5. Rotate the compass rose until the marked point is over the center line of the computer.

6. Read the wind direction (130) under the true index and the velocity (47 knots) from the grommet to the point marked.

DRIFTMETER

By this time the navigator should realize that accurate wind determination is a main source of difficulty in performing his duties. The wind problem is ever present in navigation. If the air were absolutely still, aerial navigation would be very simple. Without wind, the aircraft would not drift off its course. Unfortunately, however, still air seldom, if ever, exists. Therefore, navigation with its costly equipment and detailed procedures is made necessary. The navigator must continually determine the wind or the effect of the wind if he is to obtain the results required for accurate navigation.

Several methods of wind determination depend on the knowledge of the drift angle—the angle between true heading and track. When the earth's surface (land or sea) is visible, this angle can be measured directly with an instrument known as a *driftmeter*.

Principle of the Driftmeter

The principle of the driftmeter is very simple. Suppose that the ground is observed through a hole in the floor of an aircraft. As the aircraft flies along its track, objects on the ground appear to move across the hole in the direction exactly opposite to the track.

Thus, in figure 5-51 if the aircraft track is in the direction of line BA, a house appears to move across the hole from A to B. Suppose now that a wire is stretched across the hole parallel to the longitudinal axis of the aircraft. This wire YX represents the true heading of the aircraft. Since BA is the track and YX is the true heading, the drift angle is the angle AOX. The driftmeter measures this angle AOX. A simple driftmeter might be built as shown in figure 5-52. A glass plate which may be rotated by means of the handle on the right is placed over a hole in the floor of the aircraft. On the glass are drawn parallel *drift* lines. The drift lines, together with the two or three cross lines (timing lines) usually present in a driftmeter, are called the *reticle*. The center drift line extends to the edge of the plate as a pointer. On the floor ahead of the hole is a drift scale which shows the position of the drift lines relative to the longitudinal axis of the aircraft. Thus when the pointer is on 0°, the

