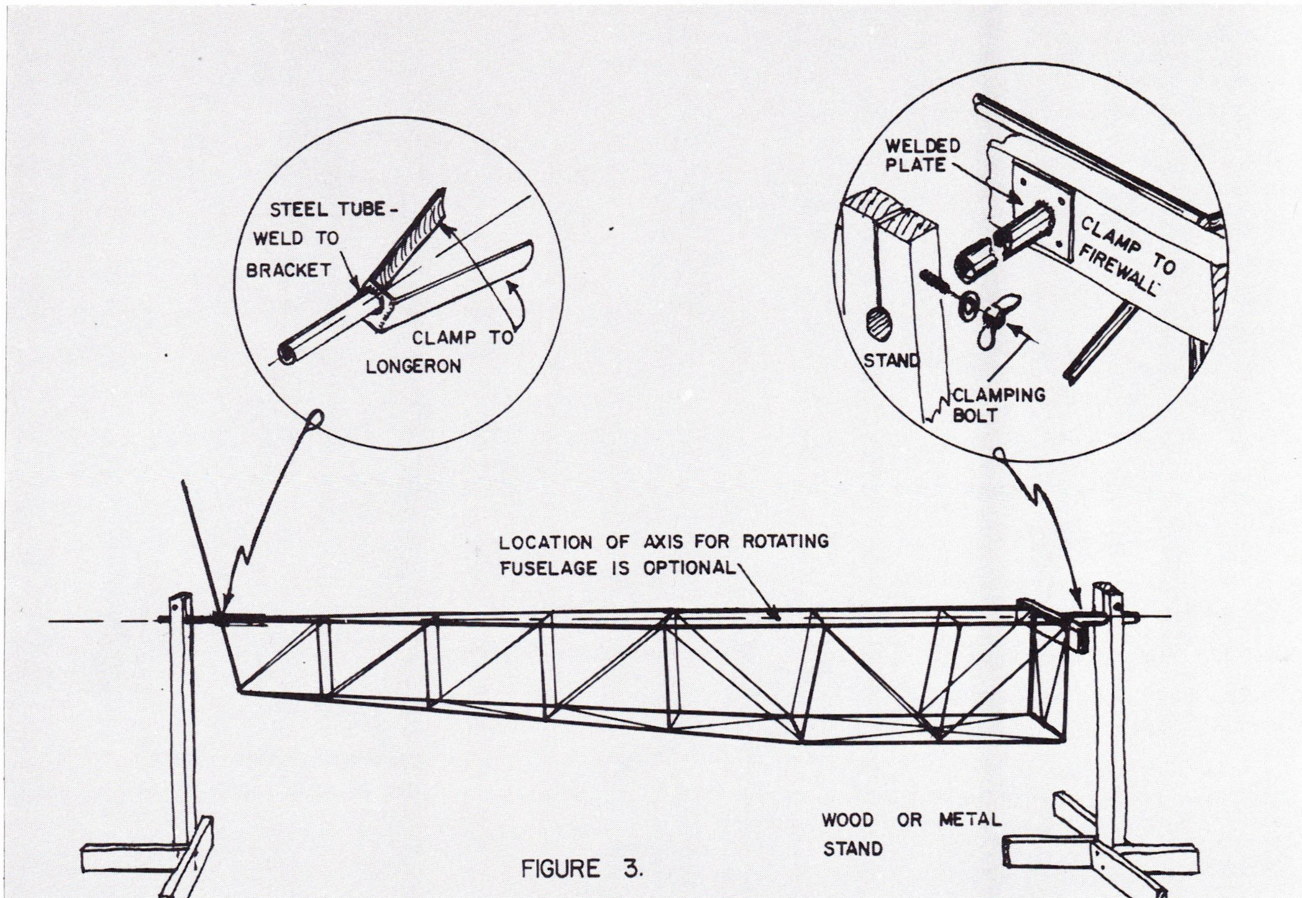


FIGURE 3.

TURN-OVER FUSELAGE STAND

a real back saver and a tireless silent servant to your needs. It will hold the fuselage structure steady for you in an infinite number of positions. It will enable you to gain easier access to hard-to-get-to areas of the fuselage and it will allow you to do a better job of welding.

You can make one of your own from odds and ends commonly found around the house and shop. Furthermore, it can be as simple or as complex as you care to make it . . . and, it doesn't have to take 9 G's either! In essence, all you need is a simple support for each end of the fuselage frame which will permit it to be rotated as if it were between centers in a lathe.

At one end, the firewall-end preferably, a provision will be needed for locking or clamping the fuselage against rotating after it has been turned to the position you want. Sketches of a few details for such a device are shown in Figures 3 and 4.

These stands work! They are easy to make since they do not have to support much more than 50 pounds on either end. I recommend the use of such a stand very highly. After all the welding is completed, use the stand later during the fabric covering process too. Similar rigs have saved a number of my friends no end of hardship and, in one instance in particular, even made the welding job possible.

About That Rust Prevention Treatment

After the welding is completed you have to decide whether or not internal oiling (rust prevention treatment) is necessary.

Some old-timers will tell you they have never found an internally rusted tube except in cases where there was a hole or crack or some form of ventilation in the structure that could have allowed internal condensation to collect.

Others will say they've replaced many a tube, especially in the tail end of tail draggers . . . so, decide for yourself.

Tubing, as received from the supplier, will have some sort of a dried film inside to protect it from internal corrosion. But as soon as you do any welding on the tubing this protective film burns off and an oxide forms. In time, corrosion appears and spreads throughout. It becomes important, therefore, to provide a new protective film to cover the inside of the completed structure. However, there is no use coating the inside of the tubing with a rust preventative film until **after** all of the welding has been completed as each time another weld is made, the process burns away the rust inhibiting film around the weld.

A good rust inhibitor is plain ol' linseed oil. Boiled linseed oil is the stuff builders and mechanics have been using since the advent of welded structures.

The rust preventative treatment requires the entire fuselage (or any other tubular structure) to be filled and sloshed thoroughly with hot linseed oil. After that chore is completed the excess linseed oil is drained and the openings sealed. Here's one way to do it.

Heat the linseed oil to approximately 200°F to make it flow better. Obtain a metal container with an outlet in the bottom. Fill it with linseed oil and hang it up high, or position it on a bench or shelf so that it will be higher than the structure being treated. This lets gravity flow to do your work.

For example, to treat a fuselage tilt it so that the tail end is low and introduce the linseed oil through the open end(s) of the longeron(s) at the firewall. Keep adding the oil to the structure until the gurgling in the

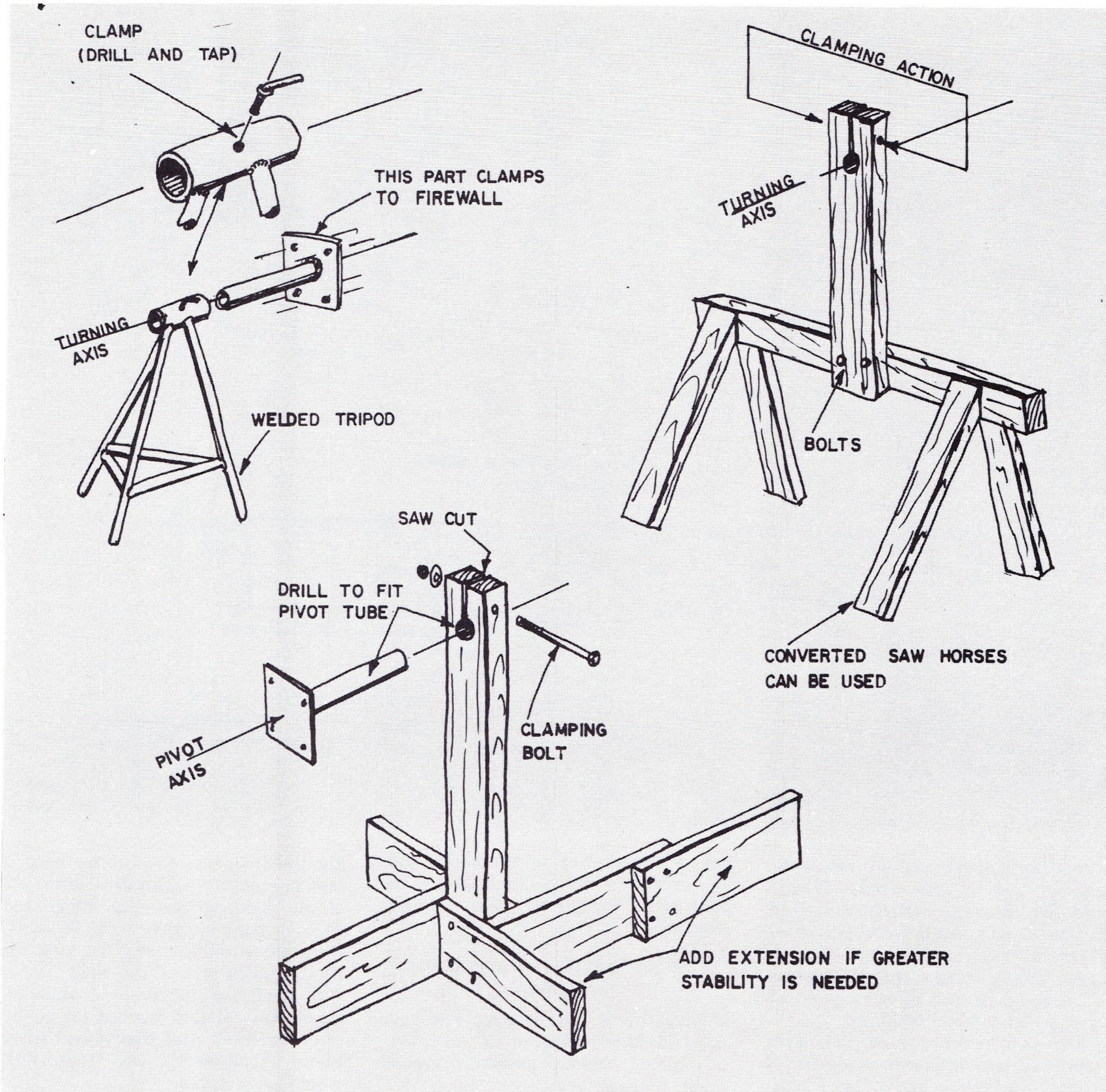


FIGURE 4.

TYPICAL FUSELAGE SUPPORT STAND DETAILS
(WITH TURN-OVER CAPABILITY)

lower end subsides or you think you have added enough to fill most of the structure. This is another job you can't hurry.

Remove the hose and then close the opening(s) by welding a small steel disc across the open end of each longeron. Since the fuselage is tilted, the oil will have flowed to the lowered aft end away from the welding heat. Be sure to clean the weld area of the rust preventative oil before making the welds (cough, cough, smoke you know).

After everything has cooled off enough to permit handling, rotate the fuselage this way and that and turn it end-for-end at least once. Allow the fuselage to remain in various attitudes long enough for the oil to seep into all the uprights, diagonals and nooks and crannies (nooks and crannies??). When you are convinced that the structure is totally oil coated internally, drill a small hole (about 3/32" dia.) in the aft end of each longeron and drain out the excess oil. Try to recapture it in a container . . . even so, it will be almost as messy a process as draining it on the ground. Still, draining it into a container will give you some measure that you have drained most of it out. If you get more drained linseed oil than you put in, you might consider going into the oil business . . . you could make a mint! The last step is to plug all external drain holes and the openings into which the oil was introduced if you haven't already done so. Use small self-tapping screws to plug the drilled drain holes.

Allow the fuselage to set a day or so in the tail low attitude and then remove the drain screws at the tail end once again. Allow whatever oil that has accumulated to drain until it quits running. Don't forget to replace the hole plugs (screws).

Now, that wasn't so hard, was it?

Where and How to Use Nut Plates

by Antoni (Tony) Bingelis

SOMETIMES IT IS years later that you realize you should have taken the time to install a nut plate . . . or anchor nut as it is sometimes called. A most shameful example is my own. Some years ago, I had quite snugly bolted my voltage regulator to the firewall and stepped back to admire my own skill in locating it in exactly the right place and perfectly aligned. (I don't recall what it was supposed to be aligned with, but it looked good.)

About three years later, I noticed that the ammeter wasn't indicating a lick of work. In time, I determined that the voltage regulator was guilty and derelict in its duties. Therefore, I decided to remove it and bring it back to my workshop. Egad! Suddenly it dawned on me that I would have to drain and remove my gas tank to get a wrench on the nuts on the back side (front side?) of the firewall just to remove that voltage regulator! What would have ordinarily been a simple five minute job suddenly developed a very real potential for a half day ordeal. Two five-cent nut plates would have made all the difference in the world right then.

Fortunately for me, this episode had a happy ending as my good friend Don Childs, an ignition wizard (homebuilder, too) saved me from the threatened slave labor bit. He drove his big ol' Chevy station wagon right up to my bird and hooked up a mess of wire, did some magic tapping and twisting, and in about ten minutes the agony was over. The ammeter became its nervous but healthy self again. Obviously, the original threat remains. If that regulator ever has to come off . . .

From now on all of my voltage regulators, battery boxes and other goodies fastened to the firewall are going on with anchor nuts.

