CHAPTER 7

COMMUNICATION INSTRUCTIONS

TIME

For reckoning time, the surface of the earth is divided into 24 zones, each extending through 15° of longitude. Each zone is different by 1 hour from the zone next to it. The initial time zone lies 7½°E and 7½°W of the Greenwich (England) meridian. It is called zone zero because the difference between standard time of this zone and *Greenwich Mean Time (GMT)* is zero. Each zone, in turn, is designated by the number which represents the difference between the local zone time and Greenwich mean time.

Zones lying in east longitude from zone zero are numbered from 1 to 12 and are designated minus because for each of them the zone number must be subtracted from local time to obtain Greenwich Mean Time. Zones lying in west longitude from the zero zone are also numbered from 1 to 12, but are designated plus, since the zone number must be added to local zone time to get GMT. In addition to the time zone number, each zone is also designated by letter. A through M (J omitted) indicate minus zones, N through Y indicate plus zones (Figure 7–1).

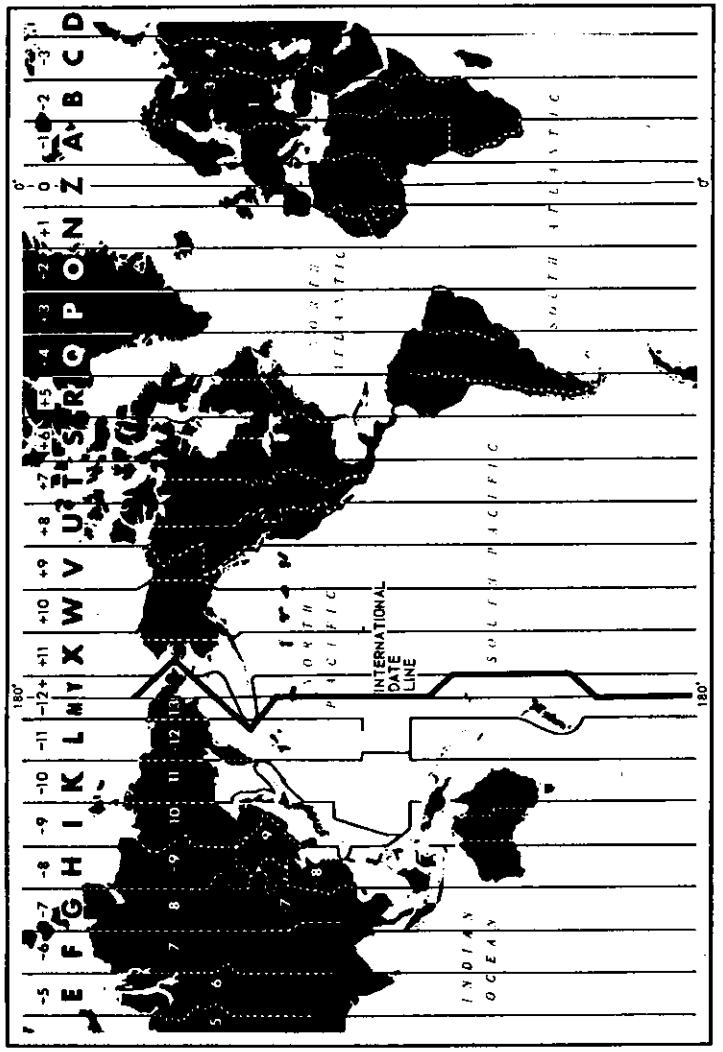

Figure 7-1 Time Zone Chart of the World

The twelfth zone is divided by the 180th meridian, the minus half lying in east longitude and the plus half in west longitude. This meridian is the INTERNATIONAL DATE LINE, where each world-wide day begins and ends. A westbound ship crossing the line gains a day, and an eastbound ship loses a day. The number of a zone, prefixed by a plus or a minus sign, constitutes the zone description. Zones crossing land are modified to accord with boundaries of countries or regions using corresponding time.

So that the same time may be kept throughout the service, GMT is used to indicate the time of origin of most naval messages. This eliminates any doubt as to which time the originator is using. The designating letter for GMT is Z.

The approved method of expressing time in the 24-hour system is with the hours and minutes expressed as a 4-digit group. The first two figures of the group denote the hour and the second two the minutes. Thus 6:30 A.M. becomes 0630; noon is 1200; and 6:30 P.M. is 1830. Midnight is usually expressed as 0000 – not as 2400 – and 1 minute past midnight becomes 0001 (most commonly used). The time designation 1327Z indicates 27 minutes past 1:00 P.M. GMT. Numbers are prefixed to the time to indicate the day of the month; in other words, to form a *DATE-TIME GROUP (DTG)*. The DTG 171327Z means the seventeenth day of the current month plus the time in GMT. Dates from the first to the ninth of the month are preceded by the numeral 0. For example, 5:15 P.M. GMT on the 3rd of the month would be 031715Z.

Local time is sometimes used in the text of a message, but must be accompanied by the zone designating letter, e.g., "Leave will expire at 170745Q". If a local time is referred to frequently in the text, the suffix may be omitted provided a covering expression is used, such as ALL TIMES QUEBEC.

CLASS "E" AND "D" MESSAGES

Class "D"

Class "D" messages are private messages for which the

Navy collects tolls. The group includes radiograms and press messages sent by correspondents aboard ship. The procedure employed with this type of message is covered in another section of this manual.

Class "E"

Class "E" messages are personal messages to or from naval personnel, handled free of charge over naval circuits. Charges are collected from the sender only when a commercial communication company, such as C.N. Telegraph, will handle the message over part of its route. For example, suppose your ship is in the Atlantic and has a class "E" message addressed to a man in CANFORHOSP, Halifax. Your ship transmits the message to Halifax Radio (CFH) where it is sent by teletype circuit to Message Centre, Halifax who in turn deliver it to the hospital. No charges are collected for this type of message. But if the message were addressed to Windsor, Ontario, a commercial telegraph company becomes responsible for delivery from Halifax to Windsor and a toll is collected for this service. Your ship would forward the money to Naval Headquarters for payment to the telegraph company.

The class "E" message privilege is primarily for purposes of morale. It affords naval personnel at sea a means of communication regarding urgent personal matters without incurring prohibitive expense.

It is not available between points on shore within Canada, and messages from ships may only be sent to points in Canada. Regulations do not allow for relaying class E messages through stations in the U.S.A. or British Commonwealth to a station in Canada. Therefore, direct contact must be made with either Halifax Radio or Vancouver Radio.

In general, the privilege is used sparingly. Subjects ordinarily acceptable for transmittal or delivery are matters of grave personal concern, such as the serious illness of a close relative; birth announcements; important non-recurring business communication; matters of life and death; and occasional greetings on important personal anniversaries. Not acceptable

are trivial or frivolous messages, those of unnecessary length, and ordinary congratulations such as seasonal greetings, (Easter, Christmas, St. Valentine's Day, etc.).

The procedure employed with class "E" messages is the same as for any military type message – using the basic message format.

Here are a few of the rules to be observed when dealing with class "E" messages on board ship:

1. Messages must be screened to determine acceptability, in accordance with GO 57.26/1. (An extract of this is usually in every radio office.)
2. Messages for delivery by commercial carrier must be addressed to NAVRADSTA ALBRO LAKE or NAVCOMCEN ESQUIMALT. Where no commercial carrier is involved, messages must be addressed directly to the ship or establishment.
3. Class "E" messages bear precedence "Deferred".
4. UNCLAS is to be the first word of the text.
5. When commercial carrier is used, the indicator "VIALT" is the second word of the text. This is followed by "CK" and the number of chargeable words, e.g., CK15 indicates "there are 15 chargeable words in this message."
6. Additional chargeable words are appended to the signature to denote name of ship. Example: "John warship St Laurent" counts as 3 words, there being no charge in class "E" for the address or signature.

BRCN 1229 gives complete information on the charges to be collected for class "E" messages. Note that there are special rates for DAY LETTER (DL) and NIGHT LETTER (NL).

PUBLICATIONS

General

Much of a radioman's work entails the use of a large number of publications, most of which are classified. A list of the more important communication publications will be found at

the end of this chapter. In order to do your job well, you must have a good working knowledge of these publications. It is not always possible for all publications connected with communications to be held in communication offices, but it is important that communication personnel know of the existence of all such publications, their general content, and how to obtain access to them.

Registered Publications

Classified publications or cryptographic devices which are intended to have a wide distribution are subject to special accounting and security precautions. These publications are assigned short titles and bear individual register numbers and are known as "Registered Publications."

Non-Registered Publications

Non-registered publications are those which do not bear an individual serial number.

Musters

Musters shall be carried out as follows:

1. *Daily,* by an officer designated by name by the Commanding Officer, for all communication publications which are handled by men and are not in the personal custody of an officer. This muster shall be carried out in the place where the publications are normally kept. A list of such publications shall be furnished to the officer designated to carry out the muster and shall be kept corrected by the Communication Officer. The result of the muster shall be recorded in the message file. The entry shall also be made in the deck log.
2. *On change of watch,* by the men in charge of crypto, radio and visual watches. Results of each muster shall be recorded and any discrepancy shall be reported immediately to the Officer of the Watch.
3. *Monthly,* by the Communication Officer, for all communication publications on his charge. The results of the muster shall be recorded in the message file and the deck log.

4. *Quarterly,* all classified publications, including unentered changes, shall be sight mustered by two officers, one of whom shall be the CB officer.
5. *On supersession of the Commanding Officer,* a muster similar to the quarterly muster is to be carried out. An up-to date list is kept posted on the inside of every stowage showing the publications which are kept there. Publications shown on this list must be accounted for at all times. Should it be necessary to remove a book from the immediate vicinity of the stowage, i.e., to another part of the ship, a receipt showing the new location must be obtained from the borrower.

Compromise

If it is known – or even suspected – that classified material has been lost, or passed into hands of some unauthorized person, the matter is said to be COMPROMISED. The seriousness of the compromise depends on the nature of the material and the extent to which the unauthorized person may divulge or make use of what he has learned. NEVER FAIL to report a compromise that comes to your attention.

It is natural to assume that a publication missing from a muster has been mislaid or borrowed by someone who has neglected to sign for it, and that it will turn up again if you are patient. You should not let this false assumption or concern over reprisals to your messmates or yourself, sway you from your duty of reporting the occurrence at once. The compromise of one document could jeopardize the future plans of all the NATO forces or destroy years of preparation. No one is capable of even guessing the havoc that could ensue as a result of a compromise. For this reason you must not try to "cover up" the loss of a document or even a page of one, no matter what justification you think you may have at the time.

CORRECTIONS

Correcting Communication Publications

The communication department has a large number of publications available for use by authorized persons. Some of

these books may be in constant use during your daily work routine, and others used only occasionally. However, all books must be kept corrected and up-to-date. The reason for this is obvious: ALL information relating to communications must be accurate.

Corrections or changes are issued to ships and establishments by the Naval Distributing Authority in your area. They may be pen and ink corrections, new pages for insertion, cut-outs, or a combination of all of these. It is the responsibility of the Communication Department to keep books which are charged to the department up-to-date. You should, therefore, know how to correct your books, and in this section we will discuss the proper method and procedures for carrying out these very important duties.

The place you choose to work should be well lighted and quiet. Do not work near an open scuttle or ventilator as there is danger of loose pages being blown about and lost. Be sure that your table or desk is clear – this will prevent the pages of your correction being mixed with other papers.

Next, read the instructions contained in the correction or change, and be sure that you understand them. If necessary, get one of your senior radiomen to explain the instructions. If there should be an "Errata" (an amendment to the correction), this should be completed before entering any of the new pages or making pen and ink changes. After you have *page-mustered the correction,* proceed to enter new pages, if any, removing the superseded ones as you go. Insert the ink amendments as directed. Use black, blue-black or green ink. Never use red ink for corrections, as it is hard to read under certain lighting conditions.

When you have completely entered the correction, each page of your publication must be carefully checked to ensure that there are no pages missing. This is referred to as "page mustering" and is done by comparing each page with the list in the front of the book, known as the *"List of Effective Pages".* This is a complete list showing each page in the book and the authority for its being there.

Example:

List of Effective Pages

Subject	*Page Number*	*Change in Effect*
	4–1 to 4–4	Original
	4–5, 4–6	Change 1
	4–7 to 4–29	(Reverse blank) Change 3

From the above list of effective pages you ascertain that Chapter 4 of your publication contains 29 pages. Pages 1, 2, 3 and 4 are the original pages which were issued when the book was new. Pages 5 and 6 were replaced by Change One and the remainder of the chapter was replaced by Change Three. There should be no other pages in this chapter, and all of the above pages must be there or the book is incomplete and must be reported to the Communication Officer immediately. When you are satisfied that the book is in good order, as a result of your correction, fill in the "Record of Corrections" page in the front of the book.

Removed pages and remaining scraps of the correction should be stapled together. Again check them to be sure you haven't removed a page in error. Then return with the publication, to the man in charge of corrections for your department. He will destroy the waste after he has checked your work. The importance of accurate checking and rechecking of publications cannot be over-emphasized. When making corrections, these rules shall always be followed:

1. Cut out long pen and ink insertions and paste them in.
2. When adding a word or sentence, PRINT it in block letters – do not use script or longhand.
3. If certain matter is to be covered, it should be deleted in ink before a cut-out is pasted over it.
4. Use mucilage rather than glue or gummed tape. Glue tends to become brittle and break. Gummed tape sticks pages together, causing them to tear when removal is attempted.
5. It is sometimes necessary to paste in a small change so

that the information under it can still be read. This is done by pasting one edge of the "flap" on the margin at the binding edge of the page.

DESTRUCTION

Emergency Destruction of Publications

Classified communication material must never be allowed to fall into enemy hands. This sometimes necessitates destruction of all such material and is referred to as *"Emergency Destruction"*. Ships proceeding into enemy waters or areas where enemy divers could salvage the ship, carry only a very small part of their normal allowance of classified material. If possible, the bulk of their publications and material will be landed before they proceed on such a mission. If this is not possible, or if there is danger of capture, the Captain will order the destruction of all classified documents. This will be carried out under the supervision of the Communication Officer and the confidential book officer.

Each ship has definite orders regarding the part the radiomen play in event of an emergency requiring the destruction of publications. These duties are assigned by duty rather than by name, so that there will always be a man available at each position where books are stowed. For example, the radiomen on watch are responsible that the books used in the offices are taken to the place of destruction. The man on duty in the crypto centre is responsible for the crypto publications and machines. You must know your specific part at all times in order that there will be no confusion or delay should the need arise to carry out "Emergency Destruction".

Method of Destruction

Burning is the principal method of destruction of publications. Other methods such as pulping are also used, but ships are not fitted with the machinery necessary for this method. Complete destruction is necessary and this is accomplished by burning. Thoroughly mixing the ashes reduces the chances of even a scrap of classified matter falling into unauthorized hands.

In emergency destruction, there may not always be time to burn all the documents and destroy the mechanical devices. In such cases material may be thrown overboard in weighted bags, or locked in a steel chest and left to sink with the ship. In shallow water (where salvage may be possible), machines should be completely smashed with a hammer and the broken parts scattered over a wide area.

Routine Destruction

Communication publications are replaced from time to time by newer editions. With some publications, this may happen at intervals of years, while others are superseded every day. The old publications cannot be discarded or just thrown out. They require just as much care and accounting as the effective editions until they are eventually destroyed. The CB officer looks after this "routine destruction" by either returning the publication to the NDA or by burning, depending on the instructions he has received. No publication can be destroyed without authority.

Safeguarding Publications

Publications not in use are to be kept locked in their approved stowage. Throughout the ship wherever classified books are used, safes, chests or cupboards are provided for the express purpose of safeguarding them. These stowages shall not be used for any other purpose, e.g., stowing valuables, stationery, etc. They are to be kept locked at all times except when books are being removed or put in. There are two types of locks used on these stowages:

1. Key-type locks, provided with two keys. One key is held by the person using the stowage, the other by the Captain. When you are entrusted with a key to a stowage, you must carry it on your person, secured safely by a key-chain or lanyard to prevent it being lost. The loss of a key is a

very serious matter and must be reported immediately. The key shall NEVER be left in the stowage or in any insecure place, whether or not there are books in the stowage. This will reduce the chances of anyone making a wax impression of your key. Keys to classified stowages are treated in the same manner as classified publications. They are included in every muster and carry the highest classification for which the stowage is used.

2. Combination locks. Knowledge of combinations is limited to those whose duty requires them to use the stowage. Combinations shall be changed on the following occasions:

   (a) When personnel having knowledge of the combination are no longer concerned with the contents of the stowage.

   (b) When the combination is compromised, or suspected to be compromised.

   (c) At regular intervals as required by security regulations.

In ships alongside open to visitors or otherwise situated so that unauthorized persons may gain access, as many publications as possible shall be returned to the approved stowage, and special precautions shall be taken to safeguard the remainder. Classified publications shall not be removed from the ship without the written permission of the captain. Publications being carried from one part of the ship to another should be carried in a canvas bag to ensure they do not fall over the side, or have pages torn out by unexpected gusts of wind. There are many rules to be observed by everyone who has occasion to use classified publications. The general rules can be found in QRCN, the *Security Manual*, the *Publications Manual* and other publications. The specific rules your captain desires for his ship will be found in the *Ship's Standing Orders*. You should know them well before accepting the responsibility of handling publications.

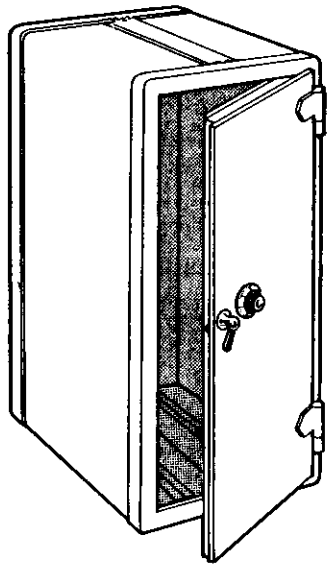

Figure 7-2 Enclosure Cabinet - Four Drawer Size

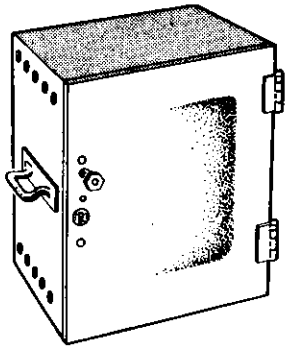

Figure 7-3 Signal Book Box (Steel)

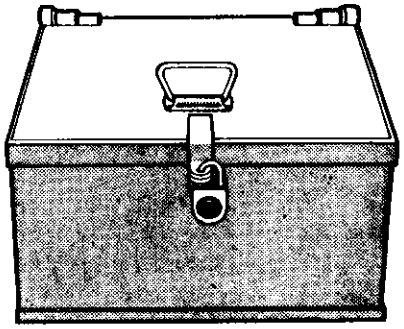

Figure 7-4 Chest

PUBLICATIONS USED IN COMMUNICATIONS

There are three main divisions of the publications used in communications:

INTRA – These are publications which are issued by the Royal Canadian Navy for its own use. Intra RCN publications are not held by our allies or by other services of Canada, and are only to be used when communicating with other ships and establishments of the RCN.

JOINT – These are publications which are issued for use between two or more services of the same country. Joint publications are available for use between Navy, Army and Air Force.

COMBINED – These are publications which are issued for use between two or more countries. Combined publications may be used between any of the services of any of Canada's allies.

List of abbreviations used in the "short titles" of communication publications:

ACP	Allied Communication Publication
AFSAG	Armed Forces Security Agency (General)
AFSAK	Armed Forces Security Agency (Key List)
AFSAL	Armed Forces Security Agency (List)
AFSAM	Armed Forces Security Agency (Material)
AFO	Admiralty Fleet Order
ALRS	Admiralty List of Radio Signals
AMSP	Allied Military Security Publication
ATP	Allied Tactical Publication
AXP	Allied Exercise Publication
BR	Book of Reference
BRCN	Book of Reference Canadian Navy
CB	Confidential Book
CBCN	Confidential Book Canadian Navy
CGO	Confidential General Orders
CSPM	Confidential Security Publication Memorandum
DNC	Director of Naval Communications

GO	General Order
JANAP	Joint Army Navy Air Force Publication
NACSIM	NATO Communication Security Information Memorandum
NCCP	NATO Commanders Communication Publication
QRCN	The Queen's Regulations and Orders for the Royal Canadian Navy
SP	Signal Publication
SPCN	Signal Publication Canadian Navy

These abbreviations are followed by a number which identifies the particular publication, and are further subdivided by adding letters to identify the particular edition. For example, ACP 122 is the short title of the first edition of Allied Communication Publication *"COMMUNICATION INSTRUCTIONS – SECURITY"*. ACP 122(A) is the first revision of *"COMMUNICATION INSTRUCTIONS – SECURITY"* and when brought into force will replace ACP 122. ACP 122(B) would be the second revision.

The following are some of the more common publications you will be using in Naval communications:

ACP 124	*Radiotelegraph Procedure*
ACP 125	*Radiotelephone Procedure*
ACP 126	*Teletypewriter Procedure*
ACP 127	*Tape Relay Procedure*
ACP 129	*Visual Signalling Procedure*
ACP 130	*Direction Finding Procedure*
ACP 131	*Operating Signals*
ACP 135	*Distress and Rescue Procedure*
ACP 150 to 154	*Recognition Instructions*
ACP 176	*Allied Naval Communication Instructions*
AFO S1	*Naval General Communication Instructions*
AFO S2	*Naval Radio Communication Instructions*
AFO S3	*Naval Command Communication Organization*
AFO S7	*Guide to Optimum Frequencies for Ship-Shore Use.*

AFO S12	*Reporting Enemy Contact*
BRCN 109	*RCN Publications Manual*
CBCN 5101	*RCN Security Manual*
ACP 165	*Operational Brevity Code*
ACP 167	*Glossary of Communication – Electronics Terms*
ACP 168	*Pyrotechnic Signals*
ACP 175	*Allied Naval Signal Book (ANSB)*
AXP 3	*Allied Naval Communication Exercises*
JANAP 195	*Basic Armed Forces Communication Plan (BAFCOM)*
ATP 1	*Allied Tactical and Manoeuvring Instructions*
BRCN 1216(1)	*International Code of Signals (Visual)*
BRCN 1216(2)	*International Code of Signals (Radio)*
JCTRI	*Joint Canadian Tape Relay Instructions*

Call Sign Publications

ACP 100	*Series Canadian and Allied Call Signs and Address Groups.*
ACP 110	*Tactical Call Signs*
ACP 112	*Task Organization Call Signs*
ACP 113	*Call Sign Book for Ships*
ACP 117	*Joint Routing Indicator Book*
ACP 118	*Visual Call Signs*
ACP 121	*Communication Instructions – General*
ACP 122	*Communication Instructions – Security*
BRCN 1204	*List of Coast and Ship Stations (International)*
BRGN 1206	*Alphabetical List of Call Signs (International)*
BRCN 1208	*Signal Letters of British Ships (International)*
JANAP 119	*Voice Call Signs*

ENEMY REPORTS

A CONTACT REPORT is a message reporting the first sighting of an enemy force. Speed of handling such a message is of utmost importance. Contact reports take priority over every other type of traffic handled by naval communications.

They are prepared in either plain language or a self-evident code.

AN AMPLIFYING REPORT follows up a contact report. It contains further information about the enemy force, such as number, type, position, course, speed and distribution. A contact report may be followed by many amplifying reports as information becomes available and the enemy shows his intentions. It is often possible to transmit some amplifying data with the contact report.

Disguised Enemy Reports (Sometimes referred to as "Secret Enemy Reports").

Security precautions do not permit a full discussion of this method of reporting the presence of enemy forces. Suffice it to say that a DISGUISED report is always codress, may carry a special operating group or two, and is transmitted on full power to the nearest shore radio station.

MOVEMENT REPORTS

The Navy always has ships on the move, either independently or in groups. It is necessary both to command and to efficient administration to have an up-to-the-hour knowledge of the location of every vessel.

This large-scale "change of address" work is carried on by the movement report system. When a ship stands out to sea, a movement report message is sent stating the time of departure, destination, route, speed of advance, and any other information the ship may be directed to furnish, such as communication arrangements for the trip.

For reporting purposes the world is divided into four zones, each controlled by a movement report centre (MRC). Each zone is further subdivided into areas controlled by movement report offices (MRO's). Each MRC receives information on movements all over the world, but MRO's have information only on movements in their own areas of responsibility.

The originator of a movement report sends it to an MRO or MRC. From here, information on the ship's movements is relayed to military and civilian activities with an official interest in the location of the vessel, such as supply centres, customs authorities, fleet post offices, and fleet broadcast stations.

QUIZ

1. List three types of material not acceptable as class E.
2. Is it permissible to transmit a class E to a British station for relay to Canada?
3. As radioman on watch, when do you muster the books on charge to the radio office?
4. Why should you not use red ink when correcting publications?
5. What is the purpose of page mustering a publication after corrections have been inserted?
6. In the discussion on EMERGENCY DESTRUCTION, we mentioned "shallow water". What opportunities exist here for an enemy?
7. If a stowage chest is empty of books, why not leave the key in the lock?
8. How should you transport publications from one part of the ship to another?
9. Give the meaning of the term JOINT as used with publications.
10. What is an ACP? a JANAP? a CGO?
11. To whom does an originator send a movement report?

CHAPTER 8

TELETYPEWRITING

Introduction

The teletypewriter is little more than an electrically operated typewriter. The prefix "TELE" means "at a distance". Coupled with the word "typewriter" it forms a word meaning "typewriting at a distance". The keyboards of teletypewriters are similar to those of typewriters. However, there are some slight differences which are explained later in this subject.

Teletype transmission is instantaneous. As the characters are being typed in the transmitting station, they are being reproduced in the receiving station. One teletypewriter will activate as many machines as may be in the network. With inter-ship RATT, an arrangement known as SIMPLEX is employed. This means that only one station may transmit at a time and its transmissions are picked up by all receiving stations.

Your job in the field of communications will include the use of the teletypewriter. As in other methods of transmission, a procedure (Chapter 9) is prescribed which must be followed. Radioteletype (RATT) is a comparatively new method of radio communication in the navy, but its use is rapidly becoming more common. Primary fleet broadcasts and fixed services use RATT almost exclusively. Most ships are equipped to transmit RATT messages ashore.

The mental and manual actions performed by an operator in converting letters to Morse code (and vice versa) are replaced in teletypewriter and radioteletypewriter by electrical and mechanical actions. To transmit a message the operator types on a keyboard similar to that on a typewriter. As each key is pressed, a sequence of signals is transmitted. At receiving stations the signals are fed into receiving machines, which type the message automatically.

Teletypewriter signals may be sent either by land-line or by radio. Land-line teletypewriter communication is used both by the military services and communication companies such as CPR and CNR. Radioteletypewriter is primarily intended to furnish high-speed automatic communication over ocean areas. Today the primary shipboard use of RATT is for reception of fleet broadcast schedules. Traffic can be cleared at speeds like 60 wpm as compared to the 25 wpm speed of the CW (Morse code) fleet broadcasts.

The most noteworthy aspect of the teletype machine is its simplicity of design. All functions required for the transmission of a message are fingertip controlled at the keyboard. The operator need only to press a key to print a letter, change the position of his paper, sound an alarm at the receiving station, or perform the many other functions necessary. The fact that each operation of the machine is governed by a key permits an operator to develop a rhythmical style. A sense of rhythm is as necessary in teletypewriting as it is in sending Morse code, or semaphore.

The touch required on the keyboard is light, only enough to release the clutch. All the mechanical labour is done by the motor. Get to know your machine through your fingertips. Introduce each finger to its allotted keys and foster their relationship until your fingers will instinctively find the keys that you require.

Although only a light touch is required to press a key, a certain amount of fatigue will be felt in seldom used finger and arm muscles. Tension, caused by poor posture, will add

Figure 8-1 Good Posture at the Teletypewriter

to this fatigue. Give your fingers a chance! Sit erect but relaxed; combat the tendency to slouch in your chair. Have patience, teletypewriting cannot be learned overnight. Each session at the keyboard will strenghen your fingers. Initial exercises should be relatively short with rest periods to suit your individual requirements. Succeeding exercises will grow longer as your fingers develop. Remember to check your posture (Figure 8–1) before commencing an exercise.

