air navigation

1951

DEPARTMENT OF THE AIR FORCE

THE LANDFALL

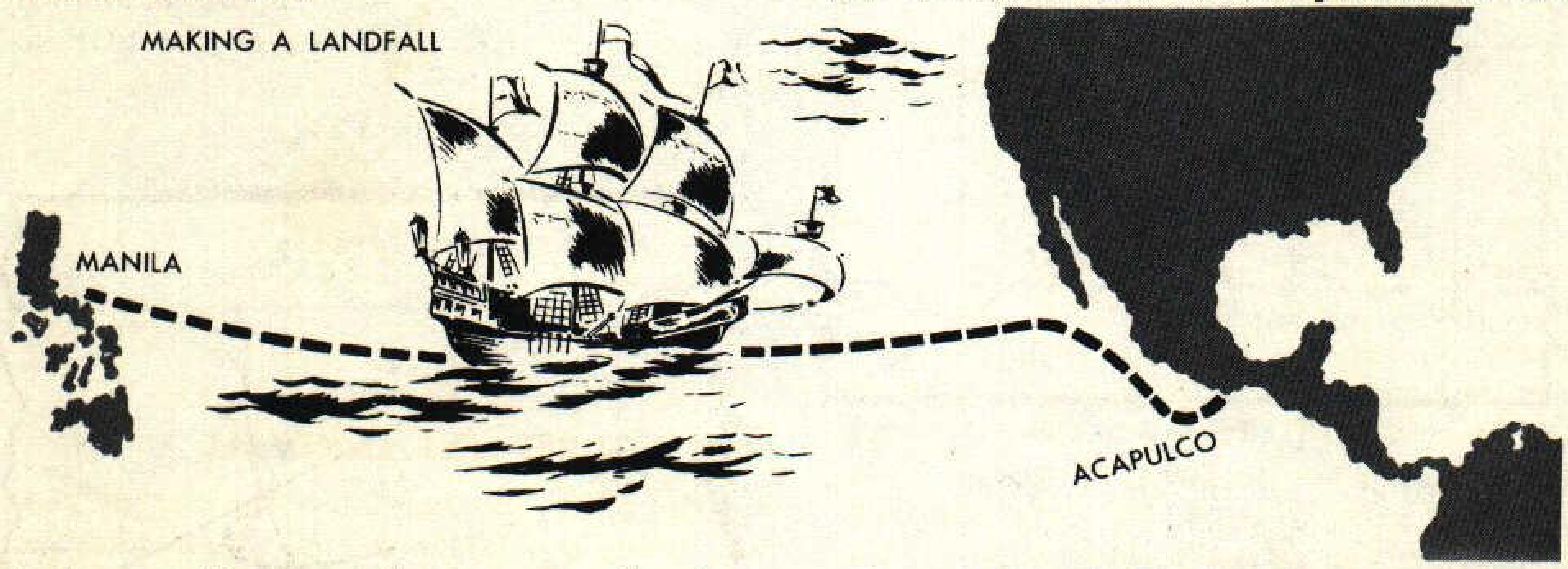
Before the development of accurate methods of celestial navigation, a mariner had no way of checking his dead reckoning when he was out of sight of land. In crossing an ocean, he might accumulate a large DR error. If his destination was on a continent or large island, he could follow the coastline to destination. But if the coastline which he first sighted was poorly charted, he might be unable to find his position. Then he would not know which way to turn to reach destination. The mariner sometimes solved this problem by setting a course definitely to one side of destination. Then when he reached the coast, he knew which way to turn. This procedure was known as **making a landfall**. In the illustration, the mariner purposely sails left of destination; then when he strikes the coast, he knows that he must turn right.

Like the mariner, you may reach destination by using some LOP which passes through destination, whether a coastline, river, railroad, lightline, or radio beam. Usually you will simply follow the LOP; but, like the mariner, you may set a course definitely to one side so that you know which way to turn when you strike the LOP. When you use a visible LOP in this manner, you are flying a terrestrial landfall.

To an air navigator, "landfall" means "celestial landfall." A celestial landfall is similar to the terrestrial landfall except that it uses a celestial LOP, which is invisible.

The celestial landfall is the most certain method of reaching destination when you are unable to supplement your dead reckoning except with LOP's from one celestial body. If you can continually fix the position of the airplane, or if you can home on a radio station near your destination, then the landfall is unnecessary. If your destination is on a large land area, usually you can find it by map reading or radio. But if your destination is a small oceanic island without a radio, you may need celestial. At night, if the stars are visible, you probably will use fixes rather than a landfall. But in the daytime, usually the sun is the only body visible; and you cannot obtain a series of fixes from the sun. Ordinarily, then, you fly a landfall only at the end of a long daylight flight over water when your destination is a small island.

