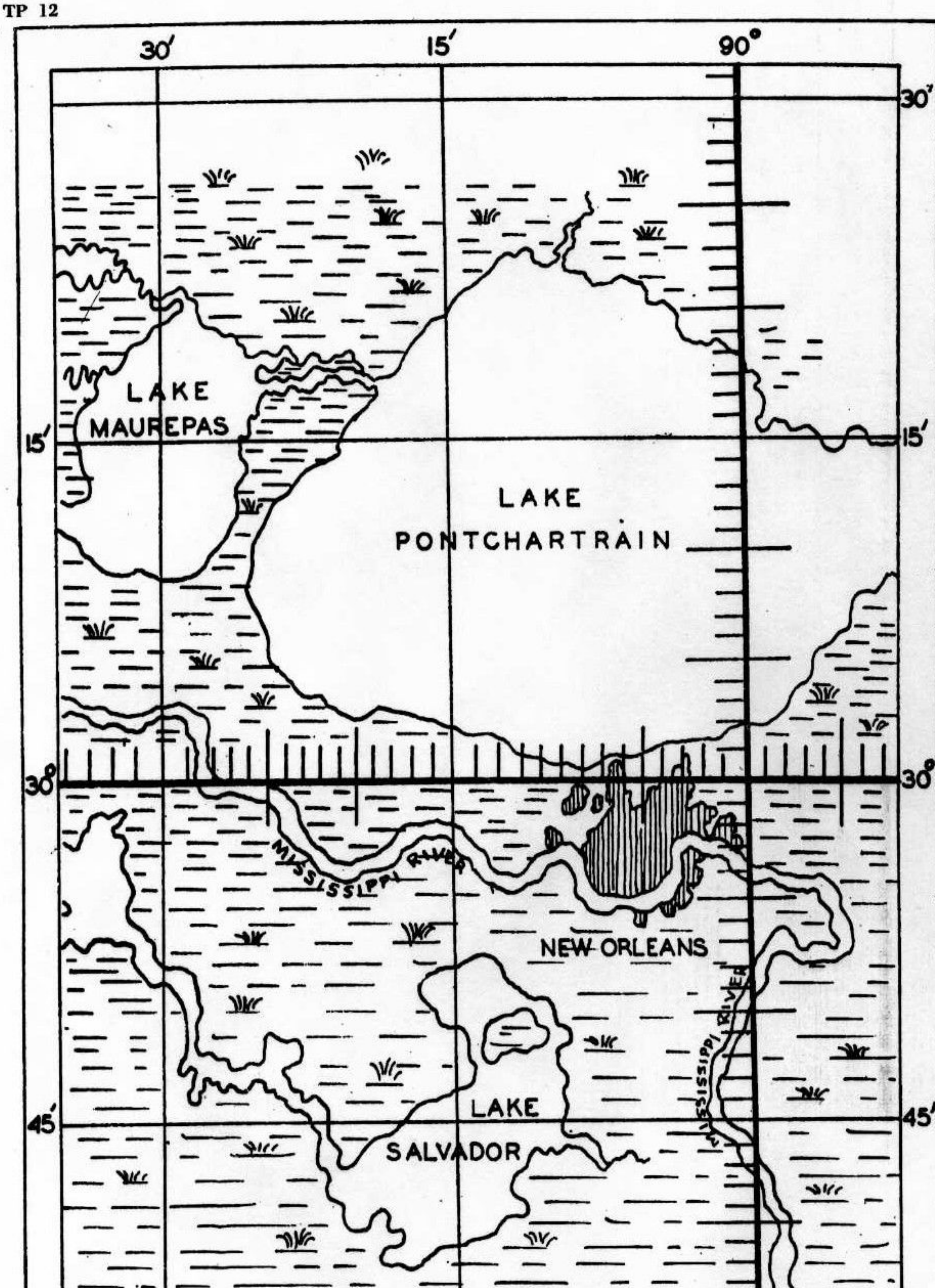

30'
15'
90°
30'
15'
30°
45'
LAKE
MAUREPAS
LAKE
PONTCHARTRAIN
MISSISSIPPI RIVER
NEW ORLEANS
MISSISSIPPI RIVER
LAKE
SALVADOR
15
SCALE 1" = 500000"
90°

Figure 2.

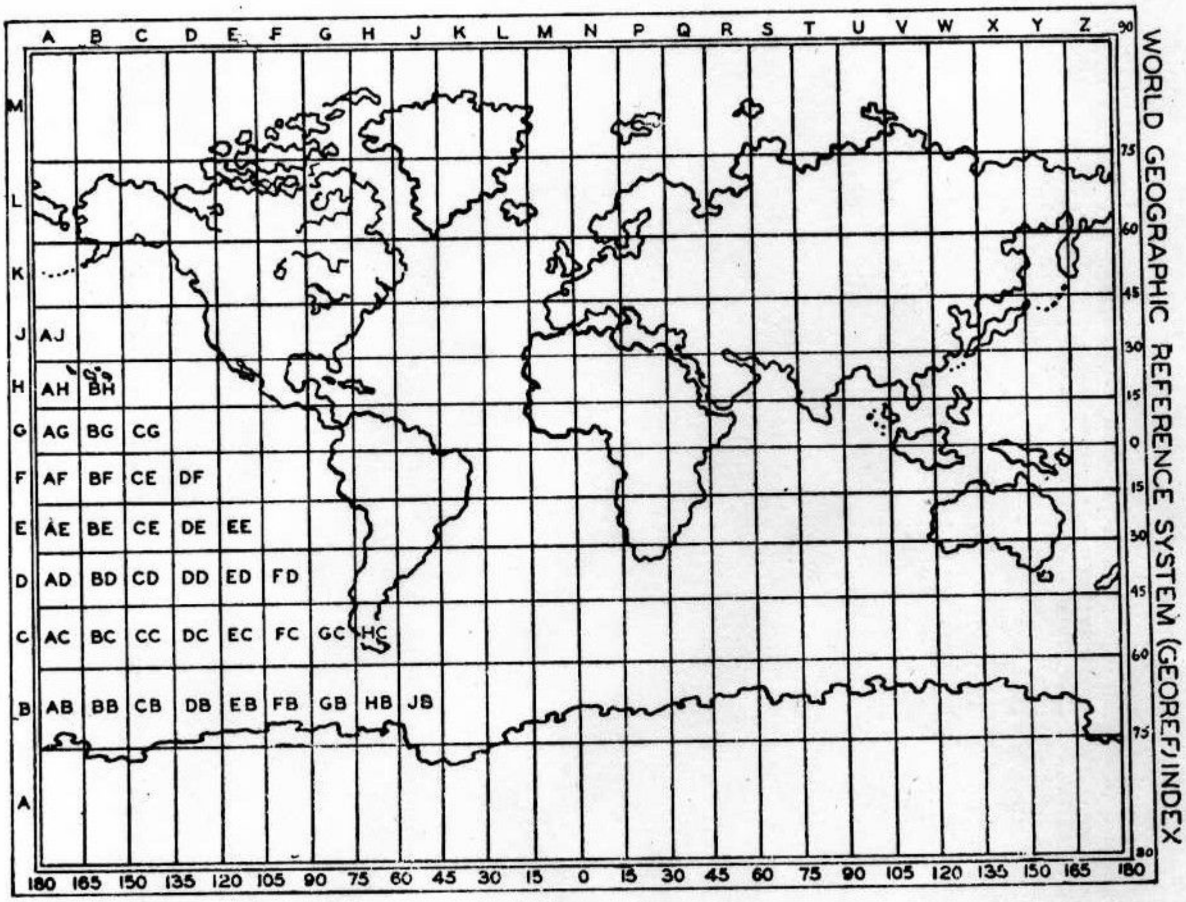


Figure 3.

Meridian and at the South Pole will be known as AA. The block to the right of this one will be called BA. etc., until you have designated by references, each block on the surface of the earth. In other words, all 288 blocks will be designated with different Grid References.

This completes the first and only major breakdown that we have in the "GEOREF" GRID. But as you can see, additional subdivisions are necessary in order to accurately pinpoint targets. The first breakdown covers too large a territory (900 miles per square) for AC&W purposes. So let us take the square or block in which Keesler Field is located and subdivide it for our own purposes.

FIRST SUBDIVISION

By looking at the world breakdown above, we discover that Keesler will fall in the GJ block. So we pull this block out, blow it up to a workable size and we are ready to start.

As we mentioned before, each block will consist of 15° on a side. Therefore, by extending the lines from each degree marker across the block we divide this block into 225 smaller blocks consisting of 01° on a side. Letters are again inserted between each degree marker starting with A through Q omitting I and O. By the same method as used in the first breakdown we can identify each small block by two letters. In other words, the lower left hand square will be AA etc. However, four references will have to be used because AA in the first subdivision could identify any of the AA blocks in any block of the major breakdowns. Therefore, it will take four grid references to properly identify it as belonging to GJ. The correct reading will then be GJAA.

By looking at this block when it is completely lettered in, we find that by Latitude and Longitude Keesler Field is now in the BA square of the GJ block. See illustration below.

SECOND SUBDIVISION

Now we have the portion of the world we are breaking down located by degrees. However, this is still not sufficient for accurate pinpointing of targets. So again we pull out the BA square which is one degree on a side and divide it into minutes. This will give us 60 minutes on a side and enable us to locate an aircraft, or target, within one nautical mile, simply by in-

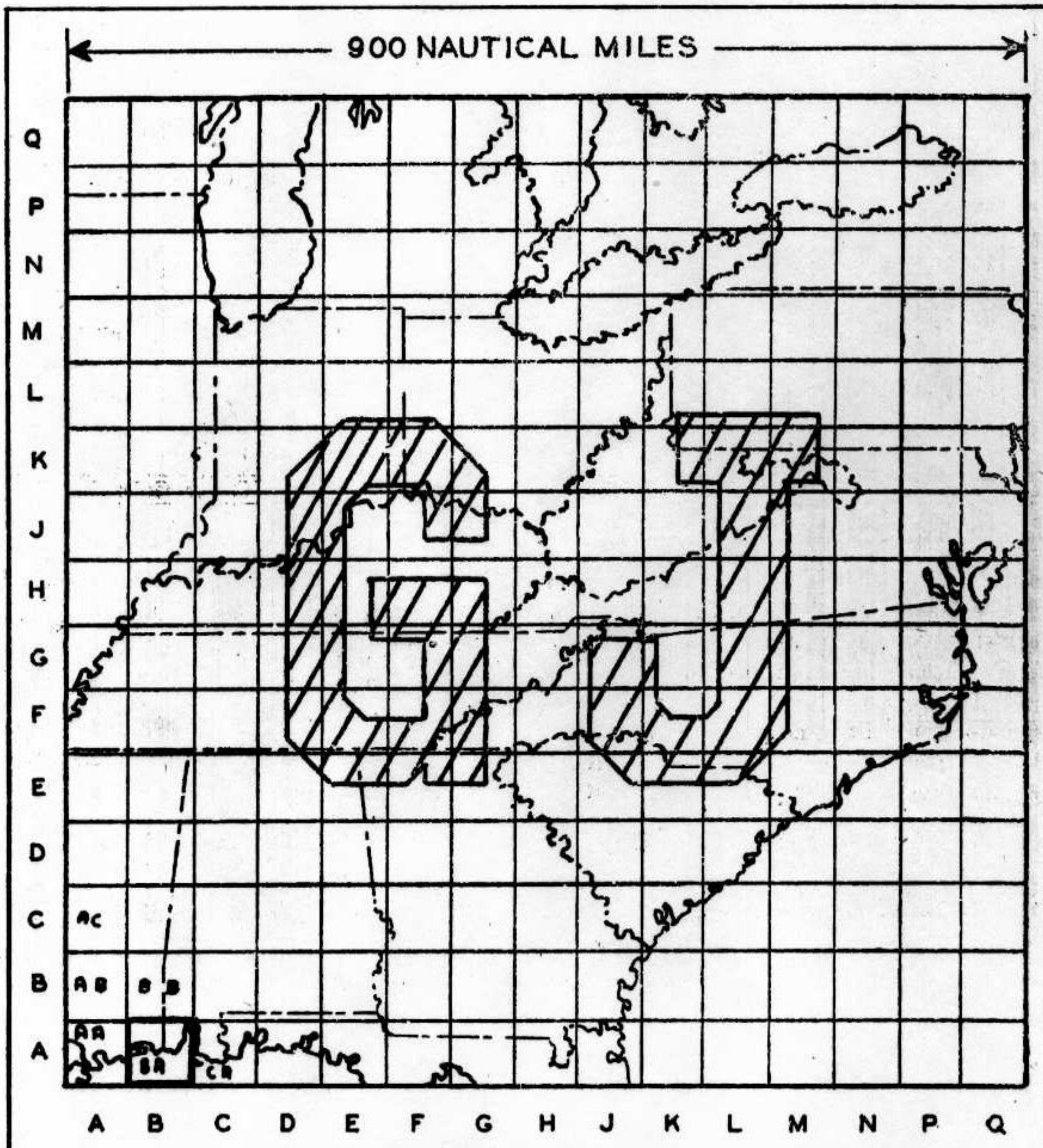


Figure 4.

terpolation in minutes. These minute interpolations will be known as coordinates. Therefore, the exact location of Keesler will be GJBA—0424. See illustration below.

You have now seen how the "GEOREF" GRID is broken down. As you progress in your work in the AC & W field, it will become more and more familiar. You will use it at all installations and possibly will break down a portion of the world at some date in the future. Learn it well, it is here to stay.

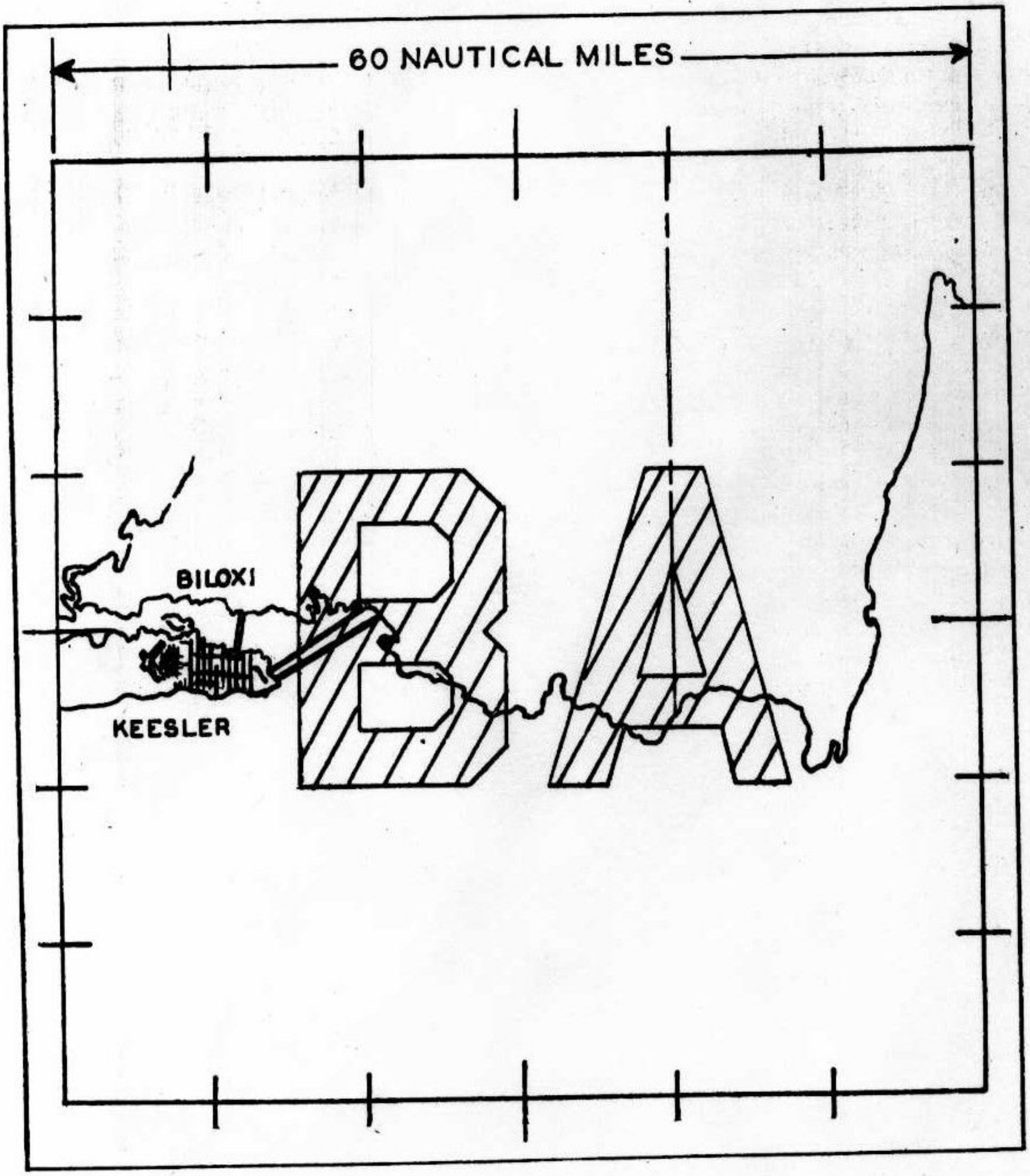


Figure 5.

ZEBRA TIME

Introduction

In leaving your home to go to your first Air Force assignment and in shipping from one Air Force Base to another you have probably traveled many miles. On one occasion or another, you have undoubtedly noticed that the time at your new station varied 1, 2, or 3 hours from the time at your old station. This circumstance exists because the time is not the same all over the United States at any one instant or any one hour. The United States is divided into four "time zones"; *Eastern* time zone, *Central* time zone, *Mountain* time zone and the *Pacific* time zone. In traveling from east to west as you enter a new time zone, it is necessary to set your watch back one hour. In traveling from west to east, it is necessary to set your watch ahead one hour. Changing the setting of your watch changes the time only for the sake of convenience, time itself keeps rolling right along. In following the established habits of our civilization, we expect 6 : 00 A. M. by the clock to indicate the start of a morning. Similarly, when the clock says 12 : 00 noon, we expect the sun to be overhead. In order for patterns of living to be the same the world over, time zones have been established but regardless of the times to which we have set our clocks, it is true that at any one instant there is but one absolute time all over the world. Time is really independent of the manipulations of our clocks. As the saying goes, "tempus fugit", or time flies.

Because of the large geographic area covered by the AC & W System, the various stations found in the AC & W organization are very often located in the different time zones mentioned above. Reports sent from these stations to higher headquarters could indicate different times for the same instant due to the location of the stations in different time zones. One station located in the Eastern zone could indicate 2000 as the time on its report while a station in the Central could indicate the very same instant of time as 1900. Both reports would be correct due to the zone system. As a result, confusion in higher headquarters due to the two indicated times could mean the loss of precious seconds in the AC & W operations. Since *SPEED* is of the utmost importance, a need was felt for one standard time to be used in AC&W work. Because of this dire need, Zebra Time was adopted.

Origin of Zebra Time

As far back as 1873, this need for one standard time was felt. Marine navigators from various countries organized together and started a worldwide campaign for adoption of a universal time.

Ten years later, in 1883, an international conference, made up of representatives from almost every country, met at Washington, D. C. for the purpose of developing and setting up a system of universal time. After discussing the problem, it was decided to accept the zone plan. Universal time was then called zone time or as we know it today, Zebra Time. The term "Zebra" comes from the phonetic letter for Z.

Under the zone plan, the world was divided into 24 equal time zones using degrees of longitude as a basis for dividing the world. Since there are 360° of longitude, each time zone contains 15° of longitude. See illustration page 102. It was decided that the *Prime Meridian* would be the center of the first time zone. The Prime Meridian is 0° longitude.

Because of the fact that the prime meridian passes through the town of Greenwich, England Zebra Time is also known as "Greenwich Civil Time." This zone in which Greenwich is located is used as the reference point for universal time. The local time in each zone is one hour later than the zone immediately to the west.

Use of Zebra Time

Now that we have a universal time, how is it used in the AC&W System? Remember that Greenwich is the reference point from which time zones are measured. If it is midnight in the Greenwich time zone, it will be 7 : 00 p. m. in New York which is in the Eastern time zone. However, when it is 2400 Zebra Time in Greenwich it is 2400 Zebra Time all over the earth. So time entries on all logs used in the AC&W System will be recorded in Zebra Time so that no confusion will result in higher headquarters.

CONVERSION TABLE

Greenwich Civil Time	*Eastern*	*Central*	*Mountain*	*Pacific*	*Zebra*
2400	1900	1800	1700	1600	2400

To convert to Zebra Time:
Eastern (1900) plus 5 hours = Zebra (2400).
Central (1800) plus 6 hours = Zebra (2400).
Mountain (1700) plus 7 hours = Zebra (2400).
Pacific (1600) plus 8 hours = Zebra (2400).

