The V-Tail Bonanza— Breaking of a Legend

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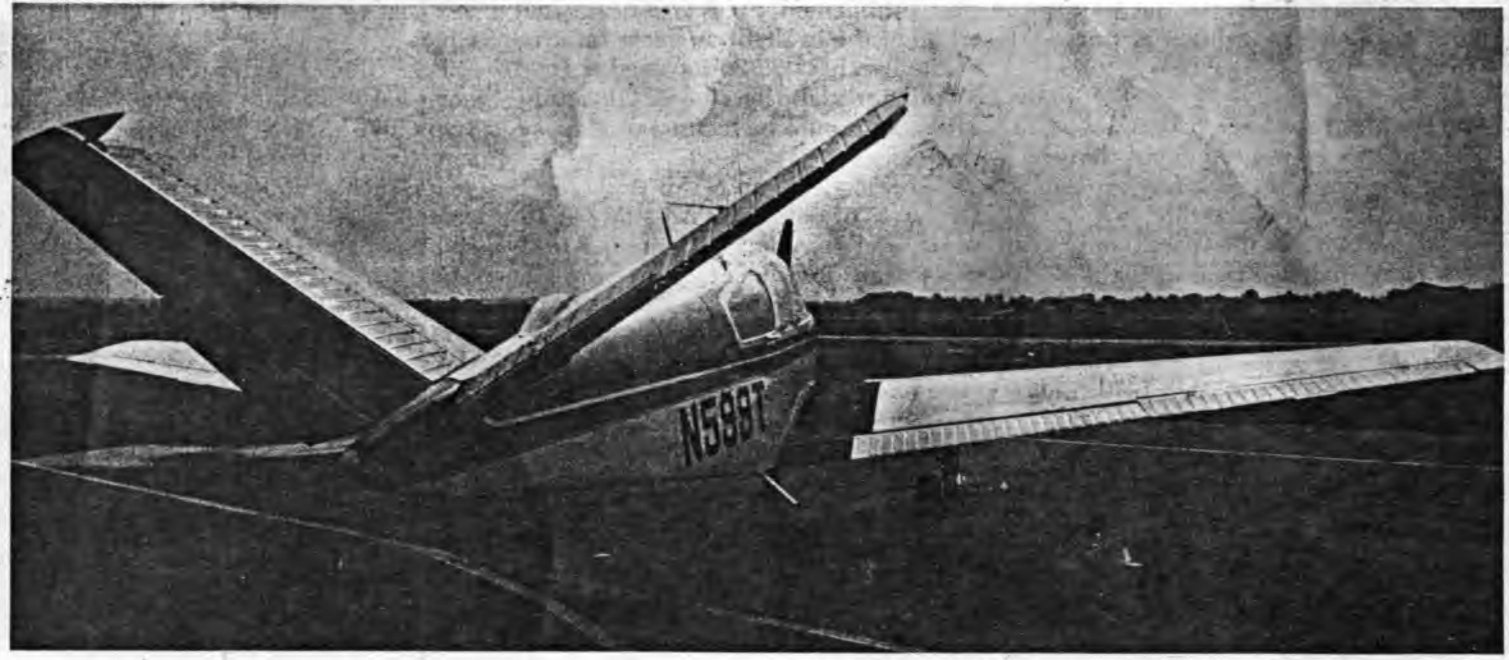
Beech's V-tail classic has a disturbingly high record of in-flight airframe failures, while the straight-tail 33 and 36 Bonanzas almost never break.



By Brent Silver, Contributing Editor, Safety

In-flight airframe failures are supposed to be rare. In April, 1979, *The Aviation Consumer* published a study that showed they are indeed rare for some airplanes, but not so rare for others. A surprising fact that emerged from that study was that V-tail Bonanzas—the Model 35 series—suffered fatal in-flight structural failures 24 times more frequently than straight-tail Model 33 and 36 series Bonanzas during the period 1964-77. Both the FAA and NTSB have published statistical studies that verify this trend.

It's surprising, to say the least, that the most popular and highly regarded retractable ever built should have such statistics. The V-tail Bonanza is one of the few airplanes that really deserves the name "legend." The Model 35 was introduced in 1947, and Walter Beech called it "a masterpiece of engineering" and "a miracle of aeronautical design." The Bonanza was indeed far ahead of its competitors, and the distinctive V-tail soon became a shining symbol of high performance, luxury and, ironically, great structural strength. The V-tail legend has grown steadily over the years, and the airplane is now entering its 34th year of production—a reign unmatched by any airplane. A recent Beechcraft ad for the 1979 V35 called it "still the one to beat. . . incomparable."

The first straight-tail Model 33 Bonanza appeared in 1960, and the Model 36, a stretched Bonanza which also had a conventional tail, was introduced in 1968. The straight-tail models now outsell the V-tail version, but of the estimated 10,000 Bonanzas now flying, about 80 percent are V-tails. More than 10,000 V-tails have been built, and an estimated 8,000 are still flying.

Engineering in Style

For light aircraft, the art of design combines both engineering and styling. The V-tail is an exercise in styling. Its purported engineering advantages in our opinion do not stand close scrutiny. As a style, the V-tail is certainly distinctive. The V-tail is the Bonanza's "cachet," or distinguishing mark. But the word "cachet" also means a sweet or inoffensive wafer that encloses a bitter pill. Is that meaning also appropriate for the V-tail? If not, why then the stark difference between the airframe failure rates of V-tail and straight-tail Bonanzas?

Possible Answers

We have searched for answers to this perplexing question and have found three possible ones:

1. Ruddervator flutter. The Beech specification for ruddervator balance is only a few inch-pounds away from proven flutter.
2. Structural weak points. The 1947-48 Bonanza has had an unusually high failure rate. It breaks most often at a point in the wing where there are several stress concentrations. Later models of the Bonanza tend to break in the tail.
3. Less-than-ideal handling qualities. The V-tail Bonanza has several quirks that can trip up an unwary pilot, particularly in turbulence and/or IFR conditions. One quirk is a poor Dutch roll characteristic, which some call the "Bonanza waggle." Another is the spiral instability of the aircraft; it can wind up in a diving corkscrew if the

pilot stops piloting. And, surprisingly, the V-tail Bonanzas have much more critical center-of-gravity characteristics than the straight-tail models, which can result in reduced longitudinal stability. All of these handling qualities can contribute to a loss of control that ends in a structural failure.

There is evidence to support each of these possible answers. Perhaps all three have been factors in the 33-year history of Bonanza in-flight airframe failures.

The Problem

The statistics leave little doubt that the V-tail Bonanzas have a safety problem not shared by their straight-tail counterparts. Over the years there have been more than 200 fatal in-flight breakups in V-tails (as of 1978). There has been just one in a straight-tail Bonanza.

The Aviation Consumer's 1979 study of in-flight breakups during the years 1964-77 showed the V-tail to have a rate of 0.65 breakups per 100,000 flight hours, compared to just 0.03 for the straight-tail 33 and 36 models combined.

Early in 1979 the FAA released a study of aircraft dynamic characteristics. This study (see *The Aviation Consumer*, May 15, 1979) took particular interest in the in-flight failure rate of the Bonanza. Over a 10-year period the FAA report noted that "the Beech 35's in-flight airframe failure accident rate, at 0.779 per 100,000 hours, is 20 times that of its straight-tailed companion and, in fact, is exceeded only by a few aircraft with substantially less exposure ..."

In May 1979 the NTSB released its own study of general aviation accidents (report No. NTSB-AAS-79-1). Even though they did not separate V-tail from straight-tail Bonanzas, they found their combined in-flight failure rate to be "considerably higher than the mean rate of the selected aircraft group" for the five-year period studied. NTSB then commented, "It is significant that all 40 of the in-flight airframe failures of the Beech 33/35/36 involved the V-tailed models (Beech 35). Obviously attention should be focused on this model."

