AOPA received a great deal of mail from members in the past year regarding the structural integrity of the Beech 35 series (the V-tail or butterfly) Bonanza.

Many were irate; many were concerned that there might be a serious flaw in their aircraft. Since the issue had been raised, we had to look into the matter.

Barry Schiff wanted to take on the task of evaluating the record and putting the controversy into perspective. It became a personal issue for him. We discussed the direction of the article several times, trying to avoid refutations of specific programs and publications. However, the impact of CBS's *60 Minutes* and an article in *Aviation Consumer* was such that Schiff felt compelled to deal with them directly.

In effect, his article is a personal statement in response to his concern about misplaced emphasis and sensationalism.

All aircraft have imperfections or operational characteristics that can put a pilot in hazard, if he is unaware of them, careless, not proficient or presses beyond the limits. The V-tail Bonanza has a higher-than-average rate of in-flight airframe failure. This does not mean that the airplanes just come apart in the air; but when pushed beyond their normal operating envelope, they are more likely to fail. Most of the accidents have been the result of pilot actions.

Awareness of the potential can help pilots avoid the condition. In this respect—getting pilots' attention—*Aviation Consumer* has performed a service. Unfortunately, the way the magazine presented the information seems to have misled as many as it informed. *—EGT*

BONANZA BESIEGED

An attempt to put the controversy into perspective.

In spite of the criticisms leveled at the V-35, Beech Aircraft Corporation is proud of the V-tail's construction. So proud that a couple of years ago they built a cutaway version of the Bonanza showing, among other things, the ruddervator mixer assembly and the internal components of the Bonanza's Continental IO-520 engine. The cutaway formerly played the trade-show circuit, but now it is on permanent display at the Smithsonian Institution's National Air and Space Museum in Washington, D.C.

PHOTOGRAPHY BY ART DAVIS

BY BARRY SCHIFF

In a speech to the House of Commons in 1860, the great British statesman, Benjamin Disraeli, said, "[It is] much easier. . .to be critical than to be correct." This philosophy is as valid now as it was then. And, if Disraeli were alive today, he might cite as a classic example the controversy stirred up by *Aviation Consumer*. In an article published last year, that magazine impugns the reputation of the Beechcraft Model 35 (V-tail) Bonanza with critical ease, at the sacrifice of correctness.

The V-tail Bonanza long has been considered a pre-eminent model of general aviation design excellence. Nevertheless, *Aviation Consumer* chose to level a series of charges against the airplane that created a flurry of wide-spread reaction ranging from confusion to rage.

The author of the article is Brent Silver, an aviation consultant and aeronautical engineer, who testifies as a paid witness on behalf of plaintiffs, in litigation against airframe manufacturers that include the Beech Aircraft Corporation. He also is one of those who appeared on a segment of the recent CBS television production *60 Minutes* to help portray a disturbing and distorted view of general aviation safety.

In the magazine article, Silver used selected statistics on the Model 35 in an effort to demonstrate that the airplane inherently is not as safe as either of its sister ships, the Model 33 (straight-tail Bonanza) and the Model 36 (stretched Bonanza). He accused the Model 35 of suffering from ruddervator flutter, less-than-ideal handling qualities and structural weak points. But, by his own admission, these were offered only as "possible answers" to his own questions regarding the integrity of the Bonanza's V-tail configuration, the only significant difference between the Model 35 and the straight-tail models.

Careful analysis of the lengthy article leads only to one conclusion: No factual proof was offered to substantiate the allegations. To demonstrate the point, each major accusation must be considered individually.

Flutter is an aerodynamic phenomenon that can be compared loosely to the fluttering of a flag at high mast on a windy day. Quite obviously, a fluttering control surface is something to avoid in any airplane. The consequences can range from airframe vibration to a catastrophically divergent (worsening) condition capable of shaking an airplane to destruction. The flutter is caused by a complex interaction between several variables, one of which can be an improperly balanced control surface.

