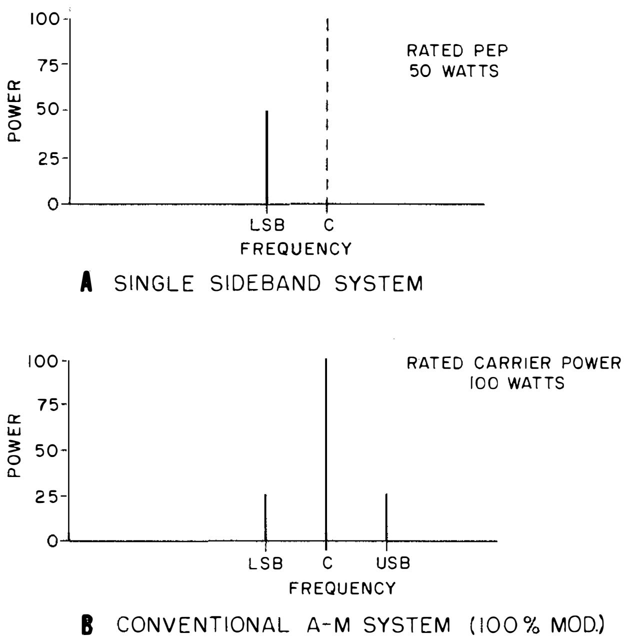

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Figure 9-1. —Comparison of frequency and useful power in SSB and a-m transmissions.

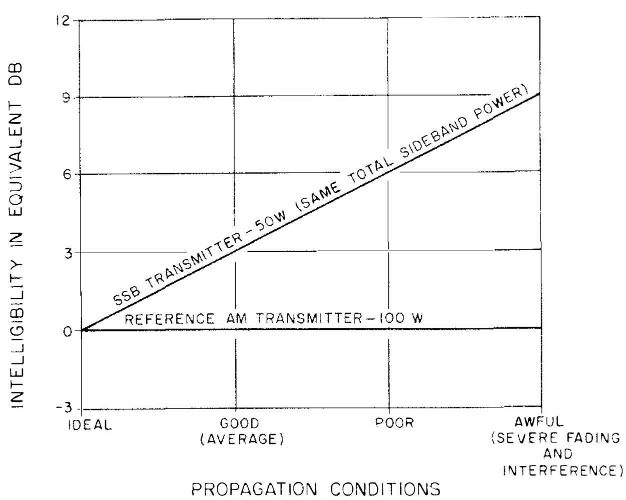

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Figure 9-2. —Comparison of amplitude modulation and SSB under varying propagation conditions.

As far as bandwidth is concerned (assuming one sideband only), the SSB system requires only about half the frequency spectrum of the conventional a-m system.

The advantages of SSB over the conventional a-m system may be summarized as follows:

1. Under ideal propagating conditions, the SSB transmitter will perform as well as an a-m transmitter of twice the carrier power rating. Under average conditions there is an additional 3-db advantage of an SSB system over an a-m system having the same sideband power.
2. If only one sideband is used, the SSB system requires only half as much r-f spectrum as the a-m system.
3. The SSB transmitting system uses smaller units than comparable a-m units because less power is required.
4. Because less power is needed in the antenna, lower voltages are required, with attendant reduction of potential breakdown.
5. The SSB system is subject to less noise interference because the bandpass is narrower.

PROBLEMS IN SINGLE-SIDEBAND COMMUNICATIONS

The advantages of SSB cannot be realized without the use of the specially designed components and circuitry. First of all, there is the problem of frequency stability, especially when the carrier is totally suppressed. This problem means that the oscillators in the transmitter and in the receiver must not drift more than a few hertz. Actually, the permissible frequency variation for SSB systems is 1/100th that for an a-m system.

In one type of double-sideband generation, filters of extreme selectivity are needed. Linear power amplifiers, which are difficult to design, are also required.

When SSB equipment is used on high-speed aircraft, doppler shift (change in pitch) represents another problem. Doppler shift is especially noticeable at the higher frequencies.

FUNCTIONAL BLOCK DIAGRAM OF A TYPICAL SSB SYSTEM

A block diagram of an SSB transceiver is shown in figure 9-3. This equipment is a single-sideband, suppressed-carrier, transmitter-receiver combination. The SSB system illustrated in figure 9-3 consists of a transmitter-receiver chassis and a power supply chassis. Some examples of SSB systems are the AN/URC-32, the AN/WRT-2, and the AN/WRR-2. The operating frequency of this system is selected from one of four pretuned channels. The signal is transmitted on the lower sideband only.

As may be seen in the block diagram, three crystal oscillators are used on transmission and reception. The three oscillators, as well as the balanced modulators that they feed, are needed to heterodyne the frequency up to the desired radiation frequency and down to the desired demodulation frequency.

TRANSMITTER SECTION

On transmission, the modulating signal (1 kHz is assumed) from the tone oscillator (block 1) or the microphone is amplified in the microphone amplifier (block 3).

From block 3 the signal is fed to block 4, a balanced modulator. Here the 1-kHz signal is combined with the 250-kHz signal from the crystal oscillator (block 5) to produce lower and upper sideband frequencies (250 kHz - 1 kHz = 249 kHz, and 250 kHz + 1 kHz = 251 kHz.) The 250-kHz oscillator frequency is suppressed in the balanced modulator. The balanced modulator is described in more detail later in this chapter.

From block 4 the two sideband frequencies are fed to a mechanical filter (block 6). The mechanical filter is a mechanically resonant device that receives electrical energy, converts it into mechanical vibrations, then converts the mechanical energy back into electrical energy (using the magnetostriction principle) at the output. This filter resonates with, and passes, the upper sideband (251 kHz), but suppresses the lower sideband (249 kHz).

From block 6 the 251-kHz signal is fed to the second balanced modulator (block 7). Here the 251-kHz signal is combined with the 1150-kHz signal from block 8. Two sidebands (899 kHz and 1401 kHz) are produced, and the crystal frequency (1150 kHz) is suppressed. Included in this block is a tuned r-f transformer, which passes the upper sideband (1401 kHz) and suppresses the lower sideband (899 kHz).

The 1401-kHz upper sideband frequency from block 7 is fed to the third balanced modulator (block 9) where it is combined with the 15,650-kHz signal (assume channel 4 operation) from block 10. The 15,650-kHz frequency is suppressed, and the two sidebands (14,249 kHz and 17,051 kHz) are fed to the tuned r-f circuits

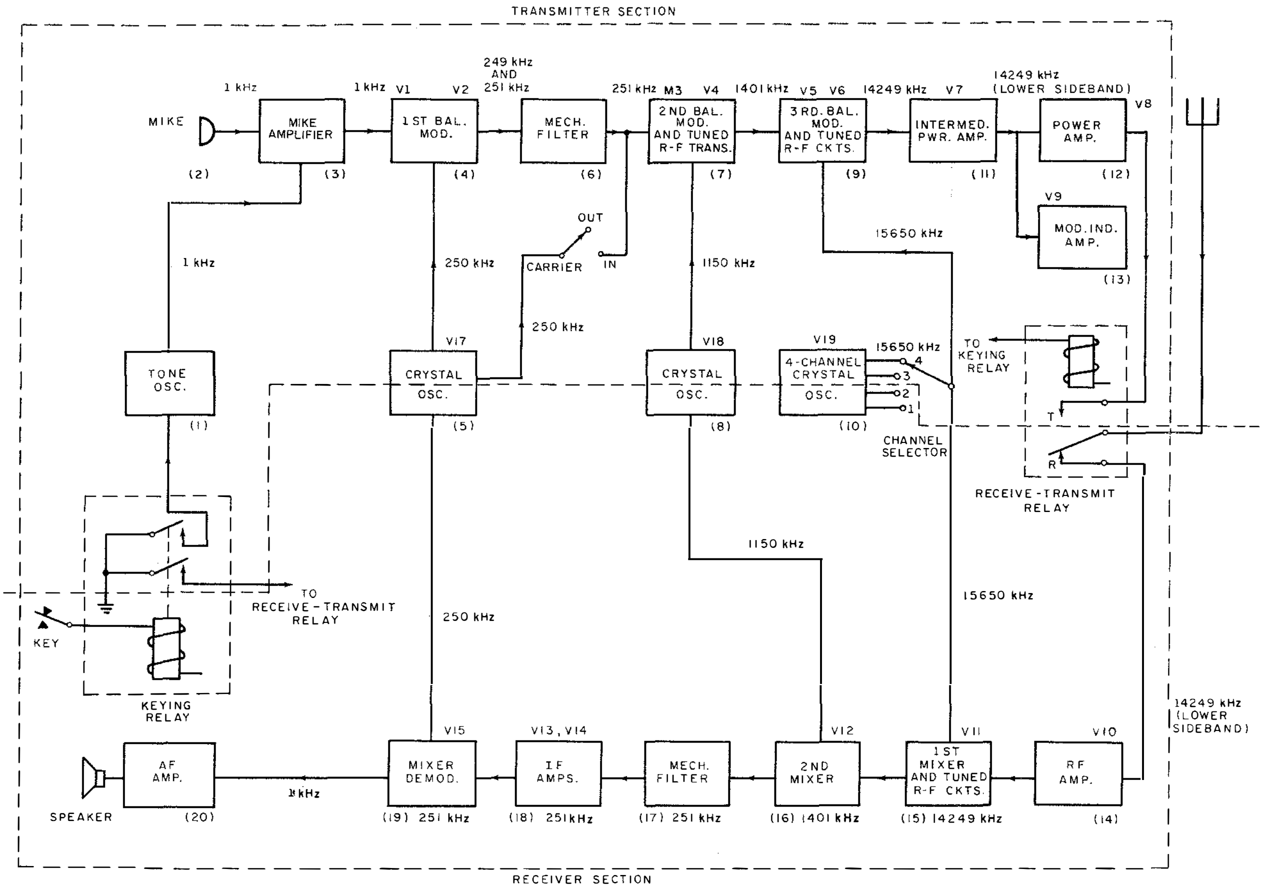

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Figure 9-3. —Block diagram of an SSB transceiver.

in block 9. Only the lower sideband (14,249 kHz) is fed to the intermediate power amplifier (block 11) and the power amplifier (block 12).

The lower sideband frequency of 14,249 kHz is applied to the antenna when the receive-transmit switch is in the TRANSMIT position. Except when actually transmitting, the receive-transmit relay contacts make electrical continuity between the antenna and receiver at all times.

The modulation indicator amplifier (block 13) amplifies the signal from the power amplifier grids and applies it to the peak modulation indicator (a lamp), which indicates modulation peaks.

RECEIVER SECTION

Reception is essentially the reverse of transmission. For simplicity, it is assumed that the incoming signal is 14,249 kHz and that the intelligence signal is a 1-kHz tone; the nominal carrier is therefore 14,250 kHz. Note that with this SSB system the carrier is not transmitted. When the receive-transmit switch is in the RECEIVE position the 14, 249-kHz signal is fed to the r-f amplifier (block 14).

From the r-f amplifier the 14,249-kHz signal is fed to the first mixer (block 15) where it is mixed with the 15,650-kHz signal from block 10. The output contains the sum and difference frequencies, 29,899 kHz and 1401 kHz, respectively. The difference frequency (1401 kHz) passes through the tuned r-f circuits to the second mixer (block 16).

In the second mixer the 1401-kHz signal is mixed with the 1150-kHz frequency from block 8 to produce sum and difference frequencies, 2551 kHz and 251 kHz, respectively. The mechanical filter (block 17) is tuned to 251 kHz, and this is the only frequency that is passed through the i-f amplifier to the mixer-demodulator (block 19).

In the mixer-demodulator the 251-kHz i-f signal is mixed with the 250-kHz frequency from block 5 to produce sum and difference frequencies, 501 kHz and 1 kHz, respectively. The 501-kHz frequency is eliminated, and the 1-kHz signal is then amplified in block 20 and applied to the speaker.

Transmission with Carrier

To make this equipment compatible with a-m equipment now in use, provision is made for inserting a carrier signal after the mechanical filter. (At the input of the second balanced modulator, see the transmitter section of figure 9-3.)

The 250- and 251-kHz signals are heterodyned in the second and third balanced modulators. The frequency difference between carrier and sideband is maintained in the output the same as in the input to the second balanced modulator. Assume channel 4 operation (15,650 kHz). The carrier will then be 14,250 kHz, and the lower sideband (produced by the 1-kHz tone) will be 14,249 kHz. The combined signal can be detected by conventional a-m receivers that are capable of being tuned to this frequency.

SIMPLIFIED CIRCUIT DIAGRAM

Figure 9-4 is a simplified schematic diagram of the circuits included in the transmitter-receiver chassis. The audio input section (including the microphone amplifier and the tone oscillator) is treated later; the audio output section is also treated later. Power supplies are covered in <u>Basic Electronics,</u> NavPers 10087; and, because the power supply is conventional, it is not covered in detail in this chapter.

CRYSTAL OSCILLATORS

The functions of the various circuits in the SSB system have been discussed in terms of the functional block diagram. It is convenient to begin the brief analysis of the circuits in the transmitter-receiver chassis (fig. 9-4) with the crystal oscillators.

Two of the crystal oscillators, V17 and V18, are of fixed frequency (250 kHz and 1150 kHz), and the necessary crystals are supplied with the equipment. The four-channel frequency crystals used with V19 are supplied separately. The nominal carrier frequency (the carrier is not transmitted) determines the frequency of the channel frequency crystals. When channel frequency crystals, are to be selected, it is a simple matter to determine the correct crystal frequencies: Simply add 1400 kHz to the desired nominal carrier frequency for each channel. Assume that the channel selector switch is set to channel 4, for example, and that a nominal carrier frequency of 14,250 kHz is to be used. The crystal frequency must then be 14,250 kHz plus 1400 kHz, or 15,650 kHz.

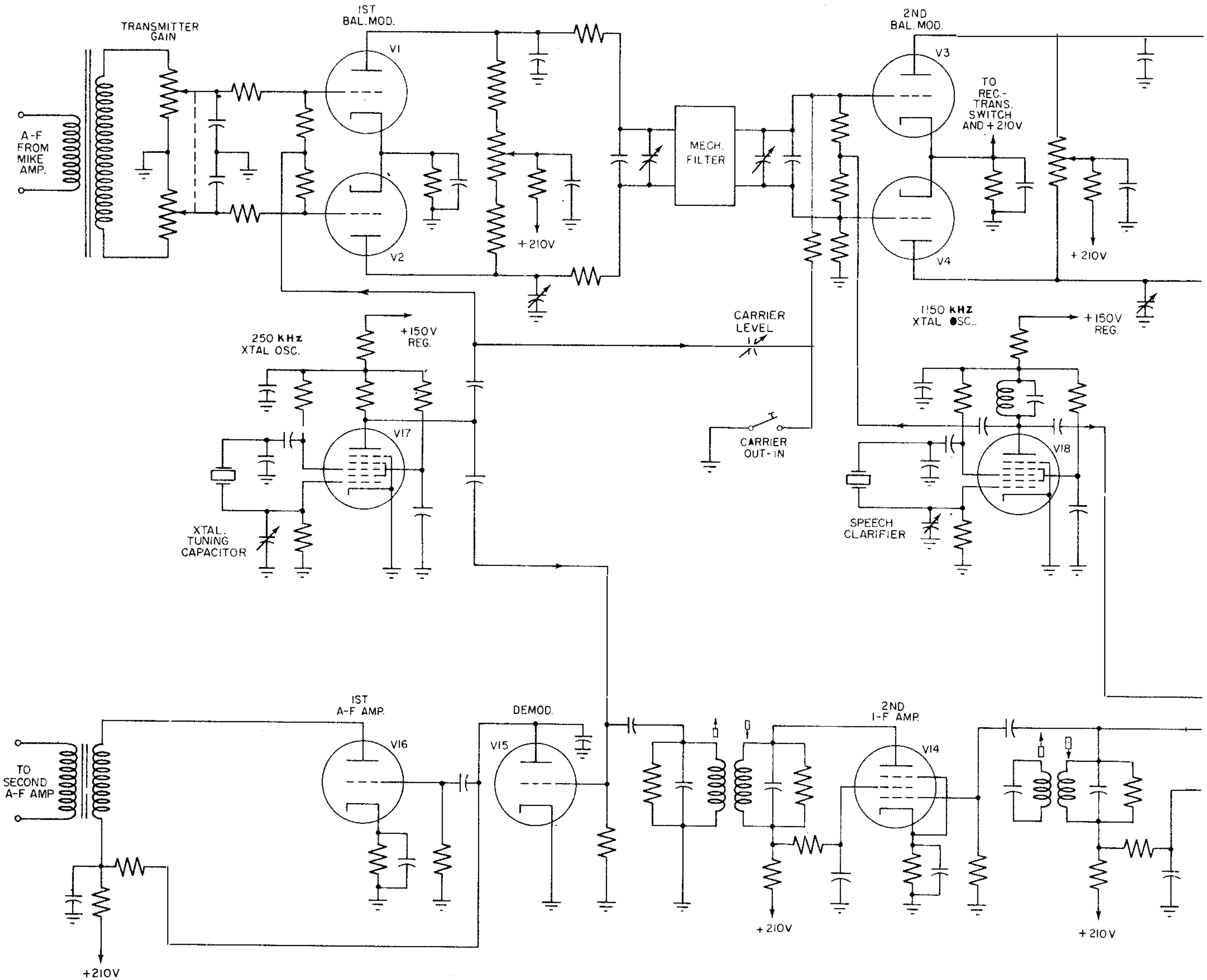
The 250-kHz crystal oscillator, V17, feeds the first balanced modulator, V1-V2, on transmission and the demodulator, V15, on reception. Both the 250-kHz crystal and the others are enclosed in an oven where a constant temperature is maintained. As indicated in figure 9-4, the plate of V17 is supplied from the 150-v regulated supply. The crystal is connected (through a coupling capacitor) between grid 3 and grid 1, making, in effect, an electron-coupled oscillator. Various types of oscillators are treated in <u>Basic Electronics,</u> NavPers 10087.

The crystal tuning capacity is used to vary the oscillator frequency over a small range. The crystal may be connected between various tube elements; for example, between the first and third grids of a pentagrid tube, between the screen grid and control grid of a pentode, or between the plate and grid or grid and cathode of a triode.

The 1150-kHz oscillator, V18, operates in a manner similar to the 250-kHz oscillator. The tuning capacitor in this instance, however, has a front-panel control, called the speech clarifier. By adjusting this capacitor the operator may bring the oscillator frequency exactly to that of the station he is working. This oscillator feeds the second balanced modulator, V3 and V4, on transmission and the second mixer, V12, on reception.

The channel frequency oscillator, V19 (a simplified diagram of which is shown in figure 9-5) employs a power pentode and any one of the four crystals. The position of the switch determines which of the crystals will be used. This oscillator feeds the third balanced modulator, V5 and V6, on transmission and the first mixer, V11, on reception.

As may be seen in the diagram, the crystal is connected between the screen grid and the control grid. Feedback occurs through the 0.01-uf capacitor (coupled to the screen grid) and the parallel combination of the 1.24-uh choke and the 1200-ohm resistor. Grid voltage is developed across a 47,000-ohm resistor for channels 1


TRANSMITTER GAIN
A-F FROM MIKE AMP.
IST BAL. MOD.
V1
V2
+210V
MECH. FILTER
2ND BAL. MOD.
V3
V4
TO REC.-TRANS. SWITCH AND +210V
+210V
250 KHz XTAL OSC.
+150V REG.
V17
XTAL. TUNING CAPACITOR
CARRIER LEVEL
CARRIER OUT-IN
1150 KHZ XTAL OSC.
+150V REG.
V18
SPEECH CLARIFIER
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V16
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V15
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V14
+210V
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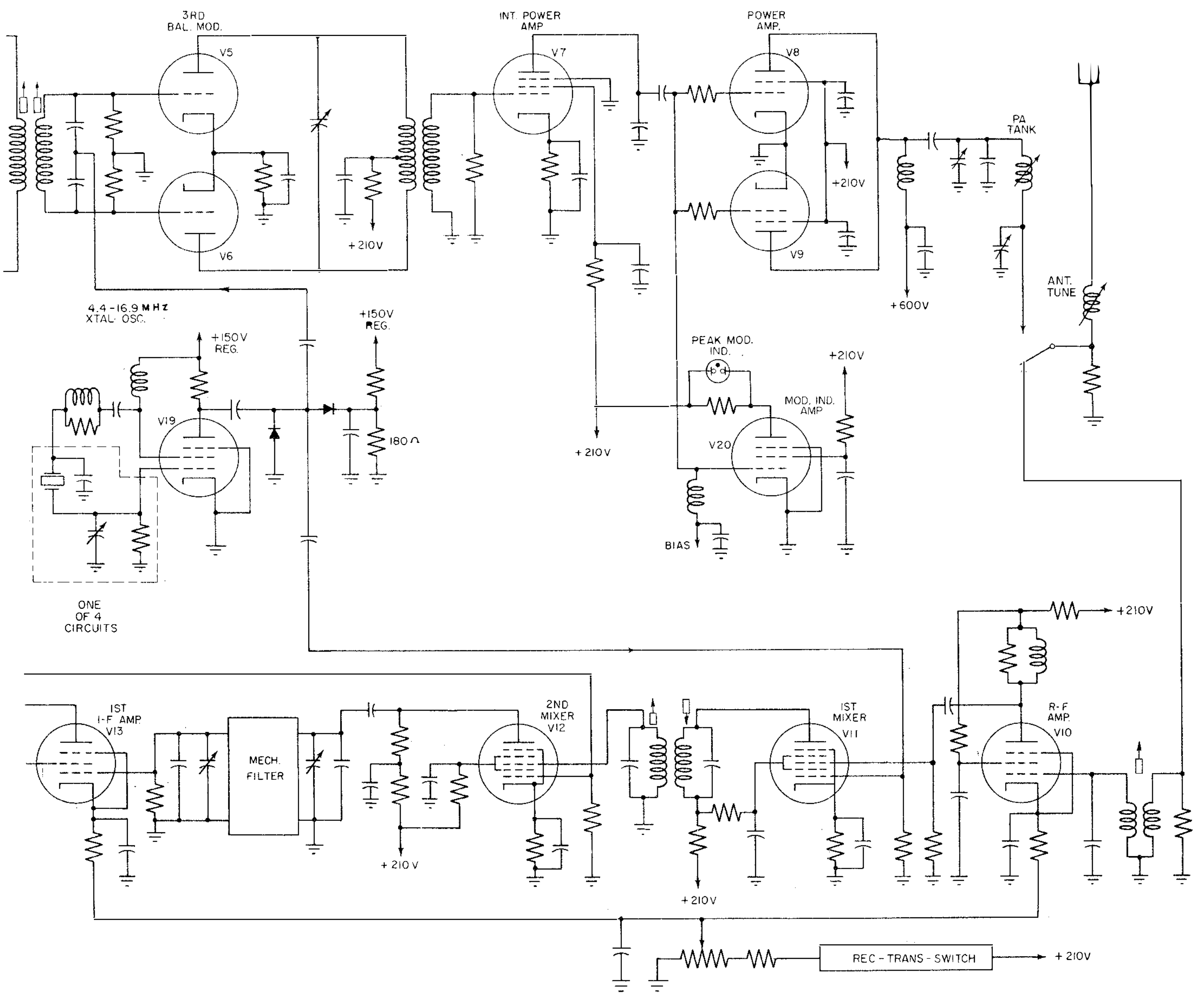

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Figure 9-4. —Simplified circuit diagram of the transceiver chassis.

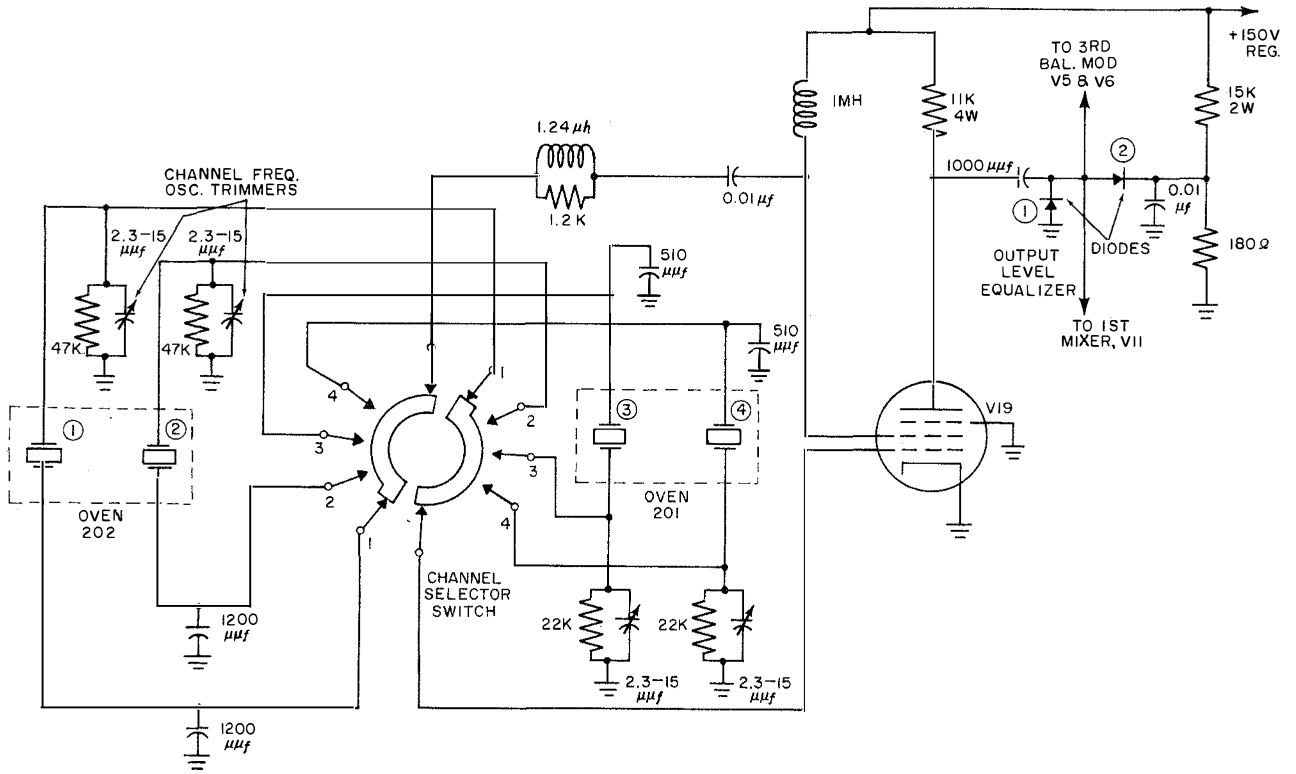

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Figure 9-5. –Simplified diagram of the channel-frequency oscillator.

and 2 and across a 22,000-ohm resistor for channels 3 and 4. For each position of the channel selector switch, a 2.3- to 15-uuf trimmer capacitor (between grid and ground) is available for adjusting the oscillator circuit to the desired frequency.

The crystal oscillator output level equalizer employed in the output of the channel frequency oscillator limits the output (fed to the third balanced modulator, V5 and V6, and the first mixer, V11) to approximately 1.8v, which is the voltage drop across the 180-ohm resistor. The limiting action may be explained by the use of the simplified diagram shown in figure 9-6. In this diagram the 180-ohm resistor has been replaced by a 2-v battery (2 volts are used to avoid the decimal), and only the plate and cathode connections of the oscillator tube, V19, are shown. The easy direction of electron flow in the diodes is opposite that of the arrow in the diode symbol.

The input voltage, Ea-g, swings 50 v above and 50 v below an assumed value of 100 v. The voltage Ea-b, across capacitor C, swings 49v above and 49 v below 99 v because of the action of the 2-v battery. The voltage Eb-g, fed to the coupling capacitor, is a series of pulses that swings between 0 and 2 v. Because of the action of the coupling capacitor and because the diodes are not perfect one-way conductors, the voltage fed to the load is essentially a sine waveform having a peak-to-peak value of 2 v.

At 0°, it is assumed that Ea-g is at its peak value of 150 v, Ea-b is at its peak of 148 v, and Eb-g is at its maximum value of 2 v. These values were established during the previous half hertz.

When Ea-g decreases to 149 v, Ea-b remains at 148 v, and Eb-g decreases to 1 v. When Ea-g decreases to 148 v, Ea-b still remains at 148 v, and Eb-g decreases to 0 v. When Ea-g decreases to 147 v, C begins to discharge through diode

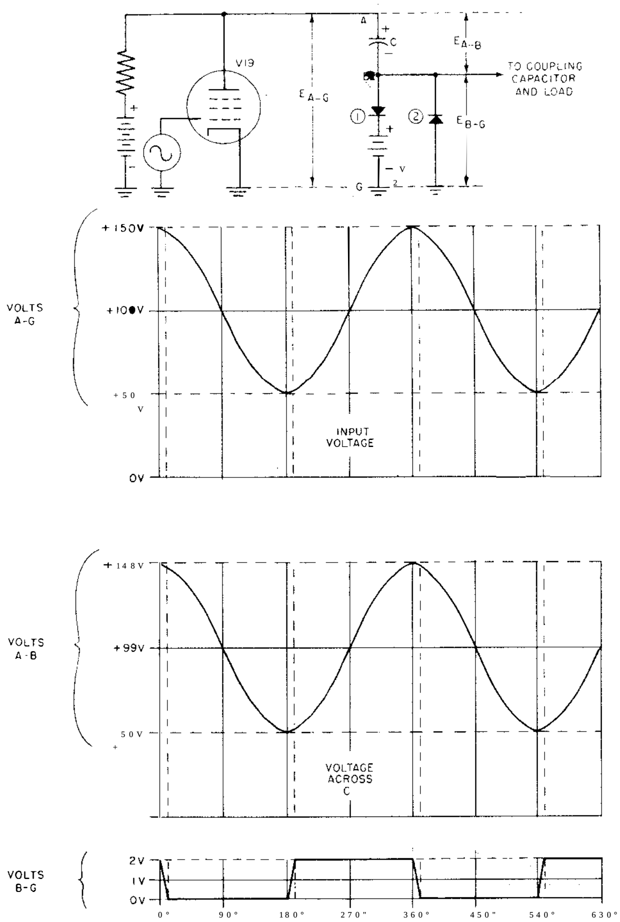

Figure 9-6.—Oscillator output level equalizer.

2, and the discharge continues to the 180° point, thus maintaining point B at ground potential during this portion of the input hertz.

At 180°, both Ea-g and Ea-b are 50 v. When Ea-g increases to 51 v, Ea-b remains at 50 v, and Eb-g increases to 1 v. When Ea-g increases to 52 v, Ea-b still remains at 50 v, and Eb-g increases to 2 v. When Ea-g increases above 52 v, diode 1 conducts, thus maintaining Eb-g at 2 v until the 360° point is reached.

Immediately after 180° the rising voltage, Ea-g, is imparted to the load because neither diode is conducting. The rise in voltage across the load is terminated at the instant diode 1 conducts and is limited to 2 v during this half hertz. Similarly, after 360° the falling Ea-g voltage change is imparted to the load because neither diode is conducting. The instant Eb-g becomes zero, diode 2 conducts, and the output remains at zero potential during this half hertz.

METHODS OF GENERATING SSB SIGNALS

Two common methods are used in generating single-sideband signals. One method uses the balanced modulator and a suitable filter. It is commonly called the filter method. The other, commonly called the phasing method, employs phasing circuits. A discussion of both methods follows.

Filter Method

A simplified circuit diagram of the first balanced modulator (V1 and V2 in block 4, figure 9-3) is given in figure 9-7. The 250-kHz signal generated by the crystal oscillator is applied in the same phase to the grids of V1 and V2, and is therefore suppressed in the output. The reason the carrier is suppressed may be explained as follows: (1) At a given instant the crystal oscillator drives both grids an equal amount in a positive direction; (2) plate current then rises an equal amount in both tubes; (3) current flows from both plates toward the movable contact on the balance control; (4) the voltages across both plate loads are equal and opposite; and (5) no difference in potential at the carrier frequency exists across the input to the mechanical filter, hence the carrier is suppressed.

The amount of carrier suppression depends on the degree of balance that is maintained. Under conditions of perfect balance, the carrier is completely suppressed.

The 1-kHz signal fed through the a-f transformer arrives at the grids of tubes V1 and V2, 180° out of phase; and, as in any push-pull circuit (see Basic Electronics, NavPers 10087), a signal appears at the output. The audio component, however, is not passed by the filter or any of the other r-f circuits.

