CHAPTER THREE

SEARCHLIGHT OPERATION

Paragraphs

Section I

GENERAL

53. SCOPE.--a. This chapter deals with the phases of searchlight operation which directly affect the illumination of targets. It does not supercede existing searchlight manuals, but is intended to supplement them. It covers technique and methods of operation essential to the one basic requirement -- the illumination of targets, regardless of the use to which the illumination is to be put, once produced.

b. Certain simple, special features of illumination, required for fighter cooperation, are stressed, in addition. Illumination produced in accord with the principles contained herein is equally suitable, however, for the needs of guns or of fighter aircraft. It is wholly unnecessary for the searchlight personnel even to know in advance the purpose for which the illumination they produce is intended -- whether guns are to fire or fighters to attack.

54. SELECTION OF A RADIO DETECTOR SITE.--a. There are two general types of interference which hamper efficient operation of a Radio Detector. These are:

(1) Interference caused by echoes from stationary objects, such as mountains, buildings, water towers, oil wells, etc.

(2) Interference from other radio detectors.

b. If the radio detector site has not been carefully selected, interference from the above sources can become so bad that the radio detector will be incapable of tracking a target. Proper care in the selection of the site, however, will materially reduce the interference which might otherwise be present. Therefore, the reconnaissance for a radio detector position should be carefully made, and the reconnaissance officer, who is usually the platoon commander, should be thoroughly familiar with the requirements for a good radio detector position. Some of these requirements are:

(1) If no mountains, other radio detectors, or other sources of permanent echoes or interference exist to the front, the radio detector should have a flat, clear field of view in front. This will allow of its attaining its maximum range.

(2) Otherwise, the radio detector should be located in a hollow or depression, rather than in an elevated position. See Figure 22. The hills or ridges forming the rim of the depression will, if they are less than 2000 yards from the radio detector, screen out interference from more distant hills, buildings, or other stationary objects which otherwise would produce echoes on the oscilloscope screens. Any objects which are visually screened from the radio detector by the surrounding hills will be also electrically screened from the radio detector.

(3) The radio detector, in non-mountainous terrain, must be capable of operating on its normal front at a minimum angle of elevation of ten degrees above the horizontal. Therefore, any frontal screening which is present must be just high enough to mask the source of distant permanent echoes or interference.

(4) In the usual situation, where the radio detector will operate on a limited normal front, the screening to the rear of the radio detector should be as high as possible, in order to provide the maximum protection from interference caused by other radio detectors operating in the rear. The height of this rear screen is usually dictated by the tactical requirements of searchlight operation.

(5) The screening at the sides of the radio detector site should be as high as is consistent with the tactical requirements for the operation of the radio detector and searchlight to the sides.

(6) It is advantageous, although not necessary, that the radio detector site be located near a commercial power line, so that the radio detector may be operated on commercial power. The radio detector power plant can then be retained as a standby for emergencies.

(7) The radio detector site should, of course, be accessible to the heavy and cumbersome equipment and trucks which must move into position.

c. A more detailed discussion of radio detector sites will be found in Appendix A.

55. DECENTRALIZATION OF CONTROL.—a. The foundation of the entire system of searchlight fighter tactics is based on the principle of decentralization of control, i.e., placing in the hands of NCO's the tactical control of the individual searchlight sections, rather than confining tactical control to higher echelons of command. In the rapidly and continuously changing situation of a multiple plane attack, it is well-nigh impossible for even the next higher echelon of command, the platoon commander, to keep accurately acquainted with the particular situation confronting each individual searchlight section. Even if the platoon commander could keep himself acquainted with the changing conditions confronting each of his five sections, he can actively control only one section at a time. If several conditions requiring instant decisions and action arise simultaneously, or nearly so, an unavoidable delay will inevitably result as the platoon commander makes his decisions and gives the necessary orders to each section in turn. Due to the speed of modern airplanes, time is a vital element in any system of tactics dealing with aircraft, and often, a few seconds' delay will allow a situation to get out of hand which otherwise might have been kept under control had action been taken in time. Furthermore, even if the platoon commander could accomplish both of the difficult tasks mentioned above, i.e., keep accurately acquainted with the continuously changing situation, and also be capable, without delay, of making the necessary decisions and issuing the required orders, such a system would be entirely dependent upon the maintenance of an adequate system of communication. The communication problem in a searchlight battery or platoon, whose sections are spread out to the extent that the platoon may cover an area of some one hundred to two hundred and fifty square miles, is a tremendous one. Any reasonable system of searchlight tactics must be predicated on the assumption that communications are very likely to fail during action.

b. For reasons discussed in the preceding paragraph, it is quite logical to place the tactical control of one searchlight section in the hands of one individual who is responsible for the operation of that single section — the section chief. He need keep himself aware only of the situation as it concerns his own section; he is not burdened with the necessity of making decisions or issuing orders concerning any searchlight other than his own. However, he will receive information from the telephone operator at the control station concerning action of the other sections in his platoon, and also the Platoon Command Post will give information regarding action in other platoons plus certain intelligence information from the AAA Operations Center. This is all important and very pertinent to the tactical decisions the Section Chief must make. Not only is he in a better position geographically than the platoon commander for making decisions which affect his section, but he is right there with the operating crew — where he can get instant response to any orders that he issues.

c. Naturally, with the burden of tactical operation being carried by the NCO's, it is extremely important that they be thoroughly indoctrinated with the basic principles of searchlight tactics, so that they can make immediate and intelligent decisions when confronted with the rapidly and continuously changing situation of a multiple plane attack. It is the responsibility of the platoon commanders to see that their NCO's are trained, and the degree of training of a searchlight platoon will usually be found to be in inverse ratio to the number of orders which the platoon commander is required to issue during operations.

d. Tactical control, however, is not entirely taken out of the hands of the platoon commander. From his observation post, the platoon commander should watch the operation of his six searchlight sections and issue such orders as are required to correct any tactical errors which his NCO's may make. This should be the extent of the tactical control exercised by the platoon commander.

