TRUE GAPLESS CONTROL SURFACES

We found the following quotation in the Minutes of the second meeting of TWITT (the Wing Is The Thing), published in TWITT's Newsletter #2, July, 1986:

"Harald Buettner then demonstrated a mechanism, which he had designed and mocked-up, which he proposed as a replacement for conventional trailing edge control surfaces. The demonstrator was a short section of a fiber-reinforced-plastic wing in which the upper and lower skins were not bonded at the trailing edge. This left them free to flex and to slide against each other from the rear spar to the trailing edge, producing a smooth change in camber over that region. A torque tube anchored to the rear spar drives a belt bonded at its ends to the upper and lower skins to flex them under the pilot's control."

No doubt about it, our interest was piqued! Our letter to Harald Buettner requesting permission to share his idea with the modeling world received a quick and positive response, and we decided to build our own mock-up to determine if the system could be used with small chord, minimum thickness wings. The result of our exercise, although crude, demonstrated that such a system could be easily installed in a five inch chord Eppler 214 wing section! Control surface movement is not only effectively achieved, but the process is both beautiful and fascinating to watch.

Our method of constructing Harald's control system adds several steps and additional parts to the building of a foam core wing: the skins must be premolded to the shape of the airfoil surface as they are not supported by the foam core; the torque tube and sufficient bearings must be installed, finally, the premolded skins must be attached to the foam core, a two stage procedure. We would be most grateful for any suggestions readers may have in the way of streamlining the construction process.

After considerable thought we have come to the conclusion that the system probably cannot be retrofitted into an existing wing. The system relies upon a flexible skin of glass fiber and epoxy only; it will not work with a balsa substrate, Rohacell sandwich, etc. Aside from that, constructing a whole new wing would probably be easier than working out a retrofit.

The major considerations to be taken into account during construction are:

(1) the control surface, when completed, will not be supported by the foam core,

(2) the "belts" connecting the flexible surfaces to the torque tube must cross so that the lower rim of the torque tube is tied to the upper surface and the upper rim is tied to the lower surface, and the belts must come off the torque tube at a 90^{o} angle,

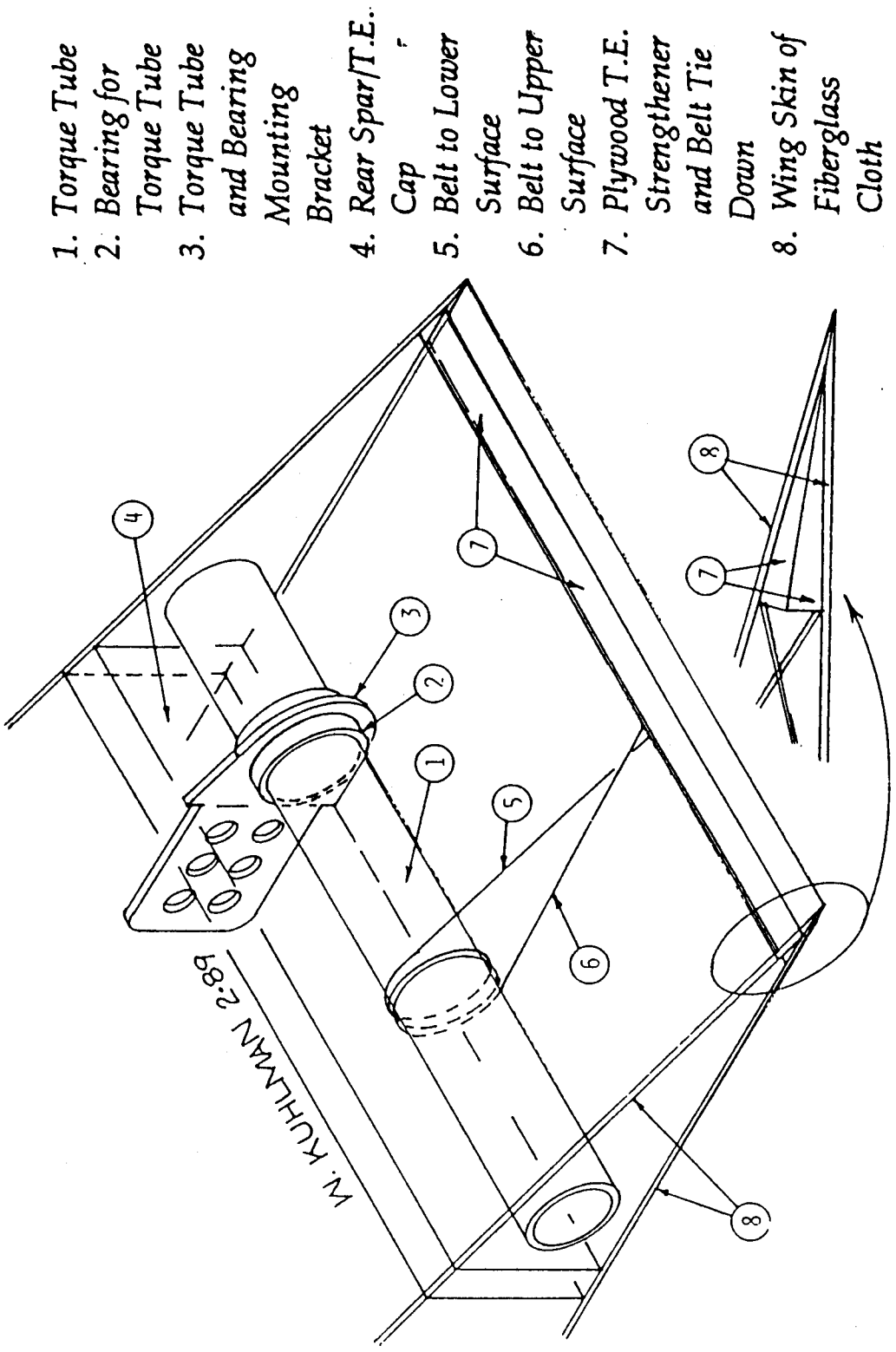
(3) flexibility, and hence control surface movement and freedom from distortion, is dependent on the weight of glass cloth used and the rigidity of the trailing edge,

