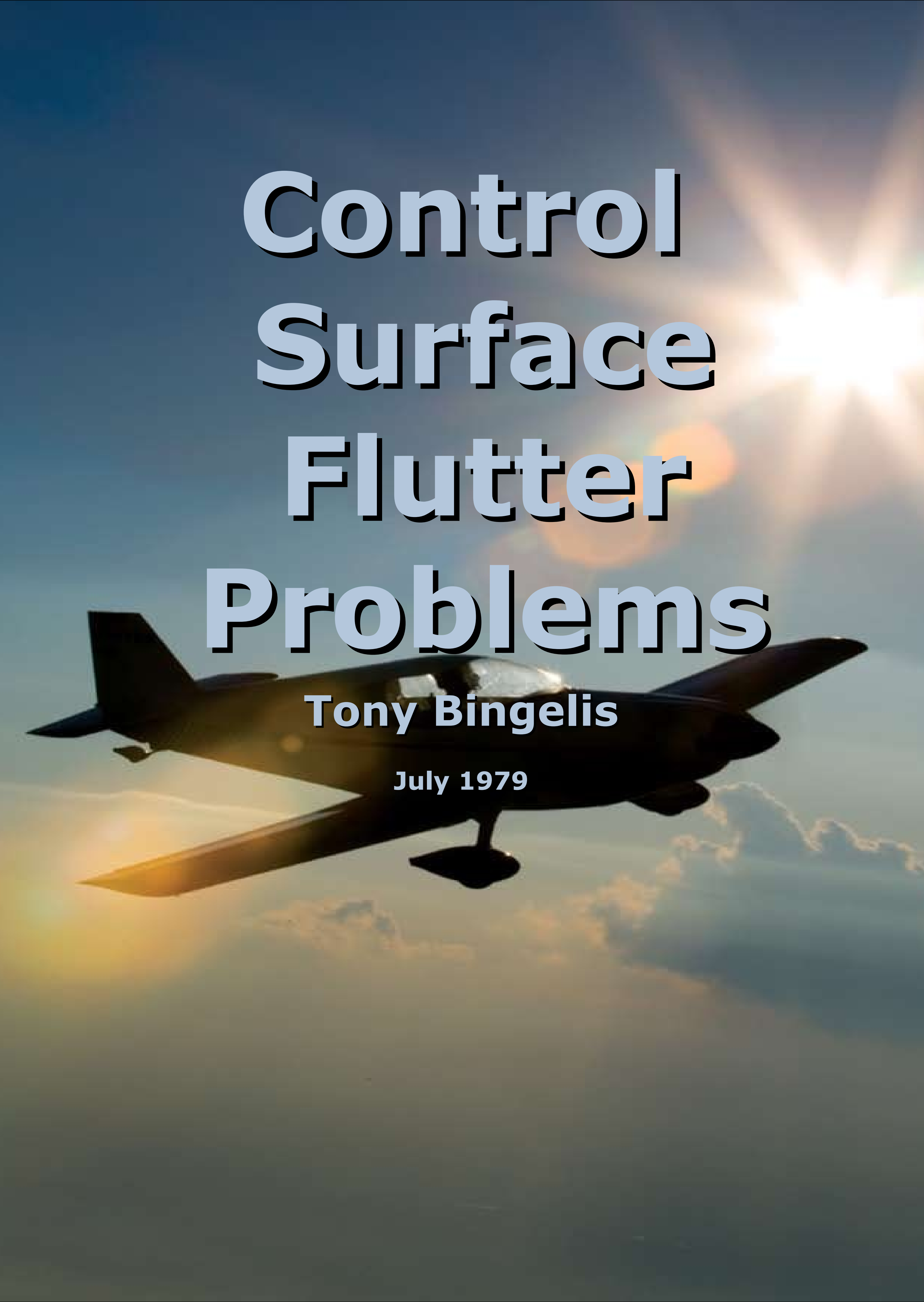

Control Surface Flutter Problems

Tony Bingelis

July 1979

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By Tony Bingelis
originally published in EAA Sport Aviation, July 1979

December 01, 1993

FLUTTER? WELL, SIR, flutter is what a flag does wildly on the flag pole on those days when it is too windy for you to fly. But to better relate it to our subject, it should be described as a potentially destructive vibration or buffeting of an aircraft due to an out-of-balance condition of one or more of its control surfaces.

