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Experimental Aircraft And Powerplant Newsforum For Designers And Builders

Pulsar: an airplane for top economy and performance

Mark Brown
Aero Designs, Inc.
635 Blakely
San Antonio Texas 78209
(512) 650 3398

If you love to fly and enjoy building things with your hands there's just nothing quite as exciting as building your own airplane. The thrill of that first flight and the years of freedom that follow are just not available from an airplane factory. You simply can't buy a sleek, efficient sport plane off the production line. You also can't buy the comfort of knowing your aircraft inside out and having the freedom to work on it any time you want, customizing those details you choose. If you want a sleek new airplane that handles like a fine sports car in three dimensions, you'll just have to build it yourself.

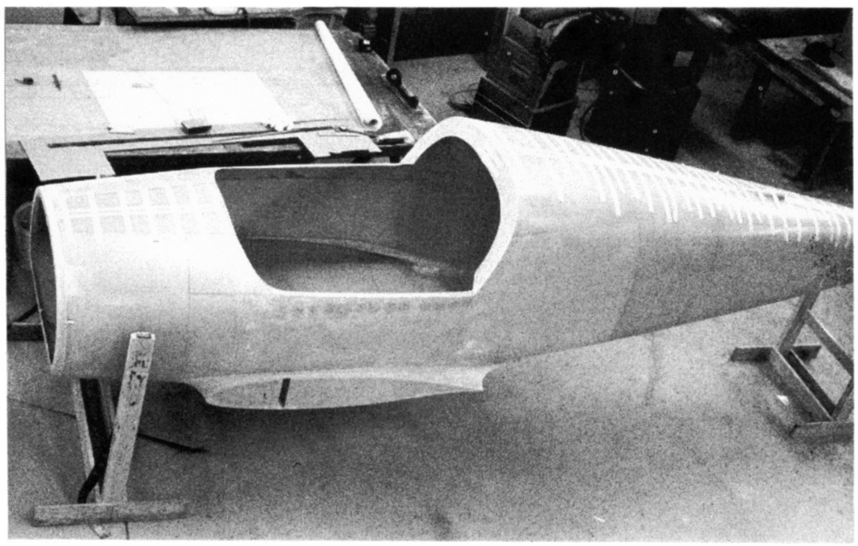
That's well and good, you say, but you don't have seven years of spare time to build from scratch or the price of a new house for the kit you like. Well, let us introduce the Pulsar. We've broken the build-time barrier with a top quality, premolded kit and we've controlled the cost by keeping it simple. It doesn't have a six cylinder engine Lycoming or a disappearing landing gear and lots of bells and whistles. But if you fly for fun then you've found the way: the Pulsar.

THE DESIGN

Aircraft design textbooks always start off with the same obvious (because it's important) point. Every airplane is a compromise. If you want to go faster you sacrifice some wing area and raise the stall speed. If you still want to go faster you get a bigger engine and sacrifice economy. If you try to get it all you'll get a disappointment. The Pulsar doesn't violate these rules but it has one thing going that gains a plus in every area. It is light weight. That factor allows it to go faster with less wing area and keep a slow stall speed. Also, it allows the Pulsar outstanding maneuverability with light responsive controls while maintaining exceptional hands off stability. Other benefits of the light weight design are exceptional takeoff and climb performance and realistic (15 minute assembly) trailerability. Weight is such a big factor in the quality of an airplane that it's the best measure of good engineering. Beyond this key factor the Pulsar is backed by 15 years of professional engineering analysis and testing. All primary structure meets FAR Part 23 design requirements and all joints are designed to a minimum margin of safety of 2.0.

THE STRUCTURE

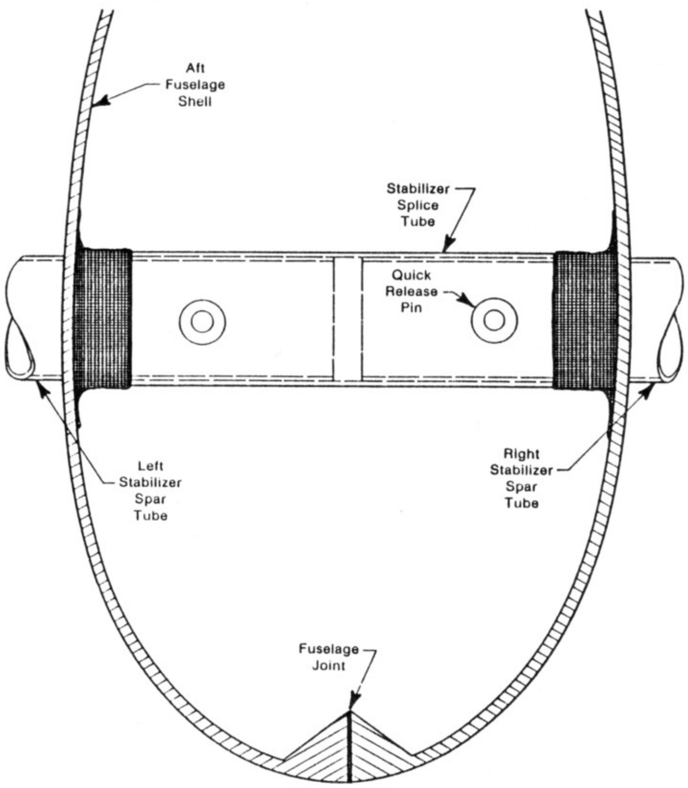
The majority of the Pulsar structure is a top quality premolded sandwich made with prepreg glass skins and a structural foam core. The skin material is called "prepreg" because the glass cloth is pre-impregnated with high temperature epoxy resin and then quick frozen for shipment and storage. The advantage of prepreg is that the quantity and distribution of resin throughout the cloth is precisely controlled to eliminate excess weight and provide a guaranteed strength to the finished part. In fact, prepreg composites are so reliable in strength and durable in service that they are certified by the FAA for use in commercial airliners.



The two vertical halves of the fuselage are joined at the centerline using several notched spreader sticks. These simple props bring the halves together accurately, eliminating messy lap joints and misalignment.

All Pulsar premolded structures consist of single layer faces of 9 oz 7781 style prepreg "C" glass with a 3/16 inch core of Klegecell Type 75 foam of four pound density certified to FAR Part 25. Parts are laid up, vacuum bagged, and cured at 250 degrees F. for one hour in an electric oven. Heating and cooling times are automatically controlled, duplicating certified processes used on the Boeing 757 and 767.

Composite parts made with prepreg also have a great advantage in thermal stability. Since the high temp resin is oven cured during manufacture of Pulsar kit components, the parts won't warp or distort below the oven curing temperatures. This type of structure also has very good fatigue properties. At the design load levels present in the Pulsar, the fatigue life is technically infinite.



Cross section showing large area fuselage joint and tube-in-tube method of attaching hortizontal tail surfaces. Note generous application of epoxy/cloth tape to secure stabilizer splice tube.

Damage tolerance is a big advantage of composite airplanes in general. The tough resilient outside skin supported by the stiff inner foam core will resist denting better than .040 aluminum. Even if a dent or puncture is sustained it is easily repaired. A composite airplane has a technically unlimited life span when protected from ultraviolet radiation with carbon black primer under the paint. It is not affected by the sun, rain, salt water or most chemicals. In fact, composite materials are used in acid vats.

Composite airplanes in general do not have a reputation of being particularly light weight. That's because some types of composite materials are 70 percent resin. Since most of the strength of a composite structure is due to the fiberglass excess resin is just dead weight. Also, a composite part made with the imperfect moldless process requires a great quantity of body filler which adds considerable useless weight. The light weight of a Pulsar airplane is a direct result of using the most advanced composite materials and processes available today. This process insures an exact 44 percent resin content to provide the highest strength to weight ratio possible.

CONSTRUCTION

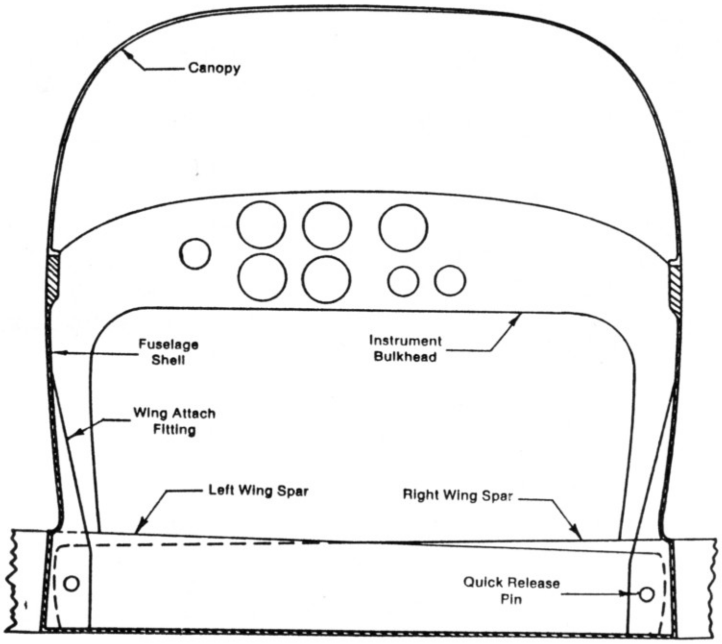
The Pulsar was designed to be as fun and easy to build as it is to fly. First of all, every part that you need to build a Pulsar is included in the kit. Only the paint and upholstery is left to the builder's preference. Even the cups to mix the epoxy are included. Second, all parts that require special tools or skills to make are prefabricated. No welding, machining or shaping is required. The control system is ready to install and all hardware is included and identified. Best of all, the Pulsar is simple. It just doesn't have any complex systems or close tolerance structure.

Also, the kit comes with very detailed plain language Construction Manuals (CM) with pictures on virtually every page. Nothing is left to the builder's imagination. The fuselage CM, which also covers the tail surfaces, contains 110 pages and 89 illustrations. The wing CM contains 133 and 119 items, respectively. The engine installation Manual has 68 pages and 36 sketches. Each Manual has a complete parts list. Unlike half tone photos with a maze of confusing detail, the sketches clearly support the text instructions.

