CHAPTER 10. WEIGHT AND BALANCE

SECTION 1 TERMINOLOGY

10-1. GENERAL. The removal or addition of equipment results in changes to the center of gravity (c.g.). The empty weight of the aircraft, and the permissible useful load are affected accordingly. Investigate the effects of these changes, since the aircraft flight characteristics may be adversely affected. Information on which to base the record of weight and balance changes to the aircraft may be obtained from the pertinent Aircraft Specifications, Type Certificate Data Sheet (TCDS), prescribed aircraft operating limitations, aircraft flight manual, aircraft weight and balance report, and maintenance manual. Removal of standard parts with negligible weight or addition of minor items of equipment such as nuts, bolts, rivets, washers, and similar standard parts of negligible weight on fixed-wing aircraft do not require a weight and balance check. Rotorcraft are, in general, more critical with respect to control with changes in the c.g. position. Refer to the procedures and instructions in that particular model's maintenance or flight manual.

10-2. TERMINOLOGY. The following terminology is used in the practical application of weight and balance control.

a. Maximum Weight. The maximum weight is the maximum authorized weight of the aircraft and its contents as listed in the specifications.

b. Empty Weight. The empty weight of an aircraft includes all operating equipment that has a fixed location and is actually installed in the aircraft. It includes the weight of the airframe, powerplant, required equipment, optional and special equipment, fixed ballast, full engine coolant, hydraulic fluid, residual fuel, and oil. Additional information regarding fluids that may be contained in the aircraft systems and must be included in the empty weight will be indicated in the pertinent Aircraft Specifications or TCDS.

c. Negligible Weight Change is any change of one pound or less for aircraft whose weight empty is less than 5,000 pounds; two pounds or less for aircraft whose weight empty is more than 5,000 and 50,000 pounds; and five pounds or less for aircraft whose weight empty is more than 50,000 pounds. Negligible c. g. change is any change of less than 0.05% MAC for fixed wing aircraft, 0.2 percent of the maximum allowable c. g. range for rotary wing aircraft.

d. Useful Load. The useful load is the empty weight subtracted from the maximum weight of the aircraft. This load consists of the pilot, crew (if applicable), maximum oil, fuel, passengers, and baggage unless otherwise noted.

e. Weight Check. The weight check consists of checking the sum of the weights of all items of useful load against the authorized useful load (maximum weight less empty weight) of the aircraft.

f. Datum. The datum is an imaginary vertical plane from which all horizontal measurements are taken for balance purposes with the aircraft in level flight attitude. The datum is indicated in most Aircraft Specifications or TCDS. On some of the older aircraft, when the datum is not indicated, any convenient datum may be selected. Once the datum is selected, all moment arms and the location of the permissible c.g. range must be taken with reference to it. Examples of typical locations of the datum are shown in figure 10-1.

g. Arm (or Moment Arm). The arm (or moment arm) is the horizontal distance in inches from the datum to the c.g. of an item. The algebraic sign is plus (+) if measured aft of the datum, and minus (-) if measured forward of the datum. Examples of plus and minus arms are shown in figure 10-2.

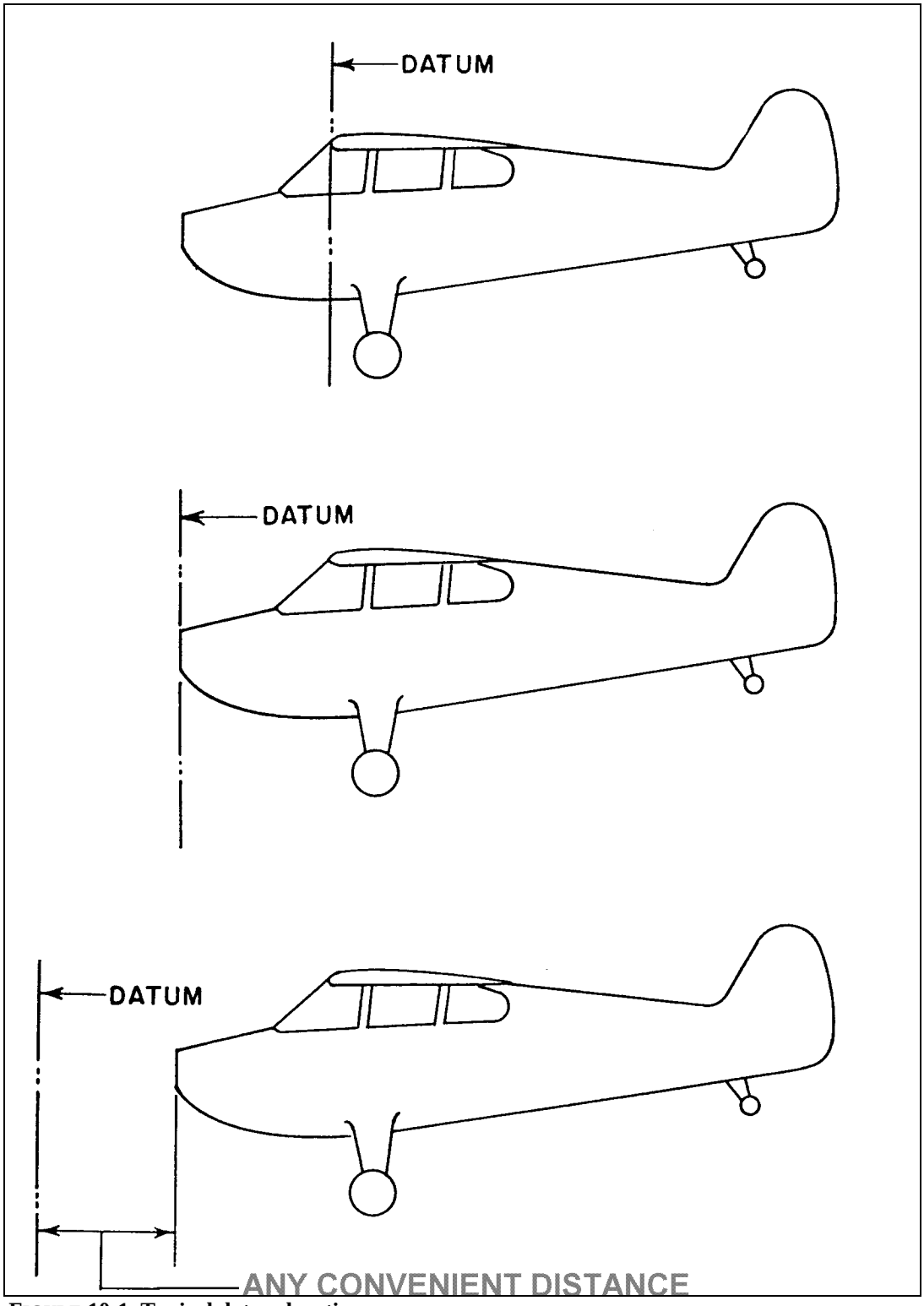


FIGURE 10-1. Typical datum locations.

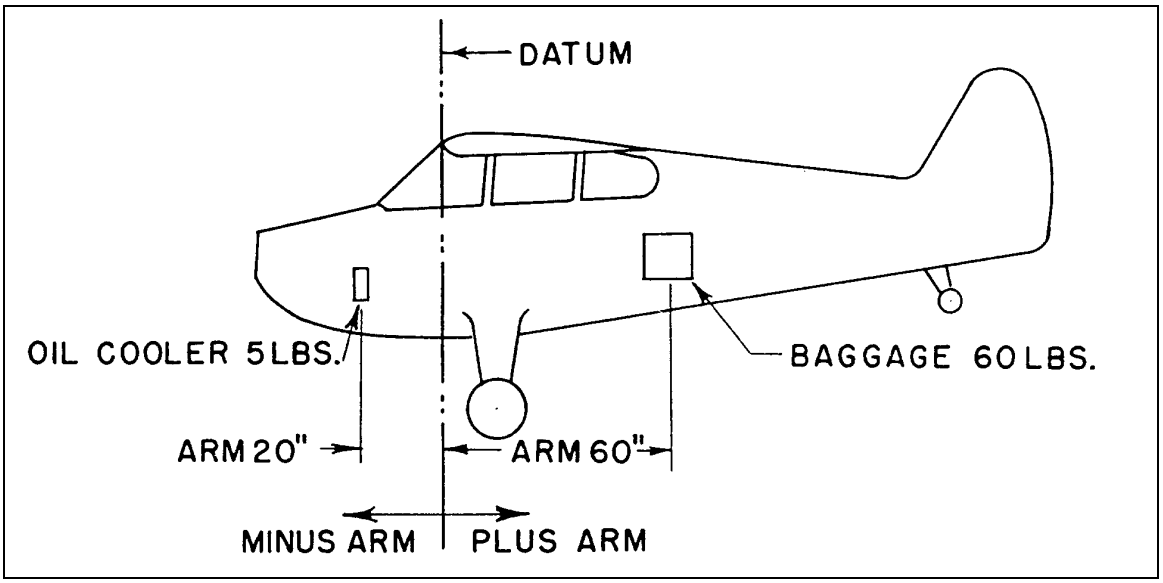


FIGURE 10-2. Illustration of arm (or moment arm).

