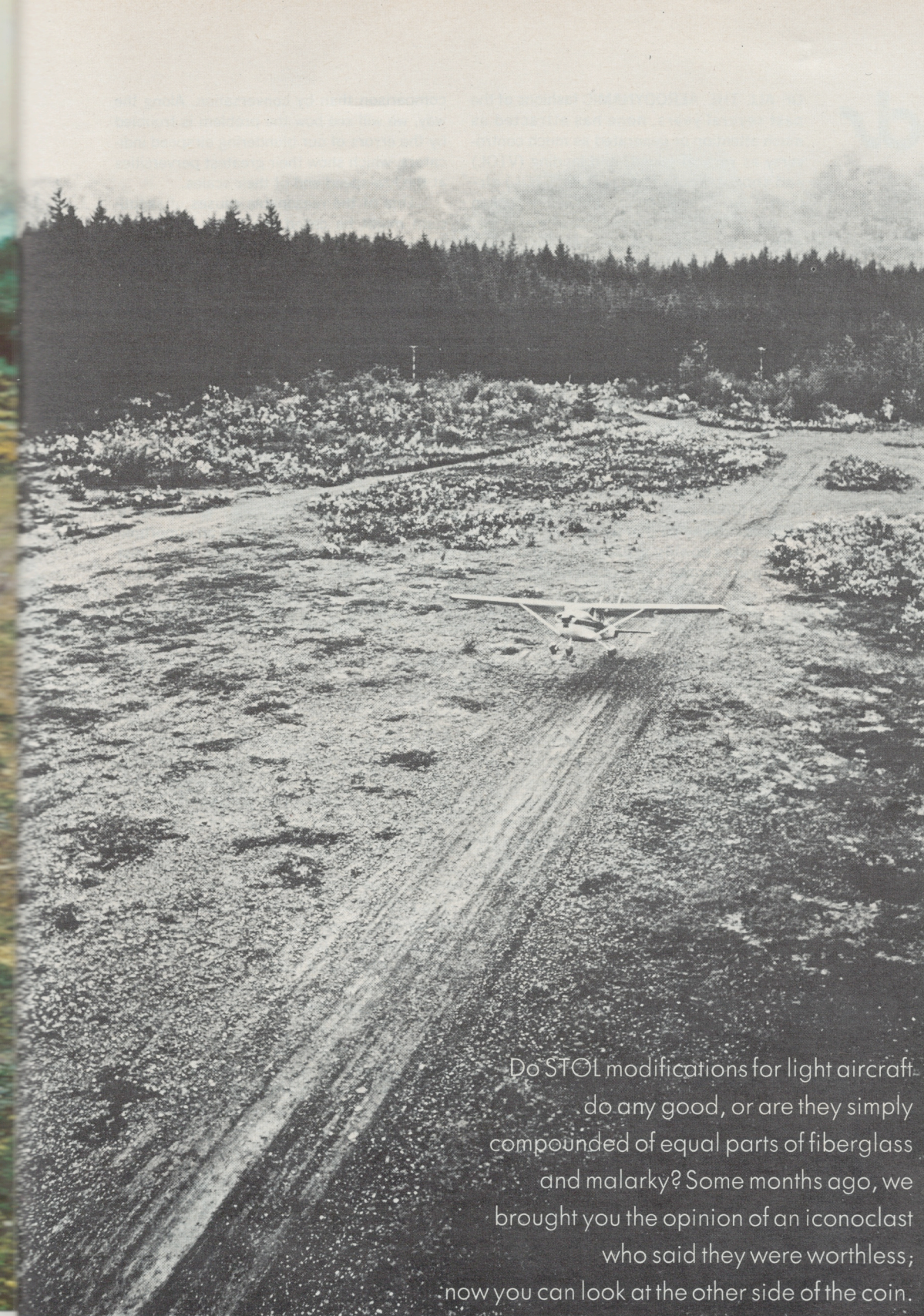




Another look at



Do STOL modifications for light aircraft
do any good, or are they simply
compounded of equal parts of fiberglass
and malarky? Some months ago, we
brought you the opinion of an iconoclast
who said they were worthless;
now you can look at the other side of the coin.

