1. The Bonanza's External Characteristics

In this chapter we are concerned with some of the essential external features of the Bonanza. We are not interested in the evolution of cosmetic details such as window sizes or tail cone shapes, instead we focus here only on those external features which have some fundamental aerodynamic importance. Specifically, we consider the wing, the tail, the manner in which the model 36 was "stretched," etc.

Wings

All of the Bonanzas have essentially the same wing. It is derived from the NACA 23000 series airfoil—specifically, a 23016.5 at the wing root and a 23012 at the tip. Both airfoils have their maximum camber located 15 percent of chord aft of the leading edge. The 23016.5 has a thickness equal to 16.5 percent of the chord, and the 23012 is thinner with a thickness of 12 percent of chord. The airfoil was developed in the mid 1930's and has been a favorite of designers ever since. It was in fact chosen for the Piper Malibu. The popularity of the airfoil derives from the fact that it has relatively high lift and low drag together with a low pitching moment coefficient.

The 23000 series airfoil also has a rather abrupt drop in lift coefficient as the stalling angle of attack is reached. Figure 1.1 compares the coefficient of lift versus angle of attack curves for the NACA 23012 and NACA 65_2-415 airfoils. The latter is used on the Piper Cherokee, an airplane noted for its gentle stall. Notice that when the stalling angle of attack is reached on the 23012 airfoil, lift falls precipitously, whereas lift drops gradually after the stall on the 65_2-415 airfoil. The chapter on handling qualities will have more to say on this point.

The wing incidence is four degrees at the root and one degree at the tip. This is called "wash-out" and is a standard design technique used to insure that the stall progresses from the root to the

2. Handling Qualities

This chapter reports on several in-flight experiments aimed at revealing something useful about the Bonanza's handling characteristics. We examine stick forces, stall characteristics, spirals, yaw stability, and several other areas.

Stick Forces and Trim with Gear, Flap, and Power Changes

In this section we discuss some experiments conducted in an A36 involving changes in gear, flap, and power settings. We begin with the flaps.

We reduce power to idle, extend the landing gear, and trim for 78 KIAS with the flaps up. The flaps are then extended, while we use one hand on the yoke and no trim change to maintain airspeed at 78 KIAS. CAR 3.13101, under which the Bonanza was certificated, requires that this be possible without "the exertion of more control force than can be readily applied with one hand for a short period." The A36 passes with flying colors—the stick force is zero. The sink rate, incidently, stabilized at 800 feet per minute. Had we made an effort to reduce airspeed in proportion to the declining stall speed, the required aft stick force would still be quite light. If we reverse the above exercise, starting with flaps out and then retract them, again we find only negligible stick forces required to hold airspeed.

The effect of power on stick force and trim is checked as follows: (CAR 3.13101(b)(1)) With power at idle, flaps retracted, gear extended, and trimmed for 78 KIAS, we add full power and use one hand to maintain airspeed. A fair amount of forward pressure on the yoke is required, but, subjectively, it feels as if a pilot of average strength could easily manage the force. Checking the trim required, we note that the exercise starts with +14.5 degrees trim, and if we trim the force out it requires a setting of +10.5 degrees trim. If we repeat the above exercise with flaps down the required push feels about the same.

3. Simple Aerodynamics of the V-tail

The following chapter gives an account of how a V-tail can accomplish what a conventional tail does. The treatment is highly simplified, abstracting completely from the following complications: (i) we ignore any effects due to the proximity of the V-tail members; (ii) we leave aside any considerations of the propwash; (iii) we don't consider the difference in incidence of the stabilizers. Finally, we are interested here only in the effects of pilot inputs, not gust response.

Elevator Inputs

Figures 3.1A and 3.1B show control surface movements and tail forces for conventional and V-tails, respectively, in response to a pull on the yoke. Dashed lines represent the fixed stabilizers and solid lines represent the movable control surfaces. The view is from the rear.

With a conventional tail, only the elevators move. Their up-travel accelerates the air on the underside of the horizontal tail, reducing the pressure there and raising the pressure above the tail. The result is a down force from the tail. This is shown in Figure 3.1A by the force vector labeled S = E to denote that the sum of the forces (S) comes exclusively from the elevator (E).

When a V-tail Bonanza pilot pulls on the yoke, both ruddervators deflect upward, as shown in Figure 3.1B. This causes the left tail member to pull down and left and the right member to down and right. The sum of the forces, S, is straight down, with the yaw effects from left and right ruddervators (L and R) exactly canceling. A push on the yoke works similarly.