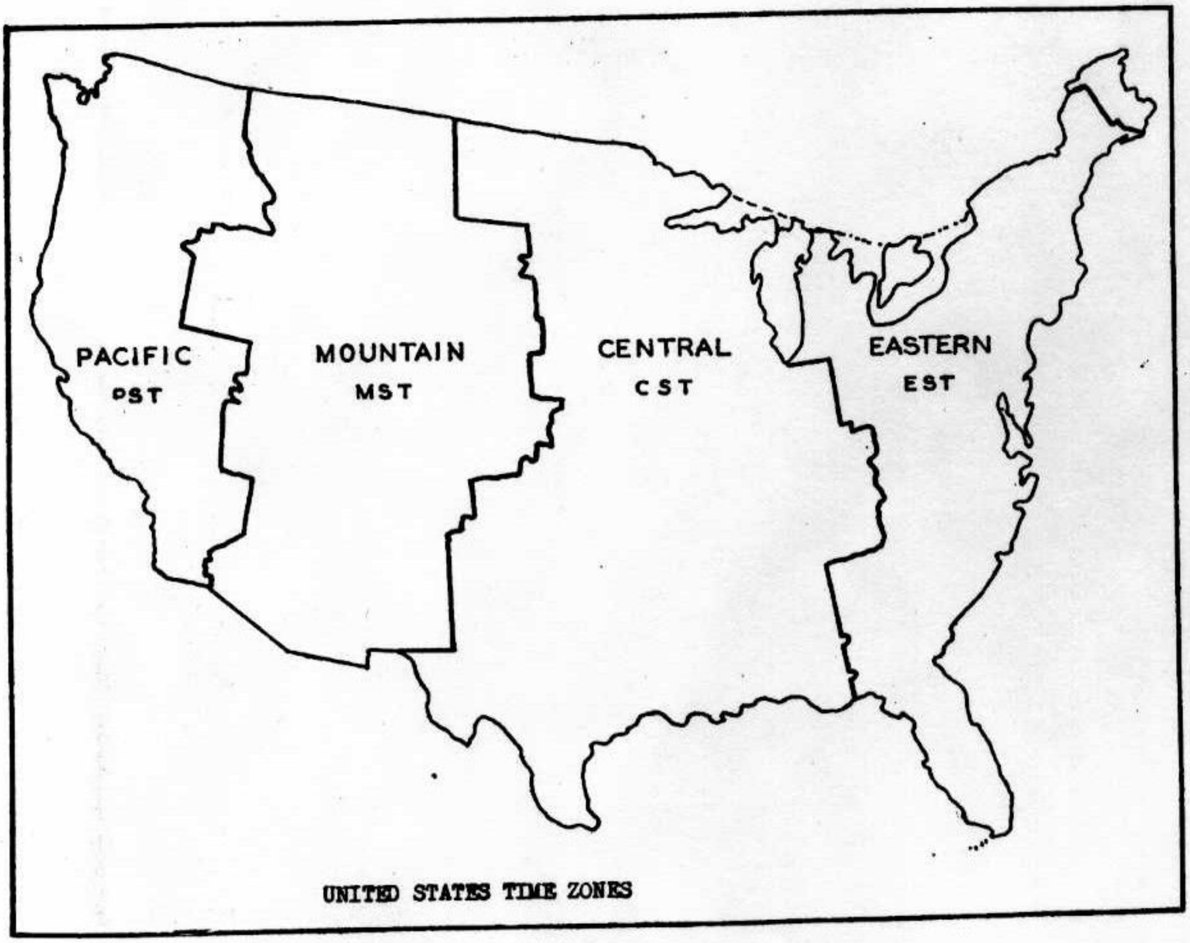


Figure 6.

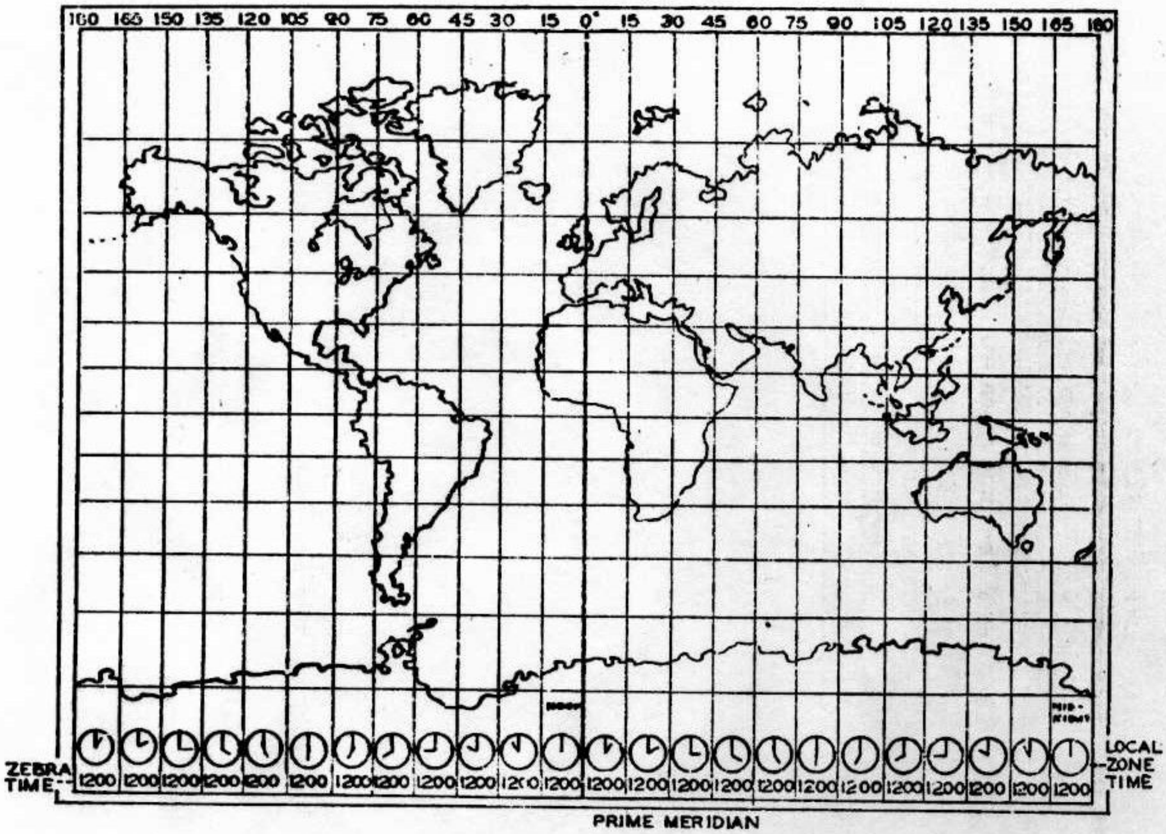


Figure 7.

QUESTIONS

1. Why was the "GEOREF" GRID developed?

2. What is the main use of the "GEOREF" GRID?

3. Upon what is the "GEOREF" GRID based?

4. What area is covered by the "GEOREF" GRID which was not covered by the old system?

5. What is Latitude?

6. What is Longitude?

7. What is the point of origin for the "GEOREF" GRID?

8. Why are the letters I and O omitted in lettering the divisions of the "GEOREF" GRID?

9. What is the size of a block located in the first breakdown?

10. To properly identify a particular location, how many letters are used in giving grid reference?

11. Why is it necessary to have one standard time in the AC & W System?

12. What is used as a basis for dividing the world into time zones?

13. What is another name for Zebra Time?

14. Do we use local time or Zebra Time in recording time entries on logs used in the AC&W System?

15. How many hours must you add to Eastern time to get Zebra Time? To Central Time? To Mountain Time? To Pacific Time?

RADAR INDICATOR OPERATION

Scope: Explanations of cathode ray tubes and the various indicators (scopes) in which they are used. Also, adjustments and General operating practices used.

Student Objective: To become familiar with various types cathode Ray tubes and their operation and to learn scope adjustment and reading.

References: T. O. 16–30CPS 6–2, T.O. 16–30CPS 4–2, T. O. 16–30 CPS 1–2, T. O. 16–30CPS 5–2, T. O. 16–30CPS 10–6

INTRODUCTION

As a radar operator in the AC&W System, you will be called upon to operate a variety of indicators or "scopes." The indicators that you will operate may have different designations or names and may be used for different purposes. However, every indicator you will encounter will employ a *C*athode *R*ay *T*ube (CRT) to give you a visual presentation of the information obtained by the radar set. Just as the speaker in an ordinary radio allows you to "hear" the information being presented, the CRT in the indicator unit of the radar set will let you "see" the information needed in the AC&W System.

CATHODE RAY TUBE

Even though the operation of the CRT is a very technical process, you, as a radar operator, should be familiar with its workings. Basically, it works as follows. In general, a stream of particles are emitted by one of the parts of the CRT and flow through controlling elements that will determine the strength of the beam, the direction and the way it will move. The beam finally strikes a "screen" where the trace of the electron stream becomes visible.

When the set is turned on, the *filaments* in the CRT heat up and cause the *cathode* to give off very small electrically charged particles called electrons. To determine the number of electrons which will be used, a type of "gate" is used. This gate is called the "*control grid*" for it controls the number of electrons in the electron beam.

To prevent the visual presentation from being fuzzy and indistinct, an element in the tube called the *focusing anode* keeps the electrons flowing in a straight line toward the face of the tube. Any electrons which veer off the straight line are forced back into the beam by the action of the focusing anode.

The next element in the tube is the *accelerating anode.* This element gets its name from the fact that it "speeds up" or "accelerates" the flow of the electron beam.

In order to have a basis for measuring time, two sets of *deflection plates* cause the beam to move up and down on the face of the scope or left and right across the face of the tube. This deflection action occurs at such a rapid speed that the electron beam appears as a line across the scope. This line is called the *sweep* or *time base.*

The inner surface of the glass face of the tube is coated with a substance called phosphor which gives off light when activated by the electron beam. This gives the visual indication of the information obtained by the radar set.

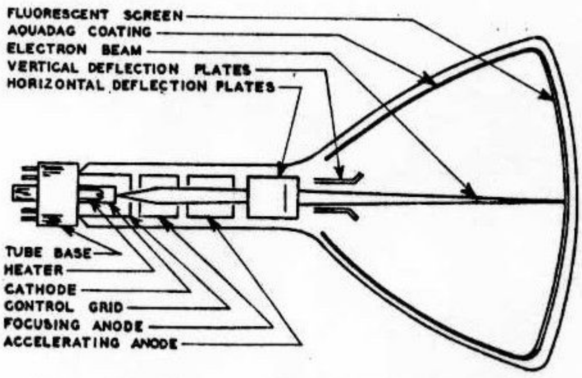


Figure 1. Cut-away View, Cathode Ray Tube.

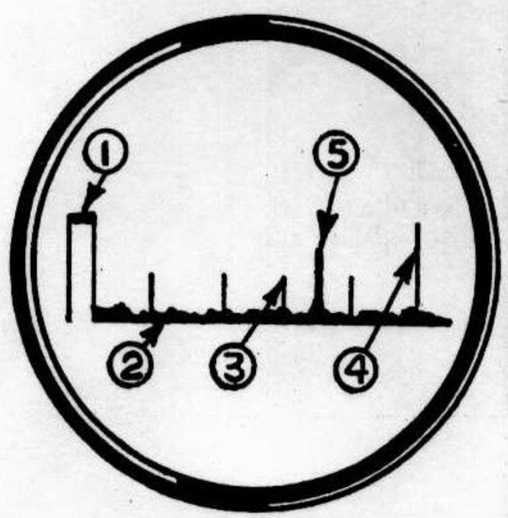
You may be asking yourself, "Why is a CRT used to present information?" In addition to providing a visual indication of the radar information, it is capable of showing signals that occur at very high frequency or are of very short time duration. It is not unusual for a CRT to be used where measurements of time as small as one-half of 1/1,000,000 of a second are to be presented. By measuring the time it takes for the transmitted signal to travel to a target and return to the radar set, accurate determination of range is possible.

"A" SCOPE

The presentation of the "A" scope is the simplest of all types of indicators. The sweep or time base is a horizontal line which runs across the face of the scope. Indications of targets are vertical pips or blips appearing along the time base. By referring to the range marks, which also appear as vertical pips at regular intervals along the time base, accurate determination of range is possible. To determine the number of aircraft in flight, all that is necessary is to count the number of pips that appear along the time base. "A" scope illustration will clarify this.

The fact that a CRT was capble of accurately determining the range of a target was the basis for the development of the "A" scope. In the early history of radar, the "A" scan type of indicator was used almost universally. Although the "A" scope was not designed to present information concerning azimuth or direction, approximate azimuth information could be gathered by rotating the antenna for maximum signal return and then noting the position of the antenna. The size, number, speed and direction of travel of the target could also be determined. As progress was made in the field of radar and new types of scopes were developed to provide more information, the "A" scope was used as a test set in maintenance work and to augment other scopes in determining the number of aircraft in a flight. A modified "A" scope is used in the CPX-1 IFF sets. The mechanics will utilize the "A" scope in testing the newer and larger sets used today.

"A" SCOPE



1. Transmitter Pulse.
2. Ground Clutter.
3. Range Markers.
4. 50-Mi. Range Marker.
5. Target.

Figure 2.

"A" SCOPE OPERATIONAL CONTROLS

A number of operational controls are provided for fine operational adjustments. Ordinarily, all scopes will be set up and adjusted to the best operating point by the maintenance personnel. However, a good operator should have a working knowledge of the operational controls so that if the occasion ever arises where a slight adjustment will mean the difference between good reception and little or no reception, such an adjustment can be made with little delay. No matter what type of scope you may be operating, remember—"Use only those controls which are designated as operational controls. Leave the maintenance and calibration controls for the mechanics."

INTENSITY Control

This control is used to increase or decrease the brilliance of the sweep. It must be neither too low nor too bright but of sufficient brilliance to present a good display. Too high an intensity will reduce the life of the CRT in that the illuminating qualities of the screen will be reduced. Too high an intensity will also produce a "noisy trace" which will reduce the effectiveness of the scope.

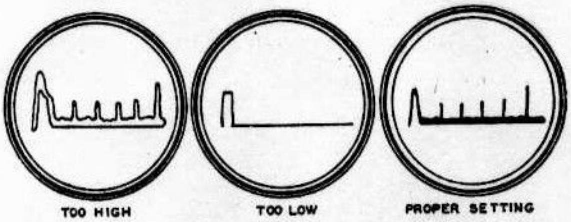


Figure 3. Control of Intensity on "A" Scope.

FOCUS Control

The FOCUS control is one of the most important operating controls. By the proper use of this control, a narrow, sharp, distinct trace is obtained thus eliminating all fuzziness from the picture presented.

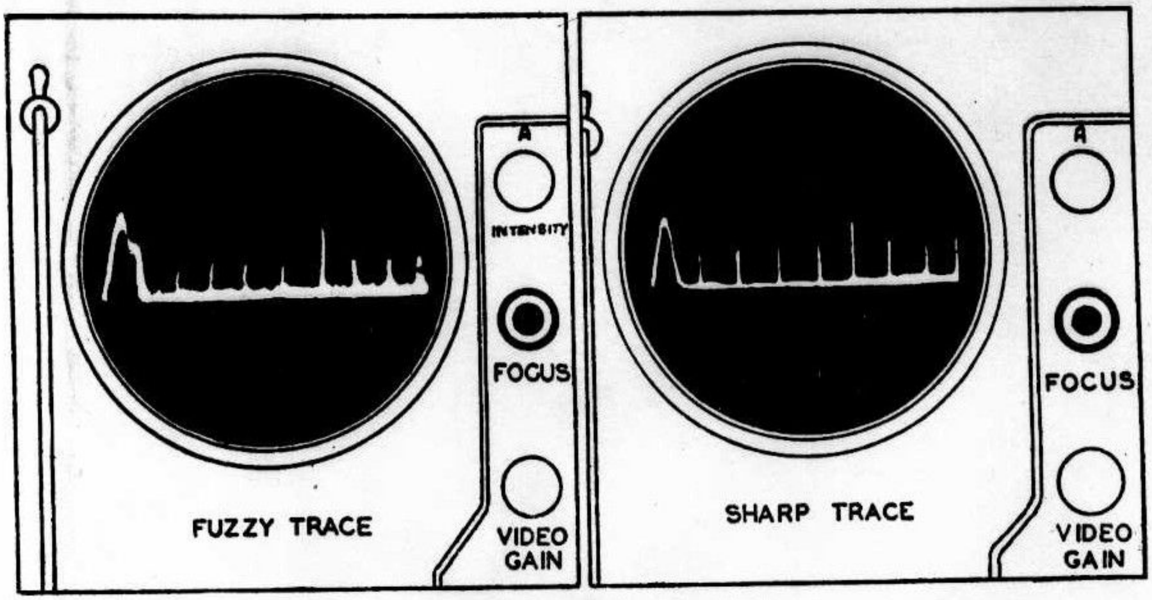


Figure 4. Focus Control Operation "A" Scope.

VIDEO GAIN

The VIDEO GAIN, sometimes referred to as the VERTICAL GAIN, will increase the height of the signal voltage and will enable you to pick up weak signals. When listening to a radio and the station to which you are tuned is not quite audible, you turn up the volume control. On the "A" scope, the VIDEO GAIN is your volume control. Proper adjustment of the VIDEO GAIN, INTENSITY, and FOCUS is important if a clear picture is to be presented.

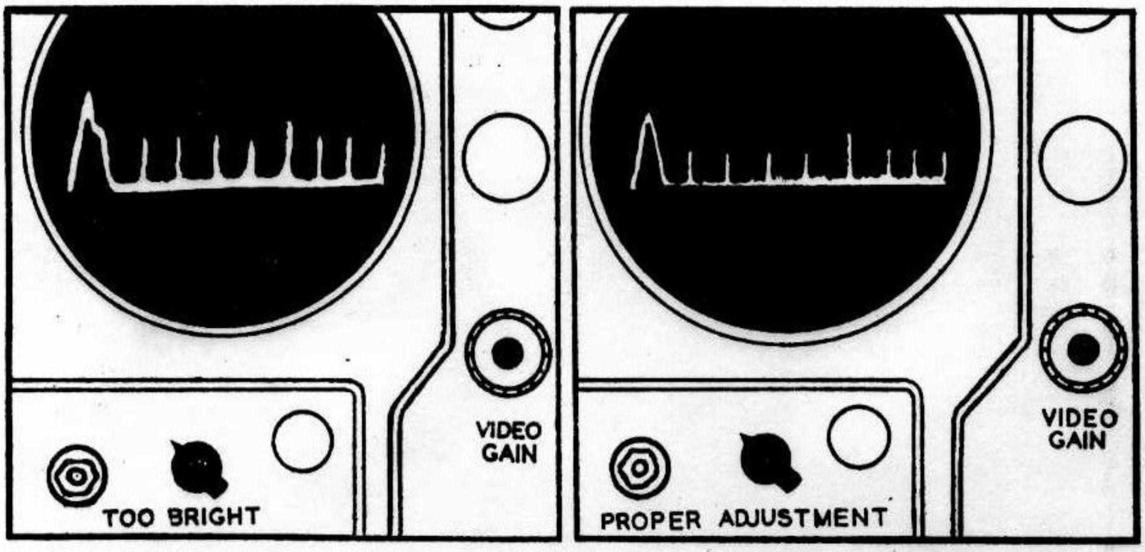


Figure 5. Video Gain Adjustment "A" Scope.

VERTICAL and HORIZONTAL CENTERING Controls

If the picture is not centered properly on the scope, all targets may not be visible. Therefore, the picture must be centered on the scope. The VERTICAL CENTER control will move the trace up and down the scope while the HORIZONTAL CENTER will move the sweep from right to left across the face of the scope.

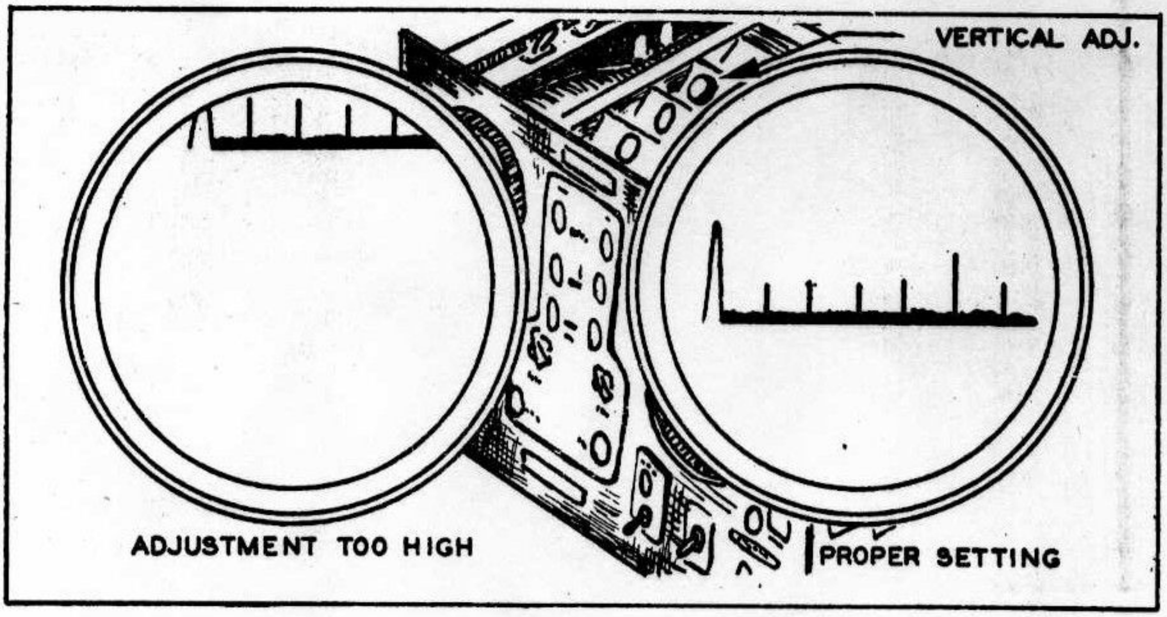


Figure 6. Vertical Centering Adjustment "A" Scope.

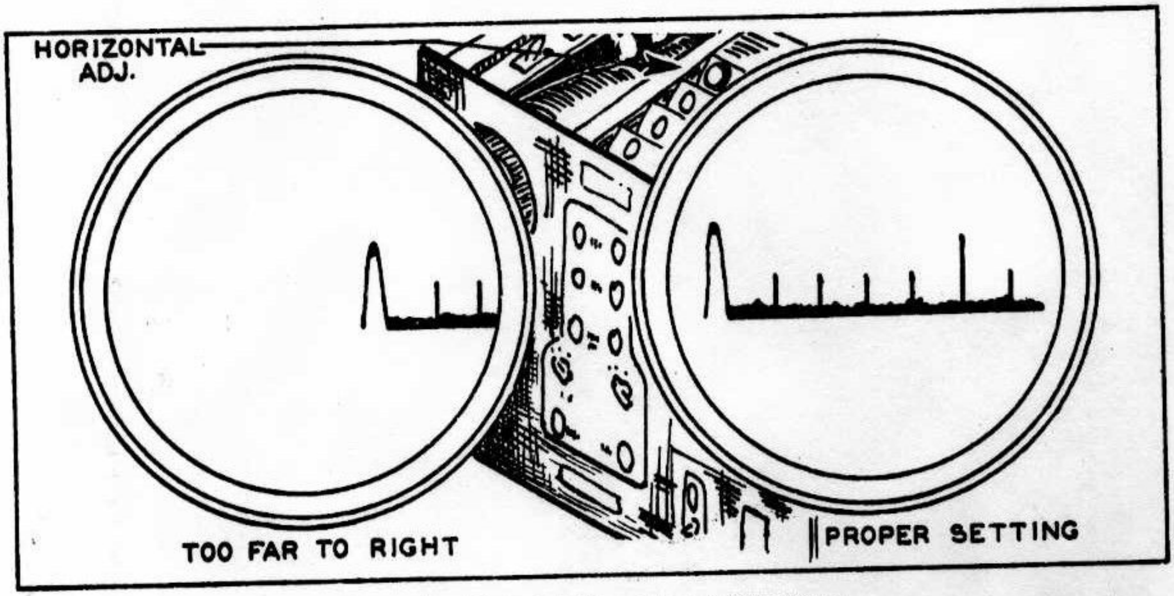


Figure 7. Horizontal Centering on "A" Scope.

