# Pressurized Lightplanes

*Turbocharging techniques create new horizons for coming generation of faster, higher-flying general aviation aircraft, AOPA survey shows*

Of the many recent sales-inducing advancements made in the state of the general aviation art, two that are receiving the greatest attention from industry leaders are turbocharging and pressurization of lightplanes.

Turbocharging of light twin and high performance single-engine aircraft is a nicety that has hovered on the fringes of exploitation for several years. A major feature of some business aircraft modification organizations, it is intended to make lightplanes more useful by helping them to fly farther, faster and higher. But its potential has been retarded by lack of suitable pressurization and structural capability of many lighter aircraft to operate at the increased ceilings the turbocharged boost makes possible.

Introduction of the fully pressurized Mooney *Mustang* this year apparently has signalled the acceleration of a trend that experts predict will be adopted by all major general aviation airframe builders within the next few years. To determine how rapidly that trend may move, AOPA recently queried some of the firms currently engaged in or gearing for production of aircraft that incorporate the twin advances of turbocharging and pressurization.

Response to AOPA's questions indicates that turbocharging, coupled with cabin pressurization, will extend to more than a third of the light twin and high performance single-engine (from the *Bonanza* on up) planes within the next decade because of the improved utility it provides. Higher flying craft are hampered by only a small part of the bad weather of the solid IFR type, icing and similar problems that limit the usefulness of lower level operations.

Supercharging is a method of increasing manifold pressure above what it normally would be by heightening the supply of air to the cylinders. This results in the availability of increased engine power at all altitudes. Coupled with pressurization, it opens new high altitude vistas for general aviation.

Pilots of lower performance aircraft —four-place and smaller fixed gear, single-engine planes of less than 200 h.p.—will have to be content with their present operating limitations, however. Nearly every manufacturer agrees that it would be impractical and economically unfeasible to pressurize that type of plane.

Advantages of pressurized, turbocharged business planes are numerous and easily recognized. They open the door to sustained flight at the more efficient, safe and comfortable altitudes above 10,000 feet M.S.L. Speed can be increased easily by as much as 25% and range by a similar amount through the use of turbochargers. Flight altitudes of 15,000 to 20,000 feet—the most economical and practical for turbocharged aircraft—put the plane above most adverse weather and offer the most favorable wind currents.

Operationally, those advantages will necessitate significant re-education of the nonprofessional pilot. He will have to learn to descend with sufficient power to keep cylinder head temperatures at the proper level. Consequently, he'll have to plan farther ahead, starting his letdown from, say, 20,000 feet, about 150 miles from his destination. At the high speeds turbochargers make possible, he will have to be on constant guard for clear air turbulence. Before embarking on a flight in a pressurized, souped-up light aircraft, he should be thoroughly familiar with the effects of high altitudes on the plane's flight characteristics as well as with the use of oxygen as a backup for cabin pressurization.

Of perhaps greater importance will be the kind of weather watch the pilot will have to make en route and the content of preflight briefings. Because he


Mooney Mustang, heralded as first completely pressurized single-engine plane, features several innovations. One is upward opening door which allows greater freedom of entry and exit, helps to prevent pressure leakage



will be able to fly above most of the weather that is regarded as bad, he may have a 1,000-mile CAVU flight, only to have to let down under any variety of weather conditions at his terminal airport.

A greater knowledge of ignition system maintenance will have to be acquired so that the pilot will be better qualified to doublecheck repairs, to insure that he gets first class work. High altitude flying is unforgiving of wide plug gaps, cracked gaskets, or greasy fingerprints on functioning parts.

Within the next two years, Cessna, Beech and Piper all are expected to begin delivery of production line pressurized planes, because the industry believes the market is ready for such equipment—provided the price is right.

Aeronautical engineers for at least one company think they have found a primary key to the economic breakthrough. It lies in using the turbocharging system to provide satisfactory cabin pressurization. Still to be mastered, however, is the problem of retaining the better features of the present generation of light business planes—good visibility, ease of entry, comfort, reliability and comparatively reasonable price.

One of the problems that has hampered the advance of pressurizing by turbocharger has been that any appreciable reduction in throttle also affected cabin pressure. But a turbine developed by AiResearch now appears to have conquered that difficulty.

Structural design is a large ponderable on the path to pressurization. At the altitudes turbocharging makes possible, the question of pressure differential—the opposing atmospheric forces inside and outside the plane—is of prime significance. Intensive research into known cases of structural failure has shed much light on such matters as pressure surfaces, rate and nature of crack growth under pressure, and materials fatigue.

