THE BD-5 BULLETIN

A quarterly publication by and for BD-5 enthusiasts

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Inside this Issue

The BD-5 Bulletin
Official Publication the BD-5 Network
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Expo 2001: October 27-28, Meacham Field, Fort Worth, Texas!

A final decision has been made as to the location of the BD-5 Expo 2001. Because of the great time we had holding the 2000 Expo at the Vintage Flying Museum in Fort Worth, Texas, this year we're going to do an encore at the same facility! So, if you missed Chuckie the B-17G Pathfinder, Jim Bede's jokes and the excellent BBQ dinner, here's your chance to make up for it! If you want to see what it's about, read on!

We have reached an agreement with the Vintage Flying Museum at Fort Worth's Meacham International Airport (FTW) as the location for this year's Expo. The facility is located at the south end of the field, which in itself lies approximately 20 minutes west of DFW airport.

The museum has a huge hangar facility, and in it they have some fantastic examples of all kinds of aircraft, from ultralight surveillance birds to the famous B-17G, named after Chuckie Hospers, wife of Doc Hospers, founders of the museum.

An information sheet accompanies this edition of the Bulletin. In it you will find how to get to Meacham, where to stay and what we'll do. This year there will be a registration fee of $40 for the Expo if paid in advance, $45 at the entrance (1/2 price for kids under 16). It will be used to cover the organizational expenses of the Expo, as well as provide the Museum with an appropriate compensation for the use of their facilities in the form of a donation. We will also be providing coffee and snacks during the activities, and a Saturday evening Texas-style BBQ, all included in the price.

All in all we hope to provide you a very interesting and exciting Expo. See you there and don't forget to RSVP using the form on the last page of this issue of the Bulletin.

Call for Authors

Do you enjoy writing and passing on information for the enjoyment of others? Do you have a personal computer or typewriter? If so, here's your chance to gain notoriety and fame in the BD-5 community.

The Bulletin needs authors to write articles about subjects related to the BD-5. Some ideas: construction tips, avionics, electrical systems, flight test reports, historical tidbits and just about anything else you can think of.

Interested? Email Juan Jimenez at flybd5@hotmail.com or mail your manuscript to the address listed on the bottom left hand corner of this page. You do the writing and Juan will take care of the editing!

Combined Issues

You will notice that this issue is numbered 27 **and** 28. We have combined much material into one issue in order to catch up from the issue 26 delay. However, this issue counts as **one issue** for subscription purposes.

BD-5 Expo 2001 Information!

The dates for the BD-5 Expo 2001 will be October 27 and 28, 2001. The location of the Expo will be the **Vintage Flying Museum**, which is located off the southeast side of **Meacham Airport (FTW)** in Fort Worth, Texas. This location is perfect for us because it is **huge**, centrally located and accessible both to GA aircraft and close to Dallas/Fort Worth International Airport.

There will be a registration fee which will include:

- Entrance to the Museum Facilities and Expo areas.
- Attendance at all the Speaker Events and exhibits.
- Coffee, donuts and snacks during the day.
- A Texas-style BBQ dinner early Saturday evening.

The Vintage Flying Museum is home to an outstanding collection of warbirds and other types of aircraft, including **Chuckie**, an airworthy B-17G in excellent condition. A portion of the proceeds from the Expo will be donated to the museum in exchange for the use of their facilities.

The closest major airport is **Dallas-Fort Worth International Airport (DFW)**, which is located only a few miles from Meacham Field. If you are flying to the Expo in your own aircraft, Meacham has excellent runways and facilities, including a number of prestigious FBO's, and the control tower is staffed 24 hours a day. Detailed information about Meacham Field can be obtained on the Internet at: http://www.meacham.com

There are literally dozens of hotels and motels within a 5 mile radius of Meacham Field. The rates are all reasonable. Some of the facilities in the area:

- **Fairfield Inn**, 3701 NE Loop 820, Fort Worth, TX, (817) 232-5700, 3.6 mi. (Rates include breakfast) **This is where most people stayed last year!**
- **Hampton Inn**, 4681 Gemini Pl, Fort Worth, TX, (817) 625-5327 , 2.2 mi.
- **Holiday Inn**, 2540 Meacham Blvd, Fort Worth, TX, (817) 625-9911, 2.2 mi.
- **Hilton**, 4400 North Fwy, Fort Worth, TX, (817) 222-0222, 2.3 mi.
- **La Quinta Inn**, 4700 North Fwy, Fort Worth, TX, (817) 222-2888, 2.4 mi.
- **Comfort Inn**, 4850 North Fwy Fort Worth, TX, (817) 834-8001, 2.4 mi.
- **Best Western Inn**, 6700 Fossil Bluff Dr, Fort Worth, TX, (817) 847-8484, 3.0 mi.
- **Studioplus**, 3261 NE Loop 820, Fort Worth, TX, (817) 232-1622, 3.1 mi.
- **Residence Inn**, 5801 Sandshell Dr, Fort Worth, TX, (817) 439-1300, 3.1 mi.
- **Courtyard By Marriott**, 3751 NE Loop 820, Fort Worth, TX, (817) 847-0044, 3.6 mi.

Most of these motels/hotels should be able to provide you with transportation to Meacham Field. Some have shuttle service to and from DFW Airport, but I suggest you rent a car if you want to be transportation-independent.