STOL mods

by Robert Blodget

STOL mods

OF ALL THE AERODYNAMIC fashions of the past several years, none has attracted as much attention or generated as much controversy as vertical takeoff and landing (VTOL) and short takeoff and landing (STOL) aircraft. Learned men on all sides have spoken on behalf of their beliefs—sometimes, alas, with more temper than temperance. There have been some rare bits of humor, such as United Captain Paul Reeder's, when he quoted an imaginary German engineer's definitions: VTOL means "Von't Take Off Loaded" and V/STOL means "Von't Still Take Off Loaded." Just plain STOL has so far defied definition, or at least qualification: Even the FAA hasn't figured out how to set specifications for a STOLport.

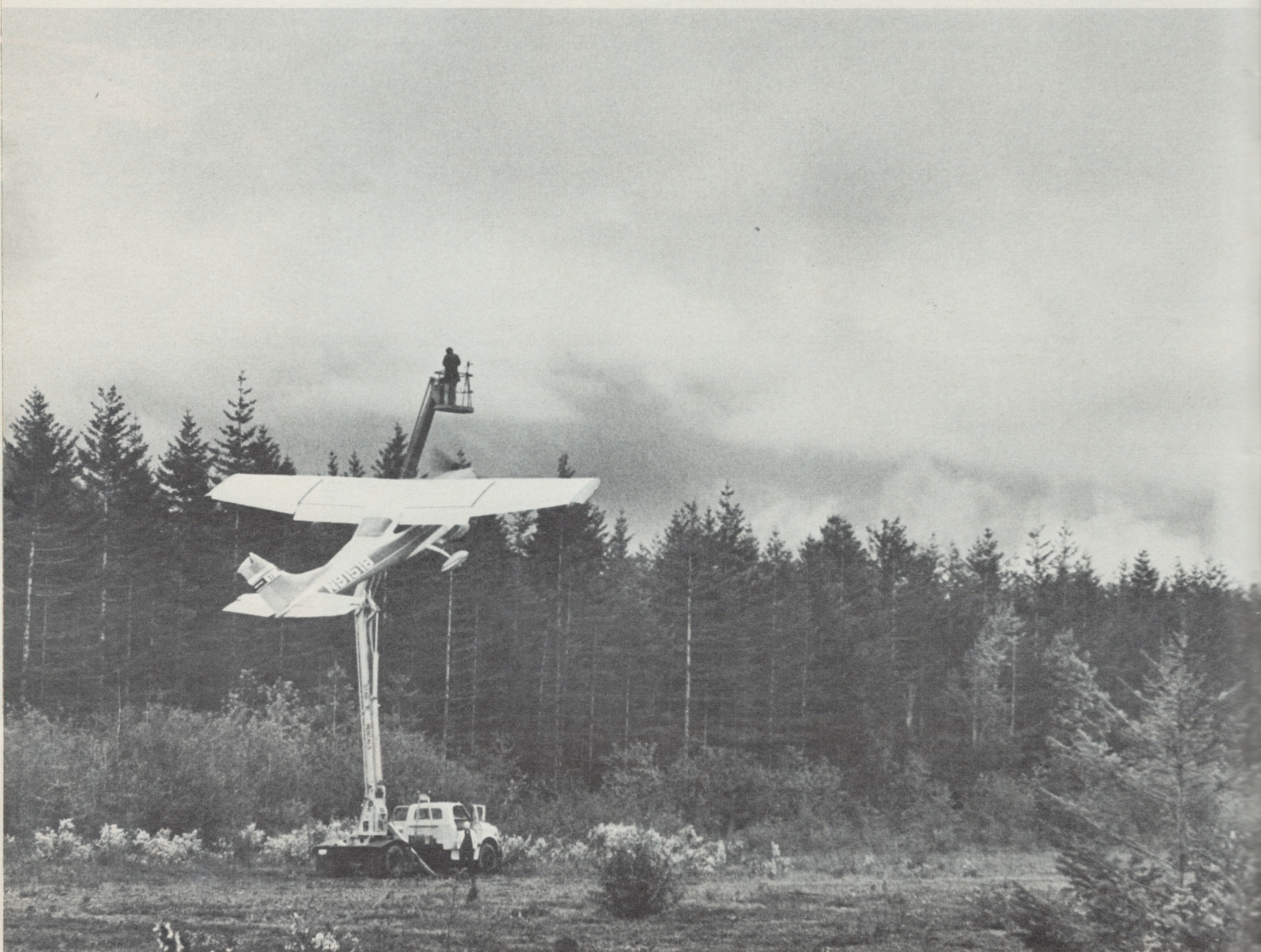
This lack of definition may well be at the bottom of the controversy, and the purpose of this reexamination of STOL mods is to develop a firmer base of understanding. If this succeeds, it may be that we will see sales departments showing greater regard for the facts, and skeptics being persuaded more by

