Chapter 3

Infill "Bench" Planes


Plane made from channel steel. The frog is welded to the sides

One way to make a plane body is to take a piece of steel or brass channel, shape the sides a bit, cut out a mouth, and add some way of holding a blade. The plane at right was made by my father during the "Great Depression" of the 1930s. The body is a length of heavy channel steel with a "frog" of 3/8" thick steel crudely welded to the sides. The blade is clamped to the frog by a bolt & heavy washer at a point well back from the cutting edge of the blade so needless to say, although it may superficially resemble a Stanley Bedrock, the performance is not quite up to that level. The sole is reasonably flat but the blade is difficult to set for a fine cut because it is tapered and loosens when tapped forward. Nevertheless, it works in its own rough way, & although it could be improved, I prefer to keep it for what it is, an example of the ingenuity & resilience shown during those tough times.

Fabricating a body from metal plate means you are not restricted by the limited choice in channel sizes & gauges. Brass and steel plate are readily available in widths & thicknesses suited to making soles & sides for planes, and no special tools are required. But we need to join the pieces to make a solid chassis, so how do we do that? There are several ways it *could* be done. Riveting, as used for the laminated planes in the previous chapter is an option and used by at least one boutique plane maker. It requires a thicker sole to accommodate the rivets, which could add considerably to the mass of the plane. This is touted by the maker as a virtue, but I think you can easily have too much of a good thing. Heavy planes have a reassuringly solid feel, they sit firmly on the workpiece and may be satisfying to use for a minute or two, but for serious work, a heavy plane can quickly become tiring.

A method more suited to joining lighter gauges is the "double dovetail". The technique has been known since antiquity, but for some reason it was not applied to making metal-bodied planes until relatively recently. Cast bodies, mostly in bronze, go back at least to late mediaeval times but the earliest fabricated metal bodies that can be reliably dated are the so-called "mitre planes", first made in quantity in the early 1800s, although they are known to have been made earlier. For unclear reasons, though perhaps conservatism on the part of both tool-makers & tool-users and availability of suitable materials all contributed their share, it was not until around the 1840s that the "infill" bench planes we know today first appeared as a commercial entity. Over the next 60 years, firms like Spiers & Norris turned infill planes into high art.

Like riveting, metal dovetails are made possible by the ductility of metals. "Pins" on one component can be hammered over through-dovetails on another to form a second "dovetail", thus locking the joint very firmly - no glue required. It is a very effective & strong way of joining metal which should appeal to the soul of any woodworker. Planes of any size can be made this way and you are not restricted to simple, square shapes. Curved sides are almost as easy to make as straight sides, and of course, the side profiles can be just about any shape you wish. There are some constraints; you do need to provide sufficient depth and thickness of sides to create an adequately stiff body & make sure there is somewhere to pivot the lever-cap or fix a bridge for a wedge. To that end, a number of fairly standard side-shapes evolved during the years infills were produced in quantity.

Some metals and alloys are either naturally brittle, or will rapidly 'work-harden' which means that when hammered, they begin to flake & split, so we need to choose metals or alloys which as well as having sufficient strength & stiffness will tolerate the deformation required when cold-worked. Steel, wrought iron, and copper alloys (bronze & brass) are the metals most often chosen because they have the desired working properties combined with adequate strength & stiffness.

Making a bench plane is a little more demanding than making the laminated shoulder planes described in chapter 2. There is extra work in cutting out & fitting the dovetails & more peening is required than clenching a few rivets. More filing is required to "tidy up" afterwards, but it is still a basically simple process & requires only a few extra tools than those used to make the shoulder planes described in chapter 2. Again, you may use powered tools where appropriate, or use hand tools exclusively. A drill-press can be a great help and I also use a small metal lathe to make my own thumbscrews, but quite acceptable thumbscrews can be made without a metal lathe (described in chapter 4). You can even make your own blades, though it will probably be cheaper & more reliable to buy commercial replacement blades at first. With patience & care, you *can* make a very good plane in a few weekends if you set your mind to it.

Metal dovetails 101

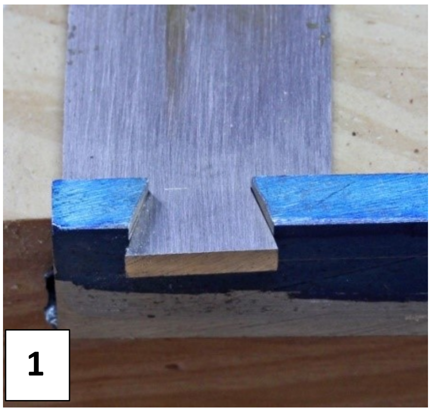
As a first step, let's try to demystify this metal dovetailing business.

To make dovetails in metal, you begin the same way as for wooden dovetails, i.e. by setting out the 'tails' on one of the pieces to be joined, removing the waste, then scribing the tails on the piece it is to be joined to. Lines can be scratched with any hard, sharp object such as an old triangular file ground to a fine point or a 'proper' metal-scriber if you have one. The use of some sort of layout dye to make lines stand out is highly recommended. A small marking gauge with a hard, sharp point is handy too, but not essential, you can set out using a metal ruler, a try-square, and a dovetail template or bevel gauge.

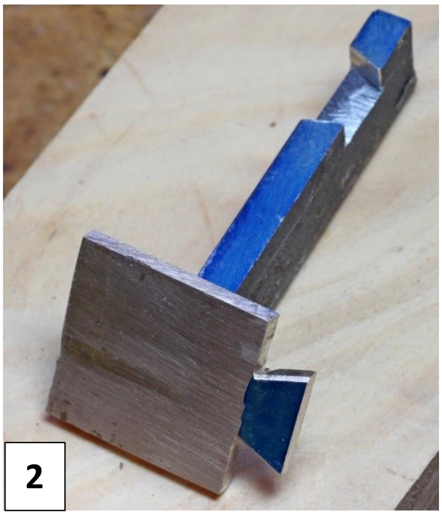
Dovetail angles

A question that's often asked is what angle should the dovetails have? There is no 'right' answer to that question. Metal dovetails are immensely strong even at an angle of a couple of degrees (in fact straight pins can work – see mitre planes in chapter 5), so it's mostly about appearance. Some people make their dovetail sides as much as 45^0 but that looks too exaggerated to me. If using brass or bronze for sides on 5-6mm thick steel soles an angle of around 10^0 (~1:6) will be quite obvious. If you are making an all-steel body (on which the dovetails won't show) a shallower angle is fine. Make a full-size drawing & try different angles to see what suits your taste.

The pins & tails need to be cut to overlap by a sufficient amount to provide the metal for peening them closed. For a typical dovetail, I have about 1.5mm sitting proud of both surfaces when they are assembled (1). This is adequate if the fit is close, but it might pay to leave bit more for your first attempt, in case the gaps are larger than ideal. As you get better at achieving a close fit and more practised with your peening, you can cut back on the excess to save work filing it all level after peening.

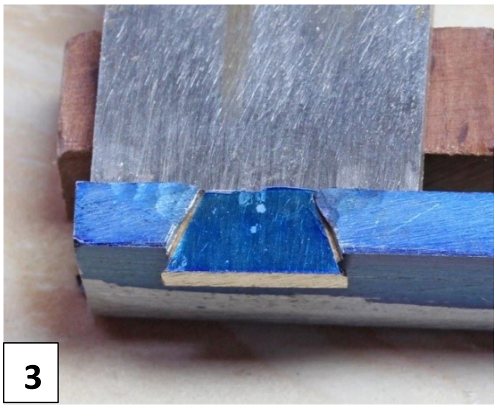


The pins & tails may be cut out with a hacksaw or jewellers saw, and tidied up with files. A jeweller's saw is the neatest & quickest method of removing waste once you become practised with it. An alternative method is what I call the "filleting technique"; you make a series of hacksaw cuts to the bottom line & break out the resulting fillets of metal with a screwdriver or small cold-chisel. Drilling a series of small holes as close together as possible along the line & breaking out the waste is another method. Both of these latter methods leave a very rough surface that requires a lot of filing to clean up.

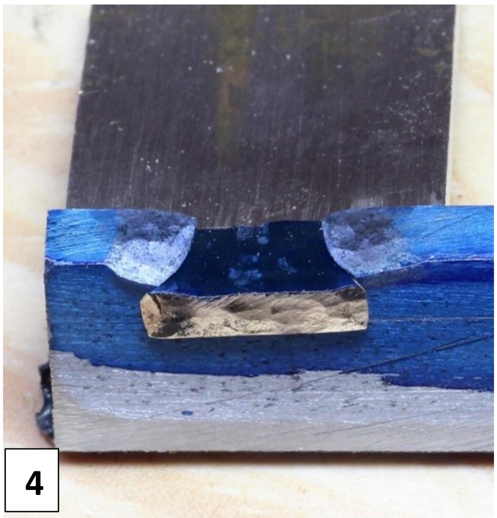


After filing the edges of the tails straight, they are scribed to the mating piece, and the waste removed from that piece. The bottoms of the sockets between pins or tails should be a precise fit, but unlike their wood counterparts, the sides of metal tails are less critical. A close fit is desirable because it makes peening easier, but you can fill quite large gaps as long as you have allowed enough extra metal.

Before assembly, a *small* bevel is usually filed on the edges of the tails to form the second "locking" dovetail (2). The bevels can be quite shallow and only need to be 1/3rd to ½ of the thickness of the material deep. In fact a bevel isn't absolutely necessary when peening steel over brass, the steel will distort the brass enough during peening to lock it firmly. However, a pre-formed bevel along the tail edge creates a more distinct "second" dovetail when the joint is viewed from the sole side. When joining two pieces of the same metal, e.g. steel to steel, some makers put a deep notch in the inner corners of the tails and only a tiny bevel along the edges. Filling the notch forms a very positive lock, and less peening is required along the edges. The notch doesn't show on the finished joint, as it would if you were joining different metals like brass & steel.



The assembled pieces are clamped tightly on a block of hard wood to maintain the desired angle of the joint (usually 90^0 but other angles are possible). Support the edge opposite where you will strike with a solid metal object such as the anvil on the back of a large metalwork vise or a chunk of steel on the benchtop and use the *ball* side of a ball-peen hammer to coax the extra metal of the pins over the bevels of the tails. (3). Work from outer to inner edges of the joints, so that it forces the parts together firmly. Begin by striking 1-2mm back from the edge and gradually coax the metal over the gap, using *slightly* oblique hits angled in the direction you want the metal to move. The aim is to fill the gaps between pins & tails from the inside out, so you don't leave any internal voids. If you beat the edges down straight off, you may quickly cover the outer part of the gaps, but not close them deeper down. This will mean a less solid joint and you are likely to uncover voids when filing off the waste metal after peening. By slowly forcing a 'wave' of metal over the gaps, you will get a more complete fill without voids. When you have moved enough pin material over to lock the tails in, you can switch to the tail ends and peen them into the corners of the sockets, but don't do this too soon or you may push the sides away from the sole. The ends of the tails usually require much less peening than the 'pins', particularly if the initial fit was tight.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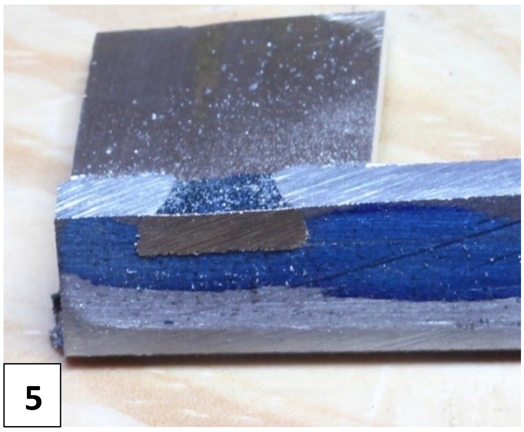
If the pins & tails were a good fit, the joints will close quite easily (4), but if you have any large gaps they will keep you hammering longer. Try not to strike the surfaces of the metal that won't be filed after peening, and whatever you do, don't hammer the metal below what will be the finished surfaces.