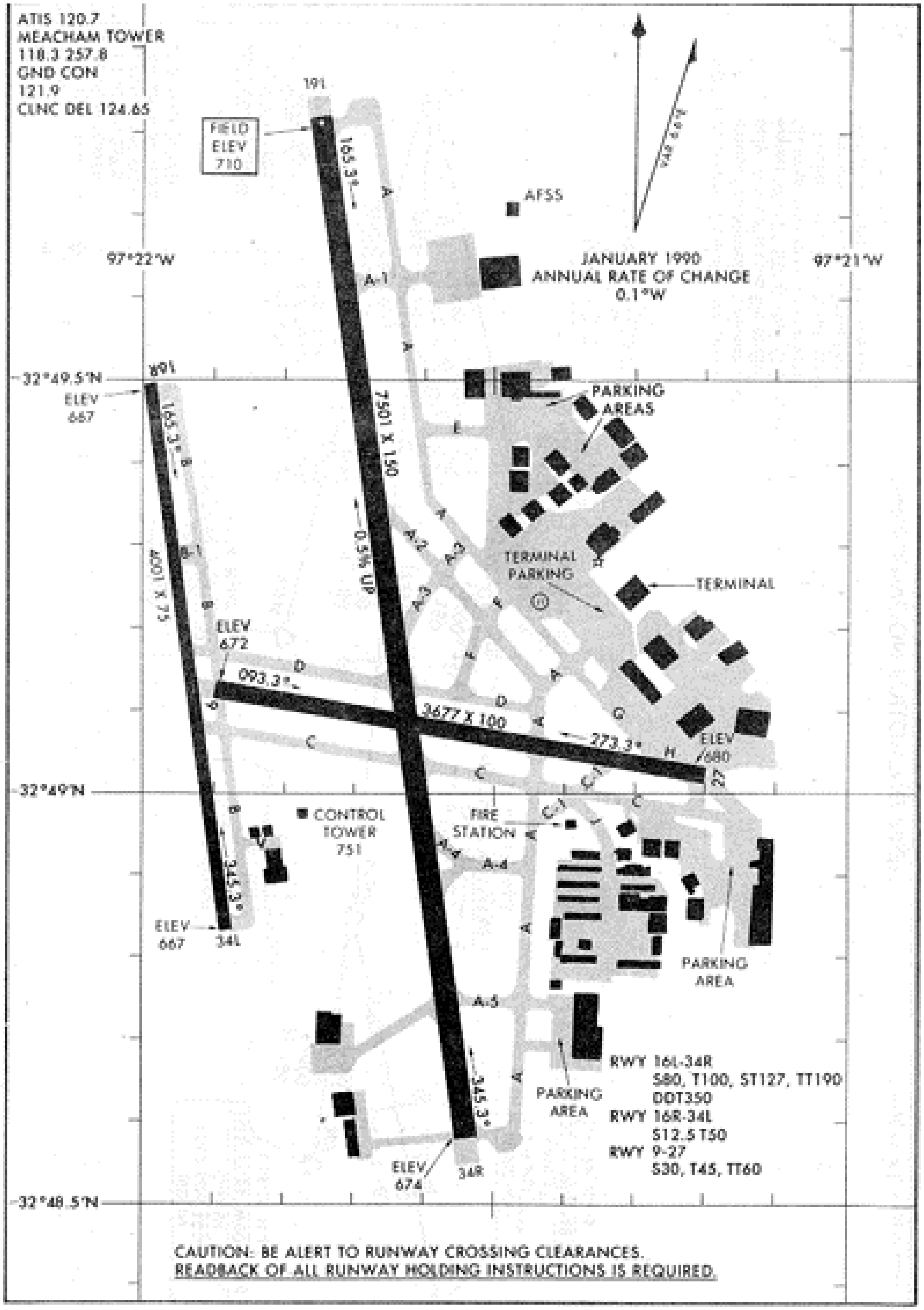
On the next page you will find an airport diagram of Meacham Field. Find the beginning of Rwy 34R at the bottom of the diagram. To the right of it there is an area identified as "Parking Area" in front of taxiway "A". The building in black within the parking area is the museum's hangar facilities. There will be plenty of parking space along the south side of the large hangar. Please do not block the hangar doors.

At the time the Bulletin was produced, the tentative speaker list is as follows:

- James Bede, Bede Corp.
- Corky Fornof, "Octopussy" BD-5J Stunt Pilot
- Gerry Kauth, BD-5 Drive System Builder
- Rich Perkins, Founder, BD-5 Network and BD-5 Bulletin

To RSVP fill out, clip and mail the coupon on the last page of the Bulletin with your payment to the address on the coupon. The pre-registration fee is $40 per person, $20 for children under 16. This fee includes the Expo presentations, coffee, snacks and sodas and the Texas-style BBQ on Saturday afternoon.

If you are planning on bringing an aircraft to the Expo, regardless of whether or not it is a BD-5, or if you are planning to exhibit a product or products, there will be no entrance fee, only a $10 fee to cover the cost of the dinner. However, you must let me know prior to October 1st so that I can plan ahead for your arrival.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ELEV 680
CONTROL TOWER 751
FIRE STATION
ELEV 667
34L
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S80, T100, ST127, TT190
DDT350
RWY 16R-34L
S12.5 T50
RWY 9-27
S30, T45, TT60
CAUTION: BE ALERT TO RUNWAY CROSSING CLEARANCES.
READBACK OF ALL RUNWAY HOLDING INSTRUCTIONS IS REQUIRED.

A Critique of the BD-5 Concept: Part II

By Seth B. Anderson, *EAA's* ***Sport Aviation Magazine****, September 1986 pps. 43-47, Reprinted with permission.*

Handling Qualities and Operating Problems

Next, what is the BD-5 really like to operate and fly? Does it require exceptional skill to safely operate this aircraft which **appears** to be short-coupled, oversensitive in pitch and difficult to land because you are sitting only 12 inches from the ground? Basically, the answer is **no**, although the BD-5 concept has some peculiarities which require attention. Some feeling for this reasoning can be obtained by going along for a typical flight. My comments are based on three flights in the BD-5J at Newton, Kansas, and over 50 hours in my BD-5B based at Watsonville, California.

First, do you have your crash helmet on? I'm a firm believer in head protection and would never fly in any small cockpit where your head is close to the canopy, particularly in high performance aircraft. After a routine ground preflight check, the BD-5B aircraft is pushed to a location where a short taxi run can be made to the active runway. Not only does this provide some needed exercise (the aircraft only weighs 500 lbs.), but it is necessary to minimize engine running time on the ground because of cooling constraints. For a normal temperature (75 degrees F) day my aircraft has only five minutes from engine startup until coolant temperatures approach 200 degrees F – an arbitrary maximum limit for starting the takeoff run. Ground cooling can be a problem for any pusher configuration because airflow from the propeller is minimal. Pusher designs with air-cooled engines may be more forgiving because they don't have coolant to eject. In addition, on my aircraft, a large torque load is applied immediately to the engine on startup because a high pitch (48x77) propeller is used. A cooling fan would ease this operational problem but was not used because of the added weight and reduced cooling duct efficiency. A controllable pitch propeller would also alleviate the ground cooling problem because less torque is required in the low pitch setting to develop thrust for taxiing. However, available models would add almost 25 lbs and cost almost as much as the original BD-5 kit. At the outset, ground cooling on my BD-5B may appear a formidable operational problem, but in fact, it is only a slight inconvenience. If incoming traffic unduly delays takeoff, the engine can be shut off which removes the propeller torque load and the engine immediately starts to cool by convection and radiation.

Directional control when taxiing is difficult for the BD-5 configuration due to the free castering nose wheel steering, narrow gear and low rudder effectiveness (no slipstream). Compared to the BD-5J, the weathercock tendency is accentuated in my aircraft by the addition of a ventral fin (tailskid) and large side force associated with the high pitch propeller. A successful operational technique to start taxiing in a strong crosswind is not to fight the weathercock tendency but rather help the aircraft around into the wind and use the built-up rotational energy to rotate the aircraft through approximately 300 degrees heading change. Power is added for forward motion as the aircraft rotates toward the intended taxi direction.

