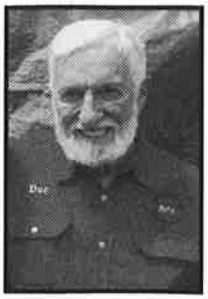
Where Do I Go After I Have the "Plans"?

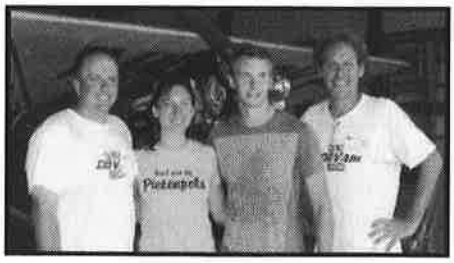
Introduction by **Doc Mosher**
Text & Pix by **William Wynne**



The Pietenpol "plans" are only the beginning....
Either set of Air Camper plans from the early 1930s (the Hoopman or the *Modern Mechanics* plans) contain only the most basic information – some have referred to them as "enhanced three-views." These have never been updated (at least in the USA). The plans were never adequate to build a safe and airworthy airplane. The plans show no seat belt or shoulder harness installation, no center of gravity limits, no brake installation, no three-piece wing, and on and on. Each builder contributes a good bit of himself in solving the problems that the "plans" don't show. Such a body of additional needed information has no authoritative and available single source, but is gained sporadically by the individual over a period of years listening to tips and word of mouth from other Piet people, sifting for himself the wheat from the chaff. Clearly, there is a need for some sort of a series of available updated notes to supplement the original plans. We feel that BPA can serve as a central point for such a positive safety program. We invite members to participate.

This year at Brodhead, **William Wynne** took action to establish an actual data base of weights of flying Air Campers. He will provide a series of articles on the findings. This is the introductory article.

Doc Mosher



From left to right above, Ryan & Jess Mueller, Emory Luth and myself.

At the 2010 Brodhead Pietenpol Reunion, three friends and I got together for a project that should have a far reaching impact on Piets of all types. Our project was to take a very accurate set of measurements and weight and balance information from as many Piets as possible. It's a lot of data, but over the next year, this information will be presented along with an educational discussion in the pages of this newsletter.

The purpose of gathering this data and performing the calculations with it goes far beyond providing the individual owners with very precise weight and balance data. The 14 aircraft measured are a fair cross section of the spectrum of Pietenpols. Utilizing this data, builders will be able to have a far more accurate picture of their final W&B while they're in the construction process.

It is my wish that current and future builders achieve several things. In order of importance: That the final configuration of their aircraft be in CG range under all the circumstances in which they fly; that their aircraft have the strongest configuration of cabane struts possible, with the front diagonals welded to the front vertical cabanes; and, that the location of the main landing gear axle be in an appropriate location for their aircraft.

Jess sits in her Pietenpol while it is on the electronic scales I brought up from Florida.

The CG issue on Pietenpols is well known. With today's heavier pilots, many aircraft are chronically tail heavy. This can easily be prevented by having the correct length motor mount. The length of this motor mount can be determined by comparing your project and your own personal flying weight to other measured, finished aircraft. The two most common semi-myths are that the wing can be moved indiscriminately to resolve any CG issue, and that some lengths of fuselage are less prone to being tail heavy.

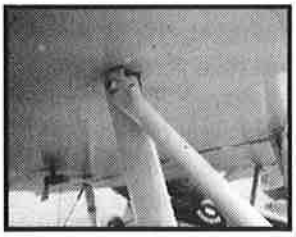
I call these semi-myths because there is some element of truth in them, but they are not true for practical purposes. Example: The wing can be moved on a finished aircraft by changing the length of the diagonal cabane struts. However, the practical limits of this are quite small. A shift of several inches may require re-making all of the brace wires. This may also require changing the lift struts and perhaps the jury struts as well. There are lots of details additionally, such as fuel lines, cockpit coaming and control cable runs.

A significant move of the wing will also change the wing's relationship to the main landing gear. Utilizing the data we collected, builders can develop a plan and not end up in this position.

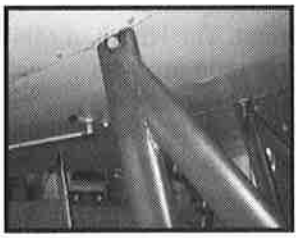
Doc Mosher and others have pointed out that the long fuselage is not a cure-all for W&B issues. While it is desirable for the purpose of cockpit room and stability, it

does not help W&B. The front bay of the fuselage is longer, effectively making the motor mount longer. But this is completely counterbalanced by the pilot's position being moved aft and the entire mass of the tail being another foot aft of the wing. The data clearly shows that an airplane built without a plan can end up with an aft CG no matter if it has a long or short fuselage.

Although the Pietenpol is a very strong aircraft with 8 decades of proven airworthiness, it does have a structural element that each builder should consider carefully: The finished wing on a Pietenpol with a full fuel tank can weigh up to 200 pounds. In an off airport emergency landing, an overshoot or an aborted takeoff, it is a very real possibility that the wing will parallelogram forward on the fuselage because of its inertia. The sudden deceleration puts an enormous compressive load on the diagonal cabanes. If these are made of small tubing or have ends that are hammered flat with a hole drilled in them, akin to 1960s swing set construction, the inertia can easily overwhelm the diagonals, and they will easily fold like cooked spaghetti. When this happens, any hard line from the wing tank to the fuselage will likely be ruptured, and exiting the front cockpit, already difficult, may become impossible. I write this from personal experience, but I have seen other Pietenpols that ended up in this same position after accidents.