You can see in picture 4 how much metal was moved to bring the sides of the pins over the tail, while much less peening was required to compress the end of the brass tail and fill the corners of the socket. Pay particular attention to all of the corners of both pins & tails as these areas are the most likely places to find small voids after filing flush.

If one metal is more ductile than the other, arrange things so it gets the most peening. By doing this you can get away with using less ductile material like C385 brass for plane sides. Doing the heavy peening on the more ductile steel of the sole means much less peening of the brass is required. Mild steel easily tolerates heavy peening without splitting or flaking.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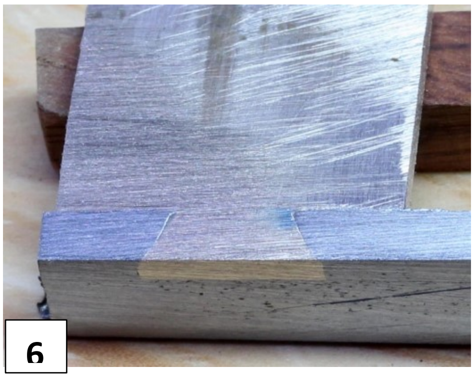
When peening is complete, the excess metal of pins & tails is filed flush with the surfaces (5).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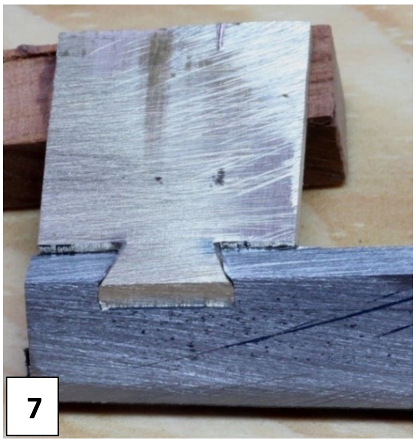
Then with a hard, flat sanding block, & starting with 120 or 180 grit the surfaces are sanded smooth (6).



This demonstration dovetail was made very quickly, and the steel obviously wasn't hammered over the brass as thoroughly as it should have been, resulting in small, visible lines towards the corners (6). Despite this, it required considerable force to pull the joint apart. The brass bent & distorted at the shoulders but the peened section is still holding (7). You can appreciate that six to eight of these joints on each side of a plane makes for a strong & rigid chassis.

When you use the same metal (brass or steel) for both parts of the joint, it should be invisible, as they usually are on the good 19th century steel-bodied infill planes.

Two pieces of brass joined by a double dovetail

To demonstrate this, I used some H62 brass alloy of Chinese manufacture, which is more malleable than C385 and peens nicely. The finished joint becomes invisible when filed flush.

After cleaning up, the joint is now invisible

It's a simple process, but I advise a bit of practice with some scrap before attempting your first plane body. Experiment with different sized bevels on the tails to get a feel for how much extra metal you need to fill gaps & how far you can force the metal over. File the peened joints flush & check that you did actually fill the gaps evenly, & finally, try breaking them apart. If you've made them at all well, you'll be pleasantly surprised at how strong even a single dovetail can be.

On your first attempt at making a plane, you might end up with a few small pin-holes or faint lines at the edges of some tails. These are cosmetic issues & won't detract significantly from the strength of the joints. Just as with wooden dovetails, you'll improve rapidly with practice. In fact, I think it's actually easier to achieve near-perfect dovetails with metal than with wood.

Planning your first infill plane

If you are designing your own plane from scratch, there are a few potential pitfalls so I think it will be useful to begin with a bit of "theory" on infill planes in general.

Firstly, concerning the appearance of the plane you wish to make. It's your plane, you can let your imagination loose and build something like a low-slung sports car, or a spaceship that shears wood (I've seen both), but bear in mind that the traditional shapes have evolved for practical as well as aesthetic reasons.

My first attempt: a 210mm "coffin-shaped" smoother with brass sides & steel sole, 60mm blade set at 55^0 , She-oak (Allocasuarina torulosa) infill.

It's also encouraging if your first efforts are rewarded by a plane that works well and a bit of forethought & planning is likely to result in a better product. Starting with very little knowledge and little guidance, I got myself into all sorts of bother with my first plane. In fact, I was on the point of binning the thing at one stage, but stubbornness & the amount of time I'd already invested drove me to keep at it. More by good luck than good management, I ended up with a working plane.

My first dovetailed infill (left) which uses a 54mm blade, and the second, based around a blade for a Bailey #3

On my second attempt, things went far more smoothly and I got a better result. I'd moved my cue up the learning curve a little bit!

Screw adjusters which work well are undoubtedly convenient but with a little practice, setting a blade with a small hammer or mallet can be just as quick and precise as with any screw adjuster, and for the 'set & forget' type planes (i.e. those you rarely alter after sharpening & setting), any loss of convenience is negligible. My advice would be not to worry about a screw adjuster for your first plane or two unless you choose to use one of the Veritas kits, which includes an adjuster.

A small smoother (or bevel-down block plane, it can pass for either), makes a good first project. Small infills were often made with a rear "bun" rather than a handle or "tote", because there is very little room behind the blade in a body less than about 200mm long. On old infill smoothers with short bodies that were fitted with handles, the base of the handle usually overhangs the sole by 25-30mm.

The handles were also 'open', i.e. not joined to the infill at the top, so they were not only exposed but somewhat fragile. It's not unusual to come across old planes that have damaged, repaired, or missing handles. The two planes in the picture at right would have had similar handles when made, but the one on the right has parted ways with its handle, and instead, someone has grafted in a piece of wood and converted it to a bun, probably a more satisfactory repair than trying to glue a broken handle back together.

Two short-bodied infill smoothers. Note how the handle protrudes on the plane at left. The plane at right has had a 'bun' grafted onto the rear stuffing, likely because its handle was broken off in an accident

Screw through grip of an overhanging handle on a Norris A5

A long screw was sometimes driven up through the grip to reinforce it, as on this Norris A5 (above). Another approach is to extend the sole under the grip to give some support & protection to the handle as on the plane at right.

Extension of sole helps support & protect overhanging handle

A rear bun is robust, easy to make, quite comfortable to use. If you happen to have a small chunk of spectacular wood that is large enough for the job, it can also look very handsome. Hard, dense woods that take a fine finish are the best choice for both durability & appearance, but they can also be a challenge to fit neatly, particularly with curved sides.

Blade Bed Angles

The angle at which a plane blade is 'bedded' is commonly referred to as the "pitch" of the plane. This angle is fundamental to a plane's performance & what it does best. You should do your own research & form your own ideas if you haven't done so already, but here's a synopsis of my experience & opinions on blade pitch.

Blades set at a high angle' (60^0 to the sole) may be quite effective at handling hard & erratic-grained woods , but that comes at the cost of extra cutting resistance and (in my experience), more rapid edge wear compared with lower-pitched blades. A standard-pitch blade (45^0) has less cutting resistance & better edge retention and with a properly-shaped cap-iron set close to the cutting edge you can greatly reduce or eliminate tear-out on all but the most recalcitrant woods.

If nothing else, a standard- pitch blade with a cap-iron makes a *versatile* bench plane, capable of handling a wide range of tasks. However, some of our very hard woods can be a challenge for cap-irons no matter how well they are set up. One reason is that despite your best efforts to achieve a perfect fit of cap-iron and blade, some woods seem to consistently find their way in between them, which causes an abrupt decline in performance. For woods like these, a single-iron, high-angle plane *may* give a better balance between speed & quality of finish. But different situations call for different blade configurations, so most of us end up with several types of planes. We will explore some of these in later chapters.

Why "coffin" shape?

A large proportion of old infill smoothers both wood & metal, had curved sides reminiscent of the shape of a coffin. Arguments have been made for the merits of the shape – it gives a slight increase in body stiffness & a decreased sole area, which reduces friction a little. Thus it would make sense if longer planes were made in this pattern, but every old infill panel & jointer plane I've seen was parallel-sided. I suspect the curved sides on infill smoothing planes had more to do with tradition and aesthetics than any perceived structural or functional advantages. Spiers offered the same sized smoothers with either 'round' or 'straight' sides (their descriptions), so presumably not everyone thought curves were desirable, particularly as they cost extra. Curved sides look interesting and are a little more challenging to make, but won't make your plane work any better.

The woodwork or "stuffing"

Many of the smaller infill planes were "overstuffed", meaning the infill or "stuffing" extended over the tops of the sides and made flush with the sides. This looks very neat but has to be done very carefully; even small gaps between wood & metal tend to be glaringly obvious & may spoil the effect. Keeping the wood inside the sides is easier, and not necessarily inferior. None of the planes illustrated at right are overstuffed but still have an interesting appearance, enhanced by chamfers and decorative treatments of the edges.

Four styles of parallel-sided infills, each from a different combination of materials. On these examples the woodwork was kept within the sides

Brass or steel?

Choice of material is mostly a matter of what appeals to you. Steel is tougher & so a universal choice for soles. For sides, it matters little from a structural perspective if they are steel or brass so it is all about appearance. If side & sole materials are the same, the dovetails should be invisible, though occasionally on an old steel plane you'll see a thin line of oxide where moisture has wicked into the join, particularly at the toe & heel, where it's more difficult to keep the joints tight. These days, people like dovetails to be seen & appreciated, so most opt for contrasting materials to show them to best advantage. That also means that any errors are more obvious, of course!

[*In one of his videos Bill Carter (http://www.billcarterwoodworkingplanemaker.co.uk/) said that using different metals for sides & soles on a big (long) plane risks possible distortion due to their different rates of thermal expansion & contraction. I don't know how likely that is, but in general, both single & bi-metal dovetailed planes seem to have held up over the long-haul*].

Side profile

The side profile of your plane doesn't *have* to follow tradition; you can opt for a more 'modern' shape such as those offered by BJS planes (https://www.bjsplanesandwoodworking.com/p/gallary.html). These are reminiscent of the shape James Krenov made famous with his laminated wooden planes. Simple lines do make it easier to cut out the sides, but don't let that influence your decision too much, sawing 3-4mm thick brass or bronze is quite easy, and cutting out your sides will be one of the easier steps in building your plane.

Whatever shape you settle on, do think about how the plane will fit in your hands in use. Handsome is good, but function trumps appearance.