Three studies—an NTSB study of five years of data, an FAA study of 10 years, and an *Aviation Consumer* study of 14 years of accident data—have all shown the same fact. Yet this is not the first time in the history of the Bonanza that this failure pattern has been observed. The evidence suggests that both Beech and the FAA have studied it extensively over the years and should have long been aware of the problem.

Chinese Water Torture

The first in-flight failure of a Bonanza occurred in 1946. During a dive test, an experimental prototype, serial number D-4, disintegrated. The observer parachuted to safety, but the pilot was killed. In the years since. there have been fatal in-flight airframe failures in every year for which data are available. As of 1978, the total of known in-flight failures of V-tail Bonanzas was 208. There was one straight-tail failure.

We do not know how many people died in these 208 accidents. However, if a sample of recent data is representative, there have been about 2½ deaths per in-flight failure. We estimate approximately 500 deaths in Bonanza in-flight breakups. Thus, probably twice as many people died in V-tail structural failures as in the worst U.S. air disaster in history, last year's American DC-10 crash in Chicago.

Like Chinese water torture, the bad news has trickled in over the years. Bad years, like 1953 with 14 accidents, were sometimes followed by relatively good years, such as 1954 with three accidents. Such swings must have encouraged apprehensive Beech designers. They were not idle. Beech made several significant structural changes to the Bonanza design as they tried to chase the gremlins out of the wing, the fuselage, the tail.

The external posture Beech adopted (and to a large extent, their internal one also) was that these accidents were due to pilot error, pure and simple. Meanwhile, Beech kept beefing up the airplane, but they did little for Bonanzas already in the field as they strengthened subsequent models.

Bonanza Model Changes

The table on page eight summarizes details of the individual models of the Bonanza Model 35 series.

Structurally the big changes came at the A, C, F, H and S models. The H model represented a particularly big change. The net result of all these improvements is that later Bonanzas are

Bonanza 35 Fatal Inflight Airframe Failure Accidents

By Model

Model	Number FIFAFAs	Number Produced	Percent FIFAFA*
35	71	1500	4.8
35R	0	13	0.0
A35	17	701	2.4
B35	11	480	2.3
C35	20	719	2.8
D35	14	298	4.7
E35	10	301	3.3
F35	6	392	1.5
G35	7	476	1.5
H35	2	464	1.3
J35	5	396	1.3
K35	4	436	0.9
M35	10	400	2.5
N35	4	280	1.4
P35	7	467	1.5
S35	7	667	1.1
V35	5	622	0.8
V35A	5	470	1.1
V35B	3	n.a.	n.a.
Total	208		

By Structural Design

Model Group	Number FIFAFAs	Number Produced	Percent FIFAFA*
35	71	1500	4.8
A-B	28	1181	2.4
C-E	44	1318	3.3
F-G	13	868	1.5
H-M	21	1696	1.2
N-P	11	747	1.5
S-VA	17	1714	1.0

Figures do not include accidents in 1962-63, or most foreign accidents.
** These percentages should not be compared directly. Newer airplanes have had less time to accumulate accidents, and therefore will usually have lower percentage figures even though their rate of FIFAF accidents may be the same or greater.*

significantly stronger than the early models. The first model, the 35 (sometimes called the "straight-35" to differentiate it from the "35-series," which includes all V-tail Bonanzas), appears to be particularly weak. This early model has been involved in 71 known in-flight failures. That means that about one in 20 of all straight 35s ever built have broken in flight. It has the worst record of all Bonanza models.

The table on page five presents the total number of in-flight failures by Bonanza model. The bottom section summarizes these accidents by model groups. While it appears that later models have a better record than the early models, one should realize that the later models have accumulated a lot fewer flight hours. That means they have had less "exposure" to accidents. It also means they have had less wear and tear.

The surprising thing, though, is that the problem has not gone away as the structure was beefed up. When actual flight hours are taken into consideration, the older Bonanzas (with the exception of the original 35) have an in-flight failure rate that is about the same as that of the newer Bonanzas.

Thus, although Bonanzas have been made significantly stronger, they still break. This recalls the observation of a Cessna Conquest pilot we talked to recently. While waiting for Cessna to fix the tail on his grounded Conquest he noted that their first fix was supposed to have been overstrength by a factor of 50, but it didn't take care of the problem. While Cessna went back to the drawing board, he observed that, "If your beefup doesn't solve the problem, maybe you don't understand the problem."

Because of the continuing accident record, we suspect that Beech either has not understood the problem or has elected not to face up to the consequences of solving it.

Bonanza 35 Fatal Inflight Airframe Failure Accidents by Year

Year	FIFAFAs	Year	FIFAFAs	Year	FIFAFAs	Year	FIFAFAs
1946	1	1955	8	1964	2	1973	10
1947	5	1956	11	1965	10	1974	13
1948	5	1957	10	1966	10	1975	10
1949	6	1958	6	1967	7	1976	3
1950	10	1959	7	1968	7	1977	6
1951	6	1960	8	1969	4	1978	7
1952	4	1961	4*	1970	2	1979	n.a.
1953	14	1962	n.a.	1971	6	Total	208
1954	3	1963	n.a.	1972	3		

Total does not include most foreign accidents. ** 1961 data are incomplete.*

Pilot Error and Adverse Weather

One of the reasons that this problem has evaded solution for 33 years is that these accidents, individually, are blamed on the pilot. The code words are "pilot error" and "adverse weather."

It is really not too hard to adopt this point of view, particularly if you don't want to think bad thoughts about FAA-certificated aircraft. Let's take a couple of Bonanza in-flight failures, picked at random:

- Near Fargo, Georgia, an M35 suffered an in-flight airframe failure with two fatalities. The pilot had a private license and was not instrument-rated. Weather conditions were noted as low ceiling (3,000 ft.), rain and fog. Four probable causes were assigned by the NTSB and all involved the pilot in command: "inadequate preflight," "continued VFR into adverse weather conditions," "spatial disorientation" and "exceeded designed stress limits of aircraft."
- A V35A broke up near Idabel, Oklahoma with three fatalities. The pilot had a private license with 534 hours, all in type, and was not instrument-rated. The weather was ceiling 25,000 ft. and unlimited visibility (over five miles), but thunderstorms were reported in the area. The pilot was hit with both probable causes: "exceeded designed stress limits of aircraft" and "spatial disorientation."

Those are fairly typical accidents. Bad weather *is* generally associated with these in-flight failures. And the typical pilot is not instrument-rated.

But there are exceptions; some of the pilots are highly qualified. In fact, recent years have seen better-trained pilots in these accidents. In 1978, the latest year for which reports are available, there were seven Bonanza in-flight failures. Five of the seven pilots were instrument-rated. Three pilots had commercial licenses and two were ATPs. (All seven of these accidents were blamed on the pilots.)

Individually, these accidents are viewed as replays of the same three-act scenario: 1. Pilot flies into weather he can't handle. 2. Pilot loses control of aircraft. 3. Aircraft breaks.

As Beech strengthened the wings, *more failures began to occur in the tail.*

The question we keep coming back to is, why is this scenario played out in the V-tail Bonanza, but not the straight-tail Bonanza? It's hard to believe that foolish or incompetent pilots gravitate almost exclusively to the V-tail airplane, leaving their more expert and prudent counterparts to fly the straight-tail models.

Studies in Failure

As indicated before, Bonanza in-flight airframe failures have certainly been studied. The CAA (and later the FAA) ran almost a regular series on this problem. Their first report, dated May 27, 1948, came out only 15 months after the Bonanza was type-certificated. Entitled "Investigation of Accidents Involving Possible Structural Failures in Flight, Beech Model 35 Aircraft," Aircraft Branch Report No. 5-6 discussed in detail the structural failures known at that time. As revised on October 26,1948, Report 5-6 also discussed the absence of a shear web in the main wing spar outboard of wing station 66 (WS 66 is a point 66 inches outboard from the aircraft centerline). The absence of the shear web in the main wing spar also was seen by a Civil Aeronautics Board investigator (the CAB was the country's accident investigating agency prior to the mid-1960's) as significant in the failure of a Bonanza wing at this station.