56. COMMANDS AND INFORMATIVE TERMS.-- Some of the commands and informative terms used in searchlight operation are listed below. The use of some of these terms is further explained in later portions of the text, while others require no additional explanation.

a. "Contact" -- Announced by detector operator -- radio detector scope operator or sound locator listener -- at first indication of presence of targets. Repeated immediately by telephone operators over platoon command net and data line, to alert the searchlight section, the other sections in the platoon, and the plotter at the AAA Operations Board.

b. "Azimuth on Target" -- Announced by azimuth scope operator or azimuth listener, to indicate to the detector commander that the detector is centered on the target in azimuth. (Not repeated over telephone lines.)

c. "Elevation on Target" -- Announced by elevation scope operator or elevation listener, to indicate to the detector commander that the detector is centered on the target in elevation. (Not repeated over telephone lines.)

d. "Range on Target" -- Announced by range scope operator, to indicate to the detector commander that the range data is accurate. (Not repeated over telephone lines.)

e. "Acoustic Corrector on Target" -- Announced by acoustic corrector operator, to indicate to detector commander that accurate acoustic corrections are being applied to sound locator data. (Not repeated over telephone lines.)

f. "On Target" -- Announced by detector commander and immediately repeated by telephone operators over the platoon net and data line, to indicate that the detector has been centered on the target and that accurate azimuth and range data can be furnished.

g. "Take" -- Warning given over data line by the azimuth reader at radio detector to plotter at AAA Operations Board, before each reading of azimuth. This warning is given only after the azimuth reader has reported "On target".

h. "Azimuth (elevation, range, etc.) off Target" -- Announced by oscilloscope operator or listener, to inform detector commander that target has been lost or that data has become inaccurate. (Not repeated over telephone lines.)

i. "Off Target" -- Announced by detector commander and immediately repeated by telephone operators over the platoon command net and data line, to indicate that the detector is no longer furnishing accurate data.

j. "Range" -- Announced by detector commander and immediately repeated over platoon command net, to indicate that the detector is still on target and that the target is at the proper position for the initial pick-up. This information is primarily for the benefit of the section chief, who uses it as a criterion for going into action for an initial pick-up.

k. "In" -- Command given by section chief to order light into action. Repeated by telephone operator over platoon command net.

l. "Out" -- Command given by section chief to order light out of action, Repeated over platoon command net. After the light has gone out of action, the chief controller will immediately traverse the control station back to the normal front, or to any direction which the light commander may designate.

m. "Traverse Right (Left)" -- Command given by section chief or detector commander to rotate light or detector clockwise (counter-clockwise). Not repeated over telephone lines.)

n. "Change Target" -- Command given by section chief or detector commander to order a light or detector to drop one target and pick up another. Repeated over platoon command net and data line.

o. "Flick" -- Announced by the chief controller when he sees through the binoculars a momentary illumination of the target while the controllers are following data. The chief controller immediately takes over the handwheels and attempts to keep the beam on the target, while the azimuth and elevation controllers simultaneously release their handwheels. Not repeated over platoon command net.

p. "Target Illuminated" -- Announced by chief controller when he has definitely caught the target in the searchlight beam and is tracking it. Repeated over the platoon command net. In a radio detector section equipped with a data line, when a target is first illuminated after having been tracked by the radio detector and plotted on the AAA Operations Board, "Target Illuminated" is immediately called over the data line by the azimuth reader for the information of all concerned. This is in addition to the announcement "Target Illuminated" over the platoon command net.

q. "Intersection" -- Term used to announce that an intersection of two searchlight beams has been formed on or near a target. Announced by detector commanders of the first 2 sections going into action and forming the intersection. The azimuth data reader immediately transmits this announcement to the plotter; the latter repeats it aloud in the plotting room for the information of the Intercept Officer. Term may be announced before "Target Illuminated".

Section II

SYNCHRONIZATION AND LEVELING OF A RADIO DETECTOR SEARCHLIGHT SECTION

57. GENERAL.--a. It is impossible to overemphasize the vital importance of synchronization. Failure on the part of operating personnel to appreciate the imperative necessity of giving the closest attention to synchronization, and to continuous checks thereof, is considered responsible for the great majority of unsatisfactory results obtained from the SCR-268. Properly maintained, with crews of reasonably good training, which is not difficult to give, and accurately synchronized, the SCR-268 will give excellent results for searchlight work. It is capable of producing, under the above conditions, instantaneous pick-ups of targets, at slant ranges of 15,000 yards, and at angular elevations of 150 to 250 mils above the angle of mask up to any altitude so far attainable by modern aircraft, 70% to 80% of the time. If only slightly out of synchronization, the percentage will be sharply reduced; if out of synchronization some few degrees or more, pick-ups of targets will not be made at all.

b. It is imperative that the following be kept in mind:

(1) That synchronization first requires determination of the electrical axis of the antennae:

(2) That this invisible electrical axis, at a given time, bears no necessary relation whatever to any visible axis:

(3) That it will seldom be parallel to the geometrical axis of the antennae, or to the axis of the dipole insulators:

(4) That, once determined, the electrical axis may be thrown off radically by any disturbance in the electrical system, such as the changing of a tube, and will wander gradually by the mere aging of tubes.