(4) the trailing edge will be only as sharp as the combined thicknesses of the finished skins, and

(5) insufficient care during construction will of course result in an airfoil and control surface which do not perform well, if at all.

We highly recommend that you construct a working mock-up prior to attempting to incorporate the system in a flying model. Some of the construction is tricky (as we found out), and it's better have negative experiences on a small scale.

Experimentation, particularly with the weight of glass cloth used, will undoubtedly be necessary. As a starting point, we used a single layer of two ounce cloth for our five inch chord mock-up. Additionally, you'll have your own favorite way of connecting servo to torque tube. With some experience it is possible to design the system to incorporate tapered and swept control surfaces, along with variation of movement across the span.


1. Torque Tube
2. Bearing for Torque Tube
3. Torque Tube and Bearing Mounting Bracket
4. Rear Spar/T.E. Cap
5. Belt to Lower Surface
6. Belt to Upper Surface
7. Plywood T.E. Strengthener and Belt Tie Down
8. Wing Skin of Fiberglass Cloth
W. KUHLMAN 2.89

Here's the step by step procedure:

(1) Cut the foam core to be used. We used pink extruded foam for its resistence to denting, increased strength, and ease of cutting by the hot wire method. The resulting core should be of full chord and allow for the thickness of the fiberglass skins which will be applied.

(2) Cut upper and lower foam beds, making sure that they are large enough to support the trailing edge along the entire span. Take as much care making these beds as you did for the wing itself; they can be used again for another wing.

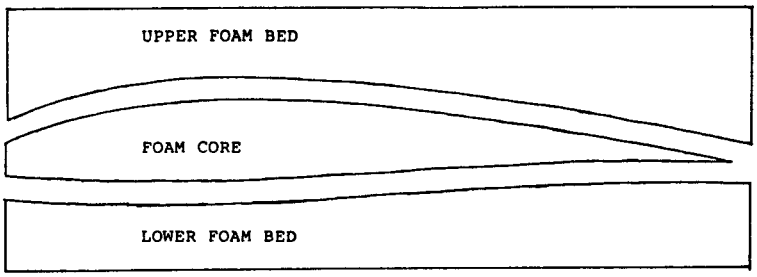


FIGURE 1

(3) Lay fiberglass cloth which has been cut to size on a sheet of mylar. Squeegee epoxy into the 'glass just as you would if creating a fiberglass skin. Use more than one layer if that is your practice.

When completed, place another layer of mylar over the 'glass and epoxy, making a sandwich.

With the wing's upper surface resting on its foam bed, place this sandwich of mylar and epoxied 'glass on the lower surface of the wing in its correct position. Now add the lower bed.

Apply weight or start up your vacuum bag.

NOTE: Since the trailing edge is so critical to excellent performance, we recommend that you do <u>not</u> attempt to 'glass the upper surface of the wing simultaneously with the lower. To do so risks deformation of the airfoil at the trailing edge due to multiple layers of mylar between the two surfaces.

