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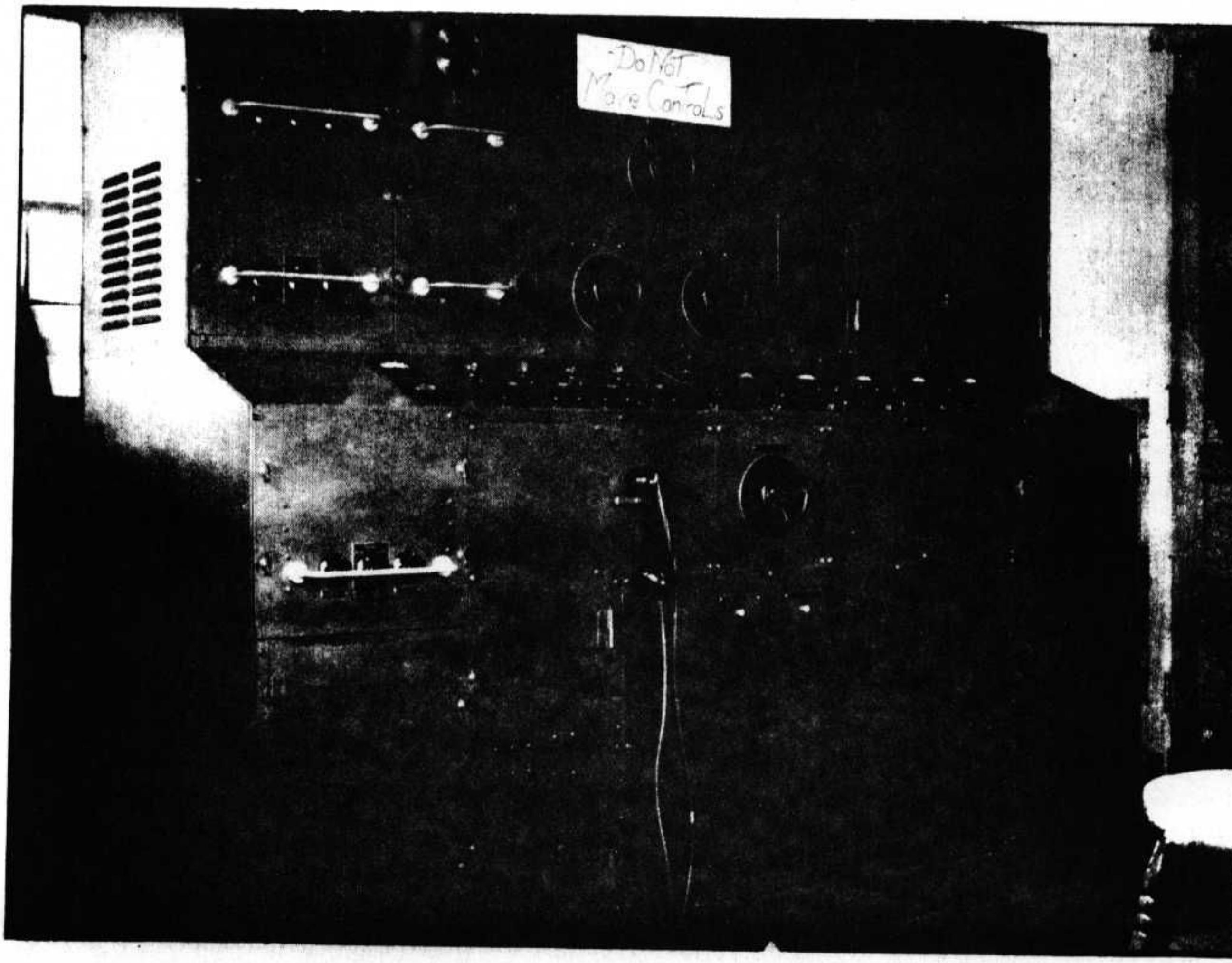

SCR — 588 TRANSMITTER
FIG. 3

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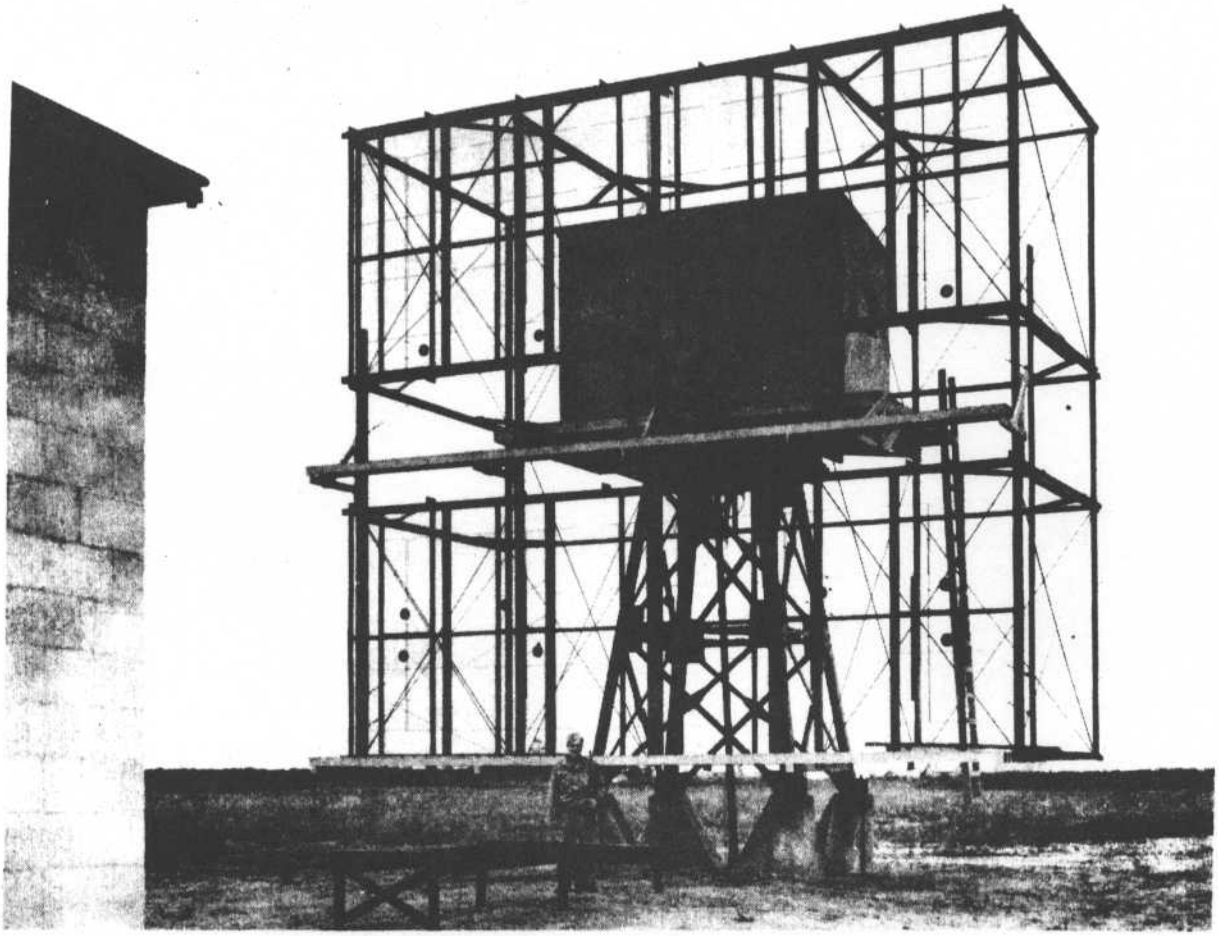

GCI ANTENNA ARRAY
FIG. 4

As a further aid in resolving ambiguities, another switch, the phase-antiphase switch, allows the signals from the top and bottom antennas to be transmitted 180° out of phase with respect to each other. A foot switch may be provided to shut off the split effect on the H/R tube momentarily in order to give an accurate reading of the range as required for the height calculation.

Limitations of the SCR-588

The GCI Controller should be familiar with the performance characteristics of his station, know its capabilities and limitations, and recognize the short-comings of his equipment.

One of the principal limitations of radar equipment now in use, including the SCR-588, is that the same installation cannot be used for low-flying aircraft detection and at the same time function as an accurate height-finding device. This is true because the effectiveness of radar at low altitudes depends upon the wave length of the tramsmitted pulse in relation to the height of the antenna above the ground. The shorter the wave length and the higher the antenna, the lower the angle of coverage; yet for GCI operations, there is a limit at which the height of the antenna can be placed. The higher the antenna the greater the area blanked out by the ground ray and the more difficult accurate height finding becomes, due to the difficulty of resolving accurate heights from the many lobes sent out by a high antenna array.

Technical difficulties also limit the length of radio wave which is practicable. Radar technicians are developing equipment using an even shorter wave length than that which is now being used, many types of this microwave application being in production.

In addition to the effect of wave length and antenna height on low angle coverage, other phenomena such as the line-of sight transmission characteristics of ultra-high frequency radio waves and the effect of the earth's curvature, definitely limit the SCR-588's ability to cope with low-flying aircraft. Theoretically, an SCR-588 station properly sited for GCI should be capable of detecting aircraft at 5,500 feet in altitude at a range of 50 miles, and of accurately determining heights of aircraft down to 13,000 feet at the same range. Actually the efficiency of such a station is somewhat less under most operating conditions.

Table I shows the theoretical detection and height-finding performance of the SCR-588 properly sited for GCI using the 25-10 pair of antennas. The figures are based on seeing a bomber of medium size at the different ranges indicated.

3. Siting of the 588 Station for GCI

Choosing a site for a GCI station is a matter of such great importance that it should be done only by an expert qualified in his field. It is a highly technical matter and cannot be discussed at great length here. Suffice it to say, however, that efficiency of equipment, of maintenance, and of operation are all a waste of time if they are applied to a station which has been doomed from the start by bad siting.

Table 1.

Theoretical Height-Finding and Detection Performance Of the SCR-588 Using the 25-10 Antennas		
RANGE (Miles	Minimum height at which an aircraft can be detected (Feet)	Minimum heights at which accurate heights can be determined (Feet)
10	250	2500
20	900	5000
30	2000	7500
40	3500	10000
50	5500	13000
60	8000	17000
70	11000	22000
80	15500	
90	21000	
130	45000	

In the strategical siting of a radar defense chain, the first step is for operations to prepare a map, get in touch with a siting expert and say to him, "We must have this area protected by over-lapping cover both from high and low-flying aircraft."

The siting expert gets to work with maps, looks for possible locations, then goes to the field where he can check actual conditions against locations on the map. Using his specialized knowledge, he will probably succeed in finding compromise sites which will meet some of the operational requirements and at the same time be suitable from a technical standpoint.

The most important single requirement for a GCi site is that it give accurate height readings. For this reason it is essential that the site, to a distance of approximately one-half mile surrounding the station, be substantially flat. If, however, only half of this amount of flat ground is available, it will mean that height-finding at the lower angles will be unreliable, while at the higher angles it may be accurate. In actual operations, an ideal GCI site does not exist and the best one available has to be used. Half a GCI is obviously better than no GCI at all.

A GCI sited on a large expanse of flat country is liable to pick up echoes from buildings, water towers, radio towers, etc. up to considerable distances. To avoid this, it is a good thing to find, if possible a flat site having a circle of low flat-top hills 2 to 4 miles distant in all directions. The top of the circle of hills if not over 200 to 300 feet high, will then screen the station from distant permanent echoes, but will not stand high enough to screen it from aircraft.

The type of site that cannot be tolerated for a GCI station is one situated on a stretch of flat ground with no protective rim such as at the top of hill. This makes the station the highest object in the vicinity and it will pick up permanent echoes from everything within miles in all directions. On GCI sites barbed wire defenses should not be permitted within fifty yards of the antennas, and no buildings of any kind should be erected (except within the "blind sector") within 100 yards. Metal buildings should not be used at all.

A perfect GCI site probably does not exist. If a place is found where the physical characteristics are just right, then probably there will be no power, telephones, water or roads. The siting expert's job is not an easy one. If, occasionally, he manages to produce anything even approaching a perfect site, he can rest assured that he has contributed substantially to the efficient operation of the station.

A. CONTROLS ON SCR-588 RECEIVER

(See Fig. 5 for location of following controls)

Compass Scale - Encircles PPI tube. Indicates direction of azimuth in which antennas are pointing..

PPI Tube - Plan Position Indicator. Aircraft positions are shown on a gridded map of the station's service area. Echoes appear as small "arcs" of light which remain as afterglow for 10 to 15 seconds before fading.

Position of aircraft is read at inside center of arc.

PPI Focus Control - Alters focus on PPI tube.

PPI Intensity Control - Increases or decreases brilliance of time base trace on PPI tube. Intensity should be turned up as high as possible without allowing random noise flickering across trace to leave afterglow on the tube.

PPI Range Control - Shortens or lengthens PPI trace to fit scale of gridded map. Used in conjunction with Time Base Shift to match calibrator pips to calibrator spots marked on grid.

Time Base Shift Control - Shifts trace in towards or out from center of PPI tube to line up first calibrator pip with center to tube. First calibrator pip and ground ray should start from station's position at center.

Breaker Switches - Safety switches which break circuits to prevent damage to set in case of overload.

Antenna Rotation Controls - Varies speed and direction of rotation of antennas. This control should never be turned abruptly but turned gradually when changing speed or direction of antenna sweep.

Calibrator Switch - Turns calibration pips on or off. Right: Calibrator "on"; Center: Calibrator and signal both "on"; Left: Signal "on", Calibrator "off".

Height-Range Tube - Used for determining heights, number of aircraft, presence or absence of IFF, range, and for detection of aircraft beyond range of PPI tube.

Velocity Control - Shortens or lengthens the H/R trace to suit the range of the station.

H/R Intensity Control - Controls intensity or brightness of Height/Range tube trace. Adjusted for operator's convenience. Should not be too bright.

Gain Control - A word of caution is necessary regarding the use of the Gain control. This increases or decreases the size of the echoes and noise on the Height/Range tube. At great ranges it may be necessary to turn the control up rather high to obtain readable responses. As the aircraft approaches the station, however, its response will become greater and it will become necessary to turn down the Gain control to prevent the tips of the echoes being cut off by the pre-set limiter in the receiver. If the tips of the echoes are cut off, it will become impossible to make a true echo ratio reading.

Tuning Controls - Tunes Radio Frequency section of receiver.

Split Separation Control - Changes distance between pairs of split echoes as seen on the H/R time base when doing height finding.