Take-off techniques are somewhat different compared to a conventional GA aircraft (Cessna 150, etc.) First, because of the low seat height, apparent speed is accentuated and you think you're going 100 mph when the airspeed indicator shows 50 mph. Second, the side stick controller requires adaptation time – what position should it be held during the takeoff run – neutral, yes, but where's neutral? One of the basic problems of the BD-5 is rotating for takeoff at a reasonable speed. The problem is accentuated at forward CG locations and by the relatively high thrust line (about the vertical CG). In addition, or all pushers there is a lack of slipstream to increase pitch control effectiveness. The side stick controller should be held in an assumed neutral position with a relaxed grip until takeoff speed (roughly 70 mph) is reached. Early application of nose-up control is not desirable since the added drag will increase the takeoff run appreciably. In assessing takeoff progress, I concentrate on watching airspeed, manifold pressure and engine RPM. If I see 40" Hg and 4,000 RPM and the engine sounds OK – I go for liftoff. With ½ flap deflection and mid-CG location, only a modest pull force is needed to rotate for liftoff. Immediately after liftoff, brakes are applied, gear retracted and engine power is reduced to 30" Hg. Although other Honda-powered BD-5's have used as much as 60" Hg and 6,000 RPM for takeoff. (which essentially doubles the HP), but I feel more relaxed with lower power knowing that the engine and drive system are operating only slightly above their nominal design limits. Incidentally, I found the BD-5J takeoff performance to be objectionably poor with takeoff runs near 3,000 feet because of the low T/W (about 0.2) available. Even with a very high pitch propeller, my Turbo Honda configuration is airborne in about 1,200 feet. Although initial acceleration is low, a marked increase in thrust can be felt at about 40 MPH when the prop blade unstalls.

Pitch controllability of the BD-5 is a safety of flight concern if power is lost during the takeoff run because a pitch trim change can place the aircraft in close proximity to stalling AOA. This nose-up trim change with power reduction occurs for any aircraft (pusher or tractor) if the thrust line is above the vertical CG. The trim changes associated with gradual power changes are negligible in the BD-5 requiring only modest forces to maintain a given attitude. A **sudden** thrust change due to a failure in the drive system or engine stoppage is more serious because of the rapid pitch dynamics, characteristic of this short-coupled (low inertia) configuration. The pilot's response is basically not quick enough to prevent a rapid increase in AOA and loss of flight path control can occur if the pilots fails to maintain a safe stall margin. **[Ed.: <u>All BD-5 pilots</u> should be very aware of this behavior and be mentally prepared to compensate for power loss on <u>every</u> takeoff. Remember, <u>always fly the aircraft first</u> and then troubleshoot the problem.]** During one of my early high speed taxi runs, the aircraft was lifted off and leveled out at about 5 feet of altitude. Power was reduced to idle to land, however, the engine stopped and sure enough, even though I was prepared (mentally) for the pitch change, the aircraft achieved an altitude of about 10 feet in a semi-stalled wing-rocking position. Fortunately, lateral command in my aircraft was adequate to make a safe touchdown.

What about Pilot-Induced Oscillation (PIO) tendencies associated in part with adaptation to the use of the side controller? As with several well-known US military jets, PIO is forever lurking in the background when high frequency pitch response is basic to the aircraft design. Throw in some undesirable mechanical control characteristics such as high friction, free motion in the control linkage, low pitch static stability (rearward CG position) – and a roller coaster ride could be experienced on your first liftoff. I had "flown" the BD-5 simulator in my pre-flight checkout for the BD-5 jet flights and felt comfortable with the side stick controller after about 10 seconds of pitch control inputs. Even so, I encountered a slight PIO when I first flew the BD-5J. The PIO problem can be "triggered" by holding the controller too tightly when pulling the gear lever back (approx. 20 lbs of pull) for gear retraction. Not a serious problem if you merely relax your stick grip momentarily – after all, it is the pilot who is inadvertently causing the oscillation to persist.

Pausing a moment to comment about the side arm controller used in the BD-5 – it is **excellent.** PIO tendencies are non-existent on my BD-5B. The well-harmonized pitch-roll response is a positive feature that deserves honorable mention for the BD-5 designers. The crisp response and light forces are such that all one essentially has to do is "think" about initiating a turn maneuver and it happens essentially with no apparent control displacement. Combine this with the good forward visibility (no propeller disc) and you feel like a jet fighter pilot.

As you explore the aircraft's capabilities in climb-out and up-and-away flight, one quickly perceives that although the aircraft is very responsive to pitch control inputs, it is also well damped; in fact, almost deadbeat (a calculated damping ration of about 0.7). The phugoid motion is only lightly damped but easily controlled since the period is over 30 sec. Stick free static stability (stick force variation with airspeed) is positive and quite satisfactory. Even though only a few pounds of stick force is needed to change airspeed over +/- 25 mph, precise control of airspeed is possible. Stick fixed stability (elevator position variations with airspeed) is also positive, but gives the impression of being neutral in that airspeed can be changed with no perceptible side stick controller displacement. In a sense, these "force" stick controller characteristics are similar to that used on the General Dynamics F-16A fighter.

A word of caution regarding flying the BD-5 with even small amounts of negative stability – it could be catastrophic! Although many types of aircraft have been flown successfully with negative pitch stability, exceptional pilot skill is required and the oscillatory period (time to double pitch attitude) must be relatively long. The BD-5 would be essentially uncontrollable if flown at negative static margins because its short period frequency response and small "apparent mass" make it too responsive. Even with the CG located within the nominal limits, adding a VOR antenna near the nose of the fuselage will deteriorate pitch stability to an unstable mode. In the same note, a high pitch propeller greatly improves static stability because of the added side force. At the same CG position, the BD-5J is less stable than the BD-5B.

Pitch trim changes due to gear of flap actuation are relatively small in an aerodynamic but not in a pilot-effort sense. The cleverly designed gear actuation system is completely mechanical, requiring the pilot to use the inertia of the gear to counter the aerodynamic loads. However, to assure full extension or retraction, the gear handle must be moved briskly, requiring an initial "breakaway" force of 20 to 25 lbs. This gear actuation technique, although acceptable, is different and requires some experience to feel comfortable.

Maneuvering flight characteristics are excellent because of the quick response and low stick forces required. The aircraft is stable throughout the load factor range with increasing pull forces required to increase G in the linear relationship. These carefree maneuvering characteristics were not completely without fault, however, as noted in the following incident. During a photo flight, I was overtaking the photo aircraft (a Cessna 175) at a high rate of closure. I elected to reposition and reduce speed by executing a quick 360 degree turn. I banked sharply and abruptly applied back pressure – instantly all reality with the outside world disappeared and I "woke up" in a slightly banked, nose down attitude. I glanced at the G-meter which indicated slightly over 3 G's. I thought, "What's going on here… I know I'm getting old, but…" There was no narrowing of field of vision, no gray-out – just instant loss of consciousness. The next day, an article in Aviation Week discussed a new phenomenon known as GLC (loss of consciousness due to G) which had been experienced by fighter pilots in highly maneuverable aircraft such as the McDonnell Douglas F-15 and the General Dynamics F-16. The loss of consciousness was attributed to the rapid G onset without cues such as out-out or blackout which occur when G's are applied slowly. The next week I flew the BD-5 in turning maneuvers and noted that I could go to about 3.5 G's before some narrowing of vision occurred. In these turns I tightened my stomach muscles and applied the G load gradually. However, when G's were applied rapidly, GLC effects set in as previously noted. Apparently the BD-5 with its inherent quick pitch response and low stick force gradient (approx. 2 lbs / G) was capable of simulating a basic problem encountered with some digitally controlled fly-by-wire fighter aircraft. I wondered if some of the unexplained stall / spin BD-5 accidents could have resulted in part from the GLC phenomenon. I wouldn't suggest increasing the stick force gradient, but rather warn other "ordinary" BD-5 pilots of this phenomenon.