comparison than by conversation. Along the way, we will see how the problem is troubled by the errors of our blundering airspeed indicators, which show their greatest perversities at the low-speed end of their scales.

One of the reasonable causes of skepticism might be called the father-knows-best syndrome: if STOL mods work so well, how come the factories don't install them? Persuasive though this sounds, it isn't really conclusive—and there are some signs that it isn't even true any more. First, let's look at an automobile comparison that is clamoring for attention, keeping in mind that analogies often fail to survive rigorous examination.

The car makers used to believe that they knew best what their customers ought to have, and Henry Ford said it clearest: "They can have any color they want, as long as it's black." This didn't stop the modifiers, and they came on so strong after World War II that Detroit saw a vision: It saw an opportunity to invent, adapt, produce and sell a vast array of variations on familiar themes. The

The pictures on the preceding pages were taken from the cherry-picker crane below—the first time STOL photos have been taken from the "air" rather than the ground, clearly showing the strip from which the airplane has lifted off.





Cambered tips aren't just cosmetic, Robertson says; they act as end plates, increasing the effective aspect ratio. They also help force the wing center to support the maximum load, with the lift pattern curving off elliptically toward the tip.

list of options eventually got long enough so that someone calculated that it was theoretically possible for every car built in a model year to be slightly different from every other. One of the last options to be offered was "handling packages." This is an important thing for us to remember.

There is a very practical reason for the factories to avoid variations as much as possible: economics. This applied earlier to the car manufacturers, and continued through almost a whole generation in aviation. Aviation is today in transition; we now have options on avionics, colors, paint and upholstery. In a few cases—especially the Piper Cherokee line—we have what approximates Detroit's horsepower options, and more and more models now offer turbocharging. We do not yet have the aeronautical equivalent of the automotive handling packages, but this is really where the STOL mods fit, so let's look at them now this way.

A good place to get our education on STOL technology is Robertson Aircraft, in Bellevue, Washington. Jim Robertson was a second-generation airman. The first generation ran Robertson Air Lines, in St. Louis. (One of their pilots on the contract air mail service was named Charles A. Lindbergh.) Jim's field was aeronautical engineering, and he specialized in high-lift devices. In the late 1950s, he had a special project at Aero Commander that was aimed at the Army. His first production design of note was the Wren, which began as a standard Cessna 182. The wing was extensively changed, including the odd anti-adverse-yaw vanes on the top, called "Wren's Teeth." An extra pitch surface was installed on the nacelle, and was called "ULS," for ultra-low-speed control.

The Wren did quite well, but it had some tricky handling characteristics. In my own experience, it seemed to me that the canard ULS operation was the worst: The extra pitch-control power it gave depended on propeller slipstream. If a pilot misjudged his final power reduction, the airplane would pitch down; and if it had been a few feet above the surface, the airplane got bent. It also seems to me that a lot of the talk we hear about bad handling of STOL mods can be traced back to this quirk of the Wren.