The two sideband components (sum and difference frequencies of 249 kHz and 251 kHz) generated in the circuits of V1 and V2 are not balanced out in the plate circuits and therefore appear in the putput. They are not balanced out for the same reason that the audio component is not balanced out. That is, each of these frequencies applied to the grid of V1 is 180° out of phase with the corresponding frequency applied

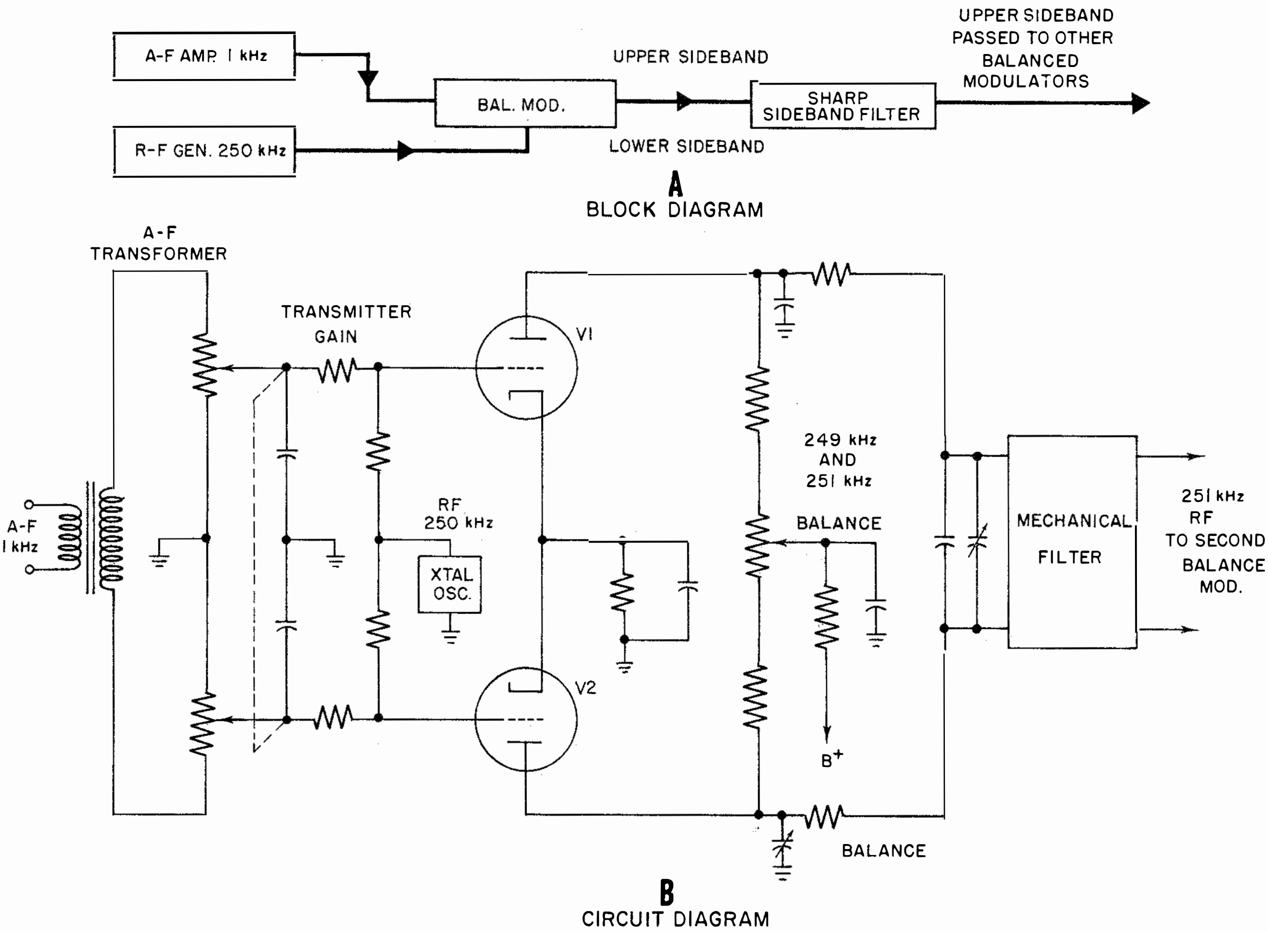

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Figure 9-7. –Block and circuit diagrams of a balanced modulator.

to the grid of V2. Because only the upper sideband is to be passed to the second balanced modulator (block 7, figure 9-3), the mechanical filter is designed to pass 251 kHz and to eliminate 249 kHz.

Phase-Shift Method

The phase-shift method of generating SSB differs considerably from the filter method. In the phase-shift method, two balanced modulators are connected in an equivalent push-pull circuit (fig. 9-8). The input signals are shifted 90°, with result that either the sum or the difference frequencies are canceled in the output, thereby eliminating the need for narrowband filters and additional stages in cascade. In view A of figure 9-8, the upper sideband is suppressed and the lower sideband is radiated; and in view B of figure 9-8, the lower sideband is suppressed and the upper sideband is radiated. Actually, the arrangement in part A can be changed to that in part B by means of a switching circuit, which is the usual method of operation. Thus, the operator has a choice of operating on either the lower or the upper sideband.

Assume that in view A of figure 9-7, the modulating frequency is 1 kHz and that the r-f carrier oscillator is 5 MHz. The a-f signal is fed directly to balanced modulator 1; it also is fed to the a-f phase shifter. From the a-f phase shifter the signal is shifted 90° and fed to balanced modulator 2.

The r-f carrier is fed to balanced modulator 1 with no shift in phase; it also is fed to balanced modulator 2 through the r-f phase shifter.

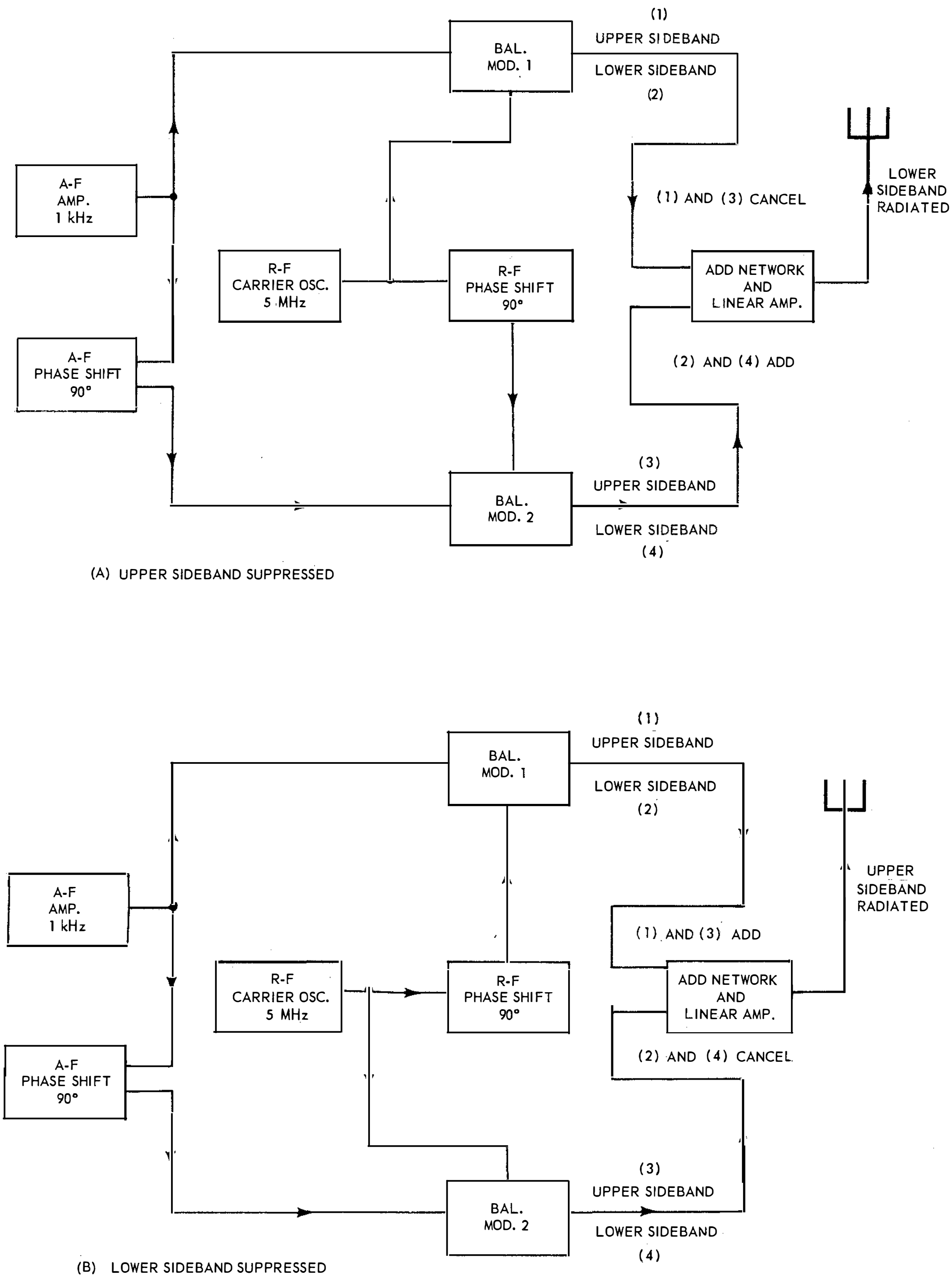

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Figure 9-8.–Phase-shift method of SSB generation.

In balanced modulator 1, both the a-f and r-f signals are combined to produce upper and lower sideband frequencies. The upper sideband from balanced modulator 1 is 180° out of phase with the upper sideband from balanced modulator 2, therefore these two signal components are canceled in the add network. The lower sideband from modulator 1, however, is in phase with the lower sideband from balanced modulator 2, and these components add in the add network.

As in any balanced modulator, the carrier (5 MHz in this instance) is balanced out and does not appear in the output.

In Figure 9-8 (view B), the a-f phase-shifted signal is fed to balanced modulator 2, and the r-f phase-shifted signal is fed to balanced modulator 1. As indicated in the illustration, the upper sideband from balanced modulator 1 combines in phase with the upper sideband from balanced modulator 2. The two lower sidebands, however, combine 180° out of phase (one is advanced by 90° and one is retarded by 90°); and these components are canceled in the add network. As in part A, the carrier is balanced out and does not appear in the output. Obviously, if the unwanted sideband is phased out by means of the phase-shift circuits and the balanced modulators, a narrowband filter is unnecessary.

Comparison of Filter and Phase-Shift Methods

The audio input and the linear power amplifier circuits used in each of the two methods of SSB generation are comparable. Great differences are apparent in some of the other circuits, however.

Modulation in the filter system must take place at a low radiofrequency (250 kHz, for example) because the percentage of separation of sidebands at low carrier frequencies is much greater than at high carrier frequencies. The filters (electromechanical or crystal lattice) must be very selective and pass only the desired narrow band of frequencies. This selection will be either the lower or the upper sideband.

Because the system starts with a low generated frequency (perhaps 250 kHz), it must be heterodyned in a sufficient number of balanced modulator stages to bring it to the desired radiofrequency.

In the filter system it is difficult and expensive to switch from one sideband to the other. This system is very stable, however, and once the initial adjustments are properly made, the equipment should operate with a minimum of internal adjustments.

Generation of SSB in the phase-shift system may take place in one equivalent push-pull stage at the radiated frequency, and thus the heterodyning process may be minimized. Because the unwanted sideband is phased out in the balanced modulator, the use of expensive electromechanical or crystal lattice filters is avoided.

In the phase-shift method, either of the sidebands may be used. This choice is accomplished by means of a simple switching arrangement. A major disadvantage of the phase-shift method is that the phase-shift networks require critical adjustments and are likely to need attention from time to time.

The narrowband filters used after the first balanced modulator in transmitters employing the filter method of SSB generation, and also after the mixers in the associated receivers, must have very high Qs and sharp cutoff characteristics. Mechanical or crystal lattice filters may be used. Crystal lattice filters have Qs of 10,000 to 200,000 or even higher. Mechanical filters have Qs of 2000 to 10,000 or more.

Compact lattice filter units have been designed to operate up to 40 MHz. At lower frequencies, however (200 to 250 kHz), mechanical filters have proven to be compact and durable. Both types are discussed in the following two topics.

Mechanical Filters

Several types of mechanical (electromechanical) filters have been designed for use with SSB equipment. Fundamentally, they all operate on the same principle. Metal rods or disks are mounted in a container in such a way as to form a group of mechanical resonating elements. Energy is put into the system by means of a magnetostrictive transducer; energy is taken out the same way. Only a relatively narrow band of frequencies can cause the resonating elements to respond, therefore only these frequencies can produce a signal in the output transducer.

One type of disk mechanical filter (actually an electromechanical filter) is illustrated in a simplified form in figure 9-9. The signal is fed into the input coil, which causes the first disk to vibrate because of magnetostrictive action of the coil and the driving wire. The wire is a magnetic material. The vibrations are coupled

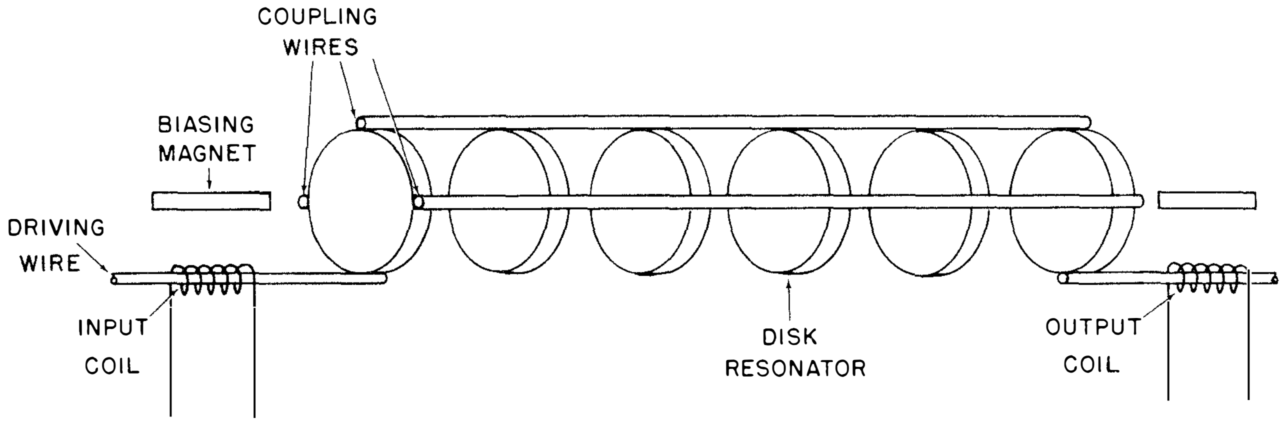

Figure 9-9. –Disk-type mechanical filter.

to the remaining disks by means of the coupling wires. Vibrations of the last disk cause the output driving wire to vibrate, and, by the inverse magnetostrictive effect, an output signal is developed in the output coil.

The disk resonators are precisely ground to resonate at frequencies very close to the center frequency of the passband. The width of the passband depends on the coupling elements; the center frequency depends on the size of the resonator elements; and the selectivity depends on the number of resonant elements.

A simplified diagram of another type of mechanical filter is illustrated in figure 9-10. This filter has seven resonant sections, and two quarter-wave end sections for support. The center resonator is encircled by a "snubber" bracket (not shown), which prevents excessive excursions under shock. The hermetically sealed housing, in which the filter is mounted, contains a dry inert gas. This filter vibrates with a twisting motion (torsional vibration), which is passed from one element to another through the coupling sections.

As with the disk-type filter, the center frequency depends on the resonant frequency of the tuned elements; the selectivity depends on the number of tuning elements; and the width of the passband depends on the design of the coupling elements.

The transducers at the input and output are precision-processed ferrite rods. The resonator rods are made of a specially prepared nickel alloy, which is heat treated to maintain an essentially constant frequency even during a wide range of temperature changes.

Crystal Lattice Filters

The equivalent electrical circuit of a quartz crystal is illustrated in figure 9-11. Capacitor C1 represents the reciprocal of the crystal stiffness–compliance, which is the equivalent of capacitance in the electrical system; L represents the electrical equivalent of the crystal mass that is effective in causing mechanical vibration; and R is the electrical equivalent of internal resistance. Capacitance C2 represents the capacitance of the crystal holder plates with the crystal plate between them. Because of the high value of the crystal Q, the equivalent circuit may be considered to be entirely reactive for most filter applications.

As indicated on the reactance curve (fig. 9-11), series resonance occurs at the point where the reactance curve crosses the zero line. In general, the resonant (series resonant) and antiresonant (parallel resonant) points will be fairly close together. By proper use of input and output reactances, however, the points may be spread apart for filter applications.

Typical crystal lattice circuit arrangements are illustrated in part A of figure 9-12. Extra elements may be added in the branches that are indicated by dotted lines.

A circuit that may be used in SSB systems is illustrated in part B of figure 9-12. The parallel-connected crystals are frequency matched as close as possible; the series-connected crystals are also matched. The resonant frequency of the parallel crystals is perhaps 3 kHz higher than that of the series crystals. Both the input and the output circuits are tuned to the center frequency of the passband. In addition

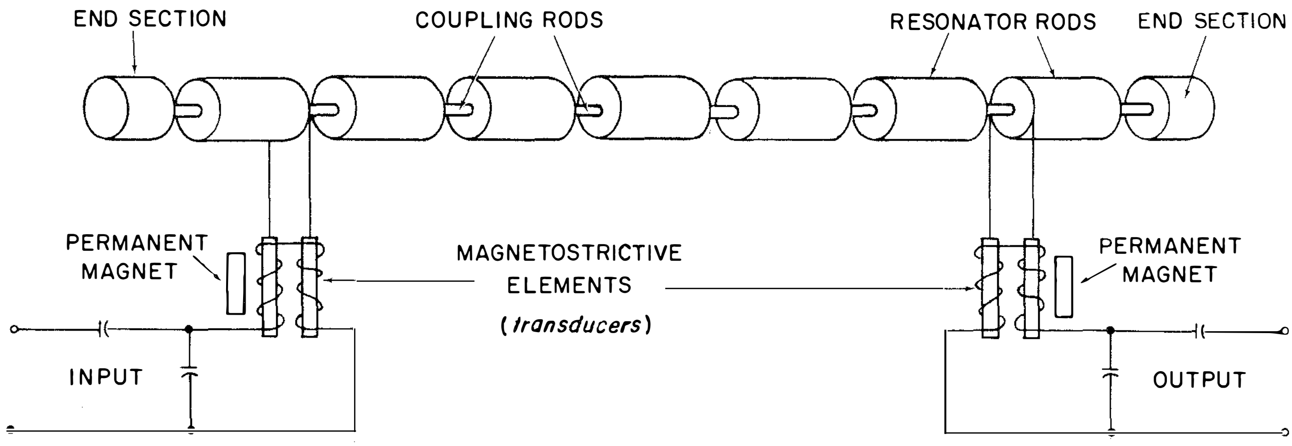

Figure 9-10.—Mechanical filter used with an SSB system.

to the capacity of the trimmer capacitor (used for adjustment purposes), there is, or course, the distributed capacitance of the crystal elements.

The crystal lattice filter is, in effect, a bridge circuit, as illustrated in simplified form in figure 9-13. Assume that the center frequency at the input is 101.5 kHz and that the crystals have resonant frequencies, as shown. At 101.5 kHz, the reactances of crystals 1 and 4 will be capacitive (see reactance curve, fig. 9-11), and the reactances of crystals 2 and 3 will be inductive. The bridge will therefore be unbalanced, and a voltage will appear at the output. The same type of reasoning may be applied for other frequencies within the bandpass. For simplicity, effects of the input and output inductances and the distributed capacitances have been neglected.

AUDIO CIRCUITS

With the exception of the receiver's first audioamplifier, the audio input and output circuits are included in the power supply chassis. For simplicity, they were not included in the simplified schematic diagram of figure 9-4. Both the audio input and output sections are treated briefly in the following topics.

Input Section

A simplified schematic diagram of the audio input circuits is presented in figure 9-14. When the two-way telegraph - phone switch is in the PHONE position, the grid of the tone oscillator is grounded, and the grid of the microphone amplifier is ungrounded. If one then speaks into the microphone, an output voltage is developed across R1. This voltage is fed through C1 to the grid of V1. The lower audiofrequencies are the attenuated in C1 and the higher audiofrequencies are shunted by C2. Actually the whole system is designed to pass from 0.35 to 3 kHz.

Microphone amplifier V1 feeds the cathode follower V2. In turn, tube V2 feeds the input to the first balanced modulator.

When the telepgraph-phone switch is in the TELEGRAPH position, the microphone output is shunted to ground, and tone oscillator V6 is connected to V1.

The tone oscillator (phase - shift oscillator) provides the tone for telegraph work. A phase-shift oscillator may have any of four common circuit arrangements consisting of a network of resistors and capacitors or resistors and inductors coupling the plate circuit to grid circuit. The arrangement shown in figure 9-14 is representative. The purpose of the network is to shift the phase of the signal voltage developed in the plate circuit 180° and to apply this voltage to the grid of the tube. In the circuit under consideration, the network of R7C7, R6C6, and R5C5 performs the phase-shift function.

The normal amplifying action of a tube introduces a 180° phase shift between the grid voltage and the plate voltage. The phase-shift network takes the signal from the plate and introduces an additional 180° phase shift, applying

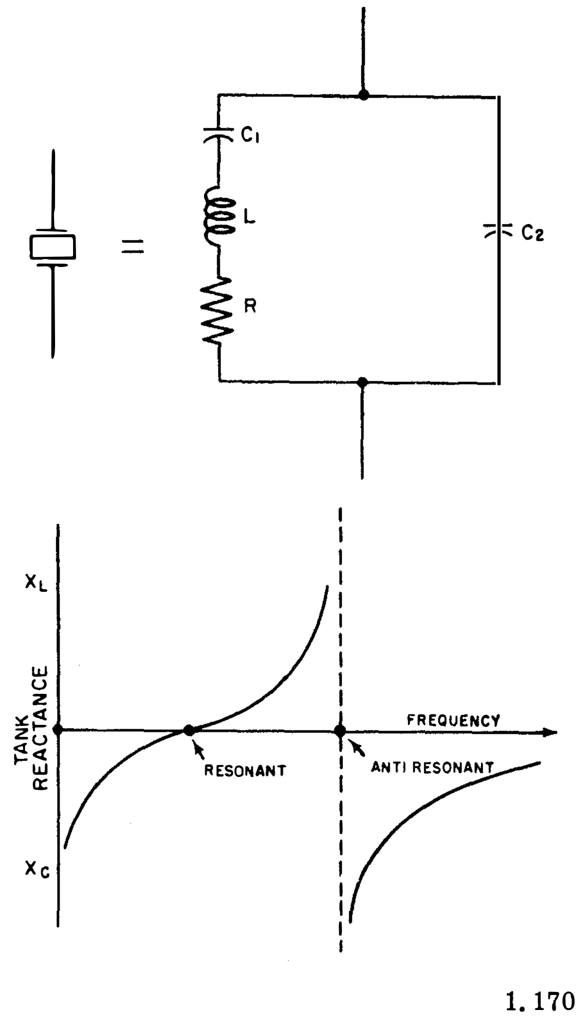

Figure 9-11.–Equivalent electrical circuit of a crystal in its holder.

the signal as a positive feedback to the grid of the tube. Sustained oscillations at one specific frequency are thus obtained.

Output Section

The a-f signal from the first a-f amplifier, V16 (fig. 9-4), is fed through a transformer to the input of the second a-f amplifier (not shown). The amplified signal is then fed to the grid of the a-f output tube; the output of this tube is applied to the speaker. Feedback improves the response.

LINEAR AMPLIFIERS

A linear amplifier develops an output that is directly proportional to the amplitude of the input signal. It is necessary to use linear amplifiers in a single-sideband transmitter in which low-level modulation is used. The single-sideband system is an amplitude-modulated system. Once modulation is performed, the amplitude relationship must be faithfully maintained.

Nonlinear characteristics of amplifiers, used after modulation of the signal, cause intermodulation of separate frequency components in the signal. Some harmonics of the intermodulation frequencies may be within the passband of the system. These spurious signals cause noise and distortion of the intelligence signal. Intermodulation frequencies near the passband may also be of sufficient amplitude to cause noise and distortion in nearby bands. These spurious signals are particularly troublesome in two-channel, single-sideband systems.

Linear amplifier design is a problem when designing a single-sideband transmitter because it is necessary to produce a high-power level to drive the antenna. It is extremely difficult to achieve the combination of high-power gain and linear amplification. Although linearity must be maintained in the amplifier stages of the single-sideband exciter, the power level of the signals in the exciter are low. This low-power level makes possible the use of receiving pentodes to obtain linear amplification with the desired gain in a minimum number of stages. The r-f power amplifier, therefore, is the most critical link between the generation of the single-sideband in the exciter and the signal that is finally transmitted in space.

Practical power amplifiers have been designed to raise the low-power level signal of the exciter to the high-level signal necessary at the antenna, yet maintain the required linearity. If the input signal amplitude at the power amplifier becomes too great, the amplifier begins to operate on the nonlinear portion of the input output characteristic. To ensure that such overdriving does not take place, the output of the exciter usually is limited by the use of an AGC circuit. A portion of the exciter r-f output is rectified to provide d-c voltage. This voltage is used to control the gain of one or more stages of the amplifier portion of the exciter.

A more detailed discussion of linear r-f power amplifiers, as used in transmitters, is included in Basic Electronics, NavPers 10087.

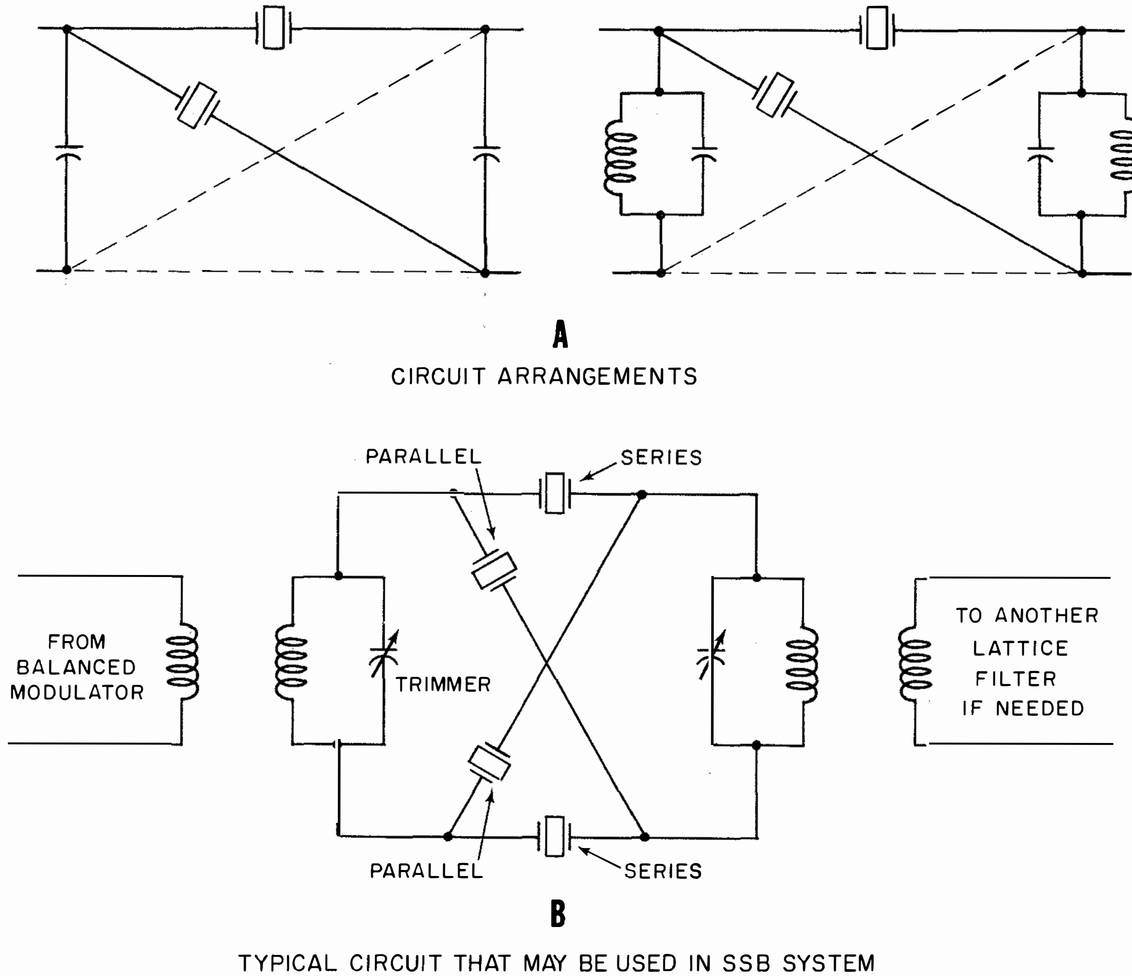

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Figure 9-12.—Crystal lattice filter configurations.

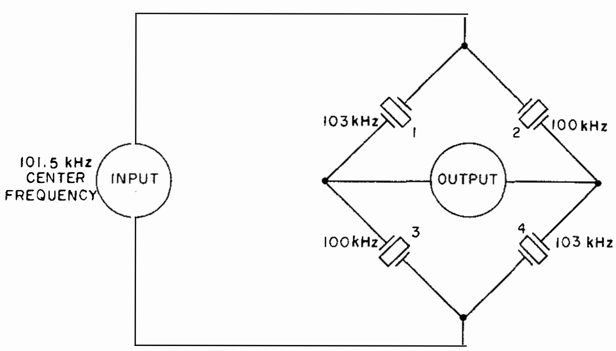

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Figure 9-13.—Simplified equivalent bridge circuit.

EQUIPMENT

In the following topics is a brief discussion of the most commonly used single-sideband equipment.

AN/URC-32 SSB TRANSCEIVER

One of the Navy's most versatile modern communication equipments is the AN/URC-32. It is a transceiver operating in the 2- to 30-MHz range, with a transmitter peak envelope power (PEP) 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.

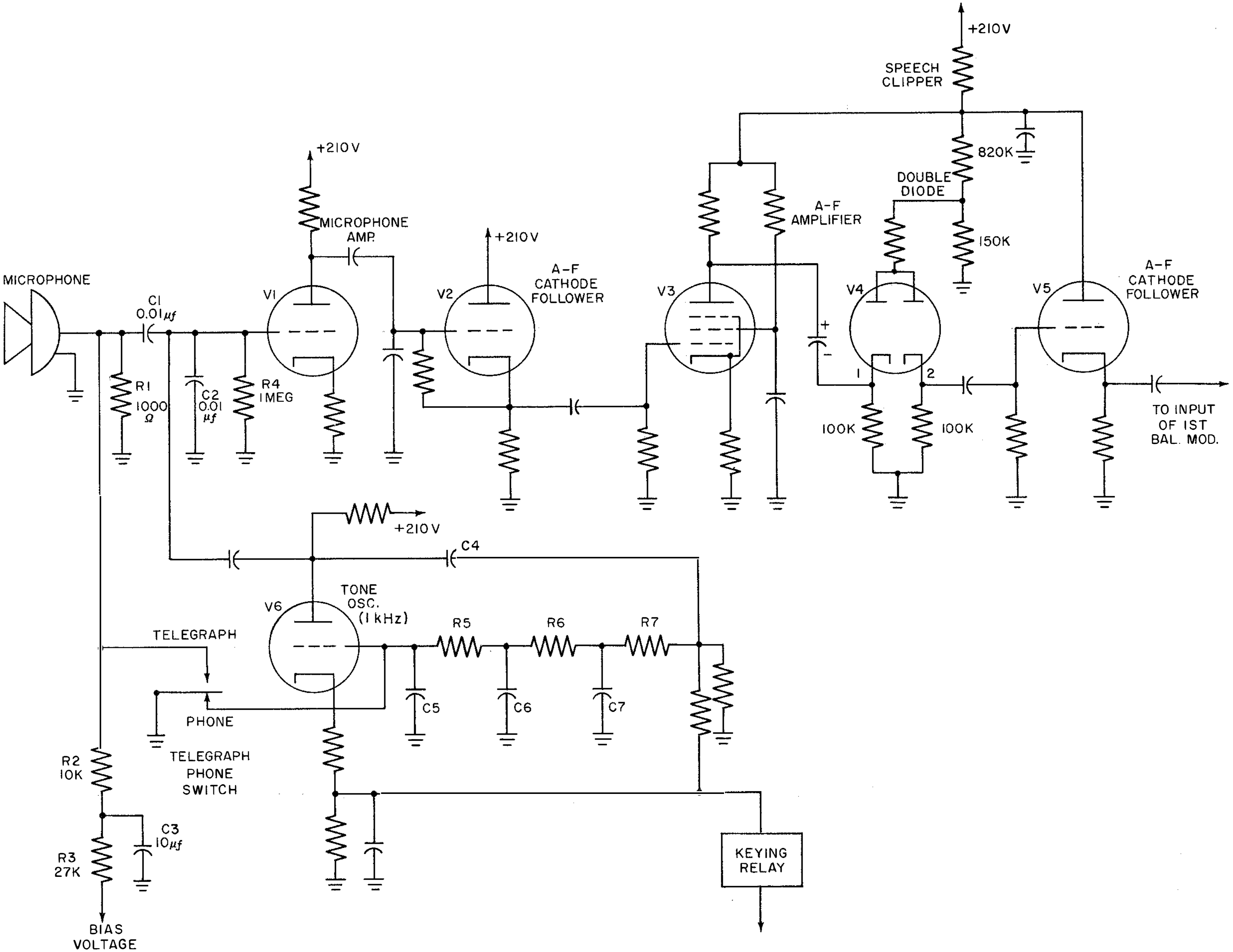

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Figure 9-14. —Audio input circuits.