Rudder Inputs

Figures 3.2A and 3.2B show right rudder pedal inputs. With the conventional tail, the rudder moves to the right. This creates a low pressure area (or “lift”) on the left side of the vertical tail, which

4. The Maneuver-Gust Envelope

When any airplane is designed and certificated, it is given certain limits which the pilot is required to observe. In this chapter we will discuss two important types of limits–indicated airspeed limits and “g” load factor limits. These limits are conveniently presented in a diagram referred to as the “maneuver-gust envelope,” “V-n diagram,” or “V-g diagram.”

Though the discussion which follows is more technical than most of the rest of this book, I ask you to follow as carefully as possible, for it is a subject of the utmost importance, and it is one that is generally not well understood by private pilots. The reason for this is that the study materials for private pilots are designed around training airplanes, which are barely capable of cruising as fast as their maneuvering speeds, and for that reason are not likely to be subjected to high g loads. Cleaner, faster airplanes are, as we will see, more susceptible to high g loads. When an airplane comes apart in flight, it is very likely that the pilot has allowed it to get out of its envelope. If you go too fast, you may excite control surface flutter, which can tear the control surface from the airplane almost instantly. If you pull too many g's, you can bend or break the airframe. We need knowledge to help us recognize dangerous situations, and a strategy to help us avoid them.

Lift and Load Factor

We begin with a definition. The “load factor,” “g loading,” or “g's” is the ratio of lift to weight, as in equation (1).

$$(1) \qquad g = \frac{L}{W}$$

In level unaccelerated flight, lift equals weight, and the load factor is equal to one. Since weight is a constant at any moment in flight, a change in the load factor would always be due to a change in lift. Let us consider lift in more detail.

5. Performance Fundamentals–Thrust and Drag

The student pilot learns in ground school that thrust equals drag and lift equals weight in level, unaccelerated flight. These are the four basic forces operating on the airplane. Later in this book we will consider the subject of weight and center of gravity in great detail. We also examine the lift characteristics of the Bonanza in several later chapters. In the present chapter we study the remaining forces—thrust and drag. The principal application of the results derived here will be in analyzing the Bonanza's climb and cruise performance—in particular, the thrust and drag results will let us explore several areas not covered in the POH, such as maximum range and endurance and climb rates at various airspeeds.

Thrust

By pushing air aft, the propeller converts the brake horsepower (BHP) exerted by the crankshaft into propulsive power or thrust horsepower (THP). If the propeller were replaced by a two-by-four, the engine might develop 285 brake horsepower, but its thrust horsepower would be zero. This is because the "propeller" efficiency of a two-by-four is zero.

Propeller efficiency, denoted by e, is defined to be the ratio of THP to BHP. It is the ratio of power output to power input. The propeller is not 100 percent efficient, because, like any airfoil, it has losses from skin friction drag, induced drag, tip losses due to near sonic speeds at the tip, etc. The typical aircraft propeller might have a cruise efficiency of 0.88, with lower efficiency at lower airspeed. This means that 88 percent of the BHP is converted to THP by the propeller in cruise. (We ignore brake horsepower losses due to accessory drives for alternators, vacuum pumps, etc.)

The efficiency of a given propeller is a function of the advance ratio, J, and the coefficient of power, C_p. The advance ratio is defined to be $15.18V_{KTAS}/RPM$. You have a high advance ratio

6. Takeoff

This book is intended to be as Bonanza-specific as possible. Since every pilot understands the basics of takeoffs, we will try not to belabor the obvious. Instead of offering a comprehensive discussion of takeoffs in general, we will focus on the interpretation of the Beech Handbook and on the use of flaps for short field operations.

Routine Takeoff

By a "routine takeoff" I mean a takeoff from a long, smooth, dry, level, hard surface runway with no obstacles or unusual winds. We might also suppose, at least initially, that the takeoff is from sea level on a standard day.

Having completed the pre-takeoff checklist, we line up on the centerline of the runway and advance takeoff power. This generally means full-rich mixture, maximum RPM, and full throttle, though some of the aftermarket turbo-charged engines have their idiosyncracies. Beech recommends full power prior to brake release, but most pilots would use this technique only on short fields.