Now, imagine one of your control surfaces acting like a flag in the breeze ... in flight at 100 or 200 mph. How long do you think it would stay with the airplane? Not for long, I'll wager!

Most of us are aware that the flutter problem is a complex one and it has been around aviation for a long time. So long that flutter specialists must be wallowing around knee deep in the accumulation of flutter fodder generated from years of research and testing. Fortunately, there are a few useful assumptions and certain recognized "good practices" which have been sifted out and any builder willing to apply the guidelines can do much to avoid having a flutter problem. But before I continue, let me discuss a few terms and phrases.

Static Balance

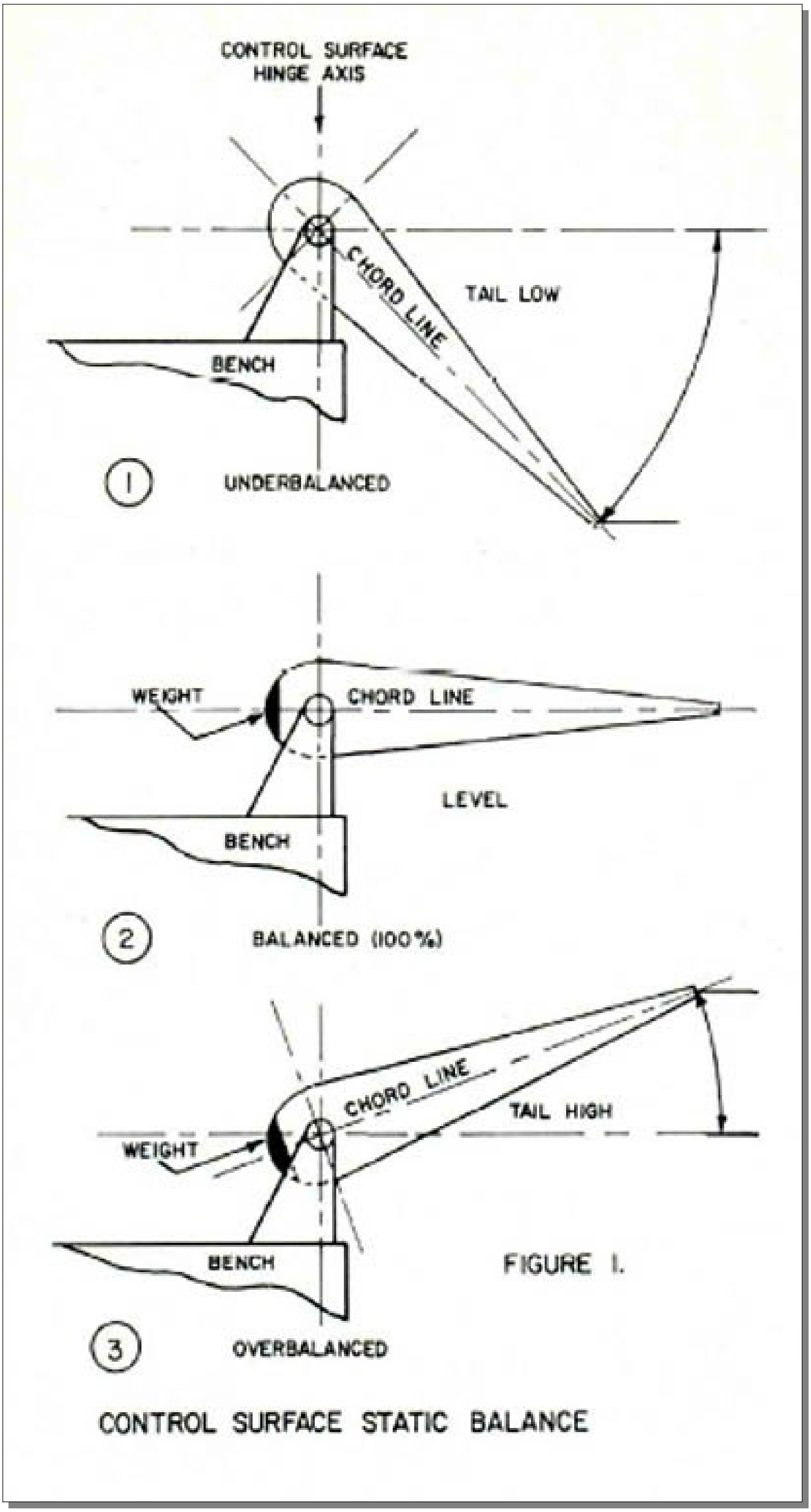
Static balance - A condition that exists when an object (wheel, propeller, control surface, anything) remains stationary while supported on, or suspended from its own center of gravity. Relating this more specifically to our subject, it also means balancing a control surface while it is at rest (not in flight).