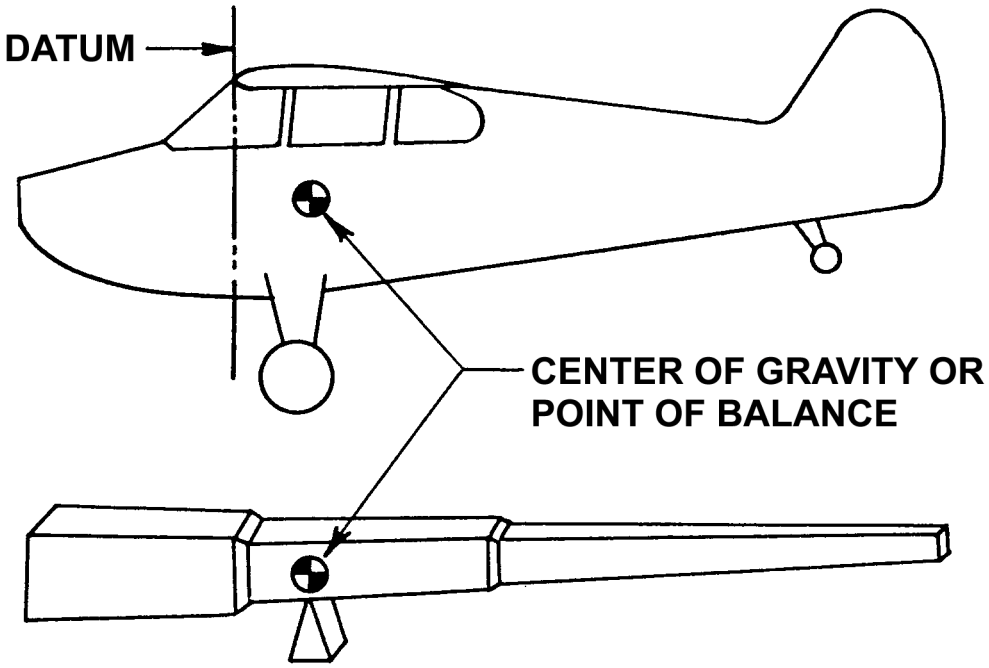
h. Moment. The moment is the product of a weight multiplied by its arm. The moment of an item about the datum is obtained by multiplying the weight of the item by its horizontal distance from the datum. A typical moment calculation is given in figure 10-3.

i. Center of Gravity. The c.g. is a point about which the nose-heavy and tail-heavy moments are exactly equal in magnitude. If the aircraft is suspended from the c.g., it will not have a tendency to pitch in either direction (nose up or down). The weight of the aircraft (or any object) may be assumed to be concentrated at its c.g. (See figure 10-3.)

j. Empty Weight Center of Gravity. The empty weight c.g. is the c.g. of an aircraft in its empty weight condition, and is an essential part of the weight and balance record. Formulas for determining the c.g. for tail and nosewheel type aircraft are given in figure 10-4. Typical examples of computing the empty weight and empty weight c.g. for aircraft are shown in figures 10-5 and 10-6.

k. Empty Weight Center of Gravity Range. The empty weight c.g. range is determined so that the empty weight c.g. limits will not be exceeded under standard specifications loading arrangements. Calculations as outlined in paragraph 10-16 should be completed when it is possible to load an aircraft in a manner not covered in the Aircraft Specifications or TCDS (extra tanks, extra seats, etc.). The empty weight c.g. range, when applicable, is listed in the Aircraft Specifications or TCDS. Calculation of empty weight c.g. is shown in figures 10-5 and 10-6.

l. Operating Center of Gravity Range. The operating c.g. range is the distance between the forward and rearward c.g. limits indicated in the pertinent Aircraft Specifications or TCDS. These limits are determined for the most forward and most rearward loaded c.g. positions at which the aircraft meets the requirements of Title 14 of the Code of Federal Regulation (14 CFR). The limits are indicated in the specifications in either percent of mean aerodynamic chord (MAC) or inches from the



The entire aircraft weight may be considered to be concentrated at the center of gravity. Therefore, the moment of the aircraft about the datum is the weight of the aircraft times the horizontal distance between the C.G. and the datum.

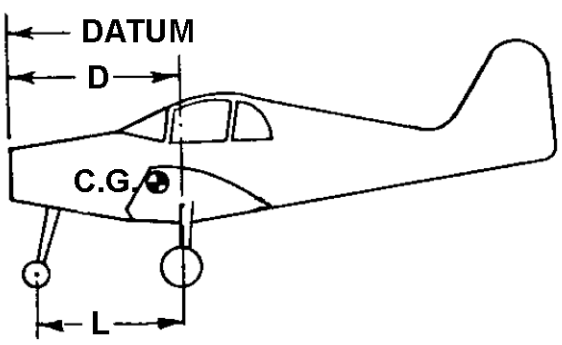
Example: If the weight of this airplane is 2000 lbs. and the arm from the datum to the center of gravity is 16 inches, the moment of the aircraft about the datum is 2000 x 16 or 32,000 in. lbs.

FIGURE 10-3. Example of moment computation.

datum. The c.g. of the loaded aircraft must be within these limits at all times as illustrated in figure 10-7.

m. Mean Aerodynamic Chord (MAC). The MAC is established by the manufacturer who defines its leading edge and its trailing edge in terms of inches from the datum. The c.g. location and various limits are then expressed in percentages of the chord. The location and dimensions of the MAC can be found in the Aircraft Specifications, the TCDS, the aircraft flight manual, or the aircraft weight and balance report.

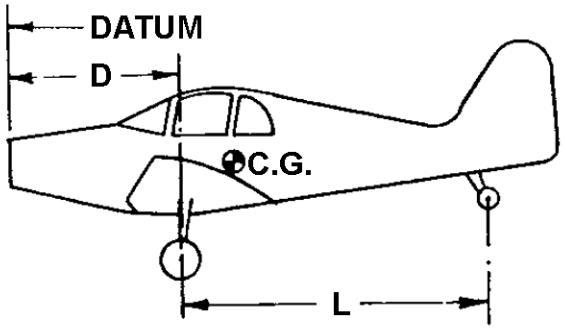
n. Weighing Point. If the c.g. location is determined by weighing, it is necessary to obtain horizontal measurements between the points on the scale at which the aircraft's weight is concentrated. If weighed using



NOSE WHEEL TYPE AIRCRAFT

DATUM LOCATED FORWARD OF THE MAIN WHEELS

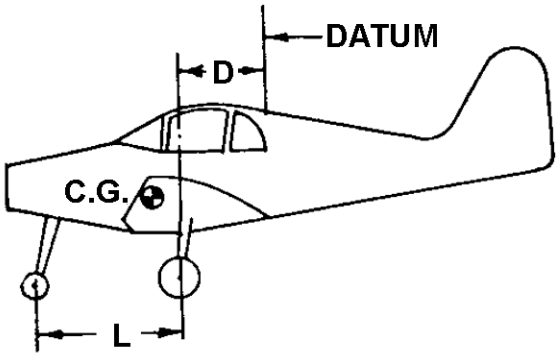
$$C.G. = D - \left(\frac{F \times L}{W}\right)$$



TAIL WHEEL TYPE AIRCRAFT

DATUM LOCATED FORWARD OF THE MAIN WHEELS

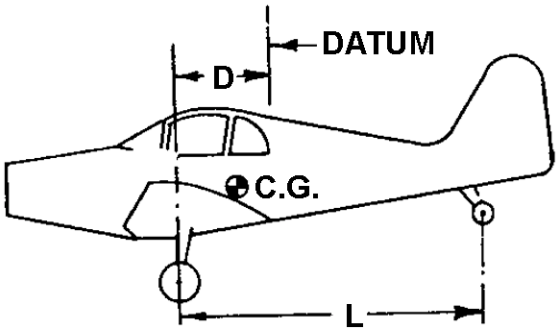
$$C.G. = D + \left(\frac{R \times L}{W}\right)$$