Getting the materials organised

Let's move on to the point where you've decided what size plane you want to make, what width of blade , and whether to use a simple plain blade or a blade plus cap-iron. Fortunately, we are spoilt for choice with many excellent off-the-shelf blades of all sizes, available in a wide price range both with & without cap-irons. Derelict wooden planes that still have useable blades are another possible source. These blades are usually very thick, which was also the case with the original blades in earlier infills, so they'll give a more "authentic" look to your plane. The downside is that the blades in "derelicts" are often in very poor shape due to rust & neglect & can be a challenge to restore to usable condition. They are usually tapered as well, which is fine if you want to use a wedge, but tapered blades don't work so well with lever-caps.

You could also consider using one of the Veritas plane kits. These have all the parts you can't easily make yourself such as an adjuster mechanism, and while Veritas intend them to be used for making wooden-bodied planes, there is no reason why you can't use the same parts in metal planes.

[*Please note that I am not trying to promote Veritas or any other company, I include brand names only as examples. In fact, I'm not a big fan of the all-in-one "Norris style" adjuster & particularly the early Veritas adaptation of the original design. The combined depth & lateral adjuster Tom Norris devised is a clever idea, but in my opinion it has a couple of built-in flaws. The "direct drive" makes fine adjustment of blade depth very finicky unless extremely fine threads are used. Veritas use a solid shaft with two thread pitches while the original Norris design has a secondary shaft that screws into the primary threaded shaft to make it more compact. In both cases, the RH/LH thread combination used has an "additive" effect, meaning the spigot (Veritas) or banjo (Norris) that* *engages the blade moves by the sum of the two thread pitches as the shaft is turned. Norris used ridiculously fine threads to slow it down, but fine threads also wear quickly, causing backlash which many find disconcerting. The other flaw in the all-in-one design is that adjusting the blade depth with the adjuster twisted off-centre (which it almost always is to counter small errors in the squareness of the cutting edge), tends to alter the slew of the blade. When trying to set your plane to a very fine & even cut, not only can you go instantly from zero to 100 with the depth, but find your blade cutting way deeper on one side. The first Veritas adjuster had significantly coarser threads than the Norris, which wasn't so bad when fitted to low bed-angle planes as they were, but much more frustrating when used with a standard-pitch blade. Veritas have acknowledged this problem by offering an alternative shaft with finer threads to slow things down. These replacement adjusters are quite inexpensive so if you are determined to have a screw adjuster, it may be worth considering using one. There are two caveats; one is that it needs 5mm holes in the blade to accept the adjuster spigot. No problem if you are using an appropriate Veritas blade, but can be a major problem with other blades. The second potential problem is that the shaft of the Veritas adjusters provided with their kits is quite short because it was originally designed for compact block planes, & while they will fit a rear-bun design (see top plane in illustration below), they are too short for a typical closed-handle plane unless you chop a large chunk out of the handle to accommodate the knob of the adjuster.*]

Size considerations

Building a large plane will keep you busy cutting, filing, hammering and lapping for many hours, which could be discouraging for a beginner, so I suggest you start with something on the smaller side. A very small plane like a palm plane requires minimal material & physical work, but fitting & closing the small joints is more demanding than making more "normal" sized joints. However, if you are comfortable working at a small scale, these can be an inexpensive & fun introduction to making metal planes.

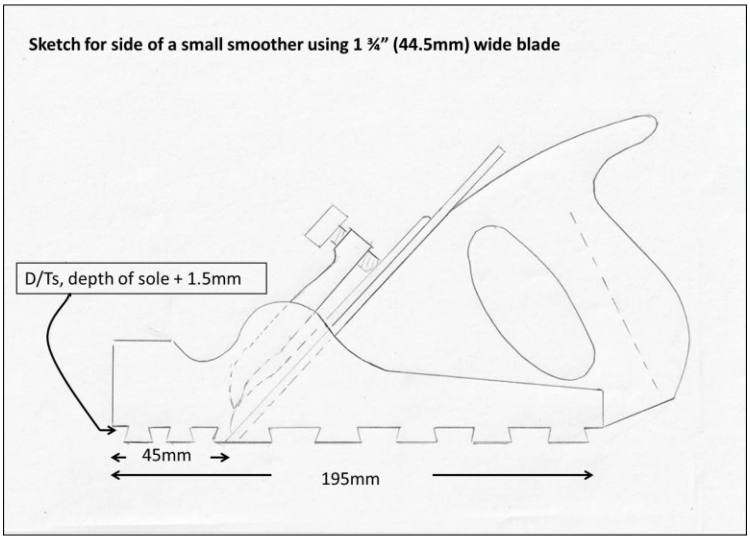
Variations on a basic pattern: Two 45^0 beds, one with adjuster, one without. The centre plane has a very heavy blade bedded at 60^0

My recommendation for a first attempt is a small smoother or block plane 150-175mm long, with a blade 35-45mm wide. This is a very comfortable size to work on and it can make a very useful addition to your tool kit. A 'regular' smoother, typically about 200-250mm long with blades 50-60mm wide, requires a bit more work & material but is also a manageable first project.

In chapter 6 I've included the basic dimensions for a small plane with a body around 160mm long. You can vary the final product by making the sides straight or curved, and fit the blade at different angles as desired. Going below 40^0 or above 50^0 for your blade will involve altering the profile of the sides to accommodate the lever-cap pivot point. The three planes shown at left were all made using the same side pattern. The plane in the centre has a single-iron blade pitched at

60^0 so the hump in the sides was brought forward a little to accommodate the more upright position of the lever-cap. The other two have ‘double iron’ blades set at 45^0, while the rear plane also has a screw-adjuster (from the Veritas plane kit). The two rear planes have curved sides and are “over-stuffed”, while the front plane has parallel sides and the stuffing does not extend over the sides. This demonstrates how both appearance & function can be easily modified from the same basic body plan.

Make a Drawing before you cut any metal



Having made your decisions on all the points discussed, it’s good practice to draw an accurate, full-size side elevation & plan of your proposed plane to provide key reference points during construction.

If designing your own plane, it can be very helpful to make a full-scale model from your drawing, to check proportions & the position of parts. Models can be made from anything convenient such as cardboard, ply or scrap wood, but it needs to be accurate or you will not pick up subtle details that may be important in the construction or function of your plane. A full-scale, accurate model allows a thorough critical evaluation of the design from every angle (what looks “right” on a drawing is all too frequently *not* so right when viewed in 3 dimensions). Of course if you are a wizard with CAD programmes you can make rotatable ‘3D’ drawings from the comfort of your chair, but turning into something solid that I can hold is my preference.

Mock-up for a skew-bladed panel plane. This shows that side profile doesn’t match the planned position of the lever cap & needs modifying

At left is a mock-up for a skewed-blade panel plane which helped solve a potential problem. Initially, I had intended to mount the lever-cap square to the plane’s axis and create the necessary skew in the end of the lever cap as I’d done for a small plane. When I made a wooden lever-cap for the mock-up I realised I was going to need a huge chunk of brass to create enough twist at the toe to match the blade bed. Changing the LC mounting to be parallel with the skewed bed (the traditional method), meant it could be made with far less waste but it would then not fit in symmetrical sides because the left axle point was behind the central hump. The model allowed me to sort out this & a few other minor details before any metal was cut.

Fitting a handle in a short-bodied plane can be a squeeze, as previously mentioned, and I made the sketch above for a short body intentionally in order to emphasise this. If the space behind the blade bed is short, a closed handle with a finger-hole large enough to fit normal-sized hands will hang over the back of the sole. As shown earlier, the protruding part can be partly or wholly supported by extending the sole beyond the sides.

Fitting rear stuffing: The bottom of the finger-hole needs to clear the sides by 4-5mm if over-stuffing so that a reasonable amount of wood can extend over the top of the side.

The Sole

A thickness of around 5mm is adequate for most planes, going thicker will greatly increase weight & the work required filing the mouth & cutting & fitting the dovetail sockets. Cutting out the mouth is the most demanding part, particularly when a blade or "chatter" block is added (see later), but it must be done carefully as this is one of the critical parts of a good plane.

Sole for a bevel-down plane from inside. Note wide pins beside mouth. The wide mouth is to accommodate a thick blade

Choice of side material

If making an all-steel plane, you can use either 3.2mm rolled mild steel, or 3mm gauge-plate for the sides. The latter is ground to exact thickness & is not coated in scale, and if you have enough spare, you could use it to make blades and defray the cost (it's expensive!). However, I suspect most will want all that effort of making dovetails to be on display, so brass is more likely to be your choice for side material. Brass is also much easier to saw & file.

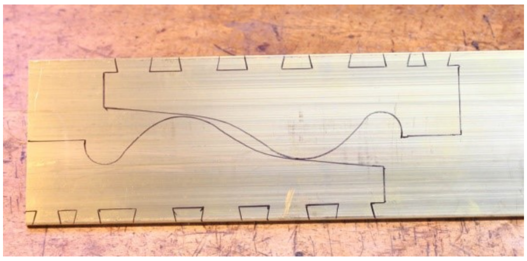
Brass bar is available in a wide range of widths, so select the width that gives the least waste. I often use 75mm wide bar because I can lay out the sides overlapping in opposite directions for a range of plane sizes and get both sides from a piece only slightly longer than the template. And unlike wood, you don't need to worry about grain direction so you can lay your templates out any way that makes the most efficient layout.

The "Build" proper

I will describe the construction of a pair of small rear-bun smoothers (from the plan given in chapter 6) to demonstrate the process step by step. Using the same basic plan, I will go through the construction of both a straight & a curved- sided plane, emphasising what needs to be done differently at the appropriate places.

[*I've based these planes around a blade of 1 5/8 inches (41.5mm) width, which is common to many models & makes of block planes. A 1 ½" (38mm) blade would also be appropriate but they are not as readily available as block-plane blades which come in a wide choice of styles and prices. Be aware* *that the multiple adjuster slots milled into many block plane blades will face 'up' if these blades are used bevel-down. This can be easily fixed by sacrificing a few mm of blade & re-grinding the bevel. The Veritas small plane kit used for one of the planes is based on their block plane blade and these have two ¼" (6.35mm) holes for accepting the adjuster spigot, which can be utilised whichever way the blade faces. If fitting one of these adjusters you must observe the dimensions given for the height of the rear bun & the pivot position in the blade bed because of the short shaft & limited travel these adjusters have.*]

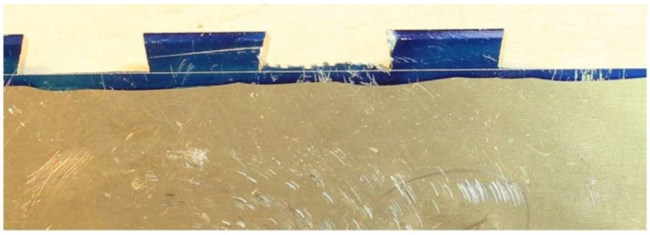
Make a full-scale template of the side profile from stiff cardboard. Don't forget the dovetails need to be about 1.5mm deeper than the sole thickness to allow for peening. As mentioned earlier, the factory edges of rolled brass are always rounded, but in this case it doesn't matter because the bottoms of the tails are going to be peened so can align the bottom of the template along the sides as shown. The bottoms of the sockets that mate to the sole must form a straight line and I usually mark these with a small marking gauge. The *edges* of the tails don't have to be perfect so tracing these off the cardboard template is fine.