Prior to installing any control surface, it first must be balanced according to design specifications. This prevents flutter from occurring within the operational limitations of the airplane. Whenever the surface is painted, it similarly must be removed and rebalanced to within prescribed limits. This is true of all airplanes, especially those of a high performance nature.

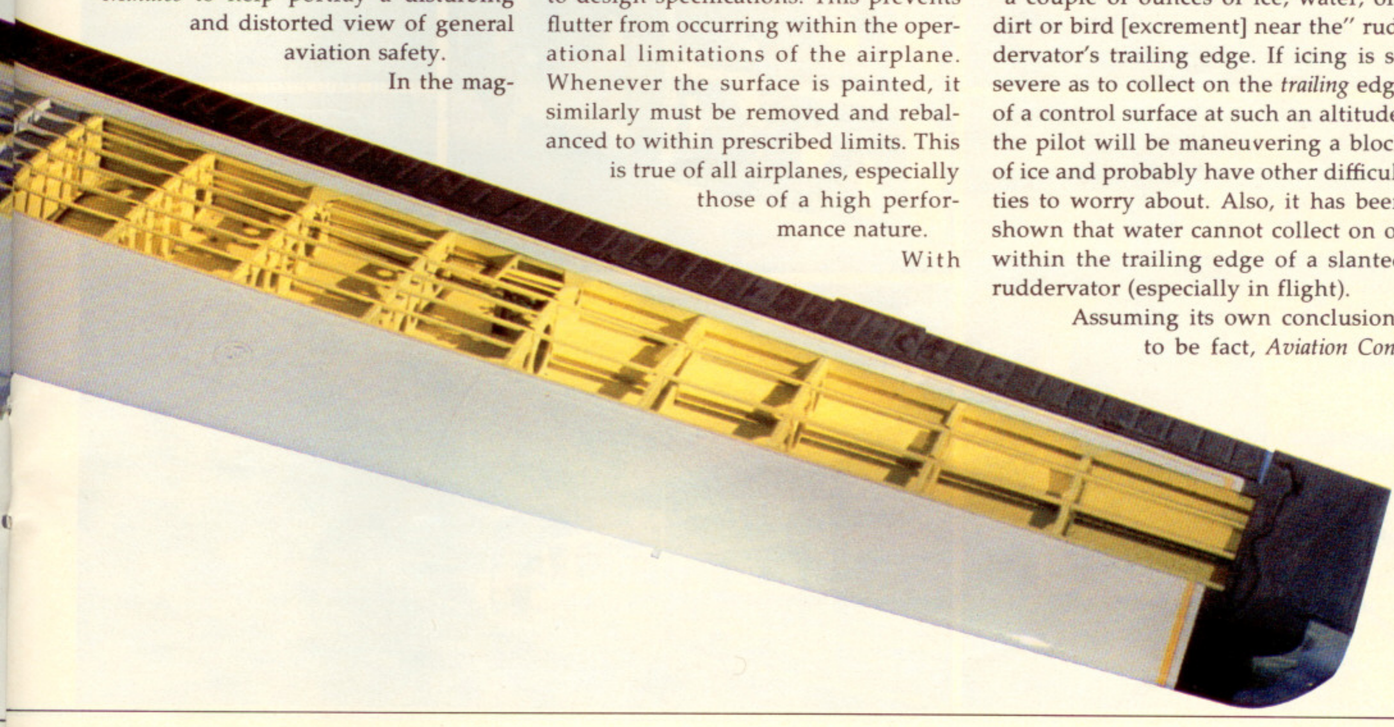
With respect to a V-tail Bonanza, the ruddervators of later models (S35 and after) must be balanced between 14.4 and 17.4 inch-pounds tail heavy, a procedure performed easily by any competent airframe mechanic.

The *Aviation Consumer* article claims, however, that if a ruddervator becomes excessively tail heavy by as little as 2.2 inch-pounds (roughly equivalent to taping two silver dollars to a ruddervator's trailing edge), this could cause the control surface to flutter, but only at or above 18,000 feet. This is incorrect. The airspeed at that altitude (the service ceiling of several Bonanza models) is so slow as to preclude the possibility of flutter. But more important is that the figures cited in the article were obtained by extrapolating results obtained in 1974 when a C35 Bonanza was placed in Lockheed-Georgia's wind tunnel. According to W.G. Pierpont, Beechcraft's chief scientist, extrapolation of this type of data to such a high altitude can introduce substantial error.

