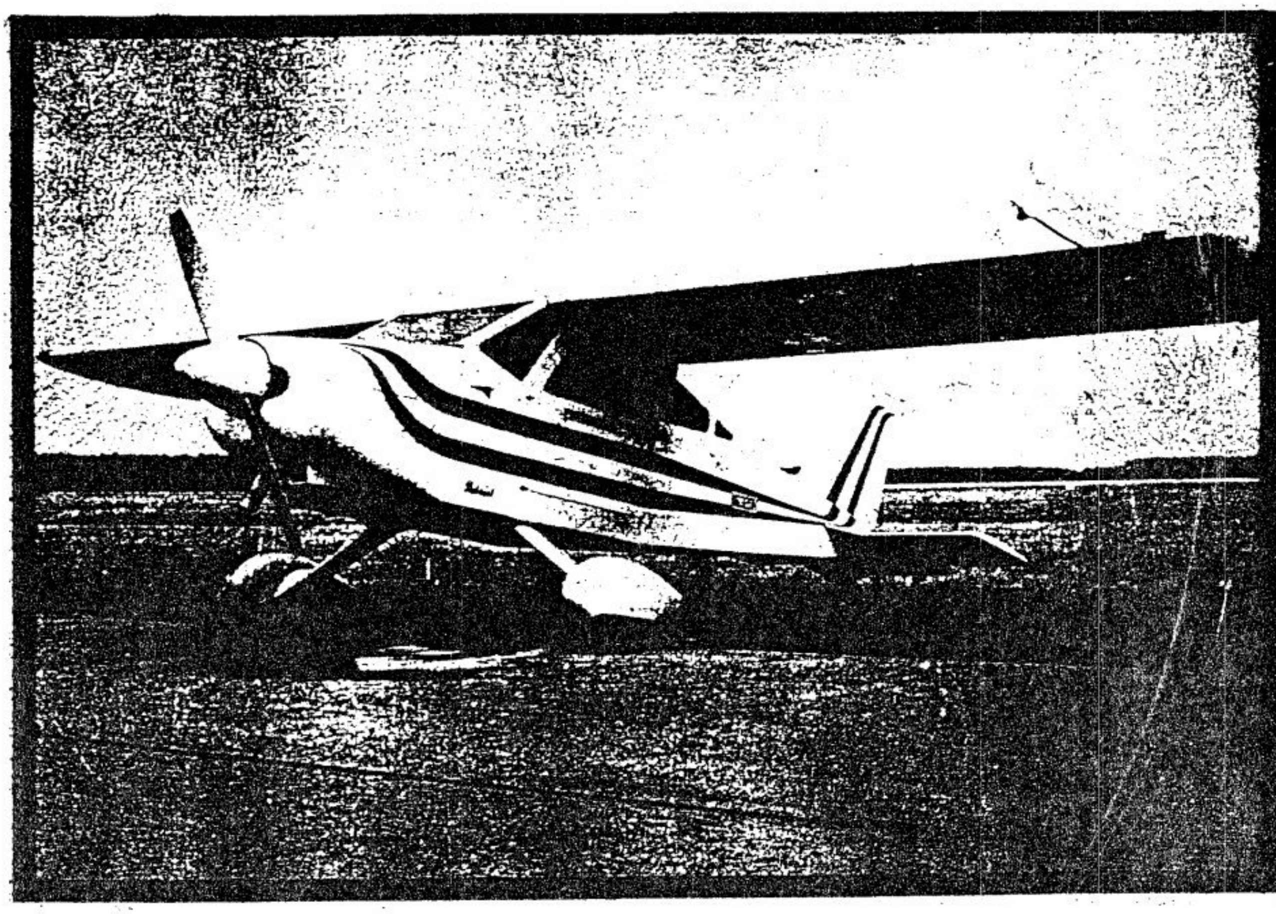
Refinement and Modification of the
VIRGINIAN PATRIOT — BD 4



SKETCHBOOK AND NOTES by Don Hewes

(intentionally left blank)

Dear Fellow BD-4 Builders and Friends,

This sketchbook about my BD-4 airplane, The Virginian Patriot, came into being primarily because of two factors: (1) my great fondness for this fine little airplane, and (2) a desire to pass along some of the things I have done in trying to improve it, and to overcome some of its relatively minor shortcomings.

As most of you are aware, no airplane design is ever “complete” when it comes off the drafting boards. Every fine airplane such as the DC-3, the Skyhawk, or the 737, is the product of fertile and imaginative minds, sound basic engineering, high quality production workmanship, far reaching experimental testing and <u>continuing development based on operational experience</u>. And so it should be with the BD-4.

Hopefully, with the establishment of the BD Four Sales Inc., some continuity in the contributions to this continuing development by Jim Bede, the BD-4 designer, will be provided. Certainly there are several others who have made and are continuing to make significant contributions. Among these are Janice and Lloyd Brekke, Hugo Schneider, Val Bernhardt, Earl Schmitz, Jack Murphy and several others I have yet to meet. Jim Bede's new book “Build Your Own Airplane” is a welcome and long over due addition which should be a great help to all the builders. It is a very much expanded and refined version of the original construction manual which was quite helpful but was lacking in many important details. This new book deals primarily with the original design and those modifications that were incorporated several years ago. It does not, however, address a few critical problems that many of us, both builders and pilots, have encountered, and have had to solve by ourselves. This is not a “put-down” on the book (I think that it is a fine book and a significant contribution to the homebuilding movement), but merely a recognition that there is more to be done.

Newsletters have been and continue to be the mainstay in providing information on design refinements, developmental testing, and operational problems. The original BD Newsletters were indispensable to me in constructing N 632 DH, as well as being a very interesting source of news on all the happenings in the BD world. It is hoped that the new publication under the BD-4 Sales banner will be able to match its quality and effectiveness. Those of you fortunate enough to know Hugo Schneider, or to have received a copy of his newsletters (no charge, but contributions accepted) know that he is to be very highly commended for his unselfish efforts. Also, Earl Schmitz, who operate B&D Products, is likewise to be commended for passing along the word in his BD-4 Builders Section that appears in the Aviation Journal published in California.

The Sketchbook is my contribution to this important phase in the refinement of the BD-4. In addition to a number of unique features that add to the comfort, convenience or appearance of the airplane, this book discusses several problems that I have encountered in building and operating my tail dragger version. Some of the problems are unique to this configuration although many apply to either version. The solutions to these problems for the most part, are those that I have worked out, based on my approach to the problem, and on the tools and materials I had at hand. As we all know, there are usually several solutions to any given problem; consequently, I do expect that some readers of this book will consider that some other approach is better. For those who would do it another way, I do hope that this book will be helpful, at least, in identifying the problems.

There are 39 pages of sketches which I hope will convey the information needed by the reader to understand the details of 55 modifications and refinements (* Footnote 1) I have found to be satisfactory in my airplane. The sketches were not intended to serve as actual construction drawings. The dimensions are shown to indicate the general size and location of the parts. For any builder desiring to make similar modifications or refinements, he should take measurements directly from his airplane on which to base the specific design of the parts for his installation. In general, dimensions and materials are critical only from the standpoint of proper fit or workability and not strength; however, the builder must make that determination for himself.

Please feel free to write me concerning any difficulties you may have in interpreting the sketches. (A self-addressed stamped envelope would be appreciated) I hope you will find this book helpful and worthwhile.

Sincerely,

Don Hewes
EAA 32101
12 Meadow Drive,
Newport News, Virginia 23606

May 1, 1978

Editors Note: Don passed away in August 1985 at age 60 of a coronary attack. Permission to copy his sketchbook was graciously granted by his estate. Don has left us with a wonderful addition to the BD-4 literature. The sketchbook is a great benefit to all BD-4 builders. 12/2008 BW

*Footnote 1 - I have shown a couple of items slightly different from the actual installation details because I consider thee to be improvements.

Refinements and Modifications of the Virginian Patriot

Before proceeding with the sketches and notes, I would like to comment on the engine compartment because it is the part of the BD-4 for which there is the least amount of detail design. This lack of detail I not considered a reflection on the quality of the design because the finishing details of the engine compartment are strongly dependent on the make and size of the engine and associated equipment to be installed. There are just too many variables in this area of a homebuilt airplane for the designer to proceed past only the very basic details.

Remember the engine is the “heart” of the airplane and is vital to the health and happiness of yourself, your family, your passengers and your insurance company. The fact is that current statistics on homebuilt aircraft reveal that failure of the engine or its related systems is one of the primary causes of accidents and fatalities in this category of aircraft. Consequently, each homebuilder should be extremely careful when putting together the engine compartment.

My recommendation for first-time builders is, first, to select a new aircraft engine (if at all possible); otherwise, get one which has a known history, or has been worked on by an expert. Don't try to develop your own engine unless you yourself are a power plant expert. (If you are, I'm sure you would use another tried and trusted airplane to perform flight tests before installing it in an experimental frame. Second, go out to the airport and look at as many open cowls as possible and talk to the mechanics as well as to other homebuilders. Take a lot of photographs and make sketches to aid in planning the installation. Consider all the equipment you want to put there before you start any installation. Very carefully work out how you are going to gain access to each item for inspection and replacement.

I purposely selected a brand new Lycoming O-320 with a fixed pitch propeller because I had no first-hand experience with any aircraft engine or its installation. I was a first-time builder myself. I selected the 150 HP engine because it more closely fitted my pocketbook than the other higher powered version, and I felt that the performance would be adequate to meet my needs. After nearly 400 hours of flight in over three years, I feel that this was a good choice even in the face of the 100 LL-octane fuel situation. (I have had only minor lead fouling problems) All of my comments and sketches pertain directly to the installation of this engine.

I have a primary concern for accessibility to the engine compartment. I consider this to be a fundamental key to flight safety because I believe that an engine that is easy to get to is one that will get its required amount of inspection and maintenance. As you will see later, I apply this principle to the rest of the airplane as well. Parts of an airplane that are inaccessible are very likely to be the sources of future failures.

The only system problem with the engine compartment was with cooling. Initially, cylinder head temperatures were somewhat high, and I attempted to open the nose inlet area. This not only had no effect on cooling but it seriously weakened the structural stiffness of the cowl and I had the problem of repairing a portion of it which was chewed up by the propeller. In a subsequent chance meeting with Jim Bede, he confirmed my suspicions that the problem was that of exit area rather than inlet area, Consequently, I added four of the “Chevron” type outlets to each side of the cowl much in the same way as other builders have done. This cured the problem and appears to have eliminated the need for using the cowl flap which stays in the nearly closed position.

LIST OF MODIFICATION AND REFINMENT SKETCHES

Figure 1 Cowl Shape Modification

The one and only SNAFU with parts and materials in my kit was the fiberglass nose bowl which, although very well fabricated, was made with the wrong contours. As indicated in Figure 1, the bowl curved in too much at the rim where it was to join with the aluminum skin. Although it matched contours perfectly in the side view and the plainview, the areas in the four “corners” curved inwardly much too much.

I was not aware of this until after I had cut the skins to match. (I used heavy stiff brown paper to make patterns, with the nose bowl temporarily held in place.) As I fitted the skins in place, I noted that the cowl had the appearance of fur bulges which were not very becoming.

The solution was to determine the tangent line around the cowl and to splice-on additional skin to extend the previously cut skins to this line. The tangent line was established by marking on the cowl with a pencil the points of contact between the cowl and a straight edge. One end of the straight edge was held at each corner of the firewall as the other end was moved around the periphery of the nose bowl.

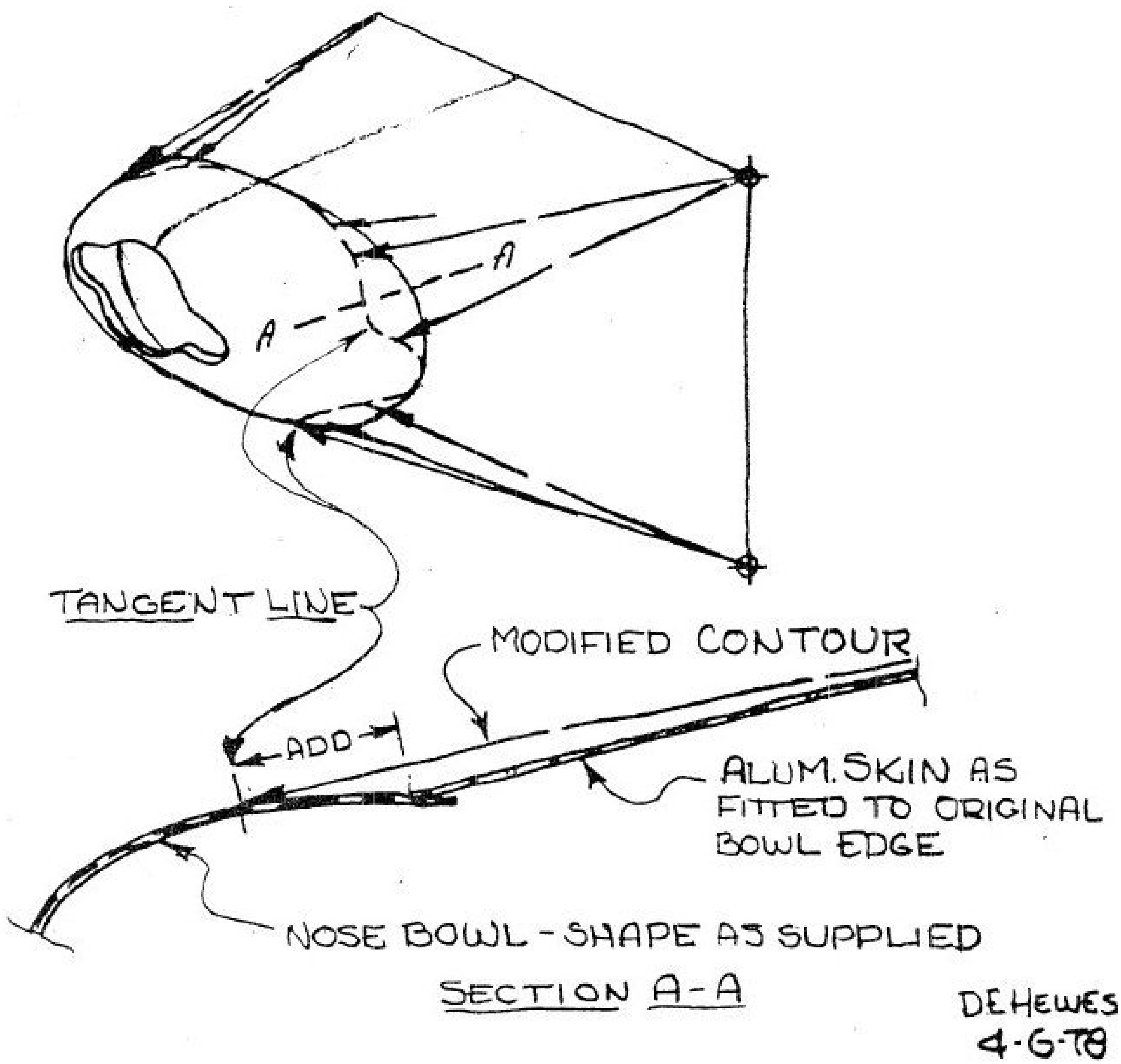
A notch was cut into the surface along the tangent line so that the skins could fit smoothly without an exposed edge. The skins were attached by dimpling the skins and using the Avex flush-head rivets.

The portions of the nose bowl rim falling behind the tangent line and not used for riveting the skins, were cut away to save a little weight and to eliminate the “catch-all” crevices.

Needless to say, when fitted at the top of the firewall, the skin did not meet properly at the bottom. The skin represented a sizable chunk of aluminum and I did not want to scrap it entirely, so I cut along diagonal lines extending from the bottom corners of the firewall to the center line at the bottom of the bowl. The resultant “V” hole was filled by splicing on some additional skin that fitted properly. At the splice I added 0.025″ X 3/4″ X 3/4″ angles to reinforce the joints.

If you haven't built your cowl yet, you can avoid this latter problem by fitting your pattern to the tangent line. It is possible that you may not encounter the whole problem at all because you may have a properly shaped bowl; however, I recommend checking the tangent line before proceeding to cut metal.

REF DRAWING
BD-4-1-18



NOTE: **4 BULGES RESULTING FROM WRONG BOWL SHAPE ELIMINATED BY ESTABLISHING TANGENT LINE USING A STRAIGHT EDGE PLACED AT EACH CORNER OF FOREWALL. ALUMINUM SKIN EDGE WAS CUT TO MATCH LINE.**

Figure 1 – Cowl Shape Modification

FIGURE 2 Horizontal Cut Cowl

After spending many hours wrestling with the original cowl in taking it off and putting it on every time I had to do anything in the engine compartment, I decided there had to be a better way! The clam-shell cowl could not be swung out to either side, as advertised, because of interference of the exhaust stack and other items attached to the cowl.

I elected to cut the cowl so that it parted along the horizontal rather than the vertical. The primary advantage here is that the top portion can be lifted just like an automobile hood, to gain access to the compartment for about 90% of all the work needed to be done there, including work on the spark plugs. Additional access can be gained merely by pulling out the side hinge pins for the lower portion so that the sides can spread out, and the bottom portion will not have to be lowered or removed.

The original parting joints of the nose bowl had to be reinforced with fiberglass to ensure adequate rigidity.

To install the cowl, the lower portion is mounted first. The bent end of the side hinge pins is placed inside.

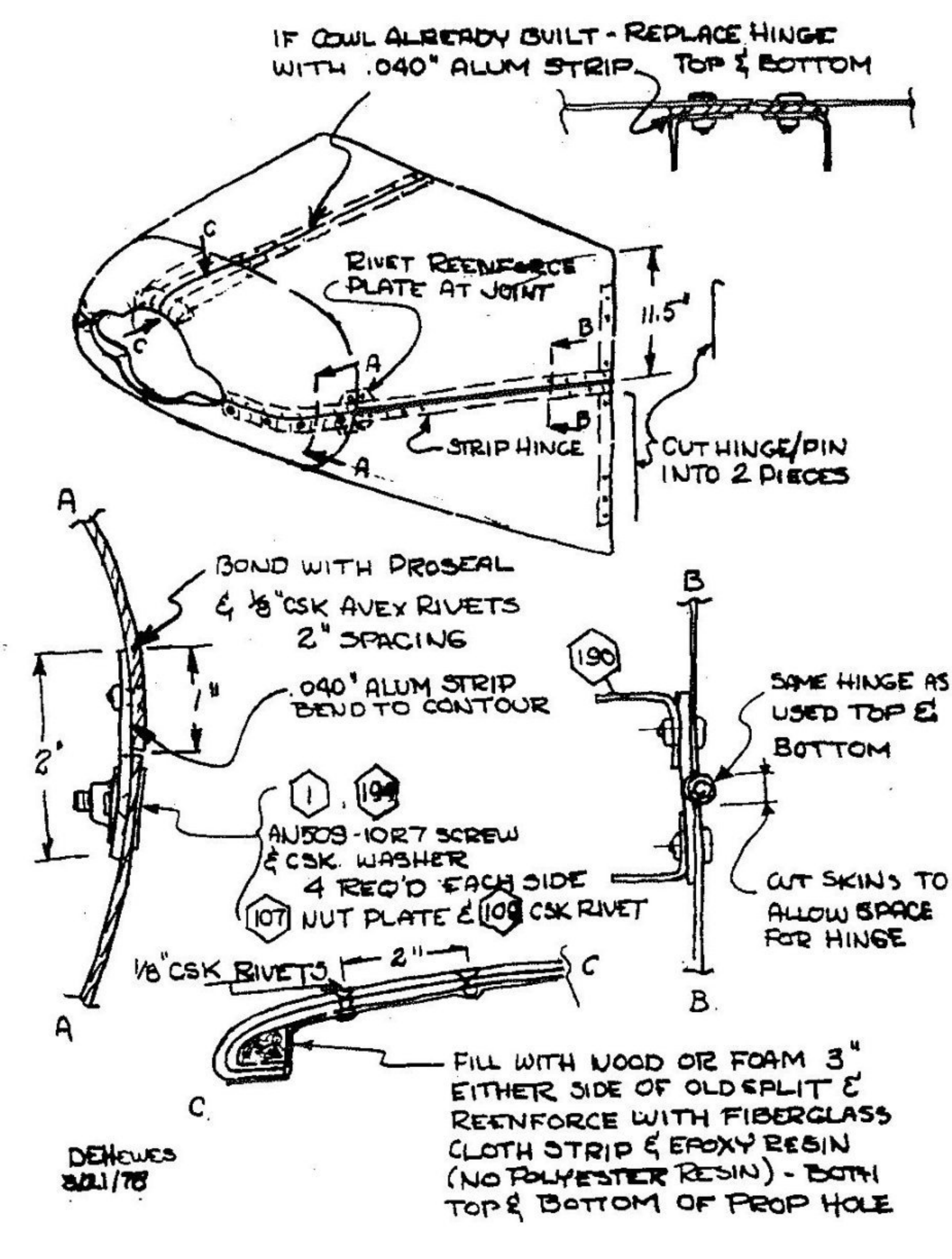


Figure 2 – Horizontal Cut Cowl

Figure 3 Oil Cooler Installation

I had read or heard somewhere about using the Corvair oil cooler but did not know any of the details. It seemed like a reasonable idea and worth the try especially since the cost of a new one was a fraction of the standard aircraft unit. I was concerned that it might not stand up because of the hinger operating oil pressures of the aircraft engine. However, it has given no problems whatsoever in nearly 400 hours of operating time spread over four years.

The particular unit I used was intended for use in later model Corvairs equipped with air conditioning and cost about $28.00. It appears to have over twice the capacity and number of cooling plates than the one that was in my standard '66 Corvair.

As the sketch indicates, the cooler was mounted directly to the left rear baffle. The size of the air passage through the baffle was made about 2 1/2″ X 6″.

An oil filter unit (not shown in th sketch) was mounted opposite the oil cooler on the right size of the firewall using a Fram HPK 2 Oil Filter Adapter kit available in auto stores for about $11.00. I use the Fram HPI Spin-0n Filter element which sells for about $6.50. There are, of course, other filters at lower cost that will also fit but I haven't tried any of them as yet.

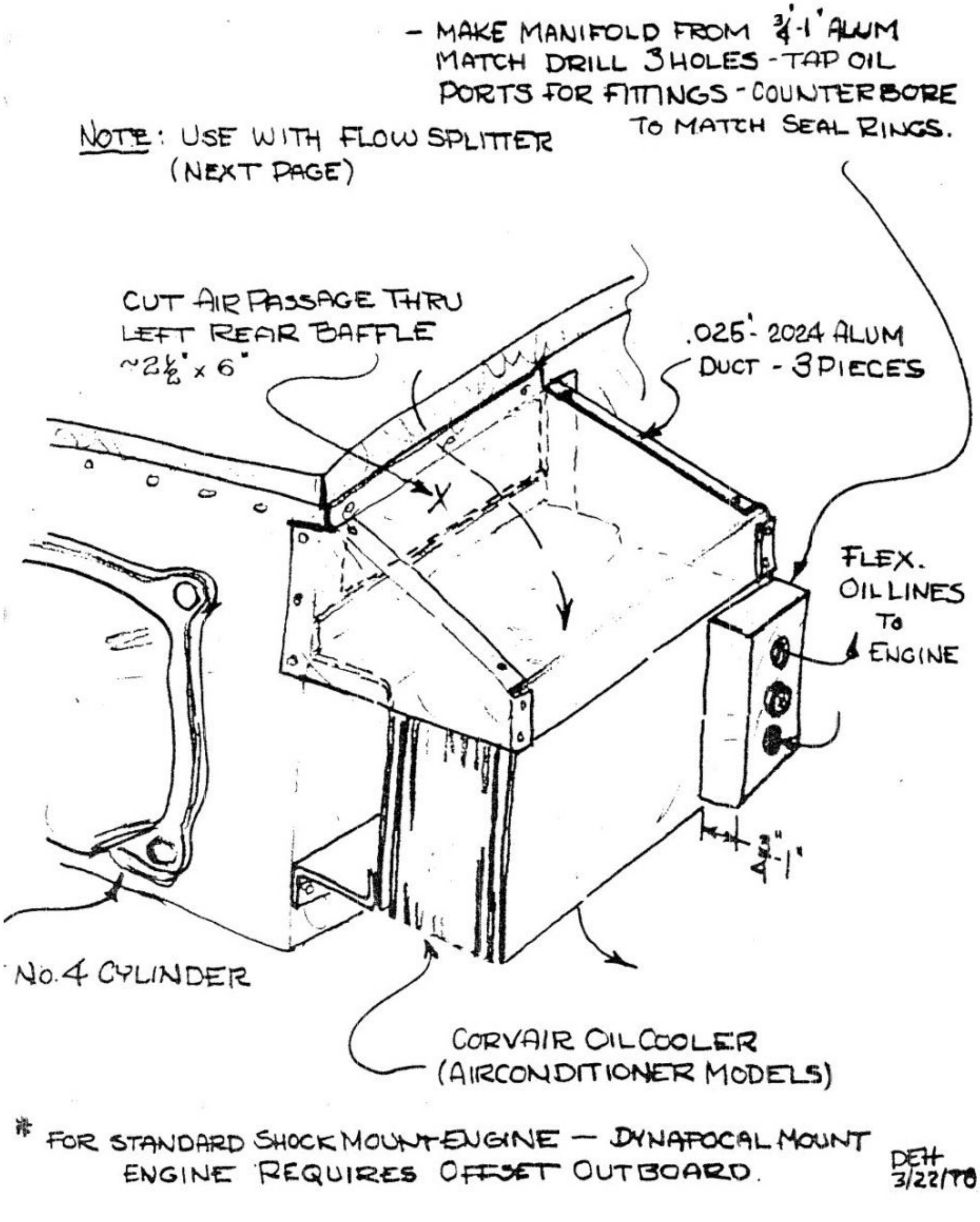


Figure 3 – Oil Cooler Installation*

Figure 4 Flow Splitter

I installed this after noting that the cylinder head temperatures on the right side were somewhat different from the left side. This seemed to have some beneficial effect and is very simple to install.