After Jim left Wren Aircraft, he joined Boeing in Seattle, where he worked on the short-field version of the 737. In his spare time, he completed the present Robertson STOL designs, founded Robertson Aircraft, and finally left Boeing to work full time in his own company.

By the time of his untimely death of a heart attack late in 1968, the entire Cessna line, up to and including the Skymaster, had received FAA supplemental type certificates. The 207 was approved this year. A beginning had been made on certification on the Cherokee 235, but it was a bad beginning: The airplane was lost in spin testing while engineering baseline data were being collected before modification.

Robertson Aircraft managed to survive the shock of losing its founder, and is still going in the same engineering direction. The new president is Jim Raisbeck, also a high-lift aeronautical engineer, who had been associated with Jim Robertson at Boeing.

The full Robertson STOL modification contains six elements: drooped ailerons, a drooped full-span leading-edge cuff (installed over the existing skin), conical cambered wing tips (similar to the drooped tips now

standard on all Cessna single-engine models), stall fences, aileron-gap seals and a mechanical pitch-trim compensation system. All contribute to improved aerodynamic performance, including the pitch-trim system, which at first seems to be only a mechanical pilot helper.

The leading-edge cuff is the easiest to install, and such cuffs are offered by several companies, including Robertson, though Robertson doesn't recommend it by itself. Here's what Jim Raisbeck says about it:

"The leading-edge cuff increases the radius of the leading edge for the full span of the wing, and makes the stall characteristics very docile. In addition, it allows the wing to reach a higher angle of attack before stall, particularly in the flaps-up condition, when the stall begins at the leading edge. When the flaps are deflected, the stall begins in large part at the trailing edge, and moves forward.

"Accordingly, the stall speed is reduced for the flaps-up condition, but not significantly changed with flaps down. The addition of the cuff does not alter the airplane's drag characteristics, nor the high power required to maintain level flight with flaps down.

"In order to make use of the decreased stall speed, the airplane must be rotated to abnormally high body angles during takeoff, slow flight and landing. In some cases, the airplane becomes 'geometry limited'; that is, the tail will hit the ground before the highest body angle can be reached in takeoffs and landings.

"However, the addition of the wing leading-edge cuff does add a measure of safety in that the airplane is less susceptible to stall upset during operation in gusty winds."

The drooped ailerons work in connection

Another look at STOL Mods

with the flaps. As the flaps extend, the ailerons move down too, up to a maximum of about 20 degrees. After that, the flaps continue to extend, but the ailerons stop, and by full flap extension, the ailerons have moved back up a little. The mechanical linkage allows maximum use of the ailerons as flaps, without reducing their roll-control ability.

There are three effects: First, the drooped ailerons give the effect of full-span flaps, with an attendant increase in lift at all angles of attack; second, they help to redistribute the pattern of wing loading toward the ideal, which is elliptical, which also reduces the induced drag of extended flaps; third, because the body angle is reduced for all flight conditions, engine cooling problems are sharply reduced. All these effects in combination reduce the power required for slow flight; Robertson says this reduction can be as much as 50 percent.

There has been a lot of disparaging talk about drooped, or conical cambered, wing tips, which were first introduced in production by Cessna on the 1960 model 210. One story says that these are no more than cosmetic, and that Cessna's extension of their use throughout their single-engine line was a marketing executive's decision. The Robertson people don't agree:

"The installation of Robertson conical cambered wing tips tends to end-plate the wing and increase its effective aspect ratio. This further helps redistribute the wing loading toward elliptical. The cruise speed can be increased two to three percent if care is taken not to overdesign these tips; otherwise, cruise drag will be increased because of the increase in wetted area. The optimum wing tips therefore lie somewhere between end plates and no shape at all. The Cessna tips are slightly smaller than the Robertson tips, but they perform the same function."

