Geodetic Aircraft Structure

By Keith D. Powell, EAA 1939

The "Player" homebuilt sport plane is in its twenty first year of flying, has appeared at three National EAA Fly-Ins and copped first place for spot landing in the 1960 flight events. Innumerable pilots (including the author) have tasted the thrill of their first flight in command of a homebuilt aircraft, and have been allowed to join Earl Player in many enjoyable hours of trouble free air time in this durable product of a "Pioneer" homebuilders skill brought into being for the fabulously low sum of $500.00 cash outlay.

All this is leading up to the reason for this article. To provide information on construction principles and to illustrate the value of wooden geodetic structure for the amateur. As a practical approach to solving the average income homebuilders biggest problem, funds over and above living expenses, the economy and proven qualities of the geodetic diamond mesh structure has long been overlooked or just not known about by the growing gang of present day enthusiasts. This article was prepared to help in the latter respect.

We are indeed grateful to Messr's. Player and Thalman for their invaluable assistance in preparing this article. Without them it could not have been written. Our present day organization owes its very existence to the efforts of such stalwart pioneers as Bogardus, Yates, Long, Rupert, Wittman, Thalman, Player and many others of the early restricted era. Knowing just two of them has been a rich experience and if EAA ever inaugurates a Hall of Fame they deserve proper recognition.

To give the reader a brief history of our subject, let's see what others have done. The British World War II Vickers Armstrong "Wellington" bomber was a well known exponent of geodetic structure. The Wellington was famed for its load lifting capacity and durability. The metal riveted and bolted mesh structure could be peppered with flak and cannon shell holes and still hang together.

Geodetic aircraft structure was used in the U. S. by the "father of geodetic homebuilts", George Yates of Beaverton, Oreg., as early as 1927. His first ship, the "Stiper", was constructed in 1930 using ¼ in. diameter steel tubing welded at each crossover of the geodetic mesh. It was still flying in 1938. The "Stiper" was a two-seat tandem parasol. Later efforts during the 1930's included the midwing Salmson powered, single-place Oregon "O", several low-wingers and a maximum effort in design during the period was the building of 2 low-wing twin engine ships powered by 40 hp Continentals (Fig. 1).

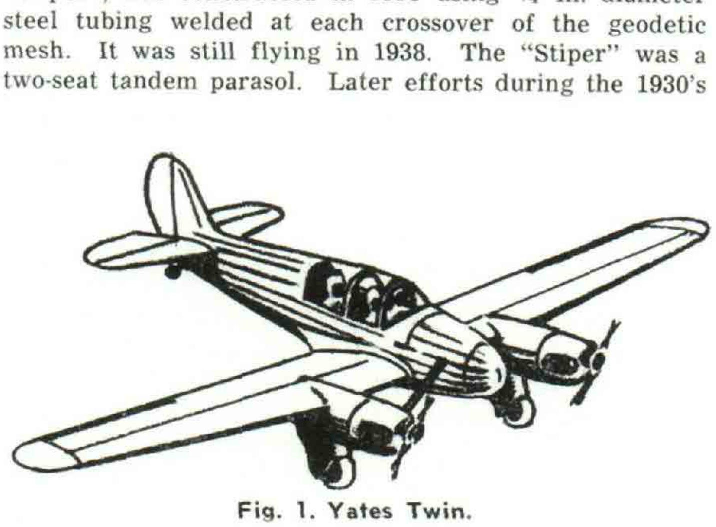

Fig. 1. Yates Twin.

The "Stiper" was the only Yates design using metal structure. A convert to the wooden materials qualities of lightness and strength, ease of fabrication and economy, all the rest were constructed of wood and glue using metals only at vital stress points; engine mounts, fittings, landing gears, etc. Mr. Yates developed geodetic for not only the fuselage structure but used it in the entire airframe; wings, fins and control surfaces. Some Yates wings were spar-less using light internal members only to form the geodetic lattice airfoil. Photos of some uncovered Yates wings show the spar to be built up truss of light spruce indicating the geodetic carried the major portion of the flight loads.

An evident takeoff of the Yates low-wing geodetic design, "The Plxweve CT-6" two-seat tandem trainer appeared in 1941 and according to specifications performed well on a 75 hp Continental (Fig. 2). Other developments by Mr. Yates and the fate of these unique aircraft is unknown to the author and additional information by someone closer to their development and use would be welcomed.

Fig. 2. Plxweve C T-6

In the mid 1930s information on Mr. Yates' system introduced Earl Player and Harry Thalman of Salt Lake City to its promising features and both were soon entangled in their own separate backyard "basket weave" projects. The "Player" fuselage was assembled in the alley behind Earl's home incidentally. How "backyard" can you get? Anyway the oft used excuse, "I don't have a place to build" doesn't seem to stop some hardy persons.

Earl's ship grew from the application of several designs popular during the thirties. The wing was built from plans of the Long "Longster" appearing in an early "Mechanix Illustrated Flying Manual." The tail planes were modified from a cracked "Curtiss Jr." and the fuselage of prime interest to us, is his own design in wooden geodetic (see Fig. 3 cutaway).

As an illustration of how the amateur builder and designer can resolve aerodynamic layout problems by

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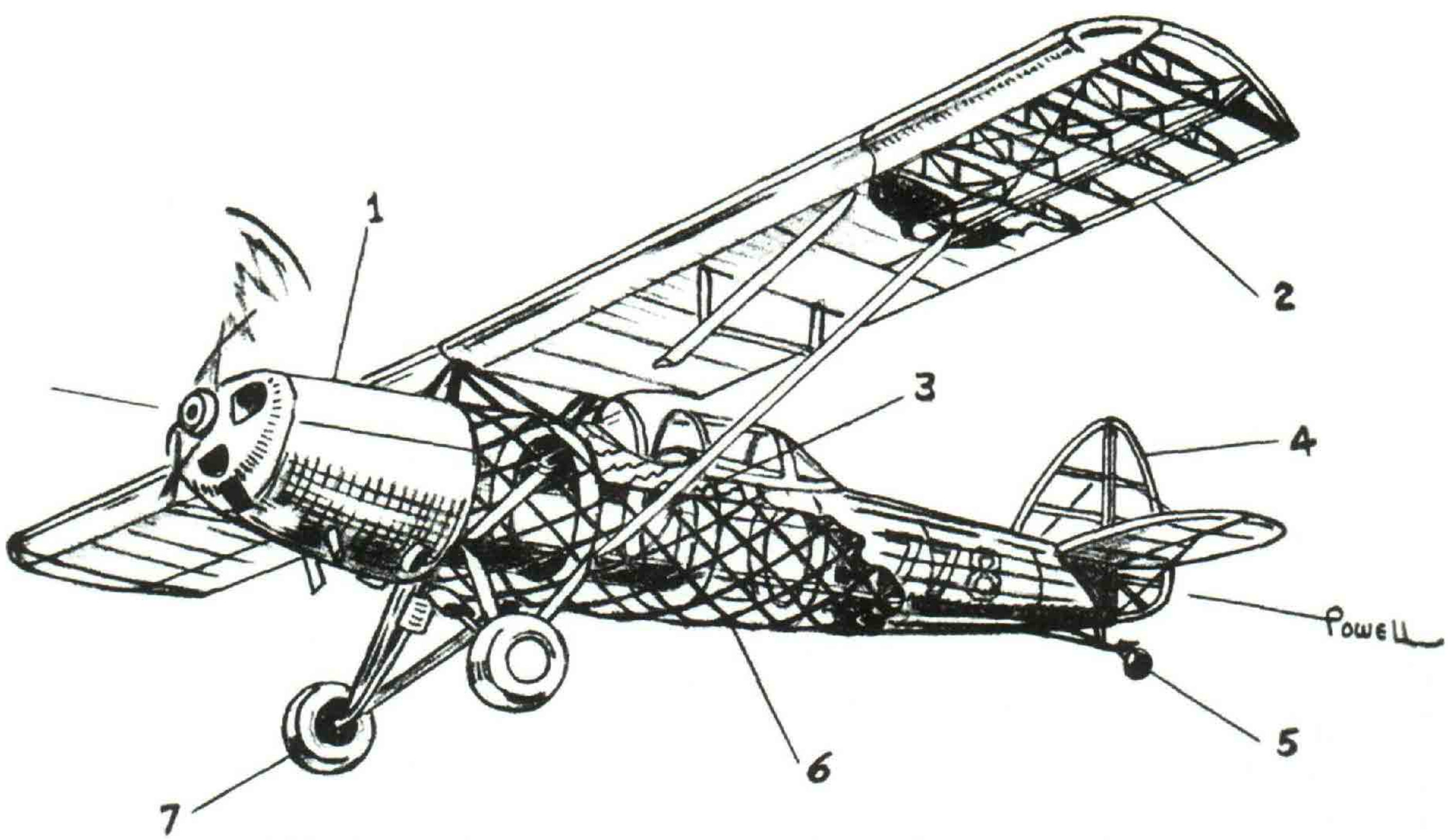

Fig. 3. Wm. Player's "Player" Sport. The "Player" is a single-place ship with half parasol and half shoulder wing, geodetic fuselage. Designed and built by Wm. E. Player of Salt Lake City, Utah. Aptly named, the ship is a frisky, fun to fly sportster.

