C.G. LOCATIONS FOR SINGLE-WING AIRPLANES

A Straight Wing

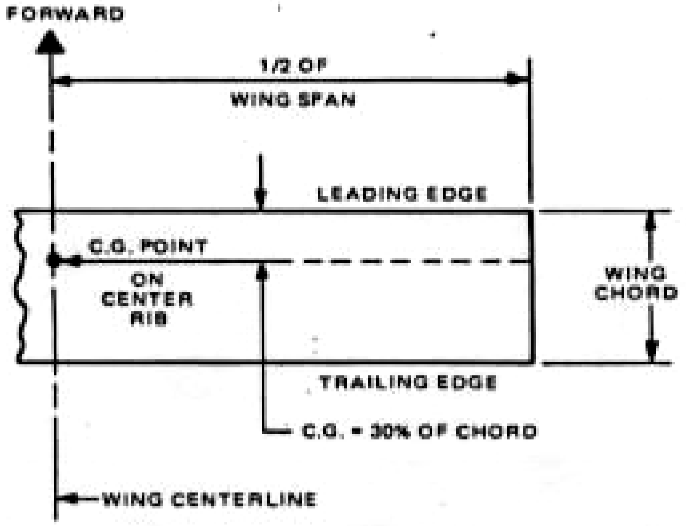

FIG. 1-10. A STRAIGHT-WING

For most R/C airplanes having only elevator and rudder control and those having additional controls such as ailerons, engine-throttle control, landing flaps, etc. (all of which will be discussed later), the C.G. is usually located at a point which is *30% of the wing chord* back from the leading edge of the wing, as shown for a straight wing (Fig. 1-10). The leading and trailing edges of this wing are parallel to each other for the full span of the wing.

Put another way, 30% of the total wing area is located in front of the C.G. and the remaining 70% of the total wing area is located behind the C.G. These percentages are the same for any wing shape. However, if the actual C.G. point is projected to the center rib of a differently shaped wing, this point will appear at a different place on its center rib when establishing the necessary 30% to 70% relationship. Let's proceed to find out why this is true, and to learn how to determine the C.G. of different wing shapes.

A Wing With its Leading Edge or Trailing Edge Swept

The first illustration (Fig. 1-11) shows a wing shape whose leading edge is straight and its trailing edges are swept forward. The second illustration (Fig. 1-12) shows a wing shape with swept back leading edges and a straight trailing edge. There are two methods for finding the C.G. point of either wing. However, you will find that the C.G. point for each wing type, when projected to its center rib, will be located in a different place.