The Beech Handbook calls for a takeoff check which most pilots ignore, though they should use it. The last item on the A36 Before Takeoff list reads "Instruments - CHECK (Make final check of manifold pressure, fuel flow, and RPM at the start of the takeoff run.)" A similar warning is made for all other models. The idea is a good one, and every Bonanza pilot should make an effort to incorporate this final check into his or her habit pattern. After all, when do you want to find out that the prop governor has stopped your RPM at 2300 or that the oil pressure is zero–at the start of the takeoff roll or as you stagger off the last ten feet of runway?

My procedure is to check each of the key engine condition instruments immediately after reaching full power. I start from the far right of the panel and sweep toward the left. When all is well, the

7. Climb

An aircraft climbs when the engine-propeller combination develops more thrust horsepower than is required for level flight at the current speed. The rate of climb comes from the following equation:

$$(1) \qquad ROC = \frac{(THPav - THPr)33000}{W},$$

where ROC is the rate of climb in feet per minute, THPav is thrust horsepower available, THPr is thrust horsepower required for level flight (at the current speed), and W is weight in pounds. The reason the formula works is that when you use more power than you need to maintain your current speed, the excess power must do something, it must show up somewhere—and one horsepower is defined to be the ability to lift 33,000 pounds one foot in one minute. For example, an A36 at 3400 pounds requires about 98 thrust horsepower for level flight, gear and flaps up at 96 KCAS at 5000 feet on an ISA standard day (see Figure 5.6 from the chapter on Thrust and Drag). If, under these conditions, the engine-prop actually develops 188 thrust horsepower, then there is 90 excess thrust horsepower, and the predicted climb rate would be 874 feet per minute (874 = 90 x 33000/3400).

Practically speaking, you are interested in three different types of climbs–maximum rate climb, maximum angle climb, and cruise climb. We consider the first two initially.

Maximum Rate and Maximum Angle

In a maximum rate climb, i.e., a climb at Vy, the airplane's *vertical speed* is as high as possible. In a maximum angle climb, i.e., a climb at Vx, the *climb path* is as steep as possible. Figure 7.1 shows ROC as a function of calibrated airspeed for a 3400 pound A36 at 5000 feet on an ISA standard day with gear and flaps up, full throttle and 2700 RPM. The data is taken directly from Figure 5.6 of

8. Cruise

Several other chapters cover some special topics related to cruise flight. The next two chapters, for instance, take up the subjects of leaning and instrument flight. And later chapters cover various emergencies which occur in cruise, including maximum range cruise. In this chapter we look at the issue of selecting the optimum altitude as a function of trip length, when the percent power to be used is given.

Many pilots habitually fly their airplanes at a fixed percentage of maximum continuous power. You might hear a pilot say, for instance, that he or she always cruises at 65 percent power. In cruise, the 65 percent power page from the Performance section of the Beech Handbook is open and the RPM and MP are set according to the altitude and temperature. (The new Beech Handbooks offer only one RPM-MP combination for any particular power setting. The old Handbooks offered two or three possible settings. The best source, however, is Continental's Operator's Manual for the specific engine—this offers an infinity of possible RPM-MP combinations for any desired power level.)

The question we take up first is, given that you have decided what percentage of power to use in cruise, how high should you climb on a trip of length X, if you want to complete the trip in minimum time? The choice of altitude involves a tradeoff. On the one hand, at a constant fuel flow, true airspeed generally increases with altitude, so it pays to be high. On the other hand, the higher you go, the longer you need to climb, and the climb itself is relatively slow and inefficient. Intuitively, the longer the trip, the higher it pays to climb. But how long is “long” and how high is “high”?

The next two sections answer these questions in detail using the Handbook for the V35B. The answers we get will be very close to accurate for any of the normally aspirated 285 or 300 HP Bonanzas, and the methods we use can be transferred directly to other models. We check 65 and 75 percent power only.

9. Leaning

Many of the Bonanzas' *Operating Handbooks*, particularly those for the pre-1984 airplanes, are not very explicit on the subject of leaning, especially with regard to exhaust gas temperature (EGT). Even the new manual for the straight 35 leaves the pilot with the rather vague instruction to lean “to smooth engine operation” during climb. Checking Beech's recommendations in the N35, we see that the advice is to “lean to the appropriate fuel flow,” presumably using the old-fashioned, inaccurate fuel flow (actually, fuel *pressure*) gauge. Though following this advice is not likely to lead to any serious problems, it does not give you much guidance in using your preferred leaning tool–EGT. With fuel and maintenance costs high and some engines burning the wrong fuel, there is considerable incentive to learn how to lean more accurately.