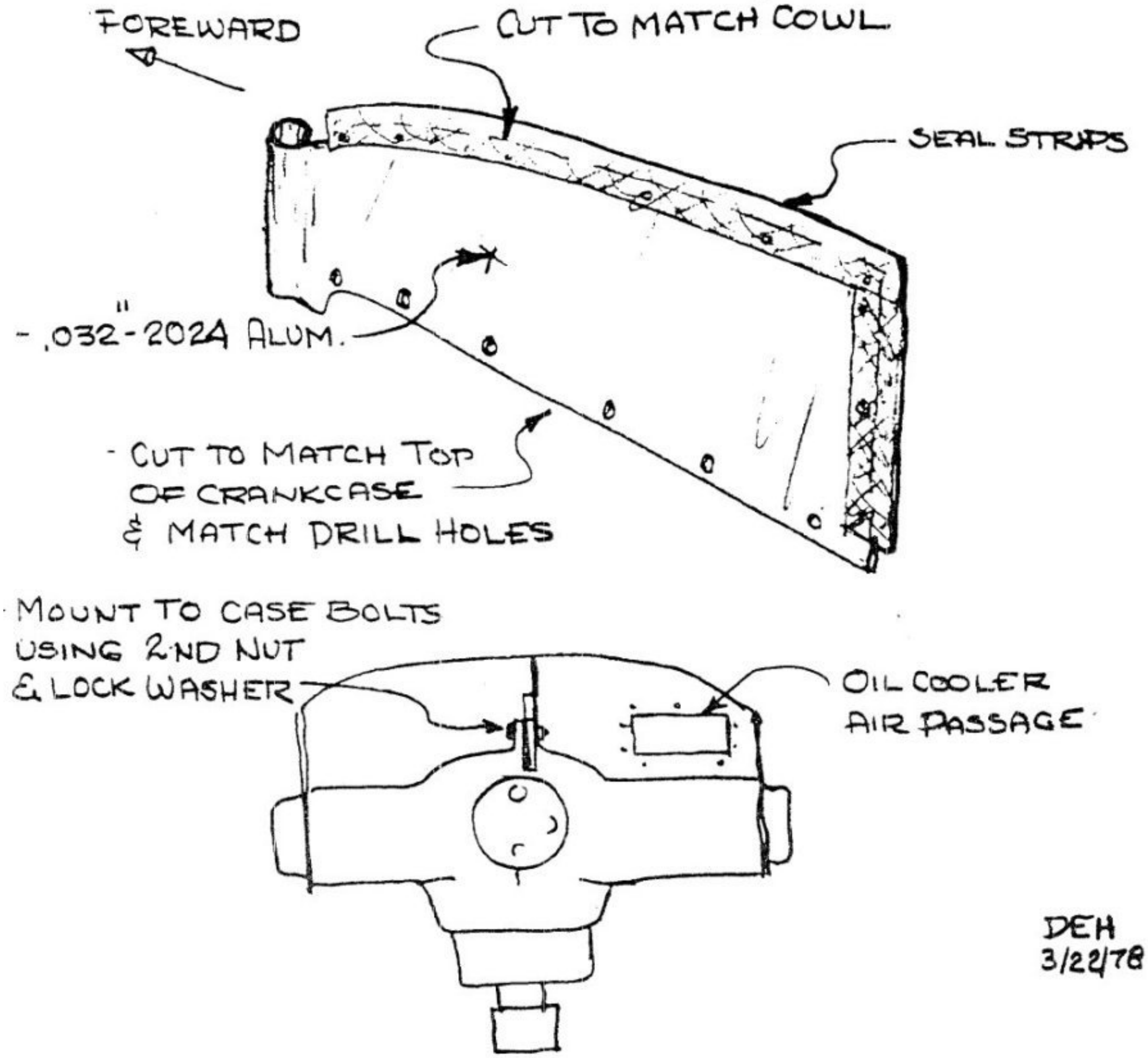


Figure 4 – Flow Splitter

Figure 5 Battery Box Installation

Shortly after starting N632DH, I did a rather quick estimate of the weight and balance situation for the tail dragger configuration. It was apparent that the center of gravity was going to be shifted aft because the moment produced by the tail wheel was much greater than that of the main gear. The obvious solution was to sift the battery from aft of the rear seat to the front of the firewall. I considered this to be a very much better location for the battery not only because of the savings of several pounds of electrical cable and the attendant reduction in electrical line losses but because this was a much more accessible area. I did not like the idea of having the battery very close to the basic structure in an inaccessible area where the very corrosive action of the battery acid could easily go unnoticed. Furthermore, the battery on the firewall is much easier to get to for attaching the booster cables when a recharge is needed.

The battery box shown in the sketch was sized to fit a 22F auto battery which I turned to after having had three of the aircraft batteries fail in a fairly short time. This battery is considerably larger and heavier than the other battery but has very much greater cranking capacity and gives excellent cold winter starts. This is the same battery as the one in my Pinto station wagon, so if I find the plane's battery a little low, I can very easily switch the batteries and not have to fuss with a recharge. (The car will recharge the low battery very quickly because it is used every day.)

The box was designed so that the battery could be tilted outward as it is being removed from the box so as to get past the diagonal cross brace of the engine mount.

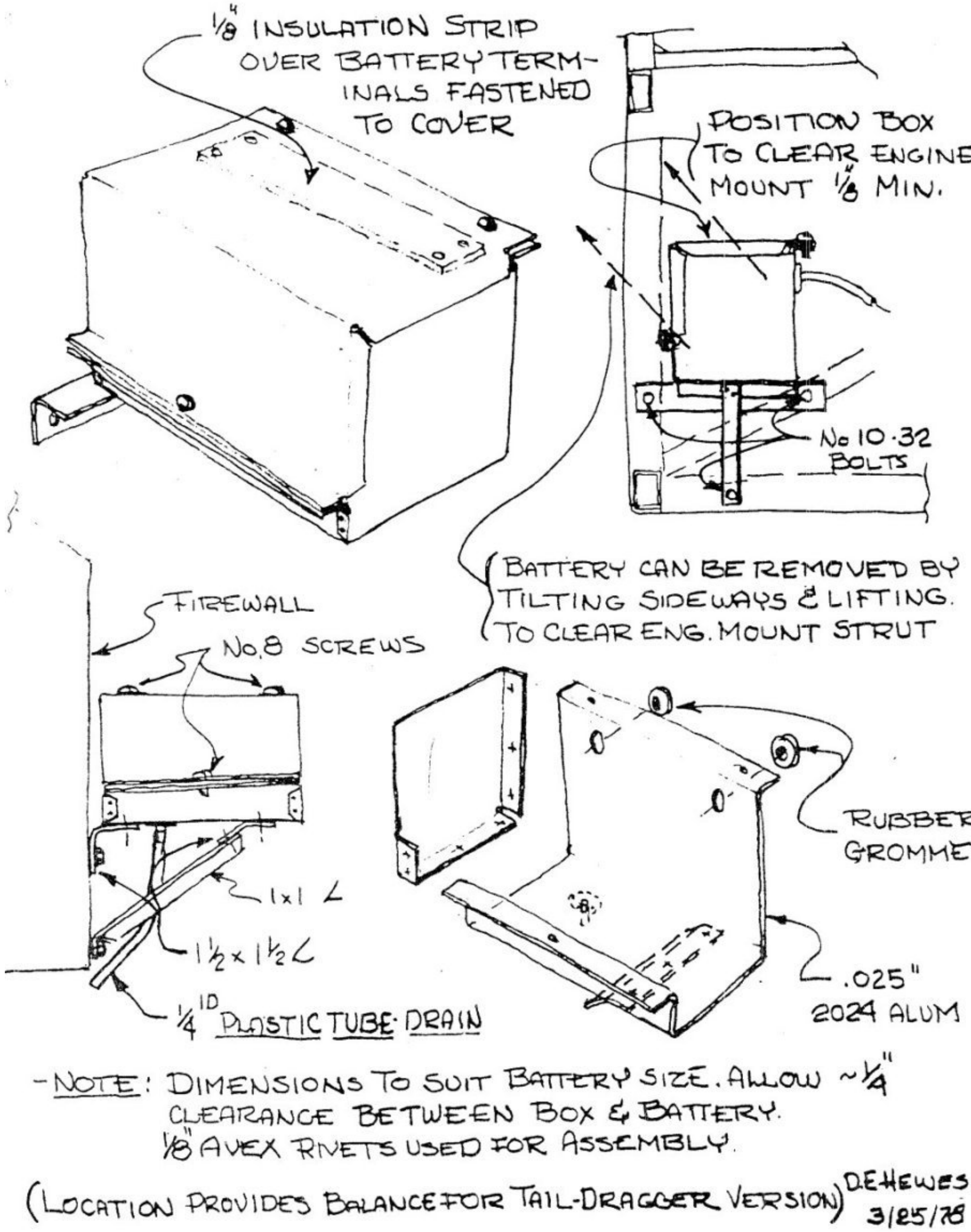


Figure 5 – Battery Box Installation

Figure 6 Cabin Air Heat Box

This cabin-air heat box provides a means for dumping the hot air overboard when it is not being used to heat the cabin. Without this feature, a very large amount of heat is transferred into the cabin, even when the valve is closed, because the heat box and firewall become very hot. This was particularly bothersome during the hot summer days.

The box mounts exactly where the original box was mounted but extends outboard so as to accommodate the hose flange for the defroster hose that is detailed in the next two pages.

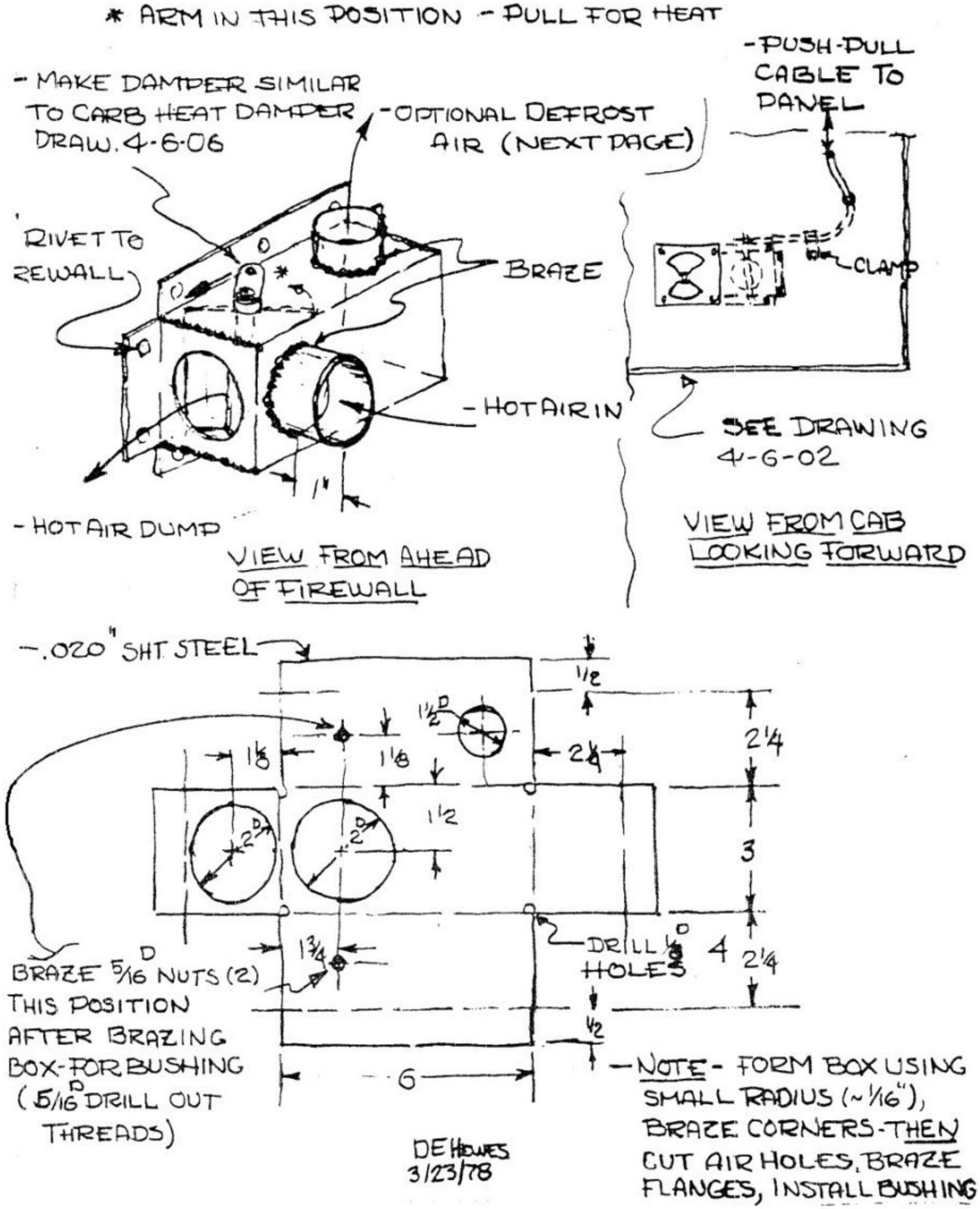


Figure 6 – Cabin Air Heat Box

Figure 7 Defroster Installation

Living on the coast, we are subjected to rather high relative humidity which during the cool days of the year tends to produce fogging conditions fairly often. On some days when there's no fog outside, the windows will be completely fogged over on the inside, especially the windshield. Therefore I devised this scheme to direct some of the heated air over the windshield so as to quickly disperse the moisture. This scheme also provides a little more uniform distribution of the heated air into the cab so that you don't have it all blasting up at you from one vent on the floor. I have installed a valve in the defroster line so as to have the option of having all of the air, part of ti, or none of it coming through the defroster vents.

Although this system works very well, I have found that it is not adequate to provide warmth to th back seat in very cold weather. Unfortunately, I have not had time to solve this problem, but plan to do so in the near future.

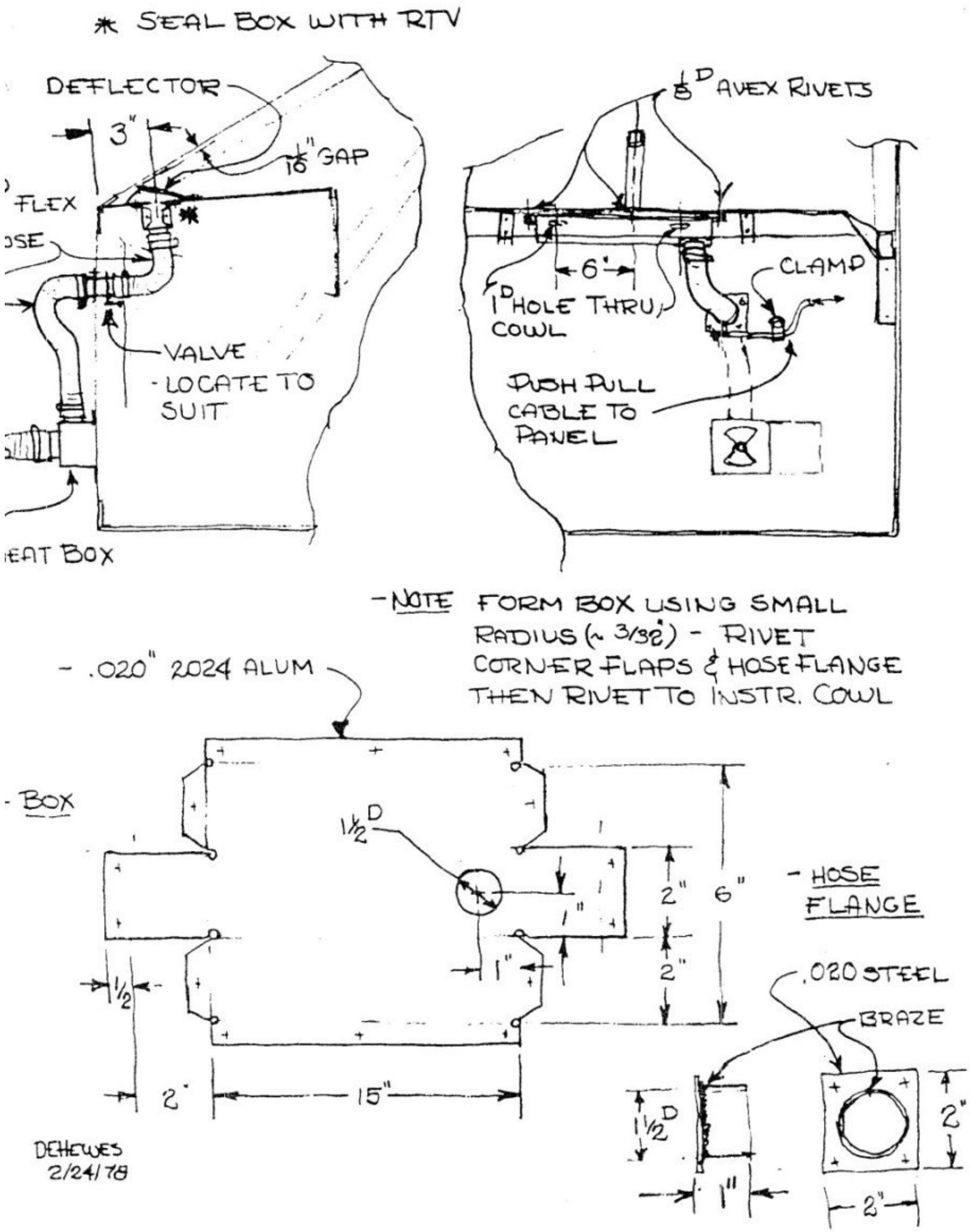


Figure 7 – Defroster Installation (continued on next page)

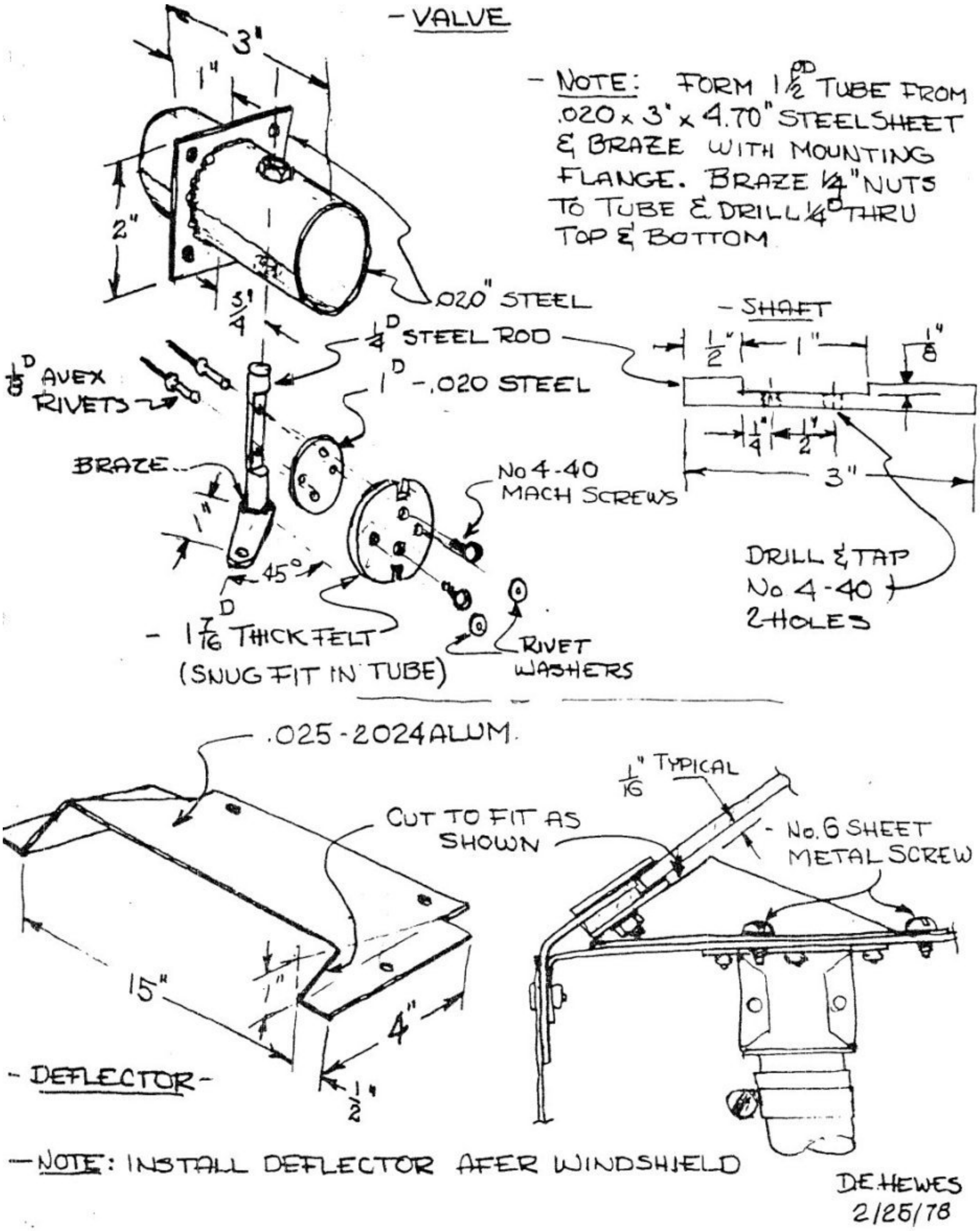


Figure 7a – Defroster Installation (Concluded)

Virginian Patriot N 632 DH

Here are some general facts, figures and notes based on my experience in testing and flying tail-dragger N 632 DH.

Construction started December 7, 1973, and the plane was test-flown one year later on December 6, 1974. It was certified for night VFR on March 12, 1975

Cabin capacity	- 4 persons	Empty weight	- 1220 lbs.
Power	- 150 HP Lycoming	Gross weight	- 2000 lbs.
Propeller	- 74″ dia. 62″ pitch	Payload	- 780 lbs.
Wing span	- 25.5 ft.	Fuel	- 55 gal.
SL rate of climb	- 1000 fpm	Fuel consumption	- 7.5 – 8.0 gal/hr
Cruise speed	- 150-160 mph		
Stall (GW)	- 60 mph (zero flaps) 55 mph (full flaps)		

The Patriot (with the larger vertical tail) has very good stability and handling characteristics in all normal flight conditions. Its riding qualities in turbulent weather are noticeably better than most other single-engine light planes because of its relatively heavy wing loading of 20 lbs. Per square foot. Approach speed is generally 80 – 85 mph with 2/3 flaps, and flare speed is about 75 mph. Lower speeds results in fairly high sink rates with power off due to the relatively low aspect ration and high wing loading. Aileron and rudder are very effective, and crosswind landings are fairly easy to control. Landings have been made in 45° crosswinds of 20 knots gusting to over 30 (not recommended as normal practice).

Normal 1-G stall characteristics are considered good and are characterized by a slight buffet and a gentle wing rock that gradually builds up in 4 to 6 cycles to a roll-off. All controls are effective until roll-off and recover is positive and rapid at any point. Release of controls results in immediate recovery; no loss in altitude with recovery except after roll-off, where 200-300 feet may be lost.