Not the best way



Much better way

A personalized W&B plan based on good data will allow builders to weld the cabane struts into a far more rigid structure that will provide a vastly improved resistance to the wing being displaced. It's not going to make it failsafe, bulletproof, nor guaranteed. It is just going to make it substantially stronger.

A number of aircraft we measured had the landing gear in an undesirable location in reference to the wing. Early Pietenpol drawings show both straight axle and J-3 style gear with the landing gear placed well back from the leading edge of the wing when the aircraft is in the level flight attitude. Many of the aircraft we measured had the landing gear 7 or 8" behind the leading edge. The original plans reflect dimensions like this because those aircraft were not equipped with brakes, and they predominantly had tail skids or non-swiveling tailwheels. Aircraft configured like this traditionally had the pilot apply forward stick and some power to make the tail very light so it could be steered in the prop blast. Without brakes, there was little danger the pilot could nose over the airplane landing into the wind.

However, this is not the correct location for an aircraft equipped with brakes. The single sheet of paper with W&B information picturing Bernard's personal Corvair powered Air Camper clearly shows that he wanted the axle ½" behind the leading edge. On the sheet, this is expressed as .5". Despite being clearly visible in the drawing, a number of builders I've met have mistakenly believed this meant 5.0" behind the leading edge. When converting my Piet to 6x6 Cleveland hydraulic drums, I moved the axle centerline to the leading edge of the wing. In operation, this allowed full application of the brakes without any danger of nosing over, even with the CG at 15". This aircraft had ground handling that most tailwheel pilots would consider normal. Although not frequently needed, the aircraft could be stopped within 150 feet from touchdown. If you're going to install brakes, you should be able to use them fully.

In the past five years, four friends of mine with Pietenpols have put their aircraft on its back. The single biggest contributing factor to this is having the axle too far back on an aircraft with brakes. While all of the aircraft are back flying and no one was hurt, it does cause a substantial amount of damage. After gathering the data, it is easy to see the reason that this is not more common is that many of the aircraft with the axle too far aft also have the CG too far aft. Taxiing an aircraft with the CG at 22" will keep an aircraft with the axle 8" behind the leading edge from nosing over when brakes are applied. However, such an aircraft in a power off stall could easily yield an unrecoverable spin.

By mistake, we flew our Piet with the CG at 21". The power on stall recovery, with prop blast aiding the down elevator, was alarmingly slow. Each aircraft, due to minor variations in construction, will have its own point of no return. There is nothing to be gained by flying your Pietenpol with the CG aft of 20" other than becoming a footnote on the list of things never to do.

A word about weights: I've worked with experimental aircraft for more than 20 years. For some reason, 10% of aircraft builders have their ego wrapped up in the empty weight of their airplane. These people may be honest in every other aspect of their lives, but they will tell outright lies about the empty weight of their aircraft. Perhaps another 25% were weighed with poor scales. I consider any W&B done on bathroom scales as unairworthy, and certainly not to be compared with those done on electronic scales. Bathroom scales invariably read too light. Seriously, how many people are going to buy a bathroom scale that reads their weight heavier than other brands in the store?

Another 15% of aircraft had their W&B done ages ago, before equipment was added, repairs and modifications made, and perhaps even paint added. A good example of this is Bernard's Last Original. The paperwork listed the empty weight as 612 pounds. I personally weighed it three years ago on electronic scales and its empty weight was 640 pounds. Thus, roughly 50% of the empty weights of aircraft are not to be trusted.

The data gathered here was done on scales that cost thousands of dollars, all on the same day, in front of dozens of people. Invariably, you will meet someone who will tell you they have a buddy who has a Piet that's a lot lighter. They may be mistaken, repeating disinformation or outright lying. Do not build your aircraft with such information. Light is important in aircraft, but it is nowhere near as important as flying within CG, with the aircraft correctly rigged. Even in a Pietenpol, empty weight has very little correlation to cruise speed or handling in the air. Of all performance factors, rate of climb is the most affected by empty weight. But even here, it is not nearly the factor that excess available horsepower is. The lightest aircraft with 65 hp climbs about the same as a medium weight aircraft with a passenger will climb on 100 hp. Hangar flying and late night stories around the campfire are all part of the lore of aviation. This project is about pure measured facts. Building your airplane utilizing this data will yield a trustworthy, enjoyable aircraft. Once you're out there flying, you'll be part of the pageant of Pietenpols rather than the recipient of old wives' tales.

William Wynne
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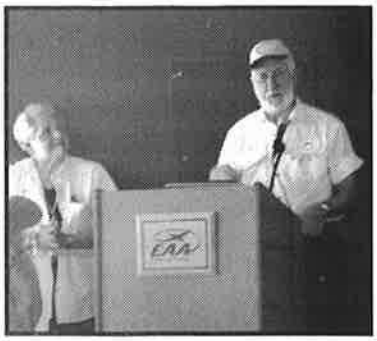
(Ed Note: In the January 1, 2011 BPANewsletter, the next article in this series will present a factual table of exact measurements and weight/balance information gathered from a number of different Piets. We expect at least three other articles to follow based upon different engine types. These tables are meant to be used primarily by people beginning to build their Pietenpol, although those with completed planes can also use them to check on "how did I do - and what can I do about it now?" Or – if you're happy with your Piet just the way it is – congratulations, you did a great job!)

Oshkosh AirVenture 2010

For the first time ever doing a Forum we were very heartened to have a full house of so many Pietenpol enthusiasts. We will definitely be planning on doing another one or possibly two Forums next year and have already recruited some well respected Pietenpol "experts" to help us out. Watch for more on this later.

The Forum itself was on the "Zen of the Pietenpol" and we had some fun talking about not the "How" to build a Piet, but the "Why". With questions from the audience we did also get down to some "How" subjects too. We had a great time doing the Forum and think from the response of the people attending that they enjoyed it too. So good Lord willing and the creek don't rise, (it sure did this year!) we'll see you in the Forum next year.



