Installation of BPE-14 Wind Powered Alternator on Aeronca Champ

By John Propst with Technical Review by Bill Pancake

Abstract: this article covers the installation of a BPE-14 Wind Powered Alternator on a 1946 Aeronca Champ.

Background: This article was written to describe details related to the installation of a BPE-14 wind powered Alternator on Aeronca Champ N3129E. The BPE-14 is approved for installation on the 7AC and 11AC aircrafts. Installation on the 7AC Champ is covered by Basic Aircraft Products STC - SA2856SO.

Champ N3129E was rebuilt by the author in 2010. The restoration involved over 30 337's of which 16 were Field Approved modifications. The plane was restored with a C-85-12 engine. The engine had a light weight electric starter and no engine mounted generator or alternator. The aircraft had a Field Approved battery powered electrical system to power the starter and various portable and panel mounted electronic devices such as GPS, Radio, and Engine Analyzer.

The aircraft was specifically restored without an engine-driven electrical system to permit aircraft operation in and around some controlled airspaces without a transponder. (See FAR Sec.91.215 (b)(3) for additional details for aircraft without engine-driven electrical system). Wind powered generator and alternators provides a means to charge a battery powered electrical system while still qualifying for the transponder exemption for aircraft without an engine-driven electrical system.

Several options for wind power were considered. A Ward wind powered generator was considered. The author had a new in the box Ward generator that could be used. It was considered less desirable because:

1. Being a generator rather than an alternator, it was electrically more complex and required an external voltage regular
2. The Ward generator weighed more that the alternator options being considered, and
3. The Ward generator was out of production with no manufacturing support.

The first wind powered alternator considered was a Gennipod brand aircraft wind powered generator. This unit is commercially available from a number of sources including Aircraft Spruce. The unit was considered because of its small size, light weight, and reports of satisfactory performance. The unit was excluded from consideration because it was not approved for installation on certificated aircraft and we did not feel comfortable seeking a Field Approval for its installation.

The second wind powered alternator considered was the BPE-14 unit. This unit is also commercially available from a number of sources including Aircraft Spruce or direct from the manufacturer. This unit was considered because of its small size, light weight, and STC approved for installation on Champs. There were several concerns related to the installation of the BPE-14 unit on a Champ:

1. The first concern is the high cost of the unit. The cost is comparable to costs related to install a modern new engine driven alternator, and is much more expensive than the experimental alternator mentioned above.
2. By far the biggest concern was that the unit's output was limited due to air flow diversion past the alternator due to the cooling lip on the bottom of the aircraft wraparound (cowling).
3. There were a couple "old" comments on the web that would indicate that the manufacturer's technical support was less than desirable.

While the cost is high, the desire to have a non-engine-driven alternator limited the choice to this unit.

I first discussed the air flow concern with Bill Pancake to learn from his experience. Bill had previously been involved in the installation of several of these units as well as a number of Ward generators. Bill confirmed that in some cases the lip did create a problem achieving rated output. Bill suggested several options:

1. Mount the unit on the left oleo landing gear frame where the natural prop wash is directed. Bill reported that this same issue came up with Ward generators and mounting the Ward generator on the landing gear frame solved the problem. This installation location is not covered by the STC.
2. Install a tab on the cooling lip to aid in the airflow to the BPE-14. It has been reported that this solution improves the performance.
3. Cut a half-moon opening in the center of the cooling lip to permit unobstructed airflow to the BPE-14 unit. Bill reported that he has seen this option successfully used.

We decided that if this unit was used, we would first mount it as specified by the STC and determine what output could actually be achieved. The current normal running load is very low and full rated output would not be required.

In order to move forward on the option of installing a BPE-14 unit, additional information beyond that presented on the Manufacturer's website was needed.

I sent an email to the manufacturer requesting additional information such as a copy of the STC, installation manual, and existing user contact information. I also expressed my concern about airflow and requested information on this topic. I almost immediately received a reply email from Ron Cox, company owner. He provided me all the information I requested plus additional information related to the airflow. He was well aware of the airflow issue and provided drawings and photos on how they and others had addressed and overcome the issue. Over the next few weeks I had several addition questions that I emailed to Ron and in every case, I received very quick response that fully addressed my questions.