Sawing the waste from between the tails with a #6 blade in a jewellers' saw is a very efficient method

On a longer plane, the saw may not be able to reach far enough to saw out the waste of the centre tails. If that's the case, use the "filleting" technique to remove it.

Sawing out the tails



The slivers of brass have been prised out with a screwdriver. This leaves a rough surface which needs more cleaning up than the sawn sockets.

This leaves a much rougher surface with more to file off, but it gets the job done.

Even the cleanest saw cuts will need some smoothing & straightening along the socket bottoms. Here is a useful tip I learnt from another maker for getting the bottoms of the sockets square and in-line. Take a block of

Using a block to file the bottoms of the dovetails straight & square

hardwood about 25-30nn thick & a little longer than the side. Straighten & square two adjacent edges. Carefully align the scribe-line for the socket bases with the straight edge and clamp firmly in a vise. Using the modified triangular file (described in chapter 1), file the bottoms of the sockets, holding the file parallel to the top of the block until it just grazes the top of the wood along the entire edge of the socket (as shown in the picture at right). By using the file with a pushing-sliding stroke (semi draw-filing), the metal is removed efficiently and evenly along the socket. The straighter you get the bottoms of the sockets, the better they will mate with the sole and the easier it will be to achieve a gapless joint line. A little extra care & time spent getting all of those sockets straight and even pays rich dividends later.

The sides of the sockets aren't as critical as the bottoms, so filing them by eye as close as you can to the scribe lines is satisfactory.

Bent sides

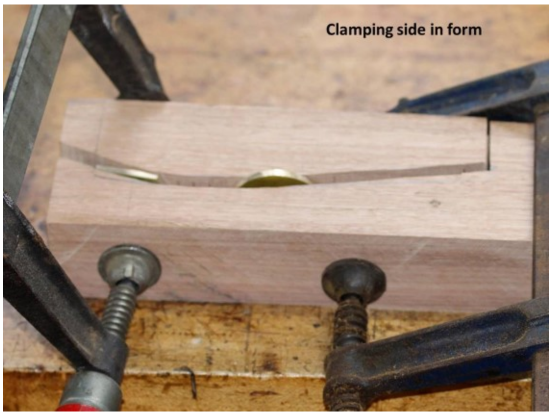
If making a plane with curved sides, these will need to be bent to match the edge of the sole. In his book "Making & Modifying Woodworking Tools", Jim Kingshott recommends bending the sides before cutting them out, to achieve a smooth bend & avoid the danger of kinking at any narrow points (the 'danger points are indicated by the arrows at left). I don't follow his method because I quite often overlap the sides on the plate, which requires at least partial cutting out. It is also far easier to saw & file the dovetails on flat material. The most likely spot to get kinking is at the dip between the front bun and centre hump, and you can usually leave this part & cut it out easily enough after the dovetails & bending are done .

Sides cut so that there is fairly constant width either side of the two main stress points (arrows) when bending

A 'bending form' can be made from a piece of scrap hardwood a little longer than the side & as thick as the maximum height. Square the block & trace one edge of the sole onto the top face. This is the actual curve we want, but bending to this line will not be enough because of spring-back after the form is released.   I'm afraid I have no simple formula for how much spring-back to expect. It will vary with the length & thickness of the side, the alloy you are using, and the radius of the curves. 'Soft' brasses like C260 or H62 spring less than the harder C385, but they still spring significantly.

Bending form: This shows the curve of the sole (top line), and where the block was cut to apply extra bend. After pressing in the form, the brass has sprung back to match the line.

The picture above left shows a form made for 200mm sides of 1/8" thick C385 brass. The actual curve of the sole is the line above the bandsaw cut, which ends about 8mm away from the cut line at each end.   The form has been closed & released and you can see how much spring-back has occurred. It's a matter of trial and error; for your first attempt, you will obviously have no idea how



much extra curve you need, and the best I can offer is to start with a conservative allowance similar to that in the picture. You can always either increase the curve in the form or make a new one.

The form may be closed in a vice or with clamps, just ensure the side sits squarely in the form before closing it. I make a 'step' (as shown at left) to register one end of the side against. For the opposite side, you need a mirror image bend, of course, which you get by simply flipping the form over. The aim is to end up with smooth bend that closely matches the edge of the sole (right).

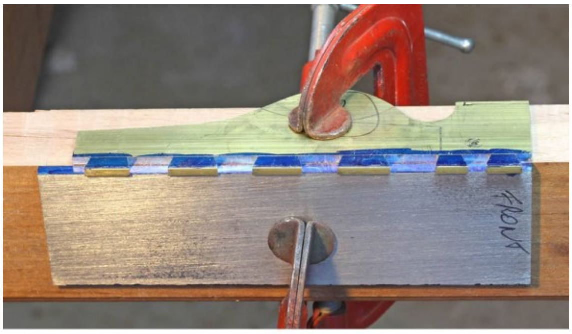
Sides bent & ready to scribe to sole

Don't get too anxious about the bending step, if you over-bend the side a little, just lay it on the bench & press it out. Even 385 brass easily tolerates a bit of re-bending. A gap of up to a mm at either end on 200mm sides is acceptable, you can easily close that up when you set it up on the peening block, but a very close match makes it easier & more accurate to scribe & fit the dovetails. Theoretically, you should have a very slight over-bend, because the arc formed by the bottoms of the sockets has a smaller radius than the outside of the sole, but in practice it's easier to just match the bend to the outside of the sole.

b. Soles:

As discussed in part 1, gauge-plate comes clean & accurately ground to size, but it is very expensive. Hot-rolled mild-steel plate is cheap, but is typically covered in very hard, thick "mill scale" which requires a lot of work to remove. Cold-rolled steel has a cleaner surface that is easier to prepare & is the better choice if you can get it. To clean the steel, I make a holder by cutting a recess in a block of scrap wood, jamming the sole in that & lapping over 80 or 120 grit abrasive stretched over a flat surface. It's quite a job to get the deeper pits out, & if you have a linisher it would certainly make this job much easier. I flip the piece around every 30-40 strokes to help maintain an even surface, & check occasionally with callipers to make sure I'm maintaining even thickness. By the time both surfaces are clean and flat you might have a difference of a few hundredths of a mm side to side or end to end, but that is quite tolerable as final lapping will likely need to remove more than that.

Scribing sides to sole



Scribing tails on sole

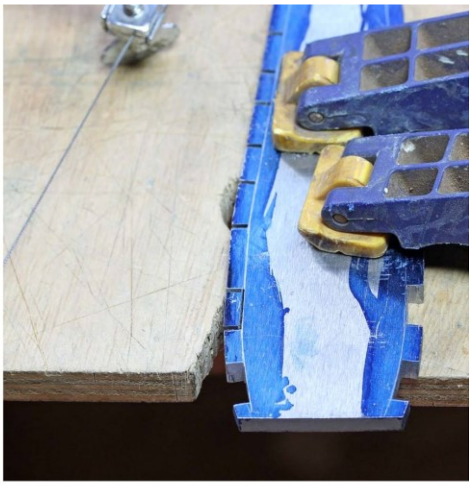
To scribe the tails on edge of the sole, the safest way is to clamp both pieces so they cannot move. For a curved sole, you can re-shape the core of the bending form to match the curve of the sole and use that to hold the parts, but I usually use it as-is by clamping the straighter, central part on the block. The sides will make contact all along the side of the sole if your bend is accurate.

Tails scribed to sole

Extend the lines scribed on the edge to meet the lines defining the inner limit of the sides. Use a small trysquare on the straight sections, but for the curved sections I draw the lines by eye, so they are roughly perpendicular to the axis of the sole.

The most efficient way to remove the waste between the pins is to use a hacksaw to make the entry cuts down to the inner lines, then cut along the inner line with a jewellers' saw.

If your saw can't reach the centre of the sole, use the 'filleting' technique (illustrated below).



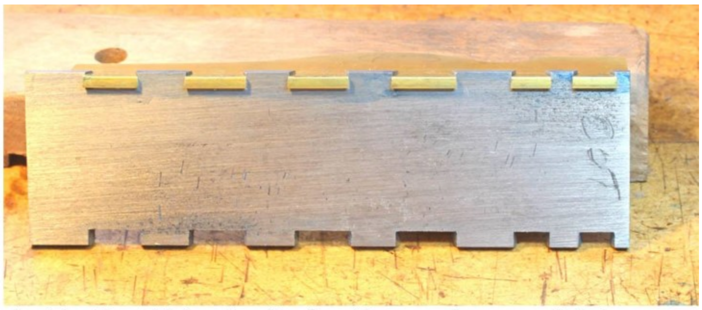
Sawing the waste from the sole pins. Note the wide hacksaw cuts which allow easier access for the jewellers saw

Clearing the waste between pins by making multiple saw cuts and knocking out the slivers with a small sharp cold chisel.

On parallel bodies, use the same hardwood guide-block method shown for the sides to level the bottoms of the sockets & ensure they are in a straight line. You can use a guide for any straight sections on curved soles but the curved sections have to be filed (carefully) by eye.

For curved sides, start with the tails along the straightest part, which should need little adjusting and gently tap them into their sockets. The edges of the steel sockets will cut the brass of the tails where they are too tight & show you where you need to make adjustments. Repeat this procedure a few times, working forward & back from the centre, until all the tails can be fully seated by gentle tapping.

Ensure the tails sit flat on the bottoms of their sockets – even a tiny amount of material left in the corners can prevent this. A teeny bit of light showing here & there is ok, peening will push the parts together and if any small gaps do remain along the junction line, these can be closed up by peening along the edge of the pin (but only do that as the last step after all of the dovetails are firmly closed up or you might push the sides further away from the sole.)

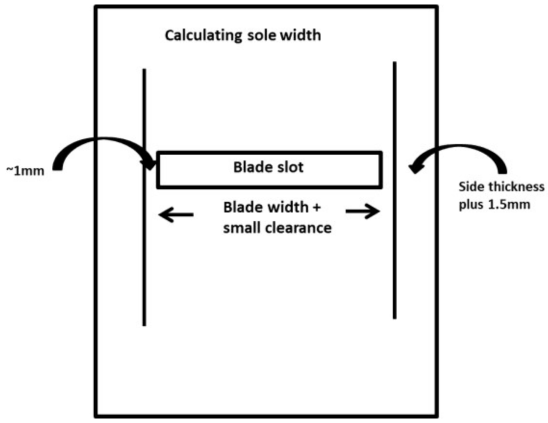


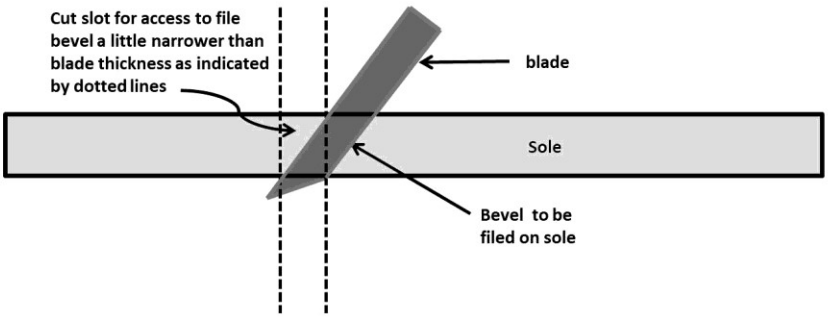
Straight sides. This is a nice , firm fit, with no gaps between tails & the bottoms of the sockets, and even projection of the pins. A good fit like this is easy to peen to a seamless joint.