Mike Cuy picture

Pietenpols at Brodhead – 2010

by Lee Stenson (from white hat list)

N #	Owner/Pilot – Home base	Engine
N5DX	Warren Bordelon (Breaux Bridge LA)	C-65
N17WR	Bill Rewey (Verona WI)	C-65
NX29NX	Rob Bach (Burlington WI)	C-65
N34KP	Ken Perkins (Olathe KS) Richard Roller (Merriam KS)	Ford
N57TL	Tim Mickel (Scioto Mills IL)	O-200
NX294RB	Randy Bush (Lexington TN)	Corvair
N497AR	Lowell Frank (Okauchee WI)	C-65
N502R	Ryan Mueller (Chicago IL)	C-65
N518EP	Ty Daniels (Brodhead WI)	C-65
N899KP	Kevin Purtee (Crosby TX)	Corvair
N929DH	Dan Helsper (Poplar Grove IL)	Ford
NX972BP	Harold Johnson (Villa Rica GA)	Corvair
NX974BP	Bruce Laird (Villa Rica GA)	Corvair
N8031	Dan Yokum (St Charles IL)	C-65
N7035N	Dale McCleskey (Mt Juliet TN)	C-65
N10743	Bill Limatainen (Monroe WI)	Scout C-65
N12939	Perry Rhodes (Carlinville IL)	Ford
N13691	Frank Pavliga (Atwater OH)	C-65

Needless to say, Brodhead 2010 was a really good experience for all who attended, in spite of the weather. Thanks again to our hosts – EAA Chapter 431 and all their hardworking friendly members. Special thanks to our happy troupe of helpers who did such an exceptional job again this year, shown below with Mike Cuy, one of our biggest supporters.

Judy Weyers, Peg Draves, Mike Cuy, Doc Mosher, Betty Schoenberger, Dee Mosher pix by Hank Weyers

Continental CG Review

by William Wynne and Ryan Mueller

In this article in this series, we will examine the weight and balance of six Pietenpols built with 65hp Continentals. The level of data that we collected and a complete discussion of all the possibilities and ramifications for each aircraft could fill a sizable book. To keep the discussion focused, we have narrowed it to its simplest elements. However, it should be understood that the data generated here is not an approximation - it is airworthy data. Staying simple, we have eliminated fuel from the discussion. In almost all cases, having fuel in the plane has negligible effect, or it improves the CG situation. We want to examine the worst possible scenario, which is the plane very low on fuel. Some planes with fuselage tanks can be brought within CG with a full tank, but can become dangerously tail heavy with it burned off. This article will primarily discuss Aircraft #1 which belongs to Ryan Mueller of Chicago. The same W&B formulas and corrective actions can be applied to the other examples with the same mathematics.

The single most pertinent piece of information is the maximum acceptable pilot weight that will keep the plane within its 20" aft of wing leading edge CG limit. Looking at the data, we can see that Pietenpols, especially Continental powered ones, have been flown well aft of **Bernard's** limit of 20". I will not debate the merits of this, but let me offer two observations. I flew my own Pietenpol **N1777W** with the CG aft of 20", and later with it moved to the middle of the range. The difference was night and day. The airplane was far more stable and easier to land at slow airspeeds when it was within CG limits. Second, in 20 years of working with experimental aircraft, I have known many experienced pilots willing to fly an aircraft over gross, but almost none willing to operate one which is aft of the CG limit. It isn't a joke – I've met people who were later killed doing this. It's a free world, but I think anyone who encourages others to fly aft of any designer's limits is making a serious error in judgment, and is morally responsible for the results.

Table #1	FL	MML	MGL	PSL	WL
Aircraft #1	171"	31"	6.5"	76"	10.625"
Aircraft #2	165"	39"	6.625"	73"	9.9375"
Aircraft #3	172.375"	27"	7.125"	76.5"	13.125"
Aircraft #4	171.5"	30"	6"	75.75"	9.875"
Aircraft #5	172.5"	31"	8.625"	76"	13.625"
Aircraft #6	174.5"	33.5"	7.75"	78"	12.25"

FL = Fuselage length. From the firewall to the tail post.
MML = Motor mount length. Distance from the firewall to the prop flange of the engine.
MGL = Main gear location. Distance from axle centerline to the datum.
PSL = Pilot's seat length. From the firewall to the pilot's seat back.
WL = Wing location. Distance from the datum to the firewall.

Table #1 illustrates the dimensions of the six subject aircraft. All of the aircraft have 65 hp hand-prop Continentals. All the lengths are in inches, all the weights are in pounds. The datum is the leading edge of the wing. Note that the term "length" is simply a distance. The term "location" will always be the distance to the datum.

In Table #1, note that all planes except #2 are long fuselages. The PSL number is the distance from the seat back at the top longeron to the firewall. Fuselage length obviously doesn't cure CG issues. Aircraft #3 and #4 are equipped with a tail skid and no brakes. Note that all of the main axle locations are too far aft for aircraft that have brakes. The late model plans specify that the axle should only be .5" behind the leading edge. The lightest aircraft, #4 is testament to the builder's lightweight construction, and this aircraft has a metal prop that weighs at least 15 pounds more than a wood one. Aircraft #5 is equipped with wire wheels. The heaviest aircraft, #5, was actually a Grega.

