Homebuildin

David Howe's Harmon Rocket II comes awfully close

Jack Cox

LEE ANN ABRAMS

g Perfection?

During EAA AirVenture Oshkosh 2002, I stopped by to admire John Harmon's new Rocket III (see *EAA Sport Aviation*, July 2003), but before I could even begin to commend him for yet another work of aeronautical art, he exclaimed, "There's a Rocket here you've got to see. It's the nearest thing to a perfect airplane you'll ever see!"

Taking John's advice, I walked down the flight line in the direction he had indicated, but first encountered Dave Anders and his familiar "world's fastest RV-4," which was the Reserve Grand Champion Kit homebuilt at Oshkosh in 1992. He greeted me with, "Jack, you've got to see this Harmon Rocket a friend of mine built. It's just a tremendous piece of work."

Two such earnest, unsolicited recommendations from two of the homebuilt world's finest craftsmen—"Wow," I thought to myself, "This airplane must really be something!"

Over the next couple of days, in one of the most extensive interviews I've ever conducted, I learned that John and Dave were right on the mark: David Howe's Harmon Rocket II is indeed one of the closest reaches toward perfection in the art and science of aircraft homebuilding any of us have had the privilege of seeing and admiring.

PHIL HIGH

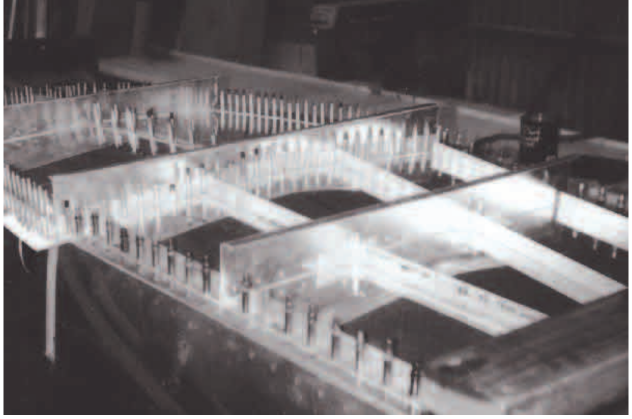
All homebuilts are a reflection of their builders to some extent, but rarely has one put as much of himself into a project as David Howe did in his N540HR. You have to know him to know the airplane.

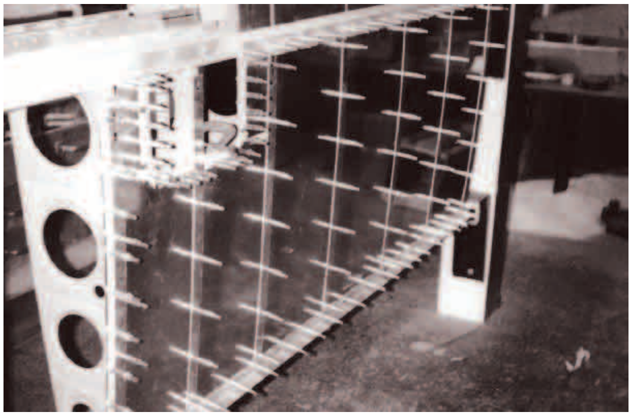
Genesis

David was born in Hanford, California, in 1949 and grew up nearby, just a few miles west of the Central Valley city of Visalia and in the shadow of the big Lemoore Naval Air Station (NAS). His family owns and has operated an irrigated farm operation there since 1931, growing cotton, feed grain, and hay. Called Westlake Farms, it encompasses 100 square miles—a rectangle four miles wide and 25 miles long. David attended area public schools and graduated from Lemoore High School in 1967. Then it was off to college at the University of California—Davis—with a rather unique send-off by his father.

"My dad, a very, very smart individual, always told my sister, brother, and me to make sure we studied something we were interested in because if we elected to come back to the farm, two things might happen. We might not like the job we would be given in the farm operation, or the farm might go broke, forcing us to seek employment elsewhere. In that event, he wanted us to be able to do something we enjoyed.

"As a kid, I was always in the farm shops. I always liked to build things. That





An exoskeleton sheet metal jig of the exact outside dimensions of all exterior surfaces was built first. Then, he built another with all the rivet holes precisely matched to those in the actual airframe that would be assembled inside. Top, the exoskeleton on belly skin while gluing to fuselage frame. Bottom, gluing lower outboard wing skin.

