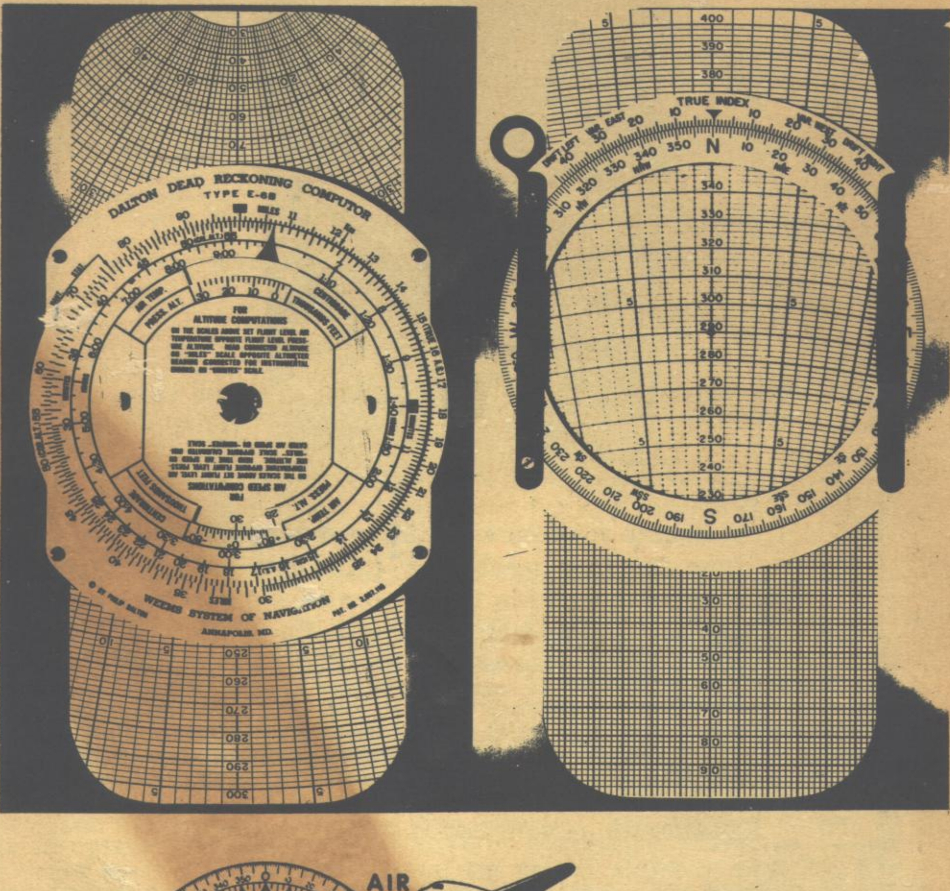
INSTRUCTIONS

FOR THE

DALTON DEAD RECKONING COMPUTER

TYPE E-6B



AIR

WSN WEEMS

SEA SYSTEM OF NAVIGATION

ANNAPOLIS, MARYLAND

EXPLANATION OF THE CIRCULAR SLIDE RULE

The Dalton dead reckoning computer, Type E-6B, was designed to simplify solution of the various vector problems encountered in dead reckoning navigation and to eliminate, so far as possible, the mental calculations usually involved.

The face of the instrument embodies a transparent plotting disk mounted in a rotatable compass rose, the center marked by a small black circle called the "grommet." A sliding grid is fitted to move beneath the transparent plotting disk. This grid is actually a section of a 360 degree plotting circle, the center or zero point not being shown since speed ranges of 0 to 30 will seldom if ever be used. The curves on the grid represent the concentric circles around this center, distance from the center being indicated at ten-mile intervals by the figures on the vertical center-line. The lighter, intermediate curves are spaced at two-mile intervals.

The radiating straight lines indicate direction from the center of the circle and are used to set up courses and headings and to determine drift angle.

Above the rotatable compass rose is a scale with a true index marking at the center. The scale runs from 0 to 45 degrees to the left and right of the true index. This scale is used for applying east and west variation to determine magnetic courses and headings, and for drift calculations.

The back of the computer consists of the dead reckoning circular slide rule. The outer, stationary scale is designated the "miles" scale. The movable part of the slide rule contains the time scales, the outer scale being in "minutes" the inner in "hours." Adjacent to the time scales are two cut-outs with corresponding scales, one for determining true airspeed and the other for altitude computations.

The slide rule face of the Dalton E-6B is standard with all major types of navigation computers. It may be used for problems involving:

(1) Fuel Consumption
(2) Time, Speed, and Distance
(3) Multiplication, Division and Proportion
(4) Correction of Altitude and Airspeed with Temperature and Altitude
(5) Distance Conversions
(6) The Radius of Action Formula

On the computer, as with any type of slide rule, the figures on the scales represent multiples of ten of the values shown. For example: the figure 24 on the miles scale may represent .24, 2.4, 24, 240, or 2400 miles; and the figure 24 on the minutes scale may represent .24, 2.4, 24, 240 or 2400 minutes. Minutes can be converted to hours by referring to the adjacent "hour" scale. Thus, from the above example, 240 minutes would be read on the corresponding hour scale as four hours and 2400 minutes as forty hours.

Care should be taken with the reading of the computer and the relative values kept in mind. For example: the numbers 21 and 22 on the distance scale are separated by 5 division lines, or spaced 2 units apart, so that reading at the second division past 21, the correct reading would be 21.4, 214, 2140, etc. The spacing of these divisions should not be hurriedly passed over as the break down of the division lines may be into units of 1, 2, 5, or 10.

The relation between statute and nautical miles should be observed. Nautical miles and Knots (nautical miles per hour) go together and in the same manner Statute miles and miles per hour are like related.

Distance Conversions.

The computer is provided with three indices on the miles scale which set up a proportional relationship between statute miles, nautical miles and kilometers. The mathematical formulas involved are: 1 nautical mile equals 1.15 statute miles.
1 statute mile equals .87 nautical miles.
1 nautical mile equals 1.86 kilometers.
1 statute mile equals 1.61 kilometers.

The three indices, or arrows, on the miles scale are located as follows: the nautical arrow marked "Naut" at 66, the statute arrow marked "Stat" at 76 and kilometer arrow marked "Km" at 122.

Problem type I: Convert 170 nautical miles to statute miles and kilometers.
(a) Set 170 on the minutes scale opposite the "Naut" arrow on the miles scale.
(b) Against the "Stat" arrow read 196 statute miles and against the "Km" arrow read 315 kilometers. (see fig. 1)

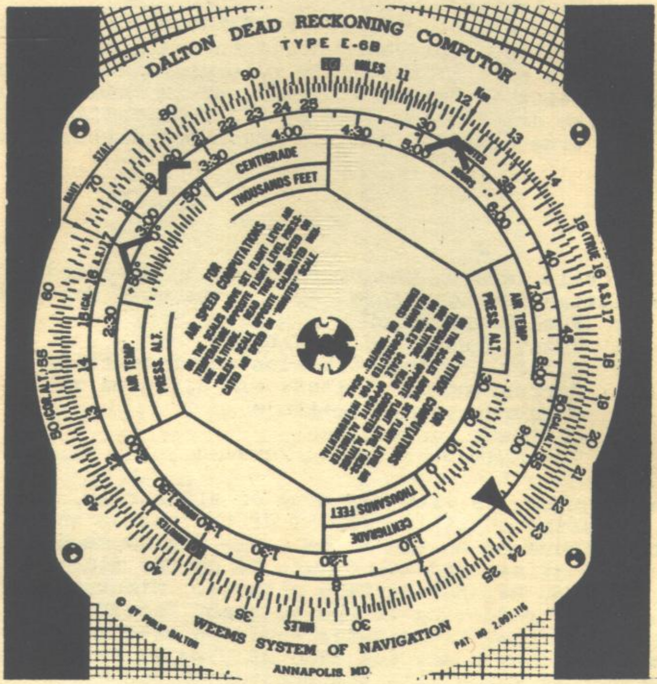


Figure 1

AIR DENSITY CORRECTIONS:

Definitions:

Indicated air speed is the speed of the aircraft through the air as read from the air speed indicator.

Calibrated air speed is the indicated air speed corrected for all instrumental errors.

True air speed is the calibrated air speed corrected for variations in temperature and pressure (altitude).

True altitude is the actual altitude of the aircraft above sea level.