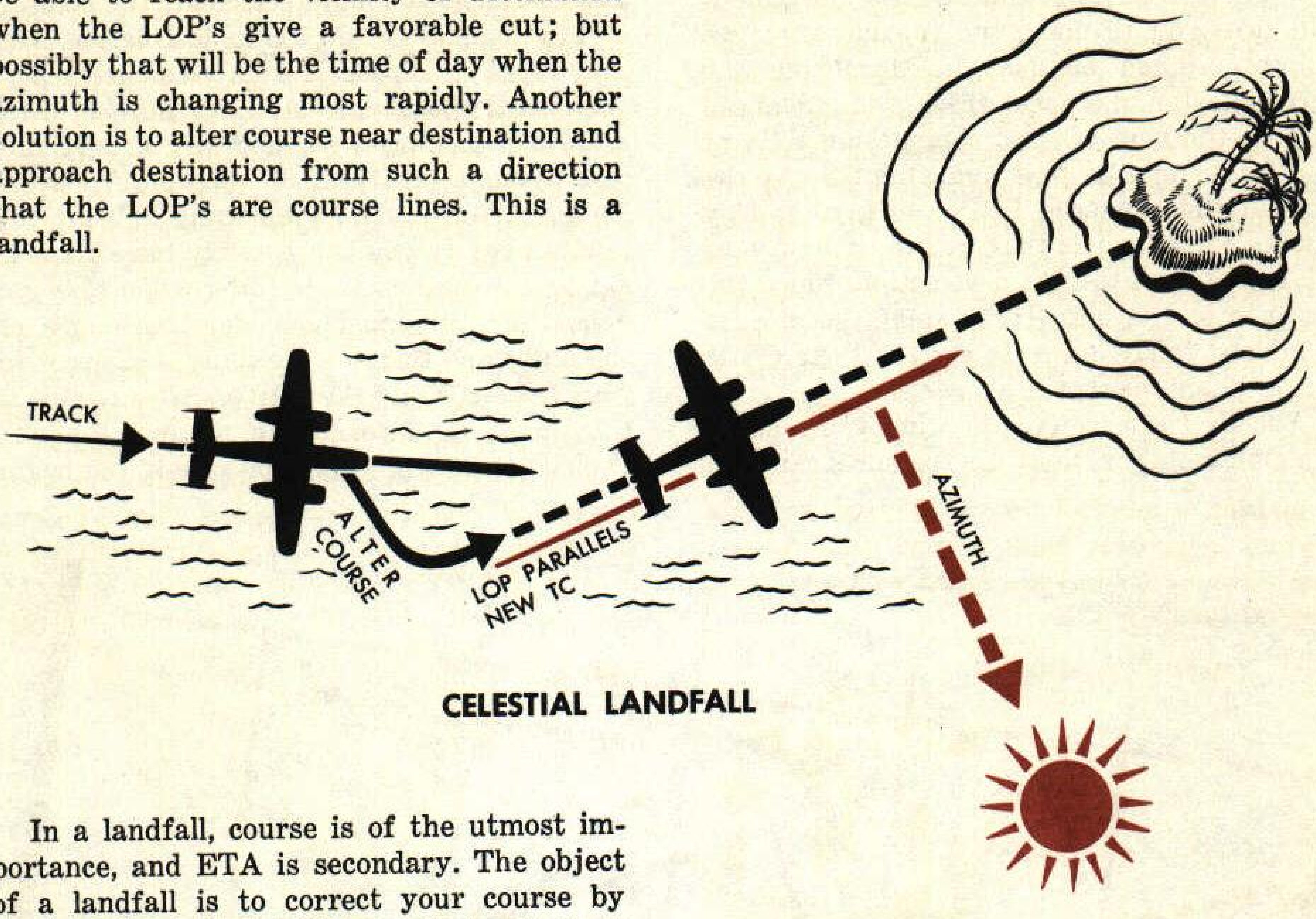
MAKING A LANDFALL



If you are aiming for a small island, course is more important than GS. If your course is correct, you will pass over the island sooner or later, no matter how inaccurate your ETA. But if you are off course and miss the island completely, an accurate GS is poor consolation.

Your LOP's may be course lines or speed lines, or they may cut the TR at some intermediate angle. Speed lines tell how far you have come and thus give you your GS. Course lines tell you what course you are making good. Obviously, then, when you are trying to reach an island, course lines are much more useful than speed lines. If the LOP's were all perfect course lines, it would be comparatively easy to reach destination.

The cut of the LOP's depends on the direction of the TR relative to the sun's azimuth. When you depart at a fixed time and fly a fixed course from departure to destination, you have no control over the cut of the LOP's. If you can set your departure time, you may be able to reach the vicinity of destination when the LOP's give a favorable cut; but possibly that will be the time of day when the azimuth is changing most rapidly. Another solution is to alter course near destination and approach destination from such a direction that the LOP's are course lines. This is a landfall.



CELESTIAL LANDFALL

In a landfall, course is of the utmost importance, and ETA is secondary. The object of a landfall is to correct your course by means of celestial LOP's so that you pass over destination. Essentially, you fly along an LOP or **celestial TC line** which passes through destination. Thus the celestial landfall is the method of using celestial LOP's as course lines into destination no matter how they cut the TC from departure to destination.

The celestial landfall presents two problems. The first problem is to get onto a celestial TC to destination. You must know the position of the TC line, you must know when you reach it, and you must know when you are flying on it. The second problem is to fly in the right direction on the TC line. It would be a fatal mistake in mid Pacific to turn the wrong way and follow the TC line away from destination.

Although all landfalls work on the same principle, there are variations in procedure. The procedure depends on whether the LOP's are more nearly course lines or more nearly speed lines on the true course. Accordingly, landfalls are classified as speed-line landfalls and course-line landfalls.

THE COURSE-LINE LANDFALL

The course-line landfall is the method you use when the LOP's fall as course lines or nearly so. It is a comparatively simple method.