Based on what I considered prompt and complete support from Ron, I ultimately placed an order directly with Ron. I felt that by dealing directly with the manufacturer, it resulted in faster and better support and I chose to reward that support by dealing directly with the manufacturer.

The unit is shipped prepainted. Ron is set up to paint the unit with any color shown on the Polyfiber paint chart. He limits the color selection to the Polyfiber colors to allow the same catalyst and solvent for all units. My concern was that I had used a Ranthane aerothane paint color that was not on the Polyfiber chart. After a couple phone calls with Dondi Miller at Polyfiber and Ron, we found out that Dondi was able to provide Polyfiber paint blended to the Ranthane "Vestal White" color. By working directly with Dondi and Ron, custom blend paint was provided to match my plane.

The alternator was received completely assembled, painted, and ready for installation. Installation instructions and other documentation such as the STC were provided with the unit.

To mount the unit, the weight of the aircraft must be removed from the front landing gear so that the upper axle pivot bolts can be removed and replaced with longer bolts. As shown in the photo on the right, I fabricated a wooden spreader bar and used and engine hoist and fiber straps to lift the aircraft by

the engine mounting frame. The aircraft was raised until both wheels were slightly off the floor.

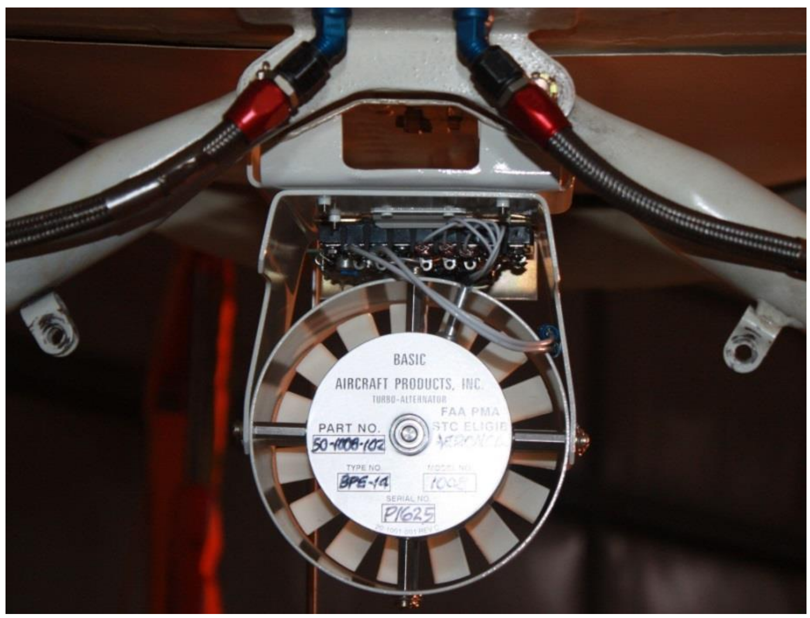
The two upper axle bolts shown on the photo above were removed. Undersized punches were inserted in the holes to temporarily position the axles in the bracket. After removing the existing bolts, new bolts approximately 1/8" longer than the existing bolts were used to mount the new alternator on the axle attachment bracket as shown in the photos on the next page.

The picture below shows the alternator from behind the unit. The hydraulic brake lines are positioned behind the axles and enter the aircraft through a bulkhead located behind the axle attachment bracket.

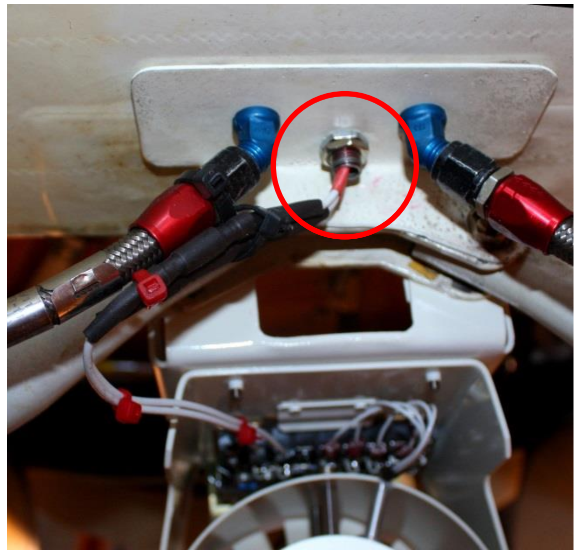
The alternator voltage regulator is located within the mounting bracket above the alternator assembly.

