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Cessna

Wings for the World II

Development of the 300 Series Twins
and Miscellaneous Prototypes



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The 310 Story

In the immediate post-WW II era, with few exceptions, there were no modern, fast, and far-ranging twin-engine airplanes in the market place. For cost reasons, corporations were using heavy and inefficient surplus twins such as the twin Beech and even surplus bombers converted to executive cabins. These were an high-drag airplanes of unbelievably heavy construction and relatively poor performance for their horsepower.

Cessna had the lion's share of these twins, with 5,040 units produced during the period 1940-1944. It seemed odd to the author that there were absolutely no memorabilia, or even a prototype or even a prototype Bobcat left; nor were any of the old timers eager to talk about them. This was the result of a management dictum *"...To focus our goals on an-metal airplanes; we are disinheriting the T'-50 completely."* A few private pilots continued to fly surplus *"Bamboo Bombers,"* but the Cessna did not acknowledge them or support them.

Evidence of management interest in a new light twin-engine airplane surfaced in the late 1940's when arrangements were made to have Henry F. (Hank) Waring, and the author evaluate existing commercial twins such as the Aero Commander, DeHavilland Dove, and Piper Apache among others. Our primary interests were engine-out performance and controllability. The Delfavilland Dove (owned by an oil company) was available only during a period of 500-foot ceilings, and I recall the nervousness of Jerry Gerteis, Assistant Chief Engineer, as Hank and I explored the airplane's controllability with one propeller feathered! Of course we never could check the single-engine ceiling.

Ted Smith had proposed that Cessna purchase his new Aero Commander project, which was already in limited production. We ran a rather extensive test on a loaned airplane and judged it to be the best of all twins that we had flown. However, it was turned down for two reasons. First, we already had envisioned a much lighter and much faster twin with better engine-out climb performance. Second, our manufacturing and engineers disliked the components and fabrication requirements. They feared heavy empty weight, excessive fabrication man-hours, and difficulty in achieving mass production with the tremendous number pieces and parts.

With this background, the preliminary design of the C-310 commenced in late June of 1951 under the direction of Virgil "Hack" Hackett. In his words:

"A major thing affecting the preliminary design of the 310 is that we wanted it to fit a '40' x28' T' hangar. Again, the phil-osophy was that Cessnas were to be able to operate anywhere (maybe this was a leftover from the *"Cessna Family Car of the Air"* advertising - but it was a factor). Anyway, this limited the fuselage length in the preliminary design phase. To get five in that fuselage, locate the spars so that they were under the seats with room for your feet, and a door that you could get into, etc., was a series of quick decisions. But then, if you'll recall, everything we did in those days took about a tenth of the time it took just a few years later.

"We wanted to use the basic 23012 airfoil used on the T-50 Bamboo Bomber. You and Hank Waring looked at a lot of the other airfoils available in those days and pronounced the 23012 as the 'best.' I sure agreed. Tom Salter wanted the fuel outboard if possible. We knew that this meant that the landing gear had to go inboard or rearward. There wasn't any space for the latter, and we sure didn't want to rotate wheels 90° on retraction - so it was *'nacelle-inboard'* for the main gear. We didn't want a constant chord wing ala Piper's later efforts, and we didn't want a fatter wing (although Ozzie Mall and the guys in structures wouldn't complain). A wet wing idea was abhorred by all. Tanks outboard of the nacelles just didn't give us enough volume with a 36 -37 foot overall wing span. So the tip tanks seemed a natural. I got it laid out in a nice little 3-view drawing and fielded a bunch of arguments. We had plain old torpedo-shaped tip tanks to start with. Later they were made oval-shaped to get 'endplate' effect, and then, eventually, to help with the 'Dutch roll.'

"Tom Salter gave us a drawing of the Continental O-470 engine with a wet sump and a low carburetor

air scoop. We saw that this made an ugly, high-drag nacelle plus the carburetor air intakes would be eating propeller dust on short fields. A prime consideration was that the 310 would operate off of dirt fields. We saw no reason that we couldn't use pressure carb-uretors, put them behind the engine cylinders into cleaner air, and have a low-drag nacelle. We laid it out, presented it, and that's where we had much discussion with Tom. He did see the advantages, and, armed with our sketch, he called in Continental. Previously I got Hank Waring to help, and we had drag coefficient figures. Our gun was loaded, for we could show increased speed and added '*nacelle-lift*' which we were going to need. In retrospect, however, I have always felt that this extra lift was destabilizing at high angles of attack, prompting the original 40-42 square feet of horizontal tail area to be increased in flight test development to 55 square feet.

"The C-310's first four years didn't change much from the preliminary design except for all the changes you and Hank Waring found necessary for the bird to fly right (empennage, etc.). I do recall that immediately after this configuration was drawn up—including fuselage layout, controls, wing planform and engine and nacelle drawings, plus landing gear and empennage—I was thrust into a Navy anti-submarine warfare airplane preliminary design, and Ozzie Mall was set up as C-310 project engineer to get it into production. I sure missed Ozzie when we got to the T-37 preliminary design work which followed the ASW proposal without a chance to catch our breath! Those were heady, hard-working days, and everyone had his boat loaded!"

Upon winning the XT-37 jet trainer competition, Ozzie Mall was assigned to that project and Don Ahrens was moved from the Structures Group to head up the C-310 project group. As Chief of Flight Test and Aerodynamics, Hank Waring and his small group had worked closely with the preliminary design group in an all-out effort to refine the exterior shape of the airplane. The author recalls endless computations of climb and cruise performance with various values (and combinations) of wing area, aspect ratio, and wing loadings. To our surprise, the optimum area was almost identical to the wing areas of our existing 4-place single-engine airplanes of that day.

It has been said that all pilots like airplanes with long tails for better stability and rapid spin recoveries. In contrast, structural engineers prefer short-coupled airplanes for minimum weight. As mentioned earlier, project engineers are influenced by such things as T-hangar size limitations. We argued with Don on this question, and he prevailed by saying "If we lengthen the tail we'll have to lengthen the nose or nacelles to balance the airplane—and that would give more weight and wetted-area drag." Reluctantly, we endorsed the short fuselage. Then we had to design oversized tail surfaces to obtain adequate stability and controllability. In later years, as the airplane evolved from a minimum 5-place airplane to a full 6-place configuration (in 1964), we paid the price by having to resort to artificial stability devices such as elevator downsprings and elevator bobweights.

An increasing number of military transport crashes causing deaths from post-crash fires had made the aviation community aware of fire hazards in airplanes having large fuel loads and sources of combustion close to the fuel tanks. Tip tanks were being tested by NACA for primary fuel storage. Our initial concerns over inertia effects on maneuverability were lessened when Lockheed used the concept successfully on the P-80 and T-33. The added advantage of achieving an "*end plate*" effect for a higher "*effective*" aspect ratio and, hence, greater rate-of-climb were further inducements. Finally, as discussed earlier, we had been unable to find sufficient internal wing volume outboard of the engine nacelles for the required 100-gallons of fuel. So all of the C-310 fuel load was to be carried in 50-gallon tip tanks.

The wing was designed for high speed using the popular NACA 230 series airfoil. The thicknesses were 18% at the root and 9% at the tip. To avoid a drag-producing flap gap, we selected the split-flap configuration. This also permitted the wing walk to be on solid wing structure instead of on a retracted flap surface. Contrary to one's expectations, the split flaps offered very high lift coefficients if the deflections were well above 60°. Of course, the flap drag would be very high, but that could be an asset for counteracting the low drag of the very clean C-310. As for flap usage in take-off, we started out with 15°, but it was becoming operational practice on long runways to use zero flaps to enable the pilot to keep the airplane solidly on the ground until (or after) minimum-single-engine-control speed (VMC) is reached. In hindsight, the split flap choice was a good one.

Structural design of the wing was conventional except for large cut-outs for stowing the main land-

ing gear wheels and struts. Additional cut-outs were needed in the leading edges for mounting cantilevered support beams for the engine mounts. To everyone's surprise, the static test revealed inadequate rear-spar strength for landing loads, even though the wing was satisfactory for flight loads. Thus it was necessary to add strength to the rear spars. Perhaps this disparity can be explained by the fact that dead weights of the engines and tip tanks relieve the wing bending loads in flight and add to landing impact loads.

To emphasize the importance of low empty weight for the critical engine-out climb performance, the company referred to the C-310 as our "light-light twin." Don Ahrens took that slogan to heart by calling for fuselage bulkheads that were unbelievably small in cross-section. I questioned him repeatedly on this, and he was adamant that they were adequate in view of (1) the large cross-sectional area of the fuselage (cabin) and (2) the short tail length and, consequently, the low fuselage bending loads. Static tests proved him to be right, and, with one exception, I'm not aware of any problems with fuselage bulkhead or skin cracks. This one incident occurred when Fritz Feutz lost the pilot's side window in a dive test beyond red line speed. In his words:

"The last flight in N37879 was on April 18, 1956. It was a VD dive test, but I can't remember for what. At VD the pilot's side window departed with the cabin decompression clearing out my sinus and ears. I chopped power and eased out of the dive and came home. Ground inspection revealed that the departing window had impacted and flattened the leading edge of the left horizontal stabilizer, but more interestingly, a collapsed rear fuselage bulkhead and skin. I don't know if Don Ahrens ever believed that this was from decompression and not my overloading it. They scrapped the airplane as I recall."

With the annoying tendency of short-coupled single-engine low-wing airplanes of that era to show Dutch roll or "snaking" motions in rough air, we were determined to prevent that in the C-310. Fortunately, we had several tilings going for us. First, we needed an oversized vertical tail for engine-out controllability and a low VMC. Second, we had the inertial effects of two engines/propellers and their resistance to rapid yawing motions. Finally, we had even more favorable inertia effects from the tip tanks' fuel weight. This last item was verified in later flight tests with tip tanks removed. In rough air, the snaking oscillations were similar to those in the Beech Bonanza. Even with the tip tanks

installed, the C-310 showed some degree of "tail-wagging" in the traffic pattern in rough air—a curse on short-tail airplanes, Don!

