Robertson's Spoiler-Equipped Bonanza

Modification produces fantastic roll rate, even at approach speeds where ailerons go mushy

by BARRY SCHIFF/
AOPA 110803

■■ When the Wright Brothers designed their biplane they controlled roll by manually warping the wingtips in flight. Then came the Glenn Curtiss craft which incorporated ailerons, a refinement of the Wright technique. Thus began a long and heated legal battle regarding Curtiss' infringement of the Wright patent.

It's a shame that these pioneering greats wasted so much time and energy during this confrontation. Each had an alternate and possibly more logical method of roll control: spoilers.

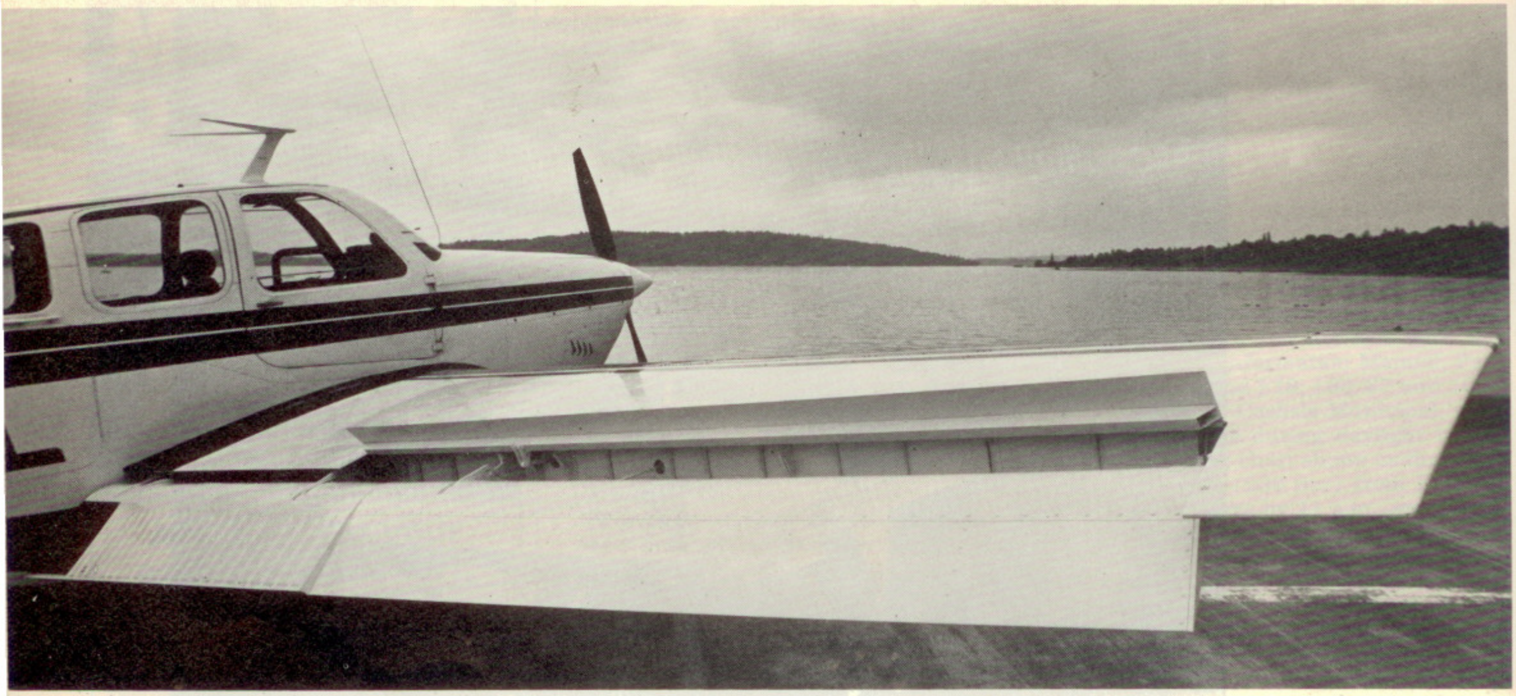
Consider, for example, that ailerons lose effectiveness at low airspeeds when crisp roll response usually is needed most; in other words, ailerons get "mushy."

And how about adverse yaw effect? Bank an airplane left and the nose wanders right, a condition requiring the coordinated use of rudder. Not so with spoilers. (Adverse yaw is the result of the "down" aileron producing more lift *and* drag than the "up" aileron.)