(5) That, in consequence, once synchronized, continuous checks, several times daily during operation, must be made.

c. The synchronization of a radio detector and searchlight consists in rendering the electrical axis of the radio detector parallel to the axis of the searchlight beam and at the same time adjusting the data transmission system so that the zero readers indicate zero when the radio detector and the searchlight are oriented.

d. From the above definitions, it is evident that for a radio detector and searchlight to be in proper synchronization, the following three requirements must be met simultaneously:

(1) The electrical axis of the radio detector must be directed at the target.

(2) The axis of the searchlight beam must be directed at the target.

(3) The zero readers must indicate zero in both azimuth and elevation.

e. By electrical axis of the radio detector is meant the direction of reception of the reflected radio waves when the twin echoes in the azimuth and elevation scopes are balanced. In other words, the electrical axis is in a line from the radio detector to the target when the radio detector is "On target".

58. SYNCHRONIZATION WITH ILLUMINATED TARGET.--a. The best method of synchronization, and the only sure method, is that accomplished by synchronizing on an airplane which is being tracked by the radio detector and at the same time being illuminated by the accompanying searchlight. By this method, the three requirements for proper synchronization mentioned above can be directly accomplished.

b. The details of this method of synchronization follow:

(1) Previous to the time the searchlight goes in action for the first time, the section chief directs the detector commander to keep the detector on target even though the target plane be illuminated, and to remain on target until he (the section chief) orders otherwise. If the first target is an initial pick-up, the detector commander orders his squad to continue tracking after "Target Illuminated" is announced, instead of the normal procedure of ordering "Change target" as soon as the plane is illuminated. If the first target in the section's area is an already illuminated plane, and the light goes in action to carry it, then the detector commander orders his detector on that target and directs his squad to track it until he receives word from the section chief to change target.

(2) Since the detector is on target, and the searchlight beam is on target, the elevation and azimuth data meters at the control station (and at the searchlight) should read zero <u>if the synchronization is correct</u>. If there is an error in synchronization, then this error will show up in the zero readers as an offset of the needles from zero.

(3) Errors observed in the zero readers will probably not remain constant over the entire course due to the fact that the detector crew will undoubtedly be unable to remain <u>exactly</u> on the target at all times. The movement of the needles should be observed to determine their <u>average</u> position throughout the course. If this average position is off zero, then an error in synchronization is indicated and a correction is required.

(4) If the zero readers are observed to oscillate approximately the same amount on each side of zero, it is an indication that the detector crew is unsteady but that the synchronization is probably correct.

(5) When an error in elevation is observed at one azimuth, and there is either no error or an error in the opposite direction at an azimuth 180° away, it is an indication that the radio detector or searchlight, or both, are not properly leveled.

c. The corrections are applied in the following manner:

(1) When the platoon commander or section chief is satisfied that he has determined the average error, he orders the detector commander and chief controller to cease tracking. Using the DEC, the observed average deviations from zero are set on the azimuth and elevation zero readers.

(2) The azimuth correction is then applied by adjusting the azimuth indicator to zero by means of the adjusting knob on the azimuth selsyn receiver at the base of the searchlight. The elevation correction is applied by adjusting the elevation indicator to zero by means of the slotted adjusting shaft on the elevation selsyn transmitter at the radio detector.

d. It has been pointed out that the method of synchronization just described is the <u>preferred</u> method, and generally it will produce optimum results. It must be borne in mind, however, that this method, due to its nature, can be used <u>only after the first plane is illuminated</u>. Obviously, the radio detector and searchlight must be approximately* synchronized before going into action, or the searchlight will probably be unable to make an initial pick-up if a target approaches its sector.

59. SYNCHRONIZATION WITHOUT ILLUMINATED TARGET.—a. There are two procedures available for insuring the radio detector and searchlight are synchronized as accurately as possible prior to the beginning of a night's operation:

(1) If the radio detector and searchlight have been left in position undisturbed, to depend upon the data transmission system to maintain the synchronization which was achieved during the last period of operation, until the first check can be made.

(2) To re-synchronize the radio detector and searchlight by means of their orienting sights, using one of the methods described in Paragraphs 62, 63, and 64. Which of the above procedures should be followed depends upon the circumstances, but it will be shown in the following paragraphs that, based upon the situation, a clear-cut decision can be made.

b. The decision as to whether or not to re-orient and re-synchronize depends upon the answer to the following question: Has the radio detector open sight been alined on an aerial target <u>since</u> the last period

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*The use of the word "approximately" must not be misconstrued. There is absolutely no intention here of inferring that an "approximate" synchronization is satisfactory. Too much emphasis cannot be placed on the necessity for the utmost care and accuracy in synchronization. "Approximately" is used here in the sense that, if lack of an aerial target prevents accurate synchronization, every effort should be made to insure that the synchronization is <u>as accurate as possible</u>, pending a subsequent, more accurate check, by the preferred method, at the first opportunity.

of operation? If the answer to this question is NO, then the radio detector and searchlight should not be re-synchronized; if the answer is YES, the radio detector and searchlight should be re-synchronized.

c. (1) The basis for the above decision lies in the fact that synchronization, as previously stated, consists in rendering the axis of the searchlight beam parallel to the electrical axis of the radio detector. The orienting sight on the searchlight is fixed in position; it is adjusted by the manufacturer to be permanently parallel to the axis of the beam; and its displacement (about 3') to one side of the searchlight drum is a negligible factor. Therefore, the line of sight from the searchlight can be considered for all practical purposes to be the axis of the searchlight beam. When the orienting sight is alined with a certain point, it can be safely assumed that the beam will strike the same point.

