Building the T18 fuselage

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Change/log

Date	Who	Change / Revision
6 / 2012	SG	Initial
7 / 2012	SG	Added appendices: Extracts from Sports Aviation June-July 1963 J Thorp articles on T18 construction #9 and 10 Incorporated links to or information from relevant Newsletter articles
8 / 2012	MW	Mark Waldron edits
10 / 2012	SG	Various additions
1 / 2013	SG	Additional Firewall information added
6 / 2013	SG	Various updates
8/2013	SG	Added comments about seat brackets

Appendices

T18 Hi Lock fastener usage

Background

Building the T18 fuselage was initially described by John Thorp, in the June and July 1963 editions of Sports Aviation (parts 9 and 10 of a multipart series on the T-18)
John Thorp's build processes are essentially unchanged over time and still followed by most builders however for the novice builder there are still many unanswered questions, progress in the area of CAD / CAM technology enhances the original concept of matched hole tooling potentially allowing for even simpler "matched hole" construction processes and increased accuracy.

The following document is intended to:

Become a single point source of information about the fuselage and:

Gather together relevant past fuselage construction advice from T18 Newsletters.

Reference past Thorp Mutual aid Society News Letters for detailed build processes or worthy modifications. At this stage only the highlights are mentioned here in this document.

Collect tips and tricks from past builders, the kind of insights that didn't make it to the original Thorp build instructions or the newsletters and might be considered obvious to more experienced builders with sheet metal experience but are otherwise helpful for the novice builder.

Describe an updated approach and assembly sequence of the fuselage for the novice builder taking advantage of CAD/CAM cut skins and frames.

Major Component Parts involved

Plan number references are to the original Thorp plans
Firewall 604, Landing attach beam 527, Dash frame 603
Frames 571- 576, 598
Bulkheads 592 596, 601
Skins 524, 593 669, 523, 580
580 Longerons and Stringers

Beginner tips (refer to News Letter 35)

1. Work bench with a top surface extending past the frame for clamping
2. Care with hand cutting
3. Scribe lines which you are going to cut to and leave about .01" clear and trim the last bit with a Stanely Surform hand plane
4. 1/8" rivets need 0.25" clearance from the edge of the material. Edge distance is always 2 x the diameter of the rivet for universal head rivets and 2.5 diametersfor flush rivets. *(Note: The T18 plans generally provide .25" minimum edge distance and will need to be varied for flush rivets or if you want to allow more margin for error during construction.*

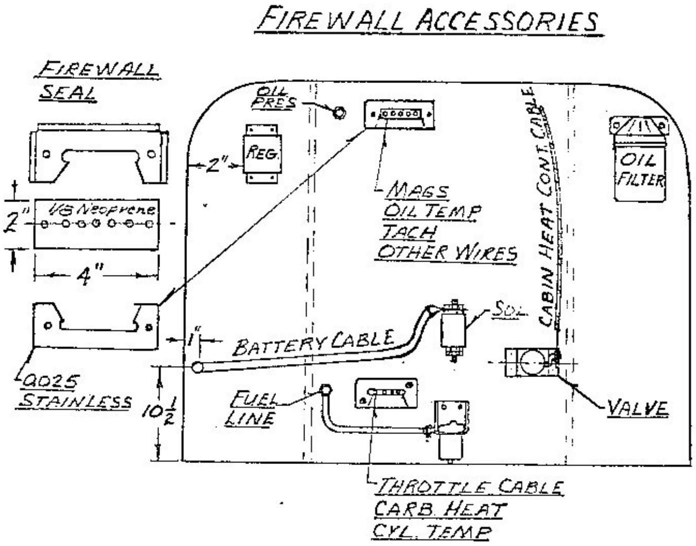
5. Reference all hole patterns to WL42 the nearest sharp edge is at 42.6”

Riveting suggestions

Reverse rivet instructions NL32 pg 204- 205
It was called the McDonnell-Douglas bell bar method and is essentially back riveting using a large “broad -surfaced “ bucking bar on the outside and a tee-shaped set from the inside.

Prepare all bulkhead frames and firewall.

Early advice on frame flange bending was provided in NL 29 pg 180
Using CAD/CAM machine cutting techniques for all frames and skins allows all holes including those for any sub components to be pre drilled. All rivet holes are CNC cut as 3/32” pilot holes, #30 holes can then be drilled when mating parts are assembled which should allow for slght misalignments to be resolved when assembling. CNC maching could potentially be done all in flat layout to finished sizes as he margin of error will be siginificantly less than for hand drilled parts. Thorp recommended that generally all rivet holes on bulkheads be laid out and punched after forming for hand formed parts. Following the CAD/CAM processes can essentially reverse this. Adopting this new approach allows all rivet layouts to be cut to precise dimensions while allowing for slight adjustments during assembly process although on balance less adjustments are likely to be required as all mating parts will have identical rivet patterns. HOWEVER accurate forming of flanges will be essential. To achieve this, full size accurately cut form blocks would be used to form all flanges. The form blocks would also need index points to key the sheet metal accurately to the form block. This can easily be achieved as the CAD drawings can be used to cut the form blocks as well. Where no form block is needed and a pan brake is used, extra care would need to be taken with each bend, accurately setting up the brake with the correct setback position and ensuring that the bend radius matched what was included in the flat layouts.



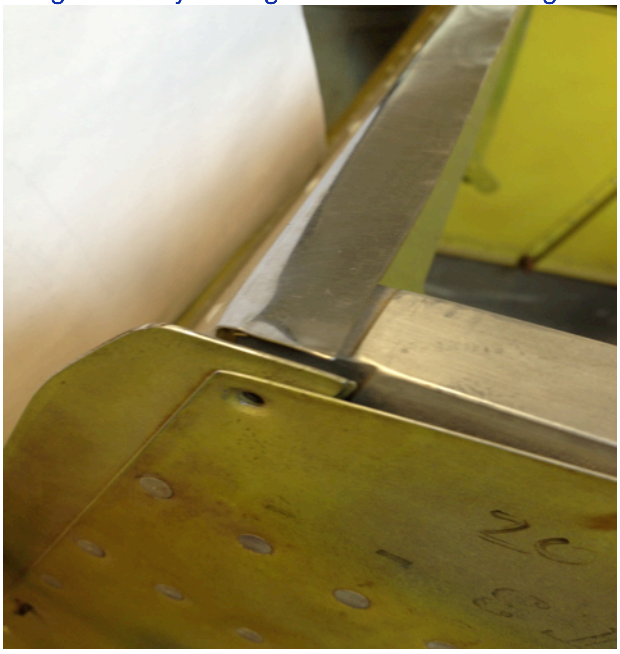
604 Firewall:

Determine the layout of as many penetrations before hand and cut holes while in the flat and separate from the airframe. Layout will vary from aircraft to aircraft. An example from NL 32 pg 212 is shown above.