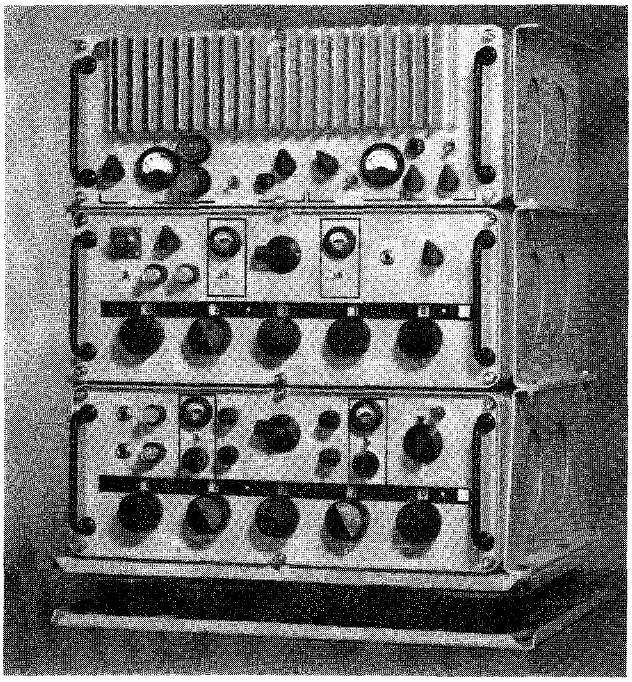

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Figure 9-15. –Radio set AN/WRC-1. Top unit: AM-3007/URT r-f amplifier; center unit: T-827/URT transmitter (exciter); bottom: units: R-1051/URR receiver.

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.

The frequency range of 2 to 30 MHz is covered in four bands. The desired operating frequency is selected in 1-kHz increments on a direct-reading frequency counter. Frequency accuracy and stability are controlled by a self-contained frequency standard.

AN/WRT-2 TRANSMITTING SET

The AN/WRT-2 is a shipboard transmitter designed for operation in surface ships and submarines. It provides complete frequency coverage in 1-kHz steps over the frequency range of 2 to 30 MHz. The r-f oscillator produces fundamental frequencies from 2 to 8 MHz. Frequency multiplication produces frequencies from 8 to 30 MHz.

The AN/WRT-2 transmitter has an output power of 500 watts on CW, frequency shift RATT and FAX, and conventional a-m radiotelephone. It has a power output of 1000 watts when transmitting on single sideband or independent sideband.

Coupling to an antenna is through a radiofrequency tuner mounted as close to the antenna as possible. The radiofrequency tuner is constructed so that it may be installed on the weather decks of surface ships.

A front panel handset jack is furnished for local phone operation of the equipment. A built-in dummy load permits off-the-air tuning under conditions of radio silence.

AN/WRC-1 RADIO SET

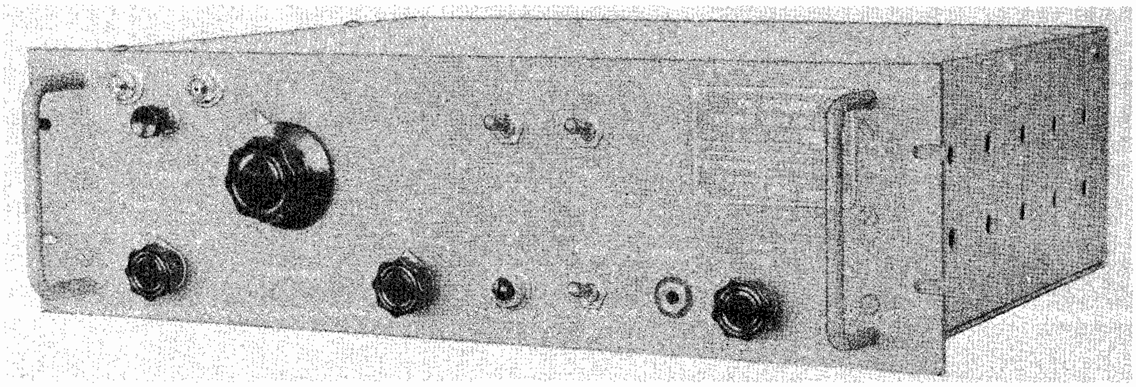
The AN/WRC-1 (fig. 9-15) is a single-sideband radio transceiver. It is capable of transmitting on any one of 56,000 channels, spaced in 0.5-kHz increments, in the frequency range of 2 to 29.9995 MHz. This set has a maximum power output of 100 watts. Vernier (continuous) tuning enables reception on any frequency in the range of 2 to 30 MHz.

The AN/WRC-1 is used for transmitting and receiving SSB, CW, compatible a-m, fsk, and and ISB signals in either a simplex or duplex operation. Figure 9-15 shows all units of the AN/WRC-1 and how they are interconnected.

The AN/WRC-1 radio set consists of four separate units: R-1051/URR radio receiver, radio transmitter T-827/URT, r-f amplifier AM-3007/URT, and an interconnection box used to connect the other three units together. Both the receiver and transmitter contain their own power supplies and can be operated as individual units.

CV-591A/URR SSB CONVERTER

The CV-591A/URR single-sideband converter (fig. 9-16) is used to convert standard communication receivers, such as the R-390/URR, for SSB use. Overall selectivity of most receiving systems is sharpened considerably, rejecting unwanted adjacent signals. Tuning single-sideband signals is simplified because final tuning is done at the converter–not at the receiver. A mechanical and electrical bandspread tunes over the i-f bandpass. This effective vernier easily tunes SSB or exalted carrier



109. 30

Figure 9-16. –SSB converter CV-591A/URR.

a-m signals within hertz of correct tone. Both sidebands are selectable, either with the band-pass tuning feature or by inverting the oscillator separation. Continuous–wave, MCW, and FS signals are easily tunable with the bandspread feature. For extreme stability, the first oscillator is switched to crystal control for both upper and lower sideband positions.

AN/WRR-2 RECEIVING SET

One of the newer shipboard radio receivers for the medium-frequency and high-frequency bands is the AN/WRR-2, shown in figure 9-17. (The same receiver, with rack mounting for shore station use, is called AN/FRR-59.)

The AN/WRR-2 is a triple-conversion superheterodyne receiver, covering the frequency range from 20 to 32 MHz. This modern receiver is intended primarily for the reception of single-sideband transmissions with full carrier suppression. It can also be used to receive conventional amplitude-modulated signals of various types, including CW, MCW, voice, facsimile, and frequency shift RATT.

In order to meet strict frequency tolerances, special features provide extremely accurate tuning and a high degree of stability over long periods of operation. Simultaneous use can be made of both upper and lower sideband channels for receiving two different types of intelligence. Both single-sideband and conventional a-m signals cannot, however, be received simultaneously.

R-1051/URR RADIO RECEIVER

Radio receiver R-1051/URR (fig. 9-18) is a triple-conversion superheterodyne receiver,

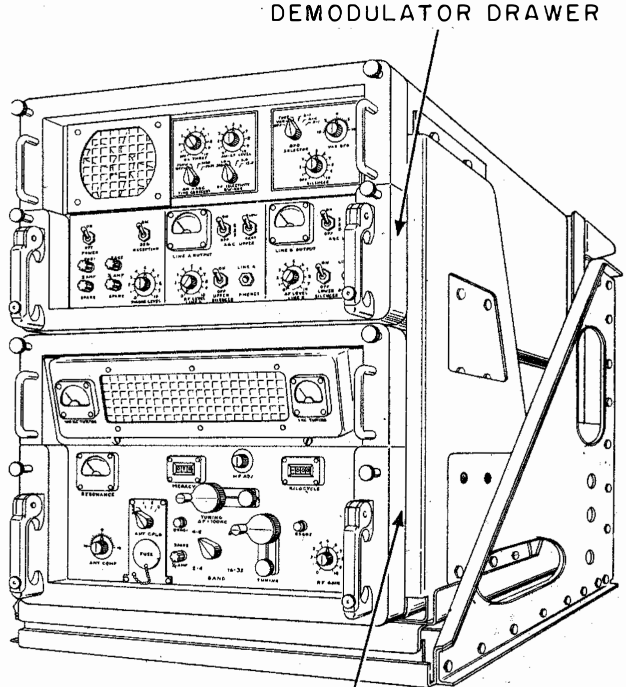


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Figure 9-17. –Radio receiving set AN/WRR-2.

tunable over the high-frequency range from 2 to 30 MHz. Tuning of the R-1051/URR is accomplished digitally by five controls and a switch located on the front panel. A display window directly above each control provides a readout of the digits to which the controls are set. The displayed frequency can be changed in 1-kHz increments. The front panel Hz switch allows the

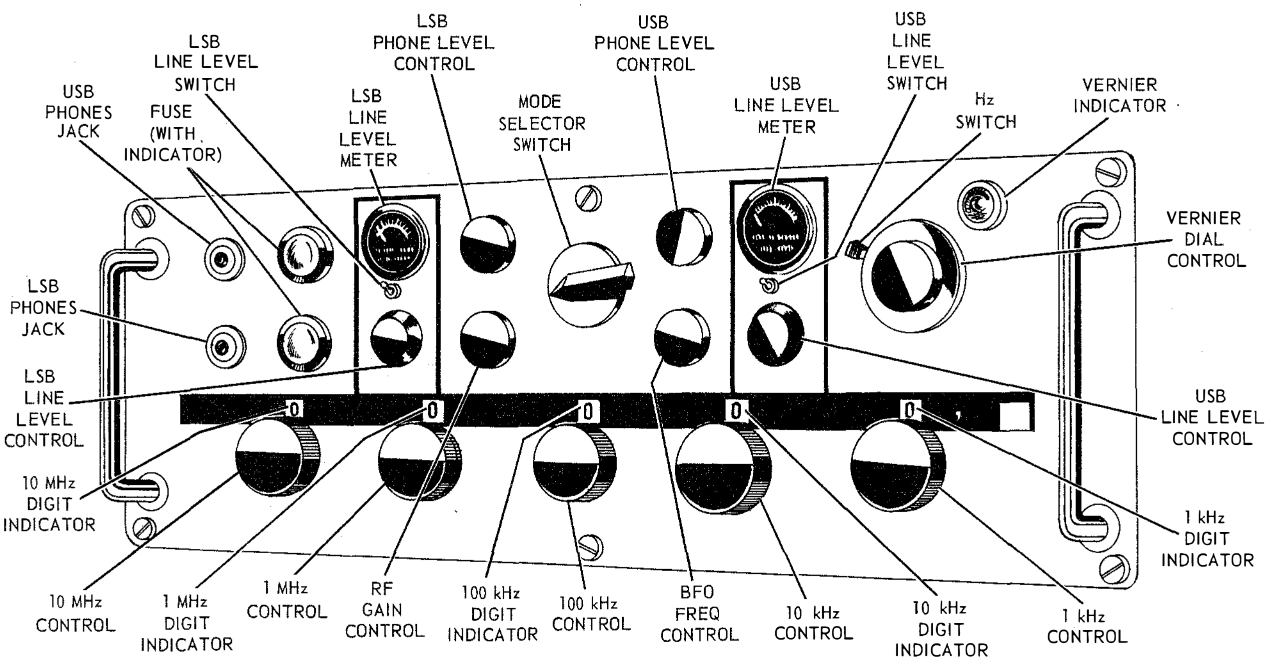

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Figure 9-18. –Radio receiver R-1051/URR–operating controls and indicators.

operating frequency to be changed in 500-Hz increments. This method of tuning provides 56,000 discrete frequencies in which the receiver is locked to an accurate frequency standard. Each 1-kHz increment can be tuned continuously by selecting the VERNIER position of the Hz switch. When using the vernier, the full accuracy of the frequency standard is sacrificed. The R-1051/URR demodulates and provides audio outputs for the following types of received signals: LSB, USB, ISB, CW, fsk, and a-m. In conjunction with a transmitter, the R-1051/URR may be operated as a transmitter-receiver in systems such as radio set AN/WRC-1 (previously mentioned). In this application, either simplex or duplex operation is possible. The R-1051/URR may also be used as a separate, self-contained receiver, requiring only a headset, antenna, and a nominal 115-vac primary power source for full operation. The R-1051/URR is intended for ship and shore installations.

CHAPTER 10

TECHNIQUES OF SUBMINIATURE REPAIR

This chapter is intended primarily for those Radiomen who have requisite skill in repairing electronic equipment. It is not the intention to encourage the unqualified Radioman (except in an emergency) to attempt repair of solid state modules until he gains the necessary skill through practice on inexpensive, noncritical training boards.

It is of utmost importance that repairmen keep abreast of the latest equipments, as well as the technical advances necessary to maintain them. Most of the newer equipments have some degree of modular construction. The techniques for repairing these newer equipments have brought about a necessity for repairmen to attain skills not heretofore required of them. It is with this thought in mind that we proceed with this chapter.

MODULAR CONSTRUCTION

A modular assembly may provide for either a single function or for multiple functions. Two or more modular assemblies may be used to form a portion of a unit that is replaceable as a whole, but has an individually replaceable part (or parts). These modular assemblies may be expanded to become building blocks in an ultimate tier. To be more specific, modular construction is a type of unitized construction consisting, predominantly, of modular assemblies. Analog computing systems, which may be enlarged by the addition of package units containing amplifiers, function generators, potentiometers, and the like, are examples of modular construction. The AN/URC-32 transceiver set is another example of modular construction. Primary advantages of modular construction are (1) the reduction of different replacement modular assemblies that must be maintained, and (2) the ease and rapidity of replacement. Modular construction provides for compactness with reliability permitting interchangeability. Examples A and B of figure 10-1 illustrate two possible configurations of modular construction. Certain standards must be met to successfully service modular assemblies. Usually, more skill is required for servicing modular assemblies than for the repair of wired circuits. Specialized techniques, an adequate complement of tools, a certain degree of dexterity, and patience are musts for this type of servicing.

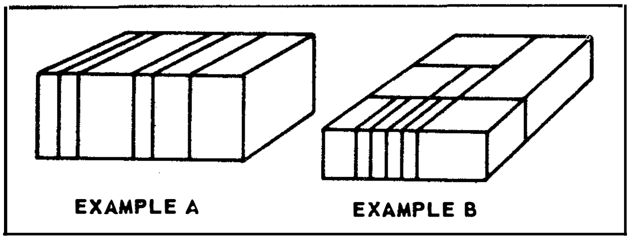

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Figure 10-1. —Modular construction.

Subminiature construction features of modular assemblies such as printed circuit boards, transistors, subminiature tubes, and pin assembly circuits (packaged units) – make it necessary in most instances to use special repair techniques. These repair techniques are discussed in the sections that follow.

TERMS AND DEFINITIONS

In discussing subminiature repair techniques, many technical terms are used. To give you a better understanding of the material, the following list of terms and definitions is provided.

Assembly: Several parts (or subassemblies) or any combination joined together to perform a specific function.

Module: A unit or standard of measurement; a fixed dimension; a packaged functional assembly of wired electronic components for use with other such assemblies.

Modular Assembly: An assembly having outline dimensions, which are multiples of a module.

Unitized Construction: A type of unitized construction consisting, predominantly, of replacement assemblies.

Modular Construction: A type of unitized construction consisting predominantly, of modular assemblies.

PRECAUTIONS AGAINST MODULAR DAMAGE

Modular assemblies, although mechanically more rugged than conventional circuits, are comparatively easy to damage by improper handling or electrical overload.

Considerable experience is required in working with transistors, printed circuits, and modular assemblies. It is necessary at all times to keep in mind certain general precautions. Several of these precautions follow.

- Do not overheat transistors, or other semiconductors, or any miniature parts. They can be destroyed by excessive heat. If it is necessary to solder or unsolder a semiconductor or other miniature parts, use a clean, well-tinned, pencil soldering iron and a good-quality, low-temperature solder. Complete the soldering process as quickly as possible. For maximum protection, hold the lead to be soldered with a pair of longnose pliers or a hemostatic clamp. The pliers or clamp should be held between the point where heat is applied and the body of the semiconductor or miniature part. Used in this manner, these tools form a "heat sink" to conduct heat away from the part itself. (Note: Place a small piece of beeswax between the semiconductor and the hemostat. When it melts, the temperature limit has been reached. This indication is a warning to remove the source of heat immediately.)

- Do not exceed the absolute maximum electrical rating of the modular assembly under test or repair. Maximum electrical ratings are given in the technical manual tables and drawings supplied by the manufacturer for each part under test. In general, transistors, similar components, and associated miniature parts are not underrated; consequently, there must be strict adherence to the maximum rating specified by the manufacturer and to the steps and procedures given in the technical manual.

SPECIAL TOOLS AND SOLDER

The prime cause for part or board damage in modular assembly repair is excessive heat and the use of improper tools and material. Special tools and material not ordinarily used in servicing the more conventional wired circuit chassis are required. The main problem is the soldering iron. A light-duty soldering (pencil) iron (23-1/2 to 37-1/2 watts) should be used. A heavy-duty soldering iron should never be used.

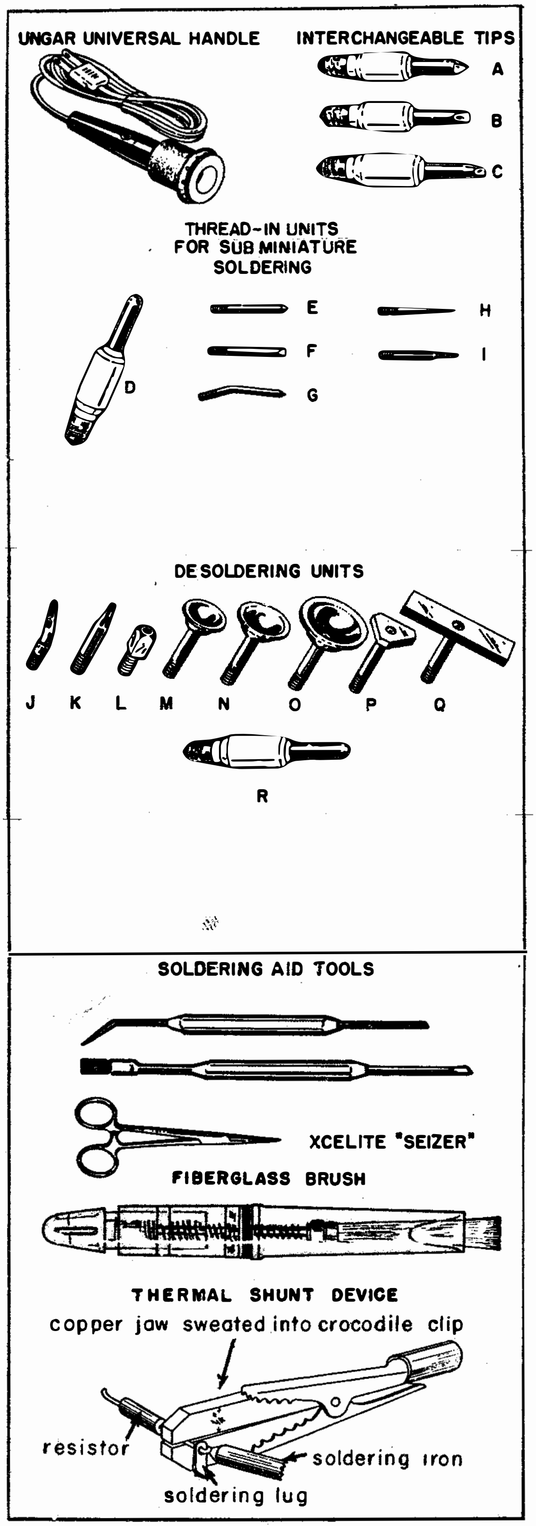
A later discussion explains in detail the techniques and specific procedures for soldering and removing parts. Personnel required to repair modular assemblies should be provided with the recommended tools. Some of these tools are listed on the electronics tool allowance list; others, indicated by an asterisk (*), are procurable through local purchase. Figure 10-2 illustrates the commercial items.

All other tools used for repair of modular assemblies are standard handtools and are listed in the electronics tool allowance list.

Selection of Proper Solder

Selection of the proper solder is the next step required for trouble-free repair. Always use a small-diameter, rosin-core solder with a tin-to-lead ratio of 40/60 (60 tin, 40 lead). Never use a tin-to-lead ratio of 40/60. Nor should you use a large-diameter solder with a high lead content. Because of the excessive melting heat required, use of this type of solder will damage the printed circuit board, transistor, or other miniaturized part of the modular assembly.

High-quality solder of small diameter requires less heat to solder a strong and lasting joint. The ideal solder is known as eutectic, a combination of 63 percent tin and 37 percent lead, which melts at 360°F. For all practical



Item	Description	Federal or Commercial Stock No.
	Soldering Iron—	
	*Ungar Electric Tools Co.	
	Pencil Iron Set	
	Handle assembly	776
	Thread-Units for Subminiature soldering	
A	Pyramid tip, 5/16" diameter	1236
B	Chisel tip, 3/8" diameter	1239
C	Chisel tip, 1/4" diameter	1233
D	Thread-in element for thread-in tips	1235
E	Thread-in straight cone tip, 3/8" diameter for element D	PL331
F	Thread-in straight chisel tip, 3/8" diameter for element D	PL332
G	Thread-in bent cone tip, 3/8" diameter for element D	PL333
H	Thread-in straight needle tip, 3/8" diameter for element D	PL338
I	Thread-in micro tip for element D	PL340
	Desoldering Units for Subminiature Repair	
J	Thread-in offset slotted tiplet for element R	862
K	Thread-in straight slotted tiplet for element R	857
L	Thread-in hollow cube tiplet for element R	863
M	Thread-in 5/8" diameter cup tiplet for element R	856
N	Thread-in 3/4" diameter cup tiplet for element R	855
O	Thread-in 1" diameter cup tiplet for element R	854
P	Thread-in 5/8" diameter triangle tiplet for element R	861
Q	Thread-in 1-1/2" x 3/8" bar tiplet for element R	858
R	Thread-in element for desoldering tiplets	4045

70.121

Figure 10-2.—Recommended tools.

purposes the 60/40 solder, which melts at 370°F., can be used satisfactorily without damaging the modular components. (NOTE: An exception to this procedure is in soldering a silverplated or solid silver circuit. For this application the solder must contain 2 percent to 3 percent silver, otherwise a chemical reaction will set in, destroying the circuit.)

CAUTION: Use only solder with a noncorrosive and nonconductive rosin core. Under no circumstances should an acid-core solder be used, because it will cause corrosion, shorts, and leakage.

POWER SUPPLY POLARITIES

Observe power supply polarities when measuring the resistance of the circuits of modular assemblies containing transistors or other semiconductors. Such parts are polarity-and voltage-conscious. Reversing the plate voltage polarity of a triode vacuum tube will keep the stage from operating, but normally will not injure the tube. Reversing the collector voltage polarity of a transistor, or another semiconductor, however, will ruin it instantly and permanently.

Inasmuch as transistors and similar components require different power supply connections, personnel who work with these parts must always be alert in connecting test equipment. Follow the directions given on the applicable tables or drawings to ensure that the correct polarity and range are observed. Recheck your work before turning on the power—the wrong polarity will destroy the part.

HIGH TRANSIENT CURRENT OR VOLTAGES

Guard against high transient current or voltages when testing or servicing. A damaging transient pulse may be caused in a number of ways. The listing that follows represents some of the most frequent accidental applications that should be prevented.

PRECAUTIONS

1. Application of a-c power-operated test equipment or soldering iron without first making certain that no leakage of current is emitted from them. The use of an isolation transformer is a good precaution to follow with all test equipment and soldering irons that are operated on a-c power, unless it has been determined that the equipment contains a transformer in its power supply or shows no current leakage. With all test equipment (whether transformer operated or not), a common ground lead should always be connected first from the ground of the circuit to be tested, and then to the test equipment ground.

2. Application of too high a pulse from test equipment. The safest procedure is to start all test equipment from zero settings, and then proceed with the test steps as outlined in the equipment technical manual. Be sure that the signal applied is below the rating given for the circuit under test. Relatively high-current transients can occur when test equipment is connected to a circuit where low-impedance paths exist.

3. Loosening connections, disconnecting parts, inserting or removing transistors or similar components, and changing modular units while the equipment power is on or while the circuit is under test. When changing modular assemblies, be sure that the equipment power is off. A loose connection or any of the actions mentioned will cause an inductive kickback. This reaction can be prevented by being sure that all parts in the circuit are secure before starting the test or turning on the equipment power. Be sure to remove all possible capacitive charges from parts and test equipment before applying them to a modular assembly.

HANDLING AND PACKAGING

Handle modular assemblies carefully at all times. Unnecessary damage has occurred to modular assemblies by thoughtless, careless action in handling and packaging. Proper packaging of modular assemblies will prevent unnecessary damage. NOTE: Because a modular assembly is defective does not mean it is beyond repair. Handle with care.

When a new module is received packaged in accordance with packaging specification, and the outer bulky casing (crate or outer carton with its shredded paper dunnage or similar material) is removed, the unit(s) will remain packed in a watertight package. This package is stored by the issuing activity until drawn by the using activity. Thus, the using activity receives the necessary packaging material with which it can properly package a defective module.

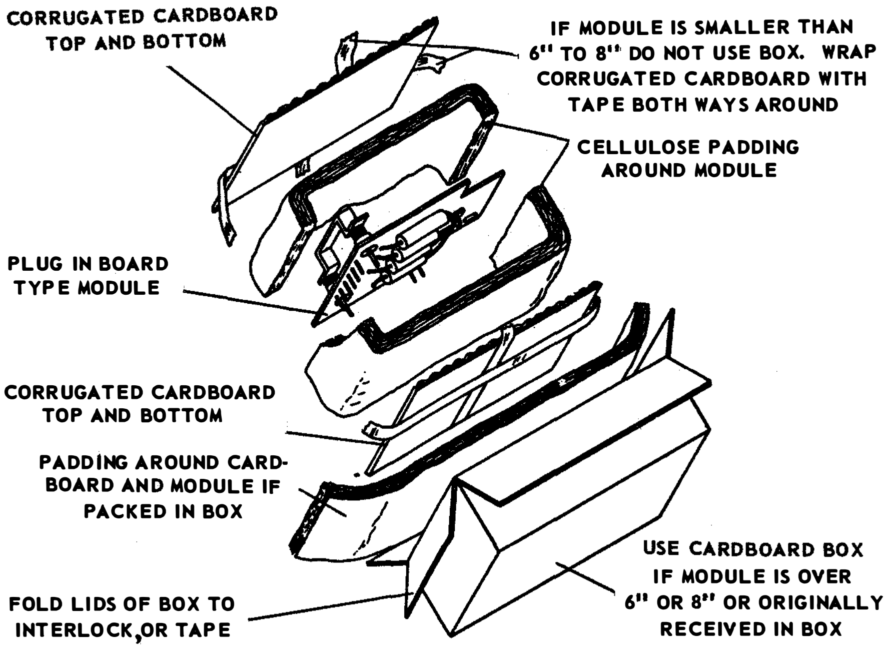


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Figure 10-3.–Protective packaging of a bolt-down chassis-type module.

For the correct method and the proper material to use for protective packaging of defective modules, see figures 10-3, 10-4, and 10-5. The material is available to all activities and should be used in the manner prescribed for storing or transferring defective modules until they are received by a shipping facility, which will properly package them for shipment to the factory or restoration facility.

Regardless of the module design, if its pins, shafts, dials, or other protruding parts are adequately fitted with packing spacers and if the module is properly wrapped with protective cellulose (Kimpak or similar material), the using activity will have done its part in preventing transport damage to the modular assembly.

Desiccant crystals normally are packaged with assembled equipment crated for shipping. These crystals are retained in a bag and placed within the crated or packaged equipment in such a manner as to prevent them from jarring loose in the equipment. Do not use these desiccant crystals when packaging defective modules. Because the module must be packaged tightly, crystals in bag form cannot be used. The use of loose crystals may cause unnecessary damage, resulting in a cleaning problem.

If a modular assembly should become exposed to loose desiccant crystals, clean the assembly immediately. Do not turn its moving parts more than is absolutely necessary until assured that all of the crystal particles have been blown or brushed away. In testing the moving parts for cleanliness, turn them very slowly and gently. (Do not force if they are gritty.) Work out the crystal particles with a brush or compressed air. Wash the modular assembly in an approved solvent (P-S661a Dry Cleaning Solvent, Type II, Stock No. W6850-274-5421), brush and blow dry, then check and test the assembly (as instructed in the equipment technical manual) before using it in the equipment. If the equipment functions improperly, check the assembly for the presence of crystal particles.

Before replacing the assembly, repeat the cleaning procedure. If the equipment remains defective, replace it. Unnecessary damage has occurred to modular assemblies because of rough handling. Particular care must be given

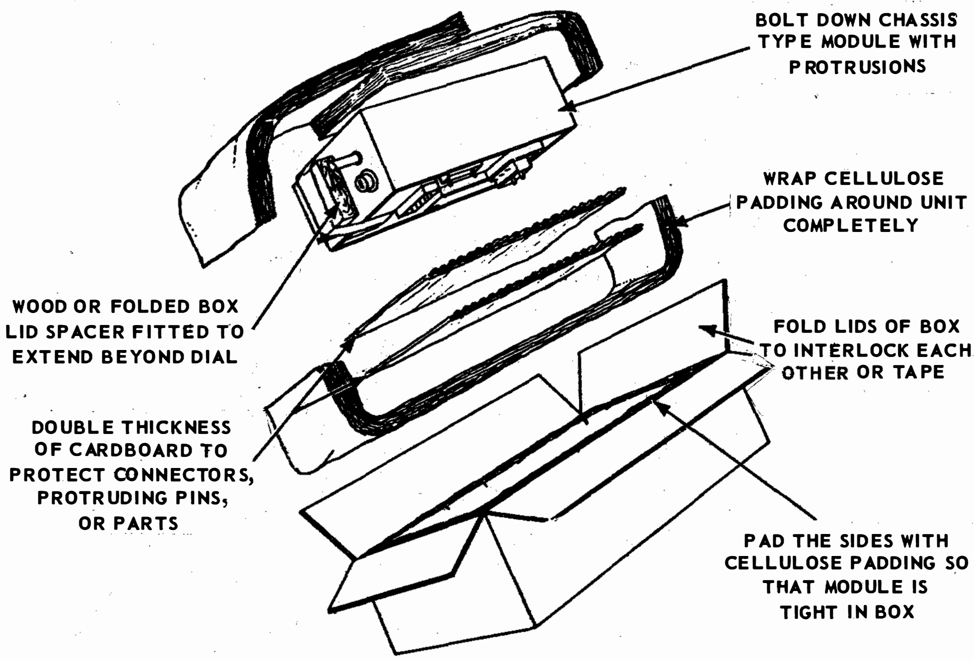

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Figure 10-4. –Protective packaging of a plug-in board-type module.

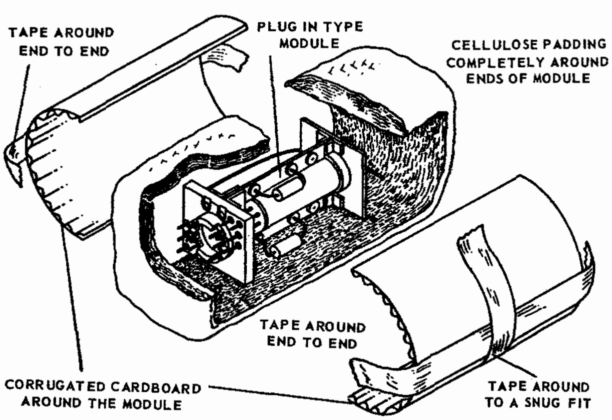

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Figure 10-5. –Protective packaging of a plug-in type module.

to the method of removing or inserting a module into the equipment. If the module is a plug-in, board-type assembly, be sure the guide pins are properly alined before pressing the assembly in place. If the board should tilt while being inserted, do not continue to press it into position; straighten it, then apply even pressure to avoid tilting. Forcing any tilted or cocked modular assembly into position may result in bent or broken pins.

When removing a modular assembly, be sure to pull it straight out from the equipment. Because of the miniaturization of parts for modular construction, leads, connectors, pins, etc., have been stiffened to make them more rugged. As a result, such fragile parts are brittle and will break easily if bent too often or if uneven pressure is applied. When handling a module that has been removed from its chassis, be careful not to press against the leads and pins. If a lead or pin is accidentally bent, do not try to straighten it unless absolutely necessary.

When repairing a modular assembly, be careful that the tool employed does not inadvertently press against leads, pins, or other parts that are easily bent. Such pressure can destroy a good part and cause needless repair.

REMOVAL AND REPLACEMENT OF PARTS

Replacement of miniature and subminiature parts found in modular assemblies requires more consideration than normally is given to parts in the servicing of other electronic equipment. Before attempting repair, maintenance personnel should become thoroughly familiar with the correct repair and soldering techniques, because servicing procedures used differ in several ways.

