- **HEADING—**is the direction in which the nose of the airplane points during flight.
- **TRACK—**is the actual path made over the ground in flight. (If proper correction has been made for the wind, track and course will be identical.)
- **DRIFT ANGLE—**is the angle between heading and track.
- **WIND CORRECTION ANGLE—**is correction applied to the course to establish a heading so that track will coincide with course.
- **AIRSPEED—**is the rate of the airplane's progress through the air.
- **GROUNDSPEED—**is the rate of the airplane's in-flight progress over the ground.

BASIC CALCULATIONS

Before a cross-country flight, a pilot should make common calculations for time, speed, and distance, and the amount of fuel required.

CONVERTING MINUTES TO EQUIVALENT HOURS

It frequently is necessary to convert minutes into equivalent hours when solving speed, time, and distance problems. To convert minutes to hours, divide by 60 (60 minutes = 1 hour). Thus, 30 minutes 30/60 = 0.5 hour. To convert hours to minutes, multiply by 60. Thus, 0.75 hour equals 0.75 x 60 = 45 minutes.

Time T = D/GS

To find the **time** (T) in flight, divide the **distance** (D) by the **groundspeed** (GS). The time to fly 210 nautical miles at a groundspeed of 140 knots is 210 divided by 140, or 1.5 hours. (The 0.5 hour multiplied by 60 minutes equals 30 minutes.) Answer: 1:30.

Distance D = GS X T

To find the distance flown in a given time, multiply groundspeed by time. The distance flown in 1 hour 45 minutes at a groundspeed of 120 knots is 120 x 1.75, or 210 nautical miles.

Groundspeed GS = D/T

To find the groundspeed, divide the distance flown by the time required. If an airplane flies 270 nautical miles in 3 hours, the groundspeed is 270 divided by 3 = 90 knots.

CONVERTING KNOTS TO MILES PER HOUR

Another conversion is that of changing knots to miles per hour. The aviation industry is using knots more frequently than miles per hour, but it might be well to discuss the conversion for those who do use miles per hour when working with speed problems. The National Weather Service reports both surface winds and winds aloft in knots. However, airspeed indicators in some airplanes are calibrated in miles per hour (although many are now calibrated in both miles per hour and knots). Pilots, therefore, should learn to convert windspeeds in knots to miles per hour.

A knot is 1 nautical mile per hour. Because there are 6,076.1 feet in a nautical mile and 5,280 feet in a statute mile, the conversion factor is 1.15. To convert knots to miles per hour, multiply knots by 1.15. For example: a windspeed of 20 knots is equivalent to 23 miles per hour.

Most flight computers or electronic calculators have a means of making this conversion. Another quick method of conversion is to use the scales of nautical miles and statute miles at the bottom of aeronautical charts.

FUEL CONSUMPTION

Airplane fuel consumption is computed in gallons per hour. Consequently, to determine the fuel required for a given flight, the time required for the flight must be known. Time in flight multiplied by rate of consumption gives the quantity of fuel required. For example, a flight of 400 NM at a groundspeed of 100 knots requires 4 hours. If the plane consumes 5 gallons an hour, the total consumption will be 4 x 5, or 20 gallons.

The rate of fuel consumption depends on many factors: condition of the engine, propeller pitch, propeller r.p.m., richness of the mixture, and particularly the percentage of horsepower used for flight at cruising speed. The pilot should know the approximate consumption rate from cruise performance charts, or from experience. In addition to the amount of fuel required for the flight, there should be sufficient fuel for reserve.

FLIGHT COMPUTERS

Up to this point, only mathematical formulas have been used to determine such items as time, distance, speed, and fuel consumption. In reality, most pilots will use a mechanical or electronic flight computer. These devices can compute numerous problems associated with flight planning and navigation. The mechanical or electronic computer will have an instruction book and most likely sample problems so the pilot can become familiar with its functions and operation. [Figure 14-16]

PLOTTER

Another aid in flight planning is a plotter, which is a protractor and ruler. The pilot can use this when determining true course and measuring distance. Most plotters have a ruler which measures in both