All the premolded composite parts are made with an internal joining flange so no wet lay-ups of fiberglass are required. The inherent stiffness of the composite structure along with the molded flange eliminates the need for assembly jigs because the shell maintains its own shape. Structural adhesive is simply spread on the flange and the parts are held together with tape until cured. The resulting joint is 5 times stronger than the basic shell and designed to be 10 times stronger than required for ultimate flight loads. All important information is premarked on the shells so measuring mistakes are eliminated.

The only internal structures in the fuselage are the bulkheads which support the tail, the landing gear, the wing and the pilots. These bulkheads are cut from a flat sheet of composite using full size patterns supplied in the kit. An ordinary hand held saber saw cuts this sheet very easily and quickly. The bulkheads are bonded into the fuselage with fillets of epoxy and glass tape to form a very strong continuous structure. Attach points for the wings and landing gear are reinforced by embedding aluminum plates in the bulkhead structure.

The engine installation is greatly simplified by the design of the unique integral engine mount. The



Cockpit cross section at the instrument panel bulkhead. Note the overlapping main spar stubs and quick release pin locations.

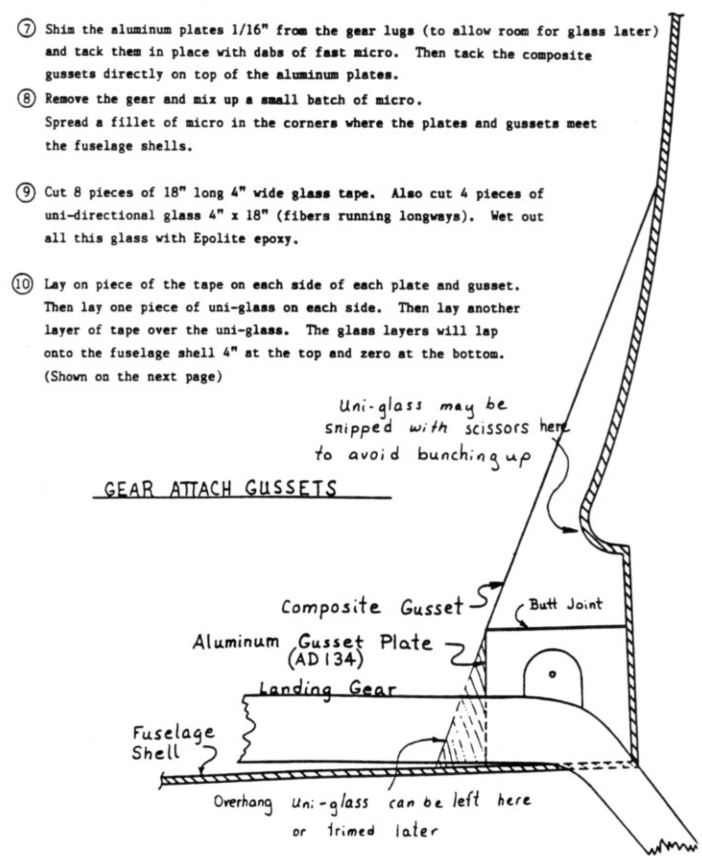
lower half of the cowling is incorporated in the fuselage structure during the molding process. This arrangement forms a true bed mount for the engine when completed by the builder. Essentially, two cross beams are bonded in place and the engine is shock mounted to these cross beams. The typical welded truss style engine mount and its cost is eliminated. The result is a simple, light weight, strong, and buildable engine mount structure. This unique design is another example of the cost effective simplicity of the Pulsar.

The cowl mounted gravity fuel tank is equally simple and efficient. The flat sandwich composite material is used to form the bottom, front and back of the tank while the fuselage shell itself forms the sides and top of the tank. The sandwich composite material in the fuselage and flat panels is fuel proof and fire proof. In addition to this, the tank is sealed with "KREEM" motorcycle tank sealant to guarantee a perfect permanent tank. The fuel filler cap is bonded and sealed into the top of the fuselage. The fittings for the instrument panel sight tube type fuel gage are also bonded and sealed into the tank.

The forward opening canopy is another uniquely simple feature of the Pulsar. The canopy is premolded and trimmed so that the canopy is a guaranteed accurate fit to the fuselage. When the canopy is bonded and glassed to the composite frame it forms a solid unit. The assembly rolls forward on three tracks embedded in the fuselage shell. Unlike most canopies which have four points of contact which inherently bind, the three point system is free and smooth in operation. Think of a four legged stool on an uneven floor as compared to a stool with three legs. Closure is secured by restraint hooks at the front, alignment pins at the rear, and a single positive latch.

LANDING GEAR

The main landing gear in the kit is a one piece composite spring design consisting of a foam core armature and an unidirectional fiberglass outer structural shell. Twenty layers of 24 oz A-260 style prepreg cloth (about .5 inch thick) are applied to the surfaces of the 3/4 inch 4 pound density Klegecell foam core and oven cured. Shear loads are managed by the unidirectional glass layups eliminating the additional manufacturing steps needed for bidirectional shear wrapping. The main gear attaches to the fuselage shell through ears that are glassed by the builder onto the gear. This type of gear design is very flexible so it absorbs normal bumps easily but it is also extremely strong so that it can deflect almost flat if necessary to absorb emergency loads.



⑦ Shim the aluminum plates 1/16" from the gear lugs (to allow room for glass later) and tack them in place with dabs of fast micro. Then tack the composite gussets directly on top of the aluminum plates.

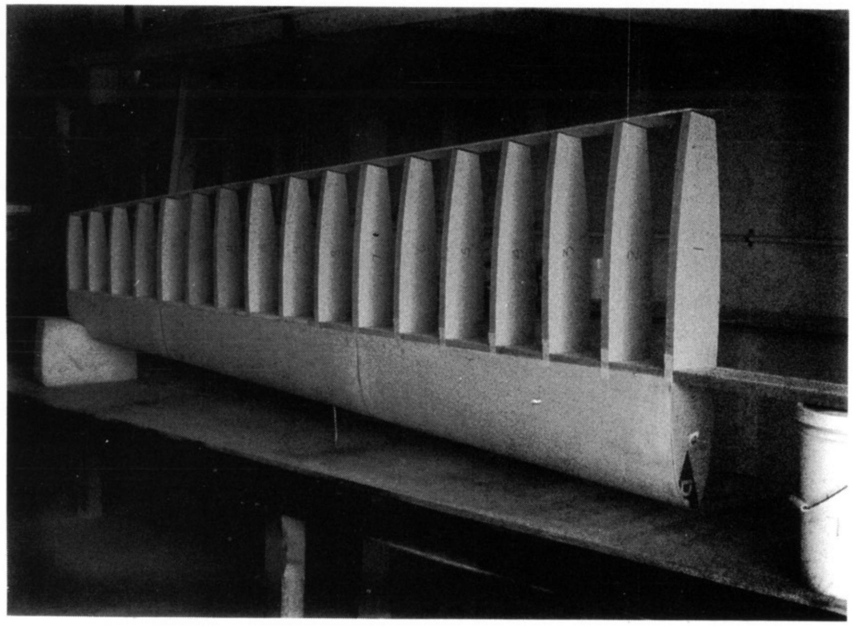
⑧ Remove the gear and mix up a small batch of micro.
Spread a fillet of micro in the corners where the plates and gussets meet the fuselage shells.

⑨ Cut 8 pieces of 18" long 4" wide glass tape. Also cut 4 pieces of uni-directional glass 4" x 18" (fibers running longways). Wet out all this glass with Epolite epoxy.

⑩ Lay on piece of the tape on each side of each plate and gusset. Then lay one piece of uni-glass on each side. Then lay another layer of tape over the uni-glass. The glass layers will lap onto the fuselage shell 4" at the top and zero at the bottom. (Shown on the next page)

Exerpt from page 48 of fuselage CM (greatly reduced!) detailing fabrication of gear attach gussets. Typical of Pulsar instructions accompanying text.

The nose gear and its support structure is fabricated from 4130 steel, heat treated, cadmium plated and reheated to eliminate hydrogen embrittlement. The design is simple, sturdy, and rugged in use.