Since Cessna lacked design expertise on retractable landing gears, Joe Phillips was brought on board. He had had experience in large airplane landing gear design, and, more recently, in designing and building his own small all-metal lightplane. I recall his chagrin at seeing the small handful of engineers that Don Ahrens had in his group! It was decided to forego a conventional hydraulically-powered landing gear system in favor of an electrically-powered system of push-pull tubes and mechanical links. This made sense in such a small airplane even though we planned to fully close all the gear doors in flight. A mock-up of the system revealed some obvious areas of high stress and localized bending of the push-pull tubes, and these components were beefed up for the prototype installation. One source of worry, however, was a welded part on the nosegear linkage that was thought to be vulnerable to fatigue failure. We all recognized that it should have been a forged part. However, the delay in getting such a part prompted us to adopt the weldment and to hope for the best. As later events proved, our fears were well-founded.

Perhaps the most unique feature of the C-310 is the slim nacelles. These resulted in not only low drag, but, also, better propeller efficiency due to minimal blockage of the propeller wash. As mentioned earlier, preliminary design chief Virgil Hack-ett conceived the concept, and he urged chief engineer Tom Sailer to specify "low-profile" engines from Continental Motors. Standard practice in those days was to place the intake air scoop and carburetor well below the engine, in a very deep nacelle.

Although the prototypes flew initially with interim 225 HP engines, Tom specified 240 HP O-470-B engines for production airplanes with a pressure carburetor mounted between the engine and firewall. There were no drag-producing external scoops for combustion intake air or for the oil coolers. Instead, intake and oil cooler air were taken from the plenum chamber above the cylinders. Engine cooling airflow, after passing through the cylinders, was directed into twin augmentor tubes located in the upper portion of the lengmened nacelles with exits just forward of the trailing edge of the wing. Motive force for the cooling air was provided by engine

exhaust nozzles located just inside the forward 6" opening of the augmentor tubes. This "jet pump" concept was popular at the time, and, although it worked, we later abandoned the principle because of the noise penalty.

Another "Tom Salter" innovation was the clever design of the engine control pedestal. We had recommended a very simple pedestal having essentially

straight lines for low manufacturing cost. However, to our surprise and delight, Tom suggested a very fancy contoured pedestal design with state-of-the-art throttle, propeller, and mixture control levers and associated low-friction flex-shaft runs to each engine.

The physical characteristics of the first production airplanes in 1954 are shown below:

Wing			35.77 ft
Span (overall)			175.0sq. ft
Area			7.3
Aspect Ratio	(Root)		NACA 23018
Airfoil Section	(Nacelle)		NACA 23015
	(Tip)		NACA 23009
			5°
Dihedral			
Control Surfaces:	Aileron		22% Chord
	Flaps		Split Type, 25% Chord
			45° Deflection
Fuselage			26.9 ft
Overall Length			10.5 ft
Overall Height			
Empennage			26.0 sq ft
Vertical Area			55.0 sq ft
Horizontal Area			
Landing Gear			6.50 x 10
Main Wheel			6.00x6
Nose Wheel			
	Swivel		55° RorL
	Steer		15° R or L
			144.0
Tread			114.3 in.
Wheel Base			
Power Plant			Continental O-470-B
Engines			240 @ 2,600 rpm
BMP			Hartzell Constant Speed
Propeller			Full Feathering
Miscellaneous			26.3 lbs/sq ft
Wing Loading			9.6 lbs/hp
Power Loading			
Limit Load Factors			3.8 Positive
Maneuvering			1.2 Negative
Landing			3.8

After completion of the prototype, N41699, Hank Waring performed the maiden flight from the adjacent McConnell AFB on January 3, 1953. With the airplane loaded to the most favorable center-of-gravity at light weight all went well. The author then acted as the flight test observer (*co-pilot*) on the first 4-5 flights (*before taking over the project*) as we explored the airplane's controllability and stability at increasingly forward and aft C.G. positions. With engine cooling optimized, we evaluated performance in twin-engine and engine-out conditions. The latter was somewhat below our expectations (with 225 HP engines), and efforts were focused on (1) reducing the carburetor air heat rise (cold) to get maximum power and (2) finding the optimum propeller diameter. The latter item required numerous sawtooth climbs and speed-power runs, because we had to determine the best compromise between climb (large diameter prop) and cruise (small diameter prop). The most memorable sawtooth climb that the author performed was with the right propeller feathered at only 500-1,000 feet above ground level. While commencing the climb at about 500 feet, I suddenly noticed a stream of liquid flowing from the cowl door gap on the operating left engine. It didn't take long to deduce that that fluid was gasoline! Power was immediately reduced on that engine as I turned back for an emergency landing at McConnell AFB. The next order of business was to restart the feathered (right) engine so that we could shut down the left engine that was leaking gasoline. As always, it was difficult to get a prompt restart with a feathered propeller. Hoping that we would not get an engine fire at 500 AGL, we finally got the right engine restarted and the left propeller feathered. This was to be the first engine-out landing in a C-310, and it all went like clockwork. After rolling off the active McConnell runway to a taxi strip, we shut down the right engine. Our experimental department mechanics drove over to remove the cowl from the left engine, and we were in a state of shock at what was revealed. A coiled copper primer line, located within inches of an exhaust nozzle, had broken. Fuel had sprayed from that break throughout the entire engine compartment as evidenced by the red dye stains from the 80-octane fuel. It was a miracle that we didn't have an explosion or, at least, a roaring fire! From that experience and one or two others involving fuel leaks in other engine compartments, I'm convinced that the possibility of inflight fires is very remote indeed!

Flight characteristics of the C-310 were very good with fairly docile behavior in twin-engine stalls. However, as one would expect, stalls with one engine-out and the other at

full power were characterized by a gradual loss of directional control (below V_{MC}) followed by a gentle roll-off into a spin. Although spin-testing was not an FAA requirement in twin-engine airplanes having a gross weight greater than 4,000 pounds, the author experienced several incipient spins which were recovered easily in 1/4 turn. The powerful rudder and elevator controls made us confident that recoveries from prolonged spins would be quite prompt. In fact, in later production of the USAF L-27A we learned that some military pilots, forgetting that intentional spins are prohibited, had spun their airplanes several turns with great success—they didn't realize that they had assumed a test pilot's role!

Landing our heavily-loaded prototypes on the short 1,800-foot strip adjacent to the factory required a sudden throttle closure in the landing flare to prevent floating. Fortunately, the high drag of the split flaps at 45° deflection provided a rapid deceleration. On the other hand it seemed that, just before touchdown, wing lift in the wake of those large idling propellers deteriorated sharply, giving a fairly heavy impact on landing. We all chuckled over our numerous "crash" landings. Of course on a longer runway, where power could be reduced gradually in the flare, the touchdown could be fairly gentle. The rather stiff oleo struts (compared to modern levered struts) were also a contributing factor. With frequent 20-30 knot crosswinds from the west flowing over the adjacent factory buildings, we faced much turbulence in the landing flare. Wing-low drift correction was impractical, and we became very proficient with kicking out 10 to 15 degrees of crab (wings level) at touchdown. This was quite easy because of the fantastic rudder control with that big vertical tail.

We had to demonstrate landings with asymmetric fuel loads and, also, asymmetric flap deflections (but not in combination). With 300 pounds of fuel in one tip tank and zero fuel weight in the opposite tip tank, the lateral imbalance could be counteracted with about 15° of control wheel deflection in the flare to about 30° at touchdown. With symmetrical full-fuel loads, the inertia effect was noticeable at low speeds, but seldom enough to cause *pilot-induced oscillations* (PIO). However, to my surprise, FAA test pilot Jack Hurley experienced a PIO on one landing approach during a gusty crosswind in the factory-induced turbulence. From the co-pilot seat I grabbed the control wheel and held it stationary for 2-seconds, and the oscillation ceased instantly. Jack then took

control immediately and finished the approach and landing without difficulty. That was the only PIO that we had ever witnessed or heard of from the field.

We did have some misgivings about a pilot's ability to make small bank corrections during instrument flying with the "high inertia" wing. However, to our pleasant surprise this concern did not materialize. Apparently the lateral motions in small-bank corrections were so gentle that inertia effects were not involved.

Similarly, the Lear L-2 autopilot was not bothered by lateral inertia effects. Fritz Feutz recalls flying the extensive autopilot development program in accordance with Part 4b regulations. This involved the determination of clutch-slippage settings and the ability to (1) induce so-called hard-over signals (electrical faults) artificially, (2) wait a prescribed number of seconds, and (3) taking manual control without exceeding the airplane's structural or airspeed limitations. We were among the first to evaluate a revolutionary Lear approach coupler that was capable of making automatic intercepts to a localizer beam on the ILS and then tracking it and the glide slope beam to the runway threshold. With rather skimpy FAA regulations to guide us, the FAA test pilot (either Jack Hurley or Hal Hermes) requested a dozen automatic pilot approaches using the ILS at Topeka, Kansas (a low-traffic airport). After observing 12 perfect intercepts and approaches, the FAA pilot said, "Let's make it a baker's dozen." To our dismay, on the 13th approach the airplane suddenly departed the localizer beam at a 90° angle! Now what should we do? With good common sense, the FAA pilot said, "If it will perform two more *perfect* approaches I'll buy it." It did and he did. I had fun kidding my airline pilot friends and my Boeing test pilot buddies about our "*state-of-the-art*" approach coupler that had not yet been used in either airliners or jet bombers.

One of our biggest challenges was propeller synchronization to eliminate the annoying audible "beat" in cruising flight. Another problem was getting prompt propeller feathering and unfeathering times in flight. The no. 1 prototype didn't exhibit these problems because it used higher-capacity surplus Hamilton-Standard governors which were no longer in production. Many flights were made to see Jim and Forest Drake at the Woodward Governor Company in Rockford, Illinois or to work with Dick Grimes or Dave Bierman at the Hartzell Propeller Company in Piqua, Ohio. The improvement objective for the governor was to optimize the speeder

spring/pilot valve combination to provide super-sensitive RPM control while, at the same time, avoiding surging or instability during throttle bursts. The propeller design challenges were to minimize friction in the pitch-changing mechanism and to optimize propeller counterweights for proper response to oil pressure variations supplied by the governor. A troublesome third factor was variable leakage in the engine crankshaft's oil transfer bearing that carried oil from the governor into the hollow crankshaft end, and then into the propeller cylinder. Dave Bierman and Dick Grimes ran a number of tests and determined that the deterioration was due mainly to less oil capacity in the Woodward governor (which has smaller internal parts) together with high oil leakage through the transfer bearing in the engine. Making alterations in the governor, propeller counterweights, and reducing the feathered blade angle from 78° to 76° considerably improved all noted problems. We finally achieved a fully acceptable solution after determining specifications for allowable transfer-bearing leakage rates. These were measured in engine-inoperative tests on the ground. In later years Woodward was successful in developing a "synchrophaser" that matched *blade positions* between the left and right propellers. This was offered to customers as an option for a higher price, and it offered proof that we had solved the "RPM-drift" problem.