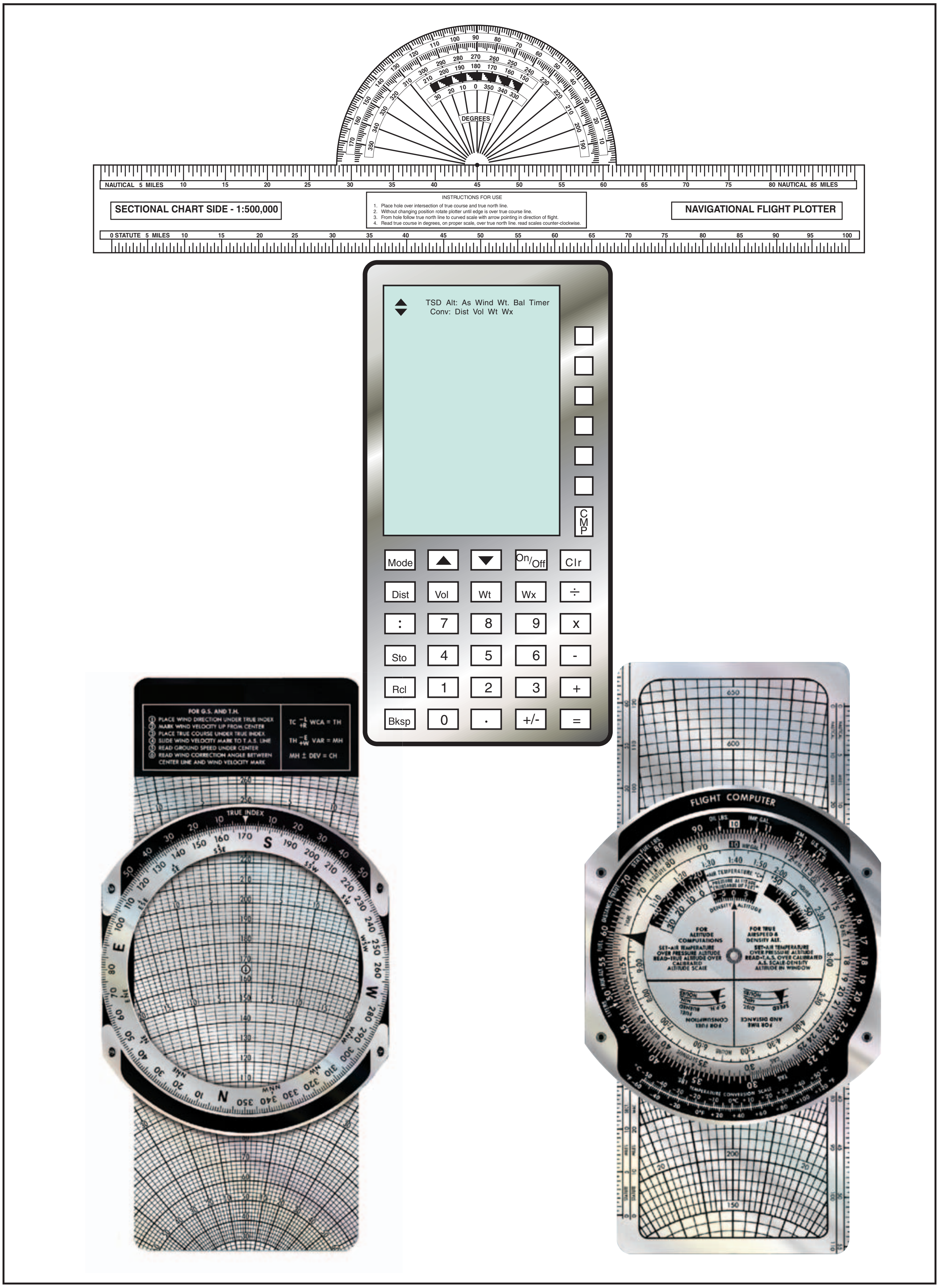

Figure 14-16. A picture of the computational and wind side of a common mechanical computer, an electronic computer, and plotter.

nautical and statute miles and has a scale for a sectional chart on one side and a world aeronautical chart on the other. [Figure 14-16]

PILOTAGE

Pilotage is navigation by reference to landmarks or checkpoints. It is a method of navigation that can be used on any course that has adequate checkpoints, but it is more commonly used in conjunction with dead reckoning and VFR radio navigation.