And then there is that dangerous characteristic of ailerons called "control reversal." Consider an aircraft flying wings-level at a large angle of attack, close to the stalling point. A slight nudge of turbulent air causes the left wing to drop. In response, the pilot moves the control wheel to the right. The left aileron deflects downward which *further* increases the angle of attack of the left wing. The simple act of trying to raise a wing can cause that very wing to stall and drop farther. The result is a potential spin in a direction *opposite* to that in which the wheel is turned. (Adverse yaw effect—if unchecked with rudder—also contributes to the spin.)

But not so with spoilers.

Another major argument against ailerons is that they occupy space on



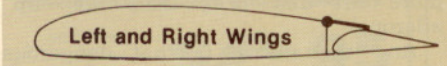
Use of spoilers, the right one shown in the up—right wing down—position, eliminates adverse yaw of ailerons and improves roll rate up to 140% at approach speeds.

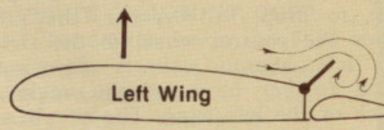
SPOILERS continued

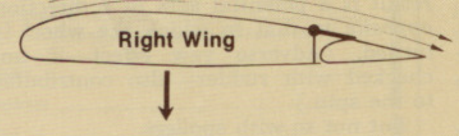
the trailing edge of the wing, space that could be used to extend flap span and increase wing lift at low airspeeds.

Considering these inherent disadvantages, it's surprising that ailerons are still being used; spoiler proponents de-

How Spoilers Work



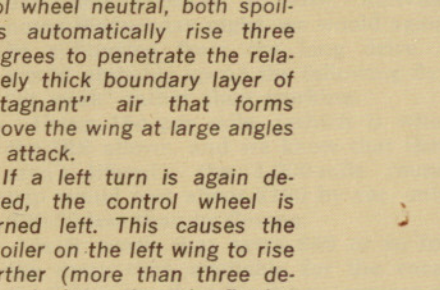




With flaps retracted and control wheel neutral, both spoilers are flush with the wings.

If a left turn is desired, the control wheel is turned left. This manually causes the spoiler on the left wing to rise in proportion to wheel movement and "spoils" or destroys some of that wing's lift which causes the aircraft to bank left. Also, this spoiler deflection (up to a maximum of 60 degrees) creates just enough drag to yaw the aircraft into the turn without the need for rudder.

In the meantime, the right spoiler remains flush with its wing.



When the flaps are extended to 20 degrees with the control wheel neutral, both spoilers automatically rise three degrees to penetrate the relatively thick boundary layer of "stagnant" air that forms above the wing at large angles of attack.

If a left turn is again desired, the control wheel is turned left. This causes the spoiler on the left wing to rise farther (more than three degrees) into the air flowing above the boundary layer and destroys some lift.

clare that ailerons are obsolescent and perhaps they're right . . . to an extent.

Spoiler development has been delayed by a few unique design difficulties. One challenge is to determine how to rig the spoilers (on any given aircraft) so that their movement is proportional to control wheel input and also provides a satisfactory "feel" for the pilot. Also, when a wing is flying at a large angle of attack, the boundary layer above the wing often thickens. This means that until the spoiler is raised sufficiently to extend above the "stagnant" boundary layer and into the airflow above the wing, the spoiler has little or no effect. The result is a small "deadband" area wherein initial wheel movement has little or no effect on roll control.

And then there is—on some experimental installations—the problem of "spoiler reversal." When the spoiler on one wing is made to rise slightly, it produces an effective local increase in wing camber (curvature). Instead of "spoiling" lift as it is designed to do, the spoiler contrarily causes a slight but distinct *increase* in lift.

But because of increasingly available jet-transport technology and various research programs involving general aviation aircraft (Project Redhawk and the NASA-sponsored, Robertson-designed ATLIT wing, for example) these spoiler difficulties have been overcome insofar as certain aircraft are concerned. Notable examples include the Mitsubishi MU-2 (designed 18 years ago) and Robertson's Seneca and Cherokee Six conversions, all of which have only spoilers for roll control. Robertson also did considerable independent research which included a standard Cessna 150 fitted with hinged spoilers and locked-out ailerons.)