WHERE TO USE NUT PLATES

You can install a nut plate in just about any place that a regular nut would be used. It is apparent that the installation of a nut plate where it is not needed is a bit foolish. You are merely making extra work for yourself. The nut plate becomes priceless when you have a bolt or a machine screw to install and you cannot easily get at the back side of it to put a wrench on the nut. It is especially effective where the bolt installation goes through a bulkhead and you need the services of another person on the other side to hold the wrench for you.

Where else can you use them? Anchor nuts are used extensively in attaching the spinner bulkheads to propeller spinners, control hinges, in fastening landing gear covers, inspection plates, instrument panels, cowlings and fairing strips. How about the attachment of a tail spring? See Figure 1.

WHAT KIND TO USE?

The type of nut plate or anchor nut you use really does not matter much if it is adaptable to the location where it is to be used. Anchor nuts are even made with a 90° offset so that they can be used in that peculiar place where nothing else seems to work.

Among the assortment of self-locking plate nuts (anchor nuts) are the standard AN366 noncountersunk, and the AN373, 100° countersunk plate nuts. They are satisfactory for use in both tensile and shear applications.

As is the case with most aircraft hardware, these nuts are identified by their AN number. The dash numbers and the thread sizes used for the AN366 and AN373 plate nuts are quite similar to other AN items. To be specific, an AN366F428 nut plate will accept an AN4 bolt (¼"). It is a ¼" x 28 (NF thread) self-locking steel plate nut, either all metal or with a non metallic insert. Here are some other examples:

Illustrated in the photos are a number of the more common nut plates that can be purchased or scrounged as well as an assortment of the different kinds of fasteners that can be used with the nut plates.

If bought one or two at a time these little jewels are pretty costly, and the going price can be from five cents to two bits per nut. Through Surplus Sales, and at Oshkosh, you can buy them in little packages or by the handful and the price may work out to as little as about one to three cents apiece.

When buying the nut plates in small grab-bag packages they may be of assorted sizes. Therefore, if you need a certain number of a specific size, you had better make sure that you get enough of the size needed for your purposes.

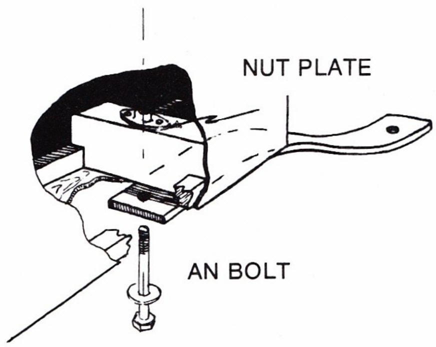
As was already mentioned, it really doesn't matter much what kind of nut plate you use provided it fits the bolt of intended use. Perhaps that is too generalized a statement to make. It does matter for instance, if you use an elastic fiber insert type of nut plate where it is subjected to high temperatures. Such conditions may be found on heat muffs and on certain areas of the engine baffles. In such locations use all-metal nut plates with self-locking features. Some nut plates are not of the self-locking variety and this you should know at the time of installation.

Another point to consider, some of those exotic anchor nuts, now available as spin-off items from our space program are really mini-sized all-metal nut plates. These tiny nut plates, while they may fit your bolt, are so small that they present very little bearing surface if installed on a wood surface or at any location where the bolt is subjected to considerable load. In such locations use the stand-

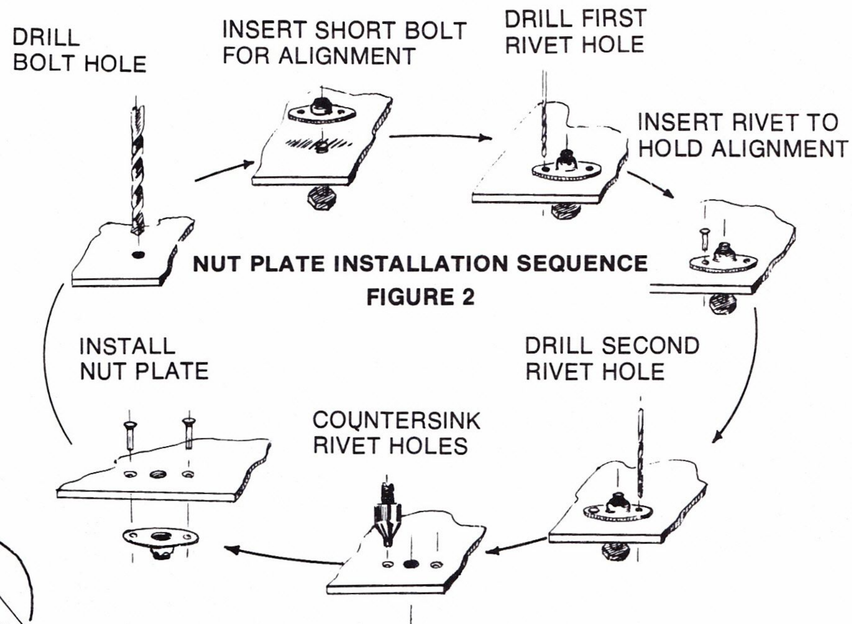
NUT SIZE	STEEL (DASH NO.)	ALUMINUM (DASH NO.)	THREAD SIZE	ATTACHING HOLE SIZE	SPACING BETWEEN HOLES*
No. 8	F832	DF832	No. 8-32 NC-2	.098	.688"
No. 10	F1032	DF1032	No. 1032 NF-3	.098	.688"
¼	F428	DF428	¼-28 NF-3	.098	1.0"
5/16	F524	DF524	5/16-24 NF-3	.130	1.0"
3/8	F624	DF624	3/8-24 NF-3	.130	1.0"

AN366/AN 373 Self-Locking Plate Nuts

*NOTE: There is such a large variety of nut plates that it would be best to check the spacing between the wing holes from the nut plate you have in your hand. Rather than take a chance on precise measurement and layout of the hole pattern, I prefer the foolproof method of drilling the holes by using a nut plate as a drilling template. See Figure 2.



USE OF ANCHOR NUT IN TAIL SPRING INSTALLATION
FIGURE 1



NUT PLATE INSTALLATION SEQUENCE
FIGURE 2

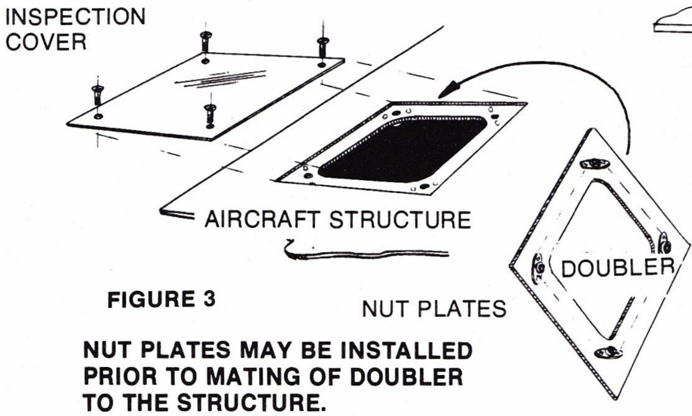
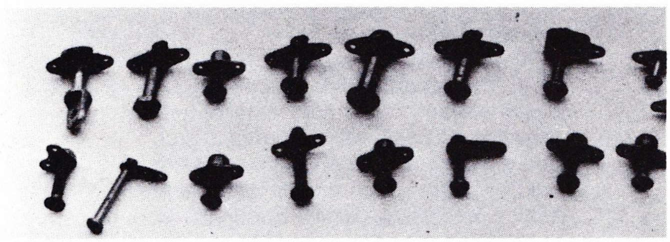


FIGURE 3

NUT PLATES MAY BE INSTALLED PRIOR TO MATING OF DOUBLER TO THE STRUCTURE.



Nut plates with a variety of fasteners that can be used.

Most commonly used nut plates.

ard (larger) AN 366 Self-locking Plate Nut or the AN 373 100° Countersunk Plate Nuts as they are better for use in tensile or shear applications. However, they are not used where the temperatures will exceed 250° F.

Nut plates are attached to the structure by making use of the holes in each of wings of the two lug anchor nut that jut outward from the nut portion. The fastening means used include rivets, screws, welds, nails, and even epoxy adhesive. Whatever the method of attachment used, you must be sure that the nut will remain secured. I can't think of anything worse happening then to have an anchor nut start turning on you when you have to remove the bolt. If you use small screws you may have to drill the holes in the attachment lugs a bit over-size to accommodate the screws to be used. If the screws are very tiny, or the wood very soft, or if you use nails, it might be good insurance to put on a dab of epoxy adhesive under the nut plate before you secure it. Rather than drill tiny pilot holes for the screws, an ice pick or an awl will make a good starting hole. Don't be mislead by an assumption that rivets are strictly for use in attaching the nut plates to aluminum and that the screws must be used in fastening the nut plate to wood frames. You can use rivets in wood also. If you can obtain soft commercial rivets for this purpose, it would make your task much easier, especially if the installation has to be made in place on the aircraft.

ATTACHMENT OF THE NUT PLATES

The holes drilled in the member through which the bolts pass need not be "close drilled". What are known as "clearance drilled holes" are snug enough for anchor nut installations. For example, a No. 12 drill is usually specified when drilling a hole for a 3/16" bolt. This would be too snug a fit for a bolt going through the structure for a nut plate. Therefore, a slightly larger (clearance drilled) hole using a No. 8 or No. 10 drill bit permits easier installation and assembly.

There's no big trick to installing nut plates. If you have never done it before, however, you are apt to make a few false starts before you figure out the best sequence of events. Installation preparations require the sequencing of two different sized holes that need to be drilled, and the countersinking of two of them. Naturally, these holes must be properly located and spaced. So you see, even the simple anchor nut installation takes a bit of pre-planning. The sketches (Figure 2) propose to show the sequence of the preparation steps required for installing an anchor nut. It can be seen that if you are installing several nut plates, switching to another drill size, and then to a countersunk, can be tiresome and time consuming. It would help if you had a couple of electric drills handy.

Sometimes, it is far easier to install the nut plates on the frame of an inspection plate opening *prior* to building it into the airplane. This would permit the riveting to be done in a vise. Squeezing rivets in the vise in preference to setting them by hammering, does give nice results. You could use a riveting gun, of course, but setting things up for bucking 8 rivets seems kind of foolish . . . unless you are building an all-metal project and are doing a lot of riveting most of the time.

Fitting a cover plate to an inspection opening sometimes takes a bit of figuring. This becomes a bit of a problem when you do not have access from behind the plate and you need to spot the places to drill in the inspection cover to match the installed nut plates. One way to do it is to grind a point on a bolt or machine screw of the proper size and screw it into the nut plate so that the point projects slightly. Place the inspection plate of cover in place and tap it ever so lightly with a tack hammer directly over the area of the nut plate with the protruding point of the bolt. A slight prick point will be made in the cover and the hole can be drilled with confidence that it is located in exactly the right place.

WILL YOU REMEMBER?

Incidentally, the EAA Service Manual is the homebuilder's equivalent to the store bought aircraft service manual. One should be activated by the builder for his project as soon as construction starts. In it would be recorded anything and everything about the airplane. *Where* you have installed nut plates is an important bit of information. Should you ever have to remove an elevator, aileron, or rudder hinge in some distant future . . . it is almost certain that you will have forgotten whether you were clever enough to use nut plates . . . and in what places.

Dzus Cowl Fasteners

By Bob Hesley (EAA 42498)

Airplane motor cowlings and other removable panels require the use of a fastener that can be removed and replaced an unlimited number of times without deteriorating as screw threads will. There are several types of cowling fasteners, but among them the DZUS COWLING FASTENER has proved the most satisfactory and is, therefore, most widely used.

It is of simple construction and, when properly installed, is quickly and easily attached or removed with a quarter turn of a screwdriver or preferably the Dzus fastener key. Homebuilders should be instructed to use this key when opening or locking fasteners. Its use prevents damage caused by slippage of bad screwdrivers. One key fits all types of Dzus fasteners.

There are three types of heads: a flat oval-shaped head, a countersunk head, and a hex head. Fasteners are designated by letters: type A has an oval head, types F and FA have a flush head, and type HF has a hex head. The letter J added to these symbols indicates that the fastener has longer undercut B below the head. This allows the fastener to eject or recede from the panel when being attached to the head. The letter O in the designation applies to a fastener without undercut. This permits removal of the fastener when unlocked. The first figure after the type letters indicates the body diameter of the fastener. The number following the dash (-) represents the length (L). For example:

Type A3-20 is oval-head fastener with $^{3}/_{16}$-in. body diameter and length of .200.
Type FJ4-25 is flush head, long undercut, $^{1}/_{4}$-in. body diameter and .250 length.
Type FAW5-35 is flush head (with rounded edge), wing attached to head, $^{5}/_{16}$-in. body diameter and length of .350.
Type AO6 $^{1}/_{2}$-50 is oval-head fastener without undercut, $1^{2}/_{3}$-in. body diameter, and length of .500.

All standard springs are designated by the letter S. The figure following this letter indicates the size of the fastener with which it is used. The number after the dash (-) in the symbol shows the height of the spring. For example, type S3-200 is a standard spring for use with No. 3 fastener and has height of .200. All standard grommets carry designations similar to springs except that they are prefixed by letters GA and GF.

