EAA Chapter 1314 December 2, 2020

Leonard Weiser

Agenda

- Get Connected
- Appointment of Chapter Officers for 2021
- Drop Tank Derby – Andy Gelston
- Geometry of Aircraft Brake Pedal Design

Officer Appointments

No nominations or requests were received in response to the solicitation email.

2020	2021
President : Warren Hurd	President: Lenny Weiser
Vice-President: Glenn Hunt	Vice-President: Glenn Hunt
Treasurer: Sindie Hurd	Treasurer: Warren Hurd
Secretary: Lenny Weiser	Secretary: Bruce Norlund
At Large: Jeff Martin	At Large: Jeff Martin

Drop Tank Derby

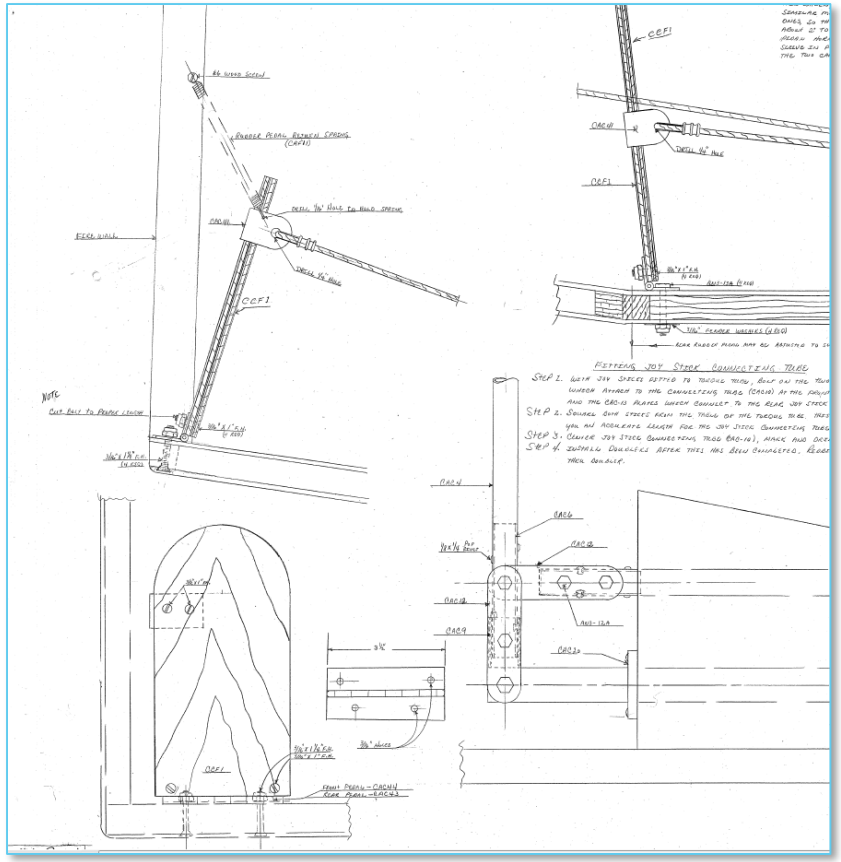
Andy Gelston

How it works

- Teams of young people design and build their own ultralight aircraft
  - Similar to Soapbox Derby
  - Judging based on quality of construction and performance
  - How long does it take for a team to learn, design and build?
  - Liability: What happens if…

My Brake Pedal Journey

My journey begins on Print #8: Controls …and of course, like everything else on this project the prints were of little help.