If you are flying a turbocharged or an IO-550 powered Bonanza, your Handbook is fairly explicit on leaning. You should follow the advice printed there. The suggestions here are offered primarily for those operating older engines, though I will have a few comments on Turbochargers and IO-550's. (In the sequel to this book, my *Flying High Performance Singles and Twins*, there are chapters on the IO-550 and on Turbochargers.)

The Continental Service Bulletin

Fortunately, we do have authoritative information on how to lean with EGT. Continental Motors has issued a Service Bulletin (M89-18) on the proper use of EGT, “when specific airframe manufacturers instructions are not available.” The following will summarize and amplify that bulletin, but we first give a brief general discussion of EGT.

Most pilots know that if you begin at full rich and slowly lean the mixture, the EGT will rise to a peak and then fall off. The reason rich mixtures give low EGT is that some of the fuel in the cylinder is not being burned in the power stroke, and the excess fuel cools the

10. IFR by the Numbers

I believe that when the VFR pilot is being lead through the difficult transition from the world of visual flight to that of instrument flight, the emphasis is all wrong. Too much attention is given to the legalisms of the FARs and the associated written test, and too little emphasis is placed on the stick and rudder basics of flying on instruments. Part of the fault lies with the FAA and its needlessly complex system of rules. I would love to have a chance to re-write the FARs. (Only half joking, here are my ideas: When would you need an alternate? When the weather is not very good at your destination. What should the weather be at your alternate? Pretty good.) Part of the fault too lies with the instructors, who often seem more interested in playing the role of high-priest interpreter of the FARs than of teaching the student how to handle the airplane on instruments. Perhaps the instructors assume that since the instrument student already knows how to fly, the student only needs to study up on how to comply with the procedures and fit into the system. But things are not that simple. Instrument flying is different, and the instrument student needs to be instructed on basic issues like what do you do with your hands and where do you look with your eyes. I have flown with countless pilots who have benefited greatly from this sort of instruction, even though they have been instrument pilots for many years. The technique that I am thinking of is called flying "by the numbers."

Pilots who practice "flying by the numbers" are likely to tell you "power plus attitude equals performance." This is a fairly old saying among aviators, dating back at least to World War II. To say that power plus attitude equals performance is, or should be, non-controversial. It is merely an implication of the physics of flight. Though it would probably be more accurate to say, "Power plus attitude plus *configuration* equals performance," where "configuration" refers mainly to gear and flap positions. But flying by the numbers is more than just flying with the realization that power plus attitude plus configuration equals performance. In a way

11. Landing

As I have said before, this book is primarily about Bonanza-specific flight situations. I have no intention here of offering a comprehensive discussion of the ABC's of landings, *per se*. In fact the Bonanza is a generally well behaved airplane throughout the landing sequence. It is not excessively heavy in the flare, and yet it is not overly sensitive in pitch. It has good crosswind capability and little tendency for excessive float. There is ample elevator power to hold the nose off on touchdown (with the possible exception of the A36 at forward cg), and wide main gear for good stability on the roll-out. In fact its easy landing manner probably does more to endear the Bonanza to its owner than any other single attribute. What I will cover here are primarily the landing sections of the Bonanza Handbooks, old and new, and the balked landing sequence–but first, a quick run through the basic elements of the approach and landing.

It is worthwhile to try to standardize your VFR pattern work. As with instrument flying, this helps to cut down on distractions from tinkering and trial and error with the controls. Something like the following might work: Power at about 15" MP (maybe 18" for turbocharged engines) and trim for 105 KIAS on downwind with the gear and flaps up. (If 105 knots is excessive, given the local traffic situation, then half flaps and a lower speed will be fine.) Check gas on a good tank. Advise passengers for seats and belts. Gear down adjacent to the runway threshold–and leave your hand on the gear switch until you verify by the sound and feel of the airplane as well as the cabin indicators that the gear is in fact down. Trim nose up. Go to half flaps on base, if they are not already out, and extend the remaining flaps on final as mixture and prop are advanced and cowl flaps opened. I often see power at about 13.5" MP on half mile final. Make final GUMP check, and trim for the desired fifty foot speed. Slowly reduce power to idle as you raise the nose at touchdown. Don't touch the flap handle, transponder, or lights until the airplane has turned off the runway and stopped, then do your post landing checks. Raise the wing flaps by looking at the flap handle and

12. Weight and Balance: Introduction

Every pilot is familiar with the fundamentals of weight and balance. For that reason we will try not to belabor the obvious here. If you feel a brush up is in order, any number of student pilot manuals will do the job. Two good ones are William Kershner's *The Student Pilot's Flight Manual* and Leroy Simonson's *Private Pilot Study Guide*.

