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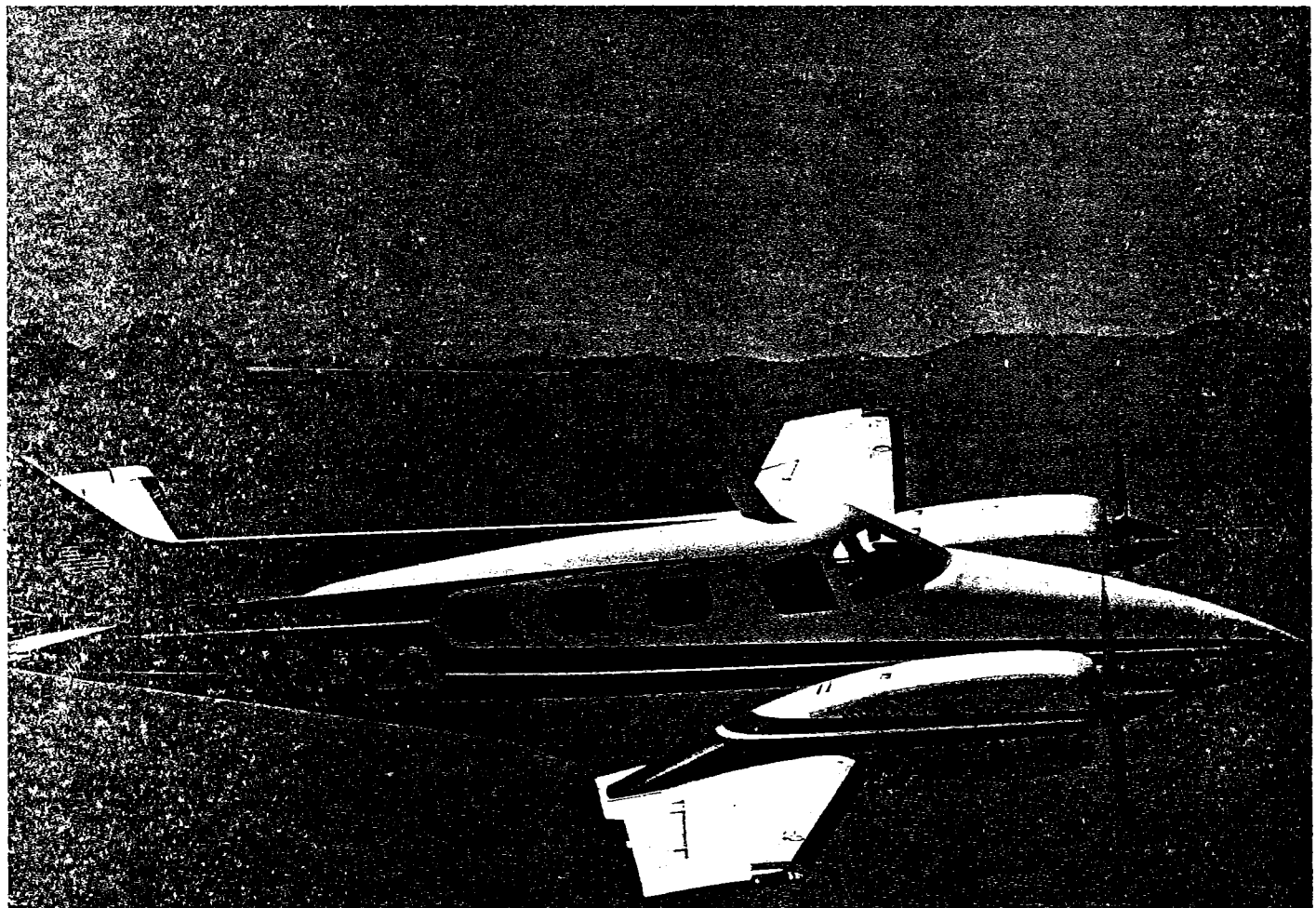


The Duke is Cool

The Future of Loran C

Favorite Fly-Out: Eskimo Country

Cool-Hand Duke Does it Better

Intercoolers Add Zip While Reducing the Sip

By Dennis Shattuck

When hangar talk swings around to big engines on small airplanes, the Beech Duke owner is one all participants hold in awe. The Duke driver holds the reins to two (2) 380-hp beauties in his fevered right hand.