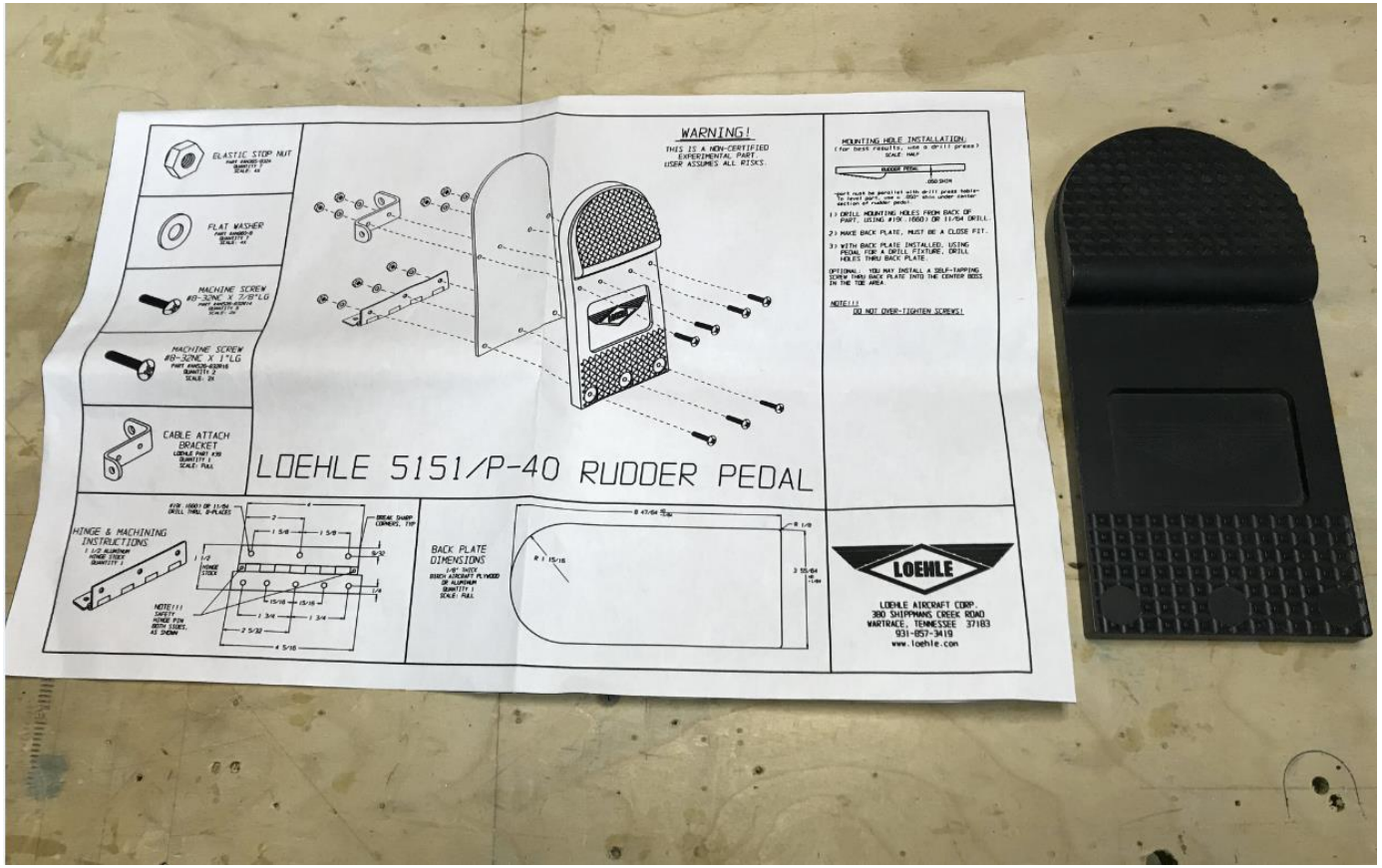


The prints don’t address brakes at all!

The depicted rudder pedal is too short and has no toe brake option.

So…

So I got some old unused inventory from Loehle Aircraft – sight unseen.



Check out that print!
All that just for a pedal!

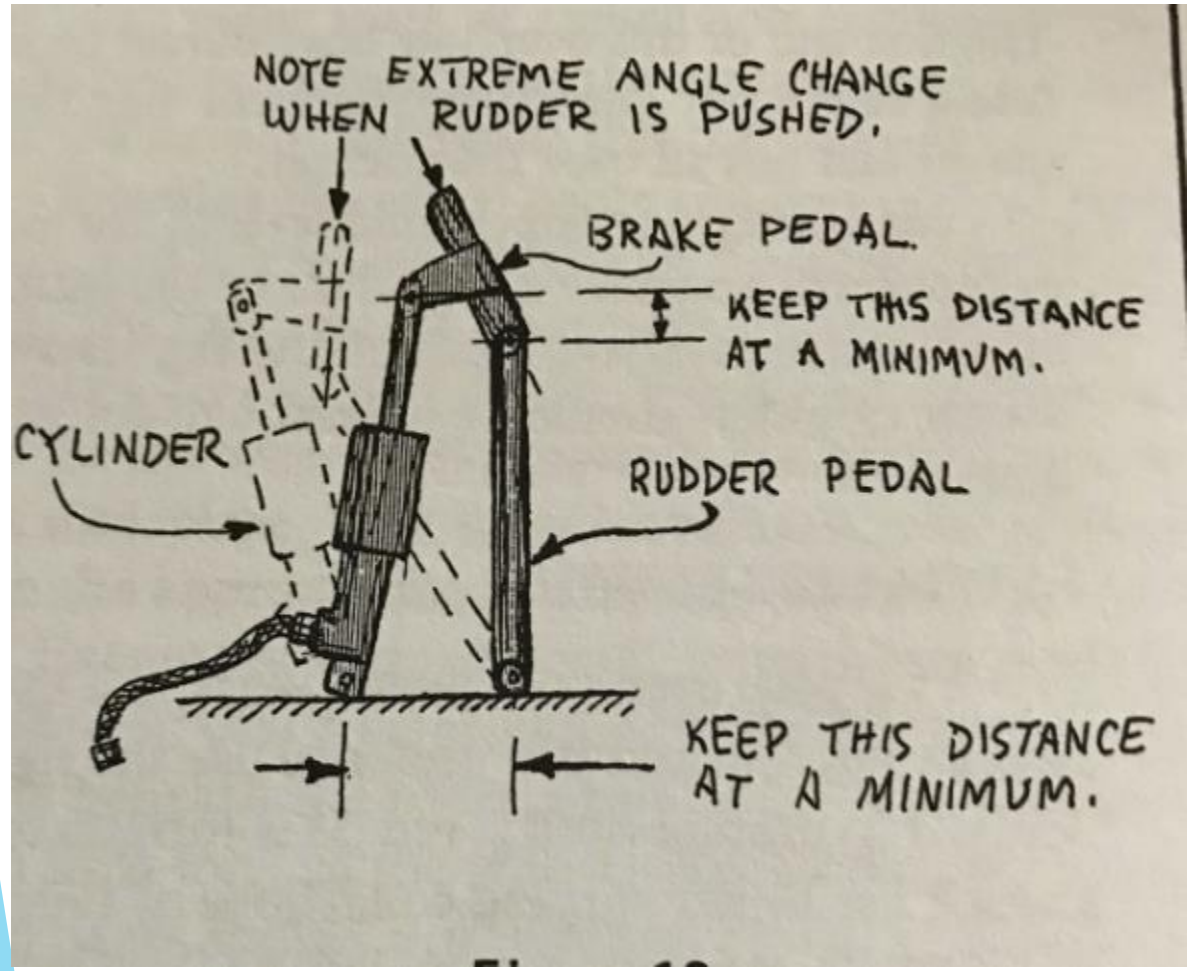
I really liked the pedals, but they did not have a toe brake.