To Be Legal

According to FAR 91.31 the Bonanza pilot must operate his or her aircraft within the limitations published in the *Flight Manual*. These limitations have to do with maximum RPM, minimum fuel for takeoff (10 gallons in each main, for us), maximum slip duration (30 seconds), etc. Included is the requirement that the plane stay within its weight and balance envelope during any flight.

This means we must know the *current* empty weight and empty center of gravity and have the flight manual on hand to compute the weight and balance for takeoff and landing. These are required (FAR 91.31) documents.

Bonanza owners are notorious tinkers. With or without the aid of an A & P, we are forever adding this and removing that. All things considered, this is probably good, since this is an excellent way to get to know the airplane. But this endless series of modifications also increases the probability that our actual empty weight and balance have crept dangerously far away from the values we use in flight planning unless the empty weight and balance is done again after every modification. Of particular importance would be items added near the tail, such as antennas, air scoops, ski tubes, air skegs, etc. AD 87-20-2 required all V-tail Bonanzas to be re-weighed and their empty cg's determined. The reason for the re-weigh is that it was discovered that many of these airplanes had put on "unrecorded" weight over the years and that their cg's had often moved aft, and an overweight/aft cg loaded airplane is unstable and dangerous. It seems

13. Weight

High weight degrades nearly every aspect of airplane performance. We'll consider a few of the most important facts.

Speed

At any given power setting, the Bonanza will be slower at high than at low weights, as long as the cg remains constant. The reason is this: In steady level flight, thrust equals drag, and lift equals weight. If we could add weight to an airplane in unaccelerated level flight, it would begin to descend. To compensate, we would have to increase lift; but with power held constant, our only recourse is to raise the nose and increase the angle of attack. Then this action increases induced drag and necessarily slows us down. The truth is, however, that the speed loss in a Bonanza is quite small. Apparently the rear cg shift with the added weight offsets the speed loss.

Climb

Any airplane will climb if it is developing more thrust horsepower than needed for level flight at its present speed. The rule of thumb is

$$ROC = \frac{(THPav - THPr)33000}{W},$$

where ROC is the rate of climb in feet per minute, W is weight, THPav is thrust horsepower available, and THPr is thrust horsepower required for level flight. (Recall that thrust horsepower equals brake horsepower times propeller efficiency.)

Looking at the performance section from the V35B manual, for instance, we see that 128 brake horsepower is required for level flight at 130 KIAS at 3400 pounds at sea level. Assume for simplicity that propeller efficiency is constant at 0.85, so the thrust horsepower required

14. Center of Gravity– General Considerations

As every pilot knows, an airplane is given fore and aft center of gravity limits when it is certificated. In general, these limits derive from the fact that the airplane must be stable and controllable in a variety of maneuvers even when the cg is in its “most unfavorable” position. For instance, the airplane must be controllable in landing, and this means that it must be possible to hold the nose wheel off in a full-stall touchdown. For reasons which we will explore shortly, this gets progressively harder (and ultimately impossible) as the cg moves forward. Hence, the forward cg limit cannot be ahead of the point at which this maneuver becomes impossible. Other stability and control requirements to be discussed shortly will set other limiting values on cg, and the final cg range will be determined by the most restrictive fore and aft limits from all of the requirements.

This chapter is more technically demanding than most of the chapters in this book. The reason is simply that the effect of cg on aircraft stability and control is inherently a more difficult subject than, say, flying by the numbers. Though I have made an effort to keep the treatment as simple as possible, I haven't, to paraphrase Einstein, tried to make it too much simpler than it is. It is very easy to load a Bonanza outside its approved cg range; it is particularly easy to load the 35 and 33 series Bonanzas aft of their rear limits. It is vitally important for you to realize that this is a potentially dangerous situation, because it means that longitudinal stability will be degraded and stick force per g will be reduced. In plain English this means that with the cg aft of its rear limit the Bonanza will be much less prone, perhaps even incapable, of maintaining its trimmed airspeed. And it will be easier for you to over-control and over-stress the airframe. Have you ever thought you had trimmed for 90 knots on base and then noticed with a shock that the airspeed is down to 75 knots? Have you ever given the customary amount of pull on the yoke at rotation or flare and had the Bonanza balloon awkwardly and

15. Bonanza CG Considerations

In this chapter we consider a variety of Bonanza loading problems. To standardize the treatment we will use the basic empty weight and cg from the sample problems in the Beech Flight Manuals. The reader is warned that the typical Bonanza in the field may be considerably heavier. A random sample of six V35Bs by the author showed the average V35B weighs 161 pounds more when empty than the Beech sample airplane. The reader is further cautioned that the problems worked here are for illustrative purposes only; it is your responsibility to see that your airplane is within cg limits for every flight.