Another propeller-testing task was measuring blade stresses on the ground and in flight. Delicate fine-wire strain gauges were affixed in an array over each blade, and these fine wires were stretched (and narrowed) as the blade flexed. This, in turn, would change the electrical voltage through the strain gauge. The various gauge wires were routed along the blade to terminate in a special slip-ring assembly called a "pineapple." The stationary part of the pineapple which was supported by a boom from the fuselage, picked up the voltage variations and transmitted them via an "umbilical" wire bundle affixed to that boom. With an oscilloscope screen showing voltage traces as cyclical waves, pictures were taken throughout the speed and power ranges of the airplane. It was interesting to observe a "*blossom*" of high stress during a sudden yawing motion following an engine-cut. However, this was of little concern because it is a non-repetitive event that would not contribute to long-term *fatigue* stress damage. Of more importance was selecting a cruising RPM range that had relatively low propeller stresses. Although, we had performed similar tests on the

C-170 and C-180, the presence of the second engine allowed us to measure stresses *inflight* for the first time. Fritz Feutz recalls that:

"These early tests were never extended into the flight phase, but they resulted in engine dynamic balance redesign and possible propeller changes. Of all the various things tried, the most memorable was the Hartzell-designed phenolic block vibration isolator, inserted between the crankshaft flange and the propeller. The initial runups looked promising. Then Dick Grimes signaled for full power. After reaching full throttle and checking the power instruments for their reading, I glanced up and saw Dick jump up and down, waving frantically for me to shut down. His instrument readings had jumped off scale, and upon inspecting the propeller, we found the block completely split and held on by only one bolt! That was the end of plastic inserts!"

To determine the aerodynamic "smoothness" of the airplane we would measure rates of descent at various airspeeds with both engines stopped and both propellers feathered. I recall our consternation for getting at least one engine restarted at the end of those long glides from 12,000 feet. If unsuccessful, we would be faced with a dead-stick landing at the fairly inactive airport called Strother Field located between Winfield and Arkansas City. It is an eerie feeling being in a twin-engine "glider" recording altitude versus time in seconds at speed increments varying from 70 to 250 mph. Most memorable is the near-vertical attitude of the airplane at the 250-mph speed. My observer was taking altitude readings every 30 seconds, and those seconds seemed like an eternity! Fortunately, engine restarts were obtained in less than a minute of cranking, thanks to an absence of engine flooding (or fuel vapor) with electric primer operation. From this flight test data we computed a remarkable profile drag coefficient of only 0.029. Prior to these tests we had evaluated power off (propellers idling) full-flap landings. The approach glide was very steep with all that flap and propeller drag, and the flare had to be just right. Fritz Feutz recalls blowing a main gear tire on a hard landing (*power-off*) from a 1.5 V_s glide during photographed landing distance tests. This led to a reduction of maximum flap deflection from 60° to 45° for the initial production airplanes.

Although the C-310 was originally conceived as a 4-place airplane, it soon became apparent that 5-place seating (with three rather slender passengers in the rear seat) would be desirable. This required a more rearward center-of-gravity limit and a higher gross weight. Longitudinal stability was inadequate at the new aft C.G. limit, and, consequently, the horizontal tail span had to be lengthened by 3.5 feet. In addition, an elevator downspring was added to give more so-called stick-free (or stick-force variation with speed) stability. The downspring increased the pull force needed in the landing touchdown, but fortunately, the extra tail span provided a very powerful elevator. Our usual practice of designing a downspring with variable geometry (to put it out of action at full-up elevator) was not possible because normal landings could be made with a fairly small amount of up-elevator. In fact, the elevator was almost too powerful for take-off rotation at an aft C.G. On the other hand, we received very few complaints of striking the tail stinger in a "too aggressive" rotation for lift-off.

At the new aft C.G. limit in the balked-landing climb configuration we experienced poor centering of the rudder after releasing rudder pedal force from a full-rudder skid. Tuft photographs from a chase plane indicated some stalling of the vertical tail at extreme yaw angles. Anticipating some benefits of flush rivets (instead of brazier head rivets) on airflow over the tail, I flew the prototype to Mississippi State University where famed Professor August Rasper could give us some advice. Gus Rasper was a worldwide authority on laminar flow testing techniques. After I greeted him in the airport office we walked out to the parked airplane which was silhouetted by the setting sun. While I mentioned how proud we were over the smooth contours of this wing he said, "Bill, you've got a flat spot on the leading edge!" In disbelief, I searched for the leading edge light shadows from 50-feet and could find *nothing* to indicate a "flat" area. He said that he would prove it tomorrow. The plan was to prepare all the airplane's leading edges (wing, nacelles, tail, nose, and tip tanks) by spraying them at dawn with a naphthalene solution. Then immediately thereafter we would fly at top speed around the traffic pattern and land. The patterns of residue from the evaporated spray would define areas of laminar flow (*solid pattern*) and separated flow (*mottled pattern*). The next morning Gus made his point that a spanwise stiffener at about 5% chord on the wing did, in fact, cause a minor "flat" that triggered slightly turbulent airflow. He indicated that this beautiful flush-riveted wing could just as well have been constructed with round head rivets downstream from that rivet line!

The same could be said for the smooth tip tanks, because the discontinuity between the fiberglass nose cap and the metal tip tank created turbulent flow aft of that juncture. We observed some evidence of very short laminar flow runs on the vertical tail which were explored in more depth in a second flight using full-rudder deflections at low speed. From this test program, Gus was able to give us advice on rivet height and placement on both the fin and rudder to help solve our rudder-centering problem, Gus was a living legend before his death in an airplane take-off

accident. His tales of teaching a pet baby buzzard to quit flopping its wings and soar with outstretched wings like oilier buzzards were hilarious! Eventually it soared with an instrument pack affixed to its body so that telemetering signals could be received in a nearby glider. This data was then converted to an unbelievably low *drag coefficient* and published in the aeronautical trade journals of the world.

The published performance of these early C-310's with the 240 horsepower engines at 4,600 pounds gross weight is as follows:

Maximum Speed At Sea Level	223 mph
Cruise Speed (70% power) At 8,000 ft	206 mph
Cruise Speed (60% power) At 10,000 ft	196 mph
Range (60 % power) At 10,000 ft	810 miles
Endurance At Cruise (60% power) At 10,000 ft	4.0 hrs
Rate Of Climb At Sea Level	1,700 ft/min
Service Ceiling	20,000 ft
Take-off Distance Over 50-ft Obstacle, Sea Level	1,405 ft
Landing Distance Over 50-ft Obstacle, Sea Level	1,720 ft
Stall Speed, Flaps 45°	69 mph
Stall Speed, Flaps Up	82 mph
Single Engine Rate Of Climb At Sea Level	380 ft/min
Single Engine Service Ceiling	7,500 ft

Subsequent performance tests on a production airplane, N4845B, in August, 1955 revealed an 8-mph higher top speed of 231 mph and a 6-mph higher cruise speed of 210 mph. Since the climb performance remained essentially unchanged, it was concluded that the production airplanes were cleaner aerodynamically than the prototype. This was also reflected in the impressive maximum glide ratio of 12.6 to 1. A consulting engineer and test pilot, Dale Ruhmel, from Ventura, California has owned several C-310's of varying vintage. He stated that:

"The series evolution produced the C-310Q, the ultimate efficient C-310 for high passenger comfort, spaciousness, performance, and low operating cost. The C-310R was the 'hot rod' of the fleet, providing all of the comfort of the Q with increased performance, but higher operating costs. The C-310 had the best single-engine stall characteristics of any twin ever built until the C-T303. The obviously unbiased opinion of an

aircraft designer/pilot/aircraft owner (and at one time a Cessna aerodynamicist) is that (he C-310 was the overall ultimate light twin ever designed. Not without fault—but overall best."

During the early 1950s Hank Waring and I shared the test pilot duties on the C-310 as well as a half a dozen single-engine prototypes. In addition, we were busy with preliminary design of the C-318 twin-jet trainer which was to become the USAF T-37. With the winning of that industry-wide competition, Hank was appointed its chief engineer and moved to a new plant on the west side of Wichita. By that time W. H. "Bill" Stinson had taken over the C-310 project test pilot responsibilities with assistance from test pilot E. F. "Fritz" Feutz and flight test engineers Ralph Price, Bob Stephens, Earl Lauer, Jack Craig, Pete Bernard, Harry Clements and Bob Crawshaw in various phases of the test program.

To check Fritz out in the second prototype, N37879 (which had just completed 1,000 landing gear cycles in a test jig). I had him run through simulated engine failures after take-off (at a safe altitude). On one gear-retraction event we heard a loud snap, and on the subsequent gear extension effort we noticed the absence of a gear-down green light. Suspecting a nosegear linkage failure, we called flight test radio to send up a chase plane. The chase pilot confirmed that the nosegear was dangling in a 45° position. This was to be the first belly landing in a C-310. I elected to land diagonally on the grass Cessna Field with the main gear retracted, nose gear dangling, and a 1/2 flap setting. There was to be no attempt to stop the propeller rotation prior to touchdown. After a McConnell AFB fire truck positioned itself at the estimated end of our landing slide, I dragged in and chopped the power a few feet above the ground. Contact with the ground was somewhat heavier than expected, possibly because of the added deceleration caused by the idling propellers striking the ground. However, the airplane almost seemed to accelerate slightly in the early part of the slide. In fact, the slide lasted about 500 feet with only a very gradual deceleration. We came to a stop right under the towering turret of the fire truck, and feared a heavy dousing of foam retardant from the turret gunner. Fritz opened the door and he, Ralph Price, and I fled the scene. A modest amount of foam was directed at the inlets to the engine compartment before Cessna mechanics disconnected the battery leads in the battery compartment in the wing adjacent to the nacelle. After hoisting the airplane, extending the main gear, and placing temporary supports along the nose gear drag link, the airplane was towed to the hangar. To our amazement we found that the rather rapid descent had *bounced* the dangling nose gear into its well and closed the two gear doors without any damage! Aside from the bent tips on the propellers the only damage was a slight abrasion to the inboard trailing edge of each flap!