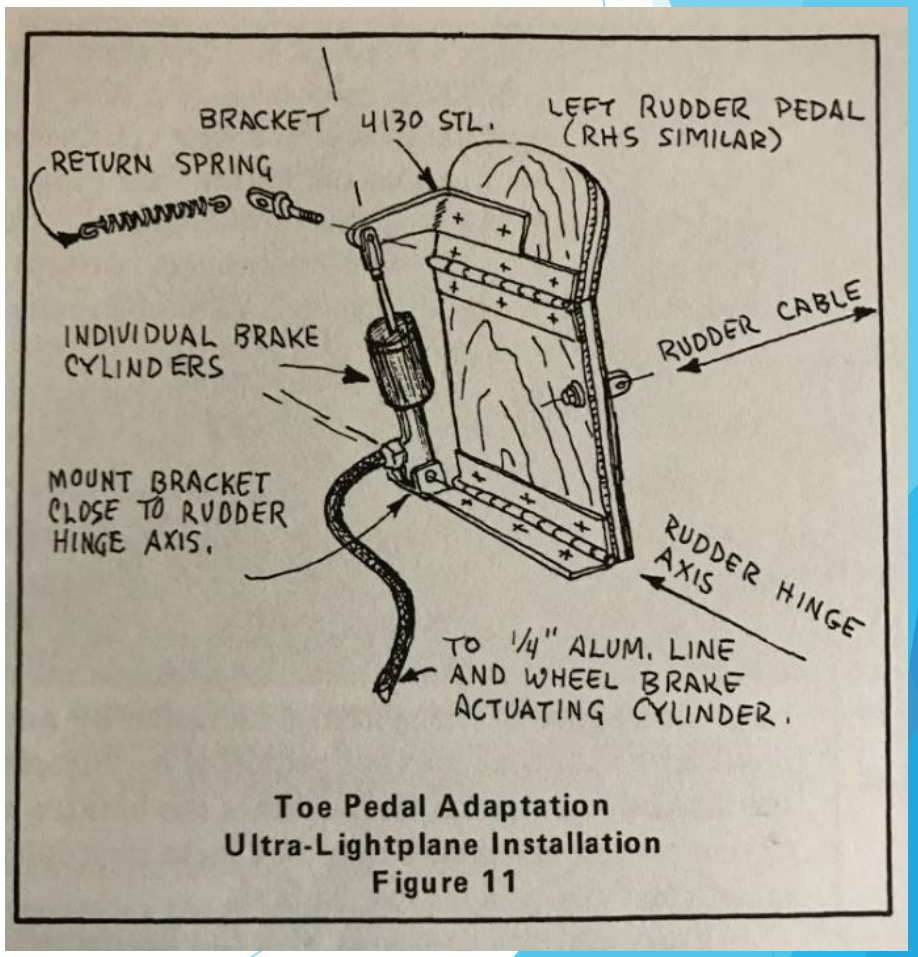
Still, I was determined to use them.

I’m thinking to myself, “This should not be that hard.”

- Confusing guidance
  - Nothing well documented
  - Manufacturers talk in abstract terms
  - Kit makers have (sometimes) figured it out
  - Plans builders are left trying to figure this out for themselves
  - Standard parts don’t exist that will fit your application
  - Certified parts are too heavy, and don’t fit your application
  - And then there’s “Internet advice”…