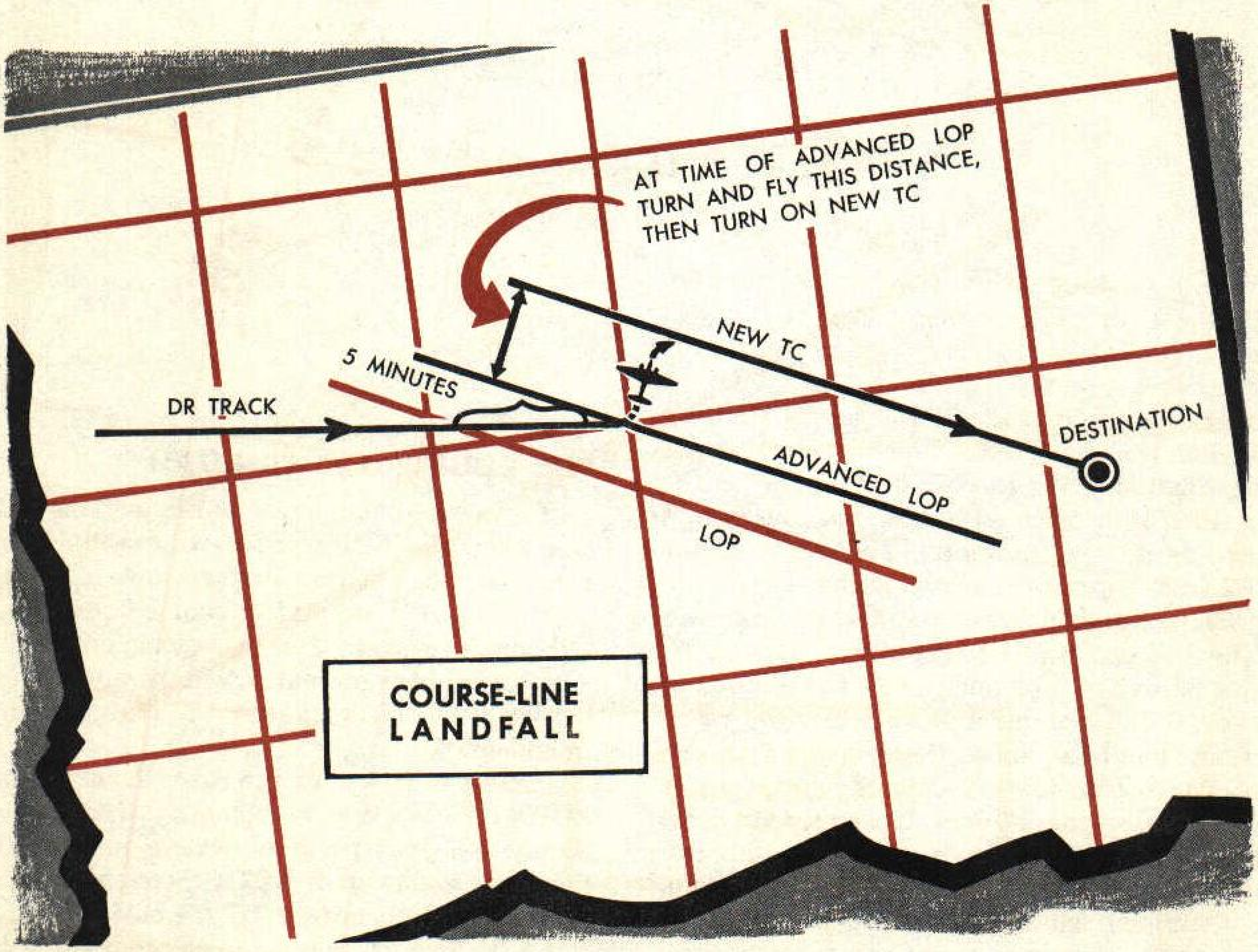
If the LOP's are perfect course lines, they tell how far you are from course and on which side. To get back on course, you merely fly the perpendicular distance from the LOP to your intended TC.

Perfect course lines are rare. Usually, the LOP's intersect the TC obliquely. Then they do not tell your position relative to the TC unless you know your GS. If the course lines do not fall parallel to the TC, the obvious solution is to fly a TC parallel to the course lines. Then the LOP's will tell you whether you are on course. Obviously, if you are to reach destination, the new TC not only must be parallel to the course lines but also must pass through destination.

When you have shot and plotted an LOP, you draw a celestial TC to destination parallel to the LOP. Now you prepare to fly to this new TC. You advance the LOP for the time it will take you to make the calculations: five minutes should be enough. Measuring the perpendicular distance from the advanced LOP to the new TC, you compute an ETA at the TC, using the best available GS. At the time of the advanced LOP, you turn and fly toward the new TC; then at the time of your ETA, you turn toward destination. Since the distance to the new TC is small, your ETA should be fairly accurate even if your GS is considerably in error.

You fly the new TC, checking your course by further observations. As the sun's azimuth changes, the LOP's do not stay parallel to your TC. Therefore, you find it increasingly difficult to tell whether you are on course. If time permits, you may recalculate the landfall and fly to another new TC to destination. You may repeat this process as often as necessary.