1. Aluminum cowling - 65 hp Continental.
2. Conventional strut braced wood wing, Clark "Y", fabric covered.
3. Plywood cockpit framing. Originally an open job, the sliding canopy is shown in the open position.
4. Wire braced tubular steel tailplanes.
5. Pietenpol tailwheel.
6. All wood geodetic fuselage. Plywood former rings decreasing in thickness from nose to tail, (i.e.) 1 in. firewall, 3/4, 3/8, etc. Four 3/4 sq. longerons, bucket pilot seat, other internal details conventional. Fabric over longitudinal fairing strips.
7. Cub type, streamline tubing landing gear.

using a proven designs features, leaving the headaches for non-conformists who want something "way-out"; Earl adapted the "Corben Super Ace" general layout, basic fuselage dimensions and station locations in the design of his airplane. The wing placement and other layout details also are the same as the "Super Ace".

The "Player" was test hopped in 1940 and except for a forced four year storage period during World War II, has been active ever since; culminating her existence by bringing home the bacon from the 1960 EAA nationals.

The Thalman midwing took to the air in 1941 and through its outstanding performance, demonstrated her designer-buiders self taught engineering prowess and the benefits of wooden geodetic. A single-seater powered by the five-cylinder Velie 55 hp engine, Harry's brainchild clipped along at 130 mph top speed, 120 cruise and landed on high elevation air strips at 38 mph. Take off and climb (1500 fpm) were fabulous for the low horsepower due primarily to the tapered 41 ft. span, high aspect ratio sailplane like wing employed. See Fig. 4 - three view.

This wing, as did the rest of the airframe, incorporated the diamond mesh, glued spruce strips. A box spar of full span and the geodetic monocoque made the wing fully cantilever and clean. The entire design displayed Thalmans' devotion to aerodynamic cleanliness. The fuselage carried thru the radial engine's circular cowling cross section ending in a pointed tail-cone. In contrast to most homebuilders who want just a sportplane featuring proven qualities for Sunday flying, Mr. Thalman went out to achieve a flying machine of superior performance with an original design.

A true experimenter and progressive backyard engineer, Harry tried two different empennage designs and several minor modifications for performance improvement on this ship. The original configuration mounted the stab and elevators on the fuselage center line (also thrust line). Final configuration changed the Thalman T-3B to a "T" tail with the horizontal surfaces mounted on the vertical fin tip. The smoother air flow over the horizontal surfaces gave better in-flight performance but caused a loss of control effectiveness during take-off. The original configuration with the elevators in the prop blast was found best; at least for a ship with low stall speed and the desired short field, high cruise performance qualities sought and achieved in the Thalman design.

Having proven his basic theories, Harry began construction of his second midwing in 1946. This ship was to be the ultimate in aerodynamic efficiency, a functional, economical mode of transportation for four persons. One which would enlarge on the hi-speed, versus low-speed compromise block that has faced the airplane designer since the Wright Brothers first took wing.

Using the same basic design as the T-3B with the sailplane like wing mounted just above the thrust line, Harry incorporated a manually retractable tri-cycle landing gear and among other innovations, concentrated on the elimination of an ever present turbulence and drag producing feature of the conventional airplane. The

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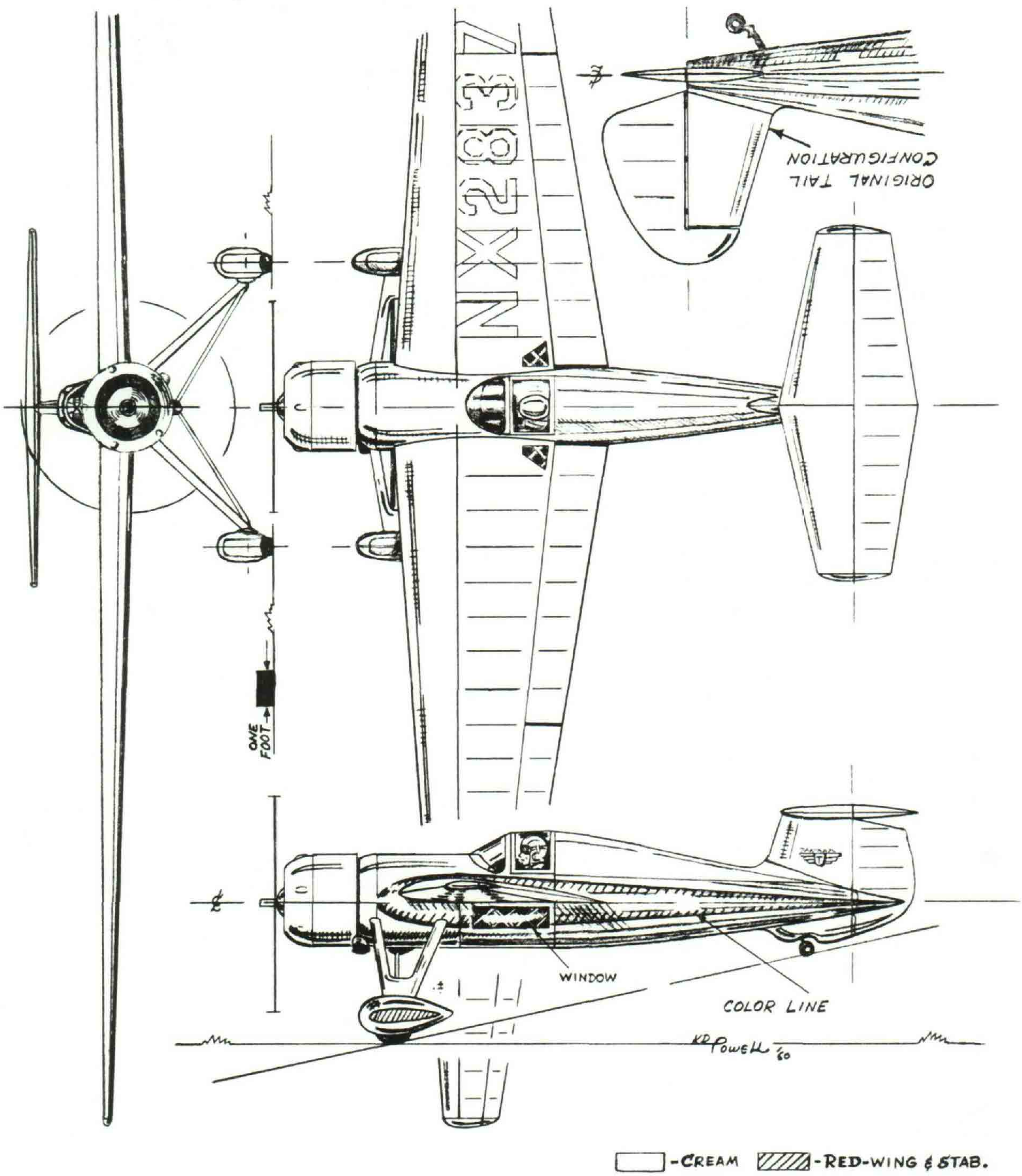

Fig. 4. NX28374 Thalman T3-B

Geodetic Construction in . . .

Earl Player's "Player"

Photo by Earl Player

"Player" original configuration 1940 — First engine was 4-cylinder "Dayton" air cooled Ford Model "A" conversion. Color was red, fuse-grey wing, silver nose. That's the Rosenhan Corben "Junior" in background.

Photo by K. D. Powell

"Player" fuselage during recover in 1958. Note the spliced in geo-strip, bucket seat and shoulder harness.

Photo by Earl Player

Wm. Earl Player in cockpit of his homebuilt, all-wood geodetic fuselage, "Player" sport during first test hops.

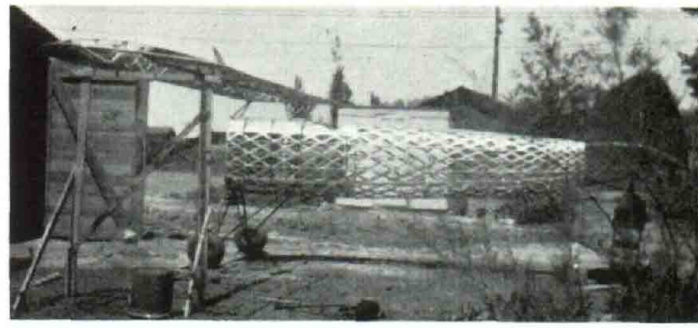

Photo by Earl Player

The "Player" construction details.

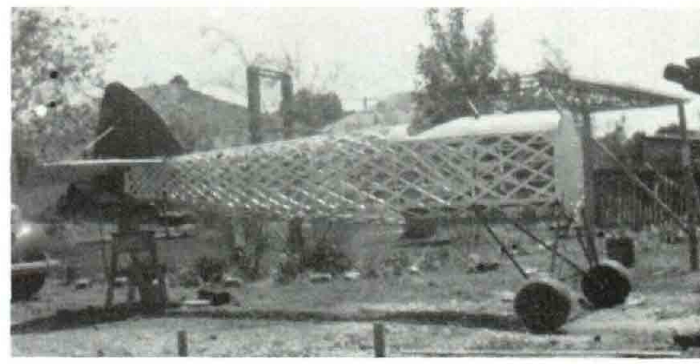

Photo by Earl Player

The "Player" under construction all-wood geodetic fuselage. Earl varnished the woodwork, then aluminum pigmented last coat — not a loose joint or wood deterioration in 21 years.