Sabre-Saw Blades for Cutting 4130

By W. A. Dickenson (EAA 49246)

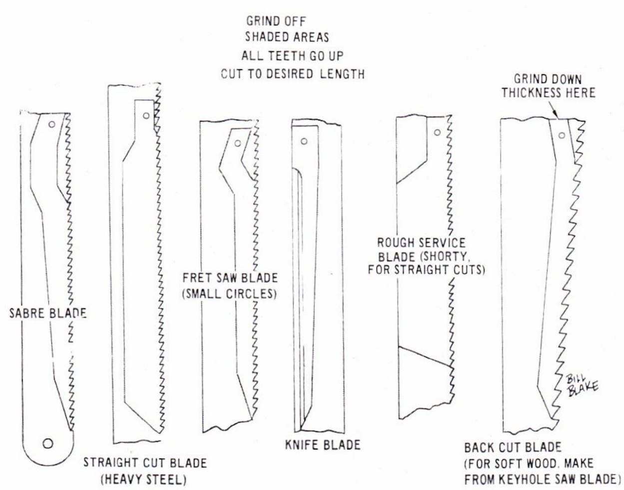
We got tired of paying eighty-nine cents for two sabre-saw blades that would not cut 4130 quarter-inch sheet, so — we made our own! And, they work like a charm!

Most hacksaw blades used around the shop break or wear out in the middle. In about three minutes, these blade ends can be ground down to fit in a sabre saw and you will have a better blade than you can buy.

Hacksaw blades come 24, 18, 14, 12, 10 etc. teeth per inch, with straight or wavy teeth patterns. The wavy patterns world be preferable for cutting hard or ferrous metals.

The teeth should pitch forward, especially for cutting such hard materials as 1/8 to 3/8 inch sheet steel; they should pitch straight down for cutting softer materials.

You can trim aluminum channel or 4130 sheet and rod right on the airplane with a good sabre saw and these blades. It certainly works well on our BD-4, cutting aluminum angles right on the side of the fuselage, just like a pair of scissors.



How to Control Fuselage and Landing Gear Alignment

by Antoni (Tony) Bingelis

If you want an airplane that tracks through the air like an arrow and not one that sort of sidles along like a scavenging land crab, you will have to control its alignment carefully during the construction and assembly phases.

A well-built structure is one whose alignment is inconspicious. If everything looks reasonably aligned nobody notices it as most of us are blissfully oblivious of the obvious norm. Let the alignment of the rudder, wing, or stabilizer end up leaning a bit from that imaginary reference line though, and you will find yourself cringing everytime you look in that direction and hear your share of snide remarks about it as a constant reminder to your transgressions.

While the requirement for good alignment during assembly must be considered as essential . . . aesthetically, it is always critical. Fortunately for some of us, absolute accuracy in alignment, although always most desirable, is not always a prerequisite to an acceptable aerodynamic performance. Sometimes, however, misalignment in a component can portend disastrous consequences.

If, for instance, the incidence of one wing is greater than the other . . . bad news. Likewise, if one wing is warped during the skinning process, poor flight characteristics will result. It is a matter of concern because even a slight twist in one wing can lead to control difficulties and undesirable stall behavior. A large error can even render the aircraft uncontrollable. Figures 1 and 2 illustrate some of the common boo-boos that any builder can make without even trying. (Notice the statements read **any builder**, and not just an inexperienced one!)

A misaligned fuselage can generate more problems than anyone deserves. This becomes apparent when we realize that the fuselage, in most designs, is the foundation for the rest of the airplane. Quite often the wings, tail surfaces, and even the landing gear attach directly to some part of the fuselage. The attachment of these

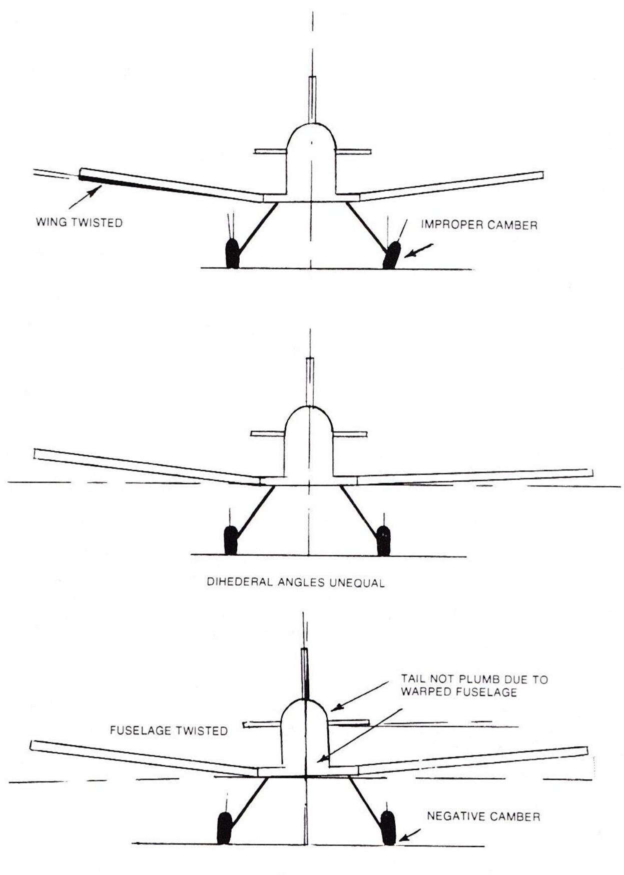


FIGURE 1

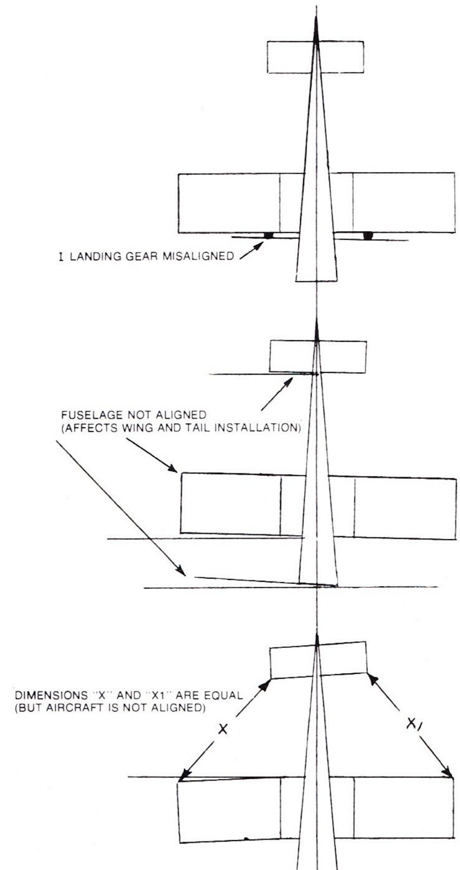


FIGURE 2

structural components are often by means of metal fittings bolted or welded to the fuselage at a particular station or bulkhead. If a builder is not careful, he will assume that that bulkhead or station location automatically locates his fitting for him and that no further alignment measurements are necessary . . . how wrong.

It is easy to be lulled into a premature sense of well being after you have completed two identical fuselage sides in the same jig. How could anything go wrong with the assembly after that. Aren't both sides exactly alike and isn't it simply a matter of cutting and fitting the cross members? True, but if the symmetry of the fuselage and the proper placement of the firewall and the various cross members and bulkheads are not geometrically controlled, the whole fuselage can be thrown off alignment. If that happens, then your wing and tail surfaces and landing gear may go on cockeyed.

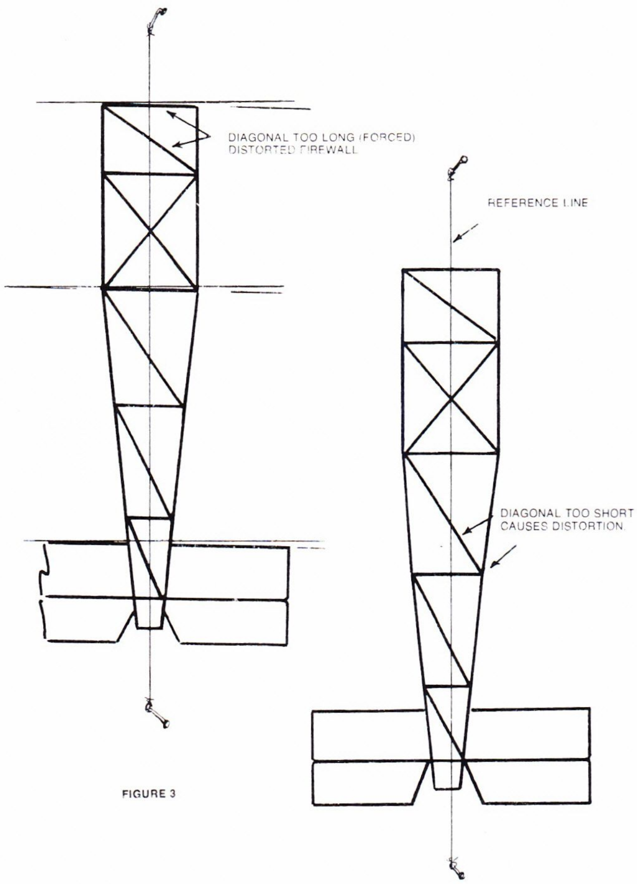
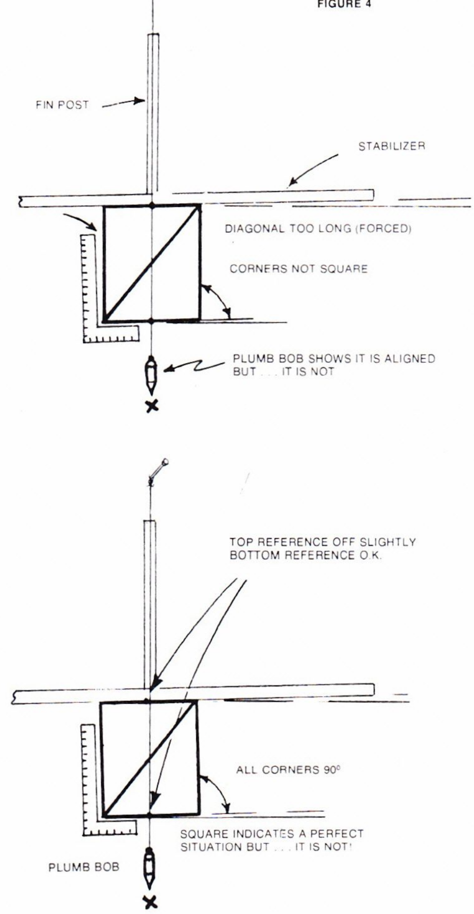


FIGURE 3

Before you start the assembly of the fuselage, a reference line should be established on your work surface over which the fuselage sides will be erected. This reference can be a drawn line or a tightly stretched wire or cord. An inked line drawn with a felt pen makes a very visible and effective reference. A stretched line can only be used if the fuselage is erected on raised supports that permits the presence of the line beneath without interference with the assembly. At one end, a line should be drawn across the reference line at a 90° angle. This is a very important starting point as the firewall will be positioned over it. If the firewall is not perfectly oriented with the reference line, any error at that point (station) will be locked in and will be continued all the way through the assembly of the rest of the fuselage. This can be serious if not caught in time and compensating corrections made to the engine mount, wing and tail attachment points. Another way the fuselage can be off is in its cross section.

If the fuselage sides are not monitored continuously for squareness with a large carpenter's square, it is very possible that the cross section may assume the semblance of a parallelogram instead of maintaining the desired rectangular shape. Such a cross sectional warping would undoubtedly also have an adverse effect on the wing alignment, the fitting of the gas tank, and perhaps, the alignment of the instrument panel.

If the symmetrical and cross sectional integrity is not maintained, the rudder post and the stabilizer installation can become very difficult as their location and alignment is definitely influenced by the fuselage and its reference points.

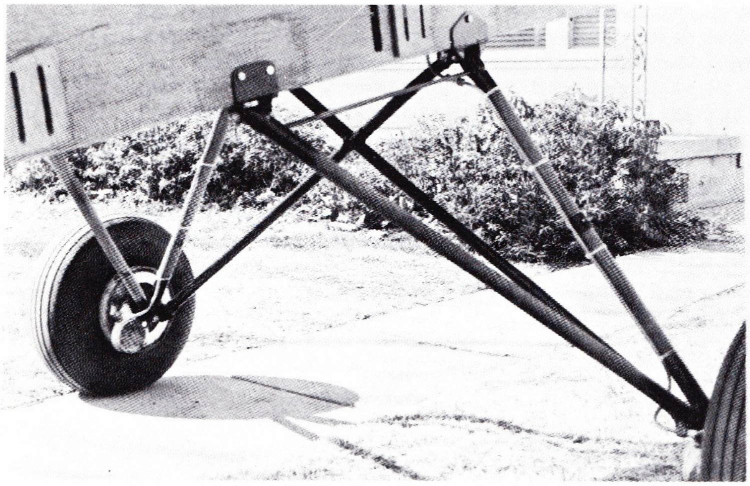
FIGURE 4


In low wing all wood fuselages the alignment of the wing with reference to the fuselage is usually fixed by the location of a main bulkhead. If this bulkhead does not set square and at the proper vertical angle to the fuselage reference line, you may have difficulty not only with the alignment of the wing, but also in the establishment of the proper incidence. Incidence error can result in an abnormal nose-low or nose-high flight attitude in cruise. Either condition is undersirable due to increased drag.