(2) The orienting sight on the radio detector however, is an entirely different proposition. Its purpose is a similar one to that of the searchlight sight, to provide a visual means of alining the axis of the instrument on a given point, but in this case, it is not the geometrical axis which is involved, but the electrical axis, and this is constantly changing in direction. This change in direction results from the gradual change in the electrical characteristics of the radio detector due to the aging of the tubes and electrical circuits involved, and to sudden changes caused by maladjustments, readjustments, or accidents.

(3) For this reason, it is impossible to set the radio detector sight so that it is permanently adjusted. Instead it is necessary to equip the sight with vernier adjustments in both azimuth and elevation, so that the sight may be readjusted as required when the electrical axis of the radio detector shifts.

(4) This means that the alinement of the orienting sight with a given point does not insure that the electrical axis is alined with the same point unless the sight has been recently alined. If there has been no opportunity during the day to check the alinement of the orienting sight on an aerial target, then any shifting of the electrical axis of the radio detector which may have occurred since the previous night's operation, will result in a corresponding error in the alinement of the orienting sight. Therefore, re-synchronization of the equipment will not correct the error introduced by the change in the electrical axis of the radio detector.

d. (1) Under these conditions it is better to depend upon the stability of the data transmission system to maintain the degree of synchronization, except for subsequent changes in the electrical axis of the radio detector, which prevailed during the last period of operation. While this procedure leaves uncorrected any error caused by a shift in the electrical axis, at least it is good insurance that any error in synchronization is confined to that produced by such a shift. In other words, it is unlikely that any additional error will be introduced since the only way the data transmission system can be thrown out of adjustment is by the failure of equipment or by the deliberate unloosening of the locking nuts on the selsyns and turning the adjusting shafts.

(2) If the alinement of the crienting sight has not been checked since the last period of operation, then a re-synchronization by means of this sight will also leave uncorrected any error caused by a subsequent shift in the electrical axis. In addition, the orienting sight on the radio detector is more vulnerable to careless or accidental mishandling; it is much more likely to be in error by an amount exceeding any shift of the electrical axis.

(3) Therefore, at best, the results that can be expected by re-synchronizing are no better than can be obtained by relying on the stability of the data transmission system, and at worst, greater errors may result.

e. The above discussion is based upon the important premise that the searchlight chassis is not moved during the interim between periods of operation.* The data transmission system, of course, will maintain itself at the proper synchronization only so long as the searchlight chassis is not moved. Any displacement of the chassis results in a corresponding error in synchronization. Since it is highly improbable that the searchlight will be returned to the exact position from which it was moved, any such movement is bound to result in an error in synchronization. For this reason, all searchlights used with radio detectors should be permanently left in position, and not brought back to a bivouac area each night after March Order. This will create an additional camouflage problem, but should be done nevertheless.

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*It is also true, of course, that the radio detector too must remain in position without being moved, but there is very seldom any tendency to move a radio detector once it is emplaced except when actually changing locations. Searchlights, however, are often moved into position just before dark and moved out again at March Order, which should not be done when they are used with radio detectors.

60. USE OF ORIENTING SIGHTS.--a. (1) In situations where the searchlight has just been moved into position, or has unavoidably been moved since the last period of operation, it is necessary to synchronize the radio detector and searchlight by means of the orienting sights prior to going into operation, since in these cases the data transmission system has not been synchronized under the existing conditions of emplacement. As explained in Paragraph 59e, the data transmission system can maintain the previous degree of synchronization only if the searchlight has not been moved.

(2) Also, if the orienting sight has been alined on an aerial target since the last period of operation, the radio detector and searchlight should be re-synchronized to correct for any possible changes in the electrical axis of the radio detector. The orienting sight should be re-alined whenever possible during daylight, and after such re-alinement the radio detector and searchlight should be re-synchronized prior to the night's operation, whether or not the searchlight has been moved out of position in the meantime.

61. ALINEMENT OF THE RADIO DETECTOR ORIENTING SIGHT.--a. As stated in the preceding paragraph, it is extremely important that the alinement of the radio detector orienting sight be checked on an aerial target at every opportunity and at least once each day. However, tactical considerations will limit the opportunities to check the alinement on illuminated targets at night, since normally the radio detector is required to change target as soon as the target it is tracking is illuminated; otherwise, a second target, following the first in column, might enter the searchlight area without being illuminated. For this reason, a section chief or detector commander should not order the radio detector squad to track an illuminated target for the purpose of checking alinement without first getting an approval from the platoon CP.

b. The details of alining the radio detector orienting sight are as follows:

(1) Each radio detector is equipped with a sight for use in synchronizing the radio detector with its accompanying searchlight. This sight is located on one of the antennae brackets, and is provded with vernier adjustments for both azimuth and elevation corrections.

(2) The orienting sight must be alined with the electrical axis of the radio detector (i.e., with the direction of maximum reception of the reflected radio wave) in order to provide a true synchronization, since the synchronization of a radio detector and searchlight consists in rendering the electrical axis of the radio detector parallel to the axis of the searchlight beam.

(3) (a) In order to aline properly the orienting sight with the electrical axis, it is necessary to put the radio detector in operation, and to track a visible target. An excellent target can be constructed by soldering together 3 pieces of wire, each about 28¼" long (the length of a dipole), in the manner shown in Figure 15, Appendix A. A machine gun target balloon, or a meteorological balloon, inflated with helium or hydrogen can be used to carry the target aloft. The gauge of the wire used is immaterial, except that heavy gauge wire, such as 10 or 12 gauge, may require more than one balloon to lift the target. In order to increase the range of visibility, the binoculars from the control station should be strapped on the orienting sight with rubber tape, friction tape, or cord. This will increase the range of visibility of the balloon to 10,000 or more yards on a clear day.