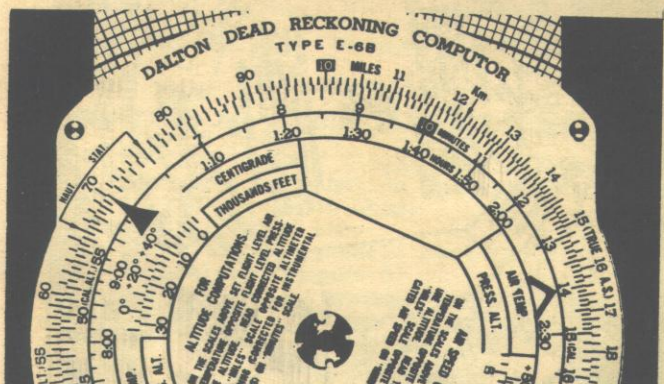
AIR DENSITY CORRECTIONS

<u>Pressure altitude</u> is the altitude of the aircraft above a certain level in the atmosphere where conditions of temperature and pressure are standard. It is the altitude as read from the altimeter when the altimeter setting is 29.92 inches of mercury.

To obtain true air speed, the calibrated air speed must be corrected for variations from standard sea level pressure and temperature. (29.92 inches at 15 degrees centigrade). Since decrease of temperature with altitude (lapse rate) may vary considerably and sea level pressure is constantly changing, the readings of the air speed indicator are frequently incorrect. The cut out marked "FOR AIRSPEED COMPUTATIONS" provides a means for correcting calibrated airspeed for these variations from standard conditions. Free air temperature may be read from a strut thermometer and the pressure altitude read from the altimeter by setting to 29.92 inches. It is not strictly necessary to set the altimeter to standard pressure as a large change in altimeter setting will cause only a small error in the true air speed.

Problem type I: To find true air speed when flying at 8,000 feet pressure altitude, free air temperature plus 20 degrees centigrade with a calibrated air speed of 140 m.p.h.

(a) In the cut out set 8 against plus 20.
(b) Opposite 140 m.p.h. calibrated air speed on the minutes scale, read 164 m.p.h. true air speed on the miles scale. (see figure 2)



<u>ALTIMETER CORRECTIONS</u>. Figure 2

The altimeter is constructed to read the correct altitude under standard conditions of pressure and temperature. As atmospheric conditions are seldom standard, the altimeter reading usually must be corrected. The E-6B computer is provided with a cut out scale marked

"FOR ALTITUDE COMPUTATIONS" to determine this correction. Indicated altitude can be read from the altimeter directly and the pressure altitude can be read by setting to 29.92. The indicated altitude is the altimeter reading when the altimeter setting is adjusted to the ground station pressure corrected to sea level pressure. It is the reading of the instrument when it is set to read elevation of the field on take-off.

Problem type I: To find true altitude of an aircraft flying at an indicated altitude of 20,800 feet, a pressure altitude of 20,000 feet with a temperature of minus 10 degrees centigrade.

(a) In the cut out, set minus 10 degrees against 20,000 ft.
(b) Opposite 20,800 on the minutes scale, read the true altitude, 22,000 feet on the miles scale. (figure 3)

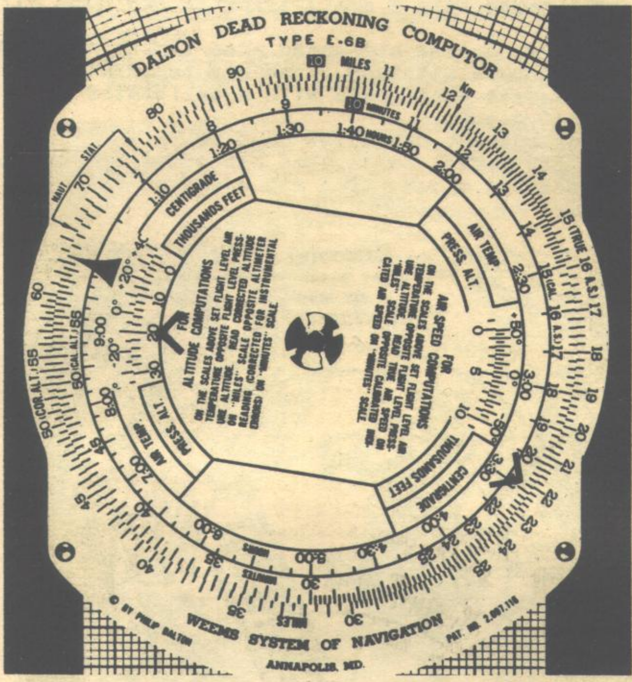


Figure 3

RATE TIME DISTANCE PROBLEMS.

The circular slide rule side of the E-6B computer solves problems involving time, ground speed and distance. The formulas involved are:

Distance equals ground speed multiplied by time.
Ground speed equals distance divided by time.
Time equals distance divided by ground speed.

The outside or miles scale is used for all distance units and for rates, as miles per hour or knots. On the time scales a large black arrow replaces the 60 minute and one hour markings. This arrow is known as the "speed arrow" and will hereafter be referred to as such.

Problem type I: To determine ground speed knowing you have passed two check points 24 miles apart in 12 minutes.

(a) Set 12 on the minutes scale opposite 24 on the miles scale.

(b) On the miles scale read ground speed, 120 m.p.h., opposite the speed arrow. (figure 4)

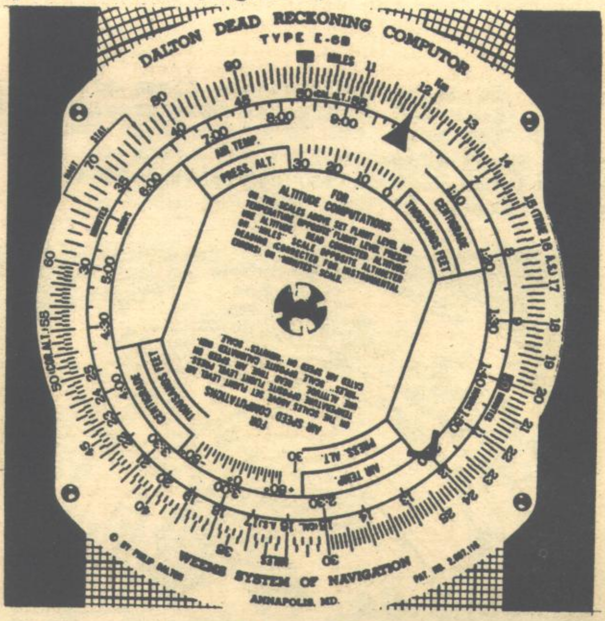


Figure 4

INSTRUCTIONS FOR DALTON DEAD RECKONING COMPUTER

Problem type II: To find time of flight knowing you are 80 miles from your destination and making good a ground speed of 145 miles per hour.

(a) Set the speed arrow on 145.

(b) Opposite 80 on the miles scale read the time, 33 minutes, on the minutes scale. (figure 5)

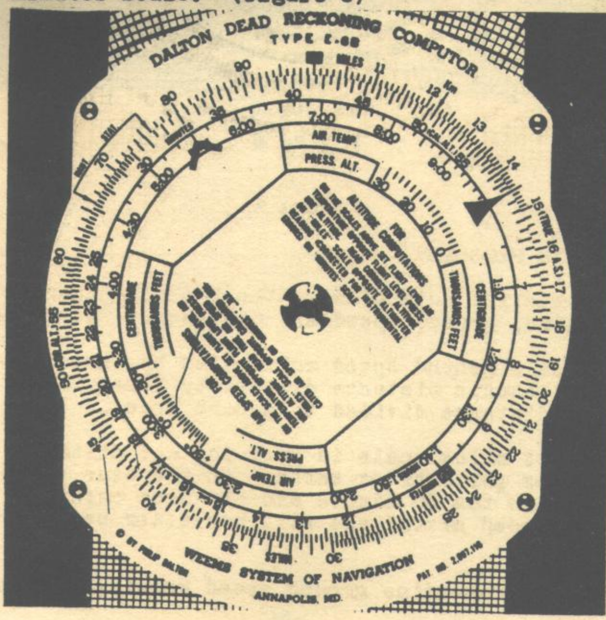


Figure 5

Problem type III: To determine distance flown after flying for 1 hour and 32 minutes at a ground speed of 137 miles per hour.