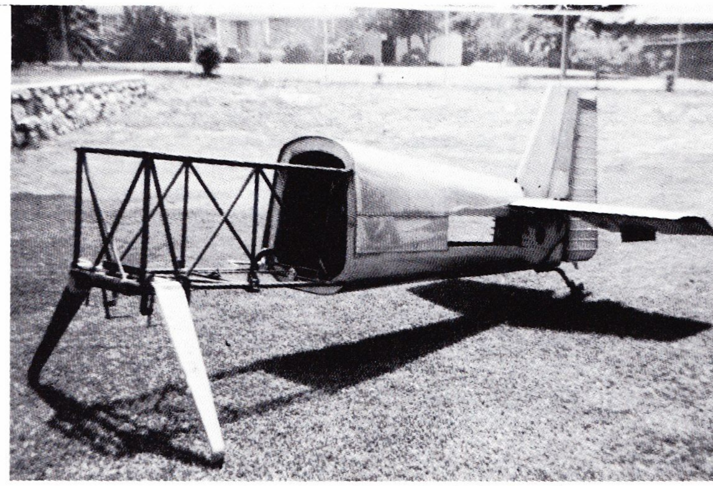
When installing a wing center section in the fuselage, an alignment error as small as 1/8" on one side of the fuselage could be compounded to a 1 1/2" error at the tip of a 12' wing. It is best, therefore, to use the full length spar or the assembled wing in making those first alignment trial fits.

WHAT CAUSES FUSELAGE ALIGNMENT ERRORS?

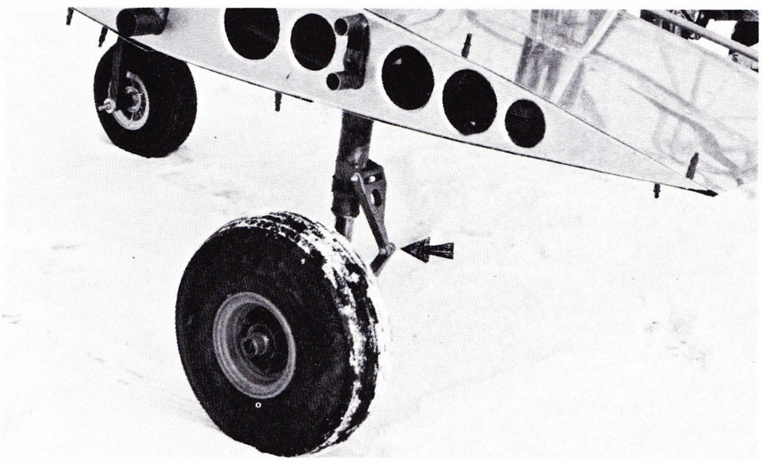
(1) The most common cause is the builder's failure to establish and work from a centerline or reference line



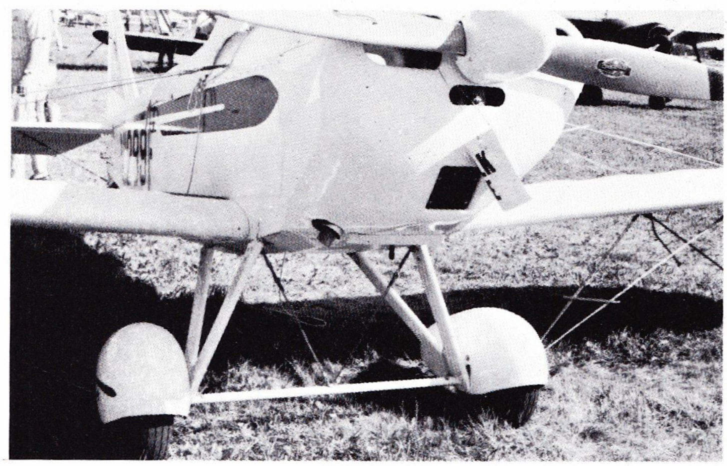
No alignment adjustments are practical with the welded tripod type landing gears.



Spring steel gears although comparatively heavy do permit a considerable degree of adjustment for both toe-in and camber.



This type of scissor permits a limited adjustment of toe-in by adding or removing washers from between the scissor links.



No camber or toe-in or toe-out problems to worry about in the Fly-Baby gear . . just install it so that wheels parallel fuselage center line.

during the assembly of the fuselage. (It is also a common mistake to abandon reliance on the centerline too soon.)

(2) Failure to align the firewall at right angles to the centerline.

(3) Failure to mark the center of each station's cross member or bulkhead and then . . . failing to make sure, with a plumb bob, that this mark straddles the fuselage reference line.

(4) Permitting the structure to be moved accidentally . . . even a slight jar will change the reference points. Keep checking periodically.

(5) A glob of dried glue, a nut, a bolt, a file, or almost anything else lying on your work surface, can accidentally find itself under one of the longerons causing it to be raised slightly off the work surface. If you don't notice it, you may proceed with the assembly of the fuselage with one side of it slightly raised.

(6) Forcing any diagonal into place, however gently, will deflect the structure at that station and either the top or bottom cross members will no longer intersect the reference line. A too short diagonal member will have a similar effect.

There are three ways of doing your alignment checking. Visually (eyeball it), measure it with a steel tape, or use instruments such as a square, spirit level, combination square, protractor, and beam trammel. In practice, however, you will find it more practical to use any combination of the three methods to the degree best suited to the job at hand. Often a point is reached where the aspired for accuracy is more a fetish than a practical requirement. For example, to achieve the ultimate in accuracy, a guy can become frustrated trying to split a 1/16" difference in wheel alignment as measured at a point well ahead of the wheel's foot print.

Rectangular fuselages are checked at each station using a plumb bob and a large carpenter's square (See figure 2). When constructing any fuselage whose bottom longerons are closer together than the top longerons, the cross sectional check at each station must be accomplished using a plumb bob (see figure 3). An alternate method would be to use a combination protractor head to check the angle formed by each side of the fuselage. The angle reading for each side should be identical. In using this method, however, make sure that the fuselage is resting on a perfectly level surface.

Still another check should be made along the side profile when bulkheads are installed to insure vertical alignment. A bulkhead that leans forward or backward could, in some cases, alter the incidence angle when the wing installation is attempted. When fitting and installing the cross pieces in the typical welded steel tube or wood fuselage, each member should be centered over the reference line and fuselage sides checked for squareness using a large square. The greatest single source of fuselage misalignment occurs during the fitting of the diagonal members. If the fit of a diagonal member is a bit snug it will almost certainly deflect the fuselage from the reference line. Likewise, if a diagonal is just a bit too short and you have to use clamps to draw the fuselage sides in, that too will cause the fuselage to distort. As you work from the front of the fuselage toward the tail you will be tempted to prematurely abandon the checks because everything seems to be going fine . . . don't give in to the temptation. Keep close check on your reference line and each station until you get to the tail end.

LANDING GEAR AND WHEEL ALIGNMENT

Misalignment of the gear may not be very noticeable, but it can result in some mighty exciting runway performances during the high speed taxi tests and particularly before and after that important first flight. Some builders proclaim the wisdom of putting in a tiny bit of toe-in while some others say a dab of toe-out is best. Some like camber, others don't. Regardless which school of thought you subscribe to, the least you can do is to assure yourself that both wheels have the same amount of whatever it is you want.

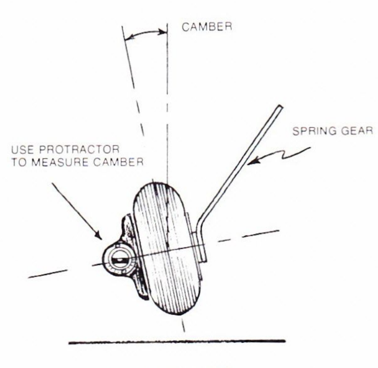
Some landing gears and wheels cannot be adjusted for alignment after installation on the aircraft because the struts are attached to the fuselage at welded attach points, which cannot be adjusted. The axles, being welded to the struts, likewise cannot be adjusted. This type of gear simply needs to be properly aligned and jigged before welding. To accomplish this means that the airplane has to be raised to a level attitude and a reference or centerline established on the floor to provide guidance in jigging the gear for the alignment and welding.

Other landing gears using the vertical strut and scissors arrangement can often be adjusted to a limited degree by adding or removing washers from between the scissor elbow hinge (scissor elbow hinge!?)

The tapered steel whip rod gear is another that has to be jigged very accurately before the welding is attempted as it too, lacks a means of adjustment after installation.

The spring steel gear is a popular installation and it has the additional attraction of being ground adjustable. Of course, no matter what type of gear installation you use, every attempt should be made to insure accurate alignment at the very outset. At any rate you can easily adjust the toe-in and camber on a spring steel gear in accordance with design recommendations. In the absence of any such guidance, it is suggested that the best alignment is one that gives you a zero toe-in and a zero wheel camber at normal gross weight. The proper amount of camber is especially important with spring steel gears.

If your aircraft is larger than a single place job but you normally fly alone, and at less than gross weight, you might want to adjust your wheel camber to give a zero angle reading at this lesser operating weight to reduce wear along the outer edge of the tires.



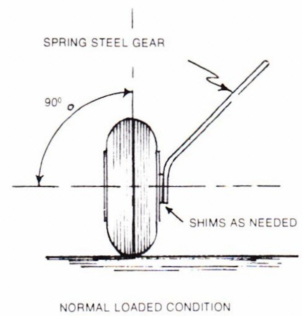


FIGURE 5

To make these adjustments tapered metal shims are used to obtain the exact alignment and camber desired. After you have driven yourself batty trying different combinations of shims to get the wheels aligned the way you want them, you may be receptive to a suggestion. Index or mark the shims, and installation in exactly the same position will be guaranteed. Make your index marks by using a small rat tail file to cut a small groove across the top of all the shims. File the notch off-center so that the shims cannot be inadvertently reversed in assembly. Use one notch for the shims used in the left gear and two notches across the shims for the right gear.

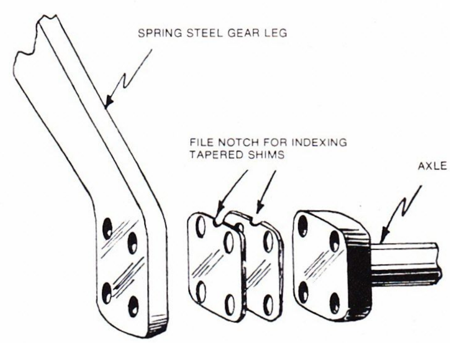


FIGURE 6

Any time in the future that it may be necessary to remove the axle from the gear leg, the shims will already be marked assuring rapid and positive reassembly. This, of course, will guarantee that your wheel alignment is not disturbed any time you have to remove a wheel and axle for maintenance or inspection.

Before You Paint

by Antoni (Tony) Bingelis

Magnificent workmanship not withstanding, nothing affects the appearance of the completed homebuilt as much as its final finish (dope, paint, lacquer, whatever).

Painting is not difficult . . . kids do it in the elementary schools and grown-ups do it (paint) in their garages and on their driveways. Painting, nevertheless, requires the exercise of common sense, observation of basic rules and instructions and at least an interest in doing a good job. Reasonable weather and working conditions do help, of course.

Unfortunately, as long as we have impatient builders, we will have aircraft with disappointing finishes. Blame it on haste if you will but techniques of application that are not under complete and absolute control play a key role, too.

Nobody has ever learned to paint by reading a book on the subject. You can learn what not to do and what to do but until you actually try it, the "how to do it" part develops only with practice. Fortunately, if you are an observant and thinking person, you will quickly learn to control your spray painting applications. Everything else hinges on methodical preparation.

There is no shortage of reading material on the subject. Each paint can has a complete course of instruction detailing how that product should be used. Furthermore, some of your best friends may undoubtedly be experts on the subject of painting and would be only too willing to explain to you in detail how to do it. Or, if you are already in process, tell you why you are doing it wrong . . . but don't hold that against them, they are only trying to be helpful.

Remember, the painting process is your last chance to turn out a beautiful airplane. So, do not get impatient at this late stage of building.

A lot of things have to be considered before you start spray painting and most of them are not described on the paint can or in any instruction booklet you may have acquired. There are some things that nobody would think of cautioning you about, simply because experienced individuals seem to assume that everybody knows about those pesky little details. Not so.

FIRST THINGS FIRST

The first step in preparing the aircraft for painting entails a close inspection of all of its surfaces for imperfections, the proper fit of parts, and smoothness of the skin surfaces.

The complete aircraft should then be cleaned with detergent and water if necessary.

All nooks and crannies should be vacuumed out to remove dust and other overlooked construction residue. Better not overlook this little detail for when you do start to spray, the force of the airblast will blow that stuff around and into your paint.

During the initial cleaning process be sure to remove all marks (pencil, felt pen, chalk, etc.). Otherwise, you might be shocked to see these inoffensive little marks bleed right through the paint.