5. COVER – Raised for access to typing unit. It is hinged at the rear and is counterbalanced by a mechanism that aids in lifting and holding it open.
6. COPYHOLDER and LINE GUIDE – The copyholder holds the message to be typed. The line guide helps the operator follow the lines as he types.
7. END-OF-LINE INDICATOR LIGHT – A red lamp which lights about six characters from the end of the line. The machine is adjusted to type 69 characters to the line, including spaces between words or groups.
8. PAPER RELEASE LEVER – Located under cover. When pushed back, this control frees the paper for adjustment. When pulled forward, it holds the paper tight.
9. LID RELEASE PUSHBUTTON – When pushed, releases lid of machine for raising.
10. LID – When raised, provides access to the paper, paper release lever, and line space lever.
11. MESSAGE – In the form of hard copy.
12. LINE SPACE LEVER – Located under cover. Pull forward to single space, push back to double space.
13. PLATEN HANDWHEEL – Located under cover. When depressed and turned, feeds paper in direction in which turned, up or down.
14. COPY LIGHT – A white lamp which is lit while the teletypewriter is on, illuminating the copy.

Keyboard

The keyboard arrangement is shown in Figure 8–14. You will notice, that there is a partial top row of six keys that does not appear on older equipment. These keys are red, the remainder of the keyboard is green. Red keys and their functions are discussed below.

1. BREAK KEY – Used in land-line transmissions. To stop (break) another station's sending, depress the BREAK key for about 2 seconds. This causes the KBD LOCK key to drop and lock keyboards on both sending and receiving

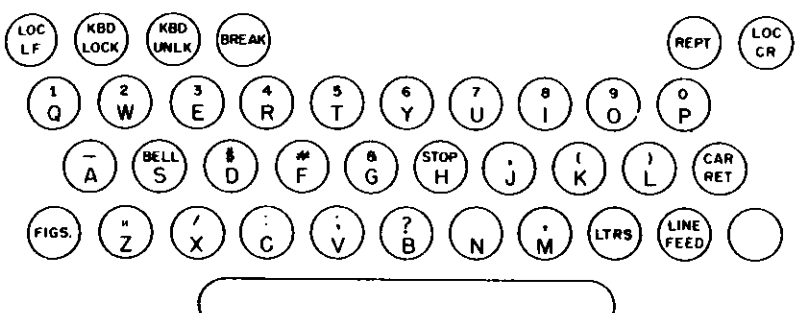

Figure 8-14 Communication Keyboard, Model 28

machines. After a break it is necessary to operate the KBD UNLK key to free the keyboard for sending.

2. REPT (repeat) KEY – To repeat a character, depress the character key and the REPT key. The character will be repeated automatically at line speed as long as both keys are held down.

The four keys described next perform their functions only on the machine on which the key is operated (referred to as "local machine") without affecting any other machine on the line.

3. LOC LF (local line feed) KEY – To feed the paper up in the local machine, depress the LOC LF key, which will feed the paper up automatically and rapidly as long as it is held down. This key is for use in locally feeding up paper to tear off a message not fed up far enough by the transmitting station. It is also used when inserting a new supply of paper in the machine.
4. KBD LOCK (keyboard lock) KEY – To lock the keyboard on the local machine, depress the KBD LOCK key. The keyboard is now inoperative until released by the KBD UNLK (keyboard unlock) key. The KBD UNLK key also drops automatically when the control switch is turned OFF, when the BREAK key is operated, or when a break is received.

The function keys for CAR RET (carriage return), LF (line feed), FIGS (figures) and LTRS (letters) may at first seem difficult to control. Keep practising until you overcome any difficulty, because mastery of these controls leads quickly to good rhythm and an increase in speed.

Teletypewriting drill pamphlets are available in ships and establishments. Use them to good advantage in your spare moments. The drills are designed to assist you in becoming proficient on the keyboard. Treat each drill separately and work on it until you have completed it *accurately* about five times. When you have done this, move on to the next drill. After completing the "reach" drills, try the progress tests. At the beginning of each progress test you will notice a "Warmup" paragraph. This is composed of "power drills" used to develop rhythm and speed. Do the warmup at least three times, then carry on with the exercise.

When correcting an exercise, note your mistakes. If letters are missing, the probable cause is *POOR RHYTHM*. If your mistakes are due to incorrect fingering, go back to the basic drill for the particular key or keys and work on it for a while. *TRY THE EXERCISE AGAIN*.

TELETYPEWRITING MACHINES

The machines most commonly used and with which you will be concerned are the Model 15 Page Teletypewriter, the Model 28 Page Teletypewriter, the Model 14 Transmitter Distributor (TD) and the Model 14 Typing Reperforator.

MODEL 15 TELETYPEWRITER

The teletypewriter keyboard (Figure 8–2) differs from the standard typewriter in that it has one fewer row of keys, and in lower case types capitals only. In upper case it types numerals, the principal punctuation marks and special characters.

To follow the study of operation of the Model 15, refer to Figure 8–3 which labels the principal parts of the machine.

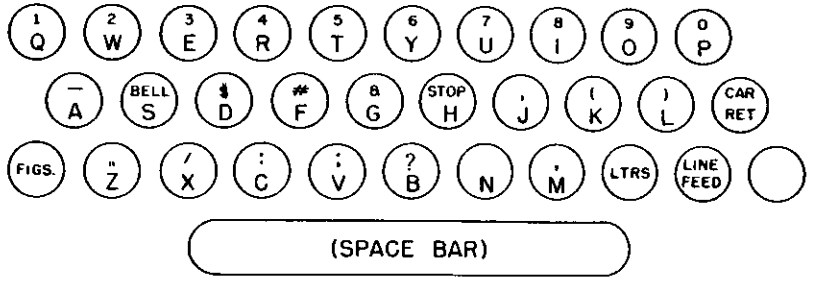

Figure 8-2 Model 15 Teletypewriter Keyboard

To start or stop the machine, the power switch is placed in either the ON or OFF position. With power ON, check the SEND-REC lever at the left side of the machine to make sure it is in the SEND position. Make sure the polar-neutral switch is in the neutral or OUT position.

Transmission begins at the keyboard. With the touch system use the CAR RET key as a guide for the right hand and the A key for the left hand. The little finger of each hand is used on the guide key. It is important that you use a light, quick, even touch on the keys. Force is unnecessary because the machine is motor driven.

Teletypewriter manual operation requires accuracy, rhythm, confidence, and speed in their proper relation. Although a light touch is essential to speed, each key must be pressed in a positive manner. Otherwise, you may be writing the word FOR and have FR appear on the page simply because the letter O was pressed without allowing sufficient time for printing of the letter F. To become a skilful teletypist, proficiency in the touch system of typing is, of course, a "must".

Notice that several keys represent "functional operations", or non-typing selections; that is, when pressed, they do not print anything on the page. Among these are the figures (FIGS) key, the letters (LTRS) key, space bar, carriage return (CAR RET) key, and the line feed (LF) key.

To shift the machine to the upper case for typing numerals, punctuation marks, and special characters indicated on the

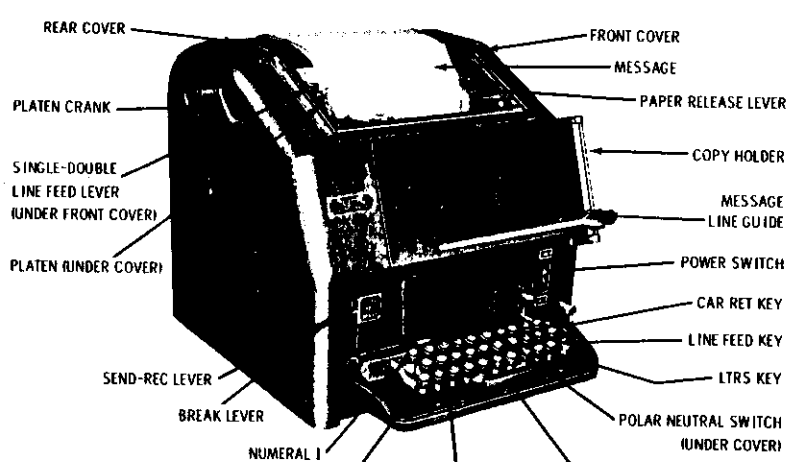

Figure 8-3 Model 15 Page Teletypewriter

upper part of the keys, press FIGS. To UNSHIFT the machine, press LTRS, and type the letters of the alphabet.

The SPACE BAR may be used to space between either words or characters. The machine will space as long as you hold down the space bar.

The CAR RET key is used to return the carriage to the left hand margin of the page. The normal length of a line is 69 characters including spaces. A margin bell will ring about 3 characters before the end of the line.

The LINE FEED key feeds the paper up, one to two lines at a time, thus preventing overlining.

Miscellaneous Features

Use the PLATEN CRANK if you wish to turn the paper up or down in your machine, without affecting the paper in the other machines on the circuit. Do not operate or attempt to hold the platen crank while the machine is in operation.

To free your paper for adjustment, push back the PAPER RELEASE LEVER, and pull it forward to hold the paper tight.

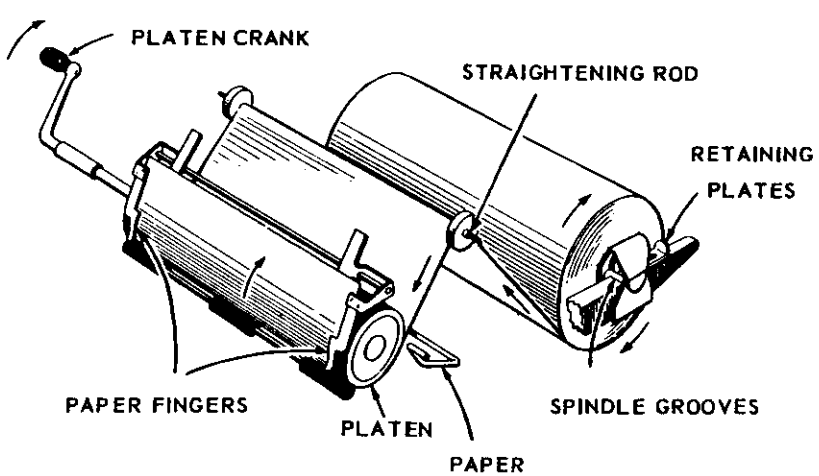

Figure 8-4 Changing Friction-feed Paper

Pull the LINE FEED LEVER forward for double-line spacing, or push it ba[illegible] single-line spacing.

The COPYHOLDER is a metal plate just above the keyboard, on which messages are placed to be read by the operator as he types. The MESSAGE GUIDE is a horizontal bar, mounted on a vertical rod, which holds the message against the copyholder by spring tension. The message guide may be lowered with each line transmitted, furnishing a line-by-line visual guide for the operator.

Changing Paper

Check the supply of paper in the machine frequently to avoid missing messages when the paper runs out. The approach to the end of the roll is indicated by a coloured streak along the edge of the paper. Change the paper outside of service hours. When necessary to change the paper during service hours, notify all stations on the circuit before doing so.

The type of paper feed currently in use is the "friction" paper feed (Figure 8–4.) Observe the following steps, using

in oil, then squeezed by hand to remove excess oil.

5. Springs require a small dab of grease where they are secured.
6. Bushing-type bearings have a small oil cup (with wick) which should be kept filled.
7. All gears, metal or fibre, require a small amount of oil.

Methods of Keying

There are two types of transmission by teletypewriter, manual and automatic. Manual transmission is made directly from the keyboard by the operator. Automatic transmission is controlled by a perforated paper tape. The perforations on the tape correspond to the keyboard, each vertical pattern of holes representing one of the keys. As the tape is fed through a transmitter distributor (TD) (Figure 8–8), the holes in the tape allow different electrical contacts to be made which operates the printer in the same manner as the keyboard.

Chad and Chadless Tape

Before discussing equipments that produce and handle messages on tape, let's get squared away on the two types of tape used for automatic transmissions. The first type is the completely perforated, or CHAD tape (Figure 8–7.) On this tape the teletypewriter code is punched, and no printing appears. The other type, only partially perforated, is called CHADLESS. The message is printed as well on this tape. (Incidentally, "chads" are those small paper discs punched from the tape to make the holes). On chadless tape the printing lags the perforated code by six spaces. In other words, the pattern of holes representing "A" may be punched as the first letter of a message, and six spaces later the printed letter A will appear on the tape.

The partial perforations of chadless tape allow enough space for the printed word, which eliminates the need for reading perforated code and also permits the transmitter distributor sensing pins to rise, transmitting the message.

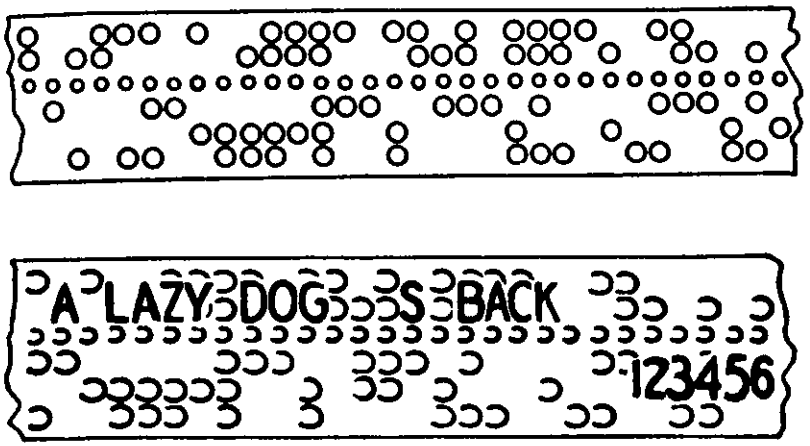

Figure 8-7 Chad and Chadless Tape

When a tape is punched completely – as in chad tape – the remaining space is insufficient for the printed word.

You may wonder why the navy uses chad tape at all when chadless is more convenient to read. The reason lies in the expense that would be necessary to build typing units into all perforating equipments. It is simpler for the operator to learn to read chad tape.

Learning to read tape perforations is an interesting personal challenge. Should you find yourself in a position where CHAD tape is frequently used, you will want to be able to read your tapes. The easiest way to master the tapes is to punch one out with all the keys in alphabetical order. Under each vertical perforation, write in pencil the key is represents. Keep the tape with you at all times and study it during your spare moments.

MODEL 14 TRANSMITTER DISTRIBUTOR (TD)

How to Operate

Feed the tape under the TAPE STOP LEVER (Figure 8–8) to the TD. Always be sure the transmitter switch is in the

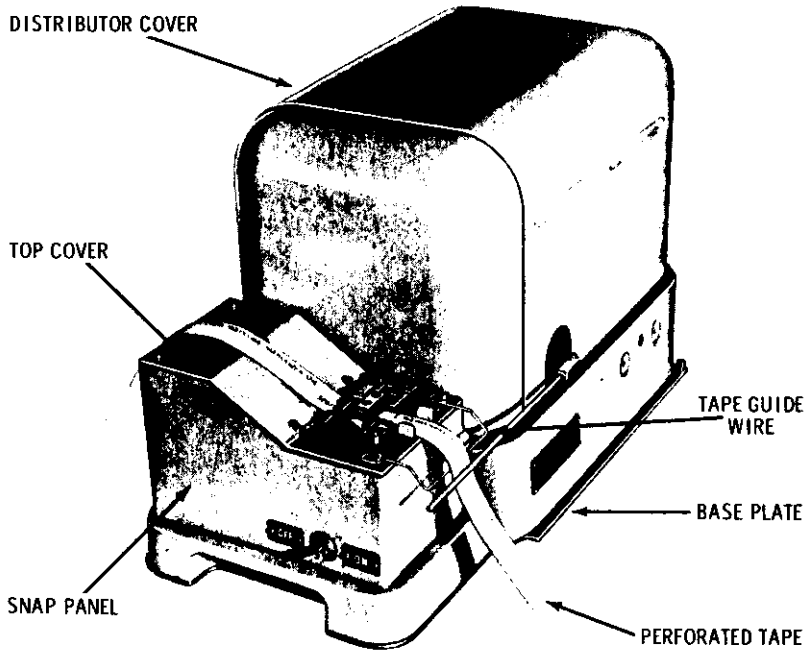

Figure 8-8 The Transmitter Distributor

OFF position, before you put in the tape. Raise the TAPE GATE and place the tape over the teeth on the tape feed wheel, with the first code to be transmitted directly over the SENSING PINS. The code perforations must match the pins. If using chadless tape, place your tape so that the printed character of the first code is matched up with the bench mark to the right of the sensing pins. Close the tape gate. Make sure your tape stop lever is down, and turn the transmitter switch to ON. Look at the tape occasionally, straighten it out if it becomes twisted.

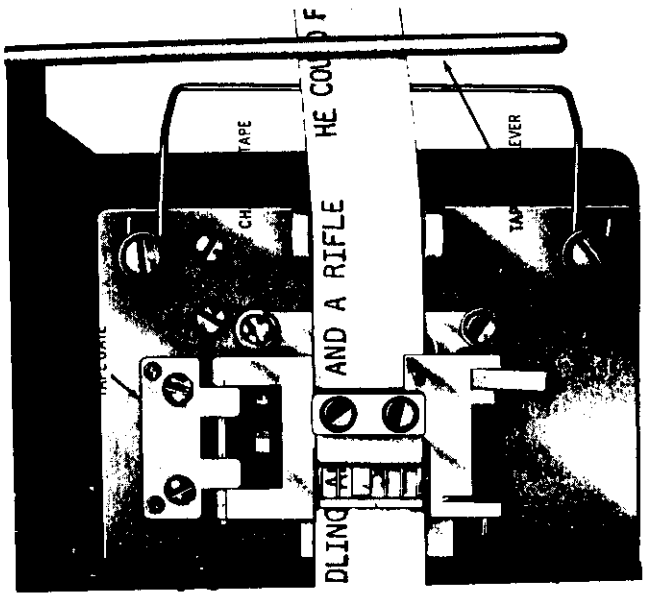

Figure 8-10 Close-up of TD Chadless Tape Inserted Gate Closed

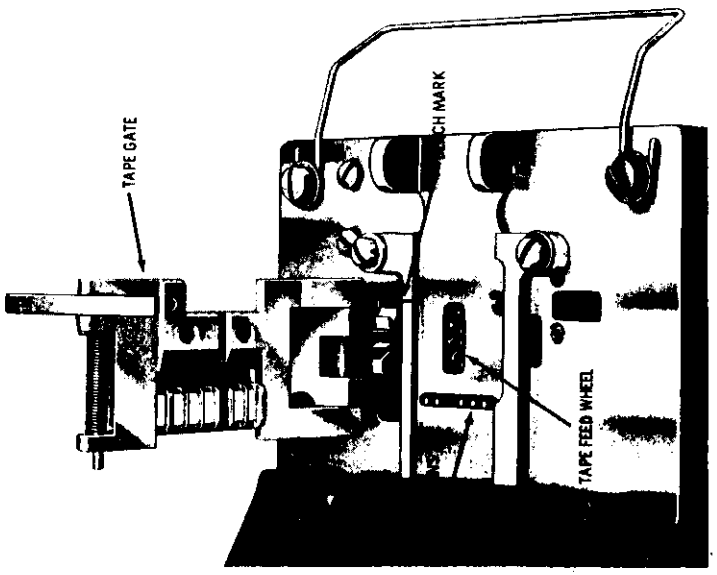

Figure 8-9 Close-up of Model 14TD Tape Gate Open

Figure 8–4 as a guide:

1. Switch off power.
2. Turn platen crank to roll back paper from under platen.
3. Push back retaining plates.
4. Remove roll from spindle grooves.
5. Remove spindle from used roll, and insert new roll.
6. Place spindle first in right groove, and then in left groove.
7. Push retaining plates forward.
8. Feed paper over straightening rod and under platen, bringing it up between platen and under paper fingers by turning platen crank. Don't disturb ribbon.
9. Push back paper release lever, straighten paper as you would in an ordinary typewriter, and pull paper release lever forward.
10. Close rear cover and roll paper up over it with platen crank.
11. Close front cover.
12. Turn on power to resume operation.

Changing Ribbon

Check the condition of the ribbon frequently and replace it when it becomes worn. Otherwise, it may produce illegible copy and cause service interruptions. If necessary to make ribbon changes during service hours, notify all stations on the circuit before doing so. Use a ½-inch ribbon with reversing rivets, on spools specially designed for teletypewriter use. Refer to Figure 8–5 and observe the following steps:

1. Turn off power and open front cover of machine.
2. Lift both spools from spool shafts.
3. Disengage old ribbon from ribbon carrier hooks.
4. Reverse arms and roller guides.
5. Remove old ribbon from spool.
6. Engage hook of new ribbon on hub of empty spool, and wind the reversing rivet on spool.

7. Pull ribbon forward around both roller guides – insert in ribbon carrier, under carrier hooks.
8. Engage ribbon in slots on both reverse arms. Do not attempt to change position of reverse arms. Take up slack in ribbon by turning free spool.
9. Close front cover.
10. Turn on power to resume operation.

Preventive Maintenance

Model 15 Teletypewriter and Model 14 Reperforator.

Many of the moving parts of teletype equipment, although rugged and serviceable, can be damaged by inexperienced personnel. After several "clean/lubricate" jobs under direction, you should be able to do the job satisfactorily alone. At first, however, you should ask an experienced man to assist you. The following articles are required for a "clean/lubricate" job and should be handy when you start the job:

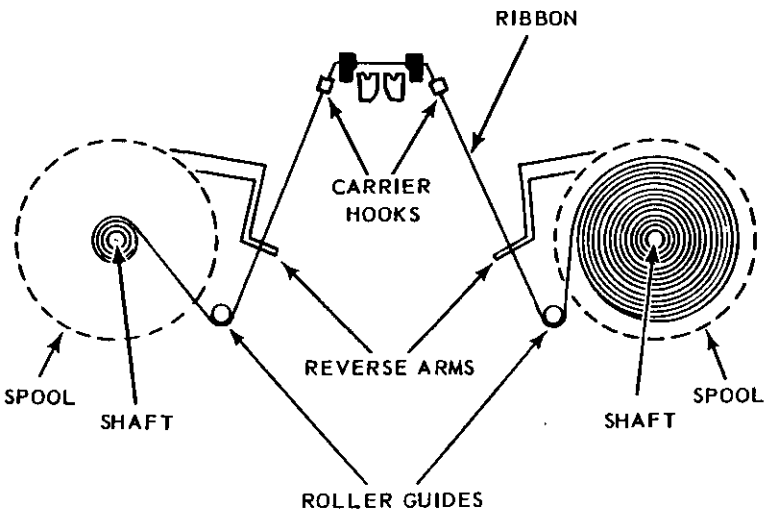

Figure 8-5 Changing the Ribbon

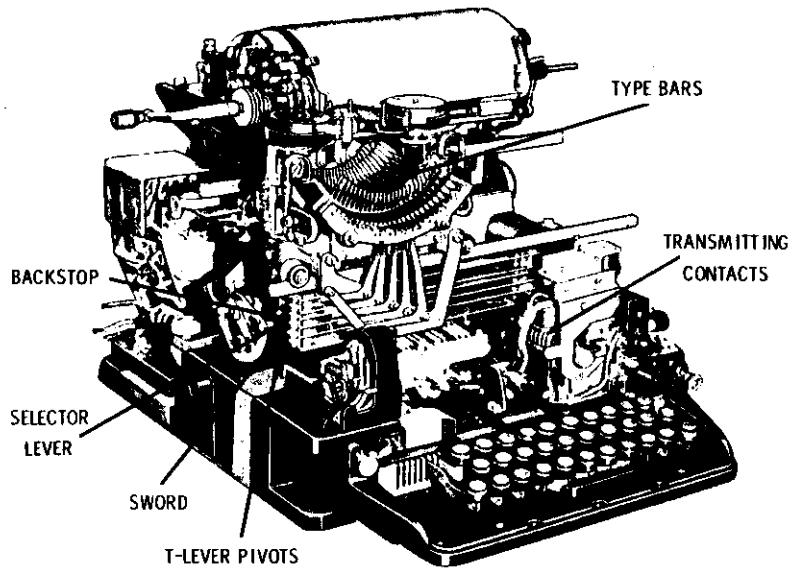

Figure 8-6 Model 15 Teletypewriter - Interior Parts

1. A cleaning stick, also called an orange stick.
2. Some clean cheesecloth.
3. An oilcan filled with a non-paraffin base oil. The can should have a 3-inch spout, curved at the end.
4. A good grade of medium density cup grease.
5. Grease gun.
6. A small quantity of cleaning fluid or varsol.
7. A small can of patented type cleaner.

Here is a step-by-step guide to assist you with your first maintenance job. Figure 8–6 should be referred to for location of parts.

1. Switch off the machine and disconnect the power lead.
2. Wipe off old grease and oil. An orange stick, piece of fibre or a screwdriver with a clean, dry piece of cheesecloth wrapped around it should be used to reach places which are hard to get at. Cleaning fluid is used to loosen gummed up accumulations of grease and dirt. You must be careful to keep dirt from falling into wearing surfaces. Avoid disturbing springs or adjustments as they may be easily knocked out of line.
3. Insert a double piece of cheesecloth between the type bars and the backstop to catch dirt and excess cleaning fluid. Clean the type thoroughly with cheesecloth moistened with varsol or type cleaner. Fluid should be used sparingly. Brush the type with a dry typewriter brush.
4. Clean the keyboard with a cloth which is slightly moistened with water. Solvents or cleaning fluids must never come in contact with the keys.
5. Place a padded cloth beneath the assemblies for code bar bearings, T-lever pivots and sword and selector lever. Pour over each assembly about a teaspoonful of cleaning fluid.

Note: The transmitting contacts should not be cleaned unless there is definite evidence of keyboard trouble. When necessary, they can be cleaned with clear cleaning fluid. Wipe dry with a lint-free cloth.

Now that your equipment has been thoroughly cleaned, it is ready for lubrication. Here are the uses of the different lubricants.

Lubricant	Used on
Oil	Small moving parts.
Grease	Large moving parts.
Oil-Grease-Oil	Ball bearings.

Obtain a lubrication chart from the teletype manual and proceed with the job. Keep these points in mind while you work:

1. Grease should be applied with a grease gun (if available), or toothpick, screwdriver blade, or similar instrument.
2. When lubricating small parts, apply a single drop of oil. At no point should more than three drops be used.
3. Oil cups should be kept full but not overflowing.
4. New felt washers and wicks must be thoroughly saturated

MODEL 14 TYPING REPERFORATOR

This equipment which produces partially-perforated chadless tape, is sometimes referred to as the "reperf". It is normally used for receiving messages in tape form only. However, it is fitted in most ships for the purpose of taping up traffic for transmission, in which case it is used in conjunction with the transmitter distributor (TD). For the latter purpose the reperf is fitted with a keyboard, but there is no platen and no page copy. All the printing appears on the tape, lagging the perforations by six spaces. The keyboard resembles the Model 15. To the left of the keyboard, however, is a BREAK button which replaces the SEND-REC lever of the Model 15 for interrupting transmissions. The power switch is located just ahead of the break button.