(b) After the target has been constructed, the radio detector is put in operation, the oscilloscope operators take their posts, the detector commander takes position at the binoculars, and the target is released. Since the echo from the target will not emerge from the main pulse on the oscilloscope screen until the range reaches about 2000 yards, the detector commander should keep the radio detector approximately on target by following the balloon through the binoculars and directing the azimuth operators to traverse right or left, to elevate or depress. During this initial period, before the echo from the target becomes visible on the oscilloscope screens, the vernier adjustments on the orienting sight should not be moved. After the balloon has drifted to a range sufficient to produce a visible echo, the oscilloscope operators begin to track in the normal manner by balancing the twin "pips". This may move the radio detector so that the balloon moves out of the center of the field of view of the binoculars, and if so, the detector commander keeps the binoculars centered on the balloon by means of the vernier adjustments on the orienting sight to which the binoculars are fastened. Care must be taken by the azimuth and elevation oscilloscope operators to rotate their handwheels slowly so as not to cause the balloon to move suddenly entirely out of the field of view, since it may be difficult to locate the balloon again with the binoculars if this happens, especially as the range approaches 10,000 yards. If the handwheels are rotated slowly, the vernier adjustments on the sight can be manipulated simultaneously, so that the balloon remains in sight at all times.

(c) Even with experienced operators, it will be found that the balloon will not remain exactly in the center of the field of view throughout the alinement. Experience has shown that variations can be expected up to about one quarter of the field of view. The detector commander should observe the meandering of the target, and endeavor to center the binoculars on its average position.

(d) During the actual alinement, the angle of elevation should be at least 30° in order to insure freedome from ground reflections -- which might produce inaccuracies in elevation. If a brisk wind is blowing, it may be necessary to tie an additional balloon to the target in order to make it rise faster.

(e) After the binoculars have been alined with the electrical axis, they are then centered on some fixed point, which may be within 100 yards of the radio detector, by means of the azimuth and elevation handwheels. The radio detector should then be held in this position without moving, and the binoculars removed from the orienting sight. Then, by means of the vernier adjustments, the orienting sight is centered on the same fixed point. Since the binoculars were alined with the electrical axis of the radio detector, and since the orienting sight has been adjusted to the same line of sight established by the binoculars, then the orienting sight has been alined with the electrical axis.

(4) An airplane which is visible from the radio detector can be used as a target to aline the orienting sight by the method explained in (3) above, but a target suspended from a balloon is preferable since it will move more slowly and produce steadier echoes.

(5) A distant, visible object, such as a water tower, can be used to aline the sight in azimuth, with perhaps even better results than when alining on a plane, since the operators can center the radio detector more easily on a stationary target than on a moving target. However, the angle of elevation in this case is usually so low that ground reflections will cause an error in elevation. When it is necessary to use such a stationary object for alinement, due to the lack of an aerial target, the elevation setting of the open sight should be checked and re-set if necessary (and it will usually be found necessary) at the first opportunity on an aerial target at an angle of elevation of 400 mils or more.

(6) For the reasons explained in Paragraph 59c (2), after the orienting sight is alined, it must not be assumed that the alinement of the sight and electrical axis will remain fixed indefinitely. For this reason, it is necessary, whenever possible, to make frequent checks on alinement of the orienting sight.

62. SYNCHRONIZATION ON A DISTANT POINT.--a. After the orienting sight has been alined, the electrical axis of the radio detector can be alined with the axis of the searchlight beam by using the distant point method of synchronization. The primary purpose of this type of synchronization is to provide a means of synchronizing the radio detector and searchlight

prior to going into operation. It should be employed whenever the orienting sight has been re-alined since the last period of operation, and whenever the radio detector or searchlight has been moved since the last period of operation. Otherwise, as explained in Paragraph 59, it is more advisable to depend upon the data transmission system to maintain synchronization, unless the radio detector and searchlight were out of synchronization at the end of the last period of operation, which should not be the case.

b. A distant object, visible from the radio detector and searchlight is selected as a synchronizing point. This distant object must be far enough away from the radio detector and searchlight to reduce the parallax error to a negligible amount. A star makes a good synchronizing point since it is so far away that the parallax error is nil. If an object such as a water tower, church steeple, or other prominent landmark is used as an orienting point, it must be at least 5 miles distant to reduce the parallax error to a negligible quantity. See Figure 23.

c. The necessity of using a point five or more miles distant when synchronizing by the distant point method arises from the fact that two separated pieces of equipment, when sighted on the same point, have converging lines of sight; since these lines of sight would be parallel for accurate synchronization, the angle between them constitutes an error. This error is known as the parallax error. The closer the synchronizing point is to the equipment being synchronized, the greater is the convergence of the lines of sight as shown in Figure 23, or, in other words, the greater is the parallax error. When synchronizing a radio detector and searchlight, which are normally separated by about 15 to 25 yards, the synchronizing point should be at least 5 miles distant in order to reduce the parallax error to a negligible quantity.

d. (1) When the synchronizing point has been selected, the orienting sight on the radio detector is centered on it by moving the radio detector with the azimuth and elevation handwheels, without touching the adjusting screws on the orienting sight itself. The searchlight open sight is centered on the synchronizing point by moving the searchlight either by hand or by the DEC. If the synchronizing point is also visible from the control station the binoculars can be centered on the synchronizing point by means of the adjusting handles on the binocular mount (for elevation) and the carrying handles on the control station (for azimuth). The azimuth and elevation handwheels on the control station should not be used to center the binoculars on the synchronizing point, since this will cause the searchlight to move out of alinement if the DEC switch be closed.

