ConAC Manual 52-27-350

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CONAC

TRAINING MANUAL

AIRCRAFT CONTROL AND WARNING OPERATOR

AFSC 27330-27350

HEADQUARTERS
CONTINENTAL AIR COMMAND
MITCHEL AIR FORCE BASE, NEW YORK

ConAC Training Manual
No. 52–27–350

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CONTINENTAL AIR COMMAND
Mitchel Air Force Base, New York

Foreword

This manual, containing material developed at the USAF TECHNICAL SCHOOL, KEESLER AFB, MISSISSIPPI, is published for the information and guidance of all concerned, and is for training purposes only.

The Training Project Outlines (TPO's) contained in this manual are individual lesson plans and work sheets for utilization by both the instructor and student, as a complete course in book form.

These individual training manuals utilize applicable USAF training material in a slightly shortened form so that training can be accomplished within the normal Air Force Reserve and Air National Guard training cycle and enlistment period.

Drawings and photographs will be included whenever possible with these outlines or as separate items for use in the construction of training aids, such as, breadboards, mock-ups, etc.

Your comments, suggestions and ideas for the improvement of these manuals are invited and may be sent to: Commanding General, Headquarters Continental Air Command, ATTN: Deputy for Operations (thru command channels).

BY COMMAND OF LIEUTENANT GENERAL JOHNSON:

OFFICIAL:
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ConAC Training Manual
No. 52–27–350

DEPARTMENT OF THE AIR FORCE
WASHINGTON, *30 December 1952*

This manual has been coordinated with and approved by the Chief, National Guard Bureau as being applicable to the training of Air National Guard personnel.

BY ORDER OF THE SECRETARY OF THE AIR FORCE:

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D. S. RUMBOUGH
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Major General
Chief
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INTRODUCTION TO COURSE

COURSE ORIENTATION

Introduction

For most of the readers of this Training Manual, the ideas and facts that are to be presented will be new. You are entering a field in which there is no carry-over of any civilian experiences or skills. As a result, a multitude of questions has filled your mind as you enter into the Radar Operator's training. You are asking, "For what duties will I be prepared?; What will be the extent and value of this training?; How difficult is this course?" and the most common question, "Where do I go from here?" The answer to the question, "Where do I go from here?" can only be answered by one person, that person being you, the individual student. The manner in which you apply yourself and adapt yourself to the new situations that you will encounter in this new field will provide the answer to that and other questions.

Type of Training

In selecting each entry into the Aircraft Control and Warning Operators Course, the Air Force has utilized the most advanced methods of career analysis and vocational guidance to determine those who are potentially qualified to absorb the level of training, and to

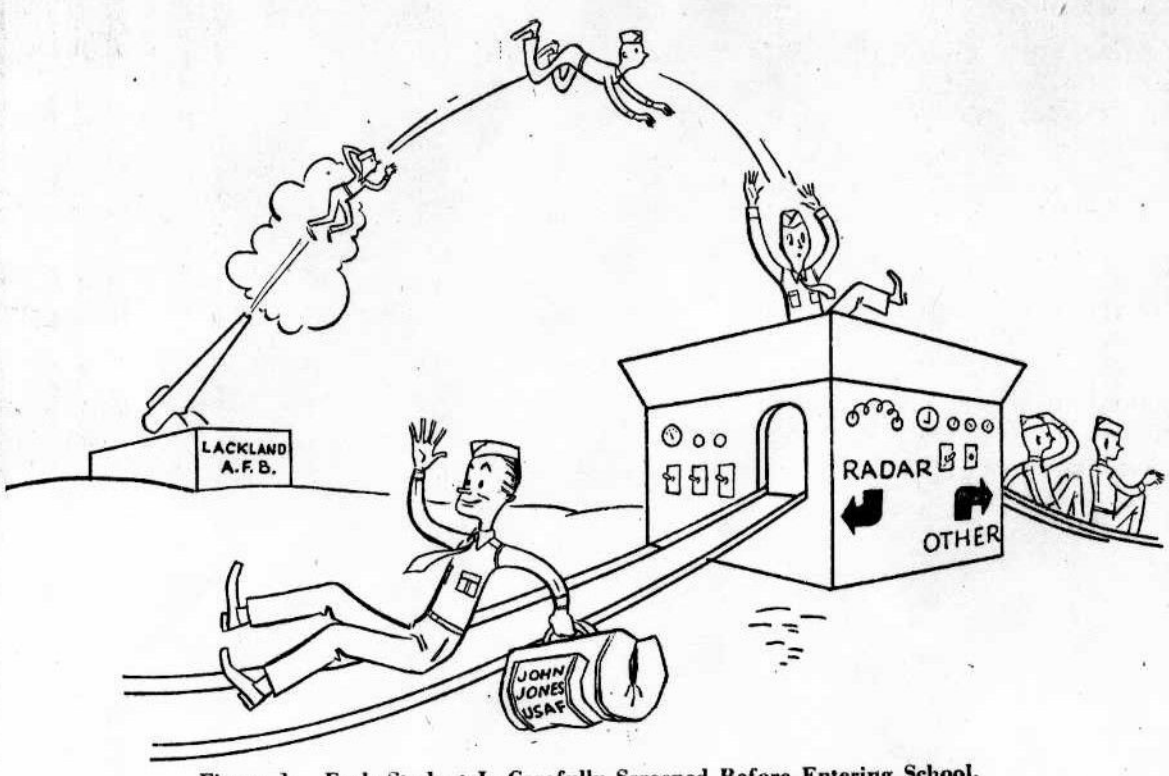

Figure 1. Each Student Is Carefully Screened Before Entering School.

develop the skills necessary to become good Radar Operators. The training conducted in this course is aimed at providing the basic knowledge, facts and skills that will be necessary for you to embark upon an Air Force Career, beginning with the fundamental assignment of Radar Operator. Some of the training will be conducted in classrooms where the *ideas* and *facts* will be presented. In addition to the classroom instruction, there will be many periods of supervised operation and practice on the radar indicators that will become your duty posts when you are assigned to a tactical organization. In your "laboratory" periods, you will learn to make fine adjustments of electronic controls in the darkness of an operations shelter. You will become familiar with the method of describing, in exact measurements, the position of an unseen aircraft many miles away by looking at a glowing spot on an indicator.

At the completion of your training, you will find that you have acquired a new vocabulary that would sound strange in the conversation with your family or friends in civilian life, but which is the everyday speech of those concerned with this vital Air Force mission.

So much for what you can expect from the course. Now, what does the unit expect from you, the student? The unit expects that each student apply himself honestly and diligently while in the course. Only by applying yourself 100% can you hope to gain all that is possible in the career field you are now entering. The unit asks that you respect the equipment that is placed at your disposal during the training periods, so that we can continue our mission of training good Radar Operators. The cost of the equipment with which you will be working runs into several hundred thousand dollars. You, as a taxpayer, are paying for this equipment, so exercise care when operating the sets. Use only those controls you are instructed to use and use them as directed by your instructors. Don't be a "screwdriver operator!"

YOUR CAREER FIELD

Introduction

What happens when you finish your training? Let's find out. When you finish the Aircraft Control and Warning Operator Course, you will be assigned to duty as a Radar Operator with the classification of AFSC 27330. This classification is not a secret code known only to high officials. It is the Air Force method of designating your career field, the channel to which you are assigned in that career field, the skill and proficiency you have attained and whether you are serving in a technical or supervisory capacity. How, you ask, can they determine all that information from a 5 digit number. Let's break down the Radar Operator AFSC (*Air Force Specialty Code*) or as it is officially designated, Apprentice Aircraft Control and Warning Operator.

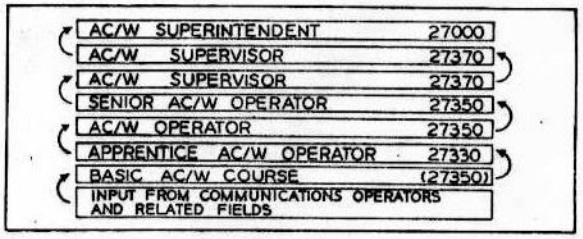

Figure 2. The AC/W Career Field.

27330 Apprentice Aircraft Control and Warning Operator

27—The first two digits indicate that you are now in the Airman Air Traffic Control and Warning Career Field.

–3—The third digit designates the aircraft control and warning channel of the Airman Air Traffic Control and Warning Career Field. If the third digit is zero (0) as in AFSC 27000, it indicates no specialization.

–3—The fourth digit designates the degree of skill and proficiency you have attained in your work. As your skill and proficiency increase, this digit will be changed to a 5 and then a 7. With a change in this digit, you will take on additional duties and responsibilities.

–0—The last digit designates that you are in the ground section of the aircraft

control and warning channel. The figure 1 inserted here in place of the 0 would designate the airborne section of the aircraft and warning channel.

What is the next step after the Apprentice Aircraft Control and Warning Operator, AFSC 27330? In the next page or so, this question will be answered. The AFSC's which follow the Apprentice AFSC will be discussed. How to attain the next AFSC, what will be expected of you, the pay grades for which you will be eligible, all those questions will be answered.

AFSC 27350 Senior Aircraft Control and Warning Operator

1. *Job Summary.* In order to receive this AFSC, you must have had sufficient training and experience to enable you to pick out and interpret visual targets or echoes (as they are called in Radar) on the Radar Scopes, or display information relative to Radar plotting.

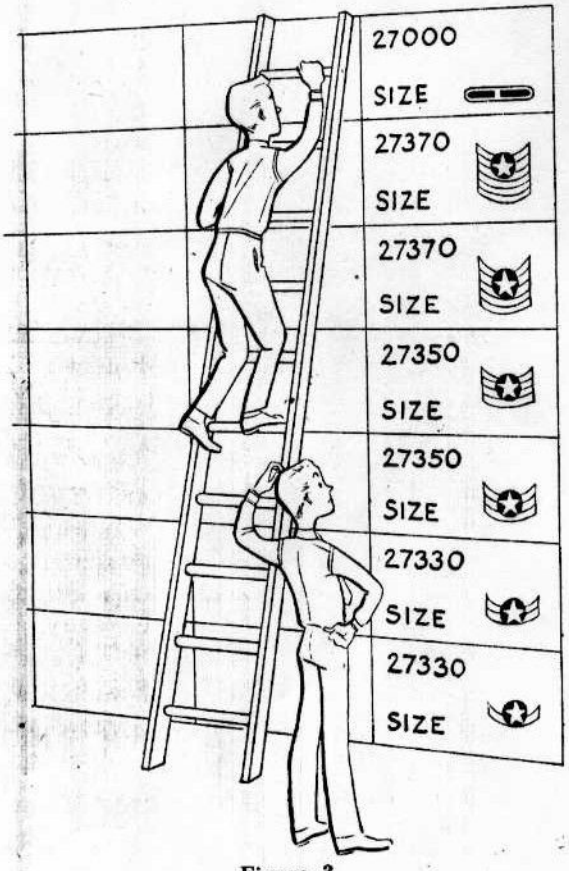

Figure 3.

2. *Job Progression:*

a. Upon attainment of this AFSC, you will be eligible for pay grades five and four (S/Sgt. and Sgt.) in the Aircraft Control and Warning Career Field.

b. To attain this AFSC, you normally will have had to proceed from Apprentice Aircraft Control and Warning Operator 27330 with necessary on-the-job-training as a Senior Aircraft Control and Warning Operator.

3. *Supervision.* You will be expected, upon attainment of this AFSC, to exercise immediate supervision over subordinate Aircraft Control and Warning Operators.

AFSC 27370 Aircraft Control and Warning Supervisor

1. *Job Summary.* In order to receive this AFSC you have illustrated your ability to supervise all enlisted men of an Aircraft Control and Warning Center.

2. *Job Progression:*

a. Pay grades seven and six (M/Sgt. and T/Sgt.) are covered upon attainment of this AFSC in the Aircraft Control and Warning subdivision of the Air Traffic Control and Warning Career Field.

Figure 4. Progression in Job Means Promotion.

b. In attaining this AFSC, you have had to prove your proficiency as a Senior Aircraft Control and Warning Operator, 27350, with necessary on-the-job-training as Aircraft Control and Warning Supervisor.

3. *Supervision.* This AFSC entails your general supervision over Senior Aircraft Control and Warning Operators.

AFSC 27000 Air Traffic Control and Warning Superintendent

1. *Job Summary.* The attainment of this AFSC enables you to direct Air Traffic Control and Warning Operation.

2. *Job Progression:*

a. This AFSC permits your promotion to any of the Warrant Officer Grades in the Air Traffic Control and Warning Career Field.

b. Your progress to this AFSC will have been made through proficiency, shown as an Aircraft Control and Warning Supervisor 27370.

3. *Supervision.* With this AFSC, your responsibilities will also increase to such a degree that you now exercise general supervision over subordinate Air Traffic Operations Supervisors, Ground Control Approach Technicians and Aircraft Control and Warning Supervisors.

STUDY TECHNIQUES

Introduction

What are the first steps in attaining your basic AFSC 27330? The initial step is successful completion of the Aircraft Control and Operator Course in which you are now entered. To attain this objective, you, as a student, must apply yourself wholeheartedly throughout the course. In this course, you will be taught the essentials of several different jobs. However, each of these jobs is dependent upon the other. It becomes your responsibility, therefore, to be able to combine the skills of each job into one smooth coordinated operation. If, you, as a student, apply yourself only part time, you will be lacking in the knowledge that is absolutely necessary for such a coordinated operation.

Figure 5. Off Duty Study Will Be Necessary.

Not only will you have to apply yourself in the classroom, but it will be necessary for you to review or study the material in your off-duty time. You will be expected to read and study this Student Study Guide. In addition, you will have assignments to complete in your Student Worksheets.

Right here, stop and ask yourself, "Why am I here?" The answer is simple. You are here to learn to be a Radar Operator. Now ask yourself, "What is learning?" Here's the answer to that one. Learning is the acquisition of new ways of doing things. Now, how does one go about this business of learning or, as mentioned before, acquiring new ways of doing things? You will not learn merely by reading a specified number of pages in this Study Guide as it is assigned to you by your instructors.

When you are given an assignment in your Study Guide or when your instructor is presenting a lecture, always ask yourself, "What am I supposed to gain from this material and how will it aid me in my work?" Inevitably, the lecture of the Study Guide material is going to contain coloring, (facts which add to the interest but are of minor value). However, the lecture or material to be studied will contain one or two important major points which will be emphasized from time to time. It will be your responsibility to pick out these major points and piece them together, to aid you in your future work.

Taking Notes for Reference

Now in picking out the main points in a lecture or assigned readings it is not enough that you just pick them out. Take notes—put the emphasized points on paper for future reference. The notes you take will not only aid you in attaining a good scholastic average, but will also be of value when you reach the field. Be referring to the notes you took in school, you can easily assume any position to which you may be assigned in the field.

Don't try to put material in your notes that you do not understand. Anything that you put in your notes should be fully understood by you because you are the one who will be using the notes. How are you going to be sure that you understand all that you put down? Simply by rewording the instructor's viewpoints in your own words. Do the same with your assigned reading. Don't copy word for word from the Study Guide. Restate the material in your own words and then copy it. It will mean much more to *you*, the individual who is going to use the notes.

Figure 6. Concentrate on Subject Material.

Concentration on Subject Material

To get anything out of a lecture or assigned reading, you must focus your full attention on the material being presented. You have to concentrate 100 percent on the subject at hand. Sometimes, such amount of concentration is hard to attain, especially in the barracks. Try to remove as many distractions as possible and then apply yourself wholeheartedly to the task of studying.

When studying, it is necessary for you to recognize how the material is organized. The first thing to do is to try to get a general picture of just what the course is trying to put across to you. Once you get the overall picture, then fit the details in to complete the picture. This is comparable to working a jig-saw puzzle. It's practically impossible to work such a puzzle unless you have the whole picture before you. When you have seen the whole picture, then you start putting in the small pieces or "details."