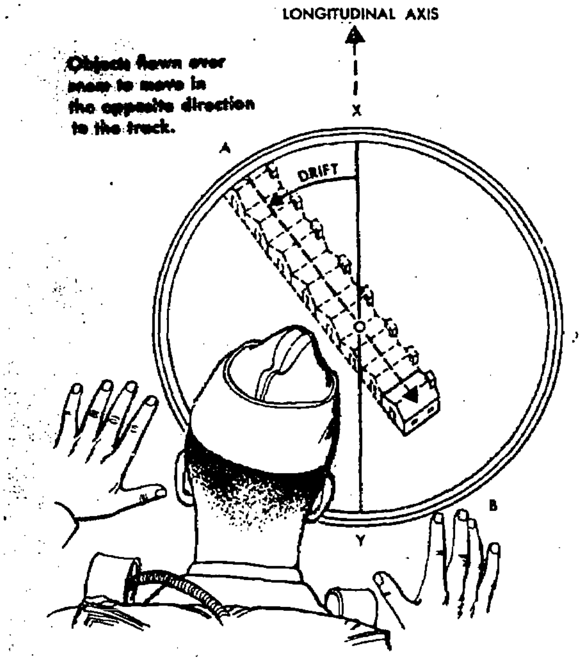


Figure 5-51. Principle of a Driftmeter

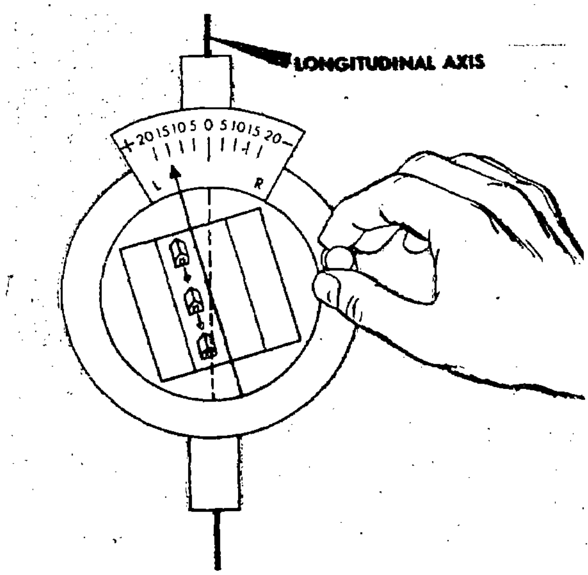


Figure 5-52. Read Drift on Scale Opposite Pointer

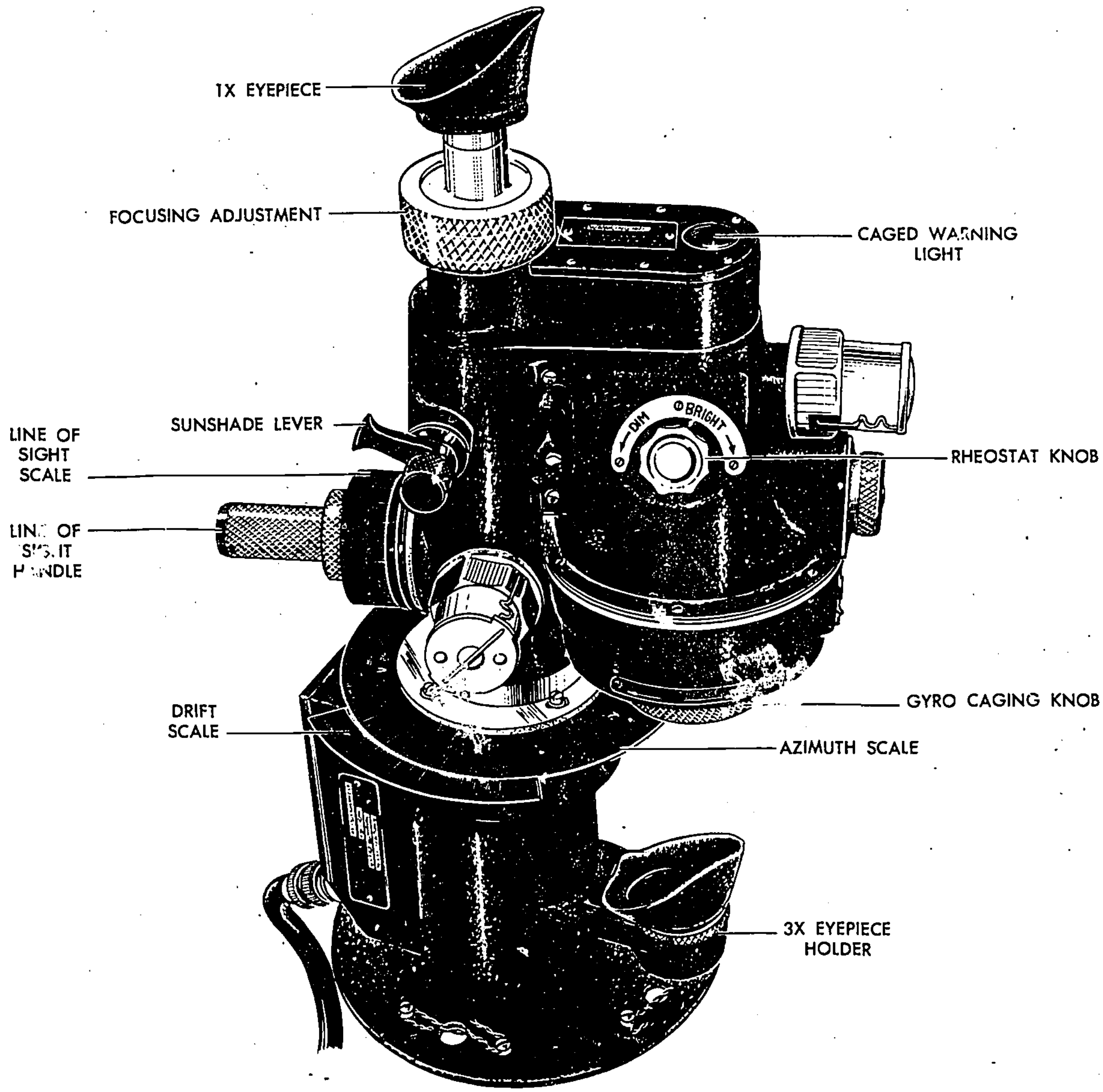


Figure 5-53. Typical Driftmeter

drift lines are parallel to the longitudinal axis; and when the pointer is on 10°R, the drift lines make a 10° angle to the right of the axis.

To use this simple driftmeter, turn the glass plate so that objects on the ground move across the hole parallel to the drift lines. Then the drift lines are parallel to the track of the aircraft. Read the drift scale opposite the pointer. If the pointer indicates 15°L, the aircraft is drifting 15° to the left. Then if the true heading is 090°, the track is 075°.

On every driftmeter, the drift scale is marked with the words "right" and "left" or with the letters "R" and "L." These words always refer to the *drift* and not to the drift correction. Normally, driftmeters have a plus and a minus sign on the scale. These give the sign of the *drift correction* (DC) which is discussed later.

The typical driftmeter shown in figure 5-53 is basically the same as the simple instrument described above, but it has many refinements. One of the most important refinements is the use of a