Like all other airplanes, the Patriot has some operational limits and in this case, one of its limits is accelerated and aggravated stalls. Based on first-hand but limited experience, these stall characteristics are judged to be very poor. The aggravated stall (pulling stick back slowly using rudder for wing leveling) resulted in a violent snap roll and a steep spin with a very rapid roll rate. Recovery was very slow requiring about 3 turns with a high speed pull-out and loss of over 1500 feet. The spin recovery characteristics, based on this one experience, are therefore judged to be very poor. **DO NOT TRY TO PERFORM ACCELERATED STALLS OR SPINS.** Normal 1-G stalls, however, are considered to be very safe as long as the are performed under normal conditions.

It should be noted that the BD-4 has never been spin-tested by Bede Aircraft, or any other person, to the best of my knowledge. You must realize that to go out and perform one or a handful of spins <u>does</u> <u>not</u> constitute an adequate test program and to do so is extremely foolhardy and dangerous. A proper spin test program requires a recovery parachute installation, quick-release doors, and a properly trained and experienced test pilot. The chances are only about 1 in 100,000 that you are such a pilot; I, for one, am not.

Figure 8 Windshield Mount

About six months after installing the windshield, I became aware of small areas of crazing near the edges which spread rather quickly to cover much of the windshield. Although not completely obscuring vision through the windshield, these fine hair-line cracks became quite bothersome especially when the light was coming from certain directions. Shortly thereafter, John Whistler, who was responsible for getting me to build N632-DH, began to have the same problem with the windshield in his BD-4. It was apparent that the original scheme for attaching the windshield was placing the Plexiglas under stresses which were causing the crazing.

An added problem with the original installation is that the windshield must be installed from the inside, and I found that to re-install a new windshield I had to remove the front side windows to gain adequate clearances.

To overcome both problems, I re-worked the installation as shown in the sketches. The windshield was cut slightly smaller than th inside dimensions of the frame so that it could be installed from outside. The Plexiglas strips that were cut off were clamped between an aluminum strip and the window frame using screws in every other of the original mounting holes. This arrangement provided an inner lip against which the windshield was placed along with a thin underlying plastic sealing strip. The gap around the edges of the windshield was filled with RTV silicone sealer and then the outside aluminum strip was installed using screws in the remaining holes. A second sealing strip was placed under the outside aluminum strip.

The outside aluminum strip was not needed at the top of the windshield because the clamping action of the strip was performed by the skin which had been extended about 1/4″ beyond the frame angle. The Plexiglas is clamped to the frame but is free to expand and contract within the restraining channel. In effect, the windshield “floats” within the soft cushions of the sealing strips. The crazing problem has not returned.

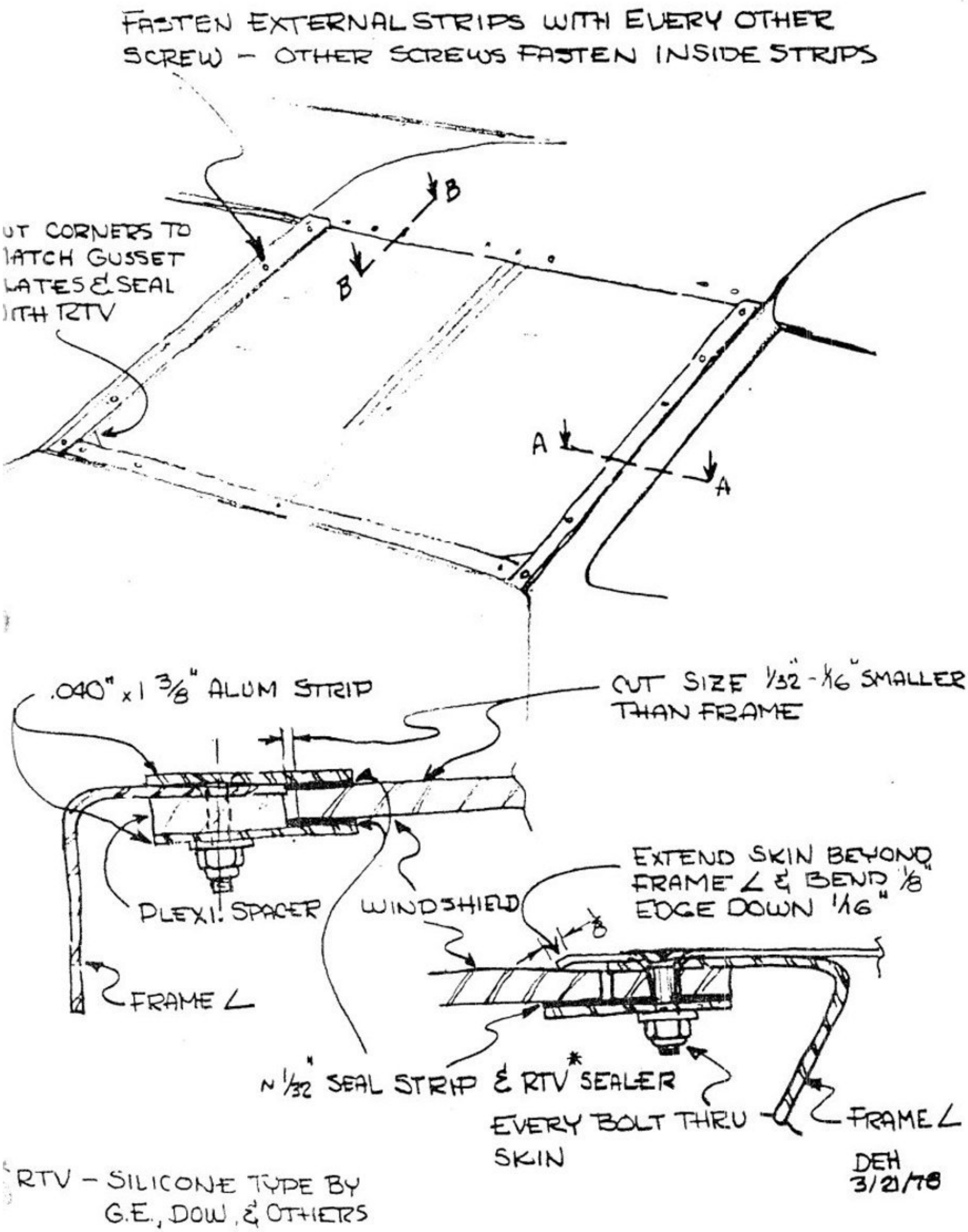


Figure 8 – Windshield Mount

Figure 9 Windshield Frame Covers and Other Cabin Details

I found that I had plenty of scrap materials left over after putting the plane together, but I knew that I probably could find ways to use most of it. (Basically, I am a miserly sort!)

Well, one of the many uses was to make framing for all the windows as shown in the sketches of this figure. I wanted to cover up all those many screws and rivets used to fasten the windows, and this was a simple way to do it.

The sketch showing a portion of the general view of the instrument panel and windshield also indicates a cushion added to the top edge of the instrument panel. I installed this primarily as protection in the event of our heads striking the panel edge in a crash. I wanted to put some shock absorption material there and felt that an aluminum strip which would bend or buckle would do the job. - - No, I haven't tested it but I'm sure it is better than nothing.

(See Figure 10 also.)

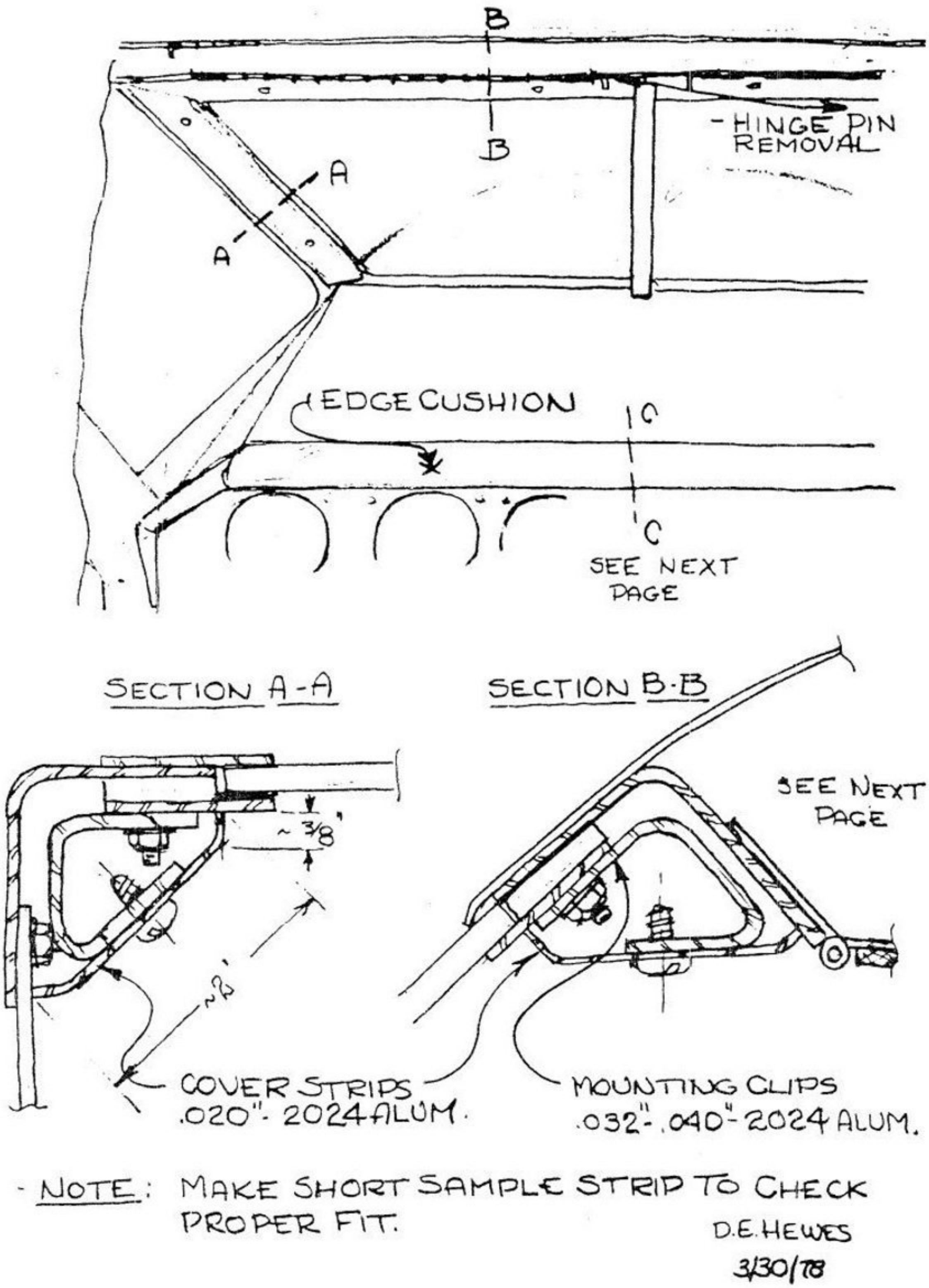


Figure 9 – Windshield Frame Covers & Other Cabin Details

Figure 10 Cabin Details

In addition t the panel cushion, this Figure shows the addition of an overhead panel which is hinge-mounted to the windshield framing angle 21. The hinge is made in two parts so that the hinge pins can be installed with the side windows in place. (See the sketch at the top of Figure 10.) The hinge pin is installed and removed near the center of the panel.

The other end of the panel is braced by a 1 X 1 angle to provide stiffness along the full length of the edge. I used two short pieces of piano hinge stock (about 4 inches) to fasten this edge to the spar. The removable hinge pins here permitted the panel to be easily lowered for access, when desired.

I covered the panel with the plastic upholstery material and then mounted the speaker, compass, swivel map-lights and switches to it. I found this area to be the <u>only</u> area where the compass was not influenced significantly by the engine. It is just above eye-level at the center of the panel, and is fairly easy to read. I use a directional gyro so refer to the magnetic compass only occasionally. This would not be a satisfactory location if I did not have the directional gyro.

The speaker which is to the far left does not influence the compass.

I found this hinged panel very convenient because it provided easy access to the jacking mechanism for my wing-folding system which is discussed later.

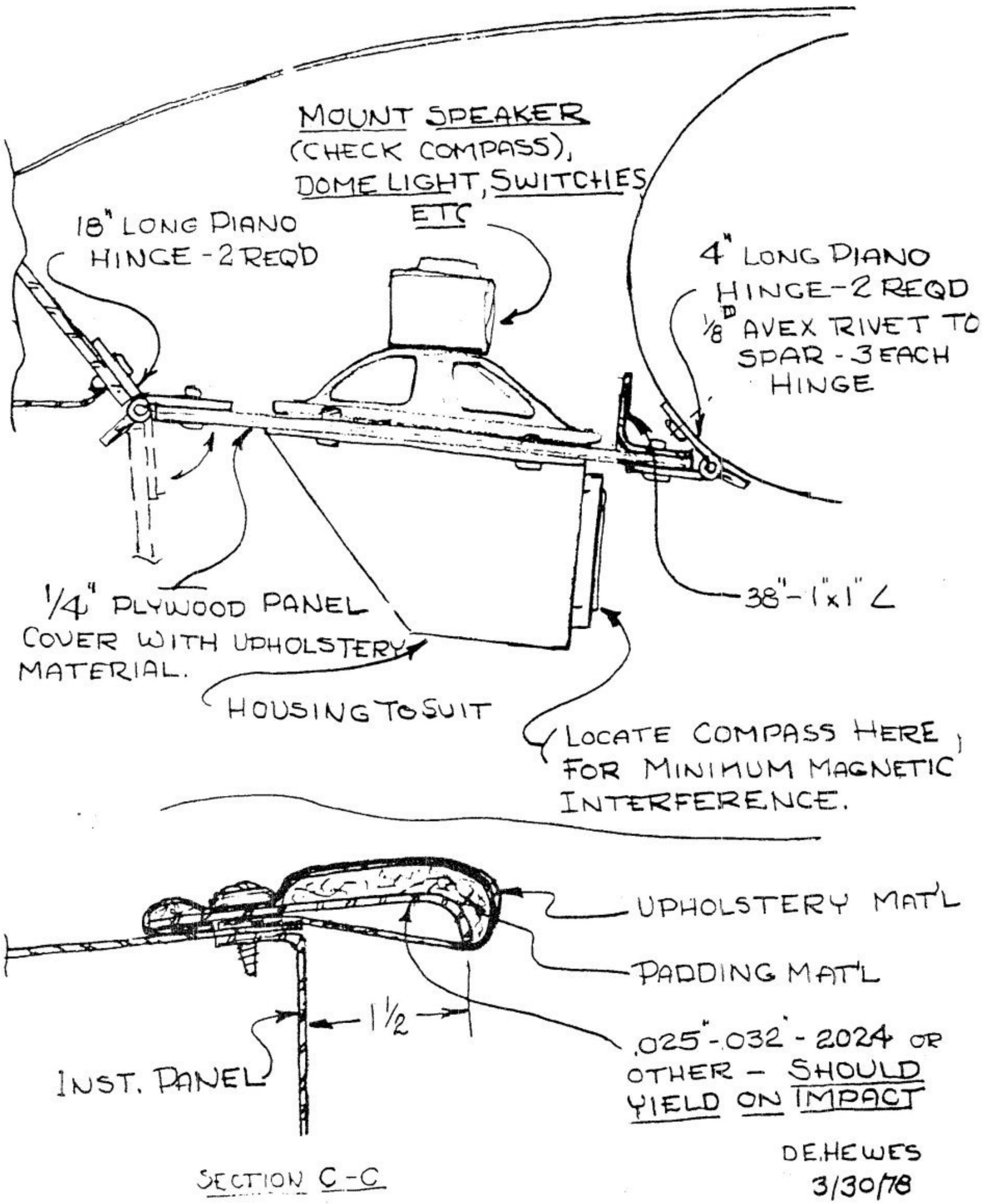


Figure 10 – Cabin Details

Figure 11 Instrument Panel Access

As I mentioned earlier, I considered accessibility to be a key factor to overall flight safety, and this figure depicts on of the key areas where accessibility is important. I installed the skins on both sides in this area so that they could be easily removed to gain access to the back of the instrument panel. (My arm was badly broken at the elbow when I was a kid, and it has very limited motion ever since. This access area provided added convenience to me because it permitted me to reach areas that I otherwise could not have reached with limited arm and wrist motion.) These areas make ti easier to do a better installation job and also do a more thorough inspection job when the annual recertification time comes around each year.

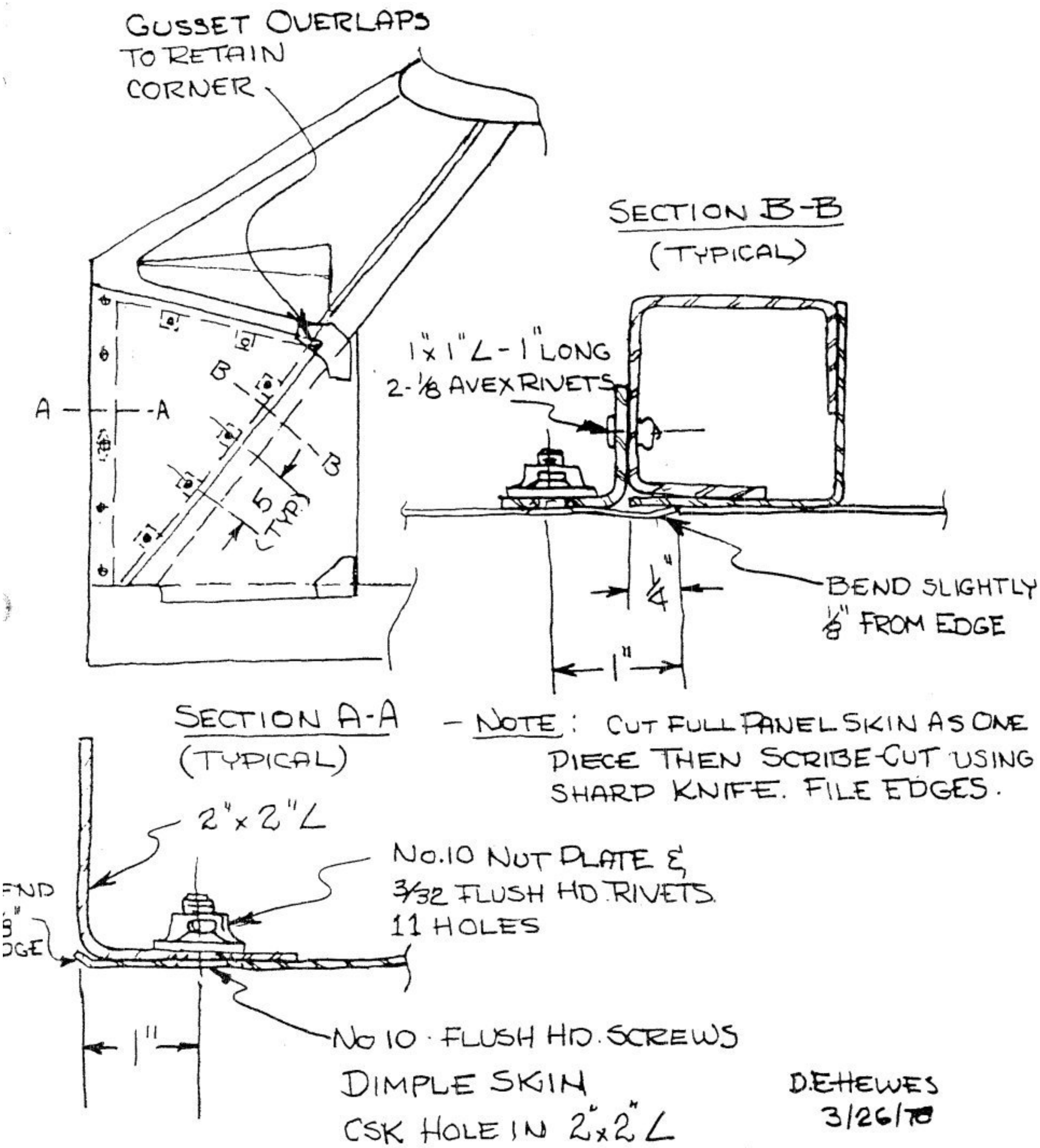


Figure 11 – Instrument Panel Access (both sides)

Figure 12 Switch and Circuit Breaker Access Panel

Here is another very important area where accessibility pays off. Frankly, I could not see how I was going to get to those switches and circuit breakers the way they were installed originally. This scheme solved the problem very nicely as all I have to do is remove fur screws at the front, and the whole panel slides out for direct access to the back.

This arrangement was made possible by the relocation of the engine controls to control console discussed later.

Inasmuch as I ended up with more switches and circuit breakers than would fit in the center of the panel, I added an auxiliary panel to the right of the engine instrument cluster with the same scheme for accessibility.

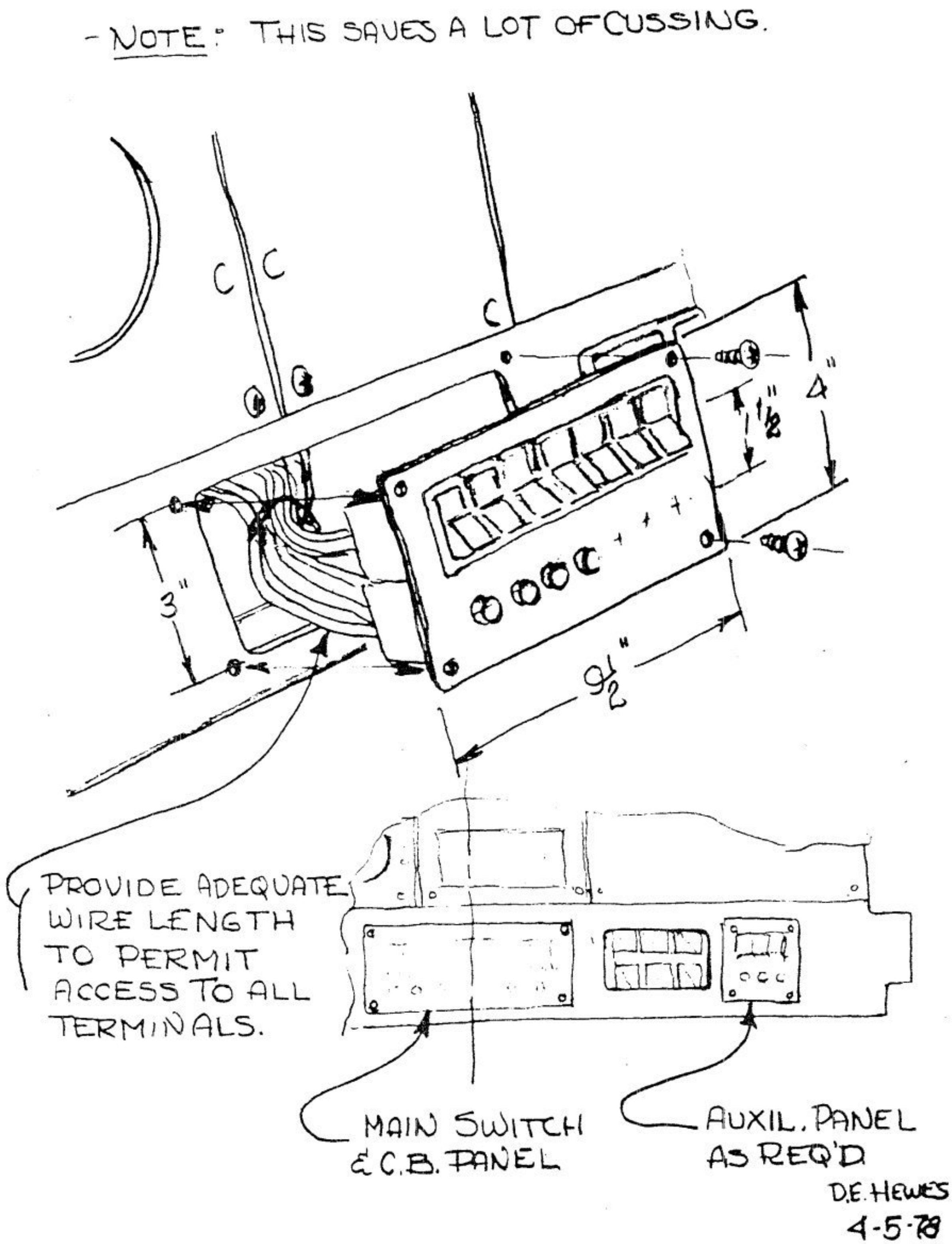


Figure 12 – Switch & Circuit Breaker Access

Figure 13 Glove Compartment

I ended up with some empty panel space at the right side, and decided to add a "glove" compartment which is extremely convenient for storing all sorts of stuff. (I don't keep any gloves there, however.) If you don't have as much space as I did, you may be able to squeeze in a smaller one following the same scheme.