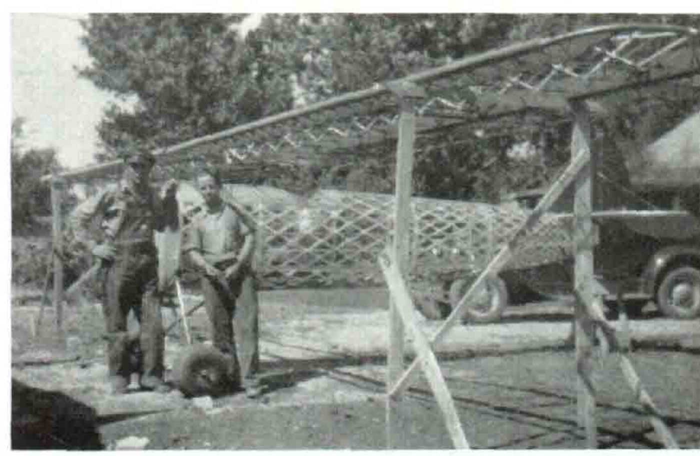

Photo by Earl Player

Earl Player (left) and Mr. Narda shown with "Player".

Photo by Earl Player

The "Player" under construction. Note the landing gear, cabane strut fittings, conventional internal braced wing.

Thalman's T-3 and T-4

Photo from Ray Millard Collection
Thalman and T-3B in flight.

Photo from K. D. Powell Collection
Thalman T-4, 4-place midwing, all-wood geodetic with latest configuration, 270 hp Lycoming.

Photo from Ray Millard Collection
Thalman T-3B — Note forward sliding canopy a la Art Chester style, Racey look and fabulous high altitude performance.

Photo from Ray Millard Collection
Harry Thalman set to go in his homebuilt Thalman T-3B all-wood geodetic midwing.

Photo from Ray Millard Collection
Harry Thalman and the "Thalman T-3" in original configuration, before "T" tail wheel pants, etc., all silver.

Photo from Ray Millard Collection
Thalman T-4 interior of fuselage from rear seat aft.

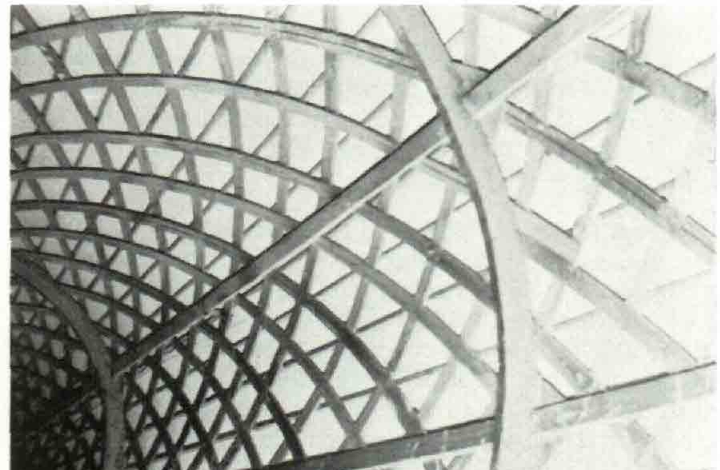

Photo by K. D. Powell
Thalman T-4 geodetic fuse construction details.

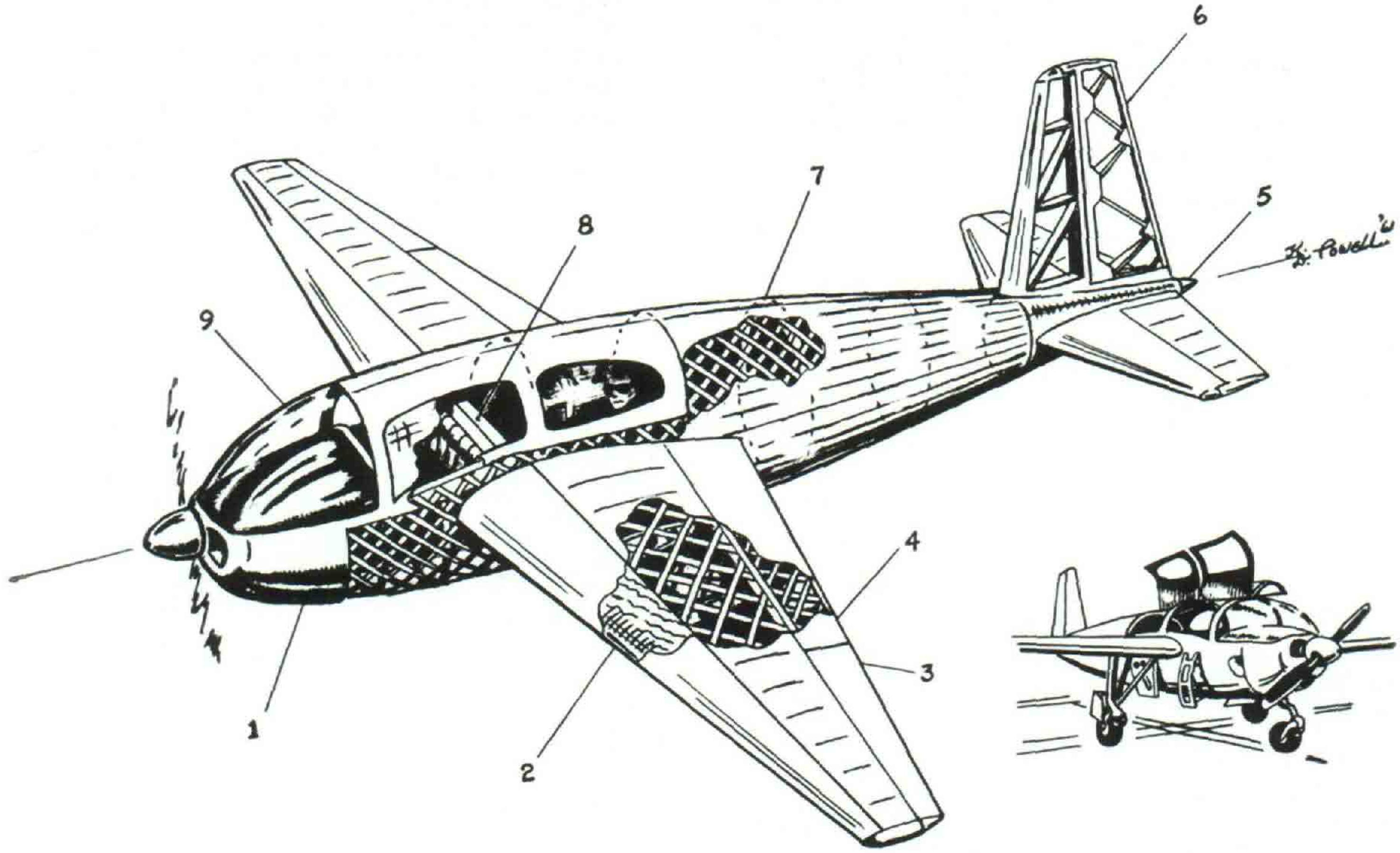

Fig. 5. Thalman T-4 designed and constructed by Harry J. Thalman of Salt Lake City, Utah. This plane is all wood geodetic 4-place midwing. It also has a manually retractable tri-cycle landing gear.

1. Aluminum cowling 135 hp Lycoming.
2. Molded plywood L. E. forms "D" section nose over geodetic. 55 gal. fuel cap. in fiberglas wing tanks.
3. Aileron.
4. Flap - 1/16 in. x ½ in. geodetic construction.
5. Conical tail navigation light cover, clear plex.
6. Canted rib wooden tail structure. Stab and vertical fin ply covered. All surfaces interchangeable.
7. Fuselage structure with built up and laminated ring formers. Fairing strips under fabric, over the geodetic, not shown for clarity in cutaways.
8. Full span main spar thru cabin. Two person seating behind spar, pilot and co-pilot forward of spar side-by-side. Access hatches swing up in Mercedes-Benz "Gull-wing" sport car fashion. Folding ladder on right side affords entry and exit.
9. Plexiglas bubble windshield. All plexiglas tinted blue.

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break in the fuselage line caused by a sharply angled windshield. The T-4 fuselage profile presents a perfect teardrop shape from prop to tail cone with the pilot and three passengers enclosed in a molded plexiglass bubble windshield. The windshield rises from just behind the propeller hub and curves back to join the clamshell access hatches providing an unbroken fuselage line and a smooth airflow. See Fig. 5.

Control surface and inspection plate gaps are sealed and all outside fittings or other speed robbing protuberances eliminated. Wing and tail surface junctures with the fuselage follow the modern trend and are clean without large flaring fillets.

Test flights in 1952 were not disappointing to anyone but the ever present skeptics. In fact the propulsive efficiency was down right gratifying and more than hoped for. Powered with 135 horses the four placer scooted along at 175 mph top, cruised 155 mph and landed at 45 mph with flaps. The ship was flown all over the west with this power and the high mountain ranges were made for it (or vice-versa as you please). Larger power plant installations later boosted speeds to 200 mph true A. S. at 8 - 10,000 ft. with all around performance affected proportionately.