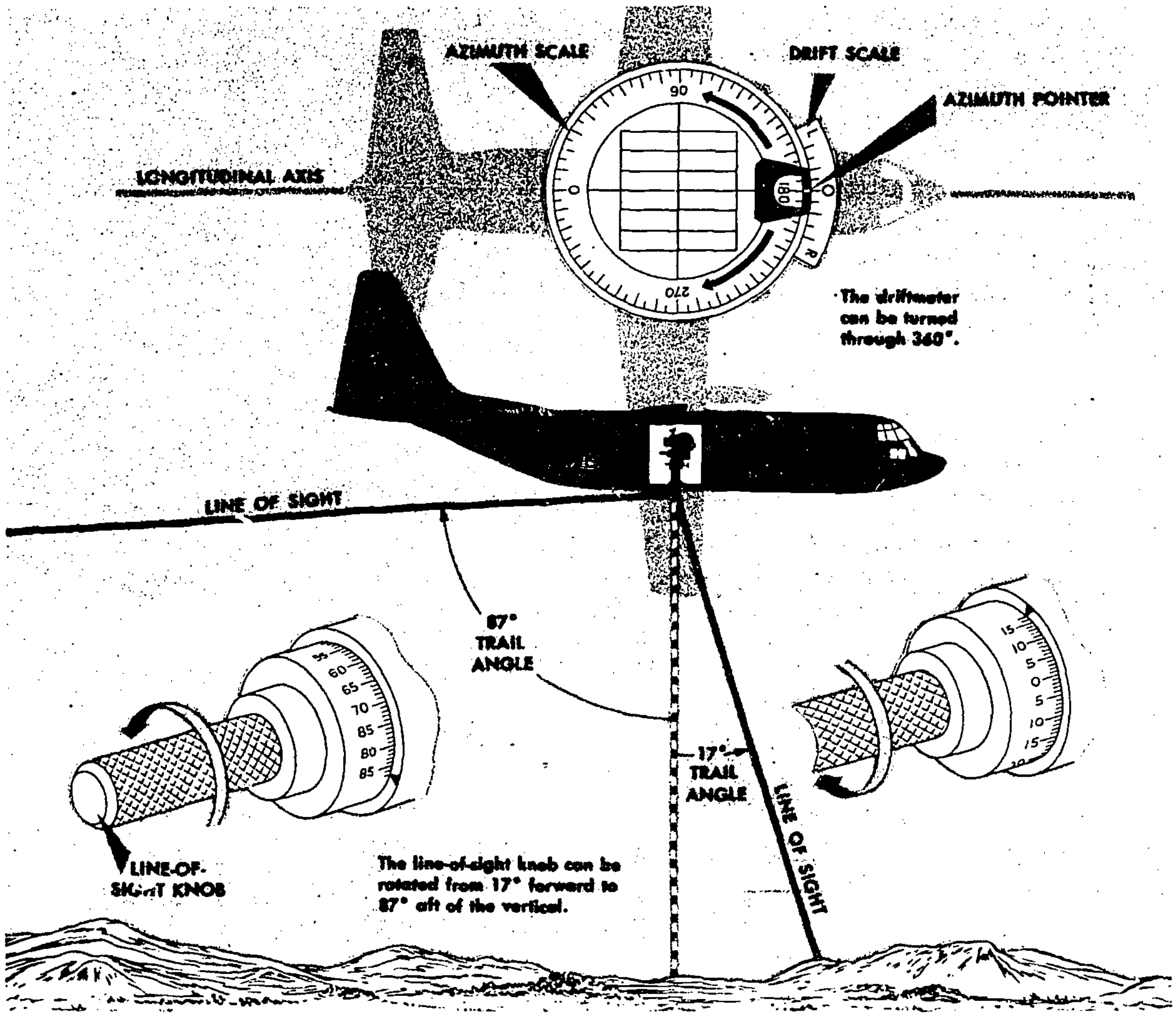


Figure 5-54. Trail Angle

gyro to keep the reticle horizontal. A driftmeter without a gyro is difficult to use in turbulent air. An azimuth scale has been added to aid the navigator in determining relative bearings of objects. Two eyepieces of varying magnifying power are provided to give the navigator a better view of the ground.

The glass plate has been improved by adding a system of prisms with which the navigator may direct his line of sight away from the vertical by turning the line of sight handle. Figure 5-54 shows that when the azimuth pointer is at 180° on the azimuth scale, the line of sight can be turned through an arc from 17° forward to 87° aft of the vertical. The angle between the line of sight and the vertical is the *trail angle*. Since the driftmeter can be rotated through 360°, a trail angle of 87° can be seen in any direction from the aircraft.

Operation

The driftmeter is a delicate instrument which requires careful treatment. Read the following operating procedure carefully:

1. Before takeoff, clean the lens at the bottom of the driftmeter tube. To remove grit, brush lightly to avoid scratching the glass. Also check the inside of the lens for condensation of moisture in the tube. If present, it may be remedied by removing the lens and wiping with a clean, soft cloth.

2. See that the azimuth pointer is at zero drift during takeoff and landing to prevent breakage of the glass by stones. With zero drift on the scale, the lens system is pointed towards the rear of the aircraft. Thus, stones or gravel flying up from the runway cannot strike the lens.

3. When the engines are started, turn on the inverter switch. After making sure that the gyro caging knob is in the caged position, turn on the gyro by means of the three-position switch.

4. When ready to read drift, uncage the gyro. Be sure that the trail angle control is at zero so that the ground directly below the aircraft is seen. Adjust the focus of the eyepiece. Adjust the illumination of the reticle by means of the rheostat knob.

5. The gyro should be kept in the caged position at all times except when actually reading drift. If the aircraft banks more than 15°, gently cage the gyro and leave it caged until level flight is resumed; otherwise the gyro may tumble. If the gyro does tumble, cage it only when the aircraft is level. Caging a tumbled gyro requires a slight but steady pressure on the caging knob. A sudden forceful pressure is likely to cause damage.

6. If the gyro becomes inoperative or tumbles frequently, cage it for the remainder of the flight. Remember to report the trouble after landing. Unless the air is very rough, drift can be read with the gyro caged.

7. Before landing, cage the gyro, turn off the power switch, and return the azimuth pointer to the zero position of the drift scale.

Reading Drift

Watch the terrain for a time through the driftmeter (at any trail angle setting). Turn the azimuth drive until the drift lines are parallel with the path of each object across the field of vision. Read the drift on the drift scale opposite the azimuth pointer.

After reading drift, turn the pointer several degrees away from the drift reading. Then when drift is read again, it will be an independent reading and not influenced by the previous reading.

Above 2,000 feet, good drift readings can be obtained on objects directly beneath the aircraft; at low altitudes, however, objects may pass by too rapidly for accurate readings. This difficulty can be overcome by using other methods of reading drift. One of these methods is to set the trail angle back to 25° or 50° and read drift in the normal manner.

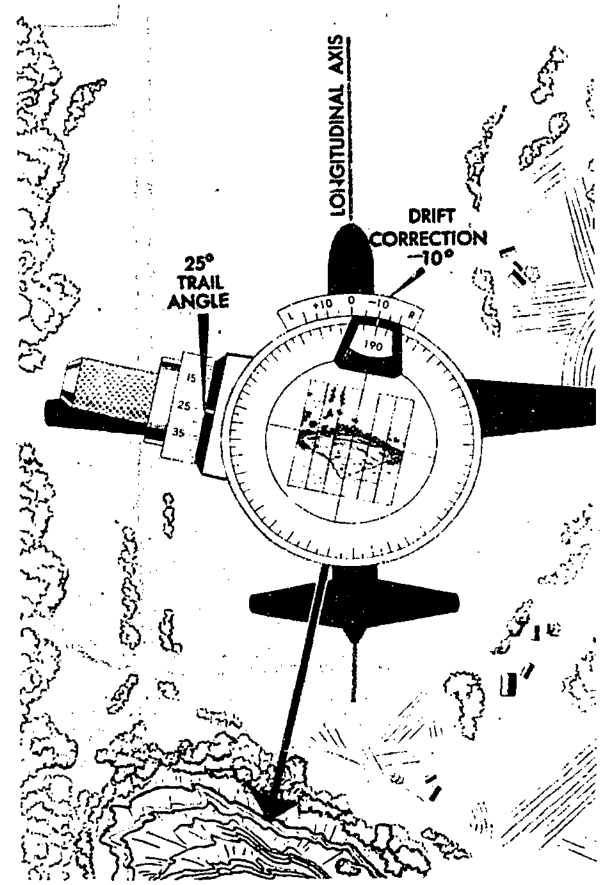
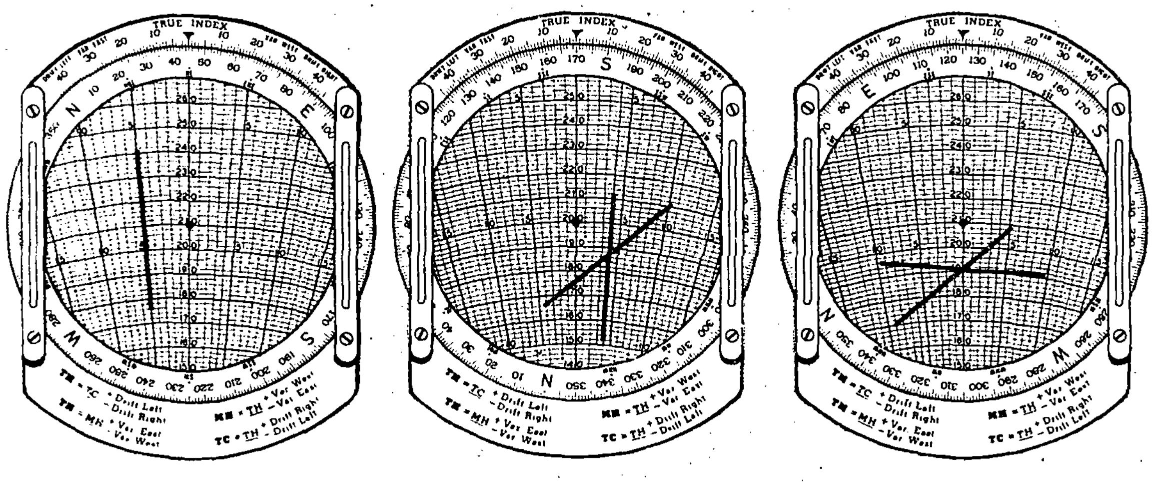