Lateral / directional stability and control characteristics of the BD-5 are straightforward with no surprises. Due to the short tail length and highly swept vertical surface (low lift curve slope), directional stability and control are relatively low. Excess aileron authority is always available in sideslip even at maximum rudder deflection which in effect could limit crosswind operation. Oscillations of the Dutch Roll mode were slightly damped with yawing motion predominating in the BD-5J. These lateral / directional oscillations are most bothersome in landing approach in gusty air. The very light rudder forces make it difficult to damp the rough-air-induced yaw oscillations. A noticeable improvement in Dutch Roll damping was noted with my BD-5 due to the addition of the ventral fin and a large side force associated with the high pitch propeller.

The spiral mode showed neutral stability (satisfactory behavior) over the speed range. Checking spiral stability in the BD-5 (as in all aircraft) requires proper trim characteristics, i.e. the aircraft flown wings level with controls free. Right wing heaviness was quite noticeable in early flights with my aircraft even though I had built the wings, tail and fuselage with hard tooling. Bending the ground adjustable aileron trim tab helped some but not enough at the higher airspeeds. When a six-inch yaw yarn was placed on the windshield, an appreciable sideslip was noticeable over the speed range. Symmetry was restored by bending the trailing edge of the rudder slightly and the wing heaviness problems disappeared. The aileron trim tab wash was reset to zero deflection. Apparently, the vertical fin was slightly misaligned. **[Ed.: This is one of the reasons why I continue to insist that builders use third-party jig alignment and drilling services.]**

Roll control characteristics are satisfactory with the side controller. Only light forces are required over the speed range and control harmony (deflections and forces between pitch and roll) are considered excellent. Adverse yaw is noticeable only at low airspeeds. Abrupt coordinated (ball-in-center) rolls are somewhat difficult to execute due to a tendency to apply too much rudder because of the light rudder forces. At high speeds (above 200 MPH IAS) a reduction of aileron control effectiveness is quite noticeable due to twist of the aluminum torque tubes which link the controller to the ailerons.

The low drag of the BD-5 becomes apparent in attempting to slow down for the landing pattern. Many people have the impression that the BD-5, being small and compact, would glide like the proverbial brick if power were lost. Quite the opposite – in the cruise configuration Lift / Drag (L / D) is relatively high (about 15) **[Ed.: This means that the aircraft will glide 15 feet of horizontal distance for every foot of vertical altitude, but this applies only to the BD-5B with the 21 foot wingspan.]** Power-off landings are relatively easy to make once the pilot has learned to judge the effects of gear and flap position on the flight path angle. In the BD-5J, a thrust attenuator is needed to get to gear-down speeds. Little trim change results and this in-flight "thrust reverser" provides additional flight path control. It is very important, however, to reposition it for forward flight when starting down for the landing approach, otherwise excessive sink rates would occur. Increasing engine power to reduce sink rate (an intuitive pilot reaction) would, in fact, only increase rate of descent and give the pilot the impression that he had lost engine power. Approach speed on finals for the BD-5B is 80 MPH and touchdown about 70 MPH. Landing approach and touchdown are not difficult to execute in either the BD-5J or BD-5B after you have conditioned yourself to the pitch response and close proximity of the ground at touchdown. Too high an airspeed (nose-low touchdowns) can cause the nose wheel to retract unintentionally if the ground drag forces are large. Taxiing in with the BD-5B is different, it is necessary to taxi in at relatively high speeds (up to 40 MPH) when conditions permit, to provide cooling flow through the radiator. Otherwise the engine may have to be shut down to avoid excessive coolant temperatures.

Stall Warning and Stall Characteristics

This area is undoubtedly the most important from a safety standpoint for this aircraft concept and a more lengthy discussion is appropriate. Many BD-5 aircraft builders may not be aware that over 80% of the accidents that have occurred with the BD-5 are due to stall / spin. NTSB records show that the typical BD-5 stall / spin situation occurs at too low an altitude for recovery. The situation arises insidiously, the pilot does not expect to stall and seriously lacks proficiency for executing an optimum recovery technique. Although the BD-5 may appear to have a docile stall, there are fundamental reasons why it may be less forgiving when flight path control is lost in high AOA flight. A clearer understanding of the stall characteristics of the BD-5 can result in safer operation.

The BD-5 wing utilizes a NACA laminar flow airfoil section varying from 64.212 at the root to 64.218 at the wingtip. No twist (washout) is incorporated since the thicker section at the tip nominally stalls at a higher AOA than the root, thus providing unstalled airflow over the outboard portion of the wing when separation has started inboard. As previously noted, this airfoil series incurs a fundamental reduction in C_{Lmax} when Reynolds number (Re) is less than 3×10^8. The small wing chord of the BD-5 results in an Re of about 0.9×10^5 at landing speeds. This scale effect is not in itself a serious deficiency, resulting in only a modest (5-7 MPH) increase in takeoff and landing speeds. What is important are some adverse characteristics of the wing flow behavior at high AOA which are discussed next.

BD-5J Stall Characteristics

First, flying the BD-5J at high AOA is reviewed and then my BD-5B, which has a modified airfoil. Stall warning in the form of buffeting or shaking of the aircraft and / or controls some 3 to 15 MPH prior to stall departure has long remained the preferred cue for maneuvering safely near stall. The pilot prefers the warning to be consistent and repeatable in straight or maneuvering flight regardless of configuration (gear / flaps up or down). The BD-5J possessed an acceptable degree of tactile (buffet) warning in slow approaches to stall as a result of inherent inboard flow separation. In rapid G onset maneuvers, however, the warning was more subtle and occurred too close to departure from controlled flight to be acceptable.

Stall departure was characterized by transient lateral (wing rock) oscillations at approximately 80 knots in the clean (flaps and gear up) configuration. The lateral oscillations increased in magnitude and were more difficult to control with rudder and aileron as the stick was brought to the full aft position. There was no "G break" evident, and airspeed increased 10 to 15 knots. With the stick held full aft, the aircraft eventually departed abruptly, rolling to an inverted, nose-low attitude. With flap and gear down, the dynamic roll oscillatory behavior was still present although considerably less in magnitude. This would be expected since pitch control power was available to obtain high AOA due to the increased nose down pitch trim moments associated with the gear and flap extension.

In maneuvering flight stalls (pull ups or turns), stall warning was essentially non-existent and the roll-off became very abrupt and violent. In a 3 G turn, the aircraft “snapped” 360 degrees very smartly at stall. Two points were of interest: (1) no stall warning by buffet or shake of the aircraft was evident, (2) stall speeds were appreciably lower, and (3) stall behavior was improved. The only stall warning evident, flaps either up or down, was a mild wing rock or rolling oscillation which I consider only marginally acceptable. Increasing AOA resulted in increased amplitude roll oscillations although bank attitude never exceeded +/- 30 degrees. It was always possible to keep the wings level with use of ailerons alone with stick full aft. Observation of tufts on the wing showed an initial trailing edge separation at the mid-semi span, progressing forward quickly to leading edge separation in this unprotected area (original airfoil). Flow outboard, ahead of the ailerons, remained smooth (unseparated) up to the highest AOA tested (stick full aft). In general, stall behavior with flaps down was milder since, as previously noted, available pitch control power limited the ability to attain high AOA.