(a) Set the speed arrow on 137.
(b) Read distance, 210 miles, opposite 1:32 on the minutes scale. (figure 6)

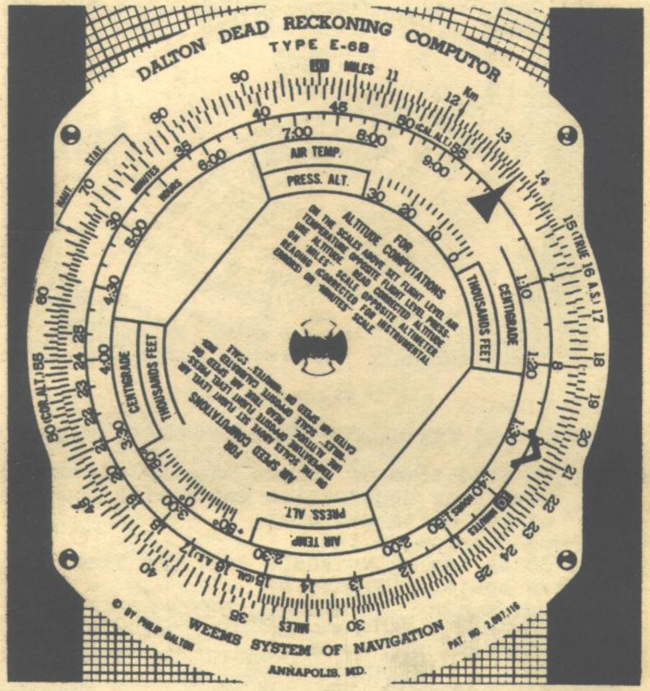


Figure 6

Fuel Consumption.

After flying for 40 minutes a pilot finds that 75 gallons of gas have been used. What is the rate of fuel consumption?

(a) Set 75 on the miles scale against 40 on the minutes scale.

(b) Read rate of consumption on the miles scale (112½ gallons per hour) opposite the speed arrow. (figure 7)

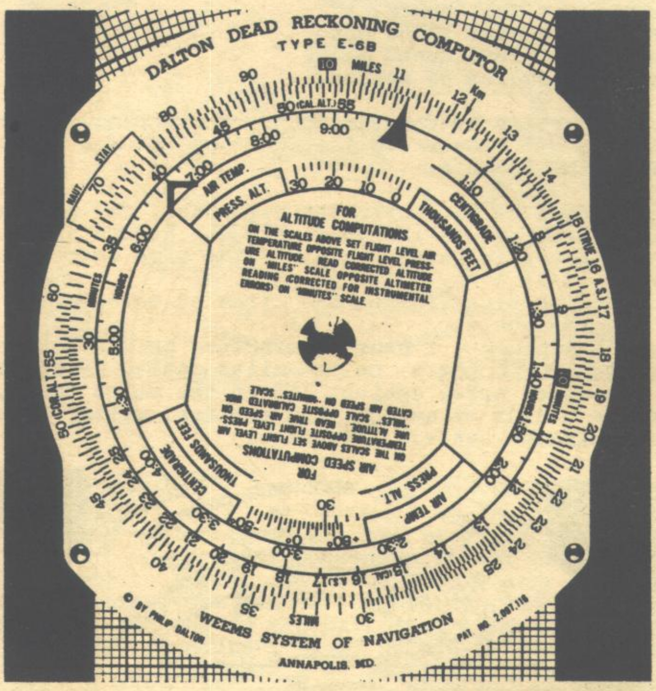


Figure 7

RADIUS OF ACTION FORMULA.

Radius of action to the same base, radius of action to a moving base and alternate airport problems may be solved using the following formulas:

t equals $\frac{S2 \text{ X } T}{S1 \text{ plus } S2}$ and R/A equals t x GS1

Where:

t equals the time out (time to turn)
S1 equals the rate of departure.
S2 equals the rate of closure.
T equals the net fuel hours.
GS1 equals the ground speed out.
GS2 equals the ground speed in.
R/A equals the radius of action.

In radius of action to the same base, the ground speeds equal the rates of departure and closure so that GS1 and GS2 are substituted for S1 and S2 in the formula.

Example: In a radius of action to the same base, the navigator finds that the ground speed out is 125 knots and the ground speed back is 140 knots. Net fuel hours is three. What is the time out (t) and the radius of action (R/A).

(a) Set 265 (140 plus 125) on the miles scale opposite 140 on the minutes scale.
(b) Read the time out, 1 hour 35 minutes, on the minutes scale opposite 180 (3 hours) on the miles scale. (figure 8)
(c) Set the speed arrow against 125 on the miles scale.
(d) Read the radius of action, 198 nautical miles, opposite 1:35 on the minutes scale. (figure 9)

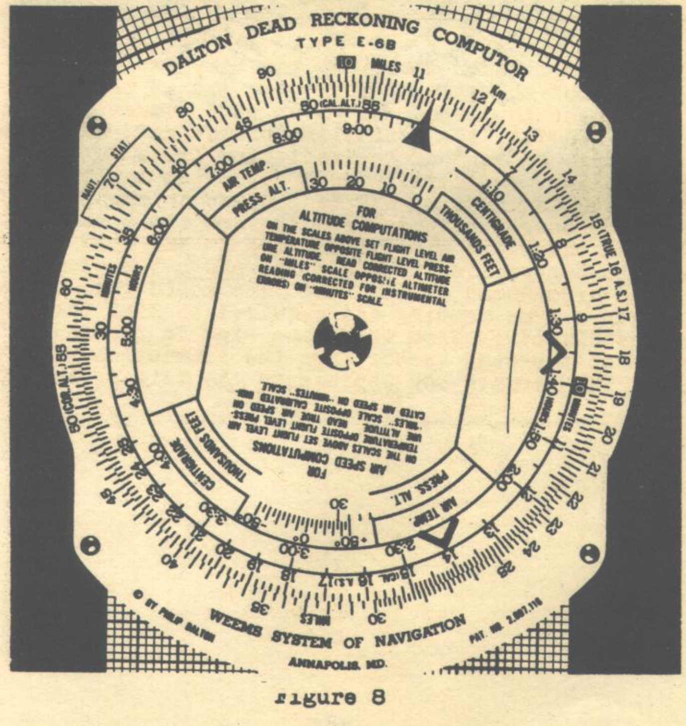


Figure 8

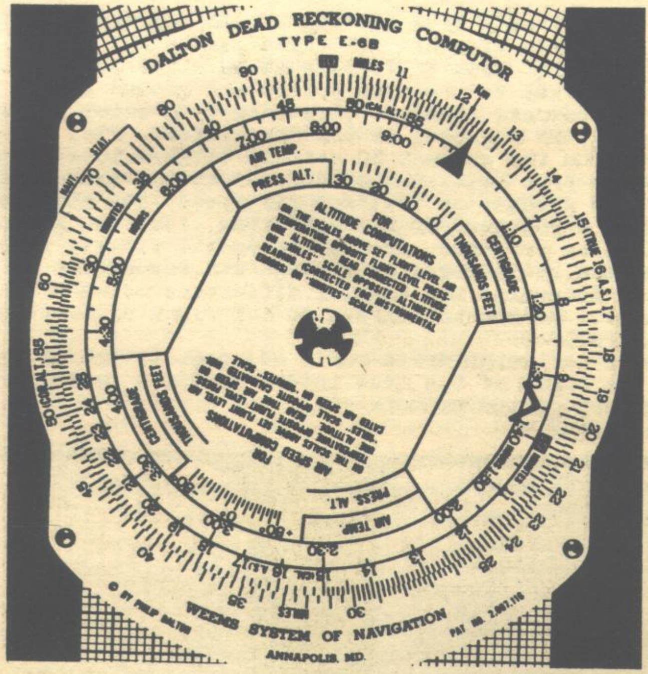


Figure 9

VECTOR PROBLEMS.

In setting up vector problems, the simplest procedure is to use the center line of the grid to represent either true course or true heading, whichever is given. If given true course and required to find the true heading, the centerline of the grid would represent the given true course and one of the radiating lines to the right or left of the center line, or course, would represent the required heading.

The wind vector must always be plotted in the following manner: If given a true course and required to find the true heading, set the direction from which the wind is blowing at the true index. Plot the wind along the center line from a point above the grommet down to the grommet. The arrow-head of the wind line would then be at the grommet. If given a true heading and required to find the true course, again set the direction from which the wind is blowing at the true index, but plot the wind vector from the grommet downward along the centerline. The grommet now represents the tail of the wind line.

Problem type I: Given a true heading of 126 degrees,
True airspeed 156 miles per hour,
Wind from 70 degrees at 30 miles per hour.
What is the true course and ground speed?

(a) On the compass rose set direction from which the wind is blowing, 70 degrees, at the true index. Plot the wind downward from the grommet 30 units. (figure 10-A)
(b) Set the true heading, 126 degrees at the true index.
(c) Set the grommet on the true air speed, 156 miles per hour.
(d) At the arrow head of the wind line, read the ground speed, 142 miles per hour, on the concentric circle. (figure 10-B)
(e) From the radiating line through the arrow-head of the wind line, determine the angular difference between heading and course. Course 10 degrees to the right of heading. (figure 10-B)
(f) On the variation drift scale adjacent to the 10 degree mark to the right of the true index, read the true course, 136 degrees, on the azimuth ring.