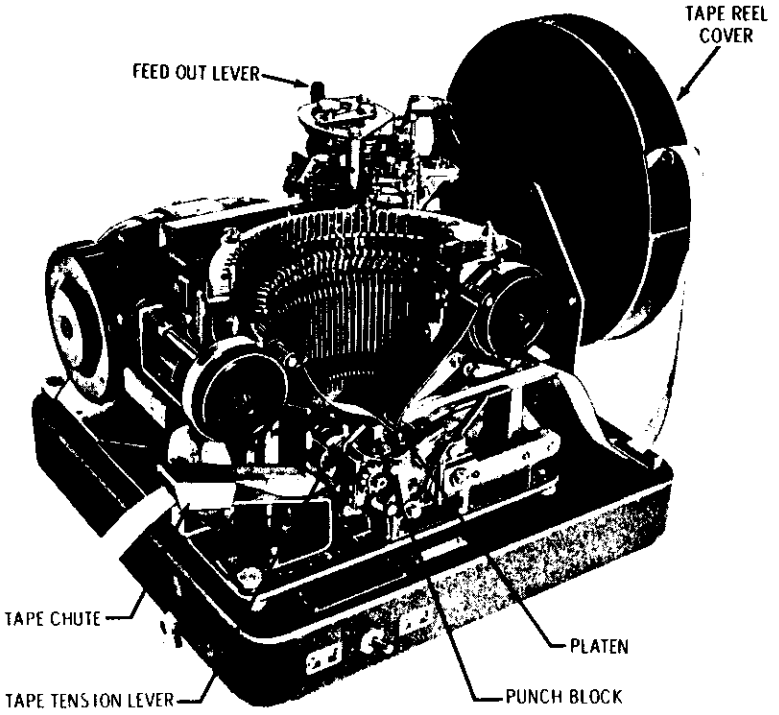

Figure 8-11 Typical Receiving-only (Low Base) Typing Reperforator

Changing the Tape

Refer to Figure 8–11 and observe the following steps when changing the tape. Better still, examine an actual reperforating unit.

1. Open machine cover and tear old tape at chute.
2. Lift off the cover of tape reel. Remove the tape holder and take out core of old roll.
3. Hold down the TAPE OUT lever and place the new roll of tape in the tape reel, with the tape feeding from underneath and out over the roller.
4. Replace the tape holder and the cover to the tape reel. Make sure that the lower edge of the cover is engaged with its hook.
5. Feed out the piece of tape in the punch block with the tape FEED OUT lever.
6. Turn off the power by operating the power switch on the typing reperf.
7. Cut or tear the end of the new tape at an angle. Turn the tape so that the right-hand edge is toward the rear. Feed the tape through the slot in the cover and into the tape chute. Then, from the tape chute, feed the tape under the ribbon – that is, between the ribbon and the platen and into the slot of the punch block. A good way to do this is to press the tape gently with the fingertips on the horizontal section of the tape chute, pushing the tape to the left. In this operation it may be necessary to pull toward you the small spring located at the left end of the tape chute. Hold out the tape tension lever and feed the tape between this lever and the feed roller and beyond the tape tension lever. Release the tension lever.
8. Turn on the power and press the tape tension lever against the feed roller with sufficient force to cause the pins in the feed roller to push through the tape. While

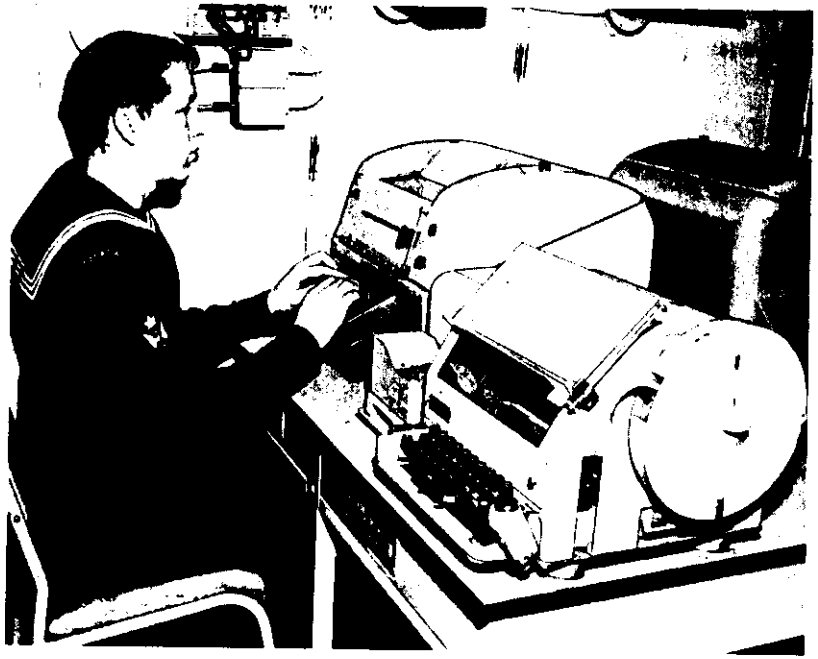

Figure 8-12 Shipboard Arrangement of Model 14 TD Typing Reperforator and Desk Model 28

applying this pressure, operate the tape feedout lever until the LTRS perforations in the tape extend beyond the tape tension lever. Close the machine cover.

Caution: Do not attempt to feed a new roll of tape by fastening or doubling the end of the tape to that of the old. Never pull the tape backward through the punch block.

MODEL 28 TELETYPEWRITER

The Model 28 is a recently developed keyboard-sending and page-receiving teletypewriter which will eventually replace existing models. It is of improved design to ensure more

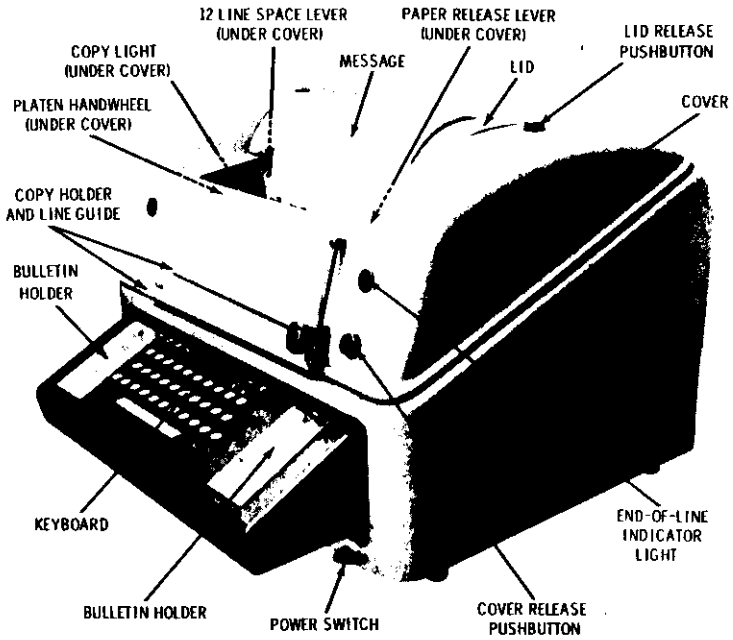

Figure 8-13 Model 28 Teletypewriter

reliable performance in ships and aircraft. It uses the same mark-space code as the Model 15 but is mechanically different.

Let us look at some of the external features of this machine. Refer to Figure 8–13.

1. POWER SWITCH – When turned ON, this switch starts the motor in the teletypewriter, and makes the machine operative. To secure the machine, turn the power switch OFF.
2. KEYBOARD – Described in next section.
3. BULLETIN HOLDERS – There are two on the machine. Used as necessary for recording any information an operator needs to have at his fingertips.
4. COVER RELEASE PUSHBUTTON – Releases cover of machine for raising.

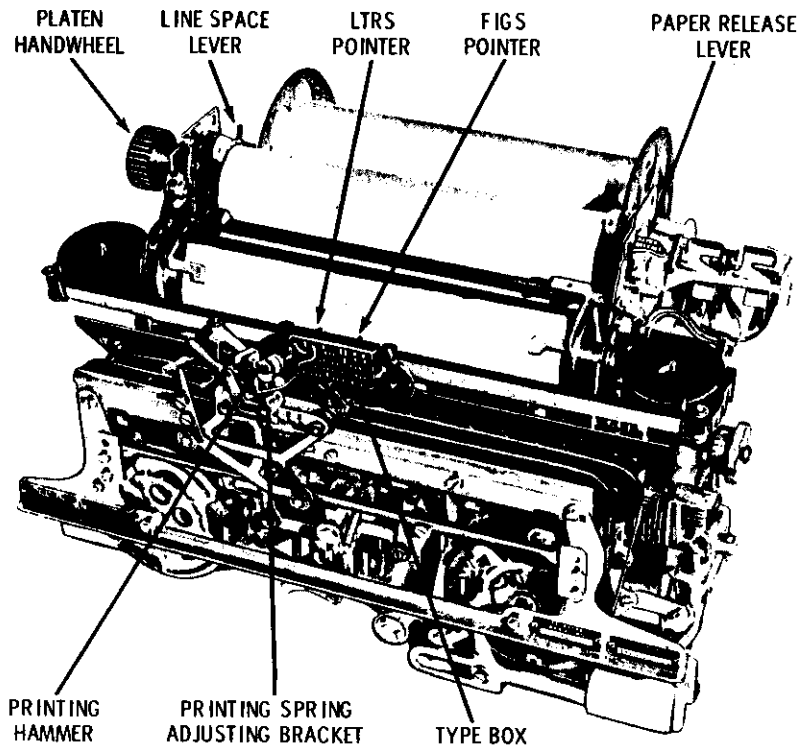

Figure 8-15 Typing Unit, Model 28

5. KBD UNLK (keyboard unlock) KEY – To unlock the keyboard on the local machine, depress the KBD UNLK key. This raises the KBD LOCK key, making the keyboard operative. Operate this key after turning on the control switch and after sending or receiving a BREAK.
6. LOC CR (local carriage return) KEY – To return the type box to the left margin on the local machine, depress the LOC CR key. This key is for use in case of omission of carriage return at the end of a transmission from another station.

Typing Unit

Printing is produced by the type box (Figure 8–15) which contains the characters and symbols shown on the tops of the keys. Operation of keys and space bar moves the type box across the platen from left to right. On each key stroke the type box is moved into position for the printing hammer to strike the proper type pallet, printing the character on the paper. Operation of the CAR RET key returns the type box to the left margin. The operation of the LINE FEED key moves the paper up to the next line.

The force of the printing blow is controlled by the printing spring adjusting bracket, which is set for the individual service requirement according to number of carbon copies required. Notch 1 is for one to three copies, and notch 2 for four, five or six copies. If copies are either too light or too dark, the force of the printing blow can be adjusted by moving the printing spring adjusting bracket, taking care not to make the printing blow any heavier than necessary to produce satisfactory copies.

Type pallets are arranged in four rows. The type box moves up and down in selecting the row in which each character to be printed is located. Lower case characters are in the left half of the box and upper case characters are in the right half. The type box moves left and right on shifting and unshifting operations, rather than in the familar up-and-down motion of carriage shifting on the typewriter and older teletypewriters. This combined vertical and horizontal motion brings the character to be printed into line with the printing hammer. There are two pointers on the type box, the LTRS pointer on the left and the FIGS pointer on the right. When typing stops, the pointer at which the printing hammer is aimed indicates where the next character will be printed. If the printing hammer is aimed at the LTRS pointer, the type box is in lower case. If the printing hammer is aimed at the FIGS pointer, the type box is in upper case. An operation shifting the type box to upper or lower case moves the corresponding pointer to the typing location.

Operating Features

To raise the cover for access to the typing unit to change paper and ribbon or to clean type, press the cover release pushbutton and lift the cover. To raise the lid for access to the paper, press the lid release pushbutton and lift the lid. To turn the paper up or down, raise the cover, and press and hold down the platen handwheel (so that it engages the platen rachet wheel) while turning it in the desired direction. Do not attempt to hold down or operate the platen handwheel while the teletypewriter is operating. To adjust the paper, raise the lid, push back the paper release lever to free the paper, straighten the paper, and pull the lever forward to its normal position. To set the line spacing for single or double space, raise the lid, press the line space lever to the left and pull it forward for single space or push it back for double space. To space to a desired location for typing, space the type box over until the LTRS pointer is at the desired typing location. Then if upper case is desired, operate the FIGS key.

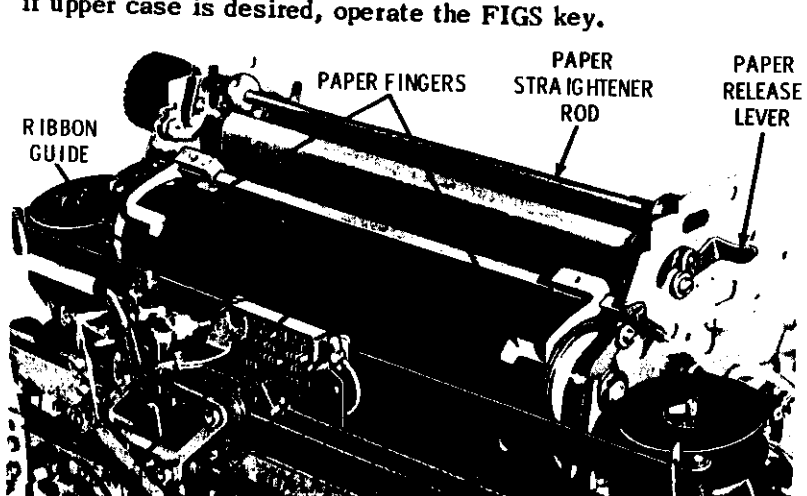

Figure 8-16 Old Roll Removed

Changing Paper

To insert a new roll of paper in the Model 28, first shut off the power. Press cover release pushbutton and lift cover. (Refer as necessary to Figures 8–16 and 8–17.) Push back paper release lever, lift paper fingers, and pull paper from platen.

Lift the used roll from machine and remove spindle from core of used roll. Insert spindle in new roll. Replace spindle in spindle grooves with paper feeding from underneath roll toward you. Feed paper over paper-straightener rod, down under platen, and up between platen and paper fingers. Pull paper up a few inches beyond top of platen, and straighten it as you would straighten paper in a typewriter. Then lower paper fingers onto paper and pull paper release lever forward.

While inserting paper, care should be taken not to disturb the ribbon or the type box latch. After paper is in place, check to see that the ribbon is still properly threaded through the ribbon guides. Also check to make certain the type box

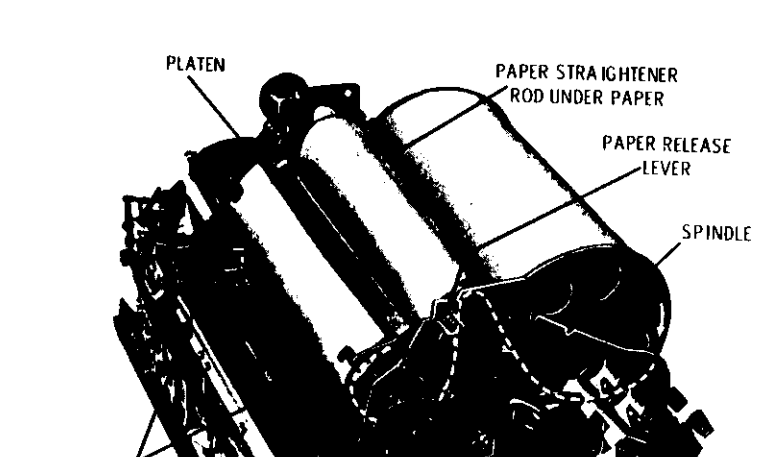

Figure 8-17 New Roll Inserted

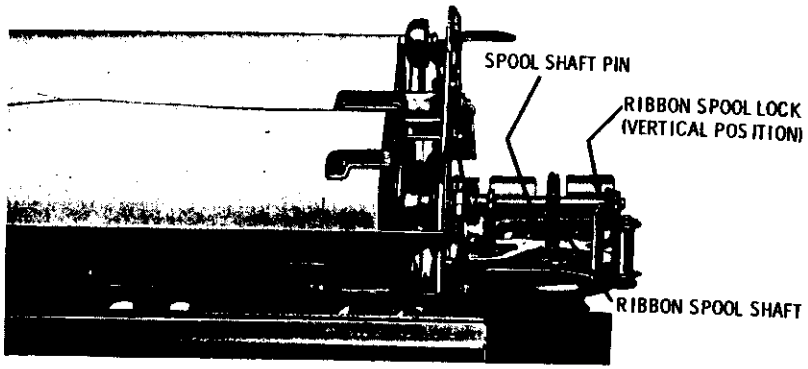

Figure 8-18 The Spool Mechanism

latch has not been disengaged. It should be in a position holding the type box firmly in place. Close cover. Open lid by pressing lid release pushbutton, bring up the end of the paper, and close lid with paper feeding out on top of it.

Changing Ribbon

Use a standard teletypewriter ribbon or, if duplicating is desired, use the proper duplicating ribbon. Press cover release pushbutton and lift cover. (Refer as necessary to Figures 8–18 and 8–19). Lift ribbon spool locks to a vertical position, and remove both spools from ribbon spool shafts. Remove ribbon from ribbon rollers, ribbon levers, and ribbon guides. Unwind and remove old ribbon from one of the spools. Hook end of new ribbon to hub of empty spool and wind until reversing eyelet is on the spool. If the ribbon has no hook at the end, the spool will have a barb which should be used to pierce the ribbon near its end.

Replace spools on ribbon spool shafts, making sure they go down on spool shaft pins, and that the ribbon feeds from the outside of the spools. Turn down ribbon spool locks to a horizontal position, locking spools in place. Thread ribbon forward around both ribbon rollers, through the slots in the ribbon levers and ribbon guides. Take up slack by turning free

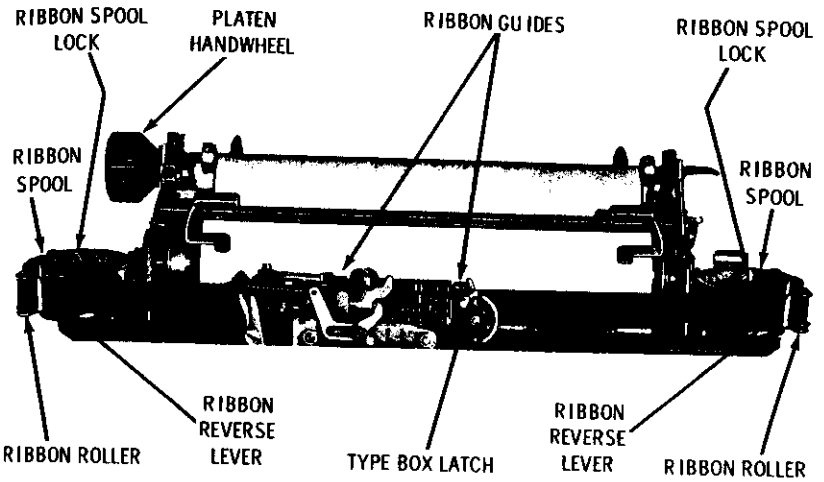

Figure 8-19 Ribbon Inserted

spool. After slack has been taken up, check to make certain that ribbon still is properly threaded through ribbon guides, and that the reversing eyelet is between spool and the reverse lever. Also see that the type box latch has not been disengaged. It should be in position, holding the type box firmly in place.

Turn the paper up a few inches by pressing down and turning platen handwheel. Close cover. Open lid, bring up the end of the paper, and close lid, with paper feeding out on top of it.

Cleaning Type

When printing is smudged the type should be cleaned. To do this you must remove the type box from the machine. Open cover and unlock type box latch by moving it to the right (see Figure 8–20). Grasp handle on right side of type box, and raise that side up and to the left until the type box unhooks on the left side and can be freed from type box carriage. Turn type box over to expose side with type (Figure 8–21) and clean with a dry, hard-bristle brush. DO NOT use type cleaning solution.

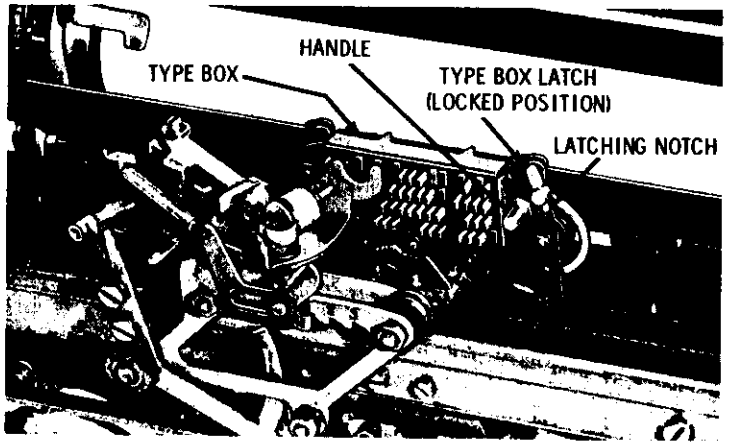

Figure 8-20 Type Box in Place

To replace type box, hold it with type toward platen and the large hook on the left. Slip this hook under stud in front of left type box roller, and push smaller hook on right side down into place on stud in front of right type box roller. Hold type box latch in horizontal position and move to left over latching notch as far as it will go. Raise latch to vertical, and press to left until it locks into latching notch. Check to see that the ribbon is still properly threaded.

TELETYPEWRITER SERVICE TROUBLES

Here are some of the more common service troubles you may encounter, with a brief description of how they may be recognized, the causes, and what action the operator may take to correct them.

Model 28

MOTOR DOES NOT START – Check for a power or fuse

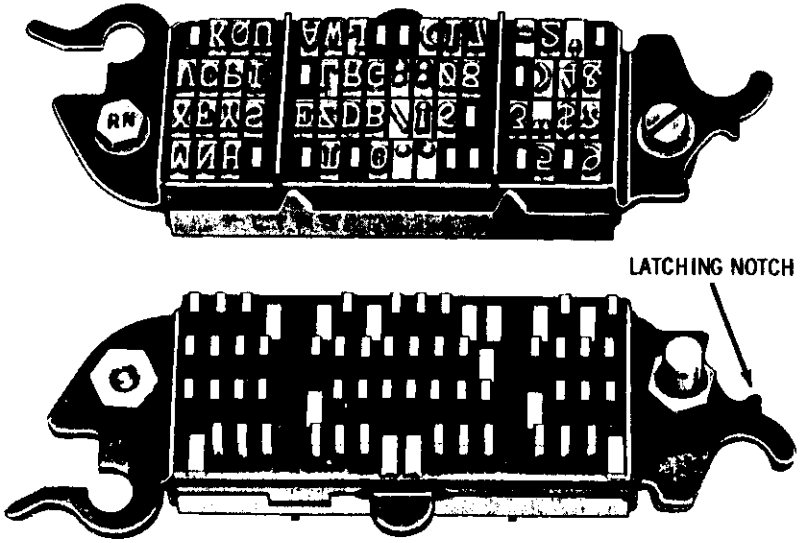

Figure 8-21 Type Box, Front and Back

failure. If a fuse is open, rotate the motor by hand and check for excessive bind.

FAILURE ON LINE FEED – There may be binds in the moving parts of linkage for line feed function. Check that these parts move freely.

FAILURE TO PRINT – This may be due to binds in the printing carriage assembly. Check for freedom of movement in moving parts, and for missing springs. Another source of this trouble may be the improper installation of the ribbon.

RIBBON FAILS TO FEED OR REVERSE – Check for binds in the moving parts of ribbon feeding or reversing mechanism.

NO SIGNALS FROM KEYBOARD – This trouble may stem from either an open or a closed signal line. The contacts should be checked to determine if they are dirty or shorted.

INTERMITTENT ERRORS – This trouble may have a variety

of sources. Among them are inadequate or excessive line current, range finder set beyond range limits, or incorrect adjustments.

The troubles presented here are only a representative sample of those that may be encountered. The instruction books give a more thorough coverage and include helpful charts to aid in tracking down the trouble.

QUIZ

1. What is a probable cause of missing letters in a teletypewriting exercise?
2. Is good typing posture important? Why?
3. Fill in the blanks. Manual operation of the teletypewriter requires_____, _____, _____, and_____ in their proper relation.
4. When is the best time to change the paper roll in your teletypewriter?
5. Is it permissible to use solvents and cleaning fluids to clean the keyboard of your machine?
6. What is the difference between chad and chadless tape?
7. What is contained in the partial fourth row of keys on the Model 28?
8. What component of the Model 28 actually produces printing?
9. What should be used to clean the type in the Model 28?
10. What is the normal length of a teletypewriter line?
11. What is the first thing you should do before opening up a machine for servicing?
12. How can you tell that the paper is running out on a teletypewriter?
13. What function does the LTRS key perform? The FIGS key?
14. What are the two methods of keying a teletypewriter?

CHAPTER 9

RADIOTELETYPE PROCEDURE

General Instructions

Radioteletype (RATT) procedure closely resembles radiotelegraph (CW) procedure. The layout of messages should follow the instructions contained in THE RCN SUPPLEMENT TO ACP 127. Here are some points which you should keep in mind when working in a RATT net:

1. RATT simplex nets are directed nets unless otherwise ordered.
2. Teletypewriters are to be set to DOUBLE LINE spacing to facilitate editing.
3. Procedure messages will be transmitted on ONE LINE, and will end with the prosign K or AR.
4. Other messages will be transmitted with each format line beginning on a SEPARATE line.
5. Plain language messages will bear the security classification as the FIRST WORD of the text.

Machine Functions

Before transmitting a message by RATT you must perform a certain number of machine functions. These are necessary to condition your machine and also distant machines so that good copies are made at all stations in the net. First, let's have a look at some of the function keys which are common to both Model 15 and Model 28.

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SHIFT KEYS – When shifting from lower case to upper case, depress the FIGS key.
– When shifting from upper case to lower case, depress the LTRS key.

CARRIAGE RETURN (CR) – This is employed to reset the machine to the left margin of the paper. Two carriage returns are used to insure the proper return of the carriage. Further reference will be made to the carriage return by using the abbreviation CR.

LINE FEED (LF) – The line feed is employed to advance the paper vertically on the page teletypewriter.

SPACE BAR – The space bar performs the same function as on an ordinary typewriter, that is, it advances the typing unit laterally without printing a character on the page.

BELL SIGNAL – The bell signal is employed to attract the attention of the receiving operator when required. It is transmitted as a series of ten characters in upper case using the letters J and S, like this:

FIGS JJJJJSSSSS LTRS. The letters J and S must both be used because some teletypewriters will respond to J while others will only respond to S.

As most of your RATT operating will be carried out using the Model 28 Teletypewriter, you should learn well the instructions which follow:

1. The machine is fitted with a START/STOP switch which automatically operates if, during transmission reception, a pause of longer than 90 seconds occurs.
2. The associated terminal sets will automatically revert to the STANDBY condition if, during transmission or reception, there is a pause of more than 3 seconds.
3. In view of these points then, it is necessary to perform the MACHINE FUNCTIONS which follow.

Initial Transmission

When establishing communication or when resuming transmission after a pause of 90 seconds or more (your machine motor would be stopped), carry out the following MACHINE FUNCTIONS:

Operation	*Effect*
1. BRK key pressed for 2 seconds.	a. Switches on own motor. b. Locks own keyboard.
2. Press KBD UNLK	a. Unlocks own keyboard.
3. 5 spaces	a. Conditions own terminal set to "transmit". b. Conditions distant terminal sets to "receive". c. Switches on distant motors. d. Clears tape if distant stations are reperforating.
4. 2 CR	a. Aligns all teletypewriters.
5. 1 LF	a. Clears all paper rolls.

Subsequent Transmissions

All subsequent transmissions after delays of less than 90 seconds (your own motor is still running) are to be preceded by:

5 spaces.
2 CR.
1 LF.

Short Pauses in Transmission

If during a transmission, a pause of more than 3 seconds but less than 90 seconds occurs, distant stations' terminal sets must be reconditioned to "receive". This is done by making 2 LTRS or FIGS shifts, depending upon whether the next character to be typed is in upper or lower case.

Initial Alignment of Terminal Sets

Prior to establishing a net, it is essential to align terminal sets of all stations. To accomplish this, the net control station (NCS) transmits a continuous SPACE BAR SIGNAL for 2 complete teletypewriter lines. During this transmission, ships in the net will adjust their terminal sets. In order that the NCS may adjust his own terminal set, a ship of the net will be ordered to transmit a similar space bar signal.

Message Alignment

Specific machine functions are necessary to facilitate the handling of messages and to align receiving page teletypewriters. These are:

1. All transmissions must be preceded by 5 SPACES, 2 CR and 1 LF. See examples at end of chapter.
2. On reaching the end of a line, make 2 CR and 1 LF.
3. To separate the pages of a long message, make 2 CR and 8 LF.
4. On reaching the end of a message, make 2 CR, 8LF, the letter N repeated 4 times, then 12 LTRS.

