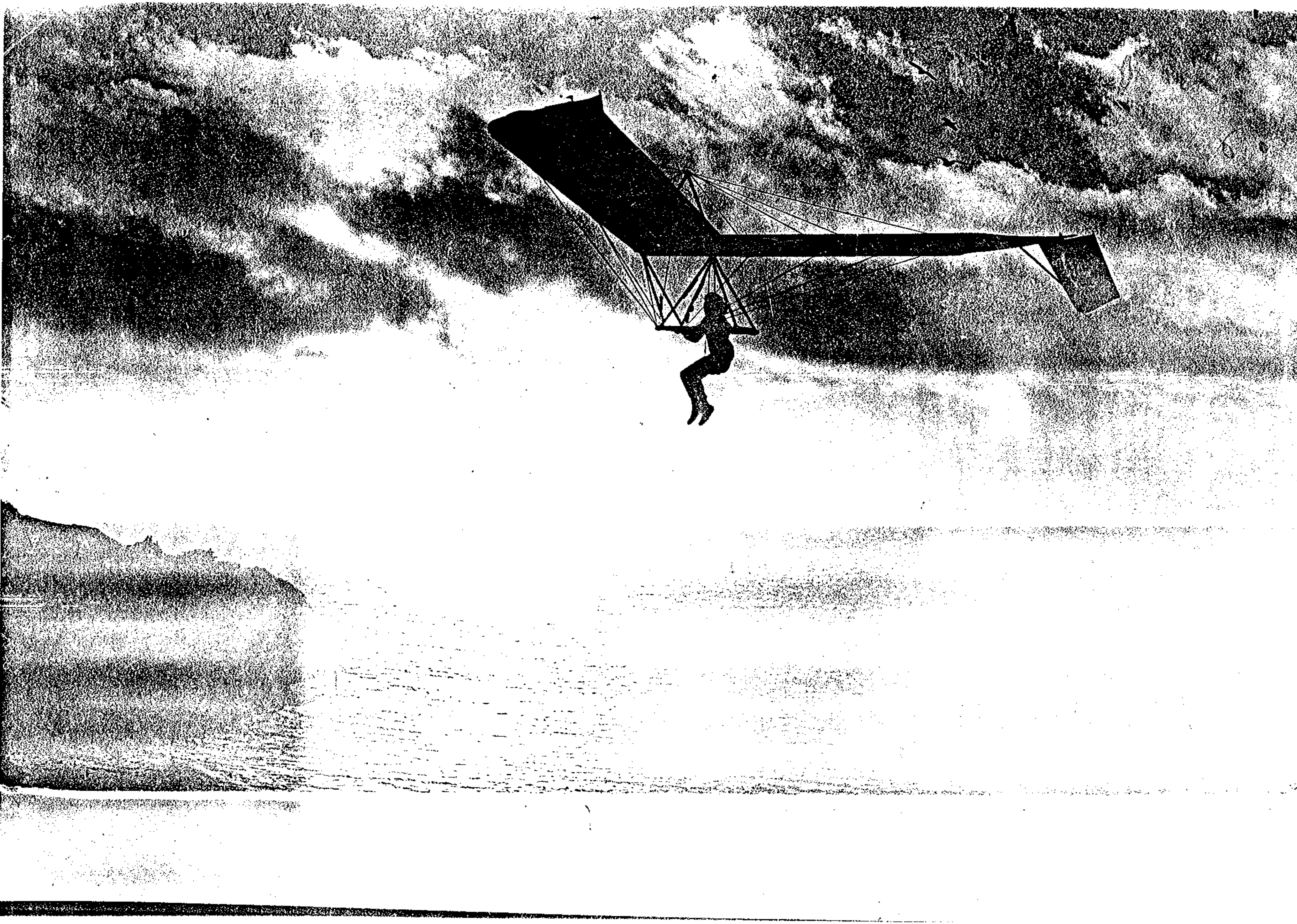

ICARUS V

An account of the construction and flight of a performance class, foot-launched glider

by

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California 92060

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Cover photograph derived by T. Balabanoff, from a photo by R. Etchells.

INTRODUCTION

This book was written in order to document my experiences designing and building ICARUS V, so that others might benefit from them and discover for themselves the thrill of true bird-like flight.

At the time ICARUS I and ICARUS II were built and flown, it was not even certain that sustained and controlled soaring flight was possible with foot-launched craft in moderate or light winds.

The emphasis was on controllability and structural integrity and light weight. Many exhilerating flights proved that ICARUS II had these qualities in good measure, and I began to look around for ways to incorporate refinements I considered desireable. The lower wing was something of a bother in that it obscured my visibility more than I liked. This was aggravated further when I closed the gap to reduce the induced drag.

About the same time I began an intensive study of recent developments in high lift,high efficiency airfoils. After considering all of the factors and blending in my experiences with ICARUS II, I came up with what I consider the "inevitable" design--ICARUS V.

Although it may not be the ultimate design, it does possess those attributes of strength, performance, controllability, and portability I was looking for, in fact, it exceeded my expectations in every way! After several dozen hours in the air, she shows only smooth and gentle characteristics, and no apparent vices. Still, as aircraft go, she is a youngster in a very young sport. Until more experience is gained in this realm of flight, every flight in every craft must be regarded as an experiment being conducted by both builder and flyer.

For this reason, <u>the drawings and text contained in this book do not express or imply that aircraft built in accordance with them meet any set standards of airworthiness or structural integrity</u>.

Finally, much of what appears in this book can be recognized as coming from my prior publications, including the book <u>Building the ICARUS II</u>. It is perhaps worth mentioning that those earlier statements seem to have withstood the test of time remarkably well, considering how quickly the sport has advanced.

CHAPTER I

HISTORY OF MODERN HANG GLIDING

The birth of the modern hang gliding movement coincides with the 123rd birthday of Otto Lilienthal, May 23, 1971. This was no accident since on this day appeared the greatest assemblage of foot-launched flyers the world had ever seen. Thanks to the efforts of Richard Miller, Jack Lambie, Lloyd Licher, Joe Faust, Bruce Carmichael, and others, this "spontaneous happening" became a landmark event in aviation.

Soaring pilot Russell Hawks' description of his flight in the author's "Batso" during that meet made entertaining reading in the National Geographic Magazine the following February--and through that article, millions of people first learned that the age old dream of unassisted man-flight had indeed come true.

Several important historical facts should be mentioned so that newcomers to the sport can appreciate how these important developments came about. First, most of the craft at the first meet were rigid-winged! Dave Kilbourne was following in the steps of Australians Dickenson, Moyes, and Bennett with his standard Rogollo, but most of the flights made with this type of craft were being performed on water skies, using boat and auto tows to gain altitude before releasing and gliding back to earth. Several variants of Richard Miller's Bamboo Butterfly (a bamboo and plastic Rogollo and using hang tubes for control) were in attendance at the first Lilienthal meet and demonstrated clearly that this design was capable of excellent control in the hands of a skilled pilot--and very limited in aerodynamic performance.

The many "Hang Loose" gliders built to plans prepared by Jack Lambie showed the opposite face of the coin--acceptable aerodynamic performance and practically no control!

The Miller "Conduit Condor" combined the best promise of both. Ably flown by Richard Miller, this tapered flying wing demonstrated that the most promising hang glider configuration did not have to look like, or fly like, some historical oddity from yesteryear.

August 22, 1971. At the following meet, held a scant three months later and commemorating the exploits of early aviation pioneer J. J. Montgomery, ICARUS made its public debut.

Step number two had been taken. For the first time, a craft with sufficient performance to permit the possibility of soaring flight in moderate conditions also demonstrated the quality of control necessary to make that hope a reality.

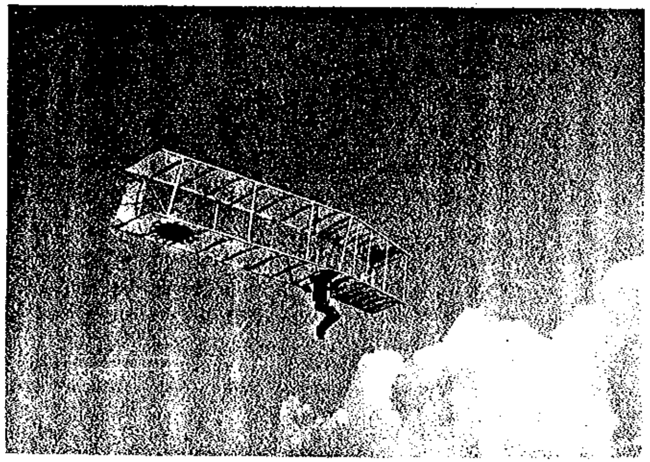
Step three followed in October, 1971, when TV viewers in the Los Angeles area were treated to the first public display of "hang-soaring". ICARUS coursed back and forth above the cliff at Torrence Beach, California. In a gentle sea breeze. This foot-launched, 45 pound craft, climbed above the take-off point making controlled 180° turns as the pilot maneuvered into favorable up-currents.

These accomplishments helped provide the catalyst to the efforts of the growing ranks of ground-skimming pilots. Polyethelene and bamboo gave way to dacron sail cloth and aluminum tubing as the "standard" narrow angle Rogollo began to show up in increasing numbers.

The lessons of the first Lilienthal meet had borne varied fruit. Volmer Jensen and Irv Culver created an outstanding cantilever monoplane, the VJ-23, by applying modern structural and aerodynamic principles to the problem of foot-launched flight.

Other designers explored the tempting path of the high aspect Rogollo, only to abandon it when the pitch instability which had been predicted by the experts proved too formidable. Bob Lovejoy created the first successful hybrid, the Quicksilver. By taking the middle course between the membrane wing of the Rogollo, and the rigid structure of ICARUS and VJ-23, he realized performance which exceeded that of the Rogollo while retaining some of its portability.

Higher and still higher mountains were chosen as jump off points, and ridge soaring off high coastal cliffs became routine, but the mainstay of soaring, the thermal, still eluded the hang pilots. Late in 1972, the ICARUS racked up another first by achieving that goal. At the same site near Palmdale where the author flew his primative bamboo and plastic "Batso" more than two years earlier, the ICARUS II spiraled in rising columns of air to gain 1000 feet above the take-off point. The extreme turbulence provided ample opportunity to demonstrate the intrinsic stability of the swept flying wing. The stage was set for ICARUS V.



The first ICARUS soaring at Torrence Beach, California, in October, 1971.

CHAPTER II

WHY THE ICARUS V?

If you should ever show up on a hillside with a foot-launched glider that looks anything like an ICARUS V you are sure to be asked a lot of silly questions. This chapter may help you answer some of them. The first is very apt to be, "Why doesn't ICARUS have a tail and elevators, or something?" The answer is because they're not needed and might indeed even prove harmful to the flight and stability characteristics. Let's look at the problem of the tail.

Longitudinal stability can be achieved in any of several ways but in the end it always comes back to the same thing. The center of pressure on an airplane wing must move rearward if the craft noses up and forward if it noses down. The aeronautical pioneers understood this without knowing about moment coefficients, aerodynamic center, metacentric parabolas, etc. For this reason, they performed their wind tunnel tests on complete wing-tail combinations, to evaluate the suitability of various designs. Out of all of this came the realization that the rear surface must in effect be at a lower angle of attack than the forward one. For a conventional wing-in-front, tail-in-back arrangement this means that the tail is at a negative incidence angle with respect to the wing. For Canards, the "little wing" up front must be at a positive angle with respect to the main wing. For upswept flying wings, the designer makes use of reflex --he turns the trailing edge upward. For swept flying wings, the tips, being farther aft, are twisted down or "washed out" with respect to the center portion. Since this is what is needed to obtain a favorable spanwise lift distribution and good stall recovery properties with a constant chord wing, we have killed several birds with one stone.

Now let's talk about the elevators for a minute.

The function of the elevator (or elevon) is to produce nose up or nose down moment on the aircraft, changing the angle of attack of the main foil, and with it the trim of the craft. With a conventional tail-in-back configuration, the elevator is so far behind the wing that the moment change is quite large for small lift on the tail and the fact that the tail is producing a slight downward or upward force is of no consequence. In a flying wing the situation is different. Raising the elevons produces the desired moment but at a cost. The elevon has, in effect, changed the camber--and with it the lift--of the wing so that the change in lift is less than the desired amount. Thus when the elevon is deflected upward, the wing pitches up, giving more lift. At the same time the up-elevons also act like up-flaps which reduce the lift on the wing! The two effects counteract each other and make pitch control difficult. Both takeoffs and landings are tricky with this configuration.

What's the solution? How about center of gravity shift? If the angle of attack of the wing is increased by moving the pilot's body weight aft, the increase in lift is exactly the same as that produced by a conventional craft with a tail, for equal aspect ratio and angle of attack change. Interestingly enough, this is the longitudinal control system used by soaring birds! Jack Lambie has pointed out that a bird does not use his tail to change angle of attack, but rather to control his trim after he moves his wings forward or backward with respect to his body weight.

Why doesn't Cessna or Piper employ this method of control? For one thing, the pilot doesn't weigh 3 times as much as the plane, as is the case with most hang gliders.

So these are some of the reasons why ICARUS II and ICARUS V were made swept, flying wings, with reflexed airfoil sections. Given the qualities enumerated above, qualities which we really looked for in the good old days (3 years ago!) when a 200 foot long flight 5 feet off the ground was the day's crowning achievement, we can address ourselves to the next problem: lateral control. How do we steer this thing? Given the intrinsically stable airfoil and the sweep, one needs only dihedral angle and rudders attached to the swept wing tips to produce a completely flyable and steerable machine. Notice I don't say anything about 3 axis control because indeed we must decide whether independent roll and yaw are important, or even desirable. It has long been recognized that rudder pedals were added to most airplanes to make up for the shortcomings of the designers. ICARUS II and V have both demonstrated continuous spiral turns at angles of bank in excess of 55 degrees with no signs of instability.

The other possibilities for lateral control are ailerons or spoilers. Ailerons have quick response, but they are tricky to build and actuate effectively, and they introduce problems of adverse yaw. Spoilers are simpler but they are basically an inefficient, energy wasting, system. Considering the problems of the above devices and the remarkable success I had with the first ICARUS, I have retained the simple, individually controlled, wing tip rudders.

Of course, one does pay a price. Roll control response is relatively slow for small corrections because the aircraft must yaw before it will roll, and the moment of inertia is not negligible about the yaw axis.

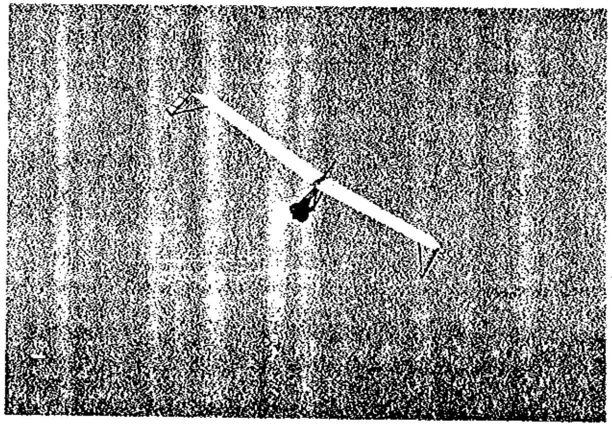
This is especially true for the 32 foot span ICARUS V. Still the actual manuverability of this craft exceeds that of most conventional sailplanes and gliders.

Craft employing tip rudders in this fashion tend to be very stable, because of the effects of sweep and dihedral. In fact, they possess such strong static recovery characteristics that in a sense the pilot just "goes along for the ride." Any disturbance from straight ahead flying automatically results in restoration of straight ahead flight. In a normal turn, neutralizing the differentially controlled wing tip rudders means a spontaneous return to normal flight.

Many inquiries are received about the airfoil designs used on the ICARUS flying wings. The airfoil used on ICARUS II was a modified Eiffel section--chosen for its low moment. The section used on the ICARUS V is more sophisticated. After studying the results of Stratford, Lissaman, Liebeck, and Wortmann, an airfoil was "eyeballed" which would have low moment and still possess high efficiency at high lift coefficients. Low moment is achieved by employing reflex in the camber line. High efficiency is obtained by generating a shape with generous leading edge radius and rather abrupt thickening, followed by a smooth, gentle, "recovery" section. Several sections were analyzed, thanks to the generosity and ingenuity of Dr. Peter Lissaman, using the Hewlett Packard computer at Aerovironment, Inc. The resulting pressure distribution and performance characteristics seemed ideal for a craft of this type and flying in this regime.

It should be noted that higher maximum lift coefficients and lower stalling speeds can be realized with highly cambered, high moment foils, but recent experience has shown that take off and landing speeds are well within the capabilities of most pilots without having to rely on ultra high lift sections. Indeed, most pilots would trade extremely low stalling speeds for high speed performance, and better high speed performance can be expected from sections without large undercamber.

Thus we can see that the final design of the ICARUS V was an almost inevitable consequence of several individual design decisions, each interlocking with, and crying out for, the other. The result is a stable, pilot-launched ultra-light glider with a glide ratio of about 10:1, a large usable range of flying speeds, and excellent controllability.



ICARUS V

CHAPTER III

SOME HANG GLIDER BUILDING HINTS

Building a foot-launched glider requires a few tools, moderate skill, and lots of common sense and perserverence. Most of the steps follow normal, good shop practice, but a few of them are rather special. The following procedures should be read and kept in mind when you begin construction. Re-read them several times during the actual building and they will begin to take on further meaning.

Bending Tubing:

The tubing on ICARUS V was bent in the following way:

1. The tube to be bent was cut 6" to 1' longer than required.

2. One end of the tube was plugged with a bit of rag or paper towel.

3. The tube was filled with playground sand and the sand tamped down by gently rapping the closed end of the tube on the ground. When full, the tube was capped with another piece of rag.

4. The tube was bent around a form of slightly smaller radius than the final desired one. When bending the ribs, the process of finding the right shape for the template was a trial and error one--depending on the tubing, sand pack, etc. Even then, some over-the-knee adjustment was necessary to get the shape just right. Note: slight gradual deviation (1/16" up front, 1/8" in back) from the rib shape is not nearly so serious as bumps or kinks in the rib shape. 3/4" plywood forms were cut out on a band saw for the ribs. The other tubing bends were made around any convenient tire or trash can.

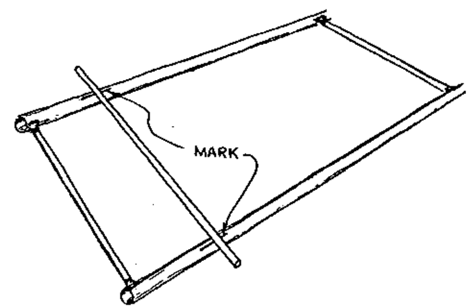
5. If the bend was made too sharp any place, it was smoothed out by rocking that area back and forth on a flat surface while pushing down on either side.

6. The sand was emptied, the tube cut to length and fitted.

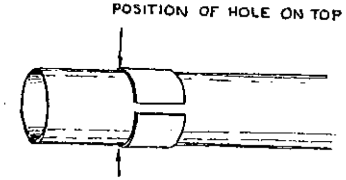
Locating holes on tubing:

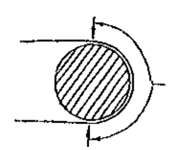
Not being able to get big pieces to the drill press, many of the holes on the ICARUS V were located and drilled like this:

The top of the spar tube was located by rubbing a piece of tube on top of the spars.



This tube was placed parallel to the ribs. When rubbed back and forth on the spars a few times, it would leave a mark directly on top of the tube. Once the top of the holes were marked, the "bottom" of the hole was located using a split scrap of 2" tubing and a piece of paper with the tube circumference and half-circumference marked on it.

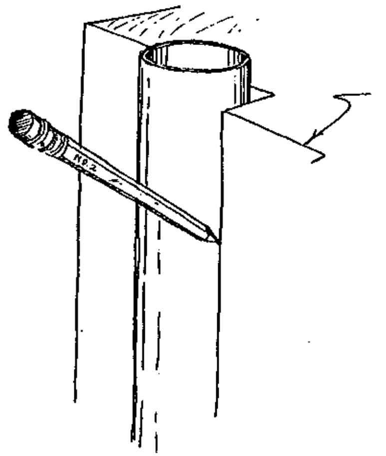




Holes that go on the front of the tube are located by measuring 1/4 of the circumference down from the top in front and in back of the tube.

Parallel holes on struts:

To drill struts so the axes of the holes at each end were parallel, the tube was marked like this to get the correct circumferential location of the holes.



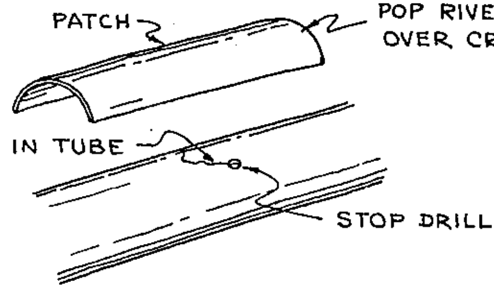
Drilling:

All holes, if not done with a drill press and "Vee" block, were center punched and drilled from both sides. When the tube had a wooden plub inside, a pilot hole of about 3/4 the final diameter was established first. This allowed for some corrections in allignment before the final hole was drilled.

Finishing metal pieces:

All metal parts had their edges filed smooth after cutting. This prevents cracks from getting a start at a small nick or notch. It's important! If a crack did form in a piece of tube while it was being worked (smashed flat, etc.) a 1/16" stop hole was drilled at the end of the crack to prevent further propagation.

If the crack was in a critical location, a patch was riveted over it after stop drilling. Needless to say, do not patch spars, hang tubes, or other primary stressed member.



Cable and Nicopress:

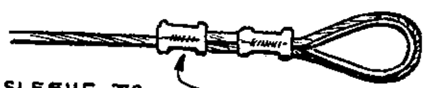
Cable attached with Nicopress sleeves has proved to be a very convenient, strong, and reliable way to rig hang gliders. The strength of various sizes of aircraft control cable is given below: Any freying or kinks can severly weaken the cable and such areas must be replaced.

Diameter	Breaking Strength/lbs.	Weight per ft.
1/16"	450	.008 lb.
3/32"	900	.018 lb.
1/8"	1800	.035 lb.

Stainless steel and galvanized cable have roughly the same strength. I have used galvanized on ICARUS V and it is holding up well. However, stainless survives much better in corrosive atmospheres (such as beach areas).

One correctly applied Nicopress sleeve makes an eye splice that is as strong as the cable itself. It is also possible to splice the ends of two cables if two nico-sleeves are used. This is just about as strong as the cable.

When making an eye splice it is convenient to use a second crimped sleeve to cover the short end of the cable. Uncovered cable ends give very painful cuts and pricks.

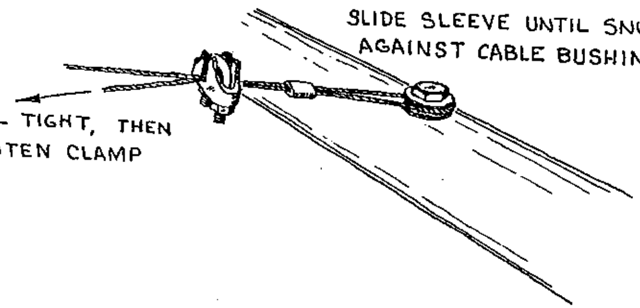


Note: A thimble or cable bushing must be used whenever an eye splice is made to keep the cable from kinking or chafing.