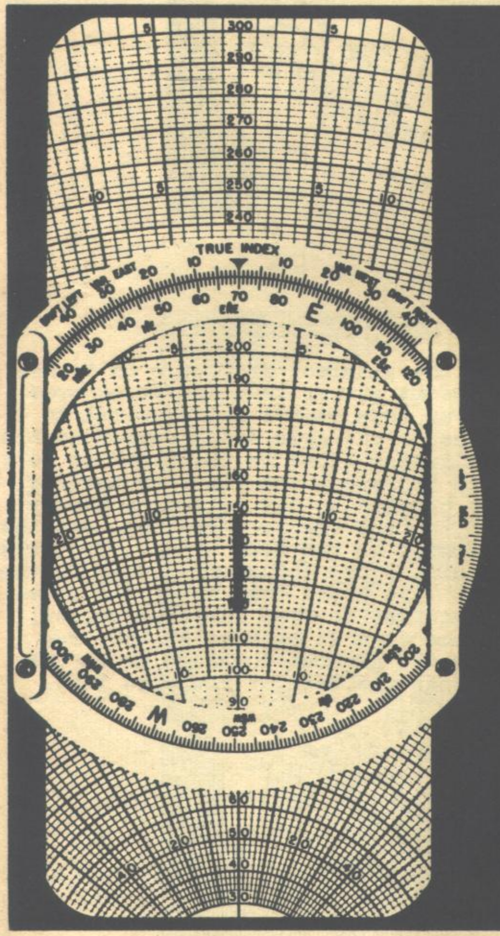


Figure 10-A

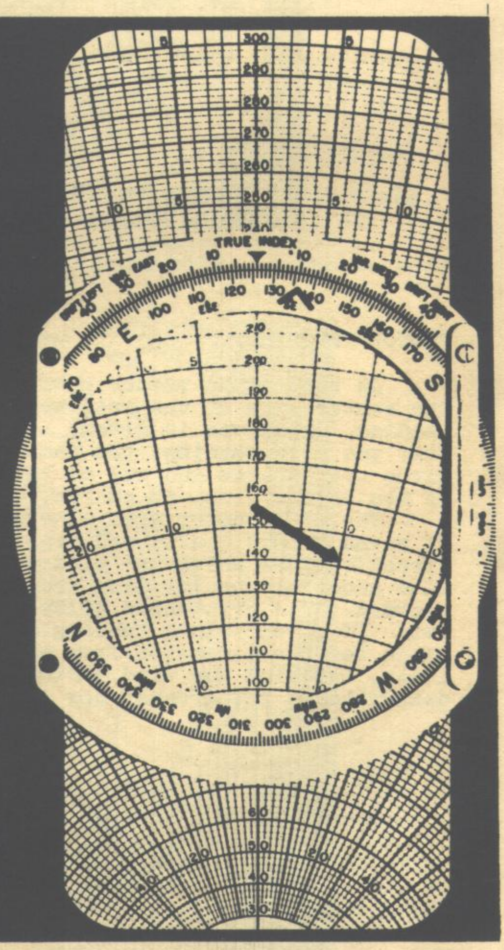


Figure 10-B

Problem type II: Given true course 22 degrees,
True air speed 162 miles per hour,
Wind from 265 degrees at 18 miles per hour.
What is the true heading and the ground speed?

(a) Set the wind direction, 265 degrees, at the true index. Plot the wind from above down to the grommet 18 units in length. (figure 11-A)

(b) Set the true course, 22 degrees, at the true index.

(c) Set the tail of the wind arrow on the true air speed, 162 miles per hour. (Use the concentric circle passing through 162 on the center line scale.)

(d) At the grommet read the ground speed, 169 miles per hour. (figure 11-B)

(e) From the radiating line passing through the tail of the wind arrow, determine the angular difference between the course and the heading. (Heading is 6 degrees to the left of the course.) (figure 11-B)

(f) On the variation drift scale adjacent to the 6 degree mark to the left of the true index, read the true heading, 16 degrees, on the azimuth ring.

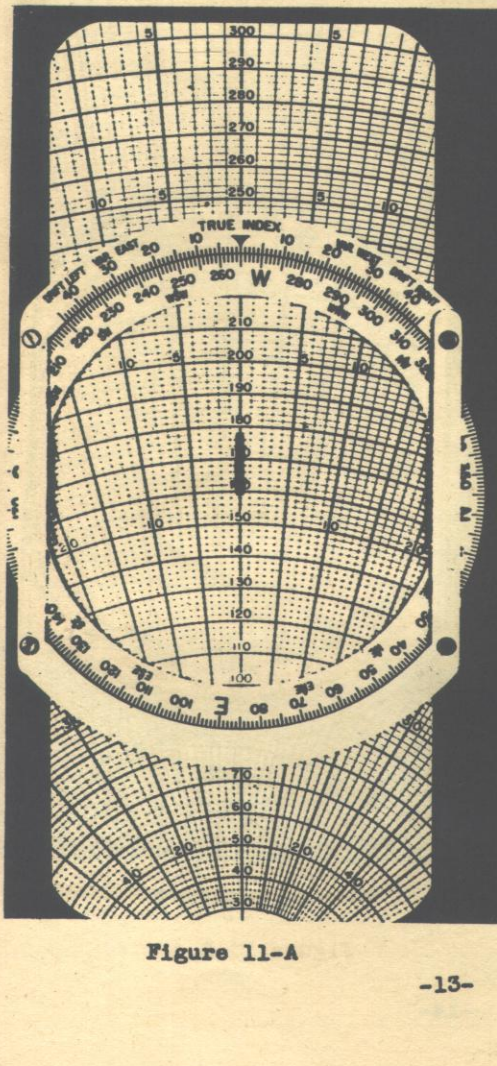


Figure 11-A

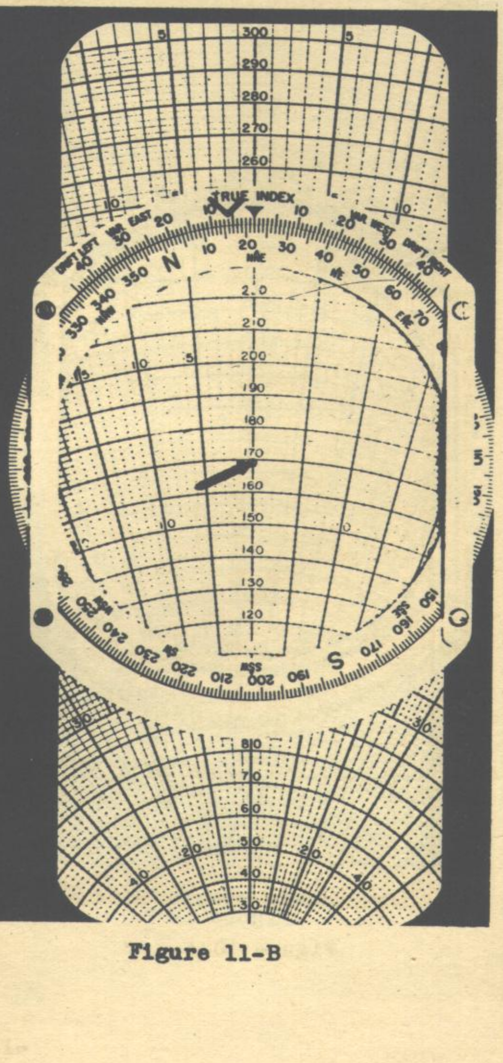


Figure 11-B

Problem type III: Given true course 220 degrees,
Ground speed 155 miles per hour,
Wind from 275 degrees at 14 miles per hour.
What is the true heading and the true airspeed?

(a) Set the wind direction, 275 degrees, at the true index. Plot wind from above down to the grommet at 14 miles per hour. (figure 12-A)
(b) Set the true course, 220 degrees, at the true index.
(c) Set the ground speed, 155 miles per hour, at the grommet.
(d) At the tail of the wind arrow read the true airspeed, 164 miles per hour, on the concentric circle. (figure 12-B)
(e) From the radiating line through the tail of the wind arrow, determine the angular difference between heading and course. (Heading 4 degrees to the right of course) (figure 12-B)
(f) On the variation drift scale adjacent to the 4 degree mark to the right of the true index, read the true heading, 224 degrees.

