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THE AUBURN CORD DUESENBERG CLUB NEWSLETTER

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The Bundy Find

An organization for the restoration and preservation of original Auburn, Cord and Duesenberg automobiles

THE YEAR OF THE CORD 810

Allan McCrary's 1936 Cord 810 Cabriolet, 2505F

Photograph by John Streeter

FOR THOSE WHO HAVE NEVER RELISHED THE COMMONPLACE

TECH TALK

Investigating Cord Radiator Airflow

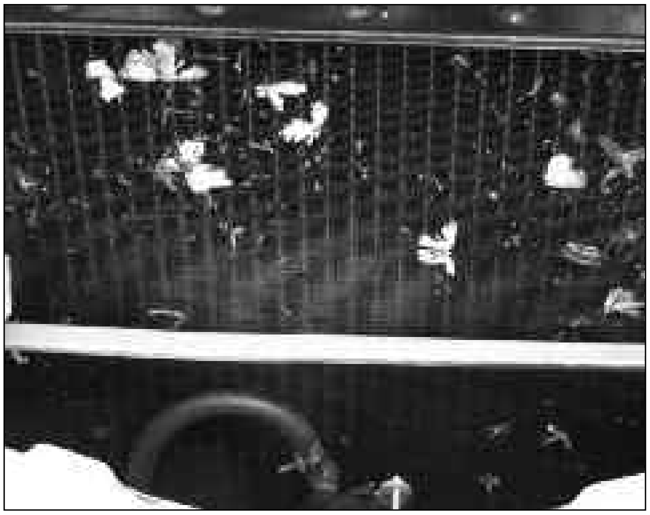
by Lynn Kissel

Part 1

In this article I describe the design of a simple, inexpensive instrument to measure the airflow through a radiator. In a subsequent article I intend to use this instrument to measure the flow through the radiator of my stock 1937 Cord. If this works as expected, it will enable a quantitative assessment of many questions associated with Cord cooling.

My wife Jeanne and I recently became the proud owners of *Ginger*, a Cord 812 supercharged Custom Beverly (serial number 310096S, engine number FC2733, ACD certification number C-306). I document many of our adventures with *Ginger* and our other cars on our website *Locomotus Primordius (www.starship.org).*

Ginger, our 1937 Cord 812 supercharged Custom Beverly, as she rolls off the van and is delivered to us on Oct. 29, 2010.

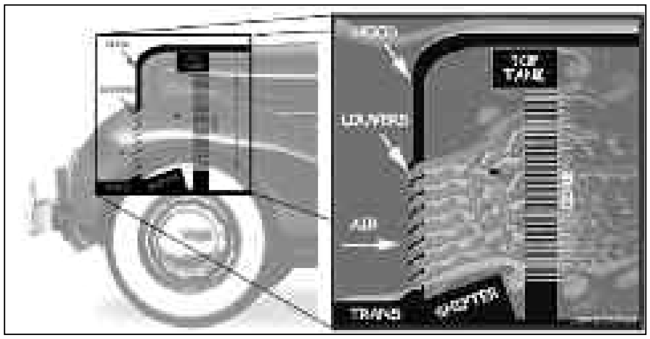


Parts of flying insects populate selected areas on the radiator of Josh Malks's *Moonshadow.* The distribution of insect bodies demonstrates non-uniform flow across the face of the radiator.

Soon after acquiring the car I was honored with a visit by northern California Cord owners Allan McCrary, Jim Lawrence and Josh Malks, who spent a day inspecting the car, offering helpful suggestions and generally sharing their extensive knowledge and Cord experience with me. At some point in the discussions, Josh related his experience during a four-Cord trip from the west coast to Auburn in 2009. The Cords drove through a swarm of yellow butterflies. Afterward, butterfly bodies were found to be concentrated at the top of the Cord's radiator core rather than being uniformly distributed over its face. This constitutes *prima facie* evidence of a lack of uniform airflow across the face of the radiator.

As a retired physicist, this story greatly intrigued me. I continued to ponder it for days after the visit and wondered how I could materially contribute to the conversation about airflow through and around the Cord radiator.

My thoughts first turned toward a simulation of the airflow. Although I do not have access to a suitable computational-fluid-dynamics code, I searched the internet and discovered the *Flow Illustrator.* Using this website, I spent some days performing two-dimensional simulations that I have summarized on my website (look under *Ginger > Adventures > 2010 > Airflow* on *www.starship.org.*)

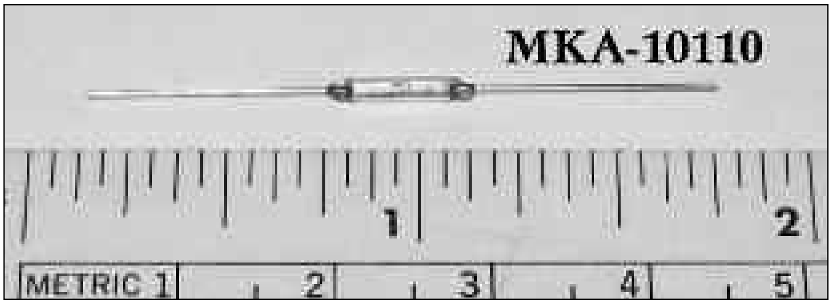


The two-dimensional geometery (left) and a frame from a *Flow Illustrator* movie (right) show a relatively uniform top-to-bottom flow through the radiator.