NO LINE IS TO EXCEED 69 CHARACTERS, INCLUDING SPACES.

Station Designations

The following station designations are authorized for use in calling and answering on RATT circuits:

1. Radio call signs.
2. International call signs.
3. Tactical call signs.
4. Collective call signs.
5. Net call signs.
6. Indefinite call signs.
7. Address groups. (When call signs have not been assigned).

Calling and Answering

Instructions for calling and answering on RATT circuits are identical with those for radiotelegraph circuits. After a preliminary call has been made and answered, the transmitting station will make 5 spaces, 2 CR and 1 LF before transmitting its message. See examples at end of chapter.

Long Messages

During RATT transmission it is impossible for a receiving station to indicate to the transmitting station that it wishes to break in. In order that BREAK-IN procedure may be carried out, you must follow these rules when transmitting a message that has more than 12 lines of text:

1. Prepare the message so that the first page contains the HEADING and the FIRST 10 LINES of text.
2. All succeeding pages contain 20 lines of text. The last page may contain less than 20 lines.

NOTE: A line is considered as a complete line of the text as it appears on the original typewritten message or its equivalent if written free hand. In encrypted traffic, a line is one complete line of the ENCRYPTED TEXT, submitted to the message centre.

3. Confirmation (CFN) and C are used at the end of each page as necessary.
4. Number the pages, starting with PAGE TWO. (See Example C.)
5. Between pages make 2 CR and 8 LF, then pause for at least 10 seconds. This will:
   a. Allow stations with higher precedence traffic to break in.
   b. Provide a visually recognizable place on the tape to the transmitting operator when using automatic tape transmission.
   c. Enable receiving operators to divide long messages into conveniently sized pages for internal handling.

Break-in Procedure

Any station with higher precedence traffic to transmit may break in when the transmitting station makes a deliberate pause. You will recognize this pause as your receiver indicator light will cease to glow. The station breaking in starts off with 5 SPACES, 2 CR, 1 LF. This is followed by an initial call to the NCS, showing the precedence and the addressee (if other than NCS) for whom it is intended. Permission to transmit the message will then be given by NCS (See Example C).

Local Processing and Logging

Operating a teletypewriter in "Local" does not prevent its receiving a transmitted signal. Never operate your machine in "Local" for the purpose of adding extra data like net title, initials, etc., as overprinting may occur. Instead, remove copy from the machine and use a pencil.

The operator's log consists of the back carbon from the message, kept in a continuous roll. When you are finished receiving or transmitting a message, write in the net title, operator's initials, time of receipt or delivery.

Tabulated Messages

A message received for transmission, the text of which is in tabulated form, should be transmitted in tabulated form. In some instances, however, headings of columns require more space than the data shown in the columns. In such cases, the headings should be written on several lines rather than on one line. The columns of data shall be as close to the left margin as possible in order to reduce transmission time.

Confirmation (CFN)

When fifty percent or less of a message consists of figures, unusual letter combinations or figure/letter combinations, such groups may be confirmed.

It is the responsibility of the station called to compare the confirmation with the text. This is to ensure correctness before delivery.

CORRECTION OF ERRORS

Keyboard Transmission

If you make an error during transmission, use the error prosign in the same manner as in radiotelegraph. Resume transmission by repeating the last word or group transmitted correctly. Errors made in the HEADING of a message or in the security classification SHALL NOT be corrected. Cancel it using the error prosign and end-of-message functions.

Example: UNCLAX E E E E E E E E AR 2 CR 8 LF NNNN 12 LTRS

Tape Preparation

Errors made in preparing CHAD tapes will be corrected by backspacing the tape and "lettering out" the error by means of the LTRS key. If an error occurs in the text while preparing a CHADLESS tape, correct it by using the error prosign in the normal manner. However, should the error occur in the heading, scrap the tape and start a new one.

End of Message

While transmitting a message you notice that an error has been made and was not corrected by any of the above methods. Such errors may be corrected at the end of the message. After the last BT, make 2 CR 1 LF. Now make your correction in the normal manner, using prosign C. When errors in the heading are corrected in this manner the entire ELEMENT in which the error occurred must be repeated. Example:

BT	2 CR LF
C FM TO TO	2 CR LF
FM CGLE	2 CR LF
TO	2 CR LF
K	2 CR 8LF
NNNN	12 LTRS.

Multiple Page Messages

Errors may also appear in messages which contain several pages. If neither the "lettering out" procedure nor the error prosign were used, correct the errors at the end of the page after the last text group. Make 2 CR 1 LF and proceed with the corrections using prosign C. When you've completed this, remember that the "end of page functions" (2CR 8LF) have to be made before starting the next page.

Suppose that while transmitting PAGE THREE, you notice an error has appeared on PAGE TWO which was not corrected. Wait until the message is completed, then correct the error on

the last page in the same way using prosign C. When this is done, carry out the normal "end of message functions" (2CR 8LF NNNN 12LTRS).

Cancelling a Transmission

To cancel a transmission while it is in progress, make the error prosign and end with AR. Separate each E in the error prosign with a space, like this. . E E E E E E E E AR.

Messages Forwarded Subject to Correction

This is a situation which may arise. You are the operator on watch on a RATT circuit when an OPERATIONAL IMMEDIATE message is being transmitted to your ship. Several garbled groups appear and there are also a few groups missing from the message. You make efforts to obtain repetitions, but with no success – the reasons for this could be various. Don't make the mistake of setting the message aside until conditions improve – *REPORT IT IMMEDIATELY*. If the message is of any value (it's not so garbled as to be useless), then it will be delivered with the appropriate notations on the message. Should the message require forwarding to another addressee, an operating signal will be included in the transmission instructions to cover the situation. Here are three operating signals which could be used:

ZDG .....Accuracy of following message is doubtful. Correction or confirmation will be forwarded.

ZEH .....Accuracy of .....portion of following message is doubtful. Correction or confirmation will be forwarded (1.Heading 2.Text 3.Group . . .to . . .).

ZEP .....This message was incompletely received. Each word or group missed, which is indicated by position of ZEP in the message, will be forwarded as soon as obtained.

A station delivering or forwarding a message "subject to correction" is responsible for obtaining and forwarding such corrections.

EXAMPLES

Note that in the examples which follow, the short break (–) is not used. This prosign does not exist for teletypewriter procedure.

The following call sign organization is in effect for these examples:

		Call Sign
Net Control Station (NCS)	HMCS BONAVENTURE	CGLE
Collective Call Sign		OFBJ
Ships in Company	HMCS COLUMBIA	CGJR
	HMCS KOOTENAY	CGKG
	HMCS MARGAREE	CGNJ
	HMCS GATINEAU	CGWF

Example "A":

Initial Alignment of Terminal Sets

All ships have been instructed to set watch at 1200Z.

1. At 1200Z, NCS calls all ships and transmits a *SPACE BAR SIGNAL.*

Transmission	*Machine Functions*
	Press BRK key for 2 seconds. KBD UNLK 5 spaces 2CR LF
OFBJ DE CGLE (BONAVENTURE now presses space bar and REPT key for two complete teletypewriter lines)	
AR	2CR LF

2. NCS now instructs COLUMBIA (CGJR) to carry out a similar transmission

Transmission	*Machine Functions*
	5 spaces 2CR LF
CGJR DE CGLE ZA18 K	2CR LF

(ZA18 means "Run space bar transmission")

3. COLUMBIA now transmits space bar signal as instructed.

Transmission	*Machine Functions*
	5 spaces 2CR LF
CGLE DE CGJR	
(COLUMBIA presses space bar and REPT key for two complete teletypewriter lines)	
AR	2CR LF

Example "B":

Establishing a Net and Transmitting a Short Plaindress Message

1. NCS calls all ships and asks what traffic they have on hand.

Transmission	*Machine Functions*
	Press BRK key for 2 seconds.
	KBD UNLK
	5 spaces 2CR LF
OFBJ DE CGLE INT ZBO K	2 CR LF

2. Stations answer in alphabetical sequence of call signs.

(a) COLUMBIA's operator indicates he has no traffic.

Transmission	*Machine Functions*
	5 spaces 2CR LF
DE CGJR QRU AR	2CR LF

(b) KOOTENAY indicates he has no traffic.

Transmission	*Machine Functions*
	5 spaces 2CR LF
DE CGKG QRU AR	2CR LF

(c) MARGAREE indicates he has a PRIORITY message for GATINEAU.

Transmission	*Machine Functions*
	5 spaces 2CR LF
DE CGNJ ZBO 1P CGWF K	2CR LF

(d) GATINEAU indicates he has no traffic.

Transmission	*Machine Functions*
	5 spaces 2CR LF
DE CGWF QRU AR	2CR LF

3. NCS instructs MARGAREE's operator to transmit his message to GATINEAU.

Transmission	*Machine Functions*
	5 spaces 2CR LF
CGNJ DE CGLE K AR	2CR LF

4. MARGAREE transmits his message to GATINEAU

Transmission	*Machine Functions*
	5 spaces 2CR 8LF
CGWF DE CGNJ	2CR LF
P 171145Z	2CR LF
BT	2CR LF
UNCLAS	2CR LF
YOUR 170925Z. ITEM WILL BE TRANSFERRED AT FIRST	2CR LF
OPPORTUNITY	2CR LF
BT	2CR LF
K	2CR 8LF
NNNN	12 LTRS

5. GATINEAU now receipts for the message.

Transmission	*Machine Functions*
	5 spaces 2CR LF
CGNJ DE CGWF R AR	2CR LF

Example "C":

Transmitting a Long Message and a Station Using Break-in Procedure

1. KOOTENAY commences transmitting a long routine message to BONAVENTURE.

Transmission	*Machine Functions*
	5 spaces 2CR LF
CGLE DE CGKG	2CR LF
R 171258Z	2CR LF
FM KOOTENAY	2CR LF

TO CANCOMFLT	2CR LF
BT	2CR LF
UNCLAS	2CR LF
(first ten lines of text...)	2CR 8LF

At this point KOOTENAY makes a deliberate pause of 10 secs.

2. COLUMBIA, who has been waiting for this pause in transmission, now transmits to NCS indicating that he has a PRIORITY message for GATINEAU.

Transmission	*Machine Functions*
	5 spaces 2CR LF
CGLE DE CGJR ZBO 1P	
CGWF K	2CR LF

3. NCS instructs COLUMBIA to transmit his message.

Transmission	*Machine Functions*
	5 spaces 2CR LF
CGJR DE CGLE K AR	2CR LF

4. COLUMBIA now transmits his message to GATINEAU.

Transmission	*Machine Functions*
	5 spaces 2CR LF
CGWF DE CGJR	2CR LF
P 171255Z	2CR LF
BT	2CR LF
UNCLAS	2CR LF
(....text....)	2CR LF
BT	2CR LF
K	2CR 8LF
NNNN	12 LTRS

5. GATINEAU receipts for the message.

Transmission	*Machine Functions*
	5 spaces 2CR LF
CGJR DE CGWF R AR	2CR LF

6. NCS instructs KOOTENAY to continue with his long message.

Transmission	*Machine Functions*
	5 spaces 2CR LF

CGKG DE CGLE K AR	2CR LF

7. KOOTENAY continues message with page two.

Transmission	*Machine Functions*
	5 spaces 2CR LF
PAGE TWO CGKG 171258Z	2CR LF
(20 teletypewriter lines of text)	2CR 8LF

.....another deliberate pause of 10 seconds.

8. As no station transmits during this pause, KOOTENAY continues with his message.

Transmission	*Machine Functions*
	5 spaces 2CR LF
PAGE THREE CGKG 171258Z	2CR LF
(remainder of text....5 lines)	2CR LF
BT	2CR LF
K	2CR 8LF
NNNN	12 LTRS

9. BONAVENTURE receipts for the message.

Transmission	*Machine Functions*
	5 spaces 2CR LF
CGKG DE CGLE R AR	2CR LF

Example "D":

Control Station Broadcasting to all Stations in the Net, and Controlling One Station to Receipt

1. *Transmission* — *Machine Functions*: 5 spaces 2CR LF

OFBJ DE CGLE	2CR LF
R 171342Z	2CR LF
FM CANCOMFLT	2CR LF
TO CANCORTRON ONE	2CR LF
BT	2CR LF
UNCLAS	2CR LF
(3 lines of text.....)	2CR LF
BT	2CR LF
CGNJ	2CR LF
K	2CR 8LF
NNNN	12 LTRS

A flow of 1 coulomb per second is equal to 1 AMPERE, a term that is at the same time a measure of quantity and time, just as the term KNOT is a measure of both distance and time.

Voltage and Resistance

Assume that a water-main is fed from a stand-pipe some miles away. Water flows because the water level in the stand-pipe is higher than the outlet of the main, and the difference in their levels causes a pressure to be exerted on water in the main.

The movement of electricity is comparable. If there is a difference in the relative electrical level between two terminals of the conductor, electrons move from the point of relative surplus (negative terminal) to the point of relative shortage (positive terminal) and a current flows. This difference in electrical level is termed DIFFERENCE IN POTENTIAL, and may also be thought of as a pressure. It is measured in *VOLTS*. An electrical conductor offers resistance to the flow of current just as the inside surface of the main offers resistance to the flow of water. Electrical resistance is measured in OHMS. To force 1 ampere through a resistance of 1 ohm requires a pressure of 1 volt.

Power

Power, the Time Rate of doing work, is the product of voltage and amperage. The electrical unit of power, the *WATT*, is the product of 1 volt and 1 ampere.

The Radio Wave

It is believed that the radio wave travels through a series of crests and troughs similar to an ocean wave, or better, the round outward-moving waves created by a stone thrown into a pond. The movement of radio waves is somewhat like the movement of water waves away from a point of disturbance.

A brief study of Figure 10–1 will aid in understanding four

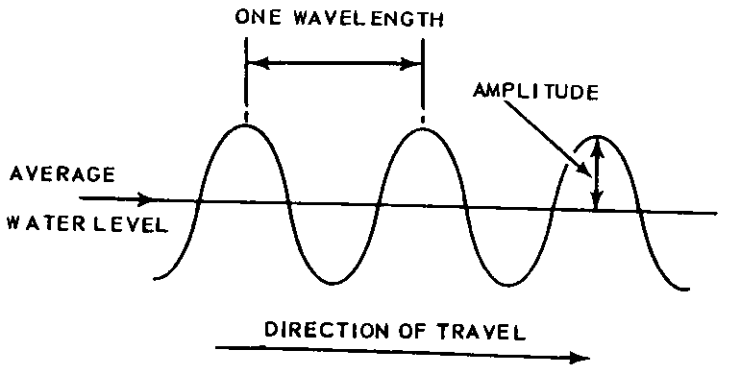


Figure 10-1 Movement of a Water Wave from a Point of Disturbance

important aspects of the radio wave: AMPLITUDE, WAVELENGTH, CYCLE and FREQUENCY. The amplitude of a wave is the vertical distance from average water level to the peak (or trough) of the wave, and is the measure of energy level of the wave – just as it is of the radio wave, which, if we could see it, would closely resemble Figure 10–1. A wavelength is the distance from one crest to the next. (It is just as accurate to measure from trough to trough, or from any point to the corresponding point on the next wave). A cycle is a complete sequence of variation of movement of the wave from a trough, through a crest, into another trough. The number of cycles which occur in a given unit of time is said to be the frequency of a wave.

Now, consider the ocean wave. With long, rolling ground swells, the wave may have a length of a half mile or more. If the cycles occur twice per minute, the ocean wave has a frequency of 2 cycles per minute. The length of a radio wave may vary from several miles down to a fraction of an inch. Its frequency may be a few thousand cycles per second or many million cycles per second.

In practice, radio wavelength is measured in metres. (A metre is 39.37 inches.) Frequency is counted in thousands

and millions of cycles per second using two prefixes from the metric system, KILO and MEGA. Two expressions in everyday use by communication personnel are KILOCYCLES (thousands of cycles per second) and MEGACYCLES (millions of cycles per second). The Navy abbreviates these words to kcs and mcs.

A frequency of 15,000 cycles per second is expressed as 15 kcs, 500,000 cycles as 500 kcs. When the number of kilocycles reaches 1000, megacycles are used instead to make the reckoning easier. Thus 82,000 kcs is expressed as 82 mcs.

It is common practice to group frequencies into bands. The so-called commercial broadcast band, extending from 550 kcs to 1600 kcs is a familiar one. Frequency band designations and their corresponding abbreviations are shown in the table below.

Designation of Radio Waves according to Frequency	Authorized Abbreviations	Frequency
Very low	VLF	Below 30 Kc/s
Low	LF	30 to 300 Kc/s
Medium	MF	300 to 3000 Kc/s
High	HF	3 to 30 Mc/s
Very High	VHF	30 to 300 Mc/s
Ultra-High	UHF	300 to 3000 Mc/s
Super-High	SHF	3000 to 30,000 Mc/s
Extremely High	EHF	30,000 to 300,000 Mc/s

Frequency directly affects the behaviour of radio waves. At low frequencies waves bend to follow the curvature of the earth and so travel farther, provided the power is there to push them. Thus shore stations with huge power and antenna installations are best equipped to give long-range radio communication at low frequencies.

After a certain high frequency is attained, the waves do not bend around the earth. Instead, they penetrate the earth's atmosphere and go into space. Most radiotelephone transmissions are at these high frequencies, and in general cannot

be heard past the point where the earth curves away at the horizon. Remember, however, that this is because of the properties of the frequencies used for radiotelephone communication, and is not necessarily a characteristic of radiotelephone itself. Radiotelephone transmissions sent out on the lower frequencies will travel far beyond the horizon.

Think once more of a stone tossed into a pond. Circular waves glide outward from the splash, one within another, until their energy is used up. A transmitting station corresponds to the point of disturbance made by the stone. In the centre is an antenna with alternating current producing radio waves in the space around it. Unlike the waves on the pond, however, radio waves move in all directions, going up into the sky as well as along the surface of the earth. Those moving along the surface of the earth are GROUND WAVES; those going into the atmosphere, SKY WAVES. Figure 10–2 illustrates the formation of GROUND and SKY waves.

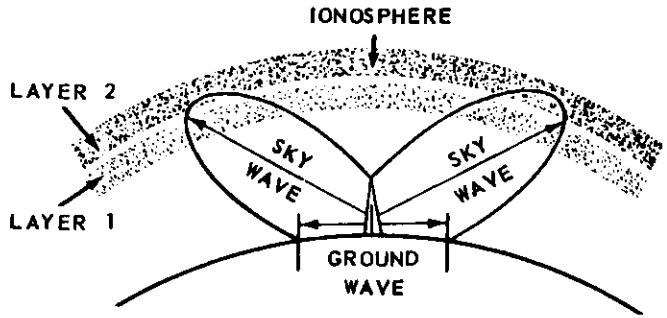


Figure 10-2 Formation of Ground and Sky Waves

Ground waves moving over the surface of the earth rapidly weaken until they are no longer of useful strength. The sky wave, when it leaves the antenna, continues to rise until it literally "bumps into" the sky. Some of the wave is absorbed on collision, but much of its energy is bent and returned to

2. MARGAREE receipts for the message.

Transmission	*Machine Functions*
	5 spaces 2CR LF
CGLE DE CGNJ R AR	2CR LF

QUIZ.

1. Are RATT simplex nets directed or free nets?
2. Should your teletypewriter be set to SINGLE or DOUBLE line spacing?
3. Procedure messages are transmitted on_____line/s and will end with prosign_____or_____.
4. Where does the security classification appear in plain language messages?
5. How is the BELL SIGNAL transmitted?
6. How long a pause is required to automatically operate the START/STOP switch on the Model 28?
7. What type of signal does the NCS transmit prior to establishing a net?
8. What machine functions are carried out at the END OF A LINE?
9. What is the maximum number of characters allowed per line?
10. Are ADDRESS GROUPS authorized for calling and answering?
11. In a long message, what does the first page contain?
12. Why should you not operate your teletypewriter in LOCAL?
13. When_____per cent or less of a message consists of figures, unusual letter combinations or figure/letter combinations, such groups may be_____.
14. While preparing a CHADLESS tape you make an error. How is it corrected? Suppose the error occured in the heading?

15. How would you cancel a message during transmission?
16. What action should you take with a partially garbled OPERATIONAL IMMEDIATE message when attempts to obtain repetitions are unsuccessful?

CHAPTER 10

RADIO EQUIPMENT

During your career as a radioman you will be using and maintaining upwards of fifteen different pieces of radio equipment. It is therefore quite important that you know something about the equipment – its capabilities and general uses, usual location in a ship, fault-finding techniques, etc. This chapter will present in brief form the BASIC principles of radio equipment. A more complete and comprehensive study of this subject is covered in the RM course at the Communications Division.

Let us begin with a review of electrical units, then proceed to the radio wave, and from there into transmitters and receivers.

Electrical Units

An electrical current is often compared to the flow of water through a pipe. To gauge the rate of flow we must have a measure of quantity (pints, quarts, gallons, barrels, etc.) and a measure of time (seconds, minutes, hours, etc.)

In an electrical circuit the current that flows is composed of electrons, which are tiny charged particles that form one of the constituent parts of atoms. The electron is far too small to serve as a measure of quantity, and a larger unit, the COULOMB is used instead. One coulomb equals 6.28×10^{18} (628 followed by 16 zeros) electrons. The measure of time is the second.

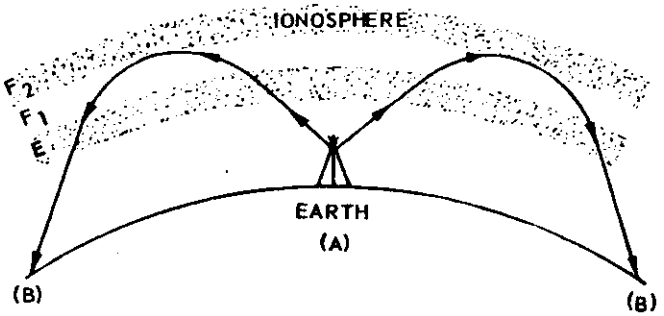


Figure 10-3 Refraction of the Sky Wave by the Ionosphere

earth again (Figure 10–3). These bent waves are very useful in communications, for they continue to bounce between earth and sky, increasing their range until all the energy is spent.

The reflecting of radio waves by the "sky" is accomplished by charged layers of particles called IONS. The intense rays of the sun striking the upper atmosphere on their way to the earth produce these ions which form in layers to become the ionosphere. This mass of particles, located from 30 to 350 miles above the earth's surface, constantly shifts and changes as the effects of the sun's rays vary from daylight to dark and from winter to summer.

A change in the ionosphere affects radio transmission and reception, since it causes more of the radio wave to be absorbed at one time, or bends it to a different degree at another time.

Wherever the bent sky wave returns to earth, it can be picked up by a radio receiver. Suppose the ground wave from your antenna travels 100 miles and the first sky wave returns to earth 500 miles from your ship. There is a strip 400 miles wide around you in which your signal cannot be detected, (Figure 10–4). This is called the ZONE OF SILENCE. It begins at the end of the useful ground wave and extends to

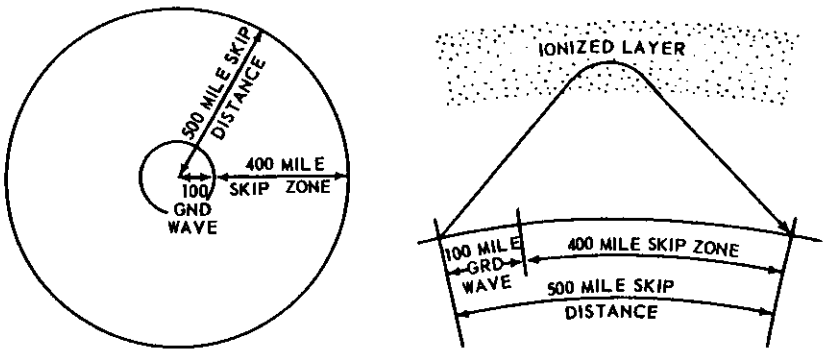


Figure 10-4 Skip Zone and Skip Distance

the first returning sky wave. The 500-mile distance between transmitter and point at which the sky wave first returns to earth is called SKIP DISTANCE.

UHF Propagation

Most radiotelephone communication takes place in the UHF band, which includes the frequencies between 300 and 3000 mcs. The low end of this band is used for communication and portions of the high end are used for radar. Several advantages are gained by using frequencies in the UHF band. Because the ionosphere is not dense enough to reflect a sky wave of UHF radiation, most transmissions are limited to the line of sight or the direct wave.

However, UHF transmissions are not always limited to line of sight. Sometimes the lower atmosphere is composed of horizontal layers in which the temperature and moisture content vary in a manner that is not usual. If variation is great enough, ducts may be formed. These ducts may channel radio and radar waves far beyond the horizon.

Line of sight reception is very satisfactory and is relatively free from static and fading. Another advantage is the secrecy

of transmissions due to the small area normally covered, but this is not to be interpreted in the sense that security precautions may be relaxed when using UHF. The usual range of transmissions is somewhat extended because of refraction; it is actually about 15 per cent beyond the visible horizon.

TRANSMITTERS

The largest transmitter in use in the RCN is situated at Newport Corner, N.S. and has a power output of 250,000 watts. The largest transmitter in the world is the U.S. Navy's VLF transmitter located at Cutler, Maine, which operates on a rated power output of two million watts. Its signal blankets most of the earth. The smallest transmitter we use is the CPRC "walkie-talkie" with an output of 0.3 watts that can be heard through a radius of only a mile or so.

Our ships are equipped with transmitters rated from 0.3 to 1000 watts. It is difficult to generalize on the maximum range of shipboard equipment, for the distance varies both daily and seasonally and is affected by atmospheric disturbances and geographical location. It may be said, however, that a ship is rarely out of communication because of equipment limitations. The general plan for all transmitters can be seen in Figure 10–5.

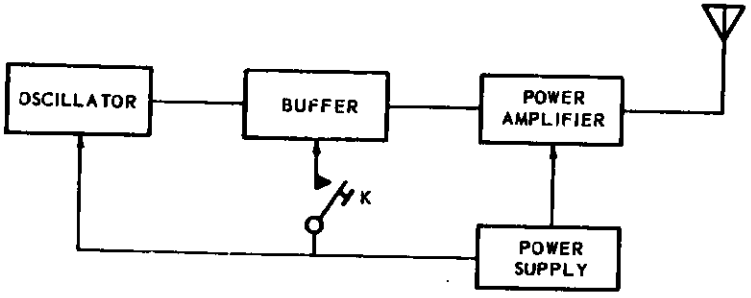


Figure 10-5 Stages of a Typical Transmitter

Every transmitter has an OSCILLATOR, which generates the basic signal. The oscillator may be of the self-excited type, which originates the signal in electron tubes and associated circuits. Or it may be of the crystal type, which employs in conjunction with an electron tube a piece of quartz cut to vibrate at a certain frequency when electrically energized. In either case the power produced by the oscillator is very small, and must be amplified many times before being passed on to the antenna to be radiated.

The BUFFER stage is a voltage amplifier which increases the amplitude of the oscillator signal to a level that will drive the power amplifier. Voltage delivered by the buffer varies with the type of transmitter, but it may be hundreds or thousands of volts. Current in most equipment is still only a fraction of an ampere.

The buffer serves two other purposes, one of which is to isolate the oscillator from the amplifier stages. Without the buffer, changes in the amplifier due to keying or variations in coarse voltage would vary the load on the oscillator and cause it to change frequency. It may also be a frequency multiplier, as we will see in a moment.

The final stage of a transmitter is the power amplifier. Power is the product of current and voltage, and here a large amount of RF current is made available to the load. This energy is passed into the antenna to be radiated.

Harmonics and Frequency Multiplication

The term HARMONICS is sometimes loosely used to designate unwanted radiations caused by imperfections in the transmitting equipment, but this is not entirely accurate. True harmonics are always exact multiples of the basic or FUNDAMENTAL frequency generated by the oscillator and are created in the vacuum tubes and their associated circuits. Even harmonics are two, four, six, eight, etc., times the fundamental; odd harmonics are three, five, seven, nine, etc., times the fundamental. If an oscillator has a fundamental frequency of 2500 kcs, harmonically related frequencies are:

5000 ..... 2nd harmonic
7500 ..... 3rd harmonic
10,000 ..... 4th harmonic
12,500 ..... 5th harmonic

The series ascends indefinitely until the intensity is too weak to be detected. In general, the energy in frequencies above the third harmonic is too weak to be significant.