Figure 5-55. At Low Altitude, Use 25° or 50° Trail Angle

As shown in figure 5-55, the aircraft has passed over the mountain. Actually, the navigator is looking down into the instrument; however, he sees the landscape behind the aircraft at a 25° angle. At this angle, the objects do not cross the field of view as fast as they do when looking straight down.

Finally, here are some miscellaneous tips. For high altitude, replace the one-power eyepiece with the three-power eyepiece. If the ground appears too bright, introduce a shade glass into the optical system by means of the shade glass lever.



A. Use track line 5° left of center line.

B. Intersection of two lines is head of wind vector.

C. Rotate compass rose until wind vector is below grommet.

Figure 5-56. Computer Solution for Wind Vector When Drift on Two Headings Is Known

Wind Determination

Wind may be determined without knowing the exact position of the aircraft. The methods of wind determination when the position of the aircraft is not precisely known are discussed under these topics: (1) drift on multiple headings, (2) multiple drift, and (3) groundspeed by timing.

DRIFT ON MULTIPLE HEADINGS. If drift can be read on two headings, the wind can be determined using the wind face of the DR computer.

Sample Problem:

Given: TH^1 045°,
TAS^1 210k,
Drift 5° L(+5°DC)
TH^2 170°,
TAS^2 200k,
Drift 4° R(—4°DC)

To Find: Wind Direction (WD) and Wind Speed (WS)

COMPUTER SOLUTION.

1. Set TH^1 (045°) under the true index and TAS^1 (210k) under the grommet as shown in figure 5-56A.
2. On the transparent circular plate draw a line over the track in the same number of degrees right or left of the center line that drift is right or left. If drift is 5°L, use the track line 5° left of the center line.
3. Set TH^2 (170°) under the true index and TAS^2 (200k) under the grommet (figure 5-56B).
4. Rule a line over the track line (4° right of center) representing Tr^2. The intersection of the two lines is the head of the wind vector; and, for any true heading, this intersection is the head of the track-groundspeed vector.
5. Rotate the compass rose until the head of the wind vector is on the center line below the grommet as shown in figure 5-56C. Read WD (125°) under the true index, and WS (19k) from the grommet to the head of the wind vector.

If drift on another heading is known, rule in another track line on the computer. If the three lines intersect at a point, use that point as the head of the wind vector. If they form a triangle, use the center of the triangle.

Wind by drift on two headings can and should be found when course is altered approximately 45° or more. If the change of heading is less than 45°, a small error in either drift reading may cause a relatively large error in the wind found. For example, assume a wind of 324°/12k. On a true heading of 080° and at a true airspeed of 150 knots, an aircraft drifts 4° right. On a true heading of 100° at the same true airspeed, it drifts 3° right. If you read drift correctly on the first heading and make a 1° error in reading drift on the second heading (reading 2° right instead of 3° right), the computed wind will be 299°/18k.

MULTIPLE DRIFT. Wind determination by measurement of drift on two headings can be used only when a reasonably large change of heading is made. On the other hand, it is quite possible to alter heading long enough to get a drift reading and then return to the original heading. If, for example, the aircraft makes a turn of 45° to the right, remains on this heading for, say, 1½ minutes, then turns 90° left for the same length of time, and finally returns to its original heading, it should be approximately back on its original track after the completion of the maneuver. In the meantime, the navigator will have had the opportunity of reading drifts on the headings of 45° to right and left of his original heading. These, combined with a drift reading made on the original heading, give him three values of drift on three headings to solve for the wind vector on the DR computer. This maneuver is called a *multiple* or *double drift*. Turns of 45°

