TAILWINDS

EAA THE SPIRIT OF AVIATION

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Hogan Field EAA 974
Butler County Regional Airport
Hamilton, Ohio

EDITOR'S NOTE

I was originally not going to publish a newsletter for January due to no meeting or other activity. However, Kevin Gassert sent me a very interesting article about prop clocking by Doug Hurd. I thought it worthwhile to publish this for all to see. It's good to have something technical and educational to place in the newsletter once in a while, and since the newsletter is basically a blank page for the month, thought it would be good to let the article take up the newsletter by itself. Thanks Doug for your contribution and thanks Kevin for sending it to me.

PROP CLOCKING BY DOUG HURD

The clocking of the prop on a Continental C75/85-12F as used on an Ercoupe

About 5 years ago I decided to allow my 3rd class medical to expire and fly as a Light Sport pilot. I purchased a light sport compliant 1947 Ercoupe 415 CD from Kurt Yearout and had Skyport Services rebuild it.

I had been flying a home built Vari-Eze canard pusher for 15 + years and it flies very different than an Ercoupe. Jonathan Hardwick gave me the transition training in my coupe. During training my coupe was vibrating and on full throttle climb out it had a hard shake. If my home built would have vibrated that bad I would have grounded it. Jonathan suggested I have Kevin Gassert check out my coupe.

Kevin looked at the position of my prop and asked if I had turned it after shutting down the engine. I said no. Kevin said the prop was probably clocked wrong.
Looking at the prop while standing in front of my coupe the Prop was at about 1:00 and 7:00 o'clock after the engine came to a stop. Kevin said he would check it.

I was very skeptical that the clocking of the prop would make any difference based on my 15 + years' experience with my home built pusher, a Lycoming powered Vari-Eze, with a 53 inch diameter wood prop that weights 7 lbs. I would clock the prop so that it was not behind an exhaust pipe when that cylinder fired because the exhaust heat would soften the glue between the plies of the wood prop.

The correct procedure to check the clocking is to rotate the engine by hand until you hear the impulse coupling on the mag “click”. The engine will now be on top dead center. If the props clocking is correct, while looking from the front, the blades should now be between 1 & 2 o’clock and 7 & 8 o’clock. But if the prop is horizontal it needs to be changed. Mine was horizontal and needed to be moved one bolt hole counterclockwise.

After Kevin changed the clocking of my prop it now normally stops at about 11:00 and 5:00 o’clock and there was a huge difference to good!!

I needed to know why!

The Continental engine in the Ercoupe is a four cylinder 180°opposed “Boxer” meaning that in each set of opposed cylinders the pistons move in and out in unison (see fig. 1). The front set of cylinders cause the problem

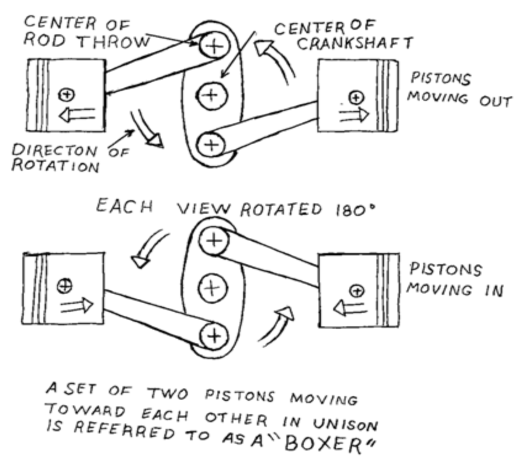
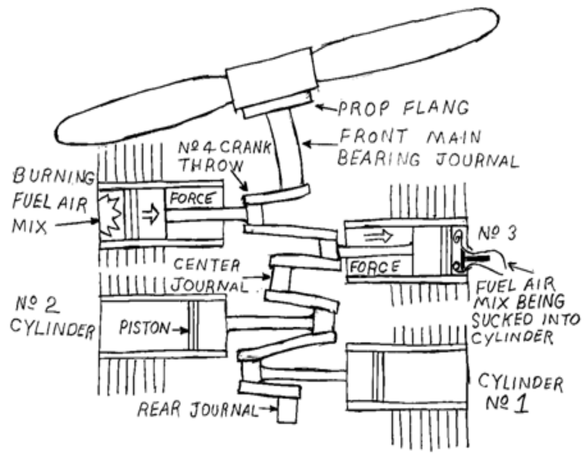


FIG N°1

The steel and aluminum the engine is made from looks and feels very rigid, but all metal can take a small bend and spring back to its original position with no damage. Although small there is always some flexing. This is all normal and nothing to be concerned about. In piston engines this flexing is called crankshaft deflection and there is a lot of published information about it but mostly concerning rotational flexing of the crankshaft from torsion and not crankshaft center line deflection that causes flywheel precession which causes our vibration problem.

In our engine when each of the cylinders is on the power stroke that piston via the connecting rod pushes on the crankshaft throw with about a max of 10400 lbs force (see note A). While the opposing cylinder's piston is on the in-take stroke, being pulled down its bore to suck in a new fuel/air charge, this pulls the crankshaft in the same direction as the power stroke piston is pushing, so both pistons are flexing the crankshaft in the same direction (see fig. 2).