My first stop for information was my text mentor: Tony Bingelis

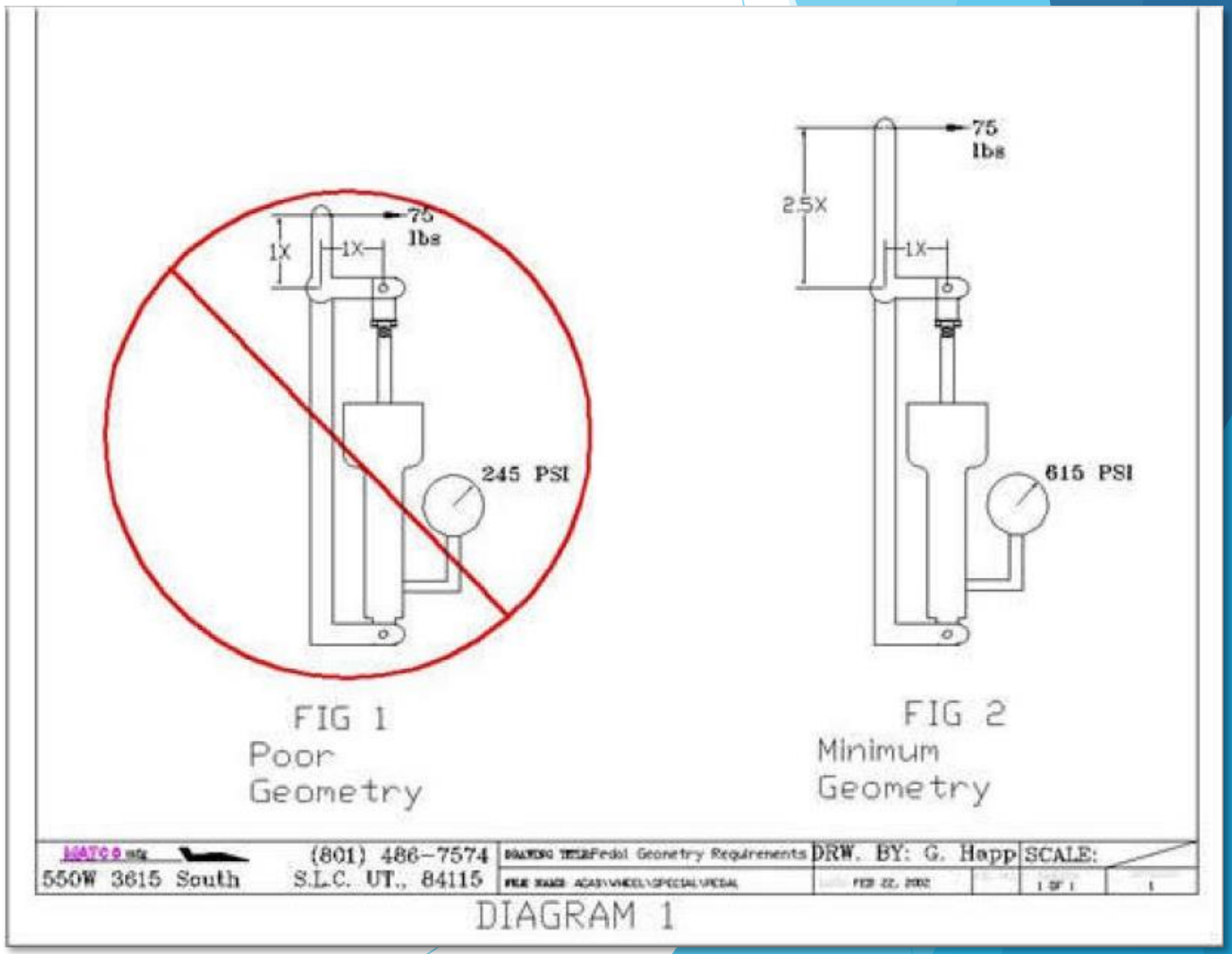




The Guidance From Matco

GET THE PRESSURE RIGHT

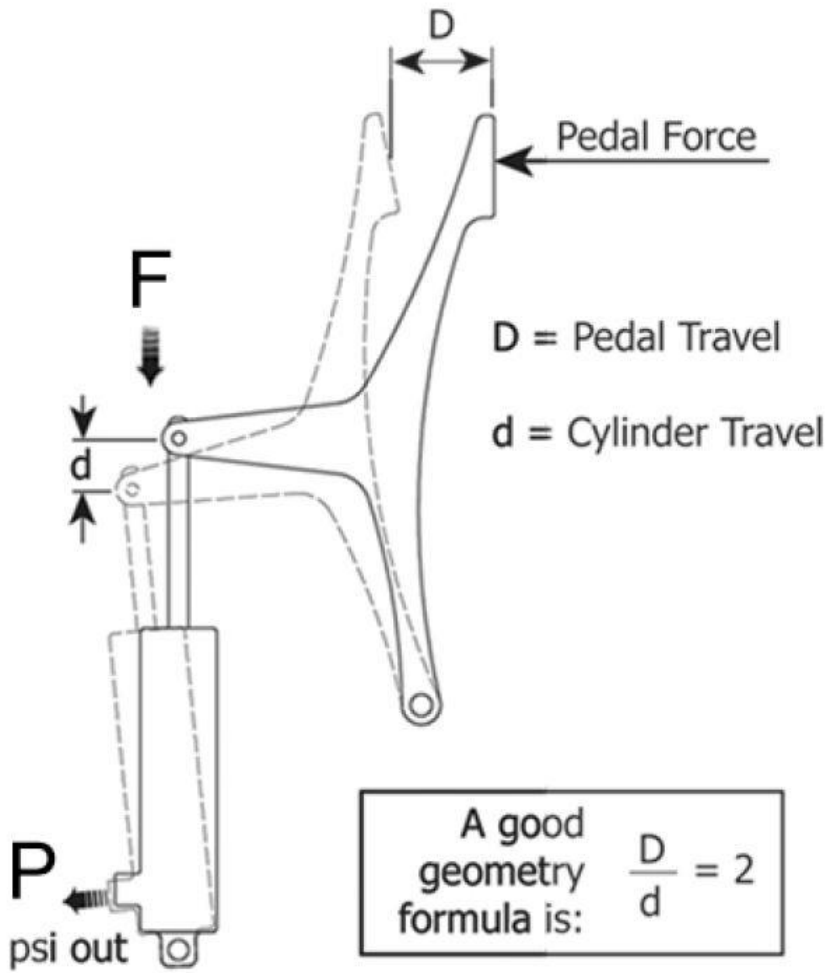
Assuming the calipers are properly mounted so that the pads make contact on both sides of the disc (*both new and worn*) and are maintained so that the calipers float freely, the most common reason for under performance of the brakes is low pressure. MATCO mfg. brakes need 450 psi to achieve their rated torque. Additional calipers can be added to get higher torque at a lower pressure but it is often more weight efficient to modify the hydraulic system pedal geometry to generate high pressures. Systems using hand or foot operated master cylinders require a minimum of 2.5 to 1 mechanical advantage when using master cylinder, MC, like the MC-4 or MC-5 which have .625 inch diameter pistons. (*Systems using MC-4* or *MC-5 with intensifiers have .500-inch pistons and require a 1.6 to 1 mechanical advantage*). Mechanical advantage, MA, is the ratio of the force applied to the master cylinder shaft divided by the force applied by the hand or foot. **Dia. 1** shows two examples of pedal geometry.



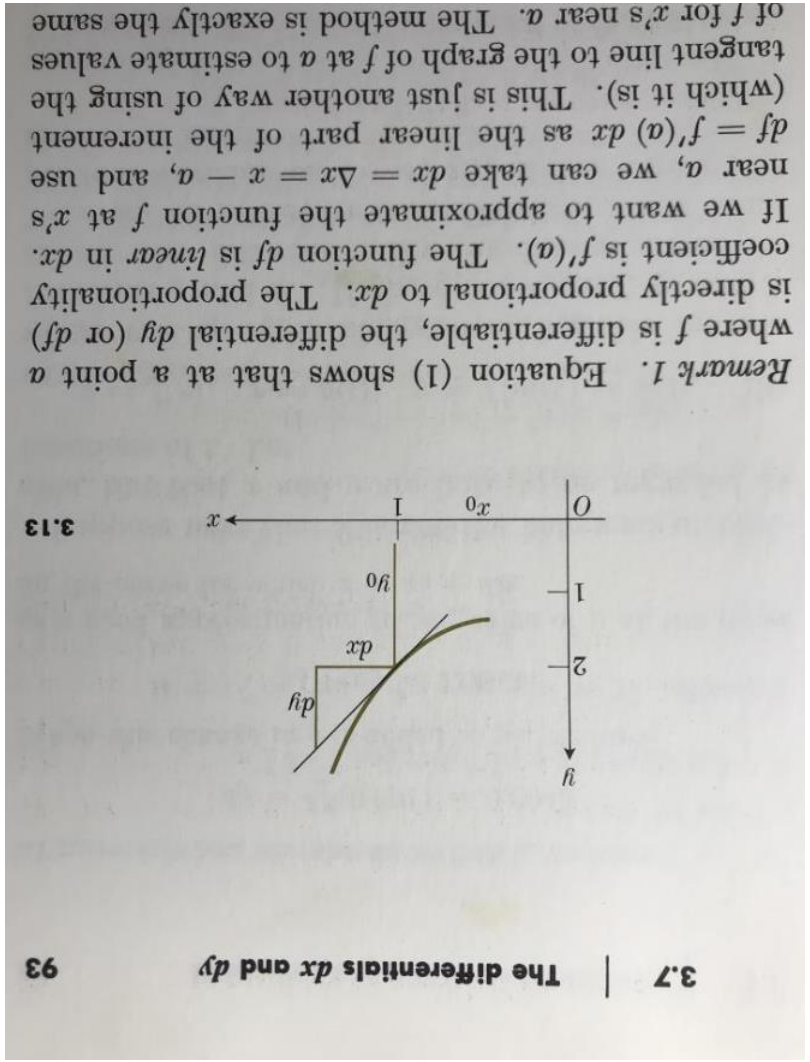
The Guidance from Grove

The brake system pressure (P) produced is P=F/A where F is the force applied to the brake master cylinder piston, and A is the area of the master cylinder piston. Most modern aircraft use a master cylinder piston with a diameter of 5/8". When a force (F) on the master cylinder of 150 lbs is applied, an adequate pressure of approximately 500 psi will result.

To achieve this force, a general rule-of-thumb is to design the brake pedal geometry to have a 2 to 1 ratio of pedal travel to brake cylinder travel. For example, 1" of pedal travel will result in 1/2" of cylinder travel. A pedal force of about 75 pounds will result in an adequate 500 psi pressure to the brake caliper using a standard 5/8" piston diameter master cylinder.