Repetition

Finally, to fully learn a subject, you must repeat. Review your material several times not just by rereading your notes but by trying to recall what you have included in your notes. Refer to your written material as a check on your memory.

To learn a certain thing is not enough. You must remember it to aid you in your future work. If you follow the suggestions offered to you, remembering the material presented to you in this course will not be difficult. A student that has learned and remembered all the points presented in this training manual will be able to accept any assignment in the Aircraft Control and Warning Organization with confidence.

SECURITY

Introduction

Before we go any further into the mysteries of Radar, it will be necessary for you to learn about security. To do this, let's go back several years and across the Atlantic to Charleon, Belgium, on the road to Bastogne. This was a very cold and lonely town on the eve of December 10, 1944. The Nazi Winter Offensive was in full swing and crushing everything in its path.

The silence was broken by sporadic gunfire and the eerie whistle of "mail" overhead.

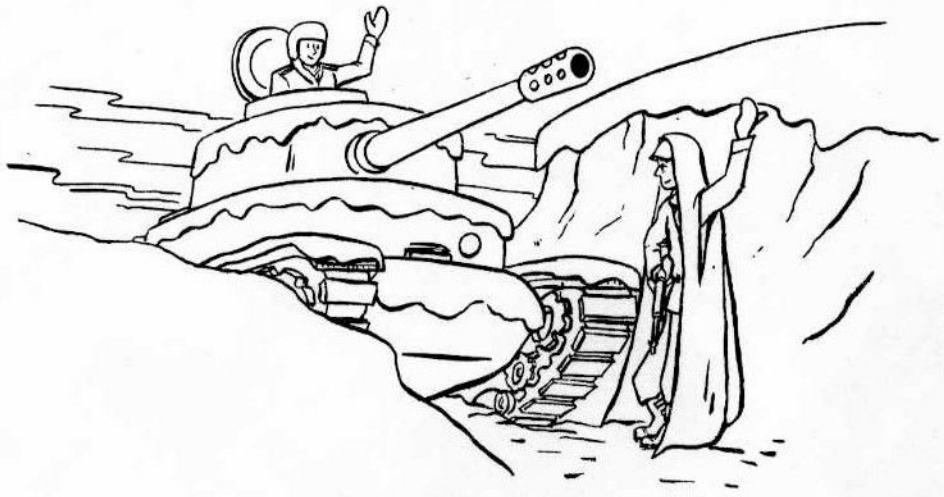

Figure 7. Lack of Security Can Be Dangerous.

An iron monster, coated in white, rumbled and roared out of the darkness, with the mechanical clank of steel treads and the deep roar of a powerful engine. The long, menacing steel shaft that extended from the turret turned slowly, inquiringly, toward a roadblock. Here, the monster stopped.

A form rose from the defenses of the hastily constructed roadblock. Ragged uniform, covered by a bedsheet in an attempt to blend into the frozen snow-covered forest, gave little suggestion that here was a member of the best-trained, best-equipped and undefeatable Allied Army.

A few muffled words were exchanged after a challenge was called out and the Goliath rumbled on; in its path, it left death and destruction for the comrades and Allies of the lonely form at the roadblock.

Dressed as members of the Allied Army, in a captured vehicle, the Germans has passed all sentries by the use of the proper password and knowledge of the countersign, thus enabling them to destroy communications and bridges in the rear areas. Only one excuse allowed the password be known to the Germans--lack of proper security?

What is security? A correct definition is "The protected condition of classified matter which prevents unauthorized persons from obtaining information of direct or indirect military value."

Responsibility

The knowledge of one word destroyed much equipment and many lives. Can you imagine what the Radar knowledge that you will soon know would mean if it were obtained by unfriendly people?

By receiving information on the frequency of your set, or even the name of the set you will operate, the enemy can determine how to counteract and perhaps avoid the air surveillance the set affords. No matter how small and insignificant a bit of information may seem to you, along with other bits of information, it can become important. If the enemy is able to do this, bombing of countless cities may very well be accomplished and thousands of lives needlessly lost.

Who will have permitted this? You, because you have failed to observe the proper security classification.

AF Regulation 205–1

Security is of such importance to everyone concerned that the Department of the Air Force has issued an Air Force Regulation 205–1 on the subject. The following information has been taken from the 205–1 file and you should become acquainted with it:

1. *Top Secret—Authority to Classify:*

a. Matter such as this may be classified only by or by authority of the Secretary, Under Secretary, or an Assistant Secretary of the Air Force, Chief of Staff, Commanding Generals

of Major Air Commands, Independent Commands, Service, Air Force Bases, Wings, Groups, or Depots, Chiefs of Air Missions, Air Attachés, Air Observers, or General Officers.

Figure 8. What You Have Seen and Heard, You Will Not Speak.

b. *Top Secret Matter.* Information and material, the security of which is very important, and the *unauthorized disclosure of which would cause exceptionally grave damage to the Nation.*

2. *Secret—Authority to Classify:*

a. Matter such as this may be classified only by or by authority of the Secretary, Under Secretary, or an Assistant Secretary of the Air Force, Chief of Staff, Commanding Generals of Major Air Commands, Independent Commands, Service, Air Force Bases, Wings, Groups, or Depots, Chiefs of Air Missions, Air Attachés, Air Observers, or General Officers.

b. *Secret Matter:* Information and material (matter), the unauthorized disclosure of which would endanger national security, *cause serious injury to the interests or prestige of the Nation, or would be of great advantage to a foreign nation.*

3. *Confidential—Authority to Classify:*

a. Anyone who may classify Top Secret or Secret Matter or by authority of such, or by any commissioned officer.

b. *Confidential Matter.* Information and material (matter), the unauthorized disclosure of which would be *injurious to the interests or prestige of the Nation or would cause unwarranted injury to an individual, or be of advantage to a foreign nation.*

4. *Restricted—Authority to Classify:*

a. Anyone who may classify Top Secret or Secret Matter or by authority of such, or by any commissioned officer.

b. *Restricted Matter.* Information and material (matter), which requires security protection, other than that determined to be Top Secret, Secret, or Confidential, will be classified as such.

Most of the material with which you will be working while in school will be restricted material. Although this is the lowest classification, material classified as restricted is not to be regarded loosely. If material is worthy of classification, it is important to the security of the country.

SAFETY PRECAUTIONS

Introduction

Another piece of information is necessary before we introduce you to Radar. Although this bit of information appears at the end of the introduction chapter, do not regard it as being unimportant. This could be the most important point in the whole course as far as you as an individual are concerned. The subject is Safety Precautions for electrical shock. Look ahead a few weeks to the point when you will be spending portions of your time in the laboratory. Realize at the same time, that the same scene could occur at a station in the field as well as the laboratory.

In the "B" scope laboratory, a man in an immaculate white uniform, astraddle a prone, limp form, is furiously applying Artificial Respiration in an attempt to pressure the still heart into action. The ominous sign "Danger! Hi Voltage!" overlooks the tense and tragic scene.

Although the doctor works continually, never pausing in his rhythmic motion, he glances at you and not a word is spoken—none is neces-

Figure 9. High Voltage Can Kill.

sary, for you can see the tragic answer written on his face. All hope is lost! Nothing more can be done.

The man, whom they are now carrying to an awaiting ambulance, your friend, could, in all probability, have been saved.

What did you do—nothing!

Procedures

What could you have done? Perhaps saved his life, if you had known the proper first aid procedure. In case of electrical shock, follow this procedure:

1. Shut off the current! If this is not *immediately* possible, use a dry nonconductor (rubber gloves, rope, board, paper) to move either your friend or the wire. Avoid contact with him if he is still in contact with the wire. If necessary to cut a live wire, use an axe with a dry wooden handle. Beware of the resulting flash.

2. *Begin artificial respiration immediately on the spot!* Do not stop to loosen his clothing. Every moment counts. Keep him warm, wrap him in any covering available. Send for a doctor. Make certain that you remove false teeth or other obstructions from his mouth.

3. Place the subject in the face down, prone position. Bend his elbows and place the hands one upon the other. Turn his face to one side, placing the cheek upon his hands (fig. 10).

Figure 10. Position of the Subject.

4. Kneel on either the right or left knee at the head of the subject facing him. Place the knee at the side of the subject's head close to the forearm. Place the opposite foot near the elbow. If it is more comfortable, kneel on both knees, one on either side of the subject's head. Place your hands upon the flat of the subject's back in such a way that the heels lie just below a line running between the armpits. With the tips of the thumbs just touching, spread the fingers downward and outward (fig. 11).

Figure 11. Position of the Operator.

5. Rock forward until the arms are approximately vertical and allow the weight of the upper part of your body to exert slow, steady, even pressure downward upon the hands. This forces air out of the lungs. Your elbows should

be kept straight and the pressure exerted almost directly downward on the back (fig. 12).

Figure 12. Compression Phase.

6. Release the pressure, avoiding a final thrust, and commence to rock slowly backward. Place your hands upon the subject's arms just above his elbows (fig. 13).

Figure 13. Position for Expansion Phase.

7. Draw his arms upward and toward you. Apply just enough lift to feel resistance and tension at the subject's shoulders. Do not bend your elbows, and as you rock backward the subject's arms will be drawn toward you. Then place the arms on the ground. This completes the full cycle. The arm lift expands the chest by pulling on the chest muscles, arching the back, and relieving the weight on the chest (fig. 14).

The cycle should be repeated 12 times per minute at a steady, uniform rate. The compression and expansion phases should occupy about equal time; the release periods being of minimum duration.

Figure 14. Expansion Phase.

It is absolutely necessary for you to continue this treatment until he starts to breathe or until there is no hope for his recovery. Do not give up easily! People have been revived after *hours* of applied artificial respiration.

Do not give him any liquids until he is fully conscious. If you must move him, keep up the treatment during the movement.

When the patient starts to breathe, stop applying artificial respiration. If you see that his natural breathing does not continue, immediately start artificial respiration again.

If relief is necessary, you will change with your relief in such a manner as not to break the cycle.

Do not permit the revived patient to sit or stand. Give him hot coffee or tea.

"An ounce of prevention is worth a pound of cure!" How often have you heard that expression? All of the above mentioned first-aid procedures are unnecessary if you remember to exercise extreme caution when operating a Radar Set. Do not touch anything you were not told to use in operating. Follow instructions precisely!

IMPORTANCE OF A RADAR OPERATOR

Introduction

At this point, you may be asking yourself, "How important is a Radar Operator?" You've probably read about or heard about the Radar net that is being constructed on the borders of the United States. Right now is not the place to dig into the intricacies of the Aircraft Control and Warning System. However,

suffice it to say that you, a future Radar Operator, will be playing a very important role in the defense of your country.

You are all familiar with the positions on a football team. Who starts the ball rolling on every play? Naturally, you answer, "The center", for it is he, who snaps the ball to the backfield. Now compare an interception of a hostile flight to one football play. You, as the Radar Operator, snap the ball and start the play. How do you snap the ball? You initiate action by reporting the presence of an unknown aircraft many miles away. After you have passed the information, the rest of the team comes into action until the interception is made or "the play is completed". Your work is the first link in the chain of events that takes place. Your importance as a Radar Operator cannot be overemphasized.

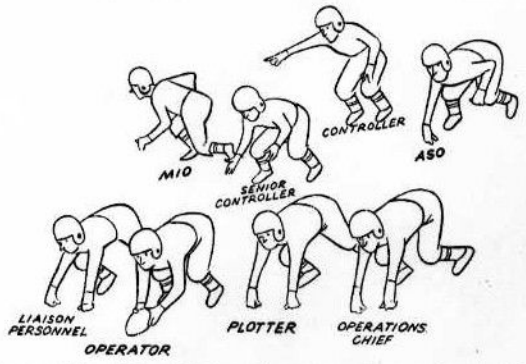

Figure 15. The Radar Operator Starts the AC&W Ball Rolling.

Who makes up the rest of the team? These positions are filled by other enlisted personnel carrying the same AFSC as the Radar Operator. They are doing the plotting, recording, telling, all the jobs that are necessary to set up the play just as the linemen set up the play with assigned blocks. The quarterback position is filled by an officer, designated as the Controller. He directs the team as the quarterback does on the playing field. The men who carry the ball or complete the play are the fighter pilots. It's up to them to score "The touchdown", the destruction of the enemy aircraft.

Remember, none of the above can be accomplished unless *you*, as a Radar Operator, start the ball rolling. Diligence, patience and perseverance are necessary virtues for the Radar Operator.

Now that you have been familiarized with the school policies, your future career possibilities, study techniques, security, precautionary measures for electrical shock, the importance of a Radar Operator, you have reached the point where you will open the door to Radar, itself. The key to this door is at your fingertips—a turn of the page. So, turn the page and you're on the way to becoming a Radar Operator. The type of operator you are, good or bad, is up to you! A word of advice, however, the Air Force has no need for inefficient operators—be a good operator!

QUESTIONS

1. What do the letters AFSC stand for?
2. What does the fourth digit of an AFSC stand for?
3. Upon completion of this course, what AFSC are you awarded?
4. What will be the rank of anyone holding the AFSC of 27000?
5. Besides listening to lectures and reading your TPO's, what else must you do in order to successfully pass this course?
6. Why did the sentry at the roadblock let the enemy pass through?
7. What is security?
8. Why are we interested in security in the AC & W System?
9. What Air Force Regulation covers security?
10. What are the four classifications used to classify material in the Air Force?
11. Most of the material used in this manual will be of what classification?
12. What is the first step taken by anyone to aid another airman who has come in contact with high voltage?
13. What is the correct number of cycles per minute when giving artificial respiration?
14. Why is a Radar Operator's job so important?
15. In what way is the AC & W team comparable to a football squad?

HISTORY OF RADAR

Scope: Origin and early use of Radar.
Student Objective: To become familiar with the history and development of Radar.

INTRODUCTION

Late in the evening of November 14, 1942, a United States warship was cruising the placid waters of the South Pacific Ocean near the Solomon Islands. This vessel was the same as any other ship in the fleet except for a piece of screen revolving 'round and 'round on its superstructure. The sea battle for Gaudalcanal was in its final phase, the outcome still undecided. If the Americans could prevent the Japanese from landing reinforcements on the island itself, the issue could be decided in favor of the Americans. Suddenly, the revolving screen stopped turning. It moved first left and then right, left and then right; at the same time, the large 16 inch guns on board started moving to the left and upwards. Fifteen long seconds ticked off from the time the screen stopped turning. Suddenly, out into the pitch black night the guns roared, flame and smoke shot skyward and the blackness of the night was aflame for hundreds of yards surrounding the warship. The sea battle for Guadalcanal was on and as yet, not a man aboard has seen the enemy with his eyes. After the very next salvo, the first kill was made, and the Americans went on to win so decisively that the battle turned into the costliest rout in Japanese history This tremendous victory was made possible by the development of a device called Radar, which was the most revolutionary and greatest single weapon to reach perfection in time for extensive use during World War II. This silent instrument has secretly shaped the course of victory in many historic battles, and we can be thankful that the discovery and development of this weapon was handled by the Allied Nations and not by the Axis Powers. It is true that the Axis had a similar instrument, but the Admirals and Generals, who decide such things, believed ours was much better, and this has since been proven by the war's outcome, and subsequent comparison of the enemy's equipment.

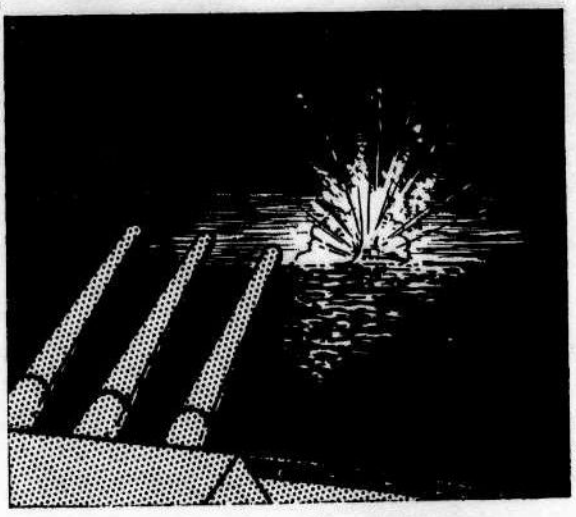

Figure 1. Radar Controlled Guns.