The alternate flush cowl attachment detail (see drawing 604/NL-XX) is considered the norm.
The flush cowl attachment strips (1.25” wide * .040 thick) can be cut as the same time as the forward floor section. Use these strips as the transfer template to mark the rivet hole locations on the curved upper section of the firewall flange. The flat section running down the side of the aircraft would be identical to the side skins. When bending the flange on the firewall the curved section will need shrinking or fluting. If using flutes first locate the rivet locations so that the rivet holes do not end up over a flute. Rivets are set at typically 1.5” apart then the flutes can be made in between.
If you start with the flutes and evenly space them around the curve then the rivet holes will need to be positioned in between them.

Fire sealant such as 3M Fire Barrier 2000 silicon or an equivalent should be used around penetrations in conjunction with heat shields.

Bending the extrusion c580 reinforcements to match the angle of the side skins. There are probably a number of ways to do this but without access to a press I used a socket and clamped the angle in a vice to achieve the required bend.
Fitting the lower longerons an alternative to joggling is possible due to the low stress in the lower flange area by milling a rebate for the flange into the longeron.



Common firewall locations used for various penetrations of major components are listed in the table below:

Item	Approximate Location	Assembly Comment
Battery Box	Top passenger side	Consider mounting with terminals facing outward to improve service access Rout Electrical cables in close proximity
Cabin Heat flap valve	Either side close to the outer skin lower 1/3	
Cabin Heat cable	flexible	
Oil Cooler	pilot side mid level	
RDAC/ Engine management / Data cables	Top pilot side	
Gascolator / fuel pump	Central	
Throttle/ Mixture cables	Near BL 0 above or below fuel tank	Alternate if you want to use a throttle quadrent
Main contactor / Starter Solenoid	Adjacent or on battery box	
Fuel tank cradle brackets	per plans	Attach to 604 before attaching to the aircraft.
Fuel line	centerline	
Doubler extrusion for side skin	per 580 revision plans	Pilot drill rivet holes while in the flat, rivet on assembly
regulator		
Brake fluid lines HP / LP	Some builders route through firewall in the lower corners near the gear legs	Can also go through the floor skin and be kept inside cockpit
Fuel line		

Notes for frames and bulkheads

Attention needs to be paid to the installation of the 575 frame as it supports the horizontal stabilizer through the placement of the 584 fittings. NL 56 pg 14 provided steps to align and locate the fittings.

In essence that procedure was to accurately mark BL 0 on the frame then mark out the WL44.625 so that the fixtures can be placed on with reference to that level line. CAD/CAM cut parts should limit the opportunity for misalignment unless twist is introduced when bending the flanges or later as the fuselage is being assembled.

All rivet patterns are laid out referencing WL42, in practice for the frames this becomes WL42.6 due to the clearance slot for the longeron (per NL 35 pg 234) when assembling either the rivet hole just above or below that WL reference should be used as the datum. Preferentially the hole above as it will not be affected by the joggle.

While most frames should have the rivet pattern in place from a matched hole transfer template if there is any doubt as to the accuracy then use the rivet hole above WL42 first and another near the bottom of the frame if these holes can be accurately set out then any slightly misaligned holes in between can be reamed to #30 on set up using the actual skins as the drilling template.

If for some reason pre drilled holes are not present on a frame's flanges, which would be the case were CNC cut skins are being used with hand cut frames then the mating part can simply be used as the template. If using machine cut skins and hand made frames then frames can be carefully marked up by laying the frame face down on a flat table and clamping it flat to mark a rivet center line .38" back from the face of the frame, any suitable 3/8 spacer can be used to allow a mark to be drawn around the frame then rivet patterns can be carefully transferred onto the frame using the relevant rivet template or the machine cut skin itself. In my case after carefully aligning the flange to the skin template a mark was carefully scribed through the center of the rivet hole perpendicular to the line previously marked on the flange.

Setting up the 601 bulkhead refer to Nl 59 pg 22. The suggestion was to assemble the 601with 602 fittings and 522 main wing spar together and drill them. This is probably still required but if the 601 part is machine cut and all holes pre drilled then extra care will be needed to ensure that bends are placed accurately, and to the correct radius and that the wing spar is also made to tolerance. For assembly NL 20 page 84 suggested that there is not sufficient clearance between the fittings and the flange on the 601 bulkhead to permit riveting. Therefore the fittings be riveted to 601 after 601 has been riveted in place. If this riveting sequence is used install the 592 frame after the 601 fittings have been installed. This might make the Hi-Shears that are called up in the original plans impossible to install so just use bolts.

Fit all the pieces with clecos before you rivet anything. This will let you see where the crunch spots will be. Fit the NAS screw/ Hi-lok and extrusion last. The doubler rivets to the side skin do not need to be flush as they will be hidden by the wing. There is probably opportunity to beef up the structure and extend the doubler further forward. (If you are keen on a redesign challenge then moving the outboard doubler in side the skin could be an interesting one.)

Newsletter articles recommended that the 592 bulkhead have 2 holes cut (diameter??? to be confirmed) in it to allow for a socket wrench to pass through it to fit on the head of the main wing spar bolts. This change needs to be incorporated into the plans.

Holes in the flanges around the dash and firewall curved sections can be drilled once the skin template is mocked up on the aircraft. (Refinements to the CAD drawings would likely include these holes on the firewall at some later point. Until then it will be necessary to draw a line along the flange rivet centre line and then look through the pre drilled holes on the skin to make fore and aft adjustments when drilling the firewall / dash rivet holes.