THIMBLE

CABLE BUSHING

To get cables tight without turnbuckles, the second end to be attached was held temporarily with a small "U bolt" cable clamp while the sleeve was being compressed with the Nicopress tool. Slide the Nicopress sleeve up close against the bushing before crimping.



After compressing, the clamp was removed and the loose end of the cable trimmed. A pair of vise grip pliers could be used in lieu of the clamp.

When using Nicopress sleeves, it is essential to have the correct size sleeve for the cable and to have the correct tool for crimping the sleeve! A tool (pliers) for doing 1/16" and 3/32" sleeves was about $20.00. They are also available for rent.

Nico-sleeves must be applied with care. They are often the only thing between a hang glider pilot and the ground. A gauge comes with each Nicopress tool, and it must be used to check that the tool is properly adjusted. An incorrectly crimped sleeve may pull out. I have seen this happen!

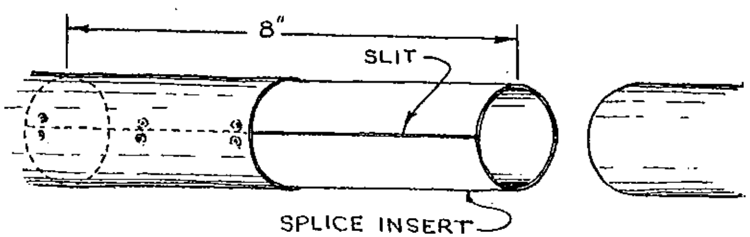
CHAPTER IV

BUILDING ICARUS V

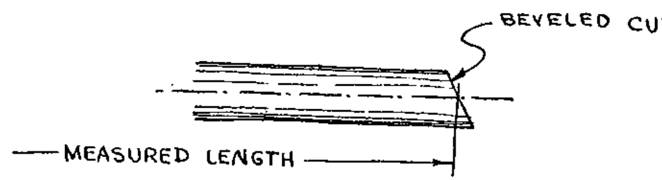
Assembling the frame:

1. The spars, sleeves, splice inserts and root tube were all cut to size using a table circular saw with a blade suitable for cutting non-ferrous metals. The sleeves were split using a single blade, but the splice and reinforcing inserts had .23" slots cut in them using two blades with a spacer between. The slot is necessary so that the splice piece will fit inside the 2" diameter tube.

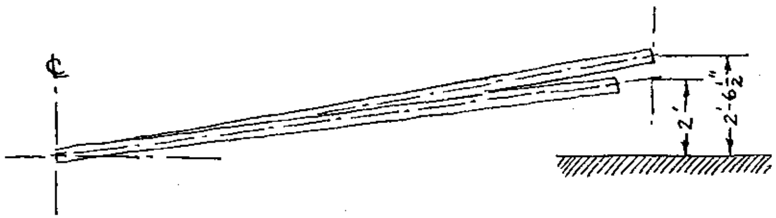
The spars had to be spliced up from 12' lengths, since that was the greatest length I could find. The location of the splices was not critical as long as it did not interfere with any other reinforcing sleeves. A splice made with an eight inch long insert and about ten pop rivets on each side is nearly as strong as the tube itself.



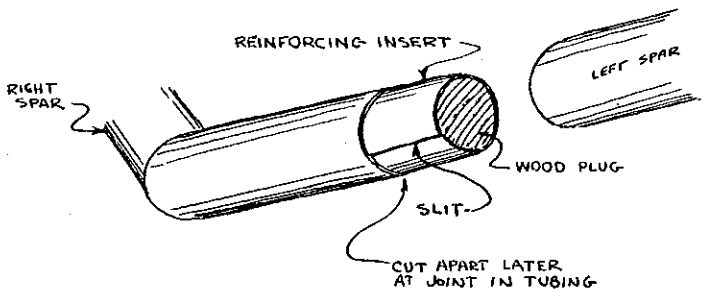
The root ends of the spars were cut at a 21-1/2° angle. This angle is greater than the sweep angle (approximately 20-1/2°) because of the dihedral angle. On plate 2 the length is given to the middle of the beveled cut. The beveled cut should be made after both the reinforcing insert piece and wooden dowel are riveted in place.



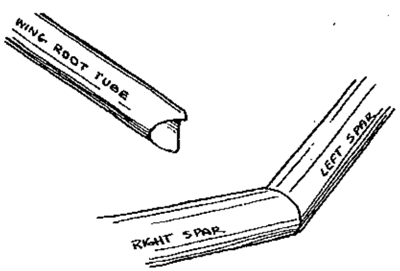
2. The spars were now set up in their correct relative positions, 6' sweep, 2' dihedral, and 7-1/2° wash out at tip. (The wash out will mean that the rear spar will have 6-1/2" more dihedral at the tip.) Because the front spar is shorter, the measurement is made to an imaginary point extended even with the rear spar.



The left hand spars were made in two pieces because the joint for separating the wings is slightly to the left of the center line. The two pieces can be held together temporarily as an aid in construction if the reinforcing inserts for the spar joint are made in one piece and not cut apart until later, at the location of the joint.



The root ends of the left and right spars were held together temporarily with tape and the ends of the root tube shaped by filing so they fit together nicely at the joint where the left and right spars join. The wooden plugs should abut nicely over the entire faces.



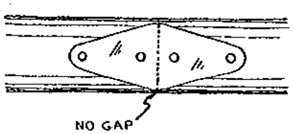
The front and rear spars should be 47" apart (center line to center line), measured parallel to the wing ribs.

The spars and root tube were now riveted together with the wing root gussets (plates 13, 14). Some thin tape (such as masking tape) can be used to hold the tubes in place while the gussets are riveted in place.

3. The reinforcing sleeves for the wire attachment bolt holes were now riveted in place as per plate 2 and the holes drilled for the wire attachment bolts. The holes should be perpendicular to the axis of the tube and to a line from the top of the front spar to the top of the rear spar. See Chapter III for suggestions for locating holes. Wood plugs are inserted inside the tubing at the locations of exterior doubler sleeves, spar joint, and at the spar center-line, as shown in plate 3. It may be necessary to drill a 1/4" diameter hole in the wooden plug to permit trapped air to escape if the tubing ends are plugged first. There is no need to make the plugs too tight--a sliding fit is O.K. The end plugs can be a little more snug.

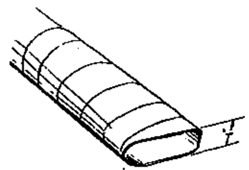
4. The compression ribs were cut, shaped to fit the spars and riveted in place with their gussets (plates 2, 3, 12).

5. The left spars were slipped off the joint reinforcing inserts. The inserts and dowels were then carefully cut off with a hack saw and the cut off ends of the inserts and dowels riveted into the ends of the left spars. The spar fittings (plate 2) were cut out, filed and drilled. The spar was drilled to accept the fittings, using the spar fitting as a locating jig.



6. The wing tips were bent and riveted in place using the gussets shown on plate 14. To fit the wing tip the outboard ends of the rear spar were deformed to a roughly rectangular section

1" wide on the shorter leg and filed to fit the wing tip. There is no need to hurry this step. You can wait until after rigging the drag-antidrag wires before securing the wing tip to the rear spar.

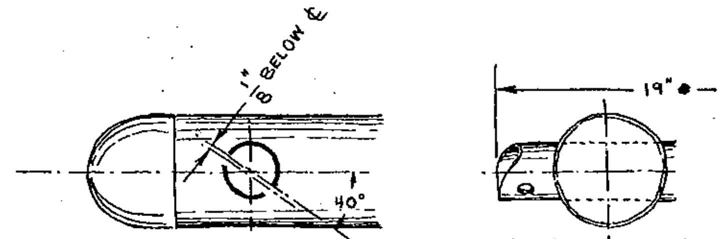


7. The 4130 steel fittings "I", "M", "N", were cut and all except the tangs "M" were drilled, as shown in plates 5 and 8. All steel parts are painted with a metal primer. Thirty-six of the rigging cable tangs are used for the flying and landing wires, two of them are used for attaching the drag and antidrag cables at the left wing root (plate 4). The rigging cable tangs "M" are used in pairs and the hole in the bottom member drilled after the pair is bent. This is to assure good allignment of the holes.

8. The aluminum fittings, "J", "K", and "P" were cut and drilled as per plates 5 and 7.

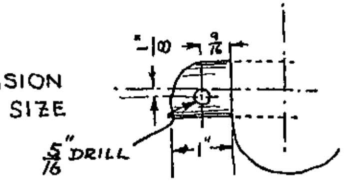
9. The hangtubes and struts were cut and drilled and the hang frame assembly built as shown on plates 5 and 7. Note that the holes in the steel tube carrythrough are tipped back 40° from horizontal to make the rigging cables fit on the bolt better, and the holes are not drilled on the centerline of the carrythrough, but 1/8" below.

If you have fancy tools you may wish to mount the rear cross member the same as was done for the forward carrythrough. Both holes must be precisely parallel--so be sure of your tools and your skill.



VIEW ALONG AXIS OF HANG TUBE

* ACTUAL DIMENSION DEPENDS ON SIZE OF PILOT

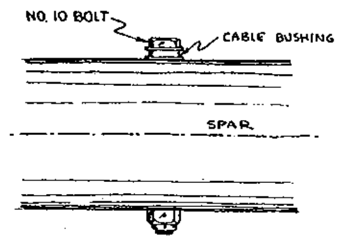


VIEW FROM REAR ALONG AXIS OF 5/16" HOLE

10. The aluminum channel wing root-hang frame fittings, "P", were now attached to the root tube with 1/4" aircraft bolts. The smaller aluminum cabane fittings, "K", were held on by the same bolts and can be mounted at this time.

11. The cabane structure was assembled as shown on plate 7.

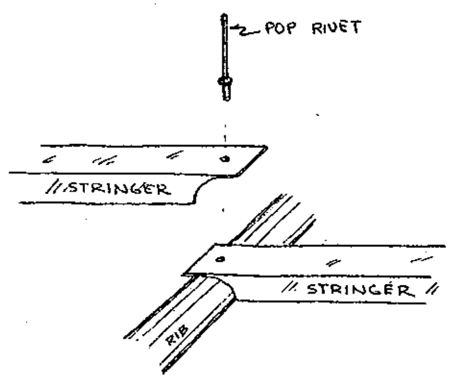
12. The drag-antidrag wires (1/16" aircraft cable) were attached. They were attached tight enough to go "bong" when plucked. (See the section on cable and Nicopress in Chapter III.) The triangular steel drag wire fittings, parts labeled "N", were placed on the top of the spars so the drag wires would better clear the ribs. There are no drag or antidrag wires in the outermost bay (see plate 2), so one of the holes in some of the triangular steel fittings were not used. The wires at the root of the right wing were anchored on cable bushings that fit on 2" x 3/16" bolts going right through the spar. These bolts were located near the root tube but not so close as to interfere with the inboard rib.



13. The ribs were bent and attached to the frame (see blueprint, plates 2, 8, 9 and the section on bending tube). Near the wing roots there are some non-standard ribs. See plate 4 for details on these. The two 1/2" x .020" tubes that serve as rib bottoms are bent slightly to conform to the undercamber of the airfoil.

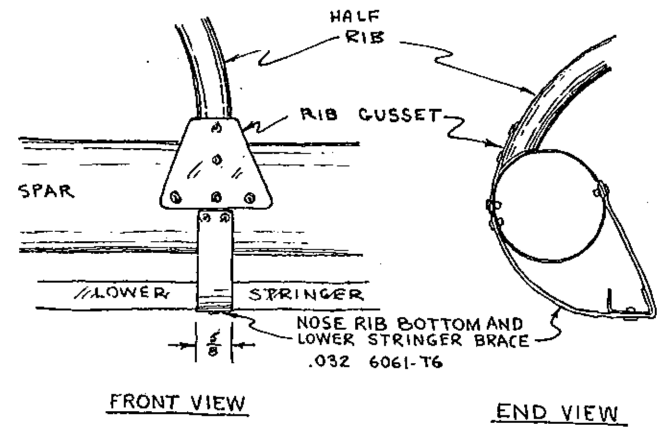
14. The 1/2" x 3/4" stringer channel was bent up from .012" 2023-T3 aluminum sheet on a sheet metal brake. Cut 28-1/2" long sections of channel, notch the ends and join them at the ribs, as shown in this sketch.

Note: The notches must be staggered to account for sweep.



15. The top and bottom stringers were attached to the ribs. Their location is shown on the rib layout.

16. The nose ribs were bent and attached to the top stringer and front spar as shown on plate 8. Bottoms were made for the nose rib out of .032" 6061-T6 sheet. These were riveted to the bottom stringer and front spar.

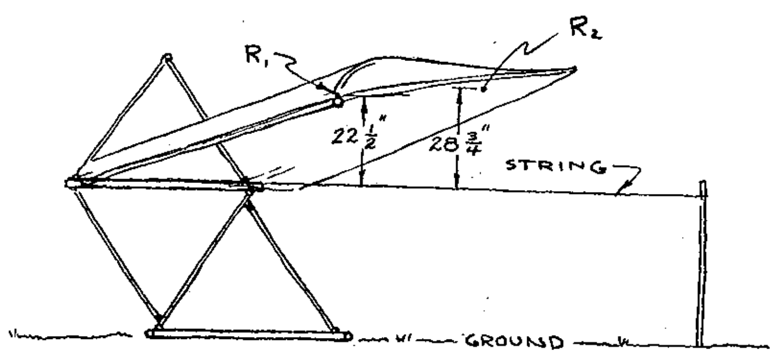


The shape of the leading edge is more critical than any other place on the wing. It is important not to have abrupt changes in curvature, sharp breaks, or waviness if you want really fine performance. The foam leading edge covering can mask some of the defects underneath because it is soft and compliant, but all curves should be as "fair" as possible.

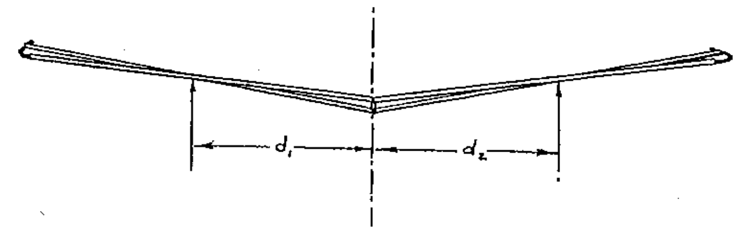
17. The rear end of the upper rib tube was trimmed to length, squashed to a roughly rectangular cross section and filed to fit the 3/8" dia. trailing edge. The trailing edge was now attached to the ribs as shown on plate 4. The trailing edge is also attached to the wing tip with a small gusset (no layout has been provided for this gusset). The end of the wing tip must be squashed and filed to fit the trailing edge.

One ICARUS builder, Sandy McAusland, suggests flattening both the upper and lower tube to the same thickness as the trailing edge, then laying them alongside each other, rather than on top of each other. A small gusset can be wrapped around the trailing edge and pop riveted to each member.

18. The wing was now ready to be rigged. The length of the various rigging cables determines the dihedral and washout the wing will have, so this is a critical operation. The cabane and hang frame were attached to the wing. Saw horses and bailing wire were used to support the wings during rigging. Rigging is a two person job. The wing was set up so that a string stretched from point R_1 near the right wing tip and point R_1 near the left wing tip passed 22-1/2" above a line extended back along the top of the wing root tube.



A string attached where the front spar joined the root tube and supported behind the plane with a stake provided an easy way to measure the line projected back. (The string was about 1/2" off center line so as not to hit the cabane structure.) Similarily, a string from R_2 to R_2 should pass 28 3/4" above the root line. The two wings must have the same amount of twist or washout. This is extremely important. It can be checked by standing 40 or so feet in front of or behind the wing directly on the center line of the craft and noticing the spanwise position where the front spar eclipses the rear spar for various eye heights. For each eye height the position must be the same for each wing.



SPARS AS SEEN FROM 40FT IN FRONT OF WING

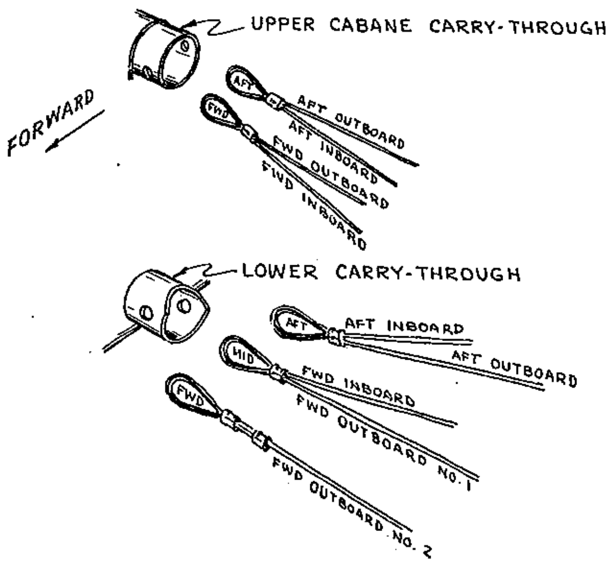
The distance where the rear spar disappears on the right side is the same as on the left side $d_1 = d_2$. Check to see that your line of sight is exactly along the center line of the craft.

In addition to having the strings correctly spaced and wing symmetrical, the cabane structure and hang structure should be vertical with respect to the wings and the wing spars should be reasonably straight (plus or minus 1/8").

With the wing now correctly set the permanent 3/32" rigging cable was attached.

First the forward outboard cables were attached, then the forward inboard. In most cases, two cables were run off one sleeve so as not to clutter the bolts at the ends of the steel carry-throughs.

There are two lower forward outboard lift cables each going to a separate bolt and fitting. These are called, for convenience, number one and number two. Number one is outboard of number two.



The cables were rigged so as to have no slack, but are not very tight. Care must be taken not to disturb the alignment of the wings while the cables are being attached.

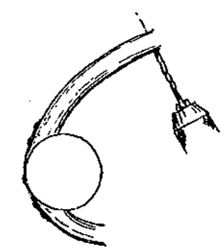
To get the cables taut without turnbuckles vise grip pliers or small cable clamps (see section on cable and Nicopress in Chapter III) are used to hold the cable while the nico-sleeve is compressed.

After re-checking the alignment of the wing, the rear cables were attached in the same way as the front. (The craft now looked like the skeleton of a giant whale. Assemble it on your front lawn and watch the expression on your neighbors' faces!)

19. The foam sheet was attached to the leading edge of each wing. Two 1" diameter holes were cut in the foam sheet where the front top-rigging cables go through the leading edge sheet. The two cables are detached from the spar, threaded through the holes in the foam and reattached to the spar. The foam was now temporarily taped in place with masking tape, using short pieces of tape at each rib and at several places in between.

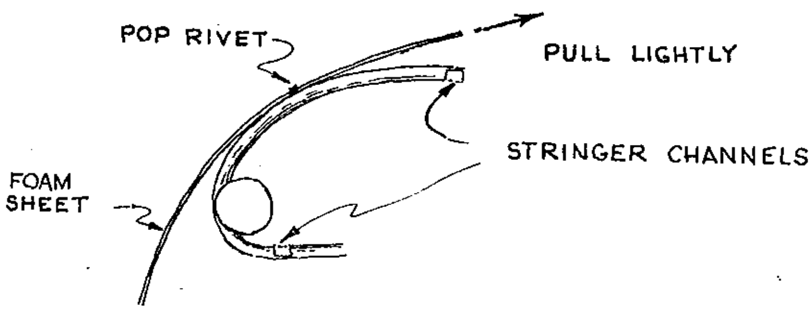
Note: The foam was attached with the plane assembled so the wing would have exactly the correct twist while it was applied.

Now the foam was pop riveted--with a large headed all-aluminum pop rivet--to each full rib in about the middle of the foam (location P_1 on the blueprint). The holes were best drilled by crouching under the wing and drilling up through the rib. Otherwise the drill made a mess of the foam. The extra hole in the bottom of the rib tube is of no consequence. Another way is to drill the hole without the foam, then poke a hole in the foam using a nail.



Now the masking tape was removed and the foam glued down with Wilhold latex contact cement. (Coat both surfaces, wait 15 minutes, then be prepared for them to stick!).

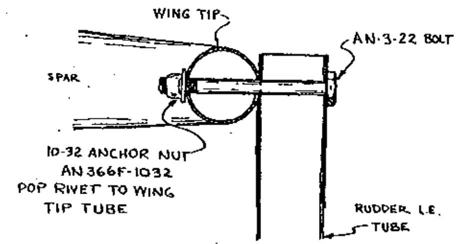
The foam was not glued to the ribs except at the wing tip and root. The foam was stuck down on the stringer channels starting at the middle and working to the tip and root. It was pulled back to keep the foam from having any loose spots.



The practice gained by putting the foam on with tape was helpful when finally gluing it down.

Note: There was some problem putting the foam over the spar fitting at the root of the left wing. I just put the foam over the fitting as best I could.

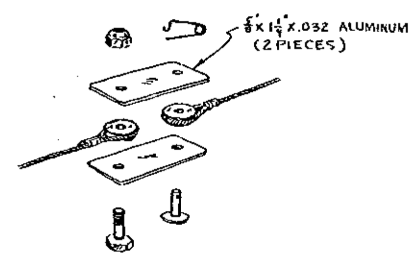
20. The wing tip rudders were now assembled as shown on plate 10. The rudder is attached to the wing tip with two 3/16" diameter aircraft bolts. The bolts go into two plate nuts which have been pop riveted on the inboard side of the wing tip tube.



The fitting for the upper end of the rudder strut was located so when seen from the front the rudder was perpendicular to the wing bottom surface. The forward bolt is located 24" forward of the trailing edge (see plate 10). The rudder brace strut is made 48" long so that three can be made from a 12 foot length of tubing. You need only two, but it is wise to keep a spare one on hand. Use 3/4" or 7/8" diameter x .022" wall tubing--the same stuff used for the rudder itself.

Pieces of 1/8" nylon tubing were used as fairleads for the 1/16" rudder control cable. See plate 2 for locations. I would have used one long piece of tubing going all the way from the tip to where the front inboard rigging wire joins the spar if I had bought enough. The tubing was held in place with carton strapping tape (filament tape). The tape was wrapped around the tubing and its support structure several times. Where the tubing leaves the wing at the inboard forward rigging point, the fairlead is taped along the rigging cable.

Provision must be made for the cable to be disconnected between the twist grip and where it goes into the wing. I made a pair of fittings out of some .032" scrap aluminum.

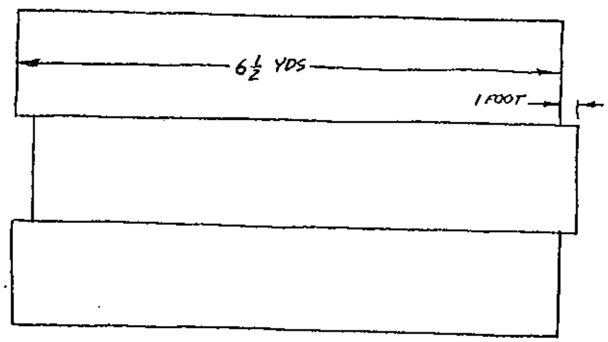


CONTROL CABLE DISCONNECT

Covering the wings:

The wings were covered with "100% polyester sheath lining". This is available 45" wide from J. C. Penney's and most yardage stores. Generally imported from Japan, it comes in a variety of colors.