It is difficult to design and build a stable oscillator for high frequencies, and, if a crystal is used to control a high-frequency oscillator, it must be ground so thin that it might crack while vibrating. To overcome these difficulties, oscillators are built to generate a relatively low fundamental frequency. Higher frequencies are developed by having the buffer stage tuned to higher harmonics. This is called FREQUENCY MULTIPLICATION and is illustrated in the block diagram shown in Figure 10–6.

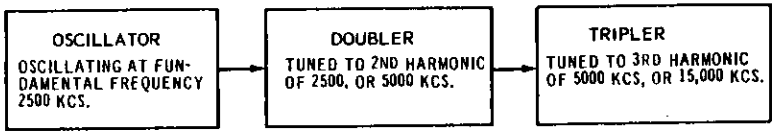


Figure 10-6 Harmonics and Frequency Multiplication

In the block diagram, the oscillator is tuned to the fundamental, 2500 kcs. The next stage, the doubler, is tuned to the second harmonic, 5000 kcs. In the doubler stage, the 5000 kcs also has harmonics; and as far as the next stage, the tripler, is concerned, 5000 kcs can be considered as a new fundamental. Therefore the tripler stage can be tuned to the third harmonic of 5000 kcs, or 15,000 kcs. Thus the output of the tripler stage is six times the frequency of the oscillator.

Modulation

We have, to this point, discussed only continuous wave

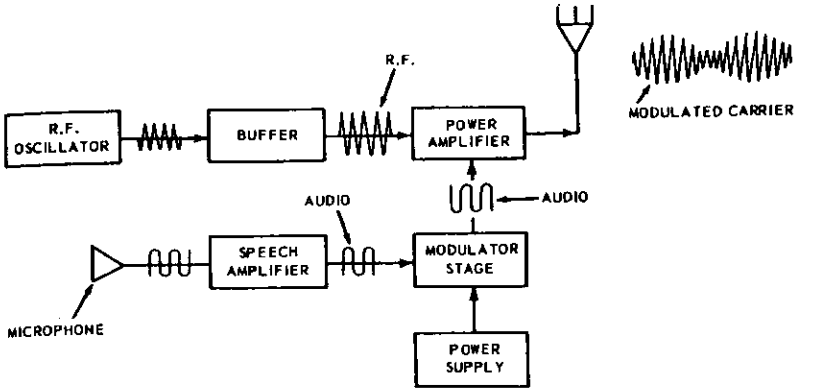


Figure 10-7 Block Diagram of a Modulated Transmission

transmitters. If the radio wave is to be made to carry voice or other sounds – that is, if it is to be MODULATED – the CW transmitter must be combined with an audio amplifier.

In Figure 10–7 the output of a speech amplifier is fed into a modulated stage, causing the output of the power amplifier to vary in accordance with the voice signal. The radio-frequency (RF) and audio-frequency (AF) voltages are combined in the power amplifier to form a wave that contains characteristics of both. Notice in Figure 10–7 that the envelope of the modulated wave has the same shape as the modulating wave. The part of the resultant wave that comes from the transmitter section is the RF component; the part from the speech amplifier is the AF component.

If the modulation voltage is sent into the power amplifier stage, such a transmitter is said to be using HIGH-LEVEL MODULATION. If the modulation is accomplished at an earlier stage, as in Figure 10–8, the transmitter is said to be using LOW-LEVEL MODULATION. High-level modulation is more efficient, but low-level modulation requires less power. Navy transmitters employ high-level modulation except when weight is an important consideration, as it is in aircraft and portable equipment (Figure 10–8).

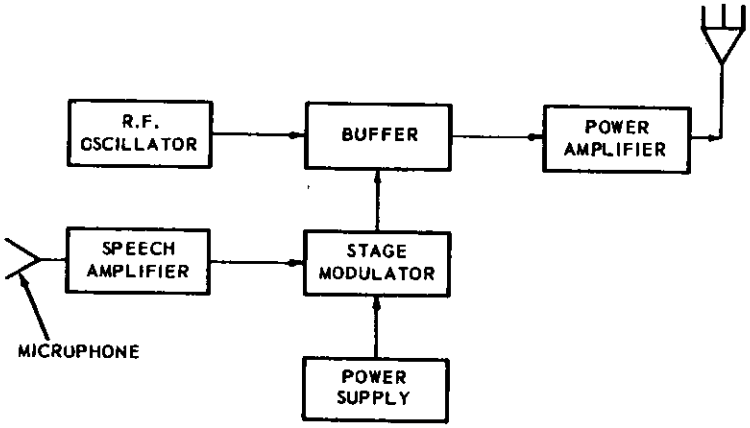


Figure 10-8 Block Diagram of a Low-Level Modulated Transmitter

Modulated CW

Some transmitters combine the characteristics of CW and modulated CW transmission. Figure 10–9 is a block diagram of a modulated CW code transmitter. An audio-frequency oscillator, generating a note of constant frequency is inserted in place of a speech amplifier. The RF section of the transmitter produces a constant wave. When the key in the audio-oscillator is closed, the AF signal is sent into the power amplifier, modulating the carrier wave. The received sound is at the frequency of the audio oscillator (Figure 10–9).

Frequency Modulation

It is possible to modulate a signal by varying the frequency (rather than the amplitude) of the carrier wave in accordance with the audio frequencies of voice or music.

The primary advantages of frequency modulation are improved fidelity and greater freedom from static. Owing to these qualities it is of considerable use in commercial broadcasting, but its shortcomings – frequency extravagance, short range on available frequencies, and others – have severely limited its military communication applications.

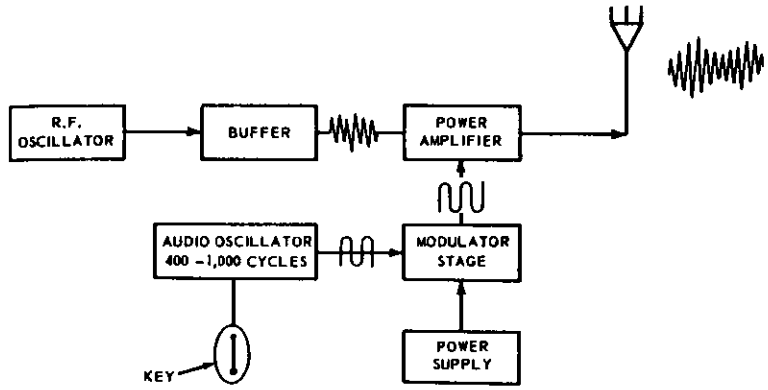


Figure 10-9 Block Diagram of a Modulated CW Code Transmitter

ANTENNAE

Radio energy generated by the transmitter is radiated by the antenna. Any wire carrying alternating current will radiate some energy. Perhaps you have noticed the interference in an automobile radio when near power lines. A power line is, of course, a poor antenna because it was designed to carry rather than to radiate energy.

One basic antenna is the dipole (sometimes called a Hertz, or half-wave antenna), a wire with a length equal to half a wavelength. It must be remembered that a transmitter is merely a high-voltage generator of alternating current. If a feeder line from a transmitter is connected to the centre of a dipole, the antenna will act as though an AC generator were set between two quarter-wave antennae, as in Figure 10–10. During one-half of the generator's alternation, electrons in the antenna will flow from right to left (Figure 10–10B). On the next half alternation, electrons flow in the opposite direction (Figure 10–10C).

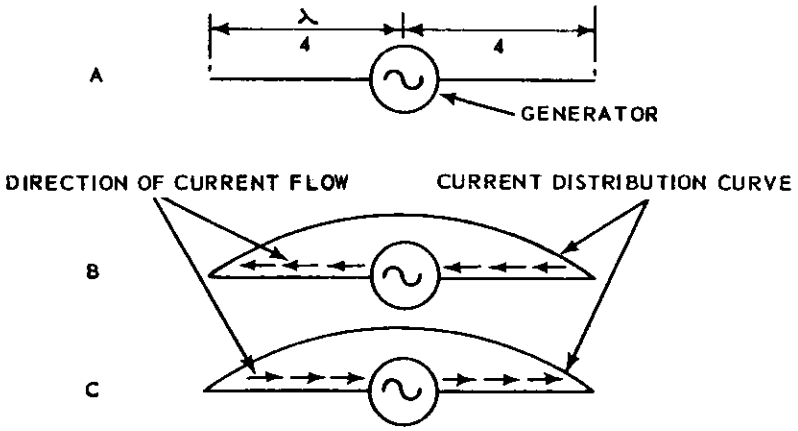


Figure 10-10 Instantaneous Direction and Distribution of Current in an Antenna

The voltage in the transmitting antenna establishes an electric field in the space about the wire, and the current establishes a magnetic field. One cannot exist without the other. The two together make up an ELECTROMAGNETIC wave, which is what engineers call a radio wave.

If the feeder line to the antenna were cut, stopping the flow of energy to the antenna, the electromagnetic field would collapse back to the parent wire. An alternating current is flowing into the wire and, as it changes direction, there is an instant when no current flows. The field at once begins to collapse, but, even though the energy is moving at the speed of light (186,000 miles per second) the outermost part of the field cannot return to the wire before the next half alternation has thrown up a new field of opposite polarity. Thus the returning field is pushed away from the antenna and becomes a free wave of electromagnetic energy radiating through space.

A vertical dipole, suspended in space away from the influence of the earth, would be surrounded by a radiation pattern

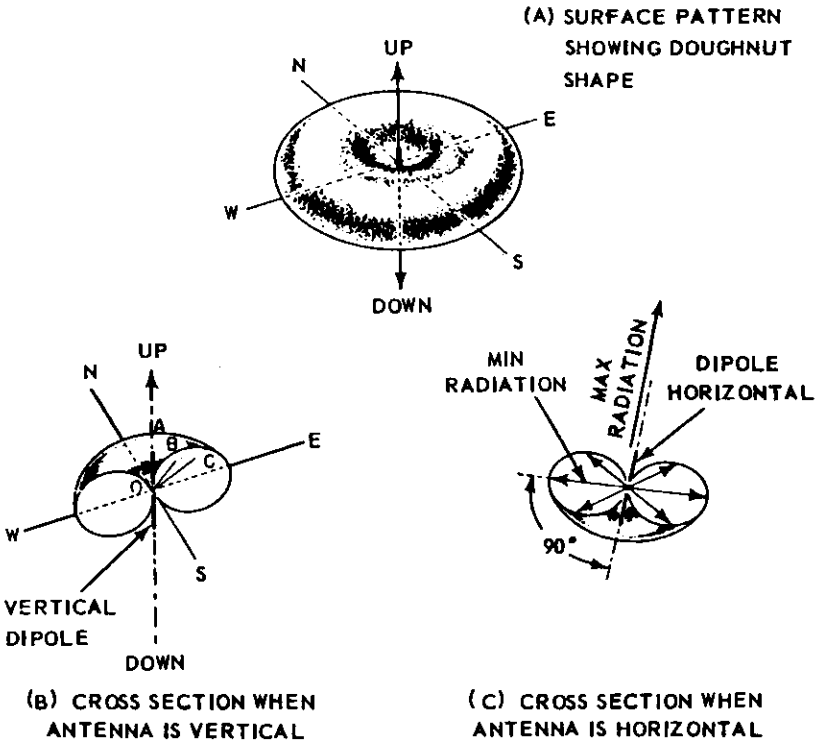


Figure 10-11 Electromagnetic Field Surrounding a Dipole

the shape of a doughnut as in Figure 10–11, parts A and B. No radiation takes place at the ends of the dipole (line OA). Radiation progressively increases through lines OB and OC, until the maximum is radiated on a plane parallel to the surface of the earth.

The field radiated by a horizontal dipole is in the shape of a doughnut standing on edge (Figure 10–11). The greatest field strength is now in a vertical plane, but still at right angles to the dipole.

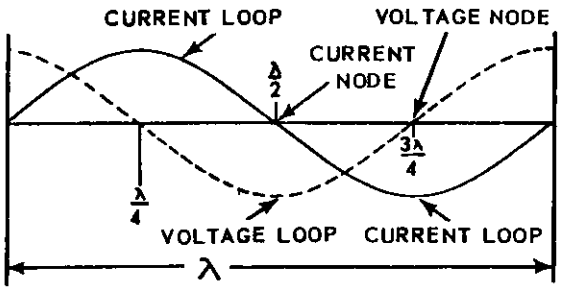


Figure 10-12 Standing Waves along Full-Wave Antenna

Standing Waves

If an antenna is energized by an alternating current of a frequency equal to the antenna's resonant frequency, the current and voltage values will vary along the length of the wire, and will always be 90° out of phase. In a full-wave antenna current will be at minimum in the centre and at the ends. These points are called NODES. Figure 10–12 shows the location of node points along a full-wave antenna. Current and voltage nodes appear every half wavelength but are separated from each other by one-quarter wavelength.

The wave of energy sent out by the transmitter travels to the ends of the antenna, from where it is reflected back along the length of the wire. The time required for this process depends upon the length of the antenna. If the dipole is resonant to the frequency generated by the transmitter, the returning wave strikes the fresh oncoming wave and the current and voltage in the two waves reinforce each other.

This condition continues as long as the antenna is energized, and the effect is the same as though there were STANDING WAVES along the length of the wire instead of two sets of moving waves, as is really the case. Only in presence of standing waves is the antenna radiating at maximum.

Actual and Electrical Antenna Length

The dipole has been defined as an antenna with a length equal to half a wavelength. Assume that a station wishes to transmit on a frequency of 3 mcs. There is a formula for finding the wavelength for a given frequency, and from that the proper antenna length:

$$\frac{300 \times 10^6}{\text{Frequency in cycles per second}} = \text{wavelength (in metres).}$$

The numerator 300×10^6 is a constant, the speed of radio waves in metres per second. Substituting, we find:

$$\frac{300 \times 10^6 \text{ (velocity in metres per second)}}{3 \times 10^6 \text{ (frequency in cycles per second)}} = 100 \text{ metres (wavelength).}$$

The dipole to be used for that frequency will be:

$\frac{100}{2}$ = 50 metres, or about 164 feet.

This formula holds true only for an ideal antenna, completely free from the influence of the earth. Since no antenna really is free from the earth's influence, the physical length of an antenna should be about 5 percent shorter than the electrical length given by the formula. A half-wave antenna for a 100-metre station will be 50 metres minus 5%, or 47.5 metres long. The physical length of a half-wave antenna for frequencies above 30 mcs can be calculated from the frequency by the following equation:

$$\text{Length (feet)} = \frac{492 \times 0.95}{\text{Frequency in megacycles}}$$

The number 492 is a constant. The correction factor 0.95 is 100 percent minus the 5 percent loss due to the effect of the earth.

It is, of course, impractical to lengthen or shorten an antenna physically every time the transmitter is tuned to a new frequency. The length may, however, be changed electrically, a process known as TUNING the antenna. Because of cost and construction difficulties, half-wave antennae are seldom used for transmitters operating at frequencies below 1000 kcs. A dipole for 550 kcs, for example, would have to

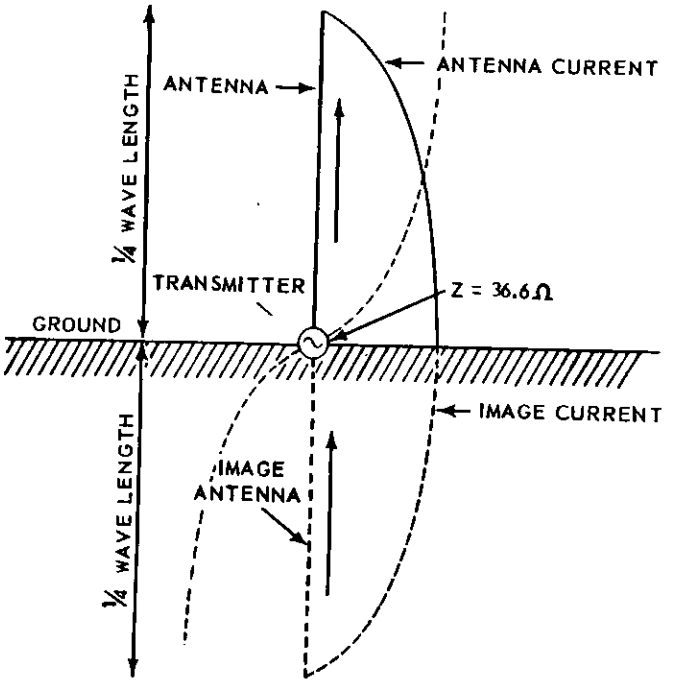


Figure 10-13 Quarter-Wave Marconi Antenna showing Image Current

be about 851 feet long. At the lower frequencies the MARCONI antenna, another basic type, affords a solution to the problem of undue length.

Marconi Antenna

The principle of the Marconi antenna (also known as the quarter-wave or grounded antenna) is illustrated in Figure 10–13. The transmitter is connected between the bottom of the antenna and the earth. Although the antenna is only a quarter wavelength, the earth itself acts as another quarter-wave antenna. By the aid of this IMAGE wave in the earth, half-wave operation is obtained from an antenna half the size of a dipole.

The relationship of current and voltage in a quarter-wave antenna is similar to that in a dipole. Voltage is greatest at the top of the antenna and least at the bottom. Current is greatest at the bottom and least at the top.

The Marconi antenna is used a great deal with portable transmitters. On an airplane, a quarter-wave mast or a trailing wire is the antenna, and the fuselage produces the image. Similar installations are made on ships. A quarter-wave mast or horizontal wire is the antenna, and the superstructure and hull provide the image.

Your Job and Antennae

You may never be called upon to rig an antenna, or even change an installation you are using, but, with mastery of the foregoing information, you should have little trouble, should the occasion arise.

In rigging emergency antennae, have your antennae already cut to proper length, with necessary insulators and turnbuckles secured to each end. 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.

Remember, the antenna's job is to radiate, in the form of electromagnetic waves, the energy delivered by the transmission lines from the transmitter. To do this, the antenna must be correctly built and correctly installed. But more important, as far as you are concerned, the transmitter must be correctly tuned and coupled to the antenna. That is your job.

RECEIVERS

The five functions of a radio receiver are to:

1. Pick up signals.
2. Select the desired station and reject all others.
3. Amplify the signal from that station.
4. Demodulate, or detect, the carrier wave.
5. Reproduce the audio signal.

Signals are picked up by the receiver's antenna. Radio waves, striking the wire, set up a tiny electromotive force (EMF), or voltage, which is induced into the tuning circuits of the receiver. The induced voltage is of exactly the same frequency, and contains essentially the identical variations that were present when the carrier wave left the transmitter's antenna.

Field Strength

The amount of EMF induced in an antenna depends upon the length of the antenna and the strength of the carrier wave at that point. The carrier wave, strongest when it leaves the transmitting antenna, is attenuated (weakened) as it travels until its energy level, called FIELD STRENGTH, is too weak to be perceptible.

Field strength is expressed as the number of microvolts that would be induced in an antenna 1 metre long. (A microvolt is a millionth of a volt.) For example, the signal from one transmitter induces an EMF of 100 microvolts in an antenna 1 metre long. A second transmitter, which may be nearer or operating at higher power, induces 1000 microvolts in the same antenna. Thus, by comparison, the field strength of the second transmitter is ten times that of the first.

The amount of EMF induced in an antenna depends on the length of the antenna as well as upon the field strength of the signal. If the field strength of a certain signal is 100 microvolts per metre, an antenna 3 metres (but less than one-quarter wavelength) long will have an induced EMF of 300 microvolts.

Sensitivity

The sensitivity of a receiver is a measure of how well it can amplify weak signals. Communication receivers are highly sensitive and can operate on far weaker signals than a home radio.

In an area of strong local interference, a receiver needs a strong signal to give good reception. If the local interference has a field strength of 100 microvolts per metre, a signal strength of from 500 to 1000 microvolts per metre is required to drown the noise. The same receiver, free from local interference, may give good reception on a signal strength of 10 microvolts per metre. It is hard to state the exact minimum field strength needed to operate a receiver satisfactorily, but many sets under ideal conditions can function on a signal strength of from 1 to 3 microvolts per metre. To bring such a signal to an audible level requires an amplification of many millions of times.

Selectivity

Selectivity is the ability of a receiver to respond to one particular signal and to reject all others. A very selective receiver is said to tune sharply. Some types of receivers are

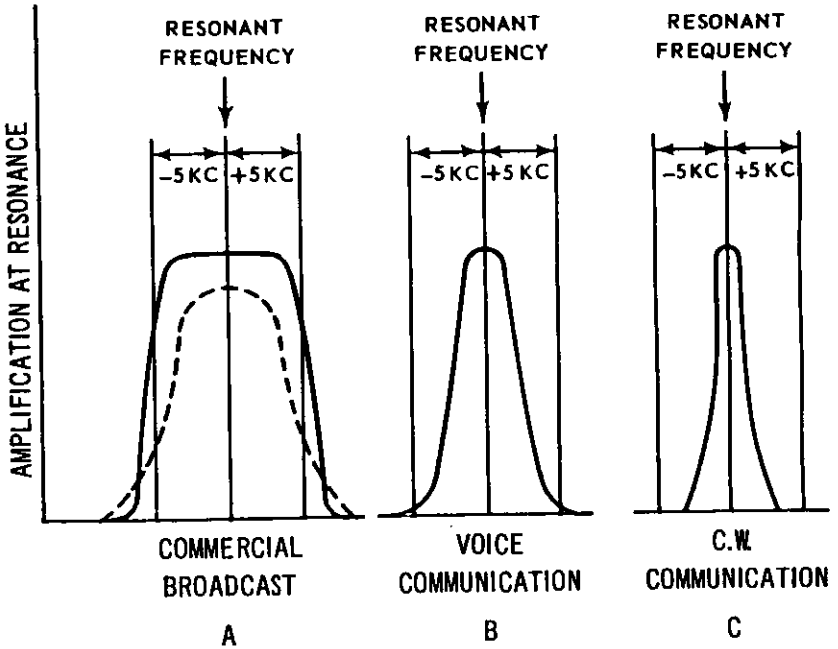


Figure 10-14 Band Widths of Three Types of Receivers

more selective than others. A radiotelephone receiver tunes more sharply than a commercial broadcast receiver, and a CW communication receiver is more selective still. You can compare the three tuning curves from Figure 10–14.

Sideband frequencies are always produced when a carrier frequency is modulated. It is these sideband frequencies which contain the intelligence transmitted. Among the sidebands will be frequencies which are the sum or difference of the radio frequency and the modulating frequency. For example, if a carrier frequency of 1000 kcs is modulated by an audio signal of 1 kcs, there will be resultant sideband frequencies of 1001 and 999 kcs.

Carrier waves from commercial broadcast stations contain sideband frequencies which extend 5 kcs on either side of the resonant frequency. If a station is transmitting on 1140 kcs, the modulated wave contains frequencies from 1135 to 1145. If a receiver tunes too sharply, some of the side band frequencies are lost, with a corresponding sacrifice of fidelity. The commercial broadcast receiver tuning curve shown in Figure 10–14 is OPTIMUM – "at its best". The top is broad and flat and the sides are steep. Actually most AM broadcast receivers have tuning curves resembling the broken line, and many frequency components of voice and music contained in the signal are not reproduced by the set.

Although sharp tuning in a home radio would make for poor listening, it is desirable for military sets for sake of frequency economy and reduction of interference. Radiotelephone messages can be sent on frequencies that extend only 2 kcs on either side of the carrier frequency. The voice may sound unnatural, like a voice on the telephone, but it can be understood.

CW sets tune so sharply that unless an operator is careful he can turn his dial through the signal without even hearing it.

TRF and Superheterodyne Receivers

There are many receiver circuits, but the majority of Navy

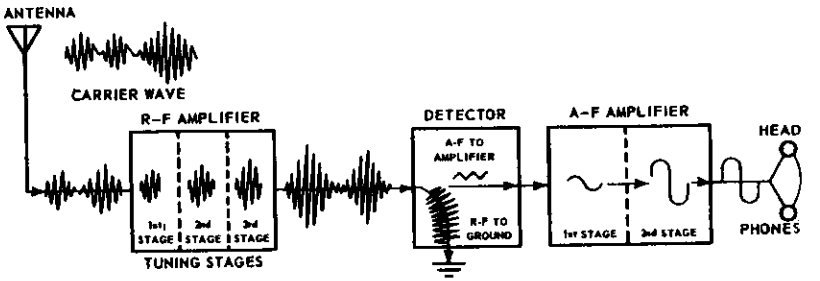


Figure 10-15 Block Diagram of the TRF Receiver

receivers belong to two classes, the **TUNED RADIO FREQUENCY (TRF)** and the **SUPERHETERODYNE**. Both perform the same basic function which is, in the simplest terms, to convert the EMF induced in the antenna into a form you can hear.

The tuned radio-frequency receiver is the simpler of the two. It consists of three major parts (Figure 10–15.) The first part, the RF amplifier, has two purposes: to select the proper signal and to amplify it through various stages. Following the RF amplifier is the detector, in which the audio-frequency component is separated from the radio-frequency portion of the signal. The RF portion is by-passed to ground, and the AF wave is passed on to the third part – the AF amplifier – where further amplification takes place. The final step is completed when the audio signal is sent into the headphones (or loudspeaker) to emerge as sound.

The superheterodyne contains all the major units of the TRF, with three additional units – mixer, local oscillator, and intermediate-frequency (IF) amplifiers – inserted between the RF amplifier and detector. Refer to Figure 10–16. Operation of the RF amplifier, second detector, and AF amplifier is the same as in the TRF receiver, but the added components (local oscillator, and IF amplifiers) change the operation of the circuit as a whole.

The carrier wave from the RF amplifier is fed into the

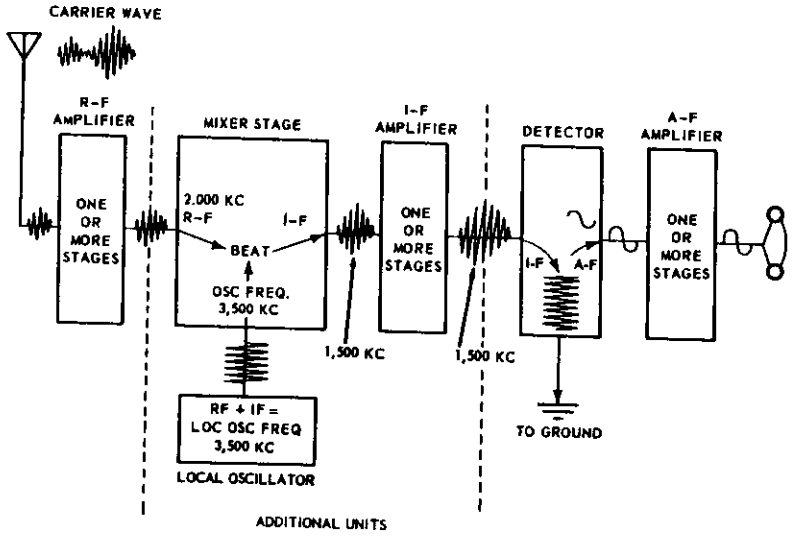


Figure 10-16 Block Diagram of the Superheterodyne Receiver

mixer stage. In Figure 10–16 the received carrier wave frequency is 2000 kcs. A second and higher frequency – 3500 kcs in the example – is produced in the local oscillator. The frequency of the local oscillator is controlled by the tuning dial on the receiver. As the receiver is tuned to a new frequency, the frequency generated by the local oscillator changes also, but always remains a certain number of kilocycles higher than signal frequency. In Figure 10–16 the local oscillator signal is 1500 kcs higher than the carrier. This signal is sent into the mixer stage to be beaten with or mixed with the carrier signal – that is, **HETERODYNED.**

The mixing or heterodyning of these two frequencies produces an **INTERMEDIATE-FREQUENCY** signal of 1500 kcs which contains all the modulation characteristics of the original signal. The intermediate frequency is equal to the difference between the station frequency and the local oscillator frequency. The intermediate frequency is then amplified

in one or more stages called intermediate-frequency amplifiers and fed to a detector for recovery of the audio signal.