A number of builders have opted to further reinforce the 601 - dash frame side skin area. This has been done with a doubler and an additional row of rivets forward of the 603 frame, Or a .040 angle aft of the 603 dash frame connecting from WL26 to WL42 and rivetd to the side skin and dash frame.

Side skins will be cut to final size with all rivet holes pilot drilled to 3/32 as per JT original plans., One small item of note is that the side skins do not finish flush with the longeron extrusions: the extrusion projects about .25" beyond the skin.
The side skins have been updated from the JT plans to include rivet holes for additional stiffeners in the tail area (avoids drumming), inspection access holes near the tail, static air source hole electrical wires into the wing. and additional dash doubler.

598-1 Aft cockpit frame

A number of builders recommend that the aft cockpit sloping frame should be reinforced top and bottom at the inside 45 degree flanges. These areas can cop a beating from baggage loading and unloading. Standard plans have no reinforcement. Also if a rear fuel tank is being considered then the top part of the frame will need further reinforcement.

Aft baggage compartment frame:

Consider thinnerman nuts for installing the rear baggage compartment cover, nut plates would also be another option. the cover is not included on the plans but recommended and having it removable for service is advisable.

575 and 576 Frames

During construction prior to the floor skin is being attached but with the tail wheel installed it is possible to reasonably easily damage and crack the 575 and 576 frames due mainly to workshop bumps and lateral loads being applied to move the fuselage around the workshop to avoid this it is worthwhile temporarily installing with Cleo's a partial floor skin at the rear of the aircraft so that any loads are distributed to to lower longerons not just the frames.
It is also worthwhile beefing up the 2 frames to provide greater service life. Methods of beefing up this area vary but essentially any additional material that distributes the landing stresses to the frame more generally should help, In this case we elected to widen the 4130 steel attachment on the 576 frame in order to transfer loads directly to the lower longeron and also to increase the width of the flange on the frame

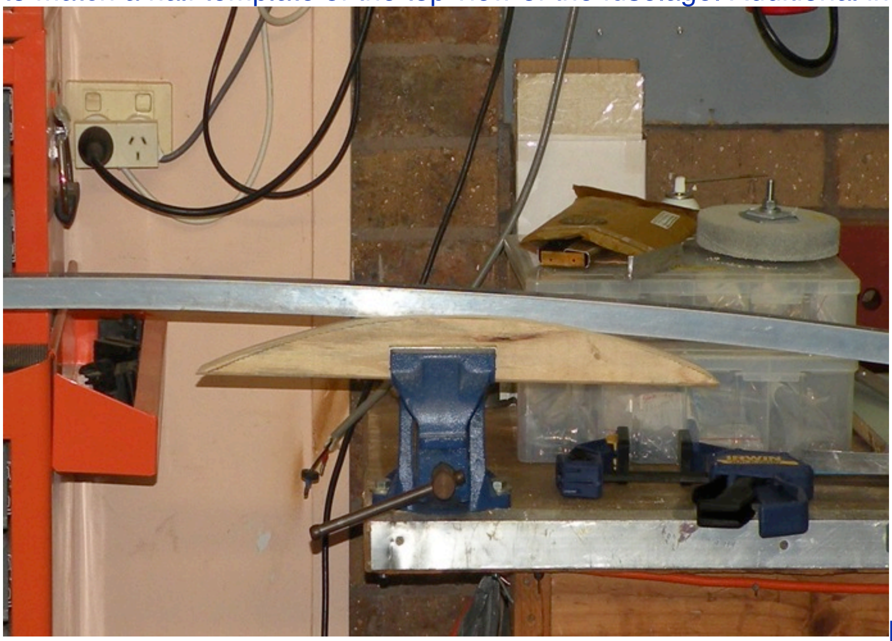
Mods and options notes

A number of builders make the forward floor removable.   Others choose to make a hinged dash.
A possible option that may appeal to taller pilots that could be included in modified version of the drawings would be to shift aft the rear cockpit bulkhead by approx 3/4". This could be achieved via the following changes to the vertical lower part and sloping upper part. The lower part was originally designed as a C beam type structure, which consisted of a sheet aluminum web and ¾" angle flanges. The open legs of the angles were facing forward in the original design. Keeping the rear

wing attachment fitting in the same place, move the sheet aluminum web aft to the rear side of the fitting. This moves the beam aft by .22 inches which is the sum of the thicknesses of the metal web and the rear wing attachment fitting. After doing this, reverse the direction of the upper angle, to make it face aft. This makes the lower part of the bulkhead a Z shaped beam instead of a C shaped beam, (same structural properties, the Z is actually more stable than the C, as the location of the shear center lines up with the web of the beam. All this allows the sloping bulkhead to shift ¾" aft to get a little more leg room.
Ultimately the skins will be machine cut to a high degree of precision. All that will be required is a light debur of the edges and rivet holes reamed to size on set up. The side skins will have inspection access panels below the horizontal stabiliser attachment to access the bay including the trim jackscrew and horizontal stabiliser mechanisms. From the Newsletter the recommendation for static air source on side of fuselage @ STA 149 and WL38 but (another suggestion was to move the static port 4-5" forward.) This would not be required if using the original fin mounted pitot air source which is considered accurate although with some potential for being damaged.
Top aft skin 524 will include a small flush inspection panel adjacent to the fin.

In order to save costs on side skin material and avoid the need to order long lengths, some builders opted to do the side skins in 2 parts with a joint just aft of the station 179.2 frame, they reported using a 2.5" doubler to join them. This seems not to be a popular choice but if this was desired there would also be an opportunity to change skin thickness from .032 down to .025 at the rear of the fuselage which might save a few pounds pound of weight. The thicker skins were added to increase aerobatic capability at increased weights but this comes at the cost of a few extra pounds.

The WL 42 longeron and others should be bent slightly close to the required shape first. Thorp's instructions had them rolled to shape or hand bent in a smooth jawed vice. The bend shape is made to match a half template of the top view of the fuselage. Additional instructions are in NL 46



pg 6 and NL ?? page 13.
The bends can basically be carefully and progressively done in a bench vice making a simple bending jig out of a couple of blocks of wood with a 12" radius slot cut in one. The radius of the block seems not to be critical, all that is required is two people to gently and progressively bend the angle over the block A simple approach is pictured. This block was cut with approximately 18" radius and the slot was made with a circular saw. One leg of the extrusion is placed in the slot then two people can apply pressure to the angle either side of the block, moving the angle longways in the slot allows the bend to be spread along the


angle with progressive gentle passes the bend can be made accurately.