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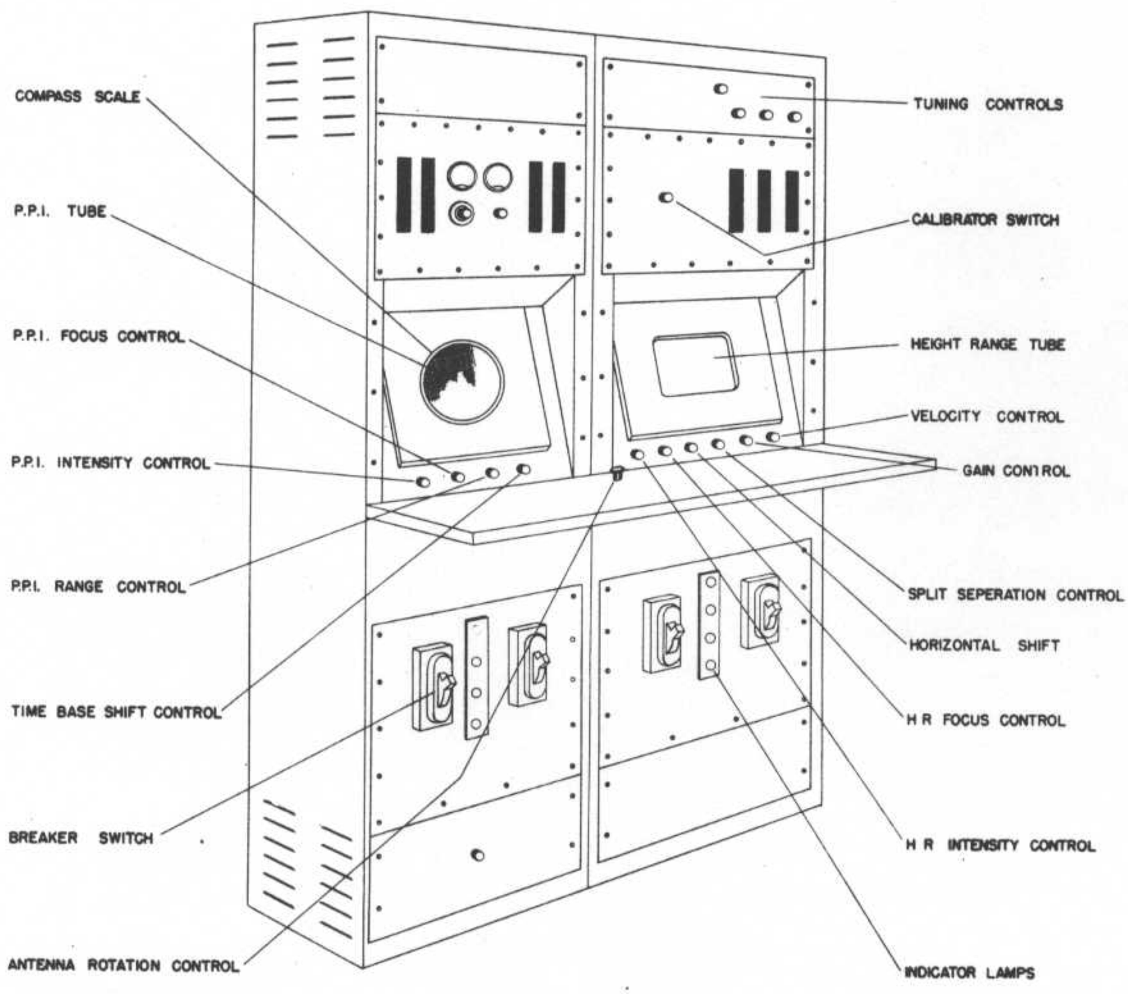
RECEIVER SCR — 588



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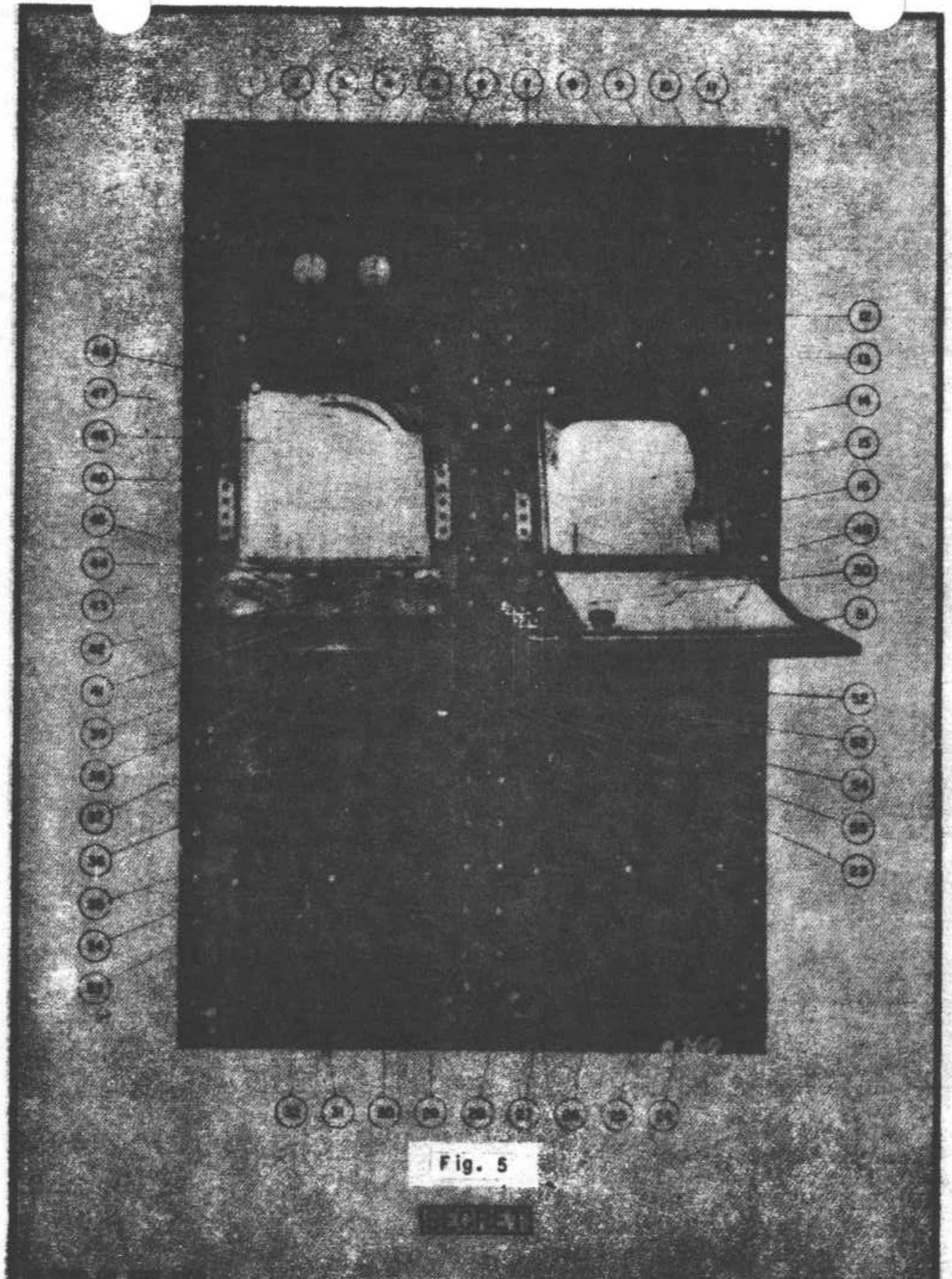


Fig. 5

1. CONTROL CHASSIS
2. RECURRENCE FREQUENCY
3. LINE VOLTMETER
4. PERCENT METER JACK
5. PERCENT METER
6. TRANSMITTER PHASE
7. RECEIVER UNIT
8. OSCILLATOR PHASE
9. MIXER
10. 2ND. R.F.
11. IST. R.F.
12. CALIBRATOR UNIT
13. CALIBRATOR ON-OFF SWITCH
14. H/R UNIT
15. H/R TUBE
16. SHIELD
23. ROTATING GEAR CONTROL
24. POWER SUPPLY
25. PLATE BREAKER
26. FUSE AND PILOT LAMP PANEL
27. FILAMENT BREAKER
28. H/R RACK (ASS'Y DWG. 1661)
29. BASE
30. RELAY CHASSIS
31. RELAY RESET
32. P.P.I. RACK (ASS'Y DWG. 1661)
33. POWER SUPPLY CHASSIS
34. PLATE BREAKER
35. FUSE AND PILOT LAMP PANEL
36. FILAMENT BREAKER
37. LINE ON-OFF MAIN SWITCH
38. LINE PILOT LAMP
39. DESK
40. P.P.I. CHASSIS
41. T.B. SHIFT
42. RANGE
43. INTENSITY CONTROL
44. INTENSITY RESET
45. FOCUS
46. SHIELD
47. PPI TUBE
48. COMPASS CARD
49. INDIRECTLY ILLUMINATED HEIGHT CALIBRA[illegible]
50. 6-8V. 3 STP. DOUBLE CONTACT PILOT LAMP
51. HEIGHT FINDING SWITCH
52. PLOTTING RANGE
53. STROBE SWITCH
54. PHASE-ANTIPHASE SWITCH
55. AERIAL SELECTOR SWITCH

Fig 5

AAFTAC-12/10/43-A832-1M

Horizontal Shift Control - Shifts the H/R trace to line up the calibrator pips with the range scale on the face of the H/R tube.

H/R Focus Control - Adjusts focus of height/range tube.

Indicator Lamps - All lamps should be lit when set is fully "on".

(See Fig. 6 for positions of following controls.)

Antenna Selector Switch - Selects either 25-10 antenna pair or 12.5/7.5 pair for height finding and desired low or high angle coverage.

Phase-Antiphase Switch - Used to resolve ambiguities in height estimations. Its operation affects only the transmitting characteristics of the antenna. In the "Phase" position it transmits maximum energy at certain vertical angles; in "Antiphase" it transmits maximum energy at different angles. The switch should be used in the position which gives the larger pair of echoes on the target being tracked. Echo ratio should be read only from the corresponding "Phase" or "Antiphase" section of the height chart.

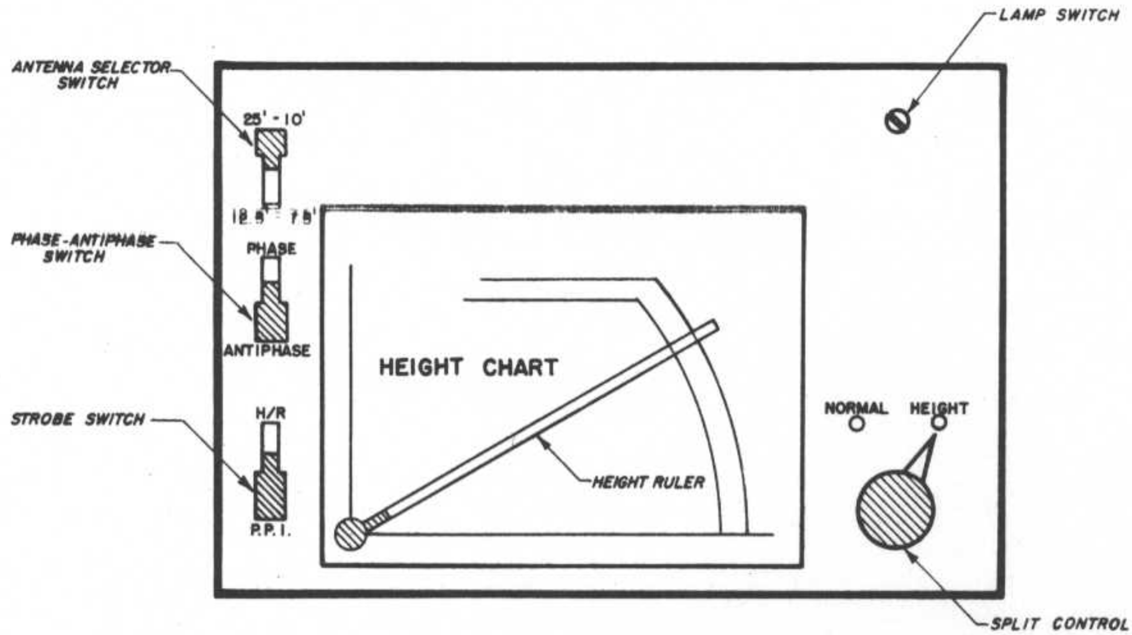
Strobe Switch - This switch has two uses. In the PPI position it is used to D/F (Direction Find) distant or weak echoes by lighting up the time base trace on the PPI tube momentarily when the Height/Range Observer sees the echo pass through its maximum.

In the H/R position, the strobe switch may be used for brightening the Height/Range tube during selected portions of the antenna sweep. In this method of operation, normally used only in GCI, the antennas are rotated continuously at high speed (3 to 4 rpm) Brilliance on the Height/Range tube is turned down until no trace is visible, and the

Height/Range Estimator operates the strobe switch to brighten the H/R tube trace only during the time the antenna is sweeping the sector in which the target is located. This method is best used with a long-afterglow Height/Range tube. It has the advantage of preventing blocking of the tube with unwanted echoes and allows the reading of ratios from afterglow on the selected echoes when the trace has again been blacked out by release of the Strobe switch.

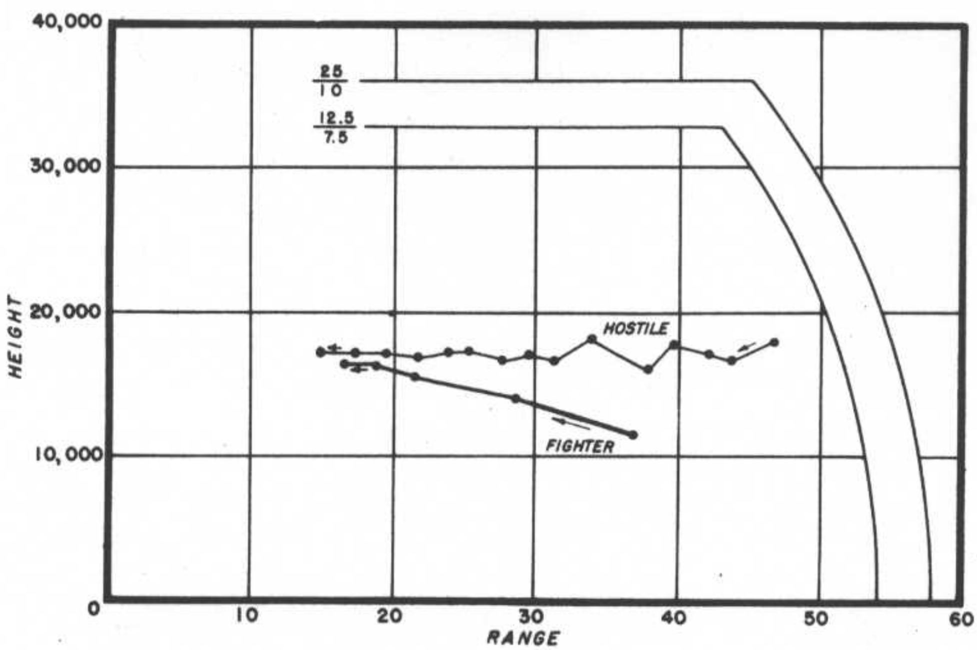
Height Chart - Used for determining heights from echo ratios. The height chart on the SCR-588 (See Figs. 6 & 7) is mounted on an indirectly illuminated height desk with a transparent rotating ruler. The surface of the chart is covered with a transparent plastic which allows the Height Estimator to plot height tracks with a chinagraph pencil directly on the chart. A sample chart which has been plotted with the tracks of a Target and Fighter is shown in Fig. 8. A few explanations are necessary regarding the height chart. Curvature of the earth on this particular chart is neglected as is shown by the fact that the horizontal height lines are perfectly straight. This assumption is possible out to a distance of about sixty miles. Beyond this range curvature of the earth begins to have an appreciable effect upon height readings.

The figures ╥ and ╥ on the chart are used to indicate at a glance which echo of the split pair is larger. They are representa-



HEIGHT DESK

FIG. 7



HEIGHT TRACKING ON HEIGHT CHART

FIG. 8

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tions of the appearance of the split echo on the H/R tube. TT , for example, indicates that in a certain section of the chart the right echo is larger than the left. The figures + and — are used to indicate position of the Phase-Antiphase switch for maximum echoes. + indicates phase and — indicates antiphase.

Height Ruler - Aligned on proper echo ratio to show angle of elevation and gives heights by reading altitude against range.

Lamp Switch - Turns on lights in indirectly illuminated height chart.

Split Control - In "Normal" position a single echo appears for each aircraft. In "Height" position Split Control splits echo into two separate responses from upper and lower antennas. Response from the upper antenna is the left one of the pair, that from the lower antenna is at the right.

Some 588's may be provided with a quick action foot switch for use in reading accurate ranges. When the Split control is on "Height", depressing the foot switch throws the receiver back to normal so that a single echo only appears on the tube at the accurate range. In use the Split control is left permanently at "Height" for reading echo ratios, and the foot switch is depressed momentarily to obtain range after the ratio has been read. The foot switch leaves the operator's hand free for manipulation of other height controls and provides a quick, accurate way of reading ranges.