The IF stage has an advantage over an RF stage in that it is designed to give optimum response over a single frequency – the IF frequency.

Tuning

Most receivers have some form of tuning aid to assist the operator in locating a desired station. This commonly takes the form of a dialing or switching arrangement (intermediate frequency bandpass control) that permits preliminary tuning to be broad and final tuning to be sharp, or of a band-spreading device that permits wide movement of the dial, and gives the effect of spreading the channel over a greater area of the dial. Many receivers have tuning eyes or meters that indicate to the operator when the incoming signal is tuned to maximum.

An additional aid to quick and accurate tuning is a calibration chart for each receiver. This is merely a record of dial settings for particular frequencies. On shifting frequencies, an operator can consult the chart to see whether the settings are entered. If not, he makes the shift and logs the settings.

Volume and RF Gain Controls

The VOLUME (or AF gain) control on a communication receiver is used to raise or lower the sound to a desired level. This identical device is found on home radios and is familiar to everyone.

The RF gain control is related to the volume control in that it can be used to raise or lower the output sound level, but it is primarily a sensitivity control. An operator receiving a very weak signal would turn the RF gain control all the way up. If the signal is too strong, he lowers the control to avoid overloading some of the tubes of the set, thus preventing distortion.

AVC and DAVC

The automatic volume control (AVC) – sometimes called

the automatic sensitivity control (ASC) or automatic gain control (AGC) – serves to keep the output volume at a constant level. This saves you the bother of repeatedly readjusting the volume control as a station fades and reappears in strength.

The AVC reduces the amplification of certain stages in a receiver as the amplitude of a received signal increases. It affects weak as well as strong signals. When a receiver is tuned, the AVC is usually cut off to afford maximum amplification for weak signals. After tuning, the AVC is turned on, provided the signal is not too weak.

In some receivers a special type of AVC, called a delayed automatic volume control (DAVC), is used. DAVC-equipped receivers do not reduce amplification of a signal until a certain level is exceeded. In this way very weak signals are not further weakened.

Noise Suppressors and Output Limiters

The high sensitivity of communication receivers causes them to pick up local noise and natural static. Interference is bothersome at best, at worst causes fragmentary reception. There are a number of devices designed to minimize the effects of interference.

The noise suppressor works in much the same way as the tone control on a home receiver. When this control is tuned for bass reception, much of the noise is filtered off and is not permitted to reach the earphones. But the noise suppressor also reduces the volume, so that on weak signals it may be necessary to throw the switch that cuts the suppressor out of the circuit.

The output limiter prevents sudden crashes of static from injuring the operator's eardrums. There are several types, but all work as a safety valve. When the output volume of sound reaches a certain level, the limiter is activated and prevents the sound from rising any higher.

Some receivers have silencer circuits which keep the set quiet when standing by for a message, and also saves you

the discomfort of spending a slack watch listening to static.

Most output limiters and silencers have OFF-ON switches and an output level adjustment. The specific name for these controls depends on the make of the set.

SINGLE SIDEBAND (SSB)

The need for SSB communication systems has arisen because present day radio communications require faster, more reliable, spectrum-conservative systems. The quantity of commercial and military traffic is presently so great in the HF spectrum that it has become necessary to restrict the use of this spectrum to those services which cannot be accommodated by other means. Land-lines, microwave links, etc., are employed to relieve the load from the HF spectrum. In many instances, these provide a better and more reliable service. There are, however, many communication services which need the propagation characteristics obtainable only in the HF range. Among these are commercial ship-shore and air-ground communications, and the many military and naval systems which require independence, mobility and flexibility. Since HF spectrum space is limited, it is essential that the best possible use be made of the space available. This means that communication systems must use a minimum *bandwidth*, that the guard bands between channels to allow for frequency drift and poor selectivity be minimized, and that spurious radiation be kept to a very low value to avoid interference between services. In addition to this, a more reliable signal is desirable if not essential. SSB communication systems in their present state of development provide these assets. For long-range communication in the low, medium and high frequency ranges, SSB is well suited because of its spectrum and power economy. It is also less susceptible to the effects of selective fading and interference than is AM (Amplitude Modulation). The principal advantages of SSB result from the elimination of the high-energy AM carrier and

from improved performance under unfavorable propagating conditions. On the average contact, a SSB transmitter will give equal performance to an AM transmitter of four times the power rating. The advantage of SSB over AM is most outstanding under unfavorable propagating conditions. For equal performance, the size, weight, power input, and peak antenna voltage of the SSB transmitter is significantly less than the AM transmitter.

What Single Sideband Means

A single sideband signal is an audio signal converted to a radio frequency (RF) with or without inversion. For instance, an intelligible voice signal contains audio frequencies over the range of 300 to 3000 cycles per second (cps). If this audio signal is converted to an RF by mixing it with a 15 mcs RF frequency, the resultant sum frequencies cover the range of 15,000,300 cps to 15,003,000 cps. Such a signal is a SSB signal without inversion and is referred to as an *upper sideband*, because it occupies the spectrum space above the RF conversion frequency (15,000,000 cps). Now, when the voice signal is mixed with the RF frequency, a *different* frequency develops which covers the range from 14,999,700 cps to 14,997,000 cps. This signal is also a SSB signal but is a SSB signal with inversion. This SSB signal is referred to as a *lower sideband* signal because it occupies the spectrum space below the RF conversion frequency.

From the above description of the SSB signal, it is apparent that only one sideband signal need be transmitted to convey the intelligence. Since two sideband signals are obtained from the mixing process, it is also necessary to remove one sideband before transmission. To receive the SSB signal, it is necessary to convert the SSB signal back to the original audio signal. This requires identical transmitter and receiver conversion frequencies.

EQUIPMENT INDICATOR LETTERS, AN NOMENCLATURE SYSTEM

Installation	Type of equipment	Purpose
A–Airborne (installed and operated in aircraft).	A–Invisible light, heat radiation	A–Auxiliary assemblies (not complete operating sets)
B–Underwater mobile, submarine	B–Pigeon	B–Bombing
C–Air transportable (inactivated)	C–Carrier (wire).	C–Communications (receiving and transmitting)
D–Pilotless carrier.	F–Photographic.	D–Direction finder
F–Ground, fixed	G–Telegraph or teletypewriter (wire).	G–Gun directing
G–Ground, general ground use (includes two or more ground installations).	I–Interphone and public address.	H–Recording (photographic, meteorological and sound)
K–Amphibious.	K–Telemetering	J–Countermeasures (receiving and transmitting)
M–Ground, mobile (installed as operating unit in a vehicle which has no function other than transporting the equipment).	M–Meteorological	L–Searchlight control
P–Ground, pack or portable (horse or man).	N–Sound in air	M–Maintenance and test assemblies (including tools)
S–Water surface craft.	P–Radar	N–Navigational aids (including altimeters, beacons, compasses, instrument landing and depth sounding)
T–Ground, transportable.	Q–Underwater sound	P–Reproducing (photographic and sound)
V–Ground, vehicular (installed in vehicle designed for functions other than carrying electronic equipment–such as tanks).	R–Radio	Q–Special, or combination of types
U–General utility (includes two or more general installation classes, airborne, shipboard, and ground)	S–Special types, magnetic, etc., or combinations of types	R–Receiving or listening
W–Underwater, fixed	T–Telephone (wire)	S–Detecting and/or range and bearing
	V–Visual and visible light	T–Transmitting
	X–Facsimile or television	W–Remote control
		X–Identification and recognition

Figure 10-17 Equipment Indicator Letters, AN Nomenclature System

EQUIPMENT DESIGNATING SYSTEM

AN Nomenclature

On the front of each item of electronic equipment is a nameplate carrying a group of letters and numbers which identifies the gear. This group is assigned in accordance with the AN nomenclature (naming) system, and one is given to all new electronic equipment procured by the Navy, Army, or Air Force.

The first two letters are AN. This is the system indicator. It does not mean that all three services use the equipment, but only that the type number was assigned under the AN system.

AN is followed by a slant sign and three identifying letters. Letters to the right of the slant are very important, for they give a brief description of the equipment.

FIRST LETTER – Where installed: whether meant for use in aircraft, ground vehicle, etc.

SECOND LETTER – Type of equipment: radio, radar, underwater sound, and so on.

THIRD LETTER – Purpose of the equipment: communication, direction finding, gun directing, etc.

For an example take the equipment designation AN/SRT 502, the ship's main transmitter. AN is the system indicator. A glance at Figure 10–17 gives us the meaning of the descriptive letters:

S – Water surface craft.
R – Radio.
T – Transmitting.

The AN/SRT 502 is a radio transmitting set for surface craft. The number 502 is the model number.

REPRESENTATIVE TRANSMITTERS

LF, MF, HF, VHF and UHF Bands

PV500LM – The PV500LM transmitter (Figure 10–18) has

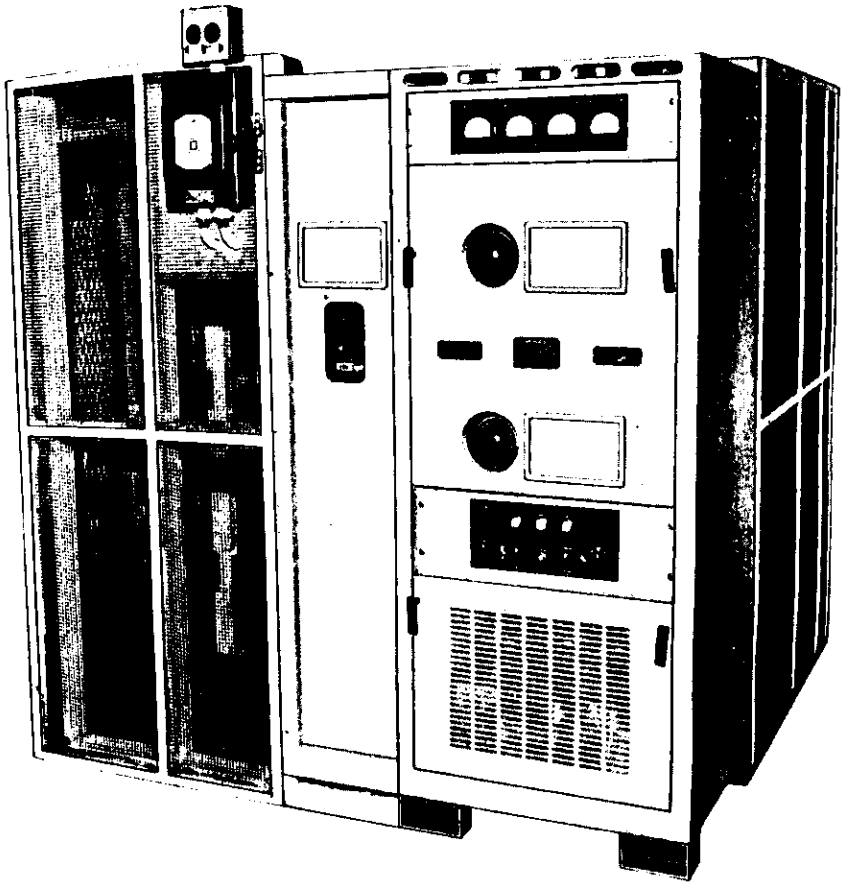


Figure 10-18 PV 500 LM Transmitter

a frequency range of 100 to 500 kcs and is the main LF transmitter wherever fitted. Although it will eventually be replaced by more modern equipment, there is still quite a number of PV500LM's being used. It has a rated power output of 500 watts and the frequency is controlled by a master oscillator. This transmitter is capable of CW and MCW transmission only, and is usually tuned to four commonly-used

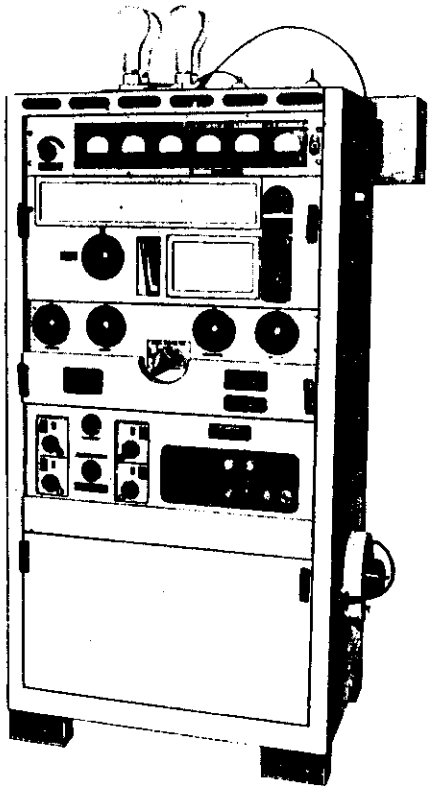


Figure 10-19 PV 500 HM2 Transmitter

frequencies. The principal feature of the PV500LM is its compact size for power delivered into the antenna.

PV500HM2 – The PV500HM2 (Figure 10–19) is the main HF transmitter fitted in RCN ships. Like the PV500LM, this transmitter will also be replaced by more modern equipment, the AN/SRT 502. The PV500HM2 has a frequency range of 3 to 28 mcs and is designed for transmission on CW only. The frequency is controlled by either crystal or master oscillator. In the frequency range of 3 to 19 mcs, the power output is 500 watts, and in the range of 19 to 28 mcs, only 300 watts. This transmitter is used for RATT transmission as well as normal CW operation.

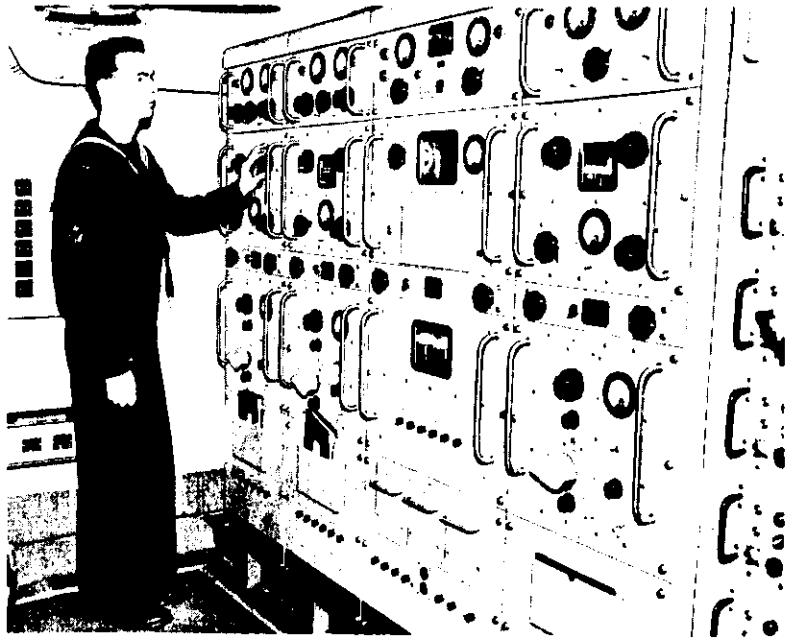


Figure 10-20 AN/SRT 502 Transmitter

AN/SRT 502

The AN/SRT 502 (Figure 10–20) is designed primarily for installation in naval vessels where it is intended to act as the main transmitter for ship-to-ship and ship-to-shore communication. Included in the set are two high-frequency (HF) transmitters, either of which may be used for normal long distance communication, and a single low-frequency (LF) transmitter which is used for short distance working. The modulator-power supply section has a power supply which is shared by all three transmitters, and a modulator unit which is used to voice-modulate either HF transmitter for radiotelephone operation.

Each HF transmitter may be operated at any selected frequency between 3 and 28 mcs and is capable of three

types of transmission: CW, R/T or RATT. The LF transmitter is not designed for R/T operation; transmission may be either CW or RATT at any selected frequency between 100 and 550 kcs.

Each transmitter is capable of producing a power output of either 1000 watts in high-power operation, or of 300 watts in low-power operation. Any two transmitters may be operated at the same time with high-power output, or, alternatively, all three transmitters may be operated simultaneously with low-power output.

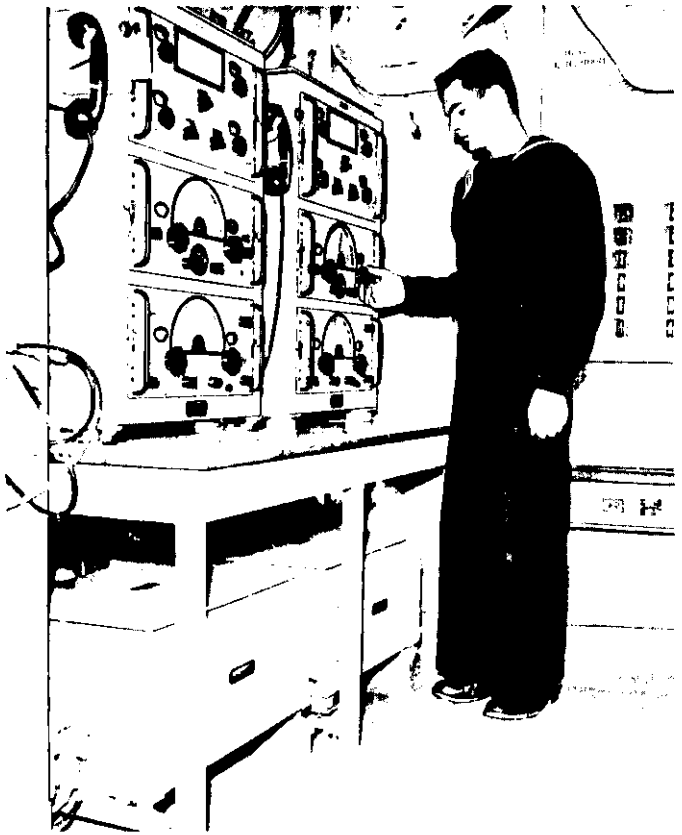


Figure 10-21 A Rack of Two CM 11-A Transmitter-Receivers with ZM11 Power Supplies

CM11A

The CM11-A (Figure 10–21) is a general purpose low-power transmitter/receiver installed in ships and stations of the RCN. It is capable of operation on LF, MF and HF using CW, MCW or R/T emission. The power output of this equipment is 100 watts on CW, 70 watts on MCW and 30 watts on R/T, satisfactory for medium distance operation. Its frequency is controlled by either crystal or master oscillator when using the 1500 kcs to 13,500 kcs range, and by master oscillator only when using 375 kcs to 515 kcs range.

The CM11-A is powered by a separate power supply unit called the ZM11, which contains the necessary rectifiers, transformers, switches, filter circuits, etc., needed to provide high tension and filament and control voltages for both transmitter and receiver.

AN/SRC 501

The AN/SRC 501 (Figure 10–22) is designed primarily for marine installations, and is intended for ship-to-ship and ship-to-shore communications over short distances. On smaller

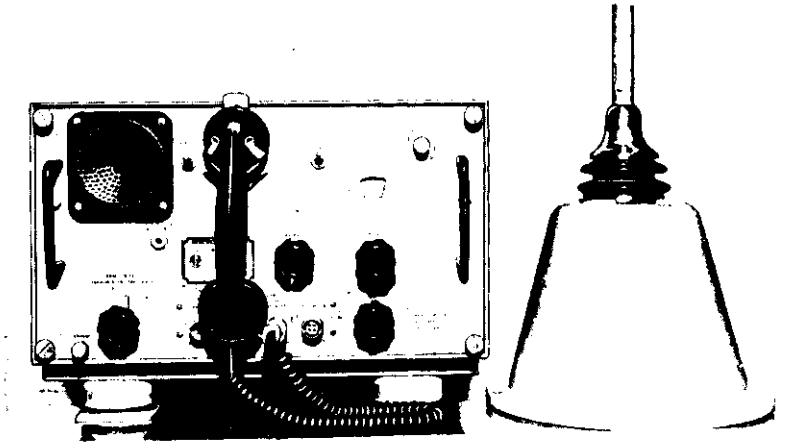


Figure 10-22 AN/SRC 501 Transmitter-Receiver Showing Base of Whip Antenna

harbour craft it may be the only medium and high frequency communication equipment in use.

The equipment provides for the transmission of R/T on any 4 pre-set crystal-controlled frequencies in the 2 mcs to 4 mcs band, and for the reception of R/T on any 4 pre-set crystal-controlled frequencies in the same band. The pre-set receiving frequencies need not necessarily be the same as the pre-set transmitting frequencies. The receiver section, in addition, can be continuously tuned for reception through both the 1.5 mcs to 4 mcs band and the 0.54 mcs to 1.5 mcs broadcast band. Selection of the desired pre-set transmitting and receiving frequencies, and of the continuously variable receiving bands, is made by the use of two independent band switches, one associated with the transmitter and the other with the receiver unit. The transmitter section of this transceiver has a power output of about 12 watts.

CPRC-26

The CPRC-26 is a portable transmitter/receiver (walkie talkie) designed for short range combat communication in forward areas. It can also be used as a ground station, or, with suitable installation accessories (mounts for antenna and set), can be used in a vehicle. This set is useful in naval service as it may be easily carried in boats, by landing parties, shore patrols, etc. Other uses include short-term communications between ships for such jobs as jack-stay transfers, underway fuelling and shoots. It is an excellent means of communication between the bridge and ECP (emergency conning position) during times of emergency.

The CPRC-26 is a self-contained, battery operated transceiver which operates in the frequency range of 47.0 mcs to 55.4 mcs. It is frequency modulated and has 6 crystal controlled channels which may be pre-set to any frequencies within the range of the set. A fresh battery should give about 20 hours of service.

AN/URT7

This is a general utility VHF transmitter fitted in most RCN ships. It has a frequency range of 115 mcs to 156 mcs with a power output of 30 watts. The AN/URT7 (Figure 10–23) is crystal controlled (4 channels), but in an emergency it may be tuned to a frequency by master oscillator. The receiver used with the AN/URT7 is the AN/URR21.

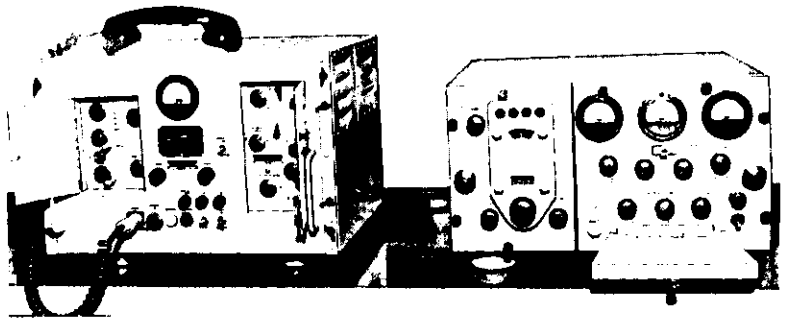


Figure 10-23 AN/URT 7 Transmitter (left) with AN/URR21 Receiver

AN/TED-3

This UHF transmitter (Figure 10–23) is designed for short range tactical communication in ships, submarines and shore stations. It has a power output of 12 to 15 watts and operates in the frequency range of 225 mcs to 400 mcs, limiting its use to "line-of-sight". The frequency is controlled by crystal; four crystals may be installed at one time but the transmitter must be tuned to each change of frequency. The receiver used in association with the AN/TED-3 is the AN/URR-35A.

Figure 10-24
AN/URC 32
Transceiver

AN/URC 32

The AN/URC 32 Transceiver (Figure 10–24) is one of the newest additions to the large family of radio equipment in the RCN. This equipment was first installed in HMCS MACKENZIE DDE 261 and it is expected that all ships will be fitted with this equipment in the near future.

The AN/URC 32 is a manually operated communications transceiver for operation in the 2 mcs to 30 mcs range. It is primarily designed for single sideband (SSB) transmission and reception on upper sideband, lower sideband or two independent sidebands with separate audio and IF channels for each sideband. In addition to single sideband operation, provisions are included for AM, CW, or FSK operation. The equipment provides its own accurate and stable frequency control but is also fitted to enable external frequency control to be applied.

Following is a list of the AN/URC 32's modes of operation with accompanying transmit power output:

	Mode	*Power Output*
(A1)	CW telegraphy	500 Watts
(A3a)	SSB, reduced carrier	500 Watts
(A3b)	Two independent sidebands, reduced carrier	500 Watts
(A9)	Composite transmission	500 Watts
(A9a)	SSB, full carrier transmit	125 Watts
(F1)	Frequency-shift telegraphy	500 Watts

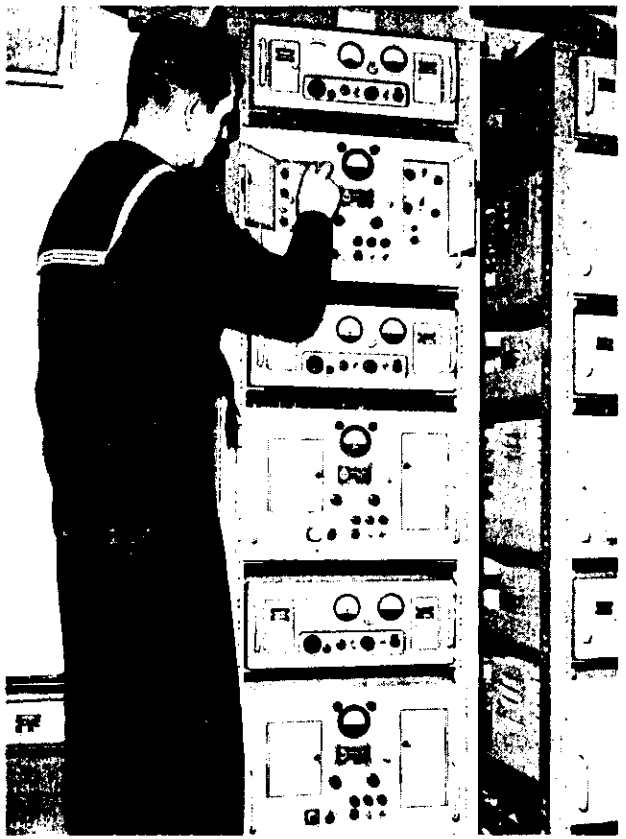


Figure 10-25 Rack Mounted AN/TED3 Transmitter with AN/URR35 Receivers above each

RECEIVERS

CSR5A

The CSR5A receiver (Figures 10–26, 10–27, 10–28) is a high-grade superheterodyne set, generally fitted in RCN ships and in some shore stations. It is the main LF, MF, HF receiver used in naval communications – you will use this receiver while performing your duties as radioman. It is possible to operate this receiver from the normal 115-volt

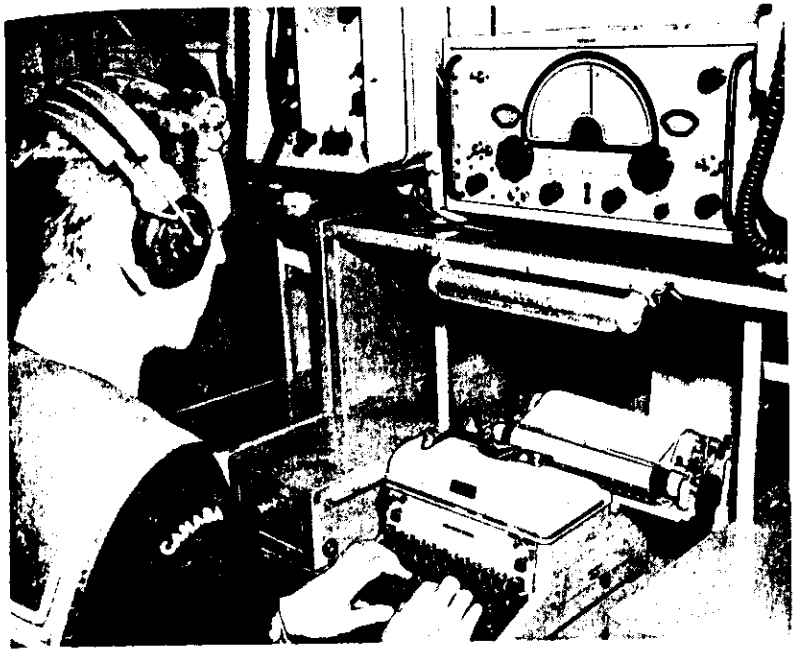


Figure 10-26 CSR5A in use on Administrative Circuit

ship's supply, or from a 12-volt battery supply in case of emergency. The CSR5A covers the following frequency range:
79 kcs to 515 kcs.
1.5 mcs to 30 mcs.
A modification has been made to this receiver. The lower band (band "F") is adjusted 10 kcs low to enable reception of the broadcast frequency 73.6 kcs. A 6-position lettered switch on the left side of the front of the receiver is used to change the frequency band. This switch is calibrated in colour code to correspond with colours of the main tuning scale for rapid selection of a frequency band.