As but one example of how extrapolation can lead to erroneous conclusions, consider the following: If the noon temperature in Las Vegas is 80°F and becomes 110°F by 3 p.m., extrapolation projects the temperature to be an incredible 170°F by 9 p.m.

Based on extrapolation and *not actual data*, the magazine warned that 2.2 inch-pounds of ruddervator imbalance (at 18,000 feet) could excite flutter and that such imbalance could be caused by "a couple of ounces of ice, water, oil, dirt or bird [excrement] near the" ruddervator's trailing edge. If icing is so severe as to collect on the *trailing* edge of a control surface at such an altitude, the pilot will be maneuvering a block of ice and probably have other difficulties to worry about. Also, it has been shown that water cannot collect on or within the trailing edge of a slanted ruddervator (especially in flight).

Assuming its own conclusions to be fact, *Aviation Con-*



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sumer then seems to have overstepped its bounds. It offered to Bonanza owners the option of rebalancing their ruddervators by adding as much lead in the counterweights as room allows. This would be courting disaster. Arbitrarily increasing the balance weight actually could cause predictable, high-speed flutter (especially for the S35 Bonanza and all subsequent models).

Precise data obtained from the wind-tunnel flutter tests demonstrated that the ruddervators had to be more than an extraordinary 30 percent out of balance before flutter could be induced. Even when the control cables were disconnected from the ruddervators completely (to eliminate control-system damping), flutter could not be made to occur until the surfaces were out of balance by more than 10 percent.

The article went on to frighten Bonanza pilots by asserting that catastrophically divergent flutter could be induced at only 92 knots, if both trim-tab cables were to break. This may be true; but since such an absurd improbability never has been reported in a Bonanza, the discussion has no practical value. It is useful, however, as a scare tactic. Also, the same consequences can be expected of any high-performance airplane with broken trim-tab cables.

More to the point is the Bonanza's actual history of flutter encounters. The first case occurred in 1948, after the airplane was repainted by a house painter using lead-base paint. The ruddervators were not rebalanced as required by the maintenance manual. Another flutter report concerned an airplane that had been structurally weakened when the pilot executed more than 60 barrel rolls at entry speeds in excess of 160 knots indicated airspeed. There have been nine other cases of Bonanza flutter. Fact: All occurred to Bonanzas built only during 1947 and 1948. Fact: All eleven aircraft were flown safely to a landing; no one was injured. Fact: The last known case of flutter occurred in 1966 (to an original Model 35).

Investigation did reveal that, in some cases, flutter was triggered by insufficient fuselage torsion strength immediately forward of the tail. Believing this to have been caused by aerobatic maneuvering, Beech strengthened the bulkhead at station 256.9, beginning with the Model A35 Bonanza (1949). Consequently, there never has been reported a case of flutter involving an A35 Bonanza or any subsequent model.

The article discussed three aspects of the Model 35 Bonanza's handling qualities: Dutch roll, spiral stability and longitudinal stability.

Bonanza pilots have little to criticize with respect to handling qualities. The airplane has a beautifully harmonized control system, exceptionally low system friction and outstanding effectiveness and response throughout the speed spectrum.

It does, however, Dutch roll in turbulence more than most other general aviation airplanes (a yaw/roll oscillation consisting mostly of yaw). This trait may influence ride quality and pilot workload in turbulence, but has no bearing on safety.

The article suggested that, "if the yawing becomes violent" when penetrating heavy turbulence at high speed, the tail may undergo structural damage from excessive aerodynamic side loading. But nothing was offered to substantiate this, except for the speculation of Irv Culver, a design consultant who acknowledged to this writer that he never has made a study of the effects of Dutch roll on the structural integrity of a Model 35 empennage.