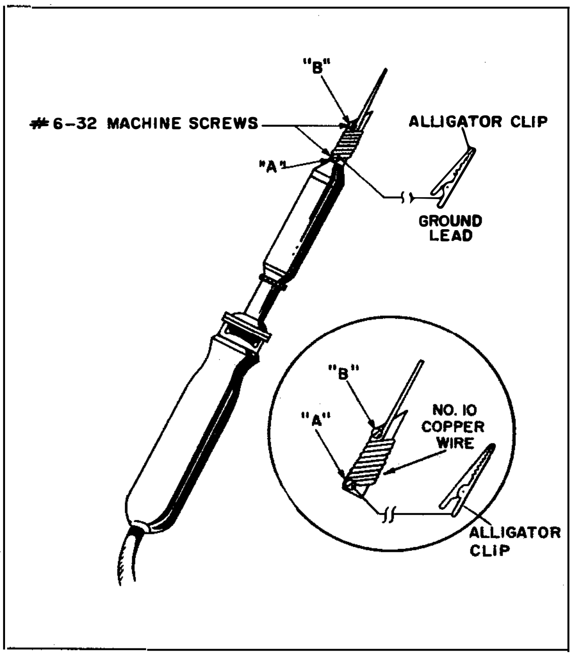
Soldering Set

The compactness of modular assemblies makes it imperative that a small, low-wattage pencil iron be used. The soldering iron should have a small tip so that heat can be applied directly to the terminal of the part to be removed or replaced, without overheating the printed board or adjacent parts. The recommended Ungar pencil iron set (mentioned earlier) is designed for this type of work. If a low-wattage iron is not available, a high-wattage iron can be effective when converted to a low-heat unit for emergency use only. To make the conversion, closely wrap any number of turns of clean No. 10 copper wire around a thoroughly clean soldering iron tip, extending the other end of the wire 1 inch beyond the original soldering iron tip. Throughly tin the formed end of the new tip before using. This improvised instrument will then serve as a low wattage soldering iron tip. (See fig. 10-6.)

To provide a tight connection and prevent possible twisting of the tip, the No. 10 wire coil end should be secured at points A and B with No. 6-32 machine screws. The foregoing instructions apply to all subsequent examples of improvised soldering tips.

A flexible ground wire (No. 14) should be attached at point A, shown in figure 10-6. The other end of this wire should be provided with an alligator clip to permit convenient grounding of the soldering iron to the module chassis.

CAUTION: If an improvised high-wattage soldering iron is to be used for work on transistors or other transient voltage-sensitive components, a ground lead must be connected from the tip of the soldering iron to the frame or chassis of the module. This precautionary measure is necessary to prevent damage to transistors and other parts from leakage of current in the soldering iron.



70.123.0

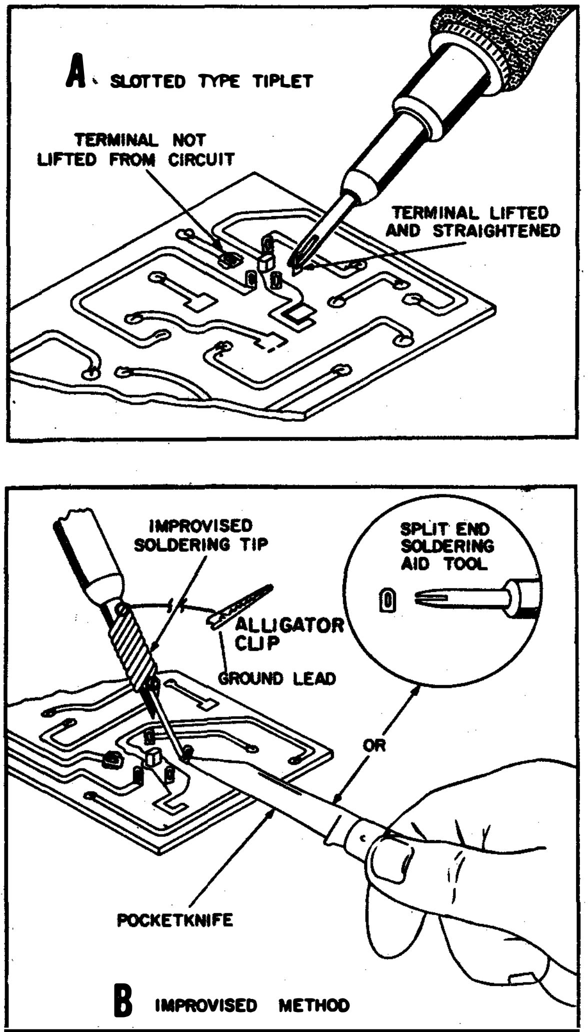
Figure 10-6.—Improvised soldering tip for modular repair.

Desoldering Set

A practical soldering iron, with tips specially designed for soldering and unsoldering parts from printed circuit boards, has been developed by Ungar Electric Tools, Inc. (See fig. 10-2.)

The Ungar offset or straight slotted tiplets (Ungar Nos. 862 and 857) will simultaneously melt the solder and straighten the leads, tabs, and small wires bent against the board or terminal, as illustrated in view A of figure 10-7. If this tool is not available, the improvised soldering tip shown in figure 10-6 may be used with a split-end soldering aid tool (General Cement Mfg. Co. No. 9093), or pocket penknife as illustrated in view B, figure 10-7.

The Ungar bar-type tiplet (Ungar No. 858) will remove straight-line multi-terminal parts quickly and efficiently, as illustrated in Part A of figure 10-8. Removal of this type of part may be accomplished by individually heating

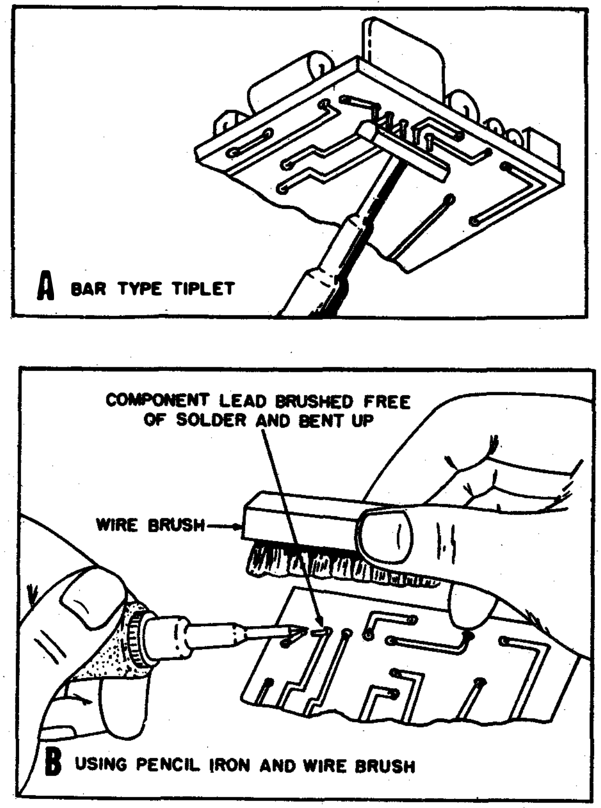


70.124FG

Figure 10-7.—Special soldering iron adaptations—slotted-type tiplet and improvised methods.

each solder connection and brushing away the melted solder with a wire brush (part B, fig. 10-8). In using this method, particular care must be taken to prevent loose solder from making contact with other parts or to the printed panel, where it may cause a possible short.

The Ungar cup-shaped tiplets (Ungar Nos. 854, 855, and 856), the triangle tiplet (Ungar No. 861), and the hollow-cube tiplet (Ungar No. 863) are specially designed to withdraw solder from circular or triangular mounted parts in one operation. (Refer to fig. 10-9.)



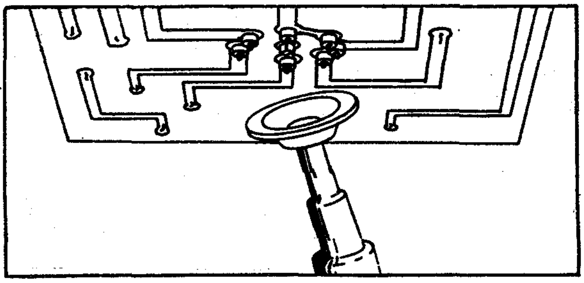
70.124AB

Figure 10-8.—Special soldering iron adaptations—bar-type tiplet and wire brush methods.

The most important technique required in the repair of modular assemblies is skill in soldering and unsoldering the parts. Careless work creates unnecessary damage. Take time and be precise!

In the application of solder, remember that the iron must heat the metal to solder-melting temperature before actual soldering can take place. The flat side of the soldering iron tip should be held directly against the parts to be soldered. The solder-melting temperature is reached in a matter of 5 to 10 seconds, therefore the soldering iron and the solder strand must be applied simultaneously. Apply the solder to the point of soldering iron contact—not to the soldering iron. Figure 10-10 illustrates both the correct and incorrect manner of the solder application.

Be sure the terminal, lead, or any portion of a part to be soldered has been properly cleaned and t i n n e d before positioning it for



70.124D

Figure 10-9.–Special soldering iron adaptations–cup-shaped tiplet method.

soldering. Do not tin printed circuit terminals; just clean moisture, grease, or wax from the printed ribbon with a stiff bristle brush and methyl chloroform (GM 6810-664-0387) or alcohol. (See Handbook of Cleaning Practices, NavShips 250-342-1.)

Be sure cleaning solvent is dry before applying the hot soldering iron. Alcohol is flammable, but heating it increases its toxic hazard. Although the vapors of methyl chloroform are much less toxic than carbon tetrachloride, they still are harmful. Use methyl chloroform only with adequate ventilation. Avoid prolonged or repeated breathing of vapor or contact with skin. Do not take internally.

Removal of a part without damaging the printed circuit board and its associated parts requires that the soldering tool be used with precision and skill. Thought should be given to the most appropriate procedure to use in the replacement of the affected part.

Defective Part Removal Procedures

The following removal procedures are typical and should be applied in any applicable combination.

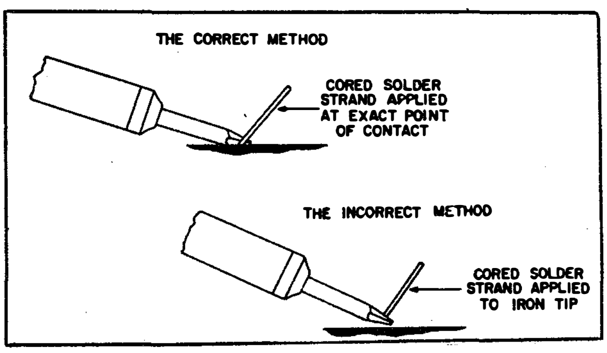
To remove a defective part, position the tip of a hot soldering pencil iron under and against the terminal, as shown in figure 10-11, drawing off the solder. The solder will flow to the soldering iron tip and is then removed from the tip by wiping it with a cloth. Remove as much of the solder as possible from each terminal. When all terminals have been loosened, lift the part from the printed wiring board.

The part to be removed should not be pried or forced loose. Any attempt to force loose a part may result in a broken printed circuit panel. If the terminals do not pass easily through their holes, all of the solder has not been removed.

If the solder remains in the terminal holes removing the leads, apply the soldering iron to the terminal hole just long enough to soften the solder. Clear the hold by inserting a toothpick or similar object to remove the softened solder.

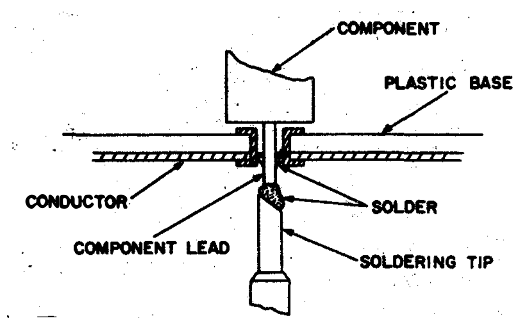
Installing a New Part

Before installing a new part, clean any moisture, grease, or wax from the area from which the old part was removed. Use a short,



70.123A

Figure 10-10.–The correct and incorrect methods of solder application.



70.123B2

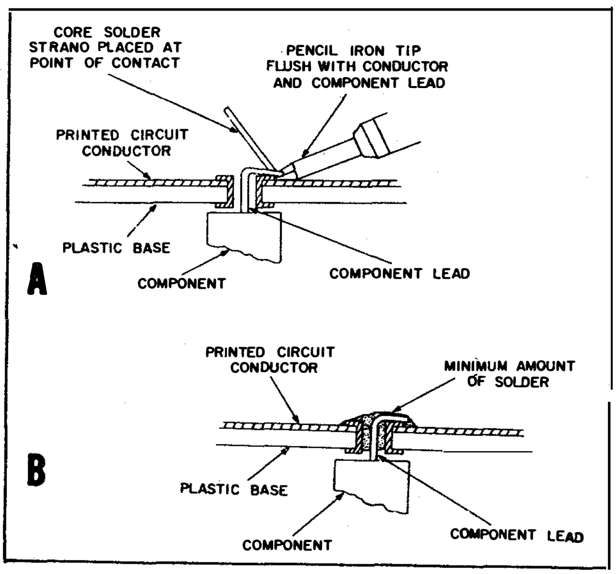
Figure 10-11.–Correct method for removing solder from component with damaging the printed wiring circuit.

firm-bristle brush and approved solvent (methyl chloroform). Be sure cleaning solvent is dry before applying soldering iron. Before installing the new part, preform and tin its leads correctly, so that the part will slip easily into position on the board, without placing strain on the printed board terminals.

Position the new part firmly. Then, with diagonal cutting pliers, trim the leads to approximately 1/8 inch from the board terminal. Bend each trimmed lead over and against the printed circuit conductor, as shown in view A of figure 10-12. Solder the leads to the printed circuit board terminal, using a minimum amount of solder (view B, fig. 10-12). Be careful to avoid overheating the printed board. This method assures a good contact with the printed circuit, and results in a rigid mounting, which prevents the printed conductor from separating from the terminal.

TROUBLESHOOTING AND REPAIR OF PRINTED CIRCUITS

Although the troubleshooting procedures for printed circuits are similar to those for conventional circuits, the repair of printed circuits requires considerably more skill and patience. The printed circuits are small and compact, and require special servicing techniques; thus, personnel should familiarize themselves with the procedures.



70.123C

Figure 10-12.—Correct method for applying solder to a replaced component.

PRELIMINARY PROCEDURES

In all instances, it is advisable, first, to check the defective printed circuit before beginning work on it so as to determine whether any prior servicing was performed. Not all personnel having access to this type of equipment possess the requisite skill and dexterity; hence, some preliminary servicing may be necessary. By observing this precaution, you may save considerable time and labor.

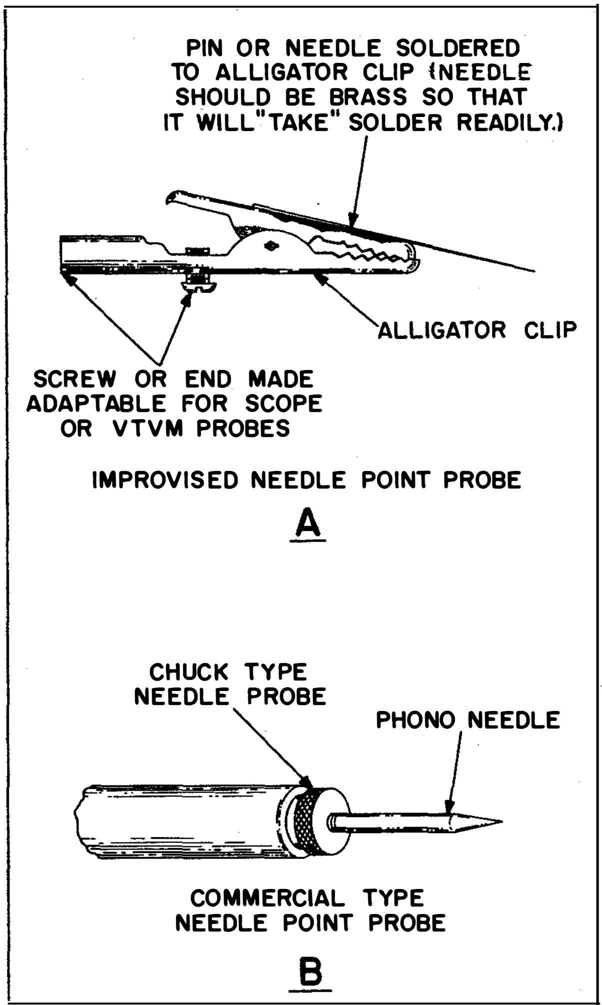
Before attempting to trace trouble on a printed circuit board, the defective part should be pinpointed by a study of the symptoms and by careful and patient analysis of the circuit. Ascertain whether the conducting strips are coated with a protective lacquer, epoxy resin, or similar substance. If so, carefully scrape it away; or, better still, use a needle or chuck-type needle probe, which will easily penetrate the coating for continuity check. Types of needle probes are illustrated in figure 10-13.

Breaks in the conducting strip (foil) can cause permanent or intermittent trouble. Often, these breaks will be so small that they cannot be detected by the naked eye. Hairline cracks (breaks) can be located only with the aid of powerful magnifying glasses, as seen in figure 10-14.

Point-to-Point Resistance Tests

To check for and locate trouble in the conducting strips of a printed circuit board, set up a multimeter (one that does not pass current in excess of 1 milliampere) for making point-to-point resistance tests. (See fig. 10-15.) Use needlepoint probes and insert one point into the conducting strip, close to the end or terminal, and place the other probe on the terminal or opposite end of the conducting strip. The multimeter should indicate continuity. If the multimeter indicates an open circuit, drag the probe along the strip until the multimeter indicates continuity. (If the conducting strip is coated, puncture the coating at intervals.) Mark the area indicated, and then use a magnifying glass to locate the fault in the conductor.

CAUTION: Before using an ohmmeter for testing a circuit containing transistors or other voltage-sensitive semiconductors, check



70.109

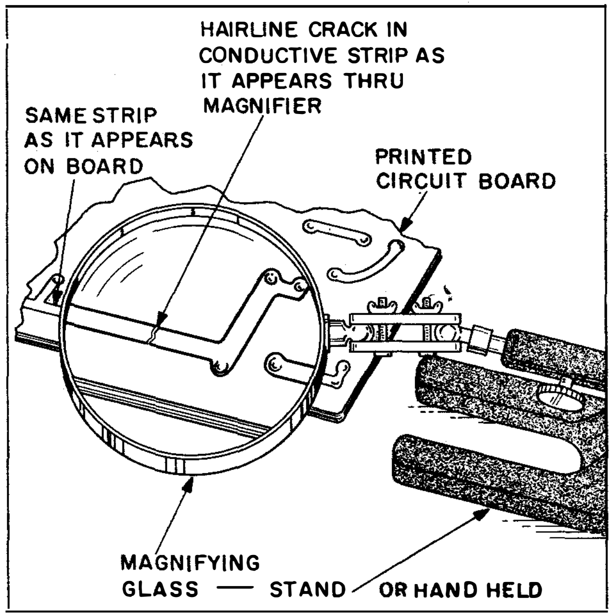
Figure 10-13.–Needle probes.

the current that it passes while undergoing tests on all ranges. Do not use a range that passes more than 1 ma.

BROKEN BOARDS

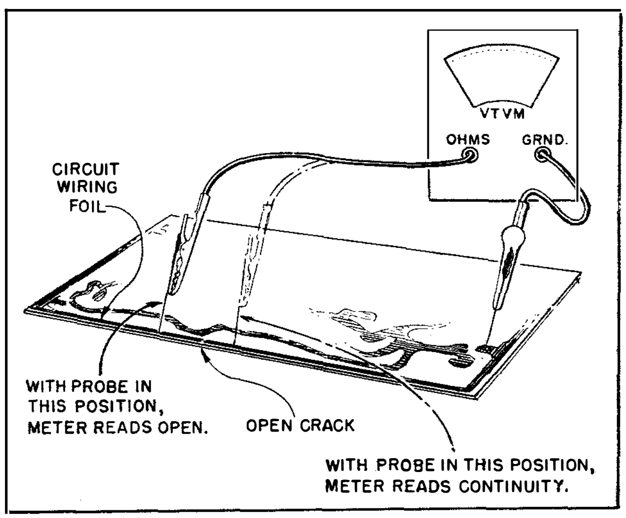
A broken board is probably the most difficult item of a modular assembly to repair. If the break is large, replacement of the entire board is usually the only practical solution.

Droppage is the most common cause of broken boards. Some boards are broken because of careless handling while the board is



70.110

Figure 10-14.–Using a magnifying glass to locate a hairline crack.



70.111

Figure 10-15.–Using a VTVM to locate a break in a conducting strip.

undergoing repair. Habitually observe the following precautions.

- Be extremely careful at all times while handling a board.
- Do not flex the board indiscriminately.
- Be especially careful when removing the board or replacing parts.
- Do not force anything associated with the board.

A printed circuit can be flexed to a certain extent. Flexing, however, may break the board, which then must be replaced at a considerable loss of time. To prevent this possibility, it is always good policy to use a chassis-holding jig or vice when servicing printed circuit boards.

NOTE: When a board is broken, it is much better to replace the entire board rather than attempt repairing it. The repair of printed circuit boards, therefore, is not covered in this chapter.

CHAPTER 11

ELECTRONICS ADMINISTRATION

A First Class or Chief Radioman probably will be either fully or partially in charge of operation and maintenance of radio equipment in his division. This chapter discusses preventive maintenance and various records and reports required of electronics installations by the cognizant authority. Contributions of certain of these records and reports to enforcement of guarantees and to development of improved equipment are also touched on in this chapter. It describes various electronics reports, and mentions certain publications and the manner in which their proper use contributes to increased equipment efficiency.

OVERVIEW OF 3-M SYSTEM

With development of the 3-M system, many misunderstandings have arisen concerning POMSEE, material history, CSMP cards, and how they are affected by the 3-M system.

Now that questions have been raised, it has become necessary to clarify not only the equipment history but also the other maintenance programs, records, and reports, together with their relationship to the 3-M system. First, though, let's explain the need for records and reports. Specific rules (as spelled out in Navy Regulations, NWP 50, etc.) stipulate that all ships and activities, to be able to carry out their assigned mission, must be kept at the highest state of material and operational readiness. One of the major factors in such material readiness is proper maintenance of material. The person charged with the end responsibility of material readiness is the individual commanding officer. To assure that the equipments within his command are maintained properly, he needs certain methods for effective planning, direction, and control of an adequate maintenance program. These methods consist of scheduled procedures to be performed by maintenance personnel, maintenance records for local command inspection (as well as higher authority), and reports to headquarters for use in possible improvements in equipment design. Until recently, the only available records and reports were the CSMP and material history record cards, POMSEE program publications, and certain reports (as delineated in the Naval Ships Technical Manual). For some years the foregoing records and reports were provided to enable commands to exercise control of material readiness. The Navy has been modernizing and growing in complexity not only in electronics but in all other areas as well. A more modern device was needed to cope with the increased sophistication being incorporated in today's ships and facilities–from the aspects of scheduling, standardized maintenance procedures, and reduction of paperwork in the form of records and reports, to the need for a centrally located data bank accessible to the naval commands. These needs resulted in implementation of the 3-Ms: the Navy Maintenance and Material Management System. It was totally new and radically different from the old way of doing a similar job of maintenance scheduling, procedures, recordkeeping, and reporting. It was so new and different that it wasn't adopted in a wholesale jump. Measures proceeded gradually with respect to putting the new setup into operation. To this day not every Navy ship or activity uses the 3-M system; those not implemented with 3-M must still operate under the old rules. Moreover, at some commands, only a portion of the 3-M system (PMS) has been implemented. (These people are sort of halfway between on the transition.) The entire business is part of a master plan for gradual changeover with proper checks and rechecks.

One side effect of the gradual changeover has been misunderstanding on the part of ships/commands of the fleet (those on 3-M, that is). It may have seemed that no instructions or rules clearly and irrevocable canceled previous orders regarding the old record cards and reports. We can only speculate that such a misunderstanding occured, because the various stages of 3-M implementation were accomplished on an activity-by-activity basis rather than by publication of a general, Navywide directive. The misunderstanding along these lines still exists; it is clearly evident just from comments received concerning the revision of the electronic equipment history cards. (Incidentally, this specific revision was made only to assist commands that still are required to maintain the history cards.)

If your command does not have any portion of the 3-M system installed, you are required to maintain electronic material history and CSMP cards, perform POMSEE procedures, and submit reports as indicated in NWP 50 and the Naval Ships Technical Manual. If only the Planned Maintenance Subsystem (PMS) portion of 3-M has been implemented, you can do away with recording under the POMSEE setup. (This alternative procedure does not mean throw away the Reference Standards Sheets and Performance Standards Sheets; it just means it is unnecessary for you to fill in the scheduled charts or checkoff lists for those equipments included in the program.) Finally, if all of the 3-M system has been implemented (MDCS as well as PMSO, just about all of the outdated cards and reports, in addition to POMSEE recording, can be superseded. There is one small stumbling block to this comment, though, and it must be emphasized: The final word concerning exactly which records will be superseded, including the extent of supersession, will be promulgated by the type commander (or equivalent level of shore activities); it is not a decision to be made by the maintenance group not the EMO. Additionally, until told to dispose of them by your type commander, you must retain those old records to make up a complete series of records (even though no new entries are to be made).

Now for a recap of the foregoing information:

1. If no 3-M at all in your command, it's the old way of doing things; no change at all.
2. If only PMS has been put into effect, POMSEE recording is superseded but the books and sheets must be retained.
3. If it's 3-M all the way (both PMS and MDCS), POMSEE, old records, and reports can be superseded as spelled out by your type commander.

Even though the 3-M system is considered a success, the intentions are to keep the old history and CSMP cards on the shelf for a long time for those of you who would like to maintain some form of local record in addition to 3-M.

MAINTENANCE AND MATERIAL MANAGEMENT

Maintenance of ships is divided into two broad categories: preventive maintenance and corrective maintenance. Preventive maintenance consists of routine shipboard procedures designed to increase the effective life of equipment or forewarn of impending troubles. Corrective maintenance includes procedures for analyzing and correcting material defects and troubles. The main objective of shipboard preventive maintenance is prevention of breakdown, deterioration, and malfunction of equipment. If this objective is not reached, however, the alternative objective of repairing or replacing failed equipment–corrective maintenance–must be accomplished.

Shipboard preventive maintenance programs in the past have varied from one command to another, resulting in various degrees of operational readiness. A relatively new, uniform system of scheduling, recording, reporting, and managing ship maintenance is now in use. This system is called the Standard Navy Maintenance and Material Management (3-M) System. It is intended to upgrade the operational readiness of ships.

The 3-M system is not to be considered a cure-all for all equipment and maintenance problems. The system does, however, envision a logical, efficient approach to these problems by launching a forthright attack on electrical, mechanical, and electronic disorders. Moreover, the system produces a large reservior of knowledge about equipment disorders, which, when fed back to appropriate sources, should result in corrective steps to prevent recurrences.

The 3-M system consists primarily of a Planned Maintenance Subsystem (PMS), which provides a uniform system of planned preventive maintenance; and a Maintenance Data Collection Subsystem (MDCS), which affords a means of collecting necessary maintenance and supply data, suitable for rapid machine processing. A man-hour accounting system, also called exception time accounting (ETA), is installed in the repair department of repair type ships in conjuction with the MDCS.

Like any other system or program, the 3-M system is only as good as the personnel who make it work. The Radioman's role in the system, as RMl or RMC, includes training lower rated personnel in its use, as well as scheduling and supervising maintenance. General information concerning all aspects of the system is included in this chapter, but a leading petty officer should keep abreast of all developments and changes to the system. Details on the system and changes related to it are available in the Maintenance and Material Management (3-M) Manual, OpNav 43P2. Other sources of information include OpNav Instruction 4700.16, NavShips Technical News, and directives issued by type commanders.

PLANNED MAINTENANCE SUBSYSTEM OPERATION

Planning and scheduling of planned maintenance is accomplished through the Planned Maintenance Subsystem (PMS). Additionally, the PMS defines the minimum preventive maintenance required, controls its performance, describes methods and tools to be used, and aids in prevention and detection of impending casualties. These factors should prove to be a definite asset to the leading petty officer in forecasting future material requirements and in properly utilizing available manpower.

The planned maintenance subsystem was developed to provide the means by which each ship, each department, and each supervisor is enabled to plan, schedule, and effectively control shipboard maintenance. When PMS is implemented aboard ship, it replaces Part II of POMSEE, Preventive Maintenance Checkoff. Part I of POMSEE, Reference Standard Sheets and Performance Standard Sheets, remains in effect.

In establishing minimum planned maintenance requirements for each piece of equipment, the Bureau of Ships Technical Manual, manufacturers' technical manuals, and applicable drawings are examined critically. If preventive maintenance requirements are found to be unrealistic or unclear, they are modified or revised before being incorporated into the PMS.

It is possible that planned maintenance prescribed in the PMS may conflict with that prescribed in other documents such as the Bureau of Ships Technical Manual. In such an eventuality, the PMS supersedes and takes precedence over any and all documentation that may be in conflict with it. All tests, inspections, and planned maintenance actions should ultimately be incorporated in the PMS.

The planned maintenance subsystem is based upon the proper utilization of planned maintenance subsystem manuals, maintenance requirement cards (MRCs), and schedules for accomplishment of planned maintenance actions.

PLANNED MAINTENANCE SYSTEM MANUAL

The planned maintenance subsystem manual contains minimum planned maintenance requirements for each component installed for a particular shipboard department. A separate section of the PMS manual is furnished for each department. Manuals are compiled individually for each ship, thereby assuring a tailored subsystem. The Operations Department Manual (OpNav 43P1) has a green cover for electronics, and is kept in the operations office. This manual is used by the planning officer and maintenance group supervisors to plan and schedule maintenance for each group. The manual contains a list of effective pages and a section for each division or maintenance group within the operations department. Each divisional section contains index pages for each system, subsystem, or component that requires a planned maintenance action. These pages are referred to as maintenance index pages (MIPs). Each MIP gives a brief description of maintenance requirements and the frequency with which maintenance is to be effected. The frequency code is as follows: D-daily, W-weekly, M-monthly, Q-quarterly, S-semiannually, A-annually, C-once each overhaul cycle, and R-situation requirement (e.g. 100 hours of operation).

An index page also includes the rate(s) recommended to perform a task, as well as average time required. A sample maintenance index page (OpNav 4700-3) is shown in figure 11-1.

Manpower available for performing maintenance varies from one ship to another. For this reason, information found on MIPs regarding rates recommended to perform a maintenance task and the average time required for the task must have certain clarification. Maintenance tasks are actually performed by personnel available and capable, regardless of the rates listed on the MIP. The average time required, as listed on the MIP, does not take into consideration the time required to assemble tools and materials to do the maintenance action nor the time required to clean the area and put away tools at the end of the task.

System, Subsystem, or Component	Reference Publications
R-390A/URR Radio Receiver	NAVSHIPS 93053

Bureau Card Control No.					Maintenance Requirement	M.R. No.	Rate Req'd.	Man Hours	Related Maintenance
CK	037CRG2	A5	BE78	M	1. Test the calibration oscillator. 2. Test tuning system and signal strength. 3. Test bandwidth and audio response. 4. Test limiter action.	M-1	RM3	0.9	None
CK	037CRG2	A5	BE79	Q	1. Test IF gain. 2. Measure overall receiver gain. 3. Test audio gain.	Q-1	RM3	0.9	S-1
CK	037CRG2	A5	BE80	S	1. Measure receiver sensitivity.	S-1	RM3	1.2	None
CK	037CRG2	A5	BE81	S	1. Clean and inspect the radio receiver.	S-2	RMSN	0.6	M-1
CK	037CRG2	A5	BE82	A	1. Lubricate mechanical tuning system.	A-1	ETSN	1.0	Q-1, S-1
					These maintenance cards were prepared for this equipment in which the following field changes have been accomplished: 1 through 5 Of these, the following field changes affect the maintenance actions: 4, 5 New maintenance requirement cards and maintenance index pages will be made available as future field changes are accomplished that affect the prescribed planned maintenance.				

MAINTENANCE INDEX PAGE
OPNAV FORM 4700-3 (4-64)

BUREAU PAGE CONTROL NUMBER C-20/2-A5

98.171

Figure 11-1.–Maintenance index page.

SYSTEM	COMPONENT	M.R. NUMBER
Communication & Control	R390A/URR Radio Receiver	C-20 M-1
	MAINT. SIGNIFICANT NO.	

SUB-SYSTEM	RELATED M.R.	RATES	M/H
Radio Communication Systems		RM3	0.3

M.R. DESCRIPTION

1. Check receiver operation.

TOTAL M/H: 0.3

ELAPSED TIME: 0.3

SAFETY PRECAUTIONS

TOOLS, PARTS, MATERIALS, TEST EQUIPMENT

1. Headphones.

PROCEDURE

Preliminary Control Settings:

1.	RF gain	5
2.	Function switch	Cal
3.	BFO switch	ON
4.	BFO pitch	0
5.	Line gain	5
6.	Line meter switch	+10
7.	Local gain	5
8.	Bandwidth	4 KC
9.	Audio response	WIDE
10.	AGC switch	MED.
11.	Limiter switch	OFF.