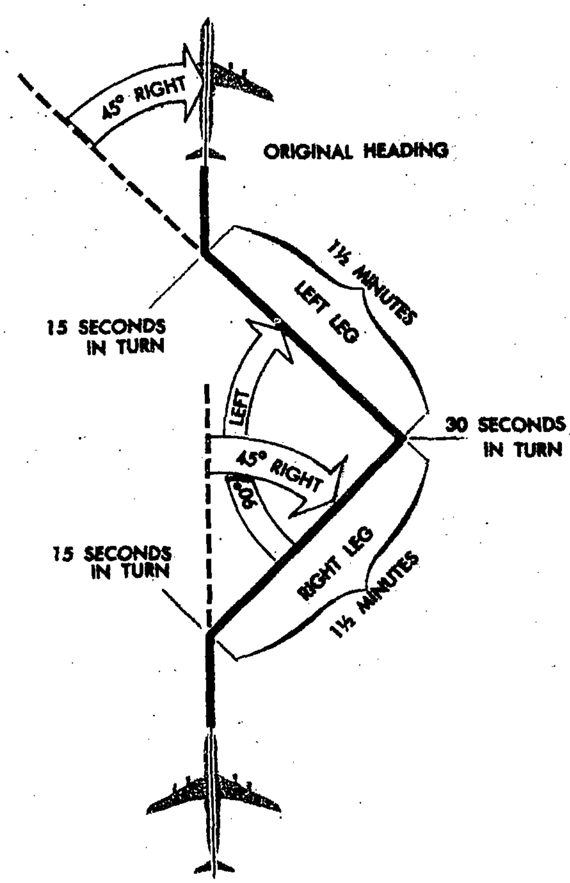


Figure 5-57. Procedure for Multiple Drift

and 90° are used in the example illustrated in figure 5-57. There are other variations to this procedure.

COMPUTER SOLUTION OF MULTIPLE DRIFT.

Sample Problem:

Given: TH on course, 175°
Drift on course, 7°L (+7°DC)
Drift on right leg, 7°L (+7°DC)
Drift on left leg, 2°L (+2°DC)
TAS, 220k

To Find: W/V
GS on course

Set in the data:

1. Set on-course TH (175°) under the true index and TAS (220k) under the grommet as shown in figure 5-58A.
2. On the transparent plate, draw a line over the drift line (7° left of center) representing track. Remember that track is the same number of degrees right or left of the center line as drift.
3. Rotate the compass rose 45° left, that is, until the on-course TH (175°) is under the 45° left-drift mark. Then the right-leg TH (220°) is automatically under the true index (see figure 5-58B).
4. Draw a line over the drift line (7° left of center) representing the right-leg track.
5. Rotate the compass rose 90° right, that is, until the on-course TH (175°) is under the 45° right-drift mark. Then the left-leg TH (130°) is automatically under the true index (see figure 5-58C).
6. Draw a line over the drift line (2°) left of center, representing the left-leg track. Note that the three drift lines in this illustration form a small triangle. Use the center of the triangle as the head of the wind vector.
7. Rotate the compass rose until the head of the wind vector is on the center line below the grommet. Now read WD (290°) under the true index, and read WS (30k) from the grommet to the head of the wind vector (see figure 5-58D).
8. Set on-course TH (175°) under true index and the grommet on TAS (220k). Read on-course GS (234k) at the speed circle passing through the head of the wind vector.

Remember, when flying a multiple drift, check the compass on each heading to be sure the pilot has turned correctly. Also, when turning 45° and using the drift scale in setting up the com-

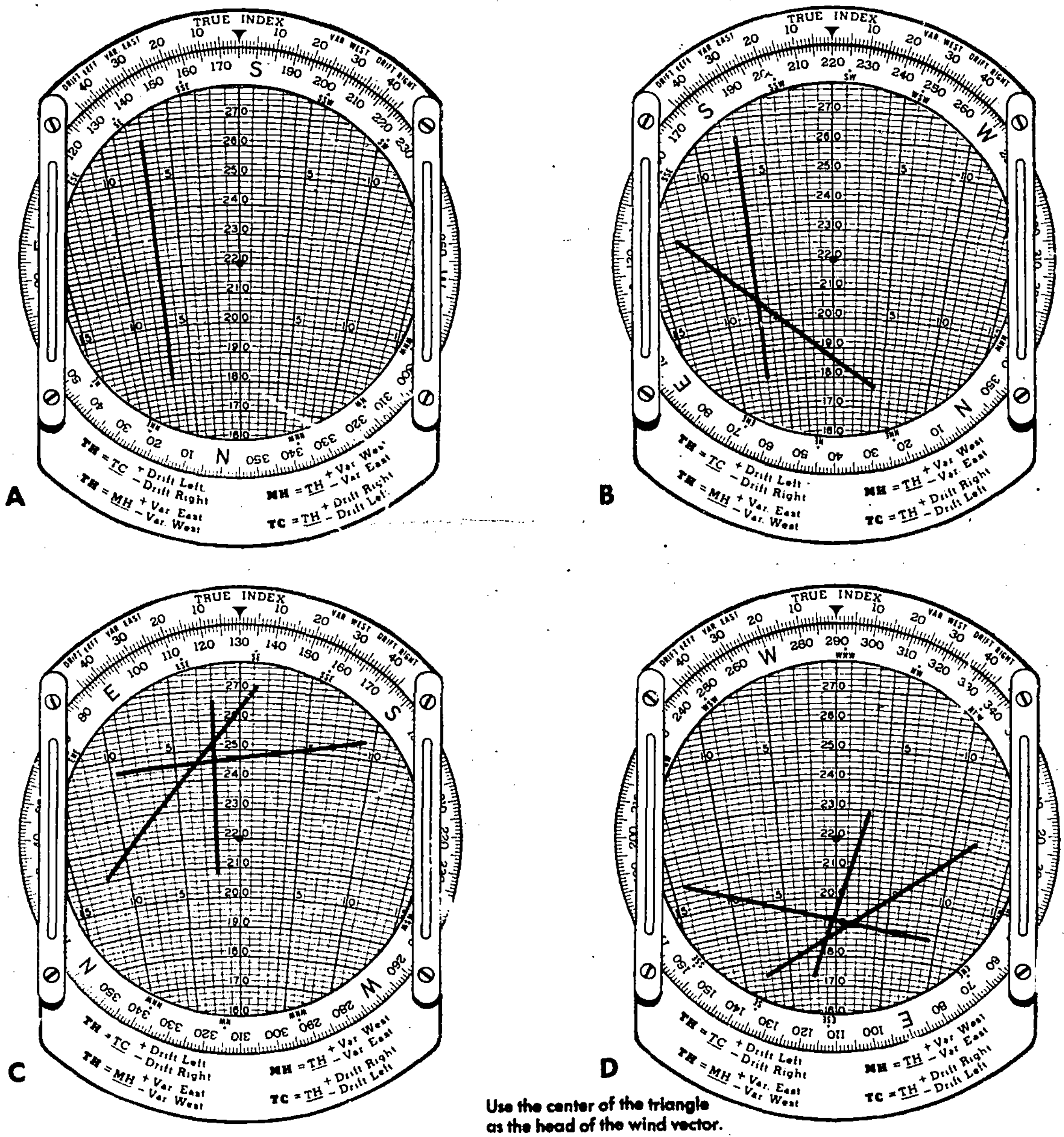


Figure 5-58. Computer Solution of Multiple Drift

puter, it is easy to turn the disk in the wrong direction. If the turn is to the right, the computer is turned counterclockwise, because the heading increases. Be sure to take enough time to get an accurate drift reading.