CAA Report 5-6 was revised at least five more times over the next 12 years; each time the number of Bonanza structural failures was brought up to date. The last known revision is dated June 1, 1960. The CAA then knew of 86 structural failures for the Bonanza. Almost all of these were associated with "adverse weather." Although this last revision states "this appendix will be revised as necessary to keep the report current," no later revisions have been found.

On June 6, 1960, an internal FAA memo listed the details of 92 Bonanza in-flight failures. About two-thirds of these accidents listed the factor, "lost control in overcast weather." Only 11 percent of the pilots were known to have had instrument experience.

On the same day, June 6, 1960, an FAA record of a telephone conversation with Beech Aircraft updated the total to exactly 100 known to Beech. Since Beech was supplying the FAA with this information, it seems likely that they were aware of the accident pattern as it developed.

In November, 1961, the FAA again reviewed the Bonanza accident experience in an internal memo. An attempt was made to correlate the structural failures with the various model

V-Tail: Style or Substance?

If there is one part of the airplane that stylists love to play with, it has to be the tail. There are swept tails, straight tails, T-tails, cruciform tails and, of course, V-tails. Tails on lightplanes are often swept back, not because they perform better, but because they *look* better. (After all, that's the way the jets do it.) Swept tails, like swept wings, make sense when you fly near the speed of sound, but don't mean much at Mach 0.2.

Horizontal tails are now changing too. The current trend is toward the T-tail. But the Piper Lance is giving up on the the T-tail and going back to its old design. And there's been a T-tail Bonanza prototype flying for more than a year now. Up and down, like women's hemlines.

But the most unusual and daring tail style has to be the V-tail. Sure, there are other V-tail designs. Given an idle hour and a copy of *Jane's* you could probable find a half-dozen, in addition to the Bonanza. The Fouga Magister and the Schreder RS-15 are two.

Theoretically, the V-tail seems to do what conventional tails do, but with only two-thirds the effort. Unfortunately, even in aerodynamics, there is no such thing as a free lunch—and in this case, you can't even get a one-third discount.

The idea of the V-tail is to get two surfaces to do the work of three. Leave off the vertical tail and cant the horizontal tails up enough to take care of directional stability and control. You have just saved one-third on tail drag and weight, right? Wrong. There are several problems with the V-tail and here are a few:

- For the same stability, the two remaining tail surfaces have to be a lot bigger. If they aren't, the airplane will have problems with Dutch roll and spiral divergence.
- A complicated control mixer is required to get both yaw and pitch control. (On the Bonanza, this mixer is called the "monkey motion.")
- The "elevators" can't be interconnected and this means more mass balance is required to be safe from antisymmetric tail flutter.
- The V-tail may actually have more drag. (Trim drag is greater for a V-tail than a conventional tail.)

As far as perfomance is concerned, Beech says the V-tail Bonanza is exactly equal to the straight-tail model. They used to claim that the V-tail was two or three mph faster, but the extra speed originated in the marketing department. An ex-Beech test pilot confided to us that tests showed the straight-tail to be a bit faster, but it was hard to measure the difference.

In the heady days of the introduction of the Bonanza, Beech told *Flying* magazine that they were going to put the "butterfly" tail (i.e., V-tail) on all their future designs. It didn't happen. Except for the Bonanza, Beech has given the butterfly tail back to the butterflies.

This might shock Bonanza purists, but Beech actually considered killing the V-tail 20 years ago. The revised Design Directive for the proposed Model O-35 in 1960 called for a straight-tail. Here is a quote from its Design Directive (August 10, 1960):

"This supplement describes the O35 Bonanza with the Model 33 Debonair empennage in lieu of the Bonanza standard "V" tail. It should be noted that the performance data is quoted without benefit of the full three percent increase for advertising purposes."

By the way, the performance quoted for the O-35 was better than that for the P35 which was actually built. And that was without benefit of the three percent increase for advertising purposes.

Styling is the real reason the V-tail is on the Bonanza. That styling was successful in a sense. Beech has built 10,287 V-tail Bonanzas as of August 15, 1979. It is one of the most successful light airplanes ever designed. According to Ralph Harmon, the chief designer of the original model 35, the V-tail came about like this, back in 1945:

"One day at lunch, one of the engineers was reading a Polish aviation magazine, and he said, 'Ralph, this is the kind of tail you ought to put on your new airplane.' It was the V-tail. Well, that went along with the philosophy of new, different and better that I was promoting at that time so I put the V-tail on it. I had an artist sketch it up and management bought it."

Summary of Bonanza 35 Series Features and Changes

Model	Year	No. Built	HP	Weights Empty	Weights Gross	Speeds (mph)*** VA	VNO	VNE	VCRUISE	Notes and Changes
35	47-48	1500	185	1558	2550	130	160	202	175	AD 63-25-01 on wing carrythrough truss. Certificated to 3.8 gs at gross weight.
A35	1949	701	185	1580	2650	130*	160	202	173	Certificated to 4.4 gs at gross weight. New carrythrough structure. Thicker wing skins. Strengthened fuselage bulkhead at tail attachment. Thicker fuselage stringers; larger wing-attach bolts.
B35	1950	480	196	1575	2650	130*	160	202	173	196 hp limited to one minute; no structural changes of significance.
C35	51-52	719	205	1647	2700	130*	160	202	178	Major stabilizer changes: increased chord by 14.4%; dihedral changed from 30° to 33°; beaded construction; change from pinned to fixed rear spar attachment. Larger rivets used to attach wing leading edge. Main landing gear same as that of T-34.
D35	1953	298	205	1650	2725	130*	160	202	180	Essentially the same as C35.
E35	1954	301	225	1675	2725	130*	175	202	186	Choice of 225-hp or 205-hp engine. Aileron trim control.
F35	1955	392	225	1697	2750	130*	175	202	186	Wing changes: .020 spar web added from WS 66 to WS 108; strengthened spar and stringers; stronger wing attach ("bathtub") fittings; numerous local beefups. Fuselage changes: third side window added; local strengthening around baggage door. Tail changes: use of modified T-34 elevator; thicker stabilizer spars, thicker stabilizer nose rib.
G35	1956	476	225	1722	2775	130*	175	202	190	Reinforced wing root rib. Thicker front spar web from WS 33 to WS 66. Wider front spar cap strip.
H35	1957	464	240	1833	2900	142	175	210	196	Wing changes: used Model 50 Twin Bonanza spar caps and fittings; spar web added from WS 108 to WS 191 (wing tip) and inboard spar webs made thicker; Model 50 leading edge assembly used with modifications; skin splices changed from single row of attachments to double. Strengthened front carrythrough structure. Stabilizer changes: strengthened main spar; added .032 "J" section to stabilizer nose; added nose rib. Elevator changes: added intermediate spar, tab hinge and rib; lengthened and strengthened balance horn with heavier (3.35 lb vs. 2.13 lb) counterweight.
J35	1958	396	250	1820	2900	142	185	225	200	No structural changes of significance. Fuel injected engine.
K35	1959	436	250	1832	2950	142	185	225	200	No structural changes of significance. Increased rudder travel.
M35	1960	400	250	1832	2950	142	185	225	200	No structural changes of significance. New "high stability" wing tip.
N35	1961	280	260	1855	3125	148	185	225	195	Fuselage changes: longer rear cabin window; thicker top fuselage skin; stronger aft belly structure. New fuel tanks. Magnesium ailerons replaced with aluminum. Bobweight added (?)
P35	62-63	467	260	1855	3125	148	185	225	195	No structural changes of significance. Redesigned instrument panel. Stall warning horn and light replaced with buzzer.
S35	64-65	667	285	1885	3300	152	190	225	205	Longer cabin (aft bulkhead moved back 19 in.); approximately 25 lbs. lead weight added to nose for balance. Engine canted 2½° right and 2° down. Stall warning horn replaced buzzer. Model 33 type pointed ruddervator balance horn.
V35	66-67	622	285	1941	3400	152	190	225	203	No structural changes of significance. New one-piece windshield.
V35A	68-69	470	285	1958	3400	152	190	225	203	No structural changes of significance. New swept one-piece windshield. Turbocharged engine in 46 aircraft (service ceiling 29,500 ft.).
V35B	70-80	1217**	285	1985	3400	152	190	225	203	No structural changes of significance. Turbocharged option discontinued in 1970 after 11 made. Anti-slosh fuel tanks. New interior.