1. Check receiver operation:

a. Connect headphones in receiver phone jack, turn megacycle change knob counter-clockwise until the first two counter digits read "00".

b. Turn kilocycle knob counter-clockwise until the last three digits read "000".

c. Turn ZERO ADJ. completely clockwise.

d. Increase RF GAIN to 10. (Cont.)

LOCATION

Page 1 of 2 | CK | 037C | RG2 | A3 | AA05 | M

Procedure Continued

e. While listening in phones and observing carrier level meter, vary kilocycle change knob for zero beat in phones coincident with minimum deflection on line level meter.

f. Turn "ZERO ADJ." maximum counterclockwise.

g. Turn "BFO PITCH" to +2. Beat note will be heard in phones.

h. Turn megacycle change knob clockwise, one position at a time from 00 to 31.

i. Observe carrier level meter while listening for beat note in each position.

j. Carrier level should indicate a minimum of 10 DB and beat note should be clearly audible in phones in each position.

k. Return "MC" change knob counterclockwise until counters are again 00.

l. Turn kilocycle change knob clockwise until last three digits of counter read 000.

m. Counters should read 00+000. This is equivalent to 1 MC.

n. Turn "BFO PITCH" control to "0" and RF gain to 5.

o. Repeat steps 1. c through 1. j.

Page 2 of 2 | CK | 037C | RG2 | A3 | AA05 | M

98.176

Figure 11-2.—Maintenance requirement card.

That portion of the PMS manual containing maintenance index pages applicable to equipment under a specific division or maintenance group is called the group maintenance manual. A copy of the group maintenance manual, in addition to the one in the departmental PMS manual, is kept in each working space as a ready reference to maintenance personnel.

MAINTENANCE REQUIREMENT CARD

The maintenance requirement card (MRC) (fig. 11-2) defines a planned maintenance task in sufficient detail so that assigned personnel can perform the task with little difficulty. Each maintenance requirement card lists the rates of personnel recommended to perform that particular task; safety precautions that must be observed; time, tools, parts, and materials required for the task; and detailed procedures for performing the task. A complete set of applicable MRCs is maintained in each working space with the group maintenance manual. A master set of all MRCs is kept on file in the departmental office. If a card becomes lost, torn, or soiled, it can be replaced by typing a duplicate card from the master set or by ordering one through proper channels.

The maintenance requirement card is one of the primary elements of the PMS system is to be used by personnel actually performing maintenance tasks. Personnel assigned to maintenance tasks must remove pertinent cards from the set maintained in the working space; obtain stated tools, parts, and material; perform the maintenance requirement specified on the card; correct and report any deficiencies noted during the performance of the maintenance requirement; and return the card to its proper place after completing the task.

Maintenance requirement cards represent minimum planned maintenance requirements of the cognizant systems command. To meet local conditions, each command has the prerogative to increase minimum requirements. If changes are of a continuing nature, recommended changes in the system should be submitted to the cognizant systems command.

SCHEDULING PLANNED MAINTENANCE

Through the use of a cycle schedule (fig. 11-3), the planned maintenance subsystem is designed to simplify planned maintenance scheduling. All required planned maintenance actions are programed throughout the overhaul cycle of a ship. Further, the subsystem is flexible enough to readily accommodate any changes in a ship's employment schedule. Cycle schedules contain a list of components for each division or maintenance group, and indicate the quarter after overhaul in which semiannual, annual, and overhaul cycle maintenance requirements are to be scheduled. Cycle schedules also list quarterly, monthly, and situation requirements that must be scheduled every quarter. In conjunction with division officers and leading petty officers, the department head utilizes a cycle schedule in making out a quarterly schedule.

By definition, the day a ship leaves the shipyard is in the first quarter after overhaul. A ship is not necessarily expected to perform all planned maintenance listed for the first quarter after overhaul, but the amount performed must be in proportion to the time remaining in that particular quarter. Steps to follow in using the cycle schedule can best be explained by reference to figure 11-3. Consider, for example, planned maintenance required for the R390/URR receiver. As indicated on the cycle schedule, a short description of maintenance required may be found on page C-20 of the PMS manual. From the cycle schedule it is apparent that maintenance must be scheduled as follows:

M 1 – each month.
Q 1 – each quarter.
S 1 – 1st, 3rd, 5th, 7th, 9th, and 11th quarters after overhaul.
A 1 – 4th, 8th, and 12th quarters after overhaul.

A quarterly schedule is a visual display consisting of two identical quarterly schedule forms (fig. 11-4), one for the current quarter and one for the subsequent quarter. The cycle schedule and both quarterly schedule forms are contained in the same visual display holder, and correspond line for line. The entire display, called the maintenance control board, is maintained in the departmental office. Maintenance control boards show the overall status of planned maintenance within a department. A quarterly schedule has 13 columns, one for each week in the quarter, for scheduling maintenance throughout a 3-month period. Each week is divided into days by tick marks (see fig. 11-4) to depict more accurately the operating schedule, thus allowing maintenance requirements to be scheduled in conjunction with ship operations. A suggested procedure for preparing a quarterly planned maintenance schedule is to first black out the dates a ship is expected to be underway during the quarter, then, with the aid of the cycle schedule and PMS manual, fill out the quarterly schedule accordingly. Monthly planned maintenance requirements should be scheduled at approximately the same time each month, and other planned maintenance actions should be scheduled at equal intervals insofar as practicable. After the quarterly schedule is completely filled in, it is a good practice to look it over closely to see if the workload is balanced throughout the quarter. If less work appears to be scheduled during one week of a quarter than in other weeks, some maintenance requirements should be rescheduled to balance the workload throughout the quarter.

Quarterly schedules are updated weekly. The leading petty officer of the division or maintenance group must cross out all maintenance requirements that have been accomplished and must circle all requirements scheduled for that week but not accomplished. All circled requirements are rescheduled by drawing an arrow to a later week as indicated in figure 11-4. A quarterly schedule is retained on board as a record of all completed maintenance actions. This record may be destroyed at the beginning of the second quarter after the next shipyard overhaul period. A quarterly schedule is also used by the leading petty officer of each division or maintenance group to prepare a weekly planned maintenance schedule (fig. 11-5). Weekly schedules are posted in each working space and are used by the leading petty officer to assign specific maintenance tasks to specific personnel.

A weekly schedule provides a list of components, appropriate page number of the PMS manual, and spaces for assignments of maintenance tasks to specific personnel. Daily and weekly planned maintenance actions are preprinted on the weekly schedule forms. All other planned maintenance requirements to be performed during a specific week are obtained from the current quarterly schedule. A weekly schedule offers flexibility for all planned maintenance actions except those required to be performed daily. When a planned maintenance task is completed, the leading petty officer should cross out the requirement on the schedule. Maintenance that cannot be completed on time is circled and rescheduled on the basis of workload and ship operations.

The weekly schedule is designed for convenient preparation and effective reuse. At the end of each week it is the responsibility of the leading petty officer of the division or maintenance group to take the weekly schedule to the departmental office, update the quarterly schedule, erase the weekly schedule, and prepare a schedule for the following week. Preparation of a weekly planned maintenance schedule necessitates consideration of available manpower, time expended on each maintenance task, and ship's operations. In assigning specific personnel to maintenance tasks, it must be remembered that the average time required to perform a task (as listed on the maintenance index page and maintenance requirement card) does not take into account the time required to assemble tools and material to do the maintenance action or to clean the area and put away the tools at the end of the task. Related maintenance requirements (see figs. 11-1 and 11-2), which are due, should be scheduled and performed together to conserve time. Any corrective maintenance, cleaning, or upkeep to be performed is in addition to planned maintenance prescribed by the PMS.

FEEDBACK REPORT

Through the use of a feedback report (fig. 11-6), the planned maintenance subsystem enables correction of discrepancies in the system. A feedback report should be originated immediately by the person who discovers a discrepancy, if one is found in the system as installed aboard ship.

A feedback report is useful only if all information concerning the discrepancy is correct and complete, including the reason for any recommended change. Before forwarding a feedback report to the appropriate systems command maintenance management field office, it should be checked for completeness and accuracy by the leading petty officer of the division.

RECORDING MAINTENANCE ACTIONS

The Maintenance Data Collection Subsystem (MDCS) is designed to provide a means of recording information concerning planned and corrective maintenance actions. Maintenance performed is recorded by code in sufficient detail to permit collection of a variety of information concerning maintenance actions and equipment performance. Use of codes in recording and reporting maintenance actions permits machine processing with automatic data processing equipment. The system also furnishes data per-

EQUIP PAGE	TYPE / CLASS / MAINTENANCE GROUP: COMMUNICATIONS / COMPONENT	SCHEDULE AS INDICATED — QUARTER AFTER OVERHAUL 1 5 9	2 6 10	3 7 11	4 8 12	EACH QUARTER
C-1	AN/URR-35					M1, M2, Q1
C-2	TED-9					M1, M2, Q1
C-3	AM-1365/URT		S1		S1	M1, M2,
C-5	AN/WRT-2	A1				M1, M2
C-6	AN/CRT-3					Q1
C-7	AN/URC-4					Q1
C-8	AN/SRR-11A					M1
C-10	AN/WRT-1		A1			M1
C-13	SCR-536	S1		S1		Q1
C-14	AM-215/U			A1		
C-16	AN/URT-7C					M1, M2, Q1
C-17	CU-692/U					Q
C-18	CU-691/U					Q1
C-19	AN/URA-8A				61(8)	M1
C-19	AN/URA-8B		C1(2)			M1, Q1
C-20	R390/URR	S1		S1	A1	M1, Q1
C-21	AN/GRC-27A					M1, M2,
C-25	AN/URC-32		A1			M1, Q1, Q2
C-25	AN/URC-32A			A1		M1, Q1, Q2
C-26	AN/SRA-22					Q1

CYCLE SCHEDULE OPNAV FORM 4700-4 (4-64) 0107-766-4000 C.40996

98.172

Figure 11-3. –Cycle schedule.

MAINTENANCE GROUP COMMUNICATIONS | YEAR 19-- | QUARTER AFTER OVERHAUL 2

MONTH JULY | MONTH AUGUST | MONTH SEPTEMBER

EMPLOYMENT SCHEDULE

	2	9	16	23	30	6	13	20	27	3	10	17	24
1.	~~M1~~	~~M2~~			~~M1~~, ~~Q1~~	M2				M1	M2		
2.		~~M1~~, ~~M2~~				M1,M2,Q1					M1,M2		
3.			~~M1~~	~~M2~~	~~S1~~		M1	M2				M1	M2
4.	~~M1~~			~~M2~~		M1			M2	M1			M2
5.		~~Q1~~											
6.								Q1					
7.			~~M1~~				M1			M1			
8.		~~M1~~			M1	A1	M1		M1				
9.									Q1				
10.													
11.		M1 ~~M2~~	~~M1~~, ~~Q1~~		~~M1~~, ~~M2~~					M1,M2			
12.												Q1	
13.	~~Q1~~												
14.		~~M1~~				M1					M1		
15.	~~M1~~				~~M1~~				C1, M1				Q1
16.	~~M1~~				~~M1~~	Q1			M1				
37.													

QUARTERLY MAINTENANCE SCHEDULE OPNAV FORM 4700-5 (4-64)

98.173

Figure 11-4.—Quarter or subsequent quarter schedule.

taining to initial discovery of a malfunction, how many hours equipment was in operation, equipment involved, repair parts and materials used, delays incurred, reasons for delay, and the technical specialty or work center that performed the maintenance. Except for routine preservation actions (chipping, painting, and cleaning) and daily or weekly planned maintenance system actions, each maintenance action is reported in this manner.

Shipboard installation of the maintenance data collection subsystem includes a central functional data collection center. Principal function of the shipboard data collection center is to screen all documents for completeness and accuracy before they are forwarded to the data processing center. During the screening process, the data collection center adds a 4-digit maintenance control number to each document.

Effectiveness of the MDCS depends initially upon personnel performing the maintenance action and the accuracy with which it is reported. Leading petty officers are responsible for ensuring that all forms used in connection with the MDCS are complete and accurate. Leading POs should also ensure that a form is submitted for each applicable action and that no action is reported more than once.

EQUIPMENT IDENTIFICATION CODE MANUAL

It is essential that all personnel charged with any responsibility for maintenance actions be indoctrinated in the proper use of the equipment identification code (EIC) manual, because it contains many of the codes used in reporting maintenance actions. Each major system is coded, and codes are broken down to the lowest part necessary for positive equipment identification. The manner in which the EIC is obtained from the manual is described in the following example.

Assume it is desired to determine the code for the voltage regulator of an AN/WRR-2 receiver. By referring to the index pages of the EIC manual, it is found that communication systems are identified by the code F, and the subsystem (in this example, communication receivers) is identified by the code FF. Next, turn to the pages of the manual with the FF codes, and go down the list of equipment until the listing for the AN/WRR-2 appears. Under this listing are the 7-digit codes for the voltage regulator. The first digit of the code identifies the system; the second digit, the subsystem; the third and fourth, the equipment; and the last three digits, the assembly. If the assembly requires further breakdown, the last digit identifies the subassembly.

Besides equipment identification codes, the EIC manual contain other codes and information of equal importance. Section I of the manual contains general instructions governing preparation of forms when reporting maintenance actions. Other sections of the manual deal with additional codes, as follows: Section II, Administrative Organization; Section III, Work Center; Section IV, How Malfunctioned; Section V, When Discovered; Section VI, Action Taken; Section VII, Service; Section VIII, Source; and Section IX, Type Availability.

A variety of information may be recorded in a relatively small space as a result of the foregoing codes. At the data processing level, these codes permit use of automatic data processing operations, which provide pertinent direct reading information summaries. Summaries can be employed profitably only if information recorded is accurate. Familiarity with the coding systems is a must, therefore; and the importance of accuracy in the recording of codes cannot be overstressed.

MDCS DOCUMENTATION

Documentation in the maintenance data collection subsystem is accomplished by completion, as applicable, of one or more standard forms. Forms used to record and report information related to maintenance actions aboard ship and within repair activities include OpNav form 4700-2B (shipboard maintenance action), OpNav form 4700-2D (deferred action), OpNav form 4700-2C (work request), and OpNav form 4700-2F (work supplement card). Detailed descriptions of entries to be made on these forms are listed in section I of the EIC manual and in chapter 3 of the 3-M Manual.

Shipboard Maintenance Action Form

A sample shipboard maintenance action form (OpNav 4700-2B) is shown in figure 11-7. This form is a single-sheet document used to record completion of planned maintenance actions, corrective maintenance actions, and authorized alterations already performed at the shipboard level by shipboard personnel. All planned maintenance actions except daily and weekly actions must be recorded on this form, as well

GROUP COMMUNICATIONS WORK SCHEDULE FOR WEEK OF 6 AUGUST 19--

COMPONENT	MAINTENANCE RESPONSIBILITY	PAGE	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN	OUTSTANDING REPAIRS AND P.M. CHECKS DUE IN NEXT 4 WEEKS
AN/URR-35	ABLE	C1			M2				
TED-9	BAKER	C2		~~M1, M2, Q1~~					
AM-1365/URT	CHARLES	C3							
AN/WRT-2	DOW	C5		M1	M1		W1		
AN/URC-4	GREENE	C7							
AN/SRR-11A	HAPP	C8				W1			
AN/WRT-1	INTRYE	C10		~~AK~~	W1		W2		
SCR-536	JUSTICE	C13							
AM-215/U	KIDD	C14							
AN/URT-7C	LORNE	C16							
CU-692/U	MAYS	C17							
CU-691/U	NAYLOR	C18							
AN/URA-8A	O BRIEN	C19	~~WK~~		M1				
AN/URA-8B	PETERS	C19				W1			
R390/URR	QUINN	C20		~~Q1~~					
R390A/URR	RUSK	C20							
AN/GRC-27A	SIMPSON	C21	~~WK~~						
AN/URC-32	TODD	C25			W1				
AN/URC-32A	USTE	C25	~~WK~~						
AN/SRA-22	VICTOR	C26							

WEEKLY WORK SCHEDULE OPNAV FORM 4700-6

98.175

Figure 11-5.—Weekly work schedule.

INSTRUCTIONS

FROM: INDICATE SHIP HULL NUMBER OR ORIGINATING ACTIVITY — SERIAL # No. in Sequence

DATE Date Written

TO: NAVSHIP/NAVORD SYSTEMS COMMAND
MAINTENANCE MANAGEMENT FIELD OFFICE

ATLANTIC	PACIFIC
BOX SECTION 604 HAMPTON ROADS BRANCH U. S. NAVAL STATION NORFOLK, VIRGINIA , 23511	CODE 0411W BOX 45 U. S. NAVAL STATION SAN DIEGO, CALIF., 92136

VIA:

SUBJECT: PLANNED MAINTENANCE SYSTEM FEEDBACK REPORT

SYSTEM Same As On MRC	COMPONENT Same As On MRC
SUB-SYSTEM Same As On MRC	M.R. NUMBER Same As On MRC
	BU. CONTROL NO. Vertical No. on R.H. Side of MRC

DESCRIPTION OF DISCREPANCY:

☐ Missing Maintenance index Page (MIP)	☐ Technical	☐ Typographical
☐ Missing Maintenance Requirement Card (MRC)	☐ Procedure	☐ Publications
☐ Equipment Change	☐ Safety Precautions	☐ MDC
☐ M.R. Description	☐ Tools, Etc.	☐ Miscellaneous

1. Handwritten copies acceptable. Use Ballpoint pen.
2. Check appropriate box.
3. Use this space for all comments. State what is wrong and recommended correction. Give reason for recommended change (Unless comment is obvious).
4. For missing MRC, MIP & when Bu Control Number is not available identify equipment by noun name and APL/CID or AN Number.
5. For equipment change report, identify equipment removed and that installed by noun name EIC and APL/CID or AN Number.
6. "Tech Publications" Block includes all BUWEPS and BUSHIPS publications. Identify Publication Number, Volume, Revision, Date, Change Number, Page, Paragraph and/or Figure. When referring to PMS/SMS Equipment Volumes 2 or 4, the "M.R. Number" and "Bu Control No." Blocks should also be completed.
7. Distribution: As shown on bottom of each page.
   Installation Team: Forward reports within 10 days of installation.
   Ship: Forward reports within 90 days after installation and as required thereafter, via appropriate TYCOM.
8. Request additional forms from Supply.

C.O. or designated Rep.
SIGNATURE

40.101

Figure 11-6. –PMS feedback report.

MAINTENANCE DATA COLLECTION
OPNAV FORM 4700-2B (8-64)

SHIPBOARD MAINTENANCE ACTION

A. SHIP NAME AND HULL NO./ACTIVITY	1. ADMIN. ORG.	2. SHIP ACCTG. NO.	3. MAINT. CTRL. NO.	4. DATE MONTH YEAR	B.
USS OVERSEAS DD 111	D070	03861	0175	1304-	

5. EQUIPMENT ID CODE	6. W.C.	7. ASST. WC.	8. REPAIR ACT. ACCT. NO.	9. MAL/MRC.	10. DISC	11. A/T	12. UNITS	13. MAN-HOURS (10THS)	E.
FF11F24	C30	068			C	C	01	0010	

14. SERIAL NO.	20. EQUIP. TIME	21. ALTERATION IDENTIFICATION
825		

F. DESCRIPTION/REMARKS

NO OUTPUT FROM VOLTAGE REGULATOR TUBE

FOR LOCAL USE ONLY

L. SIG. (3) Al Baker RM3

M. SIG. (4) Charles Dunn RMC

D-22481

17.81B

Figure 11-7.–Shipboard maintenance action form.

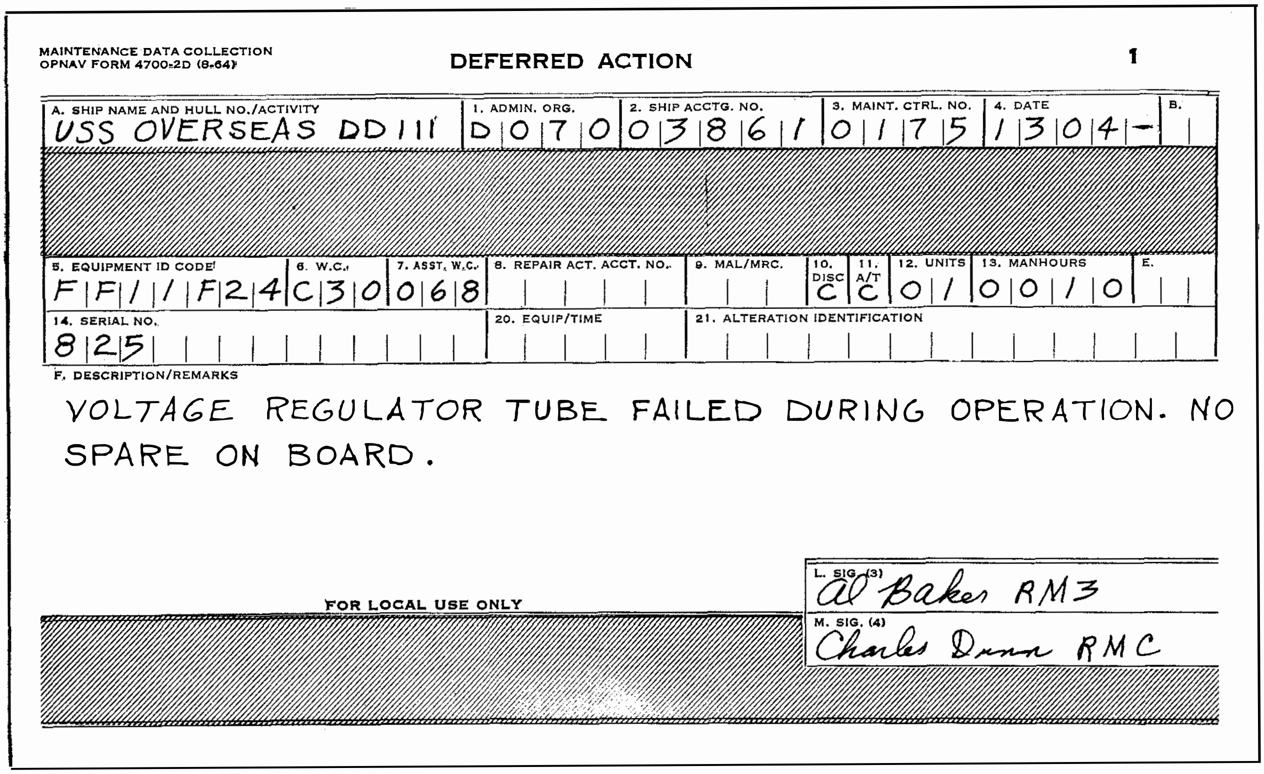
as on the weekly and quarterly schedules. Routine preservation such as chipping, painting, and cleaning should not be reported.

The shipboard maintenance action form is also used to report work done aboard ship by any outside activity that does not report under the maintenance data collection subsystem. Duplicate 4700-2B documents are prepared for ship maintenance assistance provided when a repair activity, such as a civilian contractor or a shipyard (except for regular overhauls), is not under the MDCS. Block 7 of the original document is left blank, and the code for the assisting work center is entered on the duplicate. Only the time actually spent by shipboard personnel in assisting an outside activity is recorded in block 13 of the original. Man-hours spent by an outside activity in assisting the shipboard work center are documented in block 13 of the duplicate.

Deferred Action Form

The deferred action form (OpNav 4700-2D) is a two-sheet form used to report corrective maintenance actions that are deferred because of ship's operations, lack of repair parts, or necessity for outside assistance. The first sheet (fig. 11-8) is used to record and report the reason for deferral. The second sheet (fig. 11-9) is for reporting completion of a deferred action.

If a corrective maintenance action is beyond ship's force capability, and outside assistance is required, a work request is prepared and forwarded. This situation always requires submitting an OpNav form 4700-2D. Man-hours expended (if any) by ship's force in connection with the maintenance action are documented on OpNav form 4700-2D. Man-hours concerned with investigation and removal of equipment are



MAINTENANCE DATA COLLECTION
OPNAV FORM 4700-2D (8-64)

DEFERRED ACTION 1

A. SHIP NAME AND HULL NO./ACTIVITY	1. ADMIN. ORG.	2. SHIP ACCTG. NO.	3. MAINT. CTRL. NO.	4. DATE	B.
USS OVERSEAS DD 111	D070	03861	0175	1304-	

5. EQUIPMENT ID CODE	6. W.C.	7. ASST. W.C.	8. REPAIR ACT. ACCT. NO.	9. MAL/MRC.	10. DISC	11. A/T	12. UNITS	13. MANHOURS	E.
FF111F24	C30	068			C	C	01	0010	

14. SERIAL NO.	20. EQUIP/TIME	21. ALTERATION IDENTIFICATION
825		

F. DESCRIPTION/REMARKS

VOLTAGE REGULATOR TUBE FAILED DURING OPERATION. NO SPARE ON BOARD.

L. SIG. (3) Al Baker RM3

M. SIG. (4) Charles Dunn RMC

FOR LOCAL USE ONLY

17.81D

Figure 11-8.—Deferred action form, sheet 1.

documented on the first sheet of the document. Man-hours involved in reinstallation of equipment are documented on the second sheet of forms.

If a shipboard maintenance action must be deferred because of lack of necessary repair parts or because of ship's operations, an OpNav form 4700-2D is prepared; the first sheet is submitted, using the appropriate action taken code from section VI of the EIC manual; and the man-hours expended (if any) are entered in block 13. When the maintenance action is completed, the second sheet is submitted, using the appropriate action taken code. Man-hours expended in completing the action are entered in block 13.

Work Request

The work request form (OpNav 4700-2C) is a 4-sheet document presently used to request outside assistance from repair ship and tenders. It is planned that OpNav 4700-2C also will be used, at a later date, for requesting assistance from shipyards. Part I of the work request is shown in figure 11-10. Part II of the work request (fig. 11-11) is a continuation of part I and provides additional space for written descriptions, diagrams, and sketches.

Information to be given in block F (Description/Remarks) of the work request includes name of component, CID number of component, and alteration number. If the alteration number is not applicable, it must be listed as N/A. Block F should also contain a description of existing defects and any repairs required on the component.

The original sheet of the work request is retained by the requesting activity; copies 2, 3, and 4 are forwarded to the assigned repair activity via the designated chain of command. Information concerning administrative procedures to be taken on work requests by repair activities is given in chapter 4 of the 3-M Manual.

MAINTENANCE DATA COLLECTION
OPNAV FORM 4700-2D (8-64)

DEFERRED ACTION 2

A. SHIP NAME AND HULL NO./ACTIVITY	1. ADMIN. ORG.	2. SHIP ACCTG. NO.	3. MAINT. CTRL. NO.	4. DATE	B.
USS OVERSEAS DD 111	D070	03861	0175	2704–	

5. EQUIPMENT ID CODE	6. W.C.	7. ASST. W.C.	8. REPAIR ACT. ACCT. NO.	9. MAL/MRC.	10. DISC	11. A/T	12. UNITS	13. MANHOURS	E.
FF111F24	C30	068			C		01		

14. SERIAL NO.	20. EQUIP/TIME	21. ALTERATION IDENTIFICATION
825		

F. DESCRIPTION/REMARKS

VOLTAGE REGULATOR TUBE FAILED DURING OPERATION. NO SPARE ON BOARD. SPARE RECEIVED FROM SRF YOKOSUKA.

FOR LOCAL USE ONLY

L. SIG. (3) Al Baker RM3

M. SIG. (4) Charles Dunn RMC

17.81D

Figure 11-9.–Deferred action form sheet 2.

When the work request is accepted by a repair activity, sheet 3 of the document is used as a job order and is sent to the assigned work center. Prepunched work supplement cards (OpNav 4700-2F) are also sent to the assigned work center. A sample OpNav 4700-2F is shown in figure 11-12.

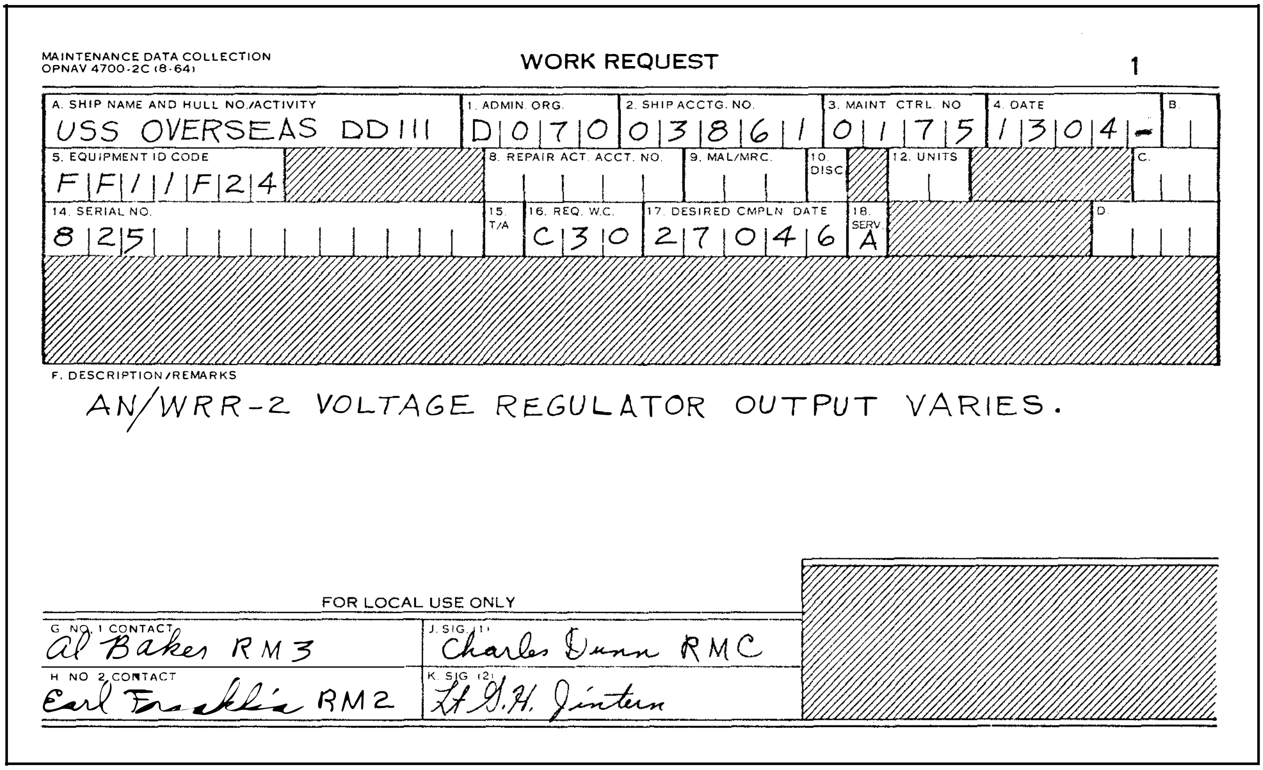
The assigned work center performing the job records maintenance data on work supplement cards. Any material obtained outside of normal supply channels is recorded on the reverse side of the card. If more than 1 work day is required to complete the action, or if assisting work centers are needed, the lead work center utilizes additional work supplement cards provided for recording daily man-hours expended. (The lead work center has primary responsibility for completion of the task described on the work request.)

On completion of a repair job, sheet 3 of the work request is completed by the lead work center and is signed by the man who performed the maintenance. An inspector from the requesting activity is contacted for final inspection and signs off the work request. After obtaining the signature of the inspector, the lead work center supervisor forwards the completed work request to his division officer.

Material Usage and Cost Data

Documentation of material usage and cost data on maintenance transactions requires the joint effort of supply and maintenance personnel aboard ship. The form used to document material usage and cost data depends on the action involved and the source of material.

The reverse side of the appropriate OpNav form of the 4700 series is used by maintenance personnel to report material obtained from outside normal supply channels. (The reverse sides of OpNav forms 4700-2D and 4700-2F are essentially the same as the 4700-2B, which is shown in figure 11-13.) Examples of material reported are parts and material obtained from



MAINTENANCE DATA COLLECTION
OPNAV 4700-2C (8-64)

WORK REQUEST 1

A. SHIP NAME AND HULL NO./ACTIVITY	1. ADMIN. ORG.	2. SHIP ACCTG. NO.	3. MAINT. CTRL. NO.	4. DATE	B.
USS OVERSEAS DD 111	D0710	038611	01175	1304-	

5. EQUIPMENT ID CODE	8. REPAIR ACT. ACCT. NO.	9. MAL/MRC.	10. DISC	12. UNITS	C.
FF11F24					

14. SERIAL NO.	15. T/A	16. REQ. W.C.	17. DESIRED CMPLN DATE	18. SERV	D.
825		C310	270416	A	

F. DESCRIPTION/REMARKS

AN/WRR-2 VOLTAGE REGULATOR OUTPUT VARIES.