With a course-line landfall there is little danger of turning the wrong way on a TC line and flying away from destination. To avoid such a mistake, you have merely to begin the landfall before you can possibly have gone as far as destination. In deciding when to begin a landfall, you must consider the length of the flight and the possible sources of error in your DR GS. Since the LOP's are course lines, they give no information as to your GS. Probably you will always be safe if you begin

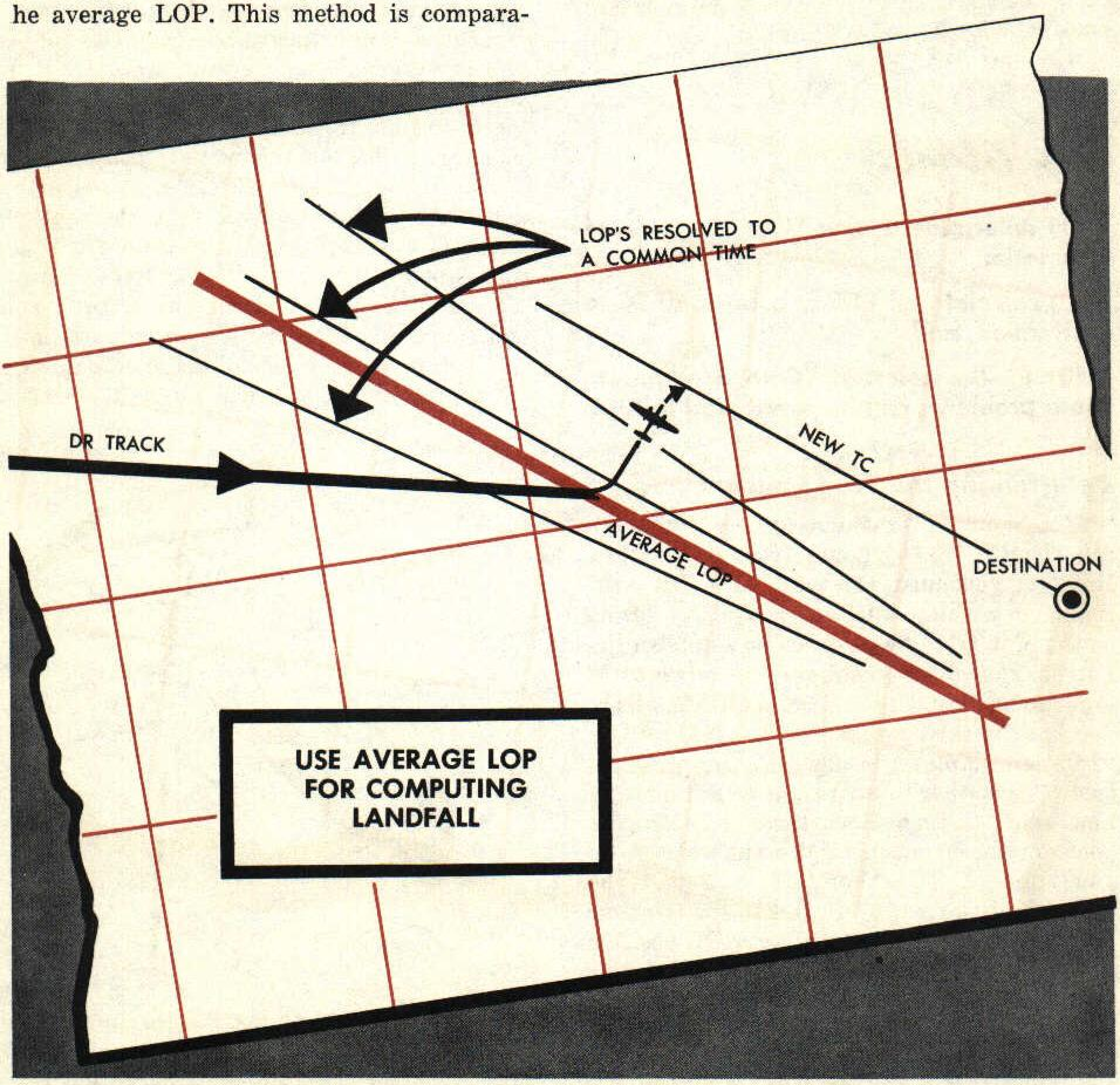


the landfall 1 to 1½ hours before your ETA at destination.

If your LOP's are accurate, you run no risk of missing destination. But it is important that your LOP's be accurate. You can use a single LOP for checking your course, but you should not rely on it for computing a landfall. Rather, you should use an **average LOP** based on three or more observations taken in close succession. You can establish an average LOP in either of two ways, each of which has its own advantages.

By the first method you take three or more observations, plot as many LOP's, and resolve them to a common time. Because of errors in your observations, and because of the change of the sun's azimuth, the resolved LOP's usually will not coincide. In the vicinity of your DR position for the time, select an average position among the LOP's, and through this point draw a line of average direction. This is he average LOP. This method is comparatively slow, but it may enable you to detect an inaccurate LOP and hence to weight the other LOP's more heavily.

By the second method you take three or more observations and plot one LOP for the average time and average Ho. No matter what the spacing of your observations, so long as they are reasonably close together, you can find the average time and the average Ho by taking a straight numerical average of each. This method is faster than the first because you have to work out only one H. O. 218 solution and plot only one LOP. But it gives you no hint of the possible inaccuracy of one of your LOP's.