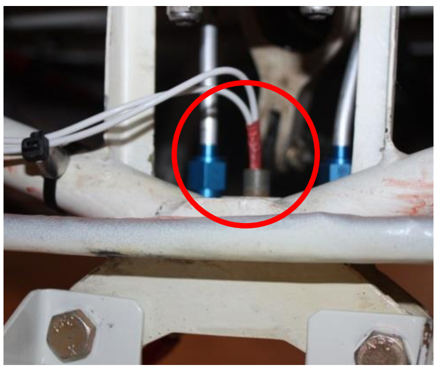
The two loose wires coming out the back of the regulator are the positive and negative leads that go to the electrical system.

The wiring diagram shown at the end of this article shows the hookup of the alternator. All wiring was completed with 14 gauge aircraft approved wire and approved crimp on terminations.



While the installation manual suggests using a grommet for transition of the power leads from the alternator to the electrical system, a different method was used on this aircraft. Previously, during the installation of the hydraulic brakes on this aircraft, a transition bulkhead was installed on the aft side of the axle attachment fittings for the hydraulic brake lines. There was adequate space on this transition bulkhead to install a cable thru-fitting. The photo on the next page shows the thru fitting. A 3/8" hole was drilled through both the inner and outer bulkhead plates. A 3/8" continuously threaded pipe was then installed through the bulkhead plate. Two jam nuts were installed on the inside and outside of the aircraft. Red thread lock adhesive was installed on the threads as an additional deterrent of the jam nuts loosening. The leads on the generator had a male crimp-on splicing connector on the positive (+) lead and a female crimp-on splicing connector on the negative (-) lead. Mating crimp-on connectors were installed on the power leads going from the alternator to the aircraft electrical system. Heat shrink tubing was then installed on each individual splice connection. In the area where the two power leads pass through the bulkhead thru fitting, additional shrink tubing (red) was applied over the two wires. The leads were then positioned and ty-wrap secured. The picture below shows the two power leads exiting through the top of the bulkhead thru fitting. The negative lead is then routed to the aircraft ground bus located on the engine side of the firewall. The positive lead is routed to the + terminal of the panel mounted 0-10 amp DC ammeter. A 10 amp push-pull aircraft circuit breaker was mounted on the aircraft panel next to existing breakers. A power lead was then installed from the negative terminal of the panel ammeter to one side of the circuit breaker. A short lead was then installed from the other circuit breaker terminal to the positive aircraft bus bar, located on the other four aircraft circuit breakers.





Testing and operation results

The initial test of the alternator consisted of mounting the discharge hose and nozzle from two large shop vacuums aimed at the BPE 14 alternator as shown in the photo to the right. The alternator circuit breaker was open and the master switch was off. When the vacuums were turned on, the alternator began spinning at a high rate of speed. A Fluke model 87 digital multimeter was connected to measure the output voltage of the alternator at the aircraft bus.

When the breaker was closed, the red master light came on. The voltage was 14.35 VDC and the ammeter read .4 amps.

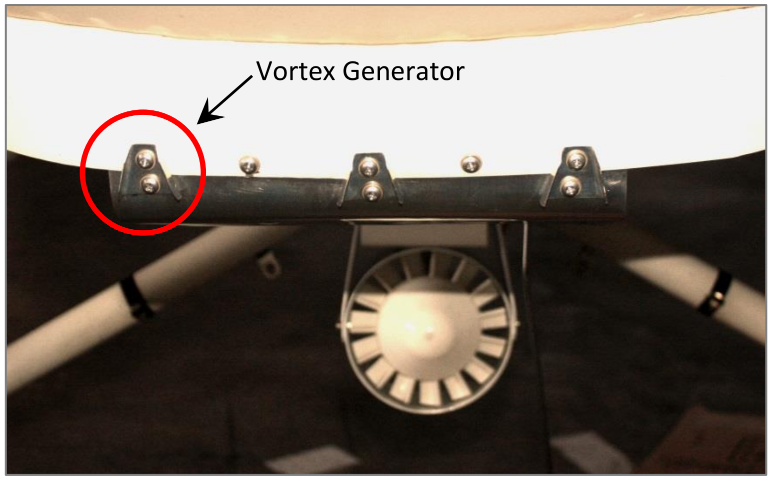
With the master switch still off and the Garmin GPS removed from the aircraft, the avionics switch was turned on to energize the JPI 830 analyzer. The analyzer powered up in its normal manner. The load on the alternator increased to about 1.2 amps. I am not certain if the load in the 830 analyzer varies or if the regulator circuitry resulted in the voltage output varying between 11.6 and 8 volts. From the sound it appears that we were at the limits of the load that could be supported by the vacuum cleaner nozzles.