FOR LOCAL USE ONLY

G. NO. 1 CONTACT	J. SIG. (1)
Al Baker RM3	Charles Dunn RMC
H. NO. 2 CONTACT	**K. SIG. (2)**
Earl Franklin RM2	Lt G.H. Jinten

17.81C

Figure 11-10—Work request, part I.

preexpended material bins; items obtained by cannilbalization or from salvage, which can be identified by a part number or Federal stock number; and consumable materials such as lumber, sheet metal, and bar stock, used for manufacture work. Economy of effort and elimination of duplicate recording are highly desirable. When there is doubt about reporting an item, however, it should be reported.

Existing supply forms are used to document material usage and cost data of repair parts or materials obtained through normal supply channels. Choice of document is determined by availability of automatic data processing equipment. If a ship has automatic data processing equipment, DD form 1348 is used. If a ship does not have automatic data processing equipment, NavSanda form 1250 is used. Maintenance personnel are required to furnish the work center code, equipment identification code, CID number, maintenance control number, name of part, and stock number when submitting form 1250 or 1348 to the supply department.

MAN-HOUR ACCOUNTING SYSTEM

The man-hour accounting system, sometimes referred to as exception time accounting (ETA), is designed and intended for use by the repair department of repair activities in conjunction with the maintenance data collection subsystem. Basically, the ETA is a management tool, and records all deviations from a normal 7-hour working day.

The mechanics of exception time accounting includes the use of codes, preparation of a master roster listing, and preparation and submission of daily exception cards (OpNav form 4700-2E). A sample daily exception card is shown in figure 11-14.

ELECTRONICS RECORDS

Details about electronics records are given in the Naval Ships Technical Manual. As a rule, these records are kept in the electronics workshop. Aboard ship, the electronics material of-

MAINTENANCE DATA COLLECTION
OPNAV FORM 4700-2C (9-64) PART II

WORK REQUEST

A. SHIP NAME AND HULL NO./ACTIVITY	1. ADMIN. ORG.	2. SHIP ACCTG. NO	3. MAINT. CTRL. NO.	4. DATE MONTH YEAR	B.
USS OVERSEAS DD111	D0710	03861	01175	1304-	

F. DESCRIPTION/REMARKS (Continued)

PAGE 1

17.81C

Figure 11-11.-Work request, part II.

ficer usually assigns responsibility for the major portion of electronics recordkeeping to ETs. These are two reasons why the leading Radioman should have a working knowledge of these records. First, a thorough acquaintance with the necessary records and the proper way to keep them is helpful in understanding capabilities and limitations of equipment, determining its reliability, and ensuring that it is maintained in peak operating condition. Second-and equally important- Radiomen quite often are called upon to perform maintenance and repairs on their own equipment.

Due to the implementation of the 3-M system previously described, many of the records and reports discussed in the remainder of this chapter are being phased out. Some of these records and reports are being replaced by a monthly report sent to the ships from the maintenance data collection (MDC) center.

The MDC report contains information furnished by the activity on the 4700-2J series forms. For the MDC report to be complete and for each activity to have a complete record on each unit of its equipment, every maintenance action taken by the activity must be reported.

The MDC report must be kept by each activity instead of the records under the Current Ships Maintenance Project (CSMP), such as the Electronic Equipment History Card (NavShips 536), Repair Record Card (NavShip 529), Alteration Record Card (NavShips 530), and the Record of Field Changes (NavShips 537). The CSMP is discussed briefly for those activities that have not yet incorporated the 3-M system (or are in the process).

CURRENT SHIP'S MAINTENANCE PROJECT

The purpose of the CSMP has been to provide an up-to-date record of maintenance, modifications, and repairs yet to be accomplished by ship's personnel or during availabilities. Some ships may only be using part of the CSMP because of the implementation of the 3-M system.

OPNAV FORM 4700-2F (7-65) WORK SUPPLEMENT

1 ADM ORG	2 SHIP	3 MCN	8 T/A	5 EIC	6 WC	9 MAL	10 DISC
D070	0386	0175	C	FF11F24	C30	068	C

REMARKS:

* - DO NOT ENTER IF SAME AS ABOVE

4.	DATE	2 7 0 4 -
5.	EIC *	
7.	AWC	
9.	HOW MAL *	
10.	WHEN DISCOVERED *	
11.	ACTION TAKEN	C
12.	UNITS COMPLETED	0 1
13.	MANHOURS (TENTHS)	0 0 1 0
	READY TO PICK UP (✓)	✓
	DELIVERED (✓)	

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

696048-0 RSC

17.81F

Figure 11-12. –Work supplement card.

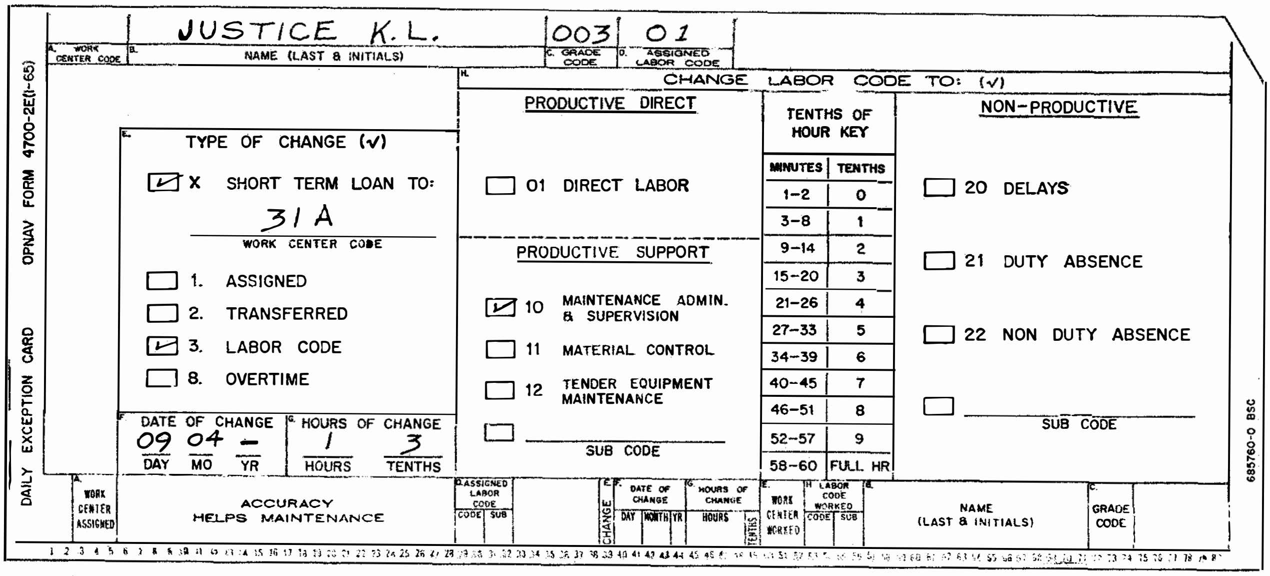
CID/APL/AEL/AN
55376101

SOURCE CODE	COG.	FEDERAL STOCK NO./PART NO.	REFERENCE SYMBOL/NOUN	MATERIAL REQ. UNITS	MATERIAL REQ. QUANTITY	MATERIAL USED UNITS	MATERIAL USED QUANTITY	UNIT PRICE
1	1N	5905-258-0034	R1445			EA	2	.38

OPNAV FORM 4700-2B (8-64) BACK

17.81B

Figure 11-13. –Reverse side of OpNav 4700-2B.


OPNAV FORM 4700-2E(1-65) DAILY EXCEPTION CARD

A. WORK CENTER CODE | B. NAME (LAST & INITIALS): JUSTICE K. L. | C. GRADE CODE: 003 | D. ASSIGNED LABOR CODE: 01

E. TYPE OF CHANGE (✓)
☑ X SHORT TERM LOAN TO: 31 A (WORK CENTER CODE)
☐ 1. ASSIGNED
☐ 2. TRANSFERRED
☑ 3. LABOR CODE
☐ 8. OVERTIME

F. DATE OF CHANGE: 09 04 – (DAY MO YR)
G. HOURS OF CHANGE: 1 3 (HOURS TENTHS)

H. CHANGE LABOR CODE TO: (✓)

PRODUCTIVE DIRECT
☐ 01 DIRECT LABOR

PRODUCTIVE SUPPORT
☑ 10 MAINTENANCE ADMIN. & SUPERVISION
☐ 11 MATERIAL CONTROL
☐ 12 TENDER EQUIPMENT MAINTENANCE
☐ ______ SUB CODE

TENTHS OF HOUR KEY

MINUTES	TENTHS
1–2	0
3–8	1
9–14	2
15–20	3
21–26	4
27–33	5
34–39	6
40–45	7
46–51	8
52–57	9
58–60	FULL HR

NON-PRODUCTIVE
☐ 20 DELAYS
☐ 21 DUTY ABSENCE
☐ 22 NON DUTY ABSENCE
☐ ______ SUB CODE

A. WORK CENTER ASSIGNED | ACCURACY HELPS MAINTENANCE | B. ASSIGNED LABOR CODE (CODE SUB) | CHANGE | E. F. DATE OF CHANGE (DAY MONTH YR) | G. HOURS OF CHANGE (HOURS TENTHS) | WORK CENTER WORKED | H. LABOR CODE WORKED (CODE SUB) | NAME (LAST & INITIALS) | C. GRADE CODE

685760-0 BSC

17.81E

Figure 11-14. –Daily exception card.

The CSMP is comprised essentially of the following three card forms: repair record card (NavShips 529), a blue card; alteration record card (NavShip 530), which is pink; and the white record of field changes (NavShips 537). As a repair is required, an alteration approved, or a field change authorized, the applicable card should be completed and filed in the material binder behind the appropriate history card. The cards are of distinctive colors, and readily direct attention to work outstanding.

Repair Record Card

When a required repair cannot be accomplished immediately or is beyond the capacity of ship's force, a repair record card (NavShips 529) should be filled out and filed behind the appropriate history card. Repair cards for work beyond the capacity of ship's force should contain information that will be needed later for repair requests for shipyard or tender work. Entering complete data at the time the need for repair becomes evident helps to guarantee successful shipyard and tender availabilities.

Electronic Equipment History Card

The electronic equipment history card (NavShips 536) is the basic material history card for electronic equipment. It provides for recording failures and other pertinent information about equipment. A separate card is prepared for each unit on board; additional cards are added, if required. All cards for a particular unit are transferred with the unit when it is removed from the ship.

The heading of the card is so designed that when the card is filled in properly, all necessary information is readily available for completing the upper part of the electronic equipment failure/replacement report (DD-787). The heading of the card should be typed, but entries on the body of the card may be either typed or written in ink or indelible pencil. Instructions must be followed closely in filling in the form, a sample of which is shown in figure 11-15.

Alteration Record Card

When an alteration is approved, an alteration record card (NavShips 530) is filled out and filed behind the history card for the equipment that the alteration is to modify or replace. If the alteration includes installation of new equipment, the card should be placed in the binder where the new history card eventually is to be inserted. Usually, information to be supplied is self-explanatory. An important consideration is adequate description of the alteration in the Work Required section of the card.

NAVSHIPS 536 (Rev. 9-48) ELECTRONIC EQUIPMENT HISTORY CARD

AN/SRR-13A	596	Radio Receiver Set, R- 1A/SRR-13	1
Equipment Model Designation	Equip. Ser. No.	Name of Unit and Type No.	Card No.

Name of Contractor	Contract No.	Date Installed	Serial No. of Unit
Radio Corp. of America	NObsr-67134	5 Mar --	596

Location Radio Central 01-52-0-C — Installing Activity NavShipYd Phila

Spare Parts — Box No. and Location: Bin stowage — Instr. Bk. On Board (Check) [X]

Date	Nature of Trouble (Or F. C. No. and Title)	Cause of Failure Brief Description of Work Done	Name of Part	Circuit Symbol	Navy Stock No.	Life Hours	Date NavShips-383 Mailed
1/6/59	F. C. #1	AS DIRECTED IN E.I.B. 499					
	REDUCTION OF						
	POWER INPUT						
	VOLTAGE.						
3/3/61	LOW SENSITIVITY	OPEN RESISTOR	RESISTOR	R-1605			

Stocked in CDS

16—52956-3

1.2

Figure 11-15.—Electronic equipment history card (NavShips 536).

Record of Field Changes

Information on field changes for electronic equipment is recorded on the record of field changes (NavShips 537). One of these cards is prepared for each equipment and is filed in the material history binder next to the history card for that equipment. Without modifications, an equipment may be dangerously out of date and subject to numerous serious difficulties. Lacking a record of field changes, it is difficult to determine what modifications (if any) have been made. Information recorded on these cards is therefore essential for routine maintenance, for troubleshooting, and for ordering parts for improved equipment.

Figure 11-16 illustrates a record of field changes (NavShips 537). Spaces for equipment model designation, serial number, date installed, and card number are filled out by typing or writing with ink or indelible pencil. The official name and Navy type number (or other official identification) of each component affected by a field change should be shown parenthetically after the title of a change.

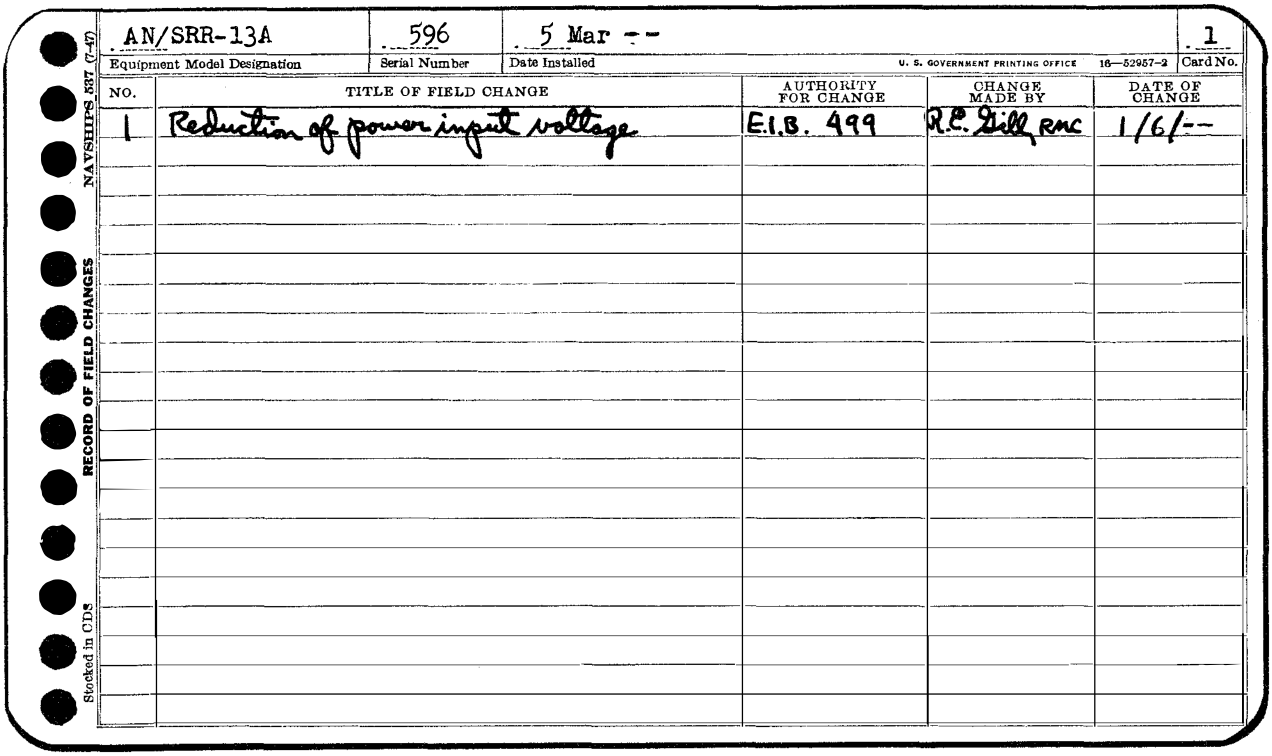
Record Retention Procedures

When CSMP work is completed, notations to this effect should be entered on the material history card and applicable CSMP cards. The latter, with the exception of the record of field changes, then should be removed and placed in a completed work section of the CSMP.

Electronic equipment history cards and records of field changes remain with the equipment referred to on the cards. If equipment is transferred, these cards are transferred with it. The history card must remain with the equipment throughout its normal service life. If an equipment is processed through equipment restoration procedures, a new history card replaces the previous card.

ELECTRONICS REPORTS

Type commanders call for certain reports such as ShipAlt completion reports, for purposes of maintaining accurate data on equipment installed on the ships of a command. This information serves as the basis for a ship's im-



NAVSHIPS 537 (7-47)

RECORD OF FIELD CHANGES

Stocked in CDS

AN/SRR-13A	596	5 Mar --	U. S. GOVERNMENT PRINTING OFFICE 16—52957-2	1
Equipment Model Designation	Serial Number	Date Installed		Card No.

NO.	TITLE OF FIELD CHANGE	AUTHORITY FOR CHANGE	CHANGE MADE BY	DATE OF CHANGE
1	Reduction of power input voltage	E.I.B. 499	R.E. Dill RMC	1/6/--

1.4

Figure 11-16. –Record of field changes (NavShips 537).

provement program, operational data, and for shipyard scheduling. The Naval Ship Systems Command requires similar data, plus other reports described here, which reveal the performance of equipments, especially directed at failures. From these data the Naval Ship Systems Command can predict required stock levels of parts to be maintained, parts allowances for individual ships, and changes to equipment to improve performance and operation. The 3-M system will eventually take over the function of these reports.

Requirements for electronics reports and instructions for their use are listed in the following references: type commander instructions and directives; NavShips Technical Manual; Electronics Installation and Maintenance Book (EIMB); and Reporting Electronic Equipment Installations (NavShips 900,135).

Ship Electronics Installation Record

The ship electronics installation record (NavShips 4110), shown in figure 11-17, is an inventory of a ship's electronic equipment. It furnishes the Naval Ship Systems Command a complete and current record of shipboard electronics installations and is a means of informing the Office of the Chief of Naval Operations, fleet and type commanders, Electronic Supply Office, and naval shipyards of electronics installations in the fleet. It serves as a basis for determining electronics repair parts allowance lists (ERPAL), and constitutes one of the factors entering into analysis of the fleet's electronic equipment and maintenance requirements. It also is used in planning future overhauls; in budgeting for, procuring, and distributing equipment; and in planning deployment of ships.

It is obvious that an error in the inventory (listing a wrong serial number, for example) is reflected as a mistake in the ERPAL, resulting first in inadequate or wrong repair parts support and, second, in improper test equipment allowance. Inasmuch as the report is originated by individual ships, the Naval Ship Systems Command can do little, except during regularly scheduled overhauls, to verify accuracy of the report. Responsibility therefore rests with the ship, and it is to the ship's benefit to have changes and corrections submitted as soon as they occur.

Details for preparing NavShips 4110 reports are contained in Reporting Electronic Equipment Installations, NavShips 900,135. Only pertinent extracts are given here. The person making the report must use the referenced publication to ensure complete adherence to procedures.

Whenever a major change is made in a ship's electronic installation, a corrected NavShips 4110 is submitted to the Naval Ship Systems Command in order that its tabulations may be transferred readily to the latest electronic tabulating system. The recorded information is punched on cards in such a manner that it shows not only what equipment is installed in each ship, but also what military requirement the equipment fills or partly fills, and whether there still are unfilled or partly filled military requirements. The system has been expanded to show also what equipment has been allocated but not yet installed.

In a concise manner, NavShips 4110 reveals what equipment is on board, where it is located, and identifies its operating voltages, along with other important information. For identification purposes, coded letter and figures are used in

NAVSHIPS 4110 (REV. 2-59)

SHIP ELECTRONICS INSTALLATION RECORD

DATE REVISED BY SHIP 6 Dec 6-

BUSHIPS REPORT-9670-2

SHIP TYPE	SHIP NUMBER	SHIP NAME	STATUS	AREA	FLT. FRON.	DIST. COMM.	BERTH AREA	PLAN. YARD	SHIP VOLT.	DATE MO.	DATE DAY	DATE YR.	DIST.	OVHL. YARD
DDG	10	SAMPSON	B	A	50			BS					05	

S.C.C. CODE FOR BUREAU USE ONLY	CAT.	LOCATION	EQUIPMENT MODEL	SERIAL NUMBER	EQUIPT. VOLTAGE 1	EQUIPT. VOLTAGE 2	REMARKS
	1	010	49546	21576		0	
	1	010	AM-215D-U	194		8	
	1	010	AN-SGC-1A	717		8	
	1	010	AN-SRA-12A	499		0	
	1	010	AN-SRR-11A	A-11		8	
	1	010	AN-URA-8B	1377		8	
	1	010	C-1004B-SG	120		8	
	1	010	CV-591A-URR	2855		8	
	1	010	R-390A-URR	4877		8	
	1	010	RE-156A-SR	39		8	
	1	010	SB-82-SRR	QTY 18		0	
	1	010	SB-83-SRT	QTY 1		0	
	1	010	SB-315B-U	2228		8	
	1	010	SB-863-SRT	QTY 3		0	
	1	010	TT-23F-SG	53		0	
	1	010	TT-69A-UG	364		8	
	1	010	TT-187-UG	546		8	
	1	010	TT-192-UG	427		8	
	1	010	TT-253-UG	205		8	
	1	010	TT-253-UG	224		8	
	1	020	AN-GRC-27A	844		8	
	1	020	AN-SRA-13	234		8	
	1	020	AN-URC-32	136		8	
	1	020	AN-URR-27	90		8	
	1	020	AN-URR-35C	27		8	
	1	020	AN-URT-7C	196		8	
	1	020	AN-WRT-1	73		11	
	1	020	AN-WRT-2	104		11	
	1	020	CU-691-U	42		0	
	1	020	SA-597-SRT	46		0	
	1	020	TED-9	179		8	
	1	030	AN-SRR-11A	A-19		8	
	1	030	AN-SRW-4	CJ-34		8	
	1	030	TCS-12	14108		8	

PAGE 1 OF 16

35.82

Figure 11-17. -Ship electronics installation record (NavShips 4110).

U.S.S. ______________
C/O FLEET POST OFFICE

OFFICIAL BUSINESS

POSTAGE AND FEES PAID
NAVY DEPARTMENT

DEPARTMENT OF THE NAVY
NAVSEC - CODE 6271C
WASHINGTON, D.C. 20360

From: Commanding Officer
USS ______________

To: NAVSEC - CODE 6271C

Change/Insertion/Delete	Serial No.	Location
NAVSHIPS 4110		DATED

____
(Authorized Signature)

50.21

Figure 11-18. –NavShips 4263, indicating minor change in ship electronic installation.

the several data columns. Meanings of these codes (for each column) are given in the previously referenced NavShips 900, 135.

Minor changes may be reported on NavShips 4263, a post card form (fig. 11-18). A minor change is defined by the Naval Ship Systems Command as one that does not affect military characteristics of the ship, such as relocation of equipment or change in operating voltage.

When a change in the electronics installation is made by ship's force, a tender, or shipyard, the 4110 report must be revised to agree with the changed installation. Necessary changes must be noted on all copies, in red pencil or red ink, and the date of the revision must be indicated at the top of the form. One revised copy is mailed to the Naval Ship Systems Command, Washington, D.C. Other revised copies are returned to the ship's files pending receipt of reprinted copies. Upon receipt of the reprinted copies, the filed revised copies are destroyed after they are rechecked carefully for accuracy by the ship.

In general, the cognizant systems command does not reprint NavShips 4110 after receiving a single minor change report from the ship, but uses and files them until several are accumulated.

A postoverhaul NavShips 4110 report is required 1 week before completion of a scheduled overhaul. The ship forwards to the cognizant systems command a revised copy of the latest NavShips #4110 report.

In summary, then, a ship's responsibility is to submit a corrected NavShips 4110 at least 1 week before completing an overhaul, as well as when a major installation or removal is made between overhauls. Minor changes occurring between overhauls must be reported promptly on the NavShips 4263 post card form.

The Naval Ship Systems Command is responsible for publishing and distributing a revised NavShips 4110 upon receipt of a postoverhaul report from the ship, upon receipt of reports of major changes made between overhauls, and 6 months before a regularly scheduled overhaul. In preparing this preoverhaul issue, the Naval Ship Systems Command uses the latest NavShips 4110 on file, consolidating with it all minor changes reported to date. The Command forwards the completed preoverhaul NavShips 4110 to the ship, type commander, overhaul shipyard, and the Electronics Supply Office.

Electronic Performance and Operational Report

The Naval Ship System Command must keep tabs on new (and modified) equipments to evaluate their usefulness. This procedure is accomplished with the electronic performance and operational report (NavShips 3878), shown in figure 11-19. Reports are not required to be submitted on all equipments. Only those equipments currently listed in the Material Command Instruction 9670.20 (as corrected by the EIB) are to be reported. Equipment listings in the EIB are changed periodically to delete certain equipments and add others. At present this report is made on only a few equipments. All newly installed equipment must be reported for 1 year. The 3-M system will eventually do away with the need for this report.

Electronic Failure Reporting System

The Naval Ship Systems Command has revised the electronic failure reporting system to overcome serious shortcomings in data collected under the system formerly used. Two major advantages of the new failure reporting system are reduction in fleet and shore station workload, and improved statistical and engineering value of reports.

By informing the material command of failures in electronic equipments, reports serve several excellent purposes: (1) They provide to the cognizant command a comprehensive presentation of the overall performance of electronic material. (2) They point out the weakest circuit components of particular equipment. (3) They are useful for calculating load lists and repair parts requirements. (4) Because new models (or modifications of older models) usually are in some stage of development, prompt receipt of failure reports enables the command to initiate immediate corrective action to eliminate similar or related deficiencies in subsequent production.

An efficient reporting system, sensitive to failure or replacement trends of parts and equipments, is required to provide information needed to measure and improve equipment reliability and maintainability. More reliable and maintainable Navy electronic equipment can result from data derived from this failure reporting program. Success of the program depends, however, on basic data being presented accurately and submitted rapidly by Navy personnel operating and maintaining the equipment.

The importance of reporting failures and their causes cannot be stressed too highly, particularly circumstances existing when failures occur under actual operating conditions. Failure reports must be filled in completely and in conformity with instructions accompanying report forms. Many reports received by the material command are valueless because they do not give essential information required by the form or because information given is incomplete. When indicating the model or type of equipment, include all significant nomenclature, modification, letters, and numbers. To avoid forwarding an incorrect stock number, check the number against the stock number identification table (SNIT) or allowance parts list (APL).

Guarantees: An additional and important purpose served by the failure reporting system is supplying information for use in enforcing guarantees on electronic material. When purchasing electronic equipment, it is the practice of NavShips in most instances to include in the contract a guarantee covering design, material, and manufacture of each set and their components and parts. In recent contracts the procedure has been to require a 1-year guarantee, to become effective upon the date of acceptance by the Inspector of Naval Material. This acceptance date (when available) and date of installation should be entered in appropriate logs, installation records, and equipment history cards.

To obtain maximum protection and effectiveness under terms of contractual guarantees, it is essential to report all failures promptly to the appropriate systems command. Information forwarded should be complete and described fully so that the systems command can conduct an analysis that will provide a basis for claim under the guarantee. An activity reporting a defect or failure may be requested to furnish additional facts to enable the systems command to pursue claims under contractual guarantees. The systems command provides instructions requiring such information after analyzing the defects reported.

Guarantees apply to replacements for parts, units and sets, as well as to the originals. Replacements must therefore receive the same consideration as original items regarding recording dates of acceptance and periods of service and reporting failures and defects promptly.

REPAIR PROCEDURES FOR REPAIR SHIPS AND TENDERS

Whenever practicable, between regular overhauls, type commanders arrange routine upkeep periods for their ships alongside a repair ship or tender. (Normally they are of 2 weeks' duration.) These intervals vary according to different types of ships. Small ships, such as destroyers, usually have an upkeep period every 6 months. Upkeep periods are planned to agree with quarterly employment schedules of ships concerned. Under normal conditions a ship knows in advance when and where she will go alongside a repair ship or tender.

Arrival Conferences

When a ship arrives at a repair activity, an arrival conference must be held promplty to discuss work requested by the ship. This conference is attended by representatives of the ship, repair department, and (usually) type commander. Relative needs of the ship and the urgency of each job are discussed. Jobs that are indefinitely stated in work requests are specifically defined and priorities are established. In other words, the arrival conference serves to clarify all uncertain items for the repair activity, which receives and studies work requests in advance.

PROGRESS OF WORK

As soon as work requests are approved at an arrival conference, jobs requiring delivery to a tender should be started immediately. Getting repair work started early is important for completion on schedule of all repair work.

Progress of repair work should be checked to be certain that (1) jobs are not delayed, (2) no job is overlooked or forgotten, and (3) all jobs undertaken are completed satisfactorily by the end of an upkeep period.

Progress of repair work in radio spaces should be known at all times by the leading Radioman. He should keep a careful check and estimate on the progress of ship's force repair work, and check on the progress of the tender or repair ship detail.

Repair ships and tenders usually assign a chief petty officer to be ship's superintendent. His duties regarding repair jobs are to act as liaison between ships alongside and the tender coordinator of shop work for assigned ships; report daily to a representative of the commanding officer of the ship to ensure that work is progressing satisfactorily insofar as the ship is concerned; maintain a running daily progress report or chart for each job, notify the ship to pick up completed material on the tender; notify ship's personnel to witness tests on repaired equipment; and, on completion of job orders, obtain signatures from cognizant officers.

PROCEDURES FOR SUBMITTING WORK REQUESTS

Procedures for submitting shipyard work requests preceding a regular overhaul are laid down (in general) in Navy Regulations and (in detail) in fleet and type commander regulations. In this topic, the method adopted by the Atlantic Fleet is used as an example. (In the Pacific Fleet, the procedure for submitting shipyard work requests differs somewhat in detail, as explained later.)

Commanding officers are required to submit their naval shipyard work lists to the type commander 60 days before a scheduled overhaul. After the type commander carefully inspects these lists, various items are approved, disapproved, changed, or corrected in accordance with standard repair policies. Lists then are forwarded to the shipyard no less than 30 days before starting the overhaul.

Ships having mimeograph machines are required to submit 30 copies of the work lists; others, an original and 6 copies. A separate (departmental) work list is made out for each of the following headings: hull, engineering (mechanical), engineering (electrical), electronics, and ordnance.

Items of work are recorded in relative order of priority for each work list of groups listed. After work lists are completed, a ship's priority index is prepared. Usually this priority index is made up in a conference of all heads of

ELECTRONIC PERFORMANCE & OPERATIONAL REPORT
NAVSHIPS 3878 (Rev. 4-60) *Submit original only to Bureau - No forwarding letter required* REPORT.BUSHIPS.9678-1

FROM: USS RANGER (CVA-61) (Ship name, type and hull no.) — LANT ☐ FLEET [X] PAC

TO: CHIEF, BUREAU OF SHIPS (CODE)

REPORT CLASSIFICATION	DATE
UNCLASSIFIED	1 Sep 6-
REPORTING PERIOD FROM 1 Aug 6-	TO 31 Aug 6-

TYPE AND MODEL OF EQUIPMENT	SERIAL NUMBER
AM-1365/URT Amplifier	383

FIELD CHANGES TO DATE	ACCOMPLISHED	NOT ACCOMPLISHED	HOURS DURING PERIOD OF THIS REPORT: OPERATED	NOT IN OPERATING CONDITION
	None	None	180	564

PERFORMANCE FIGURE (PF) & TECHNICAL EVALUATION: ☐ OUTSTANDING ☐ GOOD ☐ SATISFACTORY [X] UNSATISFACTORY

OPERATIONAL EVALUATION: ☐ OUTSTANDING ☐ GOOD ☐ SATISFACTORY [X] UNSATISFACTORY

RADAR

PEAK POWER OUTPUT (PT) dbm	AVER. VSWR IN TRANSMISSION LINE	AVER. ECHO BOX RING TIME YDS	MIN. DISCERNIBLE SIGNAL (PMDS) dbm

MAX. RANGE TARGETS DETECTED	MI	MI	MI	MAX. ALTITUDE AT RANGE DETECTED	MI	MI	MI
MAX. ALTITUDE TARGETS DETECTED	FT	FT	FT	RANGE AT MAX. ALTITUDE DETECTED	FT	FT	FT
TARGET CLASS. TYPE - DETAIL (SEE REVERSE)				TARGET CLASS. TYPE - DETAIL (SEE REVERSE)			
MAXIMUM RELIABLE RADAR RANGE MI				MINIMUM RELIABLE RADAR RANGE YDS			

SONAR

SOURCE LEVEL (LS) db//uBAR	RECEIVING SENSITIVITY db//VOLT/uBAR	SEA STATE	PROCEDURE USED			
NOISE LEVEL db//VOLT	5 KNOTS	10 KNOTS	15 KNOTS	20 KNOTS	25 KNOTS	30 KNOTS
MAXIMUM RANGE SONAR TARGETS DETECTED AND TRACKED	RANGING YDS		LISTENING YDS		SOUNDING FATHOMS	
TARGET CLASSIFICATION TYPE AND DETAIL						
BT PATTERN						
OWN SHIP'S SPEED.	KTS		KTS		KTS	

COMMUNICATIONS

PERCENT OF TIME OUT OF CONTACT WHILE WITHIN RANGE (IF ANY)	ANTENNA SYSTEMS	INTERFERENCE (Frequencies, intensity, and sources)
0 %	No problems	No problems

POWER OUTPUT	AVERAGE VSWR	REL RANGE	RECEIVER SENSITIVITY
Voice 100 WATTS	1.5:1	40 miles	NA UVOLTS

ELECTRONIC WARFARE

MAXIMUM RANGE AND ALTITUDE TARGETS ... DETECTED	MI	FT	MI	FT	MI	FT
TARGET CLASSIFICATION TYPE AND DETAIL (SEE REVERSE SIDE)						
MAXIMUM RELIABLE RANGE AND ALTITUDE	MI	FT	MI	FT	MI	FT
TARGET CLASSIFICATION TYPE AND DETAIL (SEE REVERSE SIDE)						

MAX. RANGE SONAR TARGETS DETECTED YDS	BT PATTERN	MAX. RELIABLE SONAR RANGE YDS	BT PATTERN

35.83.1

Figure 11-19. —Electronic performance and operational report (NavShips 3878).