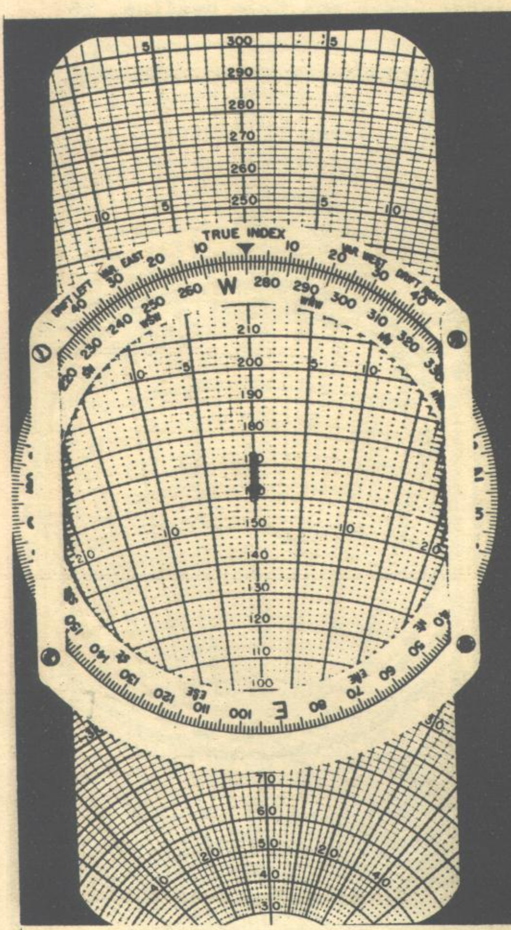


Figure 12-A

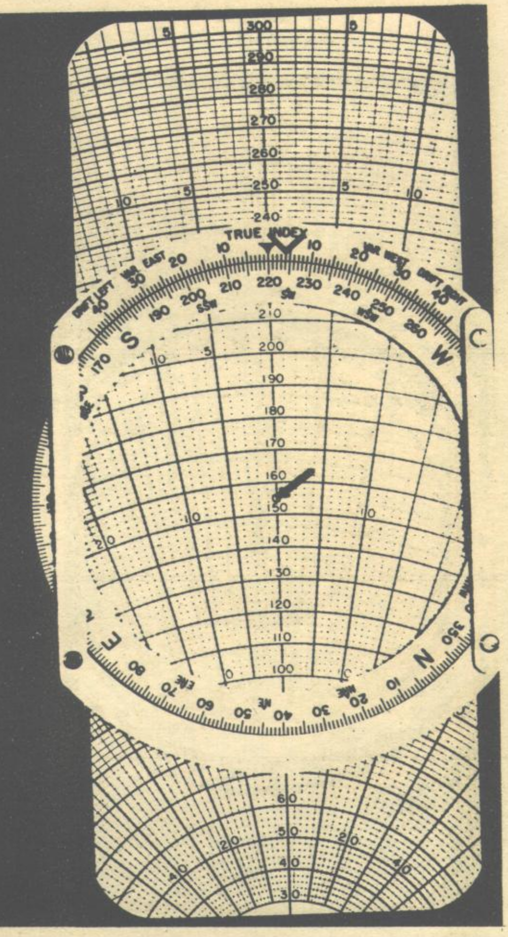


Figure 12-B

Problem type IV: Given true course 32 degrees,
Ground speed 156 miles per hour,
True heading 20 degrees,
True airspeed 143 miles per hour.
What is the wind direction and velocity?

(a) Set the true course, 32 degrees, against the true index.
(b) Set the grommet on the ground speed, 156 miles per hour.
(c) Plot a cross on the transparent disk at the intersection of the 143 m.p.h. air speed circle and the radiating line representing the given heading of 20 degrees. (Heading 12 degrees left of course) (Figure 13-A)
(d) Rotate the azimuth ring so the cross is on the center line above the grommet.
(e) Read the wind direction, 273 degrees, against the true index, and the wind force, 34 m.p.h., on the vertical scale between the cross and the grommet. (figure 13-B)

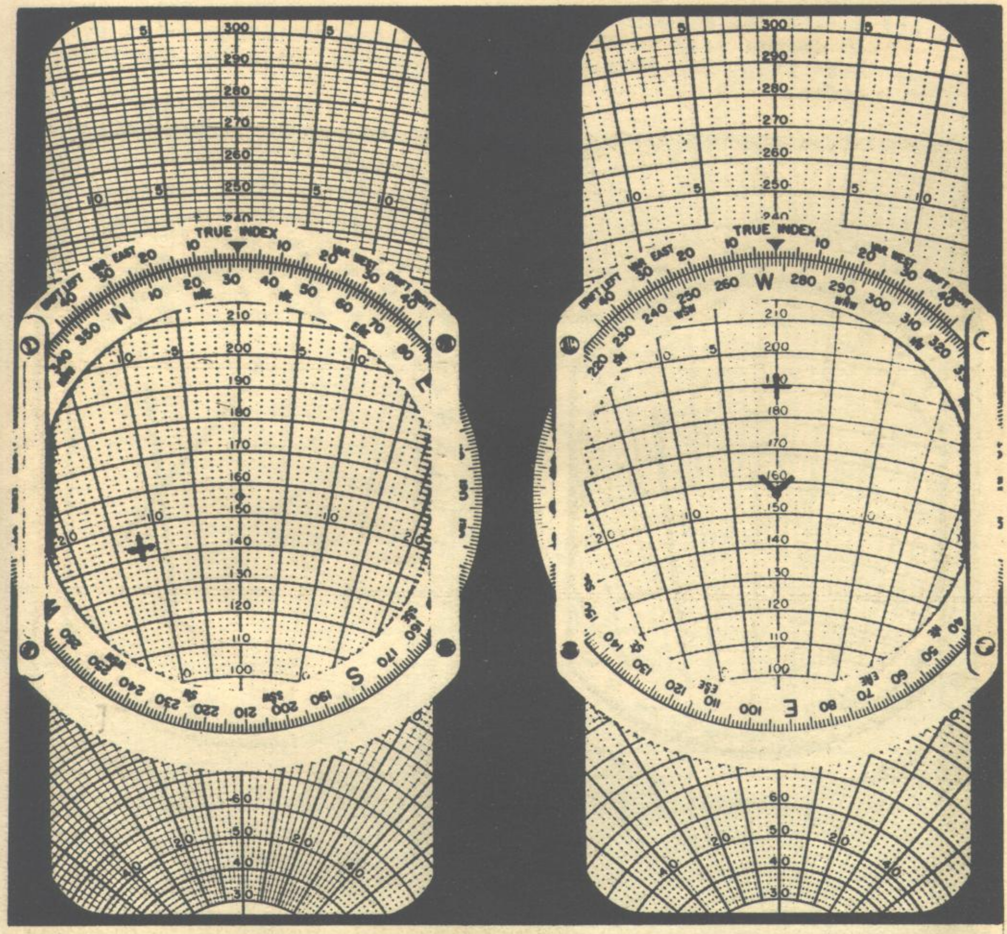


Figure 13-A

Figure 13-B

DRIFT PROBLEMS.

Double drift is the name given a method of determining wind direction and velocity. The procedure consists of flying 45 degrees to the right and left of the on-course true heading and reading the drift on each leg. Knowing wind, the true course and ground speed may also be determined.

Example: At the navigators request, the pilot flies a double drift: true airspeed 190 knots and on course true heading 40 degrees. The navigator obtains the drift readings as follows: On course drift 8 degrees right: right leg drift 8½ degrees right: left leg drift 1 degree right. What is the wind direction and force, the true course and ground speed?

(a) Set 190 true airspeed under the grommet.
(b) Set 40 degrees, on course true heading, opposite the true index. Draw a line over the radiating line 8 degrees to the right of the center line. (8 degrees right drift.) (figure 14-A)
(c) Rotate the azimuth ring so that 40 degrees is opposite the 45 degree mark on the left side of the variation-drift scale. Read right leg true heading, 85 degrees, opposite the true index.