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CHAPTER III-B

HEIGHT FINDING WITH THE SCR-588

1. General

When a station is doing Ground Controlled Interceptions the Height Estimator has an especially important responsibility. He must obtain very accurate height readings on the target aircraft for the use of the Controller. He should take as many readings as possible so as to obtain a final, accurate filtered height by the time the fighter is ready to make contact with the target. If the station is sited properly and operating efficiently, a skilled operator should be able to obtain actual heights within 500 feet and differential heights within 100 feet. Accuracy of heights may be checked (during a calibration test) by getting heights on the aircraft and then requesting from the pilot his indicated altitude. After making necessary corrections for temperature, barometric pressure, and height of the station above sea level, the two heights may be compared to check the height estimation accuracy.

Before height-finding of any accuracy can be assured, calibration flights must be run to check the station's believed theoretical performance. Flights should be made thereafter at three month intervals, or more frequently if required, to provide periodic checks on the station's performance.

It should be emphasized that height-finding with the SCR-588 is not positive unless the operator has applied intelligence to the interpretation of his results. Ambiguities may occur in a single height reading which must be resolved by subsequent readings on the same target. The accuracy of the heights should improve after several readings have been taken. A certain amount of mental "filtering" must be done before a final accurate height may be obtained.

It is especially important that crews of any station doing GCI should make use of any practice they can obtain on height-finding while the station is on a reporting status. Height estimates on targets should be made whenever possible and special emphasis should be placed on tracking specific targets as long as possible to obtain accurate heights on them. Good height-finding requires constant practice and a considerable degree of skill on the part of the Height Estimator.

2. Theory of Height Finding.

Height finding with the SCR-588 is based upon the angles at which the energy pulse is radiated from the antennas. The angles of radiation depend, in turn, upon the height of the antennas above the reflecting surface and upon the characteristics of the site surrounding the installation since the ground or sea around the antenna reflects some of the energy radiated. From figure 9 it will be seen that an aircraft can receive radio energy from the antenna via two paths, one direct and one reflected.

It can be shown that at certain angles of elevation above the horizon the direct and reflected rays reinforce each other to produce maximum field strength at the aircraft, while at other angles

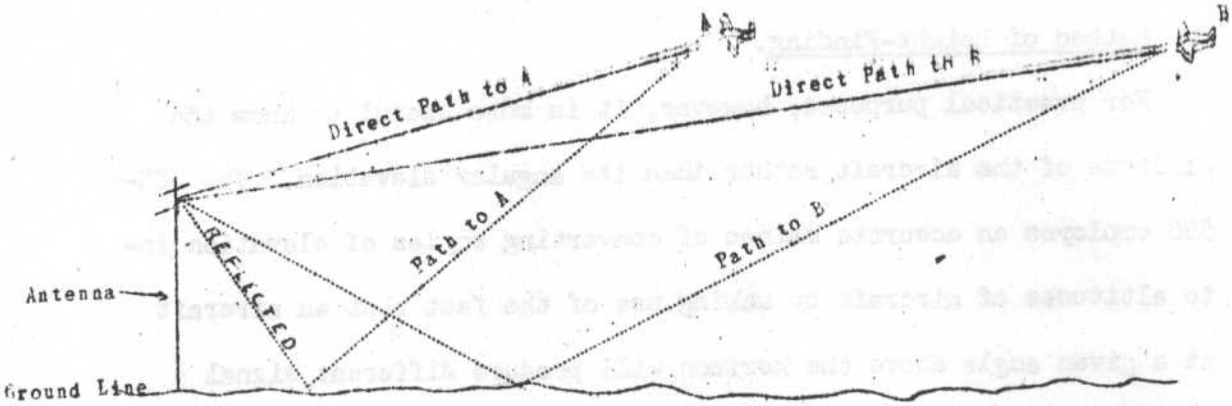

Fig 9

the direct and reflected rays cancel each other to produce minimum or no effective radiation along that angle. This is due to the fact that the reflected wave has changed phase 180° and since it is behind the direct wave, due to its longer path, it finds certain areas in space where it reinforces the direct waves and other areas where it cancels them.

The angles at which the maxima and minima occur are directly dependent upon the height of the antennas above the reflecting surface. For any given height of antennas, therefore, it is possible to calculate a "vertical polar diagram" which will indicate at a glance the strength of radiation along any angle. Two methods of drawing such a vertical polar diagram are shown in Figures 10 and 11. Figure 10 is drawn with polar coordinates and Figure 11 with rectangular coordinates. These charts form the basis for height-finding with the SCR-588. So long as the wave length of the station remains constant, the angles of maximum and minimum radiation will vary only with the height of the antenna above the ground. This phenomenon is made use of in siting the station.

3. Method of Height-Finding.

For practical purposes, however, it is more useful to know the altitude of the aircraft rather than its angular elevation. The SCR-588 employes an accurate method of converting angles of elevation into altitudes of aircraft by making use of the fact that an aircraft at a given angle above the horizon will produce different signal s strengths in two antennas at different heights. Figure 12 shows the the relative signal strengths as received on antennas at 12.5 feet and 7.5 feet above the ground.

The SCR-588 displays on the H/R tube the two responses received from an aircraft in such a manner as to make their comparative strengths readable. When the Split control is thrown to "Height", echoes from the upper and lower antennas appear separately and side by side on the Height-Range tube. The responses from the upper antenna appears at the left, that from the lower at the right. The ratio of the two responses is estimated in tenths. Ratios should always be read from left to right taking the value of the larger echo as 10. The smaller is read in relation to its size as compared to the larger. Having read the range of the echoes, heights are estimated from a calibrated height chart.

It has been shown that pulse radiation, and consequently the received signal, at any vertical angle is dependent on the height of the SCR-588 antenna above the reflecting surface. By reference to Figure

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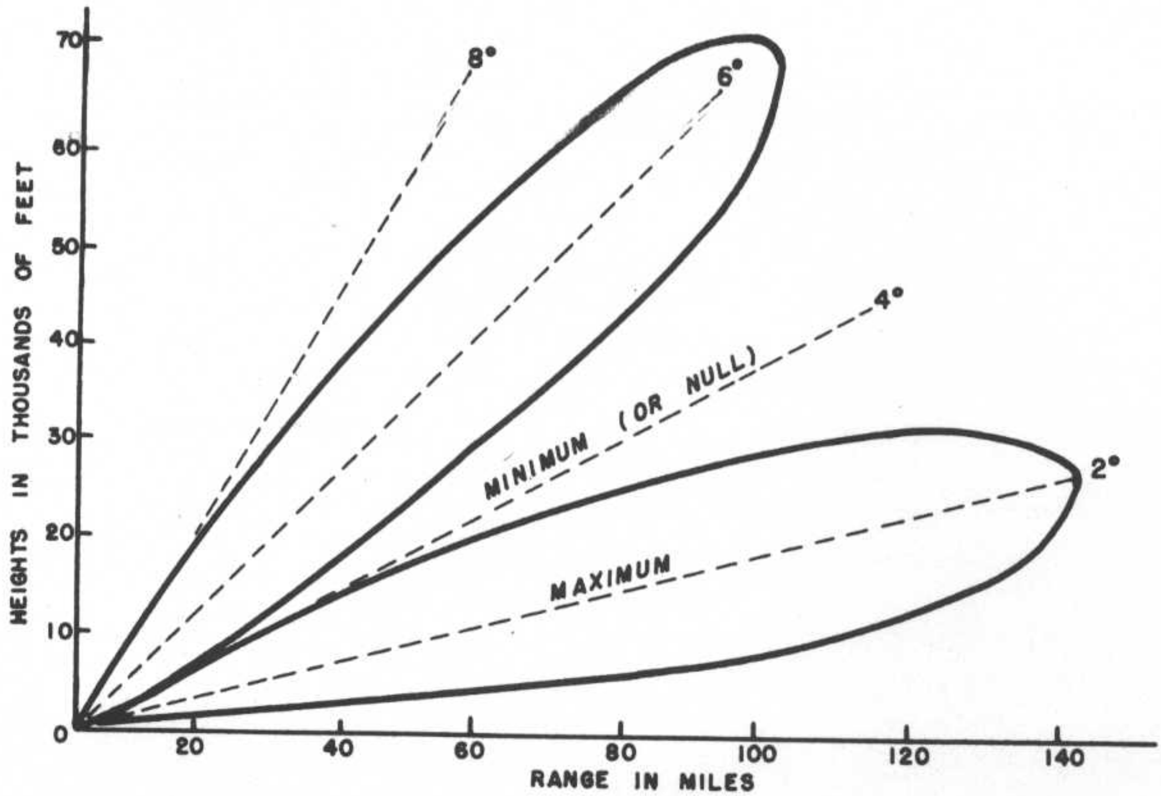

FIG. 10

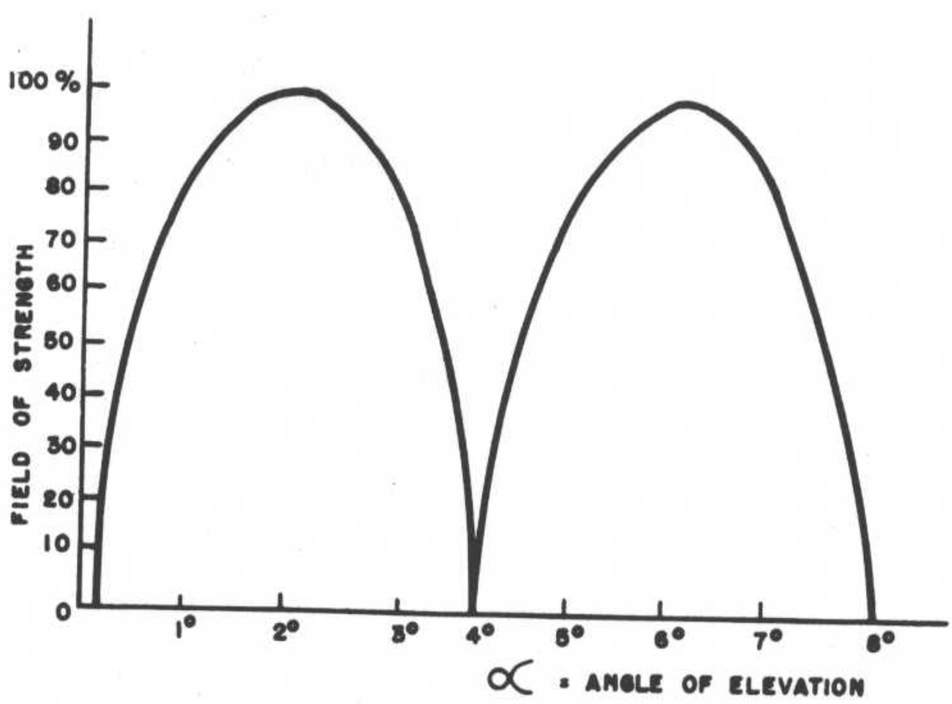

FIG. 11

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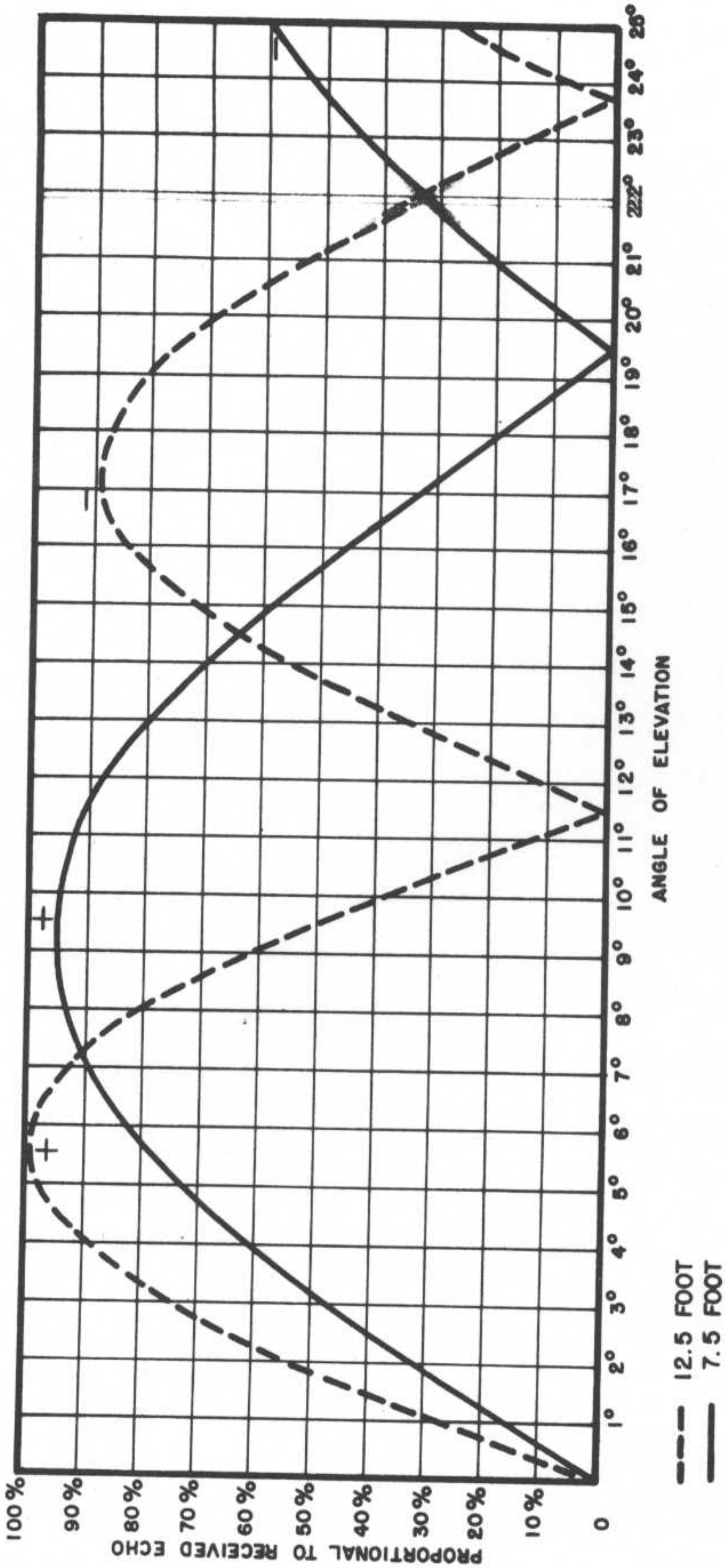

