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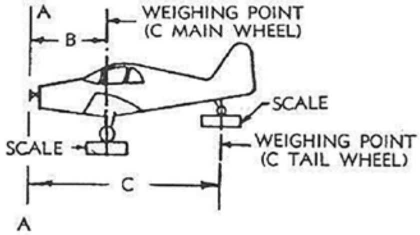
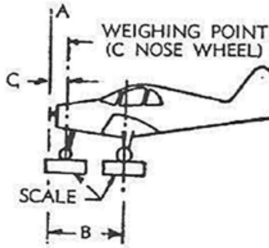
WEIGHT AND BALANCE FORM

Owner's Name John Brown Aircraft N 5641 Z Date 3-5-87

Address 4 Airport Drive

John Wayne, Indiana





A—Datum for Horizontal Arm as defined by designer or builder
B—Arm: Main Wheel Centerline in inches
C—Arm: Auxiliary Wheel Centerline in inches

Item	*Scale*	*Tare*	*Lbs. Net*	*Inches Arm*	*In. Lbs. Moment*
Left Wheel	417	6	411	120	49,320
Right Wheel	403	7	396	120	47,520
Auxiliary Wheel	27	1	26	337.5	8,775
Less Oil	-32	–	-32	81	-2,592
Fixed Ballast	–	–	....	–	....

Empty Weight Total Moment 103,023 in. lbs.

Empty C.G. = $\frac{\text{Total Moment}}{\text{Empty Weight}}$ = $\frac{103,023}{801}$ = 128.6 inches

FORWARD AND REARWARD CG EXTREMES

Item	*Weight*	*Arm*	*Moment*	*Weight*	*Arm*	*Moment*
Aircraft EW	801	128.6	103,023	801	128.6	103,023
Oil	32	81	+2,592	32	81	+2,592
Pilot	150	190	28,500	210	190	39,900
Passenger	210	153	32,130	–		-
Fuel	180	115	20,700	12	115	1380
Baggage	....	–	....	20	205	4100
Totals	1,373	136.2	186,945	1075	140.5	150,995

Forward CG 1 = 136.0 in. Rearward CG 1 = 140.5 in.

Maximum allowable weight is: 1400 lbs. CG limits are

136.0 in. Forward CG, and 140.5 in. Rearward CG

Equipment installed when weighed is as described in Aircraft Manual, Equipment List dated ....

.................., except for the following items.

Item	*Inches Arm*	*Lbs. Wt.*	*In. Lbs. Moment*

Fig. 2.6 – Reprinted, by permission, from the *EAA Service Manual* of the Experimental Aircraft Association

Now that you know the empty weight and c.g. of your airplane, what good is this information? At this point, find the figure for the safe c.g. envelope provided by the designer or by analysis if this is a home-designed airplane. You should use the empty weigh/c.g. and compare it with the safe c.g. envelope to determine if you have loading problems. One useful way of doing the comparison is to use what weights engineers call a potato diagram. As shown in ***Figure 2.7***, it is a good was of visualizing the effect of adding or subtracting things from your airplane. Most light planes have simple, rectangular gross weight/c.g. plot. Some large aircraft and helicopters have other factors that affect the diagram and yield a much odder shape which some people (weights engineers at least) feel resembles a potato - thus the term "potato diagram."

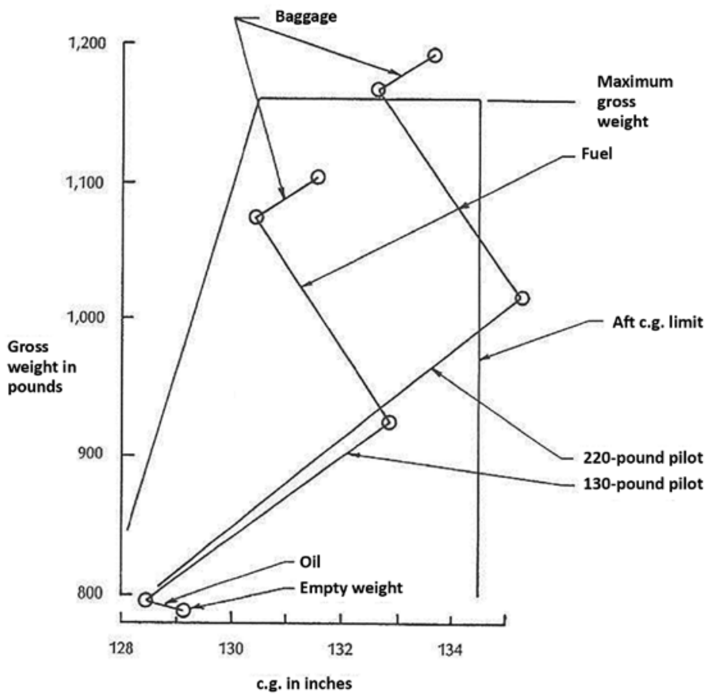


Fig. 2.7 – Potato diagram. Note that the owner of the airplane with this potato diagram has a problem. A heavy pilot and no fuel will put this airplace outside the aft c.g. limit. This is especailly dangerous because the pilot can take off within the acceptable envelope and by burning off fuel move outside the aft limit while in flight. This airplane may require a limitation on pilot weight.