SURFACE PREPARATIONS

FABRIC SURFACES. These require no special preparation and are ready for the brush application of clear nitrate dope, or whatever you are using, as soon as they are covered. It is a good idea not to leave fabric covered components around the shop too long after they are covered before giving them their finish coatings. Keep the fabric covered surfaces out of the sunlight as it is harmful to unprotected fabric. Drape the structure with a plastic sheet to keep the dust off.

Dacron, if used will, of course, require heat shrinking before additional finishing efforts are undertaken. No other special surface preparations are ordinarily required of fabric covered surfaces.

FIBER-GLASS SURFACES. Before any finish is applied to fiberglass surfaces they should be wiped down with MEK (Methyl Ethyl Ketone — paint stores handle it) and thoroughly sanded to remove all glaze from the surfaces. No matter how smooth the surface may seem to you, you can bet it will not be. After you apply a coat of paint or primer an unbelievable number of imperfections and pinholes will suddenly appear. Polyester fiber-glass is more prone to an outcropping of these surface uglies than is epoxy fiber-glass.

Cure this condition by spraying a coat of primer surfacer or paint over the pinholes. Wait a bit until the paint begins to set and then, using your finger, smear the still wet paint over and into the pinholes. Otherwise you will have to spray coat after coat to ultimately hide the pinholes.

Now, is it ready to paint? Probably not. The surfaces feel smooth and look smooth but I'll bet there still are more imperfections, pinholes, lumps, bumps and scratches than there are fleas on a stray dog.

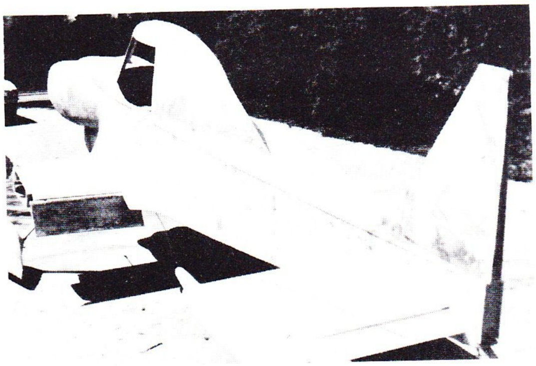
You can prove this. Take the airplane outside where the rising or setting sun shines on it. You will be appalled at the number of ripples and bumps the sunlight and shadows reveal. Back to the sanding block, eh?

Except perhaps, for fabric covering, just about any kind of aircraft surface can benefit from at least a light sanding with #400 wet/dry sandpaper. Of course, if the surfaces need basic smoothing you might have to begin with #100 or #180 aluminum oxide sandpaper. Don't use that cheap, crummy flint sandpaper! Use the best, the silicon and aluminum oxide sandpapers and the wet/dry sandpapers.

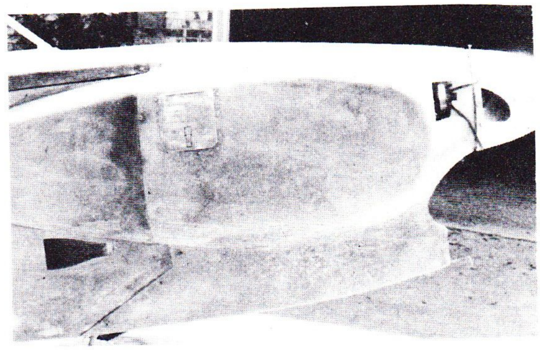
Always use a sanding block! Regular rubber sanding blocks may be found at paint stores. One should always be used to help maintain level surfaces and flowing contours during sanding.

Has it ever occurred to you that there is a right way to sand a surface to obtain the best finish? True. Never go around in circles with sandpaper. Always use that rubber sanding block and sand in one direction . . . back and forth whenever possible. A cross hatch sanding pattern also gives good results. A lot of builders don't realize that the sanding pattern is so important. It can have a marked effect on the finish.

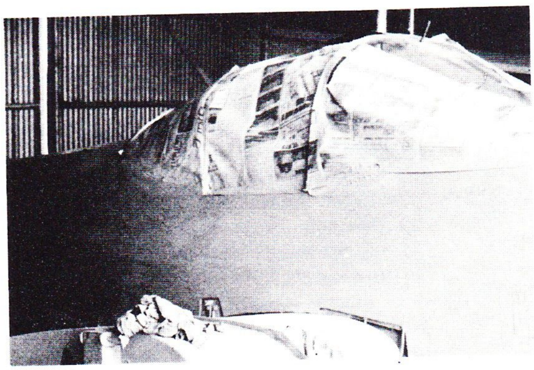
In sanding fiber-glass surfaces, an initial fast cut wet sanding with #180 paper may be needed to level the surfaces. If so, follow this up with #320 grit paper for pre-priming finishing.



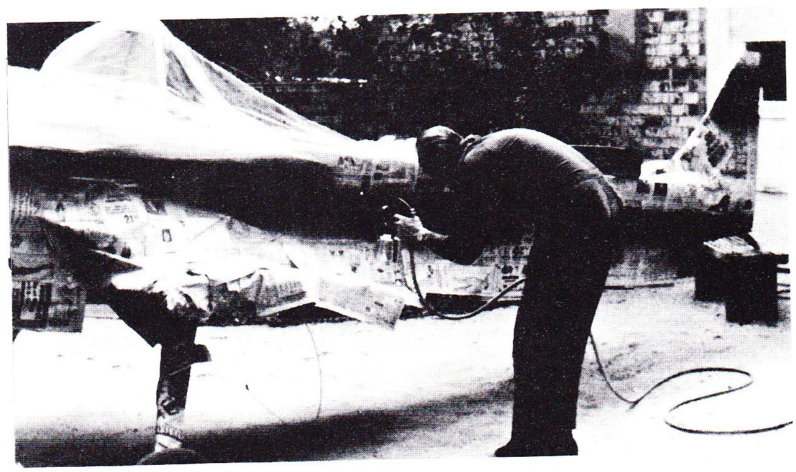
A fiber-glass covered aircraft requires much sanding. Primer/surfacer has been sanded almost completely away.



Fiber-glass at this stage seems smooth to the touch and flawless on close examination. But is it?



The overspray is certain to get on the windshield of this rather incomplete masking job.



This cheapskate (the author) used newspapers and plastic sheet for his masking covers. Note that he was also too lazy to cover the wheels.

Here's how to fold wet/dry sandpaper for hand held sanding. Fold and tear a regular 9 x 11" sheet of wet/dry paper into 4 pieces. Each piece as it is used should be triple folded, leaving one face toward the surface being sanded and the other toward your hand. The third portion is, of course, folded between the two. Use plenty of water and don't be too frugal with the paper. Change it frequently to obtain the quickest sanding results.

PLYWOOD AND WOOD SURFACES. As you may know, plywood is always sanded lightly prior to gluing. This is especially essential if birch plywood is used as it has a glaze-like surface . . . a by-product from the rolling process of manufacture. The glaze being almost wax-like may also prevent you from obtaining a good paint bond. A light sanding, therefore, is necessary to remove it.

Before applying any finishes to wood surfaces they should be smooth to the touch. Smooth surfaces reduce the amount of varnish that will be required significantly. While you're at it, remove as much of the excess glue from the joints as is practical. Varnishes do not adhere too well to glue joints as they are very smooth and slick. After this treatment, sand with #180 and #320 sandpaper. Then wipe the surface with a lightly dampened cloth. The surface is now ready for whatever finishing process you want to use.

ALUMINUM SURFACES. Aluminum skin has an oily film over its surfaces resulting mostly from its manufacture. You, in the building process will have added more oily film in the form of fingerprints. So, the first important step before doing any finishing work is to sanitize the metal. Clean it thoroughly, otherwise the paint may not stick uniformly.

What to do? Wipe it with lacquer thinner? Well, that's not bad, but not too good either. It will help, of course, and is better than nothing. But, to be sure you should wash the surfaces to be painted with a good detergent and follow that with a good rinsing. Don't forget to scrub around the rivet heads . . . use a firm sponge, a stiff brush, or a clean rag.

Next, the highly polished Alclad aluminum surfaces should be dulled or roughened for best adhesion of the paint. Even if you plan to etch the aluminum skins it is still a good idea to precede all of the finishing steps with a light sanding using #400 wet/dry sandpaper. Go over the whole aircraft.

Pop/Rivet holes should be filled as they are natural sources for corrosion. Use a drop of zinc chromate in each of them. Yes, in each of them. This is followed by filling the rivet holes and other imperfections with a glazing putty. Glazing putty, Dupont's Lacquer Spot Putty, for example. These fillers are best applied over zinc chromate or a primed surface. Check the instructions.

STEEL SURFACES. Here again, the best adhesion of the prime coat and the finish coat is that obtained on a dull and unpolished metal surface.

For steel tubing and fittings there is nothing like sandblasting to remove rust and scale. This cleaning leaves clean, virgin metal which requires no further cleaning provided a prime coat is immediately applied before any additional handling with bare hands. Brushing steel with a wire brush is acceptable for small parts but it does a poorer job and doesn't present as good a surface for the primer.

All rust must be neutralized or removed from steel parts before priming and painting. Any rust, however microscopic, remaining will continue to fester and ultimately break thru and blister the paint in the areas affected. Sanding will rarely remove all vestiges of rust and chemical neutralizing insures a long lasting finish. One such easy to use neutralizer is OSPHO. It stops rust and prepares rusted surfaces for painting. (B. J. Associates, 69 Murray St., Norwalk, Conn. 06851).

MASKING

Take the time to cover and mask all metal fittings before painting Cover the wheels and tires and don't forget the tailwheel. Protect the upholstery and control cables from unwanted overspray.

The windshield and windows need special attention and must be completely covered. Remember, certain fumes when trapped will cause the plastic to craze. For this reason it is important to remove the protective cover as soon as the painting is completed. Whatever you do, do not let any volatile substances such as lacquer thinner get on the plastic windows as crazing will surely follow at some later date.

For your masking you will need several rolls of fresh masking tape in either the ½" or ¾" widths. The tape should be no wider than that if it is to be directly affixed to the aircraft skin. Too big a risk is involved in its removal otherwise. As mentioned, the tape must be fresh so forget about putting that old stuff you have on hand next to the fair skin of your bird.

The proper way to mask an area is to first lay the tape along the line to be masked, or along the numbers as the case may be. Then, cover paper is attached with a separate piece of masking tape to that already on the aircraft. Never try to attach the cover paper directly to the aircraft as following nice accurate lines is difficult and the removal of the cover and tapes later would undoubtedly turn out to be a bit traumatic.

Masking is an eyeball exercise. The masked line must look good to te eye otherwise the painted line will disappoint you. In laying down a long straight line, affix one end of the tape for about 2 or 3 inches and unroll the entire length needed while holding the roll about 8" away from the airplane. With your eye affixed to the point where you want your end of the tape to land, slowly lower your end of the tape until it touches. All the while keep a moderate tension on the tape. It will settle in place along a straight line beautifully. You cannot really lay down a straight line if you try to press the tape down as you go a few inches at a time.

Tape, when it is in place, needs to be firmly stuck down to keep the paint from leaking under its edges. Minimize this risk by pressing your fingernail (use your thumbnail) against the tape at its edge and running the nail the full length of the tape. Any place where two pieces of tape cross, press that juncture point with the sharp edge of your fingernail to insure that there is no gap, however slight at that crossing of the tapes.

Intricate paint designs like insignias and family crests can often be masked using ¼" or ⅛" tapes to outline them. An easier way is to use stencils cut from a vinyl self adhesive decorative paper (Contact). This decorative paper can be found in the wall paper or household wares sections of discount stores. The design you want to apply is first drawn directly on the vinyl paper (select a light plain color or at least some simple pattern) and then cut out with scissors. Peel the paper backing off the vinyl and press the stencil into position. Rub the edges with your fingernail to seal them. After the painting is completed it can be easily peeled off. A little experimentation should give you a good idea how to best use this handy material for masking and design functions.

You will probably ignore this suggestion but I am sure you would be much happier if you do not have to use old newspapers for your masking covers. Use butcher paper or any other kind of roll of cheap paper obtainable from most paper companies.

There are three things wrong with using newspapers for masking covers. Newspaper print comes off. Especially on white paint and on paint that isn't completely cured. It will have a propensity for sticking and for transferring its print to your painted surfaces. The second annoyance is that caused by paint spray penetrating through the small puncture marks found along the edges of virtually all newspapers. If you must use newspapers, always make a fold about 6" wide along one edge to neutralize this booby trap. Last but not least, the newspapers are rather short pieces and you will find yourself working much longer in masking the airplane. Of course, you will also use much more tape. You soon realize how very nice it would have been to put on long strips of masking cover instead.

A single edge razor blade is an indispensible tool for cutting the tapes to the proper lengths and angles. The correct way to use the blade is to press it against the tape at the angle you want cut. At the same time pull up on the free end of the tape. It will shear nicely. A cutting or sawing motion is not recommended . . . particularly if you have a fabric covering under the blade.

These, then are some of the prepaint preparations which take so much time but are critical to the finished product. Remember, the actual painting process takes but a ridiculously short period of time, so don't slight the preparations by rushing things.

ENGINE HOSES

As airplanes and engines attain age, there appears to be a need to re-emphasize the inspection or replacement of engine hoses or lines carrying fuel, oil, or hydraulic fluid. The hose manufacturers definitely recommend the replacement of all such hoses at every engine change (except Teflon) even though they look good.