EXAGGERATED DRAWING OF A FLEXING CRANKSHAFT

FIG Nº2

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The flexing crankshaft is mounted to the aluminum crankcase via the main bearings. The pressurized oil film between the steel crankshaft and the bearing's babbitt lining keeps them from touching while the flexing crankshaft pushes the main bearings out of alignment. This causes the prop flange to be flexed off the center line of the engine. Then everything flexes back into its original position only to be flexed to the other side when the opposing cylinder is on its power stroke. This is all normal and happens every revolution, 2400 times a minute for thousands of hours.

A spinning flywheel acts as a gyroscope which becomes fixed/rigid in space and resists being moved out of the rotational plane it is spinning in. When a flywheel is forced to move it pushes back but at 90° from the location of the force in the direction it is spinning in. This is torque induced precession (see fig. 3 next page)

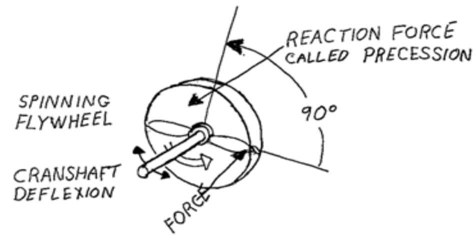

FIG. N°3

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Our flywheel is a six foot long aluminum McCauley propeller that weighs 27 lbs. This rimless flywheel does not have a continuous circumference. The prop has six equally spaced holes in the hub for the bolts that secure the prop to the crankshaft. We could think of these holes as three sets of two holes. Each set has its partner located 180° apart. One of the sets of holes is aligned with the props long axis that runs from tip to tip (see Fig 4)

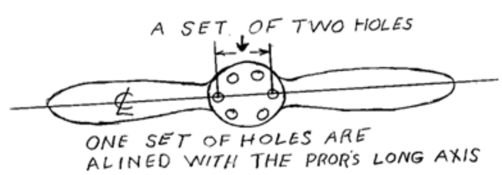
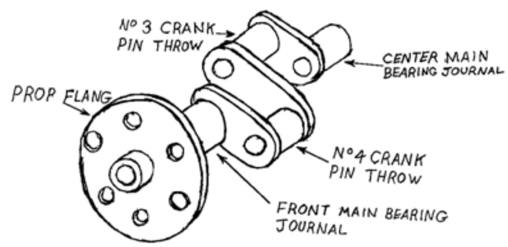


FIG N° 4

The flange on the crankshaft also has six equally spaced holes. One set of these holes is aligned with the crankshaft throws (see Fig 5). This means the prop could be clocked in three different positions.



FRONT HALF OF CRANKSHAFT

FIG. Nº 5

When the prop is clocked with its long axis aligned with the crankshaft throws the tips of the prop will be forced out of the rotational plane they are spinning in every time the crankshaft is flexed from the force of the pistons. The resulting precession pushing back is felt as a bad vibration (see fig. 6).

But if the prop is clocked so that the flex of the crankshaft causes a rotation of the prop's long axis, while keeping the tips spinning in their rotational plane there will be no precession (see fig. 7) and the engine feels smooth.

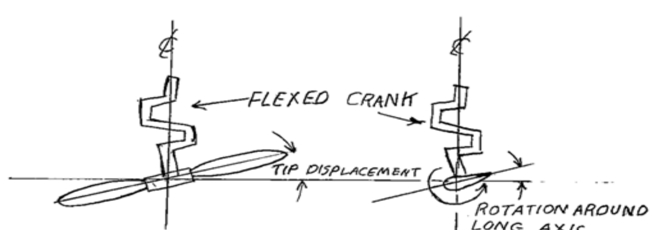


FIG Nº 6

FIG. Nº 7

Why did changing the clocking of the prop on my home built not make any notable difference in the vibration? My home built is powered by a Lycoming which has a different firing order and a flywheel plus the short light wood prop does not make a very good flywheel and the precession force is very light.

Thank You Kevin

By Doug Hurd
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Note A

When a fuel/air mixture is burned the oxygen breaks the bonds in the fuel molecule and the bond energy is released as heat. The more energy the fuel/ air mixture has in it, by compressing before the burning, the more heat energy will be released, at a rate of about 10 to 1. Starting with an ambit pressure of 14 pounds per square inch (psi) our engines have a compression ratio of 6.3 to 1. This raises the fuel/air mixture pressure in the cylinder to about 80 psi. This energy increase before burning makes the burning pressure about 800 psi.
Our Continental engine has a 4.062 inch bore. This make the top of the piston have a surface of about 13 square inches ($A = \pi R^2$). With 800 pounds pushing on each of the 13 square inches this adds up to about 10400 pounds force pushing on the crank shaft via the connecting rod.

Our author, Doug Hurd, with his lovely wife Elana and his beautiful classic Ercoupe

Doug flying his smooth running Ercoupe