1. Three 6-1/2 yard long pieces of cloth were zig zag stitched together on a home sewing machine using polyester thread.

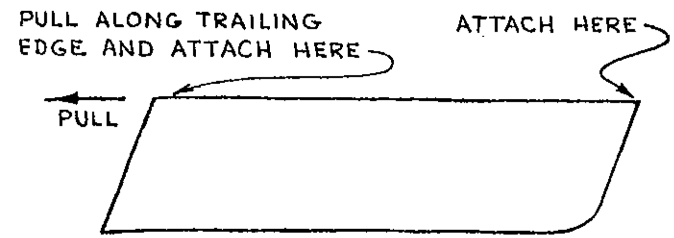


The selvage edge of the pieces of cloth were lapped over each other and two rows of stitches run down the seam. Note: For the left wing the fabric need be only 6-1/4 yds. long.

2. The cables, cabane and hang structure were removed from the wings.

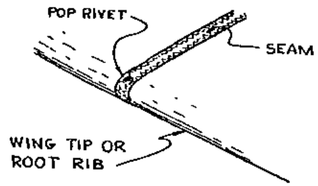
3. Wherever the cloth was going to be glued to the frame (trailing edges, ribs, wing tip, root) the aluminum was cleaned with acetone and a heavy coat of aircraft fabric cement applied and allowed to dry. An effective way of attaching fabric is to precoat the area on the frame to be glued, allow the glue to dry, lay the cloth on top, then rub thinner through the fabric until the glue softens enough to stick to the cloth.

4. One wing was set upside down on a pair of saw horses and fabric laid on top. The fabric was then glued to the trailing edge. The cloth was wrapped and glued 3/4 of the way around the tube. Best results were obtained when the fabric was attached first to one end of the trailing edge, pulled taut along the tube, attached to the other end and then attached along the trailing edge.



5. The wing was turned over, the fabric wrapped around the top and attached to the trailing edge on top. It was wrapped around about 1/2" onto the bottom surface.

6. The fabric was attached to the wing tip and root. It was pulled quite tight in the spanwise direction to minimize sag between the ribs. Where the seam in the fabric attached to the frame it was pop riveted to the aluminum so that the seam could be stretched very taut in the spanwise direction and any wrinkles removed.



7. The craft was now reassembled. Some rather large holes had to be cut in the fabric to get the cables back on. Once the cables were all attached the holes were patched with pieces of polyester cloth.

8. The fabric was shrunk tight with a hot iron using the "wool" setting. This is quite a bit hotter than required for regular aircraft dacron. The fabric was shrunk just enough to get rid of the wrinkles. Over-shrinking deforms the framework and makes as many wrinkles as it removes. Try it on a scrap piece first!

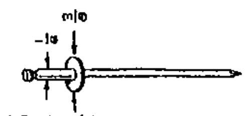
9. The fabric was glued to the foam leading edge using white glue (such as Wilhold) water mixed about 50-50. Starting from the middle, the glue was carefully brushed into the fabric trying to work all the wrinkles toward the edges. I was still not able to get all the bubbles out. The first coat was allowed to dry a while and then another two coats applied. The glue extended about 1/2" past the foam onto the fabric. It was necessary to brush white glue over the foam to protect it from the dope, which destroys it instantly. A coat of epoxy paint or glue might also serve.* Care must be taken however. When I first put on the foam I tried using spar varnish. It did not affect the foam when it lay flat and unstressed, but caused serious cracks where the foam was bent around the leading edge. These cracks didn't appear until many minutes after the varnish had been applied--so be patient!

* Volmer Jensen used epoxy on his VJ-24 with beautiful results.

10. The wings were doped. Two coats were applied to the fabric-only areas, four to the seams, edges, and over the foam.

11. The rudders were covered and doped in the same way as the wings.

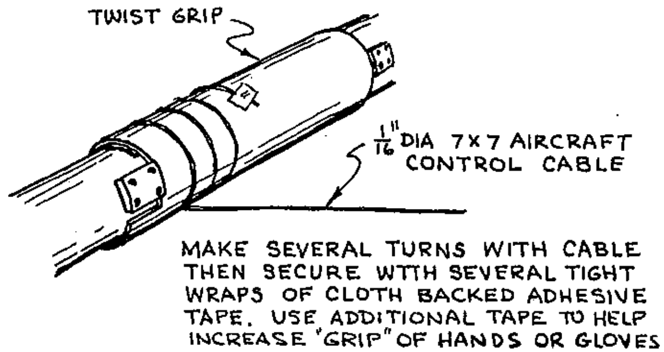
12. Rather than rib stitch the fabric to the ribs, large headed aluminum pop rivets were used to keep the fabric from pulling off the ribs. On the top surface, a pop rivet was placed about every 3". On the bottom surface, they were about 8" apart (closer near the nose). Perhaps if "Pliobond" or some other good cement had been used to glue the fabric to the ribs and a really good bond achieved, these rivets would not have been necessary.



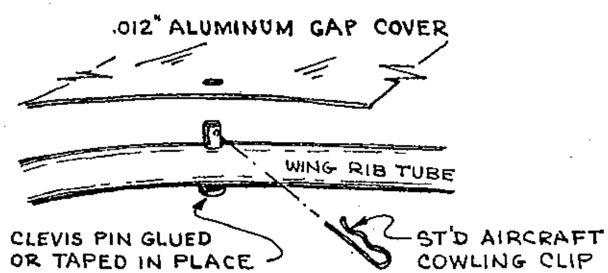
LARGE-HEADED ALUMINUM POP RIVET

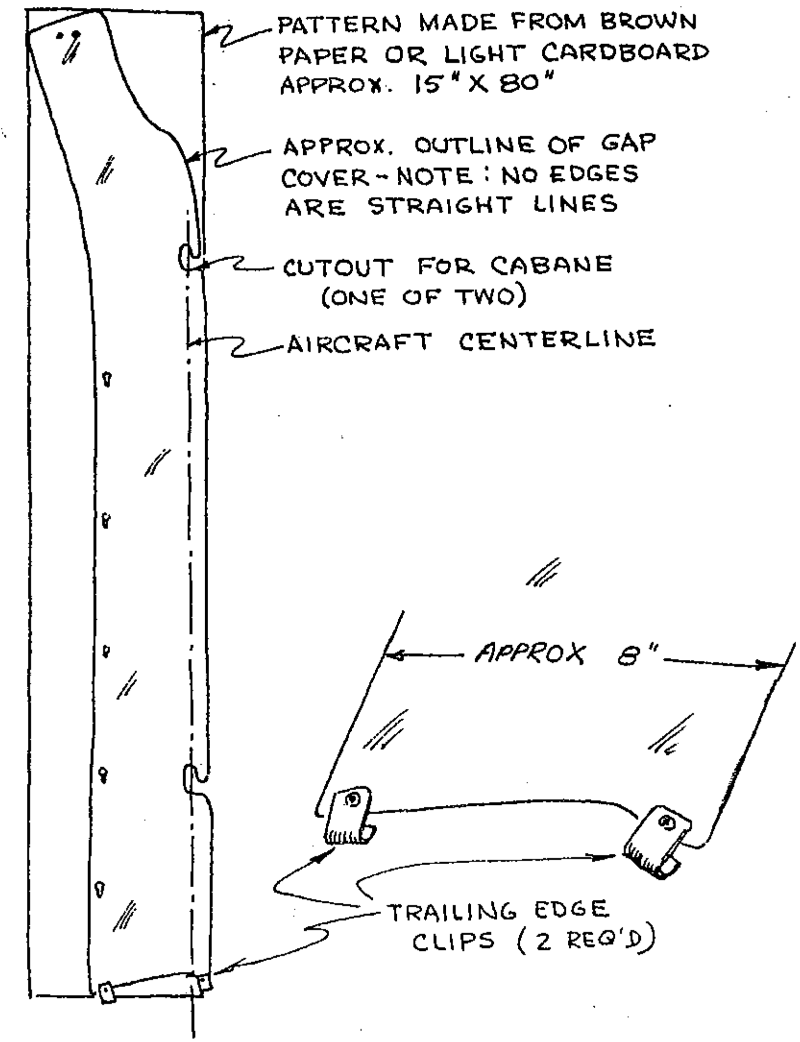
13. Cloth patches were applied over any holes and anyplace where cables went through the fabric.

14. The controls were hooked up and foam padding taped to the rear cross tube in the hang cage and to the two diagonal struts where the pilot might hit his head. A general inspection was made of the whole craft.



15. A gap cover was cut from a .012" thick aluminum sheet. This seals the gap that is left between the two wing halves when they are assembled. The cover is held on by aircraft cowling clips.





CHAPTER V

FLYING

Before taking to the air on your new wings, your time will be well spent if you look into some of the underlying reasons air behaves the way it does, especially near the ground. For starters, here are some definitions, as they might apply to foot-launched flight.

Wind - horizontal movement of the air

Up-draft - upward movement of the air

Down-draft - downward movement of the air

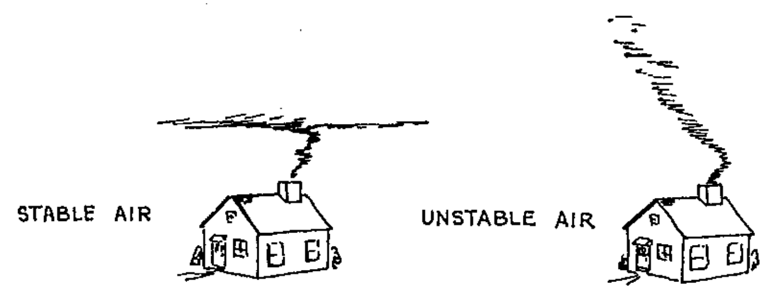
Thermal - short for thermal updraft, mass of air which rises because it is warmer (hence lighter) than surrounding air

Stable air - air mass in which the temperature drops less than 5½°F for every 1000 foot altitude gain

Unstable air - air mass in which the temperature drops more than 5½°F for every 1000 foot altitude gain

These two terms get their name from the way a blob or parcel of air behaves within the mass when it accidentally gets a push which starts it moving up or down. In stable air, the parcel will coast to a stop almost immediately and nothing much happens. In unstable air, the parcel will tend to keep moving up or down--whichever way it got started. The reason for this is easy to understand if you remember that air gets hotter when compressed, and cooler when it expands. If the parcel has had an upward movement, it will expand because the pressure diminishes with altitude. The air parcel cools because of the expansion, and if it now finds itself heavier than the surrounding air, it stops its vertical movement and comes to rest. On the other hand, if the temperature of the surrounding air is low enough at this new altitude, the parcel continues to be warmer (and lighter) than its surroundings and it continues upward like a hot air balloon. The reasons for an air mass being stable or unstable are too complex to go into here, but it depends mainly on the prior history of the air mass in question.

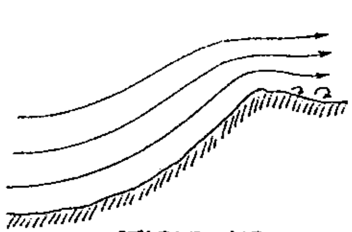
The easiest way to tell if an air mass is unstable is to watch smoke from a fire. Smoke rises in unstable air, and sinks or forms a horizontal "roof" in stable air--the behavior of dust clouds behind moving vehicles also gives similar clues.



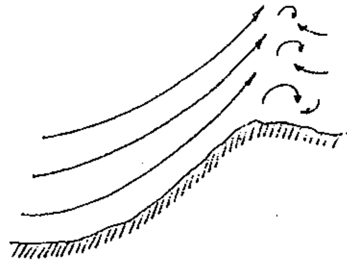
Vortex - circulatory motion of a gas or liquid

Whirlpools, tornadoes, and dust devils are all examples of vortices. Fill your bath tub with about 6" of water, trail your hand (or a stick) slowly through it and watch the "shadows" of the vortices on the white porcelin. See how they persist and how they move. These are the same ones you leave behind you when you drive your car or truck down a dusty road. They are also known as Karman Vortices, after Theodore Von Karman. Besides the isolated vortex, one can also have an infinity of vortices next to each other--this is called a vortex sheet.

Boundary layer - the region near the ground, or some other solid surface where friction reduces the speed of the air



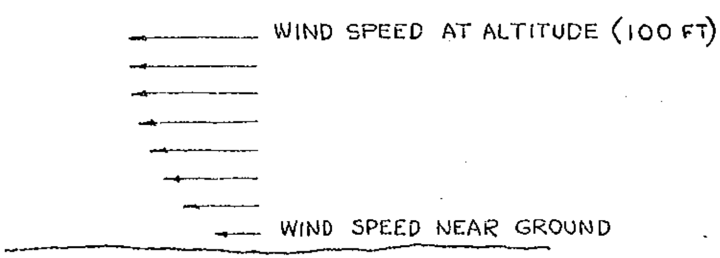
STABLE AIR



UNSTABLE AIR

Life is full of its little ironies--even for foot-launched pilots; those conditions which produce good thermal soaring also produce dangerous gusts near the ground. It is surprising how the same location will take on different qualities depending on whether the air is stable or unstable that day.

Stable air would just as soon go around an obstruction, like a hill, as it would over it. If the obstruction is a long cliff, and the air has no choice but to go over, it will resume its horizontal path soon after clearing the edge. On unstable days, the air will tend to continue upward and flying will be great and chances of catching a thermal triggered by the cliff will be good--but watch those landings! The eddies and turbulence behind the edge of the cliff can make you "eat it" very easily. My knuckles are still beat-up from a "landing" on top of Mission Ridge after a spectacular day of flying.



One other phenomenon that should be clearly understood before leaping off a hillside is that of "boundary layer".

It is fundamental to the flow of liquids or gases in contact with a solid surface that there is no movement at all at the surface itself! That's one reason dust can stick on cars and airplanes, even at high speed. On the other hand, far away from the surface, or boundary, the air goes along just as if the boundary wasn't there. The actual thickness of the boundary layer can be very great or very small. It depends on the size and nature of the boundary, and the speed of the air. A boundary layer exists near the wing of your airplane when it flies through the air, and one exists on the surface of the ocean when the wind blows. In the first case it is a fraction of an inch thick, and the second its thickness is measured in feet.

Funny thing about the boundary layer, any time you have a change in speed that is not associated with a curved path, it is equivalent to sheets of vortices. This explains some strange goings-on near obstructions on the ground.

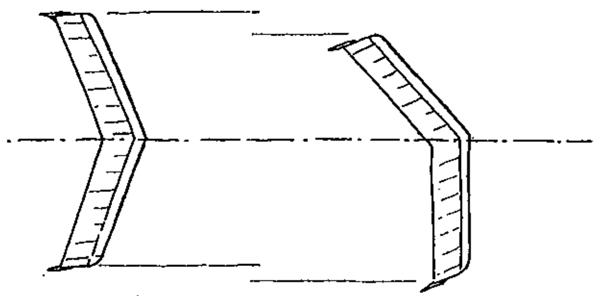
Now let's get back to flying:

After watching many attempts of beginners to fly various ICARUS type gliders, I've come to some conclusions that might be helpful to a beginner:

I. Taking off:

I think that the beginner would be much more successful if, rather than try to fly right off, he would first master the rudiments, such as figuring out and getting a good feel for how the tip rudders work. This is easily accomplished by holding ICARUS and facing into an 8-12 mph wind and balancing the craft, making it roll, or bank, first to one side then to the other. It may be helpful to have someone stand upwind of the pilot ready to grab the plane if things get out of hand. No one should hold the plane while the pilot is doing OK, though, because it is confusing and it changes the feel.

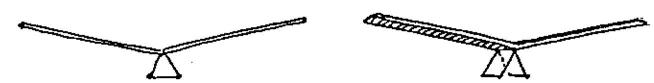
Think about the wind. Is it gusty? Does it change in speed and direction, or both. Notice that you cannot lift a wing (roll correction) without first causing a "yaw" by deflecting one or the other rudder. Think about how and why the corrections are produced. If a wing has dihedral angle or sweep, or a combination of both (as has ICARUS), changing the direction it meets the oncoming air will produce a tendency to roll, or bank, away from the oncoming wind. The reason for this is easy to understand if you consider first a wing with sweep alone.



Wind straight ahead, each wing panel presents equal span to wind

Wing yawed to left, right wing has greater apparent span--ICARUS banks to left

The effect of dihedral angle is to make the wing panel on the same side as the wind appear to be at a greater angle to the wind, hence to produce more lift. The following sketches show the wings from straight ahead.



Wind straight ahead, both wing panels make same angle to oncoming wind

Wing yawed left, more of underside of right wing is showing--its angle to the oncoming wind is greater--producing more lift

Once you get the hang of how the rudders work and feel, you can try some runs down the hill. Before you go any further, give lots of thought to the direction, speed, and quality of the wind. If the wind isn't steady, and 5 to 12 mph and blowing directly up the hill, take it apart and wait for another day. Since you probably won't be wise enough to follow this advice, let's go on to the next step. It is important to point your craft into the wind, not necessarily down hill or in the direction you are running. It is conceivable that you can run down a path, say, crabwise but with the relative wind (the wind you feel when running) meeting the wing head on.

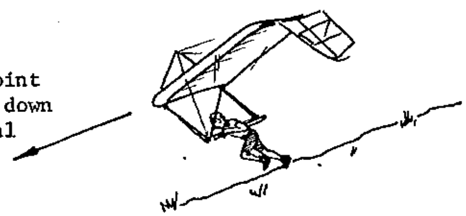
I find it best not to have any "helpers" hanging on the wings because they are in a very good position to hold back and swing the nose around uncontrollably. You find yourself "fighting" or correcting movements due not to the wind but to the actions of your helpers. Prior to take-off, stand supporting the craft with your back just under the rear spar, and hold your hands far forward to keep the nose down. When ready to go, start running as fast as you can, supporting the machine. Very soon you will find that even slight air speed will support the wings and you can devote all your energy to running, with your hands still positioned far forward, holding the nose down.

During the entire take-off run the rudders are used to keep the wings level.

Running as fast as you can, allow the wings to rise and the hang tubes to come up under your armpits; since the armpits are farther aft than your hands, the nose will rise slightly and the wings will develop more lift. ICARUS will lift you into the air!

KEEP CALM, MAN; YOU'RE FLYING! Just DON'T slide back and try to whistle off into the sky like the Blue Angels or you'll stall and come back to earth in a hurry! JUST HANG THERE! If you find yourself swooping up, slide forward a bit. If you are diving (not just settling) into the ground, slide back a bit. Aim for a smooth fairly fast flight with wings cruising along at a small angle to the oncoming wind (angle of attack).

Wing should point somewhat nose down from horizontal



Don't be seduced by the tremendous feeling of lift you get when you slide back and let the angle become large--the drag will also rise, slow you down and you will end up in a heap. At best you will wallow from side to side in an awkward fashion.

Once in the air, flying is a simple matter. The rudders are used to steer the craft and sliding one's weight fore and aft is used to control the pitch (the nose's position up and down) and with it the speed. It is essential during the flight to keep the craft flying sufficiently fast to keep it from "stalling". A stall occurs when the pilot (by sliding his weight too far back) causes the wing to meet the air at [illegible] great angle. When this happens, air can't take the curve around the top of the wing and much of the lift is lost.

ICARUS V will not stall unless something very unusual happens--like a sudden gust or abrupt weight shift. Normally it will only "mush". The craft will automatically try to keep its nose down and will wallow along if the pilot has his weight too far aft. Sinking speed will be moderate, but there is no speed reserve for flaring at landing, so avoid this condition, especially near the ground. Supporting a 65 pound craft in your arms while both you and it settle to the ground with a vertical speed of 3 feet a second is a fine test of strength--both for you and for your airplane!

An ICARUS V with a 150 lb. pilot would probably have a minimum speed somewhere around 16 mph. The air speed can be measured using a wind guage (such as is made by Dwyer) or it can be estimated from the sound of the air rushing past all the struts and wires. The sound of "the wind in the wires" is especially useful in detecting small changes in speed. It should also be possible to measure the speed by noting one's position on the hang tubes. For each pilot position the airplane will assume a certain angle and hence a certain speed. Remember that it is the angle which the wing makes to the relative wind which counts--not the angle with the ground or the horizon. It is quite possible for the wing to be at a high angle of attack while pointing downward, and it is also possible for it to be a low, or even negative angle of attack when it makes a large angle with the ground. Think about it.

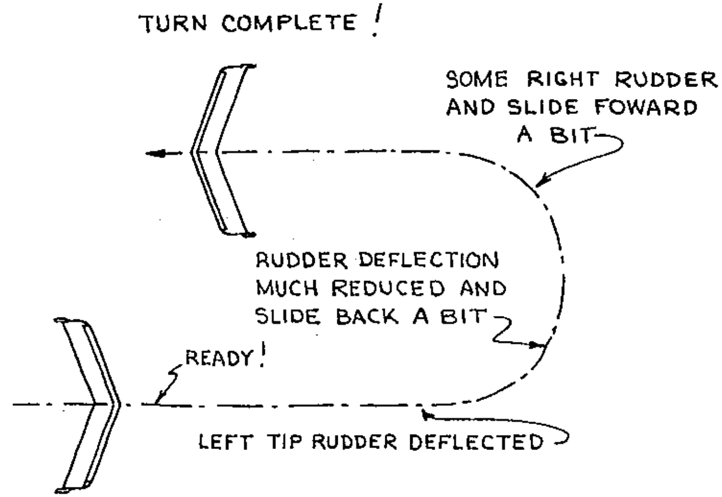
All this talk of speed now leads directly to the problem of landing. Just as one touches the ground, it is desirable, to be flying quite slowly and travelling along almost parallel to the ground (which means approaching the ground slowly). Yet when one is coming in for a landing, it is important to be flying fairly fast so that the tricky winds near the ground will not suddenly stall the wings. Also, as one approaches the ground the wind tends to decrease because of the boundary layer previously mentioned. [illegible] actually be blowing [illegible] than it would [illegible] if the hill were not there; this is because of the famous Bernoulli or venturi effect. At the bottom parts of the hill, the wind will be going much slower--maybe even down slope if the conditions are right, because of the growth of the boundary layer. Since the airplane flys bacause of air speed--not ground speed--you are faced with a constantly deminishing speed reserve as you descend. This effect depends on the wind speed. In no wind there is no boundary layer effect, and the plane will seem to glide forever--if you can ever get it off the ground. Back to the landing:

Whereas one had a nice wind of say 15 mph, at 30 feet altitude, the wind may only be 5 mph at 10 feet. So at 30 feet, one need be flying only 10 mph <u>with respect to the ground</u> to have an air speed of 25 mph, which is great except that when one gets to 10 feet where the wind is only 5 mph, the <u>air</u> speed will be 15 mph, which is less than the minimum speed and the plane will drop. For these reasons it is desirable to come in for a landing fairly fast, then when near the ground (5 feet or so) to start sliding back slowly so that the craft flies along the ground losing speed until the pilot feels he is going slow enough, touches his feet and starts running. It is important to note that even when the pilot's feet are touching the ground, the wings are developing some lift and will help hold him up. Because the center of gravity of the empty plane is quite far back, it will begin to rear up when the pilot's legs support some of his own body weight. The drag on the plane will increase and the combined increased lift (due to the nose rising) and drag will make the landing a thing of beauty--if you don't trip--so get those legs moving while your weight is still supported by the wings!