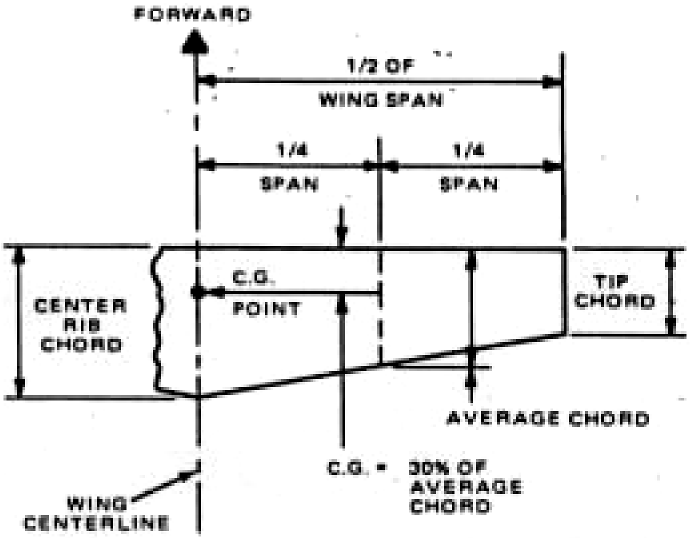

FIG. 1-11.
A WING WITH SWEPT-FORWARD TRAILING EDGES

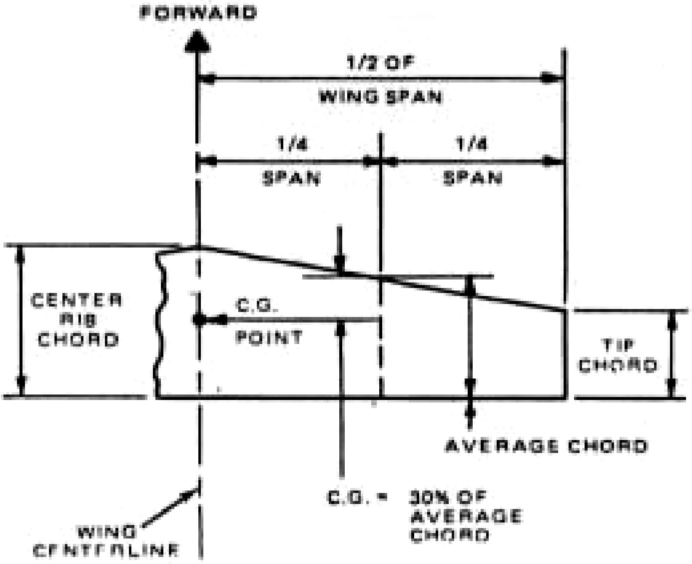

FIG. 1-12.
A WING WITH SWEPT-BACK LEADING EDGES

center-rib chord. This may be 10 inches. To find the length of the wing's *average chord*, simply add 10+6 (which equals 16 inches), then divide this number by 2 (which equals 8 inches). Now, find the place on the surface of the wing where an 8 inch chord fits perfectly between the wing's leading and trailing edges. Now, determine the dimension of 30% of the average chord (2.4 inches, in this example), measured back from the average chord's leading edge. This dimension will locate the C.G. point of the average chord which is then projected to the wing's center rib. Using this method will locate the C.G. point at exactly the same place as the first method and, just like Method 1, we have 30% of the total wing area in front of the C.G. and 70% of the total wing area behind the C.G.

A Double-Tapered Wing

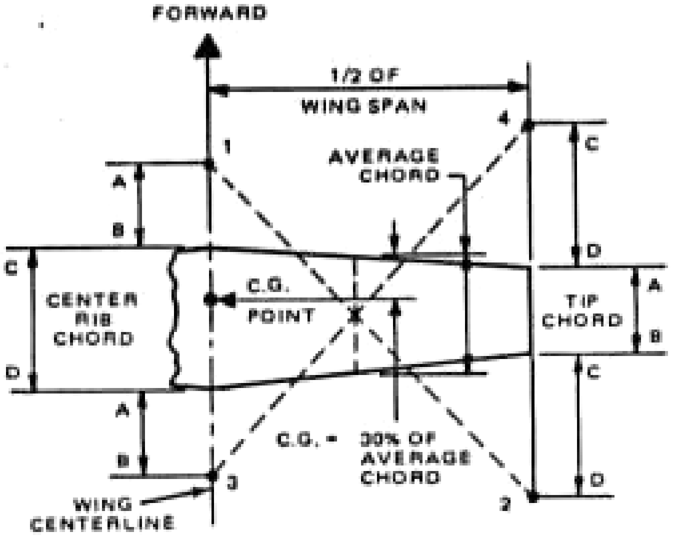

FIG. 1-13
A DOUBLE-TAPERED WING

A double-tapered wing is an often-used shape for R/C airplanes. Its leading edges are swept back and its trailing edges are swept forward. At first glance, finding the C.G. of this wing seems rather complicated. It is very simple, however, if you can make a few measurements and draw straight lines.

First, make a full-sized scale drawing of one-half of the wing's span. If you are building a kit and the C.G. is not shown, merely trace the wing half on a separate sheet of tracing tissue (available at any art supply store) or use the kit plan itself and by use of a colored pencil, draw the lines on the plan, as shown in Fig. 1-13. Find the C.G. as follows.