The longerons can be carefully held to the side skin templates and markings for 3/32 pilot holes Thorp recommended that once bent the longeron rivet centre lines can be marked on the longeron. Once placed into the frames the marks are located through the skin then drilled holes made through the skin. They are drilled out to 1/8" size on the clecoed fuselage.
Some builders reported good results by riveting the WL42 longeron to the side skin first before it was bent then attaching the longeron and side skin to the frames and in effect bending it on set up first. This has the effect of stretching the skin which has potential to make flat spots between frames due to the tension. On balance it seems the longerons need to be bent closely to shape before attaching to the skin.

Joggling the 580-14 3/4 x 3/4 stiffeners NL 29 pg 182 described the process to put in a .093 joggle as follows. Create a 3/4" bar with a recess in it then clamp the angle in a vice between it and a 1/4" backing plate. Using a punch, direct hammer blows to the standing leg of the extrusion. (I am still looking for a good reliable way to do this.)

523 Lower skin

Add stiffeners to prevent drumming

Add an upside down "V" shaped stiffener running crossways on the floor of the of the under seat compartment. Some builders add light weight angle but it gets knocked around over time the V will stand up to the punishment better.

669 Deck

The 669 Deck needs flanges bend down at 45degrees, at the fwd end the small tab needs to be bent down to 90 degrees. Suggestion is to create a partial form block with matching curve. If a top and bottom form block are used then the material can be clamped between the 2 form blocks and the flange can be bent down with a mallet. The tab can be bent to 90 and short transition approx. .5 " to the 45 bend section can be incorporated.
Once the 669 is clecoed in place deck fittings can be positioned and clecoed in place. Some builders cut a large hole in the deck to access the baggage area this will need some planning to reinforce the area see News letters for suggestions. Also note that there is a need to extend the reinforcement detailed in the A-580-16 drawing through to the back of the cockpit frame this is not detailed in the standard T18 drawings.

524 Top aft skin

In NL 42 pg 318 It was reported that some builders had included a .025 angle running along the centreline from the canopy to the fin, it helped reduce vibration of the skin.

Once the upper and lower longerons are attached to the side skins, these parts can be mated with the frames. Cleco sufficiently to accurately support the frames. To aid in stabilizing the whole structure before drilling/reaming the holes to final dimension, the rear deck and floor skins can be clecoed in place. There were also suggestions of setting up and drilling the 45degree hip skins in place as well as these effectively lock the alignment in so that the fuselage is no longer flexible in torsion.

580-1 Hip skins

See NL 79 page 13, Avoiding oil cans. The steps are repeated briefly here although this process is likely to change once the CAD drawing for this part is finished

1. Make a rough pattern from heavy paper or card board or get pre marked parts(*Who was supplying the pre marked parts?? How did they pre mark them?*
2. Make a form block from a straight 2x8*8FT lumber and put a 52 degree edge on it using a table saw (45 +7 for springback) Cut a smooth radius on the form block flange
3. Bend the 45 degree flange on the 524 top skin and check fit to the fuselage
4. The hip skin is made from a rough template. Allow for the flanges to be 1" wide as it gives more latitude in bending the flange. Only bend the rear section from the tallest point back. Use a rubber hammer on the form block. Allow the 1" flange to stick out from the form block and work along the form block. The flange going forward needs a slight curve which is patterned from the bottom edge of the hip skin use another 2x8 but just cut the edge to 90 degrees so it can be used for both left and right sides. Bend the flange progressively noting the curvature from frame 572 forward. Mark the rough location of the holes from 572 forward Use crimping pliers and put small crimps in between the holes and watch the curve form comparing it to the fuselage. (O*r use a shrinker.*)
5. Test fit- if the flange is 45 degrees it should then lay flat from 572 aft. Correct if necessary then check that there is enough material above the top deck skin and adjust the top flange location for a nice even appearance from front to back
6. With hip skin in place drill holes from bulkhead 572 aft. Cleco as you go. If the skin is still flat on the top skin it's time to locate the top holes. Using a small thin ruler establish on the hip skin the hole pattern so that is falls correctly on the top skin flange, this is fairly easy as you can lift the top skin and get a reference point on the top skin.
7. Now the hip skin and the top skin flange can be drilled at the back and working forward, it must be nice and flat. Tto do this don't pull down in the top skin, just hold them together for a nice fit and drill and cleco. Work all the way forward to bulkhead 572. At this time the forward portion of the hip skin is still floating and is not drilled.. Work forward from 572 and drill the top holes as previously done on the rear, do 5 to 6 holes and then do 5 or 6 on the bottom edge (hipskin to side skin). By working forward this way the front skin should work out with no oil cans.
8. The holes from the bulkhead edges can now be located by laying out the hip skins by back drilling through the bulkheads.
9. Remove the hip skins and trim the extra material, deburr. Dimple if needed for flush rivets
10. Final check before riveting: push down on the hip skins at the bulkhead flanges. If it goes in then include a shim between the bulkhead flange and the skin to level the area out before riveting.
11. Rivet using the same sequence as was followed in the drilling of the holes 5-6 at a time

Alignment of fuselage, NL 28 pg 171 described it, essentially the tail and wing need to be aligned relative to the water line levels and in the fore aft direction. (Using CAD cut parts should in theory avoid the need for this step but it won't hurt to check)
Install the main spar and tail. Sight to check that they are aligned true to the fuse. Once the structure is checked for accurate alignment then all the frame pilot holes can be finished to 1/8" size drilling or reaming. Once all the holes are enlarged, disassemble the structure, dimple for flush rivets if desired, deburr, reassemble, recheck alignment and commence riveting.
Back riveting is recommended wherever possible.
For flush rivets the longerons will need to be countersunk

Clean up all edges to remove scratches with draw file and then sandpaper on a stick

580-2 Top Front Skin over the fuel tank area

Refer to NL 35 232- 234 & NL 48 pg 2-3
Fitting and aligning items between the firewall and dash frames:
Make a large transfer strip (template) that covers the entire flat area on the top of those 2 frames about 16 inches wide. Drill skin and template together then assemble frames and coordinate tank cradles (review NL 48 pg 2-3)
Note the position of the fuel gauge sender and mark its location on the template so that an access panel can be included to access the sender for maintenance.. Make a flush door to cover the fuel tank filler

Stretch form the skin over the fuel tank area after the rest of the fuselage is assembled using clecos. Either "shoe shine" the skin over the edge of a wooden work table compare if you will need an assistant to help but to get that last bit of curve to match the firewall and dash frames you need to wrap the skin around a cylindrical object of smaller curvature.