Cg Limits and Bonanza Geometry

Figure 15.1 shows the evolution of the cg envelopes over the

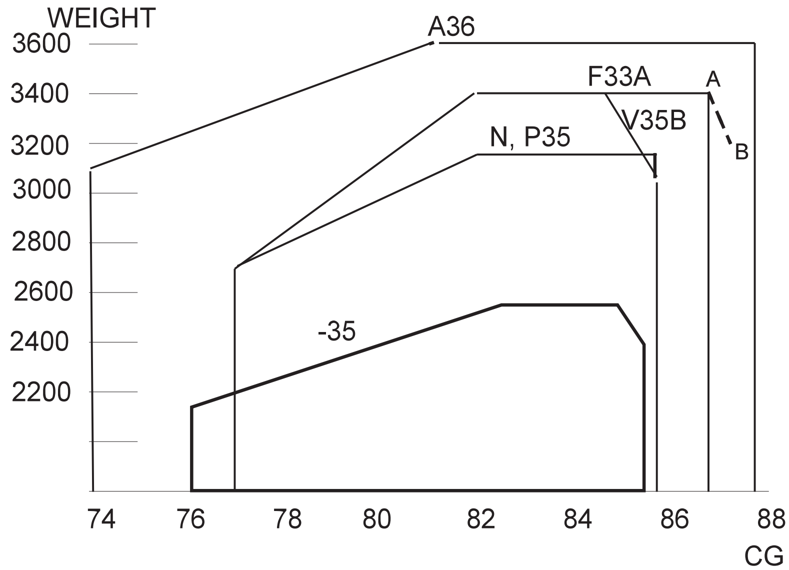

Figure 15.1. A variety of Bonanza weight and balance envelopes.

past years. Several patterns are apparent. First, maximum gross

16. Introduction to Emergencies

To some extent, all reading and writing about in-flight emergencies amounts to little more than whistling in the dark. On the ground, we can coolly analyze the critical elements of the emergency and spell out a plan to minimize the risks. We say, if emergency X happens, take actions A, B, and C. But in the air, the emergency starts with the sudden smell of something burning, and our bodies are shot with a bolt of the cold lightning of fear before our minds have time to begin the analysis. As Frank Herbert, author of *Dune*, has written, “Fear is the mind killer.” Fear can introduce a sort of unpredictable paralysis to the thought processes–we are unable to sort out our perceptions, recognize alternatives, or make decisions. Even the most experienced pilots have been known to do foolish things in an emergency.

But having said this, I nevertheless proceed with five chapters on emergencies. The reason is that, though we don't know what faculties our fear will leave us with, we might at least enter the situation with as much prior knowledge as possible. In fact, for some people and some emergencies the element of fear will be slight, and there is much to be gained from doing some calm weighing of alternatives in advance.

No pretense is made to having a complete catalogue of potential emergencies. The variety of possible emergencies is infinite, and you can't possibly have a prearranged policy for every contingency. In fact we don't even consider here some of the “basic” emergency cases, like an electrical failure. If the Beech Handbook handles the case adequately, I see no need to repeat that advice here. Instead, I consider several issues which I feel are both relatively neglected subjects and important for Bonanza pilots in particular.

17. Maintaining Control in Rough Air

When the air is so rough that controllability is in serious doubt, your first actions should be to slow down and drop the gear. In a real emergency, you can forget about the gear extension speed limits, these are designed to save the gear doors. Your problem is more serious–saving the airplane and occupants.

If your speed is above the gear limit speed, just be sure you don't raise the gear when you are past the turbulence. You may have a bent door that will jam the gear when it goes back up, and then you would have to conclude the flight with a gear up landing (a real candidate for "A Flight I Will Never Forget"). So leave the gear down and fly to a facility that can jack the plane up and check the retraction mechanism.