Forming the mouth

You can make the mouth & blade bed any time, but I like to get the sides fitted first so I can check that I've got the mouth set out neatly between the wide 'pins' that span the mouth area. However, as long as you set out accurately, it really doesn't matter which order you do it in.

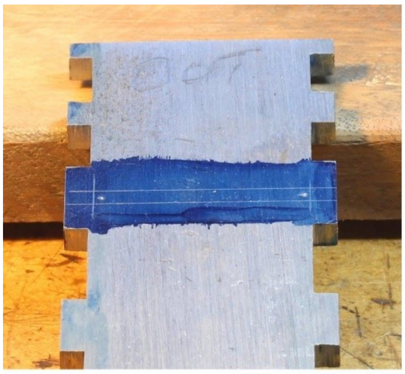
When setting out the mouth, make it 1-1.5mm wider than the blade to allow easy entry & so it can be tilted left or right a little. The total inside width of the body should be 4-5mm wider than the blade to allow lateral adjustment (the deeper the sides, the more extra room will be required). Add the thickness of the side material, plus another 1.5mm each side for peening, to arrive at total sole width.



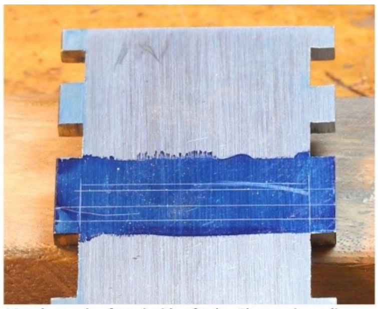


Geometry of mouth. The dotted lines indicate the width and position of the initial sawn slot. The actual width is determined by the width of the blade and the angle it is to be set at

I set out the mouth on the sole by first marking a line for the back of the bevel on the inside. With a bevel square set to the bed angle, carry that line down each edge and mark an intersecting line across the bottom of the sole. These two lines define the top & bottom edges of the bevel. Now scribe a second line, the thickness of your blade in front of the first bottom line & project that to the top, then across. Cutting out the waste inside these lines *from the bottom side* should leave a little extra metal at the front which will be filed away in the final fitting stage to form as tight a mouth as required.



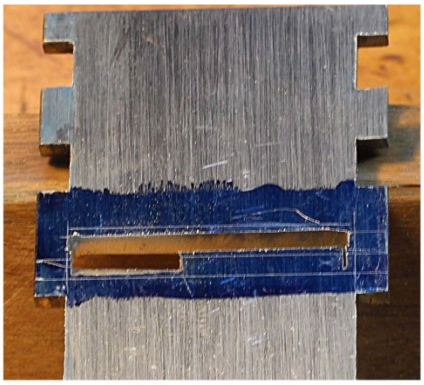
Mouth laid out on the bottom of the sole



Mouth opening from inside of sole. The two inner lines match the opening on the bottom side & the rear line defines the extent of the bed bevel. The top line is for a shallow bevel for the front of the mouth.

If these instructions seem complicated, don't stress, it should be obvious what needs to be done when you get to this stage.

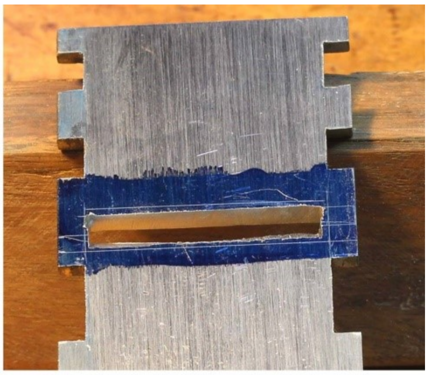
Cutting out the mouth



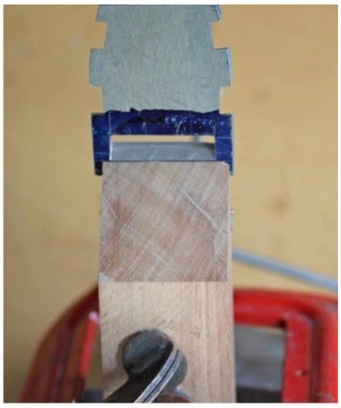
Preparing mouth. The bevel has been partly sawn away with a jewellers saw, sufficient to insert a hacksaw blade & finish the cut more quickly

A commonly used method to clear the waste is to begin by drilling a series of almost-overlapping holes, then punching out the webs between the holes until you can get a file though. I find it quicker to drill a small hole each side & saw out most of the waste before moving to the files. After the initial slot is formed, you can commence filing the bevel, but there is still a lot of waste to remove so to speed things up I also saw as much of the bevel as I safely can.

To do this I use the jewellers' saw to cut out a piece wide enough to accept a hacksaw blade, then finish the cut with the hacksaw, which cuts much faster, but needs care as the blade can easily go off-course, with disasterous results! Keep checking your lines front & back & stay comfortably clear of both, it is beter to have a little more filing than ruin your blade bed.



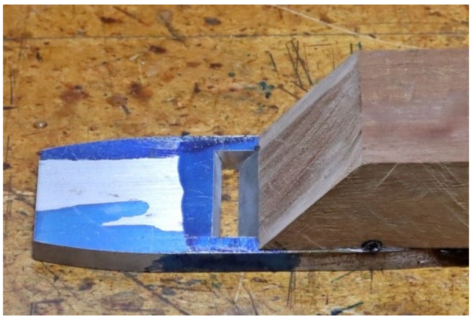
Blade bevel rough-cut. With the bulk of the waste removed, filing to the scribe lines is less work



Filing mouth bevel using a guide block to ensure correct angle.

To file the bevel I use a wooden guide-block cut to the bed angle & clamped acros the rear line of the bevel. For standard pitch planes, the block can be clamped to the sole with G-clamps. For a small plane you may need to cut a step in the block behind the slope so the clamps are not in the way. An alternative method I started using on low-angle beds where clamps always obstruct access, is to glue the guide block in place with PVA glue. Left to cure overnight, the bond is very strong & holds the block very securely with no clamps to get in the way. An old chisel tapped between the blocl & the sole will remove it when finished. The glue will cause a film of rust on the steel, but that can be sanded off easily enough.

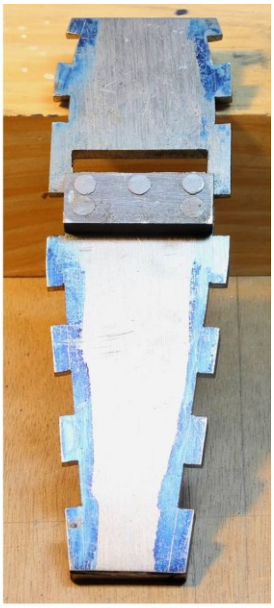
To make the bed bevel you need to be able to file the back of the slot without hitting the diagonaly opposite side (i.e. the front of the mouth). There is plenty of room for a file if using a thick, old style blade but modern bench-plane blades are usually a little less than 3mm thick, which means you will be starting with a slot close to the thickness of a typical 6 inch (150mm) flat file and you probably won't be able to tilt it without grazing the front of the mouth. This is where you need the warding file. They are thinner than regular flat files of the same length (a 6-inch warding file is typically ~1.75mm thick) and will fit in a 3mm slot comfortable so you can start cutting the bevel without filing the front of the mouth. It's inevitable that you'll graze the front of the mouth a few times but as long as you've left a little extra metal here, a few accidental file-strikes shouldn't be a problem & will be easily removed when finessing the mouth at the fettling stage.



One problem with warding files is that they are so thin they flex a little under hand pressure, which can create a slightly convex surface, which you definitely don't want on your blade bed, but by the time you get close to the layout lines, an ordinary 6" flat file should fit, and with the help of the guide-block, you should be able to create a dead-flat surface. If the blade will not quite go through by the time the bevel is finished, this is perfect because it means you have some spare metal left for straightening & refining the front of the mouth after lapping the sole.

Blade or "Chatter" blocks

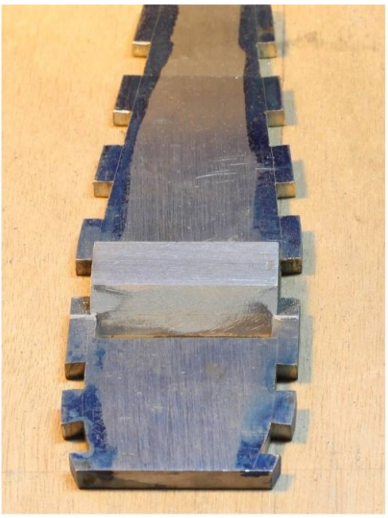
On larger planes, or if using any blade that is as thick or thicker than the sole, a blade block (sometimes called a 'chatter-block'), is generally added. This is because the thicker the blade, the further up the back the sharpening bevel extends and it may not be supported by the metal of the sole bevel. If you remember some basic trigonometry, you can calculate roughly how long the blade bed needs to be to ensure at least a couple of mm of blade are sitting on it when in a normal cutting position. On old infills, a short strip of steel was riveted on the sole immediately behind the mouth to extend the blade bevel. It's not technically difficult to add the block, but it doubles the amount of filing required to create the bed bevel and also adds some complication to fitting the stuffing. If you are using a 5-6 mm thick sole and a typical <3mm blade bedded at 45^0, the blade back will be in contact with the bevel of the sole over a couple of mm when it is in the cutting position so a blade block isn't absolutely necessary. However, a blade block probably contributes to the solid feel of a good infill, so I have always added the block on mid-sized to larger planes.



Blade block riveted to sole behind mouth

To add a blade block, start making the mouth as above, but don't file the bevel quite to the rear layout line. I make the block and file its bevel accurately, then pre-drill it for the rivets. The block is aligned with the line on the sole & clamped, then the holes transferred to the sole by inserting the same size drill bit through the block holes. The holes are counter-sunk on the appropriate sides and the two pieces riveted together using nails as rivets. Nails peen very nicely & blend in seamlessly with the steel sole when levelled. Make fairly generous countersinks on the sole surface so the rivets get a very solid grip & to allow for lapping of the sole (now, & in the future).

You can use the block it as a guide to finish filing the sole bevel to match, or if you are not confident of its precision, you can make a wooden guide to file both in situ. I rough-level the rivet heads on the sole side to make sure they have completely filled the counter-sinks, but leave the final levelling until the final clean-up after peening. Done properly, the rivets will blend with the steel of the sole & be invisible on the finished plane.



Rivets smoothed & bevels on block & sole filed flush.

Assembling the body:

The next step is to make a 'peening block' which is nothing more than a solid chunk of hardwood made to match the internal shape of the plane. Clamping the body to this block holds the parts together and keeps the sides square to the sole during peening. The sole should sit about 0.5mm or so above the block when the pieces are clamped up for peening to make sure the sole can be pulled hard onto the sides. Likewise, the width should be exactly the internal width of the plane, or just a tiny fraction less, but never wider or you won't be able to close the sides tightly against the sole.

There are several ways to make the block, & one way is to cut rebates on the sides of the block that exactly match the profile of the plane sides & support them when the tops of the tails are hammered. Having full support along the tops of the sides does make it easier, but they are not easy to make with the required accuracy. If building a single plane, it's debatable whether the benefits repay the time & effort it takes to make it, so instead it's more common to use bolts or screws to support the sides.