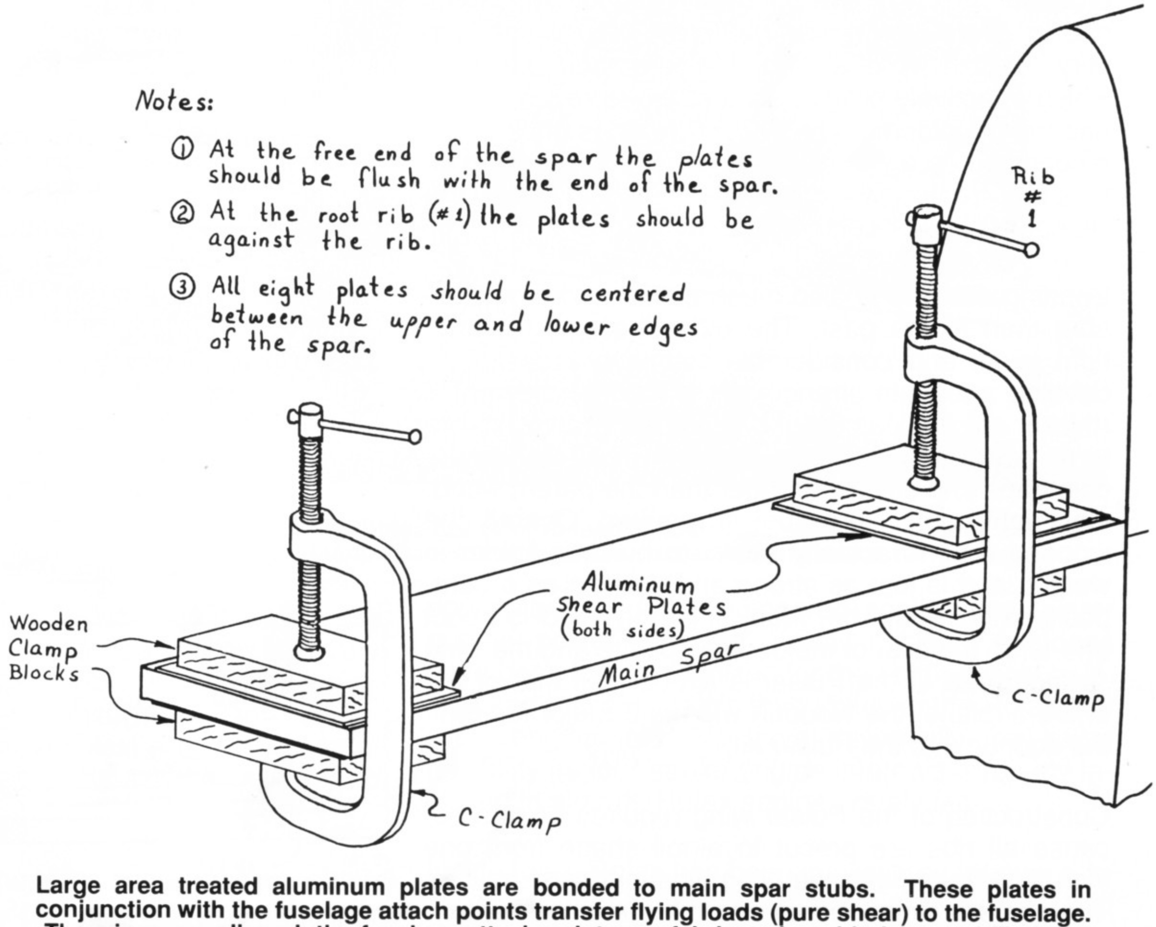


Self-jigging design of the Pulsar wing. Precut foam ribs are placed on the prefabricated main spar and glued. Wing washout is maintained by this method. Wing spar stub extends beyond rib #1.

THE WING

The only major airframe component of the Pulsar that isn't premolded glass/foam composite is the wing. It departs from the premolded concept for reasons of weight, complexity, and cost. It's made from the most advanced and complex composite of all: wood. That's right, nature's matrix of unidirectional fibers and interlocking cell structure make wood a natural composite. Even though it has been largely overlooked in recent years due to the excitement over man-made material, wood remains one of the most efficient materials ever created. It has been proven in aircraft all the way from the Wright Flyer to the sleek Falco. Of course, for compound curves like the Pulsar fuselage, wood is rather difficult to form, so the molded composites are preferred. But for a flat wrap application, like wing skin, plywood is ideal. It's unsurpassed in ease of bonding and workability and has a cost advantage of ten to one over molded composites.

Most people think that modern composite are stronger than wood but in the case of a wing skin where the primary load is shear, wood is equal to fiberglass composite for the same weight. Glass is four times stronger but also four times heavier so the strength to weight ratio is identical. Wood is also very efficient for pure bending applications like wing spars if the wing loading is fairly low. However, for greater load inten- sities, unidirectional fiberglass is more efficient. The Pulsar uses a unique combination of both materials for very strong,



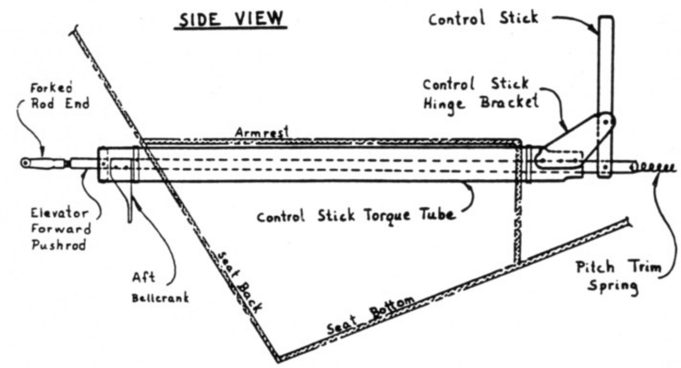
Large area treated aluminum plates are bonded to main spar stubs. These plates in conjunction with the fuselage attach points transfer flying loads (pure shear) to the fuselage. The wings are aligned, the fuselage attach points are fabricated, and holes are drilled and reamed for the two wing attach bolts. This design approach is used in many sailplanes.

light weight spars. The basic spar is prefabricated from certified aircraft grade Sitka spruce because of its light weight, flexibility and outstanding bonding characteristics. The main spars have tapered 24 oz A-260 style unidirectional fiberglass spar caps bonded to the wood to take the higher load intensity. The upper cap is .3 of an inch at the wing root; the lower cap is .25. These glass caps are cut from high strength pressure cured laminations and post bonded to the wood spars at the factory. These are then faced with bidirectional 7781 glass for additional shear strength properties.

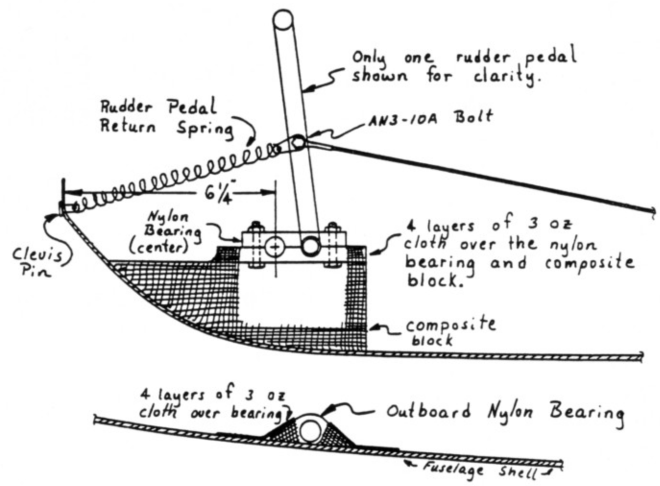
Since wood is about four times more flexible than fiberglass composites and ten times more flexible than aluminum, a wooden wing provides a very smooth ride through bumpy air. However, up until a few years ago no paint was available that would flex with wood. The resulting cracks in the finish exposed the wood to its only natural enemy, moisture. Many older planes experienced this problem and suffered what is commonly called "dry-rot". This term is somewhat misleading because the spores that deteriorate wood are only activated when the wood is wet for an extended time. Then once the spores become active they will continue to attack the wood even after the wood is dried out. Labeled with this problem of "dry-rot", wood lost a lot of support for its use in aircraft. However, with the development of very flexible finishes like polyurethane enamels which effectively protect against moisture absorbers and the development of "dry-rot" wood is once again recognized as an efficient aircraft structural material. Properly treated wood structures should equal the life span of other composite materials.

Bonding of wood is also much easier and more reliable than in the past. The old adhesives required tight joints and considerable clamping pressure to develop adequate strength. With modern thixotropic (thickened) epoxies sound joints are not so difficult to achieve because these epoxies will fill the minuscule gaps and still be stronger than the parent wood. Only light contact pressure is required. Overall, the wooden wing is actually easier to build, is lighter in weight, and is just as strong and durable as a composite wing would be. Also, since plywood is about one-tenth the cost of molded composite and the wing surface area of the Pulsar is almost half that of the entire airplane, the wooden wing is a major factor in the economy of the Pulsar kit.

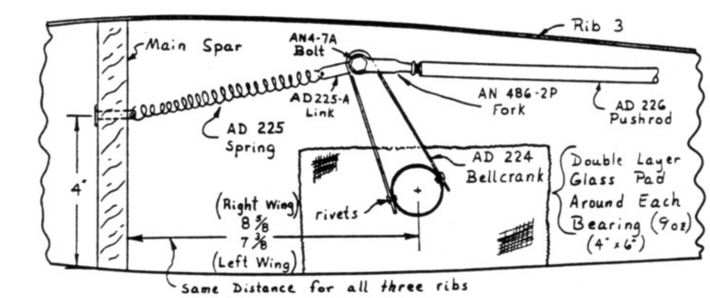
Construction of the Pulsar wing requires no jigs because all ribs are precut to airfoil shape from one inch thick foam with the wing washout twist built in. The ribs are simply bonded to the spars with epoxy. Then one-sixteenth inch birch plywood panels are

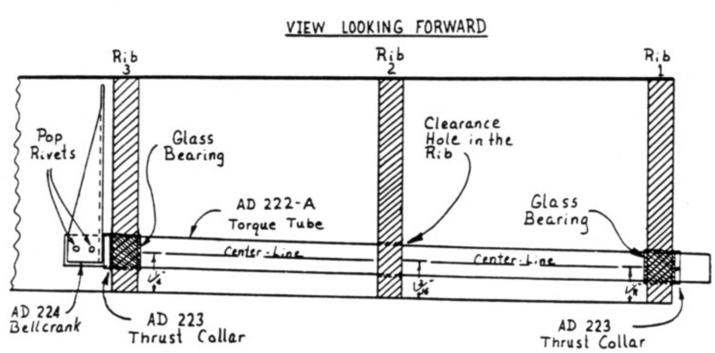


Central control stick assembly. Pushrod to elevators; bell-crank to ailerons. Note pitch trim spring and built-in armrest for pilot comfort and precision.

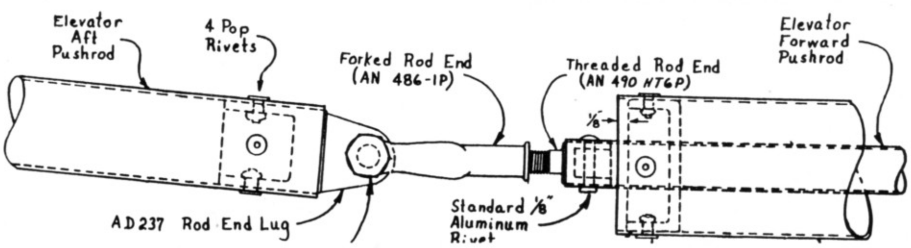


Welded rudder pedal assembly mounting to floor of airframe. Design allows for custom location and pedal angle to accommodate most people.





Inboard view (top sketch) of flap operating bell crank. Note use of "glass" bearings in forward view (bottom).