NOSE WHEEL TYPE AIRCRAFT

DATUM LOCATED AFT OF THE MAIN WHEELS

$$C.G. = -\left(D + \frac{F \times L}{W}\right)$$



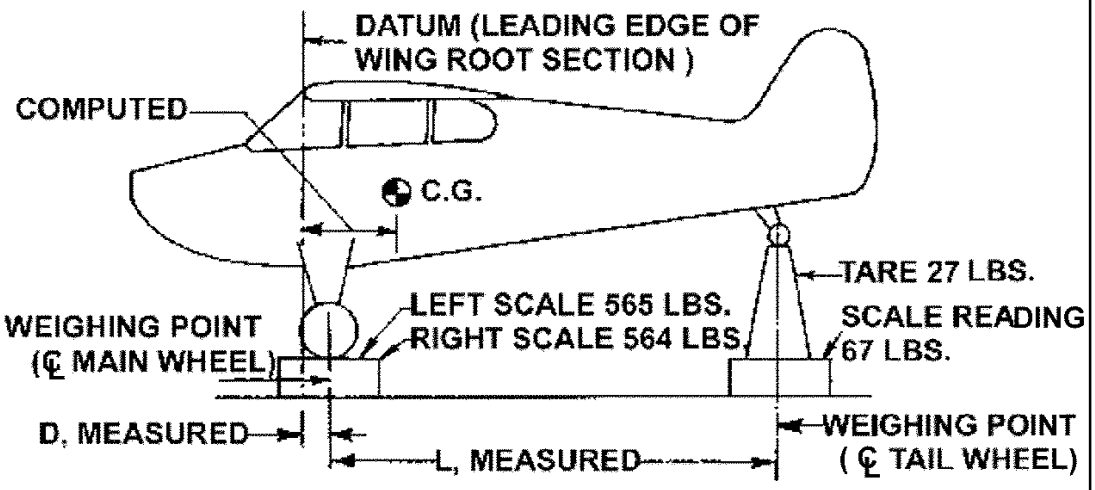
TAIL WHEEL TYPE AIRCRAFT

DATUM LOCATED AFT OF THE MAIN WHEELS

$$C.G. = -D + \left(\frac{R \times L}{W}\right)$$

C.G. = Distance from datum to center of gravity of the aircraft.
W = The weight of the aircraft at the time of weighing.
D = The horizontal distance measured from the datum to the main wheel weighing point.
L = The horizontal distance measured from the main wheel weighing point to the nose or tail weighing point.
F = The weight at the nose weighing point.
R = The weight at the tail weighing point.

FIGURE 10-4. Empty weight center of gravity formulas.



TO FIND: EMPTY WEIGHT AND EMPTY WEIGHT CENTER OF GRAVITY

Datum is the leading edge of the wing (from aircraft specification)
(D) Actual measured horizontal distance from the main wheel weighing point (℄ main wheel) to the Datum ---------- 3"
(L) Actual measured horizontal distance from the rear wheel weighing point (℄ rear wheel) to the main wheel weighing point ---------- 222"

SOLVING : EMPTY WEIGHT

Weighing Point	Scale Reading #	Tare #	Net Weight #
Right	564	0	564
Left	565	0	565
Rear	67	27	40
Empty Weight (W)			1169

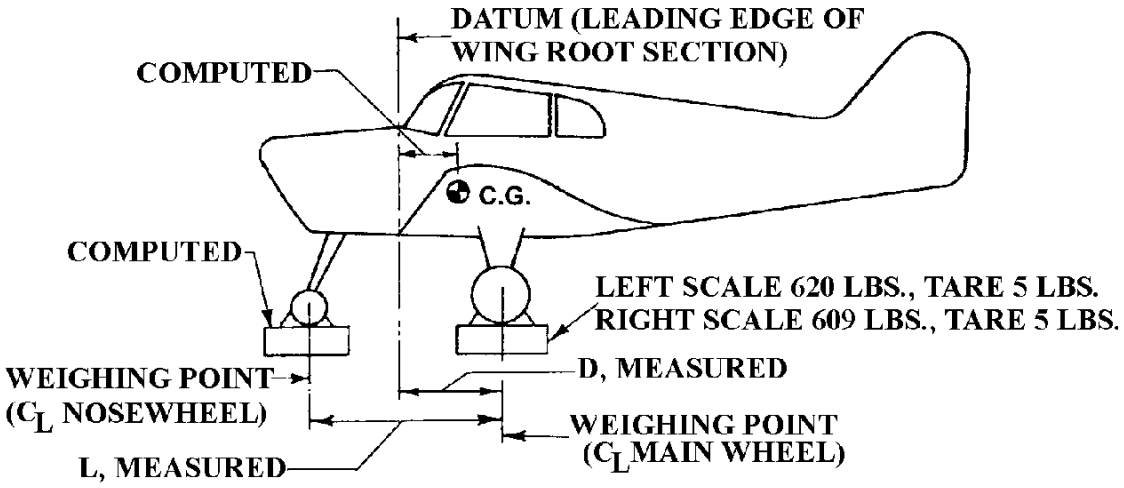
SOLVING: EMPTY WEIGHT CENTER OF GRAVITY

Formula: $C.G. = D + \frac{R \times L}{W} = 3" + \frac{40 \times 222}{1169} = 3" + 7.6" = 10.6"$

Reference for formula, Figure 10-4.

This case is shown properly entered on a sample weight and balance report form, Figure 10-17

FIGURE 10-5. Empty weight and empty center of gravity - tail-wheel type aircraft.



TO FIND: EMPTY WEIGHT AND EMPTY WEIGHT CENTER OF GRAVITY

Datum is the leading edge of the wing (from aircraft specification)
(D) Actual measured horizontal distance from the main wheel weighing point (C_L main wheel) to the Datum ---------- 34.0"
(L) Actual measured horizontal distance from the front wheel weighing point (C_L front wheel) to the main wheel weighing point ---------- 67.8"

SOLVING: EMPTY WEIGHT

Weighing Point	Scale Reading	Tare	Net Weight
Right	609	5	604
Left	620	5	615
Front	464	10	454
Empty Weight (W)			1673

SOLVING: EMPTY WEIGHT CENTER OF GRAVITY

Formula: $C.G. = D - \frac{F \times L}{W} = 34" - \frac{454 \times 67.8}{1673} = 34" - 18.4" = 15.6"$

Reference for formula, Figure 10-4.

FIGURE 10-6. Empty weight and empty weight center of gravity - nosewheel-type aircraft.

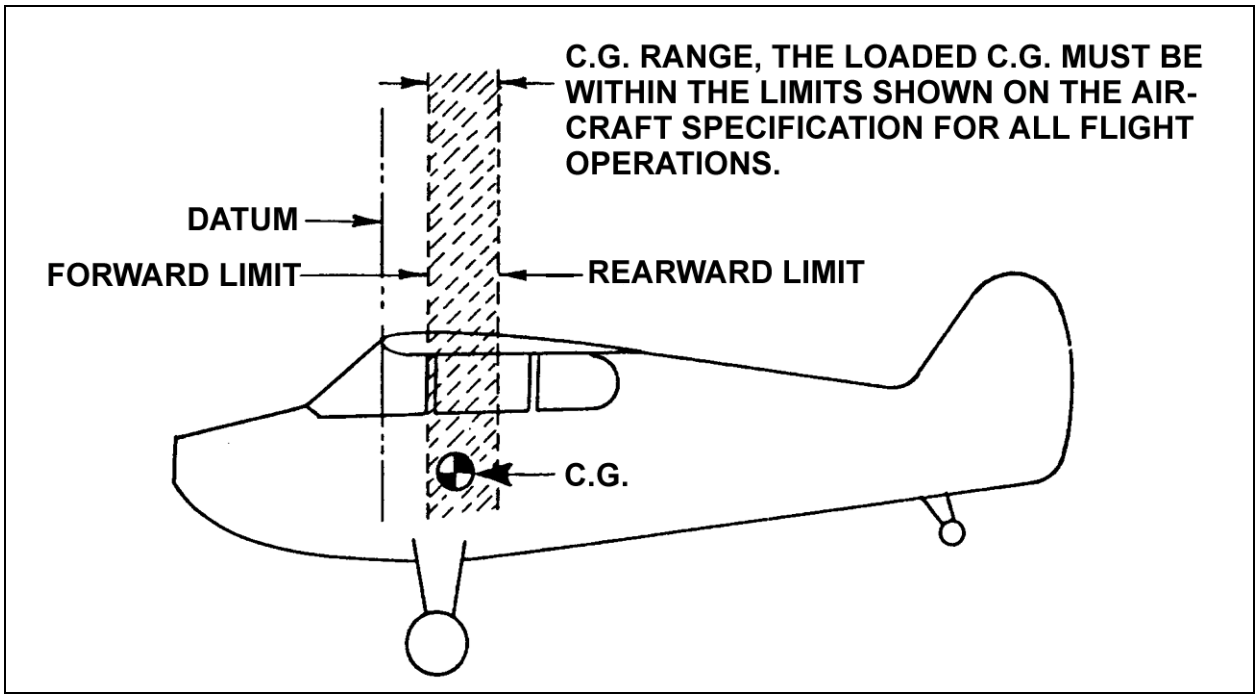


FIGURE 10-7. Operating center of gravity range.

scales under the landing gear tires, a vertical line passing through the centerline of the axle will locate the point on the scale at which the weight is concentrated. This point is called the "weighing point." Other structural locations capable of supporting the aircraft, such as jack pads on the main spar, may also be used if the aircraft weight is resting on the jack pads. Indicate these points clearly in the weight and balance report when used instead of the landing gear. Typical locations of the weighing points are shown in figure 10-8.

o. Zero Fuel Weight. The maximum permissible weight of a loaded aircraft (passengers, crew, cargo, etc.) less its fuel is zero fuel weight. All weights in excess of maximum zero fuel weight must consist of usable fuel.

p. Minimum Fuel. The minimum fuel for balance purposes is 1/12 gallon per maximum-except-take-off horsepower (METO). Minimum fuel is the maximum amount of fuel which can be used in weight and balance computations when low fuel might adversely affect the most critical balance conditions. To determine the weight of fuel in pounds divide the METO horsepower by two.

q. Full Oil. The full oil is the quantity of oil shown in the Aircraft Specifications or TCDS as oil capacity. Use full oil as the quantity of oil when making the loaded weight and balance computations.

r. Tare. The weight of chocks, blocks, stands, etc., used when weighing aircraft is called tare and is included in the scale readings. Tare is deducted from the scale reading at each respective weighing point when tare is involved, to obtain the actual aircraft weight.