After the successful removal of ailerons from Piper's Seneca and "Big Six," Robertson next chose the Beechcraft Bonanza for the probable reason that more than 100,000 of them have been built—more potential customers. In addition to swapping ailerons for spoilers, Robertson wanted to improve the Bonanza's stall characteristics. In the words of Henry McKay, Robertson's marketing chief, "We wanted to make the stall more predictable and easier to handle, especially in the full-power, flaps-down configuration."

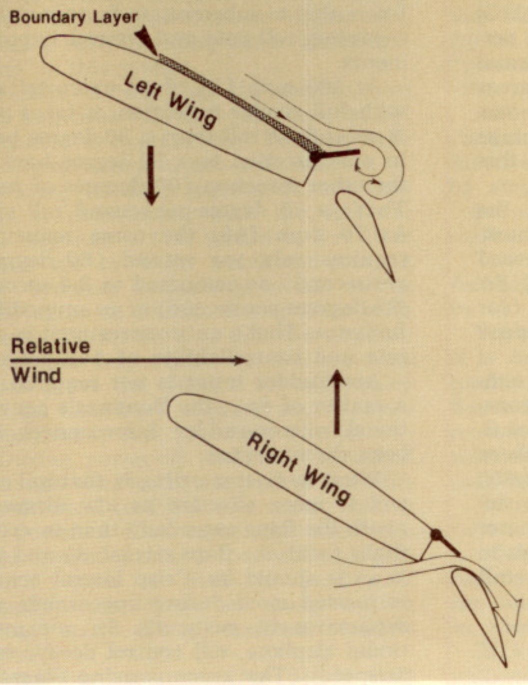
At first, Robertson applied its preferred wizardry, the leading-edge cuff. But this did little toward reaching their goals. One cuff did improve stall traits, according to McKay, but was so large that cruise speed suffered.

Finally, Robertson added a stall strip to the leading edge of each wing. These strips are narrow, longitudinal members of triangular cross section that "sharpen" the leading edge at the area of attachment to the wing. Such a strip, or "stall generator," programs the stall so that both wings "trip" simultaneously instead of one before the other. "The result," says McKay, "is a cleaner, more controllable stall."

After the Bonanza's ailerons were removed and full-span flaps installed, flight testing revealed an unanticipated difficulty. When flaps are extended on a conventional Bonanza (and most other aircraft), the nose pitches down slightly. Such a pitching moment is usually countered with nose-up trim. But, when 40 degrees of *full-span* flaps, are extended, the "butterfly-tail" of the Bonanza doesn't have enough nose-up trim to relieve the need to hold back pressure on the control wheel.

At first, Robertson tried to enlarge the stabilizers. This did add some pitch power, but not enough. And, since enlarged tail surfaces might have presented certification difficulties, the idea was eventually scratched.

Taking the easy way out, Robertson opted to restrict flap travel to 30 degrees. But the flaps didn't lose much effect in the process. The addition of



As the left spoiler is raised to five degrees above its neutral point (to bank the aircraft), the right spoiler automatically retracts to its original, flush position. This spoiler movement reduces the size of the slot formed by the trailing edge of the wing and the leading edge of the flap. Such a slot reduction causes high-pressure air, traveling from beneath the wing and through the slot, to accelerate, thus increasing airspeed above the right flap. This is a form of boundary-layer control that increases lift produced by the right wing and assists in establishing a left turn.

As the control wheel is turned farther left, the left spoiler rises to a maximum of 60 degrees at which point roll rate is at a maximum. Simultaneously, the right spoiler deflects to a maximum of six degrees downward. This further closes the flap slot which further increases airspeed over the flap to generate even more lift.

With the flaps extended, therefore, the spoilers operate differentially. It is this combination of "spoiling the lift" of one wing and increasing the lift of the other that accounts for such remarkable roll rates at reduced airspeed. The mechanics of a right turn are identical but opposite.

full-span flaps (which use the same actuator and geometry as standard Bonanza flaps) adds almost 15 square feet of flap area and increases flap span to 31.8 feet.

The standard Bonanza flap switch that allows flap selection at any intermediate setting between "full up" and "full down" has been replaced with a three-position switch. Flaps can be set *only* to "full up," 20 degrees (for takeoff) and 30 degrees (for landing).

Seeking maximum roll control commensurate with control input forces, Robertson chose to use long-span, short-chord, hinged spoilers. Each spoiler measures 4.5 by 95.5 inches, or 3 square feet per spoiler.