Once take offs, landings, and simple glides are mastered, shallow turns can be attempted. After that, higher flights and tighter turns.

II Turning:

The [illegible] are used to roll the ship [illegible] (and out, [illegible] in a hurry). To [illegible] (more than about 30° of turn) it is helpful to [illegible] just after getting into the turn and after releasing most of the control deflection. It also makes things much smoother to move forward a bit when coming out of the turn. Basically one should use body movement to prevent the ship from either slowing up or diving during the turn. All you Rogollo fans should try to remember that attempts to control your angle of bank by thrashing from side to side will do nothing for your turns or for your image as a flying ballet dancer.



All this fancy turning technique is nice (especially for reasonably tight turns), but not essential. I flew for a long time and made many turns before I figured all of this out!

III Ridge Soaring:

Once a pilot has a seat worked out and good control of the ship ([illegible] expert, [illegible] with [illegible] [illegible] ridge about 100 feet [illegible] 10-15 mph <u>smooth</u> wind blowing directly up the slope. Don't be disappointed if you find that you can't stay up if the wind comes in at an angle so that it is not exactly perpendicular to the ridge, even if of adequate strength.

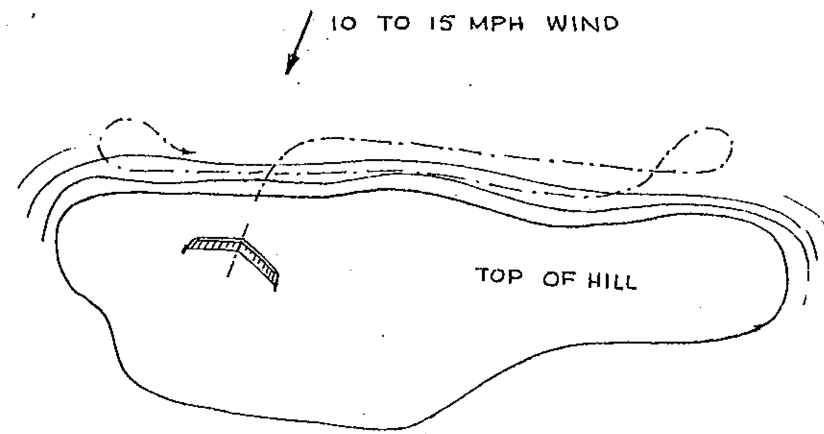
Make friends with radio control model glider pilots and get them to share their experiences: you'd be surprised how much they know about the peculiarities of local soaring sites.

If the wind is not hitting the ridge quite straight on, it is easier to take off towards the side that allows the first pass to be slightly upwind.

Just after take off, the pilot should turn up the ridge and concentrate on maintaining a good cruising speed (22-24 mph for ICARUS V). When nearing the end of the ridge, a smooth turn should be made (away from the ridge!) and the pilot allow himself to drift back toward the ridge and fly back to his takeoff point, and so on. Even though you appear to be "crabbing" sideways in your path over the ground, your path with respect to the air is straight ahead. There is <u>no</u> reason to hold steady rudder pressure on your straight passes up and down the ridge. Think about it.

Ridge soaring in a smooth wind (such as a sea breeze) is quite easy if the ridge is good. But there are some hazards: The worst is getting blown back behind the ridge where the winds tend to be very gusty. Others are stalling out of a turn and hitting the ridge or just not paying attention and hitting the hill. Landing on top of the hill can also be very tricky and dangerous, especially if the ridge has a sharp lip and if the air is unstable that day. One should always be very wary of wind that has just blown past any obstruction, such as trees, bluffs, or buildings. That's where Karman vortices are born.

Near the base of a steep hill or cliff the wind direction will be very different from what it was at the top. Be sure to [illegible] [illegible] result in repair jobs on both pilot and aircraft.



IV Thermal Soaring;

Thermal soaring should be reserved for the experienced pilot. During one of those ridge soaring passes, you may find yourself quite high, and upwind of the ridge or mountain (stay away from the lee, or downwind, side). If the air is unstable, you may sense a warm gust that jolts the aircraft--it's a thermal. On the ground the passing through of a thermal (they drift with the wind) can be detected by the warm wind which suddenly changes in direction and by the papers and debris scattering about. The techniques of thermal soaring are too complex to go into here, and the sport is so new there really isn't a source of information which pertains specifically to foot-launched gliders. [illegible] meteorology and [illegible] to [illegible] soaring a bit at a time, [illegible] of hanger flying with regular sailplane pilots, and get the SSA Handbooks. Freezing to death at 15,000 feet will surely get your name in the local papers, but only once.

Listed below are some Do's and Don't's and things to watch for that I consider before flying:

1. <u>Do</u> give it all you've got when you decide to take off. One of the hardest things to do is run along when the wings will not quite support you.

2. <u>Do</u> have plenty of speed when coming in for a landing or taking off.

3. <u>Do</u> fly over smooth, soft terrain--especially when learning.

4. <u>Don't</u> fly when the wind is gusty. (Most of my bruises were received on gusty days.)

5. <u>Don't</u> fly in places where there are objects which disturb the flow of the wind and make it turbulent. (Trees are probably the worst...you can't imagine how steep the glide path can be in this situation!)

6. <u>Don't</u> leap off hills above your ability.

Watch out for: rocks, power lines, fences, turbulent winds behind objects, dings or dents in the aircraft components that could cause collapse. Don't overestimate your gliding range.

Oh yes - another valuable hint! For a very clear and simple yet accurate description of flight, get a copy of <u>Stick and Rudder</u> by Wolfgang Langewiesche.

PERSONAL NOTES AND CORRECTIONS

ICARUS V - Materials List

Quantity	Description		Use

1. Tubing

Quantity	Description	Material	Use
8	2"x.035"x12'	6061-T6 or 2024-T3	Spars
4	3/8"x.028"x12'	" "	Trailing edge
5	1"x.028"x12'	" " or	
	1"x.035"x12'	" "	Compression rib
1	1"x.049"x12'	" "	Struts
3	7/8"x.022"x12'	" " or	
	1"x.022"x12'	" " or	
	3/4"x.022"x12'	" "	Rudders
1	2-1/2"x.049"x31'	" "	Twist grip (see plate 5)
1	1"x.049"x26"	4130 Steel	Cable carry-through
18	5/8"x.016"x12'	6061-T4 or	
	1/2"x.020"x12'	"	Ribs
2	1"x.035	6061-T4	Tips

2. Sheet Metal

Quantity	Description	Use
	6"x12" .035" 4130 steel (condition N)	
	.020" 6061-T6 Rib gussets	
	.035" 6061-T6 Bottom nose ribs	
	1'x2' .040" soft aluminum	
	1'x3' .0[illegible]" soft aluminum	
	6"x12" .0[illegible]" 6061-T[illegible] or other 1/2 hard [illegible]	
	5"x9" .093" 6061-T6 or 2024-T3 or 7075-T6	
	14 sq. ft. .012" or .016" 6061-T6 or equivalent	
	1'x6-1/2' .012" or .016" " "	Gap Cover
2	.049"x7/8"x9" "springy" steel	Skids

3. Clevis Pins

Quantity	Description	Use
1	3/8"x3-1/2"	Rear root
1	1/4"x3-1/2"	Front root
4	1/4"x2-1/2"	Spar fitting
2	1/4"x1-1/2"	Cabane
4	3/16"x3/8"	Rudder cable
2	3/16"x1-1/4"	Rudder strut

Plus safety pins for the above

4. Pop Rivets

Quantity	Description
100	1/8"x1/4" steel
100	1/8"x1/2" steel
1500	1/8"x1/8" steel or aluminum with steel "nails"
300	1/8"x1/8" aluminum with large heads

5. Nicopress sleeves

Quantity	Description
20	1/16"
30	3/32"

6. Cable

Quantity	Description
110 ft.	1/16" 7x7 aircraft control cable
150 ft.	3/32" 7x7 " " "

7. Hinges

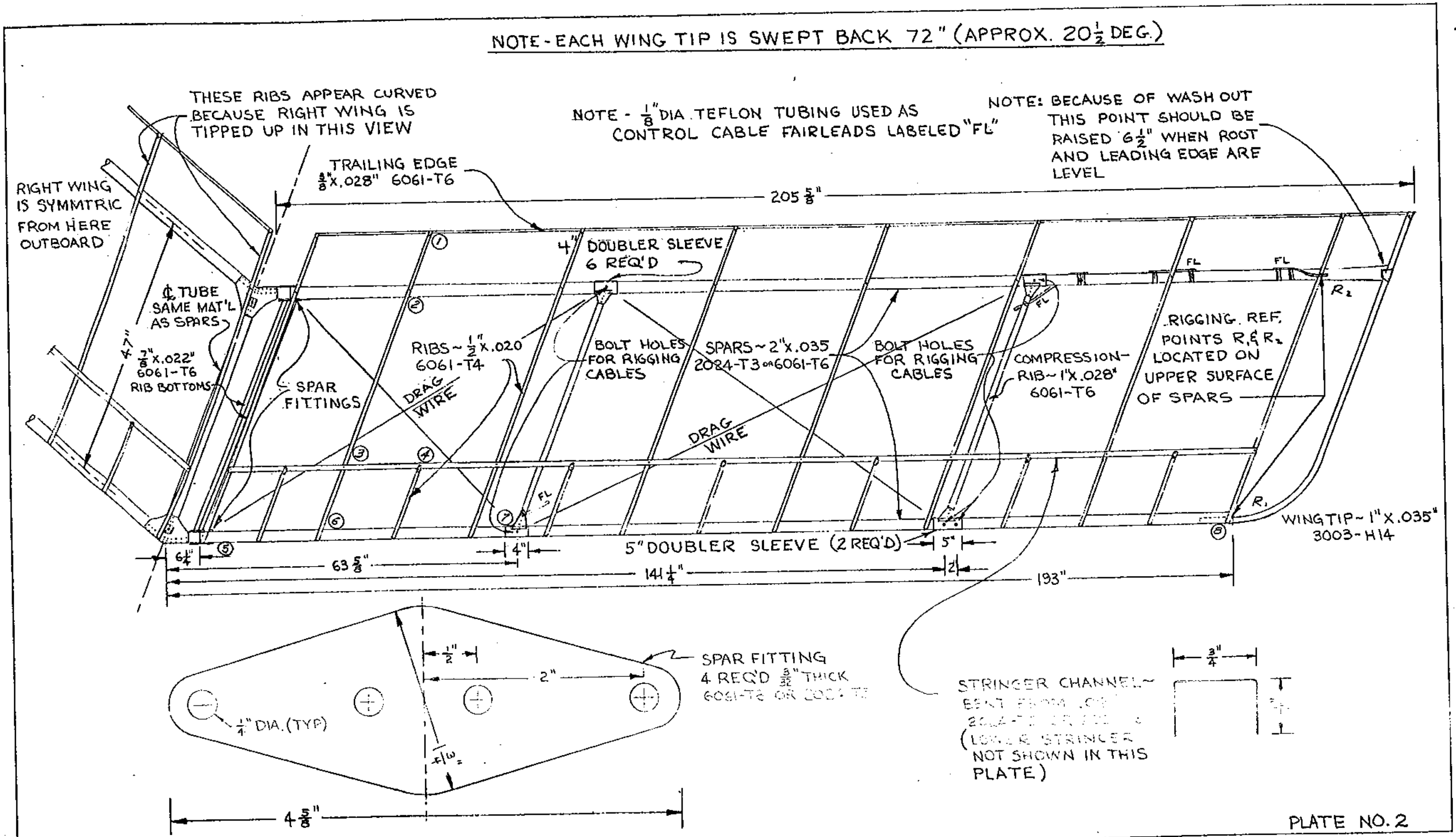
Quantity	Description
12"	Aircraft piano hinge

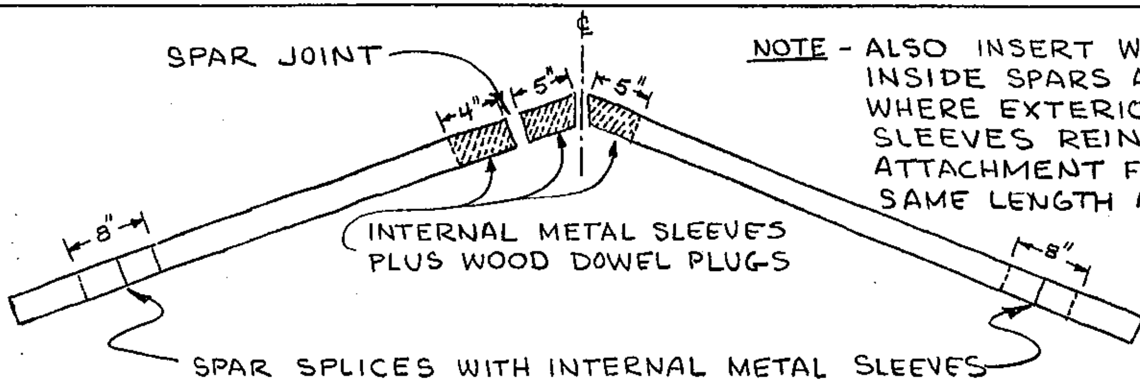
Quantity	Description	Use
8. Bolts		
2	AN-3-12A	Rudder strut
2	AN-3-4A	Rudder disconnect
4	AN-5-14	Attach wire at wing root
5	AN-4-14A	Steel strut fitting
2	AN-4-26A	Aluminum root fittings
14	AN-4-25A	Wire fittings
6	AN-4-24A	Aluminum channel fittings
4	AN-3-22A	Rudder mounting
2	AN-3-24A	Drag wire
5	AN-4-16A	Aluminum channel fittings
18	AN-3-4A	Cable to .035 brackets
9. Nuts		
30	1/4-28, lock	
4	5/16-24, castle	
4	10-32, plate (anchor)	Rudder attachment
20	10-32, lock	Drag & Rigging wire
10. Plastic		
6 ft.	1/8" dia. Nylon tubing	Fair leads for control cable. 30' req'd if one piece is used
35'	.070"x20" Foam	Wing leading edge cover
16	3/4"x3/4"x1/4" Teflon	Twist grip bearing pads

Quantity	Description	Use
11. Miscellaneous		
5	Strut brackets from ICARUS II, or 6"x12"x.040" type 4130 steel sheet	
3 ft.	1.86" diameter wood dowel	
3 ft.	1.93" " " "	
5"	3" aluminum channel (see plate 7)	
13"	1-1/4" aluminum channel (see plate 5)	
24	1/16" cable thimbles	
20	1/16" cable bushings	
4	wood ends of hang tubes	

Note: This list has not been double checked, so it should be used only to help draw up your own bill of materials.

Corrections and Additions

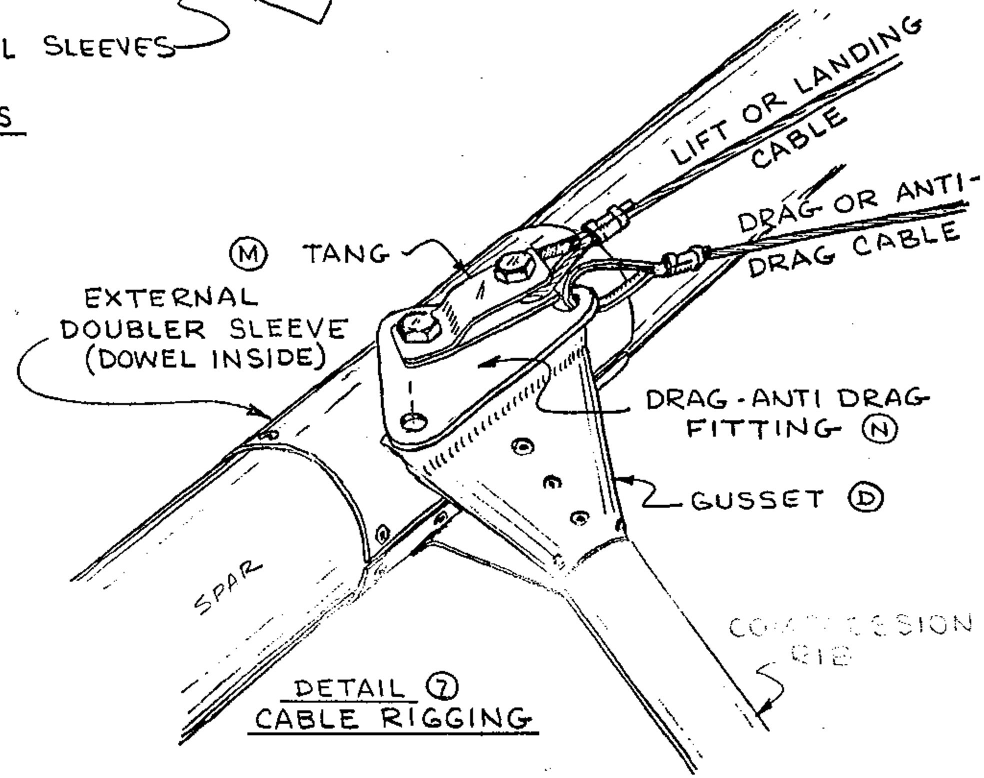

NOTE - EACH WING TIP IS SWEPT BACK 72" (APPROX. 20½ DEG.)
THESE RIBS APPEAR CURVED BECAUSE RIGHT WING IS TIPPED UP IN THIS VIEW
NOTE - ⅛" DIA. TEFLON TUBING USED AS CONTROL CABLE FAIRLEADS LABELED "FL"
NOTE: BECAUSE OF WASH OUT THIS POINT SHOULD BE RAISED 6½" WHEN ROOT AND LEADING EDGE ARE LEVEL
RIGHT WING IS SYMMTRIC FROM HERE OUTBOARD
TRAILING EDGE ⅜"X.028" 6061-T6
205⅝"
4" DOUBLER SLEEVE 6 REQ'D
FL
R₂
℄ TUBE SAME MAT'L AS SPARS
47"
⅞"X.022" 6061-T6 RIB BOTTOMS
SPAR FITTINGS
RIBS ~ ½"X.020 6061-T4
DRAG WIRE
BOLT HOLES FOR RIGGING CABLES
SPARS ~ 2"X.035 2024-T3 or 6061-T6
BOLT HOLES FOR RIGGING CABLES
COMPRESSION-RIB ~ 1"X.028" 6061-T6
RIGGING REF. POINTS R₁ & R₂ LOCATED ON UPPER SURFACE OF SPARS
DRAG WIRE
R₁
WINGTIP ~ 1"X.035" 3003-H14
1
2
3
4
5
6
7
8
6¼"
4"
5" DOUBLER SLEEVE (2 REQ'D)
5"
63⅝"
141¼"
2
193"
½"
2"
¼" DIA. (TYP)
4⅝"
SPAR FITTING 4 REQ'D 3/32" THICK
STRINGER CHANNEL ~
NOT SHOWN IN THIS PLATE)
¾"
PLATE NO. 2



NOTE - ALSO INSERT WOOD DOWEL PLUGS INSIDE SPARS AT LOCATIONS WHERE EXTERIOR DOUBLER SLEEVES REINFORCE CABLE ATTACHMENT FITTINGS. MAKE PLUGS SAME LENGTH AS DOUBLER SLEEVES.

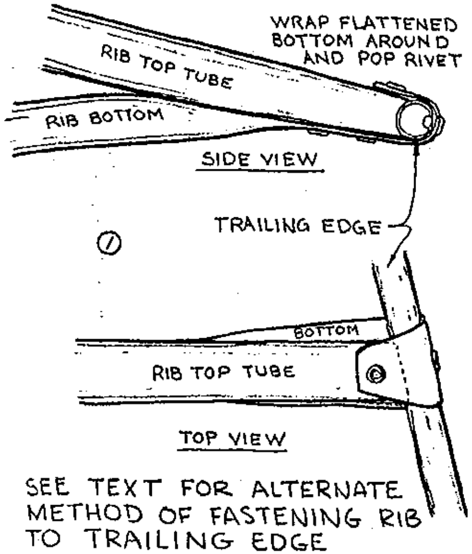
SPAR JOINT & SPLICE DETAILS

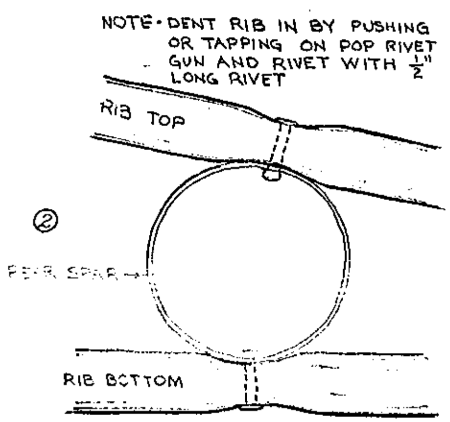
NOTE - WOOD DOWEL PLUGS WILL BE HELD IN PLACE BY POP RIVETS. HOLES SHOULD BE DRILLED AND POP RIVETS INSERTED & FLARED AS IF WOOD PLUGS WERE NOT THERE.