The Duke's powerplants are awesome. . . both for their prodigious power output and for their high cost of overhaul. An overhaul can be a major investment; current prices for the TIO-541-E1C4 show a cost of $22,500 per engine, hopefully at the full TBO of 1600 hours. Only Lycoming's other big-bore boomer, the *geared* IGSO-540-B1A, costs more to overhaul, $24,000 each, and its TBO is rated at only 1200 hours.

Engine operating costs thus can be a matter of dollars as well as sense. So, when a company like American Aviation, Inc., offers a way to make that engine last longer and operate more efficiently at the same time, then it behooves the airplane owner to sit up and take notice.

AMERICAN AVIATION has developed a full intake air intercooler system for Beech Dukes that follows the pattern of systems it previously developed for Piper Navajos, Chieftains (AERO, December 1985) and Aerostar 601s.

It all has to do with heat. Specifically, the heat of the air being used to mix with fuel for the engine's combustion process. The hotter the air going into the combustion chambers, the less fuel it can carry along with it. The cooler the air, the more densely packed are the oxygen molecules, and the more fuel molecules that can ride along. More air + more fuel = more power. In essence, that's the principle of supercharging.

However, the very act of compressing the air to get more molecules of it into a given volume creates extra heat. So, while the supercharger is pumping in the air, compression heats it up and robs it of some of its effectiveness; it's a "Catch 22" situation.

THE ANSWER, as most engine engineers can tell us, is to reduce the temperature of that incoming compressed air. The easy way to do that is to route it through an intercooler after it leaves the compressor and before it reaches the intake duct. An intercooler is like the radiator on a car: whatever flows through it transfers heat to the finned metal tubes which in turn radiates the heat to the outside air rushing through the core. In the case of an aircraft intercooler, compressed air is pumped through the radiator instead of water, but the result is the same: heat is removed.

The Duke's twin intercoolers, one under each engine, can remove as much as 200°F heat from the intake air at the aircraft's service ceiling of 29,000 feet. At 5000 feet, the intake air still can be as much as 100°F cooler than that in a standard, non-cooled Duke.

REMEMBER HOW MUCH more power your airplane seemed to have last winter? The cooler, denser air carries more oxygen and fuel molecules, which in turn generate more power. Remember the last time you flew an airplane with carburetor heat? When you pulled out the carb heat control, engine power diminished. To understand what the intercooler does, think of carb heat in reverse: If your engine was running on hot air all the time, pushing in the control (routing the air through an intercooler) would suddenly give it more power!

Here are the advantages of cooler intake air in the Duke:

—More speed or power from the same amount of fuel.

—Shorter takeoff distance on hot days.

—Better climb rate; better climb on one engine.

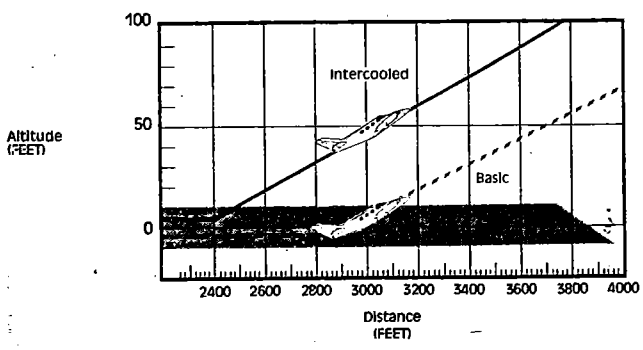
—Longer range.

—Reduced fuel consumption.