A final addition to the modification includes moving the static air sources aft and up. This substantially improves airspeed indicator accuracy at low speeds. For example, instead of indicating 80 mph at a calibrated airspeed (CAS) of 71 mph (on an unmodified Bonanza), the improvement results in an indicated airspeed (IAS) of 80 mph at 78 mph CAS.

The unmodified Bonanza is, without question, a fine-handling machine. But it must be conceded that replacing the ailerons with spoilers, increasing flap area by 80 percent and adding a pair of 24-inch stall strips (one per wing) does improve handling characteristics dramatically—especially in slow flight.

Additionally, takeoff and landing distances over a 50-foot obstacle are reduced substantially (almost 40 percent, according to McKay) and the angle of climb (with takeoff flaps—20 degrees) is steepened noticeably. (Precise performance data regarding these parameters had not been determined as this was being written.)

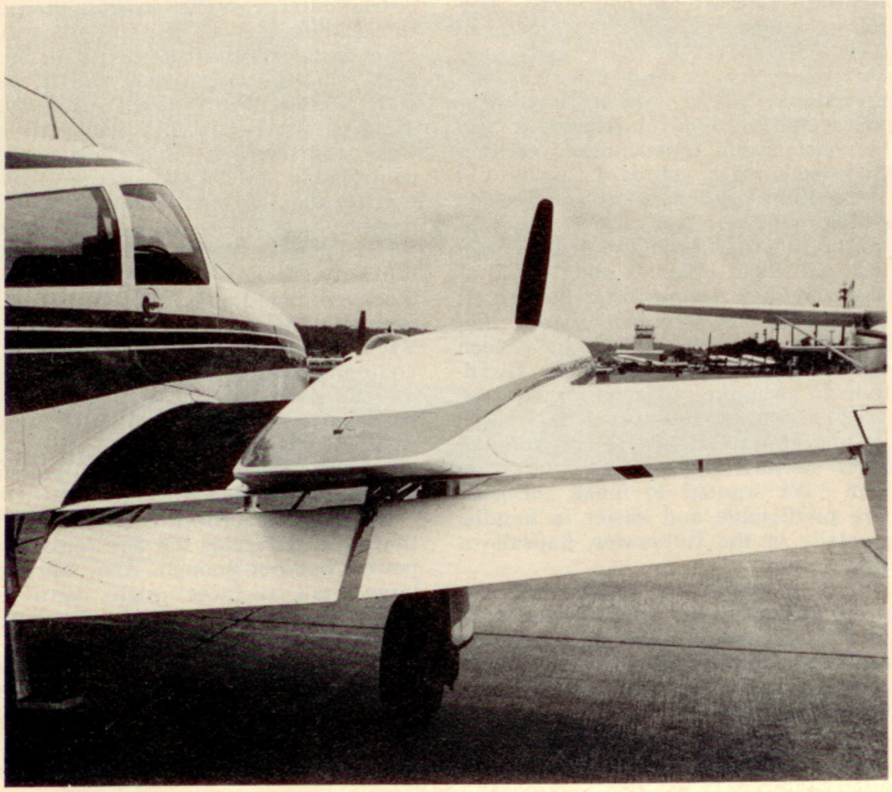
During a test flight in the prototype aircraft, a 1966, V35 Bonanza (N7857L), I was able to substantiate factory claims regarding roll rate and control improvements.

At 100 mph IAS, flaps extended and with full spoiler deflection, it takes only .8 seconds to roll from a 30-degree bank in one direction to a 30-degree bank in the other direction (60 degrees of roll). That's a 75 degree-per-second roll rate! At 70 mph IAS, the same maneuver requires only one second (60 degrees-per-second) as compared to 2.4 seconds (25 degrees-per-second) in an unmodified Bonanza. That's an improvement in roll rate and controllability of 140 percent.

And rudder input is not required. As a matter of fact, the Bonanza's conventional aileron-rudder interconnect has been *disconnected*.