THE NAME RADAR

On April 25 of 1943, the Army and Navy put out a joint press release admitting the existence of a *ra*dio *d*etecting *a*nd *r*anging device, and gave it the Navy code name of Radar. Never has a more meaningless label been glued to a more remarkable device. However, the dis-

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covery, research, and realization of Radar's possibilities goes back to more than 20 years before this release in 1943. The story is one of great discoveries, by equally great men, who, despite ridicule and disbelief by our War and Navy Departments, and hampered by lack of Congressional appropriations, still fought on and begged and borrowed, to make possible Radar as it is today.

PIONEERS AND EARLY DEVELOPMENT

The central figure in that early work was a baldish, one time University of Wisconsin professor, named Dr. Albert Hoyt Taylor. Dr. Taylor and his associates in this work, Leo C. Young and Louis A. Gebhard, were all assigned to the Great Lakes Naval Station in communications work headed by Dr. Taylor, himself. This was as far back as 1917 during World War I. In 1921, their work took them into the field of radio broadcasting, and they were then located on the Virginia side of the Potomac River. They were working with the then new super-frequency, or short waves.

From the beginning, they noticed that at certain times their signals were distorted or "obscured", as radio men put it. By extensive observation of this interference, it was determined to be caused whenever ships were moving up and down the river. This was the discovery! Since radio was discovered, almost 40 years before, it was noticed that large mountains or a great building distorted the waves. But never before, had it been observed that small objects such as ships produce the same noticeable result.

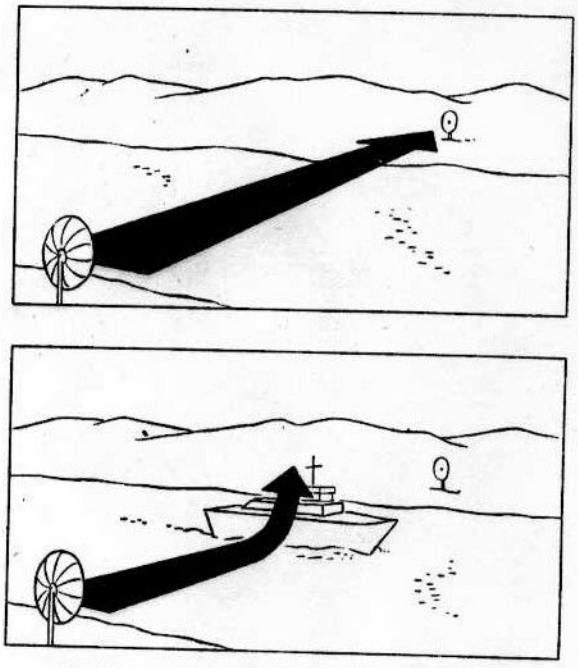

Figure 2. Ships Reflecting Radio Energy.

From this seemingly small observation on the Potomac, if others had but recognized it, it was but a short jump to the Radar of today. At this time, when their findings were proven, they suggested trying it out at sea with destroyers. But this idea was considered so fantastic as an implement of war that no one in a position to help did anything about it. The idea was dropped completely by the military. But the scientists continued to experiment further, realizing that their ideas would never be accepted until something concrete could be placed before the powers that be.

At the same time from 1925 to 1930, the Carnegie Institute was experimenting with the pulse technique of transmission. Their use of this technique was in the field of pure science. However, Dr. Gebhard collaborated with the scientists of the institute and developed the first radio transmitter employing the "pulse" principle. By using the "pulse" principle of operation with high frequency radio waves, a return or echo was observed without the receiving equipment being blanked out. Simply speaking, it meant, that a pulse of energy was transmitted, went out into space, struck the ionosphere (or electric roof) and returned, before the next pulse was transmitted. In this manner, they could measure the height of the ionosphere, by timing the pulses that were transmitted and knowing how fast this pulse traveled. In 1927, Matthew H. Schrenk, from the Western Electric Company, developed ways of sharpening, amplifying, and increasing the frequency which produced a wave similar to present-day radar pulses. These findings were published in scientific journals throughout the

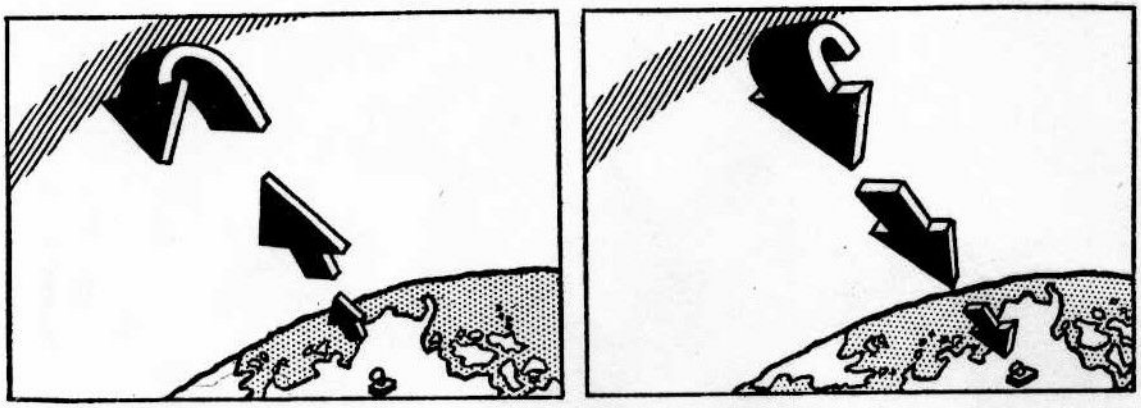

Figure 3. Height of Ionosphere Measured by Radio Energy.

world and prompted the actions of foreign powers in developing their own "Radio Locators."

Up to this time, Dr. Taylor and his associates were primarily interested in Radar as a means of detecting ships at sea, and all their thoughts were formed for practical Naval benefits. At approximately the same time, a new man had joined Dr. Taylor's staff. He was L. A. Hyland, now working for Bendix Corporation, and a great scientist in his own right. On June 24th, 1930, possibly the greatest defensive discovery was made by Taylor, Young, and Hyland than at any previous time since they had been connected with Radar.

On this particular day, they were working on a high frequency blind landing system for aircraft. Their sets were in operation at Bolling Field, Washington, with Young operating a transmitter and Hyland the receiver. Hyland was not completely satisfied with the experiment because of the periodic interference he was picking up. He checked his equipment and the surrounding terrain, but failed to find anything wrong. Then he noticed that this interference occurred only when an aircraft

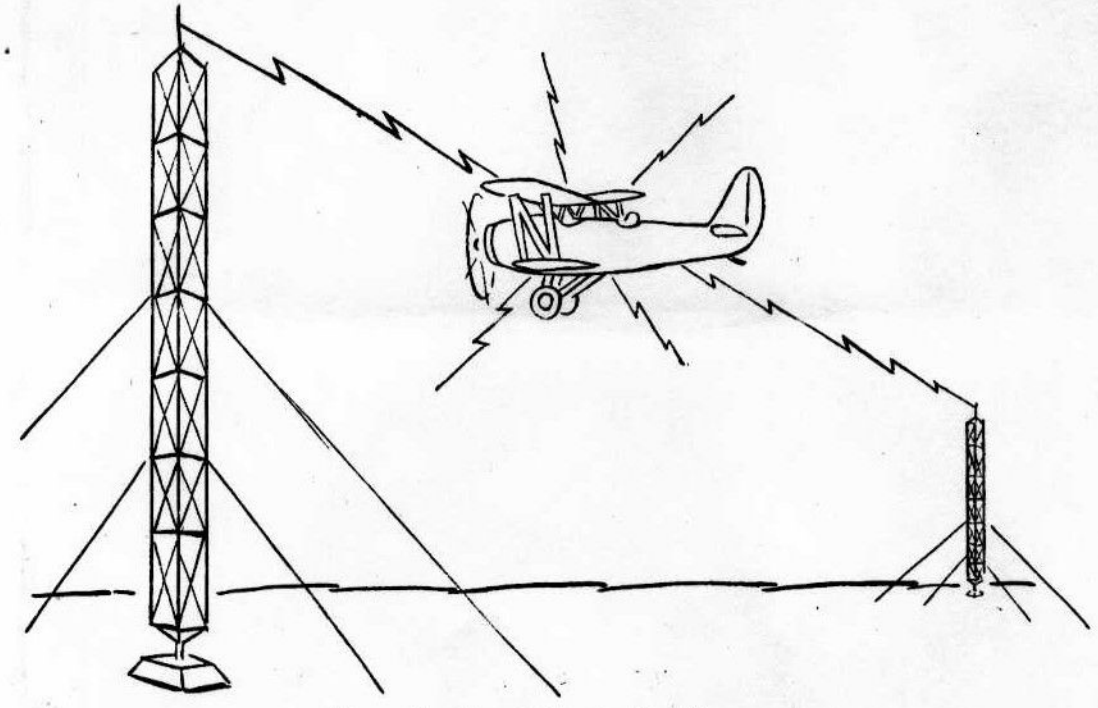

Figure 4. Aircraft Causing Interference.

passed through the beam of the radio. Right here, the basic idea of our present AC & W System was born, because both men realized the value and importance of being able to detect aircraft while in flight and the wartime as well as peacetime benefits which would be derived. Here was a discovery that sharply limited the surprise element in which the aircraft so highly prided itself. This was the greatest tactical advance in warfare since the invention of the aircraft itself.

Experiments along this line continued for months, and when the reports were assimilated, they were presented to the proper authorities under the heading "Radio Echo Signals from Moving Objects". The Engineering Bureau's Radio Division studied these reports for two months and then finally gave the go-ahead for extensive and confidential research in this field. Finally over were the 10 years that Dr. Taylor diverted funds from other projects, disobeyed orders and kept himself and his staff from becoming disheartened by those who could not anticipate the tremendous part Radar was to play in the years to come.

The full time job of further research was given to Robert M. Page, a young man from Hamline University at St. Paul, Minnesota. It is said of this young man that he made more contributions to modern Radar than any other individual. He was given an assistant by the name of Robert C. Guthrie; these two men have been associated with Radar for more than a decade.

Page and Guthrie started their experiments with all the knowledge that Dr. Taylor and his staff had accumulated. They had the basic principle; perfecting the equipment was their job. Up to this time, when a target was spotted, mathematical calculations were used to determine distance and direction. This, of course, greatly limited the set for practical use in Air Warning as we have it today. By the time you pick up a target, mathematically compute its distance and direction, the target will have changed position to the extent of making the calculations of little value. A method was devised whereby the set itself did the figuring and actual position of the target read off the indicator. Another problem to present itself was the size of the equipment. Because of the limited space aboard a ship, you could not possibly have separate antennas pointing to all directions. This problem was taken care of by employing one revolving or rotating antenna, thus covering attacks from any quarter.

After months of experimenting with no apparent results satisfactory to Dr. Taylor, Page was told to develop an operational set within six months or drop the entire project. Within five months, Page completed and had in operation a set capable of picking up targets at long range. Long range in those days was a little over five miles. This was, to everyone but Page, a milestone in electronic development. The set was demonstrated and so impressed Congressional viewers that additional appropriations were forthcoming, and within a few months, the range of the set extended to over forty miles.

It is highly commendable to mention at this point that although Congress and many other government officials appropriated money and actually viewed the first Radar sets, sharing the secrets with the developers of Radar, the project was one of the best kept secrets of World War II.

From the stage of development reached by Radar up to this time, the conclusion of its history was mostly improvements, getting it manufactured, and training men to operate it. As in any other industry, improvements have been made during later years and will continue to be made in years to come. We are thankful we had this weapon, and we owe these pioneers of the Electronic Industry a tremendous debt. Because of their realization of Radar's possibilities and their failure to admit defeat under the most trying conditions, we have today a multi-million dollar industry for peace and a weapon for war unsurpassed by any other country.

BATTLE OF BRITAIN

One of the greatest tests ever given to a new instrument of war was given to Radar during the Battle of Britain. In the cloudy years of 1940 and 1941, the German Luftwaffe was

pounding London and the major cities of England to rubble, almost at will. The Germans were in control of the air and the handful of Spitfire pilots were putting up a brave but futile resistance against them. They had to maintain a 24-hour cover over the English Coast because they never knew when another rain of death could be expected to fall on their country. Every measure of precaution then known by the British was taken, but to no avail. They were seriously short of gasoline and their pilots were flying almost constantly, resulting in pilot fatigue and serious aircraft losses. As a drowning man will clutch at any straw to same himself, Great Britain decided to try Radar. They lined the English Coast with "Radio Detectors" and started searching. The aircraft were kept on the ground awaiting "scramble" or take-off orders from the Radar. In this manner, the Luftwaffe was spotted far out over the water and many times over the Continent itself; the Spitfires were scrambled and met the enemy far from the shores of England. The same operation worked at night. By installing Radar in the aircraft itself, the deadly night fighter was born and the back of the Luftwaffe was broken. In Herman Goering's own words at the Nuremburg War Crimes trials, "The one single instrument which defeated the Luftwaffe and was instrumental in making the Battle of Britain the turning point in the war was the Allied development of Radar."

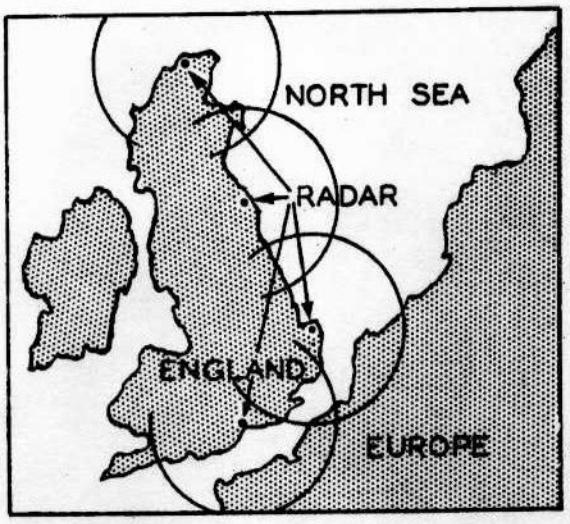

Figure 5. English Coast Lined With Radar.

PEARL HARBOR

Even after such proof as was presented by this great battle for the small island of England, the military leaders of the United States still remained doubtful of this new and all-seeing eye. It was installed in many places but with a very skeptical point of view. Proof of this was greatly impressed upon the American people on December 7th, 1941. This is a date which every living American will remember as the time of the Japanese "sneak" attack upon Pearl Harbor. It was the step that plunged us into the greatest and costliest war ever fought on the face of this earth. Yet, the damage to Pearl Harbor could have been minimized and, in the opinion of some, completely prevented had we believed in Radar.

On a lonely outpost on the island of Oahu, overlooking the Naval Base of Pearl Harbor, an Air Force Private by the name of Lockhard picked up on his radar a flight of aircraft inbound to the island. This was at 0903; he reported his find to proper authorities but because of disbelief and thinking it was a friendly flight, intercept action was not taken. The result was that 30 minutes later, Pearl Harbor was bombed, resulting in the crippling of the Pacific fleet and serious loss of life of both military and civilian personnel. In some quarters, it is believed that if the Japanese had followed up with an attack on the island itself, they could have taken it, and the outcome of the war might have been decidedly different.

It is possible to cite many instances whereby Radar could have turned the tide of battle, and more instances where it did turn the tide of battle from bitter defeat into a disheartening rout of the enemy and glorious victory for the Allies. Some of these will be mentioned in later sections, where you will see more clearly the value and greatness of this phenomenon in electronics, the ability to see through darkness, fog, smoke and clouds, this miracle called Radar.