The checkpoints selected should be prominent features common to the area of the flight. Choose checkpoints that can be readily identified by other features such as roads, rivers, railroad tracks, lakes, and power lines. If possible, select features that will make useful boundaries or brackets on each side of the course, such as highways, rivers, railroads, and mountains. A pilot can keep from drifting too far off course by referring to and not crossing the selected brackets. Never place complete reliance on any single checkpoint. Choose ample checkpoints. If one is missed, look for the next one while maintaining the heading. When determining position from checkpoints, remember that the scale of a sectional chart is 1 inch = 8 statute miles or 6.86 nautical miles. For example, if a checkpoint selected was approximately one-half inch from the course line on the chart, it is 4 statue miles or 3.43 nautical miles from the course on the ground. In the more congested areas, some of the smaller features are not included on the chart. If confused, hold the heading. If a turn is made away from the heading, it will be easy to become lost.

Roads shown on the chart are primarily the well-traveled roads or those most apparent when viewed from the air. New roads and structures are constantly being built, and may not be shown on the chart until the next chart is issued. Some structures, such as antennas may be difficult to see. Sometimes TV antennas are grouped together in an area near a town. They are supported by almost invisible guy wires. Never approach an area of antennas less than 500 feet above the tallest one. Most of the taller structures are marked with strobe lights to make them more visible to a pilot. However, some weather conditions or background lighting may make them difficult to see. Aeronautical charts display the best information available at the time of printing, but a pilot should be cautious for new structures or changes that have occurred since the chart was printed.

DEAD RECKONING

Dead reckoning is navigation solely by means of computations based on time, airspeed, distance, and direction. The products derived from these variables, when adjusted by windspeed and velocity, are heading and groundspeed. The predicted heading will guide the airplane along the intended path and the groundspeed will establish the time to arrive at each checkpoint and the destination. Except for flights over water, dead reckoning is usually used with pilotage for cross-country flying. The heading and groundspeed as calculated is constantly monitored and corrected by pilotage as observed from checkpoints.

THE WIND TRIANGLE OR VECTOR ANALYSIS

If there is no wind, the airplane's ground track will be the same as the heading and the groundspeed will be the same as the true airspeed. This condition rarely exists. A wind triangle, the pilot's version of vector analysis, is the basis of dead reckoning.

The wind triangle is a graphic explanation of the effect of wind upon flight. Groundspeed, heading, and time for any flight can be determined by using the wind triangle. It can be applied to the simplest kind of cross-country flight as well as the most complicated instrument flight. The experienced pilot becomes so familiar with the fundamental principles that estimates can be made which are adequate for visual flight without actually drawing the diagrams. The beginning student, however, needs to develop skill in constructing these diagrams as an aid to the complete understanding of wind effect. Either consciously or unconsciously, every good pilot thinks of the flight in terms of wind triangle.

If a flight is to be made on a course to the east, with a wind blowing from northeast, the airplane must be headed somewhat to the north of east to counteract drift. This can be represented by a diagram as shown in figure 14-17. Each line represents direction and speed. The long dotted line shows the direction the plane is heading, and its length represents the airspeed for 1 hour. The short dotted line at the right shows the wind direction, and its length represents the wind velocity

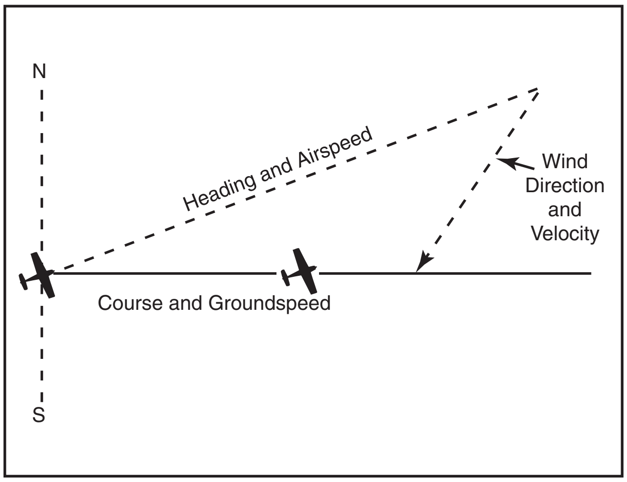

Figure 14-17. Principle of the wind triangle.