12.5 - 7.5 ANTENNAS

FIG. 12

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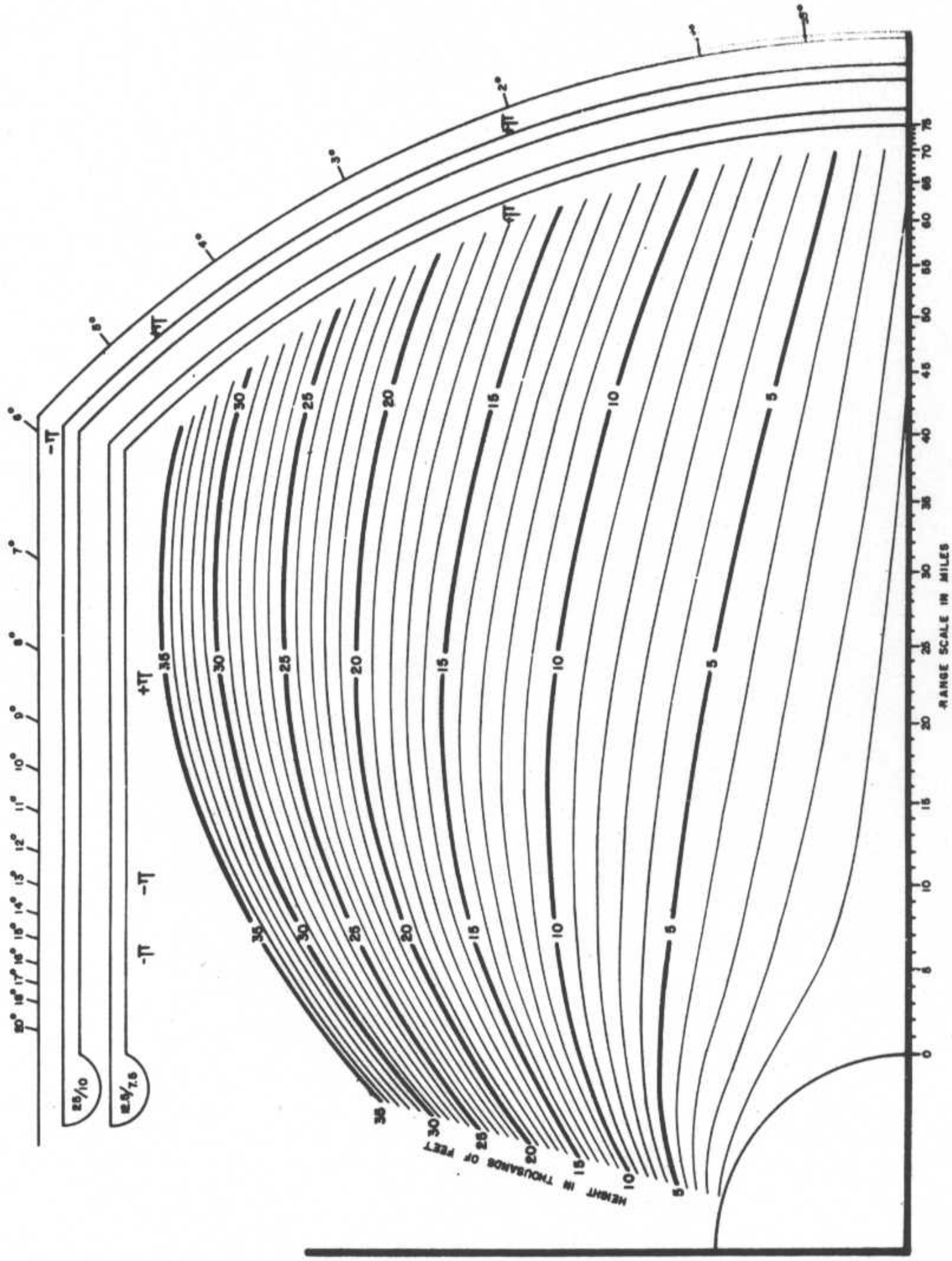

HEIGHT CONVERSION CHART

FIG. 13

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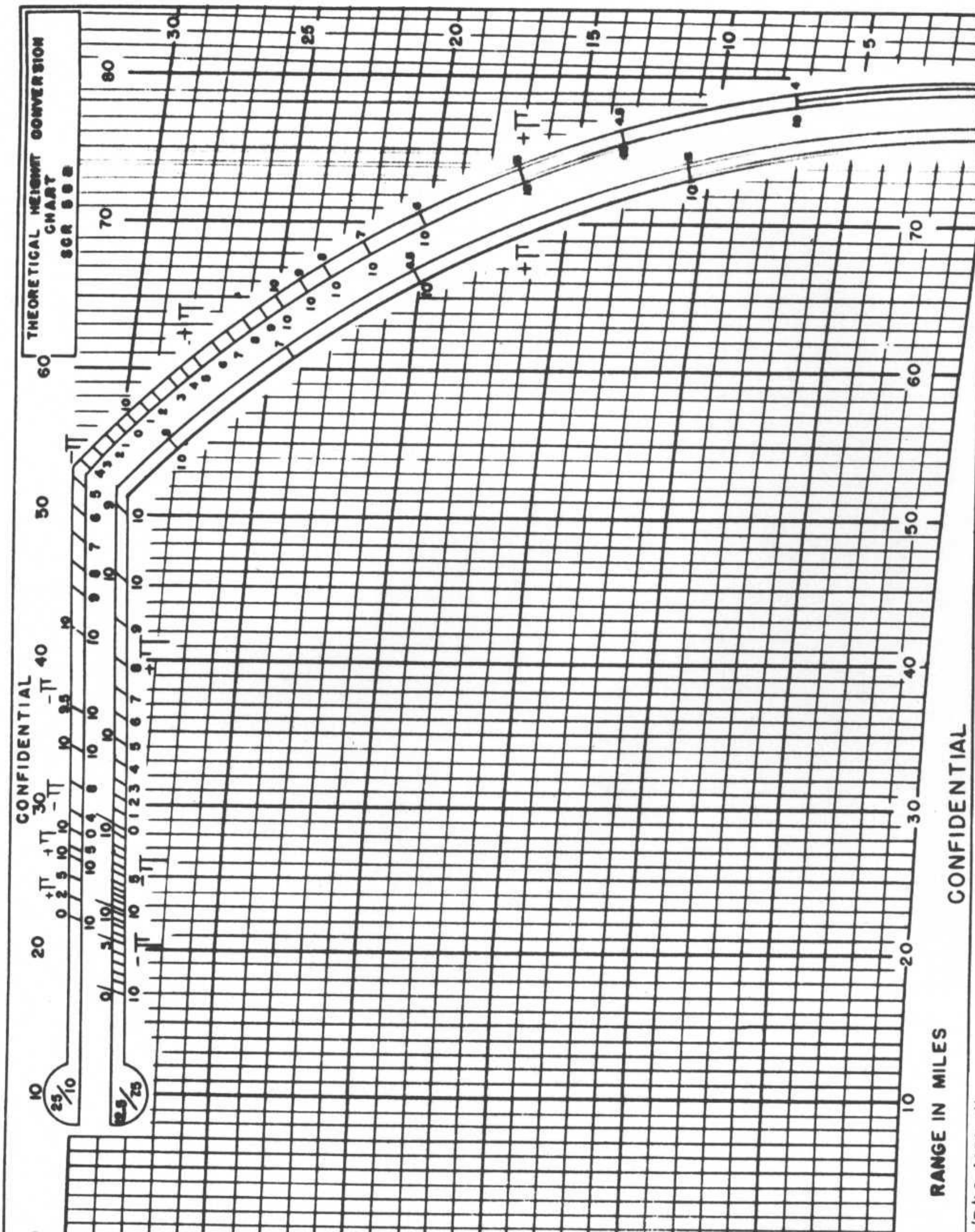

FIG. 13A

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10 it will be seen that at any given angle the received signal strengths on the two antennas are different. Thus at 3 degrees the 12.5 antenna receives 75% of what it would receive at its angle of maximum, and the 7.5 antenna received 47% of its maximum. The Ratio between the two is the approximately 10 to 6. At 7.3 degree ratio between the two signals is 10 to 10. In a similar fashion ratios can be obtained for comparative signal strengths at every other angle of elevation and recorded upon a suitable height chart such as shown in Fig. 13. Then if an echo ratio of 10 to 6 were observed, using the 12.5 - 7.5 antennas on a target, the operator could determine from the chart the height of the aircraft if its range were known. (See Fig. 14)

The following rules, if observed by the Height-Estimator will do much to insure accurate height readings:

1. Turn switch to "split" position before PPI time base reaches the echo.

2. Range can be read from left hand echo which remains fixed, if not too much "split separation" is used.

3. Read ratio between echoes only when echoes are at maximum, otherwise, readings will be in error.

4. Do not permit echoes to reach "saturation" or be limited, or readings will be in error.

5. If echoes are at "Saturation", turn down the gain. Best maximum length is with longer leg at ½ inch.

6. Always take 4 to 5 readings in quick succession, plot the

readings with dots and mentally take an average of the readings.

Actually it will be seen from examination of Fig. 12 that there will be more than one angle at which a given ratio, say 10 to 6, can occur. This condition gives rise to what are known as "ambiguities", i.e., multiple results from a single reading. In other words, a single echo ratio, if taken by itself, will give more than one angular elevation reading and consequently more than one height. Such ambiguities can almost always be resolved to a single reading by methods described below.

4. Resolving Ambiguities.

The SCR-588 when used for GCI is provided with two pairs of antennas for use in height-finding. The pair of antennas at 25 feet and 10 feet are used for determining heights at low angles and a pair at 12.5 and 7.5 feet for heights at high angles and for resolving certain ambiguities, or misleading readings, which may occur from the use of the 25-10 alone. These two pairs of antennas are separate in their operation and height-finding can be done with only one pair at a time. An Antenna switch on the height desk allows a choice of either a 25-10 combination or a 12.5 combination, or a 12.5 - 7.5 pair. The 25-10 combination gives better cover at low angles of elevation and hence should be used at long ranges.

Height readings are usually more accurate with the 25-10 but are more subject to ambiguities, that it, will give more false heights for a single reading. Most ambiguities may be resolved with the 12.5-7.5 pair. This combination gives best results at high angles and hence will be most useful when the target approaches close to the station. Height readings with the 12.5 - 7.5 combination should, therefore, be used as early as possible on a height track so as to resolve the ambiguities first. Final height readings should be taken with 25-10 after the ambiguities have been resolved.

The following sequence should be used when covering incoming target:

1. 25-10 for early pickup.

2. 12.5 - 7.5 just as soon as it will give good responses. This will give an approximate height and resolve the ambiguities inherent in the 25-10.

3. Final height readings should be taken with the 25-10 after the ambiguities have been resolved.

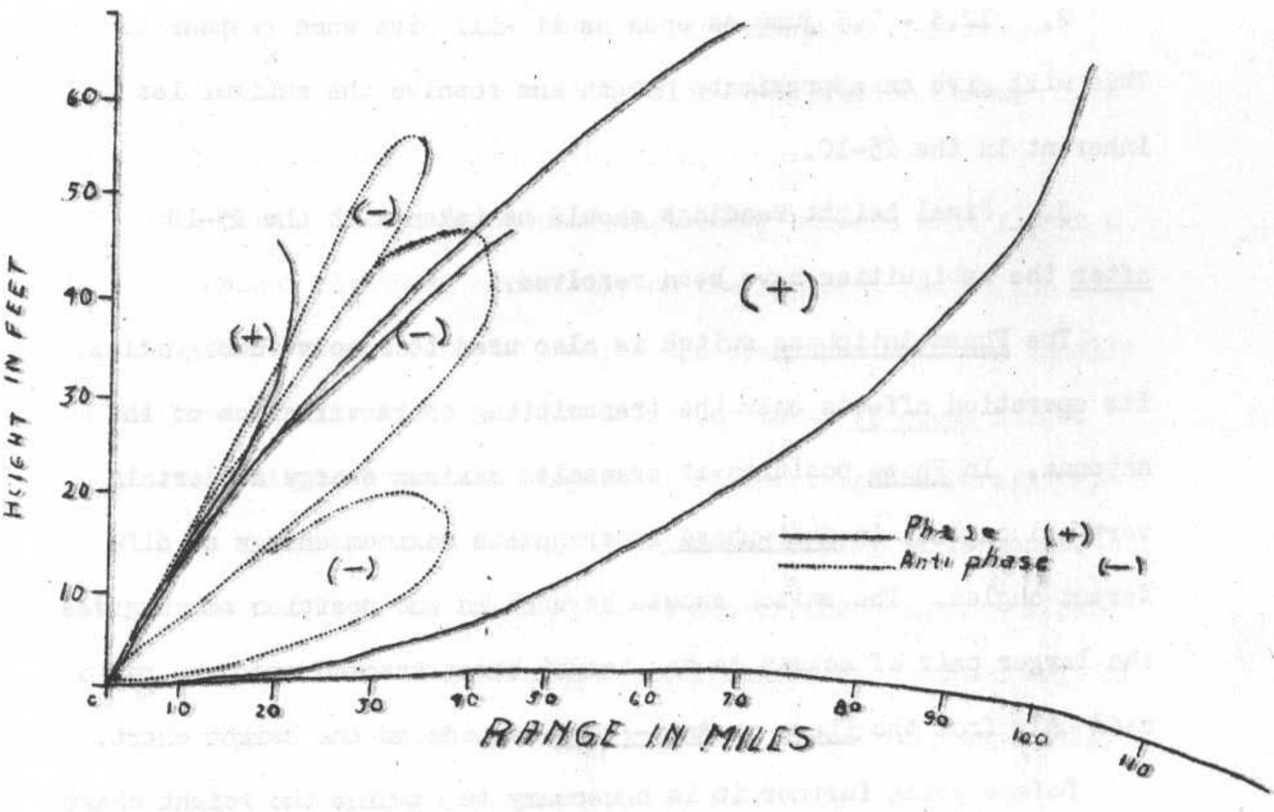
The Phase-Antiphase switch is also used to resolve ambiguities. Its operation affects only the transmitting characteristics of the antenna. In Phase position it transmits maximum energy at certain vertical angles; in Anti-phase it transmits maximum energy at different angles. The switch should be used in the position which gives the larger pair of echoes on the target being tracked and echo ratio read only from the Phase or Anti-Phase section of the height chart.

Before going further it is necessary to examine the height chart (See Fig. 7 and 13) to show the use for the Phase-Antiphase switch. Suppose a ratio of 8/10 has been observed on the tube using the 25-10 antennas. The chart shows six different positions (or angles of elevations) at which a ratio of 8/10 could be observed.

Six different heights might be obtained from this one reading. However, three of these positions are in sections of the chart marked Plus or Phase, and three are in sections marked Minus or Antiphase.

This is where the Phase-Antiphase switch comes into use. It operates in transmitting so as to transmit maximum energy at certain vertical angles in Phase position, and to transmit maximum energy at different angles in Antiphase. (See Figure 15)

(Fig. 15)



If an aircraft happens to be at or near one of the angles at which the antennas radiates most of its energy in Phase position, the echoes which are received from the aircraft will be greater when the switch is at Phase than when it is thrown to Antiphase.

The switch thus provides a method of resolving some ambiguities. It should be used in the position which gives the larger echoes on the aircraft being read. It should be emphasized that operation of the Phase-Antiphase switch has no effect on the echo ratio. It will cause both of the two echoes to become larger or smaller, but will not change their relative sizes.

The Height Estimator should operate both the Antenna Selector and Phase-Antiphase switches so as to maintain continuous cover on both Target and Fighter and to provide the Controller with consistent and frequent plots on both. This can be done by plotting their positions on the height chart and determining how the switches should be thrown to obtain maximum echoes at the expected future positions. The Height Estimator swings the height ruler to the expected future position and notes which section of the height curve it falls on. If, for example, it is at a low angle he may expect best coverage with the 25-10 antennas. If it falls in a Plus, or Phase section of the curve he may expect strongest echoes when the Phase-Antiphase control is switched to Phase.

In general, it may be stated that for ranges greater than 50 to 60 miles the 25-10 antenna should be used in Phase position to obtain early pick-up on all except very high flying raiders. At ranges less than 25 miles the 12.5 - 7.5 will give best results on all except low flying raiders. It will also give a smaller ground ray and fewer permanent echoes and thus allow better tracking in close

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to the station. The 25-10 is best used for relatively low angles of elevation and for obtaining accurate heights; the 12.5 - 7.5 should be used as soon as possible in the course of height-finding to resolve ambiguities.

This method is based on the assumption that aircraft, bombers in particular, will not execute violent changes of altitude during normal operations. There is a possibility that the enemy may resort to erratic altitude flying in order to confuse radar readings. Such a procedure would require very frequent high readings and would best be dealt with by close cooperation between radar and GCI stations covering the area.

In general, it may be assumed that enemy bombers will fly at a fairly constant altitude, especially on the approach run to the targets. Such changes in altitude as the enemy may make can usually be followed readily if the Height Estimator takes <u>frequent</u> height readings. This is especially important if the target aircraft happens to be a fighter with a high climbing and diving performance. Heights would have to be taken at least two or three times a minute if such a target were in violent vertical maneuvers. A knowledge of the operational habits of enemy raiders is also helpful, especially for quickly determining accurate heights in GCI work.