QUESTIONS

1. In what famous battle of World War II did the Americans first use Radar with success?
2. What does the word Radar mean?
3. What individual was instrumental in the early development of Radar?
4. Do radio waves reflect or penetrate the ionosphere?
5. Why was the discovery, that Radar could detect aircraft, so important?
6. Who was responsible for the completion of the experiments with Radar after Dr. Taylor?
7. What limited the first Radar sets in their use on warships?
8. What was the first and greatest test given to Radar during the last war?
9. Why were the Spitfires unable to continue the Battle of Britain without Radar?
10. Why will December 7, 1941, remain on all Americans' minds?
11. Why weren't the Japanese detected before they bombed Pearl Harbor?
12. What was the feeling toward Radar after this incident?
13. Can one Radar Set cover all directions or quarters?
14. How is the 360° coverage accomplished?
15. Can Radar see at night?

INTRODUCTION TO RADAR

Scope: Basic Principles of Radar and their uses for varied purposes.
Student Objective: To become familiar with the fundamentals of Radar theory and operation and to understand their function in the different type units.

You have read in the preceding section how radar came about, and of the vital part it played in the Allied victory of World War II. Now, you will find how it works, how it is used generally, and how you will use it in the Aircraft Control and Warning System of which you will play an integral part.

Just what does the word Radar mean? It stands for *Ra*dio *D*etection *a*nd *R*anging. The British used two expressions: Radio Location or RDF (Reflection Direction Finding). In these expressions can be found the explanation of just what radar does. It is radio equipment which can detect and locate aircraft, surface vessels, and other military targets which can be reached by radio waves. By "location" is meant the determination of the distance of the target from the equipment and its bearing or direction with respect to the equipment. Some radar, in addition to furnishing range and azimuth, can also furnish information concerning the height of detected aircraft.

PRINCIPLES OF RADAR

"How is all this done?" you ask. The operation of radar is not very mysterious if it is compared to some facts you already know.

The principle with which you have long been familiar in hearing an "echo" return to you when your voice or the cound of a fog horn

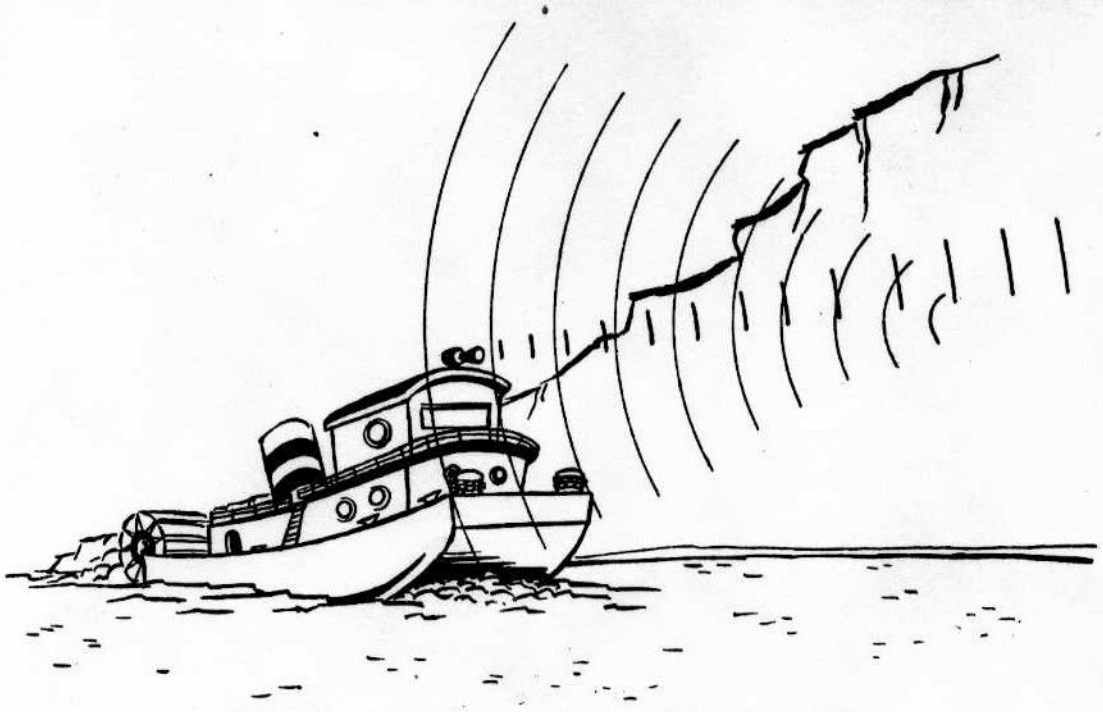

Figure 1. Sound From Fog Horn Reflected From Cliff.

bounces off a cliff or the side of a building is the same principle that makes radar possible. In fact, you will hear the word "echo" used many times in referring to the signals that are bounced back to a radar set to indicate the presence of an aircraft. However, the waves used in radar are different from the sound waves that strike a reflecting surface to be returned as echoes. The energy that is used in radar detection is not visible, like light, nor is it audible, like sound. In the process of radar detection, the radar set sends out some energy which is reflected from any surface that it strikes. The same radar set is capable of receiving this energy and using it to give indication of the distance, direction, and height of an object some place out in space. Let us see how this is done.

COMPONENTS OF A RADAR SET

Transmitter

It is obvious that if we are to have some radar energy "bounce" back from an aircraft, we must first send some energy out to strike the plane. In every radar set there is a component to accomplish this. This component is called the Transmitter. The transmitter is an electrical device that generates the type of signal that is best for developing a return signal. This type of signal is called "ultra-high" or "microwave" frequency of radio waves because it is far higher than the frequencies normally used in commercial radio broadcast or communications. Microwave frequencies are suited for this task because they can be focused into a narrow beam, just like the light beam is focused by a flashlight. In addition, they are capable of bouncing back at separate returns from objects that are quite close together.

Modulator

Before we can hear the return echo of our shout against the mountain, we must be quiet for a moment to listen. The same principle still applies in receiving of radar echoes. If the transmitter were to be operating without interruption there would be no way of knowing when a signal had been reflected back to the radar set. In order to accomplish this "waiting period", the transmitter does not work continuously, but instead it sends out a short pulse of radar energy and then is shut off while it waits for a returned echo. Another pulse will then be transmitted; and another waiting period follows. The component of the radar set that accomplishes this switching of the transmitter is called the Modulator. In commercial radio broadcasting the modulator is used to place the sound of voices or music on the radio waves. In radar, the modulator is used to provide a switching on and off of the transmitter so that a listening time will follow every pulse that is transmitted. In considering the various characteristics of different radar sets the terms "pulse repetition frequency" will be used to tell us how many times each second the transmitter is allowed to fire a pulse. The pulse repetition frequency is determined by the rate at which the modulator turns the transmitter on and off.

Receiver

We have now generated a radar pulse which is traveling out into space and the radar set transmitter has been turned off to allow a listening time. If there is an object in the path of the radar wave a portion of this energy will bounce off and be reflected to the position of the radar set. This returned energy is so small (as small as *one-billionth* of the transmitted energy) that we must build it up to become large enough to be usable in the radar set. The component that accomplished this part of the job is called the Receiver. The entire function

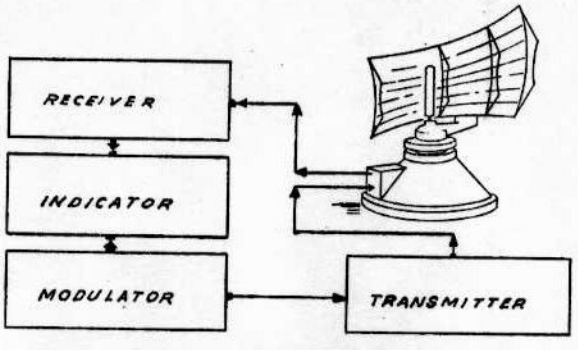

Figure 2. Components of a Typical Radar Set.

of the receiver is to amplify the tiny returned signal so that it can be used as a source of information. The name "receiver" is given to a great number of electrical circuits that perform the function of building up or amplifying the signal. The form that this energy takes while it is in the circuits of the receiver is such that it is not convenient to see or hear, so we must prepare it for use in some type of device that can readily show information concerning the presence of a reflecting object.

Indicator

In a commercial radio broadcast the energy from the receiver is applied to a loudspeaker so that the sounds may be heard. In radar, a different method is used to present the signals coming through the receiver. The radar set uses a set of components called Indicators to allow the operator to *see* the signals just as we *hear* the signals on a commercial broadcast. There are many different types of indicators but the function of any of these is simply to display the information concerning the position of the reflecting object. The indicators get a signal from the modulator which tells exactly when the radar pulse was first transmitted. This synchronizing pulse is used in the indicators in measuring the length of time it takes the echo to get back to the set after the pulse is first transmitted. Because the radar energy always travels at the same speed, we can very accurately measure the distance of an object if we know how long it takes the pulse to travel from the radar transmitter, to the object, and then back to the radar set and into the receiver.

The function of the indicators is to allow a displayed means of determining the distance, the direction, and the height of a reflecting object.

Antenna

The radar energy from the transmitter is not fired into space from the transmitter itself, but first travels to a part of the radar set which is very efficient in allowing radar energy to leave the radar and proceed into space. This component, the Antenna, is mounted in front of a large reflecting surface very much like the reflector on the headlights of an automobile or in a flashlight. The reflector focuses the radar energy into a narrow beam. This beam will point in any direction to which the antenna is pointed and will not send any pulsed energy to any other headings.

The method of causing r-f energy to travel in such a beam is complex and will not be discussed in this course.

In order to determine directions accurately, the beam is made narrow in the horizontal plane and wide in the vertical plane for search antennas. The beam thus formed is called the lobe pattern. Each radar set has its own particular lobe pattern. The shape of the lobe pattern is determined by various factors such as the type of antenna, reflector, power output of the set, etc.

One of the peculiar characteristics of the radar beam is that it will not "bend" around

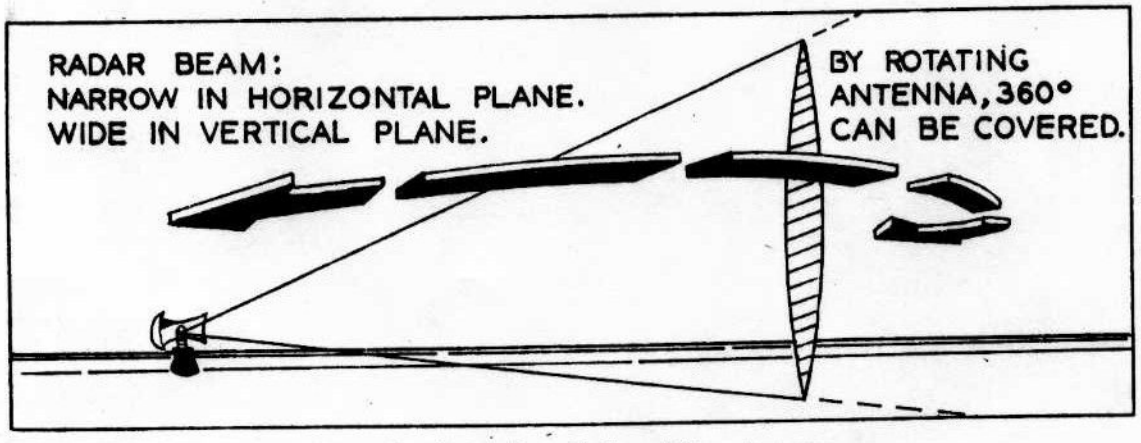

Figure 3. Radar Beam Reflected From Antenna.

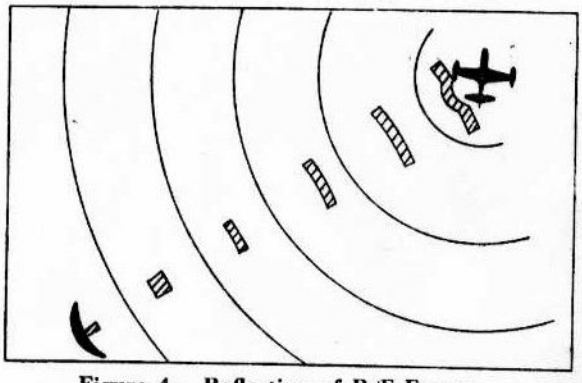

Figure 4. Reflection of R/F Energy.

objects such as mountains, tall buildings, nor will it follow the curvature of the earth. This characteristic is called "line of sight" transmission. Due to this type of transmission, blind spots or gaps may occur in the area covered by a large radar set. To eliminate these blind spots, smaller sets are used to supplement the main sets.

It is obvious that a returned signal will appear only when the radar antenna is pointing to the area in which the reflecting object is located. If we know the pointing direction of the antenna at the time than an echo returns to the radar set, we know the exact direction in which the object is located.

In order to allow the antenna to be pointed in many different directions, the antenna components are attached to a positioning system that allows the antenna to be rotated or turned either in continuous rotation, or through any particular section that is desired.

Power Supplies

All of the components of the radar set need electrical power in order to perform their respective functions. There are special circuits with each of the components to provide the type of power needed. These are called Power Supplies. The power supplies do not accomplish any of the actual radar detection but are necessary to change commercial-type power into the many different forms needed by the various components.

Summary

The general manner in which a radar set functions is as follows: The transmitter sends out into space a pulse of radar energy. The modulator is the switching component that determines when the transmitter will be developing this radar pulse. Upon bouncing off a reflecting object, some of the energy will be returned to the radar set where it will be sent to the receiver which builds up or amplifies the signal until it is strong enough to be applied to the indicators. In the indicators are devices which allow the returned signal to be displayed as visible information. The indicators also receive a synchronizing pulse from the transmitter and then measure the time that it takes the signal to make a round trip from the radar set to the reflecting object and back to the radar set. The indicators also can give information concerning the direction or height of the object because the antenna reflectors have narrowed the beam so that it points to one small sector at any time. Power supplies take the commercial voltage, or voltage developed by a generator used with the radar set, and develop it into the proper form to meet the needs of the various components of the radar set.

TYPES AND USES OF RADAR

Types

Radar equipment is of three types. Equipment installed in aircraft is known as airborne radar; equipment installed aboard ships is known as naval or shipboard radar; equipment used on the ground is known as ground radar equipment.

Uses

All three types of radar equipment have many various uses. Most of the important uses fall into one of the three main functions or applications of radar.

The first of these is *search*. The function of search equipment is to provide initial detection and continuous information as to the location of targets. Desirable characteristics of search equipment are complete coverage of an area, long range and convenient visual presentation.

The second application of radar is *fire control.* Such equipment must furnish accurate information which can be used in firing upon certain targets. A desirable characteristic of this equipment is the ability to keep the radar equipment automatically directed on the target.

The third and final general application of radar is *navigational aid.* This is becoming perhaps the most valuable function of radar. Nearly all radar equipment can be used to aid ships and aircraft in navigation. Range, coverage, and convenient visual presentation are all desirable characteristics of this type of equipment. Accuracy is also desired with the degree or amount of accuracy varying with the specific type of aid furnished.

ARMY-NAVY NOMENCLATURE

Purpose

As a radar operator, you will be called upon to operate various types of sets and equipment. By referring to the letters which name the set, you can tell for what purpose the set was designed. This is possible because of the system set up by the Army and Navy to designate equipment. It is called the Army-Navy Nomenclature System ("AN" System).

From the table below, you can decode the letters AN/CPS-6, one of the larger radar sets in existence. The AN tells you that the "AN" System is used, and stands for *A*rmy *N*avy. The letter C gives the *type of installation* and means that the set is transportable by air while the letter P tells you that it is a Radar Set (*type of equipment*). The letter S, meaning search, gives the *purpose* of the set. The number following the final letter always is the *model* number.