TARGET CLASSIFICATION

TYPE	DETAIL
1. Large Plane (Bomber)	a. Own Ship's controlled aircraft
2. Small Plane (Jet Fighter)	b. An alerted aircraft approach or contact (An aircraft whose existence and location is known prior to being picked up on own radar)
3. Group of Planes	c. An unalerted aircraft approach or contact (An aircraft whose existence was not previously known)
4. Merchant Ship	d. An opening aircraft contact
5. Warship	e. An anticipated surface contact
6. Formation of Ships	f. An unanticipated surface contact
7. Submarine	g. Snorkling
8. Buoy	h. Submerged
9. Weather Front	i. Other (Explain)
10. Land	j. Unknown
11. Other (Explain)	
12. Unknown	

OUTAGE REMARKS: (Account for time equipment was NOT in operating condition. Show casualty, corrective action, outage time and comments. Include time inoperative for preventive maintenance and POMSEE. Reference Casualty Report, if one submitted on this equipment during this reporting period).

Equipment was in use for about 180 hours when C8, P.A. plate feed through capacitor, shorted, causing overload relay to kick out. Repair part not available on board, was ordered and not yet received. Three failures of this type have occurred among the eight units installed.

GENERAL REMARKS: (Comment on any problems or inadequacies encountered in the equipment. Comment is also desired on any item above or any item not covered by this report. When detailed tracking data is available and the equipment can be evaluated operationally, comment on such items as reliability, target discrimination and clarity. If overheating occurs report ambient and equipment temperature in degree. If equipment is considered to be operating satisfactorly, so state.) (Problem areas listed below are for convenience.)

Antenna
Cabling (including wave guides)
Design
Electrical
Interference
Lubrication
Maintenance
Mechanical
Overheating
Power input
Physical operation
Safety devices
Spare parts
Test equipment
Test points
Transducer
Tube failures
Vibration
Logistic support (Manuals, repair activities, overhaul, etc)

While equipment was operating properly, 40 mile range was consistent.

The failure of C8 is considered a design problem.

Experience to date has indicated that the AM-1365/URT is saving the 4X150A output tubes in the TED-8 transmitter. Longer tube life is gained through reduced drive required from the TED-8. Ten watts output is sufficient, compared with the attempt to drive the transmitter at 30 watts before the AM-1365/URT amplifier was installed.

SIGNATURE	CLASSIFICATION (Of this report)
C. O. Holt C. O. HOLT, CDR USN By direction	UNCLASSIFIED

35.83.2

Figure 11-19. –Electronic performance and operational report (NavShips 3878)--Continued.

departments and the executive officer. From individual repair lists various items are selected and are assigned in an overall order of priority for the ship.

Certain procedures are observed in making out a departmental work request list. Some type commanders require that each work item be submitted in the following form and contain information designated.

1. Description of item, including location, nameplate data, and (where applicable) plan numbers.
2. Report of existing defects in the item to be repaired.
3. Complete and full description of repairs required to place item in satisfactory operating condition.
4. Reference to authorizing correspondence, where applicable.
5. Stipulation whether ship-to-shop or other assistance is to be provided by ship's force.
6. Ship's inspecting officer or petty officer. (Persons names should have detailed information concerning repair items.)

Pacific Fleet Procedure

The maintenance data form (OpNav 4700-2J (revised) is prescribed for use as the single form for requesting work at the tender and shipyard level within the Pacific Fleet. It is necessary to refer to the latest CINCPACFLT Instructions to determine the timely submission of maintenance data forms and any documents that should accompany them. The requesting ship should prepare and forward the maintenance data form as follows:

1. Shipyard requests:
   - (a) Prepare an original and six typewritten copies for each work request in accordance with detailed instructions provided on the following pages.
   - (b) Forward an advanced copy to the cognizant repair activity (shipyard or support ship).
   - (c) Forward the original and four copies to the type commander via intermediate commanders as designated by the type commander.

2. For tenders:
   - (a) Prepare an original and three copies.
   - (b) Forward the original and two copies to the type commander.

The information covering the earlier OpNav 4700-2J series forms is applicable to the maintenance data form, although the block titles or number may differ.

SUPPLEMENTARY WORK REQUESTS

Supplementary work requests sometimes must be prepared in order to include items that arise after submitting original lists. Additional repairs may be required because of recent voyage casualties or because of conditions discovered during shipyard tests and inspections. In submitting a supplementary list, the same procedure must be followed as for original lists. Supplements are dovetailed into a ship's priority index.

In the period (approximately 3 months) between submitting original work lists and ship's arrival at a shipyard, unforeseen difficulties might arise, necessitating shipyard repairs. In such situations, an additional repair list, called the first supplement, must be prepared ahead of ship's arrival at the yard (if possible).

In accordance with an established procedure, and as requested by the ship, a naval shipyard holds numerous tests and inspections of equipment. These tests and inspections may disclose some additional repair items. When these initial tests and inspections are completed, a supplementary repair list is made out to cover any defects discovered. This repair list is called (as applicable) the first or second supplement.

Except the two instances mentioned, there ordinarily should be no further need for submitting supplementary repair items. In other words, all items requiring shipyard repairs should be written up and submitted before a ship arrives in the yard—not after she is in the yard for some period of time. In most instances, other last-minute repair jobs indicate a ship's maintenance program is inadequate, her CSMP recordkeeping is incomplete or not up to date, or that there is a lack of experience or knowledge in submitting a complete list of repair items for a shipyard overhaul.

Supplementary work lists sometimes are needed when many repair jobs are assigned for ship's force accomplishment, because of limitation of funds available for an overhaul period. After starting a repair job, for example, it may become evident that satisfactory repairs are beyond ship's force capacity. A request must then be made for the yard to make the repairs. To avoid such a difficulty, jobs of this type are written up preferably as ship-to-shop jobs. To illustrate, ship's force disassembles, assembles, and tests equipment, and the shipyard performs the needed repair work.

120-Day Letter

Alterations for accomplishment are authorized through the medium of the 120-day letter. The term "120-day letter" is derived from the requirement that directs its issue in sufficient time to be received by action addressees 120 days in advance of the scheduled beginning date for overhaul of a ship.

The 120-day letter is issued by Naval Ship Systems Command. It notifies the cognizant type commander, planning yard, and other interested activities of the specific ship alterations, under material command cognizance, to be accomplished during the overhaul period. It normally includes the following information: work authorized; available funds; materials required; plans for accomplishing specified work; operating schedule of ship; and status of ShipAlts that already may have been started and if any material is aboard for the ShipAlts authorized.

INSPECTION DUTIES OF SHIP'S FORCE

Inspection of work performed by a repair activity for a ship is the responsibility of both the repair activity and the ship. A repair activity makes inspections that will ensure proper execution of the work and adherence to prescribed specifications and methods. A ship makes any inspections that are necessary, both during its progress and upon completion, to determine if work is satisfactory.

The leading Radioman should schedule his work in such a manner that he is free at all times to inspect and check progress of shipyard work going on in his spaces or being performed on equipment for which he has responsibility of maintenance and upkeep. Before the job is considered fully completed, a check should be made to see if any required tests are made by the shipyard. Any tests that must be made by yard personnel are listed on the naval shipyard job order.

If any unsatisfactory work is being performed by shipyard personnel, leading RMs should follow instructions put out by the ship's engineer officer. Talking over the problem in a friendly manner with workmen usually solves any difficulty. If it doesn't, the division officer should be notified, and he should request the operations officer to take up problems of unsatisfactory work with the ship's superintendent.

In many ships it is customary for the division officer or operations officer to check with the leading petty officer before he signs off a job order as completed. By continuous inspection of shipyard work and checking off jobs completed satisfactorily, required information can be supplied promptly.

YOUR JOB IN SUPPLY

All naval personnel should possess a general knowledge of principles of the Navy's present supply system, in order to utilize the system fully and correctly. Of primary significance, also, administrative and supervisory personnel must have a sound working knowledge of methods used to obtain and properly account for their particular supplies.

A Radioman First or Chief is instrumental in seeing that repair parts and other materials are available in adequate supply. He also helps in planning for future needs. In general, these are main responsibilities concerning supply. Military Requirements for Petty Officers 1 & C has an entire chapter on supply, and tells what the leading RM should know and be able to do in fulfilling this part of his job. Coverage includes departmental budgets, material identification, estimating needs, procurement, receiving and inspecting, custody and storage, inventory, and expenditure of material–including surveys.

CHAPTER 12

TRAINING AND SUPERVISION

A First Class or Chief Radioman will take on many supervisory and training responsibilities. You must be able to train Radiomen and strikers at underway condition watches, instruct other communicators in CW and radiotelephone procedure, and supervise a communication office afloat or ashore.

This chapter treats aspects of training affecting communication personnel. It discusses training procedures that have become standard through custom and usage. Covered also are training concepts stated in governing publications issued by the Chief of Naval Operations, principally the effective edition of NWP 50. (This chapter is not, however, meant to replace that important publication.) The type commander's written instructions relating to training should be consulted to provide a detailed knowledge of what is expected regarding communication training and readiness.

SUPERVISION

For a well-trained communication division to function properly, adequate supervision and good supervisors are necessary. Without proper supervision, any training program that may be adopted will be of little value.

A supervisor is responsible not only for seeing that message traffic is handled properly but also, in most instances, for training lower rated men. You must understand the need for a training program and its continuous application. Duties and responsibilities of communication supervisors are discussed later in this chapter.

TRAINING

Training is the main factor contributing to battle readiness. Battle readiness, in turn, is the ultimate goal of all naval units. Training, then is of major importance to all hands.

A review of the following sources of information will help prepare you for training duties. If you already have served as an instructor, the references may provide additional information to help improve your methods of instruction.

- As a starter, study Military Requirements for Petty Officer 1 & C, NavPers 10057. Training responsibilities are outlined, and factors and steps in training are discussed. It also has good material on training aids, performance tests, and written tests. Radiomen can apply this information in specific training situations alfoat or ashore.

- The Manual for Navy Instructors NavPers 16103 contains information of value to a conscientious instructor. This is a basic manual for improving instructional techniques.

- Study also Shipboard Procedures, NWP 50. In it is described a shipboard training program which offers many ideas that can be applied in related situations.

- Make a habit of reading the Naval Training Bulletin, NavPers 14900. It features articles on the latest training methods practiced ashore and in the fleet. Answers to many training problems may be found therein.

- The United States Navy Film Catalog, Navweps 10-1-777 lists training films that will be helpful in preparing for training duties.

- Films and publications referenced in preceding paragraphs provide general information useful in teaching almost any subject. From there, instructors can learn much about organizing a training program and improving instruction methods.

COMMUNICATION TRAINING

Setting up a training program within a communication division is not an easy job. Many matters must be considered, including (1) type of ship or station, (2) number of personnel available, and (3) daily workload of the communication division. If at all possible, one man should be assigned to the task of supervising the overall training program, and coordinating the training of different watch sections and communication spaces.

It may become the job of a First Class or Chief Radioman to act as training petty officer. In order to handle this duty effectively and efficiently, the following "rules of procedure" suggested.

1. Become thoroughly familiar with all jobs within the division. This may seem like a large order, but you should already be familiar with these jobs because you performed most of them, at one time or another, as you advance in rate. To instruct other personnel to take over these jobs, you first must know how to do them yourself and be able to answer any questions that may arise.

2. Study all information concerning the Radioman in the Manual of Qualifications for Advancement, NavPers 18068 and Training Publications, for Advancement, NavPers 10052. Training petty officers need to know this information to help other Radiomen study for advancement. Also become familiar with the Record of Practical Factors, NavPers 1414/1 in order to judge properly whether a man is trained sufficiently in each qualification.

3. When setting up or administering a program, do not depend entirely on personal knowledge. There are many excellent publications that should be used as reference material. A few of the principal reference sources are mentioned at the beginning of this chapter. All of these publications should provide a sound foundation for any training program.

4. Make a list of subjects that need to be taught, based on individual needs of men in the division, as shown in table 12-1. Keep a record of what is taught, together with each individual's progress. An example of an equipment training record is seen in figure 12-1.

SCHEDULED TRAINING

It must be assumed from the start that an inflexible training schedule cannot work. Extreme variations in workload, caused by a ship's operating schedule, do not always permit a fixed training schedule. As a result, training time must be taken whenever opportunity is available. That is, it is scheduled only to the extent that it will be done, if at all possible, sometimes during the day, but the time varies. If training is absolutely precluded because of a heavy workload, a notation to that effect should be entered in the training log. Time missed can be made up when the workload is lighter.

In planning communication drills and exercises, FXP 3 is considered the best guide to consult. A suggested communication training program for Radiomen includes drills and exercises listed in table 12-1.

Prepare a lesson plan for each subject. When lesson plans are completed, they must be approved by the division officer. He is officially responsible for the content of such training programs.

Procure space for carrying out the lecture-type portion of the training program. Usually lectures are held in one of the radio rooms. If other space is available, however, check such features as possible seating arrangements, ventilation, lighting, and outside noise levels.

The following training program can be used both ashore and afloat. It is sufficiently flexible to fit into most situations. Also, it can be made to work for various sizes and types of ships and stations, whose workloads are different and varying. Possibly only one or two of these ideas can fit a particular situation, but the suggestions may bring to mind some other ideas.

First of all the training program should be written up as an instruction so that men administering the program will have guidelines to spell out their duties and responsibilities. Duties and responsibilities of the training petty officer and watch section instructor follow. Presented next is the training program itself. The training program instructor should adhere to a similar format.

- Training Petty Officer:

1. Sets up the training program under guidance of the chief in charge and the communication officer.
2. Coordinates training between watch sections.
3. Keeps correct and up-to-date progress records, lesson plans, and assignments.
4. Makes sure all lesson plans and exercises are approved by the communication officer before they are used.
5. Assists the watch section instructor to administer training, when necessary.

- Watch Section Instructor:

1. Normally is the watch section supervisor.
2. Administers training program to his watch section under guidance and (when necessary) with assistance of the training petty officer.
3. Helps men in his watch section find answers to written questions (given at training

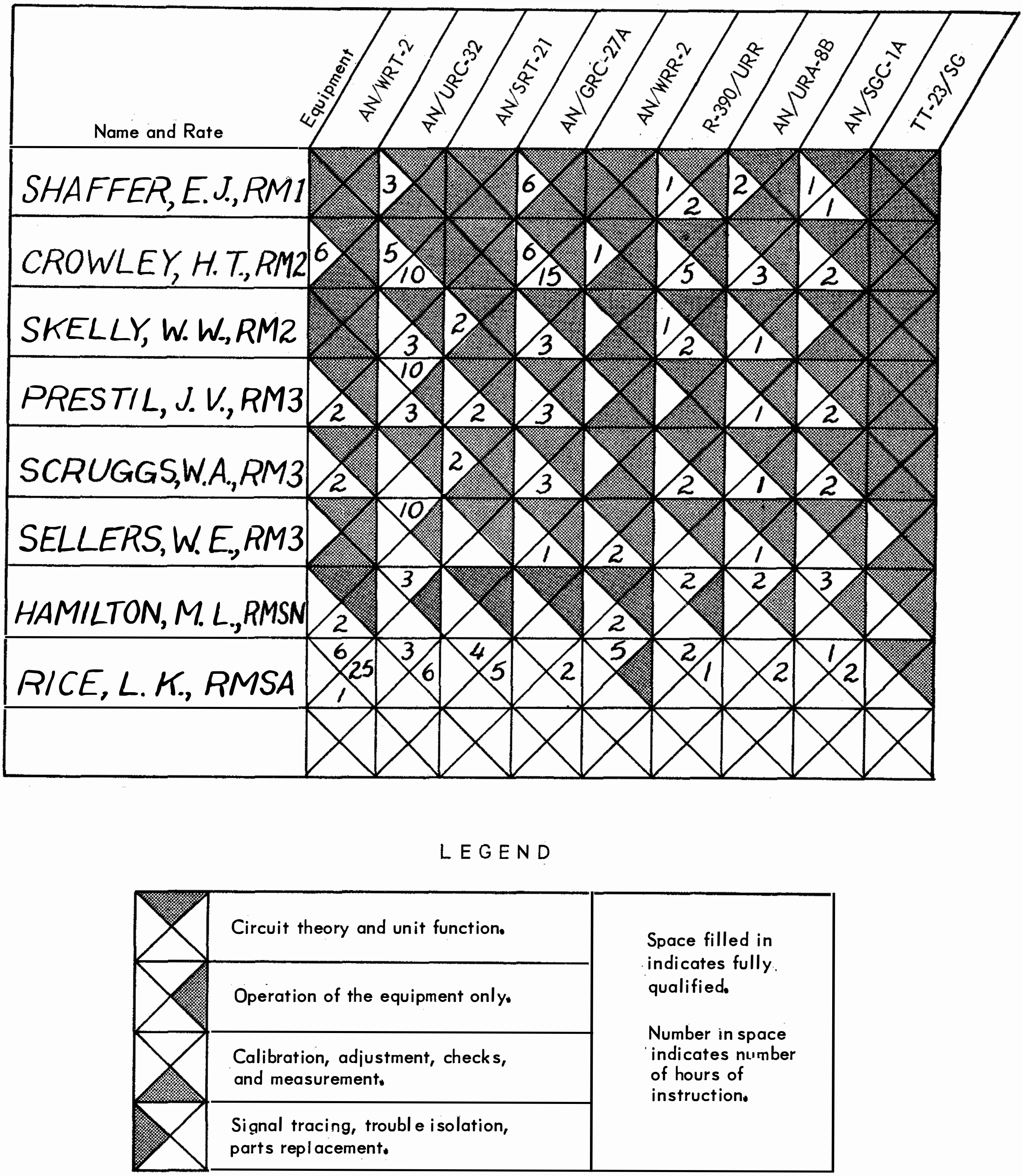


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Figure 12-1. –Equipment training record.

Table 12-1.–Lesson and Exercise Plans for Communication Shipboard Training Program

Title	Lesson	Exercise
Voice radio procedure	x	
Tactical voice radio drill	-	x
Administrative voice radio drill	-	x
Radio circuit operation	x	
Radio procedure	x	
Use of frequency meter	x	
Adjustment and calibration of radio transmitters and receivers	x	
Calibration and frequency shifting under normal conditions	-	x
Frequency shifting during conditions of radio silence	-	x
Cryptography and security	x	
Codes, ciphers, and crypto devices	x	
Cryptoboard instruction	x	
Cryptographic drill	-	x
Radio interference	-	x
Radio jamming and heckling	-	x
Radio equipment transfer panels	x	
Coordination and dissemination of tactical signals between radio, CIC, and bridge	x	
Communication publications	x	
Security of classified publications	x	
Encrypted traffic handling	x	
Authentication systems	x	
Radio call sign cipher	x	
Transmission security	x	
Distress traffic	x	
Tactical radio communications	x	
Casualties, failures, and use of emergency equipment	x	
Logs and records	x	
Preventive maintenance	x	
Radioteletypewriter procedures	x	
Teletypewriter equipment safety precautions	x	
Maintenance of teletypewriter equipment	x	
Emergency destruction procedures	x	
Transfer of control of radio transmitters and receivers to remote positions	-	x
Internal handling and tactical communications	-	x
Authentication drill	-	x
Radio call sign cipher drill	-	x
Equipment casualty drill	-	x
Main radio destroyed in battle	-	x
Rigging and use of emergency antenna	-	x
Emergency destruction of classified matter	-	x
Telephone talker instruction	x	
Telephone talker drill	-	x

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sessions) that trouble them. He should not answer questions outright, but show them where or how to find correct answers. If they still have trouble, he should explain the question(s) to them and (if necessary) supply the answer with an explanation of how it fits into their daily duties.

The Program

In the following paragraphs, a training program has been planned, and it has proven successful in many instances; however, it may not be workable in your particular situation. The main objective to keep in mind is the importance of a program of some kind rather than leave training to chance.

Designate the days afterthe first and second evening watches as training days. Have the evening watch for these two days report at least 1 hour before they are to assume the watch. Explain to the men that these periods will help make their jobs easier, help them make the next rate, and be generally beneficial both to them and to the Navy. Such an approach will help them develop a positive attitude and a willingness to learn.

The first of the two training days is divided into two periods. If each day is set up for 1 hour, each period will run for 30 minutes. The first period should be utilized for reviewing the assignment from the last two periods of the last training day. If time permits, a review can be made of subjects covered in the last two periods but not covered in the assignment.

The second period of this day should be used as an application period devoted to the subject of the last lesson–CW drill, voice circuit drill, and authentication drill, for example. This period can be used also to apply the previously learned knowledge on repair and maintenance of different equipment carried aboard.

The second day is designated as lecture and assignment day. It too can be divided into two periods, each period to cover a different subject or two parts of the same subject. Because it is a regular classroom situation, a lesson plan should be used.

Assignments should be so arranged that they may be worked on during slack periods of succeeding watches. A lesson assignment is given on the second training day, and is turned in on the first training day of the next string of watches. Such a plan gives a total of 11 days for completing the assignment. Make sure there is enough material, so that the assignment will be challenging, but not more than can be handled during the time available. If a man is in training to take over another position on the watch bill, for example, assignment questions can be made up to have him give answers on what is done at that position. During any slack period he can check with the man currently doing the job, and discuss the answers with him. It is possible that both men will learn something from the discussion. The man in training is more likely to remember the answers if he writes them down.

One point must be remembered: For any training program to work, it must be worked at.

NONSCHEDULED TRAINING

Nonscheduled training consists merely of seizing unforeseen opportunities for training purposes. To illustrate, a teletypewriter, printing unit, withdrawn from its cabinet for routine maintenance, may present an opportunity to launch into a discussion of it. It would be an ideal time to indicate lubrication points and operating adjustments on the machine. Any information that can be passed to the men–regardless of time, place, or subject matter–is actually a form of training. An accurate record should be kept of subjects taught and how thoroughly each subject was covered. The same records used for scheduled training can serve also for checking off a man on the subject covered during nonscheduled training (Refer to fig. 12-1.)

TRAINING SCHOOLS AND COURSES

Radiomen at every opportunity should take advantage of courses offered by fleet training schools and class C schools. These schools last from 2 days to 2 months. Loss of a man from the watch bill for schooling periods may impose a temporary handship, but knowledge gained by the man will help him do his job more effectively, and he probably can become an instructor in the training program. Any selection to a training school is, of course, subject to approval of the division officer.

Selection of men to attend school should be made far enough ahead of time that a replacement can be obtained for an experienced man before he is transferred. Need for someone trained in teletype maintenance or crypto repair, for instance, should be anticipated in advance.

The nuclear, biological, and chemical (NBC) warfare defense, and firefighters' school offer preparations for controlling casualties. Each Radioman should have some knowledge of these subjects.

Make sure the men know what materials they need to study to advance in rate, and that they order correspondence courses in ample time before the next exam. Let them know that you will be available to help them with the courses if they run into trouble. Because the Basic Electricity and Basic Electronics courses are difficult, some men may need encouragement in order to finish these courses successfully. They contain material that is included in the exams for advancement to all pay grades of Radiomen. Any knowledge the men can gain from these two courses will benefit the maintenance program.

COMMUNICATION TRAINING AFLOAT

When a new man reports to the communication division, an indoctrination schedule should be set up for him.

INDOCTRINATION

The sooner a newcomer becomes adapted to his new assignment, the sooner he becomes a valuable member of the communication team. A man's background and previous duty stations should be considered in determining how long his orientation period should last. Normally, a few days to a week should be enough time for indoctrinating him.

After the new Radioman is assigned a bunk and locker, introduce him to all hands in the division. Arrange a tour of the ship for him, concentrating on communication spaces. Encourage him to ask questions about unfamiliar equipment or procedures. A thorough explanation will square him away more quickly. Go over the communication division watch, quarter, and station bill and show him just where he will fit in. He should realize that soon he will be filling a responsible position on that bill.

Several publications should be made available to the new man to acquaint him with the ship's functions and with his own division's responsibilities. Check out copies of the ship's organization and regulations manual, and the operations department or communication division organization manual. It's a tall order to read through these publications page for page, so point out sections that are particularly applicable and important to a new man, and see that he has sufficient time to read them.

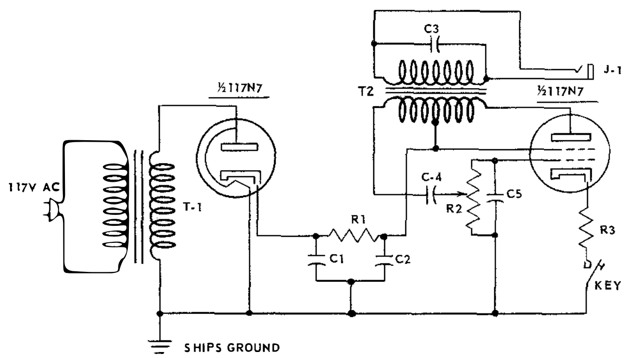
Radio Central is the best place to review ACPs, JANAPs, and other communication publications. There the new man can study them during the watch stander's slack periods.

Spend as much time as possible with the new communicator during his orientation period. He will catch on faster, and will need less of the instructor's time later on.

QUALIFYING FOR CIRCUIT WATCHES

Graduates of Radioman school reporting aboard are often inexperienced in shipboard communications. They need further training to qualify for circuit watches. Men recruited from other divisions, who did not attend Radioman school, must be trained immediately in fundamentals of radiotelegraphy and touch typing. A situation of this kind calls for an intensive training program capable of producing quick and satisfactory results.

An audio oscillator for code practice, similar to the one shown schematically in figure 12-2, can be patched into remote positions throughout the ship. The one-tube oscillator illustrated can be built from scrap parts.



T-1	1:1 ISOLATION TRANSFORMER	C1/C2	20 MFD 150 VOLTS
T-2	ALMOST ANY TYPE OF INTERSTAGE AUDIO TRANSFORMER CAN BE USED	C-3	.01 MFD 200 VOLTS
		C-4	.01 MFD 200 VOLTS
R-1	300 OHMS 2 WATTS	C-5	.001 MFD 200 VOLTS
R-2	500 K POTENTIOMETER	J-1	PHONE JACK
R-3	600 OHMS ½ WATTS		

NOTE: GROUND CHASSIS TO SHIPS GROUND TO ELIMINATE SHOCK HAZARD

50.1

Figure 12-2. –Code practice oscillator.

Transmitter and receiver switchboards installed in Navy ships make it a simple matter to patch any number of operating positions for code practice or intraship drill circuits.

Other sources of audio signals are also available in any ship for beginners' code practice. The "squeal" can be keyed from the frequency meter, for instance. Power is switched on all the time, anyway, so as to maintain constant temperature and frequency stability. Additional sources of audio signals are radio receivers, such as models AN/SRR-11, -12, and -13, which have crystal calibrators for resetting accuracy of dial readings. Turn on the calibrator switch to obtain a beat notefor patching into remote operating positions.

Be sure strikers take advantage of drill circuits available in many United States ports and U.S.-controlled ports overseas. These drill circuits provide an opportunity for live, on-the-air CW, radiotelephone, and RATT practice under strict supervision.

When Radiomen strikers are checked out sufficiently on drill circuits, have them submit afterhours fleet broadcasts and weather copy. A graduate from these assignments is ready to stand regular watches on a fleet CW circuit.

COMMUNICATION SPACES

Depending on her size and type, a shipmay have as many as five radio spaces. In a few instances there may be more than that number. As many men as possible should be checked out in all (or most) of the communication spaces. Rotate the watch bill occasionally, so that every man has a chance to qualify for watches in more than one space. Be sure the supervisor for each space is qualified to instruct the men under him in his particular space.

Men should also know the types and location of antennas on board. Be sure all of the men know how to rig emergency antennas. One or two antennas should be made up in advance, ready for rigging. All communicators should know where the antennas are stowed.

All of the foregoing details can be incorporated in the training program. The more training men receive in these routines, that much easier is everyone's job.

OPERATOR TRAINING

Men should receive proper training from the beginning. It is much easier to teach a new man the correct way to operate on a circuit than it is to break him of any bad habits he may pick up if left on his own. The next three topics deal with training new operators.

Radiotelegraphy Operator (CW) (ACP 124)

A new man on the CW circuit soon learns that an unhurried, steady pace results in faster delivery. In addition to correct sending techniques make sure the new operator observes proper circuit discipline from the start of his training. Use of unauthorized plain language and incorrect procedure result in confusion and ambiguity. It's just as easy--and always better –to practice correct procedure.

Be sure that all CW operators are thoroughly trained to handle authentication procedures. Improper use of authentication can cause a loss of valuable time and possibly have disastrous effects upon an operation.

Check a new operator's radio log for consistent accuracy. Make certain he realizes that his log constitutes a legal record, for which reason it is absolutely necessary that the radio log be complete and accurate at all times. This requirement is especially important because RM "A" school graduates are only prepared for 10 words per minute.

Radiotelephone Operator (ACP 125)

Give every new talker the benefit of close supervision. Be sure he acquires a natural delivery and uses only standard phraseology. Soon he will realize that proper delivery reduces needless repetitions.

Excessive testing, adlibbing, and improper microphone technique are old foes of correct operating procedure. Warn new operators about these pitfall as soon as they don earphones.

Radiotelephone operators must have a thorough knowledge of radiotelephone authentication procedures. Hold frequent authentication drills, stressing conformity to prescribed procedures.

Radioteletypewriter Operator (ACP 126, 127, and JANAP 128)

The mark of a good teletypewriter operator is speed without sacrificing accuracy. A light, quick, positive touch of the keys is the best sending technique. See that operators adhere strictly to authorized procedure and that they correct typing errors.

Do not consider your men trained as Radioteletypewriter Operators until you have a few 60 to 70 WPM operators. At times of peak traffic, such as during collisions, attacks, search and rescue operations, etc., outgoing message traffic increases to 10 times normal traffic flow. Considering possible equipment shortage or breakdown, 30 WPM operators will not clear a backlog if only one teletype machine is available for preparing message tapes.

PREVENTIVE MAINTENANCE PROGRAM

Plan the communication division preventive maintenance program in a systematic fashion. Assign each trainee a specific piece of equipment, then give him a thorough indoctrination on it. Show him how to perform operating tests, proper method of routine lubrication and cleaning, and correct troubleshooting procedure. Have at hand, for ready reference, the equipment technical manual and current checkoff sheets designated by the PMS program. Let the trainee locate pertinent sections on preventive and corrective maintenance. He should become familiar with the books and realize the importance of following recommended procedures.

When convinced that the trainee can take over on his own, have him make the daily and weekly tests designated as routine or operational. As his training and experience progress, give him increasingly difficult technical items.

COMMUNICATION TRAINING ASHORE

Communication for a shore station is much the same as aboard ship in that the same general communication procedure and similar equipment are used.

It would follow, then, that a shore station training program can be set up in much the same manner as that used aboard ship.

Probably the main difference between afloat training and ashore training is that at a shore station equipment used is spread out over a wider area. Each man ashore has little opportunity to be trained in operating equipment and procedures not employed in the immediate vicinity of his station.

Radiomen stationed at a tributary station, for example, rarely have an opportunity to work with antennas, transmitters, or receivers. Practically all their time is spent with shore-station teletype equipment and message center procedures. Most training in this area can be accomplished on the job. A good message center supervisor takes advantage of every opportunity to train a new man by breaking him in at an operating position as soon as he completes his indoctrination. On-the-job training is the best way of increasing a new man's efficiency. At the same time the trainee has status as a regular watch stander. Each operating position in the message center or relay center offers a chance for on-the-job-training.

Scheduled training time, such as the program mentioned previously, can be concentrated on subjects not covered by on-the-job training. These subject are what Radiomen at a shore station do not come in contact with during tours ashore but need to know in order to advance in rate and on future tours at sea.

Usually, such training aids as chalkboards, training films, and mockups are more easily obtainable ashore than aboard ship. These training aids can be used for instruction on transmitters, receivers, and other subjects not readily available at shore stations.