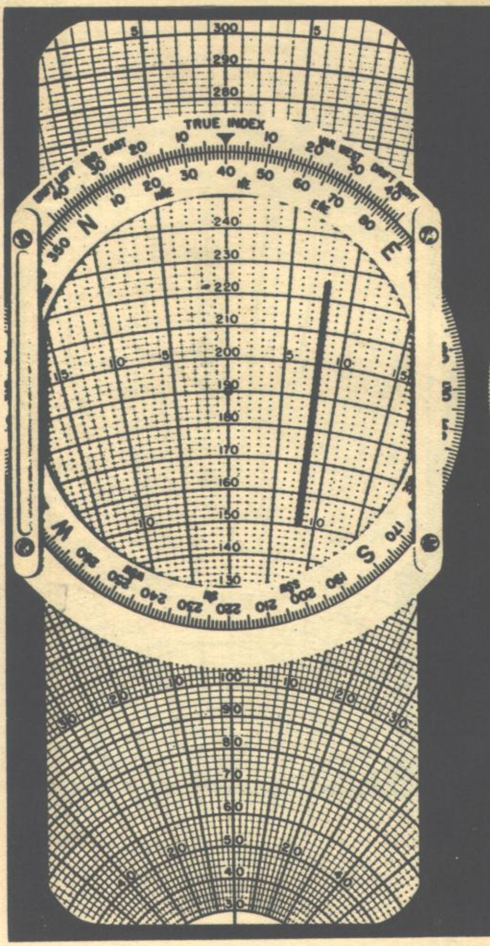


Figure 14-A

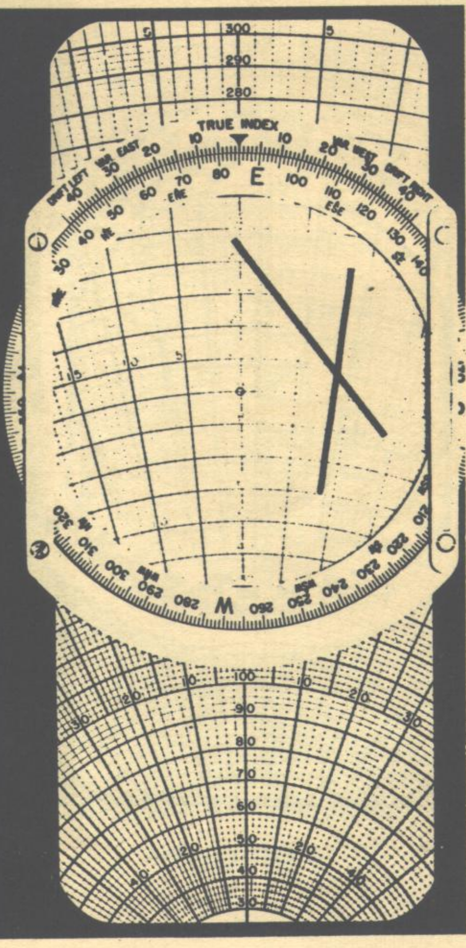


Figure 14-B

(d) Draw a line over the radiating line 8½ degrees to the right of the center line, (drift 8½ degrees right) and crossing drift line number 1. (figure 14-B)

(e) Rotate the azimuth ring so that 40 degrees is opposite the 45 degree mark on the right side of the variation-drift scale. Read left leg true heading, 355 degrees, opposite the true index.

(f) Draw a line over the radiating line 1 degree to the right of the center line. (drift 1 degree right). Cross this drift line with drift lines 1 and 2. (figure 14-C).

(g) Rotate the azimuth ring so that the center of the wind triangle lies on the center line and below the grommet. Read the wind force, 30 knots, on the center line scale and the wind direction, 348 degrees, opposite the true index. (figure 14-D)

(h) Knowing true heading, true airspeed and wind; the true course, 47½ degrees, and ground speed, 173 knots, may be determined. (see problem type I, page 13.

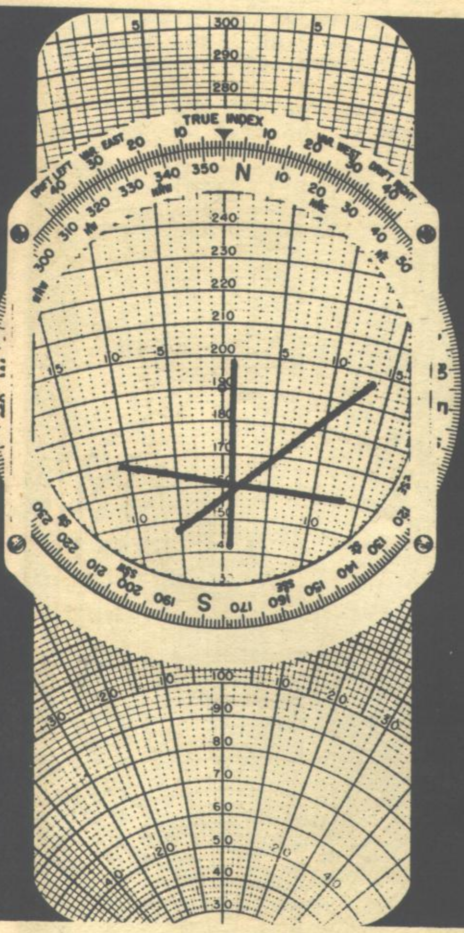


Figure 14-C

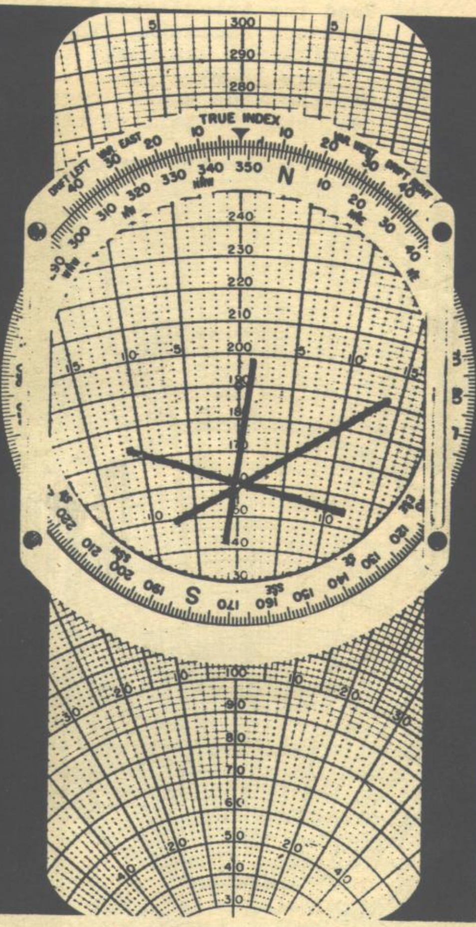


Figure 14-D

RADIUS OF ACTION TO THE SAME BASE.

Radius of action of an aircraft is the greatest distance that it may fly along a certain course under known conditions of air speed, wind, and fuel consumption; and return to the starting point. The problem consists of determining the ground speed out and back, the headings out and back, and the solution of the radius of action formula to find time of turn and the radius of action.

Example: A plane takes off to patrol a true course of 70 degrees at a true air speed of 156 knots. The plane carries enough fuel for 5 hours aside from the required reserve. The wind is from 345 degrees at 25 knots. What is the ground speed out and back, true heading out and back, radius of action and time to turn?

(a) Set wind direction, 345 degrees, against the true index and draw the wind line 25 miles down to the grommet. (figure 15-A)
(b) Set the true course, 70 degrees, opposite the true index, and the tail of the wind arrow on 156 true air speed.
(c) Read the ground speed out, 151 knots, under the grommet. From the radiating line through tail of wind line, determine heading 60½ degrees. (heading 9½ degrees left of course.) (figure 15-B)
(d) Set the true course back, 250 degrees, against the true index, and the tail of the wind arrow on 156 true airspeed.