Peening block cut out to match the profile of the sides

The bolts don't offer as much support as a matching cut-out, and although two snugly-fitted bolts can support a small, straight-sided plane body, the more support you provide, the better.

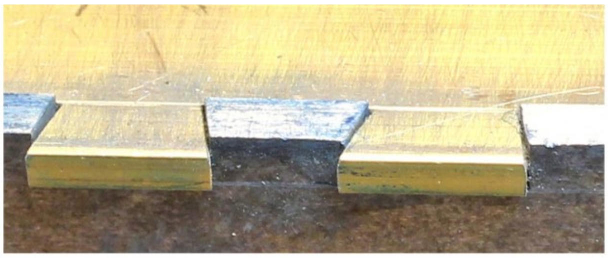
Plane clamped to simple peening block with bolts. The piece of cardboard visible at top left was used to shim the sole off the top slightly & was removed before peening commenced. Two bolts are ok for this small plane, use more on a larger one.

For small planes, especially those with complex profiles, I save the waste from cutting out the sides & screw the pieces to the block. This provides quite good support.

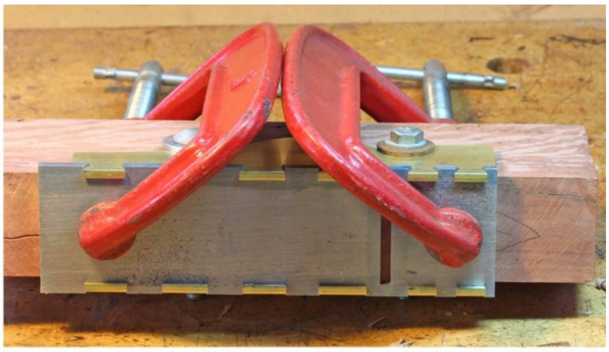
If your dovetails are a close fit, the tops of the tails will require only light to moderate peening, but if you do need to go a bit harder on them over a section that is not well-supported, sit the side directly under where you are striking on the edge of a piece of steel. This will cause some bruising of the tops of the sides but if you are careful it will be minor & easily cleaned up when you have finished.

If a blade block was added to the sole you will obviously need a matching recess in the peening block to accommodate that.

Before clamping the body to the block for peening, make sure you have made the small chamfer on the outside edge of each tail. Don't overdo this bevel, if it's too large, it will be difficult to fill. A narrow chamfer extending 1/2 to 2/3rds the depth of the brass is ample. In fact, when peening steel over brass, especially the softer alloys, you don't really need a bevel at all; peening the steel over the brass will deform it sufficiently to lock the joint very thoroughly.



Chamfers on brass tails: Note these are quite shallow and extend down to about 1/3rd of the thickness of the brass



Ready to begin peening. The clamps hold the sole firmly to the sides but restrict access & will need to be moved a couple of times until all the pins have been partially closed

When setting the plane on the peening block I place a thin cardboard shim between block & sole. After the sides are clamped to the peening block, the shim is removed & the sole clamped hard against the sides as shown at left.

You need something heavy & solid for an anvil. I use a piece of steel about 65mm square and 250mm long with smooth faces, which is perfect for this job, but any solid support such as the back of a vise will help. I've read of people using the top of their tablesaw, but I wouldn't recommend this, cast-iron is brittle stuff & you might crack it if you pounded over a weak area.

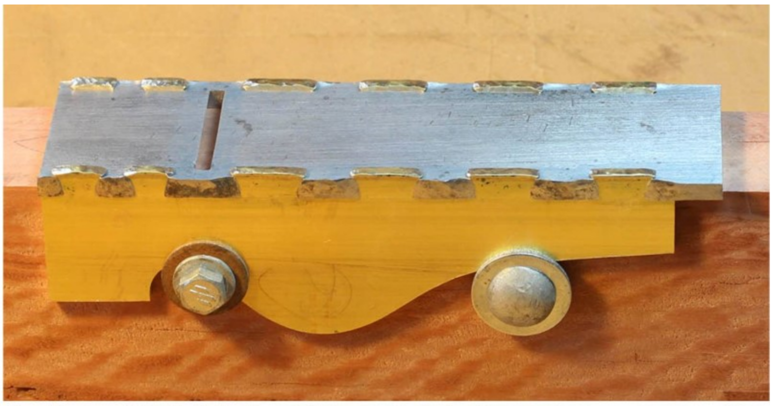
Begin by peening each pin edge until it starts to lock the tail. Starting at the outer edges & working towards the corners will help to force the parts together. I peen a little at a time on each pin to distribute the stresses evenly. The clamps will be a nuisance during the initial stage & will need to be moved a few times so you can get at all of the pins, but once the pins are starting to lock the tails firmly the clamps can be dispensed with.

As with riveting, start striking away from the edges, slowly working the metal over with firm but not heavy blows that are *very slightly* angled in the direction you want the metal to move. I hold the handle closer to the head than I would normally hold a hammer; it means less force per blow, but gives greater accuracy. Whaling into it with great big blows will certainly spread metal around, but a good deal of it is likely to end up where you didn't really want it.

Some people recommend using gaffer tape to protect the surrounding metal from mis-hits, but I find it very difficult to apply the tape close enough to help without it obscuring the gaps I'm trying to fill, & in any case, tape only marginally reduces the effect of a direct hit. Alternatively, some makers use a small cold-chisel or punch instead of striking directly with a hammer. To do this you may need an assistant to hold the plane while you work punch & hammer. I use a punch occasionally if I need to move a lot of metal over. Once you have a bit of practice, hammering directly is quicker & you'll have only occasional slips which cause small dings that file & sand out at clean-up time. However, quite a few makers use punches, so if you feel more comfortable doing it that way, that's fine.

First stage of peening. The pins have all been partially peened and clamps removed for freer access.

I don't touch the tops of the tails until the peening of the pins is well-advanced so that striking the tops of the tails can't force the pieces apart and open up gaps along the bottoms of the sockets. The gaps on the sole side should be small & it is mainly the inside corners of these joints that need to be filled. Pay particular attention to <u>all</u> corners & make sure you push the metal firmly into them because that's where small voids or pinholes most commonly appear after filing flush.



Peening complete. Note the brass tails have not required hammering down as much as the steel pins

Be patient, it may seem painfully slow at first, but it will all happen. Be careful not to hammer the steel down below the surface of the sides; if it looks like you haven't got enough metal at the edge to fill a gap, work some extra over from a couple of mm back - this is one situation where a punch or small cold chisel can help.

With the sides of the pins and bottoms of the tails thoroughly closed, I lightly peen along all socket edges to close any small gaps that may be left there. When I think I've got everything nicely closed, I take a break for a while then check each joint and go over any that look like they might not be fully closed. I also check again when I have filed off about half of the excess pin material; it's easier to see if there are doubtful areas and you still have some metal left if you do need to peen more.

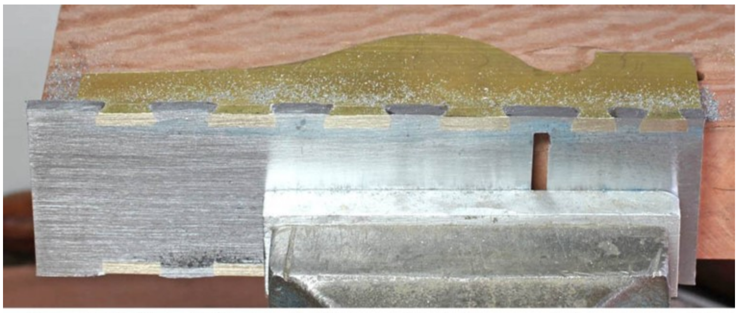
Something to mention at this point: Peening can put the joints under tension so that when you take the body off the peening block, the sides spring inwards a little. This tends to happen especially with curved sides. It is possible to lever them out a fraction but do that very carefully and preferably before you file off the excess metal from the pins so that if you see any feathering around the joints you can lightly re-peen them. It really doesn't matter if the sides are a tiny amount out of square on a curved-sided plane, but it can make fitting the stuffing tricky, so I always try hard to get sides & sole perpendicular. By the time peening is completed the pins & tails will look rather the worse for wear, but fear not, if you've hammered it all down properly, the magic is about to happen.

To get a quick buzz, I clean up the sole first. The excess brass is much easier to remove than the steel, and filing it flush gives a good indication of how things have gone. The bulk of the waste brass can be quickly removed either with a coarse file, or very coarse abrasive. After some initial levelling with the coarsest file I have, I work the sole over a tightly-stretched opened 60 grit linishing belt which quickly levels the brass to the sole.

Tails roughly levelled with a coarse file & abrasive paper

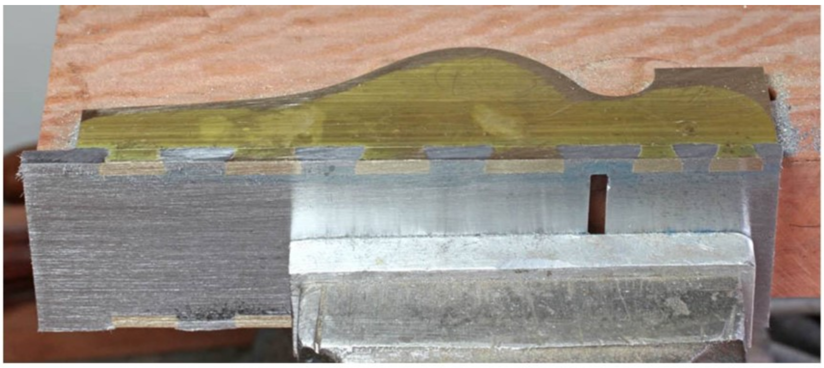
Levelling the steel pins is a bit more work. If you have a good linisher and the confidence to use it, you can speed up the process, but be careful, the merest slip against the brass could leave a deep and permanent scar. Filing is more work but a lot safer.

I leave the body on the peening block so it is easy to hold firm & square in a vise, & begin with a 10 inch bastard-cut flat file. On a medium-small plane like the one at right, it takes about 15 minutes of steady work to get the pins filed down to almost flush with the brass.



Pins partially filed. At this stage the file is used straight across, which removes metal quickly

Keep the file parallel to the sides to avoid marking the brass. A few small grazes are inevitable but as long as they aren't deep they'll clean up later. Filing across the pins at close to 90^0 hogs off metal rapidly, but leaves a coarser surface and the file tends to clog more quickly. "Chalking" the file reduces clogging, but doesn't prevent it entirely, particularly if the file is a bit dull. Dull files also tend to gouge out larger crumbs of steel which lodge in the teeth and can make deep score-marks in the surface on



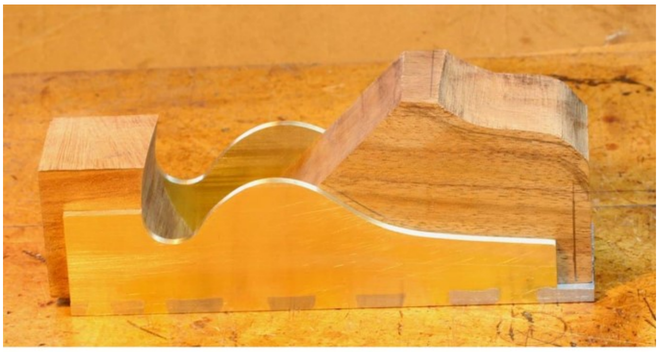
Pins filed flush with sides. The file has grazed the brass along the top of the sides a little, but this will tidy up easily later.

subsequent strokes. To avoid or at least minimise this, clean & re-chalk the file regularly. Stubborn bits of metal that lodge in the teeth may need to be poked out with a sharp nail or similar. When the pins are almost level with the brass, I switch to a smooth-cut 10 inch & use draw-filing, which means holding the file like a spokeshave & pushing it along the work, not across. The file needs to be wide enough to span two pins comfortably so it remains on the steel without gouging the softer brass. Keep going until the steel & brass are nicely co-planar. If your peening was thorough, you should now have a nice set of gapless “double” dovetails.