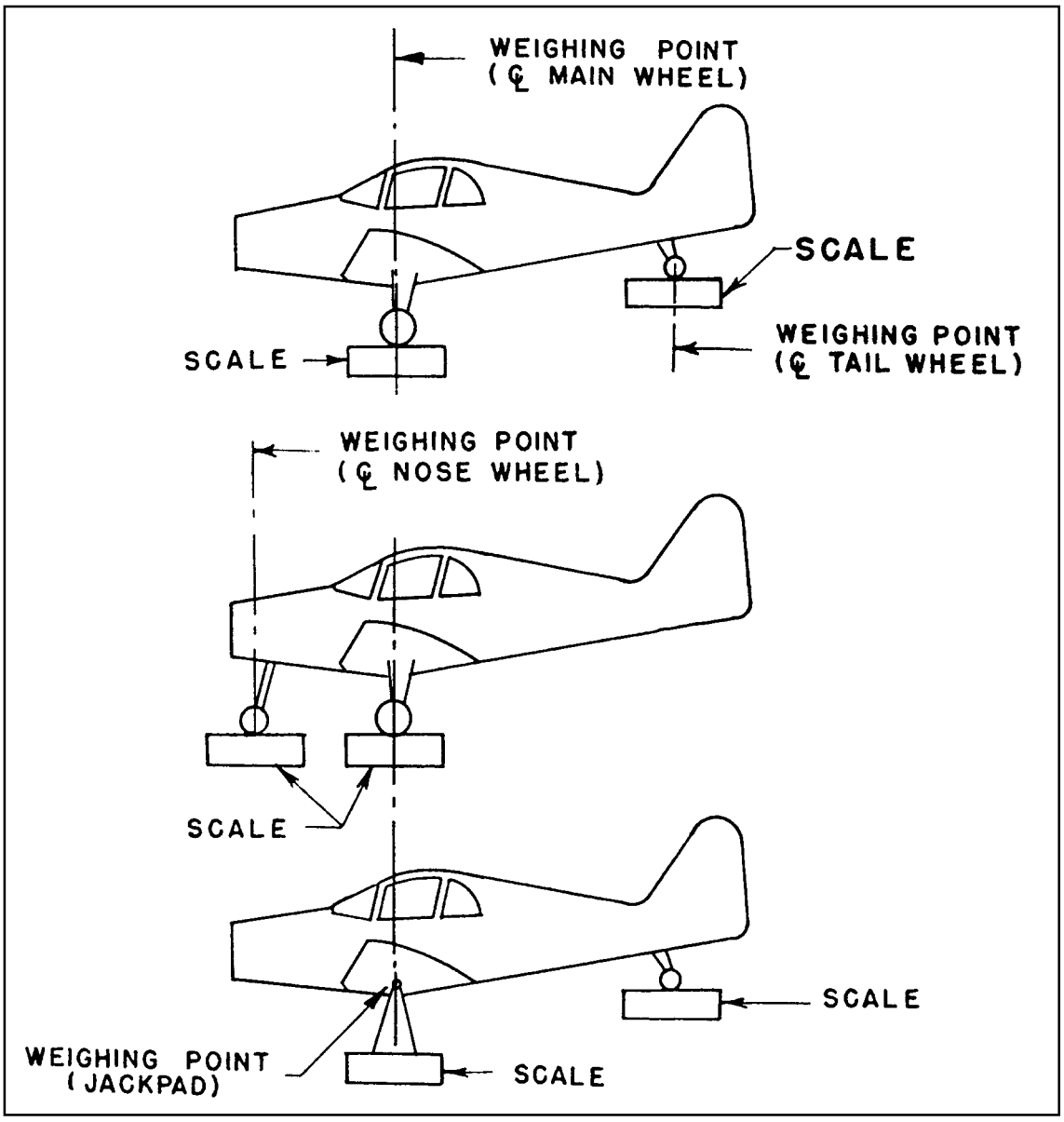


FIGURE 10-8. Weighing point centerline.

10-3.—10-13. [RESERVED.]

SECTION 2 WEIGHING PROCEDURES

10-14. GENERAL. Weighing procedures may vary with the aircraft and the type of weighing equipment employed. The weighing procedures contained in the manufacturer's maintenance manual should be followed for each particular aircraft.

10-15. PROCEDURES. Accepted procedures when weighing an aircraft are:

a. Remove excessive dirt, grease, moisture, etc., from the aircraft before weighing.

b. Weigh the aircraft inside a closed building to prevent error in scale reading due to wind.

c. Determine the empty weight c. g. by placing the aircraft in a level flight attitude.

d. Have all items of equipment that are included in the certificated empty weight report installed in the aircraft when weighing. These items of equipment are a part of the current weight and balance report.

e. The scales should have a current calibration before weighing begins. Zero and use the scales in accordance with the scale manufacturer's instructions. Platform scales and suitable support for the aircraft, if necessary, are usually placed under the wheels of a landplane, the keel of a seaplane float, or the skis of a skiplane. Other structural locations capable of supporting the aircraft, such as jack pads, may be used. Clearly indicate these points and the alternate equipment used in the weight and balance report.

f. Drain the fuel system until the quantity indicator reads *zero* or until the tanks are empty with the aircraft in level flight attitude, unless otherwise noted in the TCDS or Aircraft Specifications. The amount of fuel remaining in the tank, lines, and engine is termed residual fuel and is to be included in the empty weight. In special cases, the aircraft may be weighed with full fuel in tanks provided a definite means of determining the exact weight of the fuel is available.

g. The oil system should be filled to the quantity noted in the TCDS or Aircraft Specifications.

NOTE: On Civil Aeronautics Regulations (CAR-3) Certified Aircraft, the weight of the oil was subtracted mathematically to get the empty weight. In 14 CFR, part 23 aircraft, the weight of the oil is included in the empty weight.

When weighed with full oil, actual empty weight equals the actual recorded weight less the weight of the oil in the oil tank(oil weight = oil capacity in gallons x 7.5 pounds). Indicate on all weight and balance reports whether weights include full oil or oil drained. (See figure 10-9.*)*

h. Do not set brakes while taking scale reading.

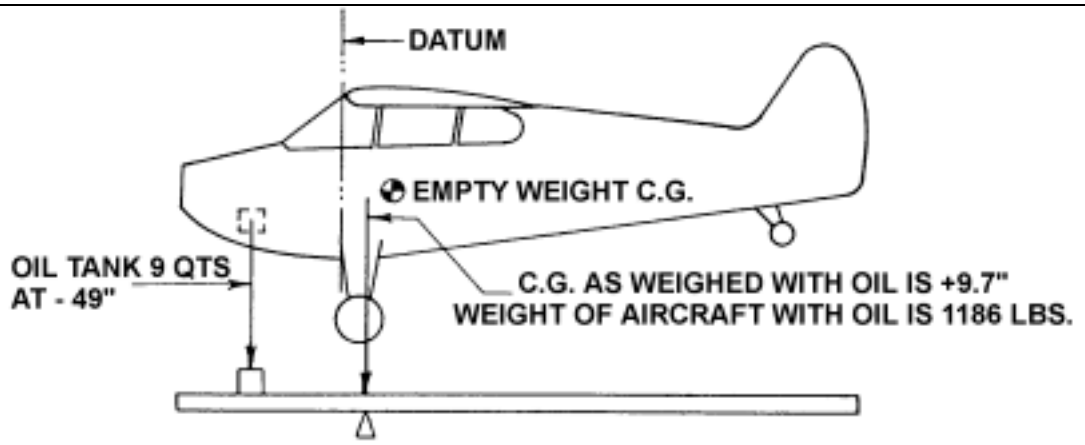
i. Note any tare reading when the aircraft is removed from the scales.

10-15a. REPAIRS AND ALTERATIONS are the major sources of weight changes, and it is the responsibility of the aircraft mechanic making any repairs or alteration to know the weight and location of these changes, and to compute the new CG and record the new empty (EW) weight and EWCG data in the aircraft flight manual.