(2) When the radio detector and searchlight are centered on the

synchronizing point, the data transmission system is then adjusted so that the needles of the azimuth and elevation zero readers are alined with the zero (center) mark on the dials. The azimuth needle is set at zero by means of the adjusting knob on the azimuth selsyn receiver at the base of the searchlight, and the elevation needle set at zero by means of the screw-driver adjustment on the shaft of the elevation selsyn transmitter at the radio detector.

e. The position of the binoculars <u>has</u> <u>nothing</u> <u>whatsoever</u> to do with the synchronization of the data transmission system which indicates the relative positions of the radio detector and searchlight only. The reason for alining the binoculars is to insure that they will be centered on the apparent end of the searchlight beam, so that when a target is being tracked visually the searchlight beam will be on the target as long as the target is in the center of the field of view of the binoculars. When several beams are on a target it is difficult, and at times impossible, for the chief controller to determine which beam is his; all he can do is to keep the target in the center of the field of the binoculars. Occasionally, when the alinement of the binoculars has been disturbed through carelessness or accident, the chief controller will track a target illuminated by <u>other</u> beams, completely unaware of the fact that his own searchlight is several beam widths off the target.

63. SYNCHRONIZATION BY COINCIDENCE METHOD.--a. If no distant point suitable for synchronization is visible, there are two alternatives which may be adopted. The first is to eliminate the azimuth parallax error by synchronizing along the prolongation of a line from the radio detector to the searchlight, producing a coincidence in azimuth of the lines of sight from radio detector and searchlight, and thereby eliminating the convergence in azimuth of the lines of sight. In this manner, the necessity of using a synchronizing point 5 or more miles distant, the purpose of which being to reduce to a minimum the convergence of the lines of sight, is obviated. Therefore, the distance to the synchronizing point can be safely decreased, to a minimum of about 200 yards.

b. Although such a method of synchronization eliminates the azimuth parallax error, the elevation parallax error caused by the difference in elevation between the radio detector sight and the searchlight sight becomes appreciable when synchronizing on a point as close as 200 yards. This can be corrected for, however, by using <u>two</u> synchronizing points, one directly below the other as shown in Figure 24. By sighting on the top point with the radio detector and the bottom point with the searchlight, the elevation parallax error can be reduced to a negligible quantity.

c. To establish the two synchronization points discussed in the preceding paragraph, the procedure is as follows:

(1) Using the radio detector sight, establish a line of sight from the orienting sight on the radio detector directly over the sight on the searchlight.

(2) Pace off 200 yards from the searchlight along the line of sight.

(3) Establish a point on the ground approximately 200 yards from the searchlight and directly in the line of sight from the radio detector. This can be done by using the radio detector sight to line up a rod or stick held vertically with one end on the ground. When the sighting rod has been properly alined, mark the point where it rests on the ground with a stake.

(4) Erect a pole about 20 to 30 feet high at the spot staked out on the ground.

(5) Fasten two targets, such as red cat's eye reflectors or painted discs, to the pole, one 7½ feet above the other.

d. The measurements given above will produce best results — i.e., minimum elevation parallax error — when the searchlight is emplaced 50 feet from the radio detector. Since the problem of synchronization is one in which the highest accuracy should be obtained whenever possible, the searchlight should be emplaced as close to 50 feet from the radio detector as is practicable.

e. The procedure in synchronizing by the coincidence method is as follows:

(1) Aline the radio detector sight with the top synchronizing point by means of the azimuth and elevation handwheels. Do not disturb the vernier adjustments on the sight itself.

(2) Aline the searchlight sight with the bottom synchronizing point.

(3) With both radio detector and searchlight sighted on their respective synchronizing points, adjust the data transmission system in the manner described in Paragraph 62d (2).

(4) Do not attempt to aline the binoculars by centering them on either of the synchronizing points, since the comparatively great distance of the control station from the searchlight (up to 500 feet) will

introduce a large parallax error into such an alinement of the binoculars. Alinement of the binoculars is discussed in Paragraph 65.

64. TWO-POINT METHOD OF SYNCHRONIZATION.—a. Another method of synchronization which can be used if a suitable distant point is not available is the two-point method, so called because two synchronizing points separated laterally are used. See Figure 25. This is another short-range method, and it has one advantage over the coincidence method in that the synchronization can be carried out in any direction from the radio detector and searchlight. It permits the location of the synchronizing points in the direction where the terrain is most suitable — i.e., clearest line of vision — and therefore, is useful in situations where terrain features prohibit the establishment of a synchronizing point on the prolongation of a line from the radio detector to the searchlight. This method, however, is likely to afford less accuracy than the coincidence method, due to the necessity of accurately laying out the base lines in order to obtain good results. For this reason, the two-point method should be used only as a last resort.

b. Referring to Figure 25, two synchronizing points, C and D, must be established, separated laterally by the same distance that separates the searchlight and radio detector. These synchronizing points should be 200 yards distant and may be in any direction from the radio

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NOTE: The figures given in paragraphs 63 and 64, and in Figures 24 and 25, for the heights of the synchronizing targets at points C and D, are based upon a horizontal distance of 50 feet between the radio detector and the searchlight, and a difference of elevation of 5 feet between the radio detector sight and the searchlight sight. This represents an average condition, and the figures based upon this average condition are used so that they may be referred to in the field to obviate the necessity of resorting to a mathematical determination in order to locate the synchronizing targets. The horizontal distance between radio detector and searchlight, and the difference in elevation between their respective orienting sights, can vary as much as 50% without introducing intolerable parallax errors. However, the exact heights for the targets at C and D which will render the elevation parallax zero, can be computed by a simple solution of right triangles, if the distance between radio detector and searchlight, and the difference in elevation of their respective sights, are measured.

detector and searchlight. The synchronizing points are established as follows:

(1) Pace off 200 yards from the radio detector. Drive a stake in the ground, to mark point C.