To form the flange for the windscreen which can fit on top (if going by the plans) or can be slipped under the skin if you are looking for a flush finish.
A bead roller can be used only to mark a crease matching the curve. Then bend the flange a little to set direction, then "massage" it up by alternately bending and stretching with VERY light tapping with a planishing hammer. Be gentle.

You do this "in place" after riveting the skin. Only way to form the skin - used a straight edge from the rollbar (spaced for Plexi thickness) to the crease to measure progress and avoid over forming!

IF the windscreen is placed under the skin flange you lose some impact resistance unless you back it with a formed "C" channel. install nut plates.

580-8 stiffener is an external 5/8*1/8" strip running outside the side skins around the cockpit area at the main W42 longeron level. The stiffener improves twist strength. Some builders extend this stiffener all the way forward to the firewall, this is done more for preference or cosmetic reasons plans are adequate and there is no need to do this.
576 Frame This frame takes substantial stress from the tail spring and has been known to crack some builders have strengthened this area. the landing gear

Baggage compartment floor

Various options exist see NL 46 pg 20 for one example
Some enclose the push pull tube and add a removable rear wall for the baggage compartment off bulkhead #571 suggest .016 or .020 sheet

604 Dash Frame and 508 Instrument Panel

Substantial bracing is desired for the dash in particular to prevent instruments moving in a crash and then hitting the fuel tank. The dash position is often determined by the instrument selection with additional depth required for some instruments to maintain tank clearance. Once the fore aft position is decided it will change the mounting detailed in the plans.

The glare shield above the dash
Including holes in the glare shield adjacent to the windscreen should be considered and helps serve 3 purposes, it will allow light to penetrate behind the dash to assist when servicing. It will allow for circulation of warm air upwards from behind the dash this provides cooling for the avionics and also for demisting of windscreen. The holes also provide a means to access the nuts securing the windscreen.

Seat Brackets

With the fuselage temporally assembled the seat brackets can also be test fitted and located relative to the side skins and longerons. Final assembly will require the brackets to be riveted to the side skins prior to the floor being fitted.

Windshield and Canopy install reference NL 46 pg 17

Position frame on work bench per drawing Windscreen install is done prior to the canopy. front deck needs to be flanged to accept the wind screen. Rivets or machine screws can be used to secure the canopy.

Fitting the horizontal tail

There is very limited space to fit the tail unless you enlarge the cut out section. It appears best to leave the trim jackscrew off until the tail is bolted in place to give more working room.

Corrosion and painting of the internal fuselage:

Probabaly best done before all skins are on and it is closed up. A primer sealer should be adequate for hidden areas, a finish top coat in exposed areas of the cockpit might be desirable if the surfaces are going to be left exposed. Ideally prime individual parts as you make them, priming sheet material while still flat prvides additional benefit by providing a writting surface.

Sound proofing

suggestion for the firewall and cabin area from early newsletters was to use 3M brand aluminum (or “aluminium”) sticky back tape also called damping or vibration tape

Overview of assembly

Working in a large flat area cleco the parts together in the following suggested sequence. There is flexibility in how you go about the initial assembly. What is probably more important is to avoid damaging any parts during the process.
Don't force parts together if it requires force then something is wrong and you are likely to do damage.

Lower longerons to the frames working from back forwards for about 6 frames.
W42 longerons to the frames.
Set the frames up on saw horses.
Aft top skin in place
Rear deck
Rear cockpit frame and rear spar bulkhead
Dash frame and 601 main spar bulkhead
Firewall with landing gear attach beams and doubler for cowl attachment, use the cowl attach strip to transfer rivet pattern to the firewall
Cleco the top skin in place along the centreline and leave the sides detached initially
Attach hip skins with Clecos
Cleco side skins to frames and bulkheads
Fit roll bar
Cleco sides of the top skin
Attach the .125 strip to the outside of the side skins
Carefully turn the fuselage on its side or back and attach the lower floor skin panels last. Connect the forward and aft sections of the floor skins in place with a bridge of material to keep them precisely aligned during subsequent drilling of rivet holes.

While the main air frame is still cleco'd together work on the cockpit area adding and test fitting the shear plates tunnels and seat components. Effectively everything above the floor skin that fits to the side can be pre fitted and aligned .needs to go in
Check alignment HOW???????

Attach the 575 stabilator hinges
Commence reaming of pilot holes out to final rivet size
Dissamble, dimple and debur. Many builders now use flush rivets although blind pop rivets were used in many cases.
Corrosion treat or prime mating surfaces
Reassemble per previous procedure.
Confirm alignment
Start riveting

Appendix 1.
Extracts from Sports Aviation June-July 1963 articles numbers nine and ten

PART IX **Building The T -18**

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BUILDING THE FUSELAGE

No part of 'the T·I8 more dramatically demonstrates the application of "matched hole" tooling techniques than does the fuselage.

It should be emphasized again that we layout each rivet pattern only once even though the pattern is normally used four or more times on the fuselage: once for each side and once for each mating surface. By duplicating the one layout three times we insure symmetry without the need for jigging of any sort and eliminate the possibility of rivet hole mis-match.

We calculated the length, in the flat, of each curved fuselage skin element between stations so that the frames come out at their prescribed stations and the skins assume smooth mathematical fore and aft curves for minimum drag.