*Recommended maneuvering speed listed. Beech's design maneuvering speed was 142 mph.
**Production total as of August 15, 1979.
***The cruise speed is TAS, the other speeds are CAS (V_A is maneuvering speed, V_{NO} is the maximum structural cruising speed, and V_{NE} is the never-exceed, or redline, speed).

changes. No definitive pattern emerged, other than that already well known: the original Model 35 failure rate was high, and there was a great deal of variation among the other models.

Obviously the CAA/FAA was concerned about the problem but did not seem to know what to do about it—other than study it, of course.

Beech Studies

Beech was also studying the emerging pattern of Bonanza failures. Beech General Engineering Report No. 742, of October 19, 1950, analyzed all Bonanza accidents for 1947 through 1949. It listed 16 structural failures under adverse weather conditions—one-third of all Bonanza fatals up to that point.

While the accident rate caused concern, it appeared that the A35 had a better record than the 35. In fact, the rate of structural failures was 70 percent better. "I believe," the author said, "it can be concluded, therefore, that the several hundred design changes between the basic Model 35 Bonanza and our current airplane have resulted in a major contribution to increased safety."

In an interesting sidelight, the same Beech document also discussed a confidential CAB report on comparative aircraft safety statistics. The report showed the Bonanza to have a much worse safety record than the Navion, Cessna 170, Stinson and Ercoupe. The Beech memo stated, "If the CAB is forced to release such a comparative analysis of aircraft accidents (to the public)—and obviously this could have a very serious effect on Beechcraft sales—we cannot say that we have had no forewarning or chance to rectify the present situation."

On April 3, 1951, Beech General Engineering Report 793 updated Report 742. Again the patterns of the various types of accidents were analyzed. By this time, 25 structural failures were known, and the previously observed pattern of accidents for the original Model 35 continued. At this time, Beech was offering to rebuild and beef up old "straight" 35s at a cost to the customer of about $6,000. Part of this rebuild program was a major strengthening of the wing. The author of Beech Report 793 gave his strong support to this program: "This report shows a definite need for the Model 35R (basic Bonanza manufacture program) ..." The 35R program was canceled four months later.

Under "Conclusions and Recommendations," Beech Report 793 stated:

> . . . it would appear that the greatest stress or efforts regarding accident elimination should be concentrated on the reduction of collisions and structural failures in adverse weather.

On January 18, 1952, Beech General Engineering Report 874 again updated the Bonanza accident patterns. This report noted that the incidence of structural failure was much improved for the A Model and subsequent models. As far as the original 35 was concerned: "Increased effort in the line of pilot education might help reduce the Model 35 structural accidents; and if conditions should warrant a possible reactivation of the Model 35R project some time in the future, it would undoubtedly give the Model 35's a comparable improvement as shown on the A, B, and C model Bonanzas."

Where Does It Fail?

Perhaps the most significant of the Beech studies of the problem of in-flight structural failures was written in December, 1958. This restricted document, Beech Service Engineering Research Study No. 103, summarized the locations of failure for each of the Bonanza models then built.

What was found was that the original 35 tended to fail in the wings, and the later models tended to fail more frequently in the tail. The original model 35 failed most frequently at Wing Station 66, the weak point that had been pointed out by the CAB a decade earlier.

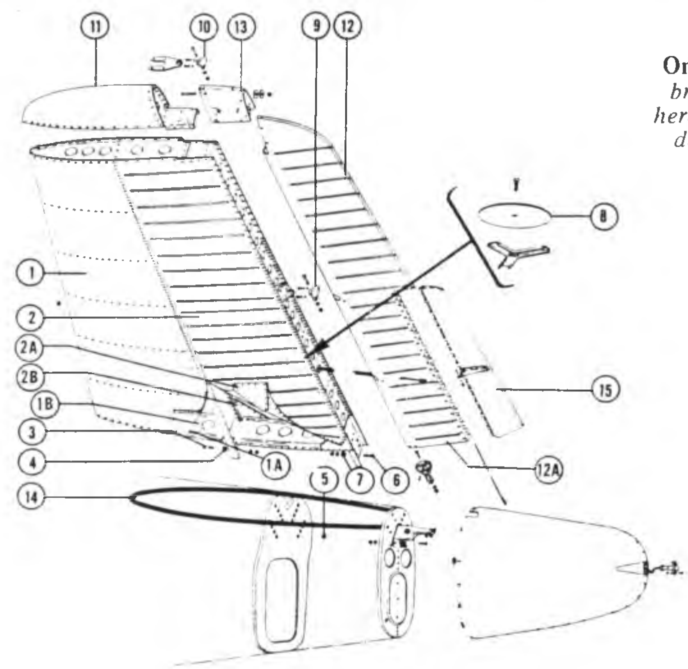
Beech Study 103 also compared the structural failure rate of the Bonanza against that of other four- or five-place aircraft. For every year from 1948 to 1957 (1947 was not listed) the Bonanza rate was higher than that of the comparison group. Over the 10-year period, the Beech data showed the Bonanza's failure rate was 50 percent higher than the comparison group's. However, this comparison group itself contained the Bonanza. When the Bonanza is removed from the comparison group (Beech did not do this), its in-flight failure rate is actually 133 percent higher than that of other four- or five-place aircraft.

It appears fairly clear to us that both Beech and the CAA should have known there was a serious problem of in-flight failures early in the history of the Bonanza. Indeed, we were told by an ex-Beech engineer who asked to remain anonymous: "Yes, we realized there was a problem within the first three or four years."

"Straight" 35

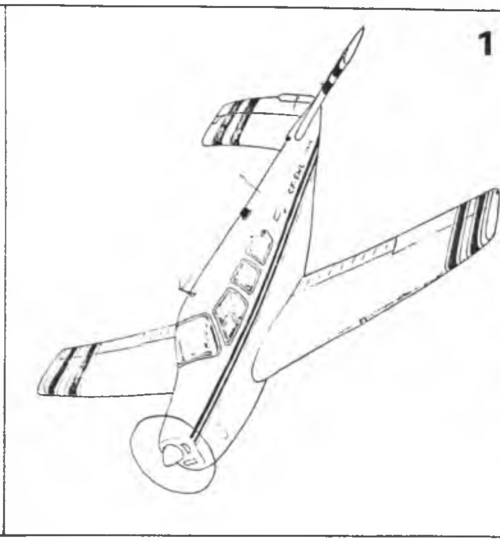
During its early history the worst record of all the Bonanza models was being compiled by the original or "straight" 35 (*not* the straight-tail), produced in 1947 and 1948.