RANGE MARK Switch

For accurate determination of range, range markers are provided and are turned on or off by the RANGE MARK switch. Normally, the range marks will be vertical pips similar to target indications and will be placed at 10 mile intervals. To facilitate range reading, every fifth range marker will be taller than the rest indicating 50 mile intervals.

RANGE Switch

The RANGE switch will allow you to work at a *S*hort, *M*edium, *L*ong range. By changing the range, you automatically vary the length of time represented by the time-base, thus increasing or decreasing the range displayed on the scope. The mileage displayed on each of the three ranges will vary on different scopes.

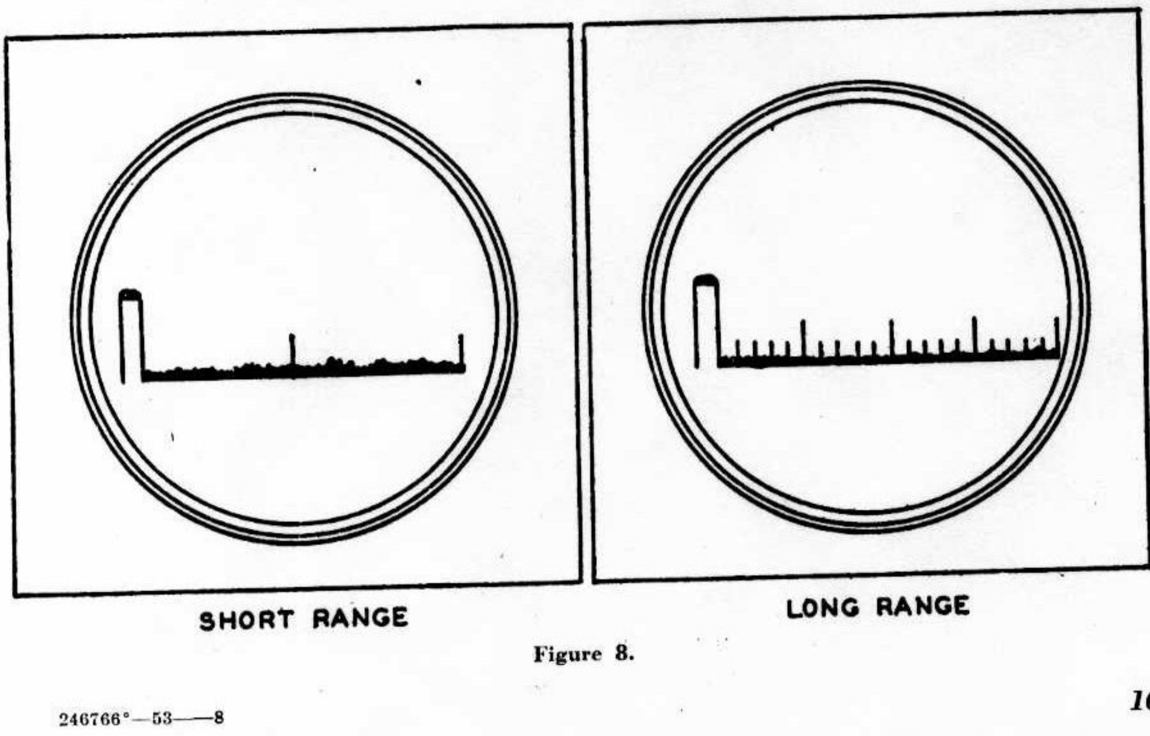


Figure 8.

RANGE DELAY

In some instances, the target you are tracking may be some distance from your station. To eliminate the ground clutter in close to the station, the RANGE DELAY will be used. In effect, you pull that portion of range you do not wish to use, into the beginning of the sweep. Similarly, you are expending the sweep for you can view distant targets spread over a larger area of the screen.

For example, the target you are tracking is beyond 50 miles and you are operating on medium range, or 45 miles. Turn the **RANGE DELAY** for 50 miles delay. Your sweep will no longer originate at 0 mile and extend to 45 miles. Instead it will originate at 50 miles and extend to 95 miles. This will allow you to track the target in this particular case with more ease.

The amount of delay used must be noted so that accurate range information can be obtained.

To turn the range delay on or off, a DELAY ON-OFF switch is provided.

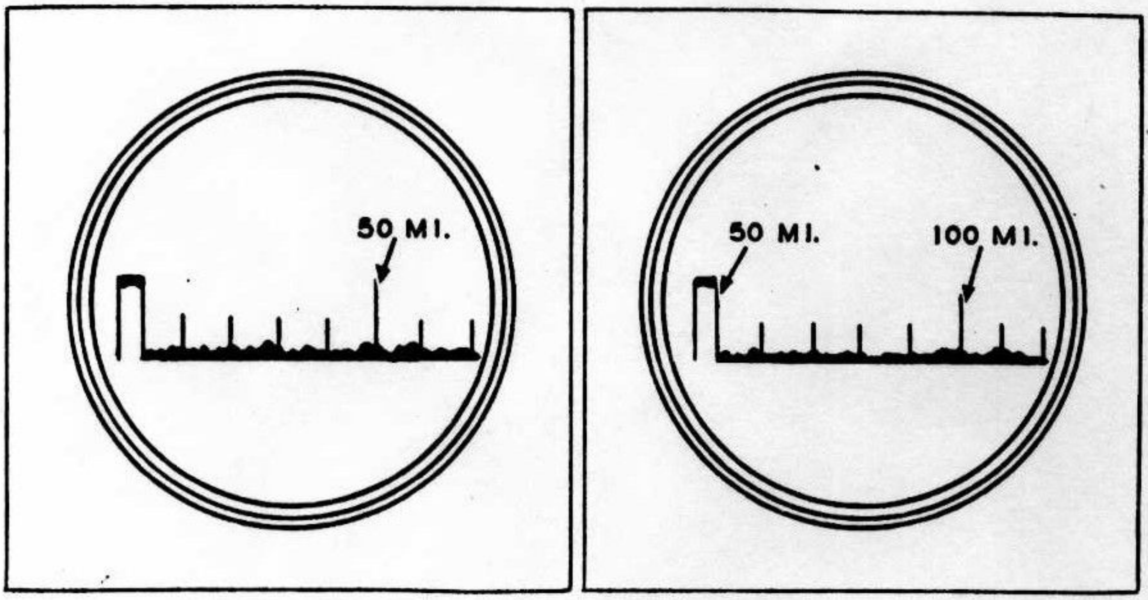


Figure 9. Range Delay.

PPI SCOPE

To meet the need of more accurate azimuth information and relative position data, the PPI scope was developed. The letters PPI stand for *P*lan *P*osition *I*ndicator. This indicator presents a map type picture of the surrounding area. The range of the indicator will depend upon the type of the set, the power output of the set and the location of the set. Most ground radar sets are capable of covering a 200-mile area.

The PPI presentation is quite different from that of the "A" scope. By referring to the illustrations, you will notice that the sweep on the PPI scope originates in the center of the scope and extends to the outer edge. The picture on the PPI is "painted" by the rotation of the sweep around the face of the tube giving a 360-degree picture. The rotation of the antenna, is synchronized with the rotation of the sweep. This means that the sweep and the antenna rotate together. As a result, when the antenna points to one certain direction, 270 degress for example, the sweep on the scope will also point to 270 degress. Due to the synchronization of the sweep with the antenna, accurate determination of azimuth is possible.

The reading of azimuth is facilitated by the use of "angle marks." The angle marks are lines electrically placed on the scope extending from the center to the outer edge. Each line represents measurements of 10 degrees with every third line brighter to indicate 30-degree measurements. In addition to the angle markers, a compass rose is provided around the outer edge of the scope to make azimuth reading easier.

Determination of range is made possible by the use of range markers. The range marks are dots of light spaced at intervals of 10 miles along the base line or sweep. As the sweep rotates, the dots paint circles of light on the scope. Every circle then represents 10 miles with every fifth marker being brighter to indicate 50 miles.

As the sweep rotates around the scope, echoes from aircraft, ground reflections, clouds and interference will be painted on the scope. These returns will appear as light spots or areas on the face of the scope. Moving targets will appear at a different place each time the sweep rotates. By the use of the angle marks and range marks, the exact position of the target can be noted. By close observation, the speed and size of the target can also be determined.

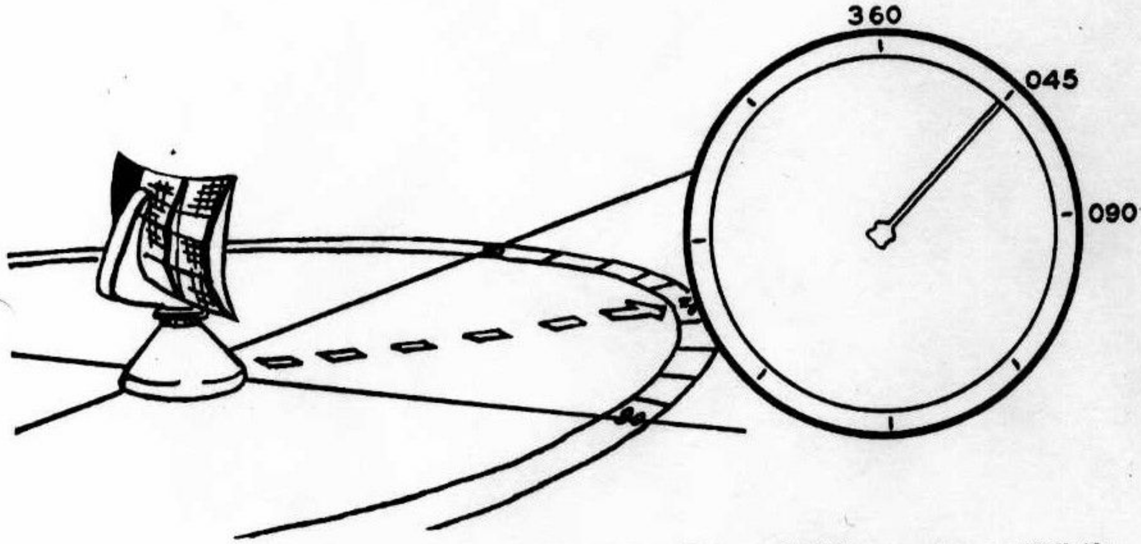


Figure 10. Antenna and Sweep Are Synchronized. When Sweep Points to 045 Degrees, Antenna Will Also.

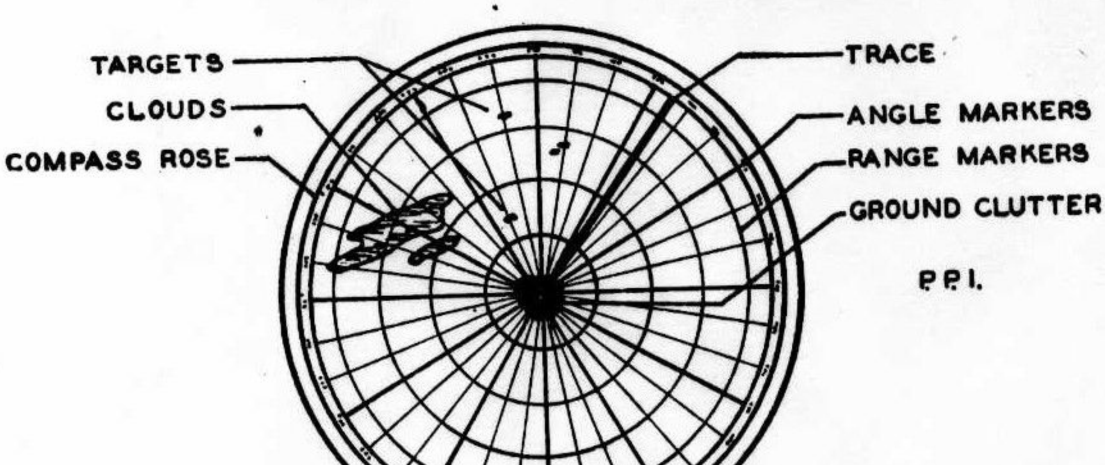


Figure 11. "PPI" Scope 360 Degree Presentation.

PPI OPERATIONAL CONTROLS

As on the "A" scope, operational controls are provided which make your work easier if used properly. The illustrations accompanying each control will show just how that control will affect the scope presentation. By associating the illustration with the control in question, you can visualize its effect. By retaining this information, you can save time in actual operation for you know what control to use to get the desired picture.

PANEL BRILLIANCE Control

This control provides illumination for the control panel and for the compass rose. The light provided aids you in locating controls and reading azimuth. After you have become proficient in operating the PPI, the PANEL BRILL. control will not be utilized, for you will be familiar with the location of all controls and capable of operation in the dark.

TRACE BRILLIANCE Control

This control will govern the intensity or brightness of the sweep. The TRACE BRILL. control should be turned up to the point where it is barely visible. Too high a setting will produce a high persistance, noise, ground clutter and burnt tube. Such conditions will obliterate weak returned signals causing you to miss seeing and reporting them. Too low a setting will cause you to miss seeing and reporting targets in that they will not be painted on the scope. Proper adjustment of the TRACE BRILL. is easily obtained with practice.

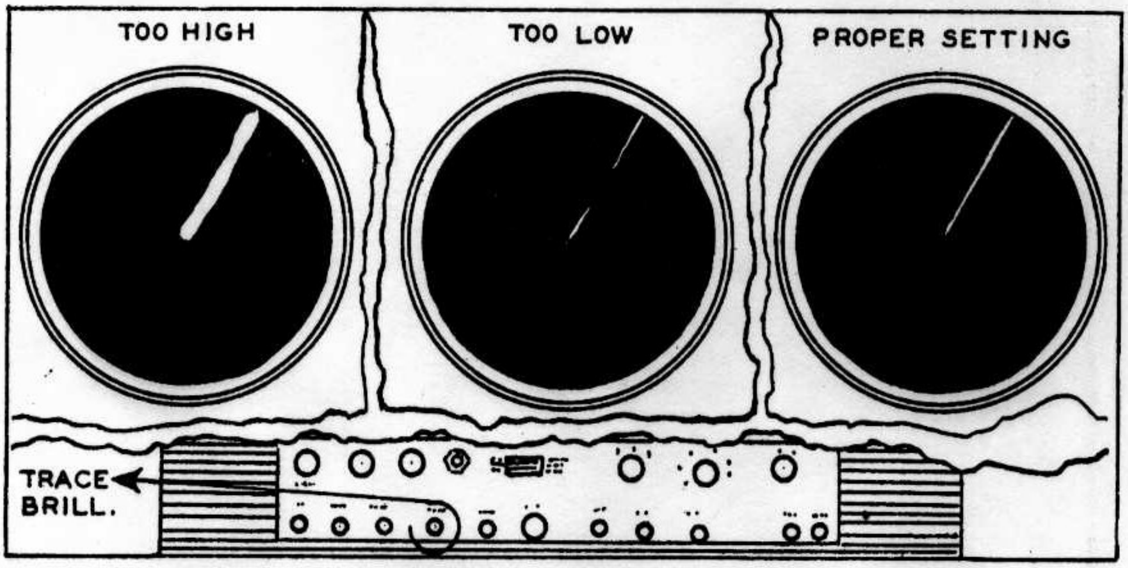


Figure 12. Adjustment of Trace Brilliance on "PPI" Scope.

FOCUS Control

The FOCUS control, used in conjunction with the TRACE BRILL, will enable you to bring out a sharp, distinct trace. By eliminating a fuzzy trace with the FOCUS control, a sharp, clear picture is obtained on the screen of the CRT. With a clear picture, accurate azimuth and range information can be determined.

SIGNAL ON-OFF Switch

When this switch is placed in the ON position, the returned signals picked up by the receiver unit are applied to the CRT. When it is in the OFF position, all signals are removed and none will be picked up.

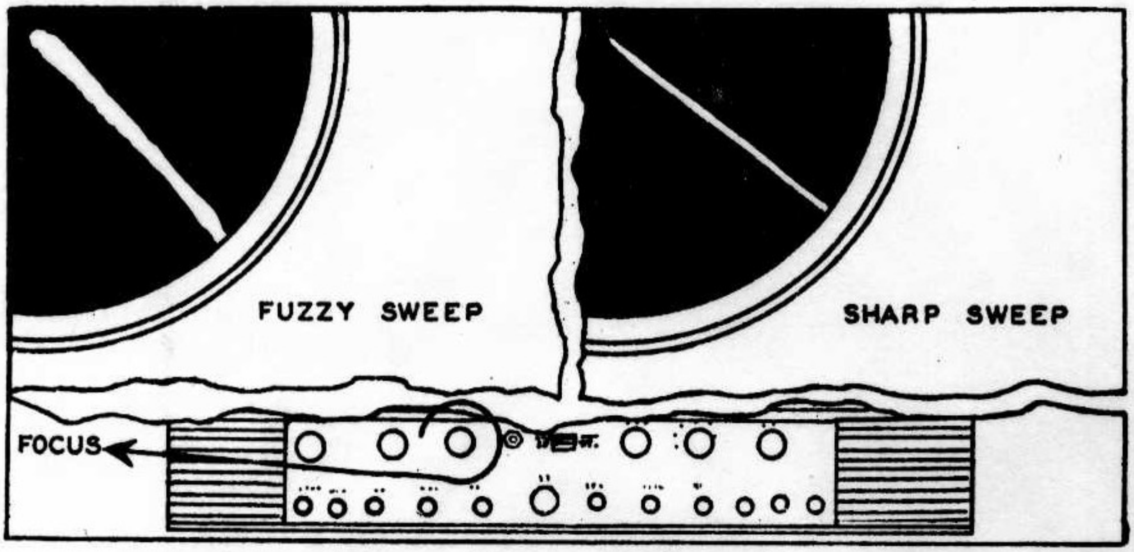


Figure 13. Correct Focus Presentation on "PPI" Scope.

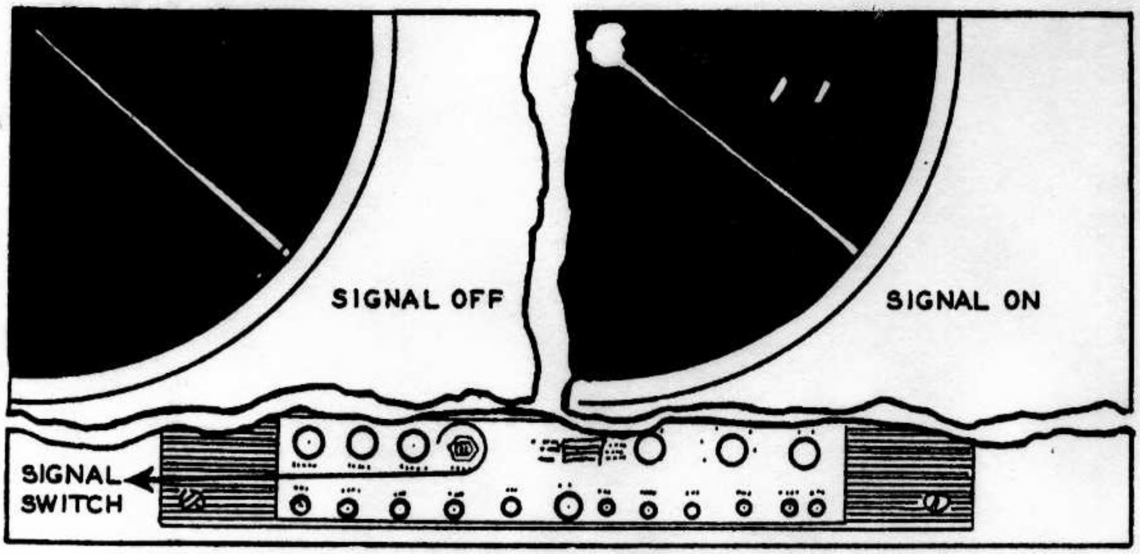


Figure 14. Signal On and Off "PPI" Scope.

SIGNAL BRILLIANCE

This control will allow you to adjust the size or brightness of the target echoes. Just as the video control on the "A" scope, the SIGNAL BRILL. on the PPI scope, compares to the volume control on the radio. It must be adjusted to the point where weak signals are discernible and strong signals can be read with accuracy. Noise due to over amplification in the receiver must be avoided.

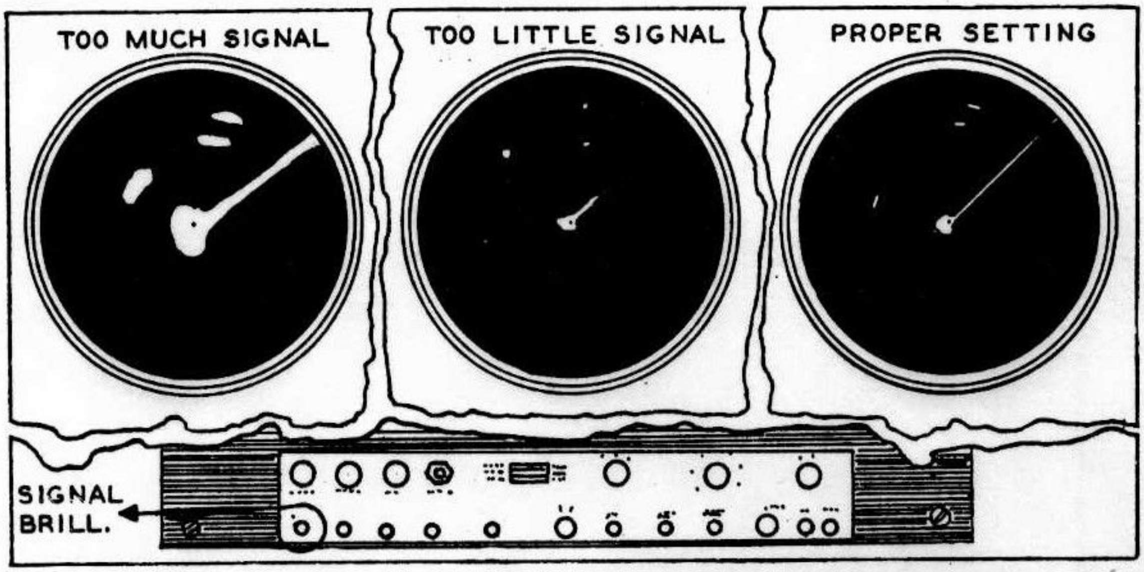


Figure 15. Proper Adjustment Signal Brilliance "PPI" Scope.