The only investment in T·I8 fuselage tooling is for some scrap aluminum sheet for templates and for some :J I XX? inch plywood for form blocks for curved portions of frames. The main layout is done directly on one of the side skins. The second piece of side skin material is placed under the first and all holes are drilled and punched at one time. Your major piece of tooling then becomes a major part of your airplane; tooling that flies.

You can make fuselage skins first or make the frames first. In either case hole patterns are transferred one to the other. Because of the relative hazards to money invested in material due to mistakes, it is probably wiser though less dramatic to make the fuselage frames first.

MAKING THE FUSELAGE FRAMES

Flat layouts have not been made for all frames. However, by following the examples of those that are made, the builder can make his own frame flat layouts. By so doing on a "half" template which is used twice, a symmetrical frame is produced.

Starting at the tail post, Dwg. No. 576 gives both the flat layout on the right hand side of the center line and the formed detail shows on the left hand side.

Templates of the right hand side of both -1 and -2 parts are laid out from the dimensions given. By duplicating the templates twice on .032 2024 T-3 sheet the flat patterns for both parts are made.

The flanges are bent up as shown using a brake with a *3/32"* radius bar.

The joggles in the flanges are formed after the flanges are broken up by using a very easily made joggle fork in a smooth jaw vise.

For the .06 joggle use a piece of .09 aluminum cut as shown: (Insert diagram)

The ,025 joggle is made the same way. However, the joggle fork is made of .040 aluminum.

The No. 582 frame is also shown as a flat layout on the right hand side of the center line. A "flop" template is made from this layout and is used twice to produce the part blank.

A "pan" brake or "finger" brake with a *3/32* radius bar is needed to form this part. An old sheet metal hand will know how to "cheat" this part through a conventional four foot folding leaf brake and my parts all bear mute testimony to the abuse. However, since a form block of sorts will be needed to turn the inside flange anyway, it is probably better to make the block good enough to turn all outside flanges including joggles as well if a "finger" brake is not available.

Three-quarter inch plywood is good enough for a form block to make one part. Because of the high springback of .032 2024 T-3, it probably will be satisfactory to ignore flange angles and cut the form block to the inside mold line of the metal at 90 degrees, An approximate *3/32* radius should be cut on the block, however.

The flanges should be formed a little at a time with a rubber mallet so as to not stretch the flange and impair the accuracy of the rivet hole layout.

A complete back-up block can be made, or to save plywood, a 2 inch strip of plywood can be clamped against the section being formed to keep the flat portion of the frame flat.

The No. 584 and No. 591 fittings are installed to complete the frame.

Frame No. 574 is made like No. 575 except that the material is .025 2024 T-3 and no flat layout has been provided. Actually, frames No. 571 through No. 574 are all of .025 2024 T-3 and are almost identical in construction. They vary only in size and will nest so that No. 573 is made from the "drop-out" from the center of No. 571 and No. 5'74 is made from the "drop-out" from the center of No. 572. Four frames are made from two pieces of .025 2024 T-3 material.

Using Dwg. No. 574 as an example of what is required for the four frames No. 571 through No. 574, we will start with the layout of the half template on a piece of scrap aluminum sheet .032 or thicker. The side flange is bent around a *3/32* radius and is 11 degrees open (79 degrees bent up from flat). The bend allowance for 90 degrees is given by the equation B.A. = (.71t) + 1.57r). If t = .025 and r=.094, B.A = .1653" for a 90 degree bend. B

The template for part No. 574 may now be completed. The blank for this part is cut from the "drop-out" of part No. 572 and is developed by "flopping" the template.

The flanges are formed on the brake or over a form block.

The ~2 (??) fitting is installed to complete the part.

The No. 571, No. 572, and No. 573 frames are made similarly.

The No. 598 sloping frame must be laid out using techniques previously discussed. In addition, a form block of masonite or hard wood will probably be needed because of the 90 degree angle on the inner flange.

The No. 598 frame may be made in two pieces and spliced together as shown, but it is not thought that this option is of any real value since smaller parts are made from the drop-out of larger parts minimizing waste anyway.

Slight curvature exists in the sides of all the sloping frames since they are crossing curved element lines. This curvature may be approximated for the No. 598 frame by two straight lines as shown.

Bulkhead assembly No. 596 is made by laying out a half template and flopping. The bends are made on a brake having a 3/32 radius and the bend allowances are shown. No new techniques are involved in this part which builds easily. The No. 597 fittings are band sawed from 3/16 2024 T-4 plate or may be purchased completely machined from Precision Machine Works, Box 121, Santa Susana, Calif., at nominal cost.

The No. 592 bulkhead assembly is very similar to No. 596.

The No. 601 bulkhead assembly is also very simple.

The No. 602 fittings are band sawed from 3/4 x 2 2024 T-4 rectangular aluminum bar or may be purchased beautifully machined at nominal cost from Precision Machine Works.

The No. 603 dash frame is something different again.

Since it is in plain sight it was decided to round up the forward top portion of the fuselage instead of using corners and flat sheet. It also makes the blending of a simple wrapped windshield easier. As a result, the No. 603 frame cannot be laid out flat as the others have been made, but must be hand formed of .032 6061 T-4 material over a form block. A half template is made of the frame and this is transferred to % (??) inch hard wood or masonite by "flopping." Thickness allowance for the metal is made and a 3 degree or 4 degree spring back allowance should be used. The corners of the block should have 3/32 radii cut on them.

The frame is hand formed using techniques shown in Chapter III of July, 1962 *SPORT AVIATION.* Rivet holes are laid out and punched after forming .

The No. 604 firewall is of .018 galvanized iron or may be of .015 type 302 stainless steel. The formability of the two materials is the same. The stainless steel is lighter, but is much more expensive. You "take your choice and pay the difference" on this one.

A masonite or hard wood form block is in order for this part. A half template is laid out and the form block is made by "flopping" about the center line.

Like the dash, the top of the firewall is rounded off using an 80 percent second degree curve. Any curve derived from a conic is said to be a curve of second degree. An 80 percent second degree curve crosses the diagonal of its inscribed frame at 80 percent of the diagonal's length.

The graphical construction of a second degree curve is shown on Dwgs. 603 and 604 in phantom lines. By tracing the intersections of the various construction lines, the technique of drawing a second degree curve may be obtained. Rivet holes are laid out and punched after forming.