To make a potato diagram, plot the gross weight and c.g. limits; for most aircraft this will appear as a rectangle. Next calculate the effect on gross weight and c.g. of adding variable weights to the empty weight. Now plot these points and the empty weight/c.g. on the diagram. If you draw a line starting from the empty weight/c.g. through the loading points as show in

Figure 2.7 you will see how your aircraft loads as you add the pilot, passengers, baggage, and, finally fuel. You want to plot the fuel last because as you burn off fuel the weight/c.g. will move steadily down that line. You should do this exercise for all the normal loadings you can think up. These should include heavy pilots, light pilots, full fuel, no fuel, light pilot with no fuel and baggage, etc. If any of the plotted points fall outside the envelope you now have a picture of the problem and what is causing it.

If you have a gross weight/c.g. problem, there are several ways of dealing with it. First, you can move parts of the airplane to adjust the empty c.g. A particularly useful item is the battery which is heavy but relatively flexible in its location. If a major change is required the engine can be moved by shortening or lengthening the engine mounts. This may be necessary if you have installed an engine significantly different from that called out in the plans. A third option is the addition of ballast. This is not a very elegant solution but it provides a simple method of tuning the empty c.g. to make the airplane more useful. A small warning that this point: If you have made a major alteration to a design, such as a bigger engine, it is smart to weigh your airplane and plot the potato diagram before it is fully assembled, in case major alterations are required. Rather than altering or ballasting the airplane, you may decide to live with the fact that certain loading will exceed the limits of the potato diagram. This should not present a problem as long as these loading are unlikely to occur or are easy to avoid.

WEIGHT AND BALANCE CARD

Flight no.	4	Aircraft	5641Z
Date	4-28-87	Pilot	J. Brown
Target weight	1,130	Target c.g.	Aft.

	Weight (lbs)	Station (in.)	Moment (in.-lbs)
Empty weight	801	128.6	103,009
Engine oil	7	81	567
Fwd. seats	0	—	—
Aft seats	185	190	35,150
Baggage	0	—	—
Ballast	5	153	765
Zero fuel weight	998	139.8	139,491
Fuel	130	124	16,120
Takeoff weight	1,128	138.0	155,611

Fig. 2.8 – Weight and balance card

As you will find out later on, c.g. is an extremely important tool in ensuring good stability and stall/spin characteristics. If your airplane is a tail dragger c.g. also will have a profound effect on ground handling. Your ability to understand the effect of c.g. on these parameters is going to depend strongly on your ability to know where your c.g. was located when certain tests were done. This requires not only a good determination of empty weight and c.g. but also a way of tracking it from flight to flight. The easy way to do this is to have a form similar to the one shown in ***Figure 2.8*** which you fill out and calculate for each test flight. You may even find you need to add ballast to achieve the desired c.g. for a given flight.

While your aircraft is level for weighing is a good time to put attitude reference marks on your windshield. Turn the airplane toward a clear horizon, sit in the cockpit and have a helper block up the tail until the airplane is level. With a grease pencil or other removable marker draw a line on the inside of the windshield that matches the horizon from your eye position. From the center of the "zero" line draw lines downward at 30 and 60 degrees as shown in ***Figure 2.9.*** Then have your helper lower the tail until the aircraft is 5 degrees nose up and draw a short line on the horizon. Repeat the process at 5 degree increments until the horizon is not visible below the nose. You now have a visual tool that will allow you to fly pitch and roll attitudes with great accuracy as long as the horizon is visible through the windshield.

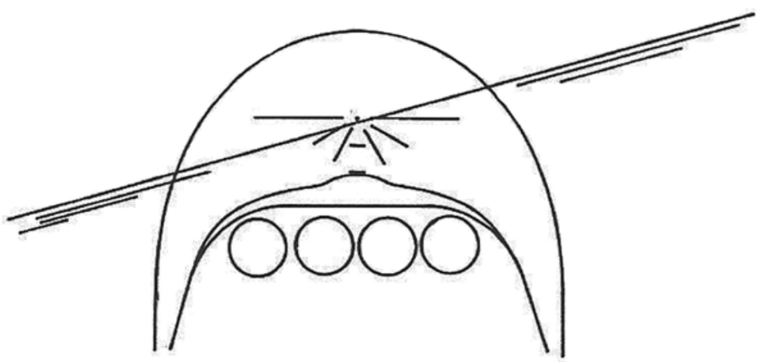


Fig. 2.9 – Attitude reference marks

Landing Gear

The rigging or alignment of the landing gear is especially critical for tail-wheel-equipped aircraft since it has a significant effect on ground stability. Get two square iron or aluminum bars and mark each one with three lines at intervals of at least two feet. C-clamp each one to the inside of each wheel's brake disk with the middle mark beneath the axle. Carefully measure between the bars at the forward and aft line and determine the difference between the two distances. Unless the plans specify otherwise the difference between the two measurements should be less than ¼ inch.

Realigning poorly rigged wheels can be difficult depending on the type of gear. Tapered shims which go between the leg and axle assembly are available for Cessna-type spring gear. Oleos can be aligned by shimming or shaving the bearing surfaces of the scissors. Live-axle or split-axle gear, as found on the Piper cub are nearly impossible to change once they are built. Your best bet with these is to be extremely careful during the building phase.