10-15b. ANNUAL OR 100-HOUR INSPECTION. After conducting an annual or 100-hour inspection, the aircraft mechanic

must ensure the weight and balance data in the aircraft records is current and accurate.

10-16. WEIGHT AND BALANCE COMPUTATIONS. It is often necessary after completing an extensive alteration to establish by computation that the authorized weight and c.g. limits as shown in the TCDS and Aircraft Specifications are not exceeded. Paragraph b(2) explains the significance of algebraic signs used in balance computations.



EMPTY WEIGHT AND EMPTY WEIGHT CENTER OF GRAVITY
(when aircraft is weighed with oil)

GIVEN:

Aircraft as weighed with full oil ---------- 1186 lbs.
Center of gravity ---------- 9.7”
Full oil capacity 9 qts. ---------- 17 lbs.

SOLVING:

	Weight #	x Arm”	= Moment “#
Aircraft as weighed	+ 1186	+ 9.7	+ 11504
Less oil	- 17	- 49.0	+ 833
Total	+ 1169(A)		+ 12337(B)

Empty Weight (A) = 1169 pounds

Empty Weight Center of Gravity $\frac{B}{A} = \frac{12337}{1169} = +10.6$”

FIGURE 10-9. Empty weight and empty weight center of gravity when aircraft is weighed with oil.

a. The TCDS or Aircraft Specifications contain the following information relating to the subject:

(1) Center of gravity range.
(2) Empty weight c.g. range when applicable.
(3) Leveling means.
(4) Datum.
(5) Maximum weights.
(6) Number of seats and arm.
(7) Maximum baggage and arm.
(8) Fuel capacity and arm.
(9) Oil capacity and arm.
(10) Equipment items and arm.

b. The TCDS do not list the basic required equipment prescribed by the applicable airworthiness regulations for certification. Refer to the manufacturer’s equipment list for such information.

(1) Unit weight for weight and balance purposes.

Gasoline ---------- 6 pounds per U.S. gal.
Turbine Fuel ------ 6.7 pounds per U.S. gal.
Lubricating oil ---- 7.5 pounds per U.S. gal.
Crew and
passengers ----- 170 pounds per person.

(2) It is important to retain the proper algebraic sign (+ or -) through all balance computations. For the sake of uniformity in these computations, visualize the aircraft with the nose to the left. In this position any arm to the left (forward) of the datum is "minus" and any arm to the right (rearward) of the datum is "plus." Any item of weight added to the aircraft either side of the datum is plus weight, any weight item removed is a minus weight. When multiplying weights by arms, the answer is plus if the signs are the same, and minus if the signs are different. The following combinations are possible:

Items added forward of the datum-

(+) weight x (-) arm = (-) moment.

Items added to the rear of the datum-

(+) weight x (+) arm = (+) moment.

Items removed forward of the datum-

(-) weight x (-) arm = (+) moment.

Items removed rear of the datum-

(-) weight x (+) arm = (-) moment.

(3) The total weight of the airplane is equal to the weight of the empty aircraft plus the weight of the items added minus the weight of the items removed.

(4) The total moment of the aircraft is the algebraic sum of the empty weight moment of the aircraft and all of the individual moments of the items added and/or removed.

10-17. WEIGHT AND BALANCE EXTREME CONDITIONS. The weight and balance extreme conditions represent the maximum forward and rearward c.g. position for the aircraft. Include the weight and balance data information showing that the c.g. of the aircraft (usually in the fully loaded condition) falls between the extreme conditions.

a. Forward Weight and Balance Check. When a forward weight and balance check is made, establish that neither the maximum weight nor the forward c.g. limit listed in the TCDS and Aircraft Specifications are exceeded. To make this check, the following information is needed:

(1) The weights, arms, and moment of the empty aircraft.

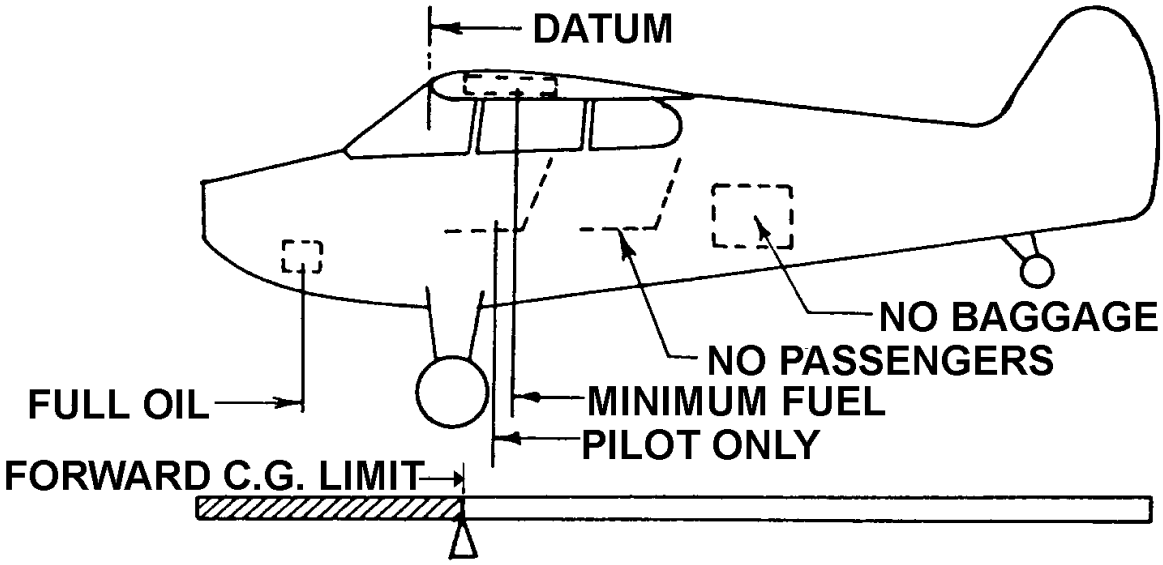
(2) The maximum weights, arms, and moments of the items of useful load that are located ahead of the forward c.g. limit.

(3) The minimum weights, arms, and moments of the items of useful load that are located aft of the forward c.g. limit. A typical example of the computation necessary to make this check, using this data, is shown in figure 10-10.

b. Rearward Weight and Balance Check. When a rearward weight and balance check is made, establish that neither the maximum weight nor the rearward c.g. limit listed in the TCDS and Aircraft Specifications are exceeded. To make this check, the following information is needed:

(1) The weight, arms, and moments of the empty aircraft.

(2) The maximum weights, arms, and moments of the items of useful load that are located aft of the rearward c.g. limit.



TO CHECK: MOST FORWARD WEIGHT AND BALANCE EXTREME.

GIVEN:
Actual empty weight of the aircraft ---------- 1169#
Empty weight center of gravity ---------- + 10.6”
*Maximum weight ---------- 2100#
*Forward C.G.. limit ---------- + 8.5”
*Oil capacity, 9 qts. ---------- 17# at -49”
*Pilot in farthest forward seat equipped with
controls (unless otherwise placarded) ---------- 170# at +16”
*Since the fuel tank is located to the rear of the
forward C.G. limit, minimum fuel should be included.
METO HP / 12 = 165 / 12 = 13.75 gal. x 6# ---------- 83# at +22”
* Information should be obtained from the aircraft specification.
Note: Any items or passengers must be used if they are located ahead of the forward C.G. limit.
Full fuel must be used if the tank is located ahead of the forward C.G. limit.

CHECK OF FORWARD WEIGHT AND BALANCE EXTREME

	Weight (#) x Arm (“) = Moment (“#)		
Aircraft empty	+ 1169	+ 10.6	+ 12391
Oil	+ 17	- 49	- 833
Pilot	+ 170	+ 16	+ 2720
Fuel	+ 83	+ 22	+ 1826
Total	+ 1439 (TW)		+ 16104 (TM)

Divide the TM (total moment) by the TW (total weight) to obtain the forward weight and balance extreme.

$$\frac{TM}{TW} = \frac{16104}{1439} = +11.2”$$

Since the forward C.G. limit and the maximum weight are not exceeded, the forward weight and balance extreme condition is satisfactory.

FIGURE 10-10. Example of check of most forward weight and balance extreme.

(3) The minimum weights, arms, and moments of the items of useful load that are located ahead of the rearward c.g. limit. A typical example of the computation necessary to make this check, using this data, is shown in figure 10-11.

10-18. LOADING CONDITIONS AND/OR PLACARDS. If the following items have not been covered in the weight and balance extreme condition checks and are not covered by suitable placards in the aircraft, additional computations are necessary. These computations should indicate the permissible distribution of fuel, passengers, and baggage that may be carried in the aircraft at any one time without exceeding either the maximum weight or c.g. range. The conditions to check are:

a. With full fuel, determine the number of passengers and baggage permissible.

b. With maximum passengers, determine the fuel and baggage permissible.

c. With maximum baggage, determine the fuel and the number and location of passengers.

d. Examples of the computations for the above items are given in figures 10-12, 10-13, and 10-14 respectively. The above cases are mainly applicable to the lighter type personal aircraft. In the case of the larger type transport aircraft, a variety of loading conditions is possible and it is necessary to have a loading schedule.