GROUNDSPEED BY TIMING. The method of computing the wind vector when the true heading-true airspeed vector and the track-groundspeed vector are known has been explained. Track can be found by applying drift to true heading. Groundspeed can also be found with the driftmeter by the method known as *groundspeed by timing*. Thus, the wind can be found without knowing the exact position of the aircraft and without altering heading.

Groundspeed by timing is a method of determining groundspeed by measuring the time in which an object on the ground appears to move

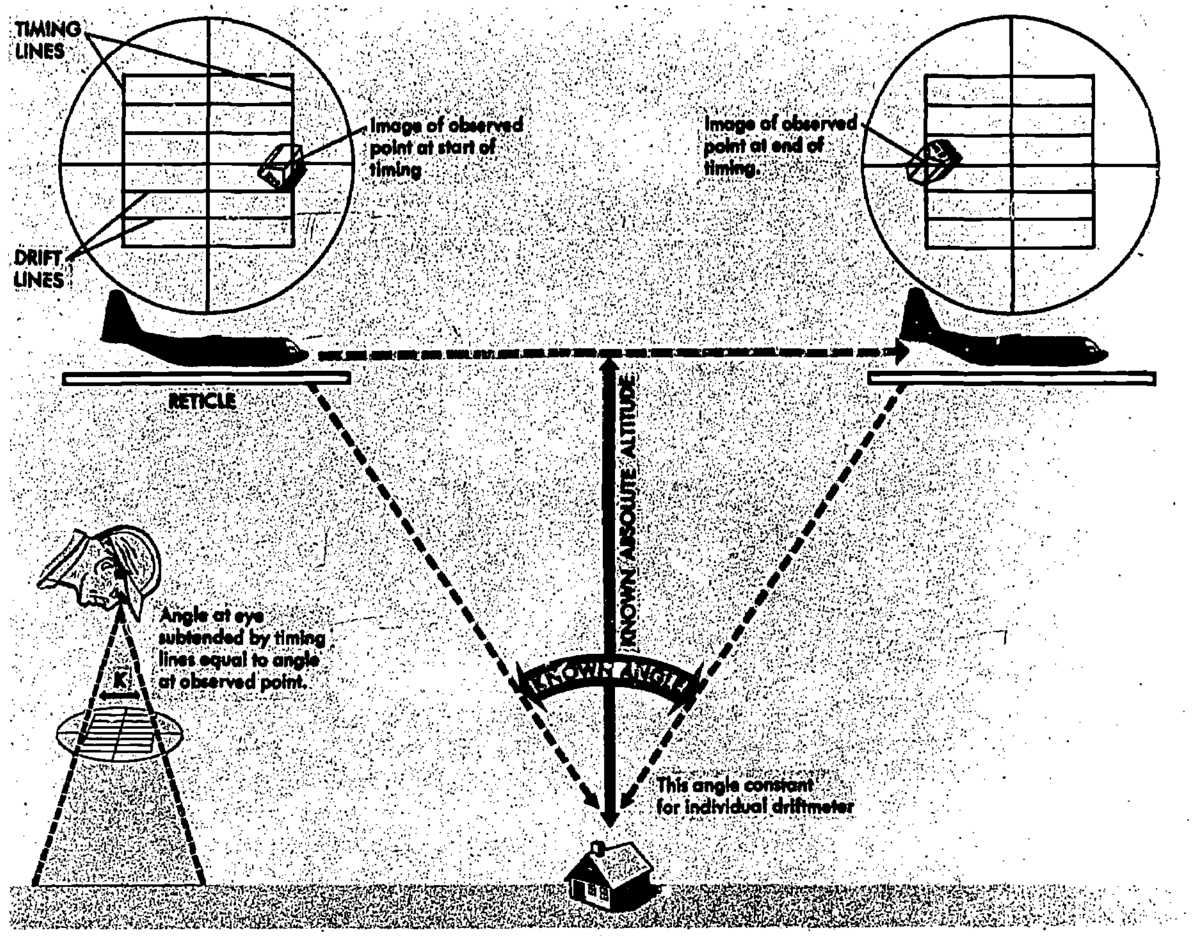


Figure 5-59. Groundspeed by Timing, Zero Trail Angle Method

through a known angle when the aircraft is at a known altitude. This is shown in figure 5-59 The angle is measured with a driftmeter and the time with a stopwatch. In addition to the drift lines, the reticle of a driftmeter has two transverse lines called timing lines. With a stopwatch the passage of an object can be timed from one timing line to the other; that is, through an angle which is constant for that driftmeter. The distance traveled by the aircraft as the object passes through this angle is proportional to the absolute altitude (AA —altitude above the terrain) of the aircraft. Knowing the absolute altitude and the angle, this distance can be computed by trigonometry. Then, from the distance and time, the groundspeed may be computed.

However, trigonometry isn't needed to work out a groundspeed by timing problem. Since the distance traveled is proportional to the absolute altitude, it is found by multiplying the absolute altitude by a factor (called the K-factor) which is constant for the individual driftmeter. The groundspeed is solved on the DR computer using time in seconds, absolute altitude, and the K-factor.