Age limit of hose has generally been established at four years. This limit of four years is generally considered to be "shelf" life. All hose manufactured for aircraft use are marked indicating the quarter year in which they were manufactured. The listing "4071" means the hose was manufactured in the fourth quarter of 1971. Maintenance personnel should not use hoses with a high "shelf" life age.

by Antoni (Tony) Bingelis

Painting the Homebuilt

PAINT AND FINISH the airplane before you take it to the airport. I think it is most impractical to fly an unpainted airplane for awhile and then have to pull it in for painting. What a job that would be. The airplane will have acquired dirt (and oil) all over it, and would require a very good degreasing and cleaning before painting. This entails a considerable amount of disassembly work. And, another thing also. Will you have the facilities for painting at the airport, or will you have to haul everything home again?

Because the average builder has never sprayed anything in his life bigger than a birdhouse, he approaches this final stage of construction with more apprehension than the situation merits. Typically, he makes his first mistake when he tries to do the job with inadequate equipment. If the proper equipment cannot be borrowed or purchased, it might be wise to get somebody to paint your airplane for you.

You will need a good spray gun and a compressor large enough to provide a flow of air that stays ahead of the gun's needs. Otherwise, you are in for a difficult time of it.

Don't even consider painting the airplane with a paint brush . . . it will look like it.

Naturally, most of us do not have access to a paint booth large enough to accommodate an airplane so, the garage, the basement, the driveway, or the yard somewhere under the trees becomes our paint shop.

The hazards of painting a homebuilt under such conditions are both real and imagined. An explanation is in order.

By hazards, I mean to include bugs, dust, wind, unexpected showers, toxic fumes, newsprint, old masking tape, unstuck masking tape, torn cover paper, runs, too little and too much paint, overspray, lack of ventilation, bleeding paint, telephone calls, visitors, and running out of time, paint and patience.

Painting the airplane in the garage or basement requires ventilation with a generous amount of fresh air in constant circulation. Take my word for it before you start. Don't try to paint your airplane in the basement . . . not unless you can physically survive the fumes and the ire of a family reacting to the instinct for survival.

Painting in the garage is a lesser evil as the doors may be left open and a fan used to help move the air. A lot of builders hang a clear plastic curtain all around the scene. This is a good idea as it helps control the dust inside of the painting area and protects your garage and possessions against overspray. However, you will have a ventilation problem to solve.

Painting the airplane in the yard or driveway introduces still other risks. Dust and bugs are two of the most common of them.

It depends somewhat on where you live and the season of the year. But, it seems that some bugs are suicide prone and will dive gleefully into newly applied paint, while flapping their wings furiously, apparently bent on self-destruction. Unfortunately, your beautiful finish is destroyed in the process.

Try to learn the time of day when bugs are least active in your territory.

Don't try to spray out of doors when it is windy. You will be wasting your time and possibly find yourself being sued by your neighbor for painting his car an offshade of chartreuse and red.

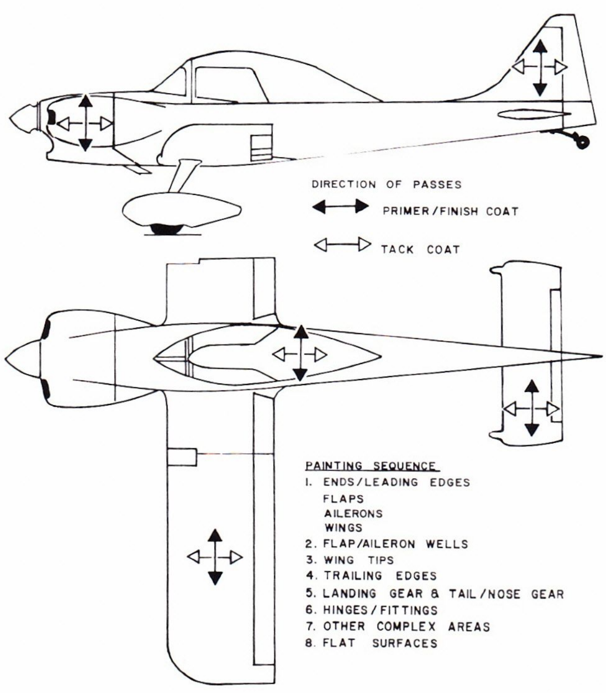


FIGURE 1.

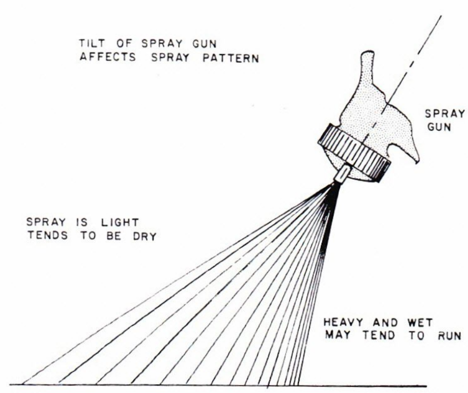


FIGURE 2.

Even in the absence of wind, dust can damage the overall finish in a manner more devastating than the localized effects of suicidal bugs.

You can help settle some of the dust by watering the surrounding vegetation and wetting down the driveway with a water hose. It would, likewise, be helpful to paint during the early morning hours when the winds are gentle and the air is not rising due to the sun's heating. However, if you are spraying dope, humidity will be a factor to consider during early morning hours.

I believe the finishing of an aircraft can be separated into two categories.

(1) Fabric covered aircraft and (2) non-fabric covered aircraft. The non-fabric covered aircraft category would include those with aluminum skins, plywood covering, fiber-glass skins, and similar "hard" surfaces. Essentially, any hard surfaced aircraft can be painted with virtually any of the finishes available today while the options for fabric covered aircraft are necessarily limited to finishes having a high degree of flexibility.

FABRIC COVERED AIRCRAFT

No matter how tight the fabric is stretched (and it shouldn't be excessive), the fabric covering does present a flexible, pliable surface in service. Therefore, any finish applied to the fabric will be constantly flexing and drumming in flight. It is easy to see why the finish used must be flexible enough to withstand the long term effects of such conditions. As a result, until recently fabric covered aircraft, almost without exception, were finished with dope . . . butyrate dope. Butyrate dope is flexible and retains its flexibility very well, with the passage of time. It survives as the most practical finish for fabric covered aircraft.

Builders dissatisfied with the many coated and tedious finishing process required with dope have tried painting their airplanes with enamel.

In the early days of the EAA, most enamels were rather brittle due to their extremely hard surface. The finish was prone to crack and chip and the repair or patching of the fabric often meant refinishing a whole panel. Blending a patched area was almost impossible. That is still the case with some enamel finishes. Spot refinishing remains a problem to consider.

Lately, however, some builders are finishing their fabric covered aircraft with Dupont Dulux enamel and the newer Polyurethane enamels with considerable success and with good surface longevity assured. So, now in addition to the traditional butyrate dope finish, you might consider a polyurethane enamel, Dupont's IMRON, for example along with their Dulux enamel. Of course, other brands of polyurethane may be equally good and their substitution would be determined more by local availability than anything else.

It takes a heck of a lot of dope to finish an airplane. For this reason, the polyurethane enamels are currently popular with the builders of fabric covered aircraft.

The Emeraude I constructed is still beautiful in its nine year old coat of Dupont Dulux enamel. However, small hairline cracks are beginning to appear along the edges of the fairing strips where the fabric changes direction rather abruptly. The white areas are less affected than are the darker colors. But, I wonder if the same condition would not have developed by now in a butyrate dope finish.

If dope is your choice, and since it does take a lot of dope to finish an aircraft, a builder should acquire the use of a pressure pot. Spraying many coats of dope from a one quart spray gun would be like trying to water the lawn with a squirt gun.

Some airplanes are built with the idea of winning awards and trophies. They receive extra preparation efforts as well as extra coats of dope or paint. Such fabric covered aircraft look beautiful the first year but, unfortunately, the heavy thick paint layers tend to develop surface cracks much sooner than the minimum coat finishes. Completely out of the trophy seeking builder's mind, I am sure, is the fact that there will also be an increased weight penalty for a super deluxe show paint job.

If you are not driven by an intense need to compete for awards, to the exclusion of having a good functional airplane, content yourself with the minimum number of coats. When enamel is used, for example, a single full coat will often suffice. (By full single coat we mean, of course, a tack or light mist coat that is followed about **10 to 15 minutes** later by a full spray top coating.)

Heavy coats of paint also affect the balance of control surfaces to the degree that they may no longer be 100% balanced.

It might even be necessary to rebalance control your surfaces after the painting (doping) is completed. Even if your design does not utilize balanced control surfaces, always be leary of adding weight aft of the control hinge axis.

It is important to remember that you cannot successfully put dope over any surface material other than fabric. Dope sprayed on metal will soon peel off . . . in sheets. This is one of the disadvantages of using dope. As a result, it is necessary to purchase matching enamel for the cowling and other metal or fiberglass parts. (Stay with the same brand for both the dope and the matching enamel.)

There are plenty of good instructions available to builders regarding dope application, finishing and refinishing aircraft. Excellent informational material is put out by Randolph Products Co., P. O. Box 67, Carlstadt, New Jersey 07072. Another good source is Stits Aircraft Coatings, P. O. Box 3084, Riverside, California 92509. An excellent manual entitled Aircraft Painting and Finishing is published by Aviation Maintenance Foundation, Inc., P. O. Box 739, Basin, WY 82410 and may be obtained for $3.00. Check locally to see if these products are handled at your nearby airport.

No attempt will be made here to repeat the manufacturer's recommended and detailed procedures, rather, let's continue to discuss lesser known little details.

After all, who knows better than the manufacturer the best way to use his products? Follow his instructions and you will have everything going for you in obtaining a good finish.

Don't mix brands. Don't use one brand of paint and another of reducer-thinner, or even two different brands of paint. It might be OK and then again it might not work satisfactorily. Why risk a poor finish or one which will break down and peel and/or crack in a few months? A good butyrate or paint job should hold up well for 10 years or longer if the airplane is kept hangared and clean.

NON-FABRIC AIRCRAFT

Because aluminum skinned, fiberglass skinned and plywood covered aircraft do not have flexible surfaces, they can be finished in almost any of the currently available finishes now on the market with the exception of dope.

Currently the popular finishes include the polyurethane enamels, the acrylic enamels, the Dupont Dulux Enamels and, in some cases, the acrylic lacquers. The use of each of these types of finishes is amply covered in the manufacturer's instruction sheets and to a degree, on the labels attached to the container.

Non-fabric covered aircraft surfaces will usually benefit from a wash primer coat after the final sanding with #320 or #400 wet-dry sandpaper. This is true of fiber-glass skins and particularly of aluminum skins. A wash primer is one which provides a mild etch to metal surfaces and establishes a good bond for top coats. Acrylic enamel top coats can be applied directly over the wash primer but many builders prefer to add a coat of epoxy primer for maximum corrosion protection before application of the top coat finish. Here again, it is best to adhere to the instructions issued by the manufacturer of your finish materials.

My own personal choice for a good all-around economical, safe to use, finish for non-fabric surfaces is Dupont's Centari Acrylic enamel. It doesn't require a primer and it will adhere to virtually any clean surface. You can paint and repaint as often as you like and it won't wrinkle. You can use it for spot painting and, best of all, it dries fast and rewards you with a beautiful self-polished shining surface.

PAINTING POTPOURRI

It is probably a universal procedure to shoot the basic color first. In other words, if the airplane is mostly white, spray all the white first. Then mask for the other color(s). There is one big exception. If your basic color is red, put on all other colors first because most red paints/dopes are what is known as "bleeding reds". That is, the pigment of some reds (Tennessee Red, Champion Red, Vermillion, Insignia Red, Stearman Vermillion, Waco Red, etc., etc.) are soluable in solvents and will bleed to the top surface of any color you put over them. This is a real trap. Repeat, do not try to paint over red with any other color. I'm sure that there are some sealers on the market that can seal the red to keep it from bleeding through but these are not commonly known or available in most home towns.

Reds, if used as a trim should be applied after all other colors have been sprayed and are thoroughly dried. A few of the reds are non-bleeding in nature but you had better make sure of this beforehand.

By the time your project has progressed this far, you will have decided on the colors and the basic paint scheme. Perhaps not. A surprising number of builders remain unsure right up to the time they stop in at the paint store.

Here's something to think about. The lighter the color, the lighter the airplane appears to look. White, somehow, makes the aircraft look cool. Furthermore, white reflects light so well that surface imperfections are difficult to discern . . . and this is good. In hot climates, this is also a very important consideration for another reason. Internal temperatures in the summer can reach close to 200° F in a relatively short period of time. The darker the colors, the higher the internal and surface temperatures.

The smaller the aircraft, the less fussy and cluttered the paint scheme should be. Most aircraft are viewed from a distance. How would your proposed paint scheme look from a distant vantage point? Well, so much for day dreaming . . .

If you do not have a spraying procedure of your own, you might consider using the general spraying sequence indicated in Figure 1. Much depends on the aircraft's size, design, and whether or not it is fully assembled . . . so feel free to modify the procedure to suit.