You will note that the wing-tip chord's dimension is indicated by the letters "A" and "B". The center rib's dimension is indicated by "C" and "D"

To obtain points 1 and 3, take the wing-tip chord dimension (A to B) and add this dimension to the center rib chord at both its leading and its trailing edges. To obtain points 2 and 4, take the center-rib dimension (C to D) and add this dimension to the wing-tip chord at both its leading and trailing edges.

Having located points 1, 2, 3 and 4, draw a straight line between 1 and 2, and another between 3 and 4. Where these two lines cross is the location of the *average chord* of the wing. Calculate 30% of the average chord length. This dimension, measured back from the leading edge of the average chord will locate the C.G. of the average chord, which is then projected straight across to the center rib. Again, we have 30% of the wing's total area in front of the C.G. and 70% behind the C.G.

A Swept-Back Wing

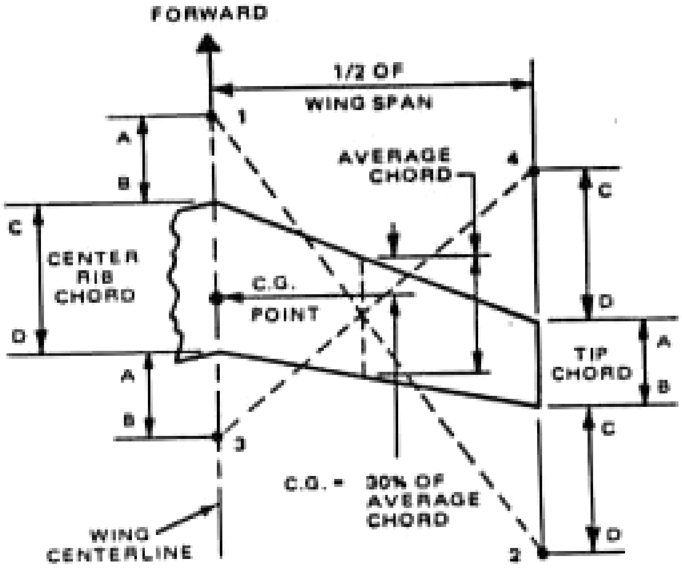

FIG. 1-14
A SWEPT-BACK WING

This, too, is a wing shape being used on many R/C airplanes, especially on those that are designed to resemble their military, jet-powered, big bothers. The leading and trailing edges of this wing are both swept back.

How is the C.G. of this wing found? Read the text on how to find the C.G. of a *Double-Tapered Wing*, and refer to the illustration for *A Swept-Back Wing* (Fig. 1-14) and you will have your answer.

In rare instances a wing could be swept-back to such an extreme that the C.G. point of the average chord could not be projected to the wing's center rib because, when projected, the wing's C.G. point would fall somewhere behind the center rib's trailing edge. In this case, measure the excess behind the trailing edge. Then, with this dimension known, mark the C.G. point on the airplane's fuselage.

C.G. LOCATIONS FOR BIPLANES

This Is a Different, But Easy Problem

Nothing captures the imagination and admiration characteristic of the "golden age" of aviation as does the biplane. The biplane dominated World War I aircraft, and this domination continued until just prior to World War II. Who can ever forget such great planes as the Sopwith Camel and the Sopwith Pup, the Fokker D-VII, the Jenny, the Gypsy Moth, the Waco open-cockpit and cabin biplanes, the W.W. II Stearman, and the modern-day Pitts Special? All of these bipes, and many more, personify true leather-helmeted, wind-in-the-face flying. Just looking at a bipe makes you feel that this is a machine that should be in the air, not on the ground.

What colorful, graceful, maneuverable and beautiful airplanes they were; and still are! Many R/C'ers are literally fanatics when it comes to their love affair with biplanes, and this is quite understandable!

I'm sure most R/C buffs love these old bipes, as well as the modern ones, but are hesitant about building one because they have two wings. C'mon gang, it has just one more wing than a monoplane. It is true, however, a bipe should not be considered a beginner's airplane. Get some more air time on your trainer or single-wing sport plane before building and flying a bipe. Don't get me wrong, they are a delight to fly, but they are *not* intended to be R/C training planes.