The ship has logged hundreds of hours, worn out three engines and is still going strong. So is Mr. Thalman, now working on another midwing featuring a plastic bonded honeycomb sandwich airframe. But that's another structures story.

Theory and Features

Let's see what the term geodetic means as applied to our subject.

Webster's Dictionary says:

Geodetic - adj.: of or pertaining to, or determined by, geodesy; geodesic; as, geodetic surveying.
Geodesic - of or pertaining to geodesy; the geometry of curved surfaces, in which geodesic lines take the place of the straight lines.
Geodesy - That branch of applied mathematics which determines the exact positions of points and the figures and areas of large portions of the earth's surface, or the shape and size of the earth.

Confused? Let's see how a couple of professionals in the arts and science of aircraft structures interpret the nomenclature and attributes of our subject. We quote first a member of Ogden Chapt. 58, Aeriel C. Knowles; "Since the actual construction is composed of a network of grid-forming members which literally form the curved surfaces of the component under construction, little imagination is needed to relate this to the mathematical definition of a geodesic line, (i.e.) The shortest line lying on a given surface and connecting two given points. Here the member (geodetic strip) actually replaces a line."

From the above we can see how our structure, which transfers loads from member to member on a criss-cross "great circle" route, derived its name.

To most, the engineering theory and mechanical function of the geodetic form seems mysterious and complicated. Fortunately this is not true but is in fact the essence of simplicity and directly related to a well known structure. The following analysis by Chapter 58's chief Aeronautical Engineer, Lt. Rod Huggelman, sheds the cloak of mystery. Lt. Huggelman says, quote:

"Nature has endowed the insect with a most excellent structure. The lowly ant for example has an exoskeletal structure of amazing lightness and strength. This closed shell structure is called monocoque in the field of aircraft structures. It has probably the highest strength to weight ratio and is widely used today in aircraft and missiles.

Any homebuilder who has tried to cover compound curves with a sheet of plywood has already had experience with one of its primary short comings. Another disadvantage is often its extreme rigidity. Rigidity is generally an asset but such structures are not normally able to take high shock loading concentrated in a small area since they cannot easily distribute the stress. An egg shell for example can take amazing loads properly applied while a sharp blow with a pointed object will easily crack it.

Often it is possible to compromise ultimate strength and rigidity in monocoque structures by perforating the shell with holes. The flexibility thus provided will enable the structure to better handle shock and impact loads. By increasing the shell thickness we can restore the ultimate strength of the structure while still maintaining some desirable flexibility, although at a slight weight penalty.

The geodetic or "basket weave" structure is simply an extension of the perforated monocoque structure. However, it is much less expensive, simply constructed and unrestricted by compound curves." Unquote.

The last sentence should be very appealing to the amateur.

The geodetic wooden aircraft structure as used in the Yates and Thalman aircraft undoubtedly reached a high point in perfection and have contributed proof of service durability and performance.

Let's check some features.

Weight - A light airframe allows greater pay load and/or more speed, better climb, etc. with lower horsepower and consequently increased economy. (Ask Steve Wittman about this. No formula was more successful.) In this respect, geodetic will go all-out.

The average basic geodetic fuselage should not weigh over 40 pounds. Yates built a cantilever wing panel that weighed only 24 lbs. Strength to weight features are evident and undoubtedly better than most conventional light aircraft structures.

Strength - Before starting design or construction of wooden geodetic, or any other wood aircraft structure, a familiarization study should be made of wood materials and their application. Several texts are available including Manual 18 and especially recommended are the Munitions Board Aircraft Committee Bulletins ANC-18, "Design of Wood Aircraft Structures", and ANC-19, "Wood Aircraft Inspection and Fabrication," available from Aero Publishers.

Chapter 3 of ANC-18 entitled "Methods of Structural Analysis" contains a comprehensive presentation on engineering data for wood aircraft structures including the monocoque and semi-monocoque plywood stressed skin structure. The application of stress analysis and design features of the monocoque shell are the basis for geodetic airframe engineering as used and recommended by geodetic exponents.

The book "Airplane Design" by K. D. Wood, 6th edition, 1941 offers our only known information in stress analysis and preliminary design for geodetic structures.

The book gives examples and mathematical equations for suggested geodetic engineering and is recommended for reference here. In his book Mr. Wood states that published data for design or stress analysis of geodetic structures did not appear to be available at that time. This seems to be the case at this late date also. The following recommendations are taken from his book:

Quote: (1) "To arrive at preliminary design and stress analysis it is probably conservative to design an equivalent monocoque fuselage and then select geodetic members of such size and spacing as to make the lattice cage have the same weight as the monocoque skin. This procedure has been used at Purdue University with a resulting margin of safety **in excess of 50%** for plywood construction.

(2) For structural analysis, a lattice cage fuselage may be regarded as a series of triangular frames with imaginary bulkheads and pin joints at all intersections. In such a framework the load which can be carried by one of the compression diagonals determines the strength of the structure in torsion and bending." Unquote.

For Mr. Thalman's explanation of the mechanical principals he references a tube, likening it to a fuselage. Imagine the tube without any internal bracing and made up of one set of equally spaced strips spiraled only one way around its diameter and length. If you twisted the tube in the direction of the spirals it would decrease in diameter. Twisting it the opposite direction causes it to enlarge in diameter. Now imagine a second layer of strips wound in the opposite direction over the first to form the diamond mesh lattice. Now twisting in either direction causes an opposing reaction and the tube is rigid and strong.

Monocoque, in nature, the structure is a strong, compact, torsion resistant component braced in all directions, yet strange as it may seem, it is also elastic in nature, shock and engine vibrations are effectively dampened. Thalman says the fuselage he builds could be twisted one quarter turn before failing. This elasticity is a prime strength feature. Standard airframe structures may receive a peak stress amount and will "give" very little before failure. Under the same energy, the geodetic would "give" more and not reach the breaking point. We hasten to add that this apparent "limberness"

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doesn't mean the wings flap or the tail shakes however. Ever see the undulations of the "Helio Courier" tail during taxiing or the "T-Crafts" shuddering when the engine is started? None of this is apparent in our structure.

Safety - This same elasticity affords a structure with the progressive failure features so necessary to safety in a crash. For those fearful of the usual splinter hazards associated with wooden aircraft crackups, the springy strips tend to bend and break outward eliminating the occupant spearing danger.

Both Mr. Player and Mr. Thalman have experienced accidents causing damage and verify the damage resistant features and another inherent valuable trait of our subject. Ease and economy of repair. Damage is usually slight and the splicing in of a few spruce strips is much easier than the usual procedures with sheet metal or tubing when an undercarriage is damaged or a wing tip hooks in a snow bank on take off run, slamming the ship to a stop in the snap of a finger.

Durability - Trapped moisture in an airplane structure can raise havoc with sometimes irrepairable damage resulting. In steel-rust, aluminum-corrosion, and wood-rot, glue joint separation, etc. Since our structure is of wood it's very gratifying to know that the physical makeup of the diamond mesh eliminates any possibility for trapping moisture. No trouble should be experienced except in an unusual case in particular design or partial use of conventional wooden gusseted structure (i.e. Jodel, Pietenpol, etc.).

The "Player" was recovered after fourteen years of outside exposure in 1958 and the only spot showing deterioration was the lower portion of the bulkhead at the tail wheel where water from the entire fuselage interior drains to. The drain hole evidently had plugged with mud or was slightly misplaced.

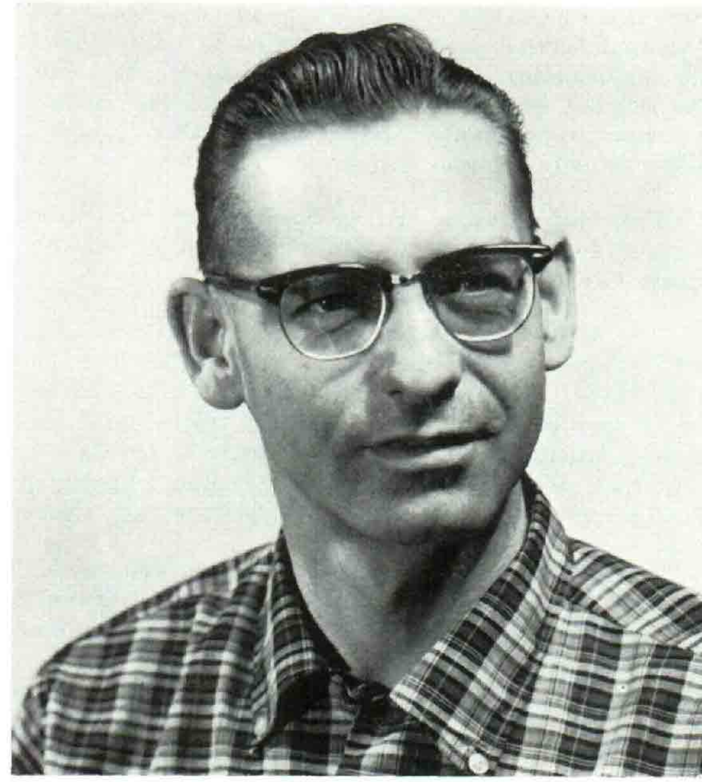
To be concluded in the August issue — watch for the construction tips to be included.