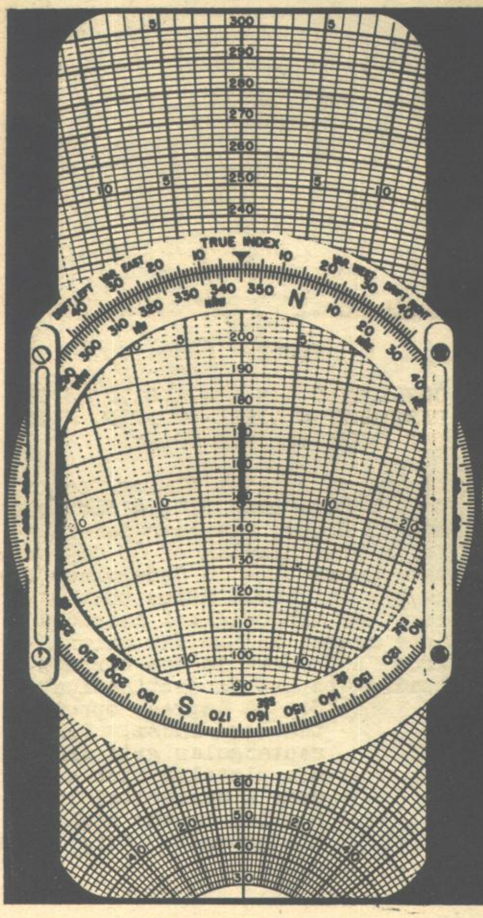


Figure 15-A

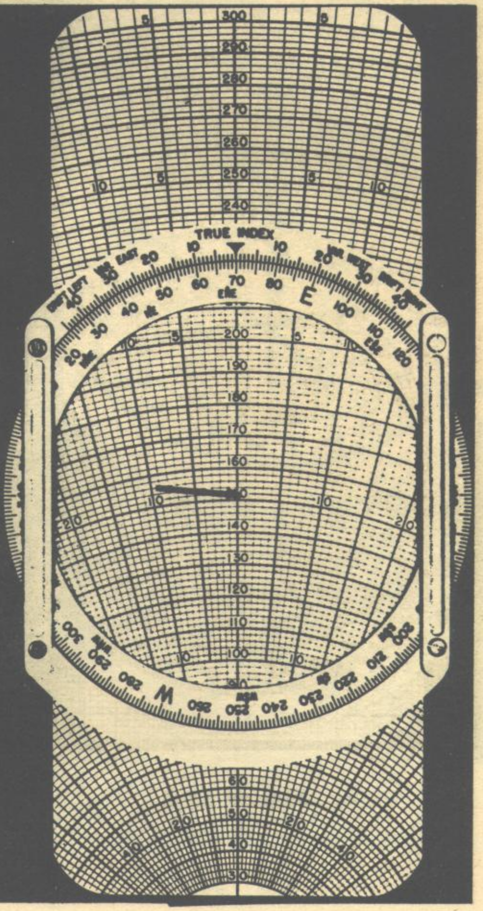


Figure 15-B

(e) Read the ground speed back, 156 knots, under the grommet. From the radiating line through tail of wind arrow, determine true heading back, 259 degrees. Heading 9 degrees right of course. (fig. 15-C)

(f) Solve the radius of action formula on the circular slide rule to find time to turn, 2 hours 33 minutes, and the radius of action, 385 nautical miles. (reference, radius of action formula, page 11.

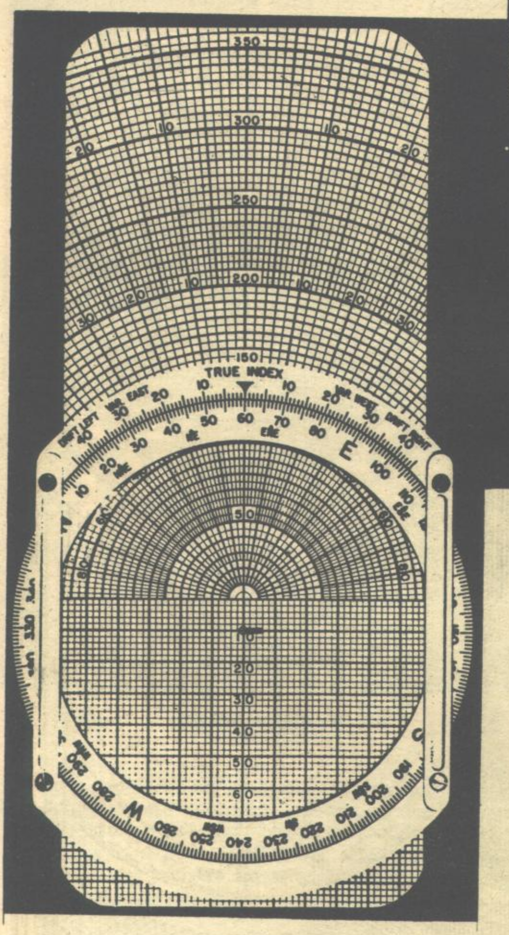


Figure 16-A

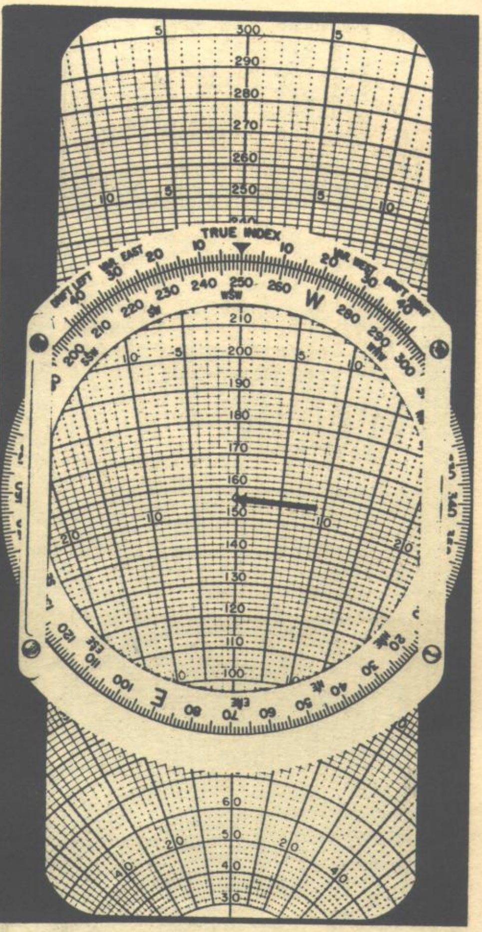


Figure 15-C

CORRECTING THE HEADING TO REACH DESTINATION AFTER DRIFTING FROM THE INTENDED TRUE COURSE.

Example: A pilot flying from town "A" to town "B", a distance of 260 miles, has been maintaining a true heading of 60 degrees. After some time he determines that he has drifted 6 miles to the right of his original intended true course and is 110 miles from "A". What is the correct heading to get to destination?

(a) Set 60 degrees opposite the true index. Place rectangular grid under the plotting disk and draw a horizontal line 6 miles to the right of the grommet. (fig. 16-A)

(b) Reverse the grid and set the distance flown, 110 miles, under the grommet. From the radiating line through the end of the horizontal line, determine drift, 3 degrees to the right. (figure 16-B) Set the distance to go, 150 miles, (260 total distance minus 110 miles flown) under the grommet. Read drift 2 degrees right. (figure 16-C)

(c) Apply the total drift, 5 degrees, to the true heading of 60 degrees, <u>in the opposite direction</u>, to obtain the true heading to destination, 55 degrees.

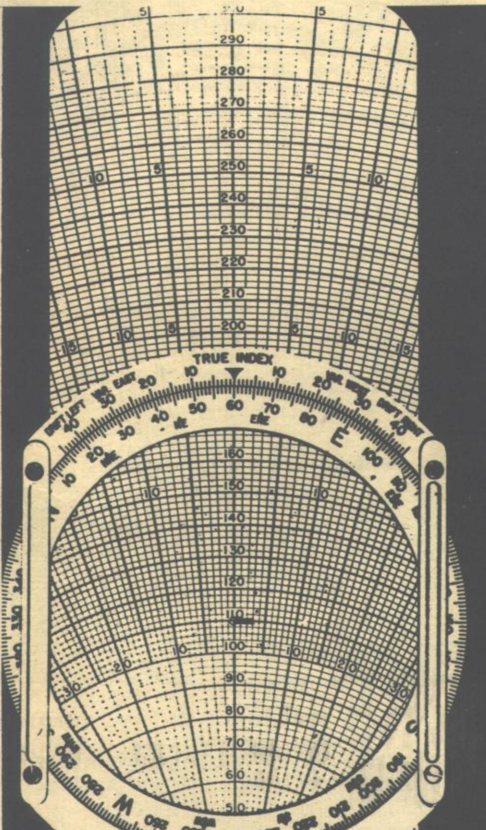


Figure 16-B

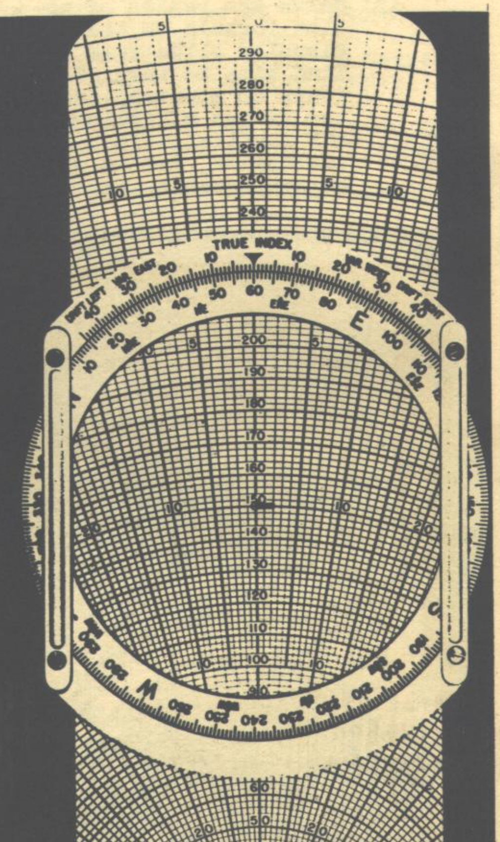


Figure 16-C

INTERCEPTION.