Detail of elevator push rod connection to central control column assembly. Aileron bell crank not shown.

bonded to the spars and ribs. Since the plywood is thin, it wraps around the nose of the ribs very easily. The 8 inch rib spacing and wide rib surfaces provide such solid support that the finished wing contour is very smooth. After four coats of primer-surfacer and one coat of polyurethane enamel, most people will assume that you have a glass wing.

The Pulsar wing design incorporates a simple, high strength system of wing attachment that allows wing detachment in less than ten minutes for realistic trailering. The builder, following instructions in the manual, bonds and glasses aluminum plates to the wing spars and fuselage shell. During the initial wing alignment and assembly to the fuselage, the plates are step drilled and reamed for 5/8 inch shear pins thus establishing permanent alignment. Since the spars of each wing overlap the entire width of the fuselage all of the wing bending loads are reacted through the shear pins. About a half hour is required to complete each hole (2 total). Rear spar joints are similarly machined to accommodate AN-4 attachment bolts. This wing attach system is so simple and reliable that it has been used for many years in sailplanes which are routinely disassembled and often stored in their trailers. Designed to FAA bearing margins of safety (M.S. 10.0) the assembly shows no wear after 400 hours and four years of flying under some rather strenuous conditions. The pin joints are performing as intended by design analysis.

We should mention here that we found, after extensive comparative testing, that Epolite 2315 has outstanding capabilities with respect to aluminum to glass bonds, a factor of five improvement over our previously specified resin. This increase enabled us to reduce the amount of aluminum plate surface area fittings while maintaining design structural integrity. All aluminum parts in the Pulsar kit are post treated using the PAA (Phosphoric Acid Anodize) MIL-A-83377B ARP 1524 aluminum treatment process to maximize shear and anti-corrosion capabilities.

Among the several innovations included in this design, the Pulsar features a simple, safe solution for protruding pitots; the 1/4 inch diameter pitot tube has a short length rubber hose splice which springs aside when contacted.

TAIL SURFACES

The horizontal and vertical stabilizers are premolded in two parts like the fuselage and are assembled by the same simple flange method. The vertical stabilizer is bonded and glassed directly to the fuselage. Each horizontal stabilizer is bonded to an aluminum spar tube which then slides into a splice tube bonded into the fuselage. This design permits the quick removal of the horizontal stabilizers for trailering if your trailer doesn't accommodate the overall 94 inch width.

ECONOMICS

Every active pilot who pays his own way struggles with the astronomical cost of general aviation. In fact, this problem is the driving force behind the kitplane market. The Pulsar solution attacks every element of the cost barrier simultaneously. First of all, the certified engine problem; a used Lycoming or Continental engine can easily cost as much as a completed Pulsar. Even the overhaul of these engines can be several thousand dollars.

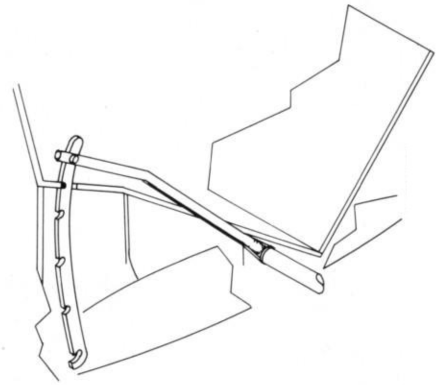
Hangar rent alone could pay for a Pulsar in just a few years. Instead, you can bring your airplane home with you on an inexpensive boat trailer and have the additional convenience of working on it and pre-flighting it in your own garage. In fact, you'll eliminate another major fixed expense by doing your own maintenance and inspections. You will save several hundred dollars a year when you perform your own annual inspection and more by doing your own routine maintenance. Of course, the recommended use of unleaded auto fuel will increase your flying budget.

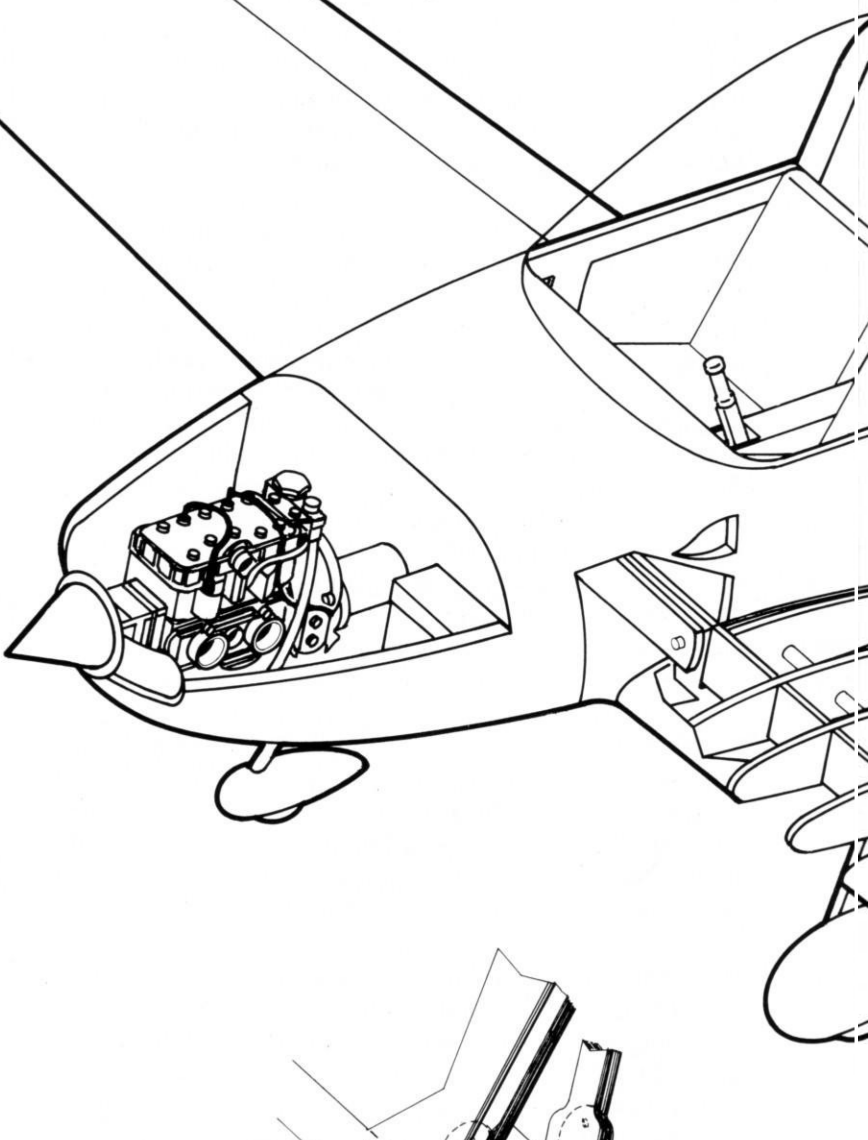
Operating cost for a Pulsar will average about half that of most two place airplanes with similar performance. At economy cruise the Rotax will burn as little as 3.8 gallons an hour. Of course, there is no oil to change; tires and brakes will last for years on such a light weight airplane. Considering all these factors together the Pulsar truly breaks the cost barrier.

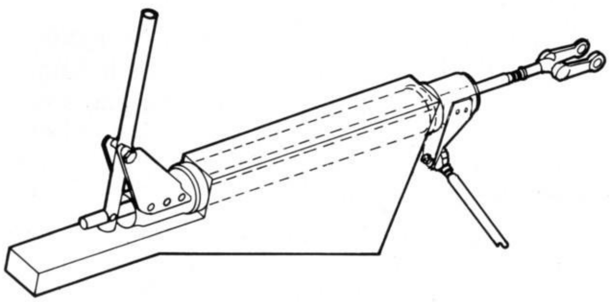
THE COCKPIT

The Pulsar cockpit is designed for creature comfort and efficient use of space. The seat back is reclined 35 degrees from vertical to provide the best piloting position as well as the most comfortable angle for uniform support of the pilot's back and legs. This