Table #2	EW (lbs)	EWCG	PCG	Min PIC (lbs)	Max PIC (lbs)
Aircraft #1	686	13.4"	53.6"	29	135
Aircraft #2	707	12.7"	55.4"	40	146
Aircraft #3	659	10.3"	53"	81	192
Aircraft #4	590	12.4"	57"	37	122
Aircraft #5	756	10.8"	55.9"	76	192
Aircraft #6	731	14.7"	55.1"	6	110

EW = Empty weight of the aircraft.
EWCG = Location of the empty CG of the plane from the leading edge of the wing.
PCG = Pilot CG, the calculated location of the pilot's weight from the datum.
Min PIC = The minimum pilot weight that is required to have the pilot and aircraft have a flying CG of 15" from the datum in this aircraft.
Max PIC = The maximum pilot weight that is allowable to have the CG of the plane and pilot at 20" from the datum.

Looking at **Table #2**, study the Max PIC column. Each of these respective aircraft will be aft of their CG limit with a pilot who is any heavier. In most cases, adding fuel or a passenger has little effect. Planes with header tanks will still be aft of the limit with low fuel. From Table #1, we can see that the landing gear is very far aft, prone to nosing over in normal conditions. However, looking at the pilot weight limit and thinking about average pilot size, it becomes much easier to understand why aircraft do not nose over very often. The goal should be for every builder to operate his Piet within the designer's recommended limits.

Examining Ryan's plane, Aircraft #1, what would we do if we wanted to have the new aft limit and pilot weight to be 215 pounds? First, we could build a longer motor mount; second, we could move the wing aft. It is worth examining the relative merits of each approach.

Making a longer motor mount is a fairly easy calculation. When moving the engine forward, you will also be moving part of the cowling, the engine, propeller, etc. all forward. On a 65 Continental, this weight can be roughly stated as 190 pounds with a wood prop, 205 with a metal prop. On a 65 Continental, this weight is roughly 10" behind the prop flange. By addition and subtraction, the engine's CG location on the Mueller aircraft as it is sits at 10.6" + (31"-10") = -31.6". The number is negative because it is ahead of the datum. Table #3 shows the effect of moving the 190 pound engine package forward 4".

Table #3				
Moving Engine 4" Forward	**Pilot Weight (pounds)**	**Aircraft Weight (pounds)**	**Moment**	**CG**
Current Max PIC CG	135	821	16405	10.0"
Engine removed from current location		-190	6004	-31.6"
Engine installed 4 inches forward		190	-6764	-35.6"
Adjusted CG	135	821	15645	19.1"
New Max PIC CG	159	845	16936	20.0"

First, the 190 pounds is removed from its current location, then it is added back at the new location. The weight of 821 pounds is the 686 weight of the plane + a 135 pound pilot. Note that moving the engine 4" nets a small change. The engine weighs a lot, but it is a small fraction of the flying weight of the plane with a pilot in it. A four inch longer mount only buys a 1.1" change in the EWCG, and the new allowable pilot weight only went up 24 pounds. Moving the wing aft is an unusual W&B calculation. Very few aircraft can move the wing in relation to the fuselage. It has a radical change in CG because everything but the weight of the wing is moving, even the pilot's weight. Follow this example closely. The empty weight of the aircraft is 686 pounds. This consists of two

components: about 120 pounds of wing and 566 pounds of the rest of the airplane. The CG location of the covered wing by itself is about 24" from the leading edge. When calculating the change by moving the wing aft, you must treat the problem as if the wing is sitting still and you are mathematically moving the fuselage forward. This is because the wing's weight is not moving in relation to the CG change, but the rest of the plane and the pilot are.

Table #4				
Wing Moved 3" Aft	**Pilot Weight (pounds)**	**Aircraft Weight (pounds)**	**Moment**	**CG**
Current Max PIC CG	135	821	16405	20.0"
Current empty weight CG		686	9174	13.4"
Remove wing from CG		-120	-2880	24"
CG with wing removed		566	6294	11.1"
Reposition CG to account for wing moved aft		566	4585	8.1"
Return wing to CG		120	2880	24"
New empty weight CG		686	7465	10.9'
New Max PIC CG	205	891	17838	20.0"

Looking at **Table #4**, we can see that the plane's EWCG is 686 pounds at 13.4". The two parts of this are the 120 pound wing with its CG at 24" and the other 566 pounds of plane at 11.1". (The moments of the two parts total the same as the original moment.) If the 566 pounds is moved forward 3", its new location will be 8.1" aft of the datum. The new EWCG is 686 lbs at 10.9"; this is a big change. Notice that 3" of wing movement produces 2.5" of CG change. It is much more effective than making the mount longer. Keep in mind that the pilot's location will also move 3" forward. Because of this combined change, the plane that previously could only take a 135 pilot can now fly with one that weighs well over 200 pounds.

Everyone moving their CG forward by making the mount longer or moving weight needs to keep in mind that not correcting the main landing gear location is going to invite a nose over. Even with a small change, taxi test the aircraft very carefully to assess the difference. With a large change of several inches, let me offer that it is a lot of work to make new gear legs, but it less work than rebuilding your plane after it ends up on its back. Notice that moving the wing back effectively moves the landing gear location forward by the same amount. Ryan's gear is 6.5" aft of the leading edge. Moving the wing back 3" will move the location of the gear to 3.5" aft of the datum. Not ideal, but moving in the right direction.

Clearly, the optimum situation is to target the correct W&B during construction, and avoid having to correct anything. Most of the aircraft in the chart would benefit from having the wing located farther aft on the fuselage, and the landing gear located far closer to the leading edge. With careful review of the data above that most closely fits the aircraft you are building, you can plan the location of your wing, the length of your motor mount, and the layout of your landing gear so it need not be adjusted. Small variations can be corrected by moving the battery, or changing the propeller material. To build an aircraft you must learn a lot of new skills. Pilots may require a refresher on W&B calculations, but the concept isn't new; you were required to know it to get a license in the first place. In certified aircraft, you can be weak on W&B and get away with it. This same weakness extended to homebuilts can carry a severe penalty.