Don’t worry about a few file marks on the sides at this stage, if you intend to use rivets to fix the stuffing in place you’ll need to do some more filing to level the rivet heads, so save the final clean-up until after you’ve installed the stuffing.

The tops of the sides may need some attention to remove any bruising caused during peening. Light marks can be removed with a slim triangular file long enough to sit comfortably across the body. Set it straight across the top of the sides, & push it back & forth along the tops. The slightly rounded corners of the file will follow shallow curves quite well and soon have the tops clean & square. You can use a round file the same way to smooth tight inside curves, but do so carefully because a round file will tend to follow small irregularities & can make them worse. A useful alternative to files for inside curves is to use coarse sandpaper wrapped around a suitably-sized dowel. Rotating the dowel with your fingers as you move it back & forth will make a very clean, smooth curve. Start with a coarse grit (120 cuts brass quickly) and work through to as fine a finish as you desire. If you are going to over-stuff, there is no need to be too fussy where the wood covers the tops, just aim for clean, regular edges that will be easy to match to the wood.

At last, some woodwork.

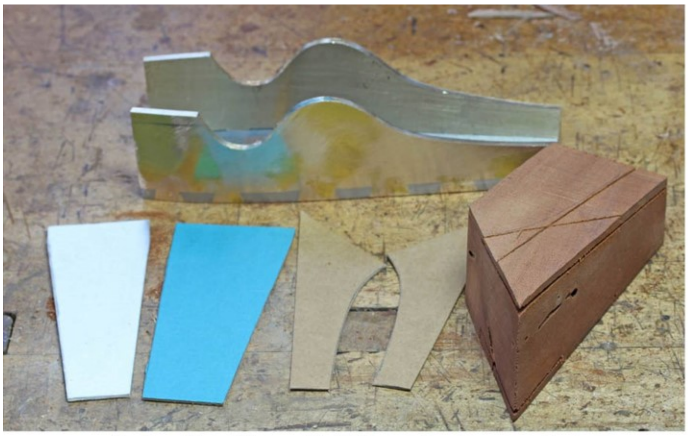

Preparing internal stuffing for parallel sides

Decide whether you are going to overstuff or keep the wood wholly within the sides. The latter is the easier option, of course, so if adding a front & rear bun on a parallel-sided plane, all you need is to prepare two pieces that match the inner width, then cut the bed angle on the rear bun, & a suitable slope on the front bun to create a good open throat. Smooth these to whatever level you desire, roughly shape the tops and they are ready to fix in the body.


A varied chamfer along the tops of the sides accentuates the curves

Before you do that, file some nice flowing chamfers along the outer edges of the sides. I like to vary the width of the chamfers so they accentuate the curves & look more interesting. I file the chamfers as cleanly as I can, then again, use sandpaper wrapped around a dowel or a straight stick to polish them. A bit of detailing like this can make quite a difference to the overall appearance.

Over-stuffing is a bit more involved. You need a very close fit between the tops of the sides & the wood to carry it off – any gaps will seriously detract from appearance.



Cardboard templates used for fitting rear bun for a curved body

I make a set of inside templates for each side, and the inner & outer shapes of the sole, as illustrated at right.

If it's your first plane & especially if over-stuffing, it can be very helpful to make a mock-up from some easily-worked scrap. This will check that the templates are accurate and help solve any problems that may have to be dealt with. It also gives you a full-size, 3D look at the proportions of the parts, so you can make any necessary adjustments before cutting up more precious wood. The plan you drew on paper doesn't always look so great "in the flesh".

Mocked-up stuffing – shows the proportions are "off". The rear bun needs to be a bit taller and the brass needs to come down to at least the thick pencil line.

That was certainly the case for the small smoother at left. On this plane I began the curve toward the heel a bit too early. This made fitting the stuffing a bit more difficult so a practise run was helpful in sorting out how to ease the wood into place. I could also see that the stuffing was out of proportion, both buns look too shallow. I decided to raise the height of the rear bun and cut some metal off above the nose to expose more wood.

The relatively small amount of time taken to make the mock-up was amply rewarded by a nicely-fitted stuffing that looks well-proportioned. I should mention that the ringed gidgee I'd chosen is bone-hard and the wild grain made it very difficult to cut a clean edge along the rebate to get a tight fit between the stuffing & the brass. The moral is, give some thought to the wood you choose for your infill, a highly-figured wood can be the icing on the cake, or the cause of much grief!

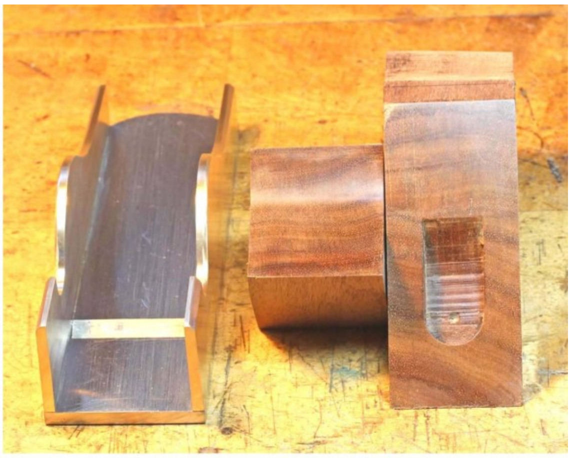
I cut the stuffing to the rough outer shape before installing, and complete it after the wood is fixed in the body. This involves using rasps, files, and sandpaper to bring the wood flush with the metal. I like to glue the stuffing in with epoxy glue, partly to keep moisture out & minimise corrosion of metal & wood movement.

If fitting a rear handle, the rear stuffing can be carved from a solid block, but it is more conveniently made in 3 pieces. A single piece 22-25mm thick forms the handle and centre of the blade-bed, and two side pieces or “cheeks” are glued to that to make up the full width required. On many of the early smoothers with “open” handles, part of the rear stuffing was made from a single block with a channel cut out of the base to accept a chunky, extended toe which was glued & pinned in the stuffing.   This method is not convenient for a closed handle, which is marginally more robust and a better choice if fitting a screw adjuster because the closed handle prevents your hand accidentally bumping the adjuster. If you are reasonably careful with your glue-up, the parts should end up well-aligned & require only a bit of planing or sanding to correct any minor misalignment of the parts. It’s swings & roundabouts as always – choose the method that seems most logical to you.

Preparing stuffing for a handled smoother. The rear stuffing is usually made in 3 pieces, glued together before being shaped to fit.

I find it easier to do most of the shaping of the grip & finger-hole before glueing the cheeks to the handle section. With the cheeks in place, the bottom of the grip and the backs of the cheeks are blended and the assembly is fitted in the plane the same way as described above for fitting a bun

Fitting the front bun follows basically the same procedure as fitting the rear bun. To make it easier to hold while you are working on a bun for a curved plane, keep the top of the block square while you shape the part that fits within the body by a combination of sawing & paring. Curved front buns can be awkward because you can’t see where any internal high spots are. Tapping or pressing the bun down from the top will make marks on the wood indicating the high spots. It’s especially important to get a tight fit at the front because any gaps here will be painfully obvious.



Stuffing ready to glue in place. The throat & bed slopes have been finish-sanded and liberally coted with paste-wax to prevent glue sticking to these surfaces

Once the bun is fitting nicely, cut the throat slope and smooth & finish it because it is awkward to do this after it is installed. Final trimming & sanding flush with the sides is done after it is fixed in the body.

Glueing the stuffing in

Apply paste-wax to the internal slope of the bun & blade bed surfaces to make it easier to clean off any glue squeeze-out (being careful *not* to get any wax on the glueing surfaces, of course).

An annoying feature of Araldite is that it has zero tack when 'wet' and in fact it acts more like a lubricant. It always surprises me that even when I think I have stuffing fitting perfectly on a dry-fit, the wet glue allows it to squirm a bit under clamping pressure and may cause the blade bed to slide forward or back by a fraction of a mm. You may not be able to see it, it is best checked by running a fingernail across the join. If you don't spot any mis-match before the glue cures, you will have to do a lot of filing to re-align the wood & metal. It's not only a very tedious job, unless you take extreme care you'll mark the sides with he file, so it's well worth taking extra care with the alignment before you set it aside to cure.

Glue squeeze-out is a messy affair with epoxy glues, too. You can either leave it and rely on the wax you applied to make it easy to peel off when it is freshly set & still a bit rubbery, or clean it off while still wet. A rag soaked with methylated spirits is my preferred method for removing any squeeze-out. Despite all care, there's often a little bit somewhere that gets missed, but that can usually be peeled or scraped off cleanly before it fully cures.

The glue would probably hold the stuffing in the body securely enough on its own – I've had to remove a glued-in bun that developed a split & it put up a very strong fight to stay where it was! However, I prefer to add some extra insurance. On the very early infills the makers used screws to hold the stuffing. These are easy to fit because you don't need to drill holes right through the plane as you do for rivets, but they are very obvious on the finished tool, and you may find that offensive. Rivets require a bit more effort than screws but there are usually only 5 or 6 to place, so it's not a huge job.

For my first plane I wasn't confident I could drill holes accurately enough through the curved sides & opted for screws. Even though I used brass screws they stuck out like sore thumbs, & for subsequent planes I've always used rivets. Drilling the holes turned out to be easier than I expected. I have a home-made drill-press vise that I use for large objects, so I set the plane in that, chocked each end so its axis was parallel with the drill-press table and clamped it up firmly. The holes all went through as planned but I did need to withdraw & clean the bit frequently when it got deeper into the wood.

It is often recommended to fit a steel bush around the rivets so that when the rivets are clenched, the sides are pulled hard against the bushes. The rationale is that if the wood shrinks, the rivets keep the sides perpendicular and solid. Of course, if the wood shrinks it will still cause unsightly gaps between body & stuffing, & if it expands the wood may press hard enough against the rivet heads to pull them slightly below the surface (I have had this happen occasionally). So I am unconvinced the bushes confer any real advantages. Fitting them is quite a chore; you need to drill through with the rivet-diameter bit first, then remove the stuffing and counter-bore for the bushes. The risk is that the stuffing gets slightly out of alignment if the counter-bored holes for the bushes aren't deadly accurate. Piloted drill bits are made for this task, but these are not cheap & not an everyday item available from the local hardware store. However, if you are willing to go to the trouble of fitting bushes you have my blessing & utmost respect.