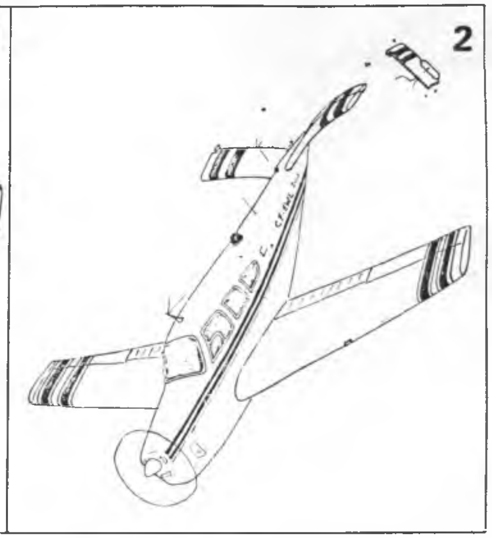
The primary design philosophy of the straight 35 was to minimize weight. This meant that the structural margins of safety were cut to the minimum allowed by the CAA. Quoting from a



One key to the Bonanza's *breakup problem may lie here: the V-tail. Structural design, ruddervator mass balance and trim cables may all play a part.*

This series of drawings depicts the in-flight breakup of a V35 TC near Pas, Manitoba in 1972. The drawings are by Bouko James Kor, who did a computerized trajectory reconstruction of the accident. The aircraft apparently stalled in IFR conditions after a vacuum pump failure, then pitched down into a high-speed dive, with wings and tail bending under the stress (1). The right ruddervator separated (2) causing the plane to pitch beyond vertical and shed its left wing (3). At this point, the engine separated (4) and general disintegration followed (5).





Beech report of May 12, 1961: "The original Bonanza structure was designed to have relatively small margins of safety above the 3.8 limit load factor (5.7 ultimate) required for normal category airplanes by Part 3 of Civil Air Regulations. The wing was developed by deliberately under-designing, static testing, strengthening and retesting." And from another Beech report (Dec. 20, 1945): "Extensive use is made of thinner than average sheet metal throughout the airplane."

This weight-conscious philosophy led Beech to use a daring structural technique. Outboard of Wing Station 66 (just outboard of the landing gear), they left the shear web out of the wing spar. Any time lift is being created, there is a bending moment in the spar. That results in what is called a shear between the top and bottom caps of the spar. The shear web, normally just an aluminum sheet, takes out this shear load. Beech decided to use the leading edge skin to carry the shear. This made the leading edge wing skin what is called "primary structure" (i.e., if it fails, the airplane fails). In this way, Beech may have saved perhaps five pounds.

The skin that carried the shear around the leading edge was only 0.025 inches thick for the straight-35. For A and subsequent models, it was made one gauge thicker, 0.032 inches.

There are several stress concentrations at Wing Station 66. Here they are:

1. No shear web in the main spar outboard of WS 66.
2. A production break in the leading edge skin and the "piano hinge" spar cap material it is riveted to.
3. A cutout in the leading edge for the landing light.
4. A cutout for the landing gear and inspection plate inboard of WS 66.
5. A diagonal rib which brings shear from the leading edge skin back into the spar.

These stress concentrations, taken together, virtually paint a dotted line on the wing of the straight-35 which says "Break Here." Thirty-seven of the 49 structural failures (76 percent) reported in Beech Report 103 broke at Wing Station 66.

A CAB accident report dated April 2, 1948 recognized the problem:

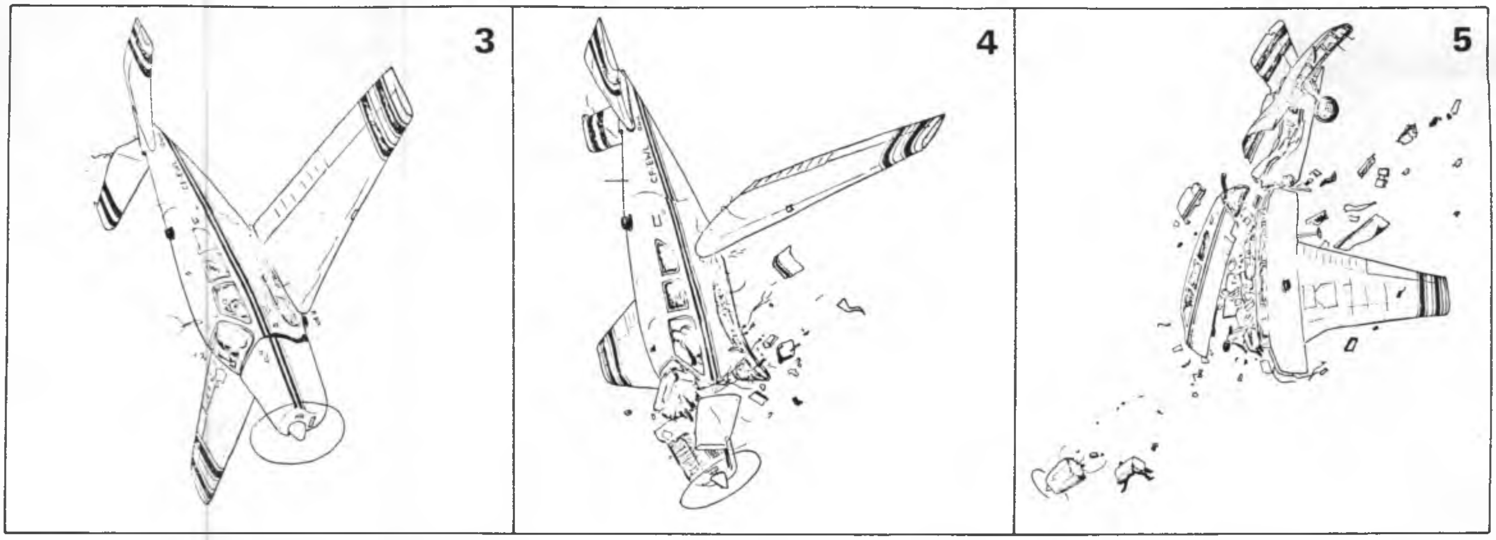
> From the experience of the undersigned in flying the Beechcraft 35, it is known that the wing structure, and the entire aircraft for that matter, is extremely flexible. Further, that the aircraft, being unusually clean aerodynamically, will accelerate very rapidly with the nose even slightly down, from cruising speed. It is, therefore, possible to exceed the design limitations of the aircraft quite easily. Due to the unusual type of wing construction, in which the normal shear web of the spar is replaced by a "D" nose section, attached by means of piano hinges, any serious deformation of the nose section, such as might be experienced in turbulent air, will result in loss of the effective shear member. This condition is made even more critical by the extremely light gage metal employed, and by fairly wide rib spacing. In addition, the countersunk 3/32-in. rivets employed give little effective head area, as compared to a 1/8-in. or larger rivet ...
>
> In view of the above facts, it is recommended that the Beech Aircraft Company, in conjunction with the Civil Aeronautics Administration, initiate an experimental program with the following objective:
>
> a. Develop an easily installed shear web for the main wing spar, if such alteration is structurally feasible, in an effort to provide greater spar strength ...

In 1951, Beech instituted the 35R program, which "remanufactured" the original straight 35. Among the numerous structural changes: a 0.025-inch main spar web was added from WS 66 to WS 136, a skin stiffener was added in the leading edge from WS 59 to WS 66, a doubler was added to the lower skin splice at WS 66, and the rivets at skin intersection points were changed from 3/32 in. to 1/8 in. Only 13 of the 1,500 straight 35s built were converted to the 35R, however.

Larry Ball, former Bonanza program manager and author of *Those Incomparable Bonanzas*, writes that at a price of about $6,000, the program was running up sizable losses. Since a new C35 cost only $12,990, Beech didn't feel they could raise the price of the modification, and so it was terminated. We estimate there are about 600 straight 35s still flying today without any major structural modification in the area of WS 66.

Tail Tells Tale

Having given up on fixing the wing problems of the straight 35, Beech continued to strengthen later models. The A35 and subsequent models were designed to 4.4 Gs, instead of the minimum 3.8 Gs used in the straight 35. While Beech found a great improvement in the structural failure rate after this change, the problem did not go away. Where it went, to some degree at least, was back into the tail. Instead of originating in the wings, most of the failures now started in the tail. An ex-Beech accident investigator said the failures "followed a changing



pattern over the years. With the early models, the wing would fail and the entire tail would come off as a unit. But as Beech beefed up the wing and increased the chord of the stabilizer, the more recent ones had an entirely different break pattern. These later models seem to fail in the fins; the fin leading edge folds over—either up or down—sometimes symmetrically, sometimes asymmetrically."