The accuracy of groundspeed by timing depends on the accuracy of the timing and on the accuracy of the absolute altitude. A 10 percent error in either time or absolute altitude can cause a 10 percent error in groundspeed. With a given groundspeed, the time for an object to pass between the timing lines increases with the altitude. As altitude and time increase, a given error in time will result in a smaller error in groundspeed. Therefore, the greater the absolute altitude, the more accurate will be the results. Ordinarily, the stopwatch timing should be accurate to about one-tenth of a second.

Absolute Altitude. The determination of absolute altitude often is a source of inaccuracy. The accuracy of this determination depends on the nature of the terrain and on the type of altimeter used. In level flight over the sea, the absolute altitude remains nearly constant, but over rough terrain, it changes continuously. Therefore, absolute altitude can be found more easily and more accurately over the sea than over rough terrain.

Absolute altitude can be read directly from an absolute altimeter. Such an instrument is an altimeter based on the reflection of radio waves and is discussed in detail later in the manual. If a pressure altimeter is used, the terrain elevation must be subtracted from the basic true altitude to find absolute altitude. With an absolute altimeter, groundspeed by timing can be done over the sea or over relatively flat terrain without knowing the position of the aircraft.

However, with a pressure altimeter, the terrain elevation must be known (when over land) to do groundspeed by timing. To know the terrain elevation, an accurate chart is necessary; moreover, the timing must be accomplished in an area where the elevation is marked on the chart. The more uneven the terrain, the more accurately the position must be known. From this it is easy to see why the absolute altimeter is a better instrument for groundspeed by timing.

Two methods of obtaining groundspeed by timing are given.

Zero Trail Angle Method

1. Uncage the gyro.
2. Read drift and leave the pointer on the drift reading.
3. With a stopwatch, record the time required for a sighted object to pass from one timing line to the other. In addition to the two timing lines near the ends of the drift lines, there is a third transverse line at the center of the field. For the zero trail angle method, use the outer lines.
4. To solve for groundspeed in knots use the following formula:

$$\text{Groundspeed in knots} = K\left(\frac{\text{Absolute Altitude in feet}}{\text{Time in seconds}}\right)$$

The K-factor is stamped on a plate which is fastened to the gyro housing. For solution on the computer, write the formula as a proportion:

$$\frac{GS}{K} = \frac{\text{Absolute Altitude}}{\text{Time}}$$

Example:

Absolute Altitude 10,000 feet
Time in seconds 7.3
K-Factor .159

Set up the proportion on the computer as follows:

$$\frac{GS}{.159} = \frac{10,000}{7.3}$$

Set 7.3 on the minutes scale under 10,000 on the miles scale. Read the groundspeed (217) on the miles scale over .159 as shown in figure 5-60.

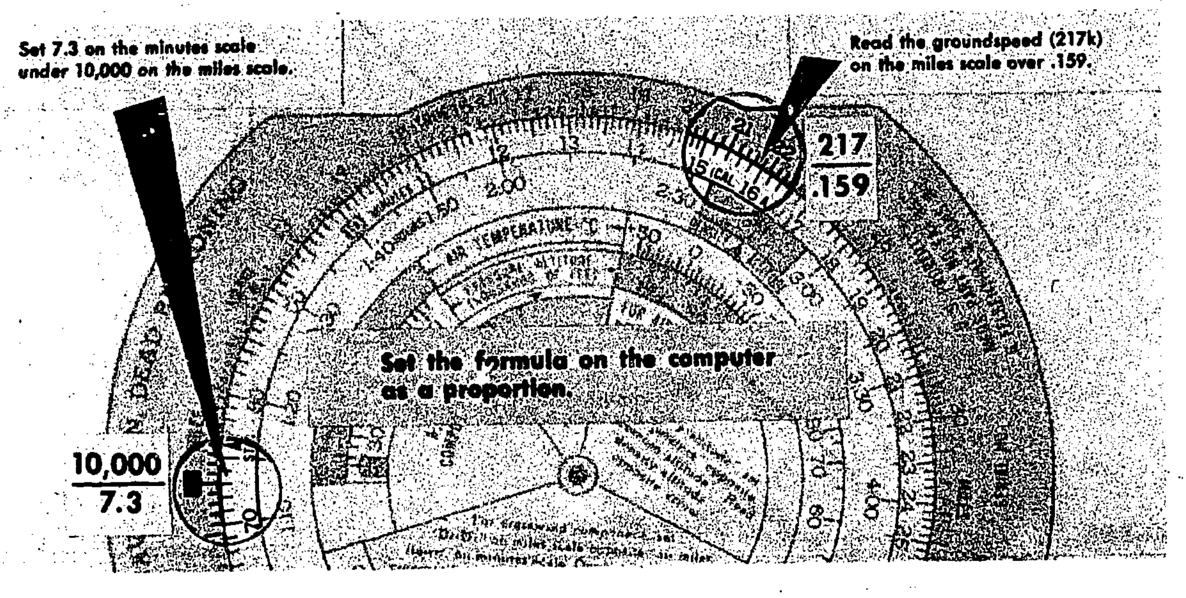


Figure 5-60. Groundspeed by Timing, Computer Solution

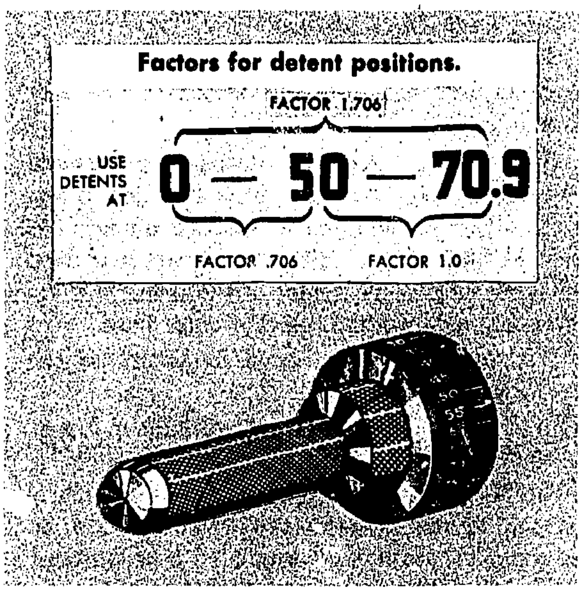


Figure 5-61. Line-of-Sight Knob Detent Positions

Trail Angle Method, 0°—50°

The line-of-sight control handle has detents or partial stops at three trail angles (refer to figure 5-61). As the line of sight reaches one of these angles, the detent can be felt and heard. By changing the line of sight from one detent to another, the passage of an object can be timed from the center timing line at one trail angle to the center timing line at another trail angle.