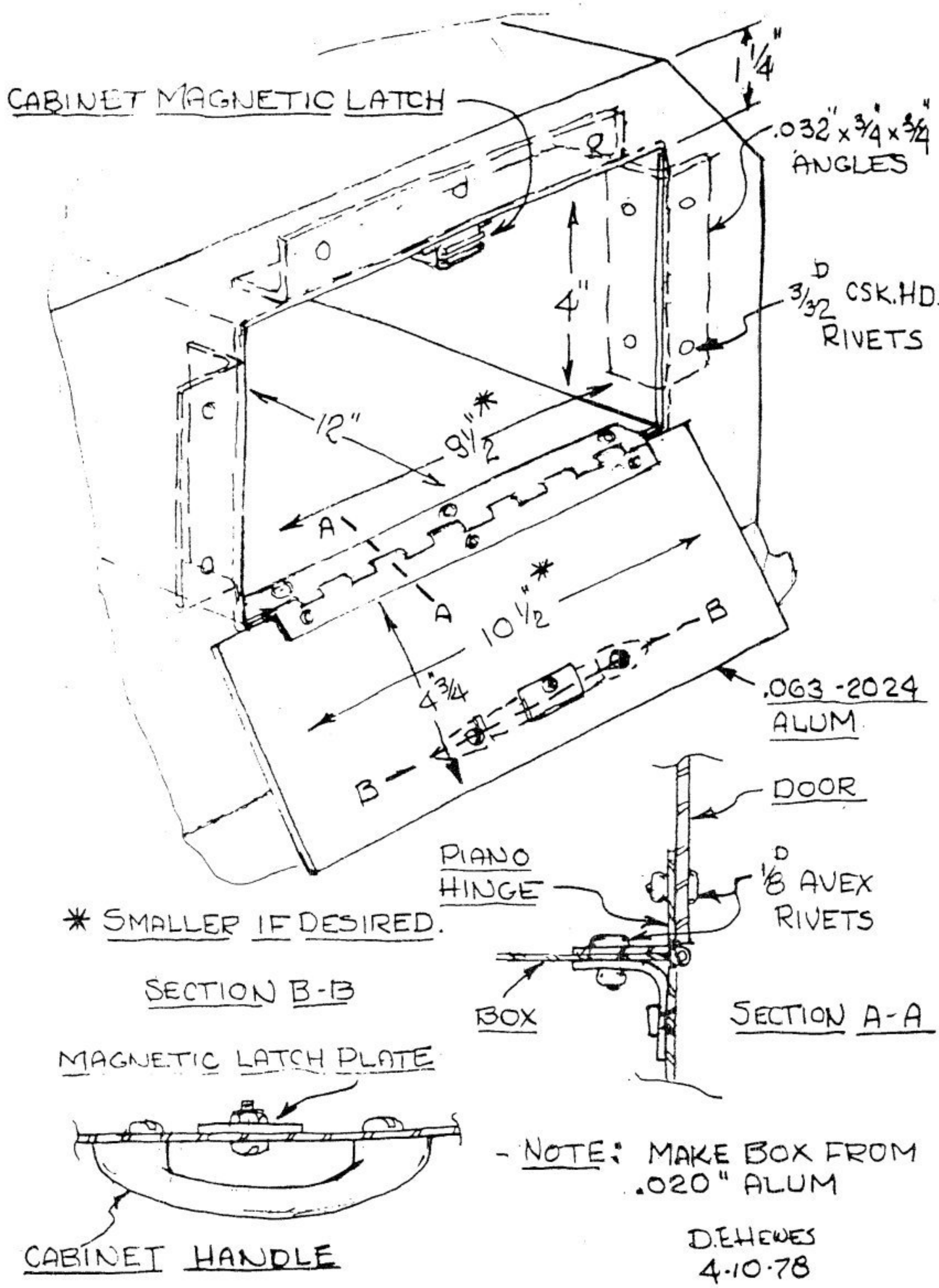
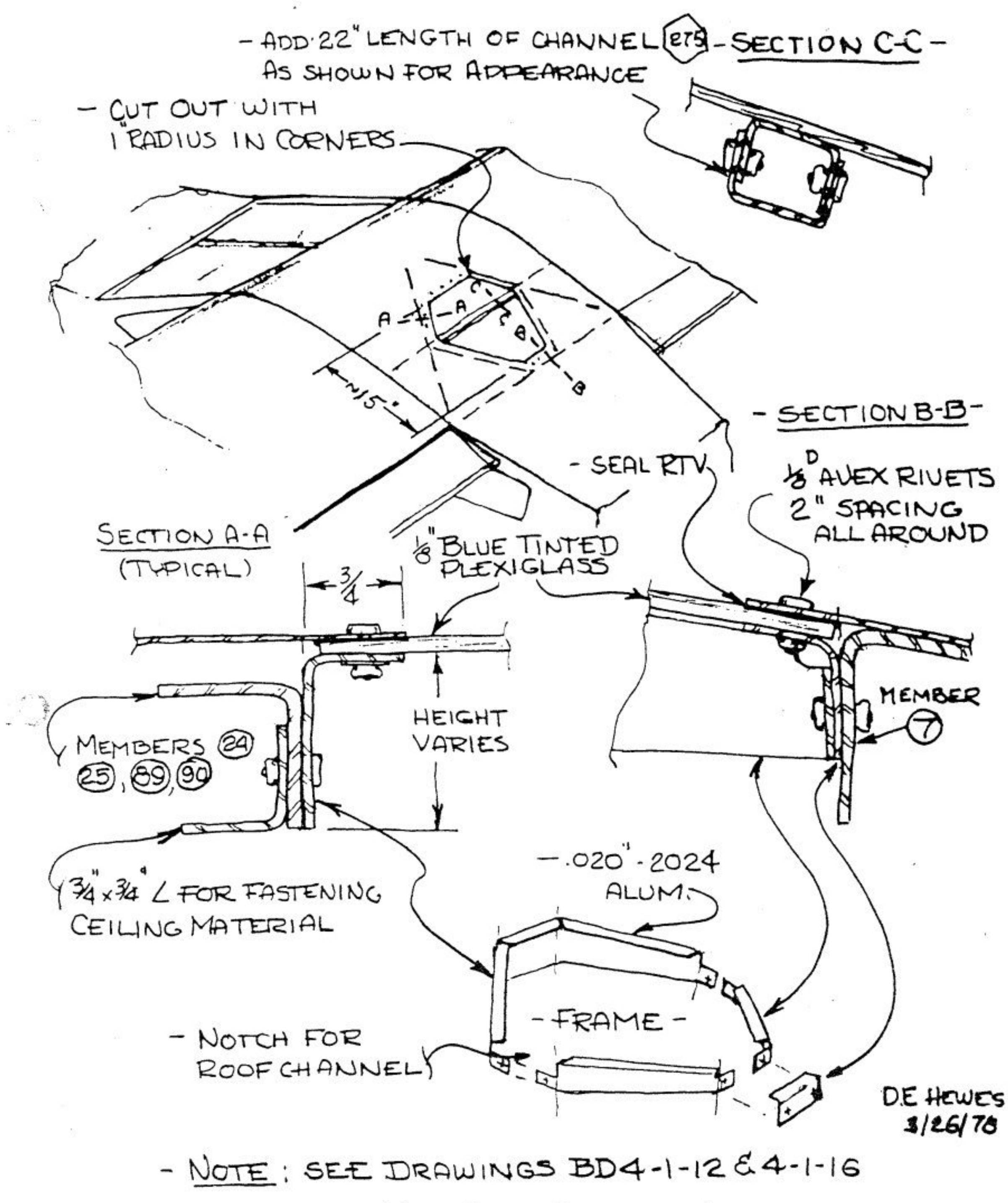


Figure 13 – Glove Compartment

Figure 14 Cabin Skylight

I believe this to be a very important flight safety item because it partially overcomes one of the worst features of any high wing airplane - - lack of overhead visibility. This window doesn't do the whole job but it sure is a big improvement. Although the size is fairly small, the field of view is quite large because your head is so close to it, and light head movement from side to side, and for and aft, permits better than 120 degree field of view.



(GREATLY IMPROVES OVERHEAD VISIBILITY)

Figure 14 – Cabin Skylight

Figure 15 Door Modifications

The bottom set of sketches show how I made the door hinges for N632DH. It appeared to me that this was somewhat simpler than the original method. It did require making the four gussets out of 4130 steel so that the lugs could be welded t them.

The top sketches show the reinforcements that I added to the door latches. I found that adding the latch plate eliminated the problem of the door popping open in flight. I did not have a good engagement of the bolt with the door post. This modification solved the problem easily.

The reinforcing clip added to the body of the latch eliminated buckling of the latch body and door skin caused by the loads on the latch bolt. The loads were produced by closing th door, and by air pressures during flight, or by the passenger in the front seat leaning against the door.

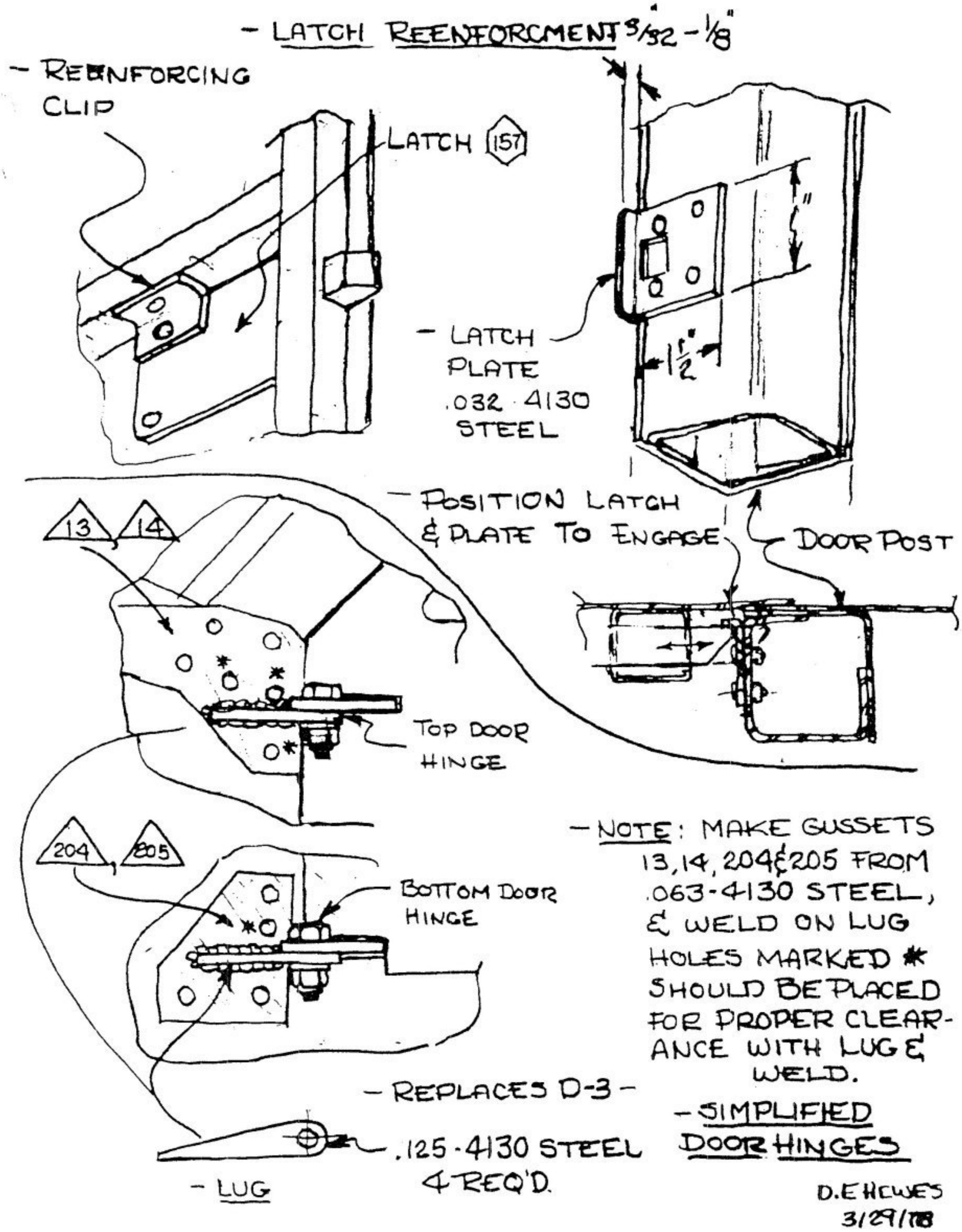


Figure 15 – Door Modifications

Figure 16 Door Stop

I have found this feature to be indispensable. I have experienced two shattered door windows as a result of winds catching the door and slamming it forward against the front side of the plane. The first time I did not have the stop installed; the second time, the stop broke because it was too weak. The notches will hold the door open at different desired positions.

Not shown in the sketch is a small spring attached at the door bracket which tends to force the rod backwards against the door. This was provided so that it released the rod from the notch whenever the door was opened slightly. This also kept the rod from engaging one of the notches unless the rod was purposely placed there. The weight of the door which tended to close the door is sufficient to hold the rod engaged until released by moving the door forward.

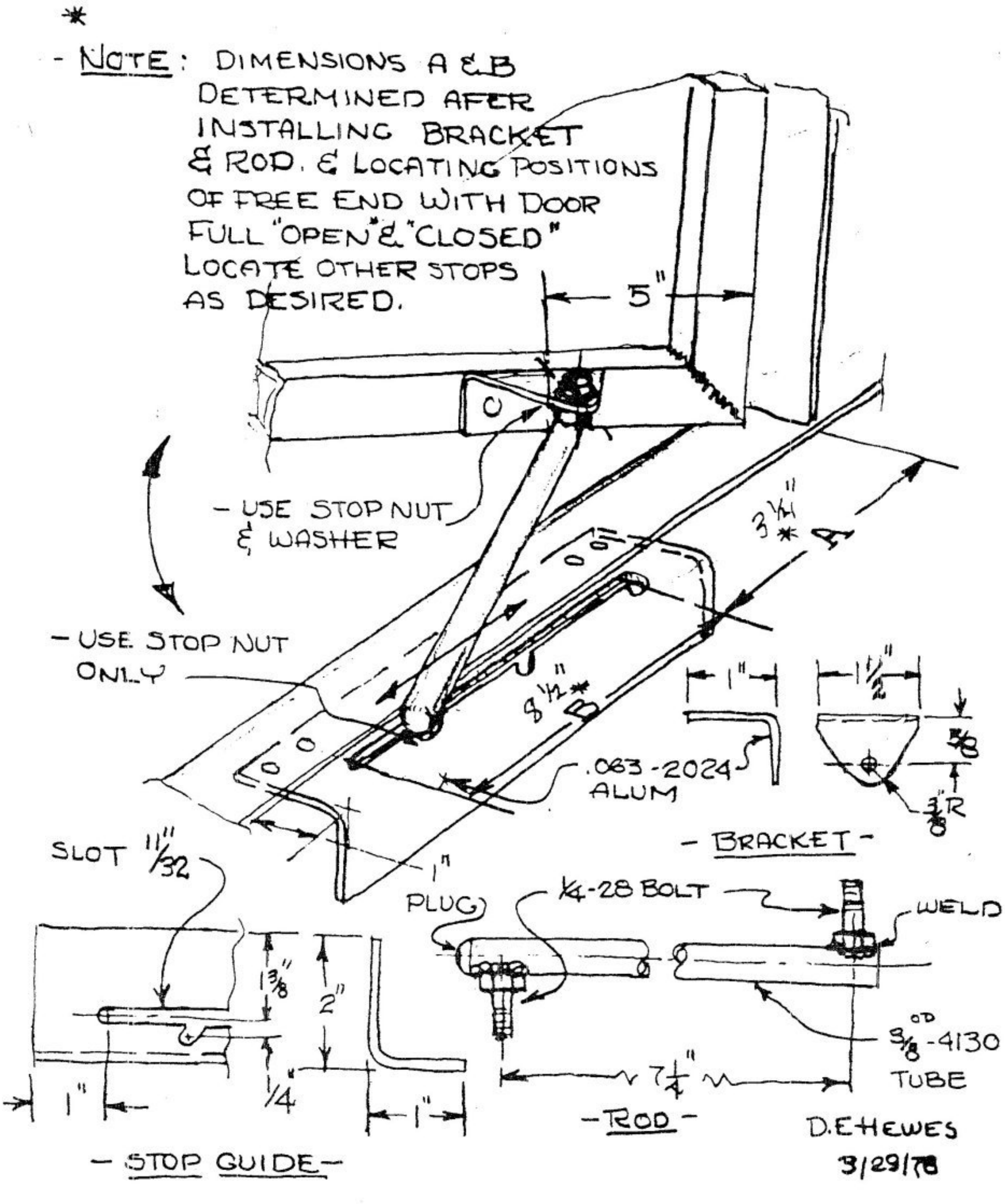


Figure 16 – Door Stop

Figure 17 Cabin Floor Modifications for Tail Dragger

The drawings for the tail dragger provided in the plans failed to show modifications required to accommodate the forward location of the landing gear box (LGM). These modifications involved the rear support of the front seat and the pivot supports for the control sticks.

Placement of the tail dragger LGM resulted in it being only about two inches ahead of the crossmember CS-35. It was apparent that the LGM could be made to serve the function intended for CS-35, and that CS-35 could be moved aft to serve as a floor support at the original location of the LGM. The need for a second LGM was eliminated by providing seat supports attached to CS-35 and the side channels 1 and 2. These seat supports were extended inboard only enough to accommodate the seat attachment fittings shown in Drawing BD-4-7-01.

Notice that this arrangement provided adequate space for the rear passenger's feet to fit under the front seat.

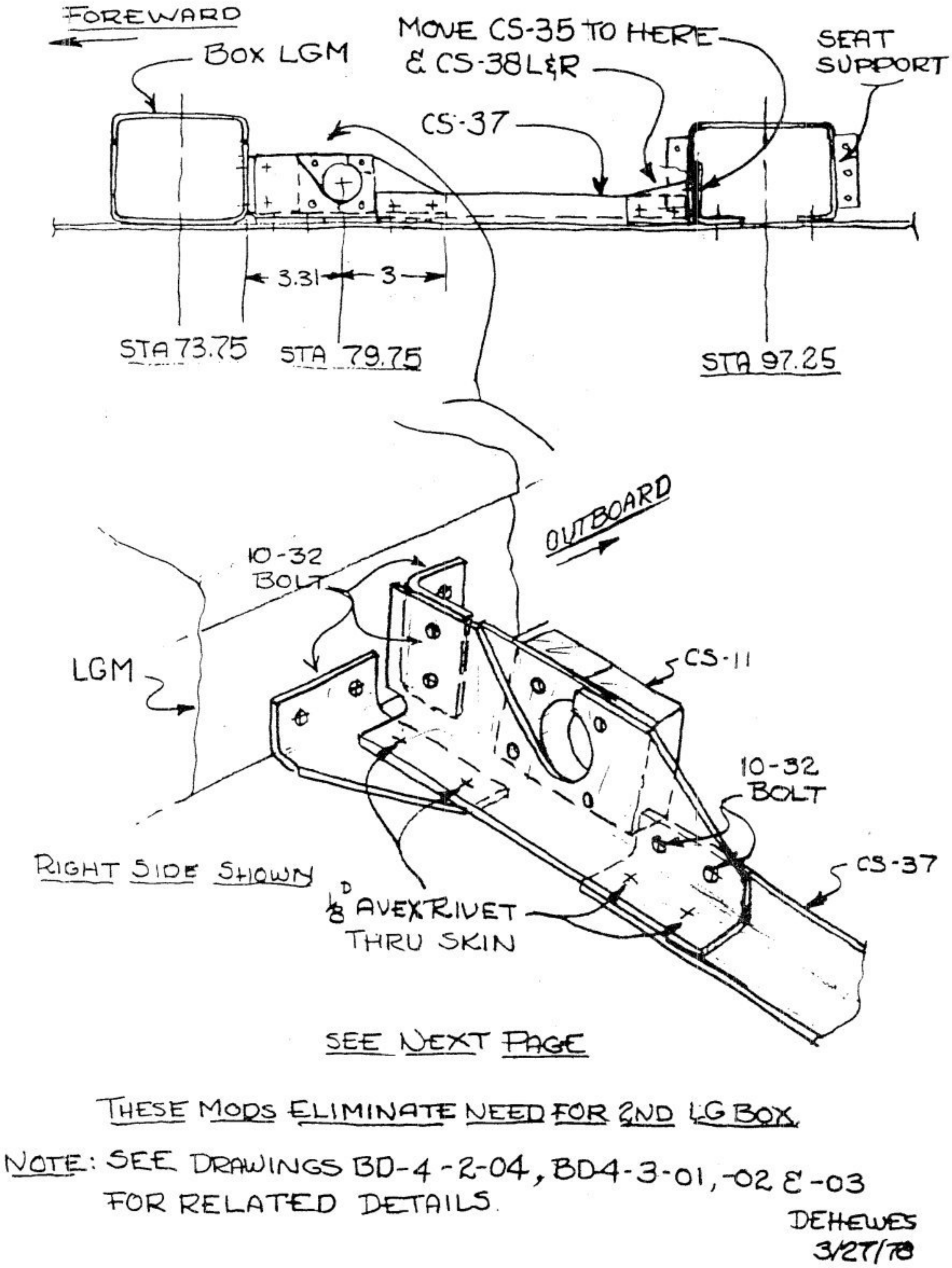


Figure 17 – Cabin Floor Modifications for Tail Dragger

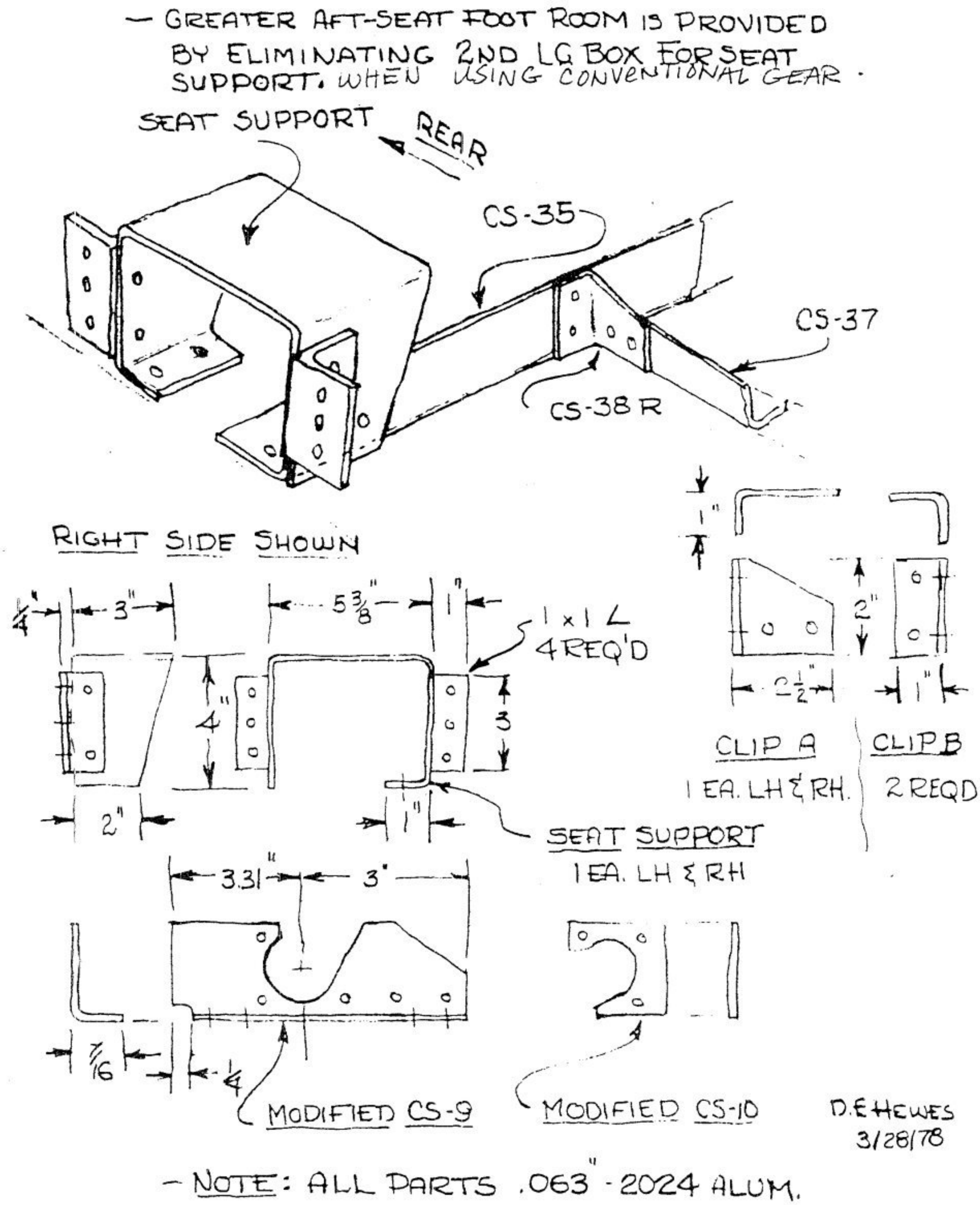


Figure 17a – Cabin Floor Modifications for Tail Dragger

(intentionally left blank)

Figure 18 Engine Instrument and Control Console

I designed this console so as to permit repositioning of the engine controls to what I considered a more convenient arrangement from the human engineering standpoint. A second reason was to unclutter the instrument panel so as to provide better access to the equipment on the instrument panel. (See Figure 12.)