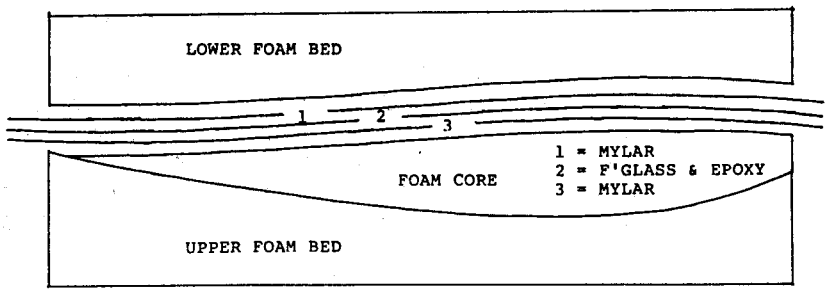


FIGURE 2

(4) After curing, remove the molded lower skin and repeat step 3 for the wing's upper skin.

(5) You now have a foam core, complete with beds, and two molded fiberglass sheets that match the contour of the airfoil over the entire chord and span.

Mark a first line on the foam core where the control surface would normally be hinged using a conventional method. Now draw another line forward of the one already drawn; the distance between them should be one half of the thickness of the airfoil as measured at the first line plus the thickness of the cap used to seal the trailing edge of the foam core. This is important, as there is very little flexing just aft of the supporting foam, and you're looking to place the center of the torque tube at the location of the conventional hinge line.

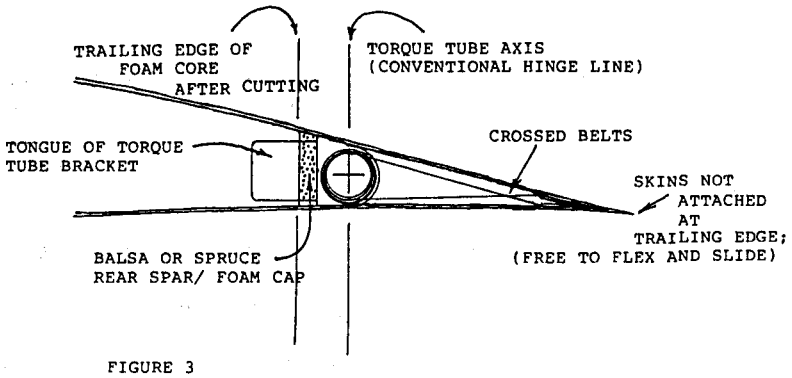


FIGURE 3

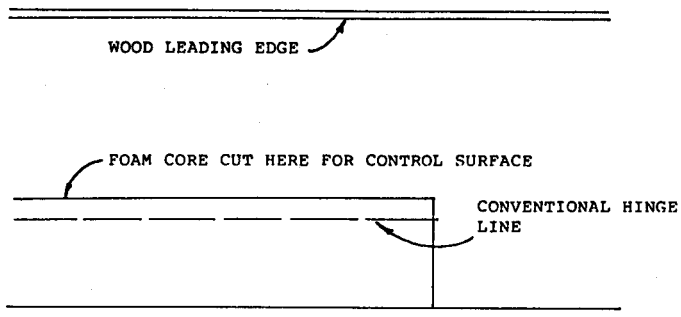


FIGURE 4

Using a straightedge, and cutting on the forward line, remove the trailing edge of the foam core where you wish the control surface to be.

(6) Install the rear spar/trailing edge seal to the foam core, followed by the torque tube and its bearings. The torque tube should be as large as possible while allowing clearance for the "belts" and the flexing skins. To assure a nonbinding mechanism, install the plywood bearings with the torque tube in place; don't forget to attach a control horn to the tube beforehand.

We found that the bearings could be cut using a short piece of sharpened tubing as a drill.

Be careful not to glue the tube to the bearings during assembly!

(7) Bond the "belts" to the torque tube with epoxy. We roughened the tube and applied a very small amount of 5 minute epoxy to carpet thread cut to lengths much longer than needed. Make sure that all of the threads are glued along a straight line on the tube's surface. After the epoxy has cured, rotate the tube until all of the epoxied points are facing the foam core's trailing edge. Temporarily lock the tube in this position.

(8) This part, and #9 that follows, takes some skill, practice, and slow cure (1 hour) epoxy! Take each end of each thread and wrap around the torque tube a full turn. The objective here is to allow the tube to make at least a half turn without placing stress

on the point at which the thread is epoxied to the tube.

Spread a thin layer of epoxy resin over that portion of the lower skin which will contact the foam core and place the skin epoxy side up on its bed. Place the foam core on its skin in the correct position. Watch the threads!

Place a thin bead of epoxy at the trailing edge of the skin and have a narrow length of sanded 1/64th inch plywood ready to bond to the skin. The plywood strip will act as both a trailing edge strengthener and as an attachment for the threads coming off the top of the torque tube. The strip should be wide enough that the flexed upper skin will not catch on it when flexed to extreme positions, yet narrow enough that the threads are attached as close to the trailing edge as possible.