In my experience, builders who are blissfully ignorant of facts can get planes done quickly. Alfred E. Neuman is their hero and their motto is "What, me worry?" For thinking people, the story is different. People who suspect they have a flawed plan work at an ever slower pace as this reality sinks in. Conversely, builders who are on the right track and know it often build planes as fast as the ignorant. When the flying begins, the ignorant creation comes up for sale with a few hours on it, and quietly it's said, "That's the kind of plane and performance you get if the designer was a farmer." Conversely, the thinking man's plane flies beautifully, is a tribute to the designer, is not for sale at any price, and is well on its way to a lifetime of fine experiences. There are two paths, and one choice. Your move.

Corvair CG Review

by **William Wynne** and **Ryan Mueller**

In this third segment of the weight and balance articles we will look at Corvair powered Air Campers. At Brodhead 2010, four of the planes that we weighed were Corvair powered. All were electric start equipped. Conversely, both of **Bernard**'s 1960's Corvair powered aircraft were very simple hand prop installations. The modern Corvair installations are approximately 10 pounds lighter than an O-200 with starting and charging systems. If you are building your Air Camper using a C–85 or an O-200 with a full electrical system, the Corvair data presented here will be the closest approximation to your aircraft. It will be a much better guide than the A- 65 information presented in the last segment.

First, some questions and points generated by the last installment: Several people asked if the .5 inches behind the leading edge was a misprint for the axle location for an aircraft equipped with brakes. It was not a misprint. This came directly from the weight and balance information provided by Bernard with his 1960s Corvair update. To amend this, a very well researched builder pointed out that Bernard later wrote that this might be slightly far forward and suggested 3 inches behind the leading edge as an optimized axle location. Over the years, I have had a number of people pilots that I respect tell me they like every axle location from 0 to 5 1/2 inches. As a builder you have to keep in mind that such information does you no good unless it is specifically referencing a CG location of the flying plane at the same time. A plane with the axle located at 5 1/2 inches with a heavy pilot bringing this CG back to 20 inches may feel fine on braking. The same aircraft with a light pilot and the CG at 15 inches would feel dangerously close to going on its back in a heavy braking situation. Tall grass, rough ground, a quartering wind or a moment's inattention on the elevator can all be factors that could bite anyone. Common sense suggests following Bernard's recommendation of 3 inches. Common sense also suggests that you are far better off erring towards 0 inches then aft of Bernard's suggestion. You will be much less likely to unbuckle your seatbelt and bang your head on the ground.

CHART ONE	FL	MML	MGL	PSL	WL
Aircraft #1	172.5"	30"	5.5'	75.5"	10.625"
Aircraft #2	168.75"	32"	4.625"	79.375"	12.25"
Aircraft #3	172.5"	33"	5.5"	76.5"	12.625"
Aircraft #4	161.25"	28.5"	8"	70.75"	5.375"
	FL = Fuselage Length	MML = Motor Mount Length	MGL = Main Gear Location	PSL = Pilot's Seat Length	WL = Wing Location

Looking at Chart One, we can see that the first three aircraft are all long fuselage models. Aircraft #1 is a wood fuselage, bungee gear, and aircraft wheels and brakes. Aircraft #2 has a very roomy steel tube fuselage and aircraft wheels and brakes. Aircraft #3 has a wood fuselage, wire wheels with disc brakes on a bungee gear. The first three aircraft all have full electrical systems. They flew to Brodhead from locations 600, 900 and 1,000 miles away. Aircraft #4 features a short wood fuselage. The discrepancy on its weight is due to the fact that we weighed it uncovered, with a number of small items missing. It has traditional wire wheels and a straight axle. All of the aircraft use standard tailwheels.

CHART TWO	EW (lbs)	EWCG (lbs)	PCG	Min PIC (lbs)	Max PIC (lbs)
Aircraft #1	781	12.0"	55.3"	59	178
Aircraft #2	842	12.0"	53.1"	66	203
Aircraft #3	767	8.2"	49.3"	151	310
Aircraft #4	637	14.7	55.8	5	95
Note: Aircraft #4 weighed minus covering	EW= Empty Weight	EWCG = Empty Weight CG	PCG = Pilot Location from Datum	Min PIC = Minimum Pilot Weight for CG of 15"	Max PIC = Maximum Pilot Weight for CG of 20"

Looking at Chart Two, the first column shows the empty weight. A quick glance tells you that these aircraft are a lot heavier than their A-65 powered brethren. Factual, but not the complete story.

Bernard's original long fuselage Corvair powered Air Camper weighed 622 pounds empty. Several years ago I weighed the "last original", Bernards optimized long fuselage Corvair powered plane. On electronic scales it weighed 645 pounds. The first resides at Pioneer Airport at Oshkosh. The second belongs to **Bill Knight** and lives at Brodhead. Each of them

can be examined up close, and it is easy to see that they are very Spartan aircraft devoid of any frills. These aircraft are directly comparable to many A-65 powered ships. Such a comparison shows that a basic Corvair is about 25 pounds heavier than a hand prop Continental. The first three aircraft shown in the chart are certainly Pietenpols, but their builders tailored them to fit their own needs. Electric start, greater fuel capacity, and an enlarged fuselage give these aircraft greater utility and make cross-country travel easier. An easy analogy for people to understand is that J-3 Cubs and PA-18 Supercubs look alike, and are aerodynamically very similar, but they do different jobs well, and they have different empty weights. We are all schooled in the beginning of our days in aviation to think of weight as the enemy. This is fundamentally true, but over time you learn to recognize the difference between unnecessary weight and the increase in empty weight that attends an increased capability. All of these aircraft can be started effortlessly and can climb out with a passenger on a hot day with authority. Serious builders will do well to carefully consider these issues. Simplistic comparisons of three digit numbers are best left with stories told late at night around the campfire.