By knowing Army-Navy Nomenclature you will know, without asking too many questions, what the equipment was designed to do.

TABLE OF SET OR EQUIPMENT INDICATOR LETTERS

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, do not use).	C—Carrier (wire).	C—Communications (receiving and transmitting).
D—Pilotless carrier.	D—Radiac.	D—Direction finder.
F—Fixed.	F—Photographic.	G—Gun or searchlight directing.
G—Ground, general ground use (includes 2 or more ground installations).	G—Telegraph or teletype (wire).	H—Recording (Photographic, meteorological and sound).
K—Amphibious.	I—Interphone and public address.	L—Searchlight control (inactivated, use "G").
M—Ground, mobile (installed as operating unit in a vehicle which has no function other than transporting the equipment).	K—Telemetering.	M—Maintenance and test assemblies (including tools).
P—Pack or portable (animal or man).	L—Countermeasures (inactivated, do not use).	N—Navigational aids (including altimeters, beacons, compasses, racons, depth sounding, approach and landing).
S—Water surface craft.	M—Meteorological.	P—Reproducing (photographic and sound).
T—Ground, transportable.	N—Sound in air.	Q—Special, or combination of types.
U—General utility (includes 2 or more general installation classes airborne, shipboard and ground).	P—Radar.	R—Receiving.
V—Ground, vehicular (installed in vehicle designed for functions other than carrying electronic equipment, etc, such as tanks).	Q—Sonar and underwater sound.	S—Detecting and/or range and bearing.
W—Underwater, fixed.	R—Radio.	T—Transmitting.
	S—Special types magnetic, etc, or combinations of types.	W—Remote Control.
	T—Telephone (wire).	X—Identification and recognition.
	V—Visual and visible light.	
	X—Facsimile or television.	

QUESTIONS

1. What is meant by the term "radar located targets"?
2. Are radar waves the same as sound waves?
3. Does the speed of r-f energy change when it is reflected?
4. Name the 5 components of a typical radar set.
5. What does the modulator do?
6. What does the transmitter do?
7. What component reflects the r-f energy out into space?
8. How does the indicator compare to your radio loud speaker?
9. How does a radar set determine direction?
10. What is the main limitation of r-f energy?
11. Name three uses of radar.
12. How is radar used in fire control?
13. What do the letters in AN/TPS–1B stand for?
14. Why do they have the Army-Navy Nomenclature?
15. What type of radar is used in navigational aids?

DEFINITIONS USED IN AC & W SYSTEM

Scope: Reasons for use of coded words and phrases and examples of source in common usage.

Student Objective: To become familiar with coded words and phrases and purpose for which they are used.

INTRODUCTION

When you complete the AC & W Operator's course of study, you will be assigned to duty. Wherever, this assigned duty will take you, whether it is to an ADCC (Air Defense Control Center), GCI (Ground Control Intercept Station) or EW (Early Warning Station), the characteristic and sometimes colorful language used by the radar technicians of today will be used.

Figure 1. AC & W Language in Action.

This section is designed to help you to understand and become familiar with the meaning of, as well as the reasons for, stating words and equipment names, altogether differently.

Let us take the word Radar as an example. Before 1943, we had heard of this word many times, yet the word itself gave no idea what radar was or how it worked. However, had the meaning of the word been released, it would have given the enemy nations an inside track on how detection was being accomplished.

Even in peacetime, in the AC & W System, code words and other phrases are used for security reasons. They could be used to make it more difficult for the enemy agents to determine what is going on in a certain restricted area. They could be used in Radio/Telephone procedures to aid monitoring of communications. They could also be used to relay more clearly information concerning a site or radar set, or actions within an area of responsibility. Some of these words are standard throughout the service. Some of them will be found only at particular installations. The language of the system like the system itself, is very flexible in every respect. In some installations, methods of doing particular jobs may vary somewhat from the procedure taught here. Also, the language will change, sometimes according to the situation and also to keep within the bounds of security.

It is not expected that you will be able to remember all of the definitions listed. However, you are expected to learn the important, everyday words used in the system and a periodic review of the others will enable you to be much further ahead of your buddy when time for advancement comes. This is true in AC&W work because advancement in knowledge and skills is the first step to advancement in responsibility and job assignment.

EVERYDAY WORDS AND DEFINITIONS

1. AAA — Anti Aircraft Artillery.
2. AAD — Active Air Defense.
3. AAOR — Anti Aircraft Operations Room.
4. AC & W — Aircraft Control and Warning.
5. AD — Air Defense.
6. ADA — Air Defense Area.
7. ADC — Air Defense Command.
8. ADCC — Air Defense Control Center.
9. ADR — Air Defense Region.
10. ADS — Air Defense Sector.
11. AIR SPEED — Speed that an aircraft is making through the air.
12. ALL WEATHER A/C — Aircraft electronically equipped to navigate under all weather conditions.
13. ANGELS — Altitude in thousands of feet.
14. ANGLE OF ELEVATION — The angle that you have to look up to see an aircraft from your station and a line parallel to the earth's surface.
15. AS — Air Surveillance (a systematic observation of electronic, visual, and all other means of an area for the purpose of locating aircraft or missiles in flight).
16. ATD — Actual time of departure, used in flight plans, for aircraft.
17. AW — All weather aircraft.
18. AZIMUTH — An angle measured in degrees clockwise from true north and in relation to your station.
19. BEARING — An angle measured clockwise from true north and is the direction a target is from you.
20. BLIP SPLITTER — A scale used to determine the exast center of target.
21. CDA — Civil Defense Agency.
22. COCKEREL — Code word for IFF (used in Air to Ground Communications).
23. CONSOLE — Any type of cabinet or frame used to display equipment.
24. CONVERSION GRID — Polar Grid with "Georef" superimposed.
25. CURSOR LINE — Adjustable curved line used to give accurate reading of targets.
26. DLI — Desired lines of interception, a line beyond which interception of hostile aircraft must be completed.
27. ECM — Electronic Counter Measure.
28. ELEVATION — Height in feet of a target in relation to your station.
29. ETA — Estimated time of arrival. Pertains to flight plan information for aircraft.
30. EW — Early Warning.
31. EWL — Early Warning Line, the line beyond which enemy aircraft must be detected if contact beyond the desired line of interception is to be accomplished.
32. FIX — Actual determined position of a target (Latitude and Longitude or Range and Azimuth).
33. GCI — Ground Controlled Interception.
34. GM — Guided Missile.

35. GROUND SPEED — Actual speed in KNOTS of a target over the earth's surface. (Formula for figuring is $\frac{D \times 60}{T}$). 60=60 Min. in hour, to get M. P. H.; D=Distance target traveled in miles; T=Time it took target to travel that distance.
36. HEADING — Magnetic Direction Aircraft is pointing (used in GCA).
37. IFF — Identification Friend or Foe.
38. IFR — Instrument Flight Rules.
39. JIC — Joint Information Center.
40. JOY — Radar contact made with target by night fighter during Ground Controlled Interception.
41. LATITUDE — Distance measured from North to South on the earth's surface by running horizontally around the earth's surface.
42. LONGITUDE — Measures distance from East to West but runs vertically or from North to South.
43. ORANGES — Visibility conditions during Ground Controlled Interception, either sweet or sour (Good or Bad).
44. PANCAKE — Aircraft landed or landing.
45. PICKET SHIP — A radar-equipped surface vessel that assists in Radar Coverage and direction of aircraft.
46. POLAR GRID — Any portion of the earth's surface measured off in Azimuth and Range.
47. PULSE INTERVAL — Time elapsed between pulses.
48. PULSE MODULATION — Principle on which radar energy is timed in pulses.
49. PRF — Pulse Repetition Frequency, the number of pulses sent out by a radar set in a second.
50. RANGE — Distance measured in statute miles from your station to target.
51. RECIPROCAL — Means opposite direction or 180° difference. If heading is from 000° to 180° and you wish to fly reciprocal heading, you add 180°. If heading is between 180° and 360° and you wish a reciprocal, you will subtract 180°.
52. STEER — Magnetic direction the aircraft is pointing (used in D/F).
53. S.O.P. — Standard Operating Procedures.
54. TALLY HO — Visual contact made with target by interceptor aircraft during Ground Controlled Interception.
55. T. O. T — Time over Target.
56. TRACK — The actual path or course being made good by a target over the earth's surface.
57. VECTOR — Magnetic direction the aircraft is pointing (used in GCI).
58. VFR — Visual Flight Rules.

QUESTIONS

1. Why are words and names sometimes coded in AC & W conversation?
2. Is this a set language, or is it subject to change occasionally?
3. What do the letters AAA stand for?
4. What is meant by the word azimuth?
5. What is the code name for altitude in thousands of feet?
6. What do the letters ATD stand for?
7. What is a blip splitter?
8. What is the difference between a fix and a steer?
9. Of what use will guided missiles be in AC & W?
10. What is the difference between latitude and longitude?
11. What does VFR mean?
12. What is the reciprocal of 180°?
13. Why is range important to a controller?
14. If an aircraft travels 10 miles in 2 minutes, how fast is it going?
15. What is a picket ship used for?

THE AC & W SYSTEM

Scope: Structure of AC & W networks and their component parts.
Student Objective: To learn the structure of AC & W networks and their component parts.

INTRODUCTION

Adequate defense of our country requires a system that will protect our offensive capabilities during the initial attack or opening of hostilities. An important threat to our offensive facilities is the possibility of enemy air attack. In this day and age in which developments in speed and range of aircraft are drawing the countries of the world closer together, we can eliminate the phrase, "possible enemy air attack." In its place, we can substitute the phrase, "probable enemy air attack."

Japan came close to throwing a knockout punch in the first round of World War II as a result of the sneak attack on Pearl Harbor. We took a "nine count" and then came up off the floor to register a knockout in the late rounds.

Consider what would happen if an enemy air armada were to attack and wholly destroy or even partially destroy our key industrial, residential, communications and military targets. By destroying the major industrial center, production of essential war materials would cease or be reduced to a great extent. Without unlimited production of such materials, carrying on a major war is practically impossible.

By attacking our large cities, the enemy would be delivering a smashing blow to the morale of the citizens of this country, who keep telling themselves, "It can't happen here." By the time they woke up to the fact that it did happen here, nothing could be done about it.

With an attack on our military installations, what offensive punch we might have had will be reduced to a token defense. It would be comparable to the situation that resulted from the attack on Pearl Harbor. For a long time after the initial attack, we were on the defensive.

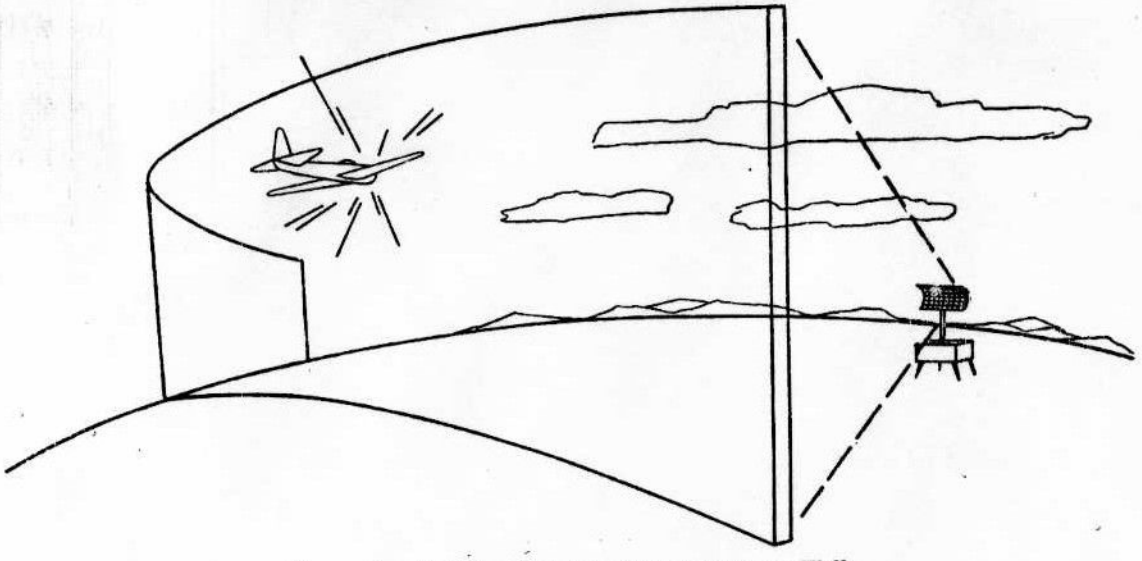

Figure 1. A Radar Net Acts Like a Defense Wall.

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It wasn't until our industries and citizens of this country got together and started mass production of essential war materials that we were able to start an offensive of our own.

Before we could carry the fight to the enemy, complete military mobilization was necessary. Our Army, which was very inadequate, had to be built up; the Navy had to have new ships and personnel to man them; and the Air Force, which was then a part of the Army, was an Air Force in name only. The number of planes we had was a mere handful compared to that of the aggressors. In addition to the delay necessary to mobilize the armed forces, time was needed to build up supplies and lines to carry the supplies where they were needed. Communication facilities had to be established to coordinate the activities necessary to carry out an all out offensive.

To prevent an attack by an enemy air armada, adequate air defense must be maintained. The air defense that is established must include any and all possible measures necessary to *prevent* an attack by enemy aircraft. If an attack cannot be prevented, then some course of action must be initiated to *interfere* with the attack. By interfering with an enemy air attack, we will be able to *reduce the effectiveness* of the attack.

COMPONENTS OF THE AC & W SYSTEM

Introduction

A basic feature of air defense is the Aircraft Control and Warning System. The AC & W System tries to prevent successful enemy air attacks by detecting, locating and tracking all air activity. The AC & W System also permits efficient control of fighter aircraft who employ counter-offensive measures designed to interfere with the attack. In addition, it also alerts other defensive forces such as the Anti-Aircraft Artillery, who in turn attempt to interfere with the air attack. The AC & W System *reduces the effectiveness* of the attack by issuing air raid warnings to civilian agencies. The air raid warnings set up defensive measures such as "blackouts" and evacuation to air raid shelters. Such defensive measures minimize damage and casualties.

You can readily see that the AC & W System plays a major part in the defense of our country. The AC & W System must supply the information on all enemy air activity. You, as a Radar Operator, are the one who will initiate any action within the AC & W System. It will be your duty to accurately detect, locate and track all air activity. If you slip up and fail to detect a hostile attack, the chain of events necessary to defend our country against enemy air attack will not take place because the first link of the chain was broken. The first link must be sturdy and dependable; it will be so, if you are alert and pick up all indications on your radar scope.

The AC & W System's responsibility for insuring proper defense is so great that the organization must be broken down into several major types of activity, each equipped to do a special type of job and each contributing to the overall mission of the AC & W System. The mission consists of three major responsibilities: to provide *air warning;* to provide *ground control* and to provide *navigational assistance.*

ADCC

The largest and most extensive of the units within the framework of the AC & W System is the Air Defense Control Center (ADCC). Essential information from many different radar stations concerning friendly aircraft and enemy air movements may be available at the ADCC. All such information is collected, evaluated and displayed as a basis for coordination and appropriate action by all defense forces, particularly fighter aircraft and anti-aircraft artillery. In accomplishing the above, the ADCC is *providing air warning*, the first phase of the overall mission.

GCI

Another component of the AC & W organization is the Ground Controlled Intercept (GCI) Station. The second and third phases of the

overall mission of the AC & W, that of *providing ground control* and *navigational assistance*, are accomplished by the GCI Station. To carry out these phases of the mission, it is necessary for the GCI Stations to maintain continuous *air surveillance*—to be continually on the alert for any and all activity. By maintaining continuous air surveillance, the GCI Stations will have a complete up-to-the-minute picture of all air activity. With such a picture available, friendly aircraft can be directed or "controlled" to intercept hostile planes. By using information obtained from the picture presented on the radar scopes, navigational aid can be given to any friendly plane requesting help.