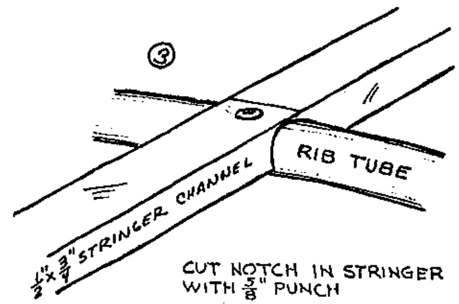


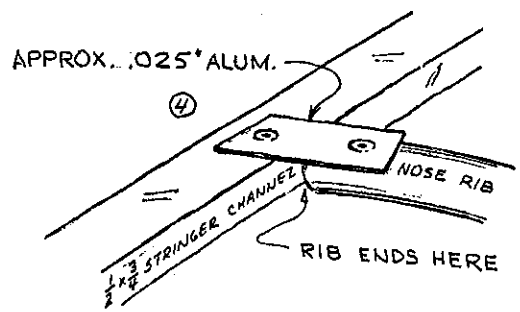
DETAIL (7)
CABLE RIGGING

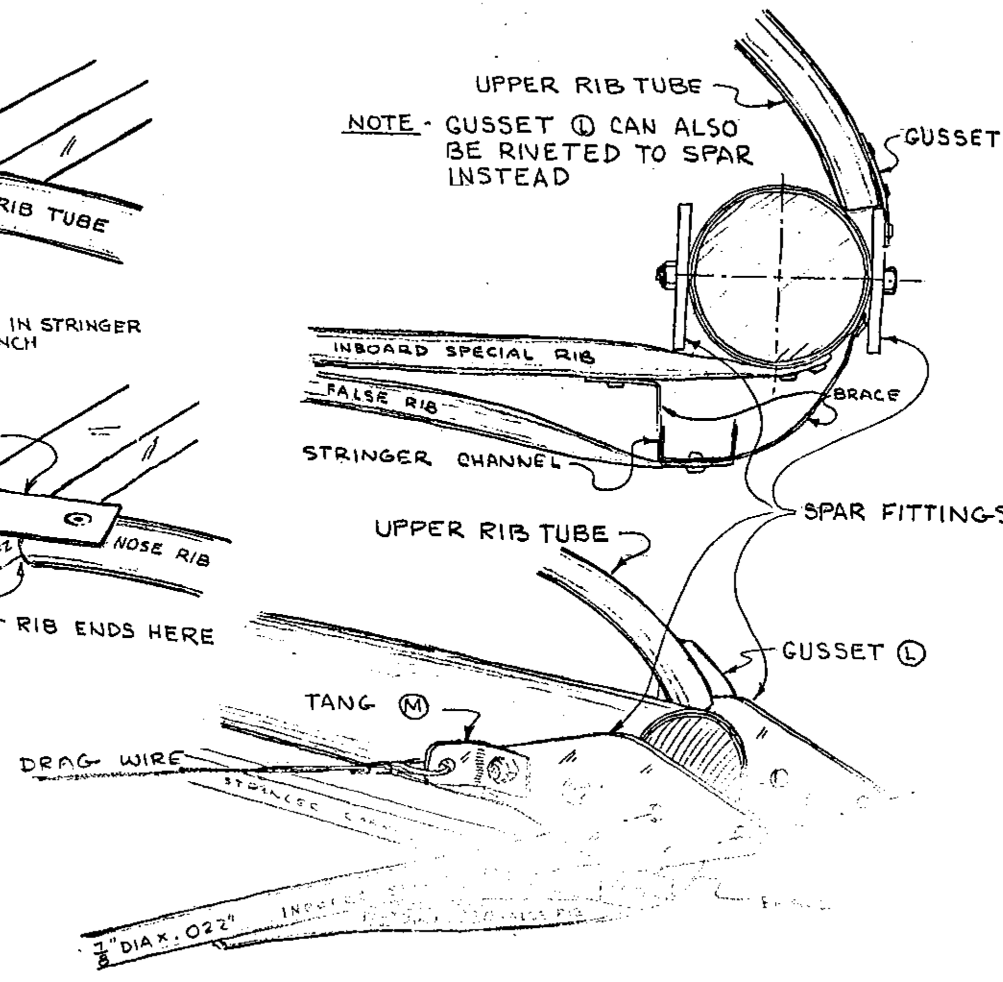
PLATE NO. 3











FOWARD SPAR JOINT DETAIL ⑤

PLATE NO. 4

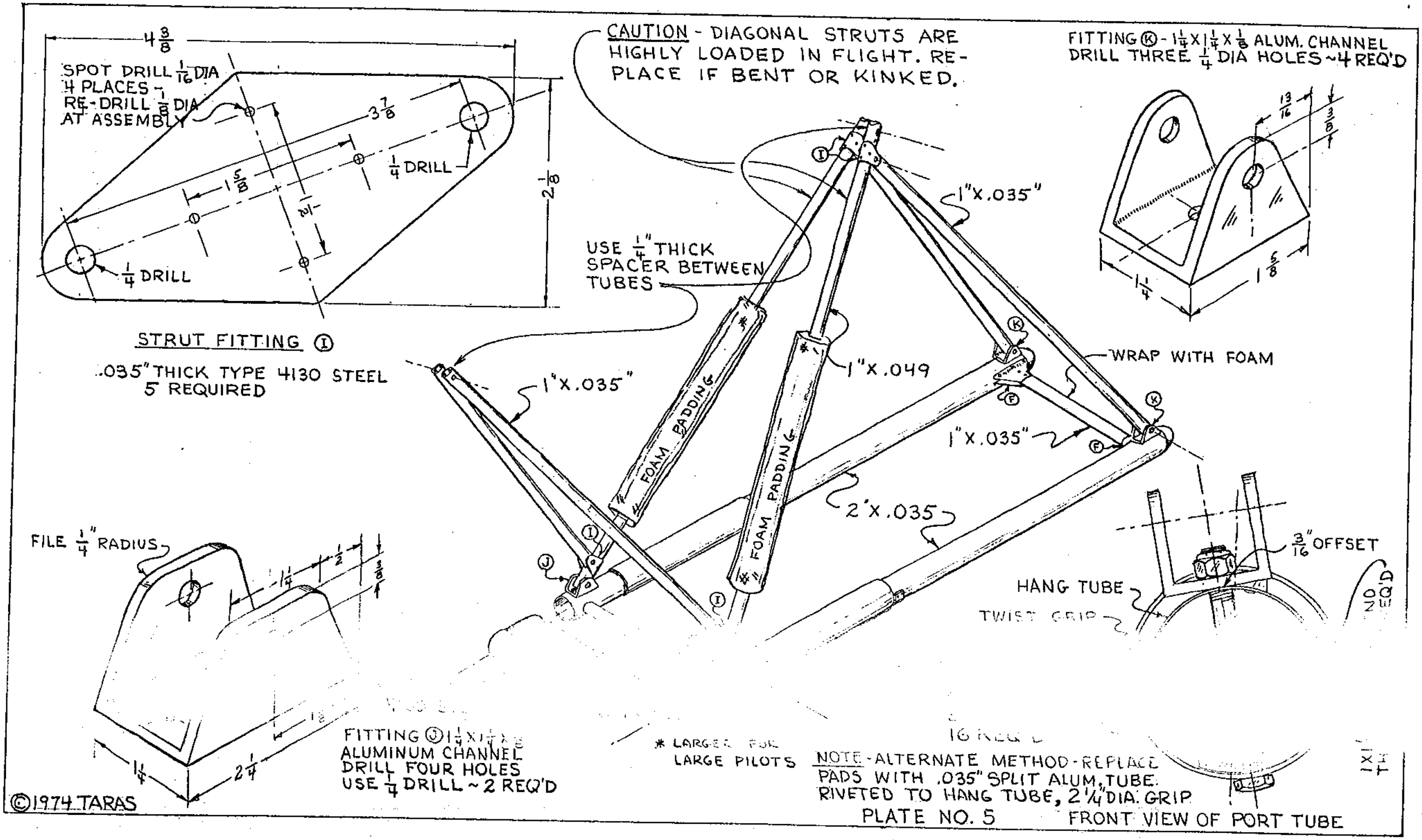

4 3/8
SPOT DRILL 1/16 DIA 4 PLACES - RE-DRILL 1/8 DIA AT ASSEMBLY
3 7/8
1 5/8
1/2
2 1/8
1/4 DRILL
1/4 DRILL
STRUT FITTING Ⓘ
.035" THICK TYPE 4130 STEEL
5 REQUIRED
CAUTION - DIAGONAL STRUTS ARE HIGHLY LOADED IN FLIGHT. REPLACE IF BENT OR KINKED.
FITTING Ⓚ - 1 1/4 X 1 1/4 X 1/8 ALUM. CHANNEL
DRILL THREE 1/4 DIA HOLES ~ 4 REQ'D
13/16
3/8
1 1/4
1 5/8
USE 1/4" THICK SPACER BETWEEN TUBES
1"X.035"
1"X.035"
1"X.049"
1"X.035"
2"X.035"
WRAP WITH FOAM
FOAM PADDING
FOAM PADDING
HANG TUBE
TWIST GRIP
3/16" OFFSET
FILE 1/4" RADIUS
1 1/4
1/2
3/8
1 1/4
2 1/4
FITTING Ⓙ 1 1/4 X 1 1/4 X 1/8 ALUMINUM CHANNEL
DRILL FOUR HOLES
USE 1/4 DRILL ~ 2 REQ'D
* LARGER FOR LARGE PILOTS
NOTE - ALTERNATE METHOD - REPLACE PADS WITH .035" SPLIT ALUM. TUBE RIVETED TO HANG TUBE, 2 1/4" DIA. GRIP
FRONT VIEW OF PORT TUBE
©1974 TARAS

PLATE NO. 5

HANG TUBE TRUSS DETAILS

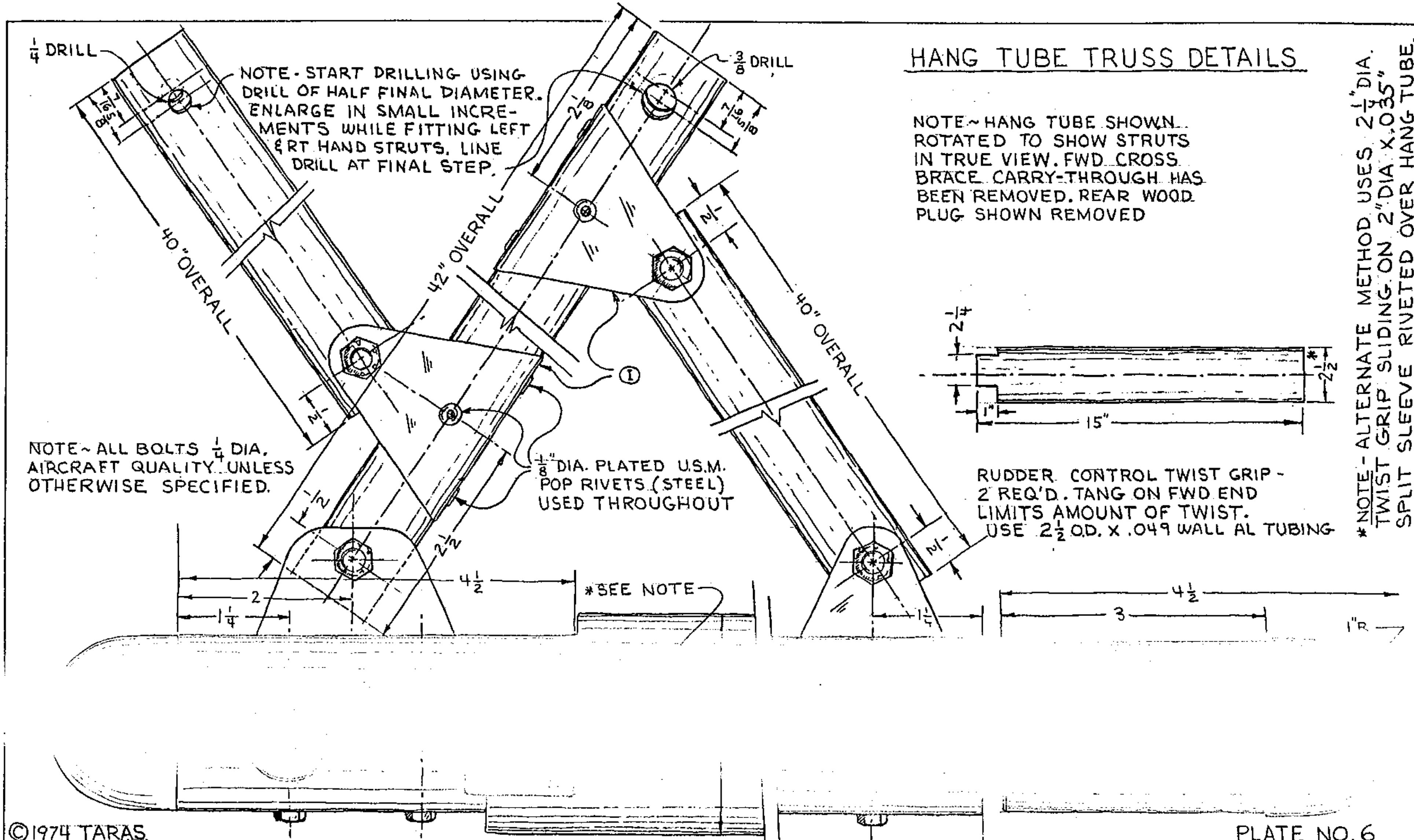
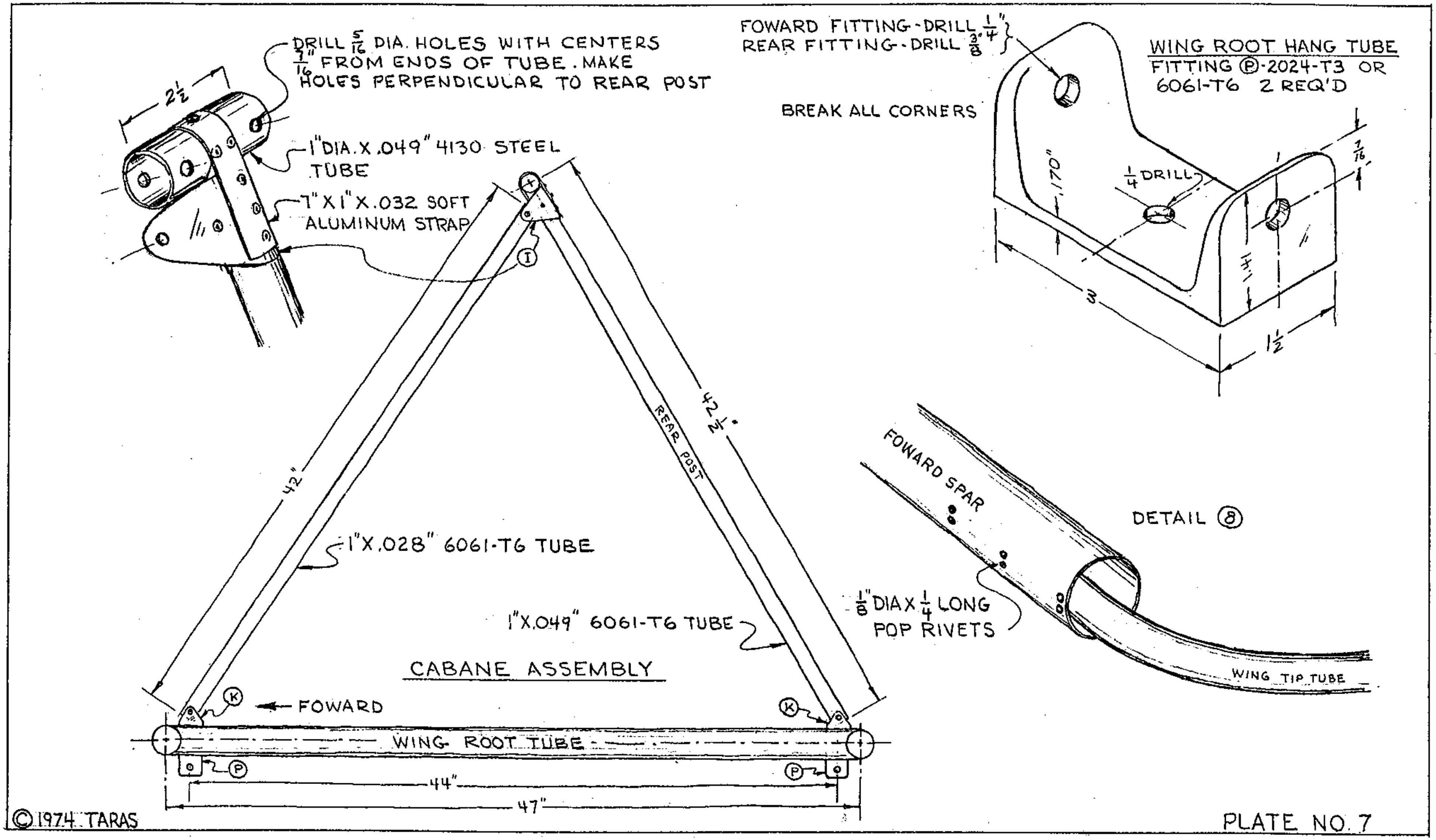
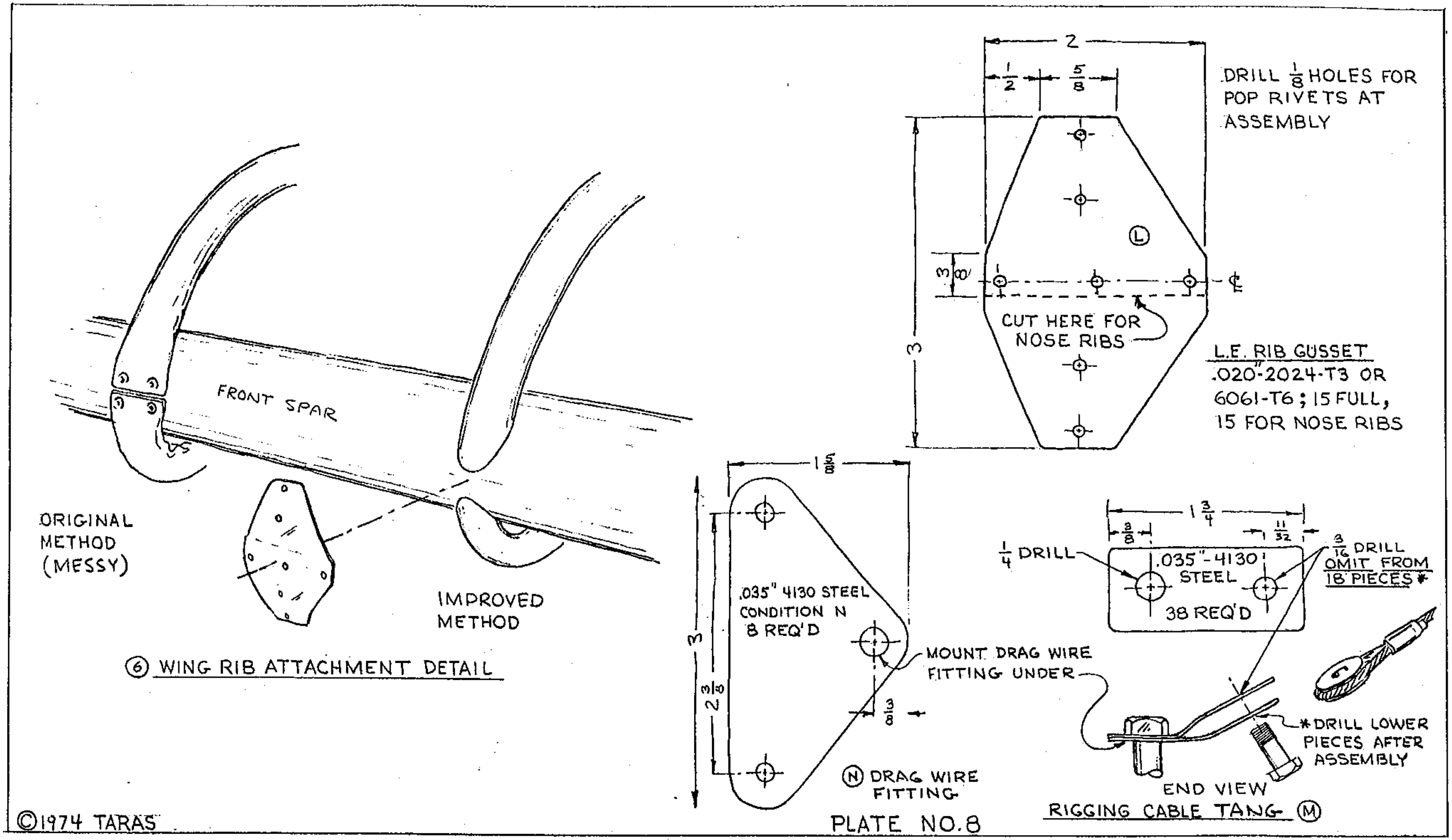
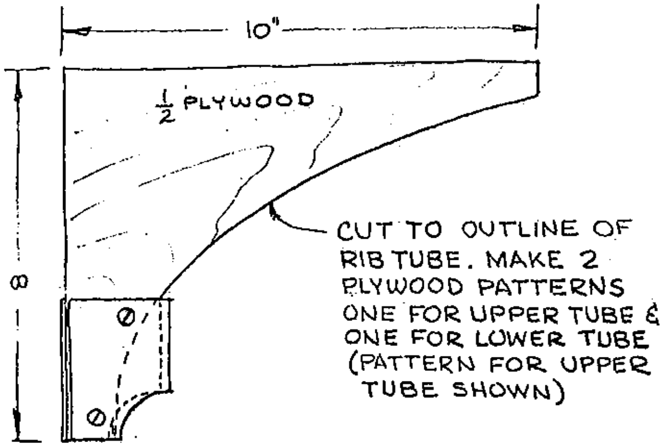
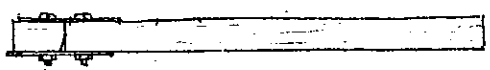


PLATE NO. 6


DRILL 5/16 DIA. HOLES WITH CENTERS 7/16" FROM ENDS OF TUBE. MAKE HOLES PERPENDICULAR TO REAR POST
2 1/2
1" DIA. X .049" 4130 STEEL TUBE
7" X 1" X .032 SOFT ALUMINUM STRAP
FOWARD FITTING - DRILL 1/4"
REAR FITTING - DRILL 3/8"
BREAK ALL CORNERS
WING ROOT HANG TUBE
FITTING (P)-2024-T3 OR 6061-T6 2 REQ'D
.170"
1/4 DRILL
7/16
1 1/4
3
1 1/2
42"
42 1/2"
REAR POST
1" X .028" 6061-T6 TUBE
1" X .049" 6061-T6 TUBE
CABANE ASSEMBLY
FOWARD
WING ROOT TUBE
44"
47"
FOWARD SPAR
DETAIL (8)
1/8" DIA X 1/4 LONG POP RIVETS
WING TIP TUBE
PLATE NO. 7

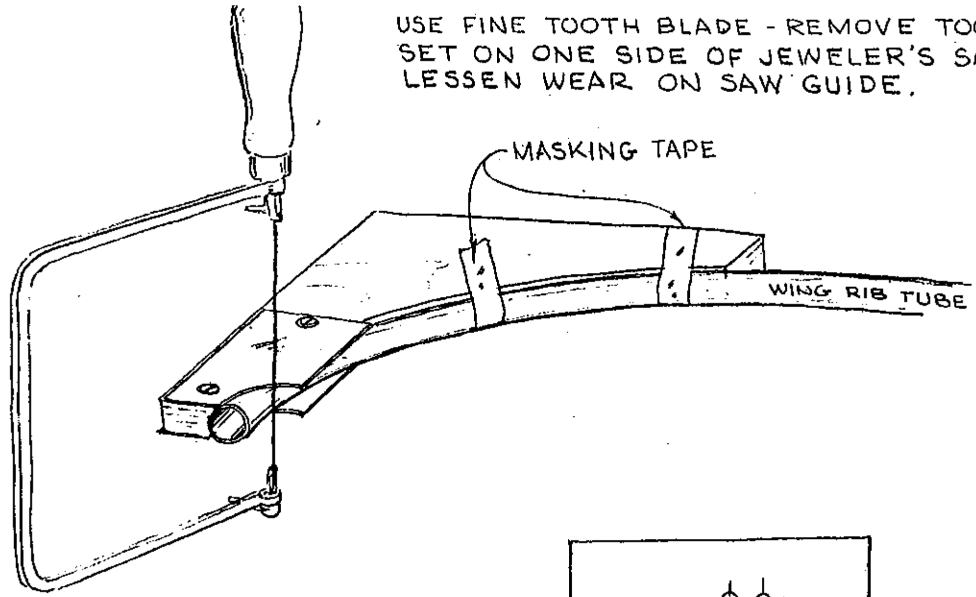

FRONT SPAR
ORIGINAL METHOD (MESSY)
IMPROVED METHOD
⑥ WING RIB ATTACHMENT DETAIL
DRILL 1/8 HOLES FOR POP RIVETS AT ASSEMBLY
CUT HERE FOR NOSE RIBS
L.E. RIB GUSSET
.020" 2024-T3 OR 6061-T6; 15 FULL, 15 FOR NOSE RIBS
.035" 4130 STEEL CONDITION N 8 REQ'D
MOUNT DRAG WIRE FITTING UNDER
Ⓝ DRAG WIRE FITTING
1/4 DRILL
.035"-4130 STEEL
38 REQ'D
3/16 DRILL OMIT FROM 18 PIECES *
*DRILL LOWER PIECES AFTER ASSEMBLY
END VIEW
RIGGING CABLE TANG Ⓜ
©1974 TARAS
PLATE NO. 8