As discussed in the previous paragraphs, the landing gear on each of these aircraft could be located a little further forward. The fourth aircraft would obviously benefit from having the wing moved backwards. This would help correct the landing gear location. Keep in mind that aircraft always have their CG move backwards when they are covered. A typical cover job on an aircraft the size of an Air Camper weighs 35 pounds. Almost all of this weight is aft of the CG limits. The first three aircraft show very good capability to lift a full-size pilot and still be within CG. Study the differences between Aircraft #1 and Aircraft #3. Notice that the wing location being moved 2" aft on Airplane #3, gives the plane the capacity to stay in CG with a pilot that weighs 130 pounds more. Part of the difference is also generated by Aircraft #3 having a motor mount that is 3 inches longer. However, the math in the previous article clearly shows that the wing location is generating most of the 130 pound capability difference.

Aircraft #2 has to be looked at as a separate creation. A quick glance at the chart shows that it is the heaviest aircraft we weighed at Brodhead 2010. Externally, it looks exactly like other Pietenpols and it exhibits a very high degree of finish work. But a close study of the plane reveals a number of changes to the original design that tailored this particular aircraft to the dreams of its builder. It has a 28 inch wide steel tube fuselage and high-capacity fuel tanks. Study of the lift struts, landing gear, cabanes and tail surfaces reveal very robust construction. If I were going to do a snap roll or land on a very rough field in any Pietenpol, I would choose this one. This plane flew up from the South in the company of an identical sister ship. They flew on to Oshkosh before making the long flight home. Watching these aircraft fly the pattern at Brodhead, nothing about their performance suggested that their empty weight was an impediment. It's a good lesson that really simplistic weight comparisons rarely offer much practical insight. Because of its unique nature, it would be wrong to utilize the numbers from this airplane in a steel tube versus wood fuselage discussion nor even a simplistic comparison of engine weights. The ship and her sisters are unique and have qualities well demonstrated on their long flights.

An overview of the data presented in both tables shows that our favorite aircraft design has less CG issues with today's heavier pilots if the engine in the plane is a Corvair, electric start Continental or a Ford. The airframe was originally designed around engines of this weight category. By default, builders choosing one of these engines will have less to worry about than their brothers operating A-65s. But the whole point of these articles is to bring builders up to speed on CG issues so that they can make educated decisions on the location of their aircraft components. If default and dumb luck were the previous methodologies, hopefully we can transition to an era where reliable data, calculations, and experienced council all work to allow each builder to use the engine of his choice and still operate the aircraft within its original CG parameters.

As the arrival of Spring brings tolerable temperatures for the workshops of builders across the country, renewed progress can be made on each builders creation. Armed with proven information and a good understanding, the fitting of components can be done with confidence. This confidence is a vital element of progress. Without it most builders proceed at an ever slower pace, awareness leading to concern, then to unspoken worry. The pure antidote for this is having a plan that you know you can count on. Every part made will serve your eventual goal. The hours spent in the shop are pleasurable because they're all well invested and worry free. Your success is inevitable if you utilize data that has been proven successful in numerous other aircraft. This is how physics and aerodynamics work. They are not fickle and they do not break their promises. Their beauty lies in the fact that they are equally willing to serve you with complete loyalty just the way that they served Bernard throughout all his years of flying. They are uncompromising but they are much better and more reliable friends than dumb luck, hangar stories and old wives tales.

Ford Model A CG Review

by **William Wynne** and **Ryan Mueller**

In this installment, we get a look at the most traditional of the Pietenpols, the Ford powered ones. If you have not yet seen a Ford powered Pietenpol takeoff from a grass strip and climb into the air, then you need to make sure that this particular item is on your aviation "bucket list." Owners of antique cars know that it is very difficult to go out and enjoy them in the company of new vehicles.

It's not just the pace of modern traffic, it's the entire experience of driving something traditional and having to pull up next to an idiot in a Prius with a cell phone headset. Thankfully, antique aircraft can be enjoyed in their element without reservation. Watching a Ford powered ship take off at dawn from Brodhead allows you to squint your eyes just slightly and place yourself back in the earliest years of **Bernard**'s work with our favorite aircraft.

Ford powered Pietenpols are an experience that is far removed from the rest of general aviation. Even people with considerable time around light aircraft are surprised and captivated the first time they see one in operation. From my own memory, I can confess that they were a lot quieter, and worked a lot better than I would have guessed. There are technical reasons for this. The low noise despite an exhaust system measured in inches rather than feet is related to the short duration of the camshaft and the motor's flathead design. The functional performance of the engine has its roots in three primary places. First, it is a full 200 cubic inches, and while they may be working at a sedate pace, this is still a lot of cubic inches. Second, flyers of these engines have their act together, and I have never seen one of these aircraft in poor tune or handicapped by a bad propeller match. The third factor is directly related to the subject of the series. Simply put, Ford powered Pietenpols are nowhere near as heavy as people suspect.

CHART ONE	FL	MML	MGL	PSL	WL
Aircraft #1	163"	29"	7"	69.5"	7"
Aircraft #2	162.5"	26"	9.125"	71.25"	7.25"
Aircraft #3	164"	31.5"	9.75"	72"	7.75"
	FL = Fuselage Length	MML = Motor Mount Length	MGL = Main Gear Location	PSL = Pilot's Seat Length	WL = Wing Location

Looking at Chart Number One, we can see that all three aircraft are short fuselage birds. The main landing gear location on these aircraft is consistent with the early plans for straight axle aircraft that were not equipped with brakes. The airframes of these aircraft were built closer to the plans than any other group we measured at Brodhead.