MARKER OFF-ON Switch

To turn on both the angle marks and the range marks, you will use the MARKER OFF-ON switch. Some sets may have individual switches, one for the range marks and another for the angle marks.

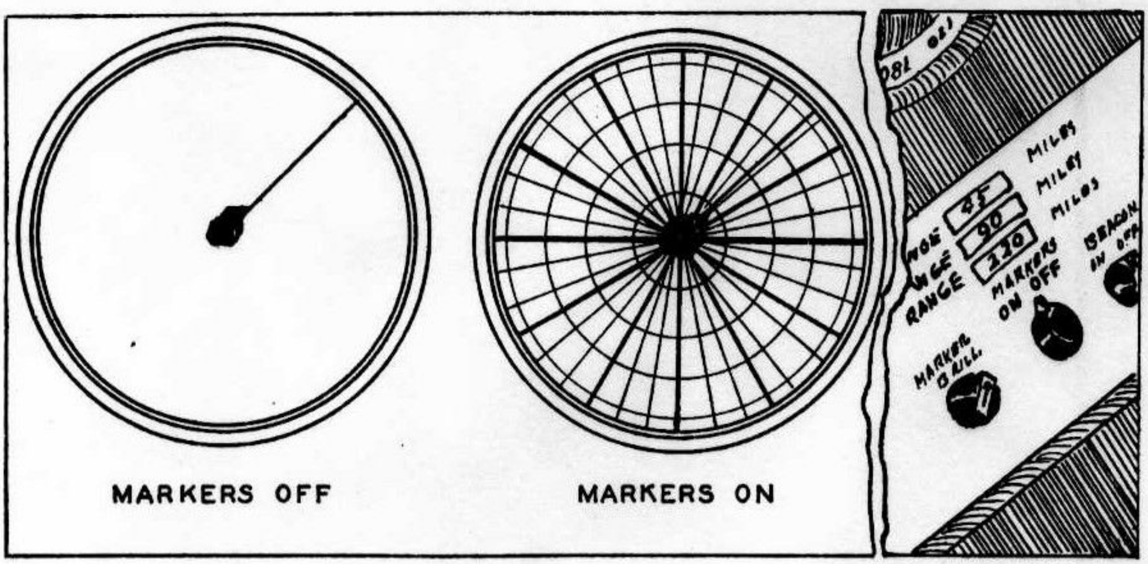


Figure 16. Range Markers On and Off "PPI" Scope.

MARKER BRILLIANCE

The MARKER BRILLIANCE also may be a single control or there may be two separate controls, one for the range marks and one for the angle marks. This control or controls as the case may be, will govern the intensity of the markers. They should be adjusted to where they are visible enough for accurate readings but not so strong as to blot out weak signals. In certain instances, it is advisable to operate with the markers off so as not to miss any weak targets. If rapid determination of azimuth and range is desired, then the markers should be left on to save time while operating.

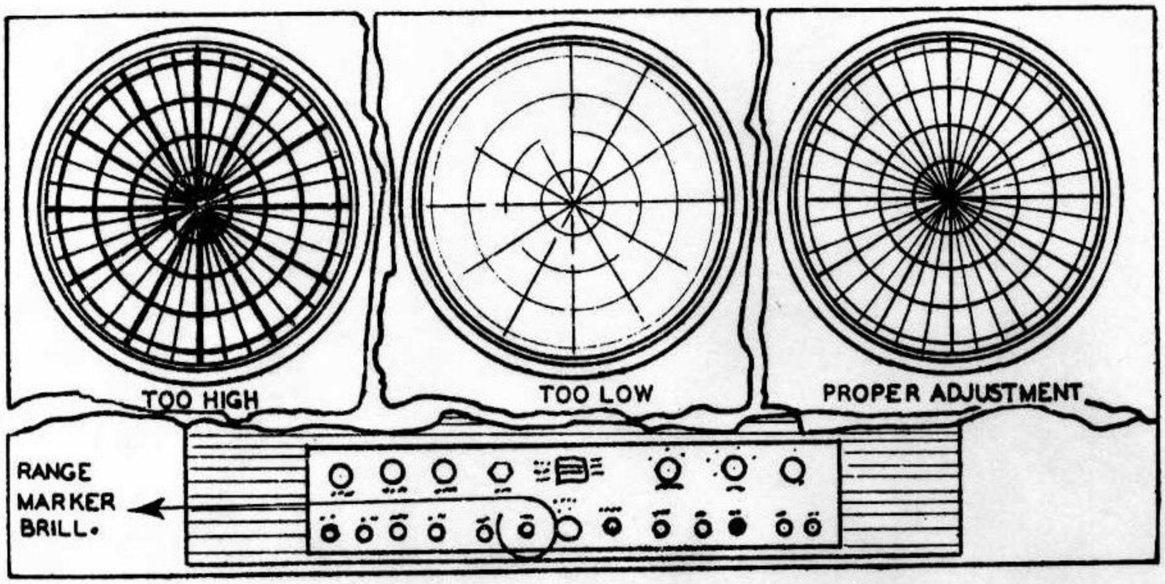


Figure 17. Range Marker Adjustment "PPI" Presentation.

RANGE Switch

As on all scopes, the setting of this control will determine the range displayed on the scope. Normally, the switch will have three positions: *S*hort, *M*edium and *L*ong range (S, M, L). The actual mileage covered by these positions will be determined by the tactical requirements and will be calibrated and set up by the maintenance men.

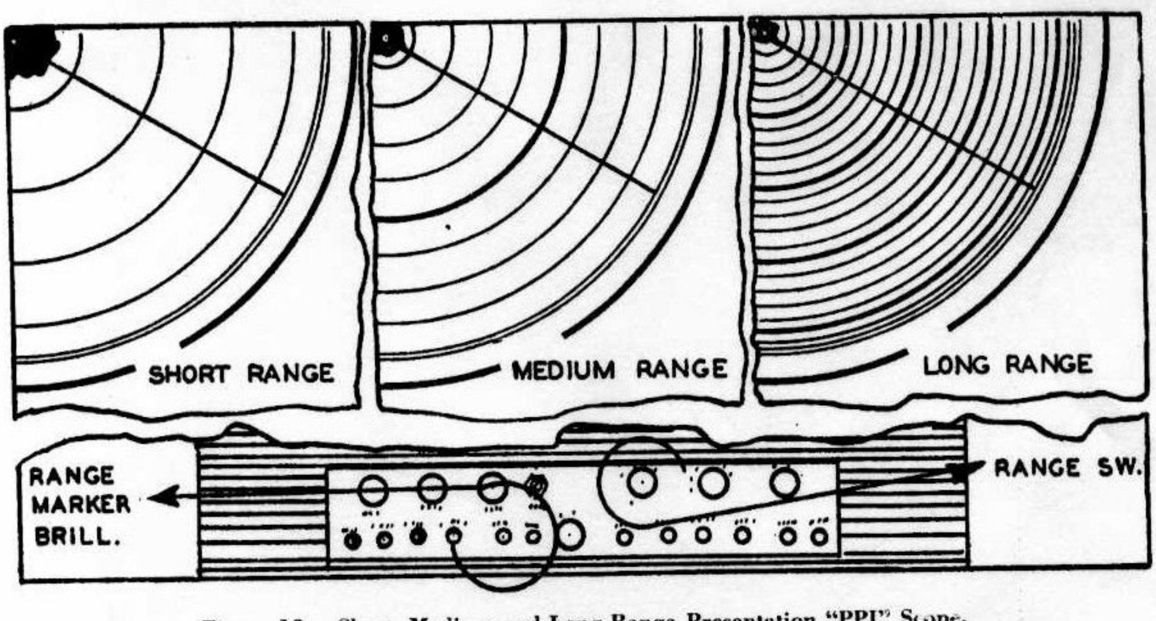


Figure 18. Short, Medium and Long Range Presentation "PPI" Scope.

RANGE DELAY Controls

The range delay system consists of two controls. The DELAY OFF-ON switch will do what the name suggests—either turn the delay on or off. When the DELAY is turned ON, it is possible to blank out or "pull in" to the center of the scope any portion of the sweep that you do not wish to scan. Suppose you are operating on a medium range of 90 miles. You are not interested in the first 40 miles in this case, so you turn ON the DELAY switch and then turn the DELAY control until you have "pulled" 40 miles into the center of the scope. Then the center of the scope will represent 40 miles while the outer edge will represent 130 miles.

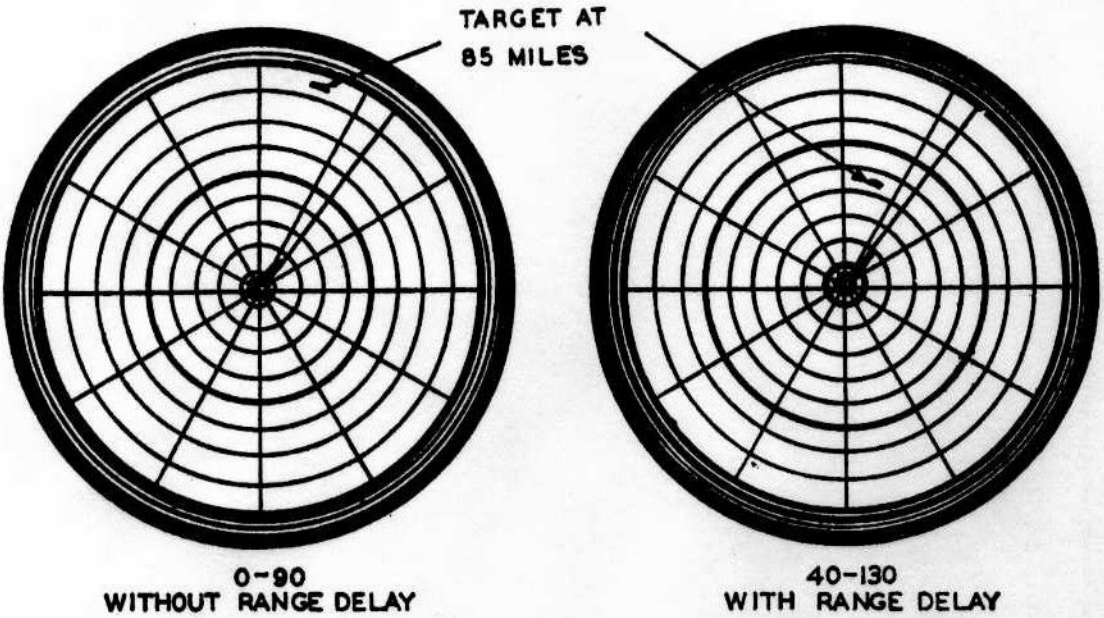


Figure 19. Presentation Range Delay "PPI" Scope.

ANTENNA SELECTOR Switch

A control not found on all PPI scopes is the ANTENNA SEL. switch. It is provided when the set is capable of sending out several different lobe patterns. On the CPS–6, the ANTENNA SEL. switch has two positions. When the switch is set in the number one position, all the lobe patterns will be utilized. When the switch is in the number two position only the lower beam will be used. With the switch in the number two position, you will be able to track low flying, long range targets.

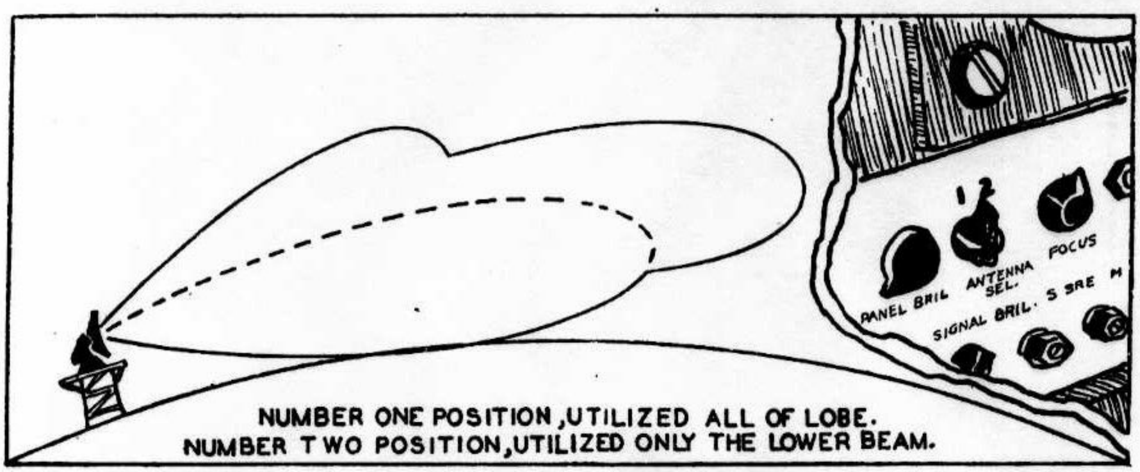


Figure 20. Antenna Selector Switch, Changes Lobe Pattern.

SECTOR SCANNING

The PPI is designed to present a 360 degree picture. Due to the fact that quite frequently air traffic becomes very heavy, a 360 degree picture will sometimes be cluttered with targets. Such a situation is beyond the capabilities of one operator. Therefore, another use of the PPI has ben devised. To make it easier for the operators to report all targets, a method of breaking the 360 degrees into sectors has been set up. This operation is called "sector scanning."

A control called the OFF-CENTER CURRENT control located on the control panel, enables the operator to perform sector scanning. When the OFF-CENTER control is turned, the sweep no longer will originate in the center of the scope but will now originate at the edge of the CRT. A 360 degree picture has then been reduced to a 90 degree picture. This is possible because the sweep will appear only one-fourth the time it previously had appeared. The sweep can be placed at any point around the edge of the scope by turning the large knob located on the upper right hand corner of the console. This knob is called the AZIMUTH POSITIONING knob.

When sector scanning, the 360° is usually broken down into four 90° sectors. When a sector is assigned to you, you must be able to determine just where the sweep must be positioned to cover the assigned sector.

Suppose you are assigned the 90 degree to 180 degree sector. First, you must determine the mid-point of that sector. Half of 90 degrees, the size of your sector, is 45 degrees. By adding 45 degrees to 90 degrees, the lower limit of your sector, you will obtain the mid-point of 135 degrees. The sweep must then be placed exactly opposite 135 degrees. This position can be determined by adding 180 degrees to 135 degrees. The result of this addition will give you 315 degrees, the point at which you must position the start of the sweep.

If the mid-point of the sector you are to scan is less than 180 degrees, add 180 degrees to determine the point at which the start of the sweep should be placed. If the mid-point is more than 180 degrees, subtract 180 degrees to determine the position of the sweep originating point.

By referring to the illustration, "Sector Scanning," you can see how the sector of 90 degrees to 180 degrees is expanded over the entire face of the scope by the use of sector

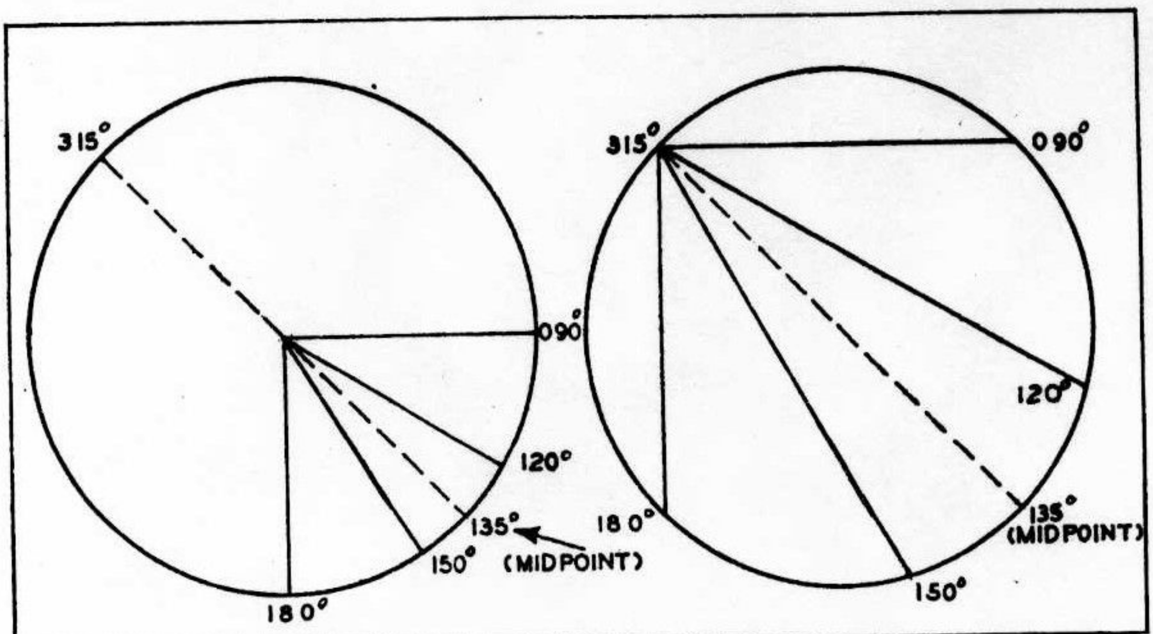


Figure 21. "PPI" Scope Before Sector Scan. "PPI" Scope After Sector Scan.

scanning. At the same time, the range has been doubled for you have doubled the length of the time base. For example, you are operating on short range of 45 miles and you are told to sector scan. When you have adjusted the sweep, the range displayed will be 90 miles but the range switch will still be on short range. This method of expanding one sector of 360 degrees enables you to read and report all targets within that sector much more easily.

"B" SCOPE

The "B' scope was developed which made targets at short range appear farther apart on the screen, thus providing still more accurate target data. Because of this expansion factor, the "B" scope is sometimes referred to as an "expanded 'B' scope." Compare the sector of 325 degrees to 045 degrees as seen on a PPI scope and how it is expanded on the "B" scope. Due to the expansion factor, the "B" scope is used primarily as a short range scope.

The "B" scope presents a limited map type picture on a 4½-inch square screen. The sweep moves across the screen as a line extending from the bottom of the tube to the top of the CRT. The sweep will be visible only when the antenna rotates through the sector for which the unit is adjusted. The "B" scope is designed to cover either a 45 degree sector or a 90 degree sector.

Range is represented by lines (range markers) which run horizontally across the scope and spaced at 10 mile intervals. Range is read from the bottom to the top of the CRT.

Azimuth is indicated by vertical lines (azimuth markers) extending from the bottom of the scope to the top. Azimuth is determined by reading from a predetermined reference at the center of the scope to the right or left. Each angle marker indicates 10 degrees.

As on the PPI scope, every fifth range marker is brighter to indicate 50 miles. Every third angle marker will be brighter to designate 30 degree intervals.

Targets, cloud formation, interference, and ground return will show as bright spots or areas of light on the screen. Since moving targets will change position with every sweep, they can be distinguished from the permanent echoes with little difficulty.

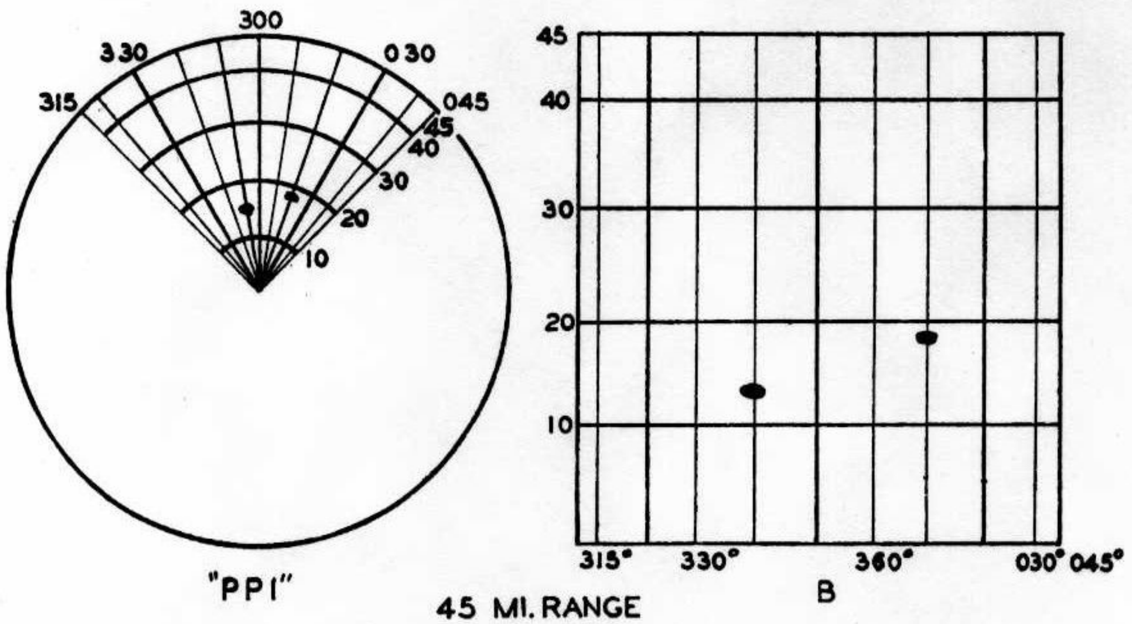


Figure 22. "B" Scope Scanning 90 Degree Sector of "PPI."

"B" SCOPE OPERATIONAL CONTROLS

Several of the controls used on the "B" scope have the same function as on the other scopes. Among these controls are the PANEL BRILL., TRACE BRILL., FOCUS, SIGNAL OFF-ON switch, SIGNAL BRILL., MARKER OFF-ON switch, MARKER BRILL., RANGE switch, RANGE DELAY controls and the ANTENNA SEL. switch. In addition to the above mentioned controls, there are several controls used only on the "B" scope.

NAR.-WIDE AZIMUTH Switch

This switch allows you to scan either a 45 degree sector or a 90 degree sector. If the switch is set on the NAR. position, only 45 degrees will be scanned. To scan a 90 degree sector, the switch must be set on the WIDE position.