(2) Measure AB, the distance between the radio detector and searchlight, and lay out the line CD parallel and equal to AB. Mark point D with a stake.

(3) Erect poles at points C and D, and fasten a target, such as a cat's eye reflector or a painted disc, on each pole, with the target at C about 5 feet higher than the target at D.

(4) Synchronize by sighting radio detector on point C, and searchlight on point D.

(5) Do not attempt to aline the binoculars on either of these points.

65. ALINEMENT OF THE BINOCULARS.--a. It must be remembered that the two short-range methods of synchronization described in Paragraphs 63 and 64 are methods of synchronizing the radio detector and searchlight only; any attempt to aline the binoculars at the same time on one of these short-range synchronizing points will introduce large errors into the alinement of the binoculars due to the wide separation of the searchlight and control station. Binoculars should be alined by the distant point method, as explained in Paragraph 62d (1), or by centering them on the apparent end of the searchlight beam. Whenever the binoculars are alined, they should be adjusted to the desired point in azimuth by slipping the control station around by means of the carrying handles, and in elevation by moving the adjusting handles on the binocular mount. The binoculars should never be alined by use of the DEC.

66. LEVELING.--a. When a searchlight beam and the electrical axis of its radio detector have been rendered parallel in elevation, and the data transmission system synchronized, they will NOT remain parallel in elevation when traversed to other azimuths unless both were level originally. As the equipment is traversed from the original direction, the electrical axis of the radio detector and the searchlight beam get out of parallelism with each other in elevation, and this error increases as the radio detector and searchlight are traversed farther and farther from the orienting azimuth. At an azimuth of 3200 mils from the direction of original orientation, the error reaches a maximum of twice the error in leveling. Thus, if the error in leveling is 1°, the error in parallelism will reach a maximum of 2° in the direction exactly opposite to the direction of the orienting point.

b. (1) Referring to Figure 26, assume that a radio detector is out of level by 1°, plus, when its searchlight is actually level. When the antenna is at the position indicated by the angular height dial as being zero elevation, it will actually be at an elevation of 1°. If the antenna is then elevated 30° from its original position, so that it is sighted on point A, the indicated angle of elevation (the angle which will be transmitted over the data transmission system) will be 30°, but the actual angle of elevation will be 30° plus 1° or 31°. If the radio detector axis and searchlight beam are rendered parallel in elevation, with the radio detector in this position, then the angle of elevation of the searchlight will be the same as the actual angle of elevation of the point A, or 31°.

(2) If the radio detector is then rotated 180° in azimuth without disturbing the elevation handwheel, the indicated elevation would still be 30°, and the zero indicators at the control station would remain unchanged in elevation, since the elevation selsyn transmitter at the radio detector has not been moved. The error in leveling of the radio detector is now in the opposite direction so that the actual angle of elevation of the radio detector is now 30° less 1°, or 29°. Since the searchlight was elevated to 31° to sight on point A, and since the elevation handwheels have not been rotated, the searchlight will still be elevated to 31° after it has been traversed 180° (assuming that the searchlight is leveled properly). Therefore, since the radio beam from the radio detector is at an actual angle of elevation of 29°, and the searchlight, with the elevation needle at zero, is elevated to 31°, the searchlight beam is 2° above the target.

c. The importance of proper leveling can be illustrated by a few figures. If the leveling is in error by 1°, the maximum elevation error of the searchlight beam will be 2° as shown in the preceding paragraph. 2° is equal to approximately 36 mils, which represents an error of approximately 36 yards at a slant range of 1000 yards. At 15,000 yards, the range at which a searchlight may go in action, the error would be 540 yards, or more than 3/10 mile.

d. In order to level properly any piece of equipment, it is necessary, of course, that the level itself be properly adjusted. Although the levels are adjusted in the factory where the equipment is manufactured, it often occurs that a level is found out of adjustment in the field. The adjustment of all levels should be checked when new equipment is received, and periodic checks should be made thereafter. The adjustment of levels on the radio detector can be checked and corrected as follows:

(1) Remove all load from the outriggers by loosening the outrigger jacks.

(2) By use of all four leveling jacks, raise the chassis of the radio detector enough to remove all weight from the trailer springs. Make certain that the weight of the chassis is distributed over all four jacks at all times.

(3) Rotate the azimuth handwheel so that the level is brought over two diagonally opposite jacks.

(4) By manipulation of these two jacks, bring the spirit bubble to the center of the level tube.

(5) (a) Rotate the antenna array through exactly 180° (or 3,200 mils).

(b) If the spirit bubble is centered after the rotation, the level is in correct adjustment, and the entire mount can now be leveled by means of the leveling jacks.

(c) If, however, the spirit bubble is not at the center of the tube after the rotation, the level is out of adjustment and steps (6), (7), and (8) must be taken to bring it into correct alinement.

(6) Leave the antenna as specified in step (5) (a). By means of the adjusting nuts at the end of the spirit tube (see Figure 27), bring the bubble half way back towards the center of the level tube. A ¼" open-end wrench may be used for this adjustment.

(7) Rotate the antenna through exactly 180° (or 3,200 mils). The bubble should now be at the other end of the tube, but at the same distance from the center as in step (6). See Figure 27. If it is not at the same distance from the center, move the bubble half way towards the center of the spirit level by means of the adjusting nuts.

(8) Again rotate the antenna through 180° and check the position of the bubble. Its distance from the center of the tube should be the same as that of step (7). If it is, the level is now in close adjustment. If not, repeat steps (5), (6) and (7), until the bubble stays at the same distance from the center when turned through 180°, then relevel and check.

(9) When the bubble remains exactly between the two center cross-lines at both 0° and 180°, the spirit level is in its final correct adjustment.