EW

Another component, smaller in scope of operations, is the Early Warning (EW) Station. As the name suggests, it is the responsibility of these stations to give the earliest possible warning of approaching aircraft, whether it be friendly or hostile. In certain localities, the coverage of the Early Warning Stations can be extended by the use of airborne radar, picket ships, and ground observers. It is the purpose of these supplemental features to reach as close as possible to the enemy lines to enable our entire AC & W organization to initiate defensive measures at the earliest possible moment. By supplying such information, the EW Station, and its supplementary features are contributing to all three phases of the AC & W mission.

Summary

In the overall picture, the AC & W System operates as follows: The Early Warning Station will report any and all information obtained from its radar equipment or supplementary features (airborne radar, picket ships, ground observers) to the GCJ station or if the situation exists, directly to the ADCC.

The Ground Controlled Intercept Station will "scramble" fighters and initiate a controlled interception. It will also pass on the information to the ADCC.

The Air Defense Control Center will receive the information, verify the "scramble" and at the same time release information to civilian agencies for air raid alerts. It will also notify AAA of the route of both friendly and hostile aircraft. If there is a possibility of the hostile aircraft entering the area of responsibility of another GCI, that GCI will be notified of that fact. Reports sent in to the ADCC from the GCI Stations are supplemented by information obtained from civilian observer stations, allied countries and other branches of the armed forces.

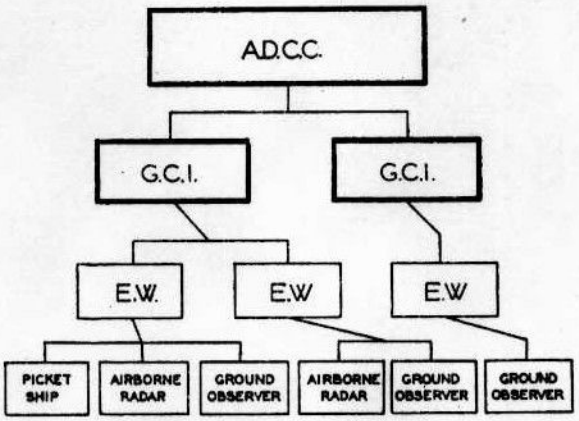

Figure 2. Block Diagram of the AC & W System.

GEOGRAPHIC SUBDIVISIONS

Introduction

In addition to having certain specialized breakdowns of type of activity and specially equipped and staffed organizations to accomplish these missions the problem of defending vast portions of continents and thousands of square miles of barren land or ocean presents itself. It has, therefore, been necessary to break down the continents and oceans into small divisions. When making up these small divisions, another factor must be considered.

Due to the fact that the combat radius of action of our fighter aircraft extends several hundred miles, our aircraft can be used best in the general defense of one certain locality rather than of any specific objectives such as munitions factories, aircraft industries, power

projects, etc. These localities are known as Geographical Subdivisions. These subdivisions with the AC & W components included can be seen in figure 3 below. Note the indications of the type of AC & W organizations assigned to each subdivision.

Territory

The largest subdivision is the *TERRITORY*. The organization of the Territory is influenced by many factors. How large should it be? What type of terrain will be included? What resources are available? What type of communications can be used? How densely is it populated? What military facilities are available? How much protection against air attack must be provided? All these questions must be considered. The Territory must be so organized to permit maximum flexibility and use of the defense agencies available. Note that the Territory is too large for any one component of the AC & W to be responsible. No single component of AC & W System can assume responsibility for coverage and operations of a subdivision as large as the Territory.

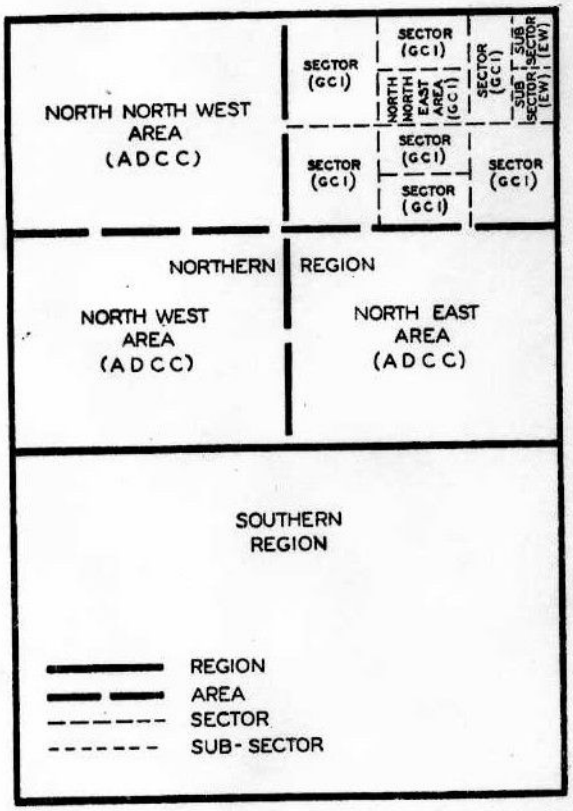

Figure 3. Geographic Subdivision of a Defended Territory.

Region

To insure closer supervision and control of all air defense agencies within a designated area of responsibility, the Territory can be divided into *REGIONS*. Degree of defense required, terrain, available communications, and the mobility of defense weapons—all these help determine the size of the Region. As in the Territory, no single component of the AC & W System can assume responsibility for the coverage and operations of a subdivision as large as the Region.

Area

The *AREA* then becomes the first division which is small enough to fall under the limited span of operational control of the air defense agencies. The tactical control unit of the Area is the Air Defense Control Center (ADCC). The type of terrain, degree of defense required, supervisory and control capabilities, the communications available and the mobility of defense weapons—all these factors help determine the size of the Area.

Sectors

Because of the limited range of radar equipment and control communications facilities, the area is broken down into *SECTORS*. By referring to the preceding page, it can be seen that the GCI station is the tactical control unit of the Sector. The size of the Sector is determined by the range and capabilities of the radar equipment used in the Sector.

Subsector

At times, the range and capabilities of the radar equipment make it necessary to divide the Sector into *SUB-SECTORS*. When such action becomes necessary, the Early Warning Station then takes over the responsibility of the Sub-Sector.

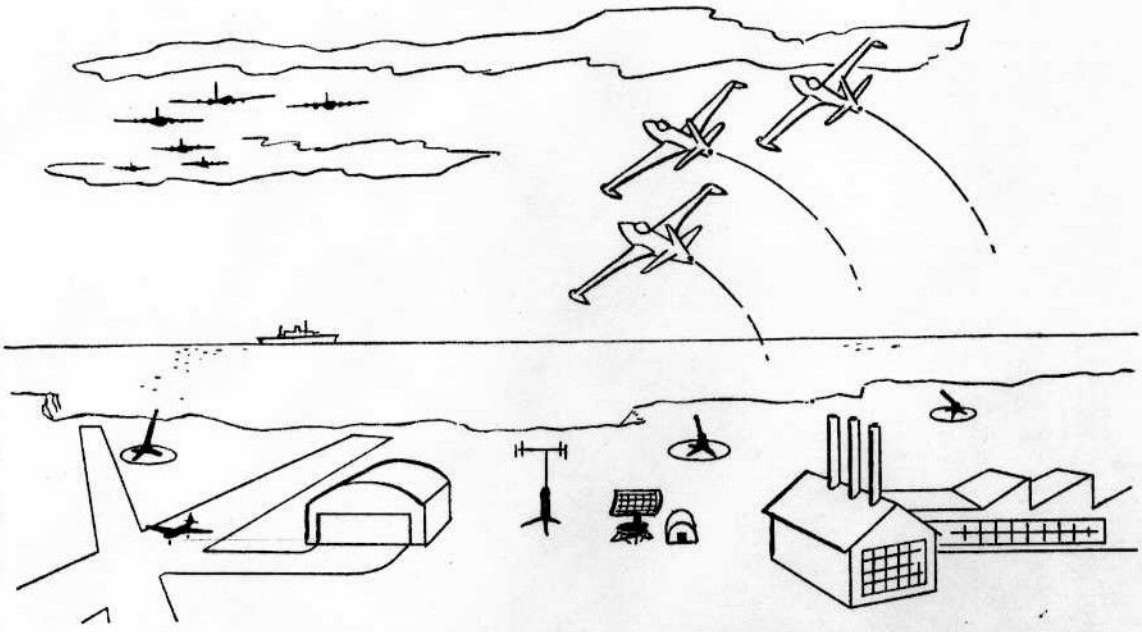

Figure 4. Aircraft Control and Warning in Action.

AIRCRAFT CONTROL AND WARNING ORGANIZATION OF A DEFENDED TERRITORY

Geographic area	Operating unit	Command and administrative control	Operational control	Tactical control
Defended Territory.	Air Defense Comd. Hq.	Territorial Air Command.	----------	Air Defense Command.
Region----------	Regional Air Defense.	Air Force----------	----------	Regional Air Defense Command.
Area----------	AC Sq----------	AC & W Group-----	ADCC (Tactical Deployment of defense forces as directed by Air Defense Division).	
Sector----------	AC & W Sq. Detachment AW Sq.	AC & W Sq., AW Sq.	GCI Station EW Station.	Air Defense Division.
Sub-Sector-----	AC & W Sq. Detachment.	AC & W Sq., AW Sq--	EW Station or Gap Filler Radar.	Air Defense Division.

ADCC—Air Defense & Control Center.
GCI—Ground Controlled Intercept.
EW—Early Warning.
AC & W Gp.—Aircraft Control & Warning Group.
ACS—Aircraft Control Squadron.
AC & W Sq.—Aircraft Control & Warning Squadron.
AW Sq.—Aircraft Warning Squadron.

SUMMARY

By referring to the illustration below, we can see how the components of the AC&W fit into the geographic subdivisions.

A flight of aircraft is picked up by the picket ship and reported to the EW Station located in the sub-sector. The aircraft have been identified as hostile. The report is immediately sent forward to the GCI station which is responsible for the sector. Located in the Area illustrated is an atom bomb factory. Realizing that the atom bomb factory is a potential target, the GCI will "scramble" the necessary fighters at the fighter strip and at the same time will report the approach of enemy aircraft to

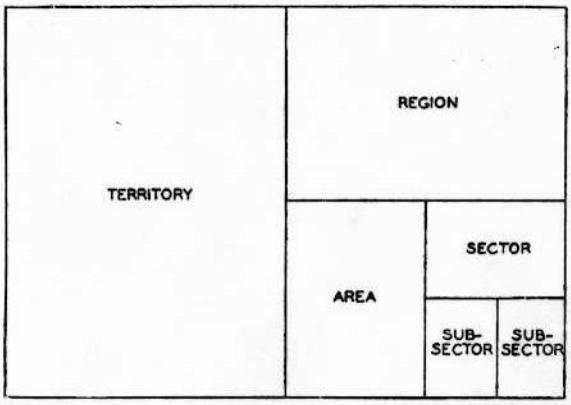

Figure 5.

the ADCC. The ADCC will then notify the AAA, and the civilian agencies. The AAA batteries will be on the alert for any aircraft that may not be intercepted, while the civilian agencies will initiate precautionary measures at the atom bomb factory. In the meantime, the GCI station is directing its fighters to a point of interception. Visual contact by the fighters is made and the enemy aircraft are shot down, completing the mission of the AC & W and saving the atom bomb from possible destruction.

Realize that the situation just described is a mock set-up, but also realize that the possibility of a similar situation occurring is not remote. You, as a radar operator, will play a major role in any operation that may occur. Suppose the radar operator in the illustration presented had lost contact with the enemy or reported wrong information as to range and azimuth. It doesn't take much thought to figure out how the ending of the story would have changed. The enemy would not have been intercepted and the atom bomb factory would have been destroyed. The importance of your job in the AC & W System cannot be emphasized too much.

QUESTIONS

1. What part does the AC & W System play in air defense?
2. What is the mission of the AC & W System?
3. Name the component parts of the AC & W System.
4. What component is the heart of the AC & W System?
5. Name the chain of command in the AC & W System, starting with the EW Station.
6. From what installation in the AC & W System are interceptions directed?
7. What is the largest of the geographic subdivisions?
8. Why do they have more than one geographic breakdown?
9. Which geographic breakdown would include an EW Station?
10. What factors determine the size of an area?
11. How many of the AC & W components would be found in a territory?
12. What AC & W component would be found in an area?
13. Draw a simple block diagram of the Geographic Sub-divisions.
14. In the block diagram of question 13, fill in the appropriate AC & W components.
15. What is the approximate size of a region?

AC & W COMMUNICATIONS

Scope: Communications Systems and channels used in various AC & W operations and techniques of R/T procedure.

Student Objective: To become familiar with channels and methods of communication in AC & W operation and learn R/T procedures and prowords.

INTRODUCTION

The function of Aircraft Control and Warning is to detect, and by radar means, bring our fighters into the interception of hostile aircraft. In many instances, units of an AC & W group are very widely scattered, therefore it is necessary to have some means of relaying information from one unit to another. This network of relaying vital target and intercept information from place to place is known as a *communications net.*

The communications net of any AC & W system consists of the entire communications hookup. Within this net will be different channels which will now be explained.

COMMAND CHANNELS

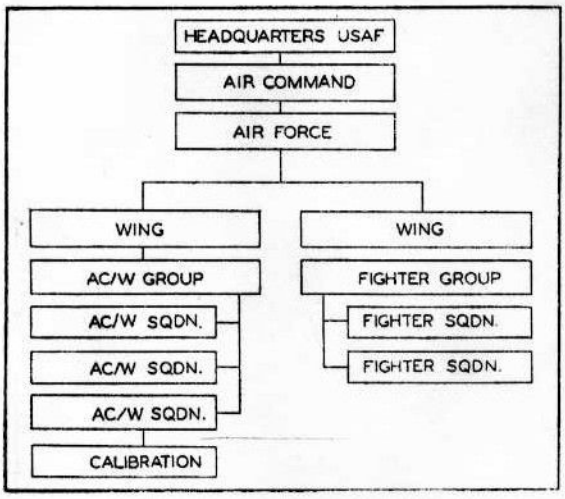

Figure 1. Command Channels.

The commander of any AC & W unit must have communications with his subordinates. He has to pass on orders, receive information as to outcome of air activities, relay instructions and pass on all administrative information.

The normal command channels of communications are from Headquarters USAF, through Air Commonds, Air Forces, Wings, AC & W Groups, down to AC & W Squadrons. In the event an AC & W group is placed under an Air Force, the channel will be direct from Air Force to the AC & W Group.

MOVEMENTS AND IDENTIFICATION CHANNELS

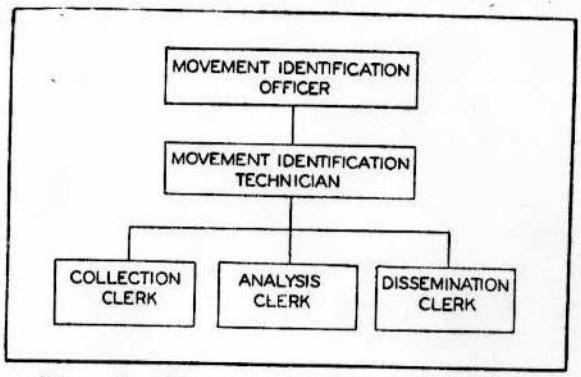

Figure 2. Movement Identification Channels.

Information on all friendly air movements must be secured well in advance, from military, as well as civil flight clearing agencies. This information must be disseminated to all operation units in an area and between adjacent areas.