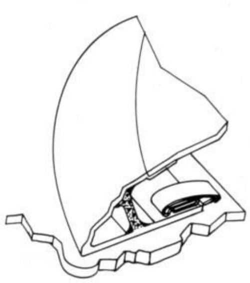
Pulsar Design Features

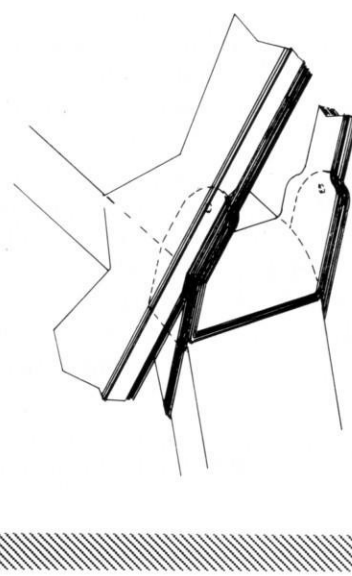






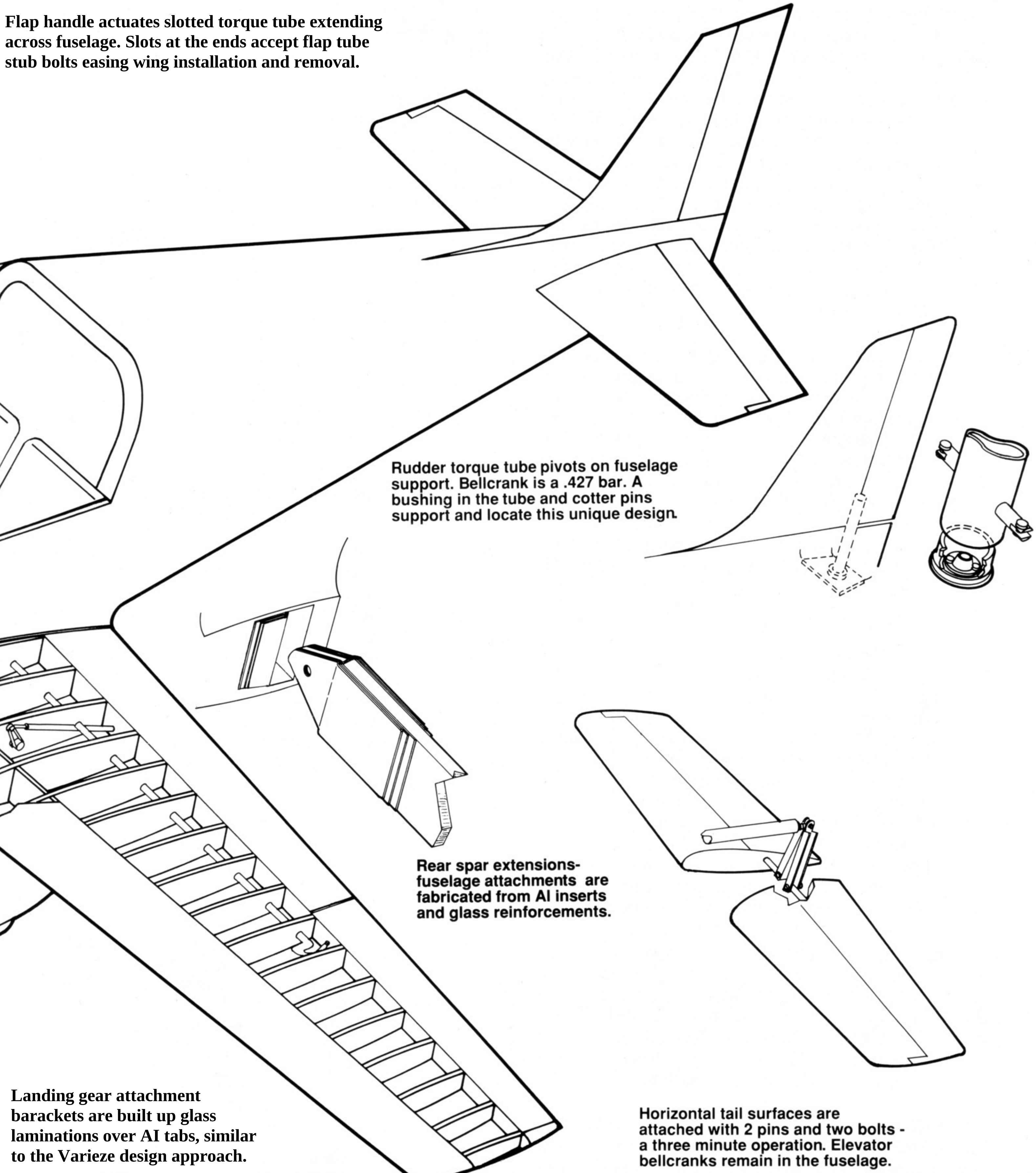
Center console configuration provides for comfort, control steadiness and simplicity.





The canopy is closed by a simple overcenter latch. Aerodynamic lift forces are managed by 2 hold down hooks on the cowl and 2 canopy pins indexing with the turtledeck structure.

Flap handle actuates slotted torque tube extending across fuselage. Slots at the ends accept flap tube stub bolts easing wing installation and removal.



Rudder torque tube pivots on fuselage support. Bellcrank is a .427 bar. A bushing in the tube and cotter pins support and locate this unique design.

Rear spar extensions-fuselage attachments are fabricated from Al inserts and glass reinforcements.

Landing gear attachment barackets are built up glass laminations over Al tabs, similar to the Varieze design approach.

Horizontal tail surfaces are attached with 2 pins and two bolts - a three minute operation. Elevator bellcranks remain in the fuselage.

position relieves the stress concentration on the pilot's posterior to make long flights more comfortable. A center mounted control stick and armrest can be used from either seat. This arrangement (a side stick in reference to the pilot) not only greatly simplifies the control system but it actually provides a control feel superior to the standard center stick or yoke. This is because the pilot's arm is supported by the armrest which provides a solid reference to gauge control motion. A good analogy is trying to aim a rifle from a free standing position compared with using a tree fork to steady your aim. That's why the F16 fighter uses a side stick. Another advantage of the side stick for a very light weight airplane like the Pulsar is that it magnifies the control forces to match pilot comfort levels.

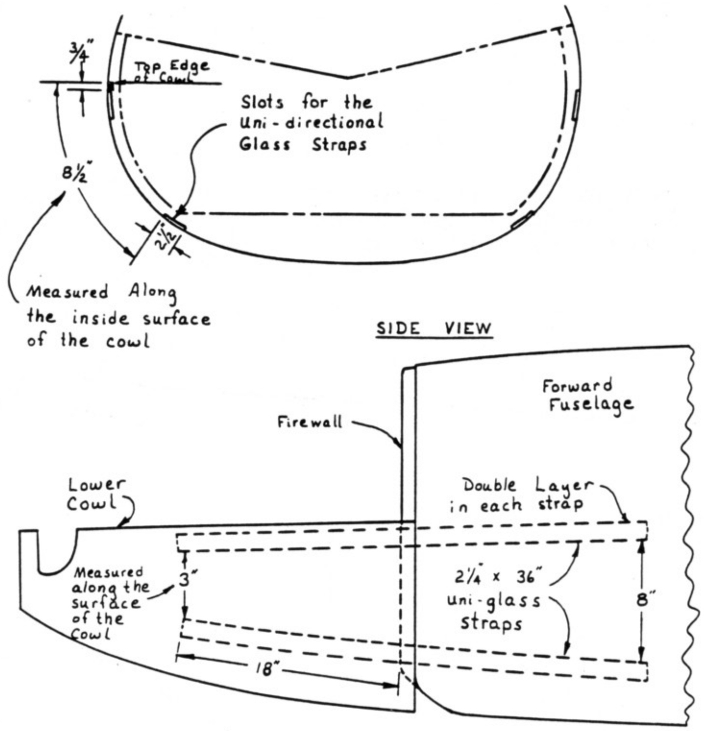
The rudder pedals are installed to fit the builder's preference but once installed are adjustable, within limits, with turnbuckles on the rudder cables. If large adjustments are necessary they can be made most easily with changes in seat cushion thickness. The brake pedals are located just inboard of the rudder pedals for heel operation. The brakes are cable actuated bands on steel drums and have proven to be very smooth and effective, not to mention their low maintenance and simplicity. We avoid the cost and additional weight of hydraulic systems. The slight difference in braking feel is easily detected and learned.

Cockpit size is designed to accommodate two 170 pound people up to 74 inches tall. Heavier pilots up to 220 pounds can be comfortable if their passenger is smaller than 130 pounds. The cockpit width is a comfortable 39 inches at the elbows and slightly wider than a Cessna 150 at the shoulders. The maximum legroom is 46 inches from the seat back to the rudder pedals. The cockpit height from seat bottom to canopy is 40 inches. Pilots taller than 74 inches would need to modify the seat bottom to lower their seating position. Behind the seat is a large baggage area that can hold up to 40 pounds with two 150 pound pilots or 20 pounds with two 170 pound pilots.

The instrument panel is shock mounted and is large enough to accommodate a full IFR package. However, to be consistent with the simplicity and economy of the Pulsar, only standard VFR instruments are supplied in the kit. We do not recommend IFR capability be installed as the additional weight will adversely affect Pulsar performance.

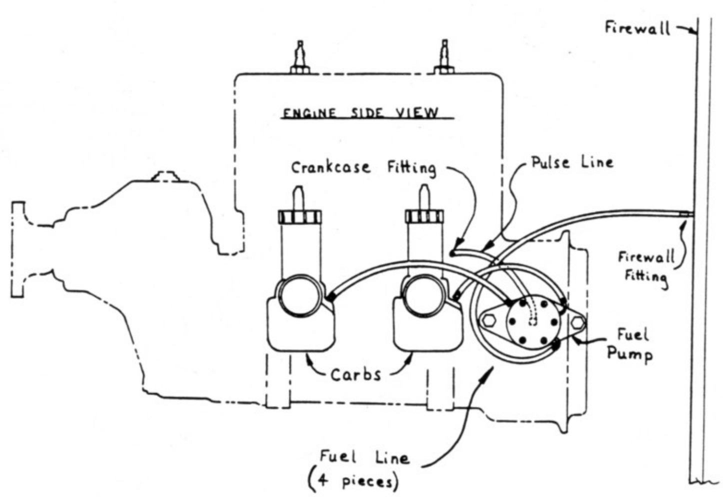
THE ENGINE

The engine mounting system is unique in that the engine is supported by two 4130 cross members which in turn transmit vertical, thrust and torque loads to



The lower half of the engine cowling is bonded to the fuselage shell. Additional strap reinforcements form a beam-like structure to support the powerplant.

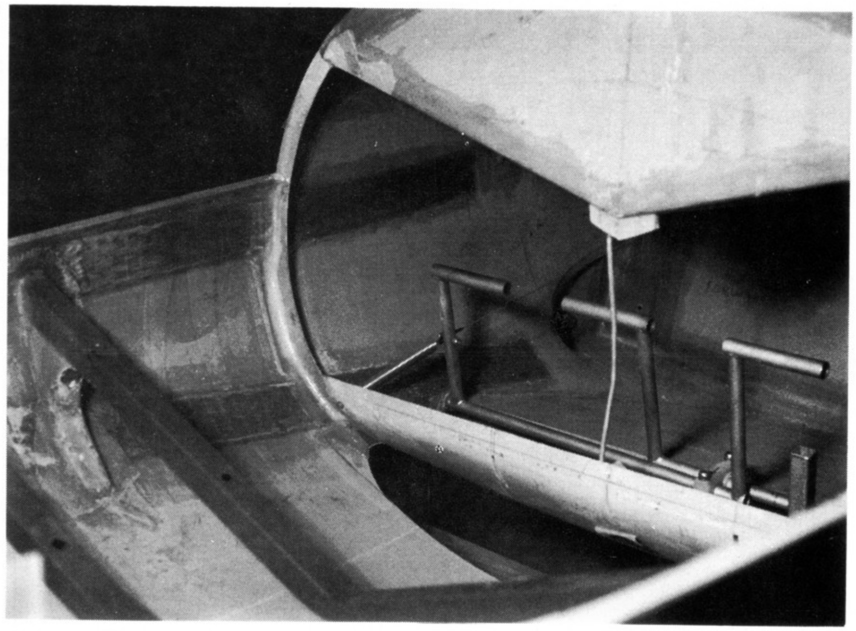
the lower fuselage/cowling extension. The lower cowling of the Pulsar, unlike most other factory and custom aircraft, is a structural member. After bonding the cowling to the fuselage shell the builder lays up four strips of unidirectional 24 oz A-260 style glass to each side of the cowling and the cockpit interior through slots in the firewall. In effect, the strips and the lower cowling combine to act as a cantilever beam-like support system for the engine. Our calculations show a 20 g support capability, in excess of safety margins designed into the typical 4130 truss tube engine mounts.