This happy damage report prompted us to prescribe an identical wheels-up landing technique in the Emergency Procedures section of the Owners Manual for the "failed nosegear" situation. In later years the Air Force requested the adoption of their standardized procedure of landing with *any* gear leg extended that is operational. We hesitated until a customer made a "main-gear-only" touchdown on a concrete runway with very minor damage. On another occasion, even less damage was incurred by moving baggage and passengers to the extreme rear of the cabin where the nose

would eventually drop to the runway at the last moment. This technique would become standard procedure on hard surface runways in the Owners Manual. However, on sod runways, it recommended our demonstrated main-gear-retracted technique.

Another important operational instruction in the Owners Manual was for "Engine-Failure After Take-off." After our submitting a preliminary draft to various departments at Cessna, the manager of the Service Department, Ozzie Kangas, asked us to rewrite and expand the instructions with his idea for a pictorial sketch of the take-off/climb-out profile. We agreed wholeheartedly and developed the "Kan-gas-inspired" instructions which have served as an industry standard ever since. Added to these life-saving paragraphs is the admonition to essentially abandon the attempted engine-out climb-out, even if it means rolling through a fence or minor obstructions. We test pilots agreed among ourselves to *not attempt the continued* climb-out in such an emergency. To our surprise some years later, Cessna salesman Bill Fergusson came by to state "Bill, your Owners Manual instructions worked! I lost an engine just after take-off with 5-people on board at Long Beach Airport and, by golly, the airplane accelerated to the proper climb speed as I cleaned it up, and we circled the airport for an engine-out landing!" He seemed pleased at the performance, but I reminded him of that last sentence saying "don't go."

Fritz Feutz became somewhat infamous for a memorandum he wrote about Cessna door handles. Returning from a solo flight in the prototype, he parked just outside the closed hangar door with no one around. While trying to open the cabin door, the door handle broke off in his hand. After a long wait he finally called for help via flight test radio. The mechanics had a wide grin as they unlatched the door from the outside. We pilots didn't think it was all that funny. Fritz maintained his rare sense of humor, however, and wrote a memo that ended with "Let it never be said that a Cessna owner will go to the land of everlasting bonfires with a Cessna door handle in his hand." Needless to say, the door handle was beefed up for production airplanes.

In May of 1953 Bill Stinson and Bob Crawshaw evaluated the effect of wing tip fuel tanks on the C-310's performance and stability. Since the same prototype airplane was used with and then without tip tanks, all testing was performed in smooth air at or above 5,000 feet. The gross weight was 4,200 pounds and the C.G. position was 25% MAC.

Configuration	Standard Tip Tanks	Tanks Removed	Percent Change
1. Top Speed, mph	216	223	+3.2 (7mph)
2. Rate of Climb @ 5,000 ft, ft/min	1,082	1,072	-.009 (-10 fpm)
3. Time to Damp Dutch Roll, sec	10.5	3.7	-65
4. Lateral Control, Pb/2V	.072	.104	+44
5. Static Longitudinal Stability, dFs/dV	0.25	1.0	+300

Test values of static and lateral stability are not shown above since they remained unchanged with removal of the tip tanks. From the above comparison one can see the price to be paid for the crash safety offered by fuel tanks in the wing tips. Most notable are the 3-fold increase in longitudinal stability with the tip tanks removed and the 65% reduction in the time to damp to 1/2 amplitude in Dutch roll. The latter item is a mixed blessing, however, because in rough air the motions are more rapid (and more annoying) as in the Beech Bonanza. The lack of a significant rate of climb advantage with the oval cross-section tip tank and the need for more lateral stability provided the impetus for the canted (upturned) tip tanks developed for the 1962 O310G.

In accordance with standard practice, we conducted a 1,000-hour accelerated service test on the first airplane built from production tooling. Fritz supervised the more limited group of Cessna employees who were rated for twin-engine airplanes. The schedule was 7-days a week from dawn to midnight with test pilots taking the night shifts after working all day on their other projects. We made it a practice to invite Boeing test pilots and SAC pilots (who flew their B-47s out of McConnell) to ride with us for the purpose of acquainting them with our overlapping traffic patterns. One Air Force captain had asked for a night flight in our C-310, and I invited him to come along while I evaluated reflections from new rotating beacons. He was quite impressed with the avionics and instrument lighting, but he almost jumped out of the airplane when I announced my intention to land on the unlighted short asphalt N-S runway on the east side of Cessna Field. The three dim green lights at each end of this runway were almost totally obscured by the glare of the bright runway lights of adjacent McConnell AFB. As I glided to the "black hole" my landing lights eventually caught the threshold and they dimly illuminated the dark, narrow runway. He said, "You guys are nuts to fly into this runway" Since then the

runway has been lengthened to 3,000 feet, giving more room for error on a dark night. In addition, runway lights have been added, but the runway is still narrow.

For some unexplained reason the prototype C-310, N41699, was 10-15 mph slower than the second prototype, N37879. Therefore, we recalculated all the level flight performance for the upcoming owners manual. Even so, the published 70% power cruise speed was an impressive 204 mph, making it the fastest light twin in the skies. In fact, it is still among the fastest reciprocating engine (normally aspirated) twins over 42 years later. Two years later the author and Ralph Price selected a second production airplane, N48458, at random for a detailed check of the performance of a typical C-310. To our pleasant surprise, this airplane had an 8-mph higher top speed and a 6-mph higher cruise speed than the published speed in the owner's manual. Since climb performance remained essentially unchanged, we concluded that the production airplanes were cleaner aerodynamically than the second prototype. Despite this finding, no change was made to the owners manual.

On a business trip to Dayton, Ohio I recall planning an 800-mile hop non-stop. In those early days we did not have exhaust gas temperature (EOT) gauges, and it was customary to lean for roughness and then advance the mixture control to the threshold of smoothness. The carburetor settings were fairly symmetrical, and usually the mixture control knobs would be aligned side-by-side with equal mixture strengths. When changing cruising altitudes periodically we would sometimes recheck mixture strength on only one engine and simply bring the other engine's mixture knob to an adjacent position. After an uneventful 3 1/2-hour flight, the line boy's eyes widened as he pumped 98 gallons of fuel into the 100-gallon tank. I looked over the exhaust residue in the augmentor tubes and found evidence of a very rich mixture on the right engine. Further investigation revealed a broken mixture control link which had allowed the carburetor mixture control

arm to vibrate to almost the full-rich position! This embarrassment was never revealed to my passenger, the college-age son of Beech Aircraft Company's sales manager, Leddy Greever. This young man had blissfully enjoyed the flight on his way to the east coast! On another business trip to the New York City area I was taxiing out at Westchester County Airport for a return flight to Wichita. A line boy flagged me down, saying that I had a telephone call from Wichita. After shutting down the engines my boss, Jerry Gerteis, asked me over the phone to avoid flying in visible moisture or ice. Derby Frye had just had a crash landing in Arizona after a double-engine failure, and they suspected intake manifold ice. Derby, Jerry Stegink and Charlie Seibel were on board this eastbound flight from the west coast on January 26, 1958. In Derby's words,

"I had been flying IFR at 11,000 feet in the clouds when the stoppages occurred east of Needles, California. We were encountering a mixture of rain and heavy snow that streamed over the wing as a slush. Suddenly one engine's manifold pressure dropped off the scale and the engine became inoperative. I advised Needles radio of the situation and started to turn to a westerly heading for an approach to their airport. After dropping slowly to 10,300 feet the engine restarted and I was able to climb back to 11,000 feet toward Needles. Then both engines lost manifold pressure and died. Hoping to get restarts at lower, warmer altitudes, the propellers were not feathered. We broke out at 6,400 feet over a boulder-strewn dry wash leading down a mountain. In rather poor visibility, we followed it down to a wall ahead, and made a turn toward an unrestricted desert floor. Now we needed a better glide angle, so, with the gear already retracted, I feathered both propellers. The airplane stalled slightly before touchdown, and the impact tore off one of the tip tanks. In the ensuing slide the other tip tank was ripped off the wing. Finally the wing impacted a 10-foot high desert tree, pivoting the airplane 90°, tearing off the tailcone and stunning me as my head struck the side post. Charlie Seibel in the rear seat was on his back kicking out the 'emergency escape' window and saying, 'Let's get out of here!' Jerry Stegink at first could not open the jammed cabin door—he had some serious back injuries. Charlie was not injured, and he finally was able to open that door. The evacuation was prompt, and, with the severed tip tanks lying up the hill, there was no fire. We were amazed that the cabin was

absolutely intact, and not a single window was broken!"

We had all thought that the pressure carburetors were non-icing, and the air intake duct had spring-loaded alternate air doors that would be sucked open if the air filter became obstructed. In fact, we originally did not believe that alternate air controls were necessary for these reasons. However, upon the insistence of some of our company pilots who had flown a lot of IFR flights, we had designed and installed them in time for all production airplanes. In addition, we had heard rumors of a double-engine failure six weeks earlier on a USAF L-27 flight in icing clouds in Montana. This accident and that incident confirmed the need for those controls.

To determine the point of the suspected ice blockage (*carburetor or intake manifold*), we constructed a transparent runner manifold and installed it in an airplane for ground tests at the factory. In the freezing surface temperatures with the engine at varying power settings, a water spray was directed into the nacelle openings. After about 8 hours of spraying in colder night-time temperatures, the ice formation was detected visually at the "Y" in the runner manifold. This again confirmed the need for alternate air controls, a source of heated air, and the instructions to use those controls prior to entering suspected induction icing conditions. We are certain that many owners don't comply with those instructions, and, to the author's knowledge, with one exception, the problem simply vanished. Perhaps that Arizona icing encounter was an anomaly. In addition, we subsequently failed to duplicate the condition in extensive icing tests on the L-27A behind an Air Force water tanker at Wright Field, Ohio. Those tests had shown ice bridging the gap between the elevator horns and the horizontal stabilizer. We had suspected this from field reports of a temporarily-locked elevator when the airplane was stabilized on a long ILS approach in icing conditions. Fortunately, the pilot could exert enough force on the control wheel to break the ice bridge. With this information in hand, the gap was increased to about 4-5 inches, and it set a precedent for successive airplane models. Another finding was that continued engine operation was possible even though the inlets in the cowling were bridged over with ice. Apparently combustion and cooling air filtered through cowling door gaps!