AUTHOR'S NOTE: The general nature of this presentation required brevity. Therefore much was left out to keep the article "magazine" size. One important part not covered was the requirement for GOOD glue joints at each crossover of the geodetic mesh strips and former to geodetic cage junctures. Good glue joints are important in any wood airplane structure but they are particularly so with geodetic since they absorb or transfer the compression stresses.

Not much is known nor can it be put down as exact fact in engineering formulas for geodetic or for that matter monocque design of any kind.

Thalman proved his structure by static loading the wing, lever twisting the fuselage section and FLIGHT TESTING (about 600,000 miles on the T-4). Thalman also states that he doubts that there is anyone who can accurately stress analyze geodetic construction "on paper".

Recent information points out that ANC-18 and 19 Bulletins and K. D. Woods' "Airplane Design" are out of print. However there are rumors that the ANC Bulletins are going to be published in sectional form and that



Keith D. Powell

"Airplane Design" will be reprinted some time this fall in a 1961 version.

Further information indicates that it will be available from the University of Colorado's campus book store "On Campus", Boulder, Colorado. Perhaps sufficient inquiries from EAAers would hasten the publication of these valuable texts.

Keith D. Powell

Welding Demonstration

The monthly meetings of Detroit Chapter #13 usually include a practical demonstration of some phase of homebuilding art for the benefit of the more inexperienced members. Here we see Phil Austin, Head Welding Instructor of the Detroit Board of Education from Trombly Trade School, showing how to weld aircraft tubing. This meeting was held at the H & S Propeller Shop, 25210 Ryan Road, Warren, Michigan. Mr. Stanley kindly offered their facilities for this meeting, and members also had a chance to tour the shop where equipment is available to handle anything from the simplest light plane props to huge turboprops.

Photo by Robert F. Pauley

Phil Austin, Head Welding Instructor of the Detroit Board of Education from Trombly Trade School.

PART TWO

Geodetic Aircraft Structure

By Keith D. Powell, EAA 1939

Economy and Ease of Construction.

Mr. Player's quotation of $500. cost for constructing the "Player" is indicative of the economy geodetic provides. This quotation is at the 1939 dollar value but even today comparable cost cannot be matched by other materials.

The geodetic strips are sawed from a good straight grain spruce plank. Much cheaper than aircraft plywood and aluminum sheet or steel tubing. Earl says the "Player" fuselage material cost about $10.00. Compare this to the $300.00 or more required for steel tubing used in the average two-place available homebuilt such as the Tailwind, Cougar, Skyhopper, and most others.

Simple tools are required. The average handyman or hobbyist should have drills, a bench saw, a saber saw and the necessary hand tools. Planing mills and cabinet shops are readily available and reasonable for the small amount of heavy "finishing" that may be required. Thalman used large spring clothes pins as clamps in gluing the geodetic spirals. Earl constructed the "Player" in less than a year without previous aircraft building experience. Ingenuity rather than several special skills, fancy tools and expensive material seems to be the answer here.

Details of Construction.

The foregoing indicates what can be done. Now let's see how we can do it with a few technical tips mentioned by the experts.

Looking at an uncovered geodetic fuselage it seems to be an intricate maze of criss-crossed thin strips spiraling hither and yon in a most confusing manner.

Closer inspection reveals the maze to have a definite pattern and lo and behold the strips are not woven over and under as the common term "Basket-weave" leads one to believe. See Fig. 6 and more on this later.

Looking deeper inside the structure we see bulkheads and formers with a longeron or two at cutouts such as the cockpit openings, high load carrying points, etc.

The geodetic strips are, in function, the stressed skin of our structure but a little ground work is necessary to provide a place for them so let's start with the innards.

Bulkheads and Formers.

We deal with the fuselage only now with the thought that references to formers and longerons will apply, in kind, the same as would ribs and spars for a wing. The bulkheads and formers must be constructed first and as the sketches show, several methods are available in design and construction. A combination of two or more types can be used in one fuselage.

The "Player" has only one type (Fig. 7) and is the easiest to build. All were cut from marine plywood sheet, graduating in thickness from nose to tail, utilizing "beef" in the load carrying areas of the forward section and thinner lighter material for the aft. We quote

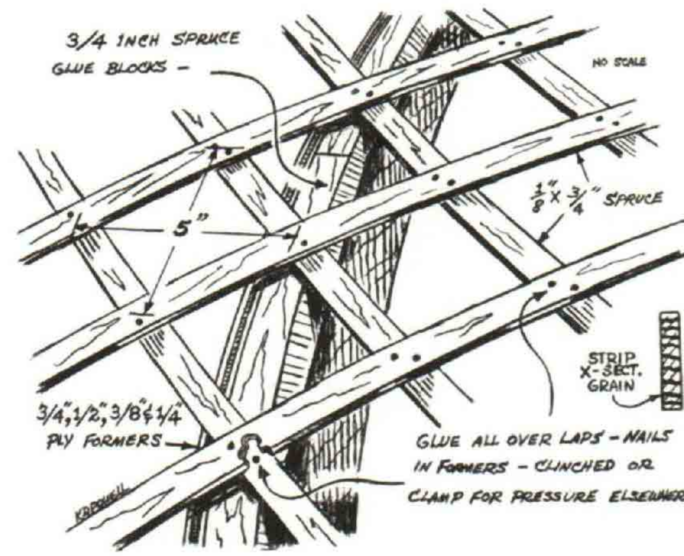


Fig. 6

from the ANC-19 Bulletin, "Fuselage rings or bulkheads are frequently cut out of solid plywood or utilize plywood webs in combination with other parts. In either instance the plywood is most easily cut to shape by routing. Fuselage rings for one plane model have been made by band sawing from plywood with reportedly satisfactory results in service. Excellent utilization was reputedly attained by cutting a series of rings of successively decreasing size from the same sheet of plywood and, in addition, using small scraps for other purposes." Unquote. A proven, simple, and economical method of fabrication for the homebuilt it seems.

Wood end grain provides a weak glue joint and at least 50% of the sawed or routed former edge receiving the geodetic strips is end grain. Small glue blocks added as shown in Fig. (7b) correct this problem.

Steel straps are bolted to the plywood at important stations such as the landing gear and strut fitting locations to relieve the wood of stresses and to transfer loads from fitting point to fitting point. Many methods are available to prevent localized stress and subsequent failure of the wood fibers. All rules of good design engineering must be followed of course. Typical methods used to spread stress over as large an area as possible are high density reinforcement plates of birch plywood, compreg, impreg, or hardwood inserts; metal plates, large wood washers, bolt bushings, etc. The EAA Builder's Manuals, and SPORT AVIATION back issues contain a wealth of information on this subject as well as the aforementioned ANC Bulletins.

The Thalman ships use the more intricate laminated and built-up bulkheads and formers. (Fig. 7c). Though more trouble to build, they feature greater strength with light weight and are recommended for the advanced designer-builder.

Thin strips of 1/8 in. thick spruce are glued up on a mold to form the laminated ring type former (Fig. 8). Very light rings are used in the aft fuselage.

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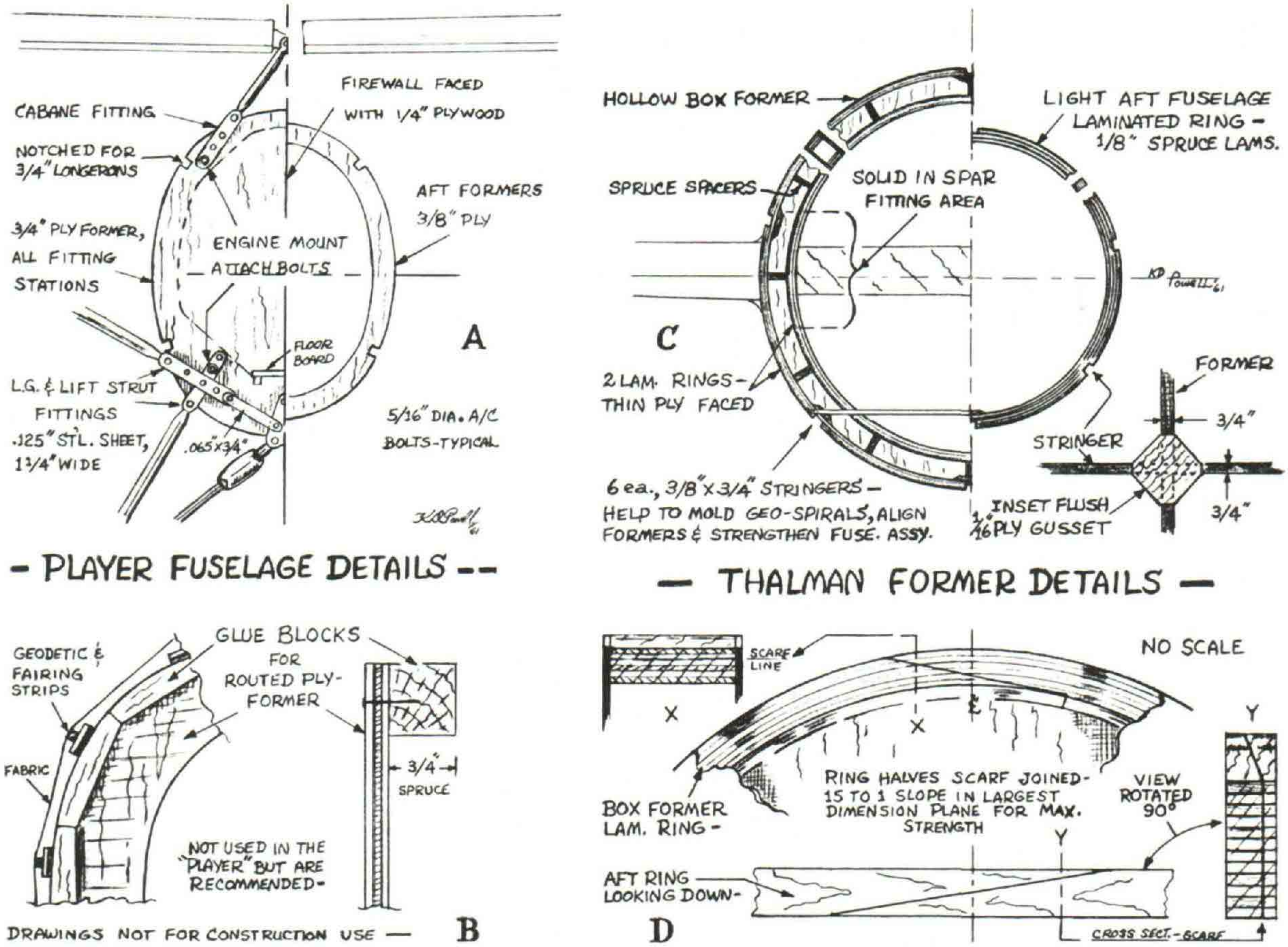