With the C model, Beech extended the chord of the stabilizer forward by 14.4 percent (on the average). This was done to give better stability. The change was made by simply extending the leading edge; the front spar stayed where it had been. This created a greater "overhang" forward of the spar. The same ex-Beech accident investigator expressed the opinion that there might have been too much overhang there, since he had seen lots of these tails fold about the front spar. "I think it is a basic mistake on Beech's part, and I would take them to task for it," he told *The Aviation Consumer.* "There should be some leading edge support in there."

In the 1950s, aircraft designer Irv Culver was asked to help the CAA investigate the structural failure of a Bonanza with the wide-chord tail. It had failed, folding up and over the front spar. He looked at the tail carefully and decided it looked "pretty flimsy." Culver and R.G. Cathaway wrote a letter to the FAA criticizing the strength of the tail, arguing that Beech should have strengthened the front spar and front ribs, or added a stub spar forward. (The FAA contacted Beech about the matter, and Beech said the tail was OK.) Culver also believes the Bonanza's poor Dutch roll characteristics play a part in the V-tail's high rate of tail failures (see interview with Culver below for details).

Irv Culver: "Beech would probably like to have me shot."

Irv Culver has had a lifetime of aeronautical activity. Culver is now semi-retired and consults on aircraft design. He invented the Attitude Orienter (an artificial horizon in which the airplane moves and the horizon stays stationary) and participated in several designs while at Lockheed-California. When we caught up with him, he had just come back from Wichita in his new Turbo 210. This is the third 210 he has purchased.

Aviation Consumer: We have a copy of the letter you sent to the FAA about the strength of the Bonanza tail ...

Irv Culver: Well, I think they fixed that problem—at least on the later models. They beefed up the root rib and the front spar of the stabilizer. I think they fixed it structurally. *[Note: the H Model and later models appear to have the change Culver speaks of here.]*

AC: The structural failures have continued over the years, even the later models.

Culver: Yes, well, the Bonanza has some other problems. It's directionally poor in rough air. It has very bad Dutch roll characteristics. It's not really a good airplane at all, but that's only my opinion. Everybody else thinks it is great.

AC: How does that relate to the structural failures?

Culver: In my opinion, the Dutch roll characteristics are so bad that in rough air it yaws to very high angles and just blows the tail off. Beech certainly has beefed up the later models. But I don't care how much you beef it up, if you lose it in rough air and it starts Dutch rolling, it can go to very high yaw angles, way beyond the design strength of the tail.

AC: Is this below red-line speed?

Culver: Oh yes. I think this occurs just above cruise speed. You know the public is misinformed about rough air, they just go booming on through. They pull their hats down over their heads and go.

Years ago I was flying a Bonanza over the desert in rough air and it was something else. But it wasn't blind (*i.e., not instrument conditions*). I'd say blind you wouldn't have a chance in really rough air at high speed.

AC: Most of the Bonanza in-flight failures are associated with bad weather.

Culver: Yeah, blind. I think most pilots could hack it in IFR conditions if they would just slow down.

AC: Back to the letter you sent the FAA. What did Beech do about that?

Culver: That was a very unpopular thing with Beech, you know. As I say, I think they have fixed the tail weakness, but they waited a while. Beech is very sensitive about such things. It is a legal thing as far as they are concerned. It has nothing to do with safety; it has to do with a legal position. And so they never react to anything until sometime later, you know, when it is all died down.

AC: We plan to quote you on this.

Culver: Beech would probably like to have me shot. Yeah, sure, you can quote me.

Butterfly Flutter

Beech's first mathematical flutter analysis of the butterfly-tail Bonanza indicated that it would flutter at "about 60 or 80" mph. This analysis was discarded. Subsequent analyses raised the flutter speed, but the margin of safety was always slim. Beech decided to rely on flight flutter tests. The shaker was not strong enough to do the job and the CAA asked for another test. In the next test, the pilot kicked the rudder pedals to excite the flutter mode. It appears that the flutter certification of the Bonanza series rests entirely on these crude tests.

It was not until 1974 that Beech really had sufficient data to show what the Bonanza's margin of safety was for tail flutter. In that year, attorneys for Beech insurance carriers decided some modern flutter tests were in order. They hired Leon Tolve, a consulting aeroelastician, to put a C35 in the Lockheed-Georgia wind tunnel. The critical "mode" or vibration he was looking for is called the "antisymmetric mode involving fuselage torsion and ruddervator rotation." What this means is that the ruddervators flap as the aft fuselage twists. The combination vibrates at a frequency of about 13 cycles per second. If the system gets into resonance, flutter can tear the tail apart in a matter of seconds.

Tolve's tests indicate that flutter depends on several factors, the most important of which is the balance of the ruddervators. Other important factors are airspeed, altitude, and tension in the rudder control cables.

If Tolve's results are extrapolated to 18,000 ft. (the service ceiling of several of the Bonanza models), they show that only 2.2 inch-pounds aft unbalance beyond Beech specs would allow the ruddervator to flutter. (Slack rudder cables would degrade even this small margin significantly.)

To put these numbers into perspective, an inch-pound (in.-lb.) is a one-pound force acting through a one-inch lever arm (or one ounce acting through 16 inches, etc.). The trailing edge of the Bonanza ruddervator is a little more than 16 inches from the hinge. Thus one ounce at the trailing edge is about one in.-lb. extra unbalance. Two silver dollars taped to the trailing edge would add a little more than two in.-lbs. aft unbalance. According to Tolve's results this is all it would take to get flutter at 18,000 ft.—and that assumes your cables are tight.

More practically speaking, this amount of unbalance could easily come from repainting the ruddervators without rebalancing afterwards. According to Beech, an average repaint job adds about 2.5 in.-lbs. of imbalance—enough to cause flutter under some conditions. It is not really an exaggeration to say that proper ruddervator rebalancing after a repaint job can be a life-or-death matter for a V-tail Bonanza pilot.

Flutter Safety

The flutter margin of safety for the Bonanza ruddervators does not seem great. It is not hard to imagine a couple of ounces of ice or water or oil or dirt or bird guano (use your imagination) accumulating near the trailing edge of the ruddervator. What is hard to believe is that it could kill you. But that's what the numbers say.

How can you buy more protection? Rebalance your ruddervators with as much lead in the counterweights as Beech specs or the room available allows. Keep your rudder and tab cables in good condition and at the proper tension. Keep the surfaces clean and the drain holes open. Don't take off with ice on or in the control surfaces.

At about this point, we should tell you that the "Establishment" view is that the Bonanza does not have a flutter problem. The argument runs along these lines: Bonanza in-flight failures generally happen in bad weather; most Bonanza flying is done in good weather, therefore if there were a flutter problem, it would show up in good weather more often than bad. Don't let this argument take you off your guard. Tolve found he needed turbulence to set off flutter in the tunnel. Where do you get turbulence? Right, "adverse weather."

Bill Guinther, editor of the American Bonanza Society newsletter, takes ruddervator flutter seriously. We asked him if he could account for the high rate of in-flight failures for the V-tail, as compared to the low rate for the straight-tail. He said, "The only characteristic that I can see that is really different between the two airplanes is the susceptibility of the V-tails to out-of-balance ruddervators. That could cause flutter. Flutter could be set off by the sharp turbulence you can get in bad weather—particularly a thunderstorm. Now I can't prove that, but it is the only explanation I can think of."

Tab Flutter

Before we leave the subject of flutter, there is one other point that needs to be made. The only thing that keeps the ruddervator trim tab from flutter are the two tab cables. Tolve showed that with the cables disconnected this tab would flutter at 105 mph, and that the motion would go divergent at 106 mph.