THE SPEED-LINE LANDFALL

The speed-line landfall is the method you use when the LOP's fall as speed lines or nearly so. It is similar in principle to the course-line landfall, but the procedure is different for two reasons. First, you have to fly much farther to reach the celestial TC to destination. Therefore, your GS must be more accurate to give a good ETA at the TC line. And second, there is danger of turning the wrong way onto the TC line and of flying away from destination. To avoid this possibility, like a mariner making a landfall, you set your course definitely to one side of destination. Then, when you reach the TC line, you know which way to turn.

The speed-line landfall presents three distinct problems:

You Must:

(1) determine a new TC to one side of destination,

(2) calculate an ETA at a celestial TC to destination, and

(3) fly the celestial TC to destination. These problems will be considered in turn.

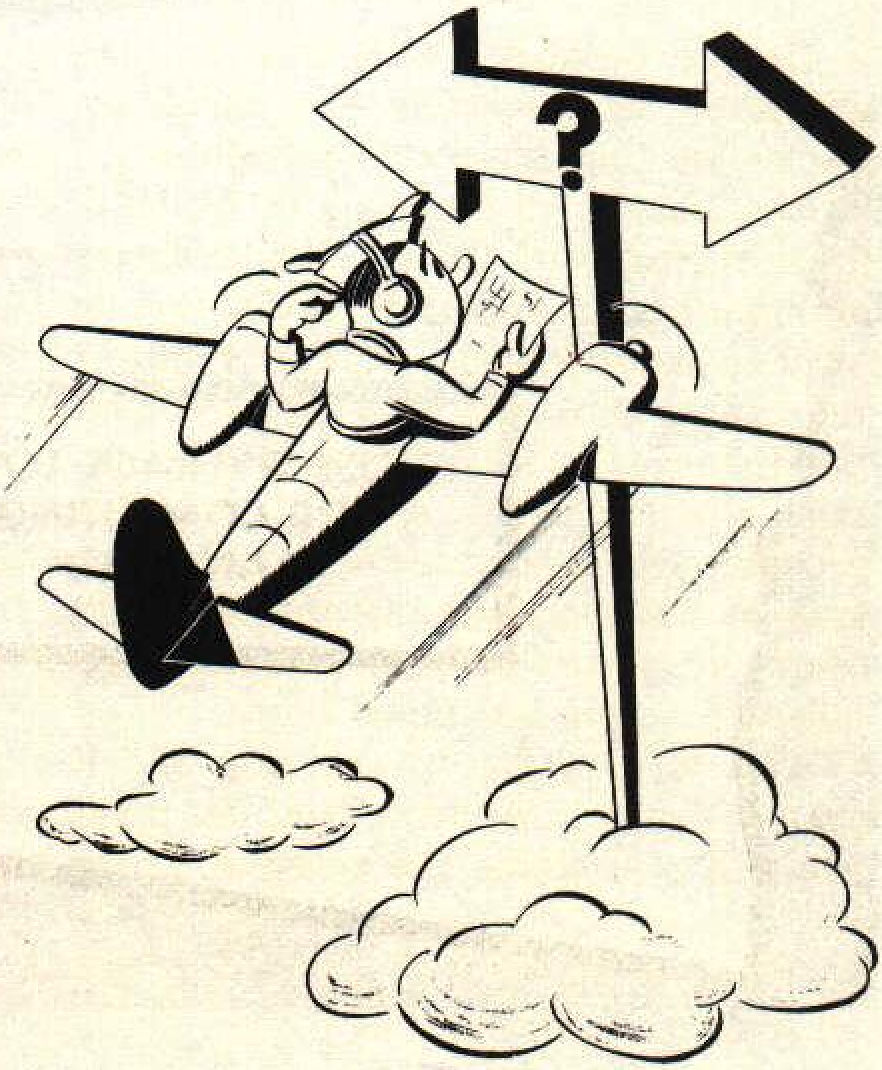
Determining the True Course

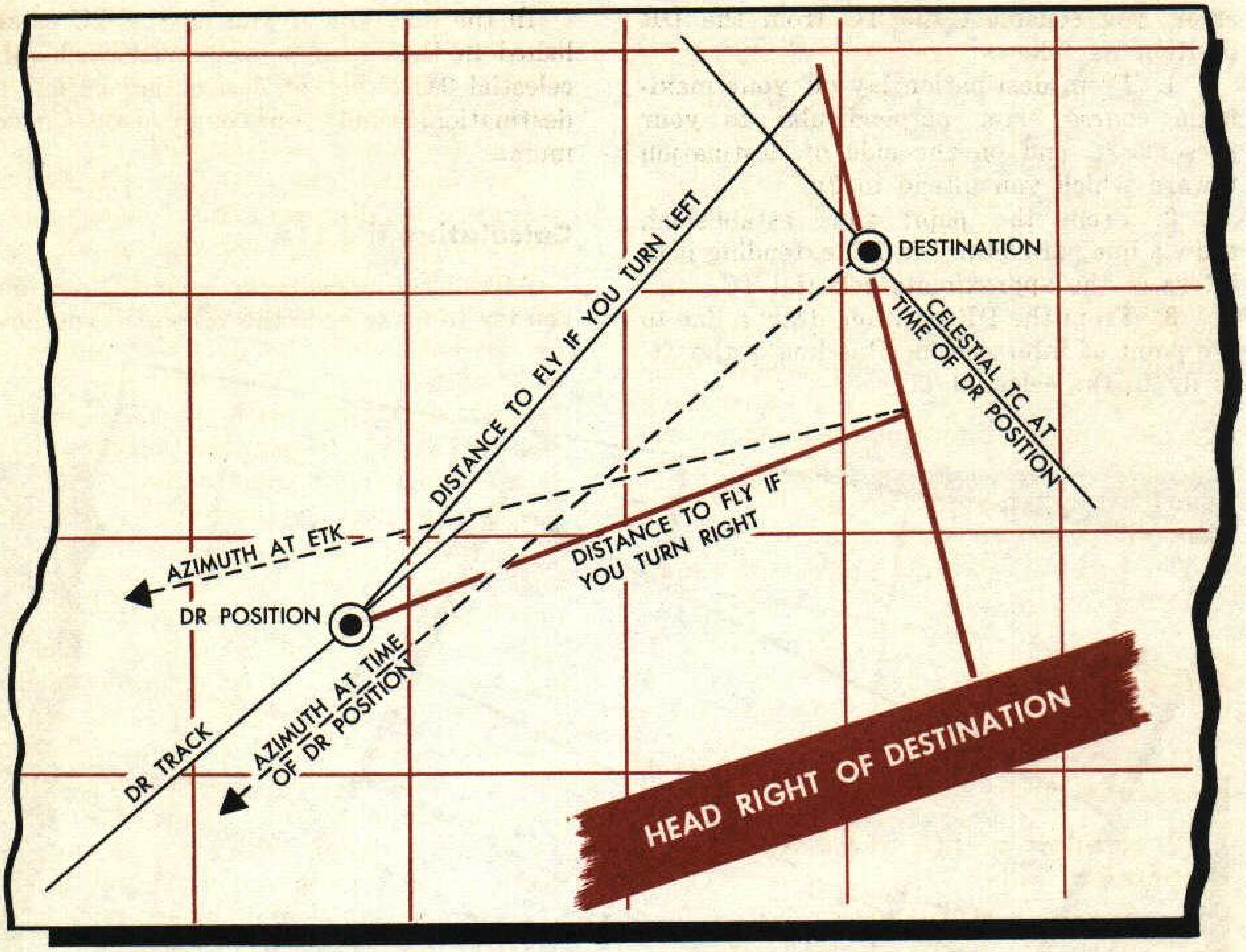
You should alter course to begin the landfall about 1 to 1½ hours from destination. But first you must (1) establish a DR position from which to alter course and (2) decide on the best TC to fly. You should establish the DR position 5 or 10 minutes in advance in order to have time to determine the TC before you have to turn onto it.

In determining the new TC, you must decide (1) whether to turn right or left and (2) how much to turn. Both these decisions depend on the azimuth of the sun relative to your present TC. Therefore, you find the azimuth of the sun by H. O. 218 for the time and approximate position of your DR position of turn. Through destination you draw a line perpendicular to this azimuth. This line is an approximation of the celestial TC which you will fly to destination. The azimuth of the sun will have shifted by the time you reach this approximate TC, so you will find another celestial TC before completing the landfall, much as you would in a course-line landfall. This approximate TC is the one you use in calculating your landfall.

In a landfall, you must fly more than the straight-line distance from departure to destination. However, you don't want to fly farther than necessary. Unless it is perpendicular to the TR, the celestial TC is closer to the DR position on one side of the TR than on the other. Therefore, you turn to the side of TR on which the celestial TC is closer. When you have drawn the approximate celestial TC line through destination, you usually can tell at a glance which way to turn.