Generally, the bottom of the aircraft is sprayed first. If the aircraft is on the gear, the tail may be raised so that the bottom of the fuselage is easily accessible. Some support must be used for the engine when tilted in this manner. At all other times, be careful to weight down the tail so that the airplane will not flip over on its nose unexpectedly while you are working. With wings and tail surfaces removed, and with the engine installed, the tail is very light and requires some restraining weight.

After the top coat has been sprayed, particularly on fiber-glass surfaces, you might be appalled at the number of tiny little imperfections that appear. If so, a second coat seems advisable. Use a small flexible squeegee (artist's spatula) and spread on a thin layer of acrylic spot putty wherever needed. (Remember, read the instructions and follow them to the letter.) After the putty dries overnight, level the treated spots with a small sanding block and #100 grit sandpaper (aluminum or zinc oxide grade). Finish the entire part with #320 wet/dry paper using plenty of water while sanding. This will really smooth the surface nicely for the next and what could be the final coat.

No attempt should be made to hide joints and seams. One example. Do not try to hide the joints between the windows and the aircraft's structure with paint and filler. It will only be a matter of time before the seams crack and look ugly. It might even be better to install the windows and windshield after painting but this depends on the means of installation.

WHAT TO DO ABOUT OVERSPRAY

Overspray results when the fine mist beyond the basic spray pattern of the area being sprayed falls on the aircraft surface in a semidry condition. This, in effect, leaves that particular area with a dull granular appearance. The dull appearance of overspray, however, can be minimized or eliminated. Enamel overspray does not ordinarily present the problem that lacquers or dopes do since its drying rate is so much slower. The enamel overspray will, ordinarily, blend into the finish while it is still wet.

Dried overspray from most paints, other than polyurethanes, can usually be "burned down" by spraying a mixture of one part retarder to two parts thinner on the painted surface while the overspray and base finish are still fresh. The mixture will soften the surface film enough to permit the overspray to sink in and gloss.

It is far better to prevent overspray effects in the first place. When spraying, tilt the gun slightly so that the overspray will be ahead of the area being painted, especially when spraying the top of the fuselage and the tops of the wings. The new paint coming out of the gun will wipe out the overspray as you work toward the unpainted area.

TAPE REMOVAL

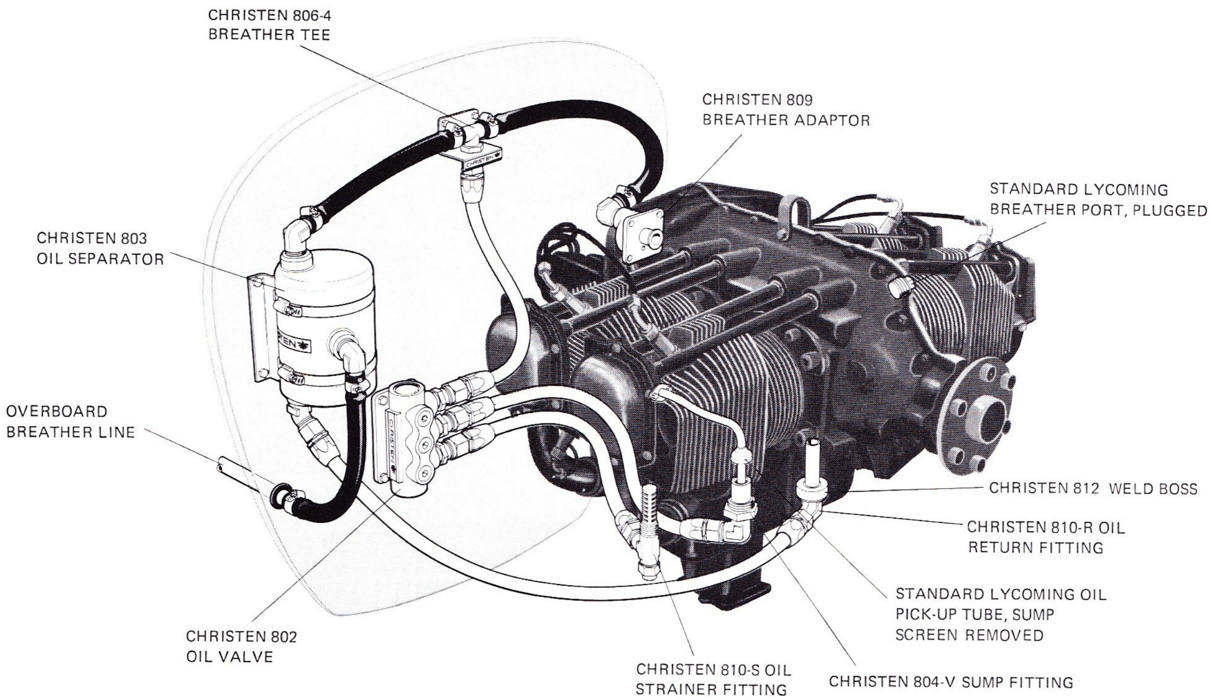
Oh boy! Here is where we have differing ideas. If the paint comes off with the tape . . . you did something wrong and I'll bet it was not in how the tapes were removed.

If you masked the airplane properly you can easily and quickly pull away the cover paper which should have been attached with separate tapes to the taped outlines. The finesse used to remove the cover tapes is not critical as the tapes are not attached to any of the painted surfaces. After the cover paper is pulled off, however, you would probably prefer to have anyone who has been helping you to go get themselves a cup of coffee or go to the movie while you, personally, remove the remaining tapes. They should be removed carefully.

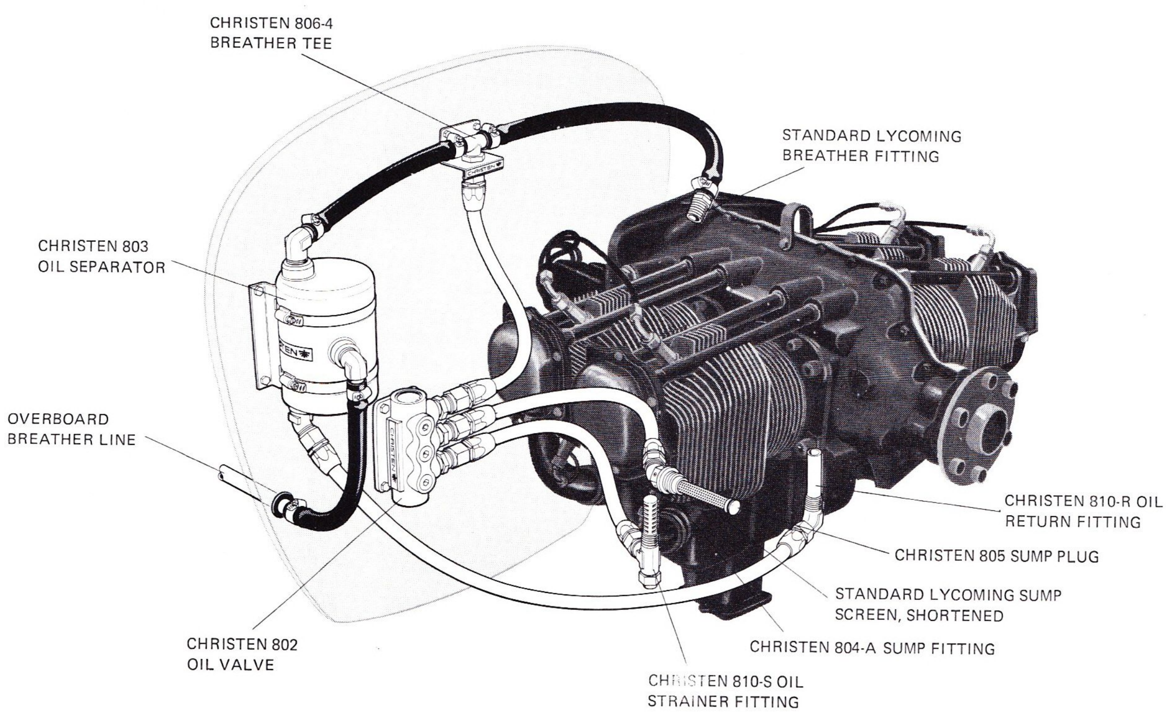
Everybody seems to agree that tapes must not be permitted to remain for long once the spraying has been completed. An hour or so is long enough even for slow drying enamels. You don't want to allow the new paint to dry to a hard surface before the tape removal because the paint line at the tape edges will be forcibly separated in a ragged manner as the tapes are pulled off.

Some say pull the tape away from the painted surface at a shallow angle. Others say pull the tape back over itself at about a 30° angle. The method doesn't matter too much just so long as the tape is removed while the paint top coat is only partially set and still relatively pliable. It does matter however, that you proceed with the pulling away of the tape slowly and smoothly. Fear not, you will develop your own personal way of doing it. If it works, you did everything just right.

Christian 801 Series Inverted Oil System



A. VERTICAL-SCREEN SUMP TYPE



B. HORIZONTAL-SCREEN SUMP TYPE

Figure 1-1. Christen 801 Inverted Oil System, Typical Installation

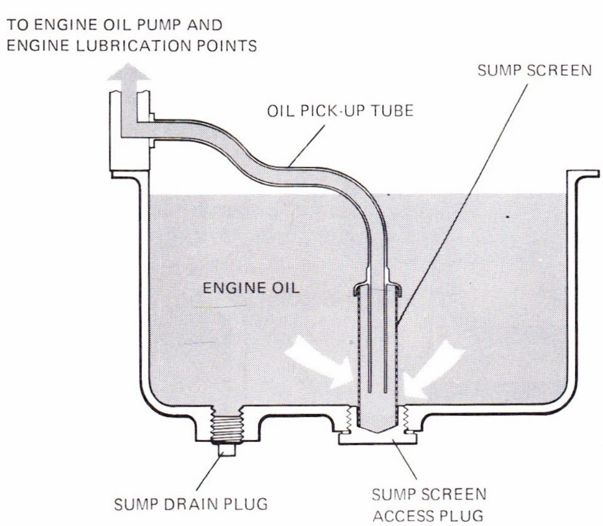
The Christen 801 Inverted Oil System, shown in Figure 1-1, is a kit-form accessory for Lycoming aircraft engines which permits normal engine lubrication, with minimal oil loss, during aerobatic flight. When installed, it becomes a self-contained extension of the normal aircraft engine oil and breather systems. Because the system control valves are gravity-operated, connection to aircraft power sources is not required.

The system functions in all inverted and negative-g flight conditions, and is particularly suited to high-performance aircraft used for unlimited-class aerobatic competition. During inverted flight normal engine lubrication is maintained, so that the aircraft may be flown inverted without time restriction.

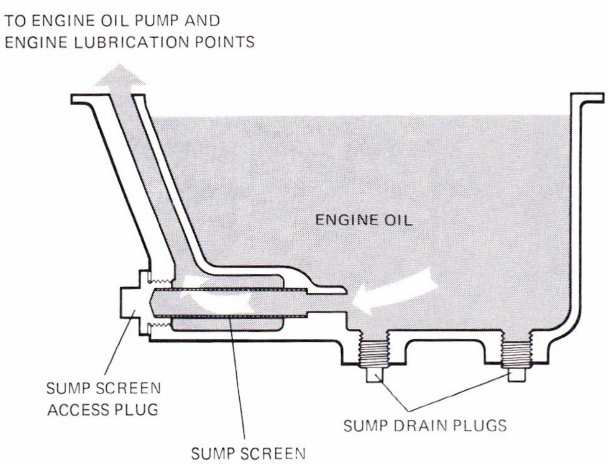
The Christen 801 Inverted Oil System is available in a number of configurations, each planned for most effective application to a particular engine type. Two basic variations in the system result from requirements for different system components on vertical-screen sump engines and horizontal-screen sump engines. Figure 1-1A shows the Christen 801 System installed on a typical vertical-screen sump type engine, such as the Lycoming O-290-D. Figure 1-1B shows the Christen 801 System installed on a typical horizontal-screen sump type engine, such as the Lycoming O-360-A4A.

Certain engine types, such as the IO-320-E2A, require an additional port to be installed in the sump. Other engine types, such as the Lycoming O-235 and O-290, require relocating the breather port. Six-cylinder engines use 1-inch diameter breather hose, and 3/4-inch breather hose is used on four-cylinder engines.