I wanted to place the throttle much lower and closer to the pilot's right hand so that he could easily place his hand on the throttle without leaning forward and raising his arm. Also, I wanted to place it close to the elevator trim know which, of course, is also operated by the right hand. This minimized the arm notions required to manipulate both controls during various maneuvers, such as landing, or leveling off for cruise, which require operation of both controls.

With the tachometer and manifold pressure gauge mounted directly in front of the pilot on the lower sloping portion of the instrument panel, all engine operating instruments and controls were conveniently clustered closely together. All other flight and navigation instruments were above these instruments, thereby simplifying somewhat the pilot's scanning pattern.

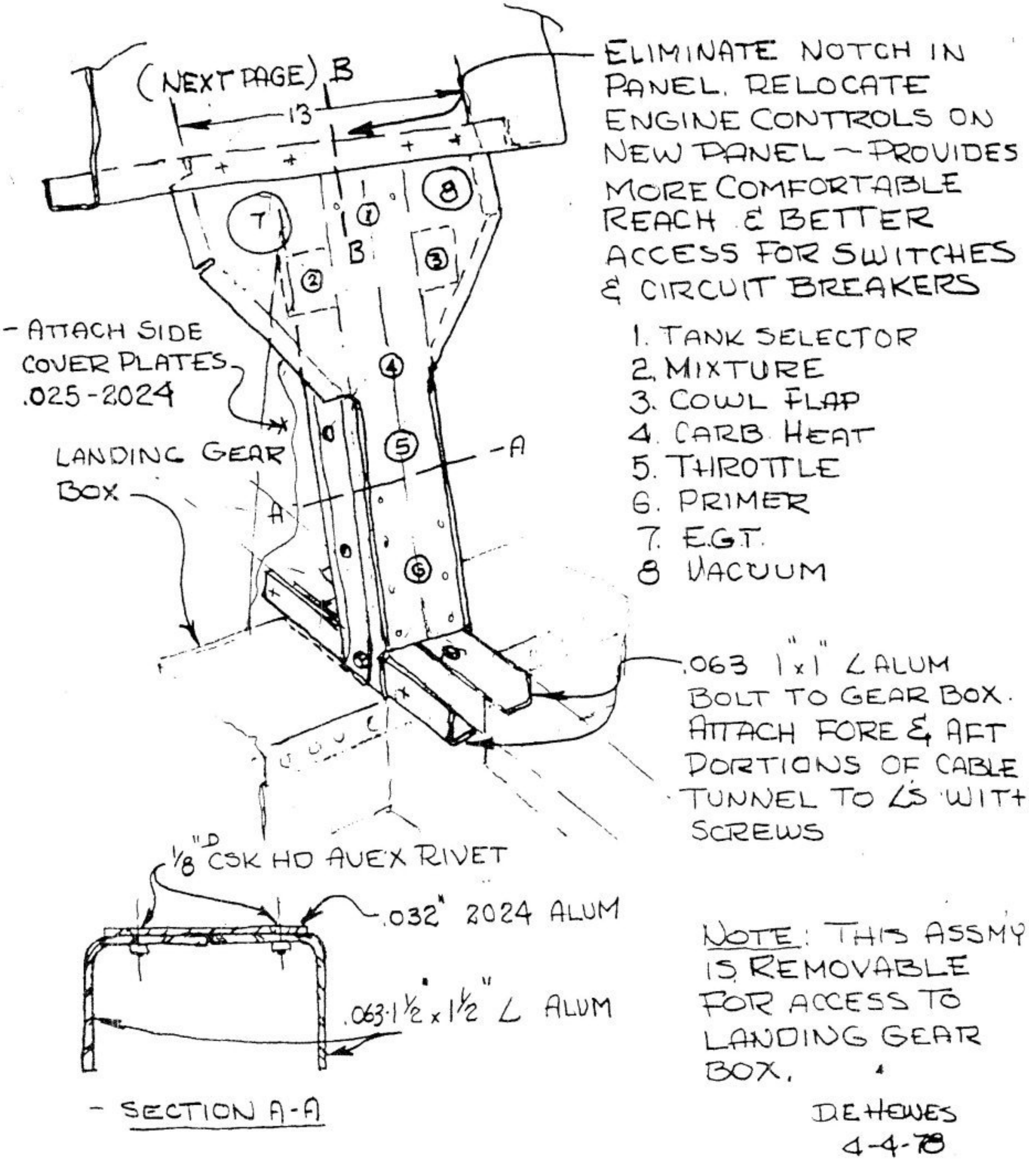


Figure 18 – Engine Instrument & Control Console

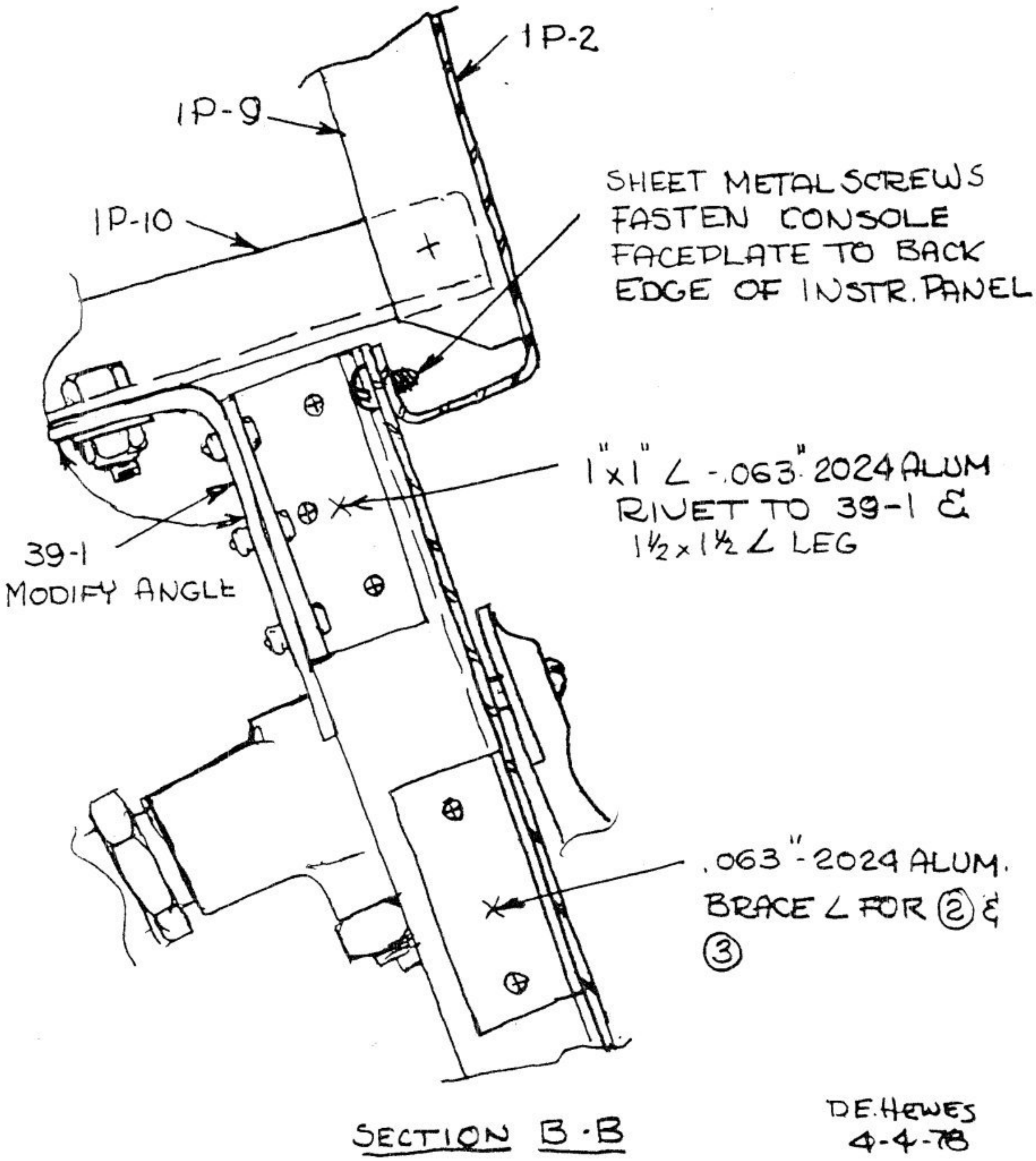


Figure 18a – Engine Instrument & Control Console

(intentionally left blank)

Figure 19 Landing Gear Access

After removing those blankety-blank screws several times so that I could inspect the landing gear fittings which were giving some problems (see Figures 20 and 21), I decided a change was in order. After analyzing the situation, it did seem ridiculous to remove the whole cover when you only needed to work in the areas at each end. The solution was then obvious - - remove only the end portions.

I cut the covers just inboard of the shock absorbers, being sure not to have the cut fall inline with any of the cover attaching screws. The tie plates were installed so as to transmit the shear and compression stresses produced by the landing loads.

I had already drilled the screw holes for the cover so there was a slight gap which resulted from the saw cut. It is suggested that in making up a new box the cover be cut before drilling the screw holes. In this way the portions of the cover can be fitted tightly together so that compression stresses will be transferred directly thorough the abutting edges. The tie plates will still be required to transfer the shear stresses, however.

An added benefit of this modification is that the covers can be removed without fear of the LGM walls buckling because the remaining center section of the cover provides necessary stiffness for the most critical areas of the walls. <u>Notice, however, that the airplane should be empty when the covers are removed and extreme care should be exercised because the unsupported portion of the walls are still subject to buckling.</u>

Editors note: There were problems reported with this mod, and it is not recommended the way it is described here. More support needs to be added to the LGM. Search the archives and the BD-4 newsletters for more information. (As soon as I can find the relevant references, I will put them here.) 12/2008 BW

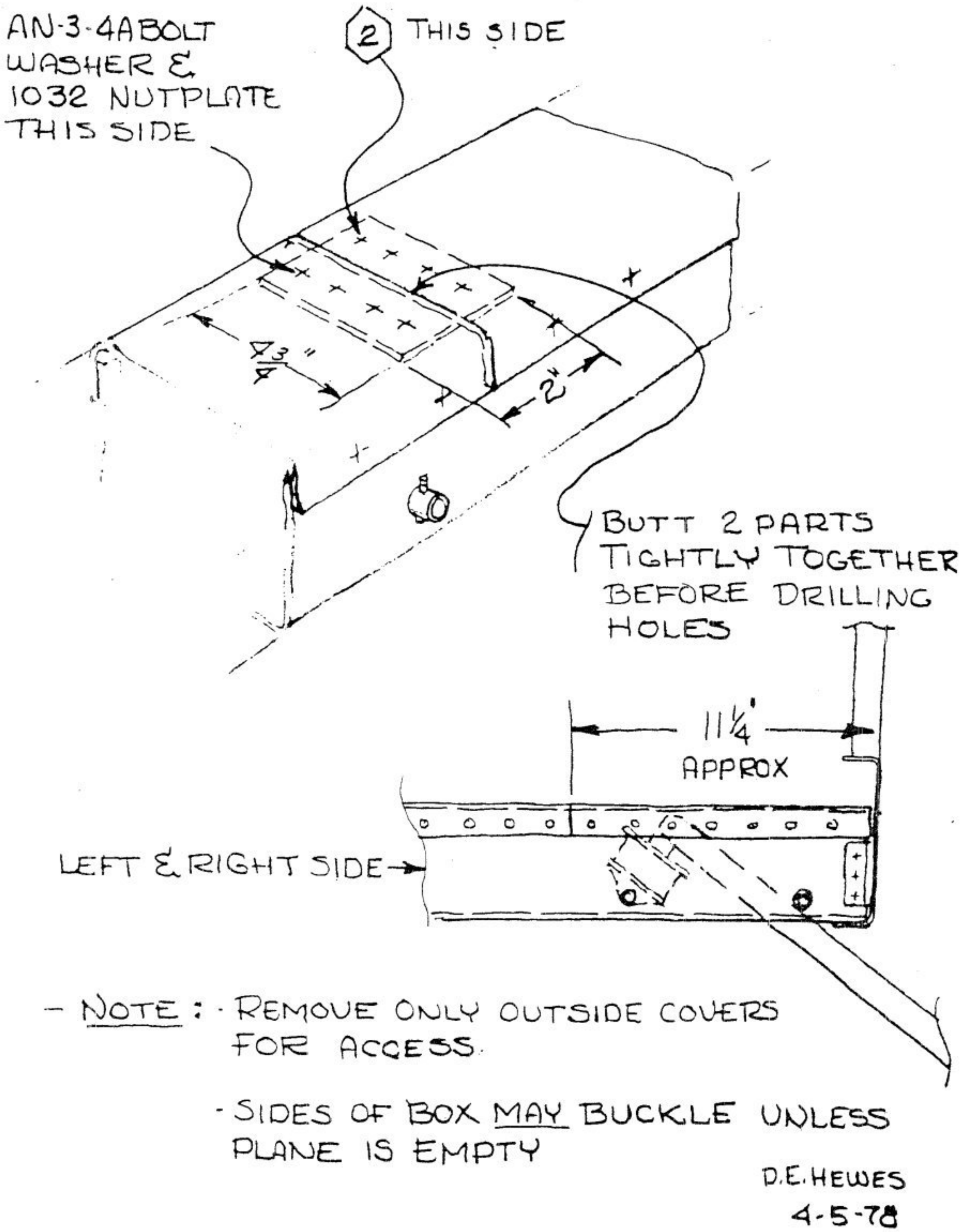


Figure 19 – Landing Gear Access

Figure 20 Landing Gear Box Reinforcement

After a hundred hours or so of operation I noticed that the screws attaching LGM-14 to channels 1 and 2 were gradually working loose in the countersunk holes through the channels. This appeared to b the result of inadequate bearing area in the channels for loads being transferred from the landing gear box. Note that the shank or straight part of the screw does not come in contact with the channel because the tapered head extends on into LGM-14. Therefore all the load is transferred from the screw to the channel by the bearing surface of the head. Since part of the head is bearing on the very thin inner edge of the tapered hole in the channel, it is doubtful that this portion is very effective in transferring its share of the load. Consequently there appeared to be a concentration of the stresses in the outer portion of the hole.

It can be observed that if the countersunk hole is made a little too deep, the screw head rests further in the hole and a significant portion of the most effective bearing area is lost. This may have been part of the problem in my case as the heads did appear to be recessed very slightly. Note also that if the countersink is a little shallow, you end up with a very thin edge of the channel material bearing against the shank of the screw. But, here again, it is believed that this thin edge is ineffective in transferring its share of the load. This seems to point to the very critical nature making proper countersunk holes for this type joint and that conservative approach should be taken at points where there are very high loads.

My solution was to add a doubler plate and more screws to transfer the load. The sketch shows a scheme slightly different from the actual method I used on N632-DH because I believe this to be much neater and just as effective. I actually placed the doubler plate on the outside to cover the old screw holes which were useless. I made the new LGM-14's with extended legs bearing against the channels so that new holes could be drilled through the channels beyond the old holes. I used four screws in a 3-1 pattern. The doubler plate was also riveted to the channel with about 10 Avex countersink rivets.

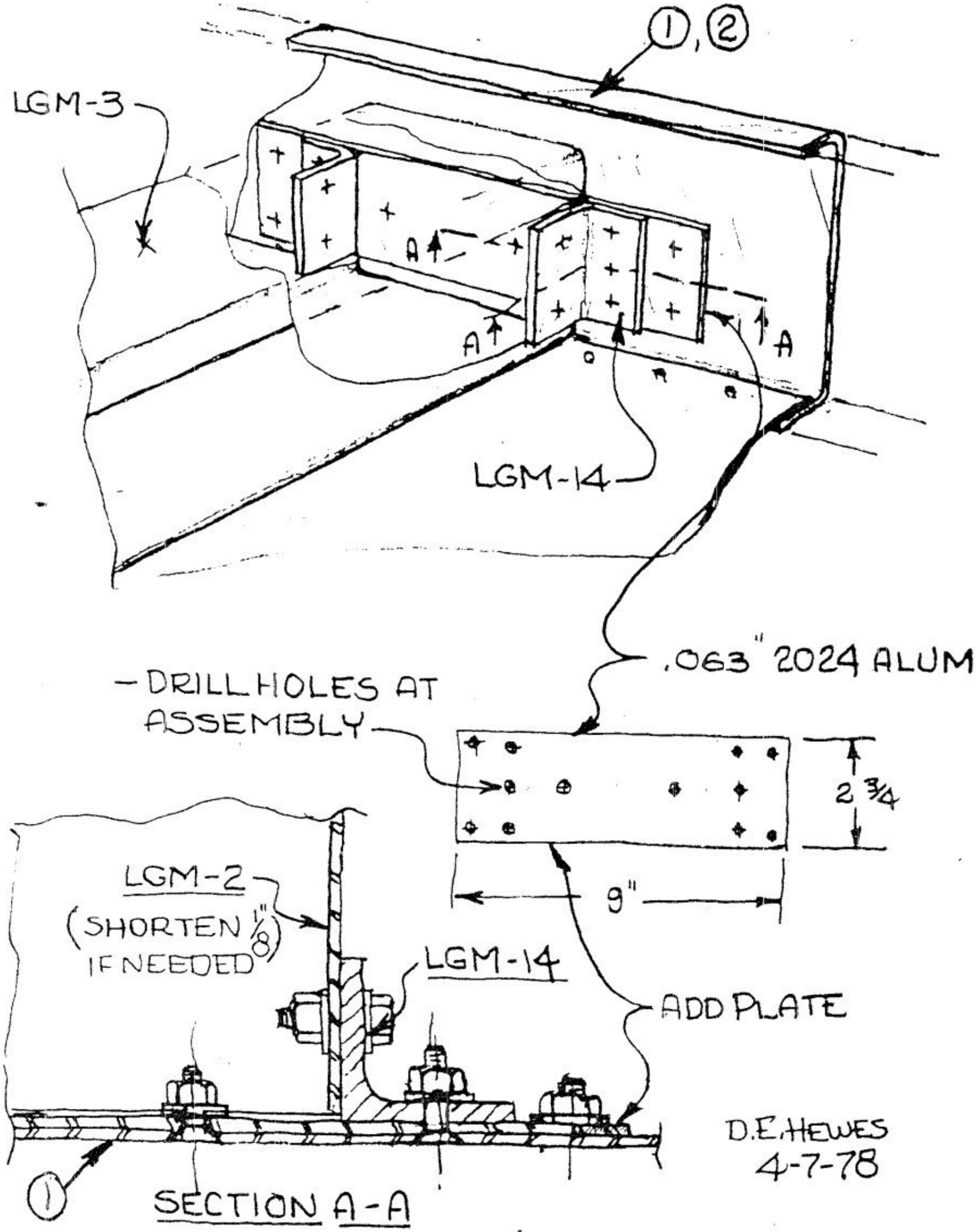


Figure 20 – Landing Gear Box Reinforcement

Figure 21 Modification to Strengthen Landing Gear Parts

The most obvious clue that the landing gear needed some beef-up was the squatting attitude of the plane that developed several times during the first couple hundred hours. About three times this squatting was found to be due to actual yielding in the aluminum legs which occurred about mid-length. The last time this occurred was the result of dropping the right wheel off the edge of the narrow concrete taxi into a mud hole just after I filled the tanks full and took on a passenger. The gear had yielded about ¾ inch measured at the lower end. The other two times both gears had yielded about 3/8 inch due to normal landing loads.

Each time I had the gear straightened by a friend who had access to a hydraulic press. On the last time, however, I had him bend the gear in the opposite direction so that the legs bowed downward about ½ inch. The net result of all this cold working of the metal is that the gear now seems to be much tougher now and has not yielded any further in over a year and a half period of operation.

The sketches show the other sources of problems with the gear and the methods I employed to fix them. The solution to all the problems was merely to weld in place small steel webs that helped transfer the loads more uniformly. IN the case of LGM-6, the tube was being distorted to an egg or oval shape by the torsion loads resulting from the drag of the wheel during the landing. It was obvious that the wall thickness was not sufficient to prevent the pivot shaft from yielding the edges of the tube. Before welding in the webs, I cut off abut ¾ inch from both ends of the tube and welded in place sections of a new tube.

I have heard several complaints about the shock donuts LGM-5 developing permanent set causing th airplane to squat; however, I have checked my units twice during the past four years and have found no evidence of set whatsoever. I suspect the problem actually is with the yielding in parts LGM-6 and LGM-8 in the shock assembly. The fix is very easy and I strongly recommend it.

As a final word, I'd like to say that I have seen several gross attempts at strengthening the landing gear system, which I consider Ill-advised! Not only do these approaches increase the airplane weight by many needless pounds but the also force some par of the cabin structure to become the point of failure in the event of a crash landing. All crash worthy studies show that your greatest change of survival is achieved when the cabin structure is maintained intact. Consequently, these attempts to over-strengthen the landing gear are inviting disaster. Personally, I would much rather wipe out my landing gear in a severe landing than to lose my life.

I have attempted to strengthen only those points that appear to be weak under normal operational loads, and left the rest of the structure unchanged. This was done at the cost of not more than 2 pounds.

Of course all of this discussion is merely opinion and is not backed up by good solid engineering analysis, but think that you will agree that it does make sense and is worth considering.