Stall recoveries were examined in detail on the BD-5B with the modified wing to compare with the “accelerated” stall problem previously noted with the BD-5J equipped with the normal wing. Similar trends were evident in that a relatively large increase in airspeed was required to avoid secondary stall during recovery. A closer examination of the stall and recovery characteristics was made to simulate the scenario for a typical stall/spin accident. At a safe altitude (over 5,000 feet AGL) with flap (1/2 down) and gear down, the aircraft was slowed down in a mild left bank simulating turning onto base for final approach. At the stall, the aircraft rolled mildly to the left or right at about 65 MPH. For recovery, back pressure was relaxed to reduce AOA, nose down attitude increased to approximately 80 MPH. Since a steeper than desired nose down attitude existed, back pressure was increased somewhat abruptly to return to a desired (less steep) approach flight path angle. Sure enough, a secondary accelerated stall (higher airspeed) occurred with a much larger roll off and nose down. The pilot’s view of the ground approaching rapidly provokes a less patient attitude about waiting until airspeed builds up and another accelerated stall can set the scene for the classic stall/spin accident where there is not enough altitude for recovery.

Is this all-too-familiar stall/spin scenario worse for the BD-5 concept? Not necessarily, but there may be extenuating circumstances which require understanding. For stall recovery, most pilots are taught to add power and bring the nose down to level flight. These actions which help reattach airflow on the wing deserve closer scrutiny for the BD-5. First, with the pusher design, wing flow reattachment is not aided to any degree by increases in engine power since slipstream effects on the flow over the wing are essentially nonexistent. Second, with the laminar flow airflow used on the BD-5, and by operating at low Re, stall occurs from the wing leading edge. This results in a relatively large hysteresis loop in AOA for flow reattachment. Compared to the AOA for initial flow breakaway, the AOA for flow reattachment must be decreased at least 5-7 degrees. This effect is accentuated if the builder ahs not been careful to avoid creases in the airfoil nose radius during handling and attachment of the wing skin to the nose ribs. Third, if engine failure has occurred, the aircraft must be accelerated by diving more steeply towards the ground to increase airspeed (and thereby reduce AOA). This would also be true for a conventional aircraft, but (and I am admittedly guessing at this point) the BD-5 pilot has a much clearer, unobstructed view of the approaching ground which may affect his timing and judgment for proper stall recovery in this high stress situation. Essentially, the average pilot may not have the patience to wait for enough increase in airspeed (low AOA) to provide a safe stall margin and the appreciation of the need to execute a gradual pitch change to avoid a secondary stall.

In Summary

What can be done to improve safety in high AOA operation for the BD-5 concept? First, the pilot must recognize when a potentially dangerous stall situation can occur, such as engine loss during takeoff. This is particularly important for the low-time pilot who has not flown a wide variety of aircraft and is in the initial checkout phase of the aircraft. Second, a clearer understanding of the causes of the problem should help improve stall recovery techniques with particular emphasis on the need for large increases in airspeed and **gradual** (low G acceleration) nose up flight path angle changes. Further, exposure to these stall characteristics at a safe altitude can be very educational. I doubt that many pilots practice this abused stall scenario. The addition of an AOA meter mounted next to the airspeed indicator on my aircraft is a great help in avoiding secondary stalls. Reducing the established aft stick travel value and favoring a more forward CG location will indirectly improve safety by restricting high AOA penetration without unduly compromising pitch control power for takeoff or landing. Finally, airfoil modifications can be made to alleviate the tendency for leading edge flow separations. Some BD-5 builders have utilized the NASA LS0413 (GAW) airfoil which also improved max lift at low Re and a favorable (trailing edge) stall separation pattern. It should be recognized that the GAW airfoil with the cusped trailing edge will reduce cruise performance on the BD-5 because it is optimized for a relatively high cruise C_L.

Modification of the airfoil as previously discussed will not only improve stall behavior but also spin characteristics. Extensive NASA-Langley stall / spin tests of a GA aircraft using leading edge protection similar to that incorporated on my BD-5B provided improved spin resistance. It was found, however, that autorotation characteristics were better when using only outboard protection compared to various full span leading edge modifications. Further work is planned for my aircraft to promote improved stall warning. A small leading edge stall strip inboard at the wing-fuselage fillet should provide ample buffet warning.

Concluding Remarks

Although the BD-5 design fell short of meeting many of its original design goals, it should be given credit for ushering in a new wave of popularity for homebuilts. Its sleek aerodynamic design is unique even today and is admired in the air and on the ground by the casual observer or the jet-set crew. It is not difficult to fly nor are there unsafe or hazardous characteristics for properly trained and adequately briefed pilots. Its short-coupled appearance is deceiving. Although very responsive in pitch and roll, adequate aerodynamic damping allows hands-off flying throughout the envelope. The cockpit arrangement and excellent control harmony provided by the side-stick controller enhance the pure joy of maneuvering flight. Someday, an ideal engine will become available (perhaps the Rotary Vee) and the BD-5 aircraft will realize its full potential.

Bede Considering Updating BD-5 Design, Producing “Super BD-5”

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James Bede, the well-known aircraft designer who some thirty years ago rocked the general aviation world with the introduction of the Bede Aircraft BD-5 single seat, high performance, homebuilt aircraft kit, is considering reviving the BD-5 design under the designation of "Super BD-5".

In an exclusive interview with ANN, Bede stated that the reason he has decided to take this step is because he has spent considerable time in past years reconsidering the design and "such things as complexity of fabrication and the difficulty of assembly, too many parts in a small compact area, and even the cramped cabin size." Bede added that he has not made a final decision on this, but he has found enough areas where the original BD-5 design could be improved that he has at least made up his mind that the project could be worthwhile.

"The BD-5 is a thirty year-old design but is even more modern than most of the new aircraft." said Bede. "I do want to emphasize that I have not made a firm decision to proceed and even after I do, it will take a while before we will see some of them flying, but frankly I am very excited about the new concept."

Asked by ANN how he is going to deal with the issue of the many people who lost deposits on the original BD-5 kits and the BD-5D certified aircraft, Bede responded that "There were really very few BD-5 customers who were upset, the vast majority were disappointed that they didn't get an airplane but understood that we gave it the best try. The worse comments would come from people who had nothing to do with the BD-5 program, but get enjoyment out of kicking someone when they are down. But for my old customers I have something in mind, that will be to their benefit."

As to specifically what he had in mind, Bede would not comment, but he did say that he still has a complete list of all the original BD-5 customers, and added that "they are the only ones whose gripes mean something to me."

Bede has established a point of collection of information on the

Internet for anyone who wants to comment on the subject with ideas on how to improve the BD-5 and what they like and don't like about it. The URL for the survey form is: **http://www.bd5.com/superbd5.htm** …and is open to anyone who wants to participate in the process.