10-19. EQUIPMENT LIST. A list of the equipment included in the certificated empty weight may be found in either the approved aircraft flight manual or the weight and balance report. Enter into the weight and balance report all required, optional, and special equipment installed in the aircraft at time of weighing and/or subsequent equipment changes.

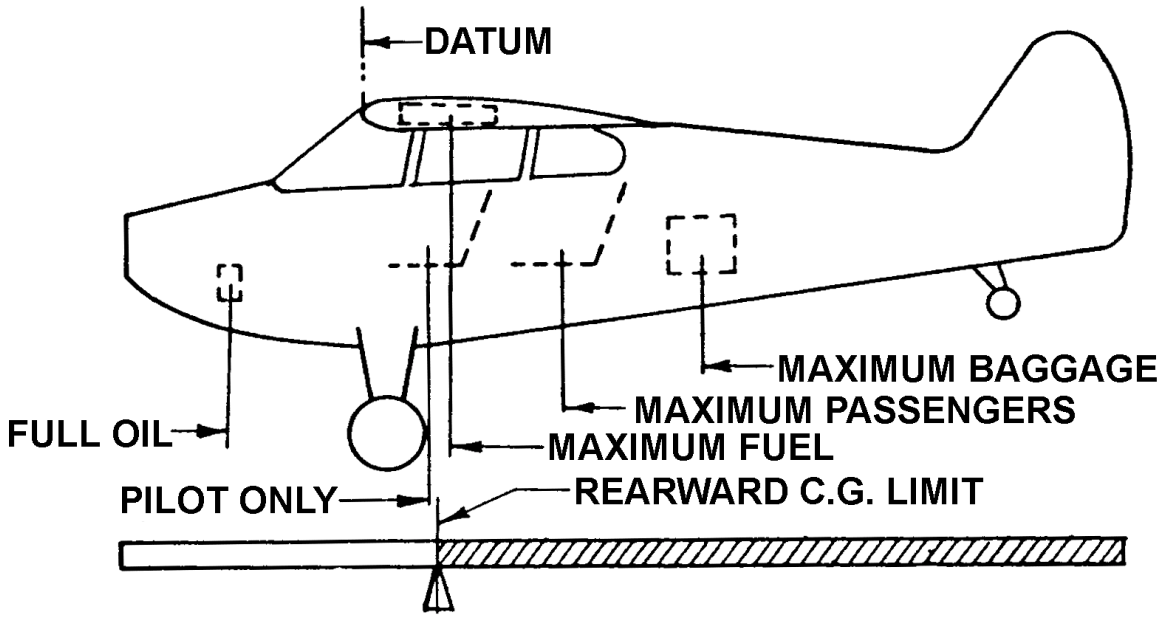
a. Required equipment items are listed in the pertinent Aircraft Specifications.

b. Optional equipment items are listed in the pertinent Aircraft Specifications and may be installed in the aircraft at the option of the owner.

c. Special equipment is any item not corresponding exactly to the descriptive information in the Aircraft Specifications. This includes items such as emergency locator transmitter (ELT), tail or logo lights, instruments, ashtrays, radios, navigation lights, and carpets.

d. Required and optional equipment may be shown on the equipment list with reference to the pertinent item number listed in the applicable specifications only when they are identical to that number item with reference to description, weight, and arm given in the specifications. Show all special equipment items with reference to the item by name, make, model, weight, and arm. When the arm for such an item is not available, determine by actual measurement.

10-20. EQUIPMENT CHANGE. The person making an equipment change is obligated to make an entry on the equipment list indicating items added, removed, or relocated with the date accomplished, and identify himself by name and certificate number in the aircraft records. Examples of items so affected are the installation of extra fuel tanks, seats, and baggage compartments. Figure 10-15 illustrates the effect on balance when equipment items are added within the acceptable c.g. limits and fore and aft of the established c.g. limits.



TO CHECK: MOST REARWARD WEIGHT AND BALANCE EXTREME.

GIVEN:

Actual empty weight of the aircraft ---------- 1169#
Empty weight center of gravity ---------- 10.6”
*Maximum weight ---------- 2100#
*Rearward C.G.. limit ---------- 21.9”
*Oil capacity, 9 qts. ---------- 17# at -49”
*Baggage, placarded do not exceed 100 lbs ---------- 100# at +75.5”
*Two passengers in rear seat, 170# x 2 ---------- 340# at +48”
*Pilot in most rearward seat equipped with controls (unless otherwise placarded) ---------- 170# at +16”
*Since the fuel tank is located aft of the rearward C.G. limit full fuel must be used ---------- 240# at +22”

* Information should be obtained from the aircraft specification.

Note: If fuel tanks are located ahead of the rearward C.G. limit minimum fuel should be used.

CHECK OF REARWARD WEIGHT AND BALANCE EXTREME

	Weight (#) x Arm (“) = Moment (“#)		
Aircraft empty	+ 1169	+ 10.6	+ 12391
Oil	+ 17	- 49	- 833
Pilot (1)	+ 170	+ 16	+ 2720
Passenger (2)	+ 340	+ 48	+ 16320
Fuel (40 gals.)	+ 240	+ 22	+ 5280
Baggage	+ 100	+ 75.5	+ 7550
Total	+ 2036 (TW)		+ 43428 (TM)

Divide the TM (total moment) by the TW (total weight) to obtain the rearward weight and balance extreme.

$$\frac{TM}{TW} = \frac{43428}{2036} = +21.3”$$

Since the rearward C.G. limit and the maximum weight are not exceeded, the rearward weight and balance extreme condition is satisfactory.

FIGURE 10-11. Example of check of most rearward weight and balance extreme.

EXAMPLE OF THE DETERMINATION OF THE NUMBER OF PASSENGERS AND BAGGAGE PERMISSIBLE WITH FULL FUEL

GIVEN:
Actual empty weight of the aircraft ---------- 1169#
Empty weight center of gravity ---------- 10.6”
Maximum weight---------- 2100#
Datum is leading edge of the wing
Forward center of gravity limit ---------- 8.5”
Rearward center of gravity limit---------- 21.9”
Oil capacity, 9 qts.; show full capacity ---------- 17# at -49”
Baggage, maximum---------- 100# at +75.5”
Two passengers in rear seat, 170# x 2 ---------- 340# at +48”
Pilot in most rearward seat equipped with
controls (unless otherwise placarded) ---------- 170# at +16”
Full fuel, 40 gals. x 6#---------- 240# at +22”

	Weight (#)	x Arm (“) =	Moment (“#)
Aircraft empty	+ 1169	+ 10.6	+ 12391
Oil	+ 17	- 49	- 833
Full Fuel	+ 240	+ 22	+ 5280
Passengers 2 rear	+ 340*	+ 48	+16320
Pilot	+ 170	+ 16	+ 2720
Baggage	+ 100	+ 75.5	+ 7550
Total	+ 2036 (TW)		+ 43428 (TM)

Divide the TM (total moment) by the TW (total weight) to obtain the loaded center of gravity.

$$\frac{TM}{TW} = \frac{43428}{2036} = +21.3”$$

The above computations show that with full fuel, 100 pounds of baggage and two passengers in the rear seat may be carried in this aircraft without exceeding either the maximum weight or the approved C. G. range.

This condition may be entered in the loading schedule as follows:

GALLONS OF FUEL	NUMBER OF PASSENGERS	POUNDS OF BAGGAGE
Full	2 Rear	100

* Only two passengers are listed to prevent the maximum weight of 2100 lbs. from being exceeded.

FIGURE 10-12. Loading conditions: determination of the number of passengers and baggage permissible with full fuel.

EXAMPLE OF THE DETERMINATION OF THE POUNDS OF FUEL AND BAGGAGE PERMISSIBLE WITH MAXIMUM PASSENGERS

	Weight (#)	x Arm (“) =	Moment (“#)
Aircraft empty	+ 1169	+ 10.6	+ 12391
Oil	+ 17	- 49	- 833
Pilot	+ 170	+ 16	+ 2720
Passenger (1) front	+ 170	+ 16	+ 2720
Passenger (2) rear	+ 340	+ 48	+16320
Fuel (39 gals.)	+ 234	+ 22	+ 5148
Baggage	----	----	----
Total	+ 2100		+ 38466

Divide the TM (total moment) by the TW (total weight) to obtain the loaded center of gravity.

$$\frac{TM}{TW} = \frac{38466}{2100} = +18.6\text{”}$$

The above computations show that with the maximum number of passengers, 39 gallons of fuel and zero pounds of baggage may be carried in this aircraft without exceeding either the maximum weight or the approved C. G. range.