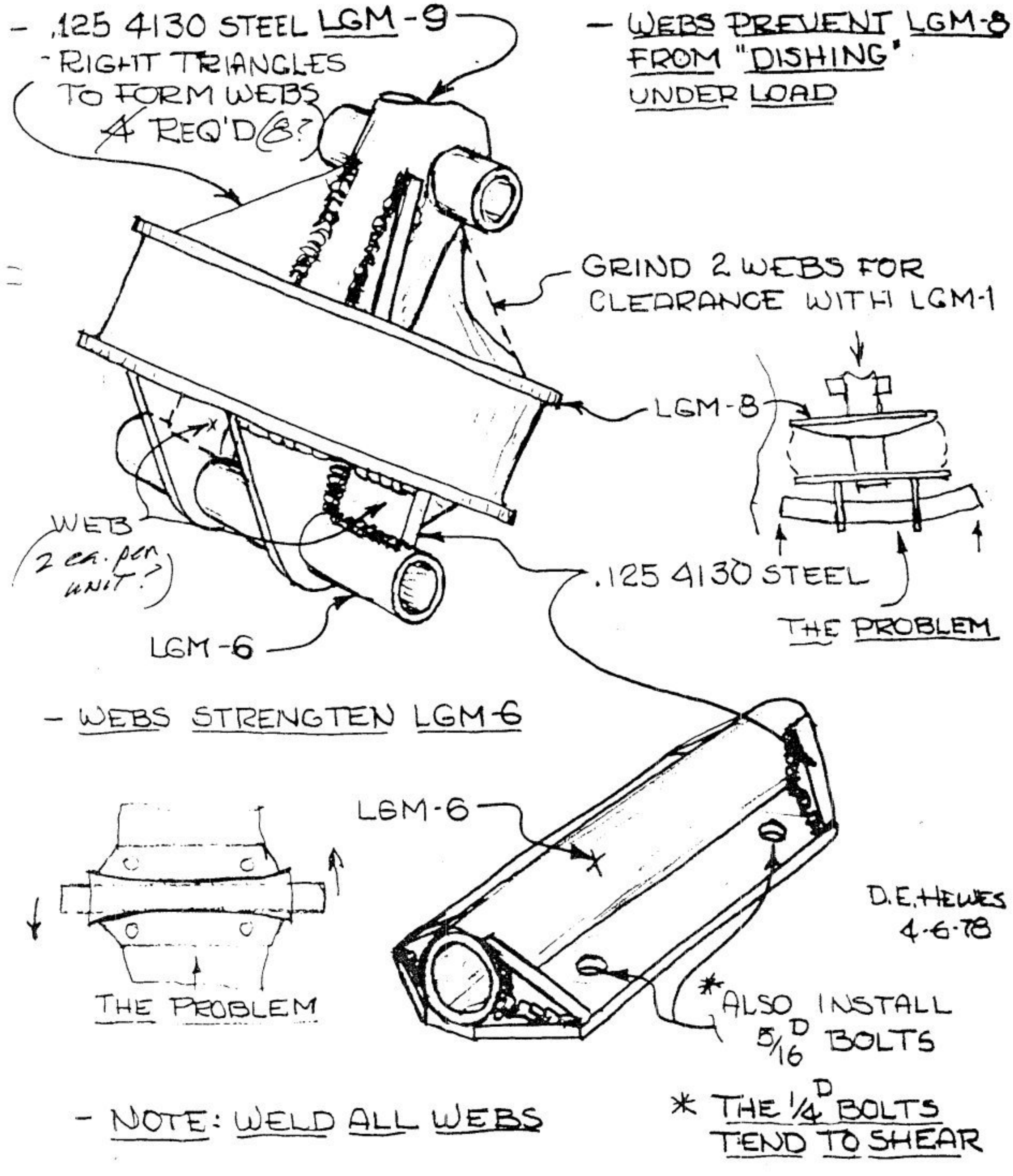
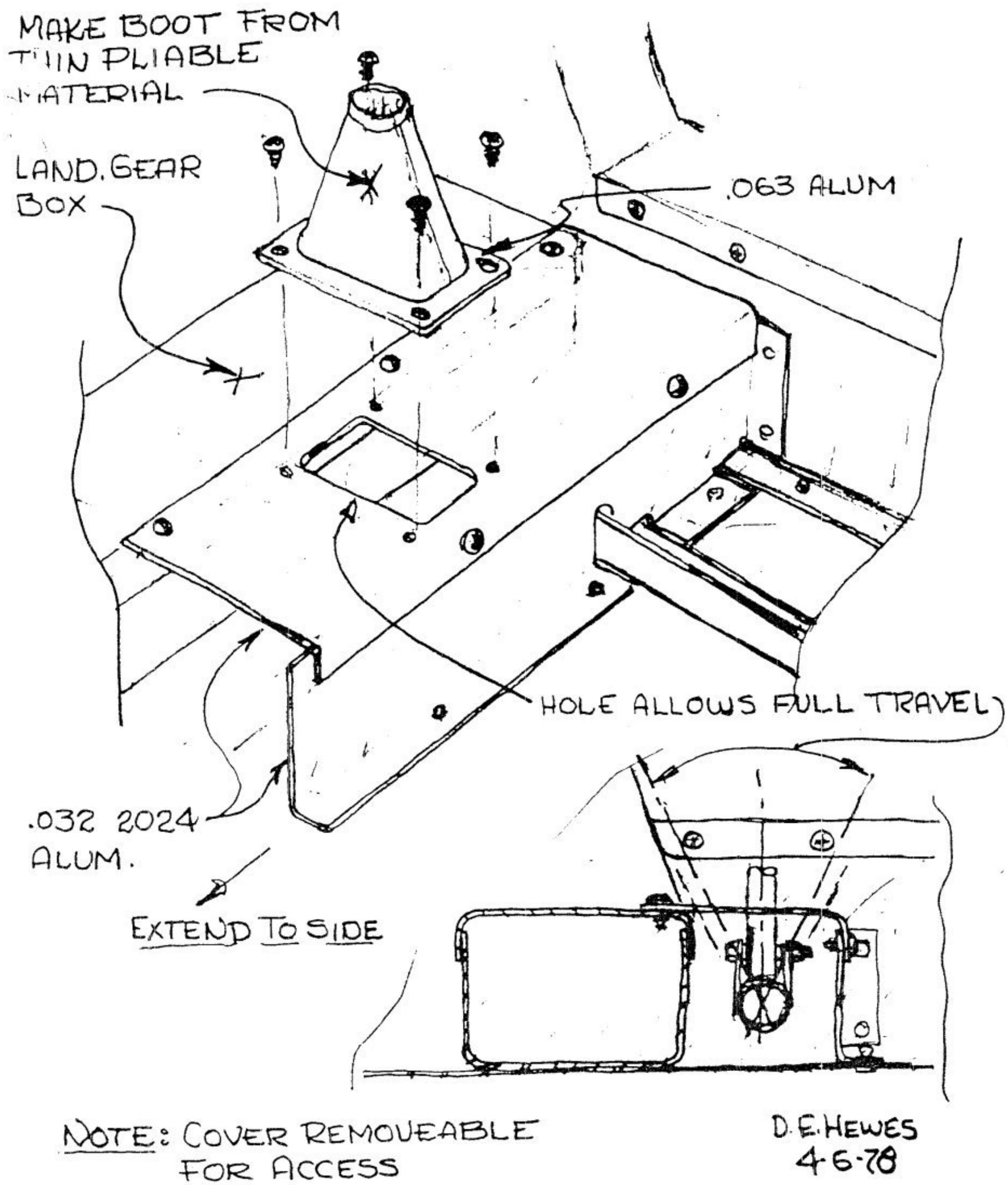


Figure 21 – Modifications to Strengthen Landing Gear Parts

Figure 22 Control Stick Cover

I consider this to be an absolute safety "must" whether it is accomplished as I have shown or in some other way. You must consider that, sooner or later, a screwdriver, a pencil or some other loose object is going to get wedged into the control stick assembly unless some shield is installed to prevent it occurring. DON'T WAIT FOR IT TO HAPPEN BECAUSE IT WILL BE TOO LATE. You'll be so occupied with trying to control the plane and maintain your cool that you will never be able to figure out the problem and locate the source. <u>Put it in now!</u>



(A SAFETY FEATURE – KEEPS OBJECTS FROM JAMMING CONTROL STICK)

Figure 22 – Control Stick Cover

Figure 23 Aileron Bellcrank Cover

I say again. Put it in now! You'll never be able to reach back there anyway.

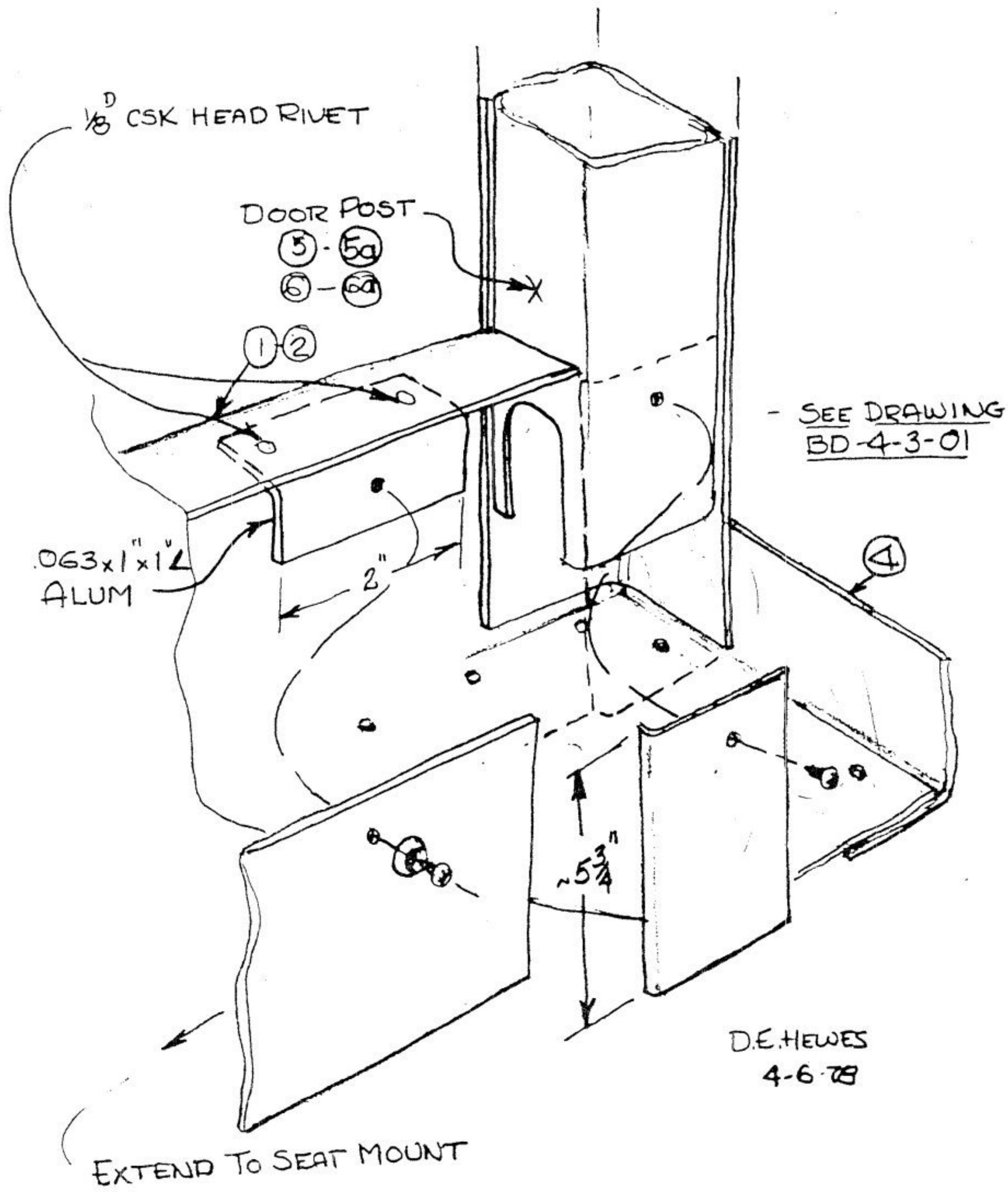


Figure 23 – Aileron Bellcrank Cover (Another Important Safety Feature)

Figure 24 Control Stick Modifications

These are two conveniences that I installed. My wife rides with me often on cross-country trips, but she does not care to fly the plane. So the stick is not needed, and it interferes with her working the charts.

I provide headphones for all passengers because of the ear-damaging noise level, (Don't kid yourself, the all are too noisy) and I have the boom mike because of the great convenience. The mike button on the stick is therefore a natural. (Also, on those long cross-country legs, you can daydream a bit – squeeze down and make believe you've got the RED BARON in our sights – TA-TA-TA-TA-TA-TA---- Be sure you switch off your transmitter first!)

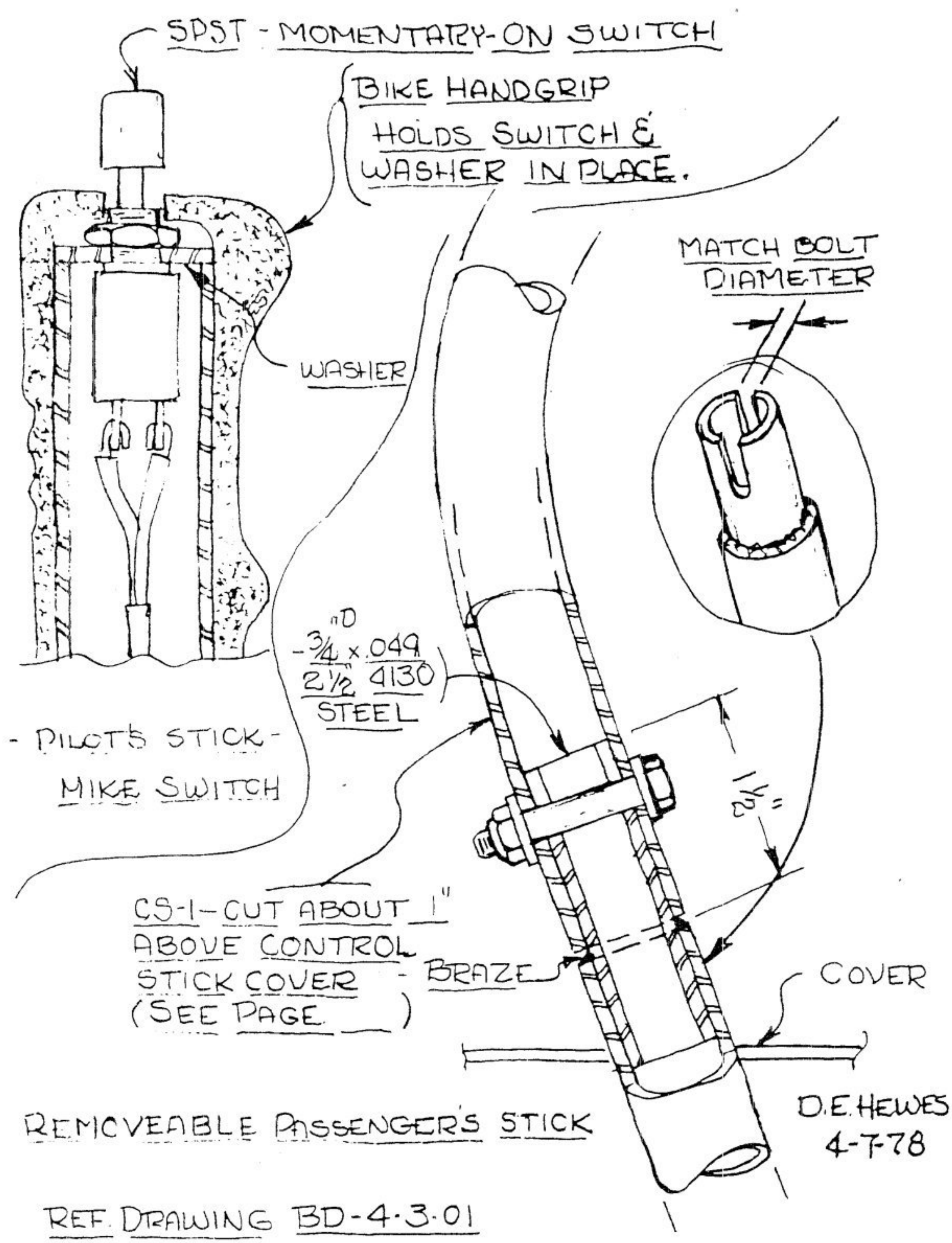


Figure 24 – Control Stick Modifications

Figure 25 Control System Modifications

I found the elevator trim extremely sensitive and very difficult to set properly at cruise speeds because of the high friction level. My solution was to grind the diameter of the groove in the wheel down to the point where the two bolts pass through. This was a big improvement. It still is quite sensitive but the influence of the friction is less. Maximum trim changes are handled by about ¼ of a turn.

When I first started my taxi tests, I noticed that very high brake pressure was required to keep from rolling during engine run up. Later, I heard of others having the same problem, so I decided to reduct the arm length from the pedal to the brake assembly by one-half so as to double the pedal's mechanical advantage. Inasmuch as a properly bled brake system requires very little displacement of the piston to activate the brakes, the resultant increase in pedal travel was not noticeable.

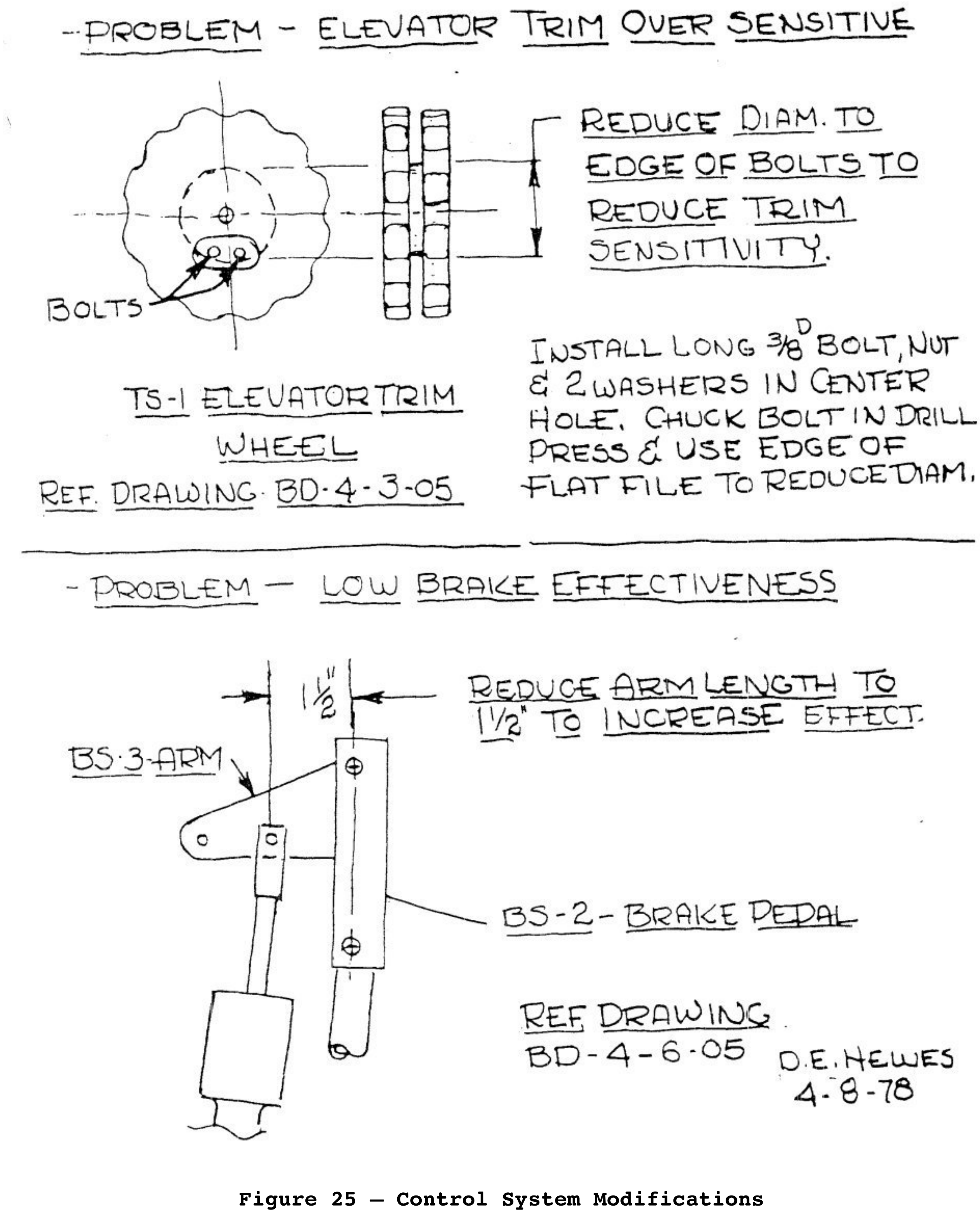


Figure 25 – Control System Modifications

Figure 26 Rudder Trim System

Although directional trim changes are fairly small, they are large enough to require some rudder for a fair portion of a cross-country flight. Inasmuch as the rudder is very effective, the use of rudder control to maintain ball-centered flight tended to be a bit tedious.

Installation of the in-flight adjustable trim tab in place of a previously installed ground adjustable tab was a very welcome addition. It is now possible to make most of the trip with feet off the pedals.

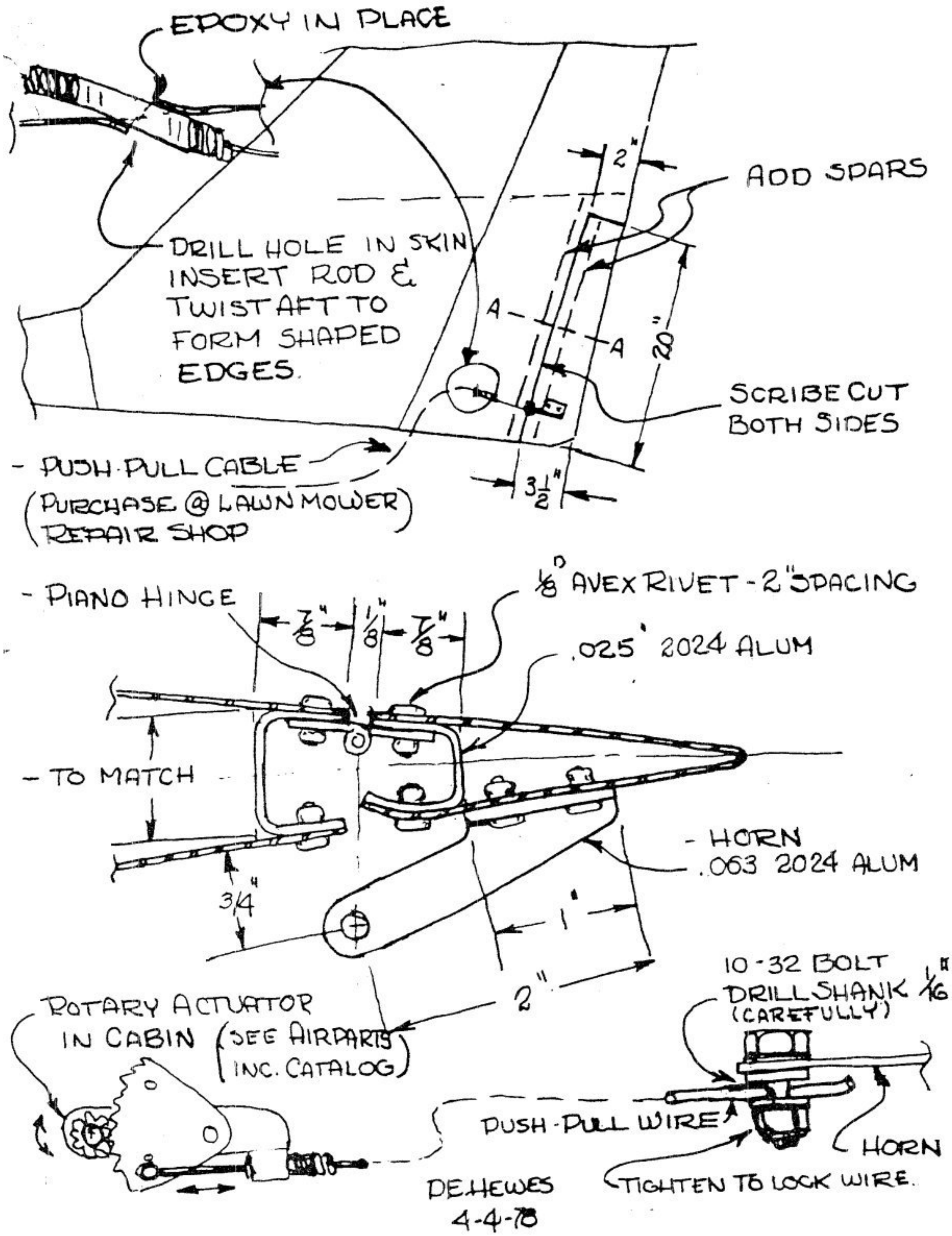


Figure 26 – Rudder Trim System

Figure 27 Rear Fuselage Access

I don't think that Jim ever tried to inspect, lubricate or adjust the rudder bellcrank and cable assembly at the rear of the fuselage; otherwise he never would have specified a 4.00 inch diameter hole through which to perform the act. Needless to say I thought I should have a little bit more. But why mess with a bigger hole in the skin when you can just as well take off the whole rear portion of the skin? It takes only a few more screws and is <u>so much</u> better. You can even get both hands in and really do a good job.