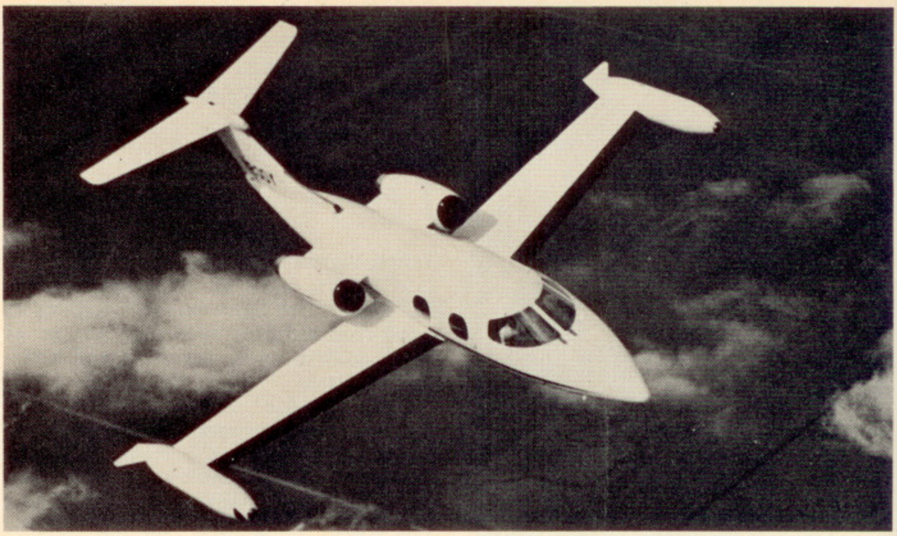
Federal Air Regulations—initially applied to transport category planes but extended to smaller models with the advent of such aircraft as the Lear Jet, the newer Aero Commander models, and the Beech *King Air*—set up definite structural requirements for pressurized cabins. They stipulate that the structure must resist a pressure differential of twice the normal operating outward or inward pressures with no other load forces applied. Regulations also require that the strength of the pressurized cabin structure be proved by one of two methods. One is to demonstrate fatigue strength by repeated variable loading tests that duplicate the predicted service life for the plane. The other is the "fail-safe" method—proof by analysis and or tests that catastrophic failure will not result from failure of any principal structural element.

Leading aerodynamicists indicate that full cabin pressurization of lightplanes will necessitate extensive modification of current airframe design and materials concepts. Pressurization, while allowing for higher, smoother, faster flight, will exact penalties in the form of increased net weight, decreased payload and added manufacturing costs. In order to provide a saleable product that will afford economy and a reasonable useful load, therefore, manufacturers and users will have to accept some compromises, in the opinion of Bernard Kreitzer of AiResearch Aviation Service.

Because pressure differential requirements of business aircraft will be less than those for heavier transport planes (perhaps on the order of 3.5 pounds per square inch which, at 18,000 feet, would be comparable to an altitude of 8,000 feet in nonpressurized craft), marked changes in airframe configurations are not anticipated by AiResearch. That firm thinks the greatest modifications will be made in pressure bulkheads, windows and doors.

In a talk last year, Kreitzer gave a thumbnail summary of what the pressurized lightplane of the immediate future might be like. Based on the current state of the art, he indicated that:

- It will be a four- to six-place plane whose turbocharger will provide both increased power at altitude and cabin pressurization.
- With a normal operating differential on the order of 3.5 psi, its fuselage will be of a multiple element primary



Lear Jet features the circular fuselage configuration that many aeronautical engineers believe will distinguish the coming generation of reciprocal-engine pressurized business planes. Most are expected to achieve pressurization as well as added speed through use of turbochargers

structure, with a stressed skin design of airline-type aluminum alloys and thin steel or titanium crack stoppers reinforcing points of potential pressure damage.

• Structural maintenance will not vary greatly from that of nonpressurized planes, except that there will be added special attention items—more frequent inspection of seals around doors, removal of service panels for signs of deterioration, checking of door lock mechanisms, control system rigging and general structure for any signs of detrimental damage or wear.

• Gross weight probably will be 6% to 12% higher than in nonpressurized aircraft if the same payload is maintained.

• Cost for pressurized models will probably be about 40% to 60% more than for their nonpressurized counterparts.

The general aviation industry, on the whole, is in agreement with E. J. Swearingen, president of Swearingen Aircraft in San Antonio, Tex., who said it is usually impractical to consider pressurization of the cabin of most present-day light aircraft. His firm is engaged primarily in the manufacture and installation of turbocharger systems.

In building a good pressurized lightplane, Swearingen said, several factors must be considered that do not apply in the design of low-altitude planes. The engine, for instance, must be capable of maintaining cruise horsepower at an altitude of at least 20,000 feet. Because cooling in that rarefied atmosphere is more difficult, better cooling systems must be devised. And too, the airframe structure must be so designed that it affords high pressure differential, yet gives an efficient ratio of empty weight to maximum gross weight. A pressurized lightplane may require some form of selectable drag, such as a speed brake, in the event pressurization fails and a rapid emergency letdown must be made. And, if the pressurized plane is to offer a true improvement in utility, it will have to be equipped to operate under a wide

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Beechcraft King Air, introduced last fall, was publicized as first production light twin to offer pressurized, turbine-powered features

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variation of climatic conditions, Swearingen believes.