CHART TWO	EW (lbs)	EWCG	PCG	Min PIC (lbs)	Max PIC (lbs)
Aircraft #1	735	11.4"	55.1"	65	181
Aircraft #2	734	10.2"	57.1"	83	194
Aircraft #3	677	9.6"	56.3"	89	194
	EW= Empty Weight	EWCG = Empty Weight CG Location from Datum	PCG = Pilot Location from Datum	Min PIC = Minimum Pilot Weight for CG of 15"	Max PIC = Maximum Pilot Weight for CG of 20"

Looking at Chart Number Two, we can see that these aircraft are much lighter than people would guess looking at a cast iron Ford engine. Aircraft Number One and Two both have wire wheels and straight axle landing gear. Both of these aircraft exhibited a high degree of finish in detail. While Ford engines are all hand prop installations, and thus the empty weight does not include a battery or starter, I would still consider 735 pounds reasonably light, and the first two aircraft did not have to strip down to spartan levels to get it. The third aircraft is truly a lightweight bird. Its primary difference from the first two is that it utilizes a J-3 Cub style landing gear and tires. These are significantly lighter than wire wheels on straight axle installations, and I believe this accounts for most of the difference between this plane and the first two aircraft. All three of these aircraft demonstrated good performance at Brodhead.

Ford engines are in the same thrust output range as a 65hp Continental, although the installation is obviously heavier. In person these three Ford powered aircraft exhibited some elegant simplicity and a respect for drag and rigging that is far above average. These factors all combined to show that for the right builder a Ford is still a viable powerplant.

All the data in the tables is sharp information that would allow anybody installing a Ford to have a running start at a good weight and balance. There is also another more subtle lesson if you study the numbers closely. Notice that Aircraft Number One has a longer motor mount and a pilot seat location that is actually slightly ahead of that of Aircraft Number Two. Their empty weights are nearly identical, which would lead you to guess that Aircraft Number One would be able to fly with a heavier pilot.

However, the calculation for the weight and balance demonstrated that Aircraft Number One's empty weight CG is actually 1.2" aft of the Number Two aircraft. This gives Number Two a slight edge in its ability to carry a heavier pilot and remain in CG. This can be explained in a number of ways. The wing on Aircraft Number Two is located slightly further back, and the builder may have put a lot of attention into making sure that the tail surfaces and the tailwheel were exceptionally light. The lesson here is that details matter, and builders would do well to study the examples closely and hedge their bets a little bit, biasing their wing installation and motor mount length toward the forward end of the CG range. In this way, finish work or a later installation detail, such as a change in tailwheel design, will not put them in an aft CG condition.

As a closing note on this weight and balance series, I'd like to dispel one old misconception that's been around for a while. The most common rationalization that builders offer to themselves after finding out that their aircraft has an aft CG problem goes like this:

"I hear Bernard was a fairly light guy, and thus his plane probably had a forward CG, he probably didn't know anyone who weighed 210 pounds like me, but if he did, he would have thought it was ok for me to be flying slightly aft of the 20" CG limit he put in the plans."

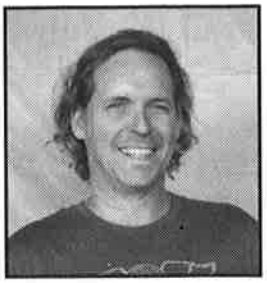
We have direct evidence in Bernard's own writing that shows the above statement to be a dangerous fantasy. A weight and balance that he conducted while setting the wing on his 1970s Corvair powered ship shows that he did exactly such a calculation for a 210 pound pilot, and he moved the wing until a 210 pound pilot would have a flying CG of 17 inches. He was well aware that pilots were this big, and the data clearly shows that he was willing to go to a significant amount of effort to ensure that a pilot in this weight category would be operating nowhere near the aft limit of his design. It is human nature to rationalize away things that would otherwise require labor to correct. But given the actual weight and balance information from the designer's own calculations and his stated CG range, I don't think that any rational argument can be made for operating aft of the limit.

If we asked every Pietenpol builder at Brodhead, to a man they would all say that they would like their aircraft to be a tribute to Bernard and pay homage to his legacy. Bernard built a wide variety of examples of his design. But, modern builders frequently feel the need to explain or justify their modification at length. I believe some of this is driven by the awareness that many modern designers like **Rutan** and **Monett** detest modifications to their airframe designs. We have no evidence that Bernard felt this way. Nothing I have ever heard about the man indicates that he had the same type of control issues that characterize a lot of successful modern designers. The evolution in Bernard's aircraft over many decades speaks volumes to me about his open-mindedness. I'm guessing that he would have very little heartburn over many of the small modifications that builders debate at great length. This said, I'd be willing to bet some serious money that the single issue that Bernard would be uncompromising on would be flying the airplane within its CG envelope. It is ironic to me that a guy proposing flying his plane at 21" doesn't generate the same type of negative reaction as a different builder proposing a slightly revised airfoil or wing span.