COMMUNICATION SUPERVISORS

Supervision includes organizing activities of group members toward accomplishment of a given task. Duties and responsibilities of each member of the watch section are spelled out in detail so that every man knows exactly what is expected of him. Merely listing duties does not necessarily ensure that they will be accomplished, however. To gain a specific objective, a supervisor must regulate activities of his men by establishing a standard operating procedure for all routine tasks.

Problems of supervision and discipline are complicated because they affect human beings. Discipline not only demands obedience from subordinates but also requires that the supervisor lead and command. Discipline demands that the supervisor assume responsibility, exercise initiative, and issue instructions. His failure to exercise authority, or misuse of authority, can destroy discipline just as surely as can disobedience. Discipline is comprised of two elements: one component coming from above (the will of the man in charge), and the other from below (the willingness of subordinates to obey). In the Navy, willingness to obey is founded on reason, reinforced by habit. Not only must trainees be taught that the law compels obedience is an indispensable element of collective action and survival. Discipline develops character instead of stifling it.

Operation and maintenance of electronic equipment call for the utmost concentration.

For this reason, trainees need periods of relaxation. If no allowance for fatigue is taken into consideration, work may fall behind schedule. On the other hand, if the supervisor grants an excessive number of breaks, he may lose control over the group. He must strive for a happy medium in each situation, and be flexible enough to allow for changing conditions. Many times an all-out effort must be made to complete a task in the least possible time. Under these circumstances the maximum effort is demanded of all hands.

RADIO

The manner in which different radio spaces aboard ship are manned and supervised depends on the size and type of ship and the number of personnel available.

A supervisor of a radio space is directly responsible to his watch section supervisor for proper operation of his space. He must see that all equipment within the space is in good operating condition and that all circuits function properly.

To carry out his duties effectively, the radio space supervisor must know how to tune, operate, and patch equipment in a minimum amount of time without making errors. He needs a working knowledge of what different circuits within a unit of equipment do and how they do it, so that when trouble occurs he can make necessary adjustments or repairs in the shortest practicable time. If a technician is needed, the supervisor should be able to explain, knowledgeably, the nature of equipment trouble. His explanation will help the technician find the trouble more quickly, thereby reducing the time required to place equipment back on the line.

Circuits for which the radio space supervisor is responsible must be operated according to established procedures. He must see that good circuit discipline is maintained at all times. To accomplish these ends, he must learn thoroughly the CW and voice circuit procedures set down in ACPs 124 and 125.

Although each radio space has its own job to do, the overall job for all of them is sending and receiving messages as accurately and quickly as possible. A good supervisor, therefore, not only knows his own space well but also has a good working knowledge of all other spaces. When he brings up a receiver or transmitter on a particular circuit, or patches some equipment to another space, he must realize how and why it is being used. This awareness helps him to know what circuits must be watched more than others, and he can set up a priority system for circuit restoration in the event of outages.

The radio space supervisor must comprehend information contained in the communication plan pertaining to his space so that he will know when, where, how, and why different circuits are set up. Thus, when his ship is about to go on an operation, he should make himself familiar with that part of the communication annex of the operation order pertaining to his space, so that his space will be setup and ready to go when the operation begins.

WATCH SECTIONS

The watch section supervisor is directly responsible to the CWO for proper operation of all radio spaces and their circuits. During his watch, he also must ensure that message traffic is handled accurately and without delay.

Besides understanding thoroughly all information mentioned previously for the radio space supervisor, the watch section supervisor should be able to coordinate activities of all spaces and see that they work smoothly together. He supervises men on his watch in doing their jobs of message handling, using correct circuit procedure, tuning transmitters and receivers, setting up crypto equipment, and operating teletype and associated equipment. He also checks to see that all equipment is patched correctly to make up the different circuits in use.

A good watch supervisor makes sure that all incoming messages are delivered as quickly as possible in a complete and legible form. All outgoing messages should be routed promptly and sent out accurately and in complete form the first time, to ensure rapid delivery and thus prevent overloading circuits with service messages. He must see that good circuit discipline is maintained on all circuits. All supervisors should know how and when to encrypt call signs, and make sure that encryption is done properly. When necessary to authenticate on a circuit, the supervisor must ascertain that correct publications are referred to and that procedures are followed.

All watch supervisors should have a good understanding of frequencies that work best during different times of day. In this way the outages are kept to a minimum on broadcast circuits and on the NavComOpNet circuit (if used). Along with this duty he supervises setting up transmitters and receivers so that they are on frequency. A receiver slightly off frequency causes incoming traffic to be garbled. A transmitter off frequency might possibly cause the same trouble at the other end as well as interference to other stations. A watch-to-watch check of publications must be made. Moreover, the supervisor should be familiar with the contents of those publications so that he will know where to look for information needed on a certain subject.

The teletype range should be checked periodically so that the optimum setting always is used. Associated equipment should be tuned correctly so that the best possible signal is received, thus ensuring that incoming messages are not garbled,

All circuits must be patched correctly to ensure that the foregoing precautions and procedures are fully effective. Make sure that equipment is patched only when necessary and that only proper equipment is used on the different circuits. Many responsibilities of a supervisor can be made lighter if he is assured that men on his watch can handle the various jobs efficiently. To accomplish such a goal, continuous and effective training should be part of their daily routine. On-the-job training, adequately supervised, is one of the best ways to ensure that men of a watch section work together smoothly.

COMMUNICATION WATCH OFFICER

Aboard some ships and stations a chief or even a first class petty officer will possibly stand watches as a communication watch officer (CWO).

While on watch, the CWO is in active and immediate charge of ship or station communications. As provided for in a communication organization, he is responsible for incoming and outgoing traffic. In this capacity, he ensures that all messages sent and received are in correct form and that they are handled promptly and efficiently. During his watch, he is responsible for proper operation of the cryptocenter and for security of all spaces. The CWO is also responsible for the security and proper operation and maintenance of equipment and other material in all spaces. He likewise must ensure that classified traffic is delivered on a "need to know" basis only, and that each copy is numbered and accounted for at all times.

EQUIPMENT CASUALTY

The speed with which corrective action is applied to a communication casualty depends on effective personnel utilization and constant training. When your ship puts out on a mission, all hands must do everything possible to keep the ship afloat and to protect the lives of the crew. A Radioman supervisor must know what to do and how to do it when accident, fire, or enemy action threatens the safety and fighting ability of his ship and men. He must indoctrinate his subordinates with the necessity for prompt action in instances of material failure or battle casualty. Wasted time may cause needless damage to equipment or even loss of life.

ADVANCE PREPARATIONS

You can avoid confusion during actual emergencies by making advance preparations. Have each man study the watch, quarter, and station bill so that he knows his assigned station and duties perfectly. See that each man checks the bill frequently for possible changes. Query each Radioman, especially a newcomer, on the exact location of his abandon ship station as well as on his assigned station for all other emergencies. Ask him the location of the first aid station nearest radio central and other radio spaces, and the site of the decontamination station. Ask him what piece of firefighting equipment he would use to extinguish a class C fire. Make sure he knows the quickest and safest route to emergency radio spaces.

Every member of the radio gang has a part in carrying out the emergency destruction bill. Your men should know the exact location of destruction material (sledges, wire cutters, screwdrivers) and weighted perforated bags. Each man should read the destruction bill carefully, and note particularly the items he is to destroy when directed.

Examine battle lanterns daily and make sure spare flashlights are available for immediate use.

Check first aid kits to see if they are fully stocked. If a kit's seal wire is broken, an item may be missing. Have the medical department replenish as necessary. (in some ships only medical department personnel are authorized to inspect first aid kits.)

Make sure that emergency, distress, scene of action, and SAR frequencies for your area are posted conspicuously. Each operator must be alert and acutely aware of the fastest means for delivery of distress or emergency traffic.

Ensure that any defect that could affect the safety of an individual or cause electric shock is corrected immediately.

See that your damage control petty officer does not neglect ports, doors, hatches, and other closures under the various damage control conditions of readiness.

In most ships, engineering personnel are responsible for weighing CO extinguishers monthly. Be sure they are weighted, and check to see that the date and charge weight are entered on the bottle tag.

In the damage control bill and associated bills, review procedures for controlling blast and thermal radiation damage resulting from attacks by nuclear weapons. Because radiological hazards occur only with nuclear weapons, procedures for controlling the effects of nuclear radiation on personnel are found in the radiological defense bill, one of the associated bills. Know the contents of this bill and make sure your men are familiar with its provisions.

Detailed information on the subject of defense against atomic attack may be found in the effective editions of Basic Military requirements NavPers 10054, Military Requirements for Petty Officer 3 & 2, NavPers 10056, Military Requirements for Petty Officer 1 & C, NavPers 10057, and in the Naval Ships Technical Manual.

STANDBY EQUIPMENT AND STATIONS

Designate backup frequencies, transmitters, receivers, antennas, and terminal equipment for emergency operations in locations as widely separated as possible. Ensure that spare emergency receiving and transmitting antennas are made up and stowed in appropriate locations for rapid rigging when required. See that all standby stations have all necessary communication publications, such as call sign books, authentication tables, call sign cipher devices, logs, and message blanks. Your operators at standby stations should monitor circuits constantly so they can take over instantly if a breakdown or more serious casualty occurs in main radio.

KNOW YOUR EQUIPMENT

Knowledge is the keystone of casualty control. During emergencies there is no time to teach a man how to tune a transmitter or patch transmitters and receivers to the various remote stations. Loss of key COMMCEN or radio central personnel may leave your strikers to carry on. Each man should know each type of equipment thoroughly. When new equipment comes aboard, study the technical manual carefully, then show your men how the equipment Stress safety precautions spelled out in the technical manual, and don't let a man touch the gear on his own until he is checked out completely.

If a frequency meter is knocked out, you must refer to calibration charts to tune some of the older model transmitters. Hold drills to see that each man can set up frequencies from these charts. Stress proper procedures for tuning transmitters under radio silence conditions. See that operators' instruction charts for tuning each transmitter are posted near the equipment.

Each man should understand the flexibility of transmitter and receiver switchboards in the various radio spaces. If a shorted trunkline occurs between radio II and radio I, for example, the desired transmitter can be patched through radio III in seconds if your men are well trained in switchboard operations.

HEAVY WEATHER PRECAUTIONS

Damage and loss of equipment sometimes occur during heavy weather when equipment is not secured properly. Loose gear can cause injuries to personnel and may start a fire if it slides into electronic equipment.

Check all radio spaces as soon as word is passed to rig ship for heavy weather. Chairs, wastebaskets, and all loose gear must be lashed down securely. Once you are certain that all necessary steps have been taken in your spaces to rig for heavy seas, notify the COMM officer and OOD.

SIMULATED CASUALTIES

Have your radio gang demonstrate ability to make repairs quickly and handle each simulated casualty or failure satisfactorily. For best results, follow a detailed plan of action, stressing necessity for speed and accuracy. To get the most from your men in the shortest possible time, follow the general procedures described in the remainder of this topic.

After first clearing through the radio officer or communication officer, ask the OOD for permission to hold a casualty drill. Brief participating personnel thoroughly on the purpose and importance of the drill and the procedure to be followed in conducting the exercise. Each man must know exactly what his job is. Questions should be asked at the briefing-not during the drill.

When you are ready to proceed with the drill, declare the casualty. State, for example, "Main radio completely destroyed," and specify "All personnel in main radio are casualties." (Or you may declare only certain individuals as casualties.) Participating personnel should then carry out the objective of the drill.

Normal communications should not be disrupted in your simulated casualty drills. Be sure to analyze errors and discrepancies, if any, and show each man how to correct them. Notify the OOD upon completion of your drill.

ACCURATE REPORTS

Many precious minutes can be saved by communication personnel in reporting casualties promptly and accurately. Drill your men in the following procedures so that, when the next emergency comes up, the casualty will be reported swiftly and correctly.

To report the casualty, use sound-powered phones, MC units, ship's service telephone, voice tubes (if installed), or messenger. The initial report should contain the following information:

1. Nature of damage (class C fire, bomb hole, shock casualty);
2. Location of damage;
3. Extent of damage (flooding, fire, smoke, or toxic gases present, etc);
4. Measures being taken to combat damage (firefighting, type of extinguishing agent etc.);
5. Assistance required.

CASUALTY SITUATIONS

Every Radioman knows that the damage control organization aboard ship is mainly responsible for accomplishing emergency repairs or restorations after damage occurs. During battle, collision, heavy weather, or serious fires, the damage control and firefighting parties are ready with trained men and special tools for action against fire and damage. A damage control party may supply casualty power, regain a safe margin of stability and buoyancy, replace essential structures, and man essential equipment. But no one can foresee just where the damage or fire will strike. Remember, COMM spaces are vulnerable to bomb and shell hits causing fires or personnel casualties. If there is a casualty in a radio space, the regular damage control party may be tied up in other parts of the ship. Your men on the spot in radio central or other communication spaces may have to fight the fire and repair the damage.

The remainder of this chapter describes common types of communication casualties and suggests remedial measures to correct them. Bear in mind that a method suggested may not be the only solution. As supervisor, be ready to improvise, because you may not have time to follow an established pattern. Remember to adapt yourself and your men as expeditiously as possible to the conditions confronting you.

CASUALTIES TO EQUIPMENT

Communication equipment failures during fleet operations or in battle are casualties that, if not corrected immediately, can have disastrous results. Communication personnel must be able to detect and remedy such casualties as quickly as possible.

In an equipment casualty, your first responsibility is to reestablish communications on alternate equipment. After shifting, direct your efforts to restore the defective equipment to proper operating condition. Equipment casualties can occur because of such a variety of causes that the remedial action needed to restore communications may be a simple matter, or it may be difficult. A power failure, for instance, may disrupt every communication circuit in radio central. The remedy may be as simple as throwing a single emergency power switch from the normal power to emergency power position. The cause of the failure may be so serious, however, as to require rigging of emergency power cables by the damage control party.

Let us consider another example: failure of the RATT broadcast receiving system. The trouble may be in the antenna, antenna filter patch panel, radio receiver, receiver switchboard, frequency shift converter-comparator, on-line cryptodevice, teletypewriter patch panel, rectifier power supply, teletypewriter switching control unit, or the teletypewriter itself. In addition to each of these system components, the trouble may be in the interconnecting lines. You have learned from experience what to check first in your own system of troubleshooting diagnosis. Shipboard equipment installations provide the needed flexibility for patching alternate equipments into the system.

After communications are reestablished, the next task is to troubleshoot the defective equipment. An important step in this process is to localize the source of trouble to a small section or stage of the equipment before making detailed checks on individual part. Proper isolation of the trouble to a definite section avoids time-wasting detailed checks in sections or circuits that may in themselves be completely free of defective operation. Consider the existing trouble instead of making spot checks all over the equipment. Many troubles, particularly in transmitters, can be traced to a section or stage with the meter readings available on the front panel of the equipment.

All equipment technical manuals include a chapter on troubleshooting. By means of charts, the repairman is guided step by step through the various stages of the equipment. The charts show him what action to take, the normal indication to be expected, and where to proceed if the normal indication is not obtained. Be sure your men consult the technical manual in their attempts to correct an equipment casualty. Because the troubleshooting chapter is not numbered the same in each book, it is a good idea to paste an index tab to mark the place in each technical manual. This method saves your men time when the information is needed in a hurry.

CASUALTIES ASHORE

Disaster control bills and emergency communication plans for your communication activity emanate from the local district communication officer (DCO) and conform to directives from DNC. These instructions specify procedures to follow in fire, flood, accident, enemy attack, hazardous weather, and other disasters. Common examples of disaster control bills are fire bills, flood bills, and hazardous weather bills. From time to time these instructions are supplemented by station regulations.

You are particularly concerned withthe fire regulations and bills posted in the COMMCEN, terminal buildings, and other operational communication spaces. Keep up with any changes in these bills, and frequently quiz your men on their contents.

FIREFIGHTING

Communication activities ashore maintain fully equipped fire departments capable of dealing successfully with practically any type of fire. At locations where COMM units are within easy reach of each other, a central fire department serves all units in the area.

What you do as supervisor of the watch until the fire department arrives is governed by conditions at the time. In general, however, the following procedures apply to most situations.

If fire is in equipment, first secure power, attempt to extinguish the fire, and always notify the fire department immediately—even for small fires. Fire spreads rapidly, and at shore stations fire extinguishers are no more effective than first aid appliances.

For continuity of communications, come up on alternate circuits or use other available equipment as soon as possible, and notify associated communication units of your actions. For example, a fire in the main building at a receiving station must be reported immediately to the associated COMMCEN and transmitting station.

Close windows and doors. Have your men shut off any air-conditioning or forced draft air heating, cooling, or ventilating system. As a last resort, it may be necessary to secure or cut electric service lines to the building.

In fighting the fire, ensure that the most appropriate extinguisher is used. Fight class A fires with extinguishers of the hand pump type (water), pressure reaction type (carbon dioxide cartridge and water), sand, or high/low velocity fog. Use the pressure reaction, foam, high/low velocity fog, or CO_2 type on class B fires. Extinguish class C fires as previously discussed.

Make sure exposures are protected. (Exposures are structures in danger of becoming ignited by fire originating in an adjoining or neighboring building.) Evacuate and protect exposures by wetting surfaces, closing windows and doors, and protecting roofs and other combustibles from sparks and burning brands. Break up radiating heat waves with heavy streams of water.

EVACUATION

If it becomes necessary to evacuate the building, evacuation is under the direct supervision of the senior officer present, supervisor of the watch, or other enlisted personnel (if designated).

Before evacuation, take the following steps to ensure protection of classified and unclassified material.

1. See that all windows are closed.
2. Make certain that all steel file cabinets and desks are closed.
3. Ensure that all classified publications and correspondence are locked in steel file cabinets or carried from the building.
4. Where practicable, have all power shut off from equipment in building.

After the foregoing precautions are accomplished, march all personnel to a place of safety. Follow the evacuation routes prescribed in your station's fire and evacuation bill.

RIGGING AN EMERGENCY ANTENNA

Loss or damage to an antenna from shell or bomb hits, heavy seas, or violent winds can cause serious disruption of vital communications. Sections of a whip antenna may be carried away, external insulators may be damaged, or a wire antenna may snap loose from its moorings or break. Your job is to supervise the rigging of an emergency antenna to restore communications on a temporary basis until repair or replacement of the antenna.

In rigging emergency antennas, have your antennas already cut to proper length, with necessary insulators and turnbuckles secured to the ends. Keep them coiled and stowed so as to be readily accessible. With these preparations made beforehand, a jury rig can be set up with minimum delay. Methods of rigging vary, of course, in accordance with the type of ship, location of transmitting and receiving equipment, and the extent of loss or damage.

Before rigging an emergency antenna, make sure transmitter power is secured, then get permission from the OOD. Men assigned to go aloft must have proper equipment, such as safety belts and necessary tools. Notify the OOD when the antenna is rigged satisfactorily, and have the transmitter returned to the new antenna.

SAFETY PRECAUTIONS

Fast action and an automatic regard for safety precautions are extremely important in coping with casualties to communication equipment and personnel aboard ship. Too often, however, measures recommended to prevent accident or damage are overlooked during actual emergencies.

ELECTRICAL SHOCK

Each man should appreciate fully the hazards of working with electricity. You should stress special precautions necessitated by using high-voltage power supply circuits and even higher radiofrequency potentials; effect of fields existing in vicinity of antennas and antenna leads that introduce fire hazards; danger of shock to personnel; explosion hazards where ammunition or explosive vapors are present; and dangers from electrical shock and toxic stack gases to men working aloft.

Frequently review the following important points with your men:

1. Basic electrical precautions and safeguards;
2. Proper methods of resuscitating a man unconscious from electrical shock;
3. Proper treatment for shock and burns.
4. Safety precautions associated with communication equipment;
5. Proper procedures in event of electrical accident; and
6. Instill an electrical safety consciousness in all hands.

If you find a man is hazy regarding safety precautions, have him reread chapter on safety in Radioman 3 & 2 training course and the following references given in that chapter pertaining to safety precautions; Chapter 1, "Safety and First Aid" in the NavShips Electronics Installation Practices Manual; Electric Shock, its Causes and Prevention, NavShips 250-660-42; Electric Shock and its Prevention, NavShips 250-660-54; and chapter 18 of U.S. Navy Safety Precautions, OpNav 34P1.

LECTURES AND DEMONSTRATIONS

Make arrangements with the medical department for lectures and demonstrations. Schedule these talks on your training program so that all hands in the division get the latest word on artificial respiration, decontamination procedures, types of bandages and splints, and other lifesaving aids and techniques.

SCHOOLS

Nuclear, biological, chemical (NBC) and firefighters' schools offer further preparations for casualties. Subject to approval of your division officer, select men to attend courses offered at these schools. Choose men who can help you as instructors in these subjects during regular shipboard training. You must adjust the watch bill accordingly, but it is well worth the effort.

The NBC warfare defense course for rated men normally lasts several weeks. There are two short courses for firefighters. The 2-day course teaches basic firefighters techniques.

Methods of distinguishing the classes of shipboard fires and use and maintenance of firefighting equipment are offered in the 5-day course.

ELECTRICAL FIRE

The senior officer or, in the absence of an officer, the senior man present is in direct charge of extinguishing the fire until arrival of the damage control party. He makes certain that the fire is reported immediately to the OOD. If you are in charge, proceed as follows:

Deenergize circuit, then attack the fire with a portable CO_2 extinguisher. For best results, direct the stream from the extinguisher at the base of the flames.

If the fire reaches a dangerous degree of heat radiation, bulkheads separating adjacent compartments must be water cooled.

If all efforts with CO_2 fail, apply high velocity fog or foam. Fog should be used first, however, due to high incidence of residual damage caused by foam. Keep these points in mind when using fog or foam. The fine diffusion of fog particles reduces but does not entirely remove danger of electric shock, and condenstation of fog on the equipment may cause serious damage. Foam also causes serious damage but to a greater extent than fog. Regardless of these disadvantages, however, employ fog or foam on class C fires whenever circumstances warrant.

To prevent spread of fire to other compartments, station men with fog nozzles near adjacent spaces on the same deck and on the decks immediately above and below. These standby firefighters are necessary if the fire begins to radiate heat to a dangerous degree in their area. If essential, remove equipment in the vicinity likely to be damaged by water.

Remember: Carbon dioxide is your first choice in fighting an electrical fire. Fog and foam are poor seconds.

ANTIJAMMING MEASURES

Jamming and harmful interference are capable of disrupting communications just as effectively as an equipment breakdown. Although some modes of radio transmission are more vulnerable to successful jamming than others, you must remember that no type of equipment can be considered to be completely safe against this form of warfare.

The success you have in the face of jamming depends to a large extent upon the antijamming procedures and techniques you use. To combat enemy jamming successfully, you must use the three R's of antijamming: recognize jamming, report it, and read through it.

RECOGNIZING JAMMING

Because radio jamming has many of the symptoms of a receiver trouble, your operator may decide that the noises he hears are caused by a faulty receiver, or, if he recognizes that the cause of the trouble is external to his set, he is quite likely to blame the whole thing on static, an off-frequency station, or electrical interference. In short, he is not certain to recognize jamming when he encounters it.

The very fact that an enemy is jamming your communications is in itself important operational information. Therefore you must recognize and report it as soon as possible.

Radio jamming is best described according to the type of modulation. Several types of signal jamming may be encountered: spark, sweep-through, stepped-tone, and noise jamming.

One of the simplest and most primitive types of radio jamming is caused by an electrical spark. You are familiar with this type if you have tried to listen to your broadcast receiver while someone nearby was using an electric razor or running a vacuum cleaner. Spark consists of numerous jagged peaks of noise of short duration having high intensity and a high repetition rate. Although they are of short duration, can blanket the desired signal effectively because of the recovery times of the receiver, the earphones, and your ear. You probably will encounter spark jamming more frequently than any other type because it is fairly easy to generate and its broad radiofrequency characteristics enable the enemy to cover a number of communication channels with one jammer.

Sweep-through jamming produces an effect similar to spark jamming. As its name indicates, this type of jamming is the result of sweeping a carrier back and forth across a frequency band at a relatively rapid rate. The effect on any one channel in the band is to produce numerous pulses of noise spaced in time frequency band at a relatively rapid rate. The result is a noise that sounds very much like an airplane engine. The recovery time of the circuits and of your ear makes this form of jamming very effective.

Stepped-tone jamming, frequently referred to as bagpipes, consists of a number of audio tones, usually three to five, repeated over and over. Because it is very annoying, it is an extremely effective type of jamming.

Noise is a highly effective form of radio jamming. Because the noise signal is flat in its audio spectrum for several thousand cycles, it places a blanket of uniform intensity over the range of the desired signal. You can recognize noise jamming because it sounds like the noise you hear if you turn up the gain of a receiver that is not tuned to a signal. It may be mistaken for receiver or atmospheric noise, thus it is particularly dangerous.

Although the jamming that you may meet in actual practice may not correspond exactly to one of the foregoing types, it probably will be somewhat like one of them or a combination of several. Sometimes recorded music may be used by an enemy for successful jamming of radiotelephone channels. The jamming is made to appear like an ordinary broadcast to conceal the fact that it is deliberate. It can be particularly effective because your operator may not even realize he is being jammed. The next two topics describe some steps the Radioman can take to help decide that the interference he is receiving is a jamming signal and not trouble in his receiver or some kind of local interference.

How To Tell Jamming From Receiver Trouble

If you receive interference about which you are not sure, disconnect the antenna from the receiver. A drop in the noise level of the interference means that the source of interference is outside your receiver and is being picked up by the antenna. The source of trouble is therefore not in the receiver. If the noise level of the interference does not diminish when you disconnect the antenna, the trouble is in the receiver, and you should shift over to alternate equipment until the defective receiver is repair.

How To Tell Jamming From Local Interference

As already stated, a decrease in the intensity of the interference when the antenna is disconnected means there is nothing wrong with your receiver. Try tuning your receiver on each side of your operating frequency. If the level of the interference remains constant, you probably are receiving interference from an electrical source close by. The cause of this noise may be a faulty generator or other electrical source. It may even be interference from a friendly radio or radar station. If, however, you find that the interference seems to be strongest around your operating frequency and diminishes as you tune away from this frequency, then you're being jammed.

REPORTING JAMMING

As soon as you determine that the enemy is deliberately jamming you, notify the communication officer immediately so that he can make the reports required by NWP 33. The mere fact that you are being jammed deliberately by the enemy is important–and could be of vital importance to operations and intelligence staffs at higher levels of command. Also report promptly all instances of interference from friendly stations so that corrective action can be taken.

Always endeavor to obtain as much information as possible about the jamming source, and report all pertinent details called for in NWP 33 and JANAP 195. The more detailed your description, the more helpful your report will be. In addition to the type of jamming, other valuable information includes the frequencies involved, the type of equipment affected, the effectiveness of the jamming, as well as the time and date the jamming occurred.

READING THROUGH JAMMING

The most important contribution you can make against enemy jamming is to keep your station operating. Whatever else you do, do not shut down, for that is exactly what the enemy wants you to do. Use all the skill and tricks you know. But, whether they work or not, keep operating.

Defense Against Jamming Signals

In general, spark and sweep-through jamming may be countered by limiting action. For example, reduce the r-f gain, increase the a-f gain, and use the crystal filter (if the receiver has one) to tune to the least jammed sideband. This procedure may enable you to read through the jamming.

Bagpipes and noise jamming have no particular weak spots that make them vulnerable to specific treatment. Bagpipe modulation is a carrier modulated by several tones. If your receiver has a crystal filter, tune to one sideband to copy the desired signal. In contrast to the high audio level recommended against spark and sweep-through to accomplish limiting, a low audio level is a more effective antijamming measure against bagpipes and noise jamming. Decreasing the gain to a point where you can barely hear the signal may make it possible for you to read through these types of jamming.

Reducing the r-f gain and reducing the bandwidth of the receiver are especially helpful againist noise jamming. Remember that this method is not a sure-fire solution, however; it works at times but fails at other times.

Work Through Jamming

With practice and training, a good operator may be able to work CW through jamming that is more than 16 times stronger than the power of the desired signal. Remember that the ability to work through interference is more important than attaining high speed. The ability to copy 30 words per minute with no jamming is of no use to the operator who is being jammed deliberately. In addition to practicing at working through jamming, your operators must learn every antijamming technique they can use. Some suggestions and hints for radiotelegraph operation that may prove helpful are given here.

TUNE RECEIVER. -If the receiver has a crystal filter, be sure your operator uses it. Its selectivity may enable him to shut out any of the jamming that is not exactly on frequency. Slowly turn the receiver back and forth across the operating frequency to find the position where the signal can be read through the jamming.

SET GAIN CONTROL. -Turn up the gain as high as it will go. (Yes, it may be hard on your ears, but turn it up anyway.) Put cotton in your ears, or put a handkerchief between the headphones and your ears, or just turn the phones around so that they are facing away from your ears. If this method doesn't improve the signal-to-noise ration so that you can recognize the signal, try turning the volume down to a very low level, and see how this plan works. Work through the entire range of this control until you find the best setting for hearing the signal.

RESET BFO. -The chances are slight that the jamming is exactly on your frequency. If you're using CW, therefore, try changing the BFO setting. This procedure may give you the message on one audio tone and the jamming on another. With some types of jamming against CW, the signal can be heard better with the BFO cut off.

CHANGE FREQUENCY. -If you are unable to work on your primary frequency, switch to an alternate one. If the number of personnel and amount of equipment allow, traffic should continue on the primary frequency, giving the impression that the jamming is not effective. Tune the alternate transmitter accurately and quickly. Employ a dummy antenna if you have one: if not, tune at reduced power. Try to get through on this new channel before the enemy jammer finds your frequency.

If your ship or station is net control, have instructions out to all stations designating which alternate frequencies to use at which specific times, and what frequency to attempt if these are not useable. Many times alternate frequencies are available but coordination is impossible due to jamming.

CHECK MESSAGES. -Be alert against deception. Don't let the enemy trick you into accepting any fake messages along with the jamming. Be careful. Authenticate. Look with suspicion upon any signal, especially one that comes in unusually strong, or that manages to lose its authenticator in the jamming every time you ask for it.

SEND CAREFULLY. -If you are trying to send a message through jamming, be especially careful with your sending. Send slowly and distinctly, and send each word or group twice. If your transmitter has MCW capability, it may be of some help against certain types of jamming. In general, however, CW is the most difficult of all transmission modes to jam. If you are transmitting radiotelephone, speak slowly and distinctly. Use the phonetic alphabet and speak each word twice. Remember that the jamming may be much worse at the receiving end.

RADIOTELETYPEWRITER

Of the two types of radioteletypewriter operation–frequency shift keying and tone shift keying–FSK is less susceptible to successful jamming.

Interference encountered on frequency shift circuits may be partially or wholly eliminated by making any or all of the antijamming adjustments suggested for radiotelegraph. You must be careful, when adjusting the BFO control, to hold the tone of the signal to certain limits–in most instances 750 to 950 Hz. A greater change in tone causes malfunction of the typewriter.

Teletypewriter circuits using the tone shift system of keying are more susceptible to jamming than straight frequency shift keying methods. The keyer-converter used in the tone shift system has filter circuits to separate the marking and spacing tones. Any interference at or very near the frequencies passed by these filters is transferred to the teletypewriter and results in garbling the desired signal. The only procedure you can follow is shift to another operating frequency.

SINGLE SIDEBAND RECEIVERS

Single sideband transmissions without carriers are difficult to jam. Receivers especially designed for single sideband reception are equipped with a number of circuits that can be switched in or out to minimize the effects of interference.

Filters separate the various channels in each sideband as well as the two sidebands from one another. Although these filters are not tunable, they permit satisfactory operation if the interfering signals are 1 pr 2 kHz outside the edges of the passed bands.

In some types of receivers, an automatic frequency control (AFC) circuit uses the transmitter carrier to tune the first oscillator stage automatically. The purpose of this arrangement is to keep the receiver tuned to the transmitter frequency regardless of minor frequency variations. It has the major disadvantage, however, of becoming disabled under conditions of jamming that are on or near the transmitter frequency. In some receivers a squelch circuit disables the AFC circuit under conditions of high noise peaks or subnormal carrier levels. When the interfering signal or noise becomes weaker, the AFC then automatically resumes operation and retunes the receiver to the transmitted frequency.

Most receivers have noise limiter or input attenuator switches. Try receiving with each of these switches first in one position then in the other; choose the switch positions that afford you the best signal-to-noise ratio. If the receiver has AFC adjustments, use them carefully to reduce the jamming signal.

OPERATOR TRAINING

Be sure that each operator has a thorough knowledge of antijamming measures. Place emphasis on the necessity for authentication. Guard against panic at the first sign of jamming. Each operator must be trained so that he is familiar with his equipment and knows its capabilities and limitations.

Keep working. Your operators have an excellent chance of working through any jamming to which they may be subjected. However, they must remain calm, concentrate on their job and keep trying all the time. Remember: There is one setting for each receiver control that is best for combating any type of jamming. Find that setting. When your operators are jammed, keep them working. Try all the suggestions given and any others you may have discovered-but keep trying.

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