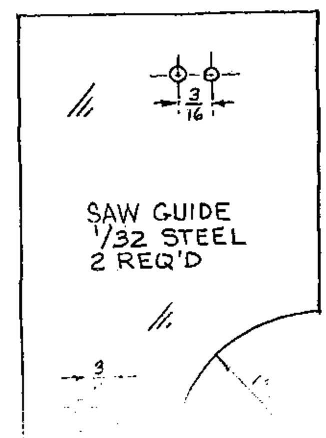


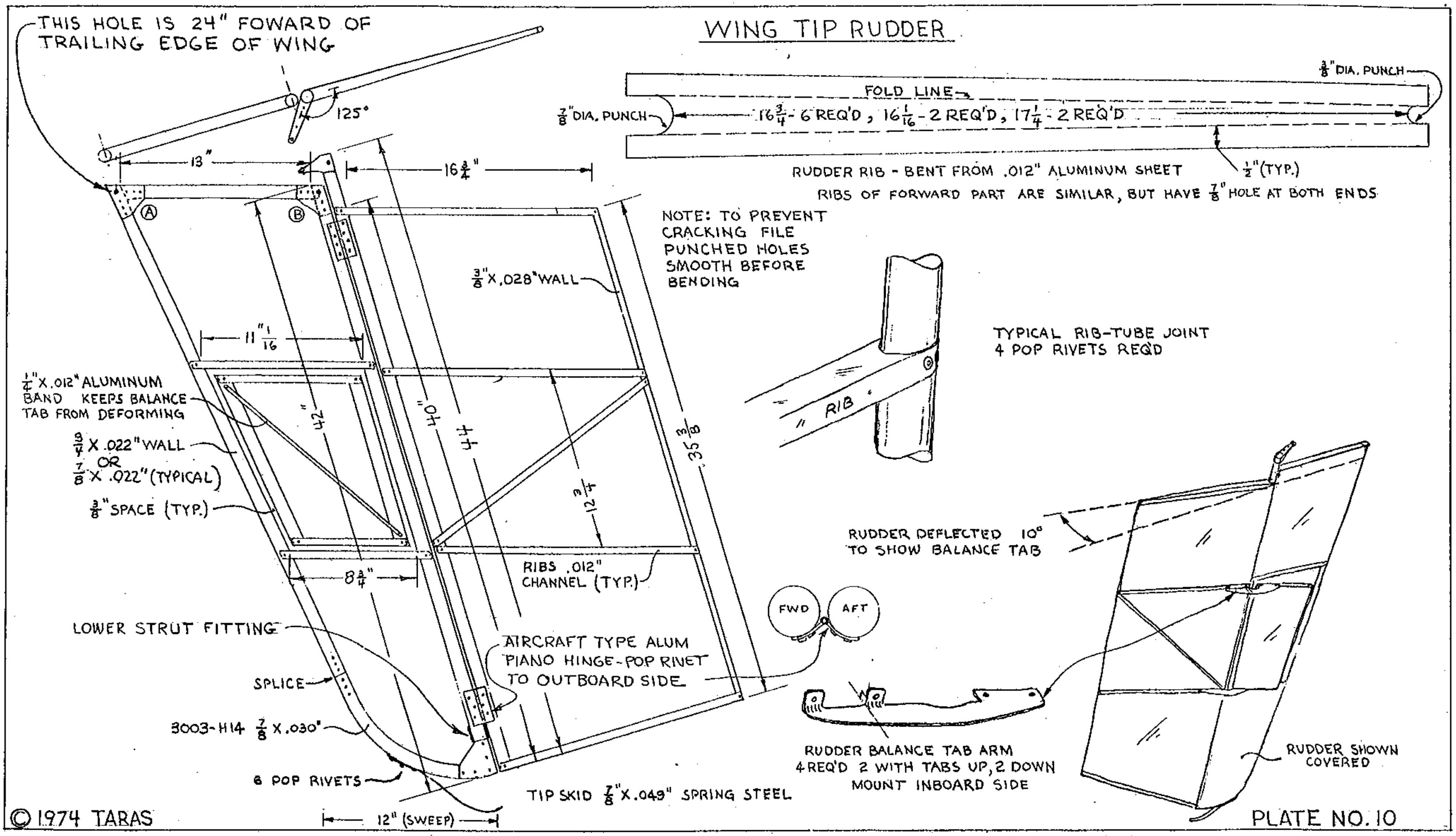
UPPER AND LOWER SAW GUIDES MUST BE DISPLACED $\frac{3}{16}$" TO PROVIDE FOR SWEEP ANGLE. RIGHT HAND WING RIBS REQUIRE OPPOSITE DISPLACEMENT FROM LEFT HAND WING RIBS. NOTE DOUBLE SCREW HOLES.

USE FINE TOOTH BLADE - REMOVE TOOTH SET ON ONE SIDE OF JEWELER'S SAW TO LESSEN WEAR ON SAW GUIDE.

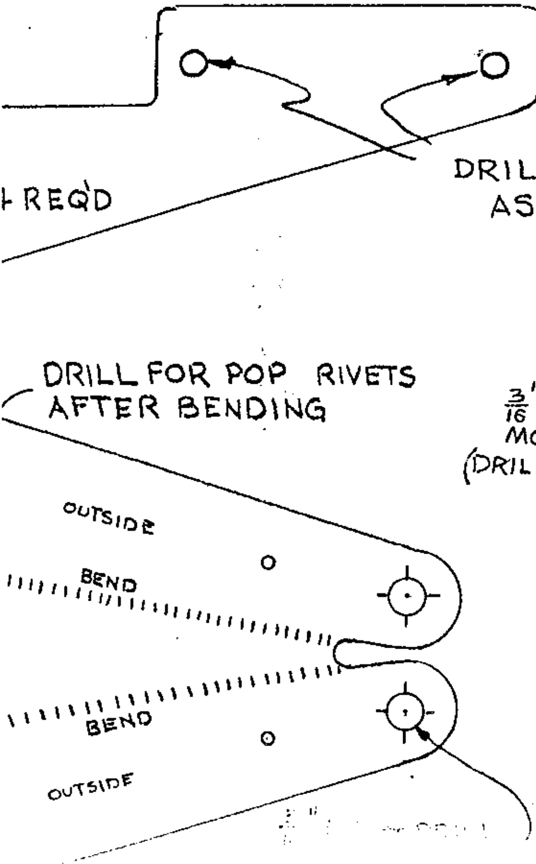


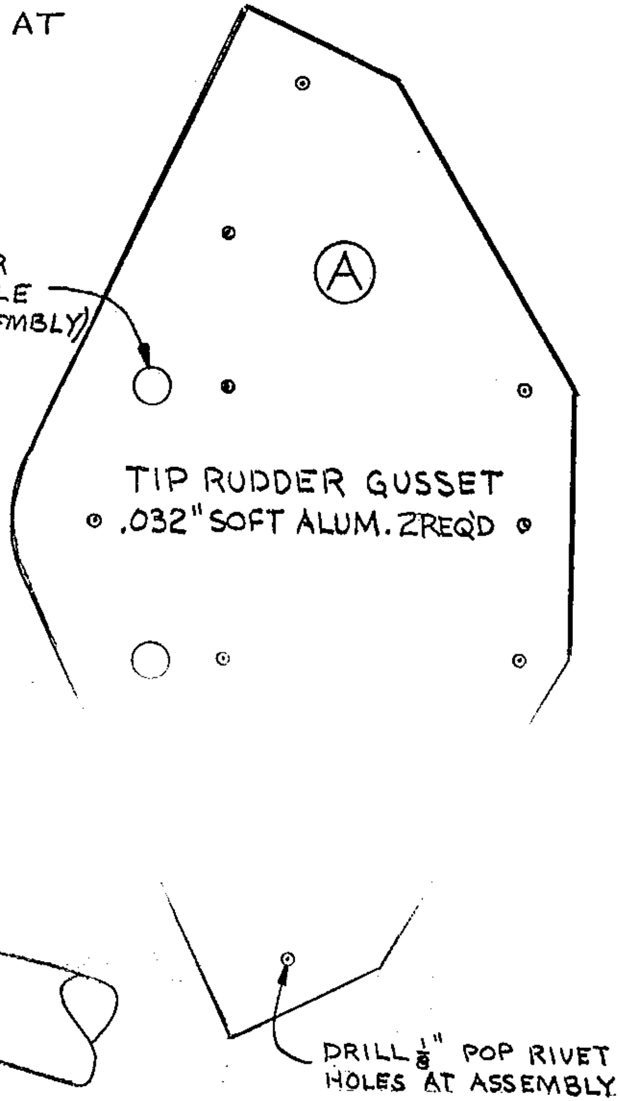
USE FILE TO FINISH TUBE

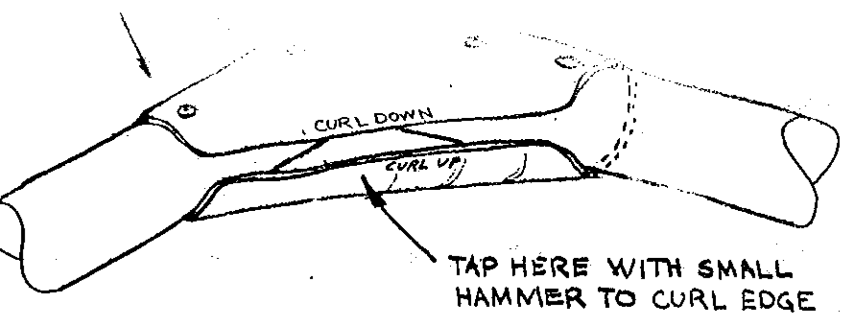



WING TIP RUDDER
THIS HOLE IS 24" FOWARD OF TRAILING EDGE OF WING
125°
13"
16 3/4"
A
B
3/8" DIA. PUNCH
FOLD LINE
7/8" DIA. PUNCH
16 3/4 - 6 REQ'D, 16 1/16 - 2 REQ'D, 17 1/4 - 2 REQ'D
RUDDER RIB - BENT FROM .012" ALUMINUM SHEET
1/2" (TYP.)
RIBS OF FORWARD PART ARE SIMILAR, BUT HAVE 7/8" HOLE AT BOTH ENDS
NOTE: TO PREVENT CRACKING FILE PUNCHED HOLES SMOOTH BEFORE BENDING
3/8" X .028" WALL
TYPICAL RIB-TUBE JOINT
4 POP RIVETS REQ'D
RIB
11 1/16"
1/4" X .012" ALUMINUM BAND KEEPS BALANCE TAB FROM DEFORMING
42"
40"
44"
35 3/8"
12 3/4"
3/4 X .022" WALL OR 7/8 X .022" (TYPICAL)
3/8" SPACE (TYP.)
RUDDER DEFLECTED 10° TO SHOW BALANCE TAB
8 3/4"
RIBS .012" CHANNEL (TYP.)
FWD
AFT
LOWER STRUT FITTING
AIRCRAFT TYPE ALUM PIANO HINGE - POP RIVET TO OUTBOARD SIDE
SPLICE
3003-H14 7/8 X .030"
6 POP RIVETS
RUDDER BALANCE TAB ARM
4 REQ'D 2 WITH TABS UP, 2 DOWN
MOUNT INBOARD SIDE
RUDDER SHOWN COVERED
TIP SKID 7/8" X .049" SPRING STEEL
12" (SWEEP)
© 1974 TARAS
PLATE NO. 10

FULL SIZE PATTERNS

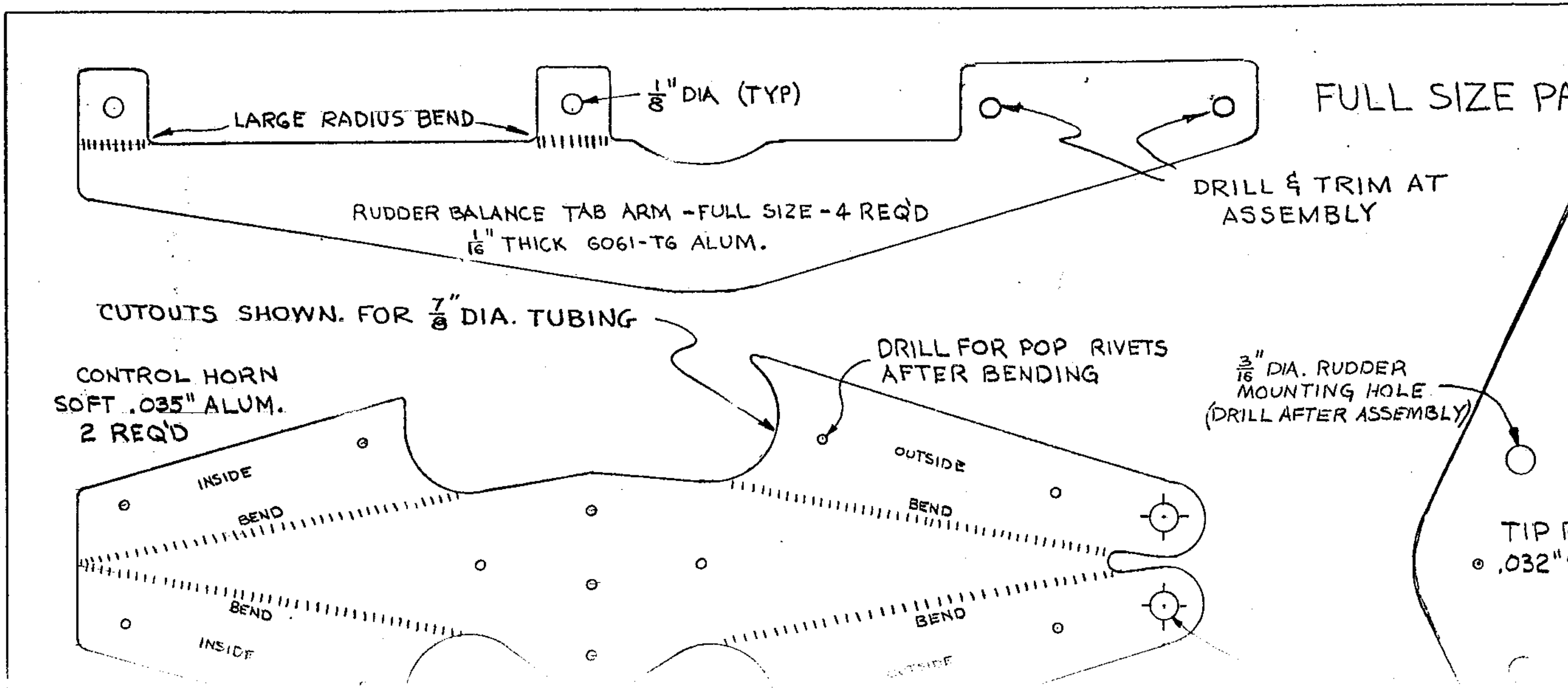


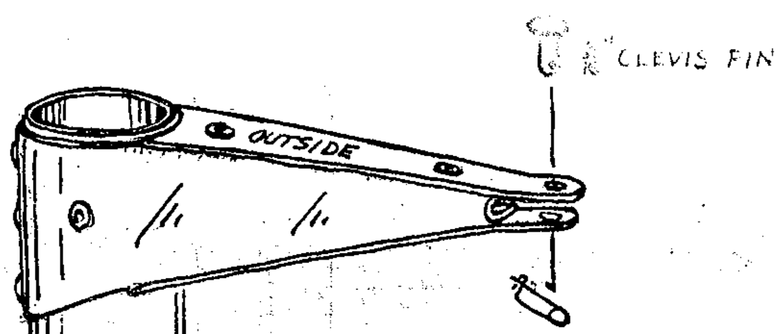




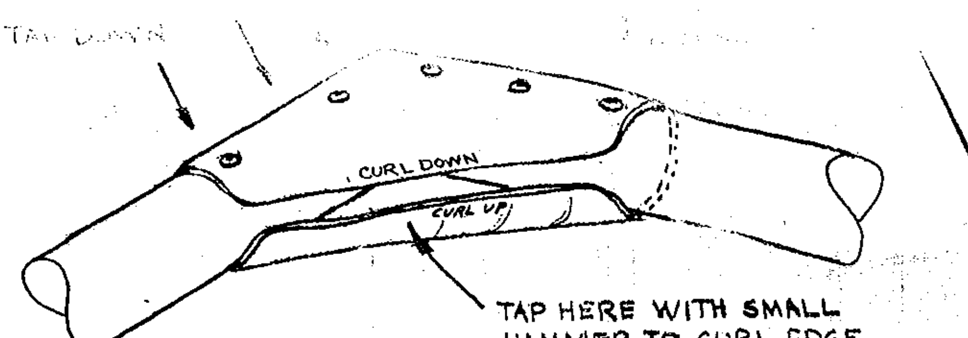
ET AFTER ASSEMBLY

PLATE NO. 11

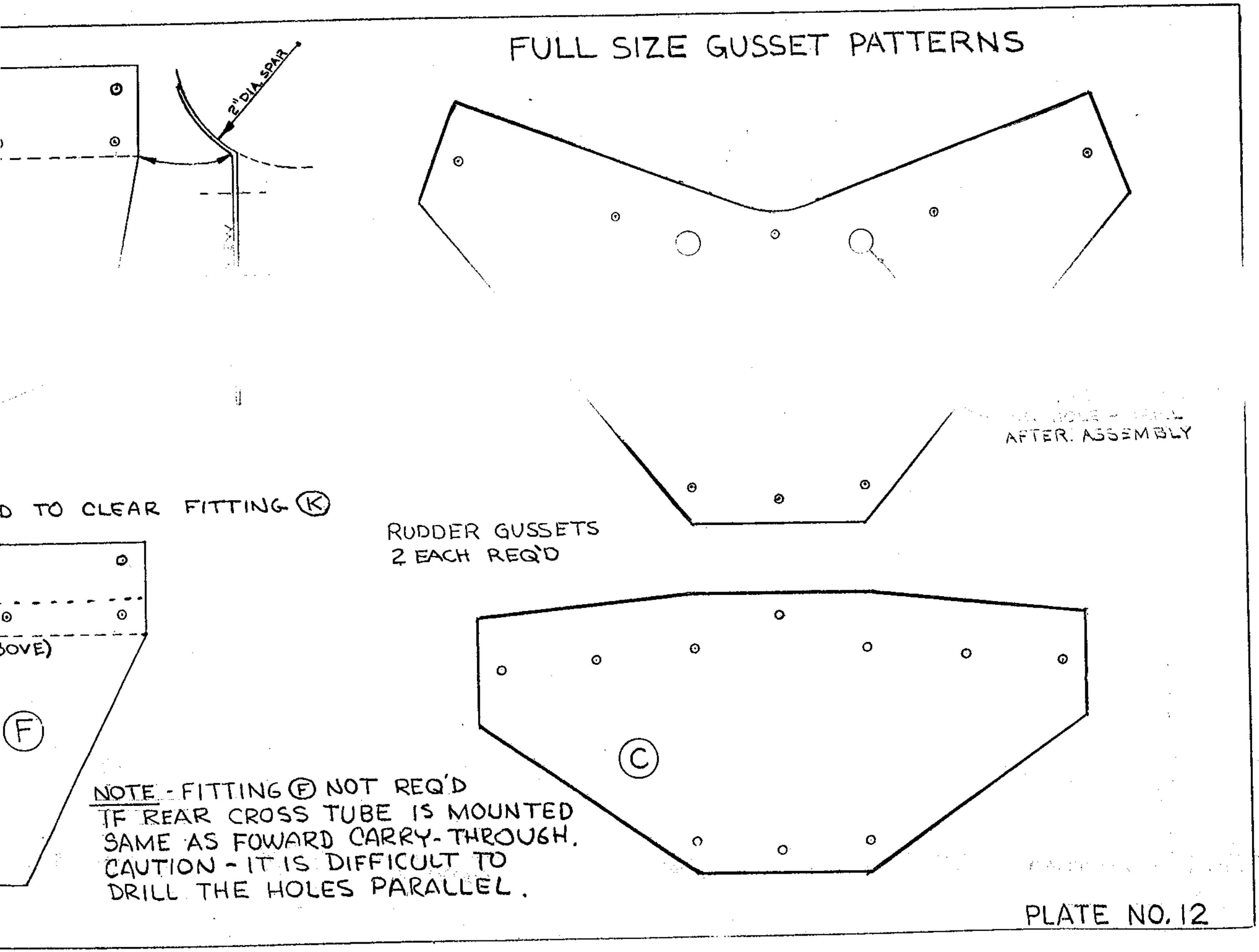




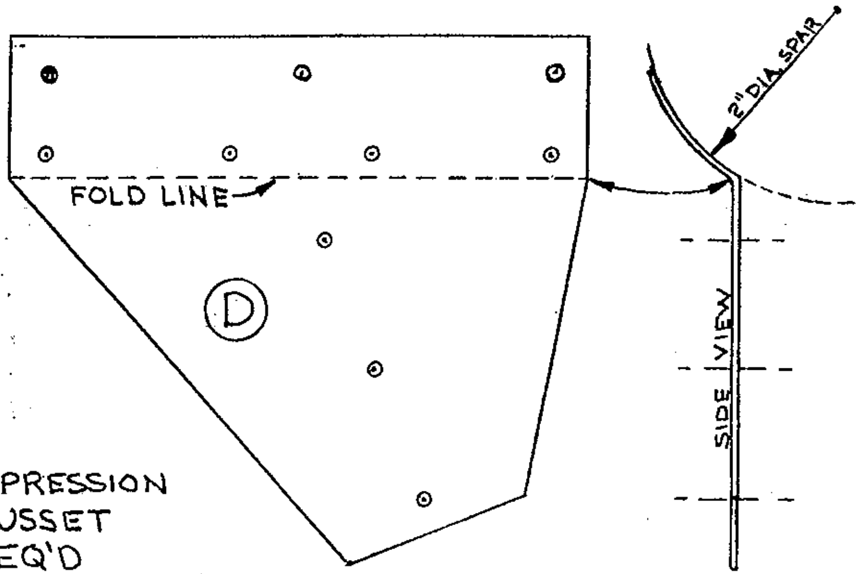
HORN ASSEMBLED



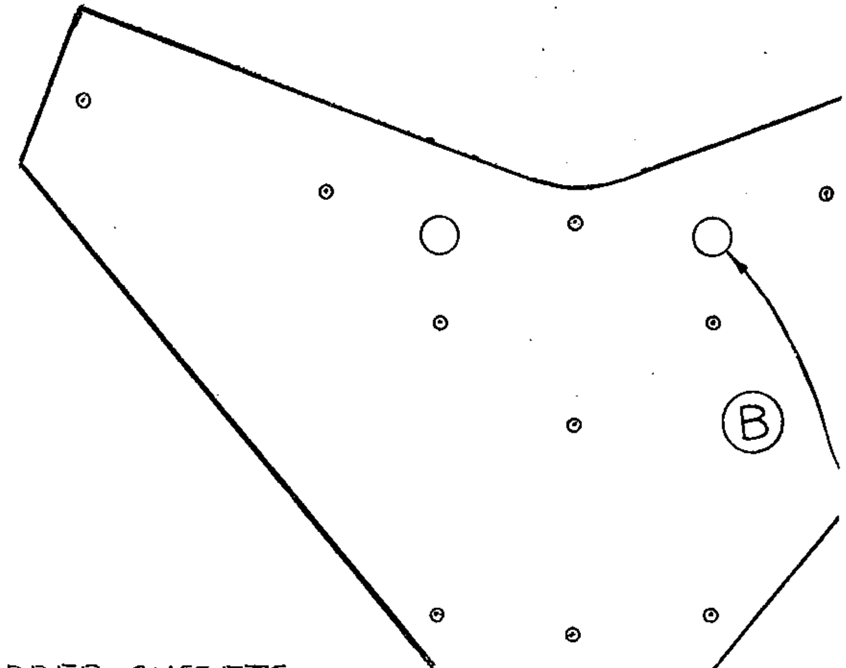
GUSSET AFTER ASSEMBLY


FULL SIZE GUSSET PATTERNS
2" DIA. SPAR
AFTER ASSEMBLY
D TO CLEAR FITTING (K)
RUDDER GUSSETS
2 EACH REQ'D
3OVE)
(F)
(C)
NOTE - FITTING (F) NOT REQ'D
IF REAR CROSS TUBE IS MOUNTED
SAME AS FOWARD CARRY-THROUGH.
CAUTION - IT IS DIFFICULT TO
DRILL THE HOLES PARALLEL.
PLATE NO. 12