Finding the exact G.C. of a biplane may make R/C'ers shy away from building this fascinating type of airplane. This need not be so, because it requires only a few simple steps to locate this point on most biplanes, and a few additional steps on others. The C.G. of various biplanes' wing positions and combinations are easily found as follows.

> *NOTE:* Some of the following text will repeat itself, even if discussing different wing positions and combinations. This is done so that you can understand each different wing configuration on an individual basis.

Although a biplane has two wings, these two wings are working together to perform the single function of a single-wing airplane . . . to create lift. Therefore, we must consider the *two* wings as *one* wing. *Figures 1-15 and 1-16*, plus the accompanying text, clearly show this relationship.

One Wing Above the Other — Both Straight

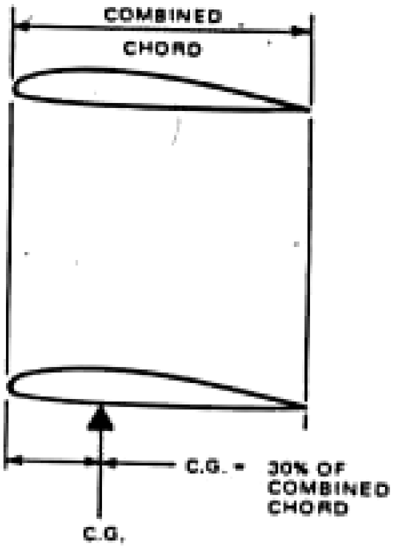

FIG. 1-15.
ONE WING ABOVE THE OTHER
(BOTH STRAIGHT-WINGS)

Figure 1-15 shows two straight-wings, one above the other, whose leading and trailing edges are in exact vertical alignment. Locating the C.G. of this wing combination is generally the same as the method used to locate the C.G. for a single-wing airplane having a straight wing. That is, the C.G. point is 30% of the *combined chord*, measured back from the leading edges of the wings. This point gives us 30% of the total wing area in front of the C.G. and 70% of the total wing area behind the C.G. As you recall, these percentages of total wing area are the same as those presented in *C.G. Locations For Single-Wing R/C Airplanes*.

Normal-Staggered Wings — Both Straight

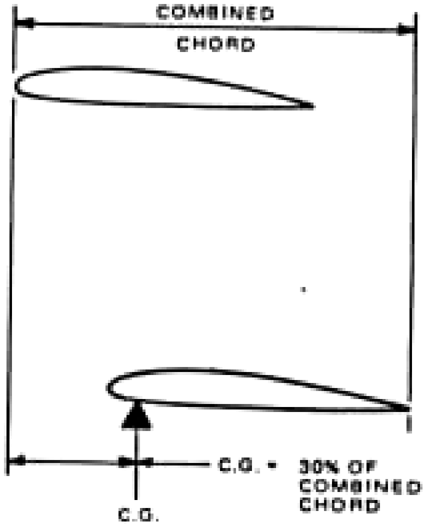

FIG. 1-16.
NORMAL-STAGGERED WINGS
(BOTH STRAIGHT-WINGS)

Figure 1-19 represents a biplane with a straight top wing and a swept-back lower wing. Since we are considering the two wings as one, the dimension of the *combined chord* is found in a different way than for biplanes having two straight wings. First, we have to find the *average chord* location for the bottom swept-wing. Refer to *C.G. Locations for Single-Wing R.C. Airplanes* and follow the illustrations and text for finding the average chord location for *A Swept-Back Wing*. After the average chord for the bottom wing is found, the combined chord is established by measuring back from the top wing's leading edge to the bottom wing's average chord trailing edge. The C.G. point for these two wings is 30% of the combined chord, measured back from the leading edge of the top wing. This point provides 30% of the total wing area in front of the C.G. and 70% of the total wing area behind the C.G.