PART TEN Building The T -18

MAKING THE FUSELAGE SKINS

The two No. 593 fuselage skins are made from one sheet of .025 2024 T-3 Alclad 60 inch by 180 inch. We obtained our sheets this size from Reynolds, but suspect that both Kaiser and Alcoa can also furnish sheets this size.

The sheet is split down the middle and Dwg. No. 593 is duplicated full size upon it, using a sharp soft pencil to draw lines. The hole patterns for the frames are located by putting the frame half templates over the appropriate center lines referenced from W.L. 42 and by "duplicator" punching. The longitudinal spacings are stepped off with dividers as shown.

The template sheet is carefully trimmed with V4 (??1/4”??)inch edge distance all around.

The two half sheets are now put together with the mill marks inside and all holes are drilled or punched through both sheets at one time.

Care must be taken in this operation to keep the sheets flat and the tool vertical to minimize transfer errors.

The trim lines for the second skin are made from the first while the two sheets are together.

While punching, drilling and scribing, it is good practice to use dowel pins or tight fitting rivets in holes spaced about the sheets to prevent shifting. Clecoes can hold sheets together, but are not precise enough to serve as dowel pins to prevent shifting.

The two side skins may now be clecoed to the frames to minimize handling damage. The assembly should be set on saw horses to provide a good working height for additional assembly.

The No. 523-1 bottom skin is best laid out for one side as a "flop" template using the frame flop templates to locate holes for frame attachments. If you do not have a piece of "expendable" material for the "flop template" or are too Scotch to use good material for this purpose, good results can be had by carefully constructing lines perpendicular to the center line for the rivet rows, by drilling the hole on the center line and using dowel (or rivet) in this hole to locate the frame "flop template" on the appropriate center line.

In layout work it is good practice to construct perpendiculars to a straight reference line anyway as sheet edges cannot be relied upon to always be straight enough for squaring.

In either ease the 523-1 sheet is .025 2024 T-3 Alclad. The longitudinal holes locations are stepped off with dividers.

When punched, drilled, trimmed, and de-burred, the 523-1 sheet may be clecoed in place on the fuselage, lining it up.

The 523-2 floor is made similarly of .040 2024 T·3 Alclad sheet.

The No. 524 aft top skin should first be laid out as a "flop template" but as with the No. 523 lower skin, can be made directly on .025 2024 T-3 Alclad sheet. The only "new" feature of this part is the 45 degree flanging operation. The flange should be started with a "beading roll" having a 3/32 radius and by finishing progressively with sheet metal tongs.

The whole flanging operation can be done with a rubber mallet over a curved piece of metal, masonite, or hard wood, having a 3/32 radius.

In both operations the radius is set first along the mold line and the remaining forming is done progressively. The curve inside view is obtained through shrinking the flange as it is slowly bent down.

The No. 524 aft top skin is now clecoed in place on the aft frames.

The No. 580-1 skins are now made by mock-up to fill in the gap of the rear top quarters. This is best done by making a heavy paper template or a scrap metal template and by refining until desired conditions are met. If all other parts are duplicates or of "flip-flop" layout only one template will be needed to make the two No. 580-1 skins. These skins are actually right or left hand depending upon how the lower 45 degree flanges are bent. The material is .025 2024 T-3 Alclad.

The 580-2 top front skin is also made by mock-up.

While the top line in side view is straight, the side lines in top view are curved. The cross-section is curved so that the part has double curvature and theoretically cannot be skinned with a flat piece of metal. Actually it is skinned with a piece of metal which is flat before it is installed, but is warped to fit on installation. In order to warp the material into place the side skins will need to be backed up by longerons which are made next.

MAKING THE LONGERONS

The 580-3 upper longerons and the 580-4 lower longerons are made from % by % (??) by 1/16 2024 T-4 extruded angle. The 580-5 longerons are 1 by 1 by 3/32 2024 T-4 extruded angles.

The curvature of the longerons can best be rolled to a half template of the top view of the fuselage. If no roll is available the angles can be bent by hand, holding them in a smooth or soft jaw vise. They should closely fit the fuselage curvature so as to not introduce strains in the fuselage skin.

The rivet fore and aft center lines are lightly scribed on the longerons before placing them in the fuselage. Holes are drilled on assembly by picking up the scribe lines under the center of the rivet holes in the skin. It is best to duplicator punch and then drill with a sheet metal grind drill, but with care holes can be drilled directly with a conventional drill. You should start at center and work out both ways.

MAKING THE *580-2* TOP FRONT SKIN

With the fuselage completely assembled by clecoeing, the 580-2 top front skin is fitted by mock-up.

A piece of .025 2024 T-3 Alclad long enough to extend from station 38 to station 84 and wide enough to lay on the firewall and dash from longeron to longeron is clecoed to the firewall and dash by back drilling the skin from holes in these parts.

The center of the sheet from station 63 + (??) to station 83.5 is cut out leaving enough material to later form the windshield attaching flange.

The sheet is wrapped tightly around the firewall and dash on both sides, drilling and clecoeing as you go. Care must be taken to keep the firewall and dash flat during this operation and it is probably well to support the upper portions with plywood or the equivalent clamped to them.

The top sheet laps over the side skin on the longerons. The rivet holes are back drilled and the sheet is clecoed in place completely.

A hollow will have appeared in each side midway between the firewall and dash as the skin approaches the longeron.

The skin must be stretched in this area. This can best be done on a plannishing hammer, but can be worked out by "bean bagging" or stretching.

A "bean bag" is 5 or 6 pounds of lead shot in a circular leather bag that will fit in the palm of the hand. The metal is stretched by slapping from the inside. A second makeshift means of stretching the sheet is to put a crown on the end of a 2 to 3 inch diameter steel bar. Carefully polish with emery and crocus cloth. Oil the bar and iron out the can with fore and aft motions, pressing the bar hard enough against the skin to produce local stretching. This might be called "free hand crowning."

In any case the skin will almost wrap so the stretching will not need to be extensive.

The ends from station 65 to 84 are now pulled down smoothly against the longerons, are back drilled from the longerons starting at the dash and working back and are clecoed in place.