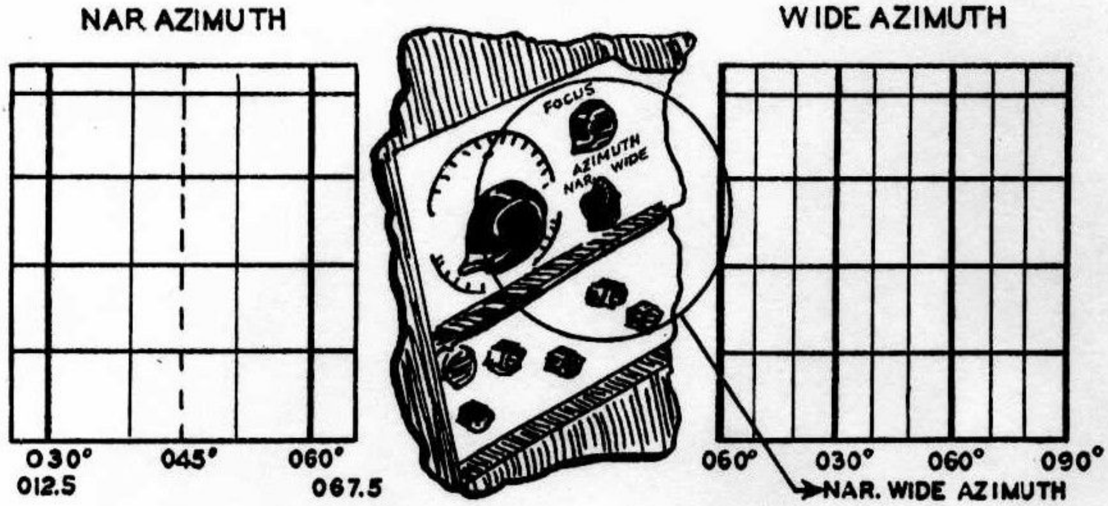


Figure 23. "B" Scan Showing 45 and 90 Degree Sector.

AZIMUTH CENTER Control

To choose one certain sector, the AZIMUTH CENTER control is used. The point at which the AZIMUTH CENTER control is set will appear on the center of the scope. For example, if the NAR.-WIDE switch is set on the WIDE position and the azimuth center is set on 180 degrees, the center of the scope would then represent 180 degrees. Since the scope is set on WIDE azimuth, the left edge of the scope would indicate 135 degrees and the right edge of the screen would indicate 225 degrees.

If, however, the NAR.-WIDE switch is set on NAR. position and the AZIMUTH CENTER remained at 180 degrees, the center of the scope would still indicate 180 degrees. But, the left edge of the scope would then represent 157.5 degrees and the right edge of the screen would indicate 202.5 degrees.

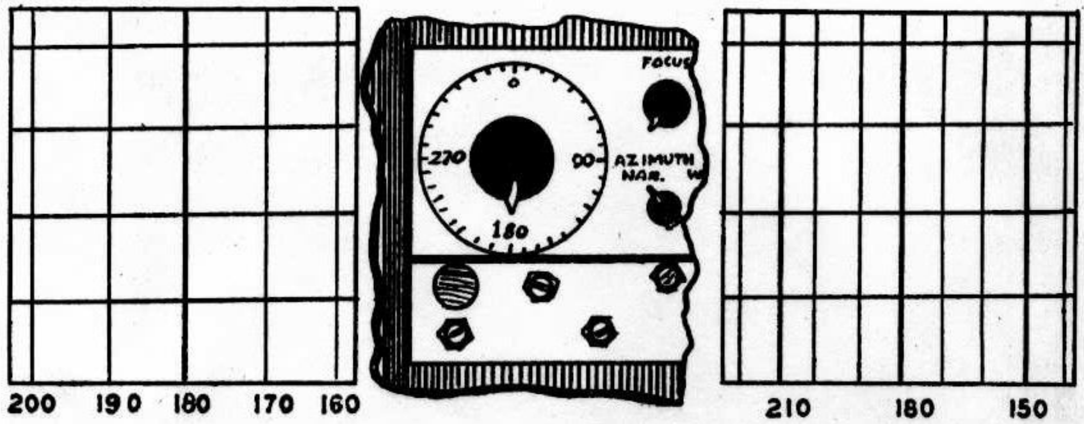


Figure 24. Azimuth Center at 180 Degrees on Narrow or Wide Azimuth.

VERTICAL SHIFT

At times, a blank space may appear at the bottom or top of the scope. By using the VERTICAL SHIFT the entire picture can be moved either up or down until it is properly spaced on the tube and all blank spaces have been removed.

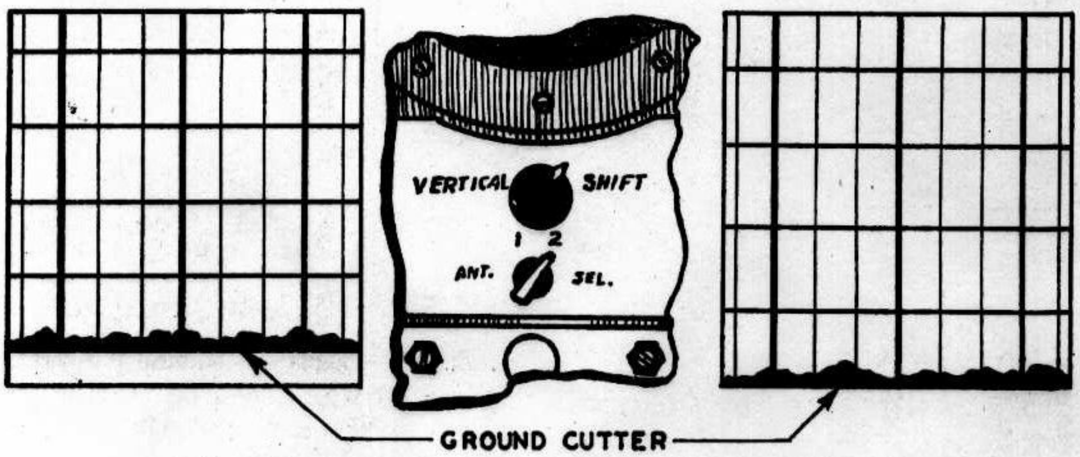


Figure 25. Vertical Shift Either Raises or Lowers Clutter.

CPS–6 HEIGHT RANGE INDICATOR

In addition to the range and azimuth information provided by the PPI and "B" scopes, some method of determining the height of the target had to be developed. To meet this requirement, the HRI type of indicator was designed.

It is essential that the height information be accurate and readily available for use in the desired operation. Accurate height information is used to determine how high our fighters must fly to be above the enemy. Today, several

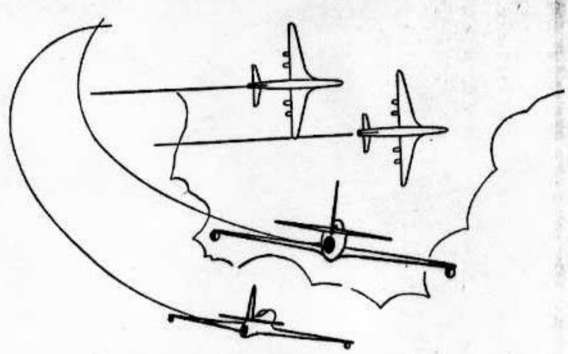


Figure 26. Intercept Aircraft, Through "HRI" Equipment, Have Altitude Advantage.

sets are available which will give the desired height information.

One method developed is that employed by the CPS–6. This method is known as "V-Beam Height Finding." This name results from the use of two antenna systems which produce beams as angles to each other in the shape of the letter "V". One of these beams is at right angles to the earth's surface and is called the vertical beam. The second beam, called the slant beam, is tilted at a 45° angle to the vertical beam.

The antenna rotates in such a manner so that the vertical beam hits the target first with the slant beam striking the target second. The higher the target, the longer it takes for the slant beam to hit the target. By using the "V" Beam method, targets up to 40,000 feet can be detected.

The picture presented on the screen of the CPS–6 HRI is seven inches square. Range markers are provided and are vertical lines running from the bottom of the scope to the top. Range is read from left to right, with the 50 mile range markers brighter than the others.

The trace starts in the lower left hand corner of the screen and moves up the scope as the beam sweeps through the angle of elevation. The HRI will present the returning echoes from both the slant antenna and the search antenna. Therefore, one target will be represented by two pips on the indicator. The vertical distance between the two pips will represent the height of the target.

The placing of the pips on the CRT from both antennas is controlled by the *phasing unit*. This unit is located on the left side of the console. At approximately 10 degrees above the base-line, a microswitch in the phasing unit will remove the vertical beam signals from the CRT and replace them with the signals from the slant antenna for the remaining portion of the sweep. The point at which the changeover takes place is called the "video switching point." Practically no visible evidence of this action is noted on the scope.

The height of the targets is read by use of height lines which are drawn on plexiglass overlays. These overlays are located in a viewing tunnel which is attached to the face of the scope. There are two overlays, one for short range and one for long range. Note on illustration that the solid lines each represent 10,000 feet. The dotted lines on the short range overlay indicate

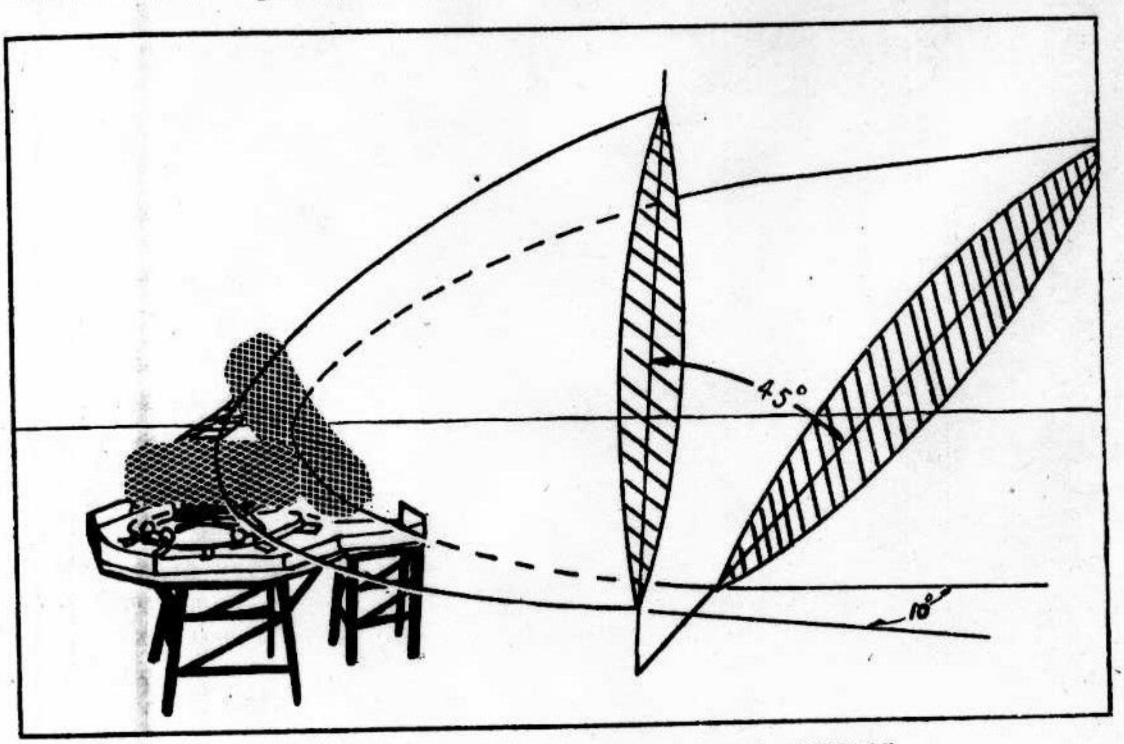


Figure 27. The "V" Beam Antenna as Used on the "CPS–6."

5,000 feet intervals. At the bottom of each overlay is a line called the *index line*. When the index line bisects the lower target, the position of the upper target will represent the height. To read the height of targets that appear between the lines, you must estimate as close as possible.

The CPS–6 HRI is just one of the several types of height indicators that you will use. Accurate height information is as important as accurate range and azimuth information. It is necessary, therefore, that you become familiar with the operation of all types of HRI scopes.

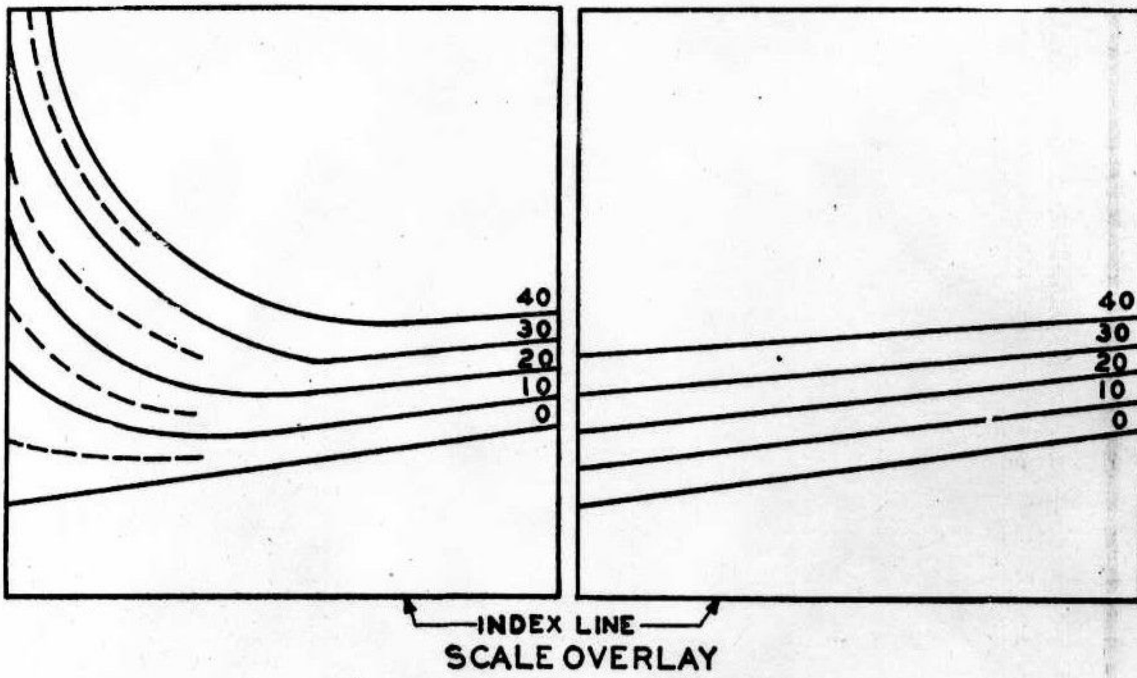


Figure 28. Scale Overlay Short and Long Range Presentation.

CPS–6 HRI OPERATIONAL CONTROLS

The controls the operator will use on the CPS–6 HRI are limited as on the PPI and "B" scopes. Once again, the controls used by the operator on the HRI are similar to those found on the other indicators. Controls such as the PANEL BRILL., TRACE BRILL., SIGNAL OFF-ON switch, SIGNAL BRILL., FOCUS, RANGE MARKER OFF-ON switch, and the RANGE MARK BRILLIANCE serve the same purpose on the HRI scope as they did on the PPI and "B" scopes.

RANGE Switch

The RANGE switch on the HRI has two ranges, Short and Long range. Short range is set for 10 to 80 miles while the Long range will cover from 70 to 140 miles. The RANGE switch will also change the plexiglass overlays in the viewing tunnel.

Viewing Tunnel Controls

On the left side of the viewing tunnel is the *BRILLIANCE control* which will provide illumination for the plexiglass overlays allowing the operator to read the height of the targets.

On the right side of the viewing tunnel is the *SCALE POSITIONING knob*. This control is used to move the overlay up or down so that the lower target can be bisected or "split" by the index line. Remember that it is necessary for the lower target to be bisected by the index line before accurate height information can be obtained.

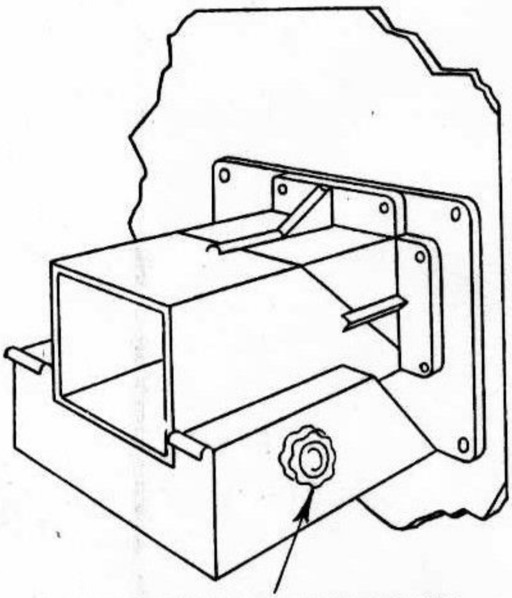


Figure 29. Tunnel Controls "CPS–6" "HRI."

AZIMUTH SELECTOR Knob

When you are asked to obtain the height of a target, you are given the track number, range and azimuth. When this information has been given you, turn the range switch to the proper range and then use the AZIMUTH SELECTOR knob to bring the target into view. This control is located on the phasing unit directly beneath an azimuth dial.

Turn the azimuth selector knob until the desired azimuth reading appears on the azimuth dial. Two targets should then appear on the scope. If only one target appeared, the AZIMUTH SELECTOR must be adjusted until two targets appear so that a height reading can be obtained.

CPS–4 HEIGHT RANGE INDICATOR

When a situation arises when it is impossible to set up a large radar installation such as the CPS–6, a combination of several smaller sets is employed. To provide search information, the CPS–1 or the CPS–5 is used. To determine the height of the targets detected by the search set, the CPS–4 is relied upon.

The search set, whether it is the CPS–1 or the CPS–5, uses a normal search antenna rotating through 360 degrees. The antenna on the CPS–4 differs from the search antenna in that it tilts up and down between the limits of 32 degrees above and 2 degrees below the horizon. Rotation of the antenna through 360 degrees is made possible by the use of a manual azimuth control. The illustration shows the scanning operations of the antenna for the CPS–4.

The search information supplied by the CPS–1 or the CPS–5 is displayed on a normal PPI scope. However, an additional unit called the azimuth control unit is placed over the face of the PPI scope. Located in the lower right hand corner of the unit is the *AZIMUTH CONTROL* knob. When a target is picked up on the PPI and the height of the target is desired, turn the AZIMUTH CONTROL knob until the azimuth pointer on the control unit bisects the target on the screen. By position-

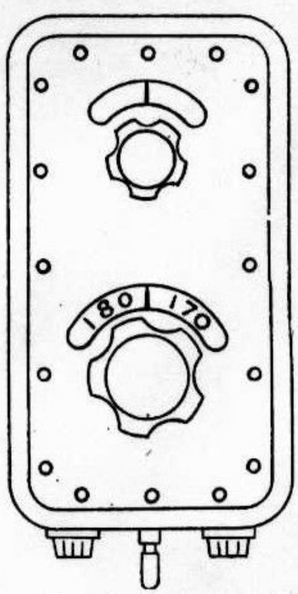


Figure 30. Phasing Unit "CPS–6."

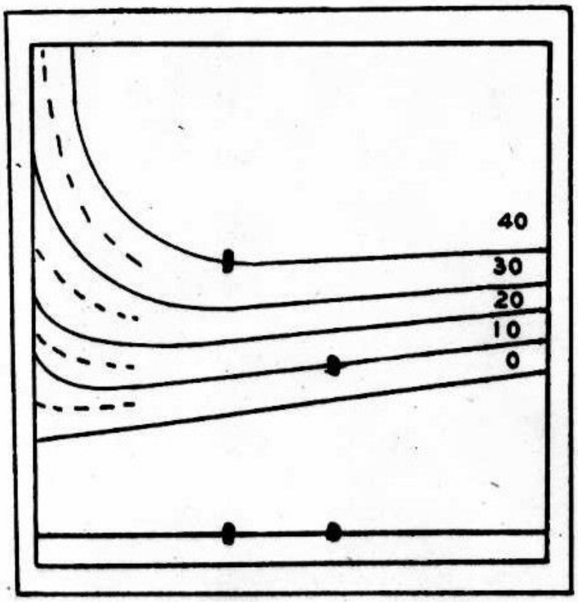


Figure 31. Two Targets on "CPS–6" HRI.

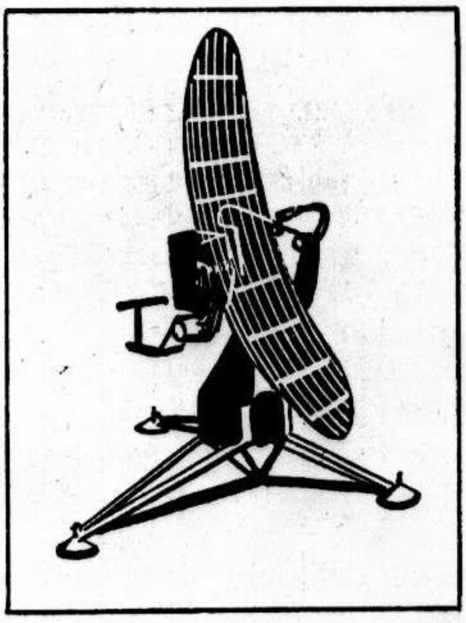


Figure 32. CPS–4 Antenna.

ing the pointer on the target you have rotated the CPS–4 antenna until it is scanning the area in which the target is located. Therefore, the HRI scope will show an indication even though the search antenna continues to rotate.

The scope presentation and operation of the CPS-4 HRI differs from that of the V Beam HRI.

The sweep will originate in the lower left hand corner of the scope which will represent the location of the radar installation. As the antenna tilts up and down at the rate of 30 times per minute, the sweep will move up and down the scope in conjunction with the antenna movement. Range markers, representing 10 mile intervals, are shown on the scope as vertical lines. By using the range markers, range will be read from left to right. To aid you in reading range, every fifth marker is brighter to indicate 50 miles.

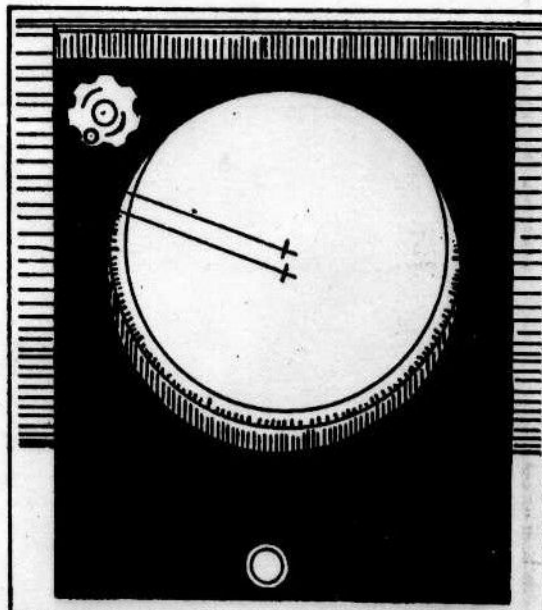


Figure 33. "PPI" Scope Used With "CPS–4."