Bonanza

The V-tail, like all propeller-driven singles, has traits of spiral instability. The remedy? Fly the airplane, do not allow it to fly you.

By suggesting that the V-tail Bonanza is less safe than either of the straight-tail models because of Dutch roll, author Silver clearly is stalking the wrong game. Independent flight-test data and Beech's stability calculations confirm that the Model 35 (V-tail) has 93 percent as much directional stability as the Model 33 (straight tail). Also, the dihedral of the V-tail configuration actually increases the lateral (roll) stability of the Model 35. The result is that, although the Model 33 has slightly less Dutch-roll tendency than the Model 35, the difference between the two is so subtle as to be virtually undetectable.

A common misconception is that the Model 36 stretched Bonanza has less Dutch-roll tendency than the straight-tail Model 33 because of its increased length. Not so. The additional 10 inches of fuselage was added *forward* of the wing's quarter-chord point. Consequently, the Dutch-roll tendency of an A36 is slightly less than that of a V35B, but *more* than that of an F33A.

Since both straight-tail Bonanzas have essentially the same Dutch-roll tendencies of the V-tail model and greater vertical fin area exposed to aerodynamic side loading in a yaw, it is logical to conclude that the vertical tail surfaces of the straight-tail Bonanzas absorb greater forces than those to which the V-tail is exposed. *Aviation Consumer* ignored this fact.

In 1966, the National Aeronautics and Space Administration published a report (TN D-3726) entitled *An Evaluation of the Handling Qualities of Seven General Aviation Aircraft.* One conclusion is, "The [NASA] pilots [who conducted the evaluation] commented that all [seven] aircraft (which included the Model 33 and 35 Bonanzas) have acceptable lateral-directional dynamic characteristics."

Aviation Consumer commented on the Model 35's spiral stability by referring to the report of one pilot. While he was reading an approach plate located to his right, the N35 Bonanza he was flying entered a 40-degree right bank and pitched down 30 degrees. This leads one only to the conclusion that either the airplane was mistrimmed or the pilot was inattentive to the demands of instrument flight.

The V-tail Bonanza can be spirally unstable to the right, but it does not have an exclusive on graveyard spirals. Virtually all single-engine, propeller-driven airplanes (especially those without aileron trim) also have traits of spiral instability. The preventive measure when operating any of them is simple: Fly the airplane; it should not be allowed to fly you.

It is erroneous to imply that this characteristic makes the Model 35 less safe than either of the straight-tail models because all three are virtually identical in the spiral mode. (When trimmed properly, they have neutral-to-positive spiral stability to the left.)

The Bonanza has an exceptionally low drag profile, a credit to the design. But does such an aerodynamic asset cause unusually rapid acceleration when the nose is pitched downward? Not at all.

The National Transportation Safety

Board published an engineering study (TR-1099-1) detailing the spiral and diving overspeed tendencies of five different lightplanes. According to the report, each airplane was displaced from cruise flight into a 15-degree, nose-down attitude with 75-percent power and held that way for eight seconds. The differences in acceleration among the aircraft were surprisingly small. The airspeed of a V35B Bonanza increased only 31.4 knots, while a Cessna 210 and a Cessna 177 with fixed landing gear gained 30.2 and 28.0 knots, respectively. (Once recovery was initiated, additional speed in each case was less than one knot.) The report states also that airplanes with low drag profiles will continue to accelerate to much faster airspeeds, but the acceleration does not increase.

This demonstrates convincingly that a proficient Bonanza pilot has almost as much time to correct a flight-path disturbance as does the pilot of any other airplane.

One limitation of the Model 35 Bonanza is its center-of-gravity envelope. The airplane does not have as liberal an aft CG limit as the Model 33. (The Model 36 has a more spacious envelope, due to the effect of stretching the forward fuselage.)

When the CG of any airplane is behind the approved aft limit, static longitudinal stability is sacrificed. When this occurs, trimming becomes more difficult, airspeed excursions are more frequent, stall/spin characteristics may not meet certification criteria, and unconventional control movements may be necessitated. In other words, a pilot flying such an airplane assumes the role of an experimental test pilot because he treads where others fear to go.