The trail angle method of groundspeed by timing is described in detail for use with the 0° and 50° detents. The method is the same with the 50° and 70.9° detents or the 0° and 70.9° detents.

1. Read drift and leave the pointer on the drift reading.
2. Turn the line of sight to the 0° detent. Start the stopwatch as an object crosses the center timing line.
3. Turn the line of sight, keeping the object in view until the 50° detent is felt. Stop the watch just as the same object crosses the center line again. (See figure 5-62.)
4. Read or compute the absolute altitude. If possible, absolute altitude should be read when the object is directly beneath the aircraft.
5. Obtain the correct factor. The factor is 1.00 for the angle from 50° to 70.9°. For the angle from 0° to 50°, the factor is 0.706; for the angle for 0° to 70.9°, it is 1.706. These factors are for groundspeed in knots.

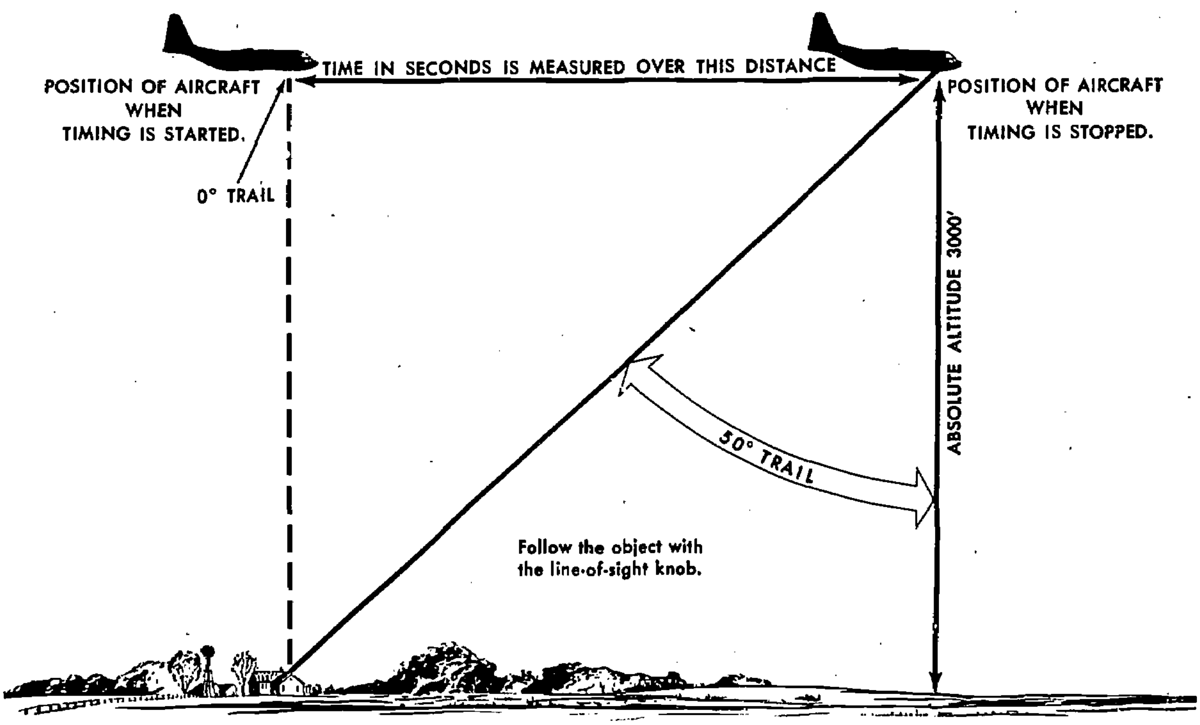


Figure 5-62. Groundspeed by Timing, 0° to 50° Trail Angle Method

TRAIL ANGLE METHOD (B-3 DRIFTMETER)

FINISH IN °	START *0°	10°	20°	30°	40°	50°
5°	.0518					
10	.1043					
15	.1587	.0543				
20	.2155	.1112				
25	.2761	.1717	.0605			
30	.3419	.2375	.1264			
35	.4146	.3102	.1990	.0727		
40	.4968	.3924	.2813	.1549		
45	.5921	.4877	.3765	.2502	.0953	
*50	.7057	.6013	.4901	.3638	.2089	
55	.8456	.7412	.6300	.5037	.3487	.140
60	1.026	.9222	.8100	.6837	.5287	.320
65	1.270	1.165	1.054	.9275	.7729	.564
*70.9	1.706	1.602	1.490	1.364	1.209	1.000

*B-3 Driftmeter has detents at these angles.

Figure 5-63. K-Factors for Groundspeed by Timing

6. Using the following formula, solve for the groundspeed.

$$\frac{GS}{K} = \frac{\text{Absolute Altitude}}{\text{Time}}$$

The same procedure may be used with trail angles where there are no detents. If this is done, it is necessary to note the value of the angle at the beginning of the run and at the end. Using these angles, the factor can be obtained from the table, *K-Factors for Groundspeed by Timing* (see figure 5-63).

The trail angle method is preferable to the zero trail angle method because the length of the timing period is increased. Consequently, the groundspeed will be more accurate because errors in timing will not be magnified as much as they are with the shorter period of time.

Finding Wind After Groundspeed By Timing. After finding the groundspeed, it is an easy matter to find the wind. Since the true heading-true airspeed vector and the track-groundspeed vector are known, the wind triangle problem can be solved on the computer.