Now this is an opportunity for some math!



3.7 | The differentials dx and dy 93

Remark 1. Equation (1) shows that at a point a where f is differentiable, the differential dy (or df) is directly proportional to dx. The proportionality coefficient is $f'(a)$. The function df is *linear* in dx. If we want to approximate the function f at x's near a, we can take $dx = \Delta x = x - a$, and use $df = f'(a)\,dx$ as the linear part of the increment (which it is). This is just another way of using the tangent line to the graph of f at a to estimate values of f for x's near a. The method is exactly the same

3.13

Where to place the hinge point?

What if brake pressure is applied while the pedal is pressed - as in turning.

As the pedal is depressed the point of pressure moves along a parabolic path.

Once the hinge point is determined then we should be able to make the 2:1 horizonal-to-vertical and the 2.5:1 mechanical advantage dimensions.

But how far to depress the toe pedal to get that?

Matco says that with hydraulic fluid in the MC there is a 1.33” maximum piston travel.

So, at what angle to the hinge point should we get to that 1.33” vertical travel?

With some research I found:

HUMAN FACTORS, 1971, 13(5), 445–456

Foot Forces Exerted at Various Aircraft Brake-Pedal Angles

H. T. E. HERTZBERG *and* FRANCIS E. BURKE[1], *Anthropology Branch, Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio*

rameters of a brake-pedal design that should maximally utilize the mechanical advantage of the Air Force pilot's foot. At the brake-off position (0% of brake application), such a pedal would begin its travel at not less than 15° past vertical, terminating its arc at 35° with 100% of brake application. This is the optimal range. But

CONCLUSIONS

Torque tests of 100 pilots' feet on an instrumented rudder pedal showed that at various angles between 5° past vertical and 55° past vertical, the highest mean forces were

exerted between 15 and 35° past vertical, for all three cockpit sizes and for both leg positions, neutral and extended. Comments on foot and ankle comfort at each angle, solicited from 86 of the men, showed a strong preference for the same arc as a zone for comfortable brake-pedal actuation. As the region of high torque output indicates the arc of maximal mechanical advantage of the foot, and thus probably the zone of least fatigue, these findings should be considered in the design of any pedal in which maximal integration of pedal action with foot motion is sought, whether it be an aircraft brake pedal, automotive accelerator, or other similar lever.

and Eberhard Kroemer of the Anthropology Branch, Human Engineering Division, for his critique of the engineering aspects of this work.

REFERENCES

AFSC design handbook. "Crew Stations and Passenger Accommodations," Series 2-0, Chapter 2, Section 2A, DN 241, Subnotes 1(1) and 1(4) (formerly AD-1 and AD-3). USAF: Hq. Air Force Systems Command, Andrews Air Force Base, Maryland, 1970. (Supersedes previous editions.)

Hertzberg, H. T. E. Dynamic anthropometry of working positions. *Human Factors,* 1960, 2, 147–155.

Hertzberg, H. T. E., Daniels, G. S., and Churchill, E. Anthropometry of flying personnel—1950 (WADC