Once the gear is down, you need to adjust power and trim to keep speed at or below the weight adjusted maneuvering speed, Va. Remember that it is physically impossible to exceed a load factor of 4.4 as long as the plane is flown at or below a speed equal to the square root of 4.4 (= 2.098) times the *present* stall speed. The word "present" is critical. The published Va in your handbook is equal to the square root 4.4 times the highest clean stall speed. If you are light, the stall speed is less. This means that the difference between the published and the present Va may be considerable, and more importantly this means that you can exceed 4.4 g's at the published, unadjusted Va. (Refer to the chapter on the Maneuver-Gust Envelope for a further discussion.)

Perhaps you put a placard by your airspeed indicator giving the likely range of values for Va, and you have used this to determine a target maximum speed. The trick for achieving this speed is to have some idea of the appropriate power setting. Then the drill is to go to that setting, hold the nose on the horizon, and wait for the airspeed to stabilize. Your "fly by the numbers" practice will have given you some idea of the right MP. You should know what MP gives 105 KIAS in level flight with the gear down, so add a little if your target is higher than 105 and vice versa. Don't haul back on the yoke to

18. Gyro Failure

The loss of gyros in instrument weather is an emergency of the first order. Even highly experienced airline crews have flown into the ground trying to sort out an instrument failure. Declare an emergency, and take all the help you can get.

If you have a vacuum/pressure pump failure, your first problem is simply recognizing the failure. If you are maintaining a good scan, the failure will show itself as a lack of agreement among the flight instruments. Airspeed, altimeter, and VSI might say that you are level, while the attitude indicator shows a climb. Or the turn and slip might show a turn, while the attitude indicator shows wings level. In a situation like this, the next instrument to look at should be the vacuum/pressure gauge. If it reads low, disregard the vacuum/pressure instruments and fly the airplane. Of course, this assumes that you know which of your flight instruments are air driven. Most horizon gyros are air driven, as are most directional gyros. The gyro in horizontal situation indicators can be either air driven or electric. Most turn and slip indicators are electric, though air driven units are available. The Brittain turn coordinator found on, for example, the B-VII autopilot is driven by air or DC, so it should work if either power source fails. Given the seriousness of a vacuum/pressure pump failure, you should verify prior to engine start that the Brittain instrument operates on DC only. If you are unsure of which instruments are air driven in your airplane (and an amazing percentage of pilots don't know), a mechanic should be consulted. You should also know which, if any, autopilot functions work on DC only.

If your scan is weak, you will probably continue to fly the attitude indicator after it has failed. If so, the first sign of trouble is likely to be your perception that something sounds or feels “funny” as the errant indicator leads you into a steep turn, dive, or climb. In this case you must diagnose the problem while in an unusual attitude and then recover.

19. Maximum Range—Zero Wind

An aeronautical engineer would say that maximum range occurs when the ratio of lift to drag, L/D, is at its maximum value, called L/Dmax. (We ignore complications due to variations in propeller efficiency and engine specific fuel consumption as power changes.) Since lift is constant and equal to weight in unaccelerated level flight, L/Dmax must occur at the point of minimum drag. (See the Appendix for a proof.) This certainly makes sense intuitively–to maximize MPG, we minimize drag.

Recall from the chapter on Performance Fundamentals that drag comes in two forms, induced and parasite. Induced drag is a by-product of the generation of lift; it increases with the angle of attack and *decreases* with the square of the calibrated airspeed. Parasite drag is drag due to the frontal area of the airplane, surface friction, cooling drag, etc., and it *increases* with the square of the calibrated airspeed. Total drag is high at high angles of attack (and low speeds), because induced drag is high. And total drag is high again at low angles of attack (and high speeds), because of high parasite drag. So we must be able to minimize drag by flying “not too fast” and “not too slow.” By itself that is not very helpful advice, especially since there is no direct way of knowing the value of either angle of attack or total drag in flight. Neither is the speed for minimum drag presented in so many words in the Beech Handbook.

Luckily, we can easily find the airspeed for L/Dmax (called $V_{L/Dmax}$) at some particular weight in one simple in-flight experiment. Then a little use of aerodynamic theory will let us extrapolate the result to find $V_{L/Dmax}$ for other weights.