NOTE: It is extremely important to sand the plywood strips to a triangle like cross section so that the trailing edge of the wing is sharp and the skins will slide against each other without binding or catching. It is also beneficial to have grooves cut into these strips which will accomodate the threads. If this is not done there will be bumps at each thread which will prevent the two skins from coming completely together.

Now pull all of the threads coming off the UPPER part of the tube across the trailing edge of the wing while keeping the threads which are coming from the lower part of the tube out of the epoxy and out of the way. Check to make sure that the threads still make a full revolution around the tube before comig off at a tangent. Lay the plywood trailing edge piece directly over the threads, trapping them. Move the threads into the precut grooves. With the torque tube still locked, pull the threads uniformly tight without distorting the skin.

Place a narrow strip of mylar over the plywood piece, then put a layer of mylar over the entire upper part of the wing, followed by the upper bed. Using weight or a vacuum bag, bond the lower skin to the foam core. Make sure that all of the threads are pulled

uniformly tight during this process. The thin strip of mylar in contact with the plywood at the trailing edge should assure that there is sufficient pressure to bond plywood, threads and 'glass.

(9) Remove this assembly from the foam beds once it has cured.

Spread epoxy over the upper skin where it will attach to the foam core and place it in the upper bed. Place the nearly completed wing on the skin, positioned correctly. Temporarily weight the wing so that it will not move. Unlock the torque tube and lift the lower skin trailing edge, exposing the upper skin trailing edge. Block the skins apart so that you have access to the interior of the eventual control surface. Pull out the thread ends - these should be from the LOWER edge of the torque tube and should still complete one revolution around the tube.

Spread a thin layer of epoxy over the trailing edge of the lower surface for the bonding of the sanded and grooved plywood trailing edge strengthener. Straighten the threads, make sure they still make a full revolution around the tube before coming off at a tangent, and lay down the plywood. Move the threads into their grooves.

Remove the blocks and insert a strip of mylar between the surfaces to prevent their becoming bonded to each other. Lock the torque tube in position once more and then pull the threads uniformly tight. Place a piece of mylar over the wing.

Place the lower bed on the wing and weight or apply vacuum bag making sure that the threads are still pulled uniformly tight.

(10) When cured, remove the completed wing from the beds and remove the inserted sheet of mylar from between the two surfaces. With a razor saw, cut the control surface free.

(11) Unlock the torque tube, and... VOILA! All that's needed now is an appropriate leading edge.

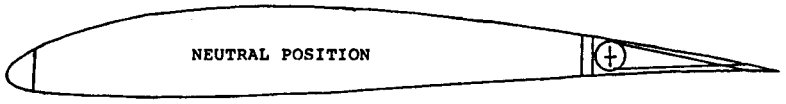


FIGURE 5A

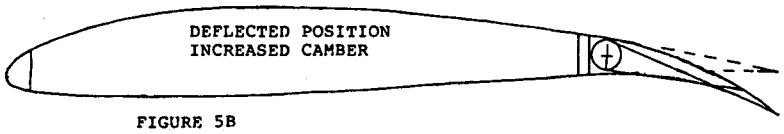


FIGURE 5B

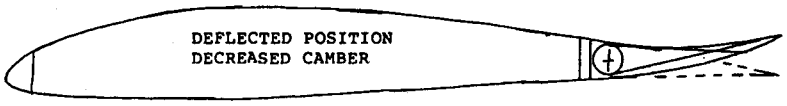


FIGURE 5C

If you're like us, you probably won't get around to putting on the leading edge right away - the control surfaces can now be flexed by rotating the torque tube and you'll be fascinated for hours on end.

As mentioned above, there are probably some improvements that can be made to the basic system. On a tapered wing, for example, the torque tube's diameter can be changed along the length of the aileron; this would provide more or less control movement at various locations along the span of the aileron.

One item that sort of "bugged" us was the open ends of the control surface. Try making a plug out of latex foam which is the same size as the open end. Held in place with a very thin coating of bathtub sealer, this sort of plug should retain a large amount of flexibility.

Many thanks are due to Harald Buettner, not only for developing this control system, but for allowing us to share it with our fellow model builders. Harald can be reached at PRECOMTEC.

TWITT's Newsletter, always filled with goodies, is available by subscription; contact TWITT (The Wing Is The Thing).

A big "thank you" is also due Jim Gray, RCSD's editor at the time of this article's publication, who, upon receiving our mock-up in the mail, immediately called us and expressed his enthusiasm and eagerness to print this information.