He expressed concern that the forecast crop of pressurized, turbocharged aircraft may not have a great enough pressure differential.

"The average airplane manufacturer appears to assume that people will not want to operate higher than 18,000 to 20,000 feet," he said, "and have chosen pressure differentials . . . which they judge to be adequate for passenger comfort without oxygen at those altitudes. In reality, by turbo-supercharging they provide an airplane that is perfectly capable of operating at 30,000 feet."

Swearingen urged that lightplane pressurization capability be matched to maximum operating capability, but he sees, as the main problem to high and fast lightplane flight without oxygen, the lack of adequate weather forecasting and interpreting. While pressurization gives the pilot more flexibility, it exposes him to more problems such as greater icing, clear air turbulence, more severe thunderstorm turbulence and much stronger winds, he said.

Pressurization advantages, however —the ability to make rapid ascents and descents without passenger discomfort, to make 200- to 400-mile trips at higher, more efficient altitudes while maintaining the cabin at ground level —generously compensate for the few disadvantages and minor technical obstacles, Swearingen claimed. He predicted that within five years pressurized planes, priced at 20% to 30% more than the same nonpressurized versions, would make up the majority of total new four-place retractable and heavier general aviation models.

Actually, one criterion on which the industry appears to be basing its pressurization plans is that of Federal Air Regulations pertaining to Positive Control Airspace. For practical purposes, PCA encompasses all airspace above 24,000 feet MSL, and flight in that airspace requires an IFR flight plan. Plane builders regard the VFR pilot also as a potential customer for the pressurized plane.

Obed T. Wells (AOPA 200817), executive engineer at Cessna, agreed that the day of the single-engine pressurized plane is approaching, but he believes it will bring a drastically changed fuselage configuration. Today's models do not provide sufficient structure for concentrated loads that arise from pressurization, he said. As a result, excessive leakage is experienced and the danger of blown-out windows and windshields becomes serious even at the moderate amount of pressurization required to maintain a 5,000-foot cabin at 15,000 feet.

Pressure differential for that condition is about 4 psi. Applied to a door surface of 1,000 square inches, that means the hinges and latches must withstand a force of 4,000 pounds while still maintaining the proper seal. There are few if any current high performance lightplanes that could be economically and safely modified to accommodate pressures of that magnitude.

Several years ago, Cessna tried to modify a 310 fuselage to sustain a pressure differential of 3 psi. Short of unbelievably exorbitant cost, company engineers were unable to supply enough air to create that pressure. At about 1½ psi, air leaks around the door became severe, and distortion of the fuselage occurred.

Piper is one of the major airframe manufacturers that appears to be cautious about embracing pressurization as the coming thing, even though the company is readying for production in 18 to 24 months of a turbocharged light twin itself, designated the PA-31. Howard Piper (AOPA 97315), vice president of the firm, indicated that existing lightplane cabins could be effectively modified for pressurization, in the opinions of company engineers. But the cost, along with loss of cabin room and useful load, would make it far from desirable.

Involvements in operating pressurized aircraft may make the concept less attractive than it first seems, Piper said. Like turbocharging itself, it may not have as much customer appeal as seems to be expected. In any event, Piper believes that widespread adoption of pressurization through turbocharging still is too far in the future to speculate on how it may evolve.

Mooney Aircraft, the first major airframe manufacturer to come out with a pressurized lightplane, feels strongly that aircraft not specifically designed for pressurization are extremely difficult to convert safely. Its *Mustang* was planned and programmed through all phases of design to accomplish pressurization. It is offered at a cost of about 25% more than that of the nonpressurized Model 21.

In contrast to other manufacturers, Mooney officials believe that the demand for pressurized lightplanes already exists, and they point to a healthy backlog of orders for their *Mustang* as proof. They acknowledge, too, that pressurization nurtures a new degree of pilot capability.

"We are aware that the addition of pressurization in the turbo-supercharged engine puts the nonprofessional pilot in a new operational environment," said Ralph Harmon (AOPA 22880), Mooney vice president. "The pressurization system becomes a safety device instead of just another air ventilation system; therefore, the pilot must be capable of planning more accurately and reacting with proper corrective action in emergencies involving it."

The consensus of these comments from the industry would indicate that turbocharging and pressurization of the more sophisticated single-engine and twin-engine general aviation aircraft is moving into a definite growth trend. But the ultimate proof of that indication remains to be borne out by the market. ●