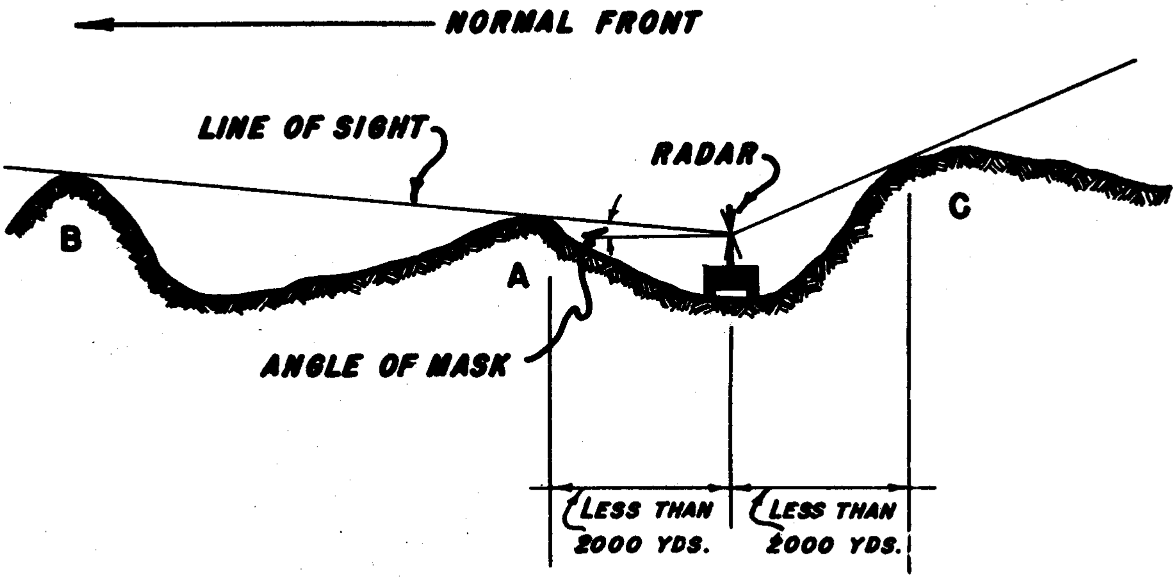

FIGURE-22.

EXAMPLE OF GOOD RADAR POSITION

(1) Hill "A" affords protection against interfering echoes from Hill "B".
(2) Hill "C" affords protection from interference from the rear.
(3) Line of sight from Radar to Hill "A" just clears top of Hill "B".

(10) After the adjustment of the bubble, the radio detector can then be leveled by the use of the leveling jacks, as described hereafter.

(11) It is important to remember that, if the bubble has moved away from the center upon traversing the mount 3200 mils, it having been centered originally by leveling the mount, the bubble is out of adjustment. No amount of re-leveling of the mount will do any good until after the bubble tube has been put into proper adjustment.

e. After the adjustment of the level has been checked, and corrected, if necessary, the radio detector can be leveled as follows:

(1) Insert under each jack plate wooden leveling blocks at least 2" x 12" x 12"; the larger these leveling blocks are, the greater will be the stability of the leveling. Individual blocks under each jack should be used, rather than a long plank which runs under two jacks.

(2) Have all seats on the radio locator occupied.

(3) Lower the outrigger jacks until they are free of any load.

(4) Turn the antenna array so that the level bubble is in line with any two diagonally opposite leveling jacks.

(5) Raise one of these jacks so that the bubble on the spirit level is brought to the center of the tube.

(6) (a) Turn the antenna through exactly 180° so that the level is in line with the same two diagonal leveling jacks.

(b) The bubble should remain centered in this new position. If, however, the bubble does not remain centered at both 0° and 180°, the bubble tube is out of adjustment, and the adjustment procedure of Paragraph 66c must be resorted to.

(7) Next bring the level in line with the other two diagonally opposite jacks, and repeat the manipulation of (5) and (6) (a).

(8) Rotate the antenna arrays through 360°, and make certain that the bubble remains centered throughout one complete revolution.

(9) The radio detector will then be leveled.

(10) Set the spirit level in line with two diagonally opposite outrigger jacks.

(11) Raise both outrigger jacks until the outriggers are held firm but not tight. Make certain by watching the spirit level that the rotatable column is not thrown out of vertical by the manipulation.

(12) Set the spirit level in line with the other two diagonally opposite outrigger jacks and repeat (11).

(13) Check the leveling of the radio detector by rotating the antenna array through one complete revolution.

(14) The radio detector will then be level and ready for operation.

f. The levels on the searchlight should be checked and adjusted if necessary in a manner similar to the adjustment of the radio detector levels described in Paragraph 66c. When leveling the searchlight, care should be taken to raise the leveling jacks high enough so that all four wheels are off the ground. If one wheel touches the ground and supports part of the weight of the light, the change in air pressure in the tire caused by a change in temperature will raise or lower that corner of the chassis, thereby changing the leveling. Procedure in leveling the searchlight is explained in the Operations Manual, G. E. 60" AA Searchlight, and also in Paragraph 64, FM 4-115.

Section III

TELEPHONE OPERATION

67. COMPONENTS.--a. As explained in Paragraph 23, the telephone communication system of a searchlight platoon has three components:

(1) The platoon command net.

(2) The intelligence net.

(3) The data lines.

b. For all three components of the communication system the telephone operators should be trained in telephone operation (clear enunciation, knowledge of tactical terms, etc.), telephone maintenance, and trouble shooting. Each telephone operator should be made responsible for the general maintenance (except repairs) of the phone assigned to him. Serial numbers should be painted on the leather cases of the phones so that each operator may be assigned a specific phone.