When the master switch was turned on and the battery was connected to the system, the voltage stabilized at the battery voltage of about 12 volts. With the limited output available from the vacuum nozzles blowing on the alternator, shop testing was discontinued.

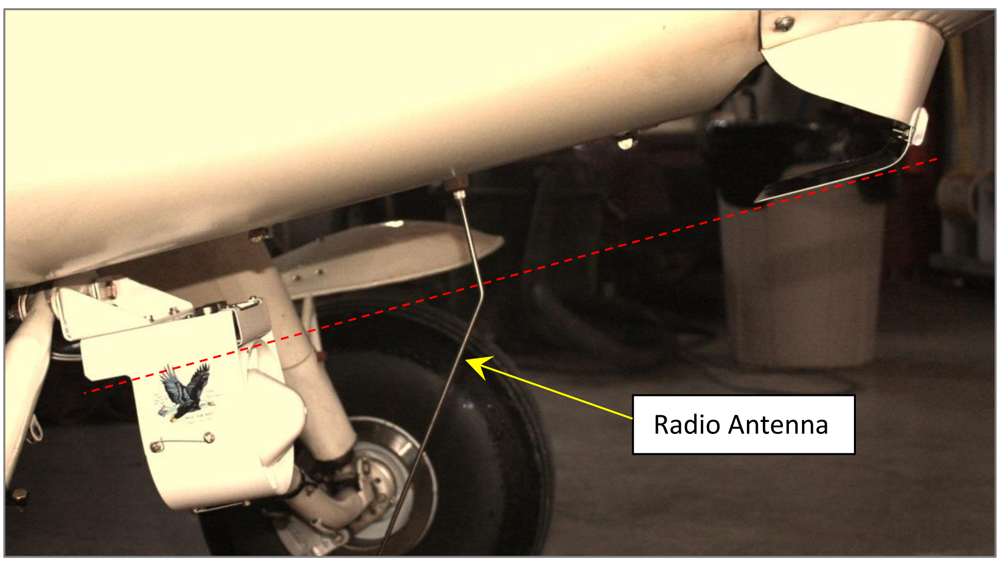
Next the alternator was tested by flying the aircraft. The engine was started with the alternator breaker open and the master switch closed. With the engine running on the ground run-up, the alternator breaker was closed. The ammeter output remained at zero even with the engine run-up at 1500 rpm.

On takeoff, it appeared that the ammeter output began to move off zero when the airspeed reached about 60 mph. After reaching level flight and a cruising speed of about 100 mph, the master switch was turn off. The following equipment was on: JPI 830 analyzer, Icom 210 radio, Garmin 296 GPS, red run light and master relay. The alternator registered an output of 1.6 amps and 13.6 volts. When the radio transmitter was keyed, the load increased to about 3 amps. When the master switch was turned on the voltage dropped to about 12.3 volt and the current output remained about 1.6 to 1.8 amps.

Based on reports by others, an air deflect was fabricated and installed on the bottom of the lip on the engine cowling as shown on the photos to the right. The theory is that the air deflect will aid in the diversion of air around the engine cowling lip to the alternator. The deflector was fabricated from .035" 2024-T3 aluminum, 6" X 9". Three pairs of miniature vortex generators were fabricated and attached to the leading edge of the air deflector. The deflector and vortex generators were attached with 6-32 aircraft screws and elastomer nuts. The leading edge of the deflector was bent into a smooth curve around a piece of 1" conduit. The trailing edge of the deflector was aligned with the top of the alternator.



With the deflector and vortex generators installed, flight tests confirmed significant improvement in the alternator output.