PHOTOS COURTESY DAVID HOWE

Is it a metal plane, or 'glass? Only the neat row of rivets gives it away.

PHIL HIGH

should have pointed me toward mechanical engineering, but as is often the case, I looked up to my older brother and, as a result, I followed him into civil engineering."

David graduated with a degree in civil engineering in 1972 and earned a master's degree in civil engineering, with construction management as his specialty, at Stanford University in 1973.

"My sister became a Harvard educated lawyer and my brother also earned engineering degrees at Stanford, but our dad still had a requirement my brother and I had to comply with before we could come back to the farm. We had to pass our registration exam and become licensed by the state of California as professional engineers. To take the eight-hour exam, you had to work for a registered engineer in your field for two years and get a written recommendation from him or her. So I worked for a water company in Fresno for two years, passed the exam in 1976, handed my registration to my dad and he said, 'Welcome aboard!'"

With 100 square miles in one contiguous block, Westlake Farms does not have to use public highways to move its farm equipment around. That allows the use of custom-built machinery much larger than would be allowed on the highways—and that has created a special niche in the farm's management for David Howe. He designs new farm machinery and takes it through the prototype, development, and manufacturing phases, which are done largely in-house. With so large an operation, Westlake Farms has its own fabrication, machine, and engine building shops—even a dynamometer shop. David also looks after the maintenance of the farm's equipment, and since 1983 has been the farm's purchasing agent.

Aviation has been an integral part of David's life literally since his birth. Aircraft from NAS Lemoore were always overhead, but closer to home, his uncle was a pilot and kept airplanes on the farm—a hobby that ultimately evolved into a corporate flight operation that over the years has made use of a number of airplanes, including a Beech Twin Bonanza and a Queen Air. A Cherokee 140 was kept on hand for daily aerial inspections of farm operations, and in 1973 it would become David's primary trainer.

"As soon as I soloed, I figured I had wasted about 15 years of my life. I loved to fly and, in fact, had 106 hours before I finally settled down long enough to get my private ticket. Later, my brother, myself and my cousin used the company Twin Bonanza to get our twin engine and instrument ratings and in the 1980s we flew a Baron we had acquired."

After learning to fly, another of David's personal traits came into play. "I've always liked to build things and I like to fly, so it was just a natural progression to homebuilding. My idea of true value is if you get some utility out of what you build, so building an airplane seemed like a good return on my investment because I knew I would enjoy both the building and the flying."

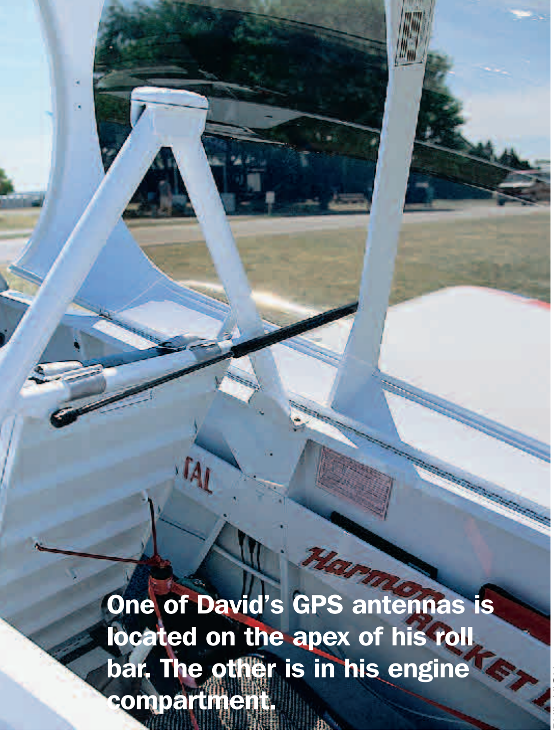
David's first homebuilt was an ultralight built from a kit produced in nearby Porterville. "I flew that for a time in the late 1970s, but with the state of development of converted snowmobile engines in use at the time, it finally dawned on me that I was subjecting myself to a level of exposure that didn't make any sense. I sold that airplane back to the manufacturer for use as a demonstrator, and then built a Volksplane. It was a cute little thing, and I enjoyed doing the woodwork involved, but I soon realized it didn't have the utility to get me out to the distance I wanted to go. With our farm as large as it was, I'd get out to the edge of the property and have to turn back to avoid running out of fuel!