The most traumatic C-310 accident with Cessna personnel occurred near Corona Pass in Colorado

when Cessna salesman Lee Renshaw was returning to Denver from the west coast with five people on board, including Clinton Aviation executives Lou Clinton and Grant Robertson. When a cylinder head from the outboard bank blew off the engine, it carried the full-length nacelle door with it and peeled it back against the leading edge of the right wing. Acting as a monstrous spoiler, it destroyed the lift over a 3-4 feet span of the wing just outboard of the nacelle. Needless to say, with only one engine operating it was impossible to maintain altitude over this high-mountain country. Lee later told us that he was attempting to reach a pasture in a nearby valley. However, the rate of descent was horrendous, and with landing gear retracted they bounced off a saddle in the intervening ridge before sliding down the slope toward the valley. The initial impact tore the tip tanks from the wings, and the leaking tanks remained up the hill. However, rivulets of fuel streamed downhill toward the intact C-310 cabin. Fortunately, one of the rear seat passengers was not injured. He kicked out a side window, crawled out, and evacuated his former seat mates who were shaken up but not too badly injured except for damaged knees. The most seriously injured, of course, were the pilot and co-pilot who suffered facial, leg, and back injuries. They had to be removed very carefully and air-lifted by helicopter to a Denver hospital for surgery and then a long convalescence. Upon receiving word of the crash, I flew chief engineer Jerry Gerteis out to nearby Eagle, Colorado to inspect the wreckage. This flight was also interesting because we had to climb to 20,000 feet to stay clear of a high dust storm just west of Wichita. After renting a car and, later, hiking over rough terrain to the crash site we surveyed the initial impact point and the track of the sliding aircraft as it was shedding pieces and parts. It was obvious that the fuel being located in the detached tip tanks was a life-saver in this accident. Although it had leaked out and streamed down to the wreckage, the engine parts had had enough time to cool down below the ignition temperature. I later admitted to Don Ahrens that his "undersized" bulkheads were more than adequate, for the cabin section was absolutely intact and crash-worthy in that slide down a boulder-strewn mountain side.

The demand for more and more longitudinal stability continued as the airplane evolved from a minimum 5-place to a full 5-place and eventually a 6-place airplane. The aft limit of the C.G. position marched steadily rearward. Substitution of engine

cowl flaps permitted removal of the augmentor tubes. This, in turn, provided space for supplemental baggage compartments in each lengthened nacelle. In addition, this baggage location would have a more favorable C.G. position. To achieve reasonable static longitudinal stability (stick force vs. velocity), we kept increasing the strength of the elevator down-spring. In time, the dynamic stability diminished (especially in missed-approaches), and long-period porpoising motions became undamped. Although relatively unimportant from a safety standpoint and of no interest to the FAA, it could be objectionable on a dark night when making a balked-landing climb-out with no visible horizon or terrain surface lights. This prompted the use of an elevator system bobweight which was located in a manner to give a downspring effect. Its weight disadvantage is somewhat offset by its sensitivity to gravity (g) loads. For example, as the airplane in turbulence (hands off the control wheel) slowly swings to a climbing attitude the extra g-load exerts a slightly greater *down* force on the bobweight and, hence, more *down* elevator force to check the oscillation. To keep the weight addition to a minimum, we used various combinations of bobweight and elevator downspring as the need dictated.

In a similar evolution, the gross weight grew from 4,600 in several increments to 5,500 pounds as the number of available passenger seats increased. To retain reasonable engine-out climb performance, engine horsepower was increased from the original 240 HP to 260 and eventually to 285 HP. Thus our "light-light" twin grew to a moderately heavy twin with wing loadings comparable to our competitors' larger twins. Indeed, the later model C-310's had a "heavy airplane" feel, even though they were still relatively small airplanes.

To improve the styling, we developed a swept vertical tail for the 1960 C-310D models. The slight degradation in rudder power was not very noticeable since we had some to spare. The V_{MC} speed remained fairly low at 86 mph. Interior styling was enhanced year by year with plush seats and highly-styled interior appointments. Not only was the C-310 the fastest light twin, it was by far the *sexiest* lightplane in the skies. Our sales pilots loved the airplane. I remember Cessna's export salesman Bruce Chuber's habit of always flying solo from the right seat. He explained that his potential customers were invariably directed to the left seat, and he wanted to be well-practiced for demonstrations (or rescue operations) from the right seat. One of the sales demon-

strators that we used occasionally for equipment evaluations had an N-number ending in "zero four Quebec." When a troublesome control tower operator hassled us in heavy traffic, we were happy to acknowledge his radio instruction with "oh four Q" in the proper intonations—that was my favorite C-310! During Bob Crawshaw's flight test development of the C-310D in 1959 our Sales and Air Transportation Department pilots complained that the computed C-310C owners manual take-off distances after an engine failure were too conservative. Further-

more, they contended that we should recommend flaps for the take-offs on all but short and rough where such a high speed would be prohibited. Therefore, Bob re-evaluated the distance required to clear a 50-foot obstacle when one engine became inoperative at 95 mph IAS. Actual air distances simulated at approximately 500-foot altitude and data recorded with a Fairchild camera. Tests conducted with flaps both 0° and 15° and with 3 seconds delay between engine failure and initiation of gear retraction and propeller feathering.

Description	Ground Distance	Air Distance	Total Distance To 50 Ft Obst
Flaps 15°—3 seconds Delay	1282	2,506	3,788
Flaps 15°—10 seconds Delay	1282	3,559	4,841
Flaps 0°—3 seconds Delay	1282	983	2,265
Current Model 310C Owner's Manual			5,230

This data substantiated the above contentions of our Sales and Air Transportation Departments and that flaps 0° should be utilized on all take-offs where safety is a major consideration. Thus the new and old engine-out take-off distances for the C-310D versus C-310C owners manuals would be as follows:

Description	Model 310D	Model 310C
Sea Level	2,265	5,230
3,000 Feet	3,295	6,680

In December of 1953 Fritz Feutz started extensive noise and vibration testing with Bob Hagan as flight test engineer. They recalled that "This was another entirely new experience for us, and very little practical research literature was available to aid our learning. Initially we scrounged an old General Radio Corporation tube-type sound level meter with a vibration analyzer (which I don't think we ever fully understood). This was the beginning of a long series of noise and vibration testing which was difficult in a light-skinned, aerodynamically clean, fast airplane." Adding to the progressive increases in empty weight were the weights of ever-increasing fiberglass batts, 1032 sound deadeners, Permacel P-12 tape, and LD-400 lead-impregnated plastic mats glued to vibrating fuselage skins. In the early development we had engaged the world-renowned

consulting firm, Boit Beranek & Newman, to make a detailed analysis of noise sources (propeller, engine exhaust, door leaks, etc.) and methods of soundproofing vital areas. For weight and cost reasons, many of those recommendations could not be adopted until later years where the heavier gross weights could accommodate the weight of extra soundproofing. We sometimes identified vibrating skin panels by placing a doctor's stethoscope on panels way back into the opened tailcone. Then the tape strips would be glued to them for a cabin noise recheck with a noise meter. On one occasion irreplaceable Fritz Feutz returned from a noise and vibration flight and walked into our flight test office with the stethoscope plugged into his ears. He spotted our feisty secretary, Ruth Hall, dressed in a rather revealing peasant blouse, and, without permission, proceeded to listen to her chest. We all expected some fireworks, but Fritz, in his best doctor's demeanor, continued the examination and gave Ruth a thumbs up report! Only Fritz could get away with that outrageous performance! On a more serious note, he recalls that:

"The winter of 1954-55 seems to have been spent in looking for ice! . . . amazing how difficult it is to find ideal icing when you want it. Initially I launched whenever snow was forecasted in the state of Kansas but never got anything but light rime—and lots of snow! I remember flight

in heavy snow when the heater went out (not uncommon), and I had to shut the defroster off to prevent snow from blowing out. I don't recall ever getting much over an inch of ice, which the boots and alcohol handled satisfactorily—the defroster was inadequate to remove anything. Removing ice from the windshield required opening the storm window and manually breaking the ice from the windshield. This test program was before the CAA required an actual icing certification, so the testing involved only stalls, dive tests, and the determination that there was no unusual handling quality effect. Consequently, we set up our own actual icing criterion. And we didn't have to placard the airplane 'Not Approved For Flight in Known Icing Conditions!'"

Although knowledge of the methods of deicing airplanes was extensive in the 1950s and 1960s, we had very little knowledge of controllability penalties in the landing approach and flare. To be conservative in our owners manuals, we suggested no-flap, highspeed landings with ice accumulations on the wing and tail. A tragic crash had occurred in a transport plane on the east coast when the pilot deployed flaps in the final approach with his ice-laden airplane. It pitched downward uncontrollably with the flap extension, killing all on board. Recognizing the impracticality of simulating these circumstances in our own flight tests, I requested some full-scale wind tunnel tests and experimented with a large variety of simulated ice shapes (plastic) on the wing and tail. Then with the airplane canted at various attitudes and with different flap deflections and tunnel airflow speeds, the pitching forces could be measured. A NASA technical report was released with the results, and, as I recall, it confirmed our operational warnings to use little or no flaps in the landing.

Some of the engineers in Virgil Hackett's preliminary design group and Don Ahren's C-310 project group were Ozzie Mall, Larry Abbott, Kenneth Yeoman, Fred Smith, Jack Saltier, Lowell Dorman, Jake Berry, Glen McCormick, Jerry Stegink, Bill Ross, Frank Harris, Bill Seidel and Carol Neverman. Frank Harris became the C-310 project engineer when Don Ahrens started the C-336 Skymaster program in 1960. Flight test and aerodynamics participants in the early C-310 development included (among others) Hank Waring, the author, Bill Stinson, Fritz Feutz, Bob Crawshaw, Dick Kemper, Lynn Ikerd, Jack Craig, Ralph Price, Joe Latas, Harry Clements and Joe Engle. Joe Engle

had worked for us during a summer vacation from Kansas University before becoming a USAF fighter pilot, space-shuttle test pilot, and, eventually, an astronaut. All of these people were also working simultaneously on single-engine model developments or other aerodynamic or, on occasion, preliminary design assignments. When Bill Stinson finished the CAA certification flight tests in early 1954, the type certificate was issued on March 22, 1954. This was 15 months after Hank Waring's maiden flight. Fritz Feutz recalls that:

"The first production airplanes started flying that summer, and I had some test flights in several of these (probably radio evaluations). When the sales department decided to launch an international sales demonstration of the airplane, there were not many sales pilots checked out in the airplane, so Bill Stinson and I were assigned as demonstration pilots that summer. The five airplanes were flown to many cities coast to coast and in Canada and Mexico. The first production airplane, N2600A, alone flew 11,684 miles in 55 hours, averaging 212 mph. We both alternated on these trips, and I really got to appreciate the unique capabilities of the airplane. I do not recall any bad incidents, but delightful times in Santa Fe, New Mexico and pre-Castro Cuba. Participating sales department pilots included Fred Roscoe, Bill Norris and others intermittently.