In addition to the standard sump modification, an extended

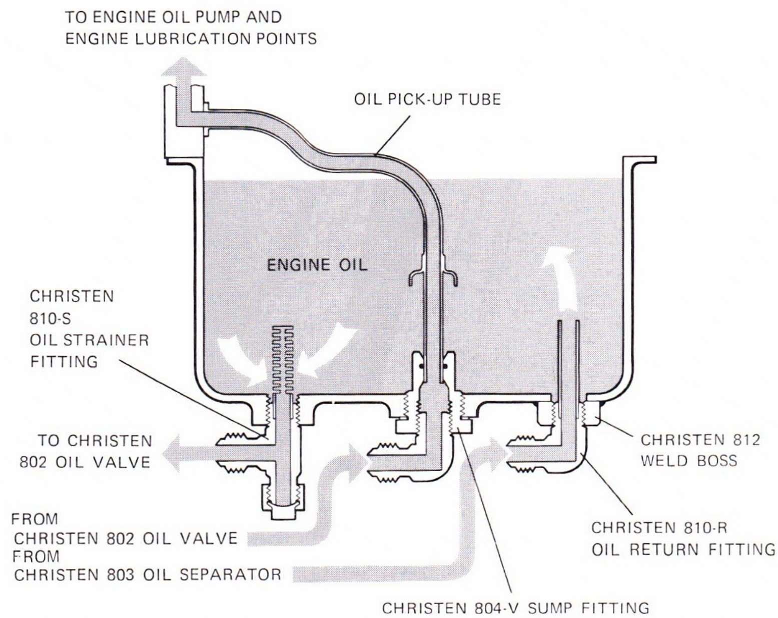


A. VERTICAL-SCREEN SUMP

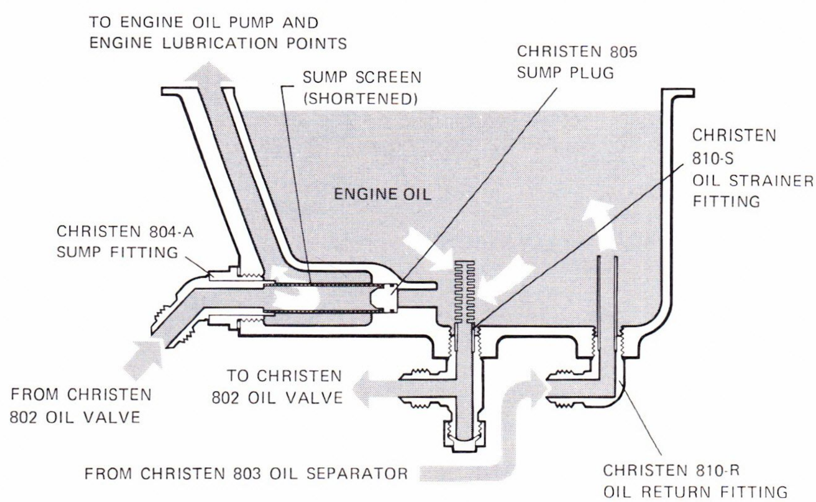


B. HORIZONTAL-SCREEN SUMP

Figure 1-3. Oil Flow, Unmodified Sump



A. VERTICAL-SCREEN SUMP



B. HORIZONTAL-SCREEN SUMP

Figure 1-4. Oil Flow, Converted Sump

sump modification is available for most engine models which relocates sump ports at optimum points for oil pick up and return, thus enhancing system performance by preserving oil pressure for longer periods under aerobatic conditions such as vertical and knife-edge flight.

Hoses and fittings for the system are available as Christen kits, or they may be user-supplied.

Many engine models can be equipped with the Christen 801 System, but special adapters and fittings may be required. Contact the Christen factory, Christen Industries, Inc., 1048 Santa Ana Valley Road, Holllister, California 95023 (Phone 408/637-7405), for assistance in designing non-standard installations.

Aircraft equipped with constant-speed propellers require evaluation before modification for aerobatic flight. During periods of zero oil pressure, some propeller types decrease pitch, while other types increase pitch. Momentary interruption of engine oil pressure during aerobatic flight, which normally occurs during certain maneuvers, may produce decreased pitch and cause engine overspeed if the propeller is of the decreasing-pitch type. For safe engine operation during aerobatic flight, therefore, the propeller should be of the increasing-pitch type. A suitable constant-speed propeller of this type, for use with the Lycoming IO-360-A series engine, is the Hartzell part no. HC-C2YK-4CF/FC7666A-2 (Hartzel Propeller Company, Piqua, Ohio 45356).

In the standard vertical-screen Lycoming sump, oil circulation is entirely internal, as shown in Figure 1-3A. Oil from the sump passes through the sump screen and flows

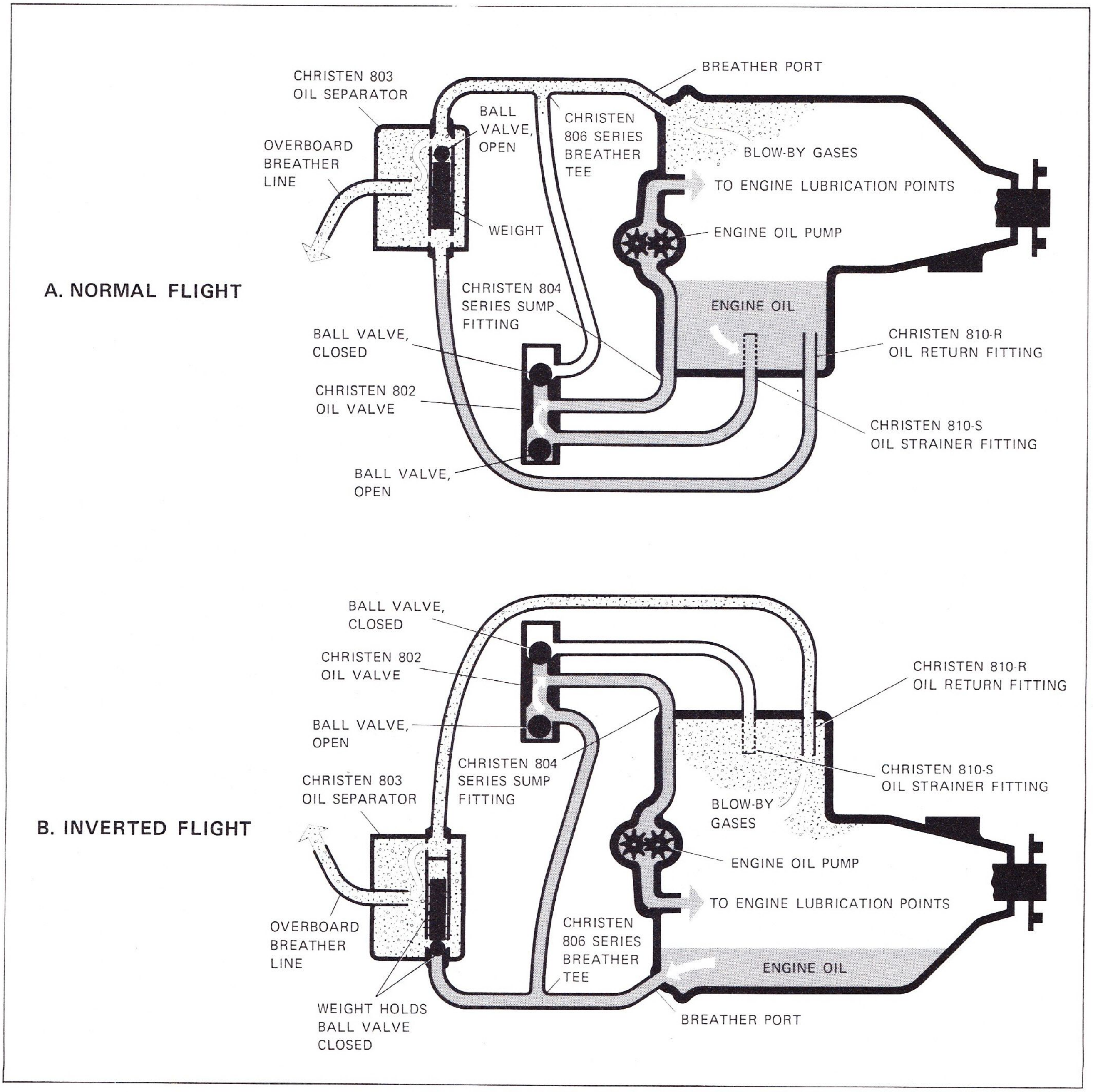


Figure 1-5. System Operation

up through the oil pick-up tube to the engine oil pump and engine lubrication points.

As shown in Figure 1-3B, oil circulation in the standard horizontal-screen Lycoming sump is similar to that of the vertical-screen type, but oil flows into the end of the horizontal sump screen and up through an oil passage to the engine oil pump and engine lubrication points.

When an aircraft using this type engine is inverted, the oil in the sump falls to the top of the crankcase, and oil pressure is lost immediately since there is no longer a supply to the engine oil pump. In addition, substantial oil loss occurs due to direct flow overboard through the breather line at the top of the engine crankcase.

Installation of the Christen 801 System results in the sump modifications shown in Figure 1-4. For most installations, modification consists of adding the fittings shown to existing sump ports, without sump removal or engine disassembly. The sump must be removed, however, for installations requiring the addition of new sump ports using the Christen 812 Weld Boss. The Christen 805 Sump Plug used in the horizontal sump screen type engine is installed, without engine removal, by insertion from the sump screen access port at the rear of the engine.

During normal flight (Figure 1-5A), the weighted ball valve at the top of the Christen 803 Oil Separator is open, allowing blow-by gases from the engine crankcase to be vented from the breather port, through the Christen 806 Breather Tee, to the top of the Oil Separator, and out through the overboard breather line. The top ball valve of the Christen 802 Oil Valve is closed, and the bottom ball valve is open. This permits oil to flow from the sump out through the Christen 810-S Strainer Fitting to the Oil Valve, back through the Christen 804 Series Sump Fitting to the oil pump and engine lubrication points.

When the aircraft is inverted (Figure 1-5B), engine oil falls to the top of the engine crankcase. The weighted ball valve in the Oil Separator closes, preventing overboard loss of oil through the top of the Oil Separator. Blow-by gases from the engine crankcase are vented from the sump to the bottom of the Oil Separator and out through the overboard breather line. The top ball valve of the Oil Valve is open, and the bottom ball valve is closed, allowing oil to flow out from the breather port, through the Breather Tee to the Oil Valve, through the Sump Fitting to the oil pump and engine lubrication points.

Any oil in lines which fails to return to the sump during the transition between normal and inverted flight drains into the Oil Separator. This oil then returns to the sump from the bottom of the Oil Separator during periods of normal flight.

Acro Sport, Inc.
P.O. Box 462
Hales Corners, Wisconsin 53130

How to Bend Tubing Successfully

by Tony Bingelis

FORTUNATELY, MOST OF our homebuilt projects do not require very much tube bending. However, I assure you that these few components are important and many of them are, for the most part, highly visible. Being so visible, their fabrication merits your very best effort. But giving it your best effort does not mean you have to make a big production out of this tube bending thing. That goes for bending steel tubes, copper tubes and aluminum tubes as well.

Anyone building a tube and fabric airplane will probably encounter more opportunities for developing his tube bending skills than he would if he were building a composite. These welded tube aircraft are ordinarily endowed with nicely curved tail surfaces made of small diameter steel tubing. Some of them also have tubular wing tip bows, fuselage formers and seat frames as well. Builders of other types of aircraft can add windshield and canopy bows, flap handles and sometimes "S" shaped control columns to the bent tube list.

Just about the only copper tubes used in homebuilts are the oil pressure line and the primer lines. Even these are falling into disuse as more builders switch to electrical gauges. These copper tubes are a mere ⅛" in diameter and may be easily bent by hand or formed around an empty tin can or jar of the proper diameter. No serious tube bending problem here.

Aluminum tubing is not only used for fuel lines, it is also used for windshield and canopy bows and wing tip bows, too. These being tubes of a larger diameter present bending problems similar to those experienced with steel tubes. Ultralight builders utilize a lot of pre-bent aluminum tubing in structural elements but these components are, ordinarily, purchased pre-cut and pre-bent from the factory or supplier. Aluminum tubes are important in fuel systems and so are the bends you make in them. After all, why use a fitting where a bend in the tubing will do as well? Tubing bends are much lighter, cheaper and, unlike fittings, can't leak.

Do not be lulled into thinking that simply because ⅜" aluminum fuel lines are rather ductile you can easily form them by hand. You can, of course, but hand formed ends often become flattened and have a poor irregular appearance. Such wavy flattened bends are the usual result of attempting to bend thin wall tubing to small radii without the aid of a tube bender. A flattened fuel line can restrict the flow of fuel and could, ultimately, fail in service.

What Happens Whan A Tube Is Bent?

To make a bend in the middle of a piece of tubing, you would grasp it at each end, right? Then you would place it over some hard curved surface and push down hard on both ends of the tube . . . and the tube will begin to bend. If the radius of the underlying object (form) over which you are making the bend is large, the bend will be large and gentle and the tube will retain its round cross section. If, on the other hand, the surface beneath has a small radius, the curvature developing in the tube will be localized. For the first few degrees of bend, the bend will develop nicely. Then, you will notice that the tube is beginning to flatten. The top side of the bend is now under increasing tension and has to stretch. The tubing, however, is reluctant to do so and takes a short cut around the bend causing that unwanted flattening in the tube. But, what about the bottom side that is jammed against the "bending form"? It is being severely compressed and although the tubing resists this crowding it is beginning to show signs of buckling across the tube diameter. If you continue the bending, the flattening on the top side will become more pronounced while at the same time, the crowded metal on the bottom side relieves the pressure by developing more wrinkles. Ultimately, the tube will suddenly bend sharply and fracture.

Thin wall tubing is more difficult to bend successfully because it is very quick to flatten and buckle.

The larger the tube diameter, the greater the pressure you must exert to make it bend. While you can easily form a 90° bend in a ⅛" diameter copper line that is only 6" long, you simply cannot do the same with a similar length of ¾" tubing. Not even if you had a form to bend it around. Why is that?

You Need Leverage

No matter how you go about bending a length of tubing, you will find it much easier to do if the piece is long enough. You can then take advantage of the leverage it affords (you know the principle). A lack of sufficient leverage could