"One day in 1985 I flew the Volksplane to a fly-in at Porterville and—I'll never forget it—while walking along the flight line, I saw an RV-3 with a builder's card that said it belonged to John Harmon. I went to school with a John Harmon, but I thought it couldn't be him. Later, I came back to the airplane and there he stood, the John Harmon I hadn't seen in 20 years. 'Hi Dave,' he said. 'Hi John,' I replied. 'Is this yours?' 'Yeah,' he said—and the rest is history. I've been involved with RVs and Harmon Rockets ever since.

"Another fellow I met that day would become a lifelong friend. Knox Nicholson had built one of the first RV-4s and it turned out that our backgrounds were remarkably similar. He went to UC—Davis, had a farm, and had the same attitudes toward life, work ethic, how you build and maintain things, and how you operate them. I began to talk to him that day and he said I had to get into his RV-4 to determine for myself whether or not the fit was right. I said I couldn't do that; there was a certain personalization about these things I didn't want to intrude upon. He insisted, however, so I reluctantly got in. He closed the canopy—and I ordered the plans the next day.

"Knox was building a second RV at the time, because, like all builders, we think we can do better on the next one. He took me under his wing and basically taught me how to be a metal craftsman during the construction of his second airplane. I got the benefit of his experience building his first and second RVs to apply to my project, so mine was like a third generation project on the first try. Later, I would discover Dave Anders, Keith Livingston, and Rod Bower, who were building their RVs together at Keith's house in Visalia, and they, too, became lifelong friends. The beauty of this experimental aviation community is that you meet like-minded people like these fellows, and you share your time, knowledge, and experience simply because you are friends. I've built parts for Dave Anders' Questair Venture racer at our shops on the farm, for example, and he shared with me the cooling and ram induction expertise he has developed—again, just because we're friends."

David began his RV-4 in January 1986 and completed it in November 1989. Powered by a Lycoming O-320-E2A converted to the D3G configuration to produce 160 hp and a Hartzell constant speed propeller, it incorporated a number of innovations, aimed primarily at enhancing safety and reliability. Dave Anders was the speed freak in his circle of aviation friends, but David's feeling was that



One of David's GPS antennas is located on the apex of his roll bar. The other is in his engine compartment.

PHIL HIGH

"if there's still a parking place on the ramp when I get where I'm going, I've gone fast enough."

David would ultimately put some 1,500 hours on his RV-4, which he still owns, but by 1993 he had already embarked on his second I-can-do-better project. "John Harmon followed up on his Rocket I with his two-place, IO-540 powered Rocket II, building it in just eight months. After we saw the performance of that airplane, all his friends threatened mayhem if he didn't kit it for us. He did and his prototype was Serial Number 001 and mine is 002.

"I didn't build my Rocket II in eight months. It took me nine years. My RV-4 project was where I learned how to build metal airplanes. The Rocket II was to see how far I could take my crafting ability. I'm a perfectionist, and I wanted to see how well I had learned the lessons with the RV-4, and how well I could apply them throughout the construction of the Rocket. I had my RV-4 to fly, so it didn't matter how long it took to build the Rocket. With it, I was trying to achieve a different goal."

Airframe

One of the main reasons it took so long to build the airplane was David's desire to make the exterior metal skins as smooth as humanly possible. Incredibly, he accomplished this by literally building the airframe exterior twice. The first was as an exoskeleton sheet metal jig of the exact outside dimensions of all exterior surfaces, with all the rivet holes precisely matched to those in the actual airframe that would be assembled inside. The second time was as the finished airframe!

Initially he bonded the entire airframe skins together using either 3M ScotchWeld 2216BA or Hysol EA-9430 structural adhesive—to clearances within the exoskeleton jig no greater than the thickness of the adhesive film—holding them together with Clecos. Once the adhesive had cured, he riveted the entire structure, taking great care to avoid deformation by driving or squeezing the rivets too tightly. Just the preparation of the rivet lines involved some 20 operational steps: the usual preparation for riveting—drilling, deburring, and dimpling the holes—plus chemically etching the surfaces to be bonded, taping the edges of the intended glue lines to capture the anticipated squeeze-out, applying the structural adhesive, then the final riveting. An added complication was his use of annealed rivets. Following a process described in a December 1987 *EAA Sport Aviation* article on Kit Sodergren's Midget Mustang and a March 1993 article on Dave Anders' RV-4, it involved heating aircraft rivets to 935°F for 15 minutes and immediately quenching them in cold water. That process softened the rivets, making them easy to drive or squeeze, but it had to be done quickly before they began to age harden.