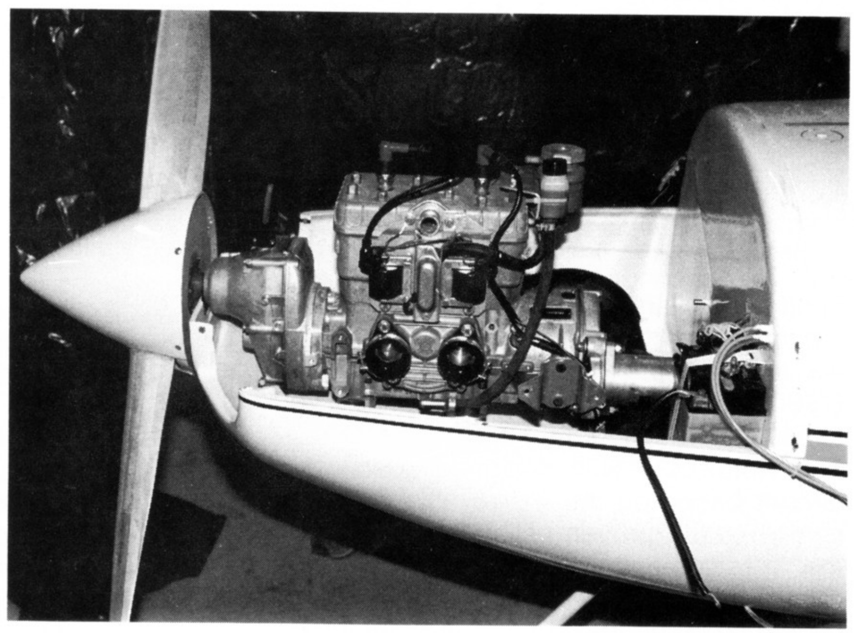
Fuel line routing from tank to engine fuel pump and carburetors. Pump is driven by crankcase pressure pulses.

We started with the Rotax 532. This engine from our viewpoint had a serious deficiency, a sharply limited band of high torque. Thus, our prototype airplane which was optimized for cruise was severely shorted needed horsepower, particularly for takeoff performance. The alternative, reduced propeller pitch for acceptable takeoff performance, compromised our cruise capability. Also, we did not think at the time that the single ignition point and condenser setup of the 532 was totally suited for the capabilities of the Pulsar. However, some 140 hours were flown with the 532 with no engine related problems.

Since the design goals for the Pulsar center on simplicity and economy which depend on light weight, the engine selection is obviously very important. In fact, the performance and efficiency of the Pulsar would not even be possible without an engine like the Rotax 582. At 85 pounds and 66 HP the Rotax 582 has a power to weight ratio almost twice as high as a Lycoming, Continental or a Volkswagen conversion engine. Of course, the reason the Rotax 582 puts out so much power for its size and weight is the two cycle advantage. It produces power on every revolution of the crankshaft instead of every other revolution like a four cycle engine. In addition to double the power per revolution, a two cycle can also safely turn more revs per minute because it has so few moving parts. The engine business basically boils down to how many times the piston pushes on the crankshaft per minute. Then to keep the propeller turning at the most efficient speed a very simple gear box is bolted on. The gear ratio for the Pulsar is 2.0 to 1. Therefore, at 5500 engine rpm (which is really loafing for a two cycle) the prop rpm is a very efficient 2750 rpm.



View rearward from engine compartment to cockpit floor. Engine supports are installed over the carbon fiber straps and stiffners.

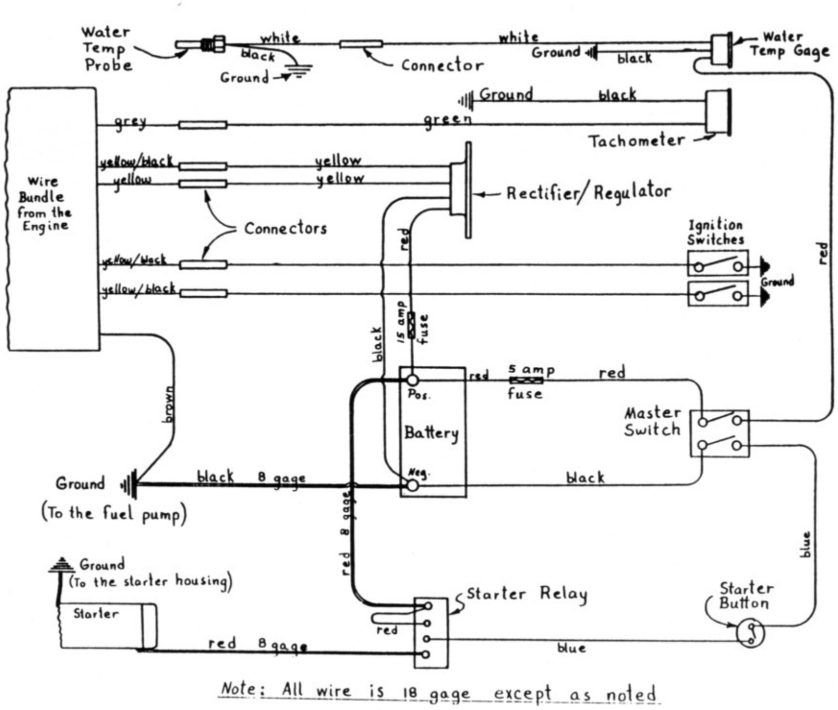


The Rotax 582 prior to installation of radiators, carburetors, and fuel pump. Accessability makes inspection and maintenance easy.

Besides the power to weight advantage the two cycle Rotax has two more pluses for the Pulsar. It is very simple and easy to work on and it is very economical to purchase and operate. These two pluses are actually related since the complexity and number of parts in an engine directly impact the initial and maintenance cost.

Another influence on the cost of the engine is the volume of production. Rotax of Austria builds over 100,000 engines per year. They are proven powerplants in fully engineered applications (water pumps, power generators, snowmobiles). Austrians have been long recognized for their high quality castings and machining. We thus maintain the Rotax two cycle engine internals have essentially the same reliability as four stroke engine internals. Properly installed in aircraft, Rotax engines rarely fail.

Incidentally, Rotax has been in business for over thirty years. In aircraft alone there are over 20,000 Rotax engines flying in everything from BD-5s to gyrocopters. In industrial applications the engines are commonly run 1000 hours between overhauls. To be conservative a 400 hour TBO is recommended for aircraft operations. Since Rotax engines are so widely used you'll find parts in most major cities and you can do your own overhaul for just a couple of



The Pulsar wiring diagram. The engine kit is shipped with necessary wire, connectors, and switches to complete the wiring.

hundred dollars. Also, there are several factory authorized service centers around the country that will overhaul the Rotax 582 for around 300 dollars (1990 prices). If you had a Lycoming you couldn't service the mags for that much.

The Rotax 582 was designed specifically for light aircraft based on the old reliable 532. This version combines the proven utility of the 532 with state of the art improvements in the 582. Using dual "electronic" ignition, the 582 not only eliminates the maintenance headaches of the point ignition system but provides the safety of two completely independent systems. The 582 can operate on either system so efficiently that you can turn off either system off at takeoff power and maintain the same rpm.

Another big factor in the reliability of the 582 is liquid cooling. Instead of suffering temperature extremes from 500 to 200 degrees F. like an aircooled engine, the 582 stays comfortably between 280 and 200 degrees F. This narrow band of temperatures reduces thermal stresses and the risk of overheat failures. In fact, the large radiators in the Pulsar can easily cool the 582 on the hottest days in Texas at full power in a steep climb while eliminating thermal shock during descent. Given such a comfortable home as a Pulsar pressure cowling the Rotax 582 should have a long healthy life indeed.

To emphasize the point, the biggest challenge in designing for and operating 2 cycle engines is cooling. Since the amount of power generated is higher for the given mass of engine, the removal of excess heat is critical. The two radiators in the Pulsar nose bowl are necessary. Our tests have shown that a high RPM relatively unloaded prop can also adversely affect cooling by introducing more air flow and causing engine leaning.

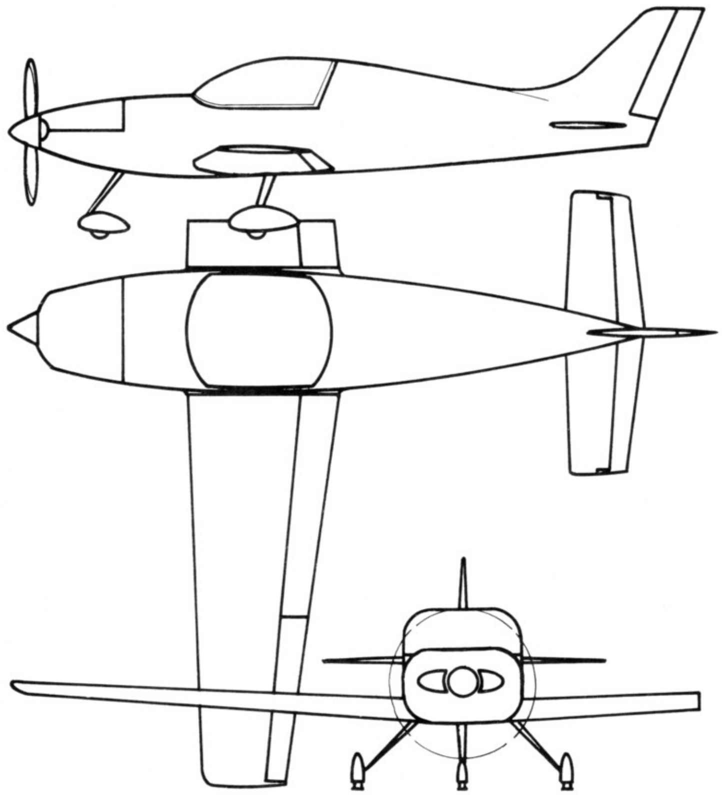
The history of the homebuilt movement tells us that the vast majority of aircooled engine problems are related directly to installation deficiencies, not the failure of internal engine components. Lack of cooling, either air or oil, is a major cause of engine failures. Lack of attention to the entire fuel system invariably manifests itself in engine quits. Omission of simple spark plug maintenance, of ignition components in general, is a sure recipe for eventual problems. Even simple items such as throttle linkages and exhaust pipes improperly installed by the homebuilder are killers.