'One of the operational problems developed during these trips was periodic engine roughness and exhaust smoke during some climb and cruise situations. Consequently, we instrumented No. 2 and discovered a large discrepancy between cylinders varying with throttle position. The temperatures indicated considerable variation in mixture distribution, resulting in several cylinders overly rich while others were lean. An extensive program evaluating various balance tube orifice sizes, carburetor discharge nozzles, and induction air straighteners resulted in an improvement with 'X' nozzles and a Cessna-designed honeycomb air box insert, but the problem was never fully solved until fuel injection became available."

When our work loads became excessive and manufacturing space became too crowded, the entire C-310/C-320 project was moved in 1960 to the newly-named Military/Twin plant at the Wichita Municipal Airport. Bob Crawshaw joined that move to keep some continuity in the booming C-310 program. He later became that division's chief test pilot, responsible for testing and certifying subsequent C-310 models and the upcoming 400, 500,

And 600 series twins. A notable change to the 1962 C-310G is that location was the incorporation of highly styled canted (upturned) wing tip tanks that could also improve the rather weak lateral stability. I recall my initial shock at seeing these tanks, but gradually had to acknowledge that they were beautiful, or “sculpted beauty” as the sales people de-scribed them. Another big change was a redesigned fuselage

Containing a heightened rear cabin, omni-vision rear-facing window, and a large ventral fin for the 1972 C-310Q. The last item was effective in directional stability tests in the balked landing, climb configuration and, to a lesser extent, in minimizing snaking motions in rough air at low speeds.

Performance and specifications for this model starting with serial numbers 0601 are as follows.

Gross Weight:	
takeoff	5,300 lbs.
Speed, Best Power Mixture:	
Maximum: Sea Level	236 mph.
Cruise: 75% Power at 6,500 ft.	221 mph.
Range; Lean Mixture, 218 mph:	
75% Power at 6,500 ft.	774 Mi.
600 Lbs, No Reserve	3.55 hrs.
75% Power at 6,500 ft.	1,565 mi.
988 Lbs.No Reserve	5.77 hrs
75% Power at 6,500 ft.	1,565 mi.
1,218 Lbs, No Reserve	7.18 hrs
Maximum Range, @ 10,000 feet, Lean Mixture, 183 mph	
600 Lbs. No Reserve	960 mi
	5.25 hrs
978 Lbs. No Reserve	1,566 mi
	8.56 hrs.
1,218 Lbs, No Reserve	1,950 mi
	10.66 hrs.
Rate of Climb at Sea Level:	
Twin Engine	1,495 fpm
Single Engine	327 fpm
Service Ceiling:	
Twin Engine	19,500 ft.
Single Engine	6,680 ft
Takeoff Performance: Takeoff Speed (90 mph, 15° Flaps)	
Ground Run	1,519 ft
Total distance Over 50-Foot Obstacle	1,795 ft
Landing Performance: Approach Speed (103 mph. 5,300 lbs)	
Ground Roll	582 ft
Total Distance Over 50-Foot Obstacle	1,697 ft
Empty Weight: (approximate):	3,214 lbs
Baggage Allowance:	600 lbs
Wing Loading	29.6 lb/sq. ft
Power Loading	10.2 lb/hp

Fuel Capacity: Total	
Standard	102 gal
With Auxiliary Tanks (40 gal Usable)	143 gal
With Auxilliary Tanks (63 gal Usable)	166 Gal
With Auxiliary Tanks (63 gal Usable) plus Wing Locker Tanks	207 gal
Oil Capacity: Total	6.0 gal
Engines	
Continental 6-Cylinder, Fuel Injection engines ()-470-VO 260 Rated HP aat 2,625 RPM	
Propellers:	
Constant Speed, Full Feathering, Two Bladed 81" Diameter	D2AF3471-L1/84JF-3

Military-Twin (later named the Wallace Division) included Bob Crawshaw, Frank Harris, Jim Wilcox, Paul Kalberer, Jim Kirkpatrick, Milt Sills, and Warren Wilson under the direction of chief engineer Max Bleck.

The durability of this "light-light" twin has been astounding- I am aware of only a very few in-flight break-ups or cracking problems with ribs, bulkheads, or skins. The one weakness, previously mentioned, is the weldment of a nosegear linkage part that was subject to fatigue cracks. It has been beefed up periodically and is now fairly durable. Perhaps the biggest complaints from customers is paint quality. It seemed like our paint vendor was continuously changing formulations to get the right combination of gloss, durability (anti-chipping), adhesiveness, application ease, short drying time, and long-lasting colors. These were vinyl finishes that sometimes would peel in a flight through heavy rain or in sub-zero temperatures. In stark contrast, the newly developed acrylic paints were excellent except for two problems. First, the long drying/curing times could not be accommodated in our mass-production paint shops which handled both single and twin-engine models. Second, the paint and application costs were astronomical by comparison. In retrospect, however, we probably would have been money ahead by establishing a separate on-purpose acrylic painting facility for the C-310 airplanes.

A peculiar structural complaint came from only one source—the FAA training academy at Oklahoma City, Oklahoma. They had experienced cracks in the brackets that support the elevator horn balance weights. This puzzled us until their instructor pilots described their pilot standardization methods which included prolonged power-on stalls with full flaps. At the typical forward C.G. location (2-people on board), it was difficult to get a stall break and pitch-down. Instead, the airplane would get into violent and continuous buffeting (a desirable characteristic) while the trainee would strive unsuccessfully to obtain a complete stall. We were appalled at this practice, but the brackets, nevertheless, were beefed up.

Normally-aspirated models of the C-310 were produced over a 26-year period. Examples of annual production quantities/prices over that span are: 228 units/\$59,950 in 1957, 200/\$62,950 in 1964, 91/569,959 in 1971, and 203/\$138,500 in 1977. The low unit production in 1971 was the result of an equal number of turbocharged C-310Q models introduced in that year. To avoid confusion, all turbocharged models will be described in the following chapter entitled "The C-320/Turbo C-310Q & R Stories."

A summary of the C-310 development by model year is presented in the table on the following pages.

Cessna Wings for the World

	MODEL YEAR	MODEL	T.O.WT. LDG.WT	BHP	BASIC CONFIGURATION AND SIGNIFICANT CHANGES
	1954 - 1957	310	4600	240	
			4600		
	1957	310A	4830	240	New Elevator Downspring to improve stick free stability (7 lb/inch)
	1958	310B	4700	240	
	1959	310C	4830	260	New elevator downspring and new rudder and elevator trim tab; nacelle extended to wing trailing edge with box mufflers.
	1960	310D	4830	260	New swept back Vert. tail & interconnect of aileron and rudder control system
	1960	310E	5000	260	Gross Wight Forward C.G. moved aft to 38.3 inches.
	1961	310F	4830	260	Simplified induction system; new nose caps, added third window and improved cabin heating system.
	1962	310G	4990	260	Canted tip tanks and rudder centering spring added. Stab. Incidence changed from 1"45' down, to "0". New elevator downspring.
	1963	310H	5100	260	Stabilator incident changed from 0 to .50' up.
	1964	310I	5100	260	Flap travel reduced from 45 to 35, & up elev. Travel reduced from 25 to 16.5; & 5lb bob weight added. Stab. Incidence back to 0. Added baggage nacelles. Added underwing exhaust.
	1965	310J	5100	260	Large elev. Trim tab; props extended 3" FWD and added new 110 lb. bob weight.
	1965	310J-1	5100	260	Submitted for Army contract competition.
	1966	310K	5200	260	Added 411 ailerons & faired in trailing edge of wing; & increased total wing area; added new downspring (16 lb at 12.75 in.) back to small elev. Trim tab. Flap speed increased to 180 mph.
	1967	310L	5200	260	On piece windshield; softer gear; gear and flap speed to 160 MPH; wight night lighting; belt-driven alternator.
	1968	310N	5200	260	Improved inst. Panel layout; Air induction intake moved to wing root; filter canister redesigned. Fuel pump bypass metering modified; IO-470 VO engs.; added oil squirts to piston skirts.
	1969	310P	5200	260	Added flap pre-select. 411 nose gear; ventral fin; E. L panels; 320 propeller; new nacelle nose cap; alternator failure lights; revised static ports.
	1970	310Q	5300	260	Added capacitance fuel guage; relocated rotatint beacon to rudder tip; nacelle - wing fillets; tip tank transfer pump; relocated stall warning vane;
	1972	310Q	5300	260	New omni-vision window; increased windshield area; glare shield change; switch relocation; alcohol windshield de-ice option;
	1973	310Q	5300	260	Teflon coated landing gear strut bearings; new overvoltage relay and balancing circuits for alternator system; light weight glareshield; 63 gallon aux fuel option; yaw damper option; new paint scheme
	1974	310Q	5300	260	Airspped change from MPH to knots; increased 15" flap spped for 160 KCAS; 35° flaps and gear extension speed to 140 KCAS; new paint scheme. Safe-flight angle -of-attack indicator option. Avionics buss installation.

Cessna Wings for the World

MODEL YEAR	MODEL	T,O. WT, LDG.WT.	BHP	BASIC CONFIGURATION AND SIGNIFICANT CHANGES
1975	310R	5500	285	Gross Weight increase to 5500#, Nose extended 32 inches, Nose gear relocated 4" Fwd., IO-470-VO replaced by IO-520-M. Exhaust augmentors replaced by cowl flaps. Only one prop available for 1 975 (3-bladed, 76.5"),
1976	310H	5500	285	Installation of Cleveland wheels and brakes, placard and marking changes to comply with 1 976 GAMA format, low fuel warning Sights, McCauiy/ARC SP-105A propeller synchrophaser, 400B autopilot, low voltage warning.
1977	310R	5500	285	installed improved wing locker fuel tanks, flight into known icing. Circuit Breaker Panel revised. Changed fuel grade.
1978	310R	5500	285	Added Ramp Wt. 5535 ids.
1979	310R	5500	285	Added elevator trim control guard. Incorporated FAA approved flight manual. Changed "safe single engine speed" to "intentional one engine inoperative speed".
1980	31 OR	5500	285	Compliance with 1980 Noise requirements, POH performance section changed pressure rates of climb to true. Tail stinger improved.
1981	310R	5500	285	A landing gear speed limits placard was added near the landing gear control.
1981	310R	5500	285	Teledyne 100 AMP Alternator

After an impressive production run of 27 years, the C-310 went out of production at the start of 1982.