FULL SIZE GUSSET PATTE

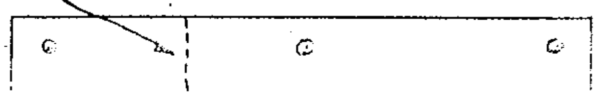


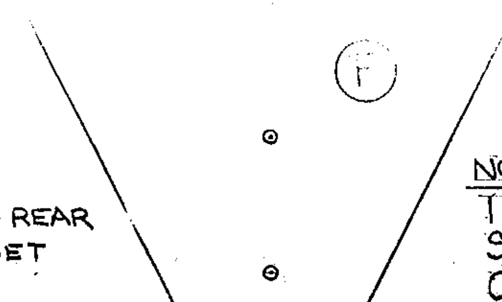
WING COMPRESSION
RIB GUSSET
16 REQ'D
(8 BENT DOWN, 8 UP)



RUDDER GUSSETS
2 [illegible]

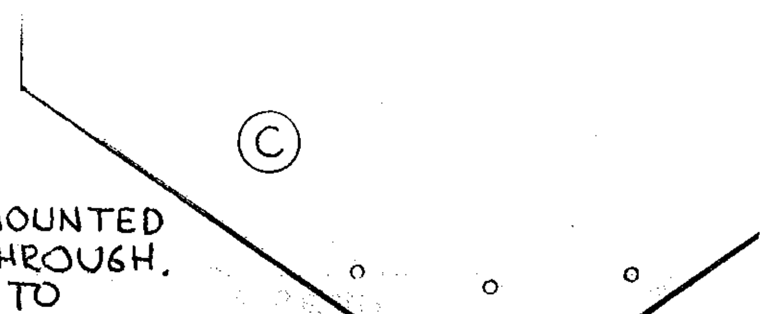
TRIM AS REQ'D TO CLEAR FITTING (K)

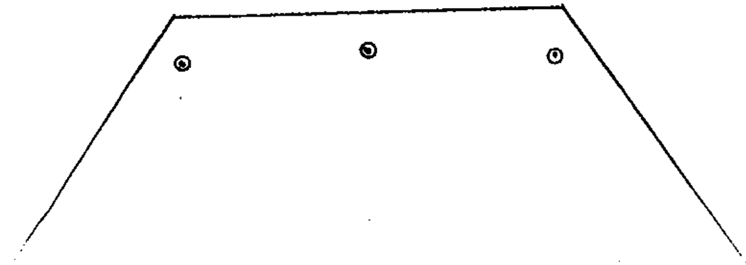


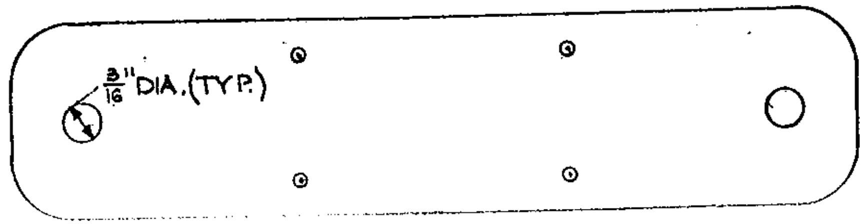


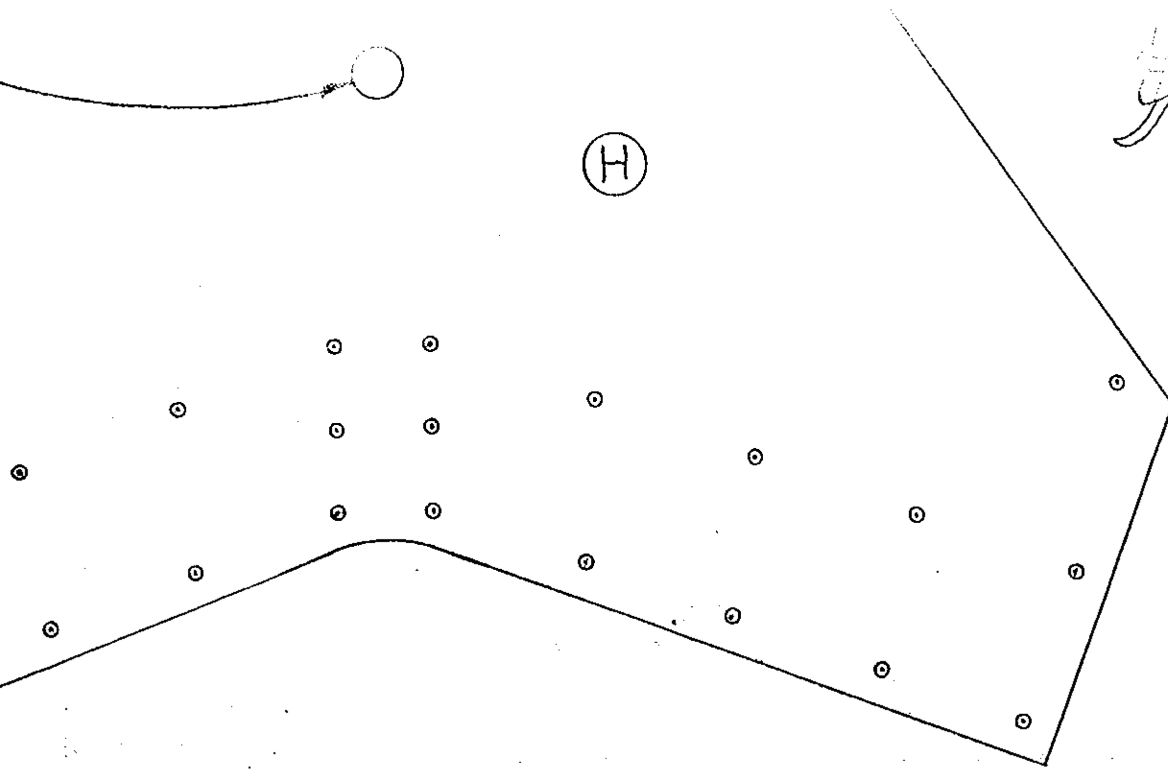
HANG TUBE-REAR
BRACE GUSSET
4 REQ'D

NOTE - FITTING (F) NOT REQ'D IF REAR CROSS TUBE IS MOUNTED SAME AS FOWARD CARRY-THROUGH. CAUTION - IT IS DIFFICULT TO DRILL THE HOLES PARALLEL.

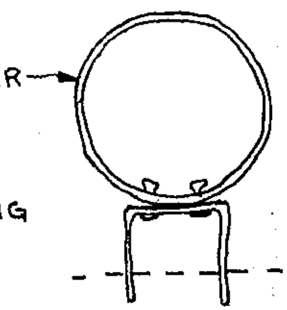








MAKE 3 RUDDER STRUTS FROM 12 FT LENGTH OF SAME TUBING USED FOR RUDDER. SAVE ONE FOR SPARE.



RUDDER STRUT UPPER END FITTING
.025" 4130 STEEL
2 REQ'D

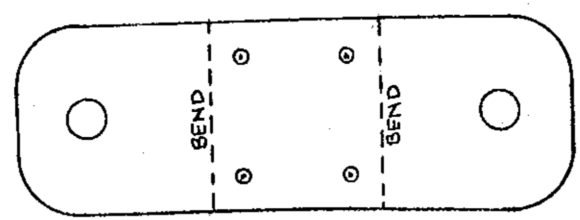
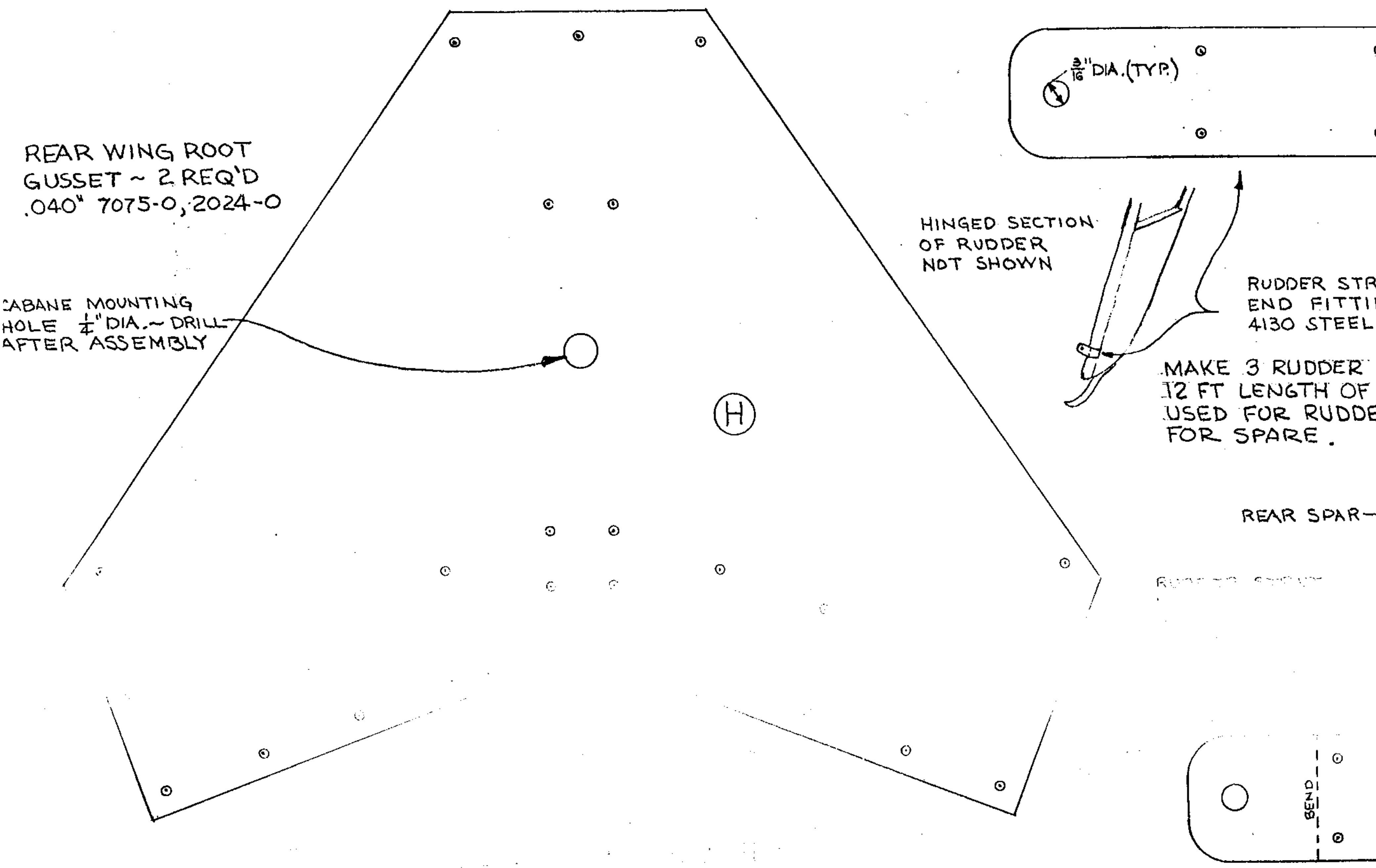
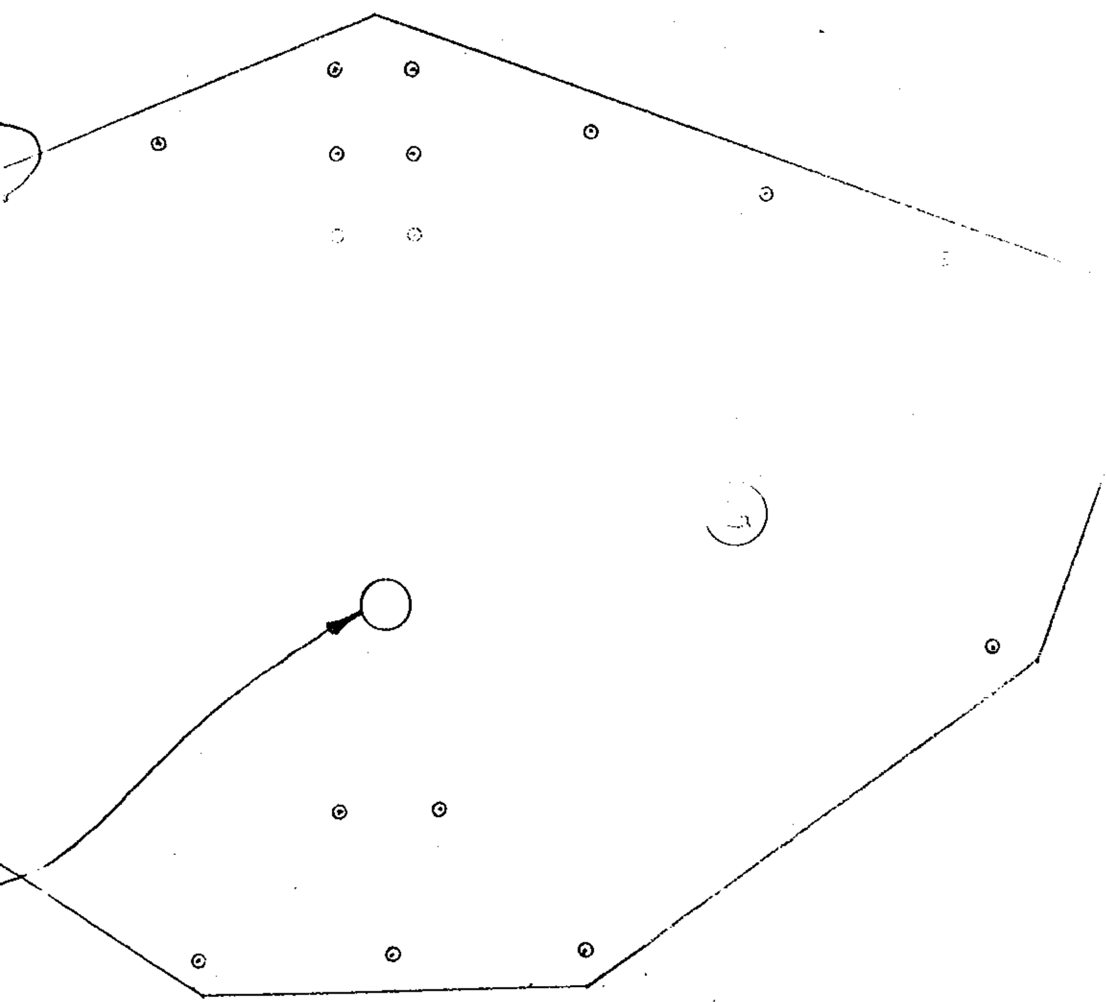


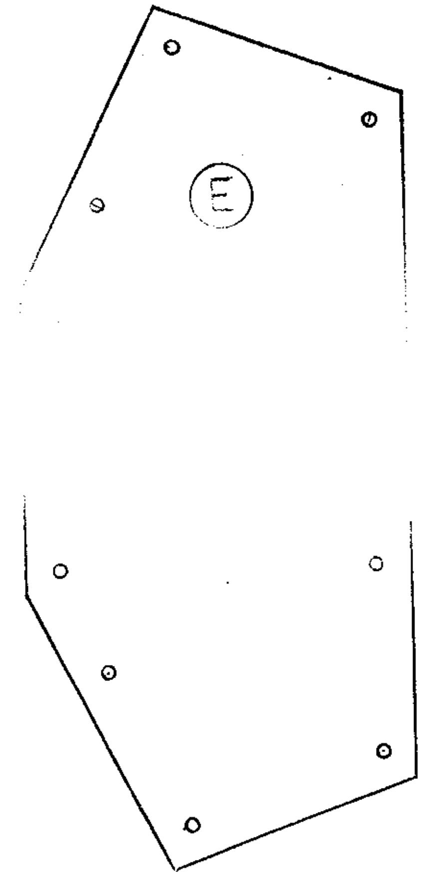
PLATE NO. 13


REAR WING ROOT
GUSSET ~ 2 REQ'D
.040" 7075-0, 2024-0
CABANE MOUNTING
HOLE 1/4" DIA. ~ DRILL
AFTER ASSEMBLY
H
3/16" DIA. (TYP.)
HINGED SECTION
OF RUDDER
NOT SHOWN
RUDDER STR
END FITTI
4130 STEEL
MAKE 3 RUDDER
12 FT LENGTH OF
USED FOR RUDDE
FOR SPARE.
REAR SPAR—
BEND

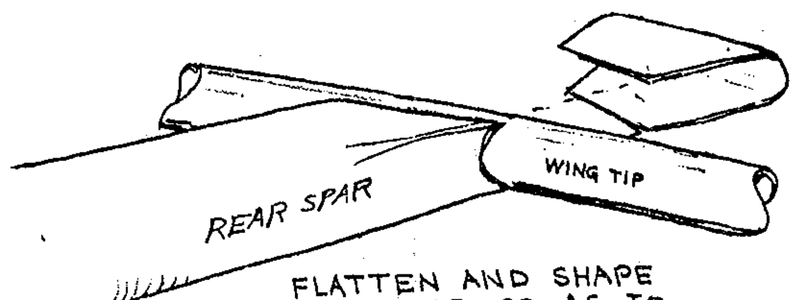


OOT GUSSET~2 REQ'D
-O ALUM. .040" THICK

FULL SIZE

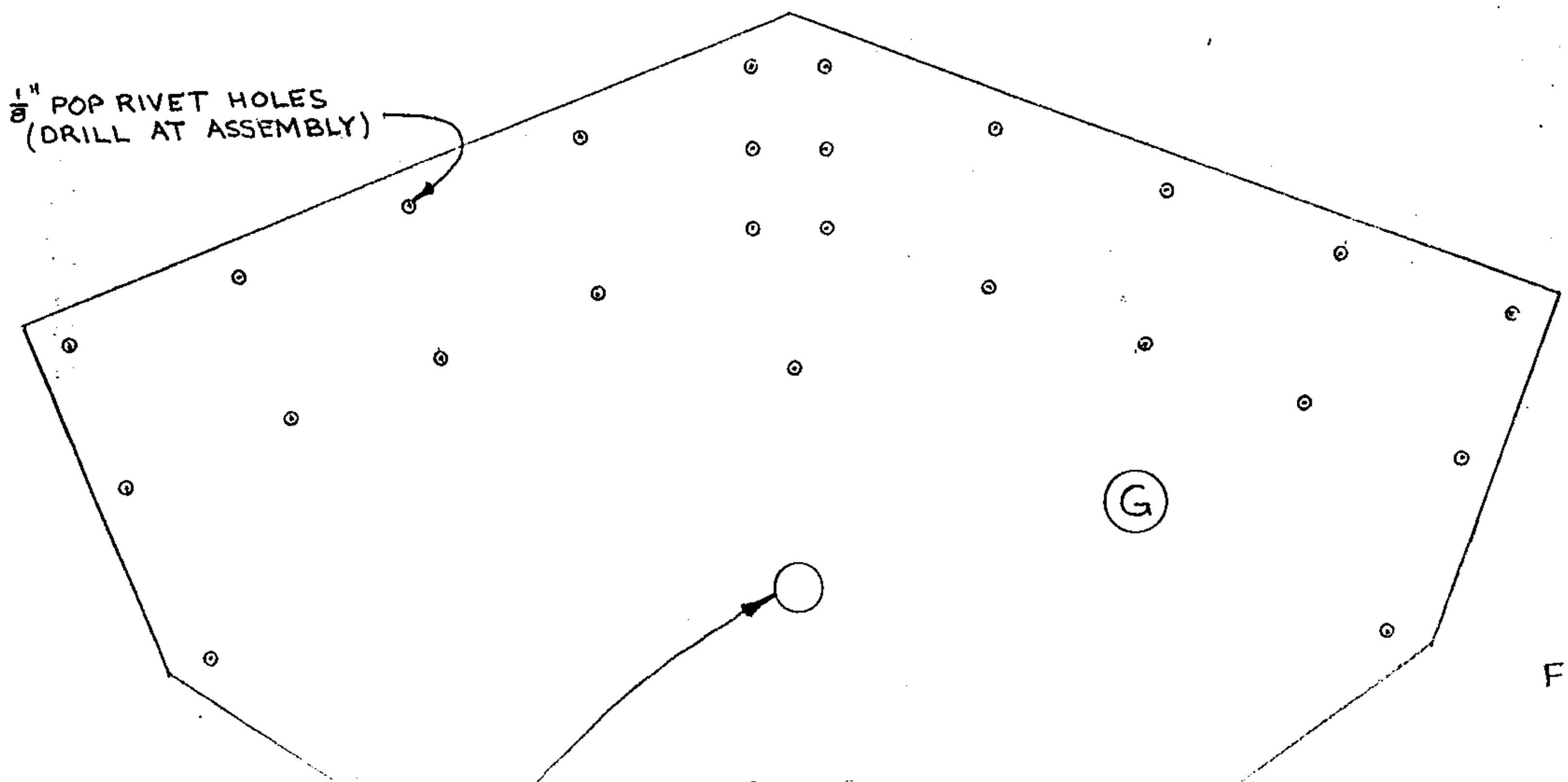


WING TIP-REAR SPAR GUSSET
.032" SOFT ALUM.~2 REQ'D



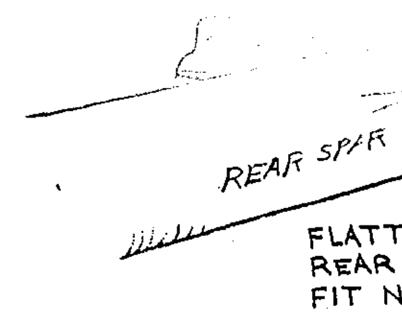
FLATTEN AND SHAPE
REAR SPAR SO AS TO
FIT NICELY AGAINST TIP