CHAPTER IV

CAPABILITIES AND USE OF THE SCR-527-A

A. GENERAL

1. The SCR-527-A is a mobile, medium range aircraft locator with continuously rotating antennas, giving a plan position indicator type of display. Designed for GCI Siting and Height Reading, it may readily be adapted to CHL & COL work. The entire unit consists of three trailers, two power vans and two spare parts trucks. (See Fig. 7)

The SCR-527-A has a carrier frequency of 209 megs. and tests indicate a very satisfactory range for GCI. (See Fig. 8)

B. COMPONENTS AND DISCUSSION

1. Receiver Indicator. This portion of Radio Set SCR-527-A consists of eleven units mounted in Cabinet Rack FM-51-A. The cabinet rack tunes the pulses sent out by radio transmitter BC-982-A and converts echos from receiving antenna AN-91-A (Fig. 1) into measureable images on PPI tubes BC-986-A, H/R Tube and BC-987-A (Fig. 2) The sweep or turning of the antenna is controlled from the controller's position.

a. OSCILLATOR BC-989-A is the uppermost unit in the PPI rack of Cabinet Rack FM-51-A. This unit includes the master oscillator and its associated circuits which control the wave forms Xmtr keying, and receiving antenna switching (Fig. 2)

b. CONTROL UNIT RM-33-A is the panel just above the PPI tube in Cabinet Rack FM-51-A (Figs. 2 and 3)

c. PPI Unit BC-987-A is located in the center of the PPI rack of Cabinet Rack FM-51-A (Fig, 2 and 3), and is used to amplify and shape the synchronizing and signal voltages supplied by the oscillator and calibrator and to project these signals upon the PPI oscilliscope screen.

d. RADIO RECEIVER BC-981-A is the uppermost unit in the HRF rack of Cabinet Rack FM-51-A and is used to receive and detect the echo signal as picked up by receiving antenna AN-91-A, (Fig. 2)

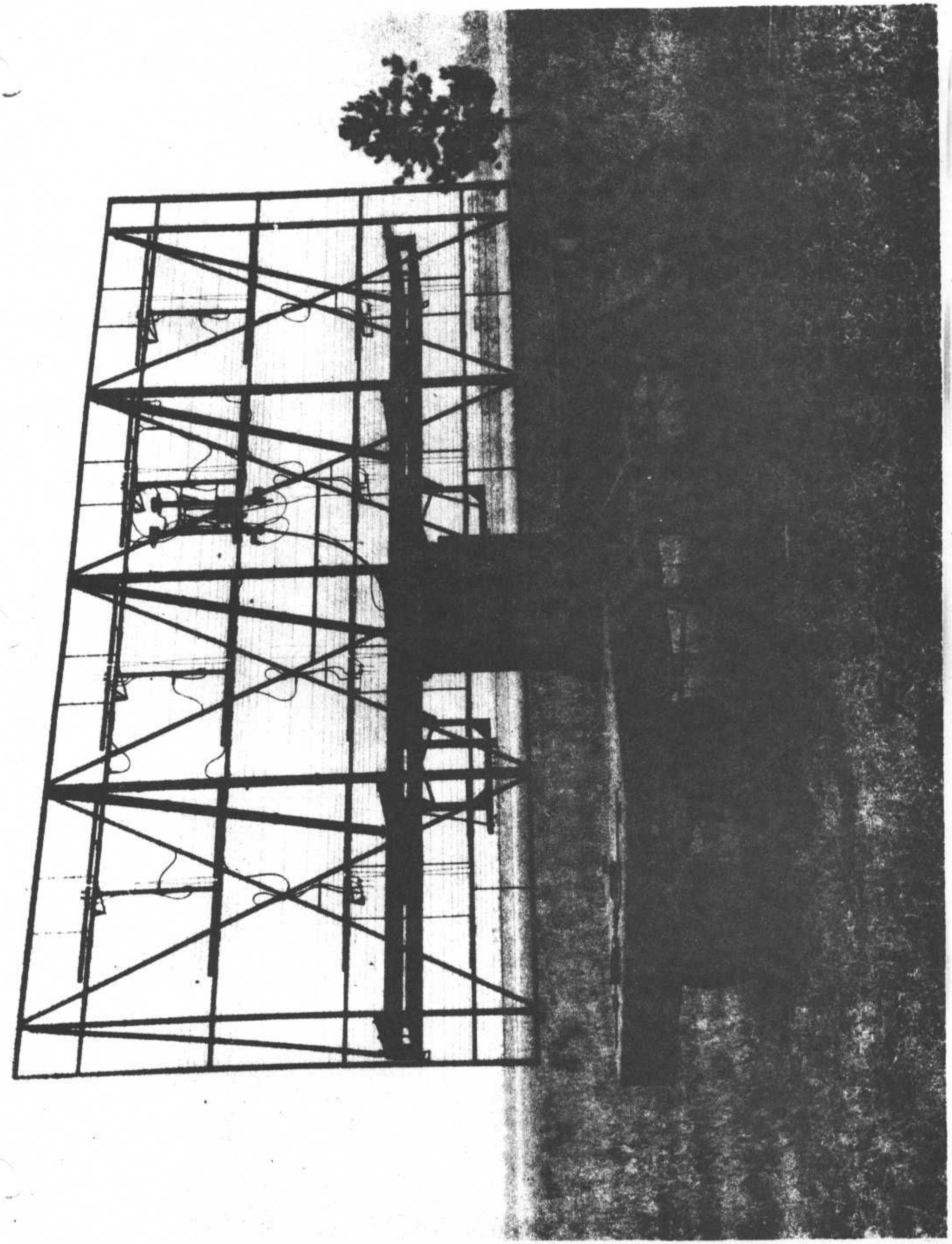
e. POWER SUPPLY UNIT PE-139-A is located at the bottom of the PPI Rack of Cabinet Rack FM-51-A and includes all power supplies for the tubes in this rack. (Fig. 2 and 3)

f. CALIBRATOR PANEL BC-9??-A (Fig. 2 and 3), located directly below radio receiver BC-981-A, is used to calibrate the PPI and HRF cathode ray tube screens and to amplify signals from the radio receivers, BC-981-A and BC-768.

g. OSCILLISCOPE BC-986-A, located in the center of the HRF rack, is used to show the range as well as the relative amplitude of echo signals as received on the receiving antenna. (Fig. 2 and 3)

h. RADIO TRANSMITTER BC-982-A, together with a rectifier and a keying unit, are mounted on a pedestal at the rear of the antenna, AN-91-A, on a trailer. (Fig. 4)

i. TRANSMITTING ANTENNA AN-91-A, (Fig. 4) and RECEIVING ANTENNA AN-92-A, (Fig. 1) are supported on two separate turntables



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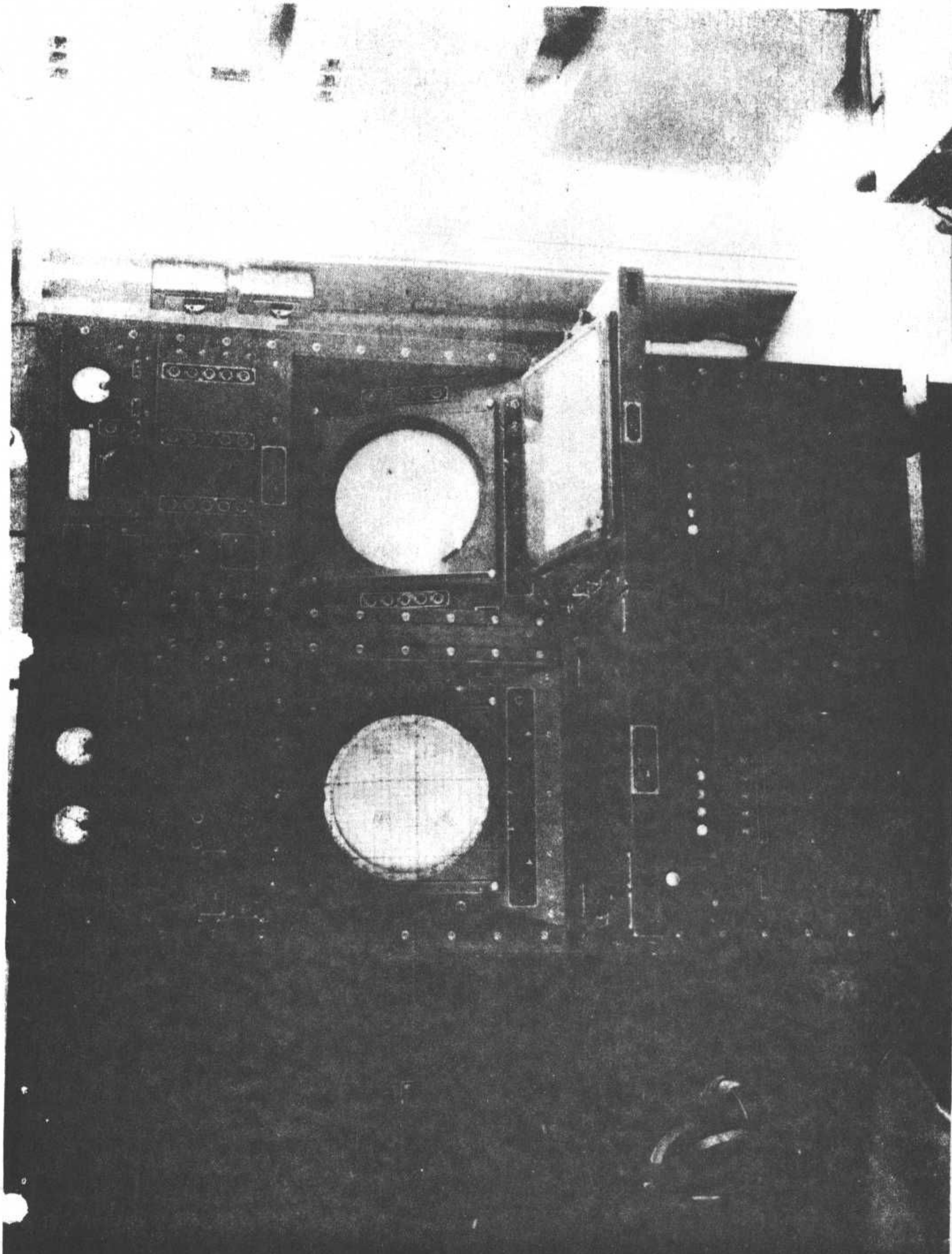

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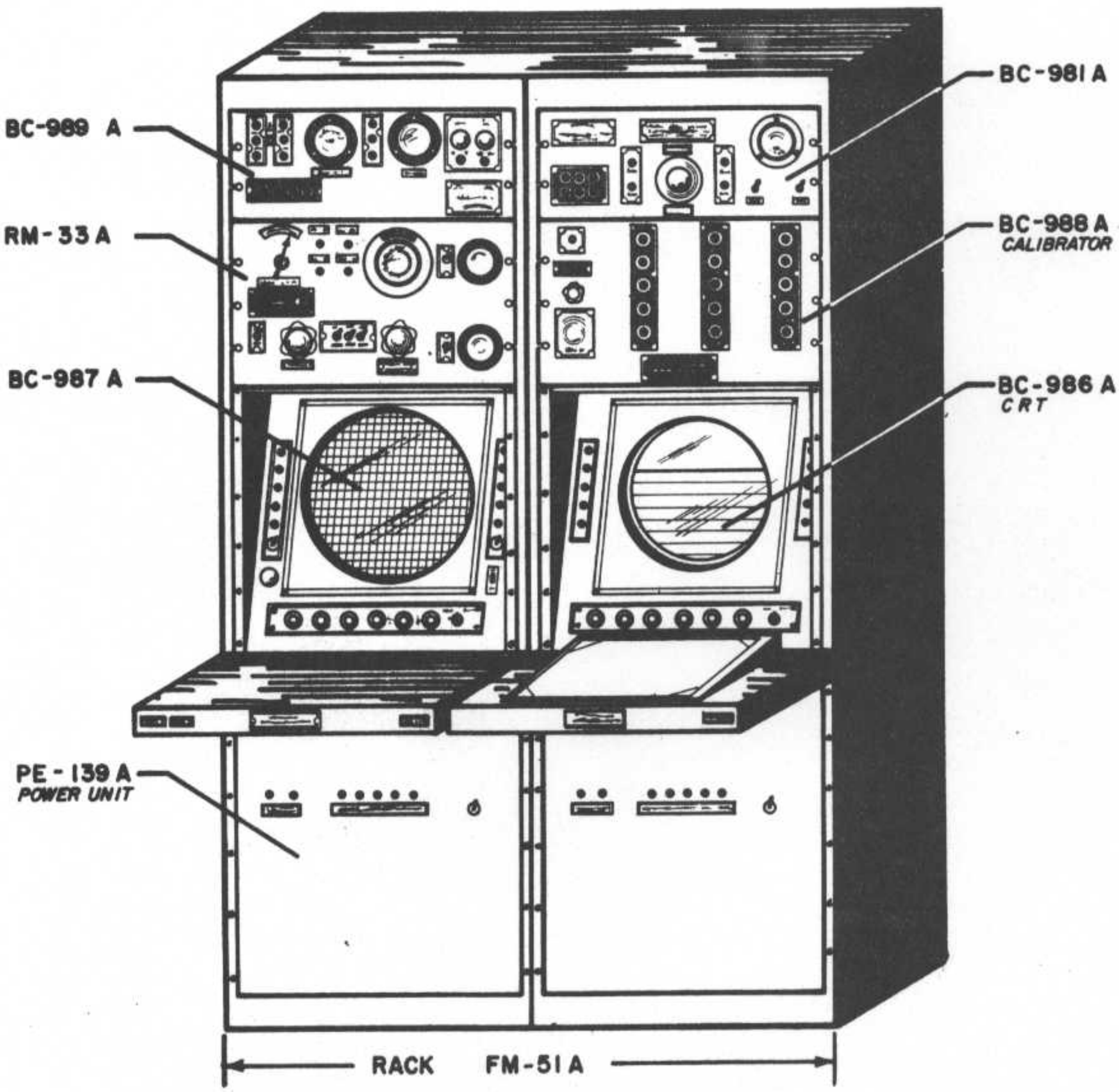