This condition may be entered in the loading schedule as follows:

GALLONS OF FUEL	NUMBER OF PASSENGERS	POUNDS OF BAGGAGE
*Full	*2 Rear	* 100
39	1(F) 2(R)	None

* Conditions as entered from Figure 10-12
(F) Front seat
(R) Rear seat

FIGURE 10-13. Loading conditions: determination of the fuel and baggage permissible with maximum passengers.

EXAMPLE OF THE DETERMINATION OF THE FUEL AND THE NUMBER AND LOCATION OF PASSENGERS PERMISSIBLE WITH MAXIMUM BAGGAGE

	Weight (#) x Arm (“) = Moment (“#)		
Aircraft empty	+ 1169	+ 10.6	+ 12391
Oil	+ 17	- 49	- 833
Pilot	+ 170	+ 16	+ 2720
Passenger (1) rear	+ 170	+ 48	+ 8160
Passenger (1) front	+ 170	+ 16	+ 2720
Fuel (40 gals.)	+ 240	+ 22	+ 5280
Baggage	+ 100	+ 75.5	+ 7550
Total	+ 2036		+ 37988

Divide the TM (total moment) by the TW (total weight) to obtain the loaded center of gravity.

$$\frac{TM}{TW} = \frac{37988}{20366} = +18.7$$

The above computations show that with maximum baggage, full fuel and 2 passengers (1 in the front seat and 1 in the rear seat) may be carried in this aircraft without exceeding either the maximum weight or the approved C. G. range.

This condition may be entered in the loading schedule as follows:

GALLONS OF FUEL	NUMBER OF PASSENGERS	POUNDS OF BAGGAGE
*Full	*2 Rear	* 100
** 39	*1(F) 2(R)	**None
Full	1(F) 1(R)	Full

* Conditions as entered from Figure 10-12
** Conditions as entered from Figure 10-13
(F) Front seat
(R) Rear seat

FIGURE 10-14. Loading conditions: determination of the fuel and the number and location of passengers permissible with maximum baggage.

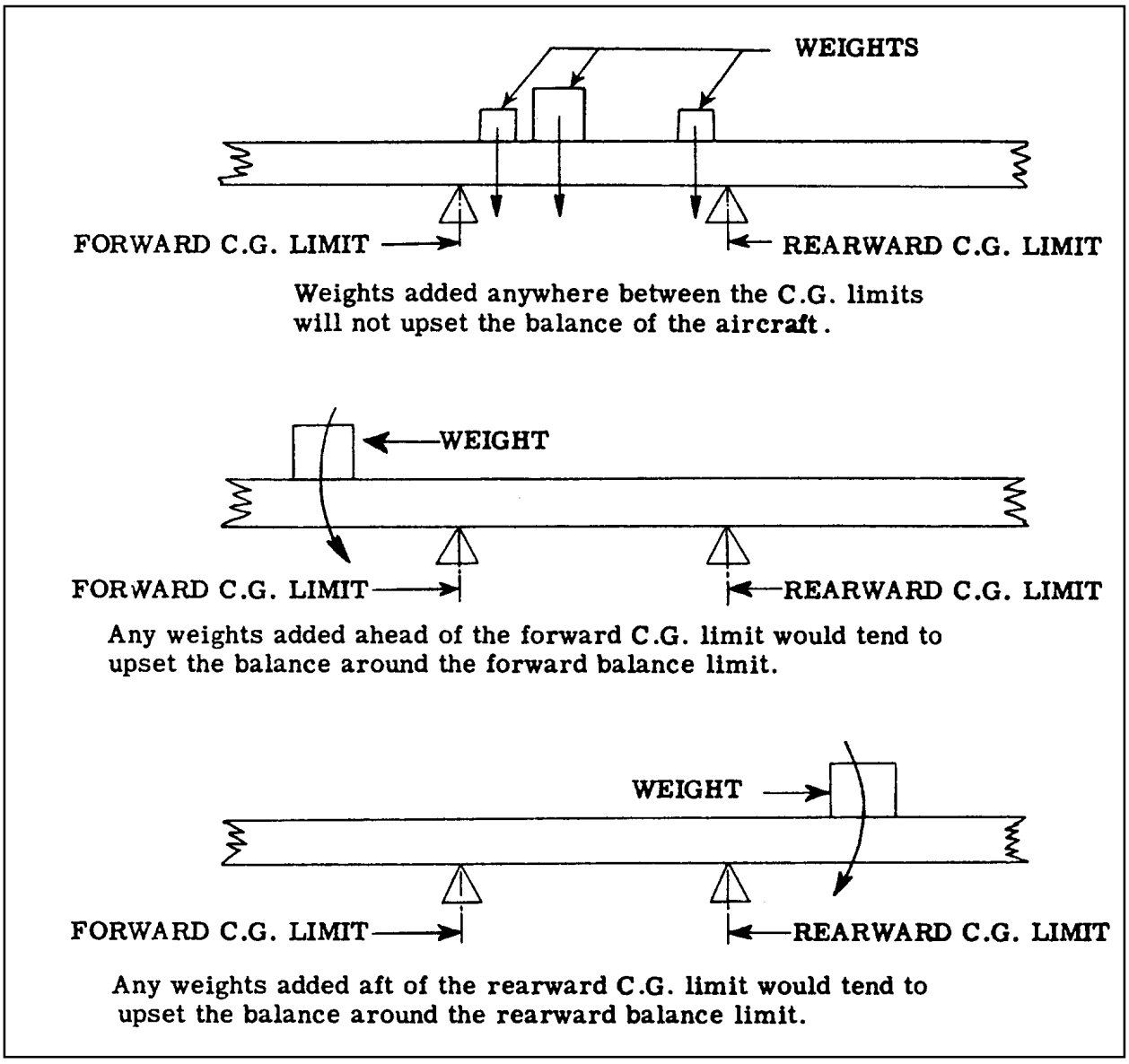


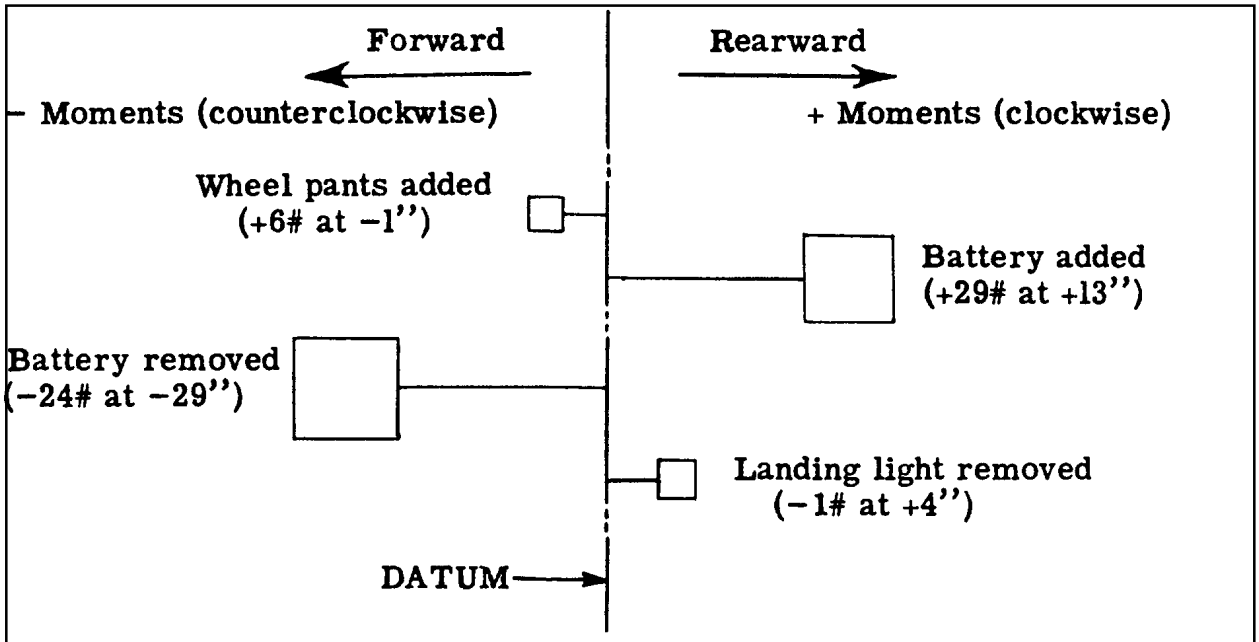
FIGURE 10-15. Effects of the addition of equipment items on balance.

Moment computations for typical equipment changes are given in figure 10-16 and are also included in the sample weight and balance sheet in figure 10-18.

10-21. SAMPLE WEIGHT AND BALANCE REPORT. Suggested methods of tabulating the various data and computations for determining the c.g., both in the empty weight condition and the fully loaded condition, are given in figures 10-17 and 10-18, respectively, and represent a suggested means of recording this information. The data presented in figure 10-17 have previously been computed in figures 10-10 and 10-11 for the extreme load conditions and figure 10-16 for equipment change, and represents suggested means of recording this information.