If the approximate celestial TC line is nearly perpendicular to your present TR, it may appear immaterial whether you turn right or left. It would be immaterial if the sun stood still; but the azimuth continuously shifts. In the time it takes you to reach the celestial TC which you will fly to destination, this TC has changed in direction from the approximate one which you have drawn. Therefore, to decide which way to turn, you must consider the direction of azimuth shift and estimate the position of the celestial TC by the time that you will reach it.





Having decided which way to turn, you are ready to determine how much to turn. Remember that the reason for altering course is to eliminate all doubt as to which way to fly on the celestial TC line. You estimate your maximum course error at destination on your present heading. This estimate requires good judgment. You must consider such factors as the distance flown since your last known position, the frequency of drift readings, the probable accuracy of deviation checks, and the type of weather encountered. Normally, DR course error probably should not exceed 10 miles for each 100 miles flown.

You turn so far to one side of TR that even if your course error is at the maximum, you will still strike the celestial TC on that side of destination. Suppose, for example, that your maximum error is 50 miles and that you are turning to the right. You must turn so far to the right that, even if you are 50 miles to the left of course, you will strike the celestial TC to the right of destination.

Estimating maximum error is very important. If you underestimate, you may miss destination altogether. Consequently, you should be liberal in your estimate. To be sure, the more you turn off course, the farther you have to fly along the celestial TC. But, unless gasoline is very scarce, it is better to take the chance of flying too far rather than the chance of missing destination entirely.

When you have estimated the maximum

error, you construct the TC from the DR position as follows:

1. From destination lay off your maximum course error perpendicular to your present TC and on the side of destination toward which you intend to fly.