SCR - 527A

FIG. 3

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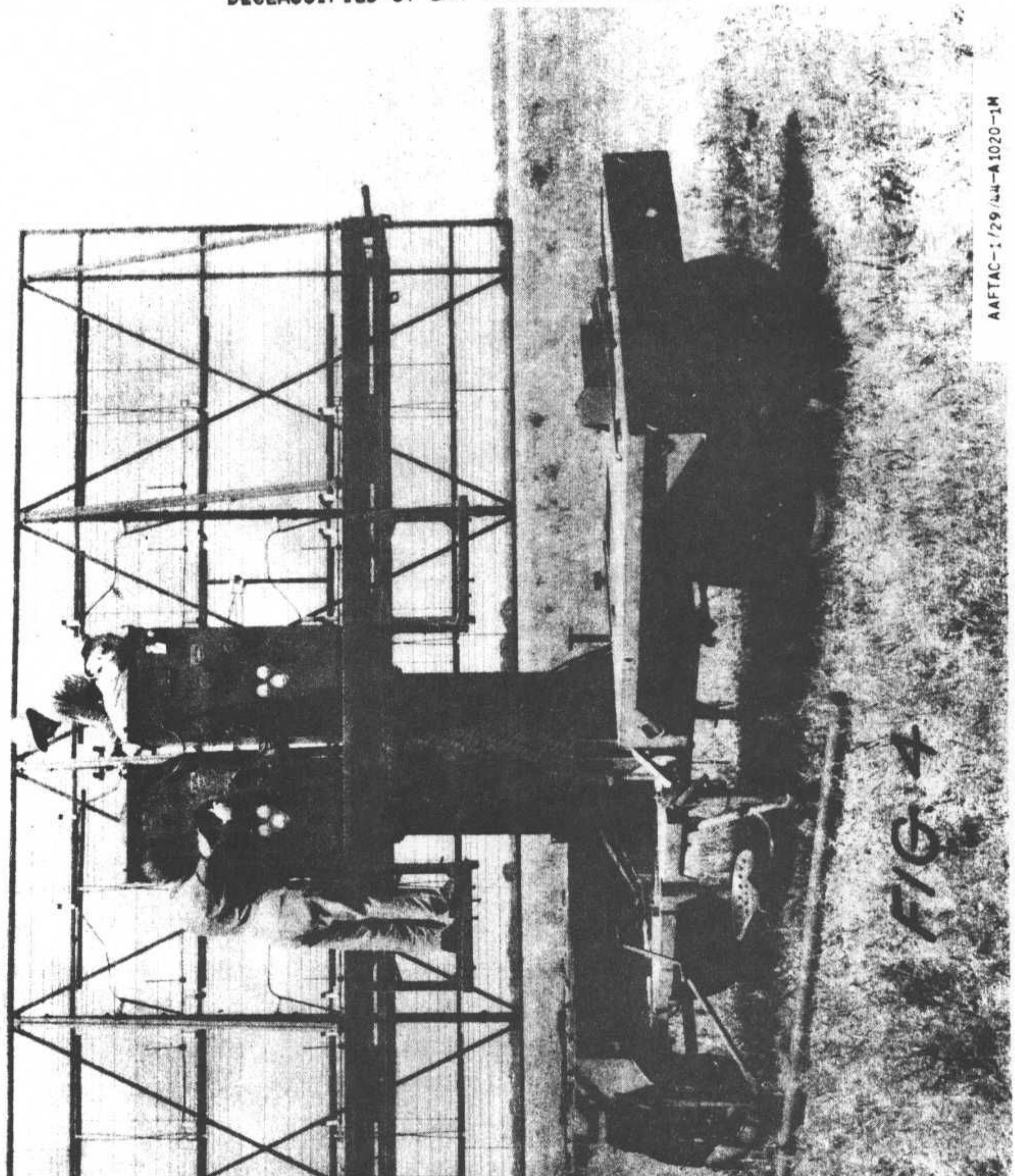

FIG 4

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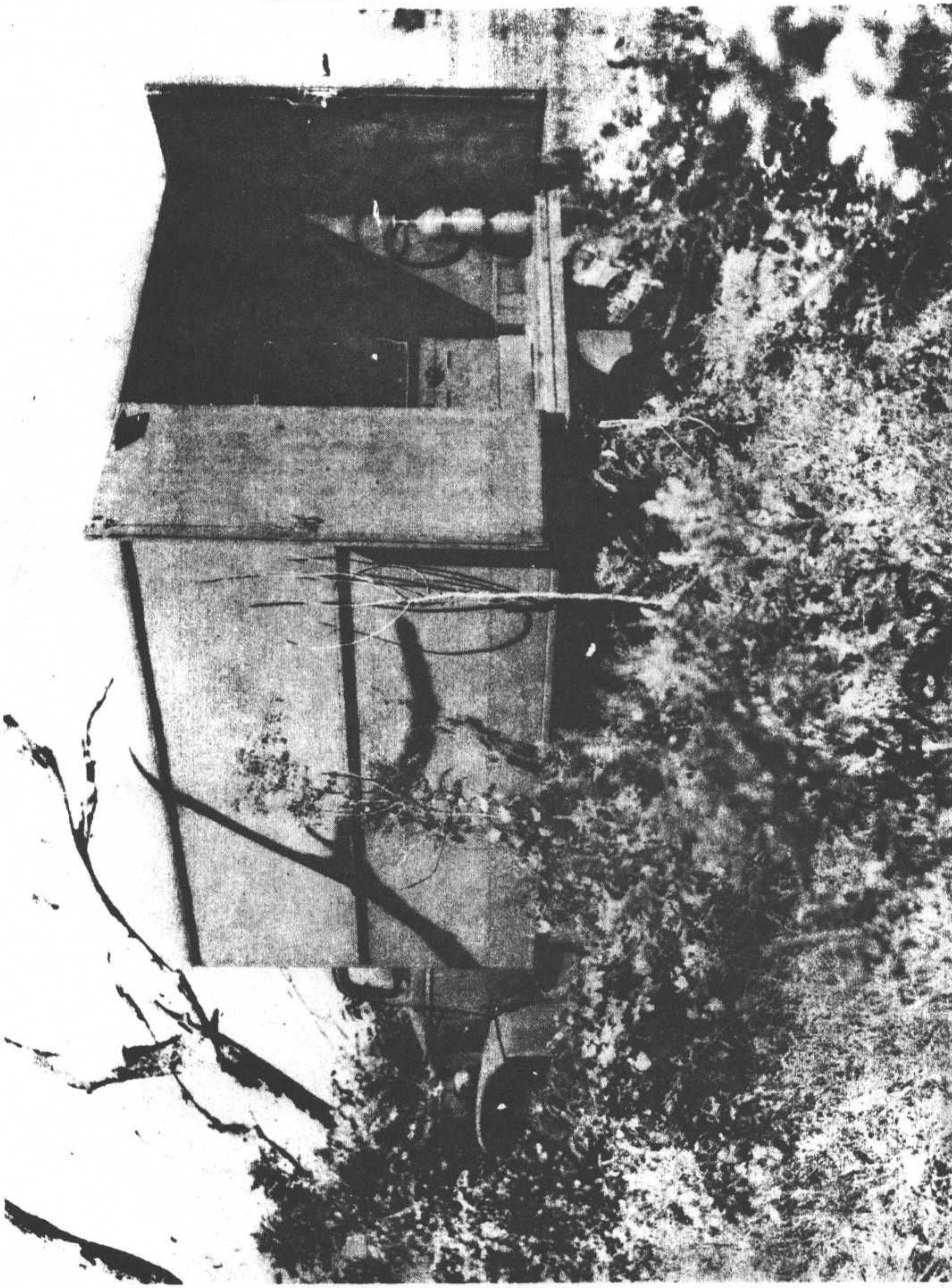

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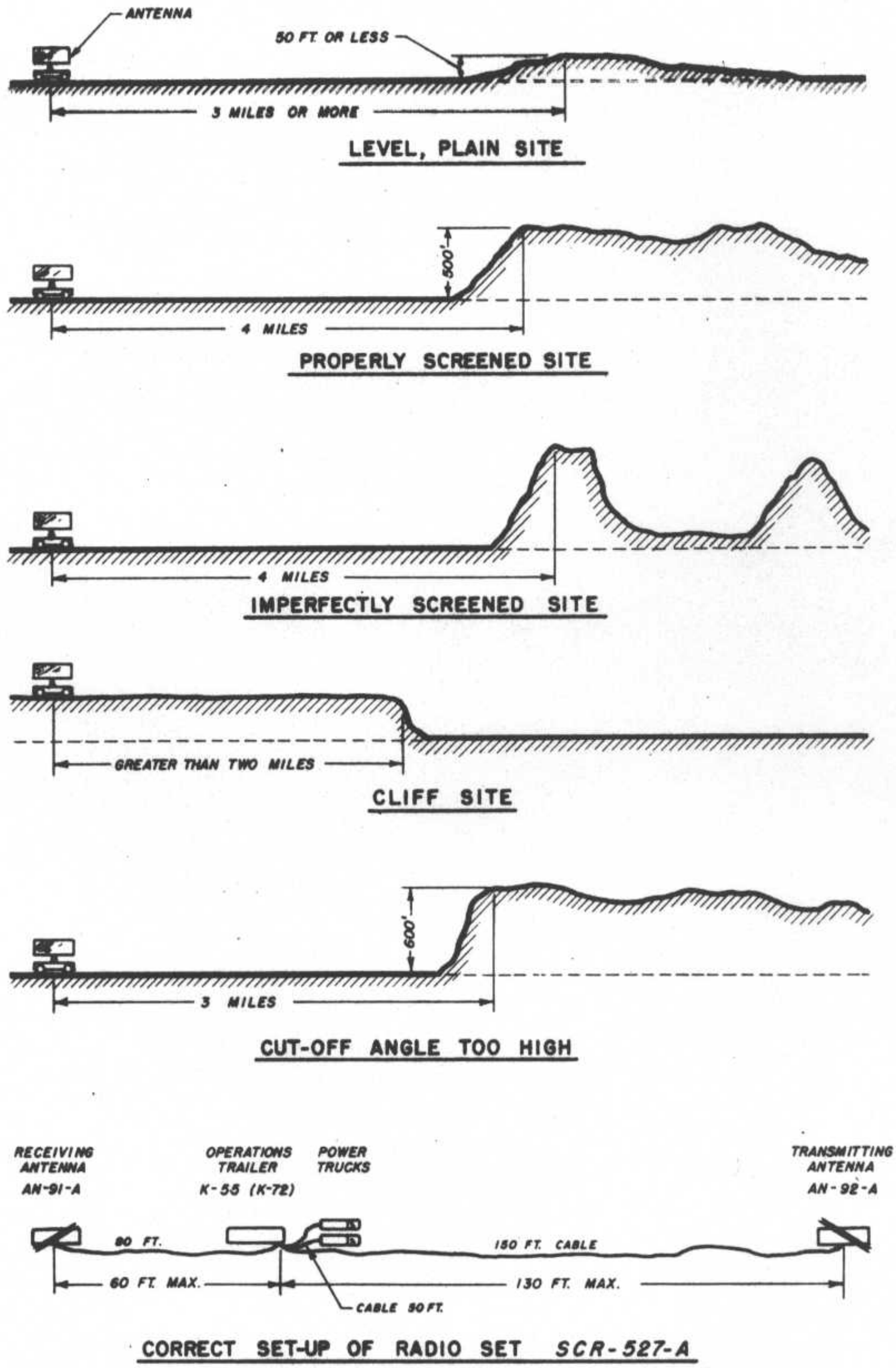

FIG. 6

AAFTAC-12/7/43-A852-1M


AAFTAC-1/29/MM-A1020-1M

which permits continuous rotation in azimuth in either direction. The antenna array consists of eight end-fed half-wave dipoles wide, and four half-wavos high.

j. POWER UNITS PE-137-A - Power for radio set SCR-527-A is supplied by power units PE-137-A, one in each of the two power trucks. Also mounted in each truck is a 25 KW 120/208-volt gasoline engine generator set (Fig. 5)

C. CHOICE OF SITE

1. In selecting a site for the SCR-527-A, there are two main requirements to be borne in mind. The ground surrounding the antennas for a distance of 200 yards must be perfectly flat to give good height measurement, and the ground contours at greater range must be within 3 degrees elevation to the horizon for GCI Siting.

2. Height finding may be satisfactory either with level or with flat, sloping sites. It is necessary, however, for a sloping site to slope the same at all azimuths, so that the height calibration does not change with azimuth. Hill-top sites are unsuitable because fixed echoes are obtained from distant objects. Saucer-shaped depressions are desirable, though difficult to find. This means that the minimum requirement for satisfactory operation is a flat, circular site, one mile in diameter, with tolerable rise to horizon within the required 3 degree elevation angle. Some permissable and not-permissable sites are shown in Figure 6.

3. Station Layout - a. Most desirable arrangements of vehicles is shown in Figs. 6-7.

b. Administrative and non-technical buildings should be located as far distant as convenient from the antennas.

c. Metal buildings should not be used unless absolutely necessary.

d. Wire defenses should not be less than 50 yards from the antennas.

D. HEIGHT FINDING WITH THE SCR-527

1. Things to keep in mind.

a. For good accuracy in height finding, stay at 6 degrees angle of elevation or above.

b. The $12\frac{1}{2} - 7\frac{1}{2}$ or split 10 as it is commonly known, receiver antenna is satisfactory.

c. Results will be essentially the same as with the SCR-588, using the lower antenna array.

d. Only one height conversion chart is necessary.

e. A relative differential, plane-to-plane, of 250 ft. can be obtained.

Fig. 8 shows some height and range findings as compiled at Pasco, Florida on May 1, 1943 for a P-70 plane head on. The siting and results of this test may be considered as above average.

CAPABILITIES OF SCR-527

FOR P-70 - HEAD ON

HEIGHT	* RANGES WITH LEVEL SITE - MILES -
50 ft.	5
100 ft.	7
200 ft.	9
500 ft.	10
1000 ft.	16
2000 ft.	22
3000 ft.	33
4000 ft.	37
5000 ft.	42
6000 ft.	46
7000 ft.	50½
8000 ft.	54
10,000 ft.	59½
12,000 ft.	65½

*Calibrated pick-up ranges

(FIG. 8)

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CAPABILITIES OF SCR-522

CHAPTER V.

1. General - The SCR-522 is an airborne VHF Receiver-Transmitter combination for aircraft installation. The set is designated for simplicity and reliability. Headphones, microphone and a five-button control box are all that the pilot has to concern himself with in the air.

2. Description - Night fighter aircraft are at present equipped with two VHF SCR-522 sets. One set carries the day control frequencies and the other set provides the GCI frequencies for night operations. This set may be installed at the GCI station as an emergency or auxiliary VHF installation for ground-to-air and air-to-ground communication.

Each 522 set is composed of five units:

a. Receiver, BC-624
b. Transmitter, BC-625
c. Control Box, BC-602
d. Contactor unit
e. Dynamotor unit (Power Unit) PE-94

The transmitter-receiver units are rack mounted to facilitate servicing and replacement and are cable-connected to the control box, contactor, junction box, and dynamotor. (See inter-connecting diagram)

Function of the SCR-522 is to provide voice communication between aircraft, aircraft and ground, ... for the transmission of a 1000-cycle note or "pip-squeak" for direction finding. The transmitter and re-

S E C R E T

ceiver operate on four pre-tuned channels, any one of which may be selected by pushing a button on the Radio Control Box (See diagram) located in the pilot's compartment. A three-position toggle switch also mounted on the Control Box is marked (T) "Transmit", (R) "Receive and (V.O.) "Remote" left, center and right. In multi-seater planes, switching from "Receive" to "Transmit" can be accomplished by a push button located on the throttle, control stick or any other position convenient to the pilot when the switch is the V.O. position. Each channel selected for transmission is indicated by a green light. A white light indicates that the "Receive" position is selected. A failure of these lamps does not interfere with the working of the 522. They are indicator lamps only. A dimming mask fitted over the push button controller lamps guards against glare when night flying.

For channels of operational frequencies controlled by the Radio Control Box of each set are as follows:

Day Frequencies

a.	Squadron Communication	(Aircraft-to-aircraft)
b.	Common	(General aircraft-to-ground)
c.	Homing	(Special frequency for homing)
d.	D/F	(Pip-squeak transmission)

Night Frequencies

a_1	GCI Control	(GCI Station #1)
b_1	GCI Control	(GCI Station #2)
c_1	GCI Control	(GCI Station #2)
d_1	GCI Common	(GCI Reserve)

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In airborne units, the functions of channels A, B, and C are interchangeable, however, channel D must be used for D/F.

Transmitter Unit - The transmitter is a crystal controlled radiotelephone transmitter designed to operate on a frequency range of from 100 to 156 megacycles. The output frequency is 18 times the frequency of the crystal. A crystal range between 5555 and 8666 kilocycles is used. Frequency change or channel selection is accomplished by a mechanical movement of four cams operated by a selector motor. When one of the buttons on the Radio Control Box is punched, the movement of these cams automatically and simultaneously puts the transmitter and receiver on pre-tuned crystal controlled frequencies.

Receiver Unit - The receiver is a VHF receiver designed to operate on harmonic frequencies controlled by a crystal in a similar manner to the transmitter. By means of its technical design, it operates on a frequency 12 megacycles less than the frequency of the incoming signal.