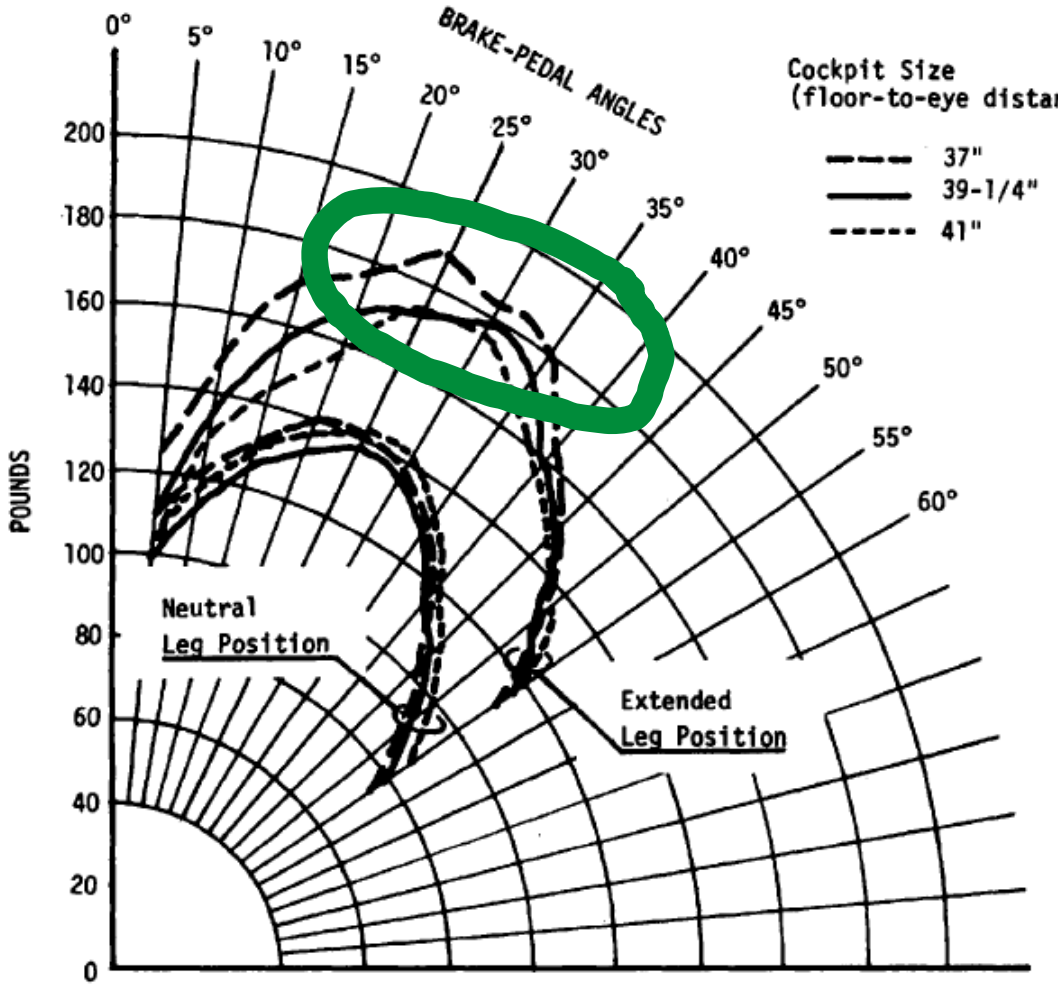


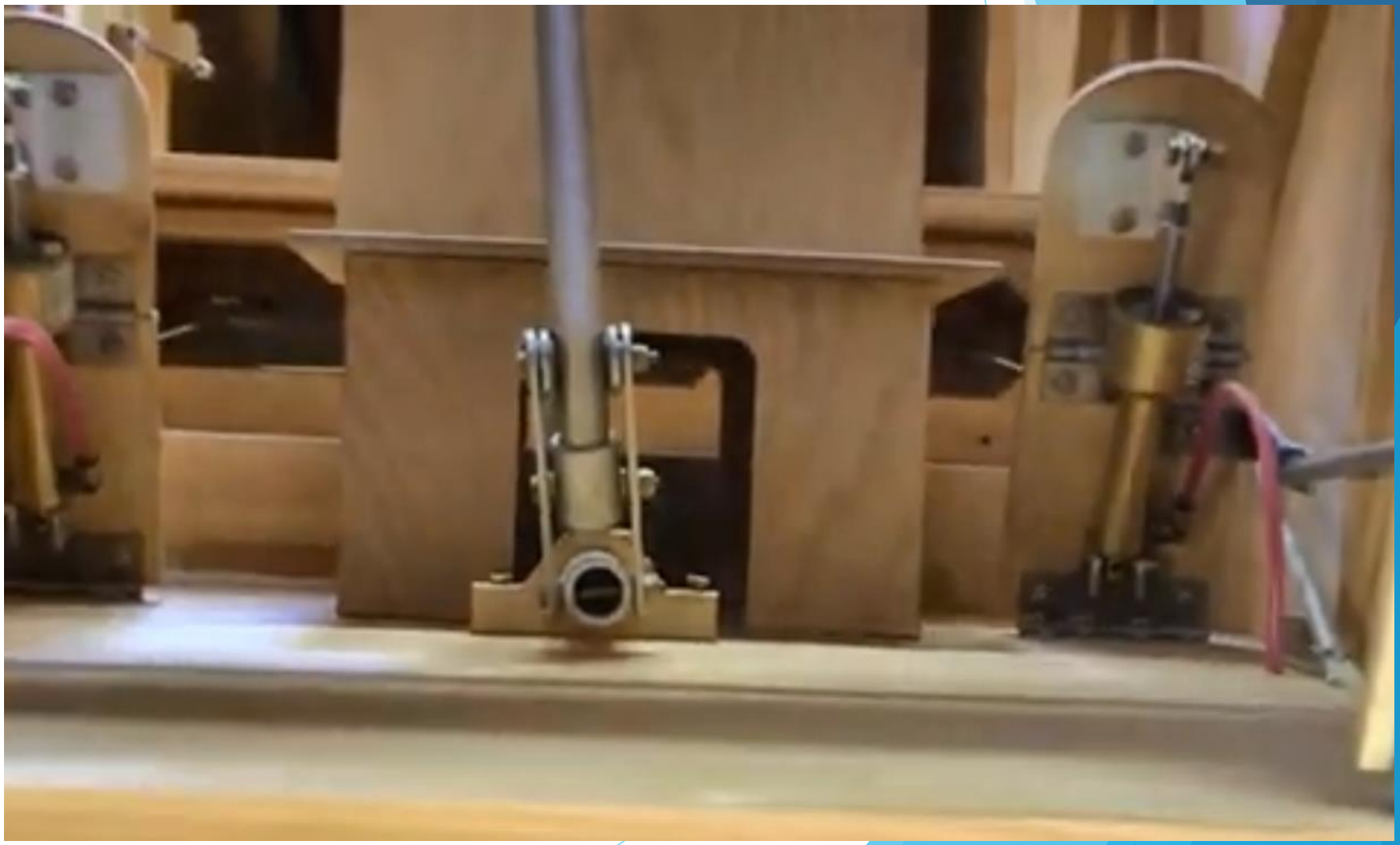
Figure 6. Maximum brake-pedal forces in various leg and foot positions (means of 100 subjects).

So now I had an idea, so I started searching the Internet for pictures

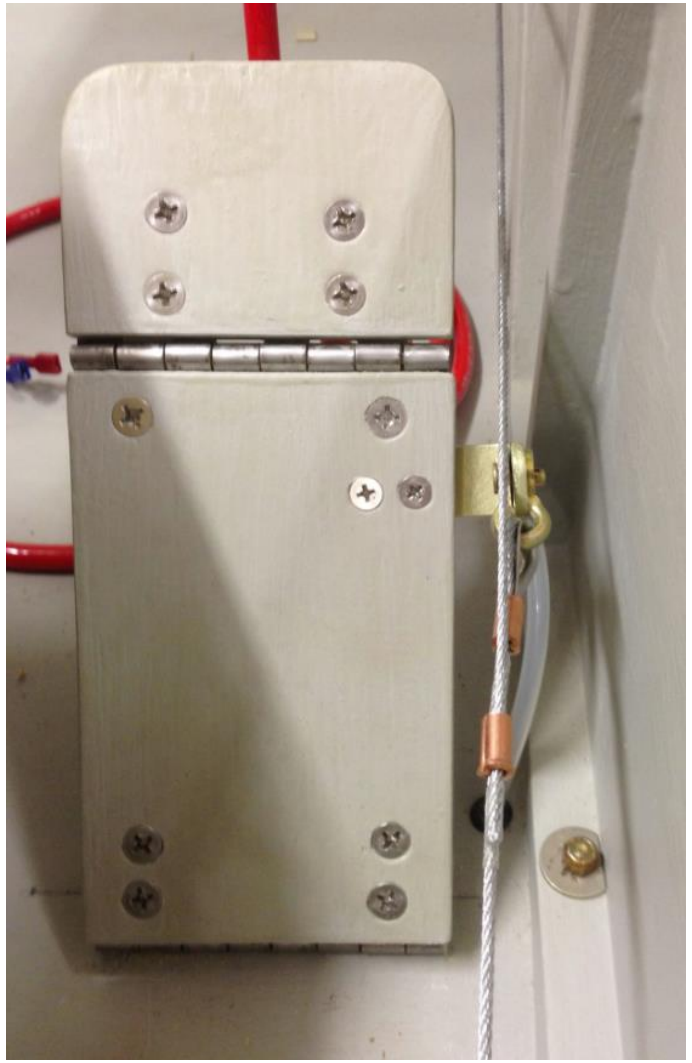
First stop: Fisher Flying Products

Worthless. No dimensional integrity.