The skin may now be removed and trimmed, leaving adequate material for the windshield attachment which will later be developed by mock-up with the windshield.

The No. 525 windshield frame is the overturn protection structure for the T-18. We can hope that it will never be needed, however, it would be unrealistic not to provide it. It would be equally unrealistic not to make the structure adequate for noseover loads. The problem is that we don't know "how hard is a crash."

In this case we will hide behind the current FAA regulations which in CAM 3.386 (c) stipulates a vertical ultimate acceleration of 3g with a friction coefficient of .50 acting at the ground.

For better or worse, this is the reason for the oversize windshield frame of heavy wall 4130 steel tubing.
1 *1/4* inch by .120 4130 steel tubing isn't easy to bend. (It wouldn't be any protection if it was). For the T·18 windshield frame it is best to make an inside template of the frame and entrust the job to a commercial tube bender. If none is within reach the job can be done by "main strength and awkwardness" by applying techniques outlined by Bob Whittier in his excellent article on tube bending in April, 1963 *SPORT AVIATION.*

The windshield frame assembly is welded together as is shown on Dwg. 525. It can be heat treated to 150,000 pounds per square inch for maximum toughness.

Since it is in a conspicuous location the frame assembly can be chrome plated, but if so should be baked immediately to prevent hydrogen embrittlement. It is probably better to sand or vapor blast it clean and paint it flat black.

The mock-up which has been clecoed together is now disassembled for de-burring, chip chasing, etc. If it is to be flush riveted, the longerons and heavy parts are machine countersunk and all sheet metal parts arc dimpled.

All faying surfaces are chromated and the structure is reassembled with clecoes.

Riveting is accomplished by whichever technique as has previously been chosen.

The windshield glass cannot be permanently installed until the elevator push-pull tube has been placed in the fuselage.

You are now well on your way to having a T-18. •

Appendix 2 acknowledgment to Matt Smith for posting on the T18 Forum

T-18 Hi-Lok Usage

Background: some of us had questions about the quantities and use of Hi-Loks on the T-18. For someone living near an aircraft surplus store (such as currently or formerly existed near major aircraft manufacturers) it was easy and cheap to obtain plenty of surplus Hi-Loks, especially in the 1960's. The race car fabricators in southern California used to be big customers of the aircraft fastener bins. Since then, a lot of aircraft manufacturing has gone away, or the lawyers have caused the aircraft companies to close their surplus stores. John Thorp didn't call out a lot of Hi-Loks in his T-18 plans, but he did call our some, and they are getting harder to obtain, especially in small quantities. Most T-18 builders have substituted AN bolts in lieu of the Hi-Loks, but some purists like to stick to the plans as closely as possible.

Note: Translating the Hi-Lok numbers. The first numbers are the type of Hi-Lok, the first dash number is the diameter in 1/32 of an inch, the second dash number is the length in 1/16 increments (no, no one ever standardized fastener call-out units). See Page 4 of http://www.hi-shear.com/brochures/Hi-Lok_Hitigue_Installation.PDF for a more complete description. Observe that Hi-shear Corp refers to their fasteners as "pins".

Most of the Hi-Loks called out in the drawings are used at the wing-attach fittings. It turns out that the Hi-Lok callouts on the inner-wing attach fittings are divided between the 537 and the 532 drawings.

From DWG 537 you need (4) 178-6-10 and (12) 178-6-14 Hi-Loks for the wing attach fitting inboard of the end rib. Then you go to DWG 532 and you need (4) 178-6-11 and (4) 178-6-15 Hi-Loks for the row of fasteners where the end rib attaches. The extra 1/32" is to accommodate the thickness of the rib.

Purchase quantities for the Center wing:
177-6-9 (8)
178-6-10 (4)
178-6-11 (4)
178-6-14 (12)
5-1-15 (4)
and (32) 179-6 collars

The numbers above include (4) 177-6-9 Hi-Loks for attaching the two 522 fittings to the inner main spar, and (4) 177-6-9 fasteners for attaching the walking beam fittings to the main spar.

Purchase quantities for the Outer wing:
178-6-8 (24)
and (24) 179-6 collars

Also note DWG 601 to attach the 602 fittings to the bulkhead assembly:
177-6-5 (2) and 179-6 collars

The discussion about the short Hi-Loks came about simply because of ones that we had on hand and not wanting to have to order 85 more just to obtain the 4 that were needed:

To answer the question about being too short: The top of a Hi-Lok collar is slightly out-of-round and it deforms to become round on the threads; this is how it provides the locking feature. Since the locking part is at the top of the collar, we cannot safely use the -10 and -14 Hi-Loks on the 532 DWG. (I tried it.) That extra 1/16" of length is where we engage the locking part of the collar. However, we could use the -10 and -14 Hi-Loks IF we use a 1032A nylok nut to retain the Hi-Lok. The 1032A nut is short enough for the nylon locking part to be fully engaged. And we can get away with this since the fasteners are loaded in shear and the nut/collar is being used just to keep the Hi-Lok from falling out (from a stress analysis point of view). NOTE: Since this is a shear-rated fastener, do not torque down the nylok nut or you start loading up the Hi-Lok as if it were a tension fastener. Tighten the nut just until it touches the fitting, tighten 1/12 of a turn more and then stop.

Using too long of a Hilock means that the locking collar will bottom out on the threads before the bottom of the collar hits the fitting. A longer Hi-Lok can be used, but only if an appropriate thickness of washer is used to adjust for the longer pin (I wouldn't recommend doing this). Note that this still assumes that the Hi-Lok is in a shear-only application, so the collar is used simply to keep the fastener in snug, but not in any tension loading.

The best solution is to order the proper length fastener. The above suggestions for using a too-short or too-long Hi-Lok are not exactly kosher for certified aircraft. We can get away with them as homebuilders, but only if you (or your tech advisor) know what you are doing and can safely make the fastener substitution. Otherwise, substitute equivalent sized AN bolts or obtain the Hi-Loks and build it per the plans.

This information is for reference purposes only. Anyone who wants to make use of the above information does it at their own risk and should consult their own technical advisor or kit supplier before making any fastener substitutions.

Here is a lot of useful info from Hi Shear Corp: http://www.hi-shear.com/fastenermain.htm