3. Operation - To place the 522 set in operation, it is only necessary to press a push-button on the control box corresponding to the channel desired. A lamp adjacent to the button depressed will light, showing which channel is in operation. When operations are finished, it is necessary to press the button marked "off".

To transmit: The transmit-receive switch on the push-button control is put to the proper position and the pilot should immediately start his transmission, going back to the "Receive" position as soon as possible. This point is often forgotten with the result that the air frequency is jammed because two or more transmitters are on at the same time.

4. Summary of Data on SCR-522

a. Frequency range - 100 to 156 megacycles (1.92-3 meters)

b. Operating power - 24-28 volts direct current

c. Power consumption - Transmitting - 11.5 amps at 28 volts.

Power consumption - Receiving - 11.1 amps at 28 volts.

d. Dimensions - 16" x 13" x 11" high.

e. Weight - 48 pounds (approximately)

f. Transmitter frequency - crystal frequency x 18

g. Receiver frequency - incoming signal less 12 megacycles.

Operational Characteristics

1. Range limited to approximate line-of-sight. This characteristic makes jamming by the enemy difficult (See chap.III, Pam. E).

2. Absence of reflected waves and skip distances.

3. Relatively free from natural interference such as static, weather disturbances, etc.

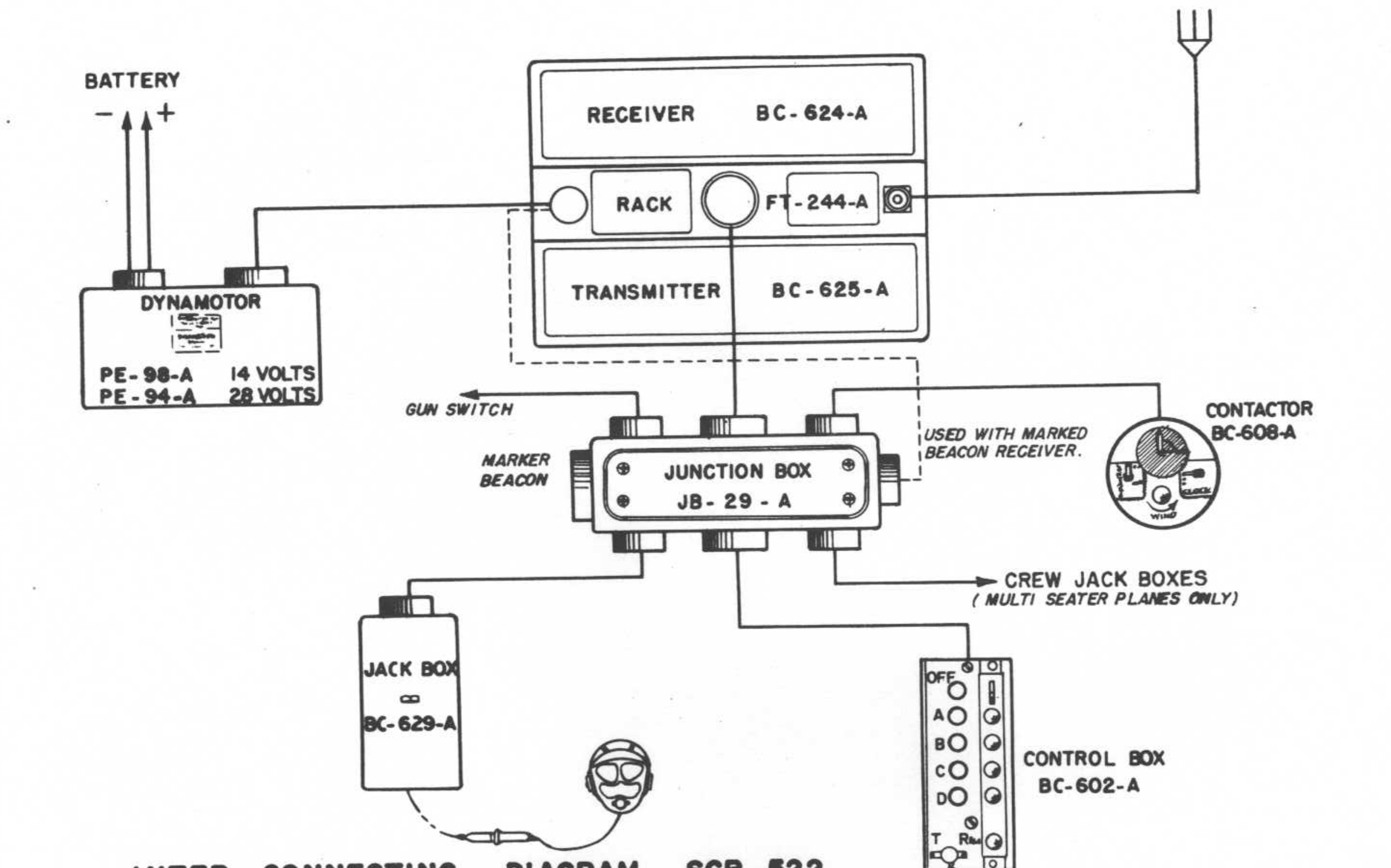
4. Very sensitive to man-made interference such as automobile ignitions, spark-gaps, etc.

5. Short antenna very desirable for aircraft installation.

6. Especially good for direction-finding due to short antenna.

7. Very little fading.

8. Relay stations are necessary to extend range.



INTER-CONNECTING DIAGRAM SCR-522

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9. Range is governed by height of ground antenna, altitude of aircraft and terrain. Formula for computing theoretical range of VHF is as follows:

$$R = 1.32\sqrt{h_1} + \sqrt{h_2}$$

R = Range in miles
h_1 = Height of plane in ft.
h_2 = Height of antenna in ft.

5. Adaptions of the SCR-522 - The SCR-522 may be adapted to many uses in the field as emergency standby equipment or auxillary installation. Should one of these applications be desirable it is suggested that proper Signal Corps assistance be obtained.

D/F Station:	Use of the SCR-522 with an Adcock antenna for direction finding and reading provides a satisfactory emergency D/F station.
Homing Station:	The SCR-522 may be used as an emergency transmitter for homing to the D/F station.
Relay Station:	An SCR-522 set-up with connecting line from Control may be adapted to relay use for extending range. Messages received over the line connected with Control must be repeated for re-broadcast.
Ground-to-ground:	Use of the SCR-522 for ground-to-ground transmission may be used in emergency if range is not too great.

The audio amplifier in the receiver also functions as a speech amplifier for inter-communication, pilot-to-crew in multi-seated planes. Not only can the crew talk to pilot and pilot to crew, but the crew can listen in on the radio channel at all times. They may also talk to the pilot during transmission or receiving on the radio channel if an emergency arises, otherwise they should maintain silence to enable all concerned to hear clearly all instructions from the ground. The circuits are designed so that the speech of the crew cannot go out on the transmitter.

CHAPTER VI

THE SCR-573, SCR-574 SYSTEM

1. The Signal Corps designation SCR-573 and SCR-574 identifies a mobile VHF communication system of two channels ground-to-air, and two channels air-to-ground, housed in the SCR Mobile Trailer Van. Included in the system are all components of operation, including antennas, auxiliary power, control panels, cables, etc.

The above system does not include the mobile D/F necessary to GCI installation. The mobile D/F truck system is identified as the SCR-566.

2. SCR-573 TRANSMITTER (See Fig. 1-2) - The SCR-573 transmitter installation consists of two (2) BC-640 VHF transmitters and one communications panel housed in the commodious mobile van. Two Bendix plywood antennas, one for each channel, are provided and an external auxiliary power trailer power trailer PE-99. Commercial power is used wherever available, and all cables, connectors and terminals are provided. This system provides two-channel ground-to-air communications as a mobile installation.

3. SCR-574 RECEIVER (See Fig. 3-4) - Like the 573 Transmitter, the SCR-574 receiving system is installed in the mobile van. The same components of external supply, (antennas, power supply provision, etc.) are standard for both the 573 and 574. The receiving system is composed of two BC-639 VHF receivers; two BC-638 crystal controlled frequency meters, for tuning and aligning the entire SCR-573-574 system,

two line amplifiers, and two RM-18-A Control boxes. The line amplifiers and control boxes provide the necessary voice level amplification and switching arrangement for land line communication between the various units - i.e., station, transmitting van, receiving van, and power trailer.

4. SCR-640 TRANSMITTER (See Fig. 2-5) - The BC-640 VHF transmitter is rack mounted, being composed of the following components:

a. Components:

1	Amplifier Panel	41.50 lbs.
1	Oscillator Panel	39.
1	Modulator Panel	48.
1	Control Panel	27
2	Power Supply Panels	84. (each)
1	Power Control Panel	40
1	Input Transformer and support	27.50
1	Steel Cabinet	210.50
		601.50 lbs.

b. Frequency and Power: - Frequency range is 99 to 156 megacycles. Output operating frequency is 18 times the fundamental frequency, which means crystals range from 5.5 to 8.4 mc/s (5,500 KC to 8,400 KC). The radio frequency (RF) power input to the antenna is 50 watts. A coaxial cable of 70 ohms impedence transfers the RF energy to the vertical diapole antenna.

c. Controls - Controls for "local" or "remote" operations are included on the transmitter.

d. Power Input - The power input panel provides terminals for commercial single phase, 50 to 60 cycle, 100-125 volts AC or 200-250

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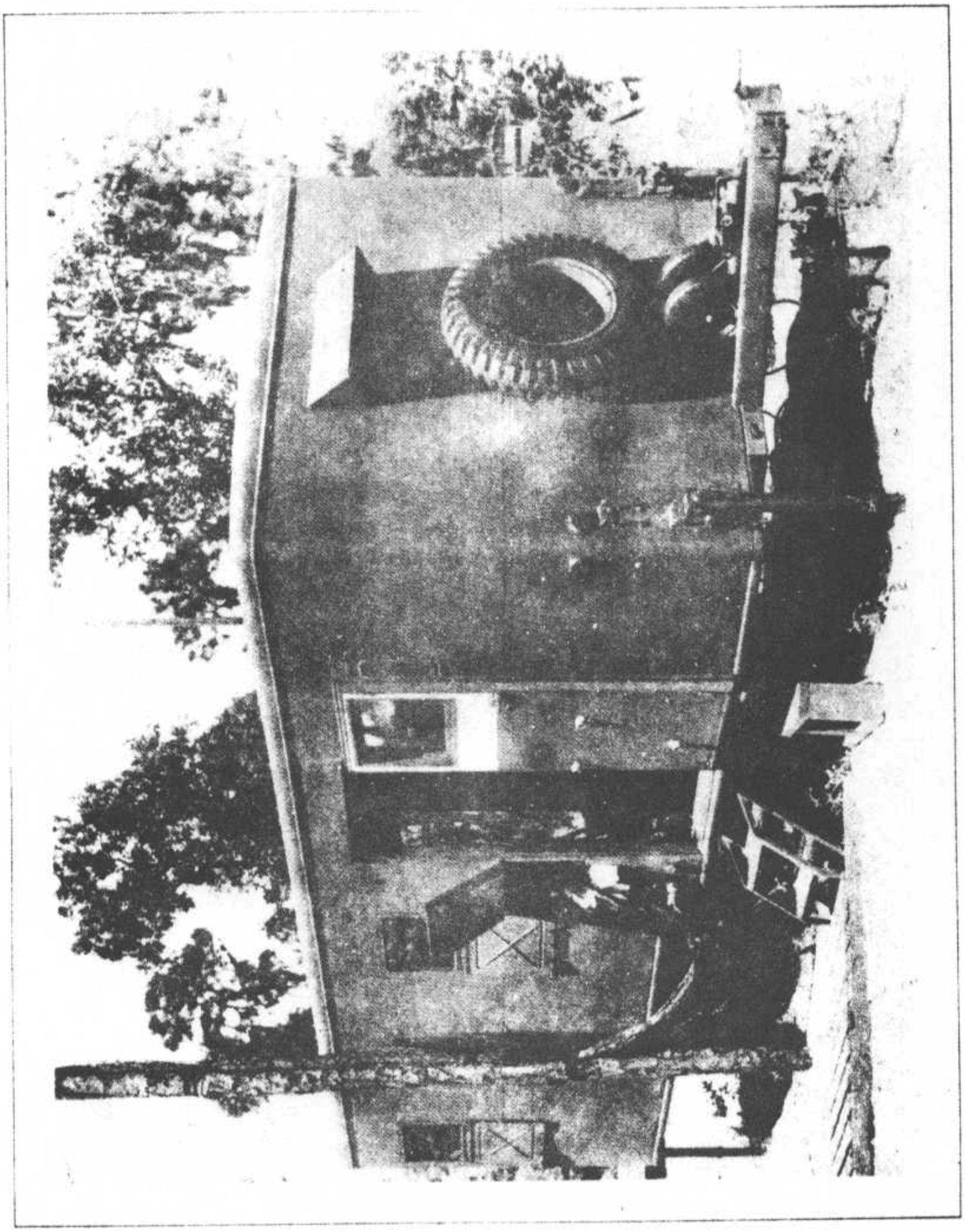