Automobile wheels, as you know, can be balanced statically (while at rest). A more effective way, however, is dynamic balancing (spin balancing). The dynamic balance of aircraft surfaces is similarly effective but homebuilders really have no practical way of working out the dynamic balance of a control surface subjected to the stresses of flight. For this reason, they must fall back on what might be called a "good practices concept" and assume that, for all practical purposes, when a control surface is properly mass balanced in its static condition, it should also be in dynamic balance. If, in principle, the main objective of dynamic balance is to prevent or minimize torsional stress in flight, we can accomplish this adequately by evenly distributing the mass balance weight along the span of the control surface.

Broadly speaking, to attain a static balance state in a control surface, we add lead weight to the nose until the center of gravity falls on the hinge axis. Let me expand on this a bit.

For example, if you were to suspend a control surface from its hinge axis, one of three static balance conditions would become immediately apparent to you.

1. If the control surface assumes a trailing-edge-low attitude, it is statically under-balanced and a tail-heavy condition exists. See Figure 1.


CONTROL SURFACE
HINGE AXIS
CHORD LINE
TAIL LOW
BENCH
1
UNDERBALANCED
WEIGHT
CHORD LINE
LEVEL
BENCH
2
BALANCED (100%)
CHORD LINE
TAIL HIGH
WEIGHT
BENCH
FIGURE 1.
3
OVERBALANCED
CONTROL SURFACE STATIC BALANCE

Operating

2. If the control surface remains in a level (horizontal) attitude, it is said to be statically 100% balanced and its center of gravity (CG) is co-located with the hinge axis.

3. Should the trailing edge of the control surface rise some position above a horizontal plane, an overbalance condition is apparent.

Two of the three conditions described above result in a control surface that will have a fairly predictable flutter-free flight performance. The one that is 100% balanced to a level attitude should consistently give good results. The other surface having a slight nose down attitude is a typical overbalance condition essential for good results in high-performance aircraft. Conversely, the static under-balance, or tail heavy condition first described, is the least desirable as it may result in unpredictable flight performance.

The conventional flap type (aileron, elevator, rudder) control surface, as constructed, is typically tail-heavy. That is to say, most of its structure is distributed behind the hinge axis. It is this sort of tail-heavy out-of-balance condition that is generally considered to be the major cause of control surface flutter and buffeting incidents. True, speed through the air is also a factor and there is no doubt that flutter is a more frequent occurrence in high performance aircraft than it is with the slower varieties. However, it would be dangerous to assume that slower home builts are immune from such a propensity. I'll bet you have heard many times that home builts having cruising speeds under 150 mph were exempt from the flutter problem. Don't you believe it! Any airplane can experience flutter ... even your light and slow VW-powered job under certain conditions.

Does this mean that you must balance the control surfaces of your project even though the plans don't call for it? Not at all. Undoubtedly the prototype of the airplane you are building was built and flown without having exhibited flutter tendencies and the designer, therefore, found no need to require static balancing of the control surfaces. However, you should understand that, although many other examples of this same design may have been built and flown, there is no assurance that yours will likewise be free of flutter problems.