Targets picked up by the CPS–4 antenna will appear as bright spots on the indicator. Height is determined by the use of horizontal lines etched on an overlay which covers the face of the scope. There is an overlay for each of three ranges; 45 mile, 90 miles, and 120 miles. Altitudes, measuring to 40,000 feet can be determined. The height lines etched on the overlay will be curved similar to the shape of the earth and will indicate 1000 foot intervals. The CPS–4 HRI will show only one indication for each target as compared to the two indications presented by the CPS–6 HRI. To determine the height of targets which fall between the height lines, you must estimate to the nearest 1000 feet.

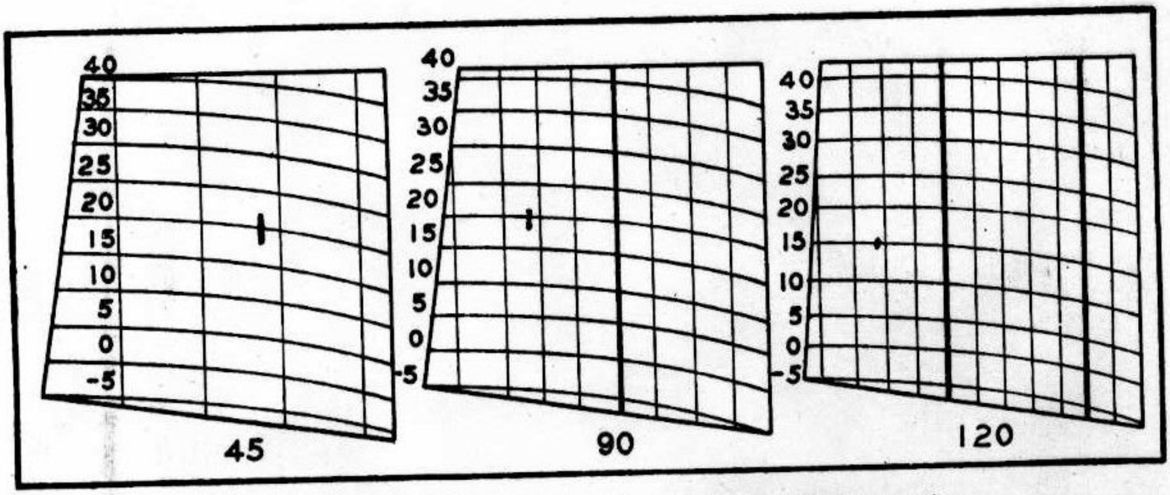


Figure 34. Short, Medium and Long Range "CPS–4" HRI Presentation.

CPS–4 OPERATIONAL CONTROLS

Most of the controls used by the operator on the CPS–4 HRI are similar to those used on the other types of indicators and serves the same function. Among these are the PANEL BRILL., FOCUS, TRACE BRILL., SIGNAL BRILL., RANGE MARKS switch, and the RANGE MARK BRILLIANCE. In addition, there are several controls which will be new to you.

RECEIVER GAIN

When the signal on the CRT is weak and the SIG. BRILL. is turned all the way up, it may be possible to obtain a stronger indication by adjusting the RECEIVER GAIN. By using the RECEIVER GAIN, you adjust the sensitivity of the receiver allowing a stronger signal to be applied to the CRT.

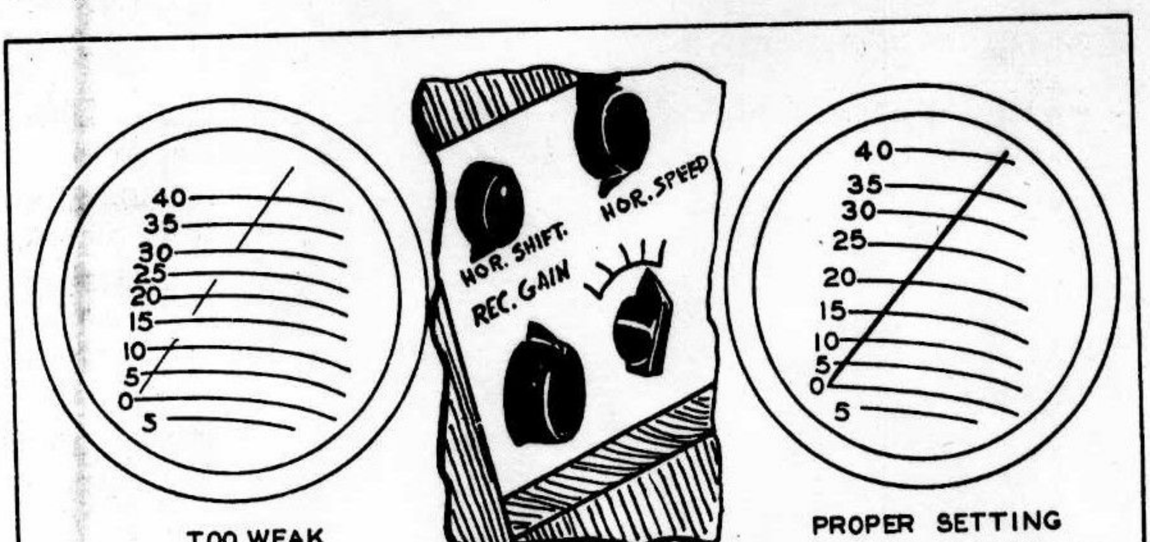


Figure 35. Proper Adjustment of Receiver Gain on "CPS–4" HRI.

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RANGE Switch

This switch has two positions, *S*hort and *L*ong. On Short range, either the 45 mile or the 90 mile overlay will be used. When the switch is changed to the Long range, then the 120 mile overlay must be used. It is obvious then, that when you change ranges, it is necessary to change your height overlays. If you change from 45 mile to 90 mile, the RANGE switch will remain in the "S" position but a maintenance man must be summoned to set up the range markers on the scope to coincide with the new range.

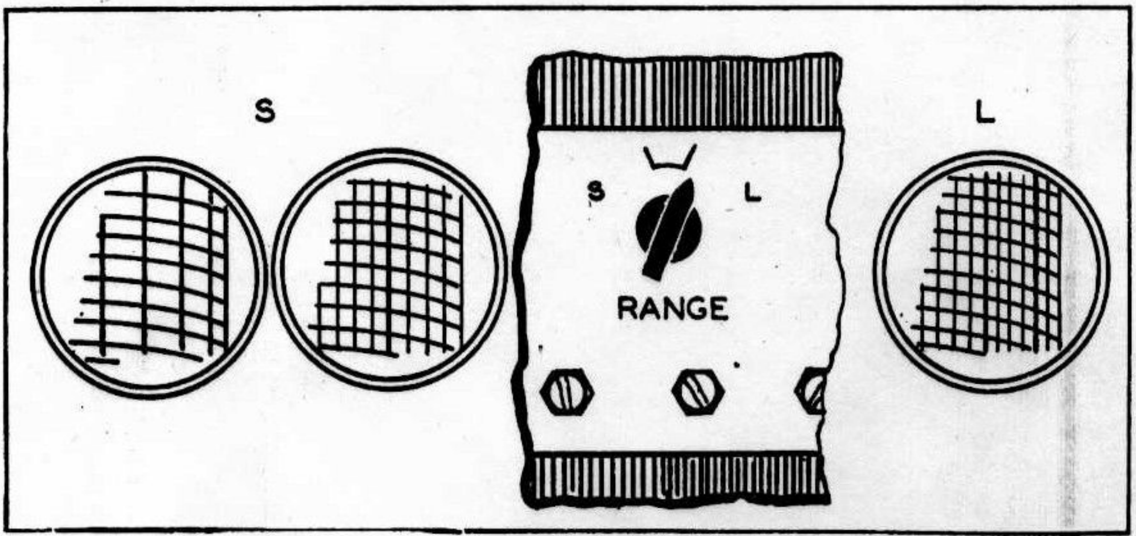


Figure 36. Short and Long Range Presentation "CPS–4."

RANGE BLANKING

To eliminate ground return on distances from 0 to 4 miles at the beginning of the sweep, a RANGE BLANKING switch is provided. It has 5 positions numbered from 0 to and including 4. The number of the position being used will indicate the number of miles you are "blanking out."

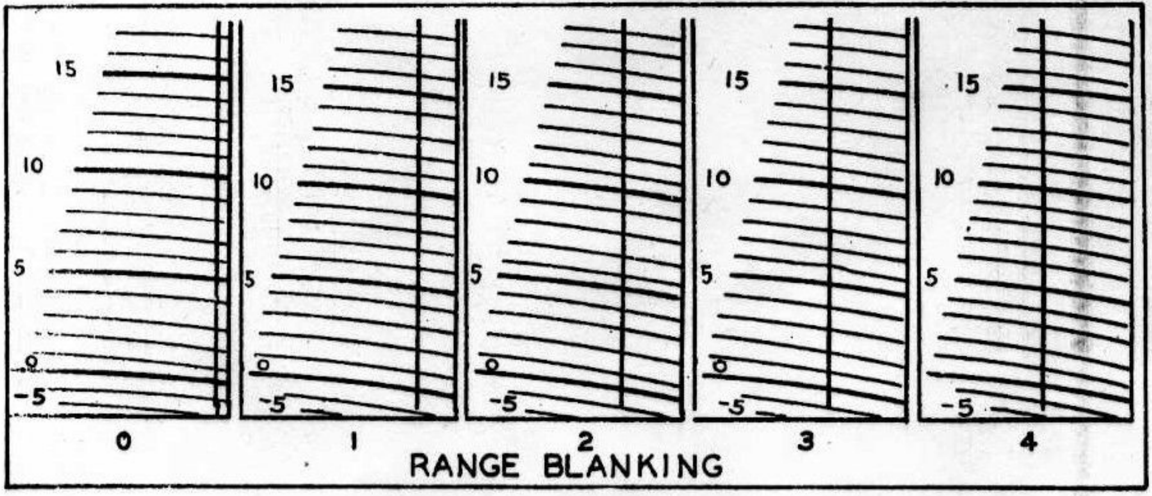


Figure 37. Range Blanking Switch "CPS–4" HRI Indicator.

HEIGHT DATA TRANSMITTER AND RECEIVER

The height data transmitter and receiver take no part in the actual determination of height but provide an important function in the tactical use of the set by conveying the height data from the height operator to the controller.

Height Data Transmitter

When an enemy plane or formation is picked up and its height is determined by the HRI, this height is set into the height data transmitter by turning the right hand crank until the height in feet is registered on the red dial. The button in the center of the crank is pushed, thus starting a timer at the height data receiver. At the same time, the height of the friendly planes which are assigned to intercept the enemy is set into the height data transmitter by turning the left hand crank until the height is shown on the green dial. Then, the button in the center of this crank is pushed, starting another timer at the height data receiver.

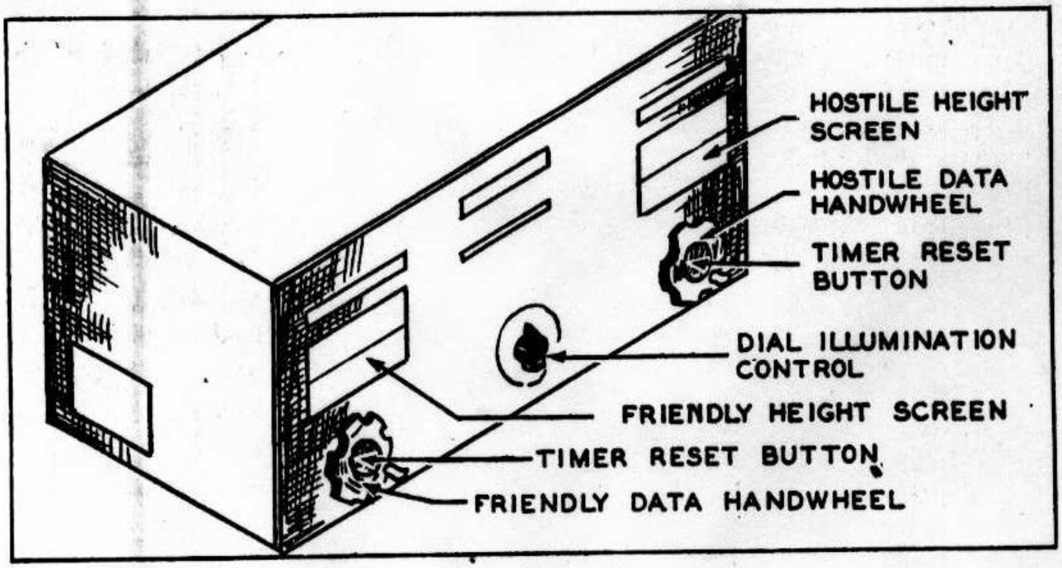


Figure 38. Height Data Transmitter.

Height Data Receiver

By electrical means, the height data of the friendly and enemy planes set into the height data transmitter appears simultaneously on the data receiver located atop the controller's PPI. As in the case of the transmitter, the data on the enemy planes will appear on the right hand dial in red, while the data on the friendly planes will appear on the left in green. The difference between the two heights appears automatically on the center dial. This information will appear in green if the altitude of the friendly plane is higher than the enemy. If the enemy is higher than the interceptors, the information will appear in red. By observing the timer above each height dial, the controller can tell exactly how long ago the height data was transmitted up to a maximum of 120 seconds.

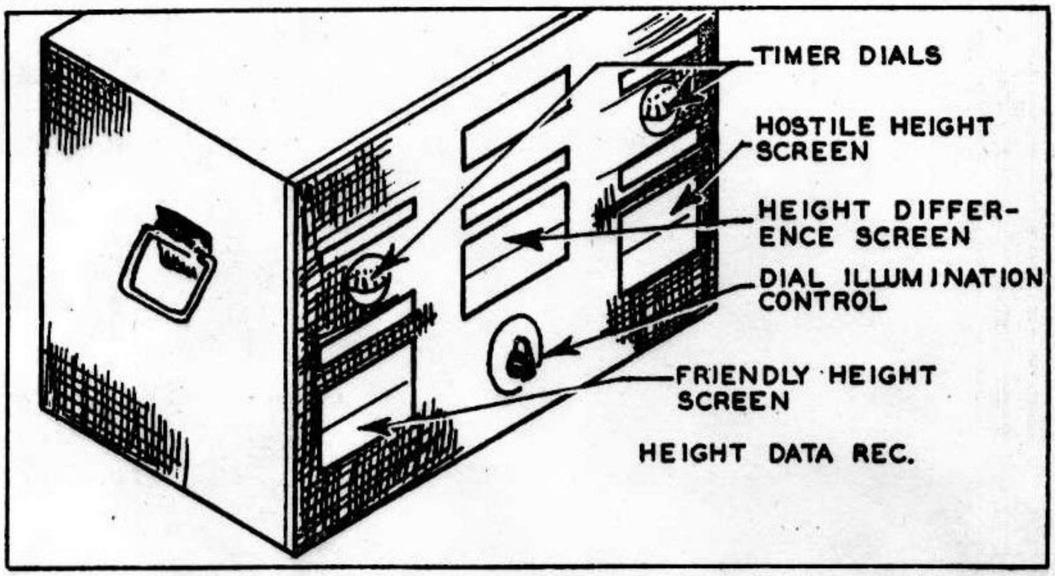


Figure 39. Height Data Receiver.

TPS–10A HEIGHT RANGE INDICATOR

A smaller and more compact unit designed for use in Early Warning Stations is the TPS-10A. Its purpose is to provide height information to supplement the search information provided by the TPS–1B or comparable set. The TPS–10A is easily transported and can be carried into mountainous terrain or forward positions with little difficulty.

The antenna action of the TPS–10A is similar to that of the CPS–4. The TPS–10A antenna tilts up and down from 2 degrees below to 23 degrees above the horizon at the rate of 60 times per minute. The TPS–10A antenna differs from that of the CPS–4 antenna in that it will rotate automatically through 360 degrees while the CPS–4 antenna must be turned manually.

The scope presentation of the TPS–10A is very similar to that of the CPS–4. The major difference is in the size of the CRT. The CPS–4 uses a 12 inch CRT while the TPS–10A employs a 7 inch tube. As the antenna tilts up and down, the sweep which originates in the lower left hand corner of the tube will move up and down the face of the CRT. Targets, cloud formations, interference, and ground return will appear as bright spots or areas on the screen. As on the CPS–4, one indication will appear for each target as compared with two indications for each target on the CPS–6 HRI.

Range markers on the TPS–10A are vertical lines spaced at regular intervals representing 10 miles. The range of the TPS–10A is limited to 60 miles and is read from left to right across the scope. There is no MARKER OFF-ON switch or MARKER BRILLIANCE control provided.

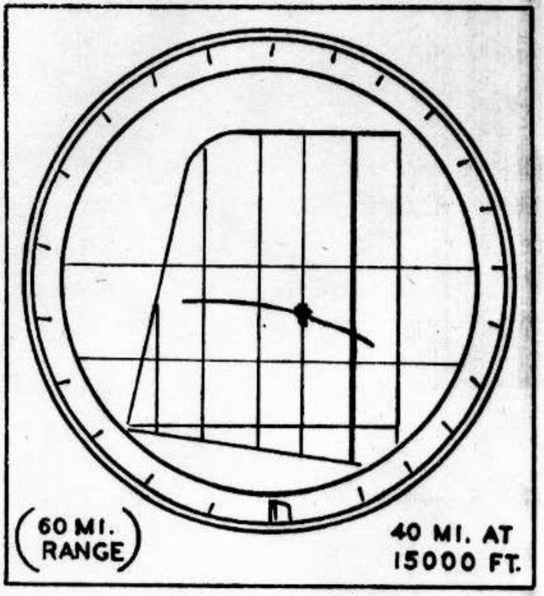


Figure 40. TPS–10A Indicator.

Azimuth can be determined by the use of the *azimuth dial* located to the left of the CRT. As the antenna rotates, the azimuth dial will also rotate thus indicating the azimuth at which the antenna is pointing. Azimuth readings are taken when the target echo appears brightest on the HRI screen.

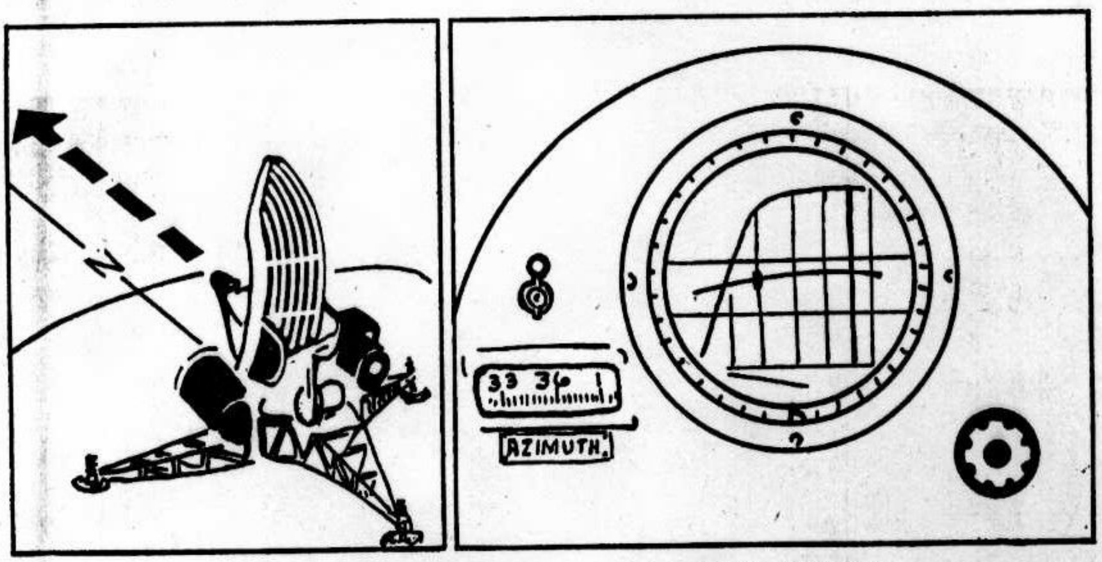


Figure 41. Method of Determining Azimuth With TPS–10A.

Determination of height is different from the method used on the CPS–4 or the CPS–6 HRI. Notice in the illustration that there is a plexiglass bar across the face of the tube. A "cursor line" is drawn on the plexiglass bar when the set is calibrated for operation. Around the face of the scope is a height dial calibrated in thousands of feet up to and including 35,000 feet, the maximum height at which targets can be picked up by the TPS–10A. To the right of the tube, is a *HEIGHT knob*, which controls the action of the plexiglass bar. When a target is picked up, turn the HEIGHT knob until the cursor line bisects the target. Then refer to the bottom of the scope and read the height off the height dial.

To control the action of the antenna, a small unit called the azimuth control box is provided. The azimuth control box has two toggle switches with each switch having three positions from left to right are (1) search; (2) off; (3) sector scan. The positions of the second switch are (1) counter-clockwise; (2) off; (3) clockwise.

With the first switch in search position, the antenna will rotate 360 degrees clockwise or counter-clockwise or will not move depending upon the position of the second switch. When the first switch is in the OFF position, the antenna will not move. When you switch to the third position, the antenna will start to sector scan. The sector that is to be scanned must be set up at the antenna by the maintenance personnel.

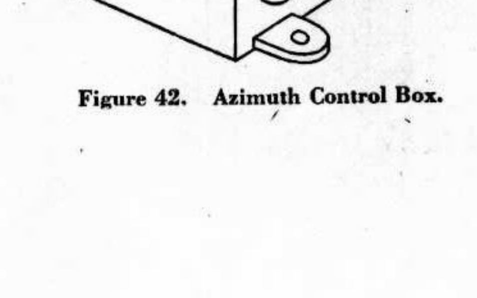


Figure 42. Azimuth Control Box.

TPS–10A OPERATIONAL CONTROLS

In addition to the azimuth dial and the HEIGHT KNOB, there are several other controls used in setting up the TPS–10A scope for operation.

INTENSITY Control

This control you have used before but under a different name. This is the TRACE BRILL. control, for it will brighten or dim the trace.

As on all scopes, never turn the INTENSITY too high for it will blot all weak signals. Too low a trace, will prevent the "painting" of a picture.

FOCUS Control

This control is common to all scopes. Without it, a clear distinct picture is impossible to obtain. This will remove the fuzzy and blurry appearance of the picture.