CONTROL CHANNELS

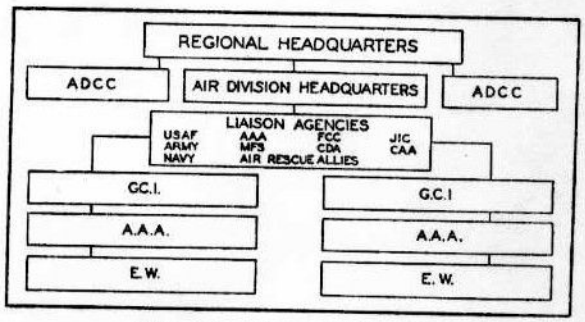

Figure 3. Control Channels.

Control Channels of communication must provide facilities for coordination of all Air Defense agencies within an area, as well as for tactical control of all friendly aircraft.

LIAISON CHANNELS

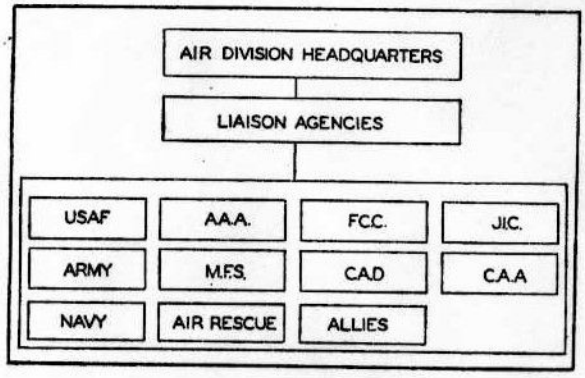

Figure 4. Liaison Channels.

In order to have complete coordination and full striking power in any area, liaison agencies must be included in the channels of communication. Such agencies would include Army, Navy, AAA, and Civil Defense Agencies.

TYPES OF COMMUNICATIONS

An AC & W communications system is perhaps one of the most complicated and varied that will be found anywhere. It has to be so designed that alternate means are available at all times regardless of the situation. In other words, if you were suddenly cut off, you would

have to switch to another type of communications in order to successfully carry out your mission and get the required information through. Because of this you will find that all communication will be divided into two main categories, *Primary* and *Secondary*.

PRIMARY COMMUNICATIONS (WIRE)

Wire communications, within a control or GCI center or between units of an AC & W group, are the simplest and most effective form of electrical communications. They are usually designated to be the *Primary* type used, because commercial facilities are generally available making installation unnecessary. The principal advantages of wire communications are its ability to provide *rapid*, *reliable* and *secure* communications. Wire communications can again be subdivided into three main types, telephone, teletype and facsimile.

Telephone communications is advantageous because of its ability to provide rapid, reliable and relatively secure voice communications. *Teletype* is used because of its automatic unattended reception, narrow channel requirements, and permanent record of the messages which is provided. *Facsimile* type of communications is used for transmitting maps and overlays over wire. This is accomplished by a mechanism somewhat like a dictaphone in appearance. The map to be transmitted is placed on a round cylinder which revolves at a certain speed. A small arm with a photo-electric cell attachment moves over this picture and records the light and dark portions of the map, transmitting them to a receiving unit. The receiving unit picks up the light and dark tones and places them by a similar process on a blank sheet of paper. This provides speedy and accurate duplications of material over long distances. Thus, we can readily understand the need and overall advantage of having wire as the primary method of transferring information within the AC & W system.

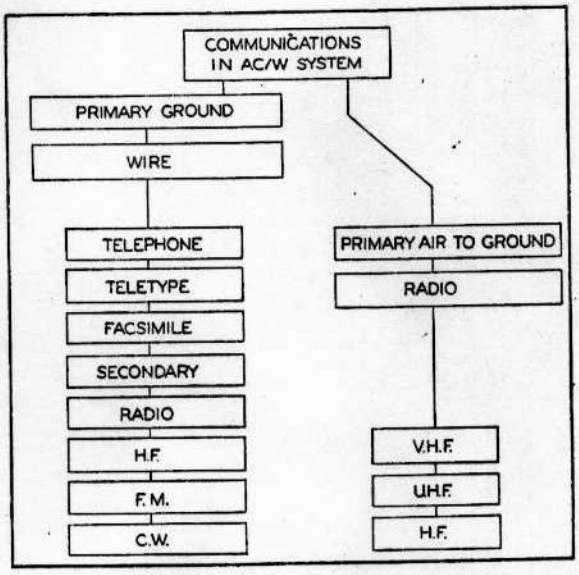

Figure 5. AC & W Communications Block Diagram.

SECONDARY COMMUNICATIONS

Radio, in all its different forms, is used in AC & W work to back up and supplement Wire, the Primary type of communicaitons. It is used as a secondary type mainly because it is not as secure as Wire communications. However, this may be improved somewhat by the use of a directional antenna which beams the energy in a certain direction, thus minimizing interception by the enemy.

Radio communications, as used in AC & W, can be divided into two main categories, air to ground and ground to ground stations.

Air to Ground Communications

In order for controllers at GCI Stations to give directions or vectors to fighter aircraft, a certain type of radio set is used. The most common air to ground TYPE is called VHF Radio (Very High Frequency). This set is carried by all military aircraft and some of the types are the 4 channel SCR–522, or the 8 channel ARC–3. The ground sets usually used in conjunction with these will be the BC–640 transmitter, and the BC–639 receiver. It will usually operate between 100 and 156 megacycles,

is static free, but limited to line of sight transmission. Therefore, the higher the aircraft is flying, the longer the station will be able to contact it. (Much the same as the beam or lobe of a Radar station.) A typical assignation of

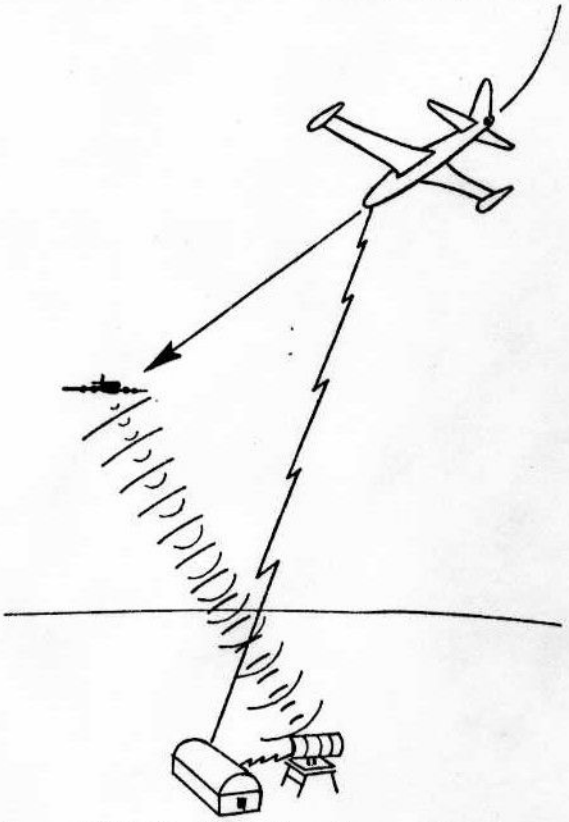

Figure 6. VHF Directs Interceptions.

frequencies assigned to a VHF radio would be something like this:

Channel	*Operational use*
A	CAA.
B	Tower.
C	Military Airways.
D	Emergency.
E	Fighter Intercom.
F	GCI, Primary, Homer.
G	Fighter Bomber Liaison.
H	GCI Secondary.

HF Radio

As mentioned in the preceding paragraph VHF Radio is limited to line of sight transmission. Thus, its range would depend upon the surrounding terrain as well as the height of the aircraft. In order for aircraft to contact stations on long range, a different type of equipment is used. This type is known as HF or High Frequency Radio. It is not carried in most fighters due to the bulkiness of equipment, therefore, only transports and Bombers will use it. Unlike VHF, it is not line of sight transmission. The energy here is transmitted out, strikes the ionosphere and is reflected back to the earth. In this manner HF has been known to travel completely around the earth's surface. However, the usual range is around 1000 miles. It operates from 1500 kc to 18 mc. Two typical HF transmitters would be the BC-610 and 191, two receivers would be BC-639-34.

VHF/DF Radio

Another form of air to ground Radio would be the VHF/DF Radio. This is a VHF set, limited to line of sight, and is used for *direction finding purposes.* If an aircraft is in distress or lost, he will transmit a signal from a clock in the aircraft, this signal is picked up by the ground station and by locating the loudest portion of the signal, the direction of the aircraft is determined and a homing is given to bring it to the nearest airfield. Another use of VHF/DF is to give an aircraft a fix. A fix is defined as: the actual location of an aircraft over the surface of the earth. This is accomplished by what is known as a D/F net. This consists of either two or more D/F stations. When the aircraft calls in that he wishes a fix to determine his exact position, he is told to transmit something from the aircraft. This could consist of the tone, as used in getting a steer, or even humming over the VHF Radio. By the same method, which is finding the direction from which the strongest tone is coming from, all these stations determine this direction. Then by comparing the lines drawn from the direction of the aircraft, to each station, a triangle is formed and at the point where the lines cross the aircraft can be located.

You have now been told about the most common types of air to ground communications. Some of these types are also used in ground to ground nets which were mentioned earlier and will now be explained more fully.

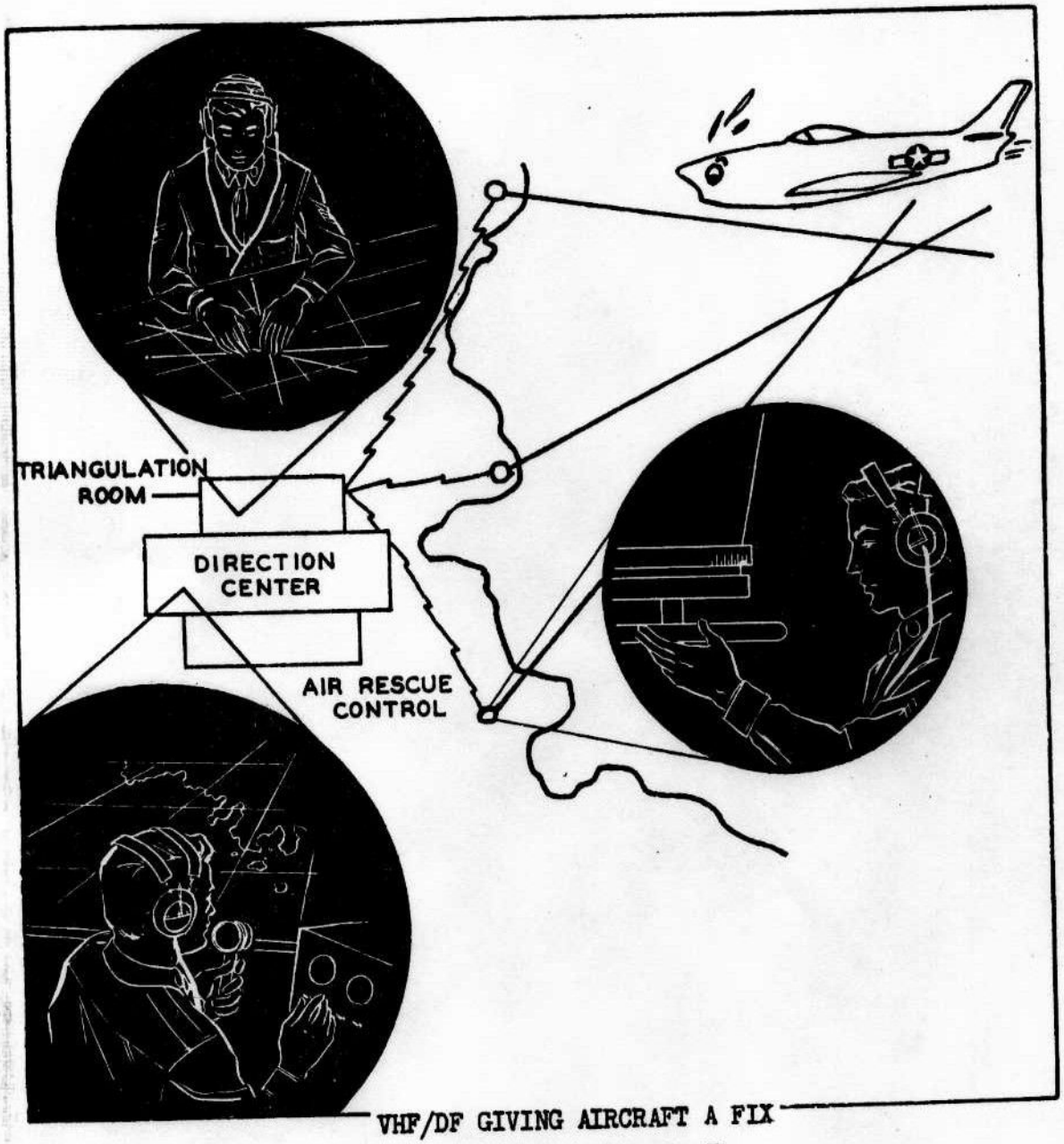

Figure 7. VHF/DF Giving Aircraft a Fix.

Ground Radio Communications

As a secondary means of transmitting target information from station to station Ground radio units are used. They are usually of the directional type which is a better method of controlling security.

The most common types of Ground Equipment will be Frequency Modulated, High Frequency and Low Frequency.

FM (or Frequency Modulated) Radio

Because of the band width of FM transmission, signals have to be transmitted over VHF or HF carrier frequencies. This has certain advantages in that these frequencies are static free, less subject to enemy interception, and can be beamed in a given direction. The disadvantage of using these frequencies is that their range is limited to line of sight transmis-

sion. Relay stations are needed about every 50 miles, depending on surrounding terrain, for long distance transmission.

HF and LF Radio

High Frequency and Low Frequency radio used in Ground to Ground stations are the same as the types used in air to Ground. They are reflected off the ionosphere and can travel great distances. Their main disadvantage is the skip distance between times it is reflected off the earth.

TYPES OF COMMUNICATIONS LINES

In the preceding paragraphs you have been introduced to the communications used within an AC & W System. Within this breakdown you will also have different types of communication lines, depending upon what the particular line is used for. The three main types will usually be Point to Point, Ring Talk, and Hot Line.

Point to Point Communications

A Point to Point hook-up will usually be the type as used in any large city. You will first contact a switchboard, and then the message is directed to a certain line leading to the receiving point you wish to contact.

Ring Talk Communications

This type of line will be direct to the receiving part but you, yourself, will do the ringing. This type can be compared to two EE–8's connected. You ring the line and the receiving party answers.

Hot Line

A hot line will usually connect two points with very high priority. It requires no ringing or passage through a switchboard. You lift the phone and talk and a monitor hears you and will answer. This type is usually found on a *scramble line*, or other line with a high priority where time delay is very detrimental.

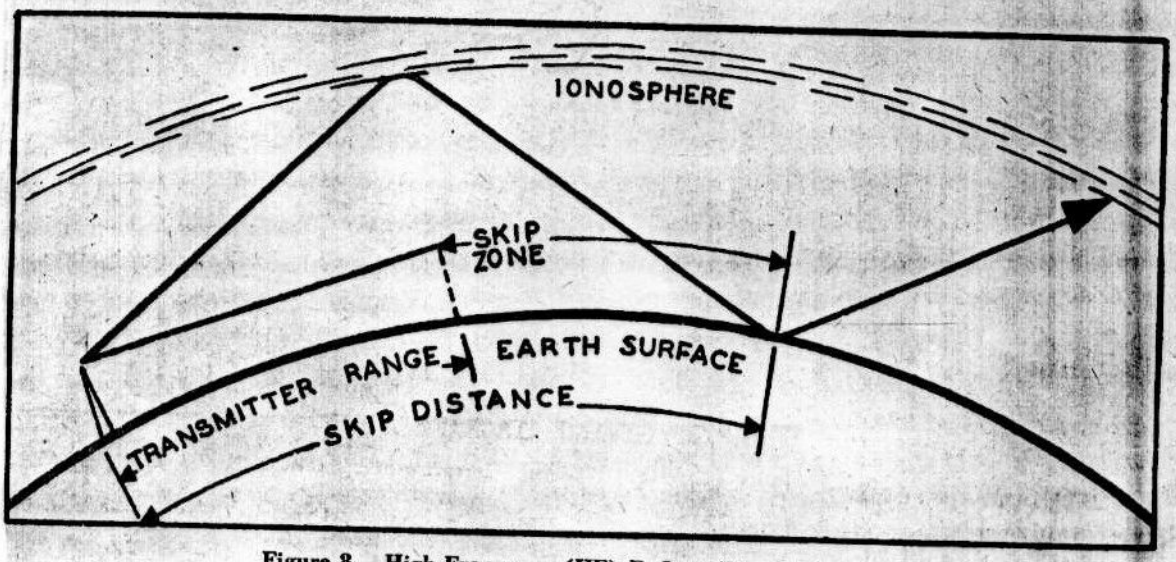

Figure 8. High Frequency (HF) Reflects From Ionosphere.