Before installing the deflector, the ammeter would not move off of zero until after takeoff and about 60 mph. With the deflector, the ammeter began to move off zero at about 1500 rpm.

At takeoff the battery voltage was 11.6 volts. After takeoff the battery voltage rose steadily to 13.6 volts.

At 95 mph the unit was putting out 5.4 amps at 13 volts

At 105 mph the unit was putting out 6 amps at 13.3 volts

The highest current output observed was about 6.5 amps. Without knowing the characteristics of the regulator, I assume the regulator is limiting the current as the aircraft battery becomes charged. Without adding additional load, there is no way to know what the maximum output of the alternator would be on this aircraft. One potential problem was experienced while testing the alternator. The following two email messages describe the problem and solution.

Below is an email I sent to Ron Cox related to the alternator tripping off

Ron, I went flying again today and had an experience similar to the one I had yesterday.

I took off and everything seemed to be working good. The voltage prior to takeoff was 11.6 volts. The alternator put out somewhere around 5.5 amps and the voltage after takeoff increased to 13.2 volts (my engine analyzer records all data points including voltage every two seconds).

At six minutes into the flight I decided to open the circuit breaker in the alternator output. The output of course went to zero amps when I opened the circuit breaker. However, when I closed the breaker the alternator output remained at zero. I continued to fly. Over the next 21 minutes the alternator did not come on. The Bus voltage gradually decreased to 11.6 volts. When I keyed the radio announcing my arrival back at our airport the alternator came back on and operated normal. I recalled that yesterday when the alternator went off after I opened the master switch, it also returned when I keyed the mic on the radio. I am guessing that in both cases the radio transmission added a sudden load to the aircraft battery.

At this point I have no idea what is happening other than the regulator has some type of protective circuits in it or the regulator is somehow malfunctioning. I would not expect the alternator to automatically turn itself off when it is suddenly disconnected from a load. Do you have any thoughts on what is happening and any possible corrective actions?

John

Below is Ron's response to my email

Hi John, yes, this is a phenomenon that has showed up in the last 2-3 years. What is happening is the high voltage cutoff voltage is set (fixed setting) not too far above the regulating voltage. The regulating voltage is normally set for around 14.5 volts, but when there is an open circuit on the load, the voltage increases upward somewhat. In some regulators, the high V cutoff point is not very much higher than the regulating voltage. When you open the CB, it allows the voltage to exceed the high voltage cutoff point. In practicality, there is no reason to ever open the CB in flight, other than to see what happens. If you want to do that, just slow the plane down until the voltage comes back on. It is just the nature of the regulator components. The tolerance on some components is maybe +/- 10%, and if the combination is just right, the voltage setting is too close to the regulating voltage. I think if you always leave the CB engaged, this should not happen. There is nothing wrong with the regulator.

Let me know. Ron

This chart displays the voltage and RPM captured during the flight in which the alternator breaker was opened and then closed. Note the increase in battery voltage on takeoff (rpm increase). At around 15 minutes the breaker was opened and the battery voltage starts decreasing. At around 37 minutes the alternator begins operating again. Shortly after the alternator begins working, the aircraft lands.

On a later test, the breaker was opened and the alternator output went to zero. The breaker was then closed and the output remained at zero. The plane was then gradually slowed. At around 60 mph the alternator output returned, as Ron had suggested.

One unanticipated issued related to the installation of the BPE-14 alternator was that the close proximity of the alternator air diversion tab to the Com antenna resulted in the degradation of the radio signal when the alternator is between the antenna and the other radio. This issue is being addressed by relocating the Com antenna to the right wing root cover during the upcoming annual inspection.

June 8, 2013

Relocating the Com antenna to the upper wing root cover solved all the radio issues. As the weather warmed up, I could tell that the air deflector was having an undesired impact on the engine oil temperature. To solve this issue, I decided to cut a portion of the deflector off and see what effect it had. I cut 1” off the trailing edge of the deflector. The following flight tests seemed to indicate that the alternator was still charging OK and that the oil temperature dropped about 10 degrees. I decided to cut another 1” strip off the trailing edge. Flight tests seemed to indicate that while the alternator output was less than before, it was still charging the battery at about 4 amps, which was adequate for me and it appeared that the oil temperature was reduced a bit more. These tests were not very scientific in that little data was recorded but my general impression was that the oil temperature returned to an acceptable level and that the alternator was still charging the battery at an acceptable level.