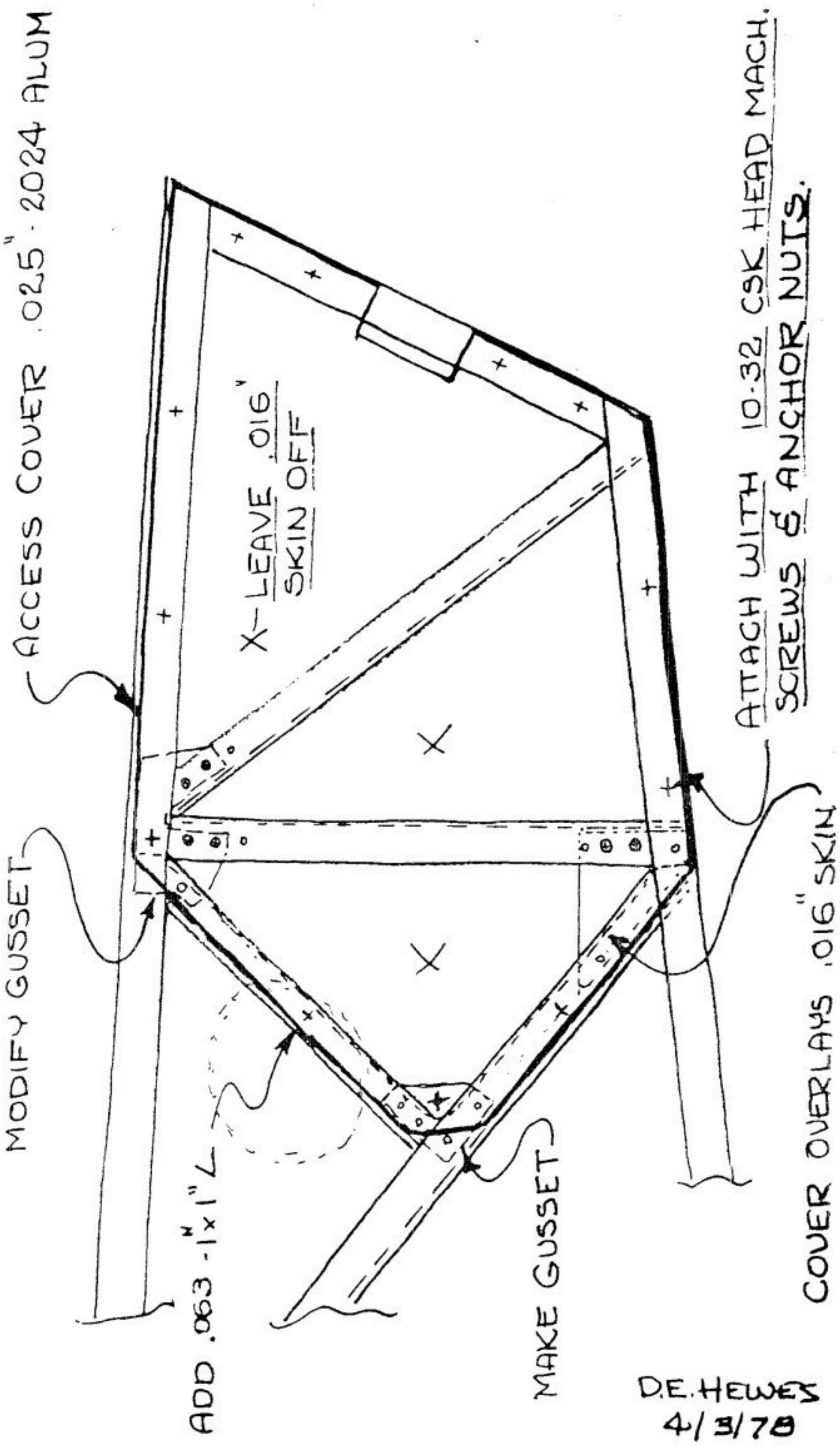


Figure 27 – Rear Fuselage Access (one side only)

Figure 28 Tail Wheel Installation

The one item Jim really goofed-up is the tailwheel spring attachment at the front of the spring. I admit that I goofed-up also because I overlooked the 0.063 inch aluminum plate called out to fill in the area between the two bottom longerons 26 and 27. Jim goofed because he called for the 2 X 2 inch angle at the front of the plate. Unfortunately the elevator push-pull tube occupied the same space as the up-turned leg of that angle. I elected to cut out the leg to allow clearance for the tube rather than vice versa for fairly obvious reasons. The net result was an upturned leg about ½ inch high at the centerline rather than 2 inches. Now, without that plate, you can guess what the end result turned out to be. Yes, on the third landing it all but fell out. (I had one heck of a time trying to tow the plane home by the tailwheel which was fastened to the plane primarily by the two cables. It was hair-raising.)

Even if I had installed the plate, which I obviously would have, I believe that this angle member would have failed with resultant excessive flexing of the tailwheel assembly.

The sketch shows my solution to the problem which has proven to be very satisfactory. Note that I did not use the aluminum plate because this fix completely eliminated the need for it. The vertical loads at the front of the spring are carried directly through the V-tube assembly to the vertical members in the basic structure. The side loads are carried to the two bottom longerons by the strap across the bottom.

Two other modifications are included in the Figure. The coil springs are mounted internally for better appearance and the top-short leaf of the tailwheel spring assembly was discarded to reduce stiffness and weight.

By the way, I reversed the location of the rudder cables and rudder push rod on the rudder bellcrank from that originally specified and as shown in Drawing BD-4-2-04 #2. I did this to reduce the rudder sensitivity and I note that Jim has subsequently done the same thing as can be noted in Drawing BD-4-3-06 which has been updated.

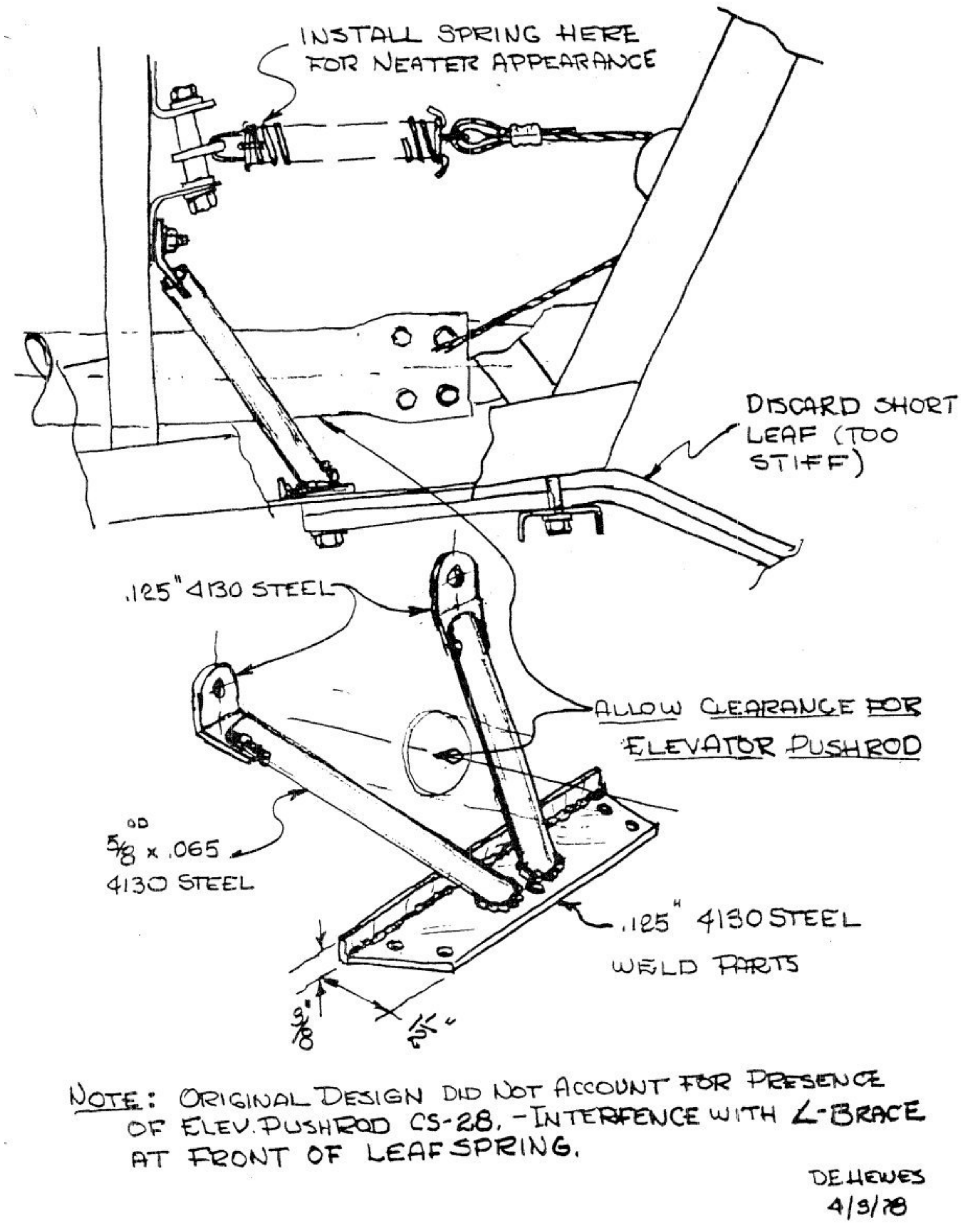


Figure 28 – Tailwheel Installation

Figure 29 Wing Fold Hinge

After observing the difficulty that John Whistler had in installing the original wing folding mechanism and getting it all properly aligned, it occurred to me that there was a simpler way – simpler at least from the standpoint of making and installing the parts. There are no critical dimensions involved in this scheme.

The hinge assembly is fastened inside the fuselage spar by two flush head machine screws attached to the micarta ring. The wing panel is attached to the assembly, which merely slides within the wing spar, by a cable attached to the spar at the wing tip. The length of the cable is adjusted so that the assembly can be pulled just to the end of the spar without extending beyond it.

With the wing in the position shown in the top sketch, it is pushed in until contacting the fuselage spar. The rings support the wing loosely so that the tip can be worked up-and-down and fore-and-aft so that proper engagement of the two spars can be obtained. Be sure, in making the hinge joint, that the center lines of the two tubes are nearly coincident when the assembly is straightened. This alignment determines the alignment of the two spars for joining. The loose slip fit of the two rings in the wing spar will take care of small misalignment.

Note that the wing should be supported fairly well in the direction perpendicular to the axis of the hinge when the assembly is straight. If the hinge is not straight, it will automatically rotate to relieve and load that tends to develop perpendicular to the hinge axis. When it is straight, however, it cannot rotate unless the hinge pin is canted with respect to the direction the load is applied. If the load does build up in the hinge, the assembly will bind and the wing will be difficult to slide onto the fuselage spar. Also, I doubt that the hinge would support the bending moment produced by the full weight of the wing.

When folding the wing back for storage, be sure the hinge pin is <u>not</u> in the horizontal position.

<u>DO NOT TRY TO REMOVE A WING PANEL IF THE TANK IS MORE THAN 1/4 FULL</u> because it will be very heavy and difficult to handle with sloshing fuel.

There are no close tolerances for any of the dimensions of these parts other than being sure the two tubes are coincident to within ± 1/32 inch or so, when assembled. The rings for the wing spar unit can be a real sloppy fit inside the spar. Be sure the rings are held by the collars so that they are free to rotate easily with no binding. <u>LUBRICATE</u>!

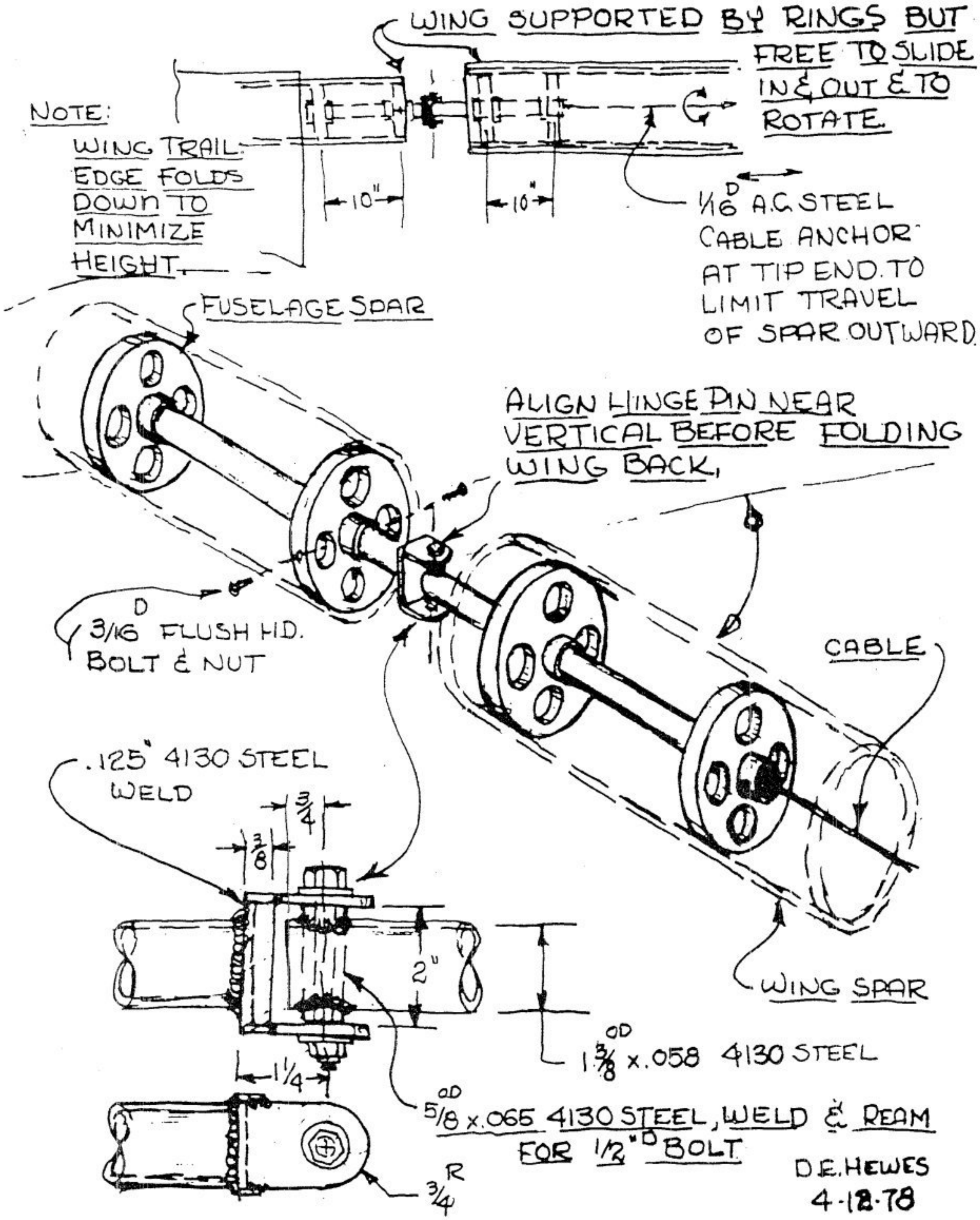


Figure 29 – Wing-Fold Hinge

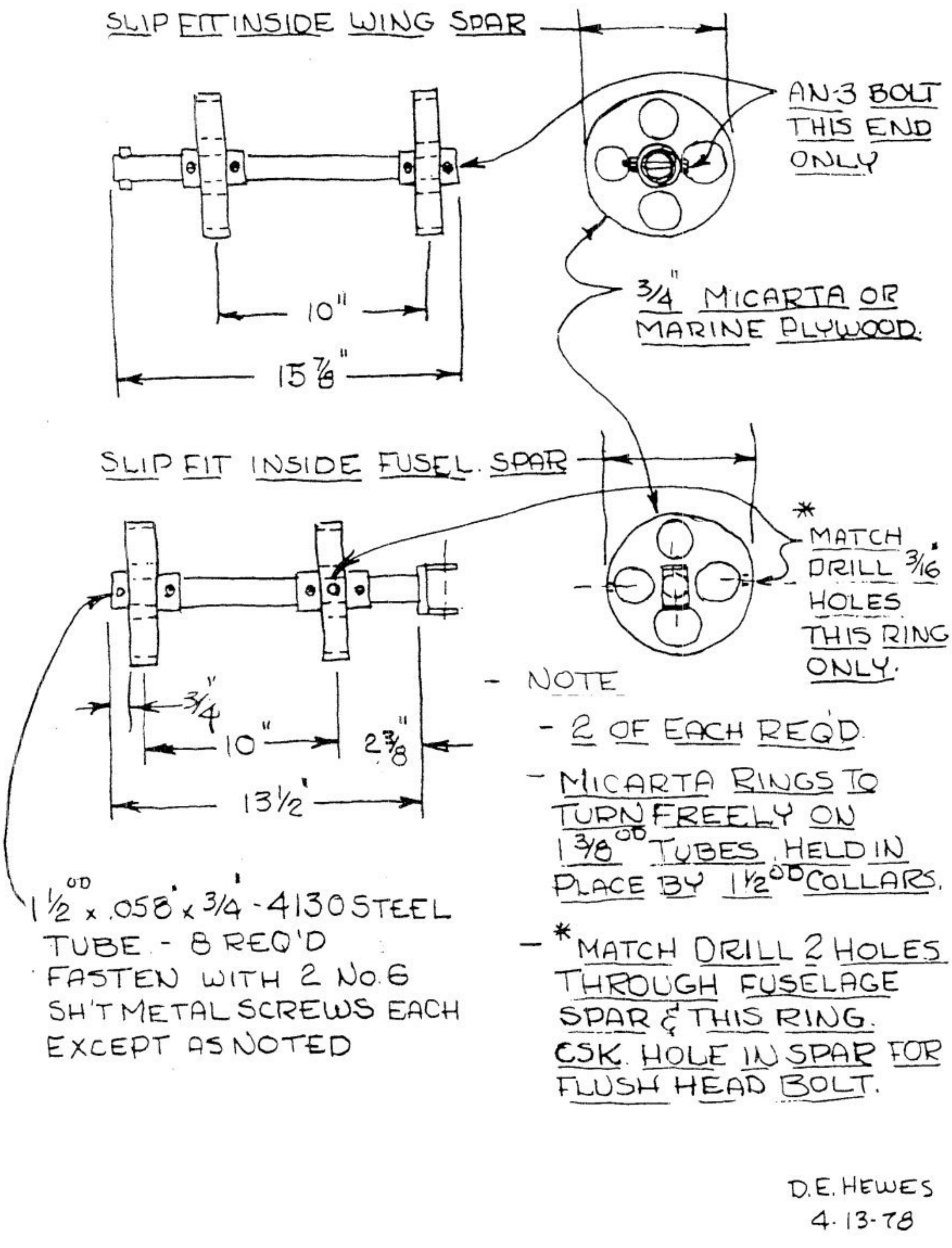


Figure 29a – Wing-Fold Hinge (continued)

(intentionally left blank)

Figure 30 Wing Rack

I fold the wings back with the railing edges down, rather than up, so as to reduce overall height to permit the plane to fit under the roof of our carport. This made it impossible to support the wings by the tie-down eyes because the bottoms of the wings faced outward rather than inward. I therefore made the rack as shown with tubes at the ends which extended through holes drilled in the skins and spars. These holes are about two thirds of the way out on the panels and in no way seriously affect their useful strength.

The rack is mounted to the fuselage just aft of the break behind the windows and just ahead of the dorsal fin.

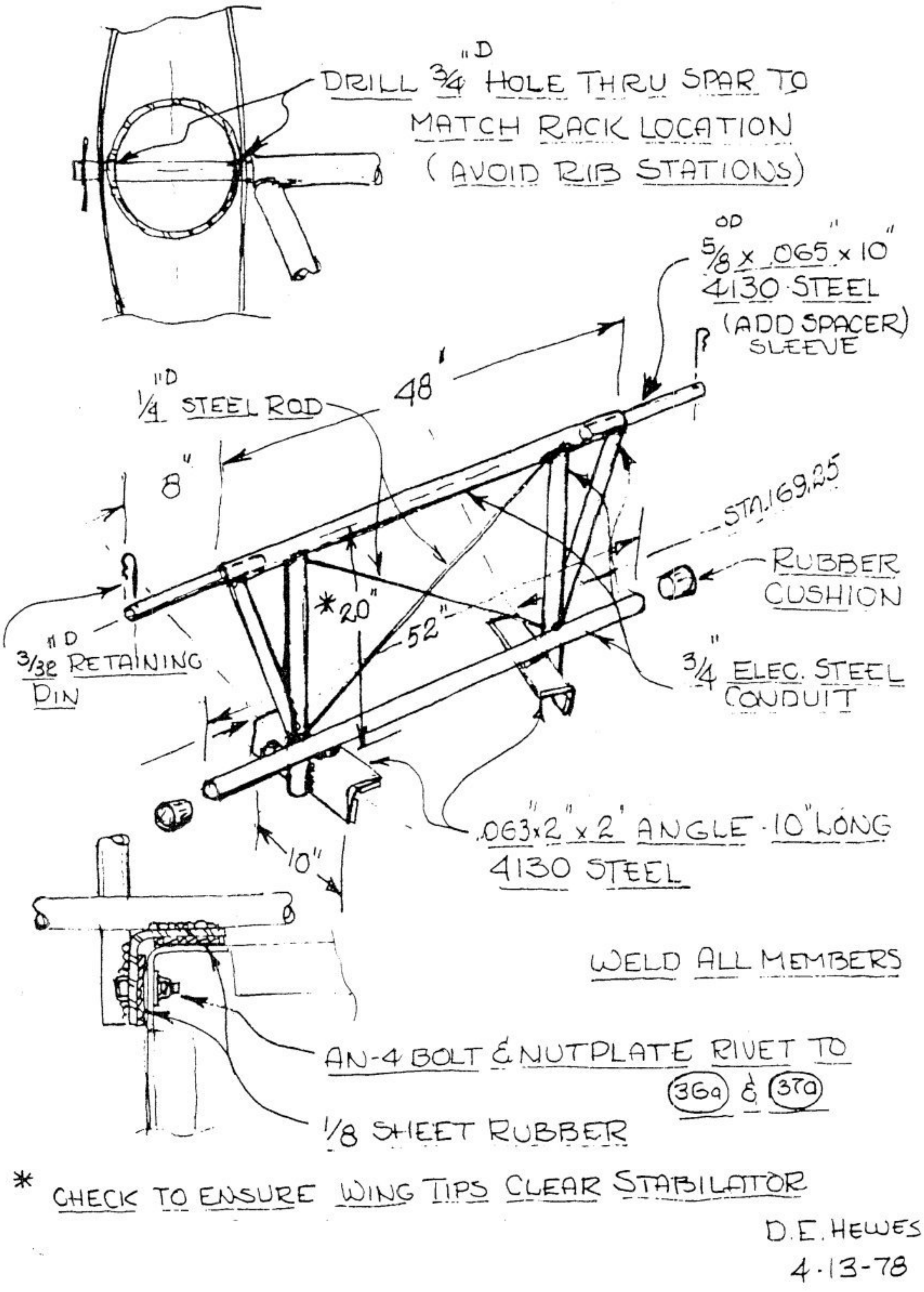


Figure 30 – Wing Rack

Figure 31 Wing Jacking System

A jacking system is required to snug the wing up to the fuselage and break it loose after a long time in place. I installed it at the front of the spar where I had convenient access as the result of installing the overhead panel shown in Figure 10. It could also be installed aft of the spar, if desired.

The bar is installed after the wing has been slid onto the fuselage spar a short distance. A person must hold the wing at the tip to relieve any bending at the joint, otherwise the spars will bind. The bar is slid between the two bolts in the pivot and through a 1 inch hole in the side of the fuselage. The bolt-end of the spar should fit snuggly into the slot in the bracket so as to stay in place as the arm is slid in place and pressed to pull the wing in. The bar is removed after the wing is in place.