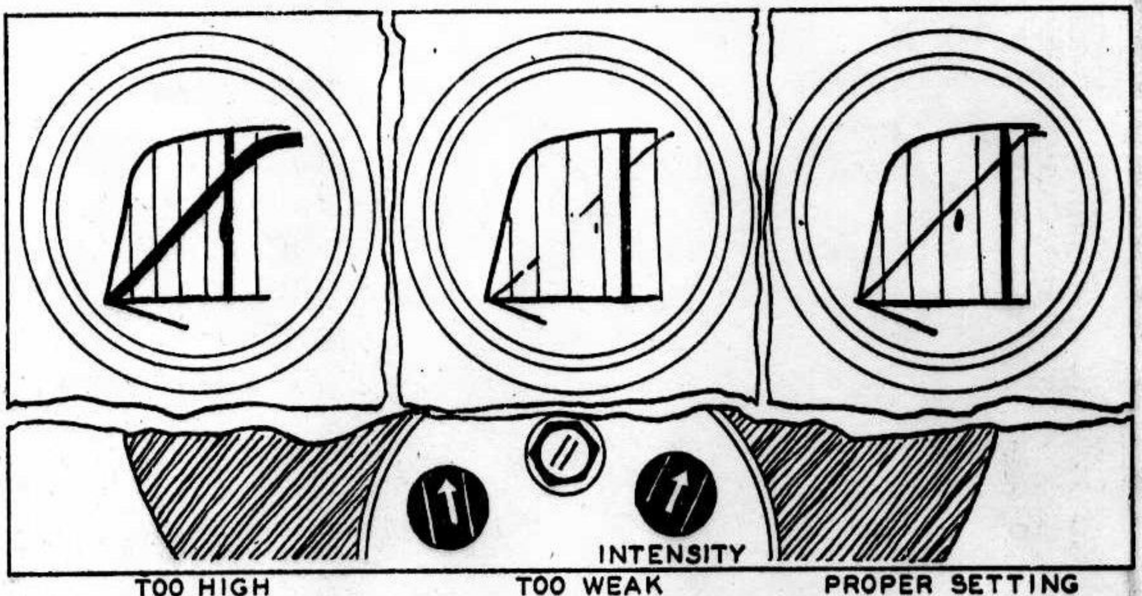


Figure 43. Proper Adjustment of Intensity on TPS–10A.

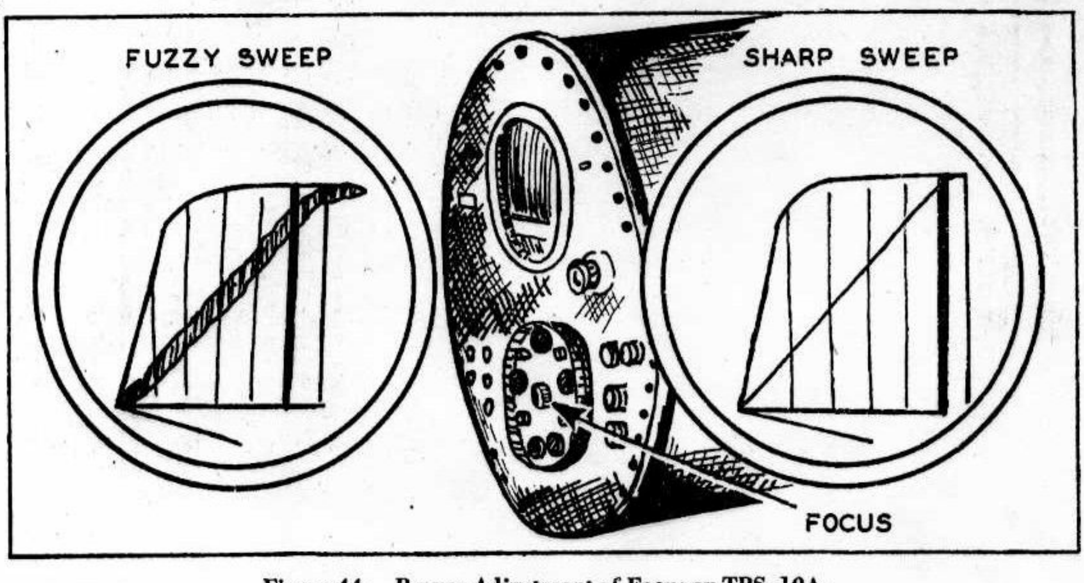


Figure 44. Proper Adjustment of Focus on TPS–10A.

VIDEO Control

On other scopes, this is the SIG. BRILL. control. If it is too low, weak targets will not be picked up. If it is too high, reading targets will be difficult because of the bright glow on the screen.

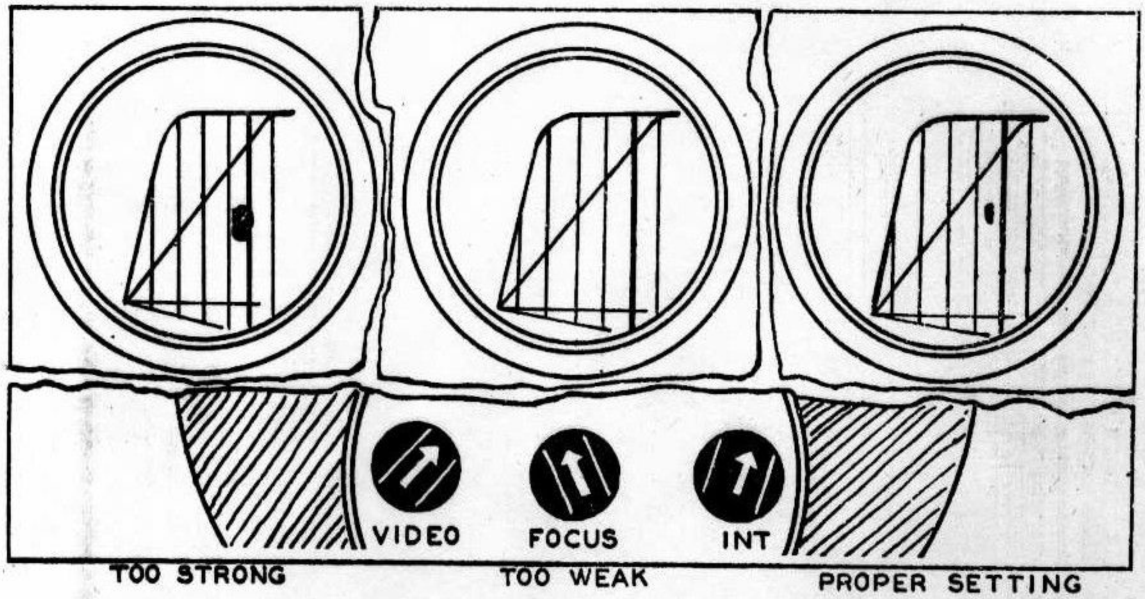


Figure 46. The A. J. Switch Minimizes Jamming.

HIGH VOLTAGE Switch

This switch supplies the operating voltages to the scope. Turn it to the ON position for operation.

ANTI-JAMMING Switch

It is well known that jamming techniques are used by the enemy to decrease the efficiency of the radar set. When jamming is detected, report it in the proper manner and then turn on the ANTI-JAMMING switch. In doing so, you are, in effect, "detuning" your receiver thereby minimizing the effects of the jamming.

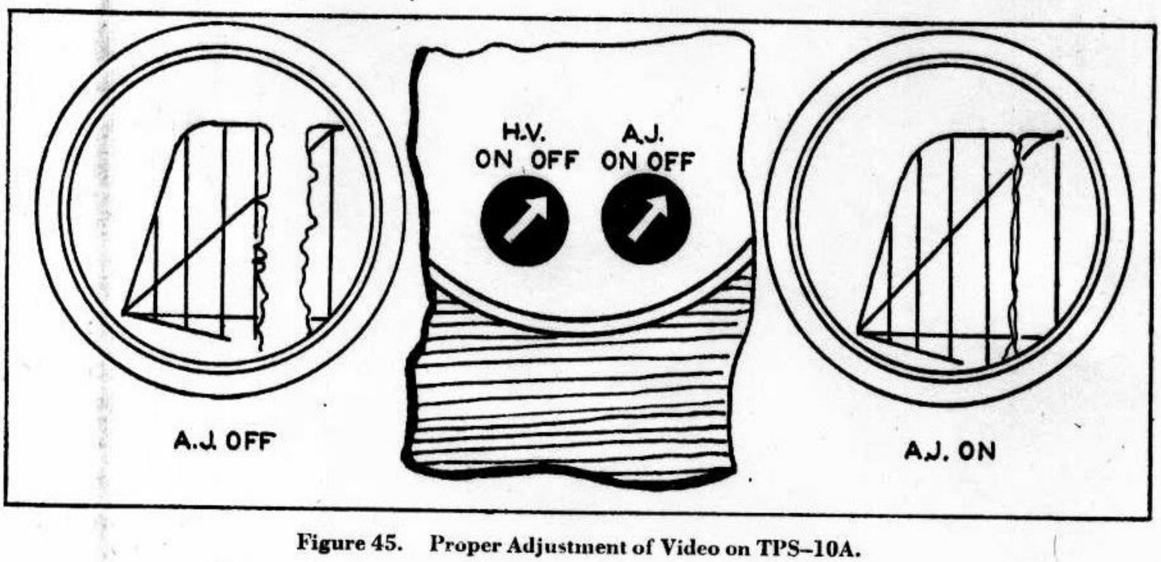


Figure 45. Proper Adjustment of Video on TPS-10A.

CONCLUSION

Correct and efficient operation of all scopes is imperative if the AC & W System is to carry out its mission with success. This responsibility falls upon the shoulders of you who are to be the radar operators. It is necessary that you utilize your laboratory periods to the utmost efficiency if you are to become proficient in your work. Practice and more practice is the key to both your success and the success of the AC & W System as a whole.

Quick and accurate utilization of every control at your disposal is essential so it is absolutely necessary that you know what each and every control will do. Remember that scope operation is carried out with a minimum of shelter illumination available. Every second you spend fumbling with the controls means miles of uninterrupted flight for a hostile plane winging its way toward its designated target which may be *your radar installation.*

Remember that the scopes you operate are essentially the "eyes" of the AC & W System. They provide the basic information through you, the opreator, upon which every other member of the AC & W organization is dependent if they are to carry out their duties. This is true even in the fighter squadrons, for the pilots depend upon you to provide accurate up-to-the-minute information concerning any and all hostile raids. Without good, efficient, trained operators, the AC & W organization will fail in its primary mission of providing air raid warning and ground control of intercept aircraft.

QUESTIONS

1. What is the portion of a radar set that presents a picture of the area being searched called?
2. What unit in the Cathode Ray Tube starts the electrons flowing?
3. What are the deflection plates used for in a Cathode Ray Tube?
4. How is the sweep presented on the fact of an "A" Scope?
5. What is the difference between an "A" Scope and a PPI Scope?
6. If the INTENSITY control is turned up too high on a Cathode Ray Tube, what harm could result?
7. Of what use is the vertical and horizontal centering control on the "A" Scope?
8. What is the main use of the RANGE DELAY on a PPI Scope?
9. If the sweep on a PPI Scope is pointing to 090°, what direction is the antenna pointing?
10. Will a PPI Scope give you a full 360° coverage?
11. If the signal switch is in the ON position, will it be possible to pick up targets?
12. What are the ranges of the PPI Scope on the CPS–6?
13. Of what advantage is the antenna selector switch of the CPS–6?
14. Why is it advantageous to be able to Sector Scan with the PPI Scope?
15. Why are targets distorted at short ranges on the "B" Scope?

IDENTIFICATION FRIEND OR FOE

Scope: Explanation of IFF and its operation.
Student Objective: To learn and understand the theory and operation of IFF.
References: T. O. 16-30TPS 1-5, T. O. 16-30 TPS 10-6, T. O. 16-30CPX 1-2.

INTRODUCTION

When the presence of an aircraft or surface vessel is detected by radar or other means, it is necessary to determine whether the target is friendly or hostile. This may be accomplished either by *recognition* or *identification.* Recognition implies that the target is established as friendly or hostile by visual observation. Identification means that the friendliness or hostility of the target is determined by means other than visual.

Methods of Identification

One method of identification is the process of elimination based on the knowledge of the movements of friendly aircraft and surface vessels. This method involves the use of flight plans and shipping schedules. This method also takes time as does visual recognition. It has been found necessary to provide a means of direct identification at the point where the target is detected by radar. Radar sets cannot, in themselves, determine whether a target is friendly or hostile. As a result, various systems have been designed which allow aircraft and surface vessels to establish their friendliness, either directly to the radar search set or additional apparatus associated with the radar set. Such systems are known as *I*dentification *F*riend or *F*oe (IFF).

MARK III IFF

Introduction

One of the systems developed is the Mark III IFF. This system consists of two separate units, a ground unit and an airborne unit. The ground unit will send out r-f energy in the form of pulses as does the radar search set. However, instead of receiving reflected signals as the radar search set, the IFF receiver will pick up a re-transmitted pulse. The re-transmitted pulse is sent out from the aircraft which picks up the original pulse, codes it, and then re-transmits it to the IFF set.

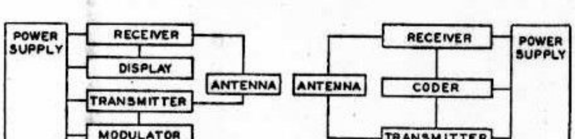


Figure 1. Block Diagram Typical IFF Set.

Interrogator-Responsor

The ground unit called the *interrogator-responsor* is located near the search set. It consists of a transmitter, modulator, receiver, display unit, antenna and power units. The transmitter and modulator make up the interrogator part of the system while the receiver and display units make up the responsor unit. One antenna is used for both transmitting and receiving. Pulses from the transmitter are fed to the antenna. By rotating the antenna the operator can examine the surrounding area with radio waves in the same manner a radar set searches a certain area.

Transpondor

When a friendly aircraft is interrogated, the *transpondor unit* in the aircraft itself goes into action. The transpondor consists of a receiver, coding unit, transmitter unit, antenna and power suply. The receiver detects the interrogation pulses, amplifies them, and passes them to the coding unit. The pulse width is varied in the coding unit but the same rate of repetition is maintained. The coded pulses are passed to the transmitter which transmits them. Because of the added "push" given to the original interrogator pulses by the retransmission of the pulses by the transpondor, the IFF equipment with its very low power will have the same range as the larger and more powerful radar set.

Receiver-Unit—(Interrogator-Responsor)

The returned coded pulses are picked up by the receiver unit on the ground. The receiver will amplify the pulses and pass them to the display unit. Since there is little delay in the transpondor, the time lapse between the transmission of the interrogation pulse and the reception of the coded reply can be used to accurately measure range.

The IFF equipment operates at a band of frequencies different from that of the radar sets. The transpondor transmitter and receiver will cover the entire IFF band of frequencies. The interrogator-responsor operates at one spot frequency within the IFF band.

Coding

The transpondor, when operating, will sweep through the entire IFF band every 2½ seconds. This means that any interrogator responsor will be answered every 2½ seconds. The coding of the returned pulses is arranged so that the transpondor will return to the interrogator every 2½ seconds, either no reply, and *narrow* pulse or a *wide* pulse. There is one exception. When the aircraft is in distress only very wide pulses will be transmitted by the transpondor. The wide pulses must be at least 2½ times as large as the narrow pulses and the very wide pulses must be at least twice as large as the wide pulses.

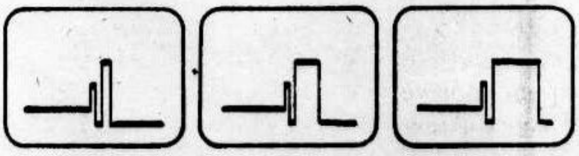


Figure 2. Typical Code Presentation of CPX–1 IFF.

The seven codes are set up as in the following table:

Code Pos.	1st Sweep	2d Sweep	3d Sweep	4th Sweep
1	N	N	N	N
2	N	--------	N	--------
3	N	N	N	--------
4	N	N	W	W
5	N	--------	W	--------
6	N	N	W	--------
7	VW	VW	VW	VW

AN/CPX–1

Introduction

The CPX–1 is an IFF unit capable of identifying aircraft detected by an associated radar search set. The maximum effective range of the CPX–1 is approximately 250 miles.

The CPX–1 is an interrogator-responsor unit consisting of a transmitter, receiver, control unit, indicator unit and antenna.

The transmitter sends out the interrogation pulse and the receiver picks up the returned signal from the transpondor. The control unit enables the IFF and associated radar sets to work together. The control unit also houses a modified "A" scope on which the received signals will appear. The indicator unit controls the action of the antenna which is used for both transmitting and receiving.

When the IFF operator is asked to interrogate a target by the height tote coordinator, he is given the azimuth and range in addition to the track number.

Determining Azimuth

To pick up the target to be interrogated, the operator must turn the antenna to the azimuth given him. This is accomplished by rotating the *azimuth dial* manually. The antenna is connected to the dial in such a way so as to follow the rotation of the dial. To make sure that the antenna is pointing in the direction the dial reads, a "tuning eye" is provided. When the antenna points in the direction the dial reads, the tuning eye will close.

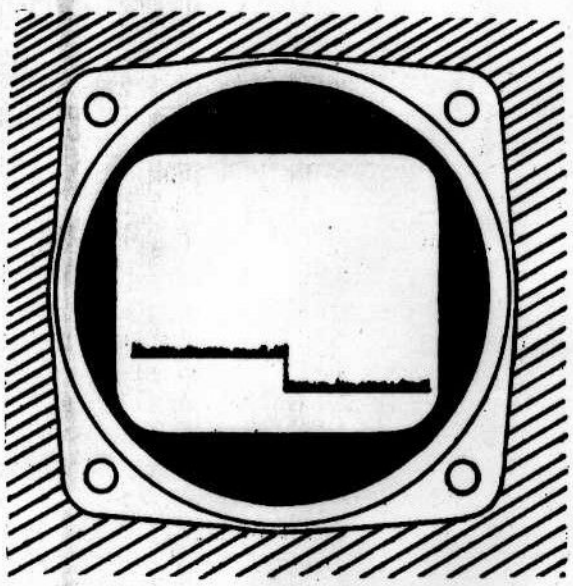


Figure 3. CPX–1 IFF Indicator Presentation.

Range Control

It is not the purpose of IFF to determine range. It is the purpose of IFF to see if a response will come from a plane at a range already determined by an associated radar search set. To do this, special features have been incorporated in the design of the CPX–1.

We mentioned previously that modified "A" scope was used to display the returned signals. On a normal "A" scope, the sweep will be a straight line across the scope. On the CPX–1 indicator, a "step" is provided in the trace line. When an "A" scope is modified by the use of a step, it is referred to as an "M" scope. The step is merely the point where the sweep drops downward. It is a reference line when making range measurements. The point at which the step is set can be adjusted by the operator by use of the *range* control. Suppose you are asked to interrogate a target at 125 miles. The CPX–1 is set on the 250 mile range. You will turn the range control until it reads 125 miles. The step will then be positioned at 125 miles on the sweep. If the target is friendly, the returned pulse will appear directly above the step.

Expanded Sweep

To further check the accuracy of a target return, you will use the 30 mile range position. When the range switch is changed to this position, you will be using an "expanded" sweep. On the 30 mile range, any 30 mile section can be made to appear by use of the range control. For example, you wish to cover the section of the 250 mile range from 150–180 miles. Set the range control on 165 miles and the 150–180 mile section will appear on the scope. The range control is set on the *midpoint* of the 30 mile section you wish to scan. Fifteen miles on both sides of the midpoint will then appear on the scope. On the 30 mile range, the step will remain stationary while the pips will appear to move across the screen.

Lobe Switch

To check the azimuth of a particular target, the CPX–1 employs the use of the *lobe switch* and the *spread control*. Normally, the CPX–1 antenna sends out 3 lobes. When the lobe switch is turned on, the middle lobe is cut off and only the two side lobes are sent out. At the same time, the spread control is turned to its extreme clockwise position. When this is done, 2 pips will appear on the sweep instead of 1 pip. If the pip on the right is higher than the one on the left, the antenna is pointing to the left of the target. If the left hand pip is higher, then the antenna is pointing to the right of the target. When the two pips are of equal height, the antenna is pointing directly on the target. The operator adjusts the antenna by using the azimuth dial until the two pips are of equal height. Refer to illustration.

Operating Procedures

Coordinating the above material, the following procedure will be followed in operating the CPX–1 in a GCI station. When an initial target appears on the plotting board, the height tote coordinator will immediately give the track number, azimuth and range to the IFF operator. The IFF operator will turn on the interrogation switch and set the range switch on the 30 mile range position and turn the range control to the reading given by the height tote coordinator. The interrogation switch will cause the transmitter to transmit interrogation pulses. He will then adjust the antenna to the azimuth given by rotating the azimuth dial. If a target appears, the IFF operator will utilize the lobe switching arrangement to determine if the target is the one in question. This will enable the operator to check the azimuth of the target he has picked up with the azimuth given by the height tote coordinator. If a target appears, an affirmative report including the code number will be given to the height tote coordinator. If no target appears, a negative report will be given. The report given will be posted on the height tote board by the height tote clerk. If the track is designated as hostile, an interception will then be activated.

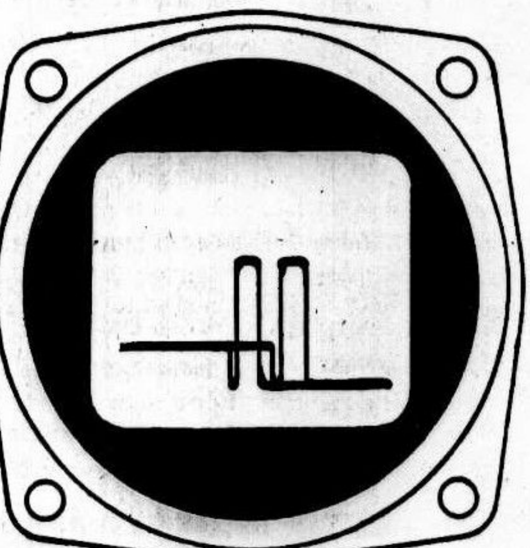


Figure 4. Matching Size of Pips on CPX–1, IFF Set, When Using Lobe Switch, Determines True Azimuth.

Introduction

Another IFF set smaller and more compact, will also be studied. This set, the TPX–1 is used as identification equipment with the TPS–1B and TPS–10A.

Since the set is small and compact, no indicator is included with the set. To display the returned pulses, it uses the "A" scope of the associated radar set. The IFF pulses will appear at the trailing edge of the radar signal. The range, therefore, is limited to the range of the "A" scope. The maximum range of the set, however, is 120 miles.