Fig. 7

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Two rings with plywood faces are employed in the built up type formers. All notched longeron receiving

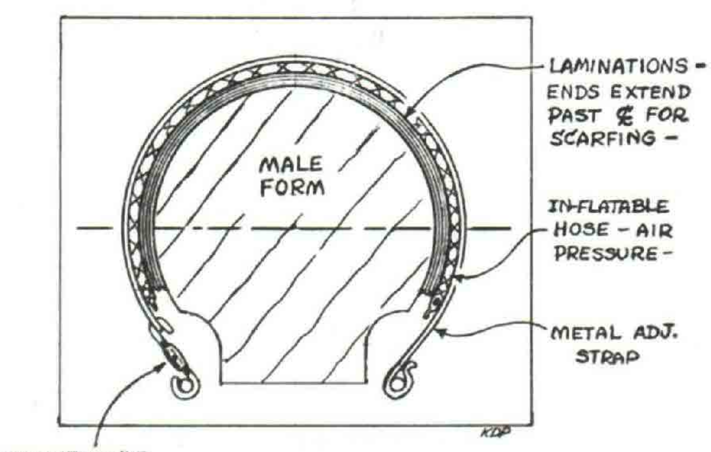

Fig. 8

areas are reinforced in proper manner. Reference (Fig. 9). Thalman builds the rings in two halves then scarf joins them at the vertical center line (Fig. 7d).

The square or slab sided fuselage cross-section shape is "out" of course in using geodetic. Cross-sections can be modified from the preferred perfect circle to the elipse or other similar shapes but they must have well rounded corners and pronounced curvature in flattened areas to maintain strength and facilitate application of the geodetic spirals. This doesn't bother the engineer however since the rounded fuselage cross-section, noted

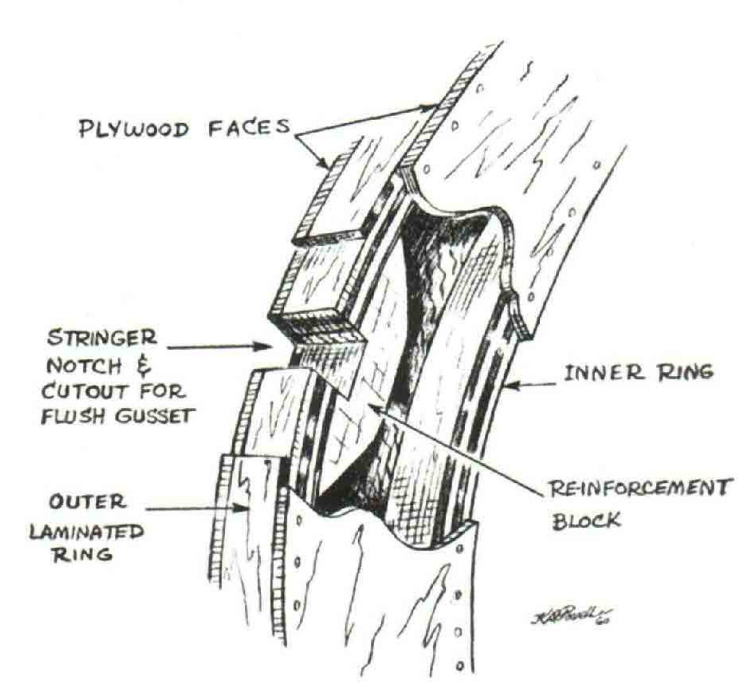

Fig. 9 — Hollow Former Detail

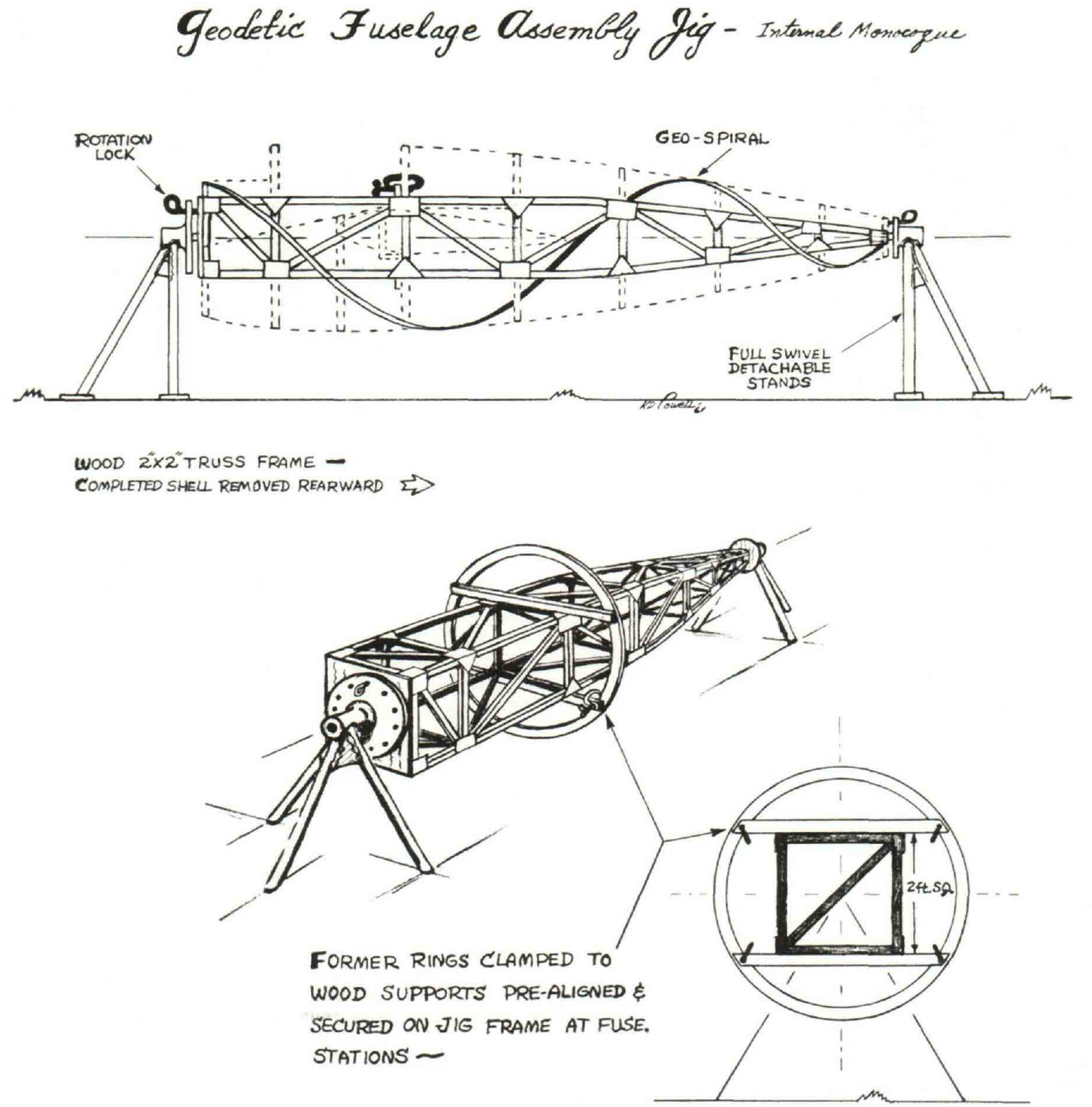

Fig. 10

for aerodynamic efficiency (looks pretty too), is made to order. Streamlining is built in eliminating the requirement for "weighty", non-functional, superstructures as used in some other airframe types.

Assembly Jig.

With the formers complete some sort of fixture will be needed to continue assembly. Since the strips are wrapped around the outside of the formers an internal jig must be used.