Most of the rivets were back driven, which meant the gun or hand squeezer was inside structures and often in some very small spaces. David made his own yokes for the hand squeezer, with all manner of shapes and deep reaches to allow him to do the dimpling and to rivet in the small and awkward areas. Surprisingly, he made them out of the ordinary mild steel plate available at any hardware store—because as an engineer he knew the modulus of elasticity of A36 mild steel was just 7 percent less than the 4130 steel commonly used.

"I made my yokes for a tenth of the cost of commercially available units. They weren't pretty, but they did the same work, which was all I cared about. I even sold a few to other builders."

Throughout the airframe construction process, David made test coupons using samples from each glue batch and each batch of annealed rivets. The gluing process had been used primarily for cosmetics—for keeping the skins smooth—but testing of the glued and riveted coupons indicated a significant increase in structural integrity over baseline riveted-only coupons.

Another innovation was David's use of a double-sided, 3M adhesive tape to install transverse internal stiffeners in all the control surfaces—for added strength and to eliminate oil canning.

The Harmon Rocket utilizes much of the standard RV-4 kit, with John Harmon's custom parts to widen the fuselage from the rear seat forward and beef it up to allow use of a 6-cylinder Lycoming. Taller main gear legs made of titanium provide the necessary prop clearance. The RV-4 wing is used, but is shortened by 14 inches and has larger fuel tanks—to as much as 54 gallons. The RV-4 wings have .032-inch skins inboard and .025-inch skins outboard and the top skins are installed last. The Rocket II has a one-piece .032 top skin and .032 and .025 bottom skins, which are the last to be installed.

Engine

Reliability was David's top priority for his engine. He had LyCon in nearby Visalia build him a custom Lycoming IO-540-C4B5, but specified that it should remain a 2,000-hour engine. LyCon builds hopped up engines for air racers and aerobatic aircraft, but David wasn't interested in an engine that made gobs of power at the expense of longevity. His engine, therefore, remained stock except for balancing, ceramic coatings for the piston domes, and a mild cleanup or "flowing" of the intake system. Even so, it dynoed at 288 hp at 2,700 rpm, a significant increase over the engine's stock 260 hp. The standard Slick mags and Bendix fuel injection system were retained and the exhaust system John Harmon makes for the Rockets was used. A B&C starter, alternator, linear regulator, and battery were fitted, and a Hartzell constant speed propeller was selected to convert power to thrust.

The big change ahead of the firewall was the addition of one of Dave Anders' composite plenums over the cylinders and his tuned/rammed/filtered induction unit, the use of which required a major rebuild of the standard Rocket cowling.

"Dave Anders, his wife, Diane, and his father, Al, came to my shop and built the components for me. I was honored to have them do it, and I owe them more than I can ever repay other than friendship and my offer of assistance on their future projects."

In addition to being awarded Reserve Grand Champion Kit Homebuilt at EAA AirVenture '02, David was also honored with the Stan Dzik Memorial Award for Design Contribution for the plenum and ram induction system, and he feels his friend Dave Anders should get the credit.

David devised his own cockpit controllable door for the oil cooler. The Dave Anders' plenum is so efficient that more than adequate air is available for the cooler off the back of the number 5 cylinder. He also installed a fire suppression system—a 3-pound Halon bottle behind the radio stack with discharge nozzles on top of the cylinders and adjacent to the fuel injection servo. A one-pound Halon bottle was mounted in the front cockpit for electrical fires and two smoke hoods were stowed under access doors in the floorboards. In addition, a .020-inch stainless steel belly pan extending from the firewall to aft of the front seat was installed for added protection.

To know when to activate the fire suppression system at the opportune moment, David developed his own fire warning system utilizing military spec thermostatic switches that triggered at 350°F. Working through two unused channels on his Electronics International 6-probe EGT analyzer, he designed the circuitry so that, in the cockpit, two green lights show the system is armed and functioning and two red lights show 350° has been exceeded above and/or below the engine. To call attention to the warning lights, a 108-decibel horn sounds, which can be deactivated to allow the pilot to concentrate on dealing with the emergency.