Azimuth

Azimuth is determined by the use of the *remote antenna drive* unit. The unit consists of an azimuth dial mounted on a tripod which is connected to the antenna. When the operator receives the azimuth of the target which is to be interrogated, he turns the azimuth dial to the proper azimuth. The antenna is set up so that it will rotate with the azimuth dial. In this manner, the antenna can be set at any particular azimuth.

Control Box

The operational controls, with the exception of the antenna rotation, are located on a separate unit called the control box. There are three controls which the operator will use; power on-off switch, the interrogator switch, and the receiver gain.

When asked to interrogate a target, the "trigger" switch on the "A" scope must be put in the IFF position. This is done so that possible returned pulses will appear on the "A" scope. The power switch is in the "on" position since the set is always in standby condition. The interrogation switch is then placed in the IFF position so as to enable the transmitter to transmit interrogation signals. The antenna must be rotated to the azimuth given by the remote antenna drive. If no signals appear on the scope, the receiver gain may be adjusted for it increases or decreases the sensitivity of the set. As on the CPX–1, if no signals appear, then a negative report is made. If signals appear, then an affirmative report is made, including the code number.

Conclusion

The TPX–1 and the CPX–1 are not difficult sets to operate but it is important that you learn to use them properly in order that you, as a radar operator, will be able to operate IFF equipment efficiently. Identification of aircraft is a very important phase of operations in the AC&W system. Improper identification can result in interception of a friendly plane or on the other hand, a great amount of damage and number of casualties can result in allowing a hostile flight to reach its target unmolested.

QUESTIONS

1. What methods are used in the AC&W System to identify aircraft as friendly or hostile?
2. What is meant by the word identification?
3. A system of electronic identification is known as?
4. What is the name of the ground unit of the IFF set?
5. Is the antenna used in IFF directional or non-directional?
6. What is the airborne unit of the IFF set called?
7. In what unit is the indicator located?
8. How much time elapses between pulses or signals of an IFF set?
9. Which unit codes the return signal?
10. How many codes are there?
11. What is the range of the CPX-1?
12. What type of scope is used in the CPX-1?
13. Of what use is the lobe switching on the CPX-1?
14. Name one other IFF set.
15. What set is used in conjunction with the TPX-1?

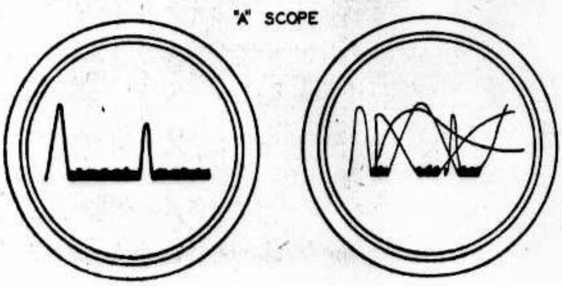
ECM ELECTRONIC COUNTERMEASURES

Scope: Electronic Countermeasures, its types, uses, and how it is overcome.
Student Objective: To learn the methods of Electronic Countermeasures and be able to recognize it and to know the proper procedures to follow when it is being used.

INTRODUCTION

The time, is early one cold and foggy morning during World War II. *The place*, one of the many Radar stations along the coast of England facing France. Normal duties are being accomplished at the station and most of the men are thinking how fortunate they are to be out of the damp cold on such a morning as this. The invasion of France has not yet taken place and attacks of the Luftwaffe are still causing many alerts to be sounded, although the Battle of Britain is over. The scope operators are scanning the skies and routine interceptions are in progress. It is not a busy day yet you never knew when to expect trouble. Remember, the enemy does not file flight plans!

Suddenly, on the face of the indicators, there appears a strange and very weird pattern. Sometimes, it looks like oval-shaped lines, running from the center to the extreme edge of the scope. Sometimes it appears as a mass of fuzzy or hazy particles completely blanking out the reception in this sector. It is, indeed, both a shock and a new experience to all of the men



(Railing)

Figure 1. Electronic Jamming.

at this particular station. Their first thought is that something had gone completely wrong with the Radar. Rather than continue operations and possibly cause serious damage to the set, it is turned off completely, to allow a very puzzled maintenance man to trouble shoot.

Unknown to this station, it is not alone in experiencing this altogether new and unprecedented trouble. Reports arriving at the ADCC's all describe the same difficulty, "Am going off the air temporarily, maintenance trouble." Site after site closed down, leaving practically the whole coast of England without Radar protection.

Approximately one hour later, a small convoy of hostile warships are spotted moving toward the open Atlantic. By closer observation it is determined to be the German Battleship *Bismark* and supporting smaller units, including the cruiser *Prince Eugene*. They had been hiding on the coast of France since the outbreak of the war and now were making their bid for freedom to prey on allied shipping in the Atlantic.

Immediate action was taken to stop them. However, it took the English over a week before final contact was made and the *Bismark* sunk. This was accomplished with a terrific loss in both men and ship, including the Hood, the largest British Battleship afloat.

You may ask yourself, "How could all this have happened in such a narrow body of water as the English Channel?" Well, it was possible because the English Radar was off the air at the exact time the *Bismark* made its break for freedom. This may sound like an astounding coincidence. But a more accurate way of describing it, is to call it the greatest deception the German had accomplished to date.

Yes, indeed, the Germans knew that the British Radar would not detect their vessels; the Germans knew because they were responsible. They were employing the first *Radar Countermeasure*.

This is how it was done. The Germans directed an Electronic beam into the British Radar, causing the erratic pictures on the face of the British scopes. The English, never before experiencing this type of presentation, thought it was caused by equipment failure and, therefore, turned off their sets, allowing the *Bismark* and her escort to sneak out and almost reach the safety of the open Atlantic. This would undoubtedly have caused serious losses in our shipments of troops and war material to England. It might well have affected the length of the war.

This method of transmitting electronic beams into enemy Radar, thereby minimizing its effectiveness, has come to be known as "Jamming" or E. C. M. (Electronic Countermeasures). On the following pages, you will be taught about jamming, its types, uses, what it looks like and what to do if you encounter it. Study it carefully, your set may be the next one to be "jammed."

General Types

Jamming is defined as "*Activities designed to introduce radiation into enemy receiving equipment in a manner which will obscure intelligence that the enemy might otherwise interpret.*" This jamming is generally divided into two main categories, Electronic and Mechanical.

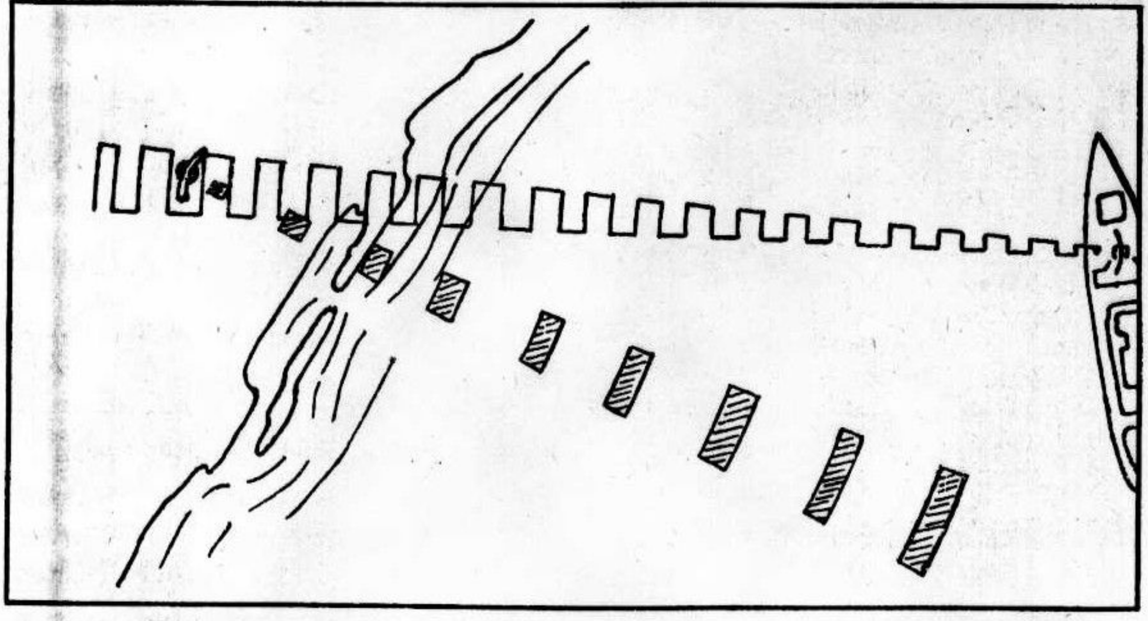
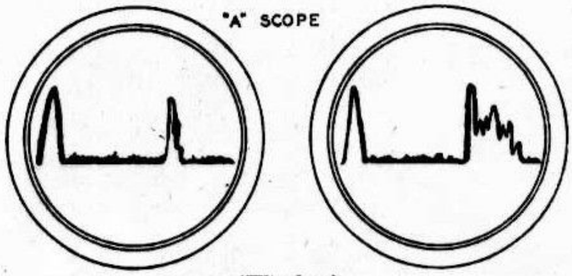


Figure 2. The Germans Directed an Electronic Beam Into the British Radar.

MECHANICAL JAMMING

Mechanical Jamming is defined as, "*Jamming caused from a great quantity of reflecting material designed to produce false echoes on a radar scope.*" This material is usually dropped from aircraft and is of a metallic or tinfoil composition. It is usually cut to a size that will cause maximum reflection on the radar to be jammed and been dropped within the coverage area of the particular radar set. There are different types of metallic jamming used and their uses as well as characteristics will be clarified and described.



(Window)

Figure 3. Mechanical Jamming.

Rope

"Rope" is the name given to one particular type of metallic jamming. It is made of tinfoil and comes in rolls about three inches in diameter. It is shiny in appearance and, like a mirror, gives off a good radar reflection. It is used to block out portions of height finding equipment, and has definite characteristics on an HRI scope. As it drops from the aircraft, it unrolls and lazily settles to the ground like a feather or falling leaf of a tree. If dropped in large enough quantities, it will appear as a cloud and enemy aircraft may sneak in while it appears on your scope. However, the one way to distinguish it is to concentrate on it as it appears. The aircraft dropping it will be visible, preceding the jamming and will continue to be visible, ahead of it, as the mission proceeds. As it falls or settles, it will disperse and any aircraft within the falling "rope" can be detected. It will take much practice and very careful scanning in order to plot through jamming accurately. The enemy will use many tricks and it is likely that when he does jam you, he will not appear within this area. He may jam one area and while the operator is concentrating on this spot, they may slip in from another direction. Always remain on the air during jamming, never shut down, and always report it to your supervisor without delay.

Chaff

"Chaff" will be the next mechanical type of jamming. This type is the same material as rope, only in a confetti form. It will block out out only a small portion of your PPI indicator and dissipate while in the air, the same as "Rope." The aircraft dropping it will always be visible in front of, or preceding, the cloud of "Chaff." The same technique of operating instructions applies to this form of jamming. Remember: Report it at once and try to read through it!

Window

"Window" is the last form of mechanical jamming to be considered. Again it is composed of a tinfoil base and is similar in appearance to "Rope" and "Chaff." However, this type is cut to one half the wave length of the set being jammed; therefore, it will be of varying lengths for different radar sets. Its method for dropping will be the same and the operator's instructions will not change.

ELECTRONIC JAMMING

Electronic Jamming is defined as any jamming produced by a radio transmitter and directed into your receiving equipment.

With this type of jamming, it is possible for an aircraft, especially equipped with a jammer, to go in with our formations on raids and so completely obscure the enemy's equipment, that the other bombers will not be detected. It can blanket out a portion of a scope and sometimes completely mask all targets for 360° of coverage. The appearance of the jamming on the face of the indicator can be changed to many shapes and forms, further confusing the operator. Remember one of the main purposes in jamming is to make the operator believe something is wrong with his set and turn it off. This leaves the enemy free to concentrate on jamming other stations still in operation.

Changes of shape and intensity of the jamming on the face of the indicator, usually means a different type of electronic jamming is in use. It is impossible at this time to touch upon every combination of patterns that will present itself on your scope. However, after reading this chapter, receiving the jamming lecture and viewing films on the subject, you will be expected to be able to recognize and define the main types of electronic jamming if ever the need arises.

The principle involved in jamming electronically, can very readily be explained by the "echo system." If a person shouts intermittently toward a cliff or other sound-reflecting surface, after a short period of time, his shout will bounce back, or reflect in the form of an echo. The time it takes for this echo to return to the sender will depend upon how far the sound has to travel before it strikes the reflecting surface. However, if another person shouts continuously at the same time as the first person, these sounds

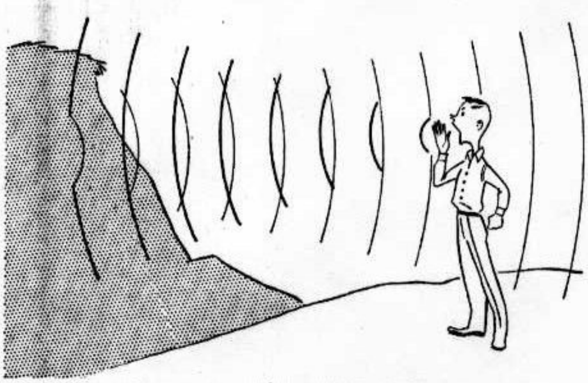


Figure 4. "Echo" Principle.

will travel, along with the echo, back to the first person and block out or confuse the returning echo. In other words, he is being jammed. Radar "jamming" works in the same way, except they use r-f energy instead of sound and a transmitter to send it on its way into the receiving equipment.

Now suppose the sender of this sound is still being "jammed" by the second person continuously shouting. He cannot hear his echo, so he shouts louder; this helps somewhat but not enough for a clear echo. Next, he changes the pitch of his tone; now it comes in loud and clear even though the "jammer" is still shouting. But our friend, the "jammer," turns on a siren which has a variety of pitches; this drowns out the echo again and is known as "*barrage jamming.*" Barrage Jamming is little more than using more than one frequency at one time. The use of only one frequency is called "*spot jamming.*"

You will now be given a brief description of the different types of electronic jamming and what they will look like when they appear. Always remember to expect jamming—it can come at any time.

OPERATORS' DUTIES DURING JAMMING

In present day warfare, the success or failure of any offensive or defensive action will largely depend on Radar. It is used by the bombers to hit their targets regardless of weather conditions and from altitudes greater than eight miles. Artillery units aim their guns with Radar while defending our cities from attacks. Aircraft carriers and all types of warship navigate as well as fight with Radar, penetrating deep into hostile territory, striking vital blows and never visually sighting the enemy. Defensively, our coast line will be screened with Radar to protect us against surprise attacks and to catch the enemy far from our shores and prevent another Pearl Harbor incident.

You, the Radar Operator, will be the deciding link in the success or failure of either our defensive or offensive actions. You will be the man operating this equipment. You will be directing the fighter aircraft into contact with the enemy, pointing our guns and dropping our bombs. Yes, you, the *Radar Operator*, will be our first line of defense.

As you know, the enemy has Radar too. He knows the capabilities and limitations of this weapon. When the time comes for him to use it against you, he will try many tricks and evasive tactics. Whether or not he drops his bombs on our cities and industrial regions will depend entirely upon you and your actions at the time.

When in any combat area, *always expect jamming*. With this view in mind while operating, you will be able to detect "jamming" easier, recognize the type quicker and take the necessary steps to nullify it much more efficiently. *The instant that jamming is sighted, report it to your Crew Chief. You will remain at your station and try to read through it.* As the mission progresses, additional information will present itself to your eyes. By adjusting the SIG. BRILL and TRACE BRILL., you will

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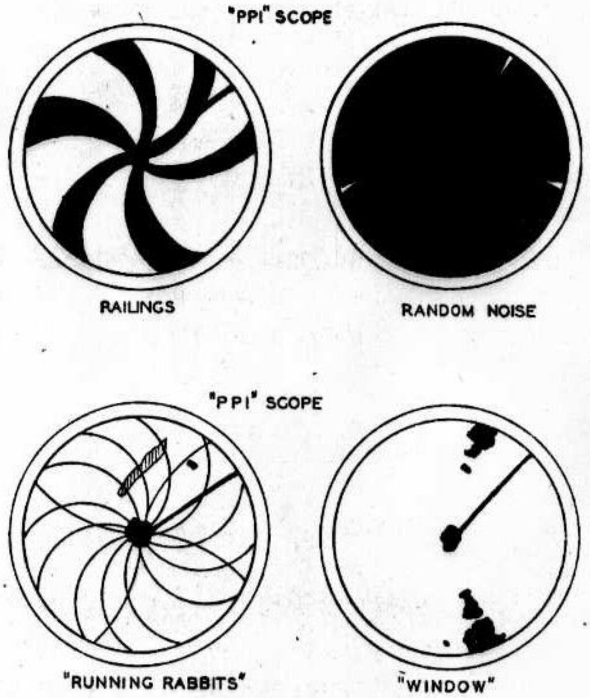

Figure 5.

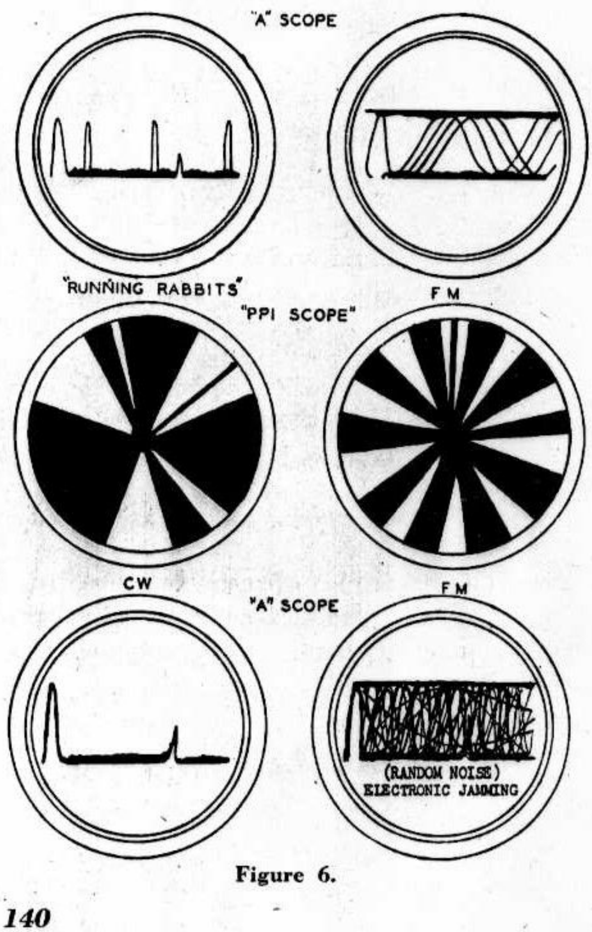

Figure 6.

be better able to cut down the brilliance of your scope and any targets within the jammed area will become more visible.

The Radar Operator's job is to interpret all echoes appearing on the face of a radar scope and accurately and smoothly plot them. However, his job becomes doubly important as well as difficult when electronic jamming is encountered. It has been said, "that a good all around scope operator is one who is not only able to interpret targets appearing under normal conditions, but is one who also expects jamming, is able to recognize it and not confuse it with interference, and one who can identify the different types immediately." The common sense behind this statement is very readily identified. Every enemy action will begin with some type of jamming. This, in all probability will be of the electronic type. The faster that the jamming is detected and action taken against it, the more time you and your allies will have to defend themselves. Even a few moments lost, could mean the difference between life and death for your countrymen, your relatives and yourself. Let us now analyze those three attributes of the operator mentioned before.

Expecting Jamming

Expecting jamming will always keep you wide awake and on your toes for any probability. You will not know from which direction it will come until it appears, so the importance of continuous and determined scanning of your sector cannot be overemphasized. Also while you are interpreting a scope with the idea of always being ready to expect jamming and it does suddenly appear, your reaction to it and ability to handle it will never be questioned.

Recognize Jamming

Your ability to recognize jamming quickly and accurately will come along with practice. At any station at which you may be serving, other radar sets as well as communications will interfere frequently with your reception of targets. Usually this interference will cover 360° of your scope and will be recognized immediately after going through a proper check. In order to determine the difference between interference and actual electronic jamming even though it appears on 360° of your scope is a very simple and accurate process. Adjust your TRACE BRILL. until just a hairline of light appears. Then turn down your SIG BRILL. slowly, keeping a close watch of your tube at the same time. If it is jamming, it will gradually dim out for the major portion of the scope. But as it reaches close to its dimmest point, an area of from 010° to 15° will still glow. The area will be the direction the jamming is coming from and frequently the jammer aircraft will be visible. If, however, the brightness of the scope when very low is still the same for 360° the brightness will usually be caused by other radar or radio equipment. However, you will report it immediately and let your controller and crew chief decide and make recommendations and final decisions.

In any event, the radar set should not be shut down even if you cannot pick up aircraft on the set. By staying on the air, you are at least keeping an enemy jammer busy, and may thus protect other friendly equipment operating on a different frequency. (Remember this: "Short of causing radar personnel to start tearing down the radar set in a futile search for non-existent trouble, the greatest success the enemy jamming can hope to achieve, is to convince the operator that further use of the equipment is hopeless.")

With practice, you will be able to detect and competently handle "Jamming" when it appears. Always keep in mind the action to be taken when and if "jamming" does appear. *First, report it immediately to your crew chief! Second, stay on the air and try to read through it! Third, identify it as soon as possible so necessary action can be taken.*

Successful reading through jamming, even though very difficult, may discourage enemy use. Turning off equipment, stopping antenna rotation assures the enemy of his success, encourages further use. Keep enemy guessing about effectiveness, and run air intercept in his jammer and he'll abandon or change techniques.

QUESTIONS

1. Why didn't the Allied Radar Operators leave their scopes on when they noticed the jamming?
2. How did the Germans disfigure the faces of the Allied Scopes?
3. What is a Radar Countermeasure?
4. What are the two main types of jamming?
5. Name three mechanical types of jamming.
6. How is mechanical jamming placed in beam of the Radar?
7. What is "Rope" used for?
8. What is the difference between mechanical and electronic jamming?
9. Is electronic jamming directional or non-directional?
10. What is the difference between barrage and spot jamming?
11. What is the first duty of the operator when jamming is noticed on a scope?
12. What is the difference between jamming and interference?
13. Why is it important to know the direction from which the jamming is coming?
14. Is it possible for two Radar Stations to determine a fix on a jammer aircraft?
15. Why should you never turn off your Radar Set?