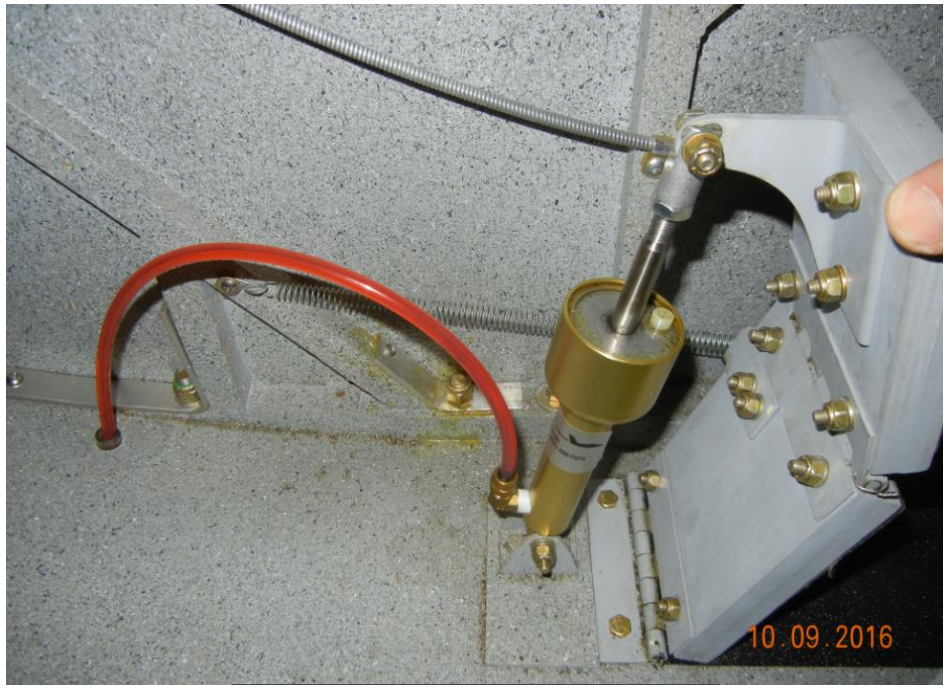
“After my third call to them I decided not to call any more because I knew more about the airplane than they did.”
-Dave Murphy