Perhaps most significant is that control forces become lighter as the CG moves aft; it takes fewer pounds of pull to create a given amount of additional G load.

One of the joys of flying a Model 35 Bonanza is the light control forces normally required for maneuvering. In the cruise range and when the CG is within approved limits, only 17 to 20 pounds of control force are required to increase the load factor from one to two Gs. Straight-tail Bonanzas require 20 to 30 pounds per G.

Since the Model 35 normally is light on the controls, moving the CG aft makes it all the easier to increase load factor by pulling on the control wheel. It is possible, therefore, for a pilot who has lost control of an *excessively* aft-loaded Model 35 Bonanza in IFR con-

INSIDE THE V-TAIL

The tail surfaces of an airplane appropriately are called tailfeathers. Without them, an airplane—like an arrow—would wallow uncontrollably through the air. An empennage serves the dual purpose of providing stability and controllability (about pitch and yaw axes).

There have been a large variety of tail designs, and almost all are characterized by a combination of horizontal and vertical stabilizers and control surfaces. One obvious exception is is the V-tail. This configuration consists of two slanted stabilizers and ruddervators, so called because each combines the functions of rudder and elevator.

Although Beech may have been the first to put the V-tail into continuous production, the stylish design has roots that originate in 1910. History notes that two German designers, Hofinger and Hopfenweiser, attempted to build an airplane with a V-tail. They apparently failed for lack of an adequate control mixer. This is a mechanical system that converts conventional movements of the control stick (wheel) and rudder bar (pedals) into a combination of ruddervator deflections that control pitch and yaw (independently or in combination).

The butterfly-tail concept was revitalized in the late 1920s by Jerry Rudlicki, a Polish engineer who sought to improve an aerial gunner's aft-facing field of fire. Subsequently and prior to World War II, the V-tail was adapted to a host of airplanes, such as the Blériot-Spad 922, the Fouga CM-170 Magister jet trainer and, of course, the Beech Model 35 Bonanza.

The V-tail configuration does offer some practical advantages that a conventional empennage does not. It is affected less by wing downwash, requires less trimming during power changes and is not as susceptible to ground damage—features also characteristic of a T-tail. Additionally, the V-tail weighs less (18 pounds in the case of a Model 35) and creates measurably less drag (because of less frontal area, less surface area and fewer surface-to-fuselage intersections). These drag and weight advantages prompted the National Aeronautics and Space Administration to recommend in a recent report that manufacturers consider V-tail technology in the design of future-generation airliners.

V-tail disadvantages include the need for a relatively complex control mixer and a slight tendency of the airplane to pitch down when the empennage is assaulted by a gust from either side. When a relative wind from the side strikes the bottom of a slanted tail surface, the air is deflected downward, resulting in a slight tendency for the tail to rise. For similar reasons, a side gust striking the vertical stabilizer of a conventional tail results in a tendency for the airplane to roll away from the gust. In each case the effect is very difficult to observe.

Another disadvantage is that the V-tail is not as suitable for aerobatics. When the pilot commands maximum elevator power (either nose-up or nose-down), the ruddervators cannot deflect to as large a *differential* while simultaneously applying maximum rudder-pedal pressure. In other words, when full forward or aft pressure is applied to the control wheel, less than maximum rudder power is available, making it more difficult to perform a snap roll. For nonaerobatic maneuvering, this is of no consequence.

Just as a quartering crosswind can be broken down into crosswind and headwind (or tailwind) components, the surface areas of a V-tail similarly can be divided into horizontal and vertical components. The tail surfaces of a Model 35 are inclined 33 degrees to the horizontal and have a total area of 41.96 square feet (beginning with the Model C35 in 1951). This results in a vertical component of 22.86 square feet and a horizontal component of 35.19 square feet. By way of comparison, the straight-tail Model 33 Bonanza has vertical and horizontal surface areas of 15.96 and 37.19 square feet, respectively. In other words, the V-tail has 95 percent as much horizontal tail area and 143 percent as much vertical tail area as the Model 33.