The straight-tail Bonanzas *have a superb record of structural integrity—only one breakup in nearly 20 years. F33A (foreground) is virtually identical to the V35 except for the tail. A36 (rear) has stretched fuselage and higher gross weight.*

Fatal Accident Rate Comparison between Beech 35 Series and Beech 33/36-Series

(Accident Years 1973-1977)

Accident Type	Beech 35-Series	Beech 33/36-Series
In-flight Airframe Failure	.82	0
Uncontrolled Collision with Ground	.33	.31
Subtotal: (Uncontrolled Accidents)	(1.15)	(.31)
Controlled Collision with Ground	.53	.42
Stall/Spin/Spiral/Mush	.51	.10
Engine Malfunction	.37	.10
Other	.37	.21
Total	2.92	1.14

Note: "Fatal accident rate" is fatal accidents per 100,000 flight hours.

"Divergent" means the airplane would be destroyed in short order. What this means to a Bonanza pilot, is that if both cables broke in cruise flight, he would have a broken airplane.

Mechanics in the field frequently find Bonanza tab cables in bad condition. In 1975, the FAA conducted a "Directed Safety Investigation" of Bonanza trim-tab cable problems. Of the 6,958 V-tails registered at the time, the FAA inspected 628. Of those 628, they found 205—nearly a third—with one or more trim cable defects. Of those with defects, 83 percent had corroded cables, 34 percent had the clevis bolt too tight (which damages the cable) and nine percent had frayed cables. FAA estimated that as many as 2,500 V-tails in the field had "discrepant" cables.

The FAA considered issuing an AD that would require replacement of all these tab cables with new ones made of stainless steel. They decided against the AD, however, on the theory that routine inspection should catch these bad cables.

However, the FAA now frequently issues Airworthiness Alerts (which go out to authorized repair stations, etc.) cautioning about inspection of Bonanza tab cables. If you fly Bonanzas, it wouldn't be a bad idea to include a look at the tab cables in your walk-around. If they are frayed or rusty, replace them. If they are covered with paint, you won't be able to tell whether they are still good, and there's a chance that chemical strippers used during the painting process have corroded the cables. Replace them. The clevis should be free to move (i.e., the bolt which attaches the cable clevis to the tab should not be overtorqued).

One structural engineer we consulted for this article has some harsh words for the Bonanza's trim cable system: "The cable tab system is just not appropriate for a modern design that flies at 200-mph-plus. [Beech should] put a mechanical system in there, like they use in their other airplanes. Get rid of those exposed cables. Go out to the airport and look at the tab cables on Bonanzas. Often you see them corroded or frayed or loose. People should realize that if the tab cable breaks you can lose the airplane."

Airworthiness Directives

Old Bonanzas, like most old airplanes, have a number of ADs. The original 35 now has 20 ADs, the A35 has 17, and the B35 has 12. Other models have between six and nine ADs. There have been four ADs which may have a bearing on structural failures:

AD No.	Action:
58-18-01	Inspect fuselage bulkheads for cracks and check balance of ruddervator. Models 35, A, B.
63-25-01	Continuing inspection, or one-time replacement, of wing carry-through truss. Models 35, R.
64-27-01	One-time inspection (and correction, if required) of control wheel aft stop contact area. Models P, S.
76-05-04	Continuing inspection, or one-time replacement, of stabilizer attach fitting. Models 35, A, R.

The carry-through truss AD (63-25-01) was apparently issued after one in-flight structural failure that originated in this welded steel truss (it carries the wing loads through the cabin). The great irony of this AD is that most of the Model 35s have failed in the wing, not in the carry-through structure. We even heard the story of one famous Bonanza pilot who flew around with her carry-through cracked. (We hasten to add that we do not recommend that.) Ironically, the *real* structural problems of the straight 35—like the lack of a shear web outboard of wing station 66—have never been touched by ADs. (One *Aviation Consumer* reader, a structural engineer, asked the FAA if he could rivet a shear web into his straight-35. They said sure, if you don't mind completely recertifying the airplane.)

Concerning AD 76-05-04, one knowledgeable Bonanza owner told us that the old stabilizer attach fitting that he took out of his airplane was a low-quality, porous casting, and that he was mighty glad to replace it, but chagrined to think of the hours he had flown with it holding the tail fins on.

Rock and Roll

If you have flown the V-tail Bonanza in turbulence, you have experienced the yawing oscillation some call the Bonanza tailwag, or wiggle, or waltz. Whatever you call it, it isn't pleasant. It is a Dutch roll oscillation and it has a natural period of about two seconds. That's just long enough to induce the pilot to try and correct it, but too fast for him to do a very good job. (The two-second period of the Bonanza oscillation is unusually short; most airplanes have a longer Dutch roll period.) If the pilot gets behind in his corrections, he can set up a nasty "pilot-induced oscillation." It may be better to plant your feet on the rudder pedals and hold on. Slowing down should also help.

Dutch roll is a combined oscillation in yaw and roll, generally more yaw than roll. It is set off by turbulence. Dutch roll can be more than unpleasant; it can be dangerous. As Irv Culver points out (see box), if the yawing becomes violent, it can expose the tail to an angle of attack that will overload it. Since aerodynamic forces go up with the square of the speed, this is a high-speed problem. If you slow down to maneuvering speed, or less, the airplane should be able to take it. Beech is supposed to have designed the tail to take full control throw at the maneuvering speed. However, the same guarantee is not extended to cruising speed. Slow down in turbulence.

NASA Evaluation

In 1965 and 1966, NASA flew several general aviation aircraft in a handling qualities evaluation. Here is what NASA said about the Dutch roll of the Bonanza:

> *Lateral-directional dynamics*—The airplanes, as a class, are characterized by poorly damped Dutch roll oscillations and low roll-to-sideslip ratios (less than 0.4). As a result of the low damping, the pilot ratings of the handling qualities are markedly degraded in turbulent-flight conditions. The oscillations of one aircraft at high speeds are severe enough to cause the pilot to be concerned about exceeding the allowable structural loads of the airplane. This aircraft is the Beech S-35 Bonanza.

The project pilot on this study was Fred Haise, who later became an astronaut. If a NASA test pilot and astronaut-to-be is concerned about the Dutch roll mode breaking a Bonanza, enthusiastic Bonanza pilots would be well advised to reconsider their practice of booming on through turbulence at cruise speed. (If you are not among the sinners, we apologize for the sermon.)

Of course, the Bonanza isn't the only airplane with an objectionable Dutch roll. The C-141 wallows, as do several other swept-wing aircraft. But they all have yaw dampers—full-time black boxes that constantly fight the yaw rate. Some smaller aircraft need yaw dampers, too. The Beech Duke generally has one installed, according to the people who make its yaw damper, Edo-Aire Mitchell of Mineral Wells, Texas. Edo-Aire says it would be happy to put a yaw damper in any V-tail Bonanza. In fact, they already have installed several dozen in Bonanzas. (We would like to hear from these pilots.)
The price for this yaw damper (YK-631) is $2,140 installed. It is entirely separate from any autopilot installation. (If $2,140 sounds like a lot of money, think how much you'll save on sick-sacks.)

Spiral Divergence

Spiral divergence is the tendency of an aircraft to roll over into what pilots call the "graveyard spiral." One of our readers, an airline pilot who commuted to work in an N35 Bonanza, put it this way: "I had the approach plate lying on the seat beside me and bent over to the right to read some of the small print. When I glanced back at the instrument panel I saw that I was in about a 40-degree right bank and about 30 degrees nose down with the airspeed building rapidly and the altimeter unwinding." The airline captain had just entered a divergent spiral, and if he had looked at his chart a while longer, he might not have been able to write about it.

This is another mode that finds some airplanes with good characteristics (or shall we say, less bad) and others with bad characteristics. In the previously mentioned NASA study, the Bonanza

Dig Hole in Sand, Insert Head

The problem of breaking Bonanzas seems to be fairly well known among insiders in the industry, if not the general pilot population. It did not come as a revelation to the people we talked to in gathering material for this story. We would start by outlining the problem. A typical response was, "Yeah, that's right, the V-tail Bonanzas do break more often." One ex-Beech engineer said the pattern of accidents was recognized at Beech within the first three or four years (i.e., about 30 years ago). An FAA man we talked with was equally unsurprised. He had written a summary of Bonanza in-flight failures almost 20 years ago.