What is most startling is that roll control is more effective at low airspeeds (with the flaps extended) than in cruise flight (with the flaps retracted) and this is as it should be. Crisp lateral control is needed most during approaches and departures in gusty air. In a conventional airplane, roll control decays with airspeed. (The accompanying diagrams

Fowler Flaps for the Cessna 310



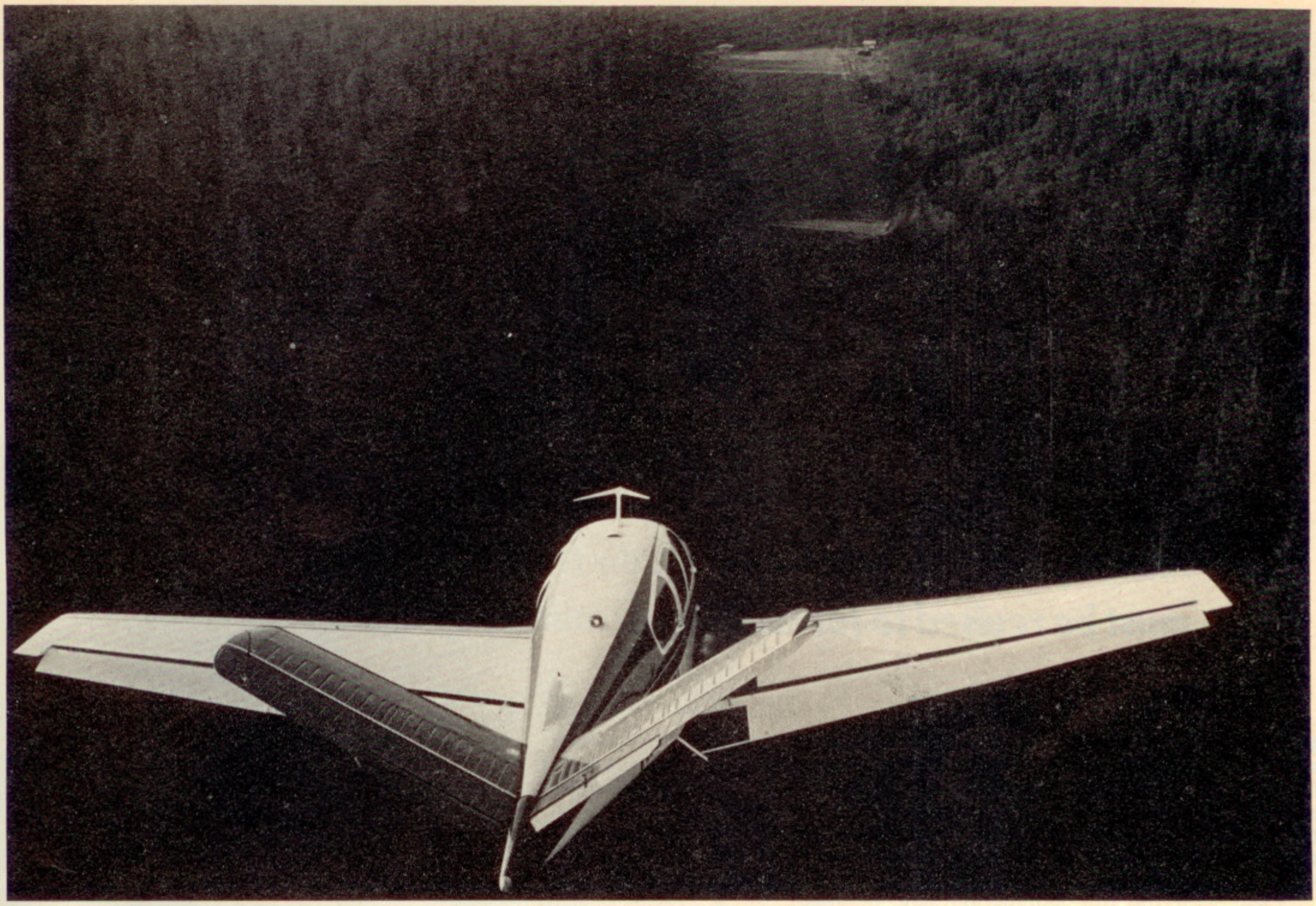
Robertson's ability to make good airplanes better is also demonstrated with the introduction of its recently certificated Cessna 310 modification. The split-flaps have been replaced with larger, Fowler flaps that increase wing area by 25.3 square feet. And because these flaps travel aft as well as down, wing chord with flaps extended (35 degrees) is increased by four inches. The modification is similar to that previously certificated for the Cessna 400-series aircraft.

Flaps-down, zero-thrust stall speed is reduced from 78 to 68 mph CAS. Additionally, Vmc has been reduced from 94 mph (on the 285-hp models) to 79 mph (with flaps extended to 10 degrees) and 71 mph CAS (with full flaps). The minimum safe approach and liftoff speeds are reduced accordingly.