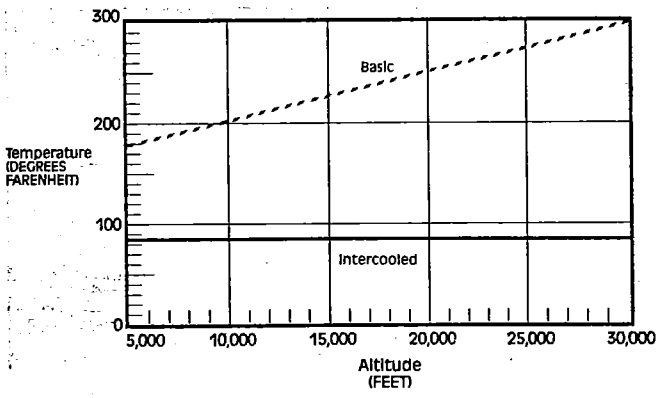
—Longer engine life.

The American Aviation, Inc., intercooler modification places hefty radia-

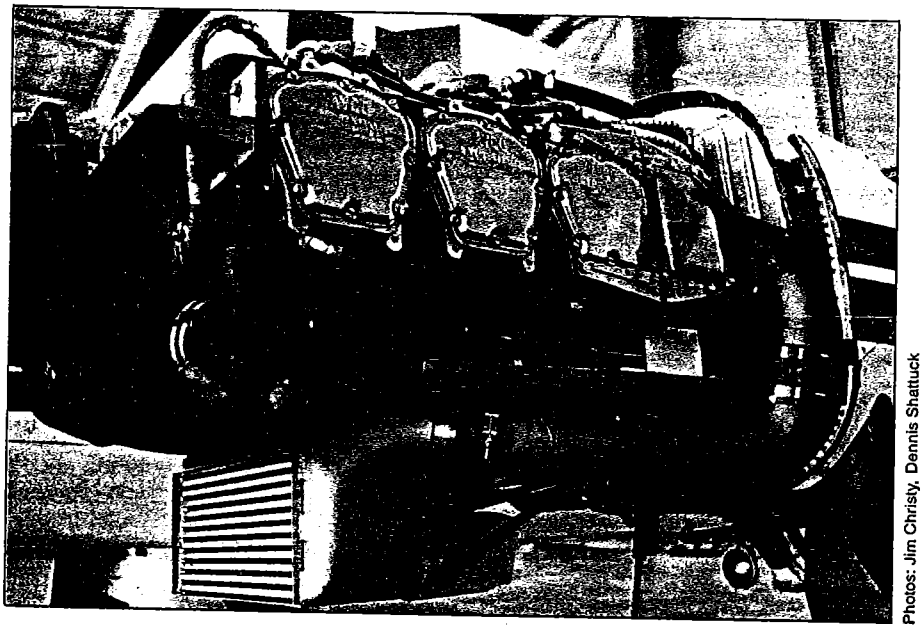
Takeoff Performance



Induction Air Temperature



Intercooled Beech Duke shows under-chin scoops that direct air to the radiators.



Photos: Jim Christy, Dennis Shattuck

Intercooler nestles up under the Duke's alternator, requires little additional space in the engine compartment.

Scoop under nacelle has neat, factory-installed appearance.

tors below the "chin" of the Duke's engine nacelles. The coolers nestle up under the bottom of the engines so that only small exterior scoops shows any sign of the change. The scoops sit in high pressure areas where they can force a constant supply of outside air through the radiators.

LONG TUBULAR ducts bring compressed, hot air from the turbo-supercharger mounted on the back of the engine and return cooled air back up to the throttle body mounted on the top of the engine. The installation is fully integrated into the layout of the big Lycoming engines with cadmium-plated and stainless steel components. AAI estimates that only .25 inch of manifold pressure is lost through the long ducting.

The chin scoops blend neatly into the bottom of the Duke's cowling and look as if they were aesthetically

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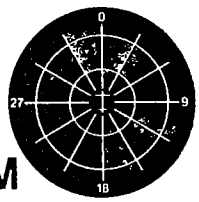

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placed there by the original designer. The aft end of the scoop carries an exit duct for air leaving the intercooler and the scoop terminates in the standard Beech cowl flap.