It would be incorrect, however, to use these figures to compare directly the aerodynamic effectiveness of these tail configurations. This is a complex problem and requires consideration of such factors as tail arm lengths, aspect ratios, surface geometry, sidewash effects and empennage interference. From a practical standpoint, the differences between V- and straight-tail effectiveness are best determined by elaborate flight testing. □

ditions to panic and exert back pressure sufficient to violate structural limits.

Since the control forces of a straight-tail Bonanza are heavier, a pilot who has entered a graveyard spiral simply may not have the strength to create the Gs necessary to induce structural failure. Unless he executes a timely recovery, he may strike the ground with the airplane intact.

In either event, the pilot is just as dead. The best preventive measure—in any airplane—is to respect and abide by published limitations.

All of this figures very prominently in the accident statistics quoted by *Aviation Consumer,* because many of the accidents enumerated by Silver occurred with an excessively aft CG.

Does any of this justify condemning the V-tail Bonanza? Of course not, but it does say something about those who either ignore operating limitations or are unqualified to fly this high-performance airplane.

Considerable space was devoted to the discussion of the Model 35's structural integrity. But most of this assault was directed against Bonanzas built more than a quarter-century ago. Although those early editions (they are regarded as antiques) either require a periodic inspection of the wing carry-through truss or have been modified, this bears no relevance to subsequent Model 35s. The later models were certificated in the stringent Utility Category and are exceptionally rugged and durable. It is uncertain why the author chose to review such ancient history. Perhaps he intended for later-model V-tail Bonanzas to be found guilty by association or lineage.

The article did contain a frightening, sequential diagram emblazoned across two full pages. This was said to represent a trajectory reconstruction of a Model V35TC that came apart over Pas, Manitoba, in 1972. What the caption failed to mention, however, were the conditions necessary to cause this structural breakup. A computer analysis of these diagrams estimates that the airplane was exposed to a peak of between 8½ and 9½ Gs at an airspeed of 300 knots. Could *any* lightplane survive such maltreatment?

Despite an elaborate effort, *Aviation Consumer* failed to find serious fault with the design and structural integrity of the V-tail Bonanza because there probably is none to find.

At first glance, the statistics cited in the article do seem to condemn the Model 35 Bonanza because more of them (per 100,000 hours of flight) have been torn apart in flight than straight-tail models. But there are a variety of ways to apply and interpret this kind of raw data. Numbers alone can be very deceptive. As but one example, consider the following:

In 1978, author Silver alleged to the Federal Aviation Administration that the Model 35 suffers from a serious flutter problem. The response to him from Robert Stephens, chief, Engineering and Manufacturing District Office, Central Region, places in perspective the statistics employed by Silver to indict the airplane (emphasis has been added):

"In all reliable reports. . .where weather conditions at the accident site were established, *at least 90 percent* of the Model 35 disintegrations occurred in IFR conditions (*with more than half the pilots non-instrument rated*). When we consider that the ratio of hours of flight in visual conditions compared to hours spent in instrument conditions is approximately 15 to one, it would appear that over 90 percent of the structural failures should occur during visual conditions, if flutter were the cause. Since just the opposite is true, we have no reason to question the probable cause the NTSB has assigned to the various accidents. Accordingly, unless a definite link between adverse weather and flutter can be established, we cannot justify the expenditure of. . .public funds to investigate an abstract theory."

Not only were the majority of accidents caused by unqualified pilots, but 40 percent of them involved flight into thunderstorm activity. There obviously are many causes for airplane accidents. But when pilots operate within their limitations and those of the airplanes they fly, structural failure rarely is one of them.

In conclusion, it is intriguing to reflect upon how such a storm of controversy can be created about a design that has been regarded as a standard of excellence for more than a third of a century. And yet, upon close examination, the storm is little more than a tempest in a teapot or, as Shakespeare said, "much ado about nothing." Fortunately, all that is required to resolve the controversy is some legitimate scientific analysis to show what is true and what is not. □