Two theories were commonly offered by those who saw nothing wrong with the airplane. One we will call the "Theory of Equivalent Results," and the other, the "Theory of Doctors and Their Bonanzas."

Theory of Equivalent Results

This theory has it that V-tail and straight-tail Bonanzas suffer from weather-related loss of control with about the same frequency. The only difference is that V-tails break before hitting the ground, and straight-tails hit the ground before breaking. The occupants of both are equally dead. The FAA recalled such a study it did several years ago, but could not locate it when we inquired.

In fact, the "equivalent results" theory doesn't hold water at all. During the period 1973-77, the V-tails had a 0.33 rate of "uncontrolled collision with the ground" accidents. The straight-tails had virtually the same rate, 0.31 per 100,000 hours. When the in-flight airframe failure rate for both aircraft (0.82 for the V-tail, 0.00 for the straight-tail) is added to the equation, here's the result: The total "uncontrolled accident" rates—with the airplane hitting the ground in either one big piece or lots of little ones—become 1.15 for the V-tail and 0.31 for the straight-tail. Obviously, those results are far from equivalent.

A well informed aviation writer for *Flying* magazine advanced the "Equivalent Results" theory recently in his monthly column. Under a heading of "Statistics Can Lie," he sought to calm the fears of readers who recently learned their aircraft have high in-flight failure rates. "Several people have expressed alarm recently over statistics regarding airframe failures in flight, because their airplanes' records were bad and they wondered if they were operating flimsy fliers." His goal was to show that such was not the case and that several aircraft had similar weather-related accident rates. His statistics showed the Bonanza with the highest weather-related accident rate of the five aircraft he presented. Unfazed, he cautioned against undue alarm over the statistics for particular airplanes.

Yes, the Bonanza's structural foibles are a touchy subject indeed for the aviation magazines. Several years ago, another *Flying* writer, in an article about buying used airplanes, wrote that early Bonanzas had "weakness in the wings." The editing department apparently didn't notice the gaffe, and it actually found its way into print. In the next issue, the editor offered a ringing apology, stating that he had been horrified when he saw it in the magazine, everyone knew the Bonanza was a "pilot's airplane" and that the wing strengthening introduced with the 1957 H35 models was "primarily to allow higher gross weights and more installed power."

Theory of Doctors and Their Bonanzas

Then there was the insurance executive who said the country would be over-run with doctors if it weren't for the Bonanza.

As you have probably guessed, the "Theory of Doctors and Their Bonanzas" says that overpaid, underproficient medicos gravitate to V-tail Bonanzas (but not straight-tail Bonanzas) and, after flying into weather that requires more than medical skill, both Bonanza and doctor gravitate toward terra firma, but in loose formation. The theory is partly right; some doctors have been involved in these accidents. But it is mostly wrong; there have also been airline pilots, engineers, salesmen and farmers. The only desirable feature of this theory is that it makes non-medical Bonanza pilots (the majority) feel much better.

was noted as an "aircraft with high rates of divergence." That means that in IFR conditions the airplane wants to drop a wing when you drop your attention. VFR, most pilots probably won't even notice it.

There are a couple of other factors in the Bonanza that make this spiral loss of control even more likely. First, the aircraft has light aileron forces (considered a plus by marketing people). The problem here is that the weight of your hand—if you rest it on the yoke while leaning over to read a chart in the right seat, for example—can command roll rates you didn't intend. The second problem is primarily with the pre-E35 models, which did not have aileron trim. If the airplane is not trimmed laterally, the apparent spiral stability is even worse.

Aft Limit

One other handling qualities quirk may figure in the Bonanza structural-breakup equation: center of gravity. The V-tails have generally stricter rear cg limits than the straight-tails, which means that the same load will put you a lot closer to the aft limit in a V-tail than it will in a straight tail. For example, the aft limit of a 1978 V35B is the 84.4-inch position. For a 1978 F-33A—virtually identical in every respect except for its conventional tail—the aft limit is 86.7. Thus a load that puts the cg at 84.2 will be comfortably in the mid-range of the cg envelope for the F-33A, but right at the aft limit for the V35B.

Flying with an aft cg markedly reduces an aircraft's longitudinal stability. This means that turbulence will cause greater airspeed excursions. It also means that control wheel forces will become much lighter, making it easier for the pilot to pull too hard and overstress the airplane. Any airplane flown in turbulence at or beyond its aft cg limit can quickly become uncontrollable—particularly in IFR conditions. The V-tail Bonanza happens to be extremely susceptible to aft cg loading. "I'd be willing to bet that at least a third of all V-tail Bonanza trips are made with the cg aft of the legal limit," one long-time Bonanza owner told us.

Summing Up

The V-tail Bonanza has an indisputably high rate of in-flight airframe failures. The accidents are typically blamed on the pilot. Careful scrutiny of the airplane, however, reveals several factors that help explain the accident pattern.

The first prototype "straight 35"—*the seminal Bonanza with the seminal structural weakness.*

Both Beech and the FAA, we believe, have been aware of this accident pattern for a number of years but have not managed to change it. If any changes are made now, they will probably have to come from the Bonanza pilots. To these individuals we offer the following recommendations:

1. Have your ruddervators rebalanced to the lowest level of aft unbalance that Beech specs or available space (for the lead weight) allows. In other words, aim for 16.8 in.-lbs. on older Bonanzas (approximately, S35 and before), and 14.4 in.-lbs. on the newer Bonanzas. See your shop manual for the specs on your airplane.
2. While you are looking at the tail, check all the cables to see that they are in good condition and at the proper tension. Look particularly at the tab cables (they rust). If in doubt, replace the cables.
3. Put in a wing-leveler (or autopilot) *and* a yaw damper.
4. If you fly into turbulence, *slow down*. If the air is really rough, slow down to maneuvering speed, or slower. (Look up your maneuvering speed now if you don't know it; you won't find it on the airspeed indicator.)
5. Stay sharp on your instrument skills.
6. If you own one of the original "straight 35s" (we wouldn't), you also have the potential of a problem in your wings. Check the condition of the wing carefully. You can start by inspecting the rivets that hold the leading edge skin to the spar in the vicinity of the landing light, particularly on the underside of the wing. If any rivets are loose (broken paint around the rivet or black aluminum oxide streaking aft from the rivet), have a mechanic look it over carefully. Also remember that a "straight 35" was barely a 3.8 G (limit load) airplane when it was new, and that was more than 30 years ago. Baby those old Bonanzas.
7. The Bonanza is a clean airplane. It will pick up speed quickly in a dive. (Beech tests showed the 35 would accelerate from 200 to 280 mph in six seconds when put in a 45-degree dive.) Remember that you can make it a dirty airplane by putting the landing gear down. Dirty airplanes are less likely to overspeed in a loss-of-control maneuver. Some people recommend that you extend the gear in severe turbulence, or if you are about to lose control.
8. Next time you buy a Bonanza, consider one with a straight tail. It is just as fast and plush, and more stable in turbulence. And it has an excellent record with regard to in-flight failures.

Much of the information in this article was obtained by the author while doing consulting work for the plaintiff in litigation involving the in-flight failure of a Beech 35 aircraft.

An attempt was made to obtain Beech's views on the matter. This offer was refused on the advice of Beech counsel. Their letter stated:

> *"In response to your letter of October 15, 1979, we would like to make it perfectly clear, on behalf of Beech Aircraft Corporation, that simply because we feel that we are not able to work with you regarding the proposed article on airframe failures does not, in any way, imply that Beech is not interested in 'finally solving the riddle of Bonanza in-flight failures,' as you put it. Beech is continuing its efforts in this area, but is simply unable to participate with you for reasons previously expressed."* □