The stall fences are curved pieces of sheet metal, sticking up from the top of the wing at right angles to the normal air flow. Their position is in line with the end of the flaps and the inboard beginning of the ailerons. Unlike the leading-edge cuff and the drooped ailerons, the fences do not make any direct contribution to lift; they act only as air-flow controllers. Robertson says:

"Although much tailoring has been done in individual wing designs, including wash-out, taper ratio and stall strips on wing leading edges, the wing still stalls within a narrow range of angle of attack; and the stall begins at the wing root and propagates outboard. Once a stall begins, the entire wing, including the aileron, is soon stalled.

"The stall fences prevent the stall from propagating into the wing area ahead of the aileron. This allows retention of full roll control, even after the inboard sections of the wing have become deeply stalled.

"It is almost impossible to stall the aileron sections of the Robertson wing until the

angle of attack required to stall the inboard sections has been exceeded by five or six degrees. Such a situation is not likely to be reached under normal flight conditions; in fact, it takes a hammerhead maneuver to induce loss of roll control in a Robertson STOL Cessna."

Two smaller things need mention here. The usual gap between the wing and the aileron is sealed on the Robertsons. This prevents the disturbed underwing air from penetrating to the upper surface and interfering with airflow over the aileron. The second is more subtle: Because the Cessna wing is tapered, and because the leading-edge cuff is a constant shape across the entire wingspan, the effect of the cuff is greater over the aileron portion. This makes a contribution to the higher angle of attack required to stall the outboard section.

The interconnection (through a spring) between the flaps and pitch-control surfaces (elevators or stabilators) automatically maintains pitch trim while flaps are extended or retracted. This saves the pilot a lot of work during times when he is busy enough anyway; but there is a further benefit. When a pitch-control trim tab is set to give nose-up during approach, it is deflected down. When the pitch surface is then moved to its full up position, the tab surface is not fully exposed to the air stream. The result is loss of elevator control power. In the Robertson system, the tab remains in about its neutral position, so that full elevator power is available. This is very important in rounding out from a steep approach.

The Robertson mods have sharply different effects on approaches than do the Wren appendages. As in all airplanes, use of power increases lift and reduces stall speed. The effect is greater in the Robertson than in standard airplanes; and completely unlike the Wren, the nose does not pitch sharply down when power is cut. Modulation of power during the approach allows a wide range of adjustment of approach angle. In the case of a descent without power, all that is required to reduce the vertical speed before touchdown is power application. Without it, the airplane will touch down firmly, but nowhere near destructively. For example, Robertson says:

"If the engine is lost and the ground cannot be seen, as in night IFR, standard practice is to apply full flap deflection, pull the yoke full back and stall the airplane. A Cessna 182 will descend at an indicated 35 mph and 600 feet per minute, still with full aileron control. While the contact with the ground is not pleasant, it is certainly survivable."

With that innocent mention of airspeed, we have touched the tender nerve, and it's time to look at some of the ways in which our trustworthy airspeed indicators tend to lead us astray, friends and foes of STOL alike.

Early in our flying careers, we are given some information to the effect that airspeed

indicators tell only part of the truth; but we are not told about some of their basic shortcomings. Probably the most important of these is the fact that they are only required to be accurate within plus or minus five mph or three percent, whichever is greater, between 1.3 times the stall speed and cruise speed. Below the 1.3 V_{so} speed, the errors can get pretty wild; and if that weren't enough, stall speeds given in airplane manuals are calibrated air speeds, but what the pilot sees are indicated speeds. The table below, from Robertson engineering data for three Cessna airplanes, shows how serious this is. These are stall speeds, in miles per hour:

210K

Flaps up	75 (CAS)	69 (IAS)	standard
Flaps down	65 (CAS)	56 (IAS)	standard
Ailerons	58 (CAS)	47 (IAS)	Robertson
Leading-edge cuff	53 (CAS)	39 (IAS)	Robertson
Power on	46 (CAS)	29 (IAS)	Robertson