Interception of a moving ship or plane can easily be solved on the computer if the following information is known or can be determined: True course and speed of the ship to be intercepted; bearing and distance from the interceptor at the start of the problem; true air speed of the intercepting plane; and the wind direction and velocity.

Required information:

True heading for interception
Time to interception
Ground speed to interception
True course to interception.

Example:

A plane takes off to intercept a ship reported to be on a true course of 45 degrees at a speed of 22 knots. At the time of take-off, the ship bears from the plane 290 degrees true, and is 210 miles away. The true airspeed of the plane is 156 knots and the wind is from 350 degrees at a force of 24 knots.

(a) Set ships' course, 45 degrees, at the true index and plot in a line upward from the grommet 22 units, to represent the ships' speed, Label the end of this line "S". (figure 17-A)

(b) Set the wind direction, 350 degrees, opposite the true index. Reverse grid, and with the aid of the rectangular grid plot in the wind of 24 knots from above down to point "S". (arrow-head of the wind arrow at point "S") Label the tail of the wind line "W". (figure 17-B)

(c) Reverse the grid so that the original side is under the plotting disk. Set the bearing of the ship from the plane, 290 degrees, opposite the true index. Set the tail of the wind arrow, "W", on the true air speed, 156 knots. (figure 17-C)

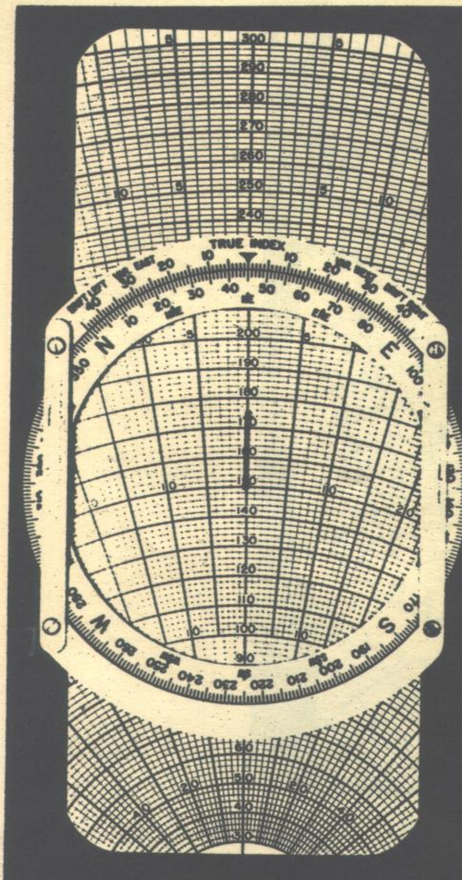


Figure 17-A

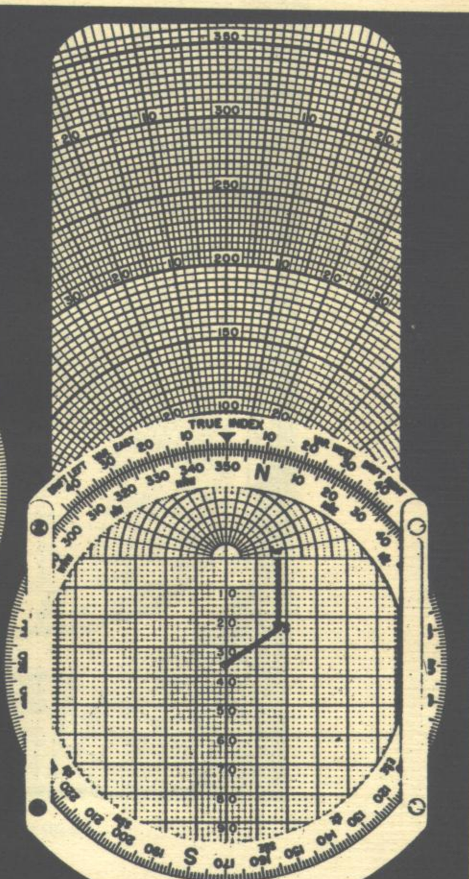


Figure 17-B

(d) The center line of the grid now represents the bearing of the ship from the plane. Under the grommet read the rate of interception, 148 knots. Read the ground speed, 140 knots, from the concentric circle through point "S". The radiating line through point "S" represents the direction of the course relative to the bearing of the ship from the plane. Read the angular distance, 8 degrees right, making true course 298 degrees. The radiating line through point "W" is the direction of the true heading, 15 degrees to the right of the bearing line, making the true heading 305 degrees. (figure 17-C)

(e) Using the circular slide rule, find the time of interception, 1 hour and 25 minutes, by dividing the initial distance, 210 miles, by the rate of interception, 148 knots.

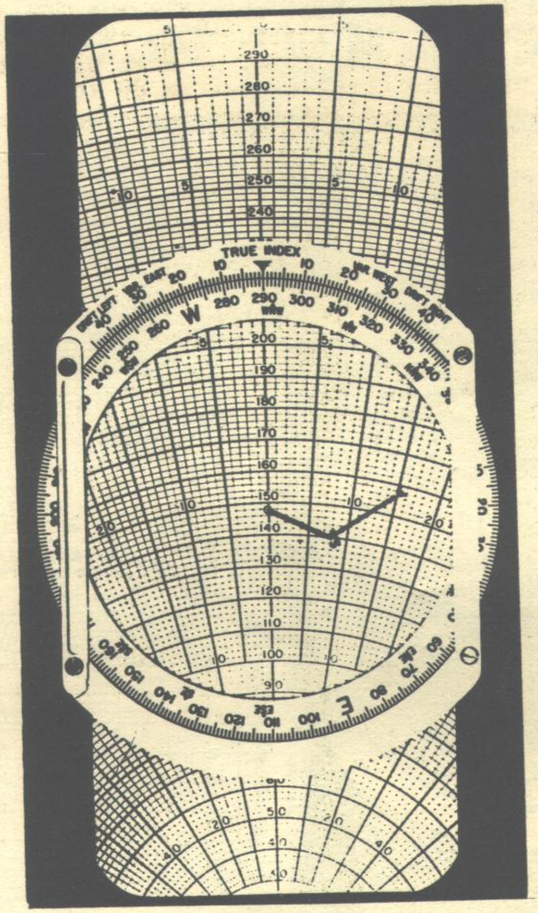


Figure 17-C

TYPE E-6C COMPUTER

The Type E-6C Computer is the same as the E-6B except for the sliding grid. The latter is 11 inches long and has speed arcs from 80 to 400 m.p.h. on one side, at the same scale as the speed arcs on the E-6B slide. On the other side is a ractangular grid to the same scale, and speed arcs from 100 to 800 m.p.h., at a smaller scale. On this high speed side the heavy, numbered speed arcs are 50 m.p.h. and the lighter arcs 10 m.p.h. apart. The E-6C slide will fit the frame of any E-6B Computer.

The instructions for use of the E-6C Computer are exactly the same as for the E-6B except for problems involving the use of the rectangular grid with the 100 to 800 m.p.h. speed arcs on the same side of the slide. Due to the difference in scales these should not be used together. Note that no change from E-6B instructions is necessary when not using the rectangular grid, or when using the rectangular grid with the speed arcs from 80 to 400 m.p.h. on the reverse side of the slide.

Weems System of Navigation

Was established in 1928 and is based on the patents, copyrights and developments of Captain P. V. H. Weems, U.S.N., Ret. It covers the entire field of sea and air navigation. So far as we know it is the only firm devoting itself exclusively to research on and development of these subjects. Some of the outstanding contributions by this organization include Star Altitude Curves, Line of Position Book, the Second-Setting Navigation Watch, the Gold Medal Text Book *Air Navigation,* the text on Marine Navigation, improvements in the Bureau of Standards Type Aircraft Sextant, the design of the Air Almanac, the WSN Skeleton Charts and numerous articles on navigation.

As a result of these activities we have built up a specialized business in sea and air navigation. A clearing house is needed for the intelligent supply of navigation equipment as well as a consultant service.

Based on years of experience, we have standardized on certain navigation equipment required for Dead Reckoning and Celestial Navigation. This equipment is used extensively by our own and other Governments, by commercial air lines, as well as by individuals on every continent. Each day the results achieved by our clients increases our confidence in the methods and equipment which we have developed or selected.

AIR

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