This same visual and aural approach to out-of-limits conditions was taken to monitor low fuel, oil pressure, and voltage; the canopy locking mechanism; and the starter

For all its structural complexity, David's panel is fairly simple day/night VFR.

PHIL HIGH

energizing system (to guard against having the starter solenoid hang up and run down the battery).

"I know from experience with my RV-4 that you don't always notice warning lights right away, but you certainly hear the horn."

An Andair fuel selector valve was used, which has detents for left and right tank selection. "Off" can be selected only by first pulling up a spring-loaded button on the selection lever.

Instrumentation & Avionics

With all David's work on the engine systems, one might expect to look into the Rocket's cockpit and find state-of-the-art avionics, digital instrumentation, sumptuous leather-lined sidewalls and the like, but that's not the case.

"I've always liked Dick VanGrunsven's description of this class of airplanes as sport utility vehicles—sporty, but utilitarian in purpose and function. That's my philosophy, also, and as a result, the inside of my airplane is very simple. There are no upholstered sidewalls, no electronics in the dash that are not really required, from my perspective, as an adjunct to safety.

"The airplane is set up for day/night VFR and I have mostly analog 'steam gauges'—because I'm comfortable with them and I believe they are appropriate for the sport utility concept. I've flown behind King avionics for 30 years and trust them, so I equipped the Rocket with a KMD150 moving map GPS and a KLX 135A COM/GPS. I would have used a King transponder, but I simply ran out of panel room. I used a slim line UPS SL70 digital transponder instead."

Gene Evans, an industrial technology instructor at Kings River Community College in Reedley, California, assisted David in the manufacture of his backlighted, dimmable instrument panel. David designed and made drawings of the panel and Gene converted them to a software program to drive a CNC machine that made the panel. David also made a drawing showing the various labels for controls, switches, and instruments and had them silkscreened on the panel to produce a neat, professional appearance.

David built his own throttle quadrant, which has a cam that rolls over a microswitch allowing the canopy to be opened to an intermediate position for taxiing on hot days without setting off the warning horn. When the engine reaches 1,700 rpm, the canopy warning light/horn warning system is activated.

David designed and built his own 3-axes electric trim system using MAC servos to drive the tabs. The servos were mounted inside the control surfaces where they can't be seen and can't produce drag. The elevator trim is a two-stage system tied into the electric flaps. When the flaps come down for landing, the elevator trim is switched to fast operation; when they come up for cruise, the trim switches to slow operation. A 3-axes trim position indicator is installed in the cockpit.

The Rocket's COM antenna was mounted on the belly between the landing gear legs, and the transponder blade antenna was mounted on the belly just aft of the rear seat. One GPS antenna was mounted on the front side of the firewall under the fiberglass cowling (and works perfectly there) and the other atop the rollover structure inside the canopy. Rocket IIs do not have roll bars, relying instead on the high aft turtledeck to provide turnover protection, but David chose to install an RV-4 type roll bar in his airplane, both for added protection and something to grasp while getting in and out of the seats. He used slightly smaller outside diameter tubes, but with thicker walls than those used on RV-4s. The cockpit side rails were also beefed up with extra angle iron mounted underneath them, again mainly for hand support when getting in and out.

Toolboxes were built under each seat, with a polarized battery plug for the external power port (on the right side of the fuselage) stored in the rear toolbox. Map pockets were provided on the right side of the cockpit.

David designed and built his own control lock system, which consists of what he calls his "turkey wishbone" that pivots out from the back of the front seat and locks into the top of the rear seat stick by means of a little threaded knob. This holds the ailerons and elevators in the neutral position. When removed for flight, the "turkey wishbone" swings down and is secured with a clip on the back of the front seat. The rudder is locked by means of rubber-faced clamps that are attached to the rudder cables where they emerge into the cockpit at the base of the rear seat bulkhead. The clamps have long red "remove before flight" streamers that wrap around the rear stick and are velcroed together.

Because he planned to increase the height of his instrument panel by half an inch and straighten out the profile of the nose, David knew his canopy and its frame would be an entirely custom installation. To make the frame, he built steel jigs that conformed exactly to the altered cockpit configuration and had his friend, Henry Charest of Visalia, an expert aircraft welder, use them to weld the canopy frame. The bubble canopy was attached to the frame and skirts with Avex blind rivets. David formed the smoothly curved metal skirts and forward turtledeck skins on slip rollers available to him in the farm shops.