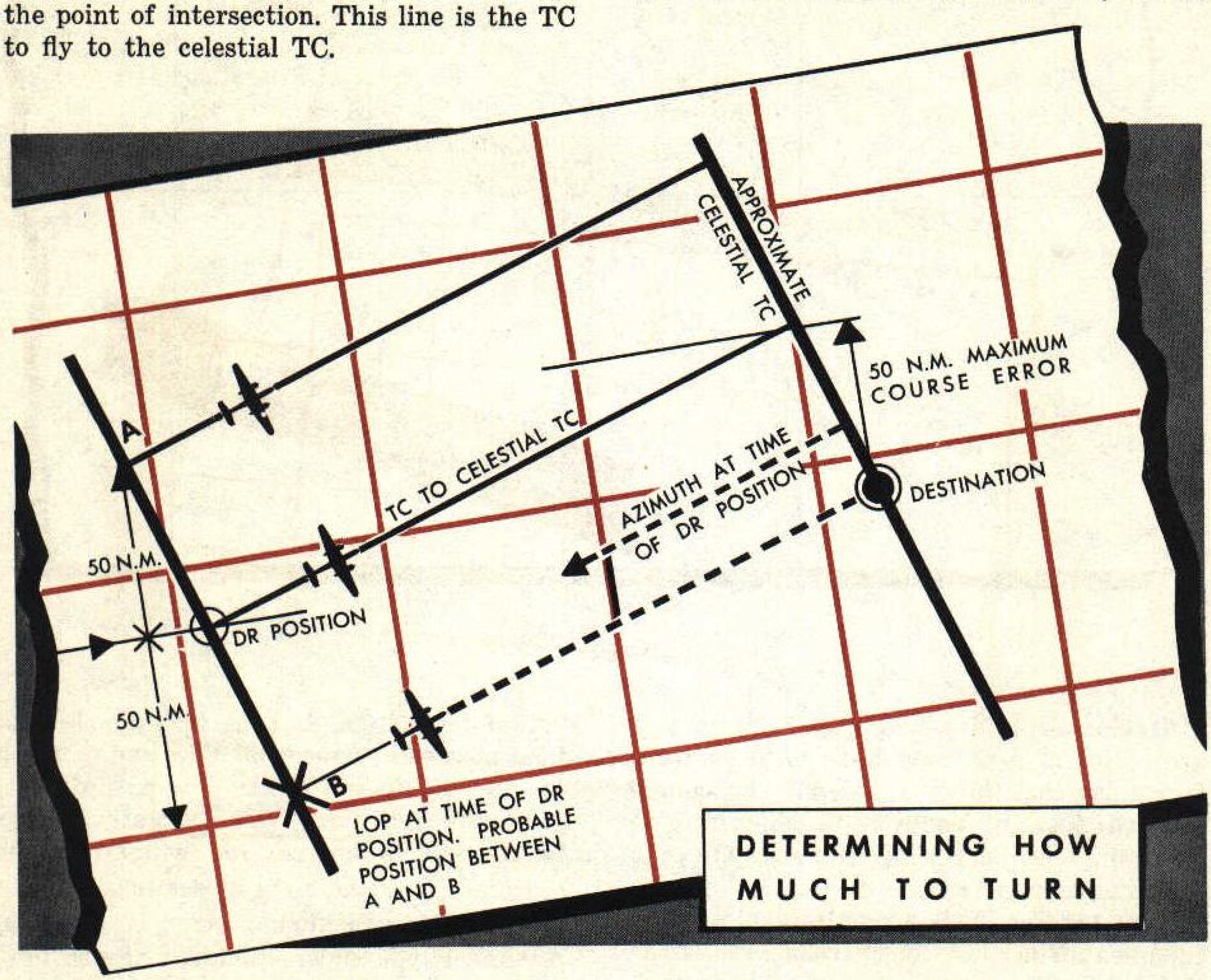
2. From the point thus established, draw a line parallel to the TC, extending it to intersect the approximate celestial TC.

3. From the DR position, draw a line to the point of intersection. This line is the TC to fly to the celestial TC.

In the diagram, if you fly the TC established in this manner, you must strike the celestial TC either at destination or left of destination, even if your course error is maximum.

Calculating the ETA

After altering course at your DR position, you try to make good the TC which you have



constructed to the celestial TC. Since your estimate of the maximum error at destination included an allowance for DR error on this leg, you should strike the course line on the correct side of destination.

Your major task is to calculate an accurate ETA at the celestial TC so that you will know when to turn toward destination. Your ETA can be accurate only if you have an accurate reference line from which to measure the distance flown along the new TC. Immediately after altering course, you establish an average LOP as a reference line.