Player spotted the formers by hanging them on a plank, braced them in position then attached four ¾ in. square spruce longerons in the pre-notched formers to start construction and tie things together. The geodetic strip application followed and when complete, the plank and internal bracing were removed. The four longerons remained a part of the structure. Earl cautions that some twisting problems developed during the spiral strip application and recommends that the assembly fixture used be completely rigid to prevent trouble.

Mr. Thalman also used an internal assembly fixture made up of a scrap wood 2 x 2 truss framework with scrap plywood gusseted joints, (Fig. 10). Remember the way we built the old balsa stick slab sided model fuselages? Two sides, then put in the cross pieces? The truss frame jig is supported with a pivot point at each end so the whole assembly can be rotated 360 deg. for ease in working. Formers are attached at their respective stations and construction started. After completion the jig is disassembled and removed.

Many other methods undoubtedly would work such as the crutch and half bulkhead system as used in modeling, or ??? (The old ingenuity factor again.) Wing

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spars and ribs properly supported are actually the jig for assembly of these components.

Wings.

At the risk of being incongruous in our step by step fabrication of a fuselage (and to break the monotony) here is the answer to the inevitable question: "How is geodetic used in building a wing?"

The Thalman geodetic full cantilever wing (Fig. 11) consists of one main box spar at about 25% chord, a rear spar to which the flaps and ailerons attach and a small false spar very close to the leading edge. Ribs are spaced at 32 to 36 in. intervals. Stringers of ⅜ by ¾ in. dimension run spanwise to align and support ribs between the spars.

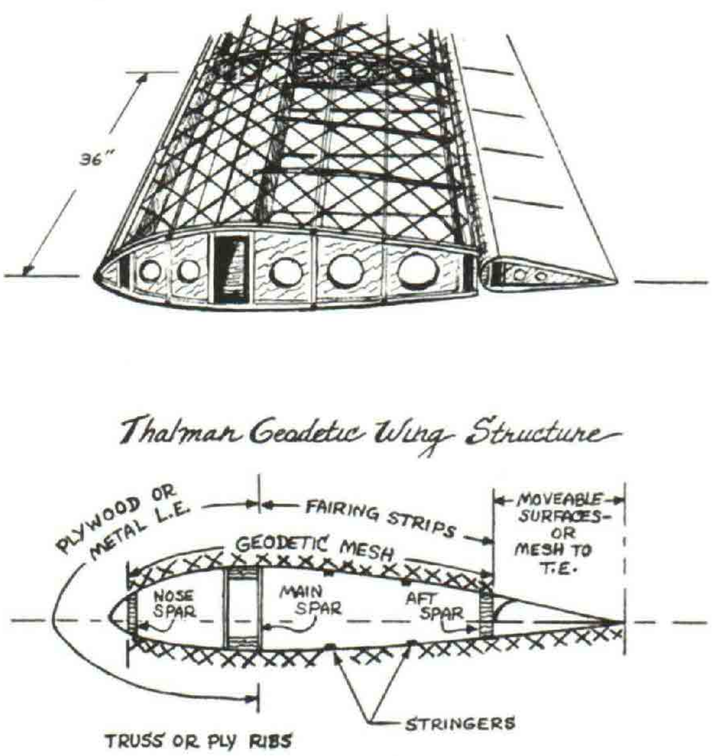

Fig. 11

The geodetic "skin" can be applied on the wing top and bottom in the same manner as the fuselage with the exception that strips are not continuous around the leading edge but terminate at the rear spar and L. E. false spar. Harry builds the diamond mesh "skins" flat on the shop floor. For all surfaces other than the fuselage, this method provides faster lattice assembly and attachment. Attachment is similar to the plywood covered wing skinning procedures. The novel exception is that you can see where the nails are going, the glue squeeze out and all the other "hidden" details not discernable during and after skinning with plywood.

A thin plywood or light aluminum leading edge covering and the fairing strips are added over the geodetic before the final fabric cover. Use of monospar, "D" spar, lift strut or flying wire braced wing variations of the Thalman system with proper design engineering would be practical.

Not to knock geodetic, but in the interest of "go-grease" for the really high performance airplane, Harry

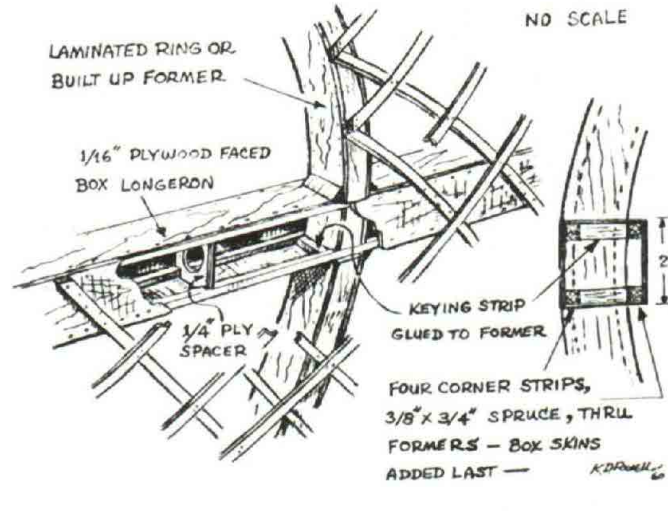

Fig. 12 — Box Longeron - Cabin Framing Detail

recommends the use of the all plywood covered wing with its smooth, airfoil preserving surface and aerodynamic efficiency. Using wings of geodetic, the ultra-light or Sunday "sportster" would reap other and possibly more important benefits. Designed and constructed carefully geodetic wings are superior or equal to the ply covered in strength, weight and other respects. The stand out and possibly determining factor again in its use would be the savings in cost of material.

Now back to the fuselage.

Framing of Cut-Outs.

The perfect geodetic structure, strengthwise, would be one without any cut-outs for cockpits, passenger compartments, wing or tail junctures; however this is impossible so such openings or breaks in the "stressed skin" must be framed and re-inforced.

It's up to the builder to determine the type of framing he needs. The "Player", a parasol monoplane with only the cockpit opening breaking the geodetic, required a simple plywood sheet framing. The 3/32 in. plywood was glued over the geodetic strips in the pre-determined area, then the cockpit opening was marked and cut through the ply and the strips in one simple operation.

In the four-place Thalman, the large cabin area presented a more difficult stress carry through problem and required additional internal structure. The internal structure consists of two sturdy beams (Fig. 12) one at both cabin window sills. By building the "hollow" beam or longeron as illustrated, the four corner strips may be bent to follow fuselage contours or a curved cut-out

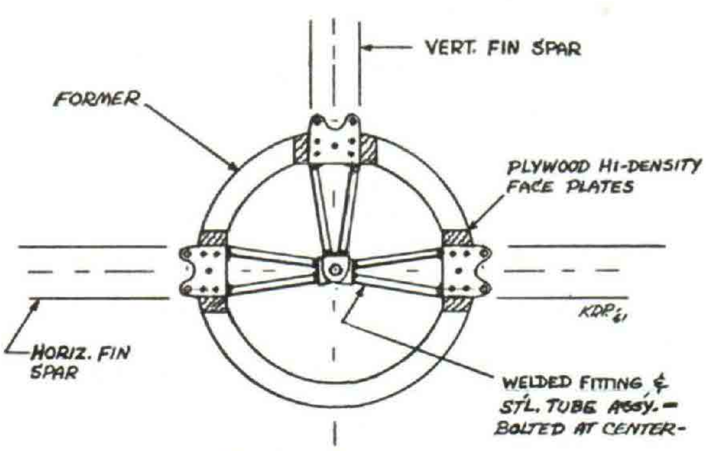

Fig. 13 — Thalman Tailplane Attach Detail. Not for construction use—design study only.

as in the T-4. They also maintain good strength carry through and can be ended neatly.

Plywood skins and stringers, seat mount and control system bracings are strategically placed to solidify yet hold the weight down. Harry cautions against adding too many solidifying members or ply-skins. For instance if the truss frame used as a jig were built in, there would be two fuselages in one and the geodetic would become useless in its elastic monocoque load carrying properties.

Thalman avoided structure weakening cut-outs at wing and tail attach points and actually made the cabin and wing mount locations work for each other by running the wing spar through the fuselage. Some Yates low wings incorporated the wing, or wing center section, and the fuselage as an integral unit. Vertical and horizontal fins may be integral also. Component junctures must be given careful consideration and good engineering practices followed. Thalman's method of attaching the interchangeable tail surfaces is shown in Fig. 13. The tubing effectively transfers flight loads from the wood bulkhead.

Geodetic Strips.

With as few "bones" as possible in place and lined up on the jig our geodetic "skin" now has a place to go. First a few pointers on the strips themselves.

The average light plane will use 1/8 in. x 3/4 in. strips ripped from a quarter sawed straight grain spruce plank. Smaller dimensions (1/16 in. x 1/2 in.) have been used successfully in smaller components such as flaps and control surfaces. Grain direction, run out, etc., is very important to prevent splitting and other application problems. Looking at the end of the strip, the wood annular ring direction must be the same as in a solid wing spar (see Fig. 6). Strips must lay flat and bend evenly when spiraled around the fuselage formers so knots and other imperfections must be non-existent or held to a minimum. We're ready to "weave" our "Sky Basket" now.

Strip Application.