AERO was asked to sample the first intercooled Duke during one of Jim Christy's sales calls. Christy, vice president of marketing for the Spokane, Washington, based company, naturally was enthusiastic about the Duke's improved capabilities.

OUR DEMO PLAN was a maximum rate climb to 21,000 feet, sampling temperatures and performance along the way, then to try a hot-day takeoff at one of our local desert airstrips. We elected to climb to 21,000 because that's the critical altitude for the turbos and because it would keep us under the heavy airline traffic of the region. ATC cleared us direct to Flight Level 210 from the takeoff runway at 328 feet elevation, so we trundled out and thundered off.

The Duke flight manual called for a ground roll of more than 1900 feet at our 70°F ambient and slightly undergross conditions. With 4700 feet available, the space was more than adequate. However our roll used up only about 1500 feet before we broke ground just above the V_{MC} speed of 85 knots.

The Duke is a heavy airplane, 6775 pounds at gross, with small wing area, 213 sq. ft. area, so it takes all of that 760 horsepower to get it rolling down the runway. Once launched and cleaned up, it more than holds its own, so we stabilized the climb at 2750 fpm, 36.5 inches Hg manifold pressure, maximum continuous power, and climbed at 125 knots indicated airspeed. Our initial climb was 1700 feet per minute but that tapered to a steady 1400 fpm as we zipped through 17,000 feet. It held that rate to 21,000, which we reached in less than 14 minutes. Along the way we recorded a fuel burn of 200 pounds (33.3 gallons) per hour per engine, compressor outlet temperature of only 235 °F and an intercooler outlet temperature of only 95°F. Cylinder head temperatures were around 175°C and oil temp at 90°C. Duke was running cool despite its full-bore climb.

AT OUR FLIGHT level, we set up 2500 rpm and 32 inches for a typical high power cruise condition. Burning 128 pounds (21.33 gal.) per hour per engine, we watched the airspeed register 163 knots, for a true airspeed of 233 kt. The Beech handbook shows a TAS of 217 kt. under the same conditions, so we concluded that intercooled

Duke was showing an extra 16 kt. on slightly more fuel flow because the engine was deriving more power from the fuel. We could have throttled back to the book speed and shown a significantly smaller fuel flow and lower power settings. Compressor outlet temperature was 247°F and intercooler outlet air temp at 102°F. Head temps were 175°C and oil 80°F.

Throttling back for a more economical cruise, we set up 2450 and 30 inches for 157 KIAS and TAS of 223 kt., again 7 kt. faster than the chart, but on the same fuel flow of 116 pounds (19.33 gal.) per hour per engine. Compressor outlet temperature dropped to 235°F, intercooler outlet temp to 95°F. Cylinder head reading was 175°C and oil temp 80°C.

At our desert airstrip, we checked the takeoff charts for ground roll distance and found a requirement of 2607 feet for the 90°F ambient temperature; the go/no-go distance was more than 4000 ft. With 5000 feet of runway available, we pointed the nose and cranked the engines up to 2900 rpm each! Again the Duke surprised us with a takeoff significantly shorter than charted, easily less than 2000 feet. At the full 41 inches of manifold pressure available, the compressor outlet showed only 185°F and the intercooler outlet temp 120°F.

Christy explained that the intercooler actually can recover horsepower on a hot day by cooling the intake air back to the ambient. On a 90°F day, the compressor outlet temp of 185°F can be cooled back to 120°F, thereby reclaiming about 20 hp per engine. As the ambient goes up, the recovered horsepower increases.

From our brief demonstration, it would appear that intercoolers would be extremely valuable for a Duke owner operating in the hotter climes, as well as for the owner seeking more efficient performance through all the envelope. The added bonus is that running cooler air into the engine should help it live longer. (A check with sales listings in a trade journal showed the average life of a Duke engine between overhauls was 1278.5 hours).

American Aviation lists the intercooler conversion at $13,950 installed at one of a half-dozen centers around the U.S. So "right" for the Duke is the conversion the AAI sold 22 intercooler mods in the first two months after receiving the STC. □

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