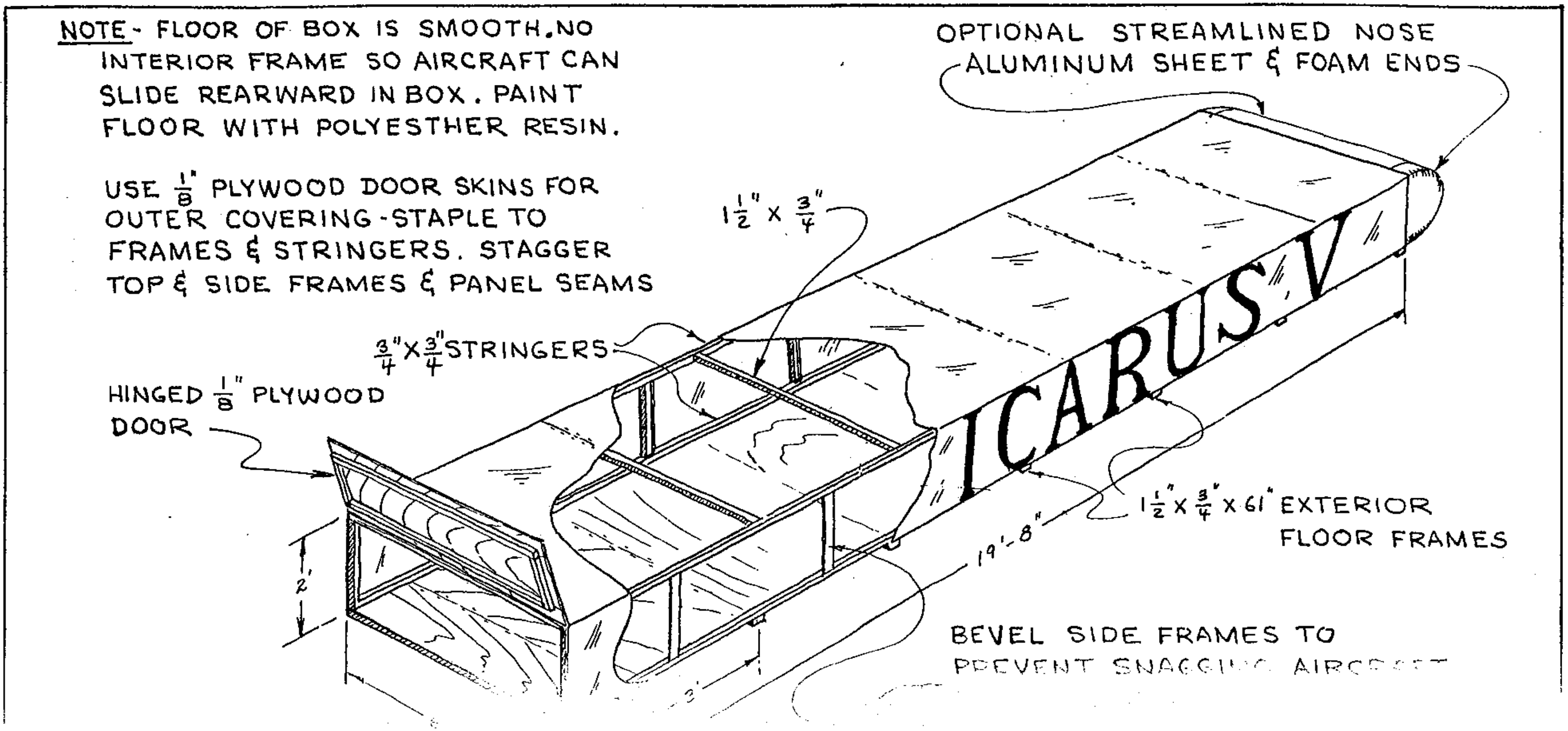
PLATE NO. 14

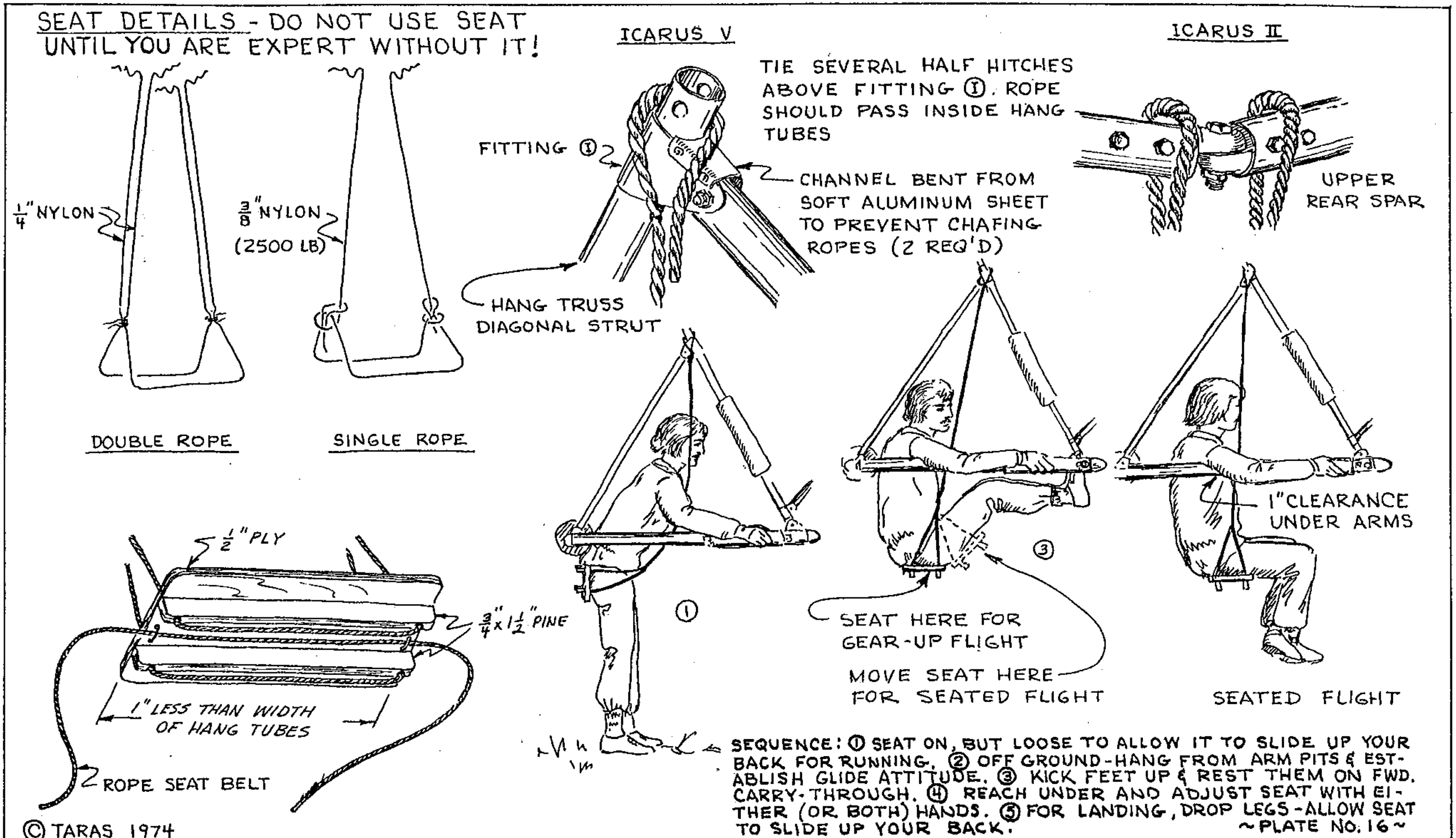


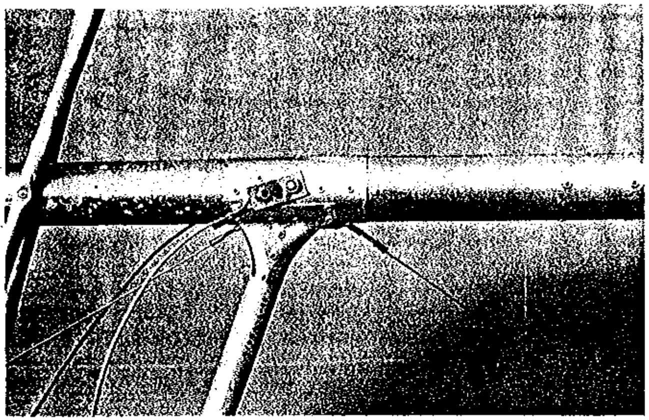
FULL SIZE

FRONT WING ROOT GUSSET~2 REQ'D
7075-0 OR 2024-0 ALUM. .040" THICK

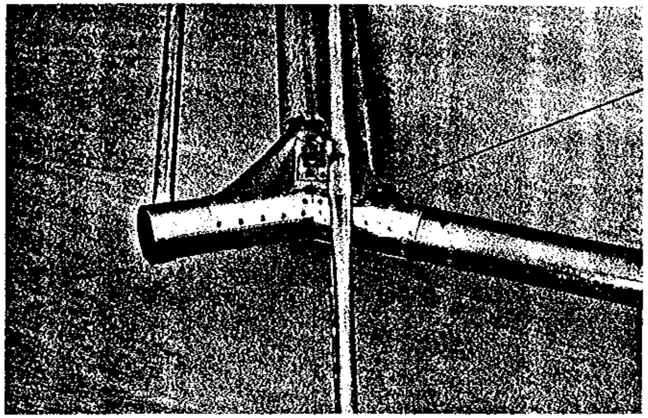



NOTE - FLOOR OF BOX IS SMOOTH. NO INTERIOR FRAME SO AIRCRAFT CAN SLIDE REARWARD IN BOX. PAINT FLOOR WITH POLYESTHER RESIN.
USE 1/8" PLYWOOD DOOR SKINS FOR OUTER COVERING - STAPLE TO FRAMES & STRINGERS. STAGGER TOP & SIDE FRAMES & PANEL SEAMS
OPTIONAL STREAMLINED NOSE
ALUMINUM SHEET & FOAM ENDS
1 1/2" X 3/4"
3/4" X 3/4" STRINGERS
HINGED 1/8" PLYWOOD DOOR
ICARUS V
1 1/2" X 3/4" X 61" EXTERIOR FLOOR FRAMES
19'-8"
2'
3'
BEVEL SIDE FRAMES TO

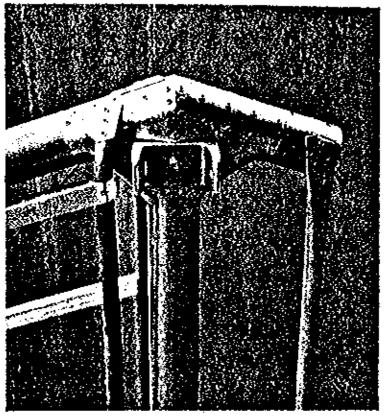

SEAT DETAILS - DO NOT USE SEAT UNTIL YOU ARE EXPERT WITHOUT IT!
ICARUS V
ICARUS II
TIE SEVERAL HALF HITCHES ABOVE FITTING ①. ROPE SHOULD PASS INSIDE HANG TUBES
FITTING ①
CHANNEL BENT FROM SOFT ALUMINUM SHEET TO PREVENT CHAFING ROPES (2 REQ'D)
UPPER REAR SPAR
HANG TRUSS DIAGONAL STRUT
1/4" NYLON
3/8" NYLON (2500 LB)
DOUBLE ROPE
SINGLE ROPE
1/2" PLY
3/4"x 1 1/2" PINE
1" LESS THAN WIDTH OF HANG TUBES
ROPE SEAT BELT
①
③
SEAT HERE FOR GEAR-UP FLIGHT
MOVE SEAT HERE FOR SEATED FLIGHT
1" CLEARANCE UNDER ARMS
SEATED FLIGHT
SEQUENCE: ① SEAT ON, BUT LOOSE TO ALLOW IT TO SLIDE UP YOUR BACK FOR RUNNING. ② OFF GROUND-HANG FROM ARM PITS & ESTABLISH GLIDE ATTITUDE. ③ KICK FEET UP & REST THEM ON FWD. CARRY-THROUGH. ④ REACH UNDER AND ADJUST SEAT WITH EITHER (OR BOTH) HANDS. ⑤ FOR LANDING, DROP LEGS - ALLOW SEAT TO SLIDE UP YOUR BACK.
~PLATE NO. 16~
© TARAS 1974



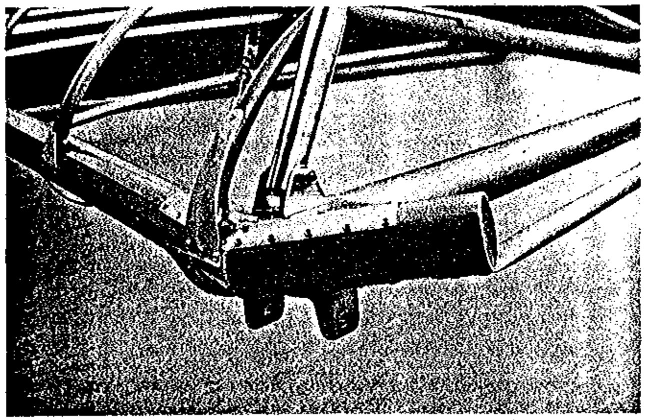
View of right inboard compression tube from below showing lift tang.



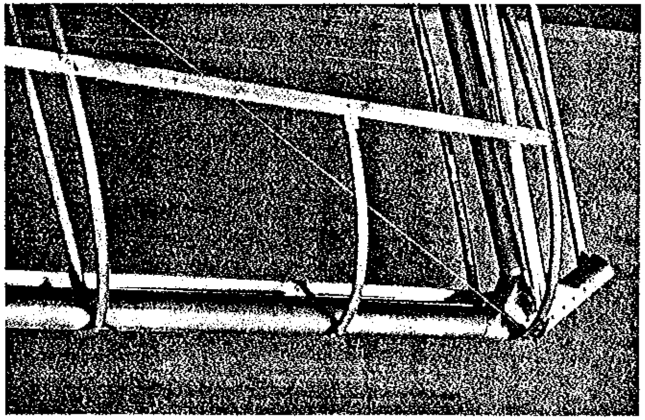
View of wing center section from above and behind.



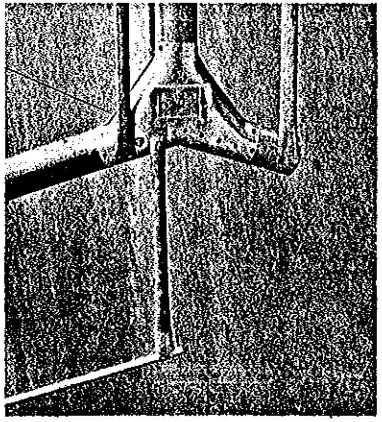
View of wing center section from below - forward spar.



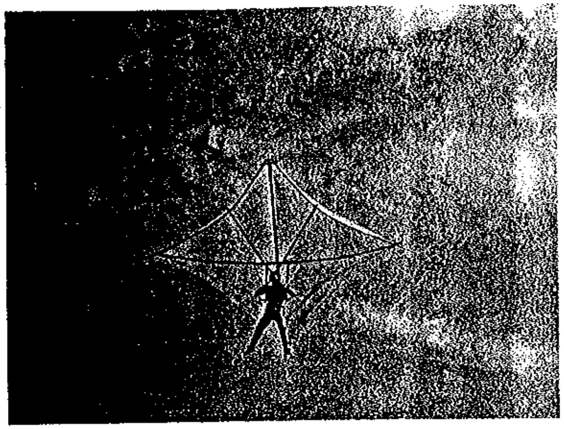
View of center section of wing.



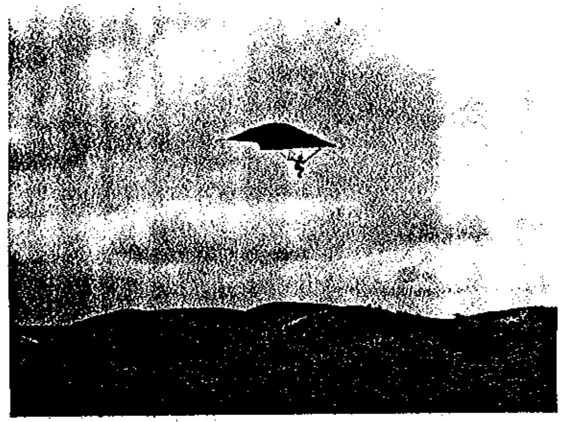
View of right wing panel from above. Note ribs and stringer channel.



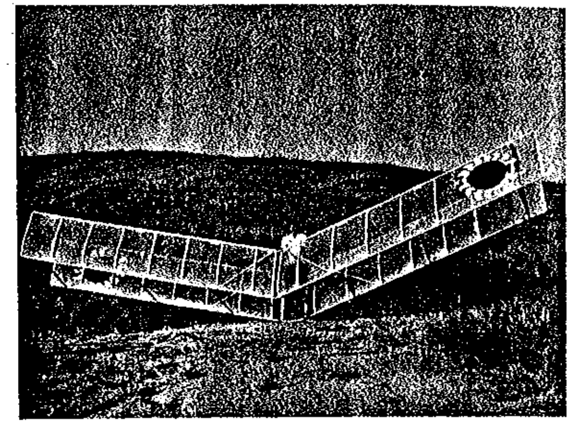
View of wing center section from below - rear spar.



Nov. 1969 - Author's first hang glider flight - modified Bamboo Butterfly design of Richard Miller.

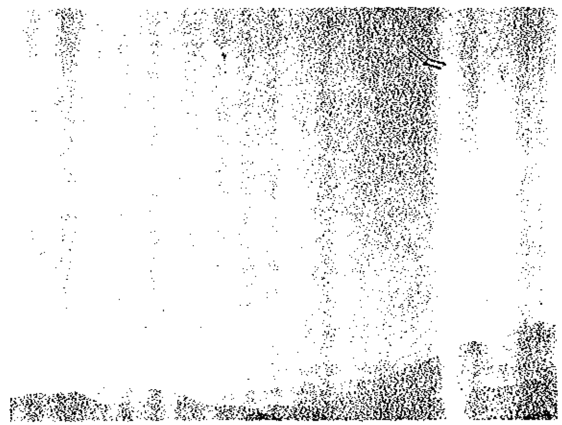


May 1972 - Tom Dickinson takes the original Batso for a long glide near Livermore, California.



July 1971 - ICARUS I poses before a test flight in the heart of Los Angeles.

Left to right: Tom Dickenson, Taras Sr., Taras Jr., Steve Elliott. The Great Low and Slow Photo Fly-In.(G. Uveges photo)

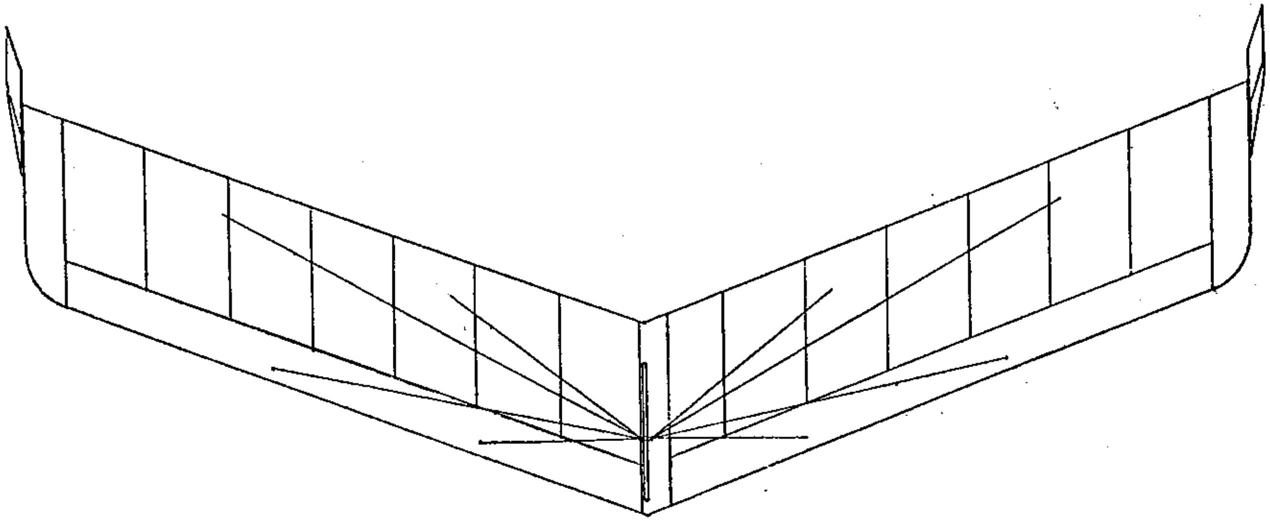


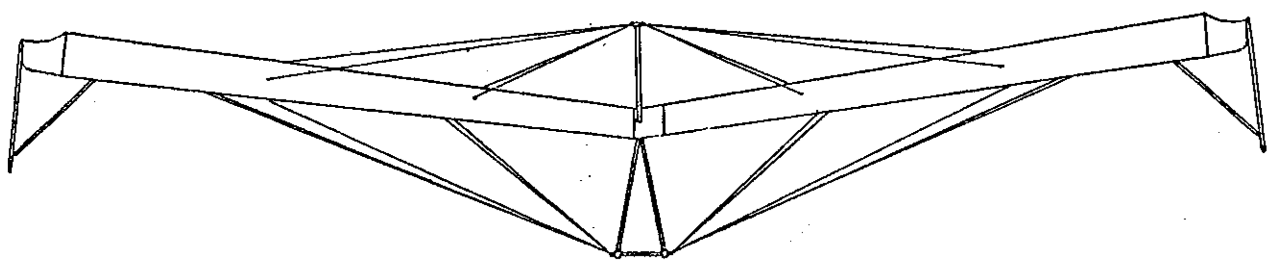
Autumn 1972 - ICARUS II strikes out for a thermal and gains 1000 feet altitude for hang gliding's first thermal flight.

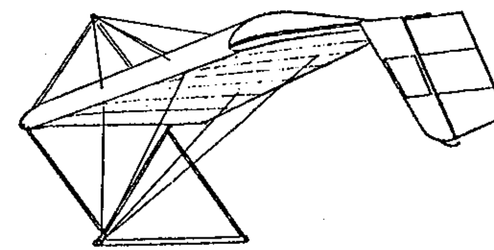
May 1974 - ICARUS V gains over 3300 feet in 1 hour 10 minute flight during Lilienthal Meet #4.

SPECIFICATIONS

SPAN : 32′
WING AREA : 160 sq. ft.
CHORD : 5′
ASPECT RATIO : 6.4
AIRFOIL : TK 7315 (HIGH LIFT, LOW MOMENT)
LOAD FACTOR : 6G (WITH 200 Lb PILOT)
WEIGHT : 65 Lb.
CONTROL : TWIST GRIP OPERATED TIP RUDDERS. FORE AND AFT, WEIGHT SHIFT.
STALL SPEED : 16 MPH
MAX L/D : 10:1 AT 22–24 MPH
MIN. SINK : 3 ft/sec AT 18–20 MPH
MAX SPEED : OVER 40 MPH







ICARUS V

PLATE NO. 1