The only way you can prove your airplane to be free of flutter tendencies is to flight test it with that purpose in mind. This is a potentially dangerous adventure and must be done only under carefully controlled conditions. You must prove that your airplane is controllable, free from flutter, and will be safe to fly. No amount of reassurance derived from theoretical calculations can substitute for this requirement.

Other Flutter Provoking Conditions

Although there is less risk of encountering flutter in slower aircraft than in high performance types, individual builders can cause changes, inadvertently, which could introduce flutter tendencies. For example, a wing lacking torsional rigidity could induce a bad case of aileron flutter even at the relatively low airspeeds generally associated with low and medium-performance aircraft.

A newly constructed aileron or elevator that is excessively heavy (due to the use of heavier substitute materials or uncalled for reinforcements) can be flutter-prone. Flutter is most difficult to suppress in very large or heavy control surfaces and the balance weight requirement becomes excessive.

Would it surprise you to learn that even time-tested production-line aircraft are not immune to the flutter phenomenon? True! The reason being that any time anything changes the balance of the control surfaces it may induce flutter in an aircraft that has had no history of such tendencies. For example, there have been instances where flutter developed simply because mud adhered to the control surfaces following muddy field operation.

In an incident reported by the FAA, moisture had collected inside the ailerons during winter operations and had frozen (seems to happen every winter) thereby causing an unbalanced condition that was not detected during the preflight ... result? In-flight flutter and an accident.

During the long days and nights in the life of an aircraft many changes take place. Dirt accumulates inside the control surfaces, patches are added to repair dings and tears, and in time, the surfaces are repainted. All of these things cause a cumulative change in the mass balance of the control surface. At some point, the amount of change becomes just too much ... and increases the risk of flutter if no steps are taken to rebalance the reworked surface.

Loose balance weights, water absorption in foam structures, improperly located or clogged drain holes are all elements which could contribute to an aerodynamic imbalance situation and result in flutter.

Avoid free play or slack in the control cables. Stiffness in the control system does have a useful damping effect on the control surfaces further inhibiting flutter tendencies. However, this should not be completely relied upon as later, in service, the wear and occasional lubrication could free the system of much of its original friction and result in an increased risk of flutter.

Adding a fixed trim tab to an aileron can further upset a marginal balance condition.

Controllable trim tabs, too, can be a problem. Trim tab control linkage failures and trim tabs with loose or improperly installed and adjusted linkages have caused a considerable number of accidents and near accidents by exciting flutter in the control surfaces to which they are attached. A recent incident of that nature has just come to my attention. Involved was a widely built and proven design ... the staid ol' Emeraude. Here's how it happened.

Flutter . . . A First Hand Account

"I knew the trim wasn't working - but who needs trim for a ten minute every-which-way hop! I'm not one for flying level long, so we went into a turning dive -somewhere over 140. All hell broke loose and I about lost control ... elevator flutter - it was violent! Honest, each wing and the whole tail was shuddering.

I came off the power ... levelled my wing ... very hard to do, and started looking for a place to dump her. About 90, the flutter slowed but still bad - at 80 it quit!

I kept my head, let her glide for a few seconds and then added power - kept my nose high and flew back to the airport but slow - making shallow turns and a long straight in to a God awful landing - but safe!

Once on the ground I found the problem - the trim tab. Suddenly I remembered. Earlier a boy and his dad were visiting with me while I was working on my brakes. The boy was in back playing with the elevator. He must have bent the tab control wire - leaving the tab to start fluttering at high speed - thus causing the elevator to flutter.

It took two minutes to fix the cable. I checked for other damage - none. She is an awful strong design, that Emeraude.

It took a little longer to get up enough guts to fly her again, but I did the same day.

She's fine now but I have a little more respect for small items. I also preflight a little more carefully now. I don't know if you have ever experienced flutter or really know what it's like - I'm afraid of it now."

There are not too many folks around who can tell you, first hand, how sudden and destructive control flutter can be. We do know it can happen and does happen all too often. This gent was lucky. He had a good stout airplane and did just the right thing.