182N

Flaps up	66 (CAS)	57 (IAS)	standard
Flaps down	57 (CAS)	41 (IAS)	standard
Ailerons	50 (CAS)	31 (IAS)	Robertson
Leading-edge cuff	45 (CAS)	21 (IAS)	Robertson
Power on	40 (CAS)	13 (IAS)	Robertson

150K

Flaps up	52 (CAS)	51 (IAS)	standard
Flaps down	45 (CAS)	43 (IAS)	standard
Ailerons	40 (CAS)	38 (IAS)	Robertson
Leading-edge cuff	36 (CAS)	32 (IAS)	Robertson
Power on	31 (CAS)	25 (IAS)	Robertson

These indicated airspeeds are taken from the engineering flight-test data, in which an airspeed boom is used. Not only do the standard airspeed indicators have no calibrations below 40 mph (a special one is available from Robertson, which has marks down to 10), the standard ASIs all show zero mph during the full-power/full-flap stall.

It's easy to see that here is where most of the trouble starts between the advocates of STOL mods and the skeptics. Some simple operational statements, accurate and innocent, can lead to serious misunderstandings.

For example, in the case of the Robertson 182, the check pilot can say: "As long as you are showing 40 mph indicated, you're well above the stall, and have a completely controllable airplane." This is perfectly true, since the calibrated airspeed at this point is at least 10 mph above the power-off stall, and about 15 mph above the power-on stall. In ordinary conversation, unfortunately, it is all too easy to drop the exact statement and simply say: "The airplane is fully controllable at 40 mph," and that is not true.

Each of the Robertson STOL features makes a measurable contribution to reduction of stall speed, an increase in lift and

improved handling. These are all straightforward, measurable, sober engineering achievements; but there is another element that appears that sounds more like witchcraft.

This can be called either Gestalt or synergism; in either case, the result can be expressed as $2 + 2 = 6$. The formal definition of synergism is: "Cooperative action of discrete agencies such that the total effect is greater than the sum of the effects taken independently." This is properly scientific, too; it's just that we don't often run across many cases of synergism in the course of a day's plowing.

One of the synergistic effects is the practical elimination of engine cooling problems at low speeds. This is only indirectly associated with increased lift; it is the increased lift at lower body angles that does the trick. Another is the much lower safe operating speeds possible in gusty air: 49 mph CAS for the Robertson versus 67 CAS for the standard airplane. When turbulent air occurs with high temperatures, which is often the case, both effects are additive.

Maximum endurance, flaps down, in slow flight is another effect. The Robertson STOL can fly 15 mph slower at about 15 percent less power than the unmodified airplane.

Somebody is saying, "This is all well and good, but it doesn't tell us what we really want to know. How do the modified airplanes fly? How do they look—has the addition of all this hardware made them ugly?"

Taking the second question first, the changes hardly show. The drooped leading edges are barely apparent, the drooped ailerons don't look very droopy (and you have to extend the flaps before they droop at all), the wing fences aren't prominent and the automatic pitch-trim compensation system is invisible. There are vortex generators on the aft nacelle of the Cessna 337, also unobtrusive. The conical cambered raked tips on the Cherokees are the most noticeable change; and to my eye, they make the airplanes look a bit sleeker.

There are two phases of the first question: How do the modified airplanes perform in "normal" operations, and how do they fly (and how hard is it to learn) in the maximum-performance conditions? Both are of equal importance.

You can take a pilot who is fully familiar with a Cessna 182, for example, and give him a Robertson to fly; he won't have to learn anything new. He may notice some performance improvement and nicer handling, but he may not. The longer he flies it, the better he will like it, and sooner or later, he's bound at least to see the "Robertson STOL" decal on the tail. The important thing is that he doesn't have to learn anything he doesn't already know, and the airplane isn't going to give him any nasty surprises.