Swept-Back Top and Bottom Wings

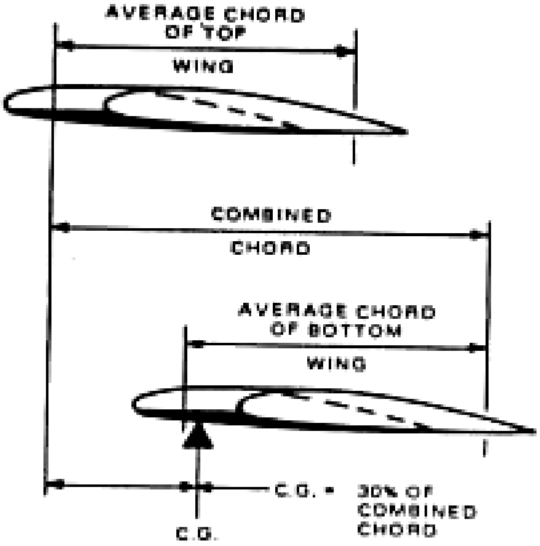

FIG. 1-20.
SWEPT-BACK TOP WING,
SWEPT-BACK BOTTOM WING

Figure 1-20 represents a biplane with two swept-back wings. Since we are considering the two wings as one, the dimension for *combined average chords* has to be found. Begin by finding the average chord location for each of the two wings. Refer back to *C.G. Locations for Single-Wing R/C Airplanes* and follow the illustration and text for finding the average chord location for *A Swept-Back Wing*. After the average chord for each wing is found, the combined chord is established by measuring back from the top wing's average chord leading edge to the bottom wing's average chord trailing edge. The C.G. point for these two wings is 30% of the combined chord, measured back from the average chord leading edge of the top wing. This point provides 30% of the total wing area in front of the C.G. and 70% of the total wing area behind the C.G.

ANGLE OF ATTACK AND INCIDENCE

Angle of attack and *incidence* will be mentioned quite often in the following discussions of aerodynamics, so it is best we become acquainted with these terms now, and know the difference between the two. They describe aerodynamic situations which are similar in function but are *not* the same.

ANGLE OF ATTACK. In our discussions of the various types of airfoils, the center line of an airfoil was mentioned quite frequently (refer to *The Semi-Symmetrical Airfoil*). This line is drawn from the center of the leading edge of an airfoil to the center of its trailing edge. We also discussed the raising of the leading edge slightly in relation to the oncoming air flow. This wing tilting is referred to as a *positive* angle of attack. When the leading edge of the airfoil is lowered in relation to the oncoming air flow, this is called a *negative* angle of attack.

INCIDENCE. If an airplane's wing is attached to the fuselage with the leading edge of the wing's airfoil centerline permanently *raised* 2°, for instance, this is called 2° *positive* incidence. Conversely, if the wing is attached to the fuselage with the wing's airfoil centerline permanently *lowered* 2°, this is called 2° *negative* incidence. If the wing is mounted in such a way as to have no incidence at all, this is obviously called 0° incidence.

ASPECT RATIO

The aspect ratio of your airplane's wing merely means the dimensional relationship of the wing's *span* to the dimension of the wing's *chord*. For instance, if a wing's span is 100 inches and its chord (or its average chord, if the wing is tapered) is 10 inches, the aspect ratio is 10 to 1. In other words, the span is 10 times longer than the dimension of its chord.

This factor rarely requires calculations because the aspect ratio has already been determined by the manufacturer of the kit you have just purchased, or the magazine plans you may be scratch-building from. However, this does not mean you should not know what aspect ratio is, and why different aspect ratios are used. *It is important.*

Aspect Ratios of Different Wing Types

Each of the wings illustrated in *Fig. 1-21* has the same chord dimension, but each has a different span. The span, in this case, changes the aspect ratios and shapes of the three wings. The wings are designed for different purposes.

Figure 1-21A shows a wing with a *high* aspect ratio. This type of wing is most often used for light-weight