BD-5 Electrical System Guidelines

By Juan Jiménez

The purpose of this article is to give the BD-5 builder a set of basic guidelines for the design and installation of an electrical system in your aircraft. The information presented here is based on the design of the electrical system on my BD-5, N522PR, my experience as an electrical and avionics line technician in the Marine Corps, as well as on **Aircraft Electrical Systems – Single and Twin Engine** by J.E. Bygate, Jeppesen Sanderson Training Products, ISBN 0-89100-357-6. I highly recommend this book for anyone who wants to understand how aircraft electrical systems work. Another excellent resource for aircraft electrical work is `http://www.aeroelectric.com`.

As I said, this article is meant to present **guidelines** only and should **not** be interpreted as professional advice. The intention is to give you a good foundation, not to provide you with blueprints. If you choose to design and build your aircraft's electrical system, consult with a local avionics shop to, at the very least, have an expert review your design and installation of the various components. If you're not sure of what you're doing, let an expert do the work.

Every aircraft electrical system has three basic components:

- A primary power source (a battery)
- An engine-driven power generating device (generator or alternator)
- An electrical distribution system

The purpose of the battery may seem obvious, but just in case… the battery's purpose is not only to provide power to start the engine (assuming your engine has a starter), but also to provide enough power to operate your aircraft's electrical system (either fully or partially) for a period of time following an electrical power generation failure.

In order to select a battery for your BD-5 you need to take into consideration several factors.

The first one is going to require a decision on your part as to how complex an electrical system you want to have on your aircraft. If all you're going to need to do is provide power for your handheld radio and perhaps a transponder and encoder in the absence of engine-generated power, you'll have different requirements than another builder who wishes to have a more complete system with exterior and interior lighting, more complex avionics and perhaps some electrically driven flight instruments.

Once you have made a decision on what electrical systems you would like to have in your aircraft, it is time to add up the numbers – the power consumption numbers, that is. The output capacity of an electrical power generating device is measured in amperes. Each electrically operated device that you want to put into your aircraft will have an electrical power consumption rating. For example, the small Terra TRT-250D digital transponder consumes some 0.75 amps. Their TX-760D digital comm, on the other hand, consumes nearly 3.25 amps when transmitting. Other devices such as a fan and a strobe light system may consume much more power. Add up all the numbers and make sure you don't miss any systems. The result will tell you how many amperes your generator or alternator must produce in order to operate all your systems. Compare this number to the power rating of the generator or alternator on your engine. If the total amps required exceeds 80% of the generating capacity of your engine, you're either going to have to bring down your expectations a notch, or find out if the engine manufacturer makes a larger generator for your engine. If the total does not exceed 80%, then you get to move on to the next step.

But before we do that, some advice. Remember that the cardinal rule for BD-5 construction is to build light. Jim Bede himself reinforced this fact during the Expo 2000 at Fort Worth, Texas. Just because you can put fifty pounds of avionics and electrical systems on the airplane doesn't mean you should. The way I see it, an ideal BD-5 avionics and electrical system should provide you with just enough instrumentation and communications capability to get yourself safely on the ground if you run into problems in the air. If you inadvertently find yourself in the clouds, you should have enough avionics and instruments to safely get back to VFR conditions. Trust me when I say that you won't be doing instrument approaches to minimums in a BD-5. It's just not built for that kind of flying, and if that's the kind of flying you want to do, you need to be looking at some other aircraft.

That said, let's move on. The next step is to find a battery that will work for your electrical design. The idea here is to provide cranking power to the starter (if installed), and electrical power to your aircraft in case you suffer a power loss in your aircraft. If your engine doesn't have a starter or generator, then the idea is to provide enough power to operate whatever electrical systems are installed in your aircraft during your flight. You also have to find a battery that will fit in your aircraft and will not weigh so much that it will throw your CG outside of the approved CG range.

You also want to give yourself enough margin of safety to get yourself either to your destination or to the nearest airport in the event of electrical generating failure. This doesn't mean that you should expect to be able to operate all your avionics and electric systems for the remainder of the duration of the flight. You should provide yourself with enough margin to operate your minimally required systems. This usually means that you should be able to operate the radio and any engine and flight instruments that require electricity from the battery to do their job. If the failure happens at night, you should be able to operate the radio, perhaps some internal lighting and, during final approach and landing, a landing light.

The same calculations should be applied to battery power as for the generator. Add up the power requirements of the minimum electrical system items that you will use in the event of a power failure. You should give yourself a margin of safety here as well. The larger the margin (within weight and size restrictions), the more time you'll be able to use the battery if the generator fails.

The battery has to be mounted somewhere in the aircraft, and most –5 builders place it under the glare shield, behind the instrument panel. The battery will also constitute a significant percentage of the aircraft's empty weight, so you will probably want to get the smallest battery that will fit your aircraft's electrical requirements.

On my aircraft, the battery is mounted on a custom battery shelf installed behind the instrument panel as far forward as possible, directly over the nose gear box. My battery is a sealed Powersonic 27 amp model. Because it is sealed, I don't have a drain from the tray to the outside of the aircraft, but if you're going to use a lead acid or other battery with openings to service the battery fluids, you'll also need to install a drain to make sure that any battery acid that spills out of the battery will be safely drained out of the aircraft. The tray should have some way to secure the battery; in my case there is a strap that is secured over the battery to keep it from going anywhere on its own.

Assuming that you have found a suitable battery for your aircraft, how do you get the juice from the battery to the rest of the aircraft?

You now need to put together a battery control circuit which will allow you to bring the electrical power from the battery to a place in the aircraft from which you can distribute it to the electrical system and devices. A basic battery control circuit is composed of the following components:

- The battery.
- A battery relay, which is nothing more than an electromagnetic switch which connects the battery output to the "busbar" when the relay's contacts close.
- A battery master switch that controls the relay.
- An ammeter, which is an instrument that showed how much current (amps) is being drawn by the system from the battery.
- The electrical busbar, a convenient point to which all the electrical loads are connected.

The battery negative terminal is obviously connected to the aircraft frame. Select a location with good contact to the bare metal of the fuselage. We will discuss wiring requirements a little further on in this article. The positive terminal on the battery is connected to the "B" terminal of the battery relay.

The output side of the relay is located in terminal "B1". The power will run from there to one side of the ammeter, and then exit out the other side to the "busbar". Another connection will run from the same "B1" terminal on the battery relay to the input terminal of the starter relay, if your aircraft is equipped with an engine starter.