In the maximum-performance areas, the Robertson people are very strong on transi-

tion training, and properly so. There is no set number of hours; each pilot gets however much time he needs to become fully competent. Having myself flown five Robertsons (Cessna 182, 207, 210 and 337, and Piper Cherokee 235) with three company pilots, it seems to me that the training is almost entirely positive. That is, the pilot must be trained in how to reach the performance the airplane is capable of giving, not in learning how to avoid disaster.

As you progress deeper into the high-performance, slow-speed corner of the flight envelope of the modified airplanes, you have an increasing feeling of good handling, excellent control response, and confidence in the machine. This requires overcoming some deeply trained responses, particularly with respect to what the airspeed indicator is showing. One of the most difficult things to learn is to deliberately hold an attitude and airspeed that sets the stall-warning horn going, instead of dropping the nose. (If I had a modified Cessna, I'd see if I couldn't get approval to use a warning light, as Piper does, instead of the horn.)

Another thing that's hard to believe is the fact that you can begin a turn immediately after lift-off, and hold a fairly tight climbing spiral thereafter. One of our common faults appears, too: Most of us never do get in enough right rudder in climbs or at slow speed with power. The slower speeds need even more rudder, and lack of it shows.

In landings at maximum performance, a technique that is quite old but lately seldom used is needed. With the steep flight-path possible, the sink rate is high at little or no power, and if we are to avoid a teeth-rattling arrival, we have to add power as we round out to arrest the sink rate. It's not really hard to learn, and it doesn't carry the possible penalty that the Wren did, if power is removed too high. The airplane will hit firmly, but it won't pitch down.

What of the factories, now? Does it look as though their minds are changing? It does, indeed. In the middle of May, four Piper company Cherokees descended on Bellevue Airfield—a 180, a 235, an Arrow 200 and a Six—for Robertson modification. Robertson has STCs on the first two; Piper is paying half the development cost on the Arrow and the Six. An increasing number of overseas Cessna customers have been ordering new airplanes to be Robertson-equipped, and it doesn't take much of a crystal ball to support a prediction that Cessna may well get into the Robertson business, possibly through their European licensee, Reims Aircraft of France.

If this comes to pass, what will happen to Robertson? The protection they have now, through their supplemental type certificates, might very well be no protection at all for factory-built handling packages. They might be able to supply some of the special mechani-

cal parts, but that's very small compared to the conversion business.

Well, Jim Raisbeck thinks that Robertson has only begun to exploit high-lift technology. In the years to come, he sees important markets in such fields as forest-fire control, and after that, field mods of existing transport-category airplanes. This would be extremely interesting, if some of the STOL city-center to city-center airplane hopes could be made to come true without having to design and build an entire new generation of heavy transport aircraft. The concept could be proved (or disproved) on the basis of relatively low-cost equipment.

Meanwhile, having found that about two-thirds of their customers are not bush pilots or others who need the maximum performance available through the handling packages, Robertson is talking "The Safer World" of Robertson STOL mods. Lots of marketing people will tell you that nobody can sell safety, but Robertson Aircraft is well on the way to proving them quite wrong. †

Calendar

January

11-14—Helicopter Association of America convention, Las Vegas, Nevada.

19—West Coast aircraft auction, 720 West Mineral King, Visalia, California.

25-27—Ninth Aerospace Sciences meeting, American Institute of Aeronautics and Astronautics, Statler Hilton Hotel, New York, New York.

31-2/3—HAA Annual convention and exhibit, Convention Center and Disneyland Hotel, Anaheim, California.

February

8-10—Conference on Aircraft and the Environment, Sheraton Park Hotel, Washington, D.C.

9-11—Instrument flight instructor revalidation clinic, Airport Marina Hotel, Los Angeles, California. Contact Claire Walters Flight Academy, 3200 Airport Avenue, Santa Monica, California 90406.

13-14—Twenty-Fifth Annual Pacific Coast Midwinter Soaring Championships, Torrey Pines Gliderport (12 miles north of San Diego). Contact J. W. Dickson, 3776 Wellborn Street, San Diego, California 92103.