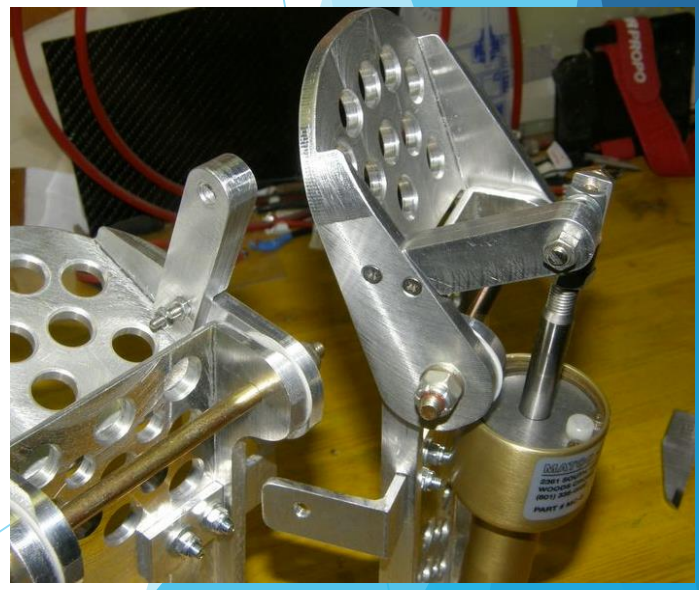
Some Celebrity Builders



Phil Ritchie - Australia

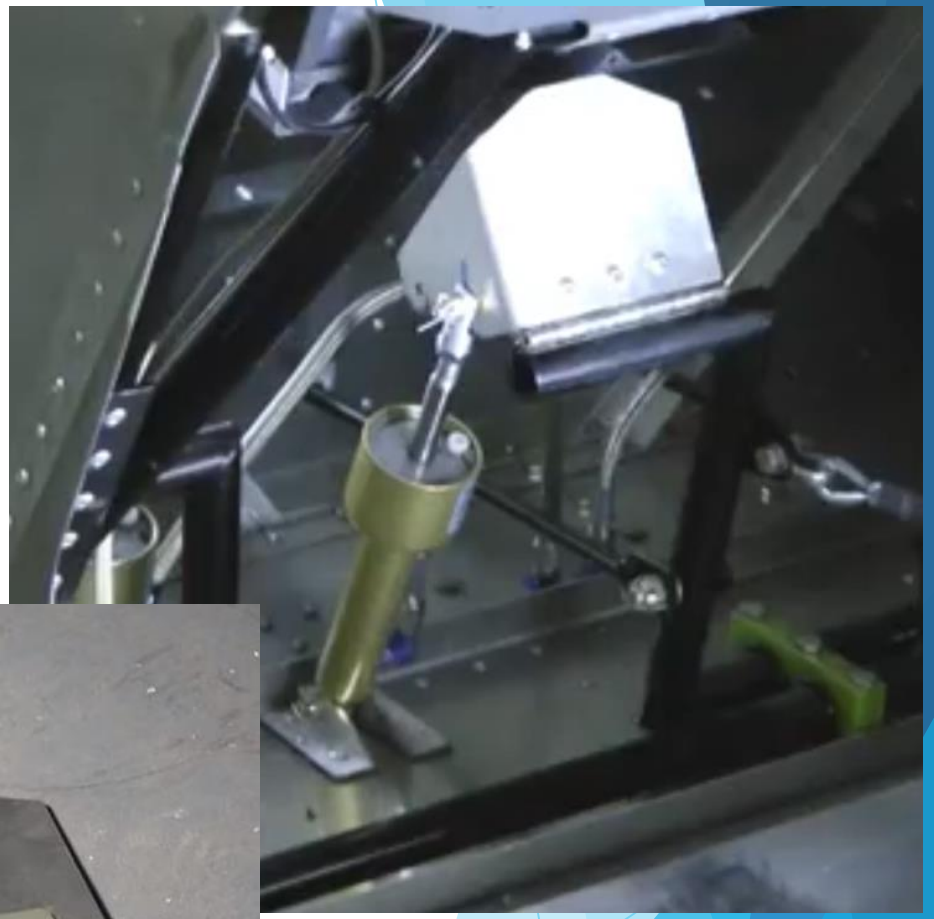


Dave Murphy – Fitchburg, MA

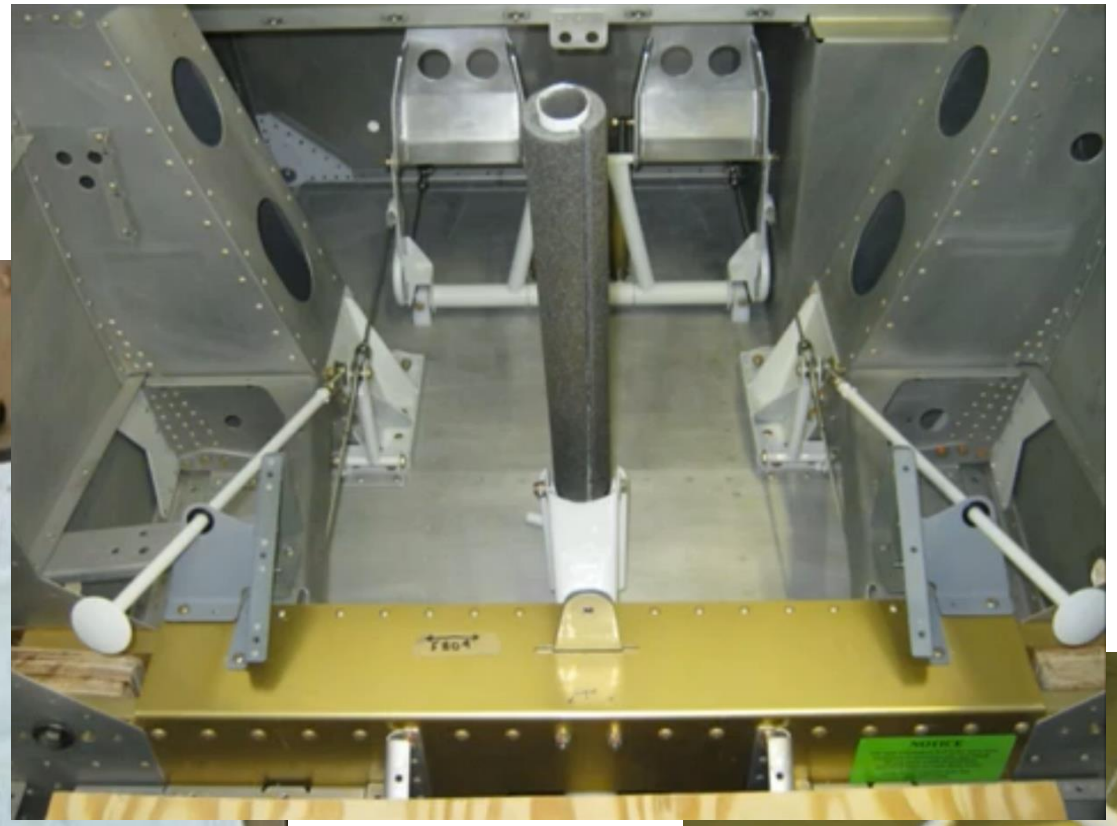


Simone del Lungo - Italy

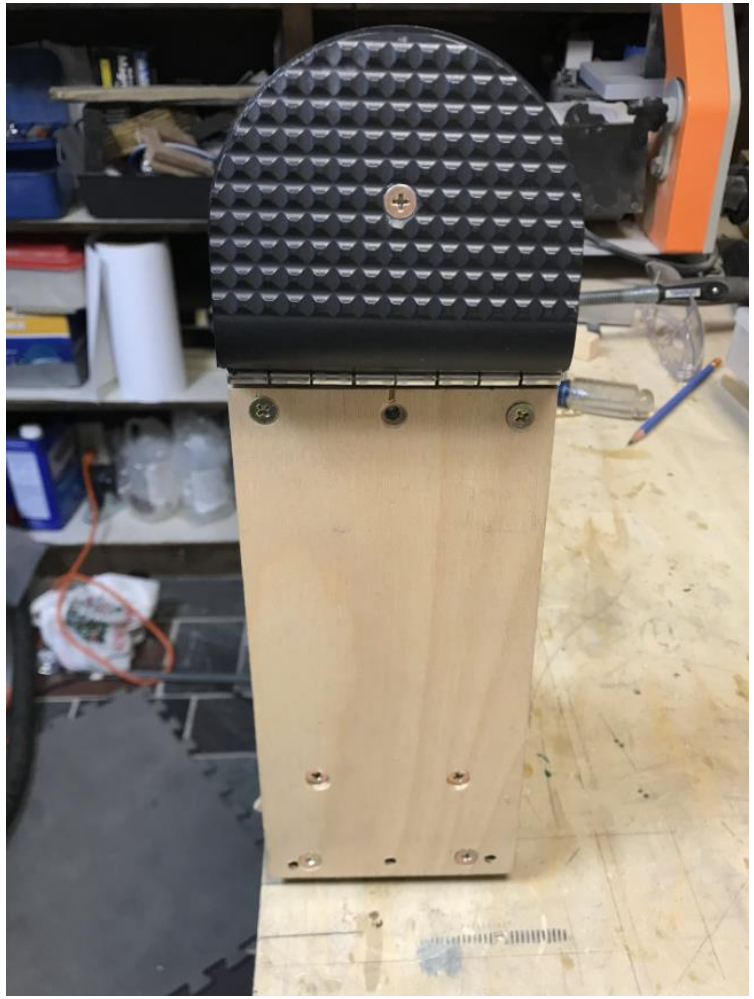
Zenith



Van's



But I still wanted to use my Loehle pedals. After 4 prototypes I settled on this one:



Specifications:

Overall Height: 12.5”
Rudder Pedal Ht: 8.5”
Hinge Point: 8.6875”
Toe Ht: 3.625”
Piston Distance: 1.125”
Mechanical Advantage: 3.22
Max Toe Deflection: 56.1°
Max Rudder Deflection:
Forward: 28.9°
Aft (Towards Pilot): 33.1°
Weight: 1.5 lbs