You're probably asking yourself "Why a relay? Why not a switch?" The simple explanation is that if you do that a single wire would be carrying the full current from the

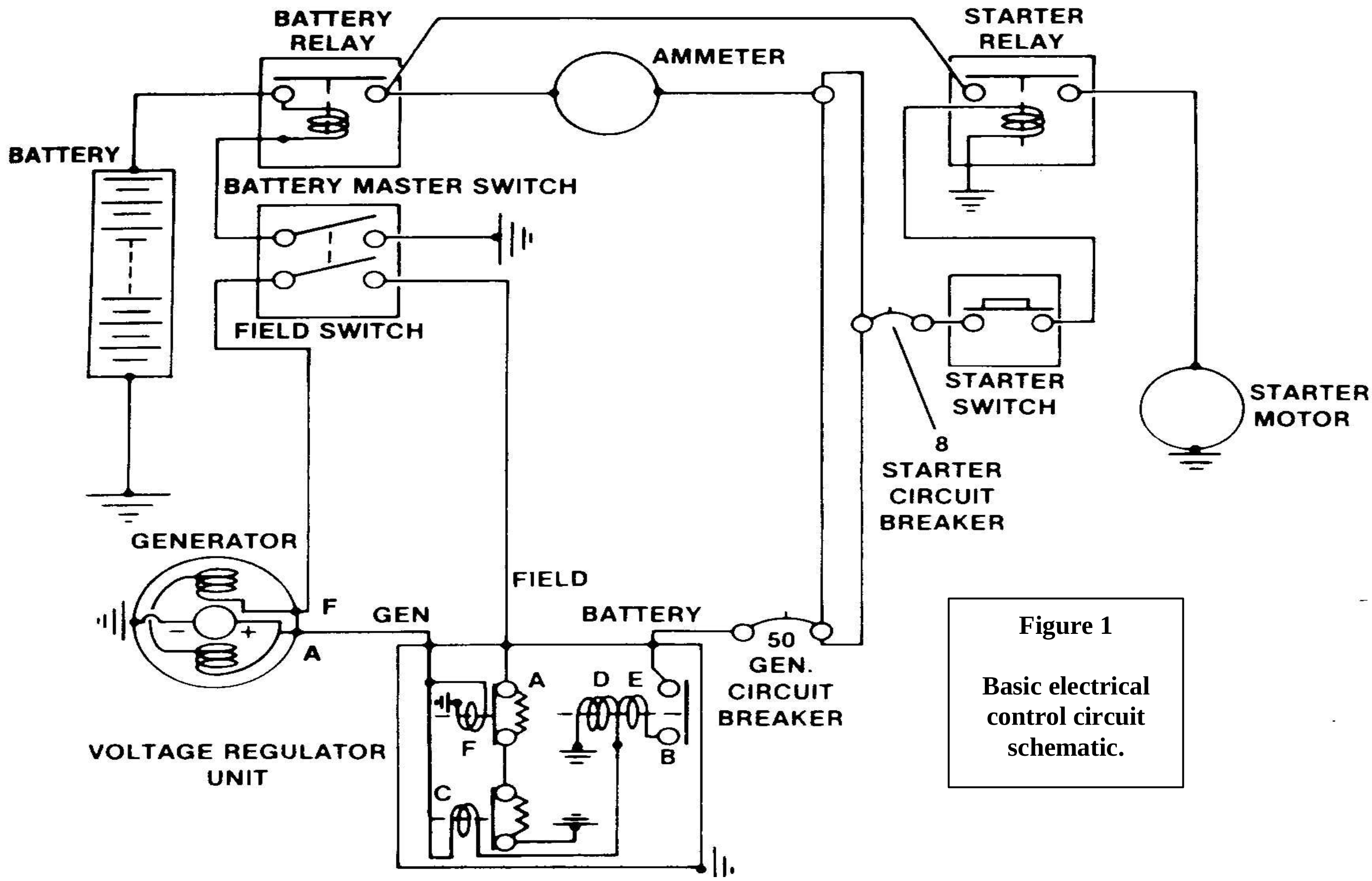


Figure 1

Basic electrical control circuit schematic.

battery to the busbar. You would need to have a very large switch to be able to handle that much current, and it would probably have to be an expensive switched circuit breaker that would take up significant space on either the instrument panel or the secondary side panels. Instead of doing that, you use a relay, which can be mounted anywhere behind the panel, and use a smaller switch and wiring to implement sort of a “remote control” for the battery power. The relay handles the current just fine, and you don’t need anywhere near as large a switch.

Getting back to the engine starter, if you do have one of those very useful gizmos, its wiring is basically a copy of the battery relay wiring. As I said before, power is taken off the same battery relay “B1” contact that goes to the ammeter. This is connected to the starter relay’s “B” terminal. The output comes out of the “B1” terminal of the starter relay and to one of the starter input terminals. The other terminal on the starter is connected to frame ground. To operate the starter relay (and hence the starter), you will need to take power from the busbar to a circuit breaker rated for the maximum power draw of the starter, and from there to the starter switch, then connect the other side of the starter switch to the “S” terminal on the relay. The switch will then act as the “remote control” for the starter relay.

Now, we’ve covered the basics of a system that doesn’t have a generator. But what if your aircraft’s engine does have a generator?

The addition of a generator means you need to add two components to the design and change another one. The generator should have three outputs; a frame ground, a field terminal usually marked “F” and a generator output terminal usually marked “A”. You will also need to install a voltage regulator to control the output voltage of the generator, and change the battery switch to a battery / generator switch (single pole, single throw to double pole, single throw). Note that some generators have voltage regulators built-in. In this case you will not need an external voltage regulator.

The voltage regulator has four terminals, the generator terminal, the field terminal, the battery terminal and a frame ground terminal. The frame ground on the generator is connected to the airframe. The field terminal on the generator is connected to one of the inputs on the battery master switch, and the output side is connected to the field terminal on the voltage regulator. The frame ground terminal on the voltage regulator is connected to the airframe. Finally, the battery terminal on the regulator is connected to the busbar through a circuit breaker rated for the maximum current that the generator is rated to produce.

Figure 1 depicts the schematic for the system I've just described.

At this point you'll have a system that gets power to a single point in the aircraft, the busbar. A busbar is nothing more than a conductive bar with screw terminals where you can attach wires with suitable terminations and run them to the places where the power is needed, i.e. your radio, transponder, indicators, instruments, etc. You now have to install a distribution system, which usually has the following components:

- The busbar itself.
- Circuit breakers or fuses to protect the individual components attached to the distribution system.
- Control switches to turn systems on and off.
- The wiring to take the power to the systems.
- The electrically powered components themselves!

The busbar is a very simple device. It usually has screws to which you can attach ring terminals on the end of electrical wire, and each set of screws go into a conductive piece of metal that evenly distributes power from the generator or battery to the individual electrical components.

Circuit breakers are installed to protect the individual circuits to the components, as well as the components themselves. We I mentioned fuses because they can in theory be used as well, but thermal Mil-Spec circuit breakers should always be used on aircraft. There are various types of breakers available, some push / pull, others have a cap that pops out when the current through the breaker exceeds the breaker's maximum capacity. Personally, I prefer the breakers that can be pulled out to cut the power to an individual system, because they allow me to turn off a particular circuit if I think it is giving me problems.

Circuit breakers should be installed in a place on the cockpit where they can be easily accessible. You don't want to hide them because that makes it more difficult to reset them in flight.

Selection of circuit breaker ratings depends on the circuit they are protecting. If it's something like a Terra TRT-250D digital transponder, a ¾ amp breaker will do, since that is the maximum power draw for that unit. However, a Terra TX-760D digital comm radio draws 3.25 amps, so you'll need the next higher value of breaker, a 4 amp unit.

Selecting what type wire to use for a particular circuit is also a very critical subject. Always use Mil-Spec insulated (Tefzel coated or otherwise) wire for aircraft electrical systems. On a BD-5 you should not have to use shielded wire unless you are wiring some sensor near the engine or something like a smoke generating system in the tail compartment, where the wire has to travel through the engine compartment and into the cockpit.