The L-27a / U-3A & B Stories

When the USAF announced its intention to buy a number of off-the-shelf light twin-engine airplanes in 1956 several of the lightplane manufacturers were invited to fly their candidate airplanes out to Edwards AFB for military test pilots to evaluate. The head of the evaluation (Bam was Paul Bikle, a world-famous soaring pilot who had just set an altitude record of 44,000 feet (higher than the X-15 rocket plane had flown at that date). When checking into Paul's outer office I was astounded to see my friendly competitor from Beech Aircraft Company, Harland Ross, who was also famous for his Ross high-performance sailplanes. Together we had instructed sailplane flying on weekends in a glider club operating out of Strother Field. He had flown a Beech Twin Bonanza out to Edwards for this same evaluation.

I recall thinking that his airplane, which was larger and more robust, would probably have more appeal to military pilots who were used to the so-called "big

iron." On the other hand, the spritely C-310 was much faster and certainly more modern looking.

While considering my chances, Paul stepped into the outer office and embraced his long-time glider buddy. I was totally ignored as they hashed over recent contests and conversations about their mutual friends. Before turning to me, Paul said "Harland, we will assign our very best test pilot and flight engineer to your airplane, and, if you need any help, be sure to contact me personally!" My heart sank! To this day I wonder if Beech had sent Harland (an aerodynami-cist) on this sales mission knowing that Hariand's good friend Paul Bikle was to judge the winner.

Paul's greeting to me was very formal and businesslike. I mentioned my early glider-flying days at Purdue (knowing he was a Michigan University graduate) and our club's spring vacations soaring over the bluffs of Frankfort, Michigan. It appeared that he was not spellbound by those revelations. In

later years, our Wichita glider group had hoped to raise enough money to finance Harland's trip to the national soaring meet in Elmira, NY. I had volunteered to solicit funds from the local airplane companies, and both Cessna and Boeing quickly pledged \$500 each provided that Beech Aircraft Company would join in with a contribution. I called Olive Ann Beech for her support, and she refused. How I wish that this refusal had been known by Paul Bickel!

As Harland and I assisted the military evaluators with our respective airplanes, it soon became apparent that the C-310 candidate would eventually be the winner. This was confirmed several months later with an initial contract for 160 L-27 A's of which 80 were delivered by December of 1957. The other 80 planes were redesignated U-3A's and delivered in 1958. Aside from minor changes in instrumentation and avionics, the airplanes were delivered as basic C-310's except for external blue paint and military insignias. They became known as the "blue canoe" for some unknown reason. These airplanes had a gross weight of 4,830 pounds, a top speed of 232 mph, and service ceilings of 20,400 feet (twin-engine) and 7,500 feet (single-engine).

The L-27A/U-3A & B service history in the Air Force was relatively trouble-free except for an occasional engine failure of the 240 HP Continental O-470-M engine. One memorable fatal accident occurred where the pilot attempted to continue a take-off climb and circle the field instead of cutting the power on the good engine and landing on the remaining 45,000 feet of runway. His turn at mid-

propeller drag was a new experience for many of the pilots. We were also disturbed to learn that some gung-ho pilots were performing intentional spins even though they were prohibited.

A major part of this contract was the preparation of a military-style "dash-one" handbook. This book, profusely illustrated, contained approximately 150 pages (8 1/2 x 11) compared to the 100-pages (5 3/8 x 7 5/8) in the commercial airplane's owners manual. Many 310 pilots with the patience to absorb all of this information and the complex presentation of performance have opted to procure this handbook from various non-Cessna sources.

In 1960 another 36 airplanes were ordered and redesignated the U-3B since it was a military version of the 260 hp C-310E. In fact, they were actually equivalent to the 1961 C-310F, having a maximum speed of 242 mph and service ceilings of 21,300/7,700 feet for twin and single engine operations, respectively. The gross weight remained at 4,830 pounds. A USAF survey after one year of U-3A operation had indicated that direct operating costs had been less than \$12 an hour. This factor, coupled with the airplane's excellent reliability record and popularity with pilots, had prompted the government to purchase the 36 U-3B's in 1960.

Along with the extensive T-37 production, the L-27A/U-3A & B production gave Cessna a solid and long-enduring relationship with the USAF. In contrast, Beech directed its Twin Bonanza to the U.S. Army where it found favor as a twin capable of operating from rough fields. That relationship also lasted many decades with subsequent purchases of

The C-320 - Turbo T 310Q & R

The biggest challenge to C-320 project pilot R. L. "Bob" Crawshaw was engine cooling at high altitude where indicated airspeeds are low in cruise and the air is thin. The nacelles had to be fitted with an array of fixed cooling air outlets and supplementary louvers in parts of the cowl doors. This last item gave us, for the first time, a clear view of the cherry-red exhaust manifold in night flights—a rather shocking sight which pilots of today are used to seeing.

A second challenge was developing a combustion air inlet system having minimum restrictions to air flow. The C-310's sheltered inlet screen within

the engine compartment had to be replaced with an external inlet that could retain almost full impact pressure. This was especially important above critical altitude since the turbocharger increased the unregulated manifold pressure by a factor of 2.2. Therefore, it was mandatory to get as much *initial* manifold pressure as possible. The solution was an inlet in the wing leading edge just inboard of each nacelle. From there the air was ducted to the turbo-charger's compressor (an integral part of the turbo-charger unit) behind the engine.

Continental's engineer, Jim Champion, was almost a permanent visitor during this program. At the

Continental factory in Muskegon, Michigan, a similar program was being conducted on Continental's C-320 prototype with Bill Scheltema doing the test flying. I recall the paint peeling on their airplane's upper cabin and wondering if it would be troublesome in production airplanes. However, to my knowledge, it was not typical. With all of the extra exhaust manifolds and so much testing at 25,000 feet and higher, we were somewhat concerned about the possibility of in-flight fires. A parachute bail-out at 25,000 to 30,000 feet without oxygen was not a pleasant thought. However, we encountered no fires or smoke in any of the turbocharger programs on twin-engine or single-engine models—maybe the air was too thin to support combustion!

In 1962 the C-320 was by far the fastest general aviation airplane of its day. With a gross weight of 4,990 pounds it had a top speed of 260 mph at 16,000 feet and a maximum cruising speed of 244 mph at 24,000 feet. However, its popularity was somewhat hampered by its reputation as a "hot rod" of the skies, and only 110 units were delivered in the 1962 model year at \$67,500. Not many owners flew it routinely at efficient cruising altitudes because of the new experience of needing oxygen and, after landing, resupplying the tanks. Engine maintenance was also a consideration because of the possibility of pulling so much more horsepower at high altitude where engine cooling was often marginal. The turbocharged engines carried a recommended time between overhaul (TBO) of only 1,400 hours compared to a 1,500 hour TBO for the normally-aspirated engines of that time. The 260 HP TSIO-470-B, C, & D engines were installed in the 1962-1965 Skyknights, and from 1966 through 1968 the Executive Skyknight featured 285 hp TSIO 520-B engines. This power increase boosted the top speed to 275 mph, the twin-engine service ceiling to 29,300, and the single-engine service ceiling to 18,500 feet. The gross weight increased in 1963 to 5,200 pounds and 5300 pounds in 1967. In 1966 a total of 130 units were delivered, and deliveries in 1967 and 1968 were 110 and 45 units, respectively. In its last year of production (1968) the price was \$85,500.

The service life of the turbocharger unit itself was quite variable. Those pilots who impatiently shut down their engines without a "spin-down" period often experienced a "coking" contamination of the

turbine bearing. This was caused by a cessation of oil pressure in the engine (and turbocharger) upon shutdown. However, the turbine wheel would have enough inertia to spin another few minutes and build up heat in the bearing with the absence of oil flow. The result was "coking."

The author recalls a serious C-320 accident in the 1980s where a pilot and his three passengers were departing Spokane, Washington for a mid-winter flight to Acapulco, Mexico. While assisting defense lawyers as an expert witness, I learned that while climbing in a blizzard to 20,000 feet he experienced an engine stoppage (on instruments). While preoccupied with getting a restart, the second engine failed. Now they were a *glider* descending IFR to a 300-foot ceiling! Upon break-out over rolling terrain, the airplane impacted heavily on a knoll, giving serious leg and back injuries to all the occupants. However, the remotely-located tip tanks again prevented a crash fire.

In analyzing the accident, it appeared that heavy snow and ice had gradually blocked the intake screens or ducts in the long climb to 20,000 feet. Unfortunately, the pilot had neglected to pull the alternate air control knobs upon entering the clouds after take-off as mandated in the owner's manual. When the dual engine failures occurred at such a high altitude, the difficulty in getting a restart (with alternate air selected) was compounded by the distinct possibility of a flooded start in the thin air. Contributing to this difficulty was controlling the airplane under these rather frightening circumstances. To the author's knowledge, this was the sole incident of this nature, and therefore, it did not warrant a redesign of the inlet ducts.

In 1969 the turbo-system C-310-P was introduced with a completely revamped engine cooling system, nose gear mounted vertically for a smoother taxiing, a ventral fin for improved directional stability, and a "pre-select" flap switch. Priced at \$65,950, there were 240 deliveries that year. This popularity continued with 130 C-T310 Q's in 1970, 290 units in 1971, 144 in 1972, 204 in 1973 and 260 in 1974. In this period the gross weight increased from 5,200 to 5,500 pounds. The C-T310 R series started in 1975 and ended in the 1981 model year. Over this period 1,331 units were delivered with only 40 units sold in that final year. The price in 1981 was \$219,850.