To assist in making sure the strips lay flat and bend to the exact true contour he requires, Mr. Thalman places temporary template intercostals between each former. Template strips are scrap wood spaced about two inches apart, projecting past the outer edge of the formers. These are marked using a long, even flexing wood spline and shaped to the longitudinal loft lines. Former edges are also blended to the loft lines during the shaping operation. Use saddle gussets clamped to the formers to anchor the template strips. Avoid nailing to the formers to prevent damaging them. Use templates at your own discretion. Many haven't. The longitudinal stringers built into the fuselage (Fig. 7c) serve a dual purpose here.

Start the first layer of geo-spirals at the top center of the firewall bulkhead and wrap the strip clockwise making one and one half to two easy turns in the length of the fuselage. Glue and nail the strip where it crosses over each bulkhead or former and other points as required. Do the same with the next one making sure to space it and those that follow so the diamond mesh will be about five inches across (see Fig. 6). Diamond dimensions may be varied in accordance with load design requirements remembering that strength and rigidity decrease as diamond dimensions increase. The strips may be spotted to clear fittings in most cases. Thalman marks the firewall, tail cone and at least one middle former with pre-determined strip locations to control even placement of the first layer of spirals. He also advocates in-setting the first spiral strips flush with the former outer edges for increased strength and positive alignment. This is extra work and may not be required at the builders discretion.

After finishing the clockwise layer of spirals, reverse the spiral direction (counter-clockwise) for the second layer of strips, winding them over the top of the first. Maintain the diamond spacing and glue and nail (or clamp) each strip crossover point. Strips may be cut out to prevent crowding where the fuselage narrows toward the tail. The strips also have a tendency to want to reverse their twist direction in this area and Thalman found it necessary to split them intermittently wih a narrow saw cut dividing the 3/4 in. dimension. This allows more flexibility with a negligible loss in strength. Strips may be scarf joined, preferably at a former station, to obtain lengths if necessary.

With the last strip in place we're nearing completion of the basic airplane structure. The plywood framing of cockpits or other cut-outs is now done. Internal details, controls etc., are installed and we're about ready for the fabric.

Fairing And Streamlining.

Few builders place the fabric directly over the geodetic although it may be done. The Wellington Bombers wing in in-flight photos show the diamond shaped bulges on the upper surface fabric covering but longitudinal strips fair the fuselage. Our specialists use 1/4 in. square spruce strips aligned in the airflow direction on all components. In the interest of aerodynamic cleanliness their use is recommended.

If the geodetic spirals are not contoured evenly in some areas the fairing strips will now have to be notched and tailored to give the smooth, true fuselage shape we want. By skillful manipulation of a narrow strip of sandpaper, long enough to go around the circumference of the fuselage, the installed fairing strips can be smoothed to perfection. This is like using a strip of crocus on a steel tube only on a larger scale.

Now last, but not least before covering — Varnish, varnish, and varnish. Smooth wood surfaces, well preserved, are beautiful to behold and impervious to deterioration. Don't skimp here!

Summary.

Geodetic aircraft can be treated in structural design basically the same as their monocoques or semi-monocoque stressed skin counterparts. Intimate details of design and engineering are left to the Experimenter, you the reader, and undoubtedly those interested in using the geodetic system have, or can obtain, this very necessary data and the help of a qualified engineer.

Some of Mr. Thalman's tips on designing for aerodynamic efficiency are:

1. Keep weight down by using hollow built-up members where practical.
2. Make everything smooth.
3. Pay attention to shape. (This applies in fabrication also). No abrupt contour changes or irregularities.
4. If protrusions are necessary, (and the wings and tail are) make them 90 deg. to the surface they extend from.

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Shaping Tube Ends On A Metal Lathe

By Francis H. Spickler, EAA 4209

One of the most important steps toward making a good weld is to produce parts that fit accurately. The writer is using a simple attachment for a metal lathe to shape tube ends to fit other tubes accurately and quickly and at any angle.

The main body of the attachment is made of hard maple 2 in. x 2 in. x 4 in. A ¾ in. x 4½ in. hexagon head machine bolt is turned as shown for a 9 in. South Bend metal lathe, or modified as necessary to fit the lathe available. The small piece of mild steel is fitted to the block and screwed in place in order to keep the block in proper alignment with the compound rest at all times and yet permit easy exchange of blocks for forming any desired size of tubing.

Slide the head of the bolt in the "T" slot on the compound rest and slip the block on the bolt through the 11/16 in. hole. Seat the block so that the piece of mild steel slips into the "T" slot and fasten the block securely with a washer and nut. Place a drill of the desired size tubing in a chuck on the spindle of the lathe and drill a hole through the block. A second hole for a different size tube is also drilled the same way. Remove the block from the lathe and split it in half by sawing on a circular saw and the attachment is completed. As many blocks can be made as desired to prepare for tubing of various sizes. By placing the 11/16 in. hole slightly off center a larger hole and a smaller hole can easily be accommodated on one block.

In using the attachment the piece of tubing is clamped in place on the compound rest, the compound rest is set to the desired angle and tightened. A standard reamer with the diameter of the tube against which the shaped tube will butt is mounted between centers of the lathe. Flood the reamer with cutting oil, feed the tube into the turning reamer with the cross feed, and in a matter of moments one has a perfectly fitted pair of tubes.

Fitting tubes on an angle is no problem. One only has to measure the angle of the center line of the tubes on the jig or from an accurate plan, set up the compound rest for the desired angle, and feed the tube into the reamer as it turns. The fit will be better than absolutely necessary with less than a minute spent in making the cut.

To obtain the proper length, cut the raw stock as closely as possible to length, form one end, form the second end being careful to align the tube in the block so that the two ends will be on the proper angle with each other. Next try the tube in the jig. At this point it is easy to measure how much must be removed to achieve the proper length. If the lathe has a graduated cross feed it is a simple matter to remove precisely the required amount. With practice one can usually cut the tube to the proper length so that it fits accurately the first time.

The writer first tried the idea without the mild steel guide block. It worked satisfactorily, but alignment of the tube was tedious, and took more time than forming the tube end. Cutting and fastening this small item saves much time on setting up the tubes for forming.

Carbon steel reamers are satisfactory as long as plenty of cutting oil is used with relatively slow speeds. Of course high speed reamers will stand up better.

Be sure to remove all cutting oil before welding in accordance with good welding practice. ●

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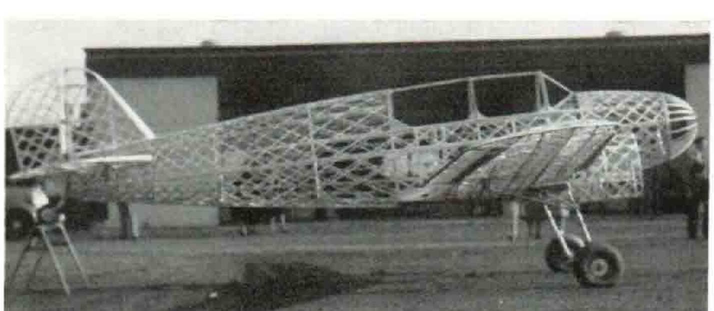
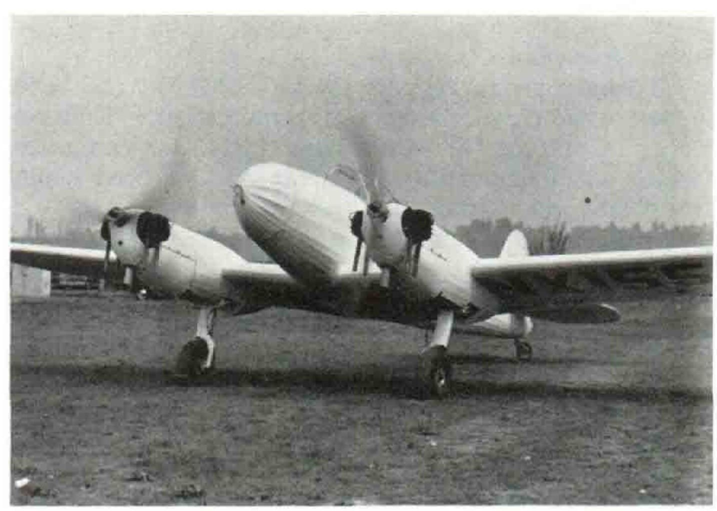
5. Close exterior gaps. Keep outside air out and inside air in. Prevent leak through from one surface to the other at control gaps.
6. The midwing is the most efficient and doesn't need fairings at the fuselage juncture, but small radii at such points help.

Looking at the T-4 you know he practices what he preaches.

Wood geodetic for light aircraft is a safe, proven, strong, light, easy to fabricate, versatile and IN-EXPENSIVE construction medium well suited to compound aerodynamic form. Through intelligent use of its in-



North Pacific Aircraft Corp., Portland, Ore. geodetic plane before covering.



North Pacific geodetic aircraft ready for flight.

herent features it is hoped that the average EAA member, of modest means, may obtain his long dreamed of custom made "Set of Wings".

A couple of new "Flying Baskets" showing at one of the not so distant future EAA Fly-Ins would be payment aplenty for our efforts here.

Many thanks to Mr. Player, Mr. Thalman, and all the Ogden Chapter 58 members who helped with research, time, and technical advice.

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