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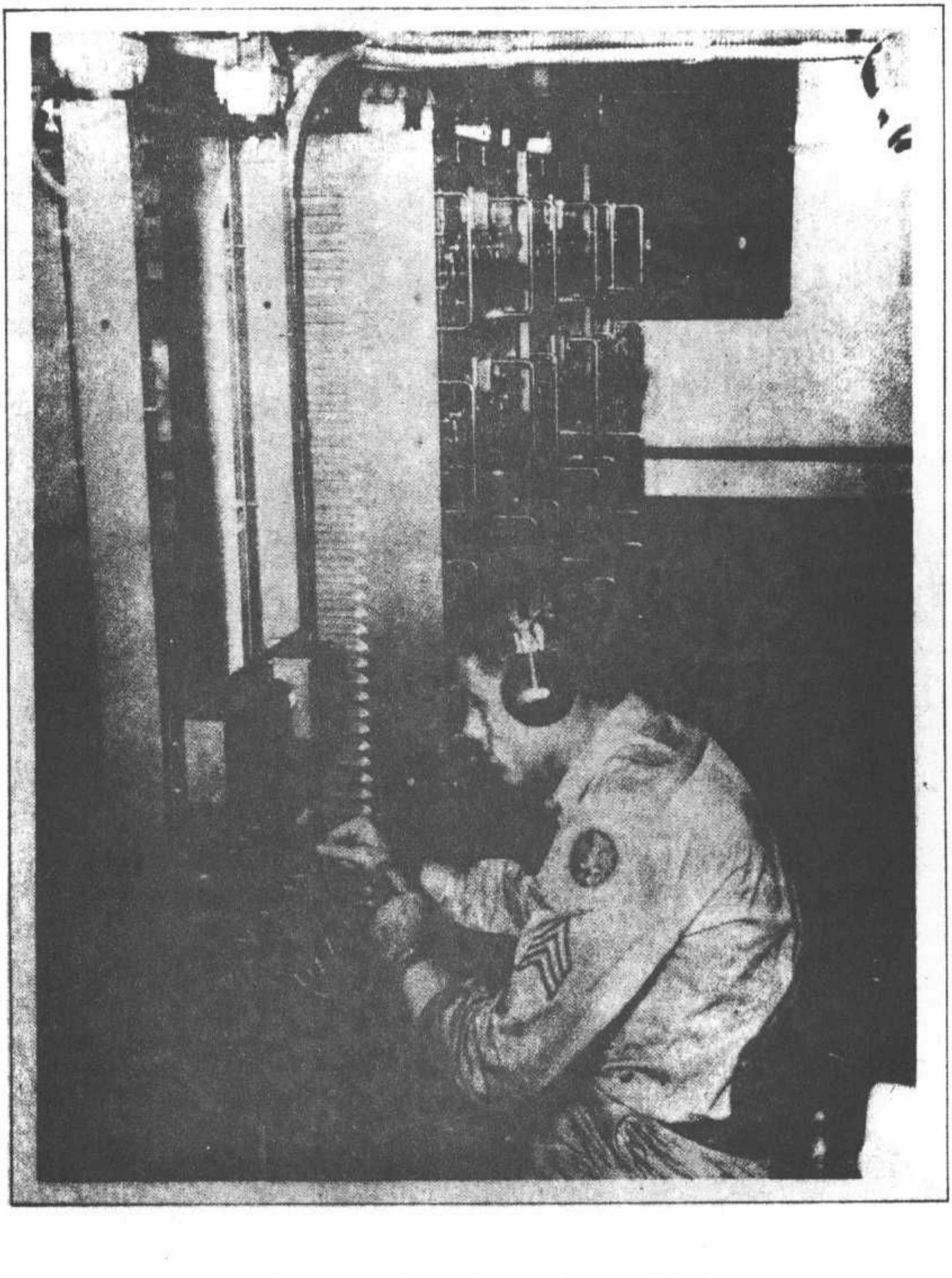
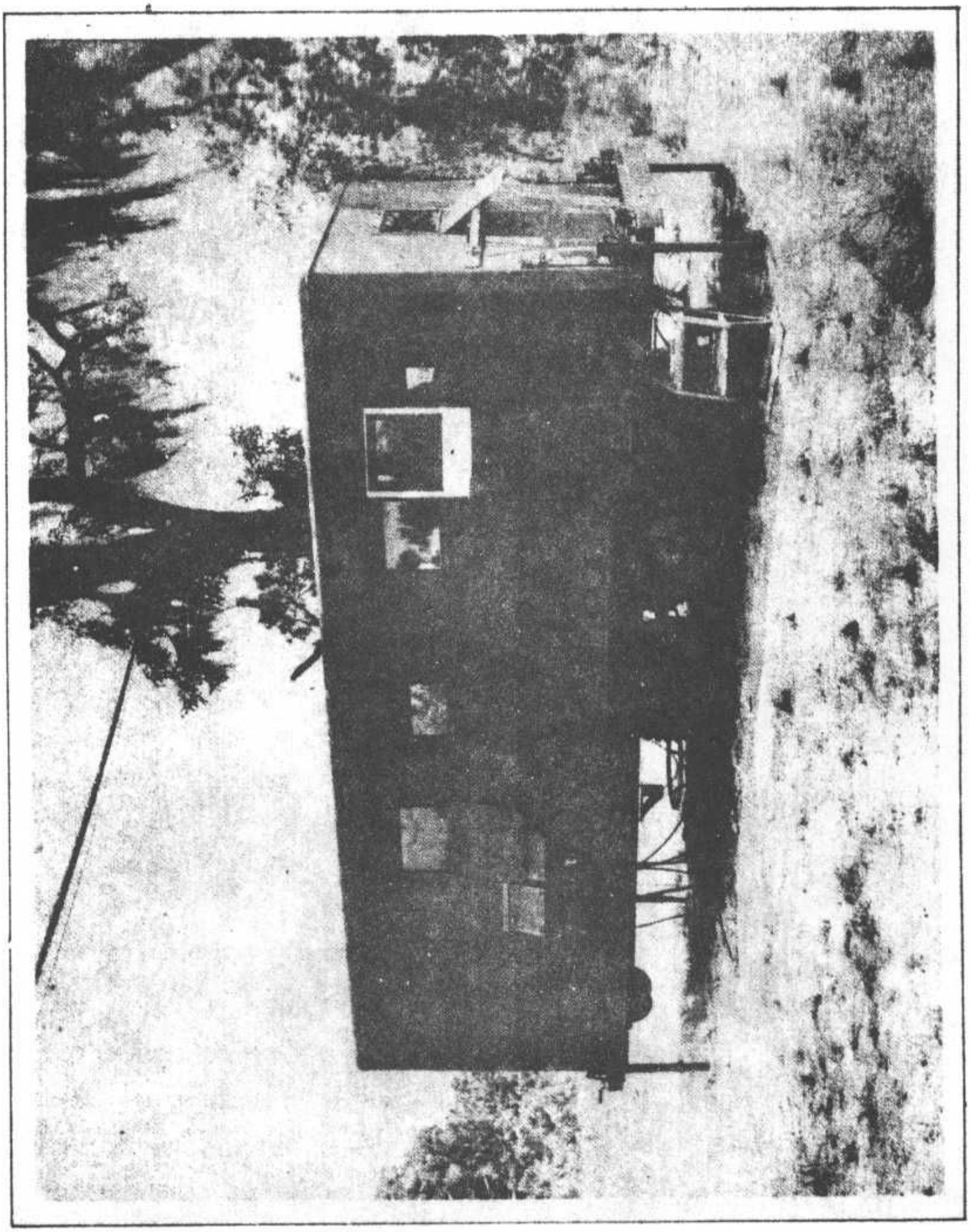


TRANSMITTER STATION OPERATOR

AAFTAC-12/7/43-A852-1M

FIG. 2



RECEIVER TRAILER

AAFTAC-12/7/43-A852-1M FIG. 3

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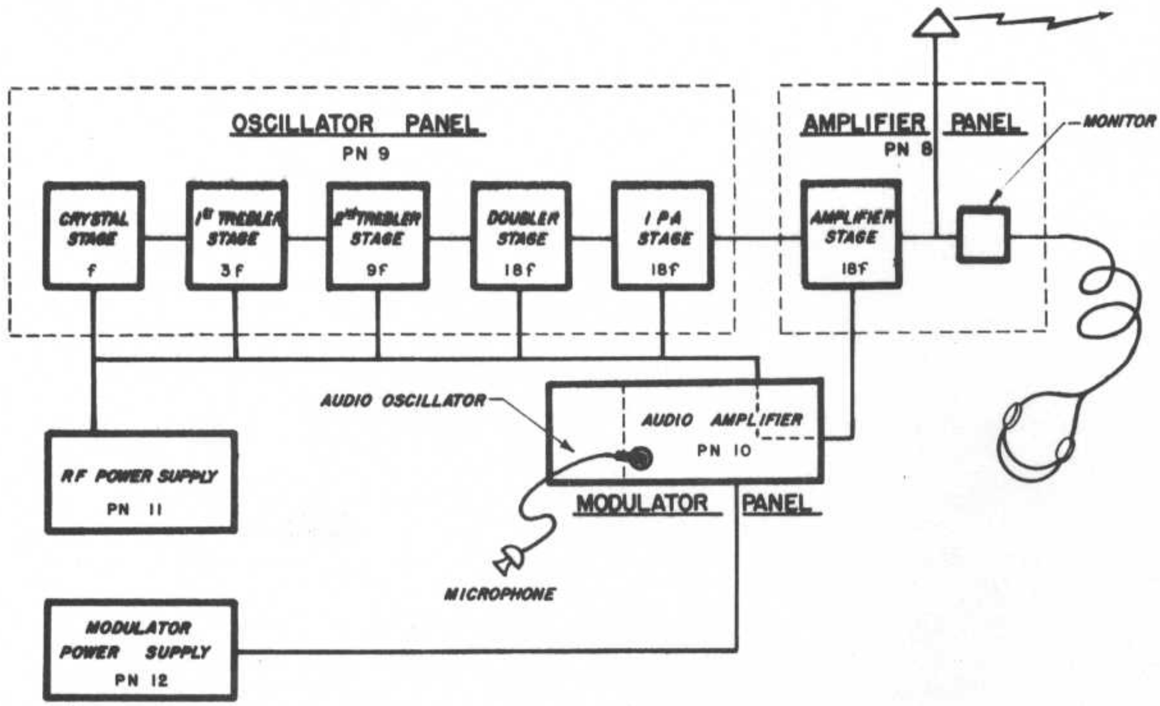
RECEIVER STATION

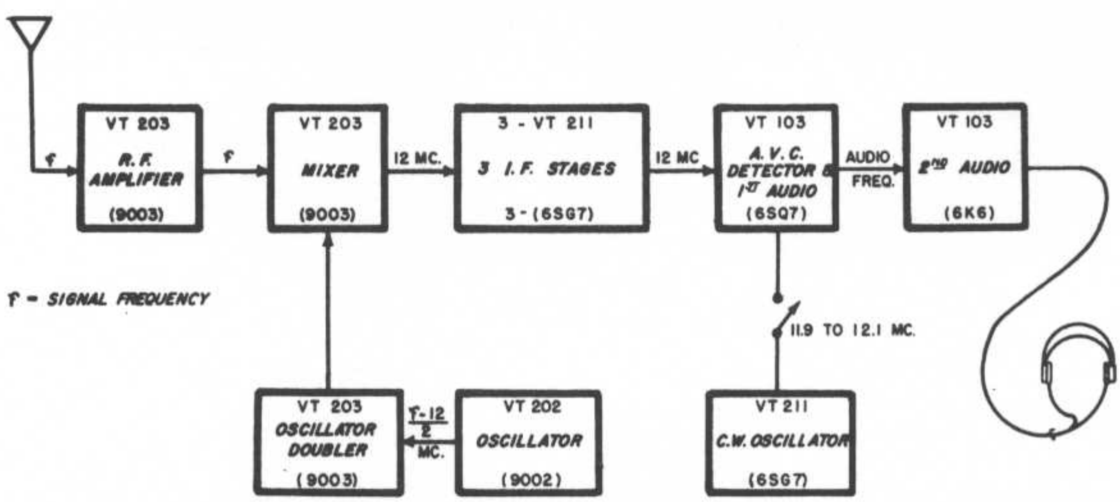
AAFTAC-12/7/43-A852-IM

FIG. 4



BLOCK DIAGRAM BC-640A GROUND TRANSMITTER

FIG. 5



BLOCK DIAGRAM BC-639A RECEIVER

FIG. 6

AAFTAC-12/7/43-A852-1M

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volts AC. When operating from the auxiliary power trailer unit, PE-99, three phase is used. Voltage regulation is accomplished by built-in controls on the power panel.

e. Range - RF power output is sufficient for point to point communications of $11\frac{1}{2}$ miles on the ground, or point-to-point ground-to-air 135 miles, if the aircraft is at 10,000 feet. Varying conditions of terrain and altitude will substantially effect the range. The following formula may be used with good satisfaction for calculating the necessary height for A/C or antenna for any desired projected range:

$$X = \frac{2}{3} D^2$$

X = Height of the a/c or antenna in feet.

D^2 = Projected range or distance in miles.

The above formula is based on average siting on level plane or table top land. (Also see range formula, Sect. B. Chap. V, Page 5)

5. BC-639-A RECEIVER (see Fig. 4-6) - The BC-639 is a VHF Superheterodyne receiver for use as ground station receiver. It is cased for rack mounting along with the separate components necessary to one receiving position.

a. Components of 1 Receiving Position

1 Rack Frame, FM-39	121	lbs
1 Radio Receiver BC-639-A	36	"
1 Rectifier Panel RA-42	26	"
1 Desk Unit, PN-1	8	"
1 One Socket & Connecting Panel PN-4	7	"
1 Fuse Panel, PN-5	24	"
1 Control Unit, [illegible]-23	18.25	"
1 Frequency Meter, BC-638	35	"
	275.25	"

Dimensions (See Fig. 4) - Overall size of complete rack mounted position is: Height 72"; Width 20½"; Depth 15".

c. Electric Characteristics: - Tuning range 100 to 156 megacycles. The tuning dial is calibrated in a direct reading megacycle scale, with a signal strength meter alongside. When the set is turned up properly and calibrated with the BC-638 frequency meter unit, dir ect reading of frequency is possible. Approximate controls for gain, sensitivity, and CW or speech reception are provided.

d. Uses: - Principle use being to provide air-to ground reception in SCR-574 system. When used with frequency meter unit BC-638, may be used for determining frequencies, or if provided with an externally mounted, rotatable adcock antenna it may be used for D/F.

e. Input to Receivers: - Input is matched to the standard 70 ohm coxial cable from a vertical diapole antenna.

f. Range: - This receiver has very high sensitivity and is limited only to line of sight VHF characteristics.

g. Power Input: - Power for the receiver, is provided by the rectifier unit installed in the receiver rack. Rectifier will take the same types of power source as the BC-640.

6. NOTES ON SITING VHF EQUIPMENT.- It has been found that the problem of siting will naturally affect the VHF performance. For example: It is possible for poorer performing radio equipment properly sited to give better performance than a more satisfactory type radio

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improperly cited. In localities where the terrain is level and no hills or large buildings or other obstructions are present, the problem of communication station siting is not a serious one. Aerials should extend above any close-by objects and should be placed on as high ground as possible. Receiving station should be well removed from travelled roads or any other sources of electrical interference. Natural camouflage can and should be taken advantage of wherever possible and aerial masts may be erected in a wooded area, when desired, so long as the antenna extends 20 or 30 feet above the trees. Siting in mountainous terrain may present a complex problem. Considerable care and an intelligent study of the regions topography will very probably be required before siting such a station. Generally, there are two methods of selecting a satisfactory site. The first and best is to place the station on the highest surrounding point of ground. This is not always possible due to the inaccessibility of some types of terrain. When the terrain does not permit the location of the station on the highest point, the second method of siting becomes necessary. That is, the station must be removed as far as possible from any mountain peak or ridge over which it may be necessary to work in order to lower, as far as possible, the angle from the aerial over the mountain ridge. Wherever sited, care should be taken to remove the receiver sufficiently far from the radar transmitter so that the reception of the former is not interferred with.

CHAPTER VII

SCR-566 MOBILE D/F SYSTEM - SCR-634 AIR TRANSPORTABLE D/F SYSTEM

1. SCR-566 Mobile D/F Unit (See Fig. 1) - SCR-566 is the designation of the mobile, van-truck installed D/F System. This system consists of two BC-A receivers and auxiliary communications panel, mounted in a relay rack adjacent to the antenna rotating controls in the center of the truck. The adcock antenna section above the truck is rotatable and collapsable for transporting. Provision is made to work on either, commercial or generator power. The gas engine-driven generator for field use may be carried in the truck or it may be the conventional PE-99 mounted in a trailer.

2. SCR-634 Air Transportable D/F System - is comprised of the same components as the SCR-566, except it is packaged and housed for air transportable use. Collapsable hut 8' x 8' or 8' x 8' tent is provided. The frame supporting the adcock antenna is part of the structure, and installation of equipment goes in a light weight knock-down rack and operating table. A variety of portable power plants are available, mounted on carrying frames with a light weather protecting cover, and 300' cable for isolation. The entire unit less the hut weighs 454 lbs.

3. Definition: - D/F is simply direction finding. When applied to GCI becomes a D/F method of obtaining identification, and keeping azimuthal track on aircraft requested by the controller.

4. Voice-Fixing D/F - For GCI operations voice fixing provides the only method of D/F'ing our Aircraft. Each and every time R/T is received from A/C the azimuthal bearing is obtained with special equipment, and told over a land line into the plotter computer. The new Craig Navigation table has a rotating beam of light, projected outward from the station point in the center of the map, which is controlled from the D/F station. Each time the a/c calls in, the light swings to its azimuth. This is invaluable where any fading occurs on the scope and the a/c has to be dead reckoned. It is equally valuable in identifying a/c when they are turned over to GCI, and first call GCI control.

5. Requirements for D/F - Three things must be accomplished in order to D/F.

a. A direction finding antenna must be employed which can be rotated and sensed, to prove front or back direction from antenna to a/c.

b. A sensitive receiver must be used with appropriate R/F gain controls to allow proper reception without blanketing.

c. Bearing rings must be provided on the antenna rotating device, (See Fig.2) from which true bearing and direction of the a/c can be read.

6. Receiver Operation: - It has been found that the received signal from an a/c at ten miles is so great, proper reduction of the R/F and audio gain controls is necessary to obtain accurate bearing,