My efforts did not reproduce what I call the "butterfly effect" but one could easily question their validity. As it would be difficult for me to do much more with the tools that I have available, I began to think about an experimental approach to the problem.

If we can establish, in detail, the "baseline" airflow for a stock car, it may suggest how cooling can be improved. Further, we can definitively discuss effectiveness of various modifications – some already suggested by other Cord owners – by comparing the modified airflow with that from the baseline.

What I want to know is the speed of the airflow at all points across the face of the radiator. We need to take the measurements with the hood closed and it will also be desirable to take measurements while driving down the road. So an instrument that can be monitored remotely is needed. Finally, I don't want to spend a lot of money on the effort. Is this a *Mission Impossible* assignment? – maybe not.



This 10mm magnetic reed switch, acquired on eBay for less than two dollars, can switch up to 15W in about 0.001s. Normally open, the switch will close when a magnet is brought sufficiently close.

I found many designs for anemometers[1] (wind speed meters) on the internet. Small, handheld units incorporating a turbine are readily available on eBay and they come close to being suitable for our purposes. The main drawback of these devices, besides the expense, is the lack of a remote readout.

My "eureka moment" came when I saw a rotating-cup anemometer (the familiar ones used for measuring wind speed in a typical weather station) that someone built using ping-pong balls. The enabling idea was use of a digital bicycle speedometer (the kind where a magnet on a spoke triggers a sensor attached to the frame) to measure rotational speed. I've adopted this concept in the design of a turbine anemometer using the components from computer muffin fans.

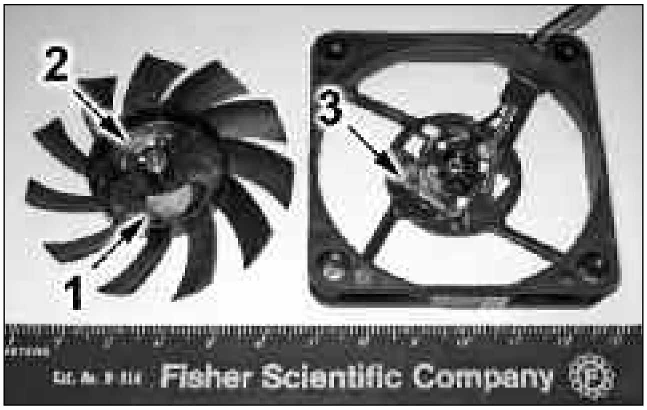
The design has gone through several revisions. The earliest version was cobbled together from a used bicycle speedometer and a 3" (76 mm) muffin fan. Removing the permanent-magnet motor from the fan, I epoxied a small magnet to the tip of a blade and attached the speedometer sensor to the outer edge of the fan case. Placing the assembly over one of the registers of our forced-air furnace, I was delighted to see the fan spin and the speedometer display *48*. Yahoo! I had built a working prototype from parts out of my junk bins!

Unfortunately this fan had simple bushing-type bearings so it was not sensitive to the slower air speeds that I encountered across the radiator of my idling Cord. Happily I was able to find relatively inexpensive muffin fans ($5-15 depending on size) with high-quality ball bearings at a nearby computer store.

Computer cooling fans typically have a permanent-magnet electric motor under the large central hub of the fan. This motor needs to be removed before the turbine can be used for our inexpensive anemometer. I broke two fans before discovering the small split washer that retained the fan axle in the case (typically hidden under a sticky paper label on back of the fan). Once the fan is separated from the case, the motor permanent magnet can be easily pried out from its press fit inside the fan hub; the circuit board and motor windings can then be removed from their press fit in the case. This leaves us with a high-quality turbine that will spin freely on a low-drag axle.

The Trek™ LCD bicycle speedometer I have uses a magnetic reed switch to sense a moving magnet. I was able to find inexpensive, high-quality, magnetic reed switches in various sizes on eBay and I acquired a selection for further experimenting. The small permanent magnets I used came from the backing mounts used for novelty "blinky-light" LED jewelry.

In my third-generation anemometer design, I mount the switch, magnet and counter weight under the central hub of a gutted muffin fan. A ten-foot length of coaxial cable (to shield against noise from the engine ignition) connects the converted fan to one of two readouts that I've used, my Trek speedometer or an automotive tachometer and battery.