The SELECTIVITY switch at the upper right corner of the receiver panel controls the band width of the received signal. It enables you to separate stations which are very close to-

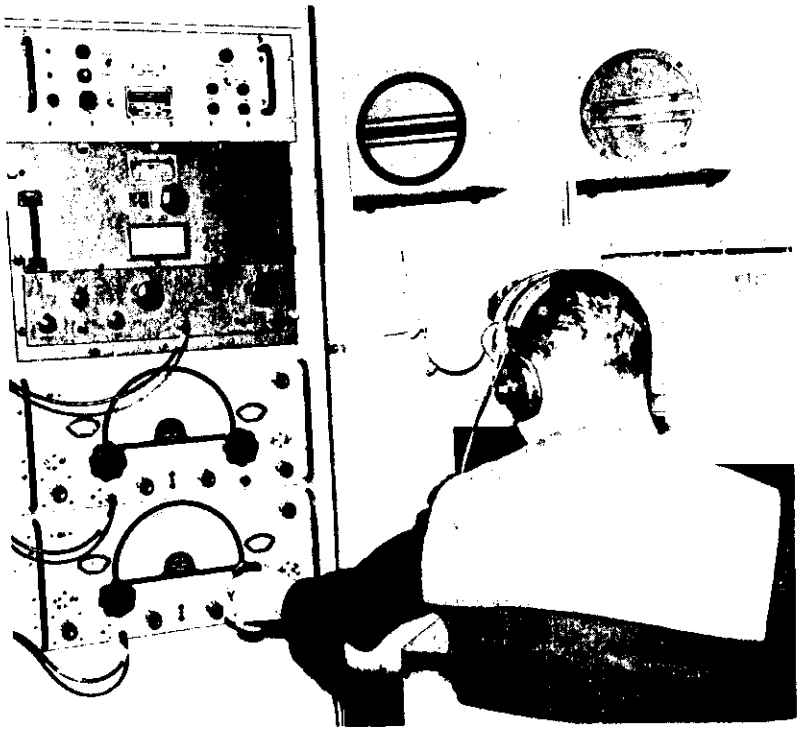


Figure 10-27 Two CSR5A's at the CW Broadcast Bay

gether, and to cut down on interference. Normal positions for the selectivity switch are:

Position 1 – For reception of radiotelephone messages.

Position 2 – For reception of CW signals when conditions are normal.

Position 3 – Used when interference is being experienced from a station close to the one you are reading.

Position 4 – Used when interference is heavy.

The NOISE LIMITER is designed to cut down on static and ignition noises, and operates best when the RF GAIN is high and the VOLUME is set low.

The CSR5A is also the receiver used with the CM11 transceiver as shown in Figure 10–21.

Figure 10-28 CSR5A (Crystal Inserted) in use at RATT Bay

RAK5

The RAK5 (Figure 10–29) is a 6-tube Tuned Radio Frequency (TRF) receiver fitted in RCN ships as the main LF receiver (See also Figure 10–27). Its frequency range is 15

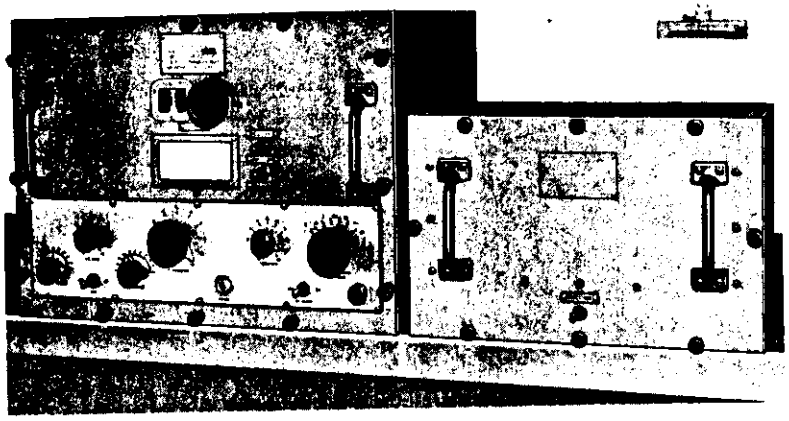


Figure 10-29 RAK5 LF Receiver with Power Pack

kcs to 600 kcs and it is designed for the reception of CW and MCW signals. The set is powered by either AC or DC. For AC operation, a power pack which is connected to 115/230 volt supply is used. For DC operation the set can be connected to a 180-volt "B" battery and a 6-volt "A" battery.

BC221-M Frequency Meter

This equipment is designed to provide a means of accurately calibrating transmitting and receiving equipment within the frequency range of 125 kcs to 20,000 kcs (20 mcs) where no crystal is available for a given radio channel. The BC221-M (Figure 10–30) is a portable heterodyne-type frequency metre with built-in crystal calibration. A calibration book which lists the frequency corresponding to the dial settings is supplied with the equipment. This set is battery powered – 135-volts H.T. and 6-volts L.T. Most ships and stations have a BC221-M wavemetre – a very necessary and useful instrument in the field of radio communication. All radiomen must have a good working knowledge of this gear.

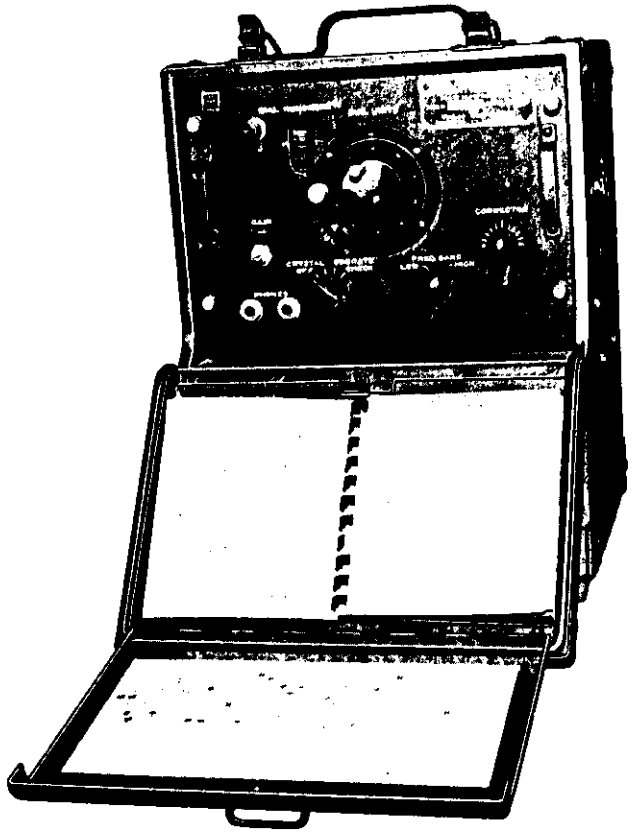


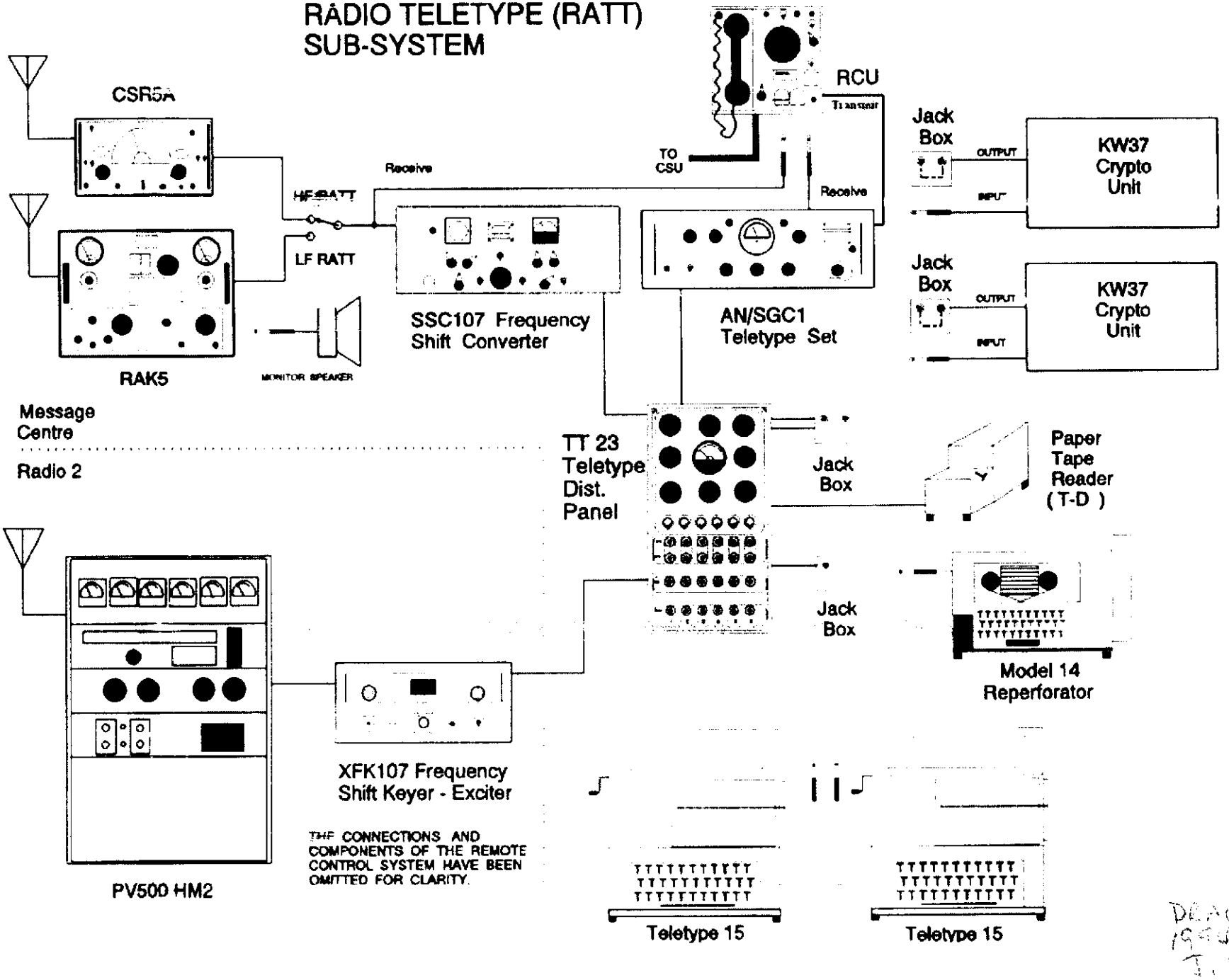
Figure 10-30 BC221-M Frequency Meter

AN/URM 32 Frequency Meter

This frequency meter replaces the BC221-M in the RCN. It is an accurate frequency measuring device for calibrating to .01% an exact frequency in the range 125 kcs to 1000 mcs. It is used extensively for accurate tuning of transmitters when crystals are unavailable.

The AN/URM 32 (Figure 10–31) is a portable instrument which can be powered by either batteries or 115/230 volts AC. It is also used as a signal generator, which provides a

RADIO TELETYPE (RATT) SUB-SYSTEM



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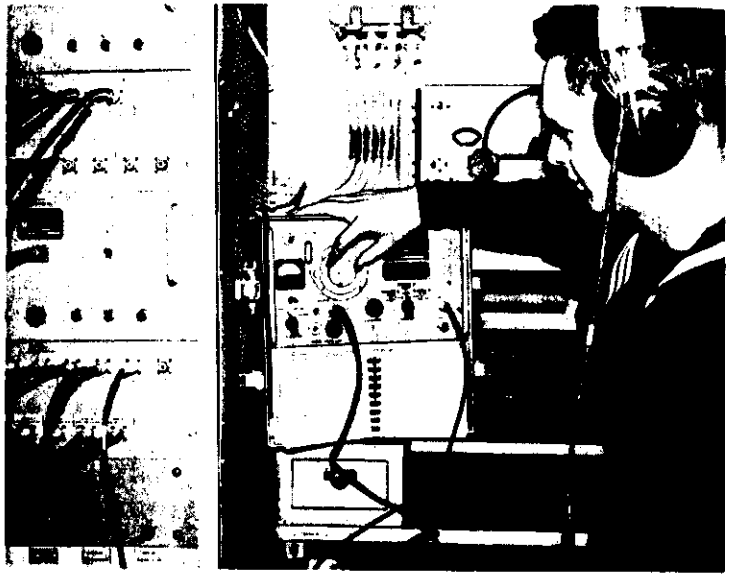

Figure 10-31 AN/URM32 Frequency Meter

choice of modulated or unmodulated signals for testing and calibrating radio equipment.

SP600-J

The SP600-J (Figure 10-32) is a superheterodyne communication receiver covering a frequency range of .54 mcs to 54 mcs in 6 bands. This receiver is capable of receiving CW, MCW and R/T. The power required to operate the set is 110

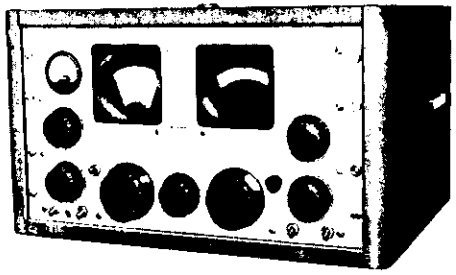

Figure 10-32 SP600J Receiver

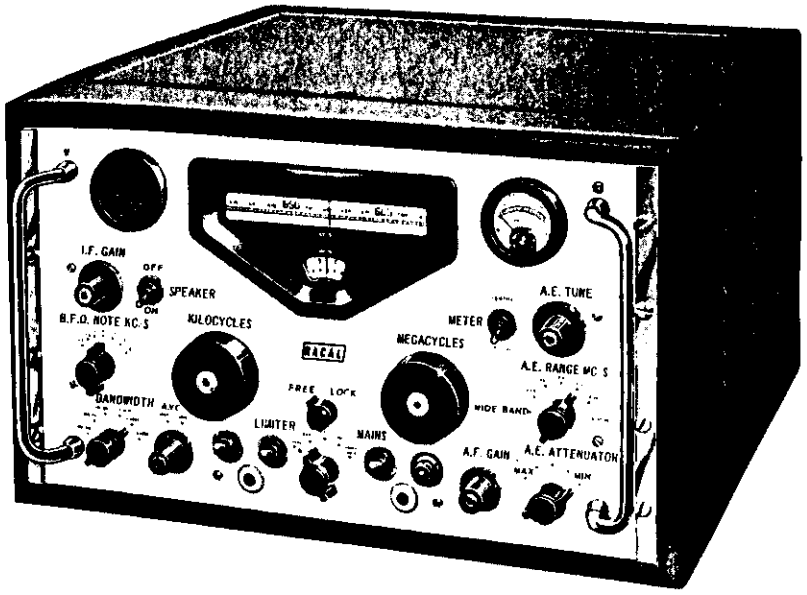

Figure 10-33 AN/URR 501 Receiver

volts AC. The SP600-J is installed in new construction as the main MF/HF receiver.

AN/URR 501

The AN/URR 501 is a general purpose receiver which has recently been brought into service in the RCN. It is a sturdy receiver of British design and bears the manufacturer's name – RACAL. During your course for Radioman you will be given complete instruction in the operation of this set. However, to acquaint you with the URR 501, here is a brief list of some of the features to be found:

1. Operates on 110-220 volts 60 cs AC.
2. Receiver equipped with individual mcs and kcs tuning controls.

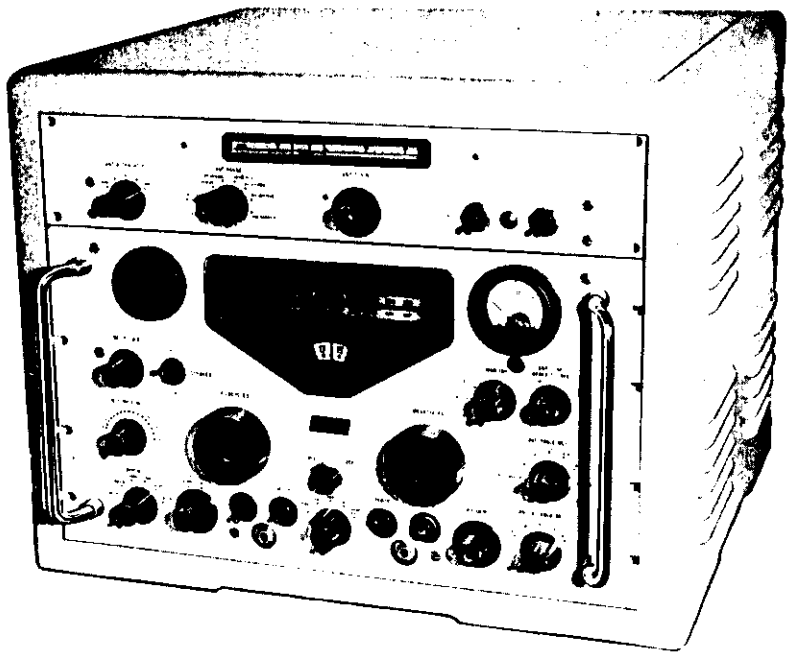

Figure 10-33(a) AN/URR 502 Receiver

3. Frequency range is 1 to 30 mcs but will go down to 500 kcs with slight loss of efficiency.
4. Set has an antennae range switch and attenuation control.
5. Signal may be injected every 100 kcs to check receiver.
6. Receiver is equipped with built-in speaker.

AN/URR 502

The AN/URR 502 employs the basic receiver AN/URR 501, with a low frequency adapter to extend the frequency coverage down to 10 kcs.

RADIO HAZARDS

When working with radio, or with any electronic equipment, there is one rule that cannot be too strongly stressed: **SAFETY**

FIRST. Dangerous voltages energize much of the equipmen with which you work. Power supply voltages range up t 40,000 volts, and radio-frequency voltages are even higher

Special precautions are also necessary because of th effect of electrical fields existing in the vicinity of antenna and antennae leads which may introduce fire and explosio hazards, especially where inflammable vapours are present Additional precautions are needed for personnel workin aloft to prevent injuries due to falls and funnel gases.

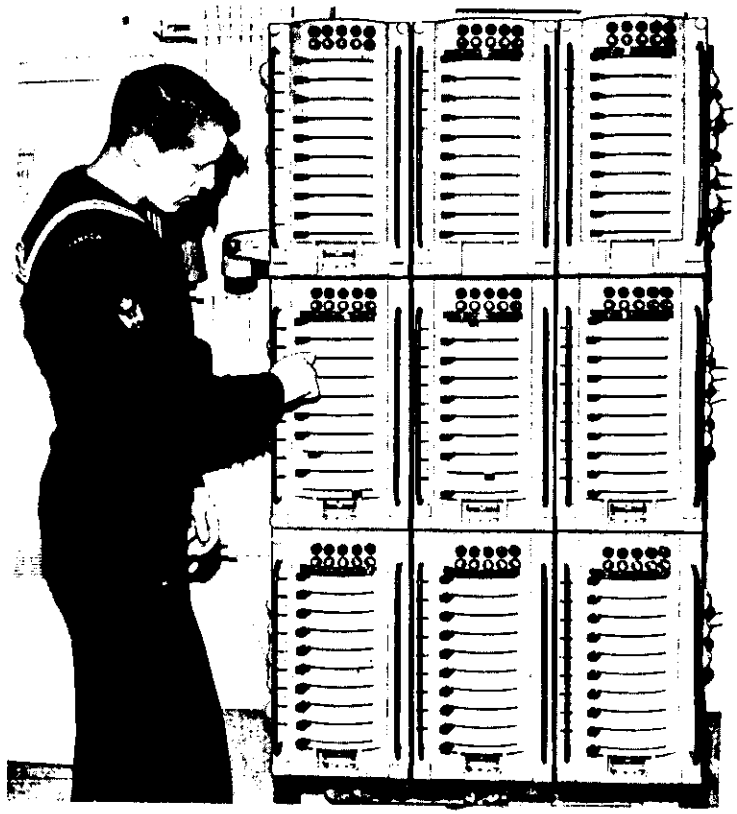

Figure 10-34 Channel Switching Unit - Part of the RCN Remote Control System

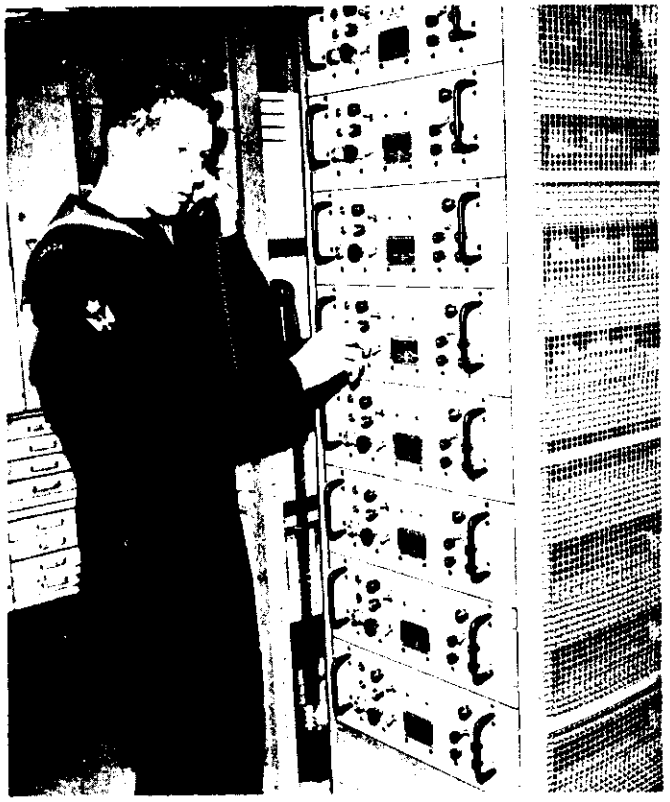

Figure 10-35 Channel Amplifier Unit - Part of the RCN Remote Control System

When you join a ship, be sure to familiarize yourself with the location of all danger points such as transmitting antennae, radar antennae (rotating), etc. Make careful note of applicable safety information for the equipment which you will be using. If at any time there is doubt as to what steps and procedures you should follow while working on electronic equipment, consult the technician or radioman in charge.

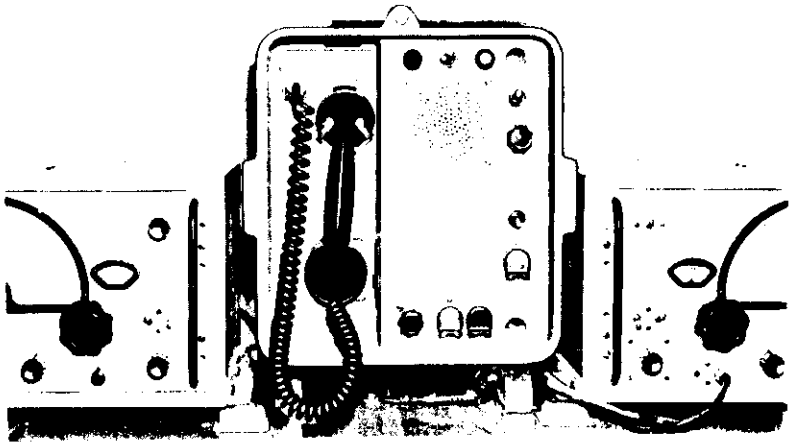

Figure 10-36 A Remote Control Unit (Centre), One of the Many Such Units Located Strategically throughout the Ship

Fundamentals of Electric Shock

How much does it take? If a 60-cycle alternating current is passed through a man from hand to hand or from hand to foot, the effects when current is gradually increased from zero are as follows:

1. At about 1 milliampere (0.0001 ampere) the shock can be felt.
2. At about 10 milliamperes (0.010 ampere) the shock is severe enough to paralyze muscles so that the man is unable to let go of the conductor.
3. At about 100 milliamperes (0.100 ampere) the shock is fatal if it lasts for 1 second or more.

It is important to remember that it is the current that kills rather than the voltage.

Body Resistance

It is important to recognize that the resistance of the human body is not enough to prevent fatal shock from 115-volt or even lower voltage circuits. It is true that when the ski

is dry, it has high resistance where it makes contact with the electrodes through which current enters and leaves the body. The resistance may be high enough to protect a man from fatal shock even if one hand touches a bare conductor on one side of a 115-volt line while another part of his body touches a bare conductor on the other side of the line. On board ship it is far more likely that the skin will be wet with sweat or salt water. Contact resistance falls when the skin is wet, and body resistance, measured from electrode to electrode, is low. Under unfavourable conditions it may be as low as 300 ohms. If 0.1 ampere is enough to cause death, and if body resistance is as low as 300 ohms, it follows that 115-volt circuits can supply more than enough current to be fatal. The truth of this grim application of Ohm's Law is shown by the fact that about 50 per-cent of shipboard electrocutions are caused by circuits of 115 volts or less.

"We're just going to hang the mate, sparks! get the 'man aloft' boards!"

Working Aloft

While doing your job as a radioman you may find it necessary to go aloft. Observance of a few precautions will make

going aloft a relatively safe adventure. Each ship has certain requirements which must be met before the OOD can give his permission to a man to go aloft. These will be found in the Ship's Standing Orders, and you should read them carefully as soon as you join the ship.

Generally, the dangers to be encountered and the necessary precautions to meet them are:

1. Electric shock	Remove "man-aloft board" (radio and radar fuses).
2. Fall	Life-line securely tied and tended by someone on deck. Check each hand and foot hold before placing weight on it. Most ships are equipped with a leather safety harness for use when working aloft. Use it whenever possible.
3. Choking by funnel gas	Check wind direction – wear oxygen mask if available.
4. Dropping of tools or parts	Secure each piece of equipment before disconnecting it or removing it from tool bag.

The dangers of shock are twofold. The amount of electricity may be sufficient to electrocute, or the surprise of a small shock may cause a person to loose his hold on the mast or rigging.

Falls can be caused by shock, rotating radar antennae, faulty support or plain carelessness. Proper use of a life-line, removal of radio and radar fuses, care while moving about, and making sure that someone is watching you from below will help preserve your life. The old rule, "One hand for the Queen and one hand for me", is a good one to follow.

The direction of the wind should be checked before going aloft, to ensure the fumes from the funnel do not pass through, or close to the area where you will be working. These gases are hot, and contain, among other toxic substances, carbon monoxide. Carbon monoxide is too unstable to build up to a high concentration in the open, but prolonged exposure to

even small quantities is dangerous. There is a case on record in the USN of a man who was working aloft while the funnel exhaust was blowing his way. He worked in it for half an hour and then came down, complaining that he couldn't stand it any longer and would have to wait for the wind to change. About an hour later he collapsed and was taken to the hospital. He died that night.

QUIZ

1. What is the unit of measurement of difference in potential? Of electrical resistance? Of power?
2. Define amplitude, wavelength, cycle, and frequency.
3. What is the meaning of the metric prefixes KILO and MEGA?
4. Radio waves moving along the surface of the earth are called.....; those going into the atmosphere are called.....
5. Why does a change in the ionosphere affect radio transmission and reception?
6. Every transmitter has an.....which generates the basic signal.
7. What is the third harmonic of 4200 kcs?
8. What is meant by the sensitivity of a receiver? The selectivity?
9. What is the name of the equipment designating system?
10. List three uses for the CPRC-26 portable transceiver.
11. While working aloft, why may even a small shock prove fatal?
12. Where do you find the orders pertaining to "Man aloft" for your ship?
13. Name two conditions that must be met for current to flow through a man.