The selection of wire gauge depends on what load the wire will carry. Going back to our electrons as water molecules analogy, the more pressure (current) moving through a wire, the thicker the wire needs to be. Wire is classified by its AWG (gauge) number, with the highest used on aircraft electrical systems being 22 AWG (thinnest) and the lowest being 2 or 00 AWG (thickest). Primary loads such as the battery, battery relay, starter relay and starter require the thickest wire because of the high current to those parts of the system.

The main power feed wiring to the busbar usually carries some 30 amps of current. These wires should be between 10 and 6 AWG. The same goes for the main generator output to the busbar. Generator field wiring only carries 2 to 2.5 amps, so 20 AWG will do nicely.

The wiring from the battery master switch, generator master switch and starter switch to their respective relays only needs to be 20 or 18 AWG because they only carry small currents to activate the coils of the relay and close them. The same applies to the wiring from the busbar to the individual systems.

This article only scratches the surface of aircraft electrical systems. For more information, see FAA Advisory Circular 43.13-1b. This very comprehensive document explains the FAA-accepted procedures and methods to install and service electrical systems in an aircraft. Finally, please, follow Juan's Golden Rule. **When in doubt, ask. There is no such thing as a stupid question.**

EM Aviation's *RiteAngle III* AOA System Enters Production

Emphasis remains on providing safety of flight and reliability

EM Aviation LLC has completed design work and put into production their new RiteAngle III angle-of-attack (AOA) system for experimental and ultralight aircraft. This third generation system utilizes state-of-the-art digital technology in the control box, and continues to use the reliable LED indicator technology that was first introduced into the product line in 1992. A new machined stainless steel vane and potentiometer rated for two million cycles are also part of the new system.

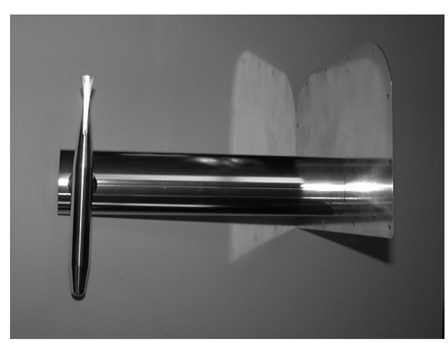
The RiteAngle system is the oldest AOA system specifically produced for sport aircraft and the first to use LED technology, according to Mr. Elbie Mendenhall, President of EM Aviation and a 25,000-hour airline captain who recently retired from American Airlines. The original system, using a vane, potentiometer and a meter to display the AOA, was designed in er1967 and tested on a Super Cub. Since then it has been continuously upgraded, with the RiteAngle III as the latest version of the product.

Installation of the system is straightforward, and involves placement of the display indicator on the panel, the processor unit which is normally placed behind the panel and the vane assembly, for which various installation adapters are available. On aircraft equipped with flaps and / or retractable landing gear, flap position sensor and landing gear position warning options are available. Of the units that have been sold, approximately 97% have been installed on experimentals and some 3% have been installed in what Mendenhall refers to as "true" ultralights.

Mendenhall has also been working with several kit manufacturers -- such as BD Micro Technologies of Siletz, Oregon, manufacturers of the FLS-5 series of kit planes – to provide them with custom-designed RiteAngle III installations in order to enhance the safety of their finished products. One of the most interesting features of the unit is that it can be interfaced into the audio system of the aircraft. It then provides you with audible spoken prompts for various conditions, such as if you forget to lower your landing gear. It also understands when the flaps are extended and, if programmed correctly, will adjust its indications to take flap extension into account. Some flight adjustments must also be made, but everything is done with a small programming control which is disconnected and stored once the system is programmed.

The RiteAngle III AOA system retails for $295 for the basic system. In addition, you must select the appropriate mounting system – wing vane with or without combined pitot tube, jury strut or fuselage mounts – and the landing gear and / or flap options, if necessary. The typical system for a complex aircraft runs around $400 total, including shipping.

For more information, call (360) 260-0772 .



BD-5 Vendor List

The following vendors provide parts, services and kits for BD-5 builders. We list them here in alphabetical order, for your reference.

Alturair

1405 N Johnson Ave
El Cajon CA 92020-1630
Ph: **619-440-5531**
Fax: **619-442-0481**
Email: alturair@alturdyne.com
Web: http://www.alturair.com
Contact: **Paul Ross**
BD-5 kits, parts, builder services, engines (rotary engine in development).

BD-Micro Technologies

1260 Wade Rd
Siletz OR 97380
Ph: **541-444-1343**
Email: sales@bd-micro.com
Web: http://www.bd-micro.com
Contact: Edward Karnes
FLS-5 kits (recip, turboprop, jet), parts, builder services, engines (2-stroke, turboprop).

Gerald "Jerry" Kauth

9810 State Ave #9
Marysville WA 98270
Ph: **360-435-8109**
Drive system sales and upgrades, landing gear parts and assembly services.

Robenalt Engraving

1423 Broadway
Burlingame CA 94010-2082
Ph & FAX: **415-348-6262**
Contact: Stanley Robenalt
Custom instrument panels, engraved placards.

Seneca Light Aircraft Systems

5479 E Cty Rd 38
Tiffin OH 44883
Ph: **419-585-7002**
Fax: **419-585-6004**
Contact: **Matt Dandar**
Hirth aircraft engine sales.

Miscellaneous Suppliers

The following vendors carry inventories of all types of aviation goods, tools and other items which you may need during your project to finish a BD-5.

Aircraft Spruce & Specialty East

900 S. Pine Hill Road
Griffin, Georgia 30223
Ph: **770-228-3901**
Fax: **770-229-2329**
Order Dept: **877-4-SPRUCE**
Customer Service: **800-443-1448**
Email: east@aircraft-spruce.com
web: http://www.aircraft-spruce.com
General aviation parts, supplies, tools.

Aircraft Spruce & Specialty West

225 Airport Circle
Corona, California 91720
Ph: **909-372-9555**
Fax: **909-372-0555**
Order Dept.: **877-4-SPRUCE**
Customer Service: **800-861-3192**
Email: info@aircraft-spruce.com
web: http://www.aircraft-spruce.com
General aviation parts, avionics, supplies, tools, instruments.

Aircraft Tool Supply Co.

P.O. Box 370
1000 Old U.S. 23
Oscoda MI 48750
Toll Free: **800-248-0638**
Ph: **517-739-1447**
Fax: **517-739-1448**
Email: info@aircraft-tool.com
Web: http://www.aircraft-tool.com
Aviation tools and supplies.

The Wag-Aero Group

1216 North Road
Lyons WI 53148
Ph: **262-763-9586**
Fax: **262-763-7595**
Order Line: **800-558-6868**
wagaero-sales@wagaero.com
Web: http://www.wagaero.com
General aviation supplies, avionics, instruments, parts.

Wicks Aircraft Company

410 Pine Street
Highland, IL 62249
Orders: **800-221-9425**
Help Line: **618-654-7447**
Fax: **618-654-6253**
Email: info@wicksaircaft.com
Web: http://www.wicksaircraft.com
Aviation supplies, avionics, instruments, parts.

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