If we objectively examine the Rotax record in homebuilts we see the same ignorance of basic engine installation principles. For example, people overlook the fact that the Rotax engine generates 65 horsepower in a small package, which in turn demands more cooling. The air/fuel mixture is sensitive on two cycle engines; leaning must be limited. Many experimenters have not recognized these critical engine operation parameters and have incurred the penalty for inattention.

When designing the Pulsar these experiences were studied and taken into account when engineering the installation. In fact, the Pulsar has an abundance of cooling as compared to factory specifications. To offset this, thermostat control is incorporated. Sitting on the ramp at 110 degrees F. ambient in San Antonio presents no problem.

The introduction of the 582 dual ignition system a year and a half ago essentially replaced the 532. The larger displacement was offset by more conservative porting, increasing the width of the torque curve. Although there is a slight gain in horsepower the main advantage of the 582 is found in improved cruise performance due to improved propeller/torque match.

Both engines have a gear reduction ratio of 2.0. We will test the 2.238 ratio which we think will further improve the propeller/torque match. The takeoff and climb performance of the Pulsar now exceeds our design requirements. We look to achieve better cruise performance as the airframe is capable of absorbing more usable thrust.



Designers have the option of optimizing the airframe structure to a given engine or over-design for future engine growth. The Pulsar design is based on the use of Rotax power. To ensure overall design objectives are not thwarted, Rotax engines are an integral part of the kit package. We do not recommend engine modifications.

We continue to review engine options. One such effort is the Pulsar XP. It is in response to a market demand for 4 cycle power. The result is another set of compromises: the more powerful 912 weighs more. The overall weight increase of 100 pounds (engine and extensive airframe design changes) virtually equals the light weight performance advantages of the 582. The more complex 912 places more demands on air, water, and oil cooling.

The domino like effects of 912 parts complexity are also reflected in the cost of the kit; the Pulsar kit is $15,200 while the Pulsar XP is $21,950.

We are using Pennzoil 2 cycle motor oil additive. For reliability we do not use the Rotax oil feed system,preferring to mix it ourselves during fueling. Our trials with a synthetic oil after two hundred hours showed early formation of a hard residue on the rings. Internal damage due to sticking rings was averted.

The 582 is supplied in the kit with an electric starter, 15 amp alternator, custom Pulsar exhaust system, and dual carburetors.

FINISHING

We at Aero Designs are familiar with and prefer the use of Ditzler Durathane polyurethane coating systems for composites. More expensive than the Ditzler Deltron product, the initial cost is offset by greater durability. The entire Ditzler line of compatible primers, surfacers, and reducers are also used. Ultra-violet protection is provided by Ditzler DP90 primer.

The process of finishing the wing surfaces is being revised based on several years of environmental exposure on the prototype aircraft (Starlite and Pulsar). The builder is now advised to cover the untreated wood surfaces with 1.4 ounce plain weave fiberglass cloth, and the kit laminating resin. The glass and wood is wet out, essentially sealing the wood from weather checking.

Thinning the resin for greater wood penetration is not recommended by resin supplier Hexcel as their tests show a weakening of the matrix (the chemical/mechanical resin structure which holds the working fibers in place). The kit contains Epolite 2315 which, while more expensive than other widely used epoxy resins (twice the cost of Safe T Poxy!), has low viscosity and high interlaminar shear properties.

In general, composite surfaces although smooth develop small pin holes as a consequence of the vacuum bagging cure process. These should be filled and sanded before applying the color coats to prevent potential bubbling.

The time it takes to build the Pulsar will vary considerably depending on the experience level of the builder and the degree of perfection sought in the details. Average construction time is 1000 hours which is about 12 months of calendar time if you work 2 hours each day and 8 hours on the weekend.

For first time builders the Pulsar is ideal because it is engineered to be the most simple kit in the market. The construction manuals cover every detail in a step-by-step format in non-technical language, and large margins of safety are designed into all areas that are assembled by the builder. The premolded shells make the Pulsar so easy to build that you will enjoy the project from the first step to the first flight.

FLYING QUALITIES

The old saying that "an airplane will fly the way it looks" is generally true. If you see an airplane with a tiny thin wing you can bet it is a hot potato in the traffic pattern, needing lots of real estate for takeoff and landing. An airplane with a short fuselage and a small tail is going to feel touchy and unstable, while a boxy airplane with struts and wires isn't going to win many races. By these examples you can see that flying qualities are an important aspect of the basic design. The Pulsar was designed from the wheels up to be fun and easy to fly.

The most important influence on how an airplane flies is its wing. The Pulsar has a vary generous wing area for its weight which gives it a very slow and comfortable stall speed. In addition, it has 1 1/2 degrees of washout, which provides the pilot with good roll control throughout the stall to prevent unintentional spins. The airfoil has a big effect on the stall characteristics. The Pulsar uses the MS(1)-0313 which has a very gentle break. This airfoil is also very forgiving of surface imperfections whether caused by the structure, the paint, or the bug population. The MS(1)-0313 also contributes to the speed because it has a Cl max of 1.7, while maintaining a very low drag coefficient of .005 in cruise. With large flaps included for glide path control and even slower speed, the Pulsar is a real joy to takeoff and land.

The wing design also plays a big part in cruise quality. The highly tapered platform reduces the rolling moments caused by gusts, while decreasing resistance to roll inputs from the ailerons. The result is a much higher roll rate when you want it and much less when you don't. The tapered wing also produces less drag for a more efficient cruise and improved climb performance. Rounding out the Pulsar's wing design is the differential Frise type aileron system. This system reduces adverse yaw for much simpler turn coordination.

The next most important factor in aircraft handling qualities is tail volume, which is the length of the fuselage from the wing to tail, times the area of the tail. This, along with the c.g. position determines the stability of the airplane. The Pulsar has a very effective tail volume due to its long fuselage and large tail area. This configuration gives the airplane its uncommon stability so in cruise you can trim it out and fly hands off indefinitely. The large margin of stability also gives the Pulsar a very solid feel in maneuvers; the controls aren't at all touchy or over-sensitive. Even with such outstanding stability, the Pulsar is still very responsive and maneuverable because of its extreme light weight. In short, it stays hands off where you put it; it moves gently with small control movement, and maneuvers like a fighter with large control input.

One aspect of flying quality that is difficult to control but has a major effect on flying pleasure is rough air. The Pulsar even has a solution to help that problem. First, the wing loading is high enough that small gusts don't have much effect. Any weather suitable for Cessna 152 is O.K. for Pulsar. The big help is really in climb performance. The Pulsar is so light weight that it climbs like an elevator. The rough air doesn't have much time to bounce you around because you are quickly above it. Even on a hot summer day you can be up in the 60 degree air before you know it. You'll have automatic air conditioning and the true airspeed boost will help you on your way. The Pulsar is a natural mountain airplane because it will takeoff at 7500 ft altitude better than most airplanes do at sea level.

The airplane cruises at 130 miles per hour. Actual flight time to the 1990 Sun n Fun, a flight plan distance of 1200 statute miles, was 8.8 hours using the standard kit propeller produced by PXP Perry Experimental Propellers in Brookshire, Texas. The return time with headwinds was 10.1 hours. The flight to the Prescott, Arizona CopperState Fly-In took 8.0 hours for a distance of 980 miles, the return took 8.5 hours. A non-standard prop, less the stock spinner, was tried out for the latter trip. Long trips such as these provide us with information on different prop manufacturers' configurations which are applied to our production kit when appropriate.

The Pulsar is designed to meet FAR Part 23 Airworthiness Standards to the Normal Category limits (same as Cessna 150/172). The Pulsar is not designed for acrobatic flight.

SERVICES

Aero Designs Inc. has ten full time employees at the present time (early 1991). Starlite kit production is suspended due to all space being devoted to Pulsar activities. Our staff is knowledgeable in all facets of kit assembly and is available to answer questions during working hours (8-4:30 CST/CDT). A newsletter is published bimonthly. Some 100 Starlite and 100 Pulsar kits have been delivered to date. We are aware nine Pulsars are now flying. The first Pulsar built and flown by Mrs. Lavern Lawrence of Loco, Oklahoma, was completed in July of 1989...in just six days short of six months!. More on Lavern in the August 1990 issue of Sport Aviation.

Prospective builders of Pulsar kits are welcome to visit our facilities and evaluate the Pulsar flight characteristics by appointment.

BUILDER SURVEY

Mark Brown kindly provided his listing of kit owners for my survey of builder satisfaction and this independent report-MCM.

One hundred one questionnaires were sent out to those who had taken delivery as of January 17, 1991. Of those, twenty-five builders were located overseas, a surprising number of customers around the globe. The builders were asked to rate their satisfaction with the Pulsar program on a scale of 1 to 10, 10 being highest satisfaction.