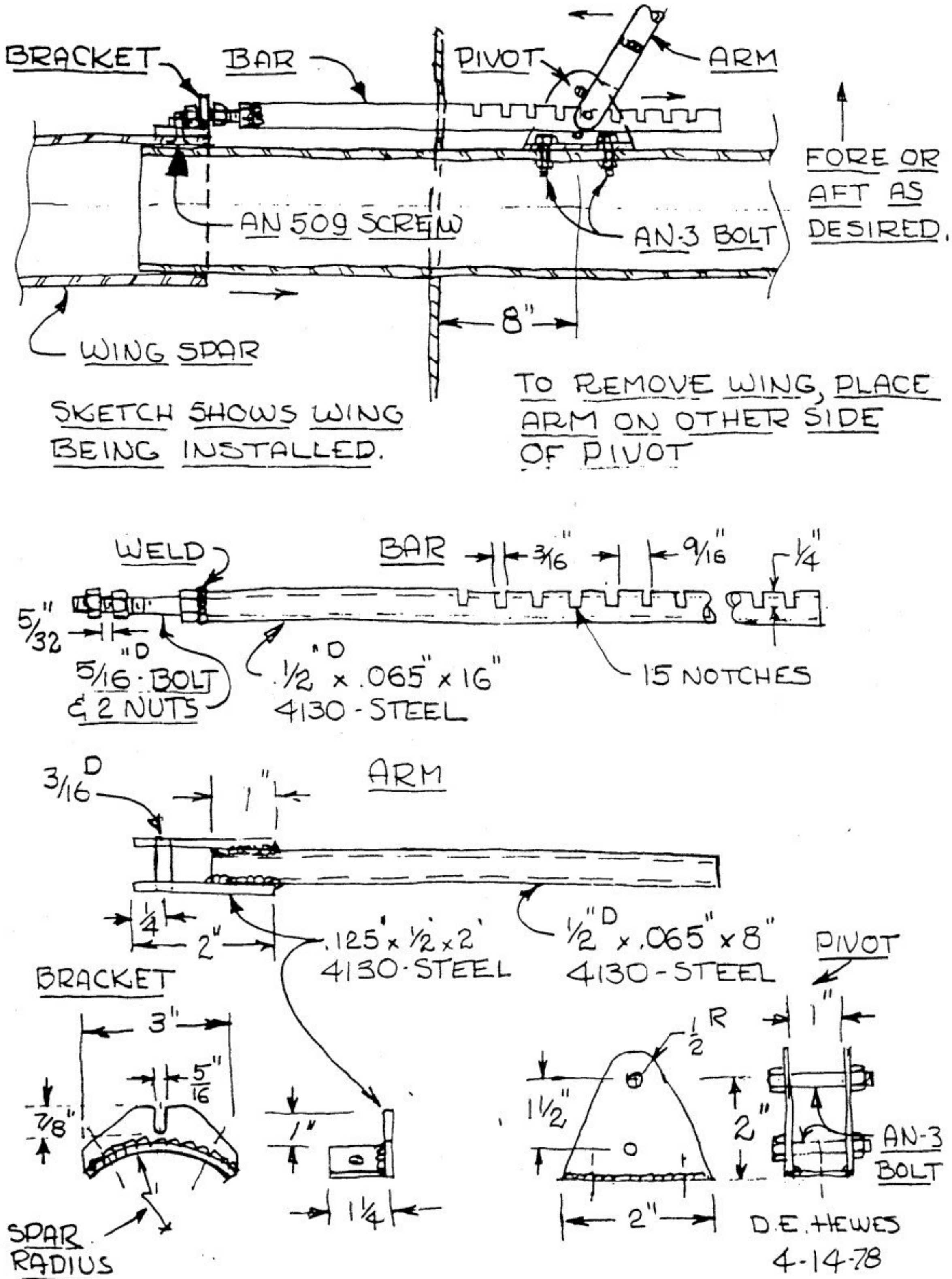


Figure 31 – Wing Jacking System

Figure 32 Wing Handling Equipment

A wing panel is a rather delicate but awkward object to handle. Unfortunately no suitable provisions were made for conveniently lifting the wing at the tip. The fiberglass tip is very flimsy and will buckle quite easily if you try to lift the tip. Consequently, I devised a rather simple solution by merely clamping a suitable length of a 1 inch diameter tube to the end of the spar and extended it so that it just passed through the tip where it was filed flush with th surface. (The tube was the left-over pieces of the aileron torque tube. You see, I told you I was a miserly sort.) For handling I merely insert a short rod or tube, and lift. When finished handling, I remove the rod and snap on a small aluminum hole cover.

When installing the wing onto the airplane (or taking it off) I use a separate handling rig which provides convenient handles to facilitate maneuvering the panel into position either at the spar or at the rack. It is indispensable when lifting the wing off the rack, swinging it around the spar position and then lifting it up over my back so that it can be slid on the fuselage spar.

I find that I can stand facing inward or outward under the wing with my head bowed and with the horizontal cross-bar resting across my shoulders and gently press forward to either install or remove the wing. A gentle sideways or up and down motion of a half-inch or so using my body will help break the wing loose from any binding tendencies due to misalignment.

Even with this handling equipment, I find the job of installing or removing the wings a rather tiresome task and I do it as seldom as possible. Keeping the pane home and running out to the airport to go flying and then returning is not a practical scheme with this airplane. You will soon tire of the task if you attempt it. It usually takes me 30-45 minutes to do the job one-way <u>not</u> including the time to drive to the airport or back.

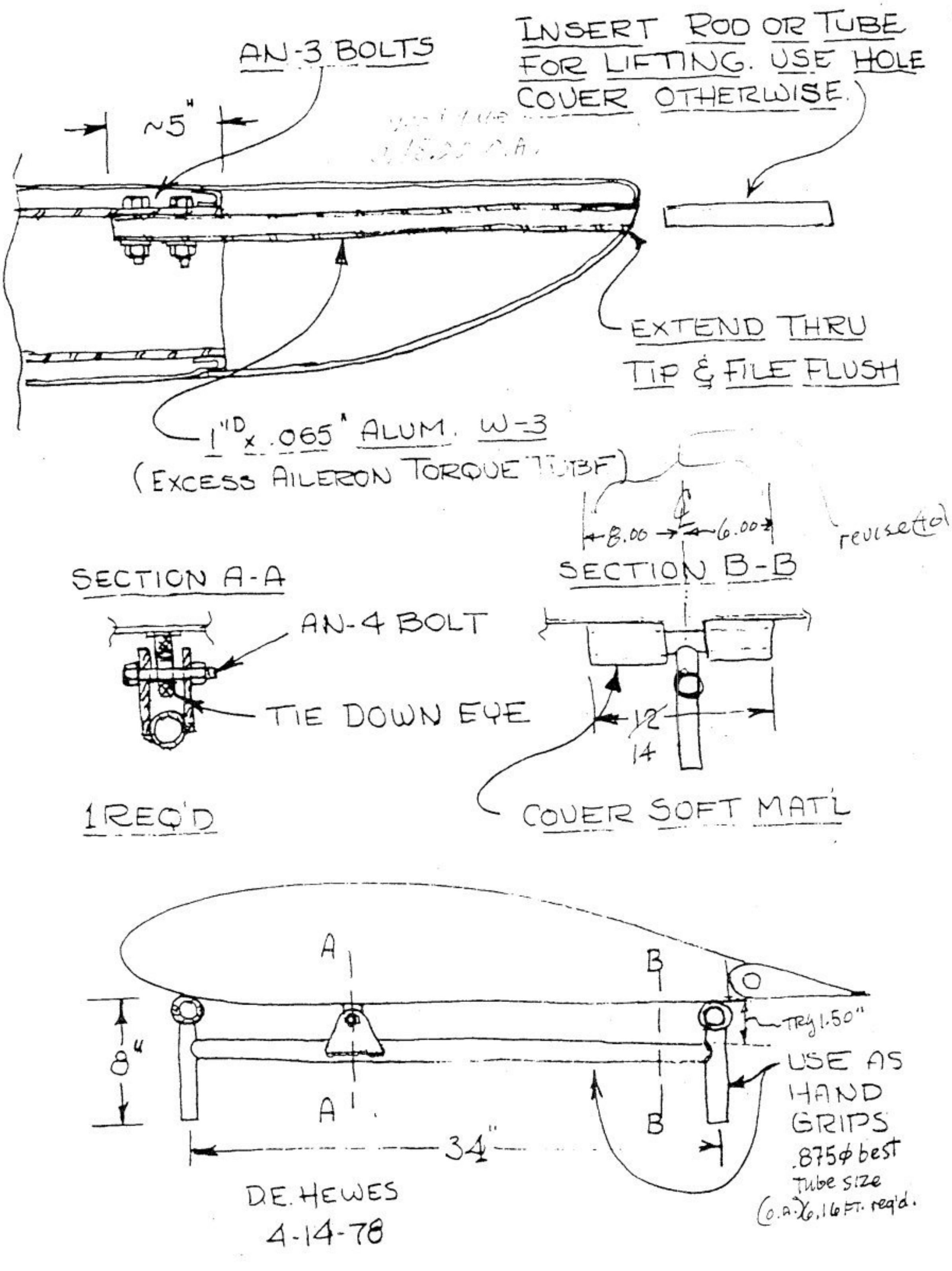


Figure 32 – Wing Handling Equipment (use when removing wings)

Figure 33 Gas Tank Modifications

Because of the integrated construction of the fuel tanks and the lack of wing dihedral, there are some problems relative to low-fuel conditions. First, when the plane is in level flight attitude, the fuel is spread throughout the whole tank rather than being concentrated at the inboard end which would be the case if the wing had positive dihedral. Second, the fuel pickup ports are installed so that they are about ¾ inch above the bottom of the tank. The result is that a fairly large quantity of fuel can be remaining in the tank when the fuel pick-up ports start picking up air. Third, whenever the plane pitches up for a climb or down for a descent, these ports will start to vent whenever more fuel is remaining in the tanks. Fourth, because of the high sensitivity of the rudder, the airplane is very easy to sideslip, and it is quite easy to be flying inadvertently with rather large amounts of sideslip for long periods of time. This can result in even fairly large amounts of fuel being forced away from the fuel ports.

To help overcome these problems, which can result in some rather breathless moments, I installed the fittings shown in the top sketch on each of the fuel pick-up fittings. With these in place, I have run tests with one tank to check on residual fuel fro normal straight and level flight, and found that in one test there was 1 ½ gallons left and in the other test there was 1 gallon remaining. This is as good or better than in most any other airplane, I believe. Without the fittings installed, I believe the residual fuel would be about 3 gallons in the tank, although I have not made actual tests to prove it.

I have developed a piloting technique to help counter the remaining problems of fuel starvation under low fuel conditions. First, I don not take off unless I have at least one-fourth full fuel tanks, and I use the one with the most fuel. Second, I always try to fly with the ball centered as closely as practical. Third, I plan on stopping for fuel before running low. Fourth, if I am caught in a situation where fuel is running low, I purposely will slip the plane slightly to force fuel in the tank being used to run to the inboard portion of the tank where the pick-up fittings are located. I also avoid any large or rapid changes in pitch or roll attitude so as not to slosh the fuel around.

I found it impractical to install finger strainers on the pick-up fittings I installed because of the lack of adequate clearance with the bottom. However, I wanted to have strainers for the tanks to prevent contamination of the fuel system. Consequently, I installed the strainers depicted in the lower sketch; not only do they keep out any foreign solid materials, but they also provide a very easy way to make a visual check to see if the screens have become clogged. Of course if they have, the line boy will be the first to find out because he will get a face full of fuel if he squeezes the handle too hard and isn't looking. The screens can be easily removed for cleaning.

An added bonus is that the bottom serves as a cup and will hold a portion of any water that seeps through the cap or is pumped in with the fuel. Therefore, it provides a means for visually checking for water. If the gas attendant has pumped in watered fuel, you have the proof right there.

Figure 33 (continued)

When installing the fuel filter, I moved it forward slightly to permit the strainer assembly to clear the spar and also to place the filter at the highest point of the tank for the tail-dragger attitude of the airplane sitting on the ground. This provided the means for getting the maximum possible amount of fuel on board. It was also necessary to extend the fuel vent line forward to a point just behind the filter. With these modifications I am able to put 27 ½ gallons of fuel in each tank which is composed of four panel sections. That gives the airplane an endurance of almost seven hours, which is at least four hours pat my endurance or "capacity".

The bottom sketch is a fix for a very serious problem that I encountered this winter. I was very fortunate in that the flight I took lasted only about 15 minutes rather than my potential three hours I just mentioned. If I had gone much longer, either the engine would have quit or my left wing tank would have ruptured, with unknown results in either case. The problem was caused by some very humid weather followed by a quick freeze, and by low air pressure in my right tire, and having selected the left tank for the flight.

Because of the low tire, the right wing was slightly lower than the left wing as the plane sat on the ground. Because the weather was cool and very humid, moisture collected on the inside of the vent lines, and because of the wing tilt, the moisture drained out the right line but could not drain from the left line. Because the weather quickly turned cold at night, the moisture froze solid in that line and because I took off early the next morning, before it warmed up, using the left tank, the wings began to collapse as a result of the vacuum being created by the fuel pump. This would have gone unnoticed until too late if the flight hand been any longer. Needless to say I was pretty well "shook up" when I got out and saw the panels looking like a dried prune. There was great relief when I pried loose the gas cap an the panels popped back to normal shape.

I hope that this fix will eliminate this very freaky problem by providing a small vent hole located far enough above the horizontal section of the vent line so that the moisture cannot block the hole. Any fuel venting throughout the line should pass on down past the small hole that is located only on the top of the line.

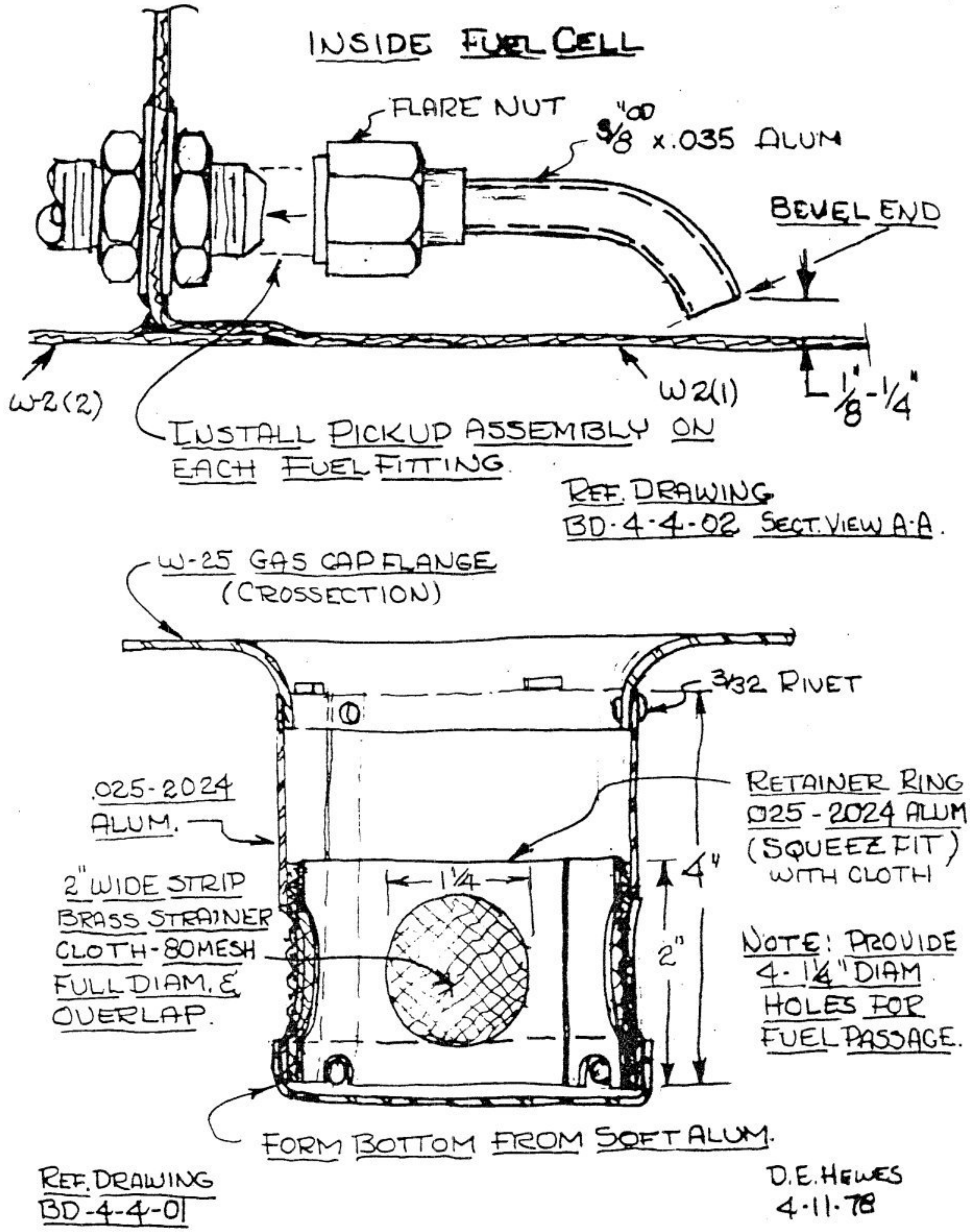


Figure 33 – Gas Tank Modifications (see next page)

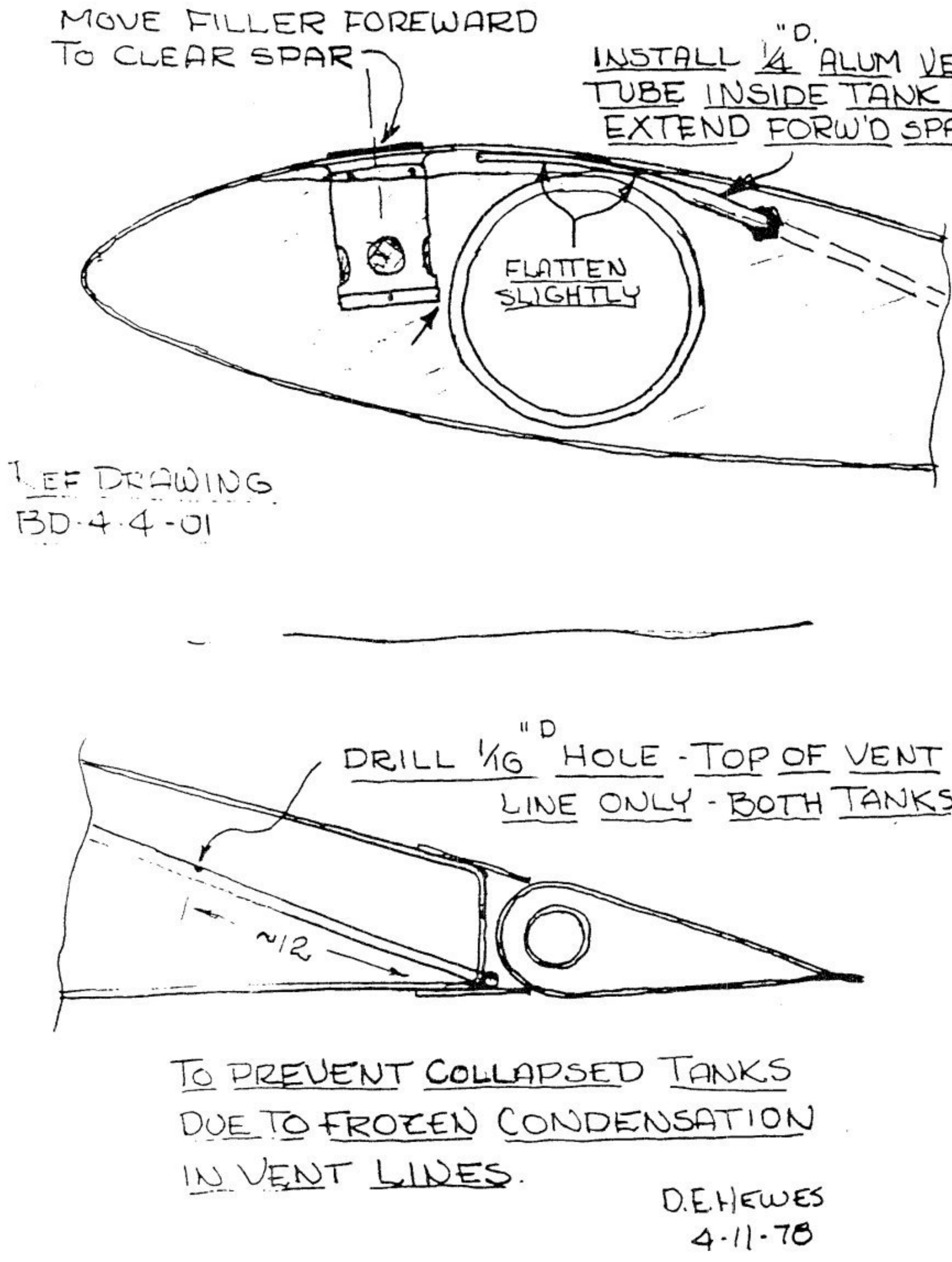


Figure 33a – Gas Tank Modifications (continued)

Figure 34 Electrical System

The over-voltage relay shown in the bottom sketch is my poor man's version, and seems to work satisfactorily. It is simply a 12-volt relay obtained from Radio Shack and hooked up in series with a potentiometer used to adjust the pull-in voltage level for the relay. The relay actually pulls in somewhere around 5 to 6 volts so the pot is used to create the difference needed to make the relay pull-in at the desired voltage at the bus. An override switch is provided to permit the alternator to generate power if the relay should malfunction. (Note, I also have a voltmeter installed on my panel so that I can have a direct indication of the voltage status.) The relay will not reset until the bus voltage is dropped below the drop-out voltage for the relay. Consequently, the master switch should be turned off briefly to reset the relay. The red light provides a warning that the relay has pulled in.

The last item at the ope of this figure is a very simple yet effective device that provides a safety feature in the form of a low oil pressure warning light. The same device also serves to tell me that "I have done done it again!"

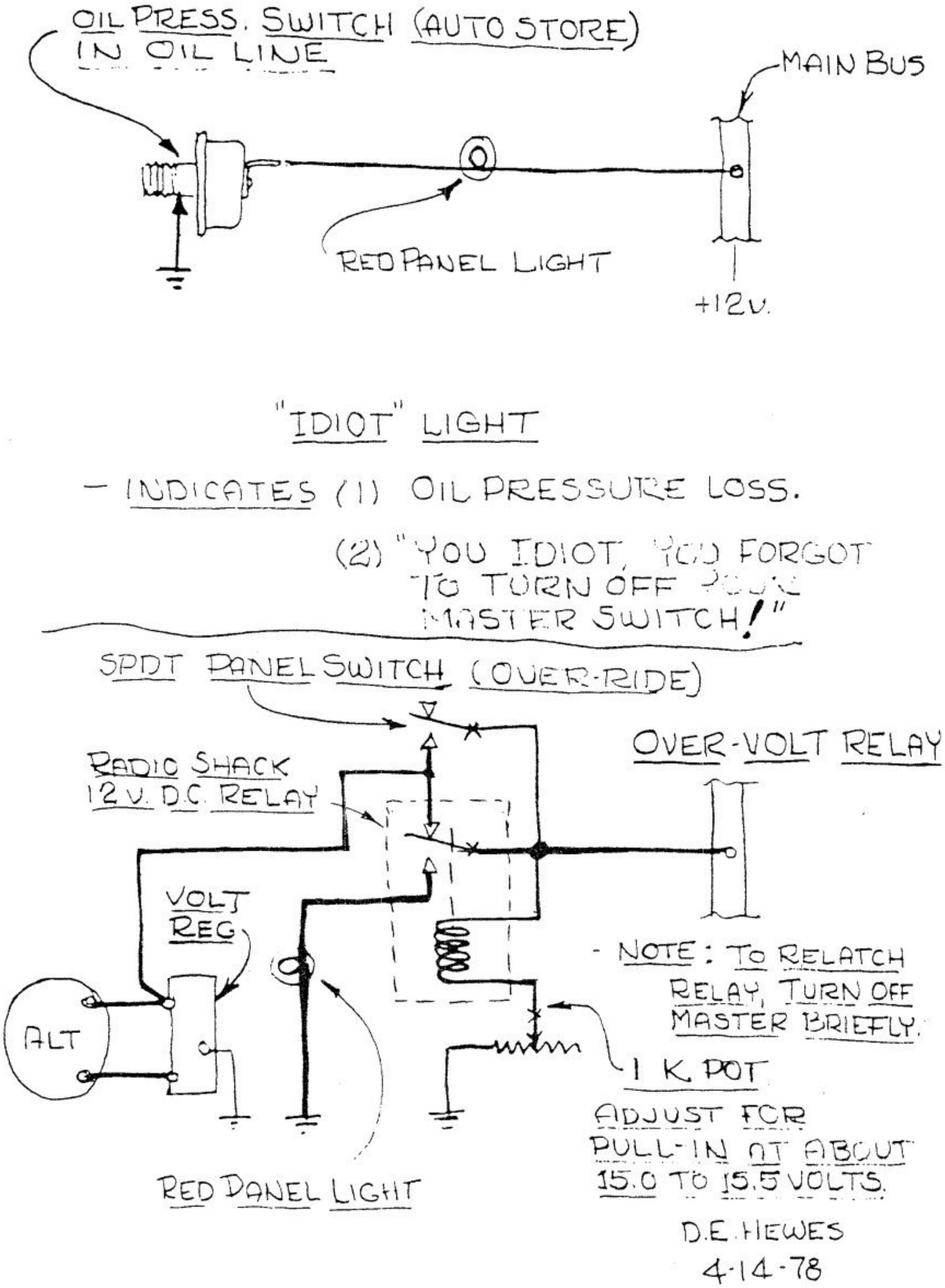


Figure 34 – Electrical System