10-22. INSTALLATION OF BALLAST. Ballast is sometimes permanently installed for c.g. balance purposes as a result of installation or removal of equipment items and is not used to correct a nose-up or nose-down tendency of an aircraft. It is usually located as far aft or as far forward as possible in order to bring the

c.g. position within acceptable limits with a minimum of weight increase. Permanent ballast is often lead plate wrapped around and bolted to the fuselage primary structure (e.i., tail-post, longerons, or bulkhead members). Permanent ballast invariably constitutes a concentrated load; therefore, the strength of the local structure and the attachment of the ballast thereto should be investigated for the design loading conditions pertinent to that particular aircraft. Placard permanent ballast with *Permanent ballast - do not remove*. It is not desirable to install permanent ballast by pouring melted lead into the tail-post or longerons due to difficulties that may be encountered in subsequent welding repair operations. It should be noted that the installation of permanent ballast results in an increase of aircraft empty weight. See figure 10-19 for ballast computation. The local strength of the compartment in which the ballast is carried and the effect of the ballast on aircraft weight and balance should be investigated when disposable ballast is carried.



	Weight (#)	x Arm (")	= Moment ("#)
ADDED			
Item 204 wheel pants	+ 6	– 1	– 6
Item 302b Battery	+ 29	+13	+377
REMOVED			
Item 302a Battery	– 24	–29	+696
Item 303 Landing light	– 1	+ 4	– 4

This condition is shown properly entered on a sample weight and balance report on Figure 10-18 under Equipment Change.

FIGURE 10-16. Example of moment and weight changes resulting from equipment changes.

MAKE MA-700 MODEL A SERIAL # 0000 REGISTRATION # N1234 .
DATUM IS leading edge of wing .

COMPUTE AS FOLLOWS IF AIRCRAFT WEIGHED

1. Leveling means: level top longeron between front and rear seats.
2. Main wheel weighing point is located (_____ "FORWARD) (+ 3 " AFT) of datum.
3. Actual measured distance from the main weight point centerline to the tail (or nose) point centerline 222 ".
4. Oil over and above "ZERO" tank reading = (a. ---- Gals.) (b. ---- Lbs.) (c. ---- In.)

ACTUAL EMPTY WEIGHT

Weight Point	Scale Reading -	Tare =	Net Weight
5. Right	564	0	564
6. Left	565	0	565
7. Tail	67	27	40
8. Nose	----	----	-----
9. Total Net Weight	X	X	1169

CENTER OF GRAVITY AS WEIGHED

10. C.G. relative to main wheel weighing point:
    (a) Tail wheel airc. (Item 3, 222) x (Item 7, 40) / (Item 9, 1169) = + 7.6 = C.G.
    (b) Nose wheel airc. (Item 3 ----) x (Item 8 ----) / (Item 9 ----) = _____ = C.G.

11. C.G. relative to datum:
    (a) Tail wheel airc. (Item 10a, + 7.6) added to (Item 2, + 3) = +10.6" = C.G.
    (b) Nose wheel airc. (Item 10b,) added to (Item 2,) = _____ = C.G.

COMPUTE IF AIRCRAFT WEIGHED WITH OIL (Item 4)

	Weight x	Arm =	Moment
Aircraft Less Oil	(9) (4b)	(11) (4c)	
Empty Totals	(a)	X	(b)

(b) ---------- = (c) ----------" = Empty weight C.G.
12. (a)

REPAIR AGENCY _____ _____ DATE _____
Name Number

FIGURE 10-17. Sample weight and balance report to determine empty weight center of gravity.

EQUIPMENT LIST

*Required or Optional Item Numbers as Shown in Aircraft Specification						
1	2	101	102	103	104	105
106	201	202	203	301	302(a)	303
401(a)	402	----	----	----	----	----

Special Equipment				
Item	Make	Model	Weight	Arm
3 Flares 1-1/2 Min.	XYZ	03	25#	105”

Enter above those items included in the empty weight.

WEIGHT AND BALANCE EXTREME CONDITIONS

Approved fwd limit 8.5” Approved max. weight 2100# Approved aft limit 21.9”

Item	FORWARD CHECK			REARWARD CHECK		
	Weight	X Arm =	Moment	Weight	X Arm =	Moment
Airo. Empty	+ 1169 (9 or 12a)	+ 10.6 (11 or 12c)	+ 12391	+ 1169 (9 or 12a)	+ 10.6 (11 or 12c)	+ 12391
Oil	+ 17	- 49	- 833	+ 17	- 49	- 833
Pilot	+ 170	+ 16	+ 2720	+ 170	+ 16	+ 2720
Fuel	+ 83	+ 22	+ 1826	+ 240	+ 22	+ 5280
Passenger (s)				+ 340	+ 48	+ 16320
Baggage				+ 100	+ 75.5	+ 7550
TOTAL	+ 1439 = TW	X	+ 16104 = TM	+ 2036 = TW	X	+43428=TM

TM = 16104 = +11.2” = Most Forward C.G. location
TW 1439

TM = 43428 = +21.3” = Most Rearward C.G. location
TW 2036

LOADING SCHEDULE

Gallons of Fuel	Number of Passengers	Pounds of Baggage
40	2(R)	100

The above includes pilot and capacity oil.

EQUIPMENT CHANGE

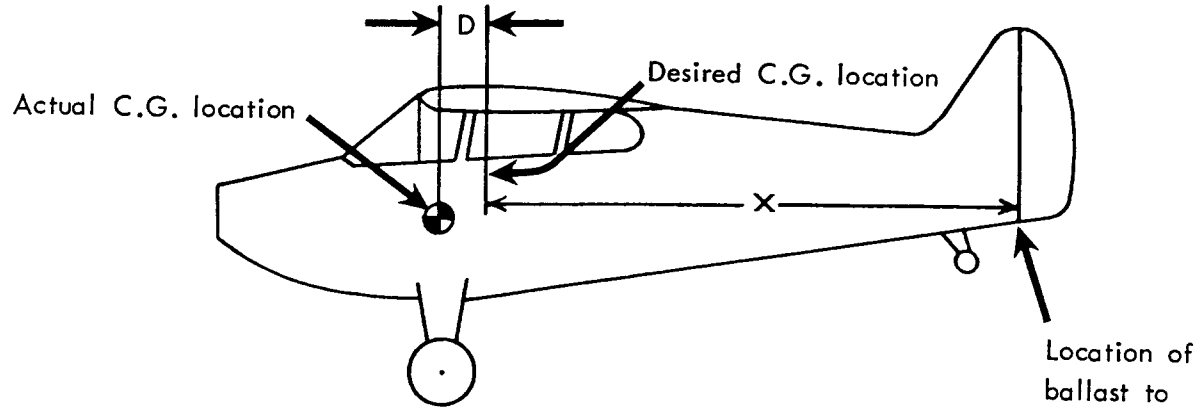
Computing New C.G.			
Item, Make, and Model*	Weight X Arm		Moment
Airc. Empty	+ 1169 (9 or 12a)	+ 10.6 (11 or 12c)	+ 12391
204 added	+ 6	- 1	- 6
302(b) added	+ 29	+ 13	+ 377
302(a) removed	- 24	+ 29	+ 696
303 removed	- 1	+ 4	- 4
NET TOTALS	- 1179 = NW	X	+ 13454 = NM

NM = 13454= +11.4” = New C.G.
NW 1179

*ITEM NUMBERS WHEN LISTED IN PERTINENT AIRCRAFT SPECIFICATION MAY BE USED IN LIEU OF “ITEM, MAKE, AND MODEL”.

PREPARED BY_____ DATE_____

FIGURE 10-18. Sample weight and balance report including an equipment change for aircraft fully loaded.



D - Distance in inches desired to move C.G. of airplane.

W - Weight of airplane as loaded.

X - Distance in inches from point where ballast is to be installed, to the desired location of the new C.G.

B - Weight of ballast required in pounds.

$$B = \frac{D \times W}{X}$$

Compute the new C.G. of the aircraft with ballast installed.

NOTE: If greater accuracy is desired, repeat the entire formula using the NEW aircraft weight and the NEW C.G. in the second operation.

FIGURE 10-19. Permanent ballast computation formula.

10-23. LOADING SCHEDULE. The loading schedule should be kept with the aircraft and form a part of the aircraft flight manual. It includes instructions on the proper load distribution such as filling of fuel and oil tanks, passenger seating, restrictions of passenger movement, and distribution of cargo.

a. Other means of determining safe loading conditions such as the use of a graphical index and load adjuster are acceptable and may be used in lieu of the information in paragraph 10-18.

b. Compute a separate loading condition when the aircraft is to be loaded in other than the specified conditions shown in the loading schedule.

10-24.—10-34. [RESERVED.]