David relocated the canopy access handle further aft than on other Rocket IIs to put it within reach while standing on the ground, rather than having to step up on the wing.

For day/night VFR operations, David installed Whelen wingtip strobe/nav lights and landing lights in the wings. Following instructions in one of Tony Bingelis' books, he made male and female molds and formed the two Lexan lenses to fit the curvature of the Rocket's wing leading edges, then built frames much like those on Beech aircraft to hold them in place.

Because the Harmon Rocket II sits at such a relatively high angle of attack, David installed MAC servos behind each of the 55-watt Halogen lights to allow him to toggle them from the cockpit into the desired angle for taxi, takeoff, and landing. The landing lights have two functions—a flashing mode for recognition and a steady beam for taxi, takeoff, and landing operations. A little red light on the instrument panel blinks when the lights are in the flashing recognition mode and burns steadily when the lights are also burning steadily.

Needless to say, a system of circuit breakers protects all the lights, avionics, and light and aural warning systems.

Other than mounting the bubble canopy, the task most dreaded by RV and Rocket builders is sealing the fuel

A spike in the air inlet evens out the airflow for the induction system.

PHIL HIGH

tanks. To avoid getting Pro-Seal all over himself and the airplane, David taped around every Pro-Seal seam to catch any squeeze-out. To save money, he bought 1.5-ounce empty cartridges from the McMaster-Carr catalog, loaded them with just the amount of Pro-Seal he intended to

LEE ANN ABRAMS

use at a given time, then applied the goo with a $3.95 caulking gun he had modified to accept the smaller cartridges. All this took a lot of time and effort, but in the end it was simply a matter of pulling out the tapes—with no sticky mess to deal with.

As previously noted, David did not upholster the sidewalls of his cockpit—he painted them instead. All the instrumentation and avionics were removed and the fuselage was turned upside down so he could sit on a mechanics' rolling stool and spray up over his shoulder. The paint used on all the airframe parts was PPG's Concept acrylic urethane—white inside the cockpit and on the exterior surfaces, with red and blue trim. While the fuselage was upside down, the belly was painted and the wings and control surfaces were painted separately. The sides of the fuselage were painted last because of all the masking required for the trim stripes. David butted rather than overlapping the colors, so the masking was extensive and had to be painstakingly applied to avoid gaps. PPG Concept is a single stage paint—no clear coat—so a final slick finish required a lot of color sanding and buffing. The final touch was the application of gold pin-striping tape to separate and highlight the trim stripes.

David says he hates the painting process, but he turned out a beautiful job nevertheless.

The Rocket II project began in March 1993 and was finally completed early in 2002. The airplane was signed off on May 26 and the first flight took place the following day, May 27, David's birthday.

"Since I had 1,500 hours in my RV-4, the transition to the Rocket was nothing more than adjusting to a different nose position in flight. The Rocket is six inches shallower at the firewall than the RV-4, so the nose is significantly lower in view in climb, cruise and approach. It is very light on the controls, much quicker in roll than my RV-4. With the additional horsepower, it is faster, of course, and certainly has a lot more vertical performance. I'm really happy to have a 3,500 fpm rate of climb.

"The airplane weighs 1,295 pounds empty, which is about 100 pounds more than John Harmon's prototype. I paid a penalty for gluing the airframe together as well as riveting it, but I think it was worthwhile. The CG came out such that I literally cannot put enough weight in the aft baggage compartment, with my wife, Lindsey, myself, and full fuel, to fall out of the backside of the envelope, so I'm not sorry about the extra weight.

"I typically cruise at anywhere from 18 to 21 inches of manifold pressure and 2,130 to 2,300 rpm and get all the speed I want. To go faster would simply burn more expensive fuel. Like all the RVs and Rockets, it is smooth and coordinated in all axes. Just a great flying airplane."

A great flying airplane—and one of the most intensely personal and meticulously built airplanes ever to grace the skies, it is the product of a builder who knew precisely what he wanted and was willing to work to the limits of his skill, knowledge, and resources to complete it. He set out to please no one but himself—and succeeded magnificently.