RADIOTELEPHONE PROCEDURES

Introduction

Radiotelephone code is a language designed for efficient communication by voice radio, especially in the use of voice radio in air-ground and air to air contact. Like other living languages, it is constantly changing to fit new terms and conditions, and the linguist must acquire and maintain a broad vocabulary to

speak it fluently. Although the dictionary of Radiotelephone code words and phrases is extremely short, the fact that there are few synonyms makes it imperative that the user learn it in its entirety.

R/T code was developed to meet two requirements: the basic need for a medium of exchange for information and ideas in any group activity, and second, the necessity of such medium being concise, clear and universally understood by its users. The latter requirement has been fulfilled by the adoption of a common dictionary by all branches of the military and naval establishments—Operational Brevity Codes ACP 165.

Adapting the Voice to Radiotelephone

The following characteristics are the fundamentals of good speech in any language, but their application to Radiotelephone speech is made more pointed by the limitations of radio equipment.

a. Rate, the number of words per minute, or per second.

b. Placement or Pitch, the frequency of the voice.

c. Intensity, vocal power.

d. Rhythm, the difference in time between words and phrases.

As mentioned above, Radiotelephone imposes a need for better speech because of imperfections inherent in radio equipment, especially of the type used in aircraft. These shortcomings may be partially compensated by study and application of the above mechanics. However, more is demanded than mechanical perfection. Confidence, continuity, and conciseness, while more difficult to acquire, are also attributes of good Radiotelephone speech.

Component Parts of a Radiotelephone Message

A radiotelephone message consists of three components, a "call sign", "text" and "ending".

a. The "call sign" is the code word or number (in case of aircraft) by which stations are identified. It is usually preceded by the word "hello" and followed by the "call sign" of the originating station. Example: "Hello *Walter Control*, this is *Air Force 8345*, how do you read, over". (The over designates end of transmission and signifies station being called, to answer).

b. The "text" is the body or subject matter of the message. The "text" may include instructions, information, requests or inquiries. Since the other two components of a radiotelephone message vary little or slightly, it is important that the text is most important. It should be spoken as clear, yet in as few words as possible. In the case of the example in paragraph A, the words, "How do you read" is the body or "text."

c. The "ending" like the call is a means of controlling a conversation in which the participants are far removed from each other. All transmissions will end with the words "over" or "out."

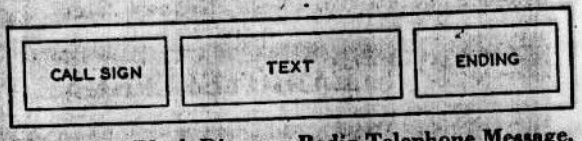

Figure 9. Block Diagram Radio Telephone Message.

Basic Types of Radiotelephone Messages

a. Initial Contact—The first transmission and the response. In the initial contact the words "This is," and the transmitter's identification is always used. As a general rule, it may be said that no commands are given, no information sought, or given, in the initial contact message. It is customary in replying to the initial contact to tell the transmitter how he is being received.

b. Subsequent Messages—All subsequent messages are divided into three groups: Command, Information and Emergency.

Phrasing of Radiotelephone Messages

While the entire dictionary of radiotelephone code has been compiled to limit transmission time, and to insure clarity by the use of familiar words and phrases, the sequence of words and phrases is as important as it is in everyday conversation.

Unity of thought is of paramount importance.

The necessity for pre-planning a message should be apparent. Time wasted by a misunderstood message may be easily saved by com-

posing the entire message in good form before transmitting.

Transmission Errors to be Avoided

It is seldom advisable to interrupt a radiotelephone conversation. This practice generally results in neither message being received and additional time is wasted because closing the transmission key automatically cuts off the receiver.

Mumbling—speaking indistinctly or unintelligently—is perhaps the most frequent of transmission errors, as well as the easiest to overcome. Conscious effort toward clarity is all that is necessary.

GENERAL INSTRUCTIONS

Words or phrases as given herein are for purposes of standardization and abbreviation. They have no security. If necessary for purposes of clarity or reliability, the use of the complete phrase under "Meaning" is authorized. The use of self-evident plain language is authorized wherever there can be no confusion, e. g., North, Close, Request, etc.

In most cases, the brevity code words are listed only in the Section wherein they will have primary usage. Certain words or phrases, however, have application to several or all of the individual codes, and therefore the use of the word or phrase is authorized with any code regardless of its specific listings.

RADIOTELEPHONE PROCEDURE PROWORDS

Voice	*Meaning*
ACKNOWLEDGE	Let me know that you have received and understood this message. (This is not a proword and can only be used on the authority of the originator of the message; acknowledgments thereto are only originated by the addressee to whom the request for acknowledgment was made.)
ACTION	The addressees whose designations immediately follow are to take action on this message.
AFFIRMATIVE	Yes. Permission granted. (This is not a proword.)
ALL AFTER	The portion of the message to which I have reference is all that which follows _____.
ALL BEFORE	The portion of the message to which I have reference is all that which precedes _____.
BREAK	I hereby indicate the separation of the text from other portions of the message.
CORRECTION	An error has been made in this transmission. Transmission will continue with the last word correctly transmitted. An error has been made in this transmission (or message indicated). The correct version is _____. That which follows is a corrected version in answer to your request for verification.
DISREGARD THIS TRANSMISSION.	This transmission is in error. Disregard it. (This proword shall not be used to cancel any message that has been completely transmitted and for which receipt and/or acknowledgment has been received.)

Voice	*Meaning*
DO NOT ANSWER	Stations called are not to answer this call, receipt for this message, or otherwise to transmit in connection with this transmission. (When this proword is employed, the transmission shall be ended with the proword OUT.)
EXECUTE	Carry out the purport of the message or signal to which this applies. (Used with executive method only.)
EXECUTE TO FOLLOW	Action on the message or signal which follows is to be carried out upon receipt of the proword EXECUTE. (Used with executive method only.)
EXEMPT	The addressee designations immediately following are exempted from the collective call.
FIGURES	Numerals or numbers follow.
GROUPS	This message contains the number of groups indicated by the numeral following.
INFO	The addressee designations immediately following are addressed for information.
I READ BACK	The following is my response to your instructions to read back.
I SAY AGAIN	I am repeating transmission or portion indicated.
I SPELL	I shall spell the next word phonetically.
I VERIFY	That which follows has been verified at your request and is repeated. (To be used only as a reply to VERIFY.)
MESSAGE FOLLOWS	A message which requires recording is about to follow. (Transmitted immediately after the call.)
NEGATIVE	Not received. No. (This is not a proword.)
NUMBER	Station Serial Number.
ORIGINATOR	The originator of this message is indicated by the address designation immediately following.
OUT	This is the end of my transmission to you and no answer is required or expected.
OVER	This is the end of my transmission to you and a response is necessary. Go ahead: transmit.
READ BACK	Repeat this entire transmission back to me exactly as received.
RELAY TO	Transmit this message to all addressees or to the address designations immediately following.
ROGER	I have received your last transmission satisfactorily.
SAY AGAIN	Repeat all of your last transmission. (Followed by identification data means: Repeat _____ (portion indicated).)
SILENCE	Cease transmissions immediately. Silence will be maintained until instructed to resume.
SILENCE LIFTED	Silence on this net has been lifted. (When an authentication system is in force, all transmissions lifting silence shall be authenticated. Silence can be lifted only by the station imposing it or higher authority.)

Voice	*Meaning*
SPEAK SLOWER	Your transmission is at too fast a speed. Reduce speed of transmission.
THAT IS CORRECT	You are correct. What you have transmitted is correct.
THIS IS	This transmission is from the station whose designation immediately follows.
TIME	That which immediately follows is the time or date-time group of this message.
UNKNOWN STATION	The identity of the station with whom I am attempting to establish communications is unknown.
VERIFY	Verify entire message (or portion indicated) with the originator and send corrected version. (To be used only at the discretion of or by the addressee to whom the questioned message is directed.)
WAIT	I must pause for a few seconds.
WAIT OUT	I must pause longer than a few seconds.
WILCO	I have received your message, understand it, and will comply. (To be used only by the addressee. Since the meaning of ROGER is included in that of WILCO, the two prowords are never used together.)
WORD AFTER	The word of the message to which I have reference is that which follows _____.
WORD BEFORE	The word of the message to which I have reference is that which precedes _____.
WORDS TWICE	Communication is difficult. Transmit(ting) each phrase (or each code group) twice. (This proword may be used as an order. request or as information.)
WRONG	What you have just said is incorrect. Correct version is _____

SURVEILLANCE, WARNING AND REPORTING

Voice	*Meaning*
ALTITUDE	Altitude of aircraft, *in feet.*
ANY FACE	AEW Aircraft.
BANDIT	Aircraft identified as enemy.
BENT	Equipment indicated inoperative or unserviceable.
BOGEY	Unidentified aircraft (implies: Investigate with caution—may be friendly).
BOWWAVE	Long form weather report giving:
	B—*Below* or *base* of cloud in thousands of feet. If below one thousand feet use hundreds of feet but add the word "hundred".

Voice	*Meaning*
BOWWAVE—Continued	O—*Over* or *top* of cloud level in thousands of feet. If unknown use the work UNKNOWN. NOTE: If there is more than one cloud layer, report the Base and Top of the lower formation, followed by the Base and Top of the progressively higher layers (e. g., "two, twelve, seventeen, twenty-five").
	W—*Wind* (8 points, N, NE, E, SE, S, SW, W, NW) plus the velocity in knots. When wind is missing; omit or use the word UNKNOWN.
	W—*Weather*—General description of weather in plain language such as clear, partly cloudy, cloudy, overcast, light, moderate or heavy rain, mist, haze, thunderstorm, and distant lightning. Amplication of the weather should be made at the end of the report under "E".
	A—*Amount* of clouds, in tenths.
	V—*Visibility* in miles. Use a fraction if less than one mile.
	E—*Extra* phenomena of significance such as turbulence, icing, heavy sea or swell, and description of front. This is an elaboration of the report which includes anything of interest in plain and concise language.
BOXCAR	Heavy/very heavy bomber aircraft.
CAPREP	A report made by the air control ship/station composition, height, and patrol position of the CAP.
CEASE REPORTING	Cease reporting the Track/Raid designated.
CHECK CONTACT	Check the designated contact for purpose of identification.
CHICKENS	Friendly fighter aircraft.
CLARA	Radar scope is clear of contacts other than those known to be friendly.
CLIMBING	Aircraft gaining height.
CLOUD	Cloud or other atmospheric echo on radar scope.
CLOSING	Range appreciably decreasing.
COCKEREL	IFF Mark III (cockerel CROWS and is "heard" not "seen").
CONFUSED	Intense activity, individual tracks not identifiable.
CONFIRM	Verify existence of designated raid or track.
CONTACT	I have an indication on my radar. (See CONTACT, Section 6.)
CONTACT LOST	The indication on my radar has faded.
CRAMBO	No contact on voice radio.
CROSSING	Passing (from ------ to ------) but not appreciably changing range.
CROW(ING)	Show(ing) IFF Mark III, (CROW(ING) is "heard" not "seen").
CROW(ING) ONE TO CROW(ING) SIX.	Show(ing) IFF Mark III, with code 1 to 6.
CROW(ING) MAYDAY	Show(ing) IFF Mark III, emergency code.

246766°—53——4

Voice	*Meaning*
DIVING	Aircraft losing height.
EAGLES	Medium bomber aircraft.
ESTIMATE	Provide a quick estimate of the altitude and size of designated contact.
FADED	Contact has disappeared from reporting station radar.
FEW	Two to ten aircraft.
FISHES	Torpedo aircraft.
FRIENDLY	Friendly aircraft or ship.
HAWKS	Dive bomber aircraft.
HIGH	Between 25,000 and 40,000 feet.
INTERFERENCE	Plot or altitude not reliable due to interference.
INTERROGATE	Interrogate the Raid/Track indicated.
JET	Jet propelled aircraft. (May be used as prefix to further explain any standard term, e. g., "jet bogey", "jet rats", etc.).
LOW	Between 2,000 and 10,000 feet.
MANY	Eleven or more aircraft.
MAYDAY	Distress call.
MEDIUM	Between 10,000 and 25,000 feet.
MERGED	Contacts/plots have come together.
MISSILE	Guided Missile including pilotless aircraft.
MIX-UP	Mixture of friendly and hostile aircraft.
MONSTERS	Cargo/transport aircraft.
MUGS	External Fuel Tanks.
NEGAT	Cancel, cease.
NOT RELIABLE	Plot or altitude not reliable.
OPENING	Range appreciably increasing.
ORBITING	Circling and searching.
PHONEY	Decoy target.
RACKET	Intercepted unidentified or enemy electronic emission.
RAID	Unidentified or enemy contact/track. (Air designated by numerals surface by letters.)
RATS	Fighter aircraft identified as enemy.
RECOMMEND	Recommend ---------- as best qualified station to pick up contact.
RELIABLE	Plot or altitude reliable.
REPORT	Pass frequent reports on the track/raid designated.
SCAN	Search ---------- to ---------- and report any contact.
SCRUB	Erase the track/raid indicated from all plots.
SHADS	Shadower aircraft.

Voice	*Meaning*
SHINING	Radar is transmitting (specify type if necessary).
SIGHTED	Track/raid indicated in sight.
SINGLE	One object.
SITREP	Situation report.
SKUNK	Enemy or unidentified ship or surface craft.
SNOOPERS	Low shadower aircraft (aircraft below 2,000 ft).
SPLITTING	Contact is dividing.
SWEEP	Keep all around search and report any new contacts.
TAKE	Take over and intercept raid/track designated.
TOO NEAR	Contact has entered scope clutter.
TRACK	A series of related contacts displayed on a plotting board.
TRACTORS	Towing aircraft.
UNKNOWN	Information not available. (Not used to mean unidentified target.)
VERY HIGH	Above 40,000 feet.
VERY LOW	Below 2,000 feet.
VISUAL	Visual contact.
WATCH	Continue to sweep as directed and concentrate on the track/raid designated, but do not report unless there is a material change in this track/raid.
WEATHER	Short form weather report, giving: V—*Visibility* in miles. A—*Amount* of clouds, in tenths. T—Height of cloud *top*, in thousands of feet. B—Height of cloud *base*, in thousands of feet. (The reply is a series of four numbers preceded by the word WEATHER. An unknown item is reported as "zero".)
WINDMILLS	Helicopter aircraft.

AIRCRAFT CONTROL

Voice	*Meaning*
ALOFT	I have reached my maximum operational altitude.
ALTITUDE	Altitude of aircraft, *in feet.*
AMMO MINUS	Have less than half of ammunition left (Caliber may be specified.)
AMMO PLUS	Have more than half of ammunition left (Caliber may be specified).
AMMO ZERO	Have no ammunition left (Caliber may be specified).
ANCHORED	Am orbiting a visible orbit point.
ANGELS	Altitude in thousands of feet.
AT ANGELS	Am at and holding ANGELS ordered.