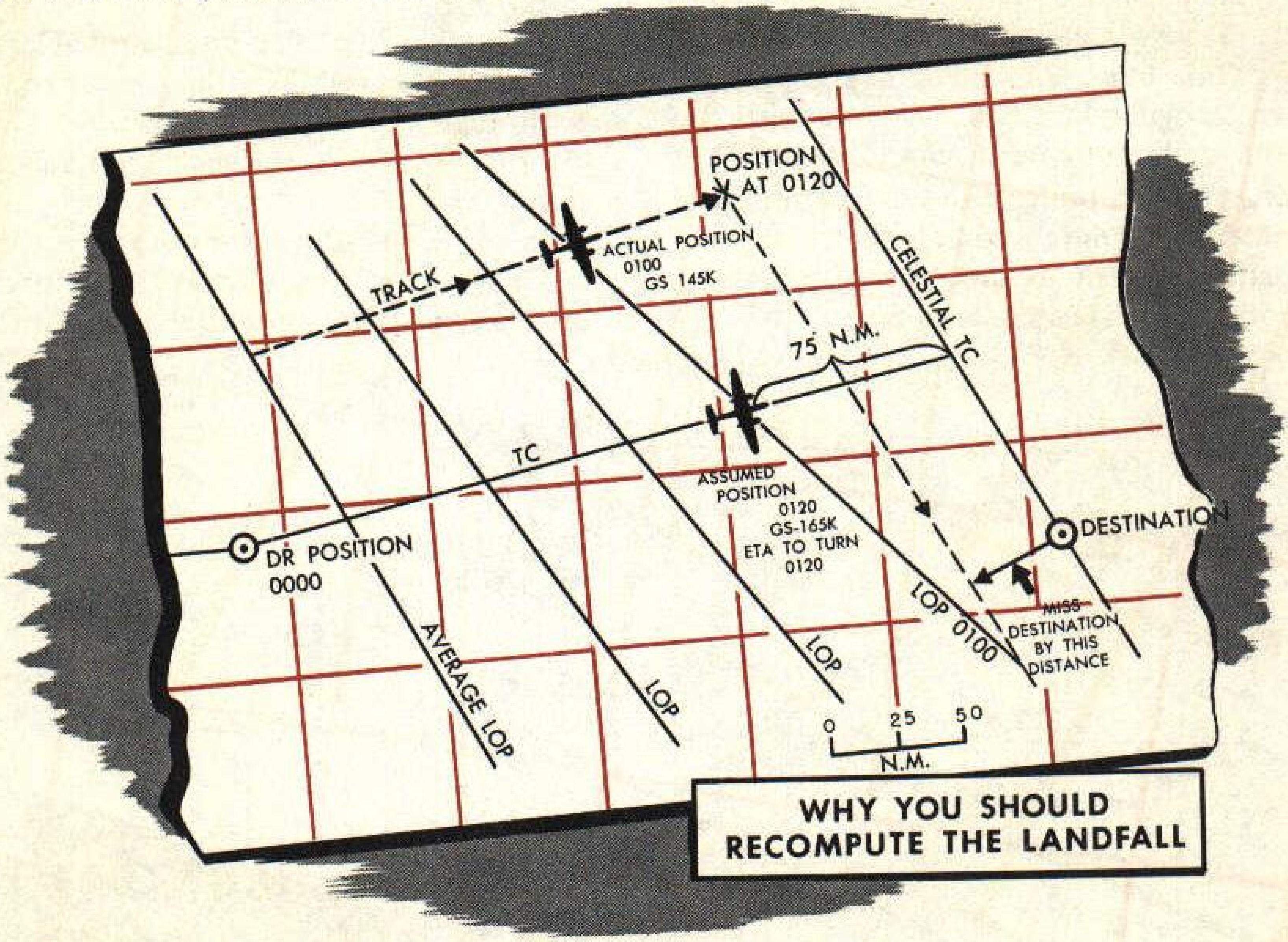
Through destination you draw a new celestial TC parallel to the average LOP. From now on, you disregard the approximate celestial TC which you first plotted through destination.

The average LOP is parallel to the celestial TC to destination. Therefore, the distance between the LOP and the celestial TC is the same if measured along lines parallel to the present TC. Thus, even though you do not know your position on the average LOP, you know the distance along the present TC to the celestial TC to destination. If you know your GS, therefore, you can calculate an accurate ETA to the celestial TC.

To navigate from the average LOP to the celestial TC, you use standard navigational methods. If you can read drift, dead reckoning alone probably will give you a good ETA to turn. However, you should check your GS by more LOP's.

Because the sun's azimuth shifts, successive LOP's are not parallel to one another or to the average LOP and the celestial TC to destination. Therefore, the distance between two LOP's varies when measured along different lines parallel to the TC. Likewise, the distance from an LOP to the celestial TC varies. Since your GS and ETA depend on these two distances, your GS and ETA will not be correct unless you are on your DR TC line.

To avoid missing your point of turn, you may recompute the landfall shortly before your ETA is up. You shoot and plot another average LOP and draw a new celestial TC to destination parallel to it. Since the average LOP will be very close to the celestial TC,



WHY YOU SHOULD RECOMPUTE THE LANDFALL

you can make a fairly accurate ETA to turn, even if your GS is in error. Suppose, for example, that you have 60 miles to fly and that the true GS is 180K. If your GS is off 10K, your ETA will be off 1 minute, and you will turn about 3 miles from the TC to destination.

Flying the Celestial True Course to Destination

Once you have turned toward destination, your precedure is the same as in a course-line landfall. You check your course by LOP's and calculate a course-line landfall if necessary.

Finding Destination

The landfall does not provide an accurate ETA at destination. You calculate the ETA entirely by dead reckoning. If your DR error is large, the ETA error will be large. Because of inaccurate LOP's, you may not pass directly over destination. Therefore, you should begin looking for destination well in advance of your ETA. Likewise, after your ETA has expired, you should continue on course looking for destination. If you are sure that you must have passed to one side of destination, you should begin a systematic search.