Although takeoff, landing and climb data was not available at this writing, a demonstration flight in a modified, 1976 Cessna 310R (N1332G) demonstrated subjectively that performance gains are dramatic. Normal takeoffs are made with 10 degrees of flap extended (instead of the customary zero flaps) to take advantage of the 15-mph reduction in this configuration.

Although no gains occur at the high-speed end of the envelope, maximum flap speed has been increased slightly from 182 mph (for 15 degrees of flap) to 192 mph IAS (for 10 degrees of flap) to facilitate speed bleed and descent.

The similar, Cessna 400 series conversion incorporates drooped ailerons, a pitch-trim compensator and an anti-servo rudder tab. However, these items are not included in the $14,450 conversion of the 310 because, according to Robertson, they are not needed: "Fowler flaps alone seem to have accomplished our goals of stall and Vmc speed reduction."



Full-span flaps, another part of the Robertson conversion, add almost 15 square feet of flap area and reduce takeoff and landing distances over a 50-foot obstacle almost 40%.

and explanation detail how Robertson achieves this desirable result.)

At 140 mph IAS and flaps up, maximum role rate is 46 degrees per second.

And Robertson appears to have solved the "deadband" problem that plagues spoiler-system designers. Any control wheel input, however so slight, produces a corresponding bank. There's no "slop" in this system.

McKay claims that the modification also improves yaw and roll stability, but is unable to explain why. Frankly, such an improvement is not noticeable.

During landing approaches, it's very easy to overcontrol with the spoilers; roll response is *that* sensitive. But after about six to eight touch-and-goes, a pilot becomes acclimated to the system and learns to handle the spoilers with finesse. He learns also that the airplane is almost impervious to roll-inducing gusts. Move the wheel a bit and you've put the wing back in place, pronto, even at unusually low approach speeds.

During power-off stalls, the modified Bonanza behaves like any other Bonanza —politely. The difference comes during full-power stalls, especially with the flaps extended. In a conventional Bonanza, such a stall—if performed sloppily—can result in sharp rolling moments and, if not corrected, inverted flight.

In Robertson's aircraft, such a stall occurs at 40 mph IAS and results in only mild wing dropping. This is corrected easily by turning the wheel in the appropriate direction. Spoilers remain crisply effective throughout the stall. As a matter of fact, the roll axis of the autopilot can contain a full-power, full-flap stall with the wheel held fully aft for as long as you'd like. The buffeting, however, does get a bit uncomfortable after a while.

Although spin tests had yet to be conducted, it is not hard to believe Robertson's claim that spin rotation can be stopped abruptly with brisk wheel (spoiler) input. Rudder input, they claim, would be helpful but not required.

The additional flap area decreases full-flap stall speeds (power off or on) by six mph CAS.

With so much additional flap area, it is not surprising that the nose-down pitching moment is increased when the flaps are extended. These moderate, nose-down forces do necessitate considerable nose-up trim; and an electrically-operated tab would come in handy.

When the flaps are extended fully at normal approach speeds, maximum available nose-up trim is required. Without my 110-pound wife in the back seat, the aircraft would have been deficient in nose-up trim.

McKay says that the production mod will incorporate a pitch-trim compensator (patented by Robertson) to relieve much of the need to trim and leave a surplus available during full-flap landings at a forward C/G.

Conversely, flap retraction results in moderate nose-up pitching.

FAA certification of the Bonanza mod, is expected by July and will apply to all V-tail models. Installation at a Robertson-approved installation center requires 13 working days, a check for $8,000, and an addition to the empty weight of 17 to 22 pounds.

Similar "spoilerization" and full-span flaps are scheduled for all straight-tailed Bonanzas as well as the twin-engine Baron. According to Robertson, these aircraft have more powerful pitch control and will be configured with a full, 40-degree flap range.

With respect to the Baron only, increased flap area is expected to reduce V_{mc} by an estimated 13 mph. If this modification produces the same results for the Baron as it does for the Piper Seneca, the results will be nothing short of fantastic.

During a ride in a spoiler-equipped Seneca with full-span flaps. McKay took delight in demonstrating an *engine-out takeoff*. With one engine idling (not feathered), McKay proceeded to take off (from a standing start) and climb out with only one engine developing power. ☐