July 2013

As the ambient temperature increased to the mid 80's to low 90's, I was still concerned that the deflector had some impact on the engine temperature. I decided to totally remove the deflector to see what impact its removal would have. When it was removed, I noticed that the alternator output dropped to just over one amp while there was no appreciable change in the engine temperature. This suggested to me that while the small deflector had little impact on the engine temperature, it did have a significant impact on the alternator output. Therefore, I reinstalled the small deflector.

Electrical Loads

Icom A210 - 11.5-27.5V DC (negative ground). Current drain (at 13.8 V DC) Transmit 5A max, Receive 4A max., 0.5A – Stand-by

Garmin 296 – 11 – 35 VDC, 0.20 amps @ 14 VDC

JPI 830 Analyzer – 10.5 – 35 VDC, 1 amp startup, .5 amp normal

Ipad power consumption approximately 3 watts

Red Light K17-410 – 2 watts

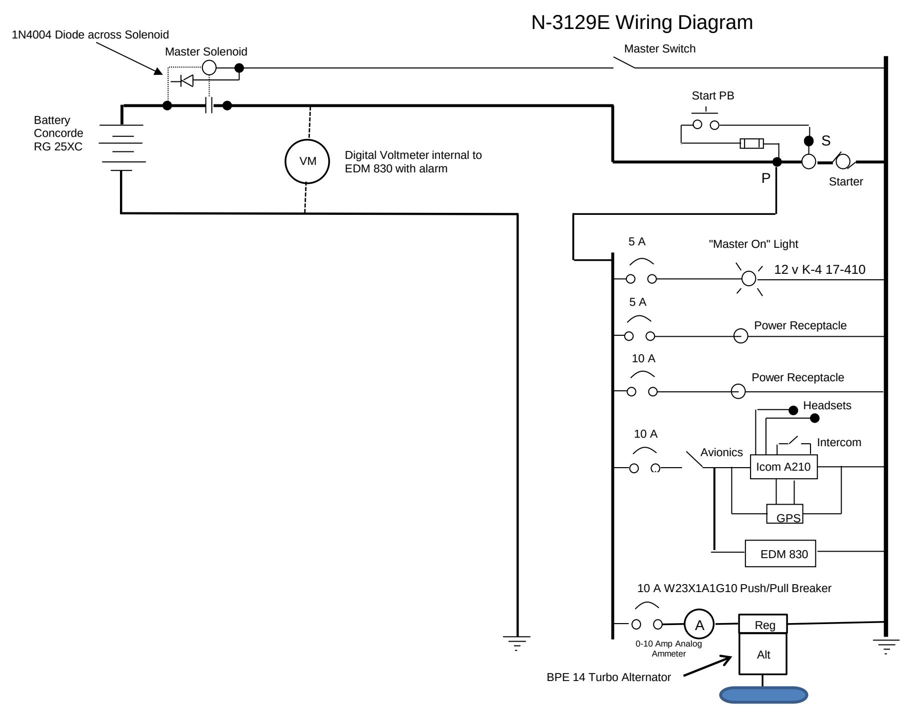
Master Relay (solenoid) – 9 watts

Sky-tech starter -

Electrical Rating of Alternator

6 amps at 80 mph, 9 amps at 100 mph. 14.0 +/- 0.5 VDC

Electrical Schematic Diagram



Weight and Balance when installed on an Aeronca Champ

The installation instructions for the BPE-14 Model 1008 alternator installed on a Champ indicates that the units center of gravity is located 1.6” forward of the aft mounting holes as shown below. The unit weight is listed as 4.0 pounds. As shown below, the aft mounting holes are .88” forward of the face of the mounting bracket. When using the wing leading edge as the datum for aircraft weight and balance calculations, the center of the aircraft axle is 1/4” forward of the aircraft datum. Based on dimensions shown on Aeronca drawings 1-2326 and 7-450, the front face of the axle attachment bracket is located 0.825” forward of the aircraft datum. Therefore the alternator assembly results in a weight of 4 pounds located 0.825” + .88” + 1.6” = 3.31” forward of the aircraft datum. This yields a moment of 3.31” X 4 lb = 13.22 in-lb.