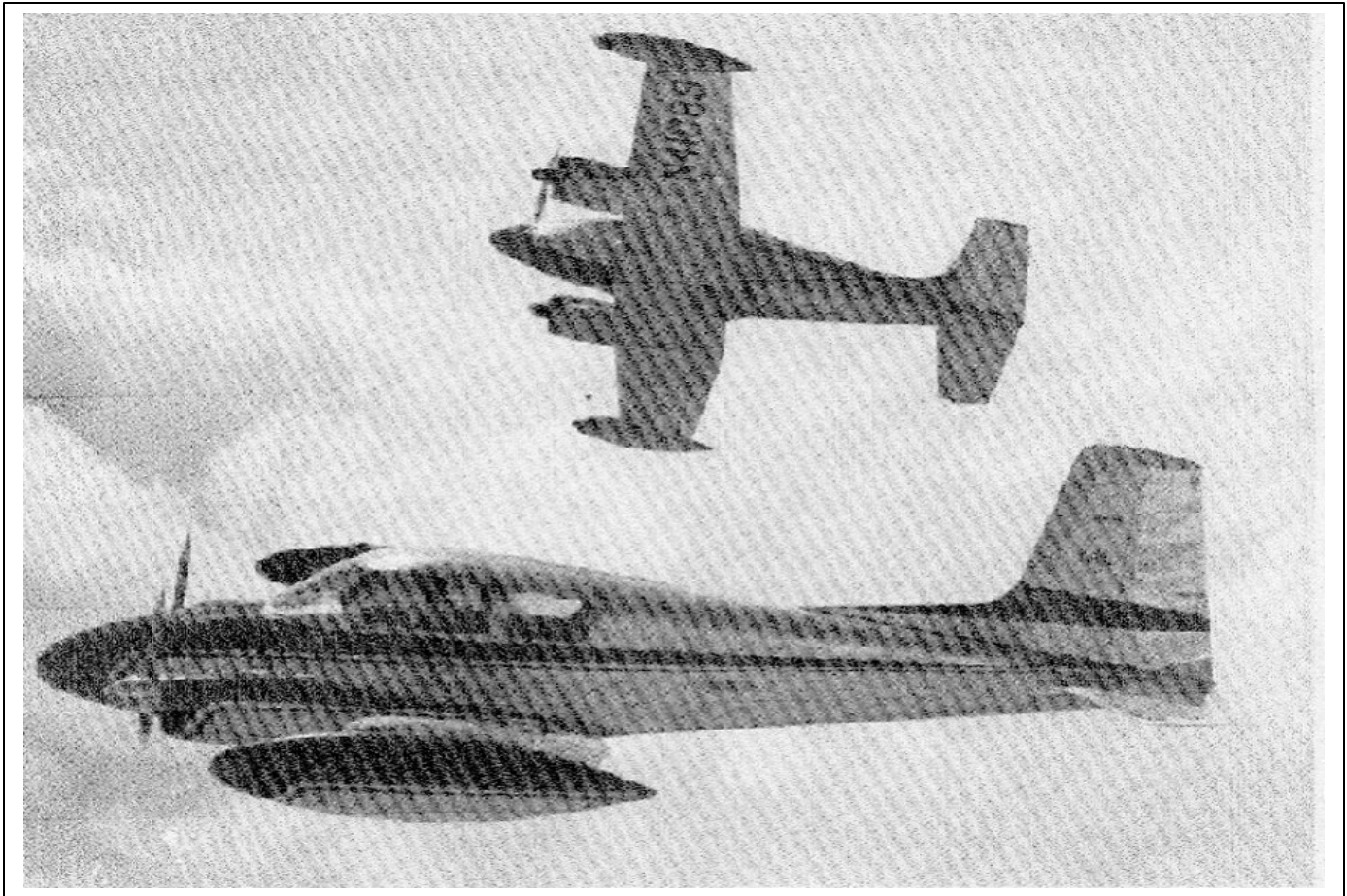
A summary of turbocharged C-310 series developments is presented on the following pages.

Cessna Wings for the World

MODEL YEAR	MODEL	T.O WEIGHT	BHP	BASIC CONFIGURATION AND SIGNIFICANT CHANGES
1962	320	4990	260	Similar to 310F except for turbocharged engines; nacelle; cabin height; and 0° stabilizer incidence .
1962	320-1	5200	260	Aft C. G. moved aft to 43.6' or 35% MAC; fwd. Gross moved forward to 38.0' or 25.8% MAC; fwd regardless increased to 4,300 lbs; added rudder centering spring.
1963	320-A	5200	260	Canted tip tanks; rudder-aileron interconnect spring removed.
1964	320-B	5200	260	Bagge nacelles added; 5 lb. bob wt. installation; flap travel reduced from 45° to 35°; up elevator reduced from 26 to 16.5°; now fwd; engine exhaust with inconel bellows & new stall vane location
1965	320-C	5200	260	Baggage compartment extended fwd in nacelles; working light moved to tip tanks & exhaust system revised.
1966	320-D	5200	285	Increased elev. Trim tab size & increased rudder travel from 29° to 34°. New cowl assy & new cowl flaps; engines canted 4"; nose down; installed 50 amp. Alternators; installed larger aux. tanks & new aux. tank vents; 15"; flap speed increased to 180 mph' bob weight changed to 10 lbs; and new downspring (1.5 lb/in)
1967	320-E	5300	285	New nose; one piece windshield; new weather window; new inst. Sub-panel; moved baggage door; softer gear; gear and flap speeds to 160 mph; incr. gross wt.; new ailerons.
1968	320-F	5300	285	Modified engine air intake system, new instrument panel layout; new circuit breaker panel; modified exhaust assembly; instrument panel white lightint; tip tank valves as standard. 9C-320 models were discontinued after S/N 320F0045 in 1968).
1969	T-310-P	5400	285	Basically a Model 310P with model 320F wings and engines. Added tip tank fuel transfer pumps mid-year.
1970-71	T-310-Q	5500	285	Increase mas gross wt. to 5,500 lbs. Incorporated the capacitance fuel measuring system. Relocated rotating beacon from fin tip to rudder.
1971	T-310-Q	5500	285	Paint only.
1972	T-310-Q	5500	285	New omni vision window; increased windshield area; glare shield change; relocate switches; alsohol windshield option.
1973	T-310-Q	5500	285	Teflon-coated landing gear strut bearings; new over-voltage relay and balancing circuits for alternator system; improved overboard exhaust stack coupling and redundant retention system; new integrated absolute and pressure ratio turbocharger controller - 63 gallon aux fuel option; yaw damper option; new paint.
1974	T-310-Q	5500	285	Airspeed change from MPH to knots; increase 15° flap speed to 160 KCAS; 35° flaps; and tear extension to 140 KCAS; new paint scheme; Safe Flight angle-of-attack indicator option; avionics bus installation.
1975	T-310-R	5500	285	Nose extended 32 inches; nose gear relocated 4" forward; new engine nose caps & cowl exits; Only one prop available for 1975 (3-bladed 78")
1976	T-310-R	5500	285	Installation of Cleveland wheels and brakes; placards and manual changes to comply with 1976GAMA format; low fuel warning lights; McCauley /ARC SP-105A propeller synchrophaser; 400B autopilot; low-voltage warning.
1977	T-310-R	5500	285	Improved wng locker and fuel tanks; flight into known icing; circuit breaker panel revised; max cruise power available at a lower RPM; changed fuel grade.

Cessna Wings for the World

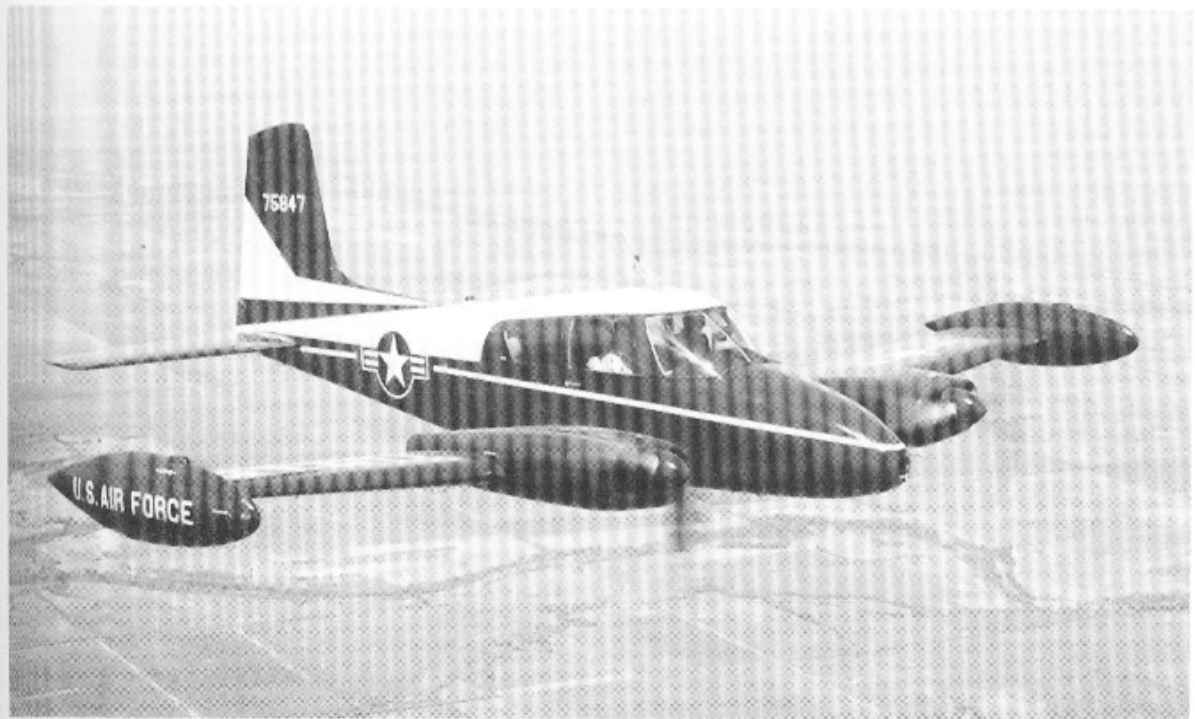
MODEL YEAR	MODEL	T.O WEIGHT	BHP	BASIC CONFIGURATION AND SIGNIFICANT CHANGES
1978	320	4990	285	Zero fuel wt. changed from 4,900 lbs. Added ramp weight 5,535 lbs.
1979	T-310-R	5500	285	Added elevator trim control guard. Incorporated FAA approved Flight Manual. Changed "Safe Single Engine Speed" to international "One Engine Inoperative Speed".
1980	T-310-R	5500	285	Tail Stinger improved to facilitate removal. Compliance with 1980 nose requirements; POH performance section changed pressure rates of climb to "True"
1981	T-310-R	5500	285	Threadless hub McCauley propellers replace the threaded hubprops. A landing gear speed limits placard was added near the gear control.
After a production run of 12 years, the Turbo 310 series was discontinued with the 1981 model serial number 310R214C				







U-3B (C-310E), 1961.



L-27A with straight vertical tail.