CHAPTER 11

SECURITY

Security

In your daily work routine as a radioman you will handle information of great strategic importance to the military forces and to the nation. Most of the vast amount of intelligence carried in the messages handled by naval communications passes at some point through the hands of radiomen – data which, if available to an enemy, would enable him to learn the strength and intent of our forces, and to gather a wealth of technical information relating to the procedures and operations of the Royal Canadian Navy.

Further, you will use many official documents and publications which relate to such communication matters as frequencies, call signs, and procedures. Their content must also be protected, for the more an enemy knows about our communications, the better his chances of deriving intelligence from them.

Classifications

Security is a term which describes the methods used by the government to safeguard material from unauthorized disclosure. Such information is afforded a greater degree of protection than other material and is given a special designation – CLASSIFIED MATTER. This term includes all publications, doc

ments, cipher keys and aids, code books, letters, and messages in the four security classifications: *TOP SECRET, SECRET, CONFIDENTIAL* and *RESTRICTED*. Following are examples and definitions of each:

Top Secret

The Top Secret classification is limited to defence information or material requiring the highest degree of protection. It is applied only to information or material the defence aspect of which is paramount, and the unauthorized disclosure of which could result in EXCEPTIONALLY GRAVE DAMAGE to the nation, such as:

1. A war, an armed attack against Canada or her allies, or a break in diplomatic relations that would affect the defence of Canada.
2. The unauthorized disclosure of military or defence plans, intelligence operations or scientific or technological developments vital to the national defence.

Secret

The Secret classification is limited to defence information or material the unauthorized disclosure of which could result in SERIOUS DAMAGE to the nation such as:

1. Jeopardizing the international relations of Canada.
2. Endangering the effectiveness of a program or policy of vital importance to the national defence.
3. Compromising important military or defence plans, or scientific or technological developments important to national defence.
4. Revealing important intelligence operations.

Confidential

The use of the Confidential classification is limited to defence information or material the unauthorized disclosure of which could be PREJUDICIAL TO DEFENCE INTERESTS of the nation, such as:

1. Personnel security investigations and other investigations, such as courts of inquiry, which require protection against unauthorized disclosure.
2. Operational and battle reports which contain information of value to the enemy.
3. Intelligence reports.
4. Military radio frequency and call sign allocations which are either of special significance or are changed frequently for security reasons.
5. Devices and material relating to communication security.
6. Information which reveals strength of our land, air, or naval forces in Canada and overseas areas; identity of composition of units, or detailed information relating to their equipment.
7. Documents and manuals containing technical information used for training, maintenance, and inspection of classified munitions of war.
8. Operational and tactical doctrine.
9. Research, development, production, and procurement of munitions of war.
10. Mobilization plans.
11. Matters and documents of a personal or disciplinary nature which, if disclosed, could be prejudicial to the discipline and morale of the armed forces.
12. Documents used in connection with procurement, selection, or promotion of military personnel, the disclosure of which could violate the integrity of the competitive system.

Restricted

The classification RESTRICTED means that the matter to which it applies, while not qualifying for a higher classification shall be used for official purposes only, and may not be published or disclosed to the press. The compromise of restricted material could cause embarrassment to government agencies.

Unclassified

The term "Unclassified" is not a security classification. However, it has been included in this list for convenience and it may also be referred to as a classification when it is expedient to do so. Unclassified matter is that which requires no security protection. Whether classified or not naval matters should not be discussed with people outside the service.

Types of Security

Communication security is defined as "the various measures taken to prevent an enemy from gaining information from our communications". The term *"Communication Security"* is a general term covering such measures of security as are necessary to protect transmissions, publications and material. Transmission security then, is that component of communication security which results from measures necessary to protect transmissions from interception, D/F and traffic analysis. Physical security is that part of communication security which results from measures taken to protect communication equipment and material from access thereto by UNAUTHORIZED PERSONS. Physical security simply means the use of guards, alarm systems and secure stowage spaces to protect our equipment and material.

Crypto Security

Cryptography is the science of cloaking information in codes and ciphers. A code is a system whereby words, phrases, numbers, or syllables are replaced by numbers, letters or code words. The code word for the Normandy Landings, operation OVERLORD, is an example of the use of a code to prevent betrayal of intentions, dates or geographical locations, in the event of document associated with the invasion falling into enemy hands.

A cipher is a system in which individual letters of a message are replaced, letter for letter, by other letters rather than by complete words, phrases, or numbers. Cipher texts are usually transmitted in five letter groups.

The enemy is constantly and painstakingly studying our codes and ciphers in an attempt to discover the keys to our many cryptographic systems. This technique is known as cryptonalysis. The best defence against this type of enemy intelligence is cryptosecurity – the careful use of technically sound cryptosystems. The cryptoboard, under the direction of the Communication Officer, is responsible for the proper encryption and decryption of messages. Reliable petty officers are appointed to this board, along with officers assigned communication duties. Members of the board, known as cryptographers, must be proficient in the use of all codes and ciphers held by the command. An especially grave compromise results from the loss of a cryptographic publication or the transmission of a faulty encryption. Since it must be assumed that the enemy has received enough information to discover the key to the system, such a cipher must be discontinued and immediately replaced, for subsequent transmission in the same system might be little better than plain language. The work and expense of superseding a cipher system, though great, are insignificant compared to the consequences of compromise.

Transmission Security

A communication may be sent by a variety of means:

1. Messenger.
2. Registered mail (guard mail, Canada postal system, or diplomatic pouch).
3. Approved wire circuits.
4. Ordinary mail.
5. Non-approved wire circuits.
6. Visual (semaphore, flag-hoist, flashing light, etc.)
7. Sound (whistle, siren, etc).
8. Radio

Messenger

Classified matter is transmitted by messenger when security, not speed, is the paramount objective. An officer specially detailed for this purpose would carry out the duties of messenger, although non-commissioned ranks could be used, depending on the circumstances (security classification, etc.).

Mail

In addition to transmitting unclassified material, the Canada Post Office system is used to transmit classified material except for Top Secret matter and cryptographic aids and devices. Secret matter must be sent by REGISTERED rather than ordinary mail, and transmittal must be entirely within the limits of Canada or United States. A considerable amount of the Navy's administrative traffic is sent by mail, thus reserving radio circuits for operational traffic as far as possible.

Wire Circuits

When available, wire circuits invariably are used in preference to radio, since they are less susceptible to interception. There are two types of wire systems – APPROVED and NON-APPROVED. An approved circuit is one designated by appropriate command as suitable for transmission in the clear of messages classified no higher than SECRET. Approved circuits usually lie entirely on military property. A non-approved circuit is one which does not lie entirely within military property, has a radio link, or for some other reason is not considered safe enough for transmission of traffic in the clear. It is forbidden to send classified messages in the clear over a non-approved wire.

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

casual interception. Tapping may often be discovered by physical examination or by transmission irregularities. Interception by induction, however, can escape detection completely. Supersensitive devices placed near the wire circuit will pick up sounds through a 2-foot wall. Tiny microphones, hidden in telephone receivers, will pick up not only telephone conversations but voices anywhere in the room. Underwater cables are also liable to unauthorized interception, although they are more difficult to tap than land-lines. Submarines are able to make successful interceptions through induction. The point where the cable emerges into shallow water is the most vulnerable.

Visual Communications

Visual communications systems are used in preference to radio except at night when there is possibility of divulging the ship's position. They are more secure than radio because reception is limited to units in the immediate vicinity of the sender. Visual communication methods are ranked in decreasing order of security according to the di[illegible] which the signals can be seen. In daylight the re[illegible]rder is semaphore, directional flashing light, panels, flag-hoist, pyrotechnics, and non-directional flashing light. At night the order is infra-red, directional flashing light, pyrotechnics, and no[illegible]tional flashing light.

The greatest care must be taken to ensure that signal lights are used only when necessary, and that the minimum of light is employed. An exception is for recognition signals, which must be sent on a light sufficiently brilliant to be seen at once.

Transmission of plain language messages is kept to a minimum within the vicinity of the beach. Many persons in addition to communication personnel are adept at reading lights and flags.

Sound Systems

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

Radio

Radio is potentially the least secure means of communication. A message sent by radio is open to interception by anyone who has the necessary equipment and is within reception range. Thus, in addition to obtaining intelligence through cryptoanalysis, the enemy may be able to fix the location of operating forces through direction finding. Through deceptive techniques he may be able to confuse and hamper our communications and, by traffic analysis, forecast the intentions of our forces.

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

Radio Silence

An effective defensive measure against enemy intelligence is radio silence. It is apparent that the enemy cannot gain intelligence from radio transmissions if none are sent. Radio silence is placed in effect when it is reasonable to assume that the enemy is ignorant of the location or impending movements of a ship or force. In peacetime, radio silence is imposed when required for operational purposes or training.

Imitative Deception

There are many deceptive techniques the enemy might use to obstruct our radio communications. He may, for example:

1. Remove a message from one circuit and introduce it on another circuit to waste time, create confusion, and produce service messages.
2. Intentionally garble the text of a genuine message with the heading of another, with the group count corrected, and introduce it on a different net.
3. Originate and transmit counterfeit plain language messages.
4. Call a unit in the hope of taking bearings on the answer.
5. Partly obliterate a false message in order to conceal lack of knowledge of authenticators or call signs.

Authentication

The best defence against imitative deception by the enemy is proper authentication. An authenticator is a letter, numeral, or groups of letters or numerals inserted in a message to prove its authenticity. By its correct use, the operator can distinguish between genuine and fraudulent stations or transmissions. Authentication is mandatory when:

1. Making initial radio contact.
2. Transmitting operating instructions which affect the communication situation. Example: closing down a station or watch.
3. Transmitting (except by broadcast method) to a station under radio silence. Broadcast method – ship addressed does not answer, thus avoiding disclosure of position.
4. Calling a unit afloat for the first time and requiring that unit to break radio silence in order to answer.

Good judgment sometimes dictates that an operator accept a message rather than argue over authentication, even though doubt exists as to its genuineness. Such a message should be delivered promptly to the addressee with the operator's notation that it was not properly authenticated. The decision as to its authenticity is made by the addressee.

Whenever an authentication system is promulgated, accompanying instructions specify how and when it is to be used.

Procedures will vary slightly with the form of authentication and the means of communication employed.

Other effective defences against imitative deception are:

1. Thorough training in operating procedures.
2. Alert operators who recognize irregularities in procedure and the minor implausibilities that often characterize enemy deceptive efforts.
3. Direction finding on transmissions of questionable origin.
4. Minimum use of plain language and procedure messages.

Operators who maintain a high degree of circuit discipline also lessen the chances of enemy deception. Circuit discipline can be obtained only through net control, monitoring and training. It includes adherence to prescribed frequencies and operating procedure. Negligence, inaccuracy, and laxity, as well as lack of circuit discipline and operator training, are some common causes of the violations which endanger radio transmission security.

Traffic Analysis

In addition to hampering our communications through imitative deception, the enemy may gain valuable information from traffic analysis. This is the technique of obtaining intelligence from a study of communication traffic without recourse to cryptoanalysis. It includes statistical study of message headings, receipts, acknowledgements, relays, traffic peaks, and tabulation of the volume and type of traffic.

Assume that within a short time a radio message is transmitted from point Bravo to point Romeo, another to Victor, another to a unit of the fleet operating off point Whiskey, and a fourth to a unit off point Oscar. The enemy's traffic records show that messages are rarely transmitted to these four addressees simultaneously. They also show that previous transmissions of this type were followed by arrival of a convoy at point Romeo. The enemy may logically conclude that a convoy from Bravo to Romeo is being planned, and that these transmissions are probably arranging for an escort.

The following are some measures intended to render traffic analysis by the enemy more difficult:

1. Minimum use of radio when alternate means of communication are available.
2. Rotation of frequencies.
3. Minimum number of service messages.
4. Use of the broadcast method wherever possible.
5. Control of the timing and volume of test transmissions to avoid revealing information about future operations.
6. Concealment of originator and addressee(s) in the text of an encrypted message (Codress).
7. Avoidance of plain language transmissions.
8. Encryption of unit call signs and address groups.
9. Keeping external routing instructions to a minimum.

Radiotelephone

Security violations on voice circuits are as serious as those occurring on radiotelegraph circuits. Although radiotelephone transmissions are usually limited to the line of sight, on occasion they have been readably intercepted at distances up to 2500 miles. Radiotelephone transmissions are actually less secure than radiotelegraph transmissions of the same frequency, because anyone can understand them even without a knowledge of the Morse code.

Circuit discipline is just as important on the radiotelephone as on radiotelegraphy. Radiotelephone is used for tactical or operational purposes on most frequency bands by all forces and types, so strict adherence to correct operating procedure is mandatory. Poor circuit discipline slows communication, causes confusion, and may give information to the enemy.

In addition, practice in proper enunciation and pronunciation are requisite to a properly manned radiotelephone circuit. The following practices are specifically forbidden:

1. Violation of radio silence.
2. Unofficial conversation between operators.
3. Transmitting in a directed net without permission.
4. Excessive tuning and testing.

5. Transmission of an operator's name or personal sign.
6. Unauthorized use of plain language.
7. Use of unauthorized prowords.
8. Linkage or compromise of classified call signs and address groups by plain language disclosures or associated with unclassified call signs.

The following are to be avoided:

1. Use of excessive power.
2. Needless loss of time in tuning, changing frequency or adjusting equipment.
3. Transmission beyond the capabilities of receiving operators.

Are You a Security Liability or a Security Asset?

Here is a way to test your "security consciousness". Each question requires only a "yes" or "no" answer.

1. Do you always report immediately any loss, possible compromise, or disclosure of classified information?
2. Do you take classified manuals, documents or excerpts thereof home?
3. Do you carry a combination to a safe in your billfold or pocket?
4. Do you talk about your work when off the job?
5. Do you know how to check the identity, clearance status and "need to know" of a visitor?
6. Do you conscientiously withhold classified information from anyone who cannot establish his offical need for it?
7. Do you always make sure that all classified notes and work sheets are stamped with the proper classification?
8. Do you always keep classified papers covered when other persons are near, when visitors are present, or when you leave your work for a moment?
9. Do you know how to dispose of classified waste?
10. Do you ever discuss classified information on the telephone?
11. Do you know how to make a complete security check of your working area before you leave?

The correct answers appear at the end of this chapter. Add your score. If you have 11 correct, you are a security ASSET. If you have less than 11 correct you are a *SECURITY LIABILITY*. There are *NO* in-between levels in measuring security consciousness!

Personal Responsibilities – Security

The radioman, in the course of his duties, may find himself in possession of highly classified information – the existence of which is oftentimes shared only by himself, the Communication Officer, and the Commanding Officer. It is his duty to be alert against a slip of the tongue which might reveal this information to someone not authorized to know. The security books tell us that "Indiscreet conversation and personal letters constitute the greatest menaces to security". The only safe policy to follow is: *Say nothing about classified matter to anyone not authorized to know*. Off duty, say nothing about your work to anyone, including family and friends. Information innocently imparted to unauthorized persons may be repeated by someone, ignorant of its importance, until it becomes common knowledge.

Loose talk in public places is even more dangerous. Conversation in restaurants, hotel lobbies, railroad stations, elevators, taverns, and other public places can be easily overheard. Foreigh agents are scientifically trained to collect particles of seemingly harmless information from such conversations. Once pieced together and analyzed, they sometimes reveal military information of incalculable value. Mail is likewise subject to interception by the enemy. The following topics are not to be mentioned in personal correspondence:

1. Location, identity, or movement of ships or aircraft.
2. The forces, weapons, military installations, or plans of Canada or her allies.
3. Casualties to personnel or material by enemy action.
4. Criticisms of equipment or morale of Canada or her allies.

Personal censorships also extends to telephone conver-

sations. As we have seen, telephone wires can be tapped, and conversations can be overheard at the switchboard and other points along the circuit. Never discuss classified information over a non-approved telephone line.

Diaries can be fruitful sources of information for the enemy. They sometimes reveal secrets which the enemy is laboriously attempting to extract through cryptanalysis. Even in peacetime, lost and stolen diaries can cause serious damage to the prestige of the nation.

The security precautions mentioned here do not guarantee protection, nor do they attempt to meet every conceivable situation. However, the man who adopts a common sense outlook in addition to knowledge of the few basic regulations can solve most security problems.

Discussing service matters in the home may result in embarrassment to the Navy and ultimately necessitate disciplinary action against the persons responsible for this breach of security.

QRCN Article 19.36 states in part:

"No officer or man shall publish, communicate or otherwise disclose any information or opinion relating to military subjects acquired as a result of his naval service to any person who is not entitled to receive such information or opinion".

You should become thoroughly familiar with this section and also with Appendix I to QRCN which is entitled *"The Official Secrets Act"*. As you have probably already discovered, the excuse "I didn't know", is not acceptable in the Navy. Be sure you know.

CORRECT ANSWERS TO THE SECURITY TEST

1. Yes
2. No
3. No
4. No
5. Yes
6. Yes
7. Yes
8. Yes
9. No
10. Yes
11. Yes

APPENDIX I

ANSWERS TO QUIZZES

CHAPTER 2

INTERNATIONAL MORSE CODE

1. A dit is one third the length of a dah.
2. Never count dits and dahs because when the code speed picks up you will not be able to count fast enough.
3. Counting a dit as a unit, there is one unit between each element of a character. There are three units between each character and seven units between groups or words.
4. When printing, you can avoid confusion between zero and the letter O by writing zero with a slant through it-Ø.
5. CLOSED and OPEN are terms applied to the gap between the contacts of a telegraph key. CLOSED indicates a short gap; OPEN a long gap.
6. Place just enough tension on the key so that it is easily depressed, yet springs upward at the end of each dit or dah.
7. When using a telegraph key, your elbow should not protrude over the edge of the table because the pressure on the underside of your forearm will obstruct blood circulation and cause fatigue.
8. A good way to develop rhythm in sending Morse code is to follow, on a dead key, the call sign tape of a CW broadcast station. Better, listen for re-runs of commercial traffic and send it together with the broadcast station.

CHAPTER 3

RADIOTELEGRAPH

1. A message is a written thought or idea, expressed in plain or secret language, and prepared for transmission by the most suitable means of communication.
2. An action addressee is responsible for taking action on the contents of the message and for originating any necessary reply. Information addressees have an official concern in the subject of the message, but do not have the primary responsibility for taking action.
3. Messages are divided into types, according to the way they are addressed, as follows: single address, multiple address, book, and general messages.
4. A CANGEN is a general message on miscellaneous subjects, addressed to all ships and establishments from CANAVHED.
5. There are three parts to a message: heading, text, and ending.
6. The components in the heading of a message are: procedure, preamble, address, prefix.
7. The elements which may be omitted from an abbreviated plaindress message are: precedence, date, DTG, group count.
8. An example of a SINGLE call – CGJD DE CGLE K. (there is only one station being called).
9. Plaindress, abbreviated plaindress, codress.
10. A prosign is one or more letters or characters or combinations thereof, used to facilitate communication by conveying, in a condensed standard form, certain frequently used orders, instructions, requests and information relating to communications.
11. Yes. These signals beginning with Q are the only ones a merchantman understands.
12. No. If an OP SIG appears in a message for relay by radiotelephone, it is spelled phonetically.

13. Call signs – (CGLE) HMCS BONAVENTURE, (CKN) HMCS ALDERGROVE, (VGRLB) RCN aircraft.
14. To communication personnel, precedence indicates the relative order of handling and delivery, i.e., you would handle and deliver a PRIORITY ahead of a ROUTINE.
15. The originator is the command by whose authority a message is sent. The drafter actually prepares the message. The releasing officer authorizes transmission of the message for and in the name of the originator.
16. Unnecessary breaking in, use of plain language where call signs or operating signals could be used, excessive tuning and testing, violation of radio silence. Page 54 lists ten malpractices. Learn them well.

CHAPTER 4

COMMERCIAL PROCEDURE

1. Three times.
2. In commercial procedure the prosign $\overline{\text{IMI}}$ is used following the operating signal, to ask a question.
3. Prefix A indicates, "this is a service message or advice".
4. A commercial message ends "$\overline{\text{AR}}$ GRWK (call sign of station transmitting) K. A naval message simply ends with prosign K or $\overline{\text{AR}}$, whichever is appropriate.
5. 1 – this is my first message to you this day.
   15 – there are fifteen chargeable words in the message.
   15 – date 15th.
   0900GMT – the message was handed in for transmission at 0900 Greenwich Mean Time.
6. A Class D is a radiotelegram, prepared in commercial form, on which tolls of an amount per word are collected.
7. $\overline{\text{SOS}}$. MAYDAY.
8. – – – – – – – – – – – – – $\overline{\text{SOS}}$ $\overline{\text{SOS}}$ $\overline{\text{SOS}}$
9. To enable a vessel hearing the distress call or message to take a D/F bearing.

10. No. Orders to acknowledge must come from the Captain.
11. QRT. QUM.

CHAPTER 5

RADIOTELEPHONE

1. You should listen before transmitting because there may be a transmission already in progress. Interruptions cause delays.
2. ACP 125(B).
3. Prowords are words and phrases used to speed the handling of radiotelephone messages. They correspond to prosigns used in other procedures.
4. The word would be preceded by the proword I SPELL.
5. The governing pennants are PREPARATIVE, INTERROGATIVE, and NEGATIVE.
6. DISREGARD THIS TRANSMISSION.
7. The executive method is used to execute tactical signals so that two or more units can take action at the same time.
8. An acknowledgement is a reply from an addressee indicating that he has received a certain message, understands it and can comply with it. Only the Commanding Officer, or his authorized representative, can authorize sending an acknowledgement.
9. In alphabetical order.
10. Wait five seconds, then answer.
11. CORRECTION.
12. The proword WORDS TWICE is used when communication is difficult.
13. The proper way to test a microphone is by counting. Do not blow into the mike.
14. I VERIFY.
15. The proword READ BACK is used when transmitting messages which are: 1. of a very important nature. 2. difficult to transmit or receive.

CHAPTER 6

RADIO ORGANIZATION

1. The primary method of passing messages to ships is broadcast.
2. AFO S7.
3. AFO S7.
4. Position in Lat. and Long. plus the time (GMT).
5. A merchant ship transmits its message to a coast station on MF. There is no relay involved for delivery.
6. To maintain a continuous receiver watch with a transmitter ready for immediate use. A complete log is kept.
7. LANTCOMOS is the short title for ATLANTIC COAST COMMUNICATION ORDERS.
8. 500 kcs is used by ships in distress and requiring assistance. It is also used as the calling frequency by any mobile station wishing to contact a coast station.
9. WWV transmits on 2.5, 5, 10, 15, 20, 25 mcs.
10. The abbreviation CTG means COMMANDER TASK GROUP.

CHAPTER 7

COMMUNICATION INSTRUCTIONS

1. Types of material not acceptable as Class E are: trivial of frivolous messages, those of unnecessary length, ordinary congratulations such as seasonal greetings (Easter, Christmas, St. Valentine's).
2. No. Direct transmission to CKN or CFH is necessary.
3. On change of watch. If you are not in charge of the watch then you will assist the charge hand to muster books. Record results and report any discrepancies.
4. Red ink is not used when correcting publications because it is difficult to read under certain light.

5. You must page-muster a publication after inserting corrections to be sure that there are no pages missing. It is possible for pages to become mixed with waste material, then accidentally destroyed.
6. Shallow water is of such a depth that the enemy could successfully carry out salvage operations.
7. A key must not be left in a CD chest, even if the chest is empty, because it affords an opportunity for unauthorized persons to obtain wax impressions of the key.
8. Publications should be transported from one part of ship to another in a canvas bag to prevent loss of pages.
9. Those publications which are issued for use between two or more services of the same country are termed JOINT.
10. An ACP is an *Allied Communication Publication.* A JANAP is a *Joint Army, Navy, Air Force Publication.* A CGO is a *Confidential General Order.*
11. An originator sends a movement report to the nearest Movement Report Office (MRO) or Movement Report Centre (MRC).

CHAPTER 8

TELETYPEWRITING

1. The probable cause of missing letters in a teletypewriting exercise is POOR RHYTHM.
2. Yes. It combats fatigue at the teletypewriter and reduces errors.
3. Manual operation of a teletypewriter requires accuracy, rhythm, confidence and speed in their proper relation.
4. The best time to change the paper roll in your machine is outside service hours – when the circuit is closed down.
5. No. Use a clean rag dampened with water.
6. Chad tape is completely perforated and carries no printing. Chadless tape is only partially perforated and has printing.

7. The partial fourth row of keys contains six red keys for the special teletyping functions of local line feed, keyboard lock, keyboard unlock, line break, repeat character operation, and local carriage return.
8. Printing is produced by the type box in the Model 28.
9. A dry, hard-bristle brush should be used to clean the type in the Model 28. Cleaning solution must NEVER be used.
10. The standard teletypewriter line is 69 characters in length, including spaces.
11. Switch off the power.
12. The approach of the end of a roll of paper on a teletypewriter is indicated by a coloured streak along the edge of the paper.
13. The LTRS key shifts the machine from upper case to lower case type. The FIGS key shifts the machine from lower case type to upper case (numerals, special characters, punctuation marks).
14. The two methods of keying a teletypewriter are MANUAL and AUTOMATIC.

CHAPTER 9

RADIOTELETYPE PROCEDURE

1. RATT simplex nets are directed unless otherwise ordered.
2. DOUBLE LINE spacing.
3. Procedure messages are transmitted on ONE line and will end with prosign K or AR.
4. The security classification in plain language messages appears as the first word of the text.
5. The bell signal is transmitted: FIGS JJJJJSSSSS LTRS.
6. A pause of longer than 90 seconds will operate the START/STOP switch in the Model 28.
7. A space bar signal.
8. 2CR 1 LF.
9. 69 characters including spaces.
10. Yes, if call signs have NOT been assigned.

11. In a long message, the first page contains the heading and the first ten lines of text.
12. Operating in "local" does not prevent reception. Therefore, you should not operate your machine in this position as overlining will result – and this means a garbled message.
13. When 50 per-cent or less of a message consists of figures, unusual letter combinations or figure/letter combinations, such groups may be CONFIRMED.
14. By using the error prosign in the normal manner. If the error occurred in the heading, scrap the tape and start a new one.
15. A message is cancelled during transmission by sending the error prosign and ending with AR.
16. A partially garbled OPERATIONAL IMMEDIATE message must be reported immediately.

CHAPTER 10

1. The unit of measurement of difference in potential is the volt; of electrical resistance, the ohm; of power, the watt.
2. The amplitude of a wave is the difference from average level to the peak (or trough) of the wave. A wavelength is the difference from one crest to the next. A cycle is a complete sequence of variation of movement of the wave from a trough, through a crest, into another trough. The number of cycles which occur in a given unit of time is the frequency of a wave.
3. The metric prefix KILO means thousand. MEGA means million.
4. Radio waves moving along the surface of the earth are called GROUND WAVES. Those going into the atmosphere are called SKY waves.
5. A change in the ionosphere affects radio transmission and reception because it causes more of the radio wave to be absorbed at one time, or bends it to a different angle at another time.

6. Every transmitter has an OSCILLATOR which generates the basic signal.
7. The third harmonic of 4200 kcs is 12,600 kcs.
8. The sensitivity of a receiver is a measure of how well it can amplify weak signals. Selectivity is the ability of a receiver to respond to one particular signal and to reject all others.
9. The equipment designating system is known as the AN nomenclature system.
10. The CPRC–26 portable is used by shore patrols, landing parties, between ships for short-term communications while on shoots, etc. Also used in emergencies between bridge and ECP.
11. A small shock may prove fatal by causing a man aloft to loose his hand-hold and fall to the deck.
12. Orders pertaining to "Man Aloft" are contained in the ship's standing orders.
13. Two conditions that must be met for current to flow through a man are: 1. He must form a part of a closed circuit through which current can flow. 2. Somewhere in the closed circuit there must be a voltage to cause current to flow.

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