Four areas of possible interest to potential Pulsar buyers were chosen. Written comments were also solicited. In addition, flight performance expectations were requested of those flying their airplanes. Please keep in mind that the following ratings, an average of 37 returns, are highly subjective:

(A) 9.40 scheduling/delivery
(B) 9.29 kit completeness
(C) 8.48 instruction manuals
(D) 8.55 building ease
(E) 9.70 factory assistance

Manuals (C) were rated consistently lower than other program aspects and prompted a few negative comments and some "5s". When I first reviewed the manuals I found the content to be quite good. I now think that a builder unaccustomed to a lot of detailed text, drawings and sketches would welcome more illustrations/ photos and less text. I was surprised by the rating given scheduling/delivery (A). I expected a much lower rating simply because of a possible conflict between placement of orders at one time and production tooling limitations. The other ratings speak for themselves.

The people now flying Pulsars are very pleased with the airplane. Here are excerpts frommysurvey: " the ideal aircraft..easy to fly-", "Mark gives 100 percent to questions","quite pleased ..climbs and flys faster than expected","about as advertised", "have taildragger..140 mph

Mr. Glenn Huff, 738 South 78th, Kansas City, KS, responding to the survey: "after 25 hours.. flight performance a 10+. It climbs and flies faster than expected".

SPECIFICATIONS	*PULSAR*
OVERALL	
span	25.0 ft
length	19.5 ft
height-level	6.3 ft
height-ground	6.3 ft
FUSELAGE	
seats	2
frontal area	8 sq ft
cockpit width	39.0 in
cockpit height	38.0 in
PERFORMANCE	
Vne	150 mph
Vc, 75% power	130 mph
Va	105 mph
Vs	45 mph
rate of climb	1000 fpm
service ceiling	15000 ft
takeoff, 50 ft obs.	800 ft
landing, 50 ft obs.	800 ft
range, 75 % power	400 mi
fuel capacity	16.0 gal
wing loading	11.25 lbpsf
power loading	13.6 lbphp
G load +	6.0 ult
G load -	4.0 ult
WEIGHTS	
gross	900.0 lb
payload	440.0 lb
baggage limit	40.0 lb
WING	
span	25.0 ft
area	80.0 sq ft
aspect ratio	7.87
chord-root	48.0 in
chord-tip	26.0 in
CG-fwd	20 %
CG-aft	35 %
airfoil-root	MS(1)-0313
airfoil-tip	MS(1)-0313
dihedral	4 deg
washout	1.5 deg
sweep	0.0 deg
incidence	+3.5 deg
AILERONS	
span	72.0 in
area	8.0 sq ft
def-up	25.0 deg
def-down	20.0 deg
type	Frise
FLAPS	
span	72.0 in
area	17.0 sq ft
type-def	plain 40.0 deg
TAIL(horizontal)	
span	7.5 ft
stab area	10.5 sq ft
elevator area	3.0 sq ft
airfoil	0012 NACA
def-up	20.0 deg
def-down	15.0 deg
incidence	0.0 deg
TAIL (vertical)	
span at rudder	3.25 ft
stab area	7.0 sq ft
rudder area	2.0 sq ft
airfoil	custom
deflection	30.0 deg
POWERPLANT	
make	Rotax
HP	66.0
max RPM	6500
max torque	55 ft-lb
fuel quality	auto unl
PROPELLER	
make	Perry
type	fixed
material	wood
diameter	56 in
pitch	44 in

Switch On! Welcome to the second issue of Contact! The next GP-4 and Prowler stories are now in progress. They will follow the same format in covering unique design details, construction and specifications. With time and your comments as guides Contact! will cover related subject in future issues. Flight performance evaluation is one area sorely needing attention. Professional acquisition of valid performance numbers is long overdue. I am asking for donations of a police radar, an anemometer, a recording barometer, cockpit control load cells, accelerometers and telemetry equipment. Yes, I will need the services of a retired engineer willing to contribute to this effort. A senior airline captain and homebuilder of the highest integrity and skill has already indicated he will be available. Your continued support of Contact! will make it happen.
Sincerely, Mick (Michael C.Myal)

Pulsar Kit Package

Fuselage kit (shells are pre-molded)
- Fuselage shells
- Vertical Stabilizer Shells
- Vertical Stabilizer Spars
- Vertical Stabilizer Hinge
- Rudder Shells & Torque Tube
- Rudder Hinges & Hardware
- Molded Glass Landing Gear
- Landing Gear Attach Hardware
- Axle Weldment & Hardware
- Wheel Assembly, Tires & Tubes
- Brake Assembly & Hardware
- Stretch-Formed, Tinted Canopy
- Pre-molded Canopy Frame
- Canopy Tracks, Rollers & Hardware
- Fuel Tank Hardware & Cap
- Tail Skid and Tie Down
- Access Cover Hardware
- Air Vents, Doors & Hardware
- Aircraft Log Book
- Pattern Blue Print
- Wheel Pants and Hardware
- Composite Flat Panels
- Glass Tape
- Structural Adhesive
- Epolite Epoxy
- Mixing Cups & Sticks
- Fuselage Construction Manual

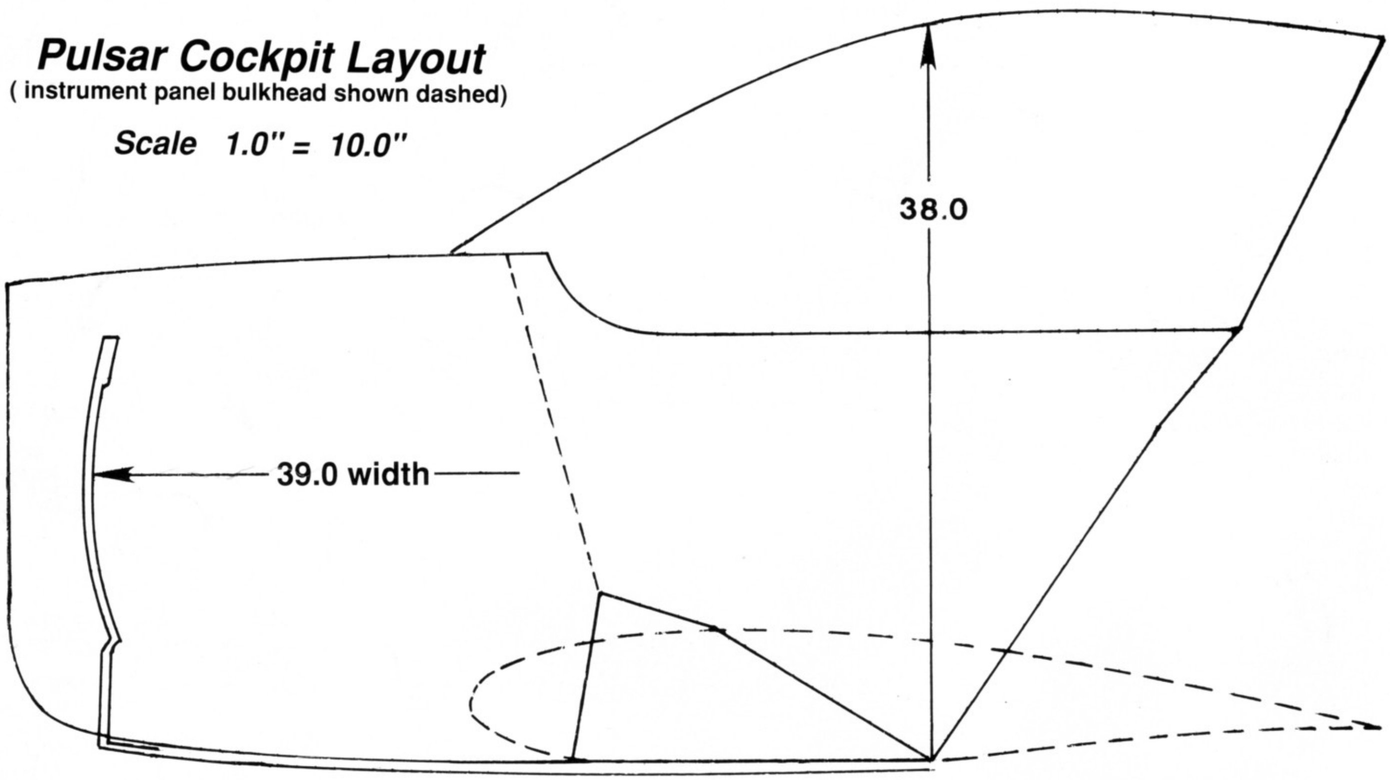
Wings & Controls Kit
- Glass Reinforced Main Spars
- Milled Rear Spars
- Precut Foam Rib Sets
- 1.5 mm Plywood Wing Skin
- Pre-molded Wing Tips
- Wing Attach Plates
- Main & Rear Spar Pins
- Tie Down Fittings
- Pilot Tube & Hardware
- Horizontal Stabilizer Shell
- Stabilizer Spars & Splice Tube
- Elevator Shells & Torque Tubes
- Ailerons & Flaps With Hinges
- Aileron & Flap End Ribs
- Aileron & Flap Control System
- Elevator & Rudder Control System
- Brake Cables, Pedals & Hardware
- Pitch Trim System
- Epolite Epoxy
- Glass Tape
- Wing Construction Manual

Engine Kit
- Rotax 582 with Gear Drive
- Dual Radiators With Plumbing
- Custom Exhaust System
- Engine mount Beams
- Engine Shock Mounts & Hardware
- Propeller, Frontplate & Hardware
- Spinner, Backplate & Hardware
- Cowling Shells
- Cowling Mount Hardware
- Electric Starter & Solenoid
- Instrument Panel & Shock Mts
- Certified Altimeter, Airspeed & Compass
- Tachometer, Exhaust Gas Temp & Probe
- Water Temp Gage & Probe
- Engine Primer System & Clamps
- Throttle Lever, Cables & Hardware
- Seat Belts & Shoulder Harness
- Fuel Lines, Filter, Pump & Hardware
- Coolant Recovery System
- Air Filters
- Electrical Wire, Connectors & Switches
- Engine Installation Manual

Pulsar Cockpit Layout

(instrument panel bulkhead shown dashed)

Scale 1.0" = 10.0"



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2900 East Weymouth
Tucson Arizona 85716

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