At Pioneer Airport in Oshkosh, on the wall of the Wittman hangar, hangs a photo taken at Oshkosh in the early 1970s. It is a black-and-white that has 10 of America's greatest light aircraft designers standing together. Bernard stands between **Steve Wittman** and **Matty Laird**. If you study the photo closely, the dress, posture and expression of the men speak volumes about them. It is very easy to imagine **Paul Poberezny** calling up Bernard in Cherry Grove a few days earlier and asking him to come over for the event that is captured in the photograph. The image in the photograph is of a man who was quietly confident and unassuming. It fits my image of Bernard as the social antithesis of Burt Rutan. Keep this image in mind when you look at the weight and balance paperwork included with the Pietenpol plans. Think of this same relaxed man sitting at the typewriter working on the weight and balance form. It has a lot of information, all in small print. At the very bottom there is a line about the aft CG limit. I picture him as pausing for a moment before depressing the shift key on the typewriter and typing in all capital letters the sentence, "**NEVER FLY WITH THE CG AFT OF 20 INCHES**." It is a clear warning from a man who didn't make a lifestyle of telling other people what to do. If you're going to honor the man's legacy, maybe this is the sentence to begin with. **You**.

Overview of the Brodhead CG Review

by **William Wynne**



In the previous four issues of BPAN, we covered a lot of CG issues using the data we developed from using electronic scales to measure 13 Pietenpol Air Campers at Brodhead 2010. At Brodhead 2011, we had a chance to get the weights and measurements on 11 additional Air Campers. This new batch, measured on the same scales, contains a broader variety of powerplants. The new group adds a Lycoming O-145, a Rotec radial, and a Funk engine to our data collection. We will use the information from these aircraft for a new set of articles in future BPA Newsletters. But before jumping into more calculations, it is worth pausing to remind ourselves what the target of the exercise was in the first place.

On the opposite page is the Weight and Balance sheet for **Bernard Pietenpol**'s personal aircraft, **N7533U** built in 1968. This sheet is part of the Long Fuselage and Corvair supplemental drawings sold by the Pietenpol family. Today, this aircraft resides at Pioneer Airport, the site of the EAA AirVenture Museum in Oshkosh, WI. It stays in Bernard's hangar, which was brought over from Cherry Grove, MN by a group of volunteers to its present location. The plane is fenced off by a low set of theater ropes, but you can get a very good look at it. It was the first purpose-built Corvair powered Air Camper, and I am pretty sure it is the original long fuselage Piet. Most aircraft designs are a period piece of their times, stagnantly locked to a date. N7533U is at the opposite end of the spectrum from this. It obviously has Air Camper DNA, but it represents how Bernard chose to build his design after 36 years of working to refine it. For this reason alone, this airframe deserves your close study.

Bernard left behind a lifetime of work, much of which has been studied and emulated. Builders intrinsically understand that he was a very clever man, even when he was young. While this is certainly true, I can make a very good case that the man kept learning, evolving, and distilling his thinking all along. Many people miss this because they focus on Bernard's efforts before WWII, and never contrast them with his later work. I am not suggesting that every new Piet built should be a clone of N7533U or *The Last Original*.

I like Ford powered planes, and straight axles, and aircraft that look like they just came out of the *Flying and Glider Manual*. Rather, I think that every builder, especially people working on pre-war period pieces, should emulate the technical refinements that Bernard put into his later planes. Specifically, I believe every builder should get a good look at the operational CG range of this aircraft and its landing gear location.

Notice that the main landing gear axle is actually half an inch ahead of the leading edge of the wing. The mean location of the axle on Piets we measured in the past year is almost 7" further back. This is the single biggest contributor to the number of aircraft that have ended up on their backs in recent years. There is no good argument for putting the landing gear in the location shown in the 1932 drawings when this document shows where Bernard thought it should be after three-and-a-half more decades of building his design. It will not detract from the looks of a straight axle, spoked wheel airframe, to have the axle located near the leading edge. Having a plane on its back always detracts from its appearance.

On the weight and balance front, notice that this plane weighs only 622 pounds, even with a Corvair engine. Bernard uses a different math formula, but if you check the numbers with common notation, they are correct. The weight includes 49 pounds of fuel in a header tank. Even if you mathematically remove this, N7533U can still fly with a very heavy pilot without going out of the aft limit. Bernard's second calculation is with a 210 pound pilot, and it is still at 16.94". If you remove the header tank fuel, the CG only moves to 17.64". To get the plane to its 20" aft limit, the pilot needs to weigh 270 pounds. Bernard knew this plane better than any man, he had nearly 40 years to refine his thoughts when this sheet was typed, and we can say with assurance that this is how he thought the plane should be set up. The bottom line on the sheet states that the **CG "SHOULD NEVER BE OVER 20"**. Clearly the plane can handle the weight of the biggest pilot that would fit in the cockpit if the wing is in the correct location. This historical data demonstrates that there is no justification for accepting an aft CG.

PIETENPOL FIELD

D is .5" back of weighing point

L equals 158.5"

R weighing point

1966 PIETENPOL AIR CAMPER POWERED WITH A 110-66 CORVAIR ENGINE

(D) Actual measured horizontal distance from the main wheel weighing point to the datum. Datum is the leading edge of the wing on this aircraft.

(L) Actual measured horizontal distance from the rear weighing point to the main wheel weighing point.

(R) Weight of the tail at the weighing point. Tail weight is weighed 1.5 forward of the tail post.

Empty weight and 1 Gal. oil		Plus 8 Gal. gas & 167 Lb. pilot	Plus 8 Gal. gas & 210 Lb. pilot
Right wheel	296	377	397
Left wheel	296	377	397
Tail weight	30	84	98
Total weight (W)	622	838	892

$C.G. = D + \frac{R \times L}{W}$

$= -.5 + \frac{30 \times 158.5}{622}$

$= -.5 + 7.64$

$C.G. = 7.14"$

$= -.5 + \frac{84 \times 158.5}{838}$

$= -.5 + 15.89$

$= 15.39"$

$= -.5 + \frac{98 \times 158.5}{892}$

$= -.5 + 17.44$

$= 16.94"$

C.G. (measured from leading edge) SHOULD NEVER BE OVER 20"