Construction details of my third-generation 60mm anemometer. A small permanent magnet is hot glued to the underside of the fan hub at **1** while a counter weight (portion of a #6 flat washer) is attached at **2**. The ends of a 10mm magnetic reed switch have been soldered to the fan power leads and glued to the frame of the fan at **3**. Once reassembled, the reed switch will momentarily close once per revolution of the fan.

Absolute calibration of these homemade anemometers isn't critical for my anticipated use, which is to understand the uniformity of the flow across the face of the radiator and to investigate the effectiveness of modifications. Still, an absolute calibration would allow us to compare measurements from different anemometers, perhaps used by different individuals on different cars.

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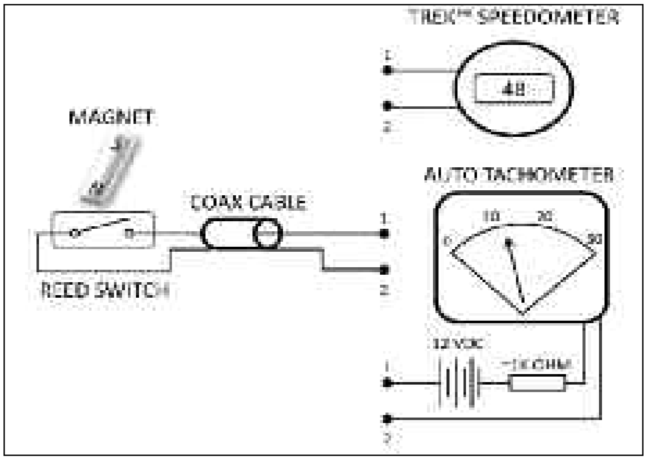
[1] Pronounced "a-nə-MOM-e-ter". These instruments were first described about 1450 by Leon Battista Alberti, a remarkable polymath who has often been described as a model of the Renaissance "universal man."



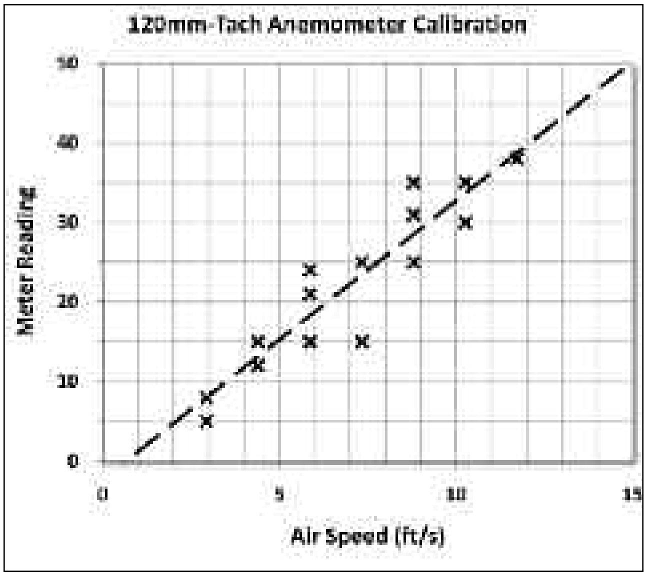
A circuit diagram of my homemade anemometer. Either the speedometer or tachometer can be used as readout for the instrument.

Lynn prepares to record calibration readings on one of his homemade anemometers.

To this end, I attached my anemometers to the end of a wooden dowel and took readings from the passenger seat as Jeanne drove our car around a parking lot.

Using this approach I've constructed and calibrated three anemometers using an auto tachometer as the readout.

I have used one of my second-generation instruments to make a preliminary survey of the airflow through my Cord's radiator. I have already observed some interesting things! I will describe them in my next article once I confirm them through a more careful survey with my third-generation instruments.



A straight line is fit to the meter readings that Lynn recorded with the 120mm anemometer using the tachometer readout. The instrument was stuck out of the window of a moving car for this calibration. The air speed is inferred from the car's speedometer reading using the conversion that 60 MPH is about 88 ft/s. With an air temperature of 45°F and winds of 1-2 MPH, multiple readings with the car moving in different directions were taken to average over the background wind.

For those of a scientific bent, here are the formulae I used:

The calibrated air flow, y (in ft/s), is obtained from the tachometer reading, x (in arbitrary units), using the following formula.

$$y = m_i{*}x + b_i,$$

where m_i and b_i are parameters specific to a given instrument. For the 60-, 120- and 200-mm instruments that I have built, the calibration parameters are:

$$m_{60} = 0.17,\ b_{60} = 2.79;$$

$$m_{120} = 0.29,\ b_{120} = 0.64, \text{ and;}$$

$$m_{200} = 0.21,\ b_{200} = 4.46.$$

Looking at these parameters, one can see that the 120mm instrument appears to have the lowest friction bearings. It requires significantly less airflow to generate an initial reading compared with the others (smallest y-intercept, b). Remarkably these instruments all have similar dynamic responses (similar slopes, m, computed as the change in y divided by change in x). Maybe this results from their original design as cooling fans.