To begin with, if we want maximum MPG, we are going to want maximum efficiency from the propeller. In general this means a low RPM and a high advance ratio. (Refer to the section on propeller efficiency in the Performance Fundamentals chapter.) There is a chart in the performance section of the new Beech Handbooks giving the approved manifold pressure and RPM combinations. The lowest approved cruise RPM for the IO-520 powered A36, for instance, is 1900. We will use this value for our in-

20. Engine Failure

A surprisingly large proportion of "engine failure" accidents follow this pattern: The engine dies, the pilot does a forced landing. On examination it is found that the fuel selector is on an empty tank, and there is gas onboard in some other tank. Here is the text of a typical accident report of this type:

> When the aircraft took off, the (selected) tank was nearly empty. The pilot climbed to his cruising altitude. . . and relaxed until the engine stopped. Assuming that a cylinder had failed, he set up for a forced landing into trees. By the time he realized he had run the tank dry, he was too low to switch tanks. (*Synopsis of Aircraft Accidents-Civil Aircraft in Canada*, Issue 3, 1984, p. 13).

The pilot had a commercial license, 2500 hours, and 135 hours in type.

Immediate Action Items

Some Bonanzas have as many as five fuel selector positions, so it is not uncommon in a Bonanza to have a tank run dry when there is fuel in another tank. This suggests that if the engine should smoothly die, your first actions should be to switch tanks and turn on the fuel pump. A glance at the fuel flow gauge should confirm the source of the problem. To prevent a propeller overspeed after restart, the throttle should also be retarded somewhat until RPM stabilizes. With the engine running again, the fuel pump should be shut off–but if this kills the engine, the failure is in the engine driven fuel pump and the auxiliary pump should be turned back on and the mixture adjusted. Be careful not to flood and kill the engine with the fuel pump. This is a distinct possibility if either the engine driven pump is still working but a tank has run dry or if the mixture is not adjusted after the electric pump is turned on.

It is probably a good idea to go through the following drill in

21. Miscellaneous Minor Emergencies

This chapter treats two minor (or at least what *should* be minor) emergencies: an open cabin door, and manual gear extension.

Unlatched Door

This is really not an emergency at all and would not prompt any comment here were it not for the fact that some pilots panic or allow themselves to be distracted when the door pops open, and then their panic or distraction (and resulting failure to fly the airplane) rather than the open door itself creates an accident. Here is a sad case in point that involves three fatalities:

> The private pilot transmitted to the control tower shortly after liftoff that he had a door ajar, and he was turning back to the runway. Witnesses saw the aircraft execute a teardrop type of turn back to the runway with a nose-high attitude, gear down and in a tight turn. The witnesses then saw the aircraft stall and enter a left spin until impact. There was a post-crash fire. The cabin door mechanism was found only partially engaged. (Reference Number: 86-1383, cited in *Safety Review, Beechcraft Bonanza/Debonair*, AOPA, 1994.)

The usual sequence of events is this: Prior to takeoff, the door was shut but the inside handle was not turned so as to tighten the door's upper hook latch on the roll pin in the latch bracket above the door opening. Or it may be that the handle was turned, but the latch did not catch the pin. The door looks closed and even a bump against it at shoulder level will not pop it open, but in fact it is not latched. (Be sure that you always push firmly against the *top* of the door to verify that the latch has caught the pin prior to takeoff.) When the airplane rotates on takeoff, the low pressure area above the wing will draw the door open. This happens about the time the airplane leaves the ground. There is a startling “bang” and then a good deal of wind and noise. Light, loose objects, like charts and toupees, will fly out the door opening, which is about three inches wide at the aft end of the door.

22. Conclusion: Some Important Speeds

In the introduction to this book, I said that it takes both skill and knowledge to become a good Bonanza pilot. First, you must develop the skill to get the airplane to do what you want–for example, to come over the fence stabilized at 75 KIAS with gear and flaps down. And second, you must do enough homework to know what you *should* want from the airplane in various circumstances–for instance, how fast should you fly in turbulence at light weights? Much, but not all, of this second skill involves knowledge of the proper airspeed for each flight operation. Consequently, we will end this book with a summary of the most important speeds.

Table 1 lists twenty important speeds. The values shown are for the pre-1984 A36, but the subsequent discussion should give you enough guidance to complete a similar table for your own Bonanza. For reasons which will be obvious shortly, some of the speeds are approximations, but the errors are probably well within the range of error of the airspeed indicator, which is plus or minus three percent. When a speed range is quoted, the lower speed applies to a minimum weight of 2800 pounds and the higher speed applies when weight is at maximum gross. I will discuss the table line by line:

1-4. The power idle stall speeds are read from the chart in the Performance section of the new Beech Handbook. The power-on stall speeds are not reported in the new Handbooks, but the old Handbooks gave this information and showed the stall speed to be about 15 knots lower with full power.

5. The normal liftoff speed range is taken from the Take-Off Distance page of the Performance section of the new Handbook.