If you choose a dense wood with a low shrinkage co-efficient for your infill, and make sure it is well-seasoned before you use it, you should have no serious trouble from wood movement. Dense woods like Gidgee and She-oak, for example, which are very slow to "dry", are equally slow to pick up moisture again and once equilibrated remain quite stable through even quite severe moisture cycles. These woods have proven very stable and I've had trouble with wood movement only once, when I used some wood I knew was probably not properly seasoned. I've learnt my lesson.

I like to set the rivets before the epoxy has completely cured. Epoxy glues remain plastic for some time, which means there is less danger of the glue cracking or separating from the metal (the metal/epoxy bond is usually the weaker of the two). I try to set the rivets between 12 & 24 hours after glueing but it is probably quite safe for up to a week (with slow-set epoxy, at any rate). If using screws, you can drive them in while the glue is still wet, but as I've discovered, they can pick up enough glue to lock themselves <u>very</u> thoroughly in the wood, so make sure you have got them properly tightened before you leave the glue to cure, because they'll be rather tough to move once the glue cures.

[*A warning about any rivets you place close to the blade bed in the rear stuffing*: *If you included a blade block, make sure you avoid it when setting out your rivet positions, you don't want to be drilling through that! Similarly, if you are using a cap-iron, make sure your rivet holes are placed so they don't go through the slot in the bed for the cap-iron screw*.]

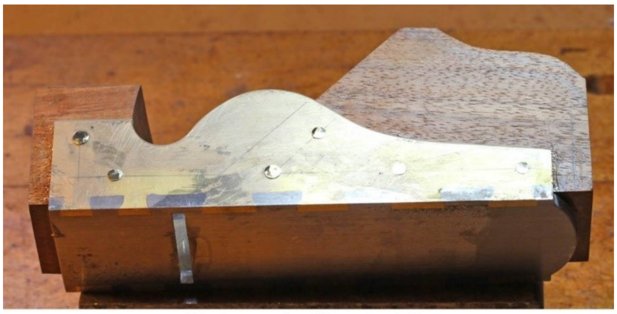
Rivet holes drilled and a small countersink has been made on each side

Drilling deep holes with long, fine bits can be a fraught process. Make sure the plane is properly secured because if it moves, the drill bit is likely to break and getting the broken end of the bit out will not be a fun procedure. Dense woods like gidgee tend to compact in the lands of twist-drill bits & need frequent clearing. Don't be tempted to just force it through or the bit is likely to wander & may exit way off where it should have (don't ask me how I know, as they say!).

Some people like to use steel rivets against brass, it's a matter of personal taste.

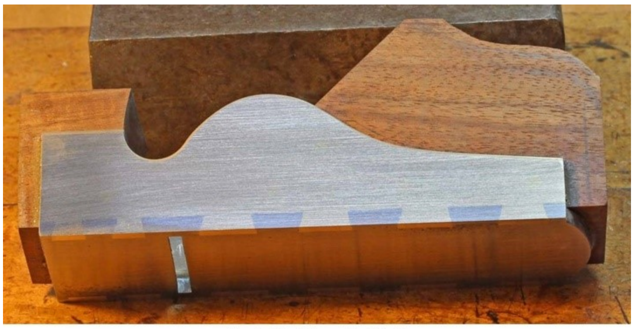
Setting rivets has already been covered, but I should re-emphasise that as with peening the "pins" it pays to start with just the right amount of protrusion of your rivet – not too much & definitely not too little. Having the rivets protrude by half their diameter works well for me, but you may find a little more or less is better, depending on the size of the counter-sinks you make.

Steel rivets (nails) contrasting with the brass sides of this plane



Rivets peened to fill counter-sinks

Once the rivets have been thoroughly peened, file them as close to flush as you can without marking the sides, then use sandpaper on a firm, flat block to finish smoothing the sides, or, for flat sides, stretch a roll of paper over a flat surface and rub the whole plane on the paper. Starting with 180 grit paper will remove the rivet heads very quickly and they should soon disappear.



Rivets filed & sanded flush

To shape & finish the woodwork use whatever tools you have that are appropriate, but rasps, files, sandpaper (cloth-backed for any rounded parts) and scrapers are my preferred tools for this task.

Fitting blade & lever cap

a) Blade bed

If using a cap-iron, you will need to make a recess in the blade bed to accommodate the head of the cap-iron screw. This can be done before or after the stuffing is set in the body, but leaving it until the stuffing is in makes it easier to be sure you have it correctly placed. Make the recess long enough for the blade to fully extend, with some

clearance on the sides for lateral adjustment. After calculating the length of slot required, I set the plane up on the drill-press so the bed is horizontal, and use a Forstner bit to drill a neat, flat-bottomed hole ~2mm larger than the diameter of the screw head and a mm or so deeper. I then chisel a short ramp down from the top of the blade bed to allow the blade assembly to slide in & out easily under the lever-cap. You could make the whole slot with a chisel if you don't have a suitable Forstner bit, it doesn't *have* to be round at the end.

b) Lever cap

This section is concerned only with *fitting* the lever-cap, making a lever-cap from brass bar is covered in chapter 4.

Some makers, with far more confidence than I have, drill all holes for rivets and lever cap in the sides before assembling the body, but I've not had the confidence to do that, for two reasons. The first is that even when I'm meticulous in fitting the sides to the sole they can end up slightly misaligned – particularly curved sides. Minor front & back misalignment can be easily squared off but the pre-drilled holes can't be so easily fixed. Misalignment of the lever-cap holes will twist the LC and apart from causing a problem getting it to sit flat against the blade or cap-iron, it won't rotate freely in the body. A very small amount of misalignment is tolerable, you can trim the toe end of the LC a little & get it to fit on the cap-iron, but it's far better to get it true so that everything works together as it should. If using a wooden wedge instead of a lever cap, slight misalignment of the retaining pin or cross-bar is less critical as it's easy to trim the wedge to make it engage both pin & blade snugly.

Perhaps the main reason I'm reluctant to commit to LC holes too early in the build process is because most of the planes I've made have been one-offs, and between concept drawings & fitting lever caps I have often changed my mind about the blade, cap-iron or lever-cap I ended up using. Any of these can affect the pivot position. So I feel safer starting with a blank canvas when fitting the lever cap. The down-side is that it can be a bit tricky setting out the pivot points precisely on a small curved body, and by the time you reach this stage, a lot of work has been invested in the plane so the last thing you need is a blunder that could potentially spoil the whole thing. So far, I have gotten away with it, though I did have one minor disaster on my first plane, when the drill bit wandered & one of the holes in the lever cap ended up off-axis. This was caused by using a poorly-sharpened bit, a sure recipe for a misaligned hole! I was able to recover from my disaster because you can plug holes in brass very neatly by hammering in a slightly tapered brass pin. Done properly, the pin locks in place almost as solidly as the original metal, making it easy to drill an overlapping hole.

The method most used by the 19th century British makers was to use a steel rivet right through the LC which was peened flush with the sides. This is a tricky operation to get right & it's easy to end up with an excessively tight lever cap unless you take steps to prevent the sides being pushed against the LC by the peening. Also, it has been very convenient for me to be able to remove the LC when refining the fit against the cap-iron, or to alter the slope of the nose of the LC if it causes choking as happened on my first plane. So my

Lever-cap screw made flush with the sides preferred method is to use a couple of “Cheese-head” screws as stub-axles rather than rivets. These screws have short, cylindrical heads which make little axles for the LC to pivot on. The result is a neat and sound arrangement.

If using a single iron, the LC can be positioned as far down as it can go without obstructing the throat, as represented in diagram C. If using a cap-iron, the toe of the LC should bear on the top of the arc of the cap-iron as shown in diagram D. This allows adjustment of the blade assembly over a short distance with minimal alteration of the pressure on the cap-iron. If you place it too far forward or back from the top of the arc, the blade will tend to ‘jump’ as you tap it & your plane will be very difficult to set accurately. This aspect is another advantage of the curved Stanley-style cap-iron over the single-bend style. The top of the CI that the lever cap sits on is a flatter arc and there is more constant pressure when the blade is moved back & forth over the small range required for normal adjustment. In both cases make sure to position the LC high enough to allow easy removal & insertion of your blade assembly (this aspect is further discussed in section 4).

C: Lever cap position for single iron plane: Cap may be set close to cutting edge, but far enough back to avoid obstruction of shavings.

D: Lever cap position for double-iron plane: LC should bear on the topmost part of the cap-iron.

There are various ways to locate the positions for the LC screw or axle holes after the plane is assembled. One way is to set the LC in position and use the square peg method (described in chapter 2), to transfer its position to the outside. With a parallel-sided plane they can be set out from the outside by careful measuring. ***Check your setting-out thoroughly before drilling any holes you might regret!***

Transferring LC pivot positions using a straight stick cut out to fit firmly over the side material.

For a plane with curved sides, if you’ve kept the centre section of the plane close to parallel, setting out the LC points should be no more difficult than for a parallel-sided body. Having the body parallel around the throat also allows the LC to rotate freely over a sufficient arc to allow easy blade removal & insertion. If you find the toe of the LC fouls the sides, it can be tapered a little to clear the sides as it’s rotated. This doesn’t affect its ability to clamp the blade assembly significantly, but be sparing because you can create niches where shavings can jam.

After drilling the pivot holes in the sides, put the blade & LC back in their correct positions and mark the screw positions on the LC. I do this by inserting the same drill bit used for the side holes, & lightly twisting it against the LC sides with my fingers. This gives a clear mark which can be centre-punched ready for drilling (a centre bit is invaluable for starting the holes accurately). I aim to get the pivot points on the LC at or close to half the thickness of the LC. If all is in order you can proceed to drill and tap the pivot holes in the LC, or through-drill if you want to rivet the LC in.

Fix the lever cap in place with the screws or by temporarily inserting the rivet & check that it rotates smoothly & the toe meets the blade or cap-iron evenly. An advantage of using screws for axles is that the slight play in the fit of screw-heads in the side holes can compensate for slight errors in alignment & allow the toe of the LC to twist to a firm fit across the cap-iron when tightened down. A feeler gauge is very handy to check for gaps and if you find that you can feel or see gaps, take the LC out & make the necessary adjustments. You can remove small amounts of brass quite accurately by wiping the toe edge over tightly-stretched 180 grit paper, whilst applying pressure over the high side. Proceed carefully, it may take a couple more test-fits to get it right, but a well-fitted LC can make a big difference to performance.

With the LC in place, you can now get serious about flattening the sole. Insert the blade, with the edge safely retracted & tighten the lever cap. I like to use zirconium paper for the initial flattening (an opened linisher belt stretched tightly over the tablesaw top). Ordinary white garnet paper will do the job but loses its 'bite' very quickly & soon stops cutting the steel, so if you use that you will need to replace it several times if there is any serious lapping to be done. Hold the plane down firmly on the paper and make even back & forth strokes, maintaining a constant pressure on the plane. Flip it back to front every 20 - 30 strokes to counter any tendency to lean on one side more than the other. Sweep the swarf off the paper regularly, otherwise it reduces the cutting efficiency of the paper and also increases the rounding of the ends as it is forced under the sole. A small amount of rounding -over on the back & front of the sole is desirable, but not too much.


Initial lapping of sole: Sole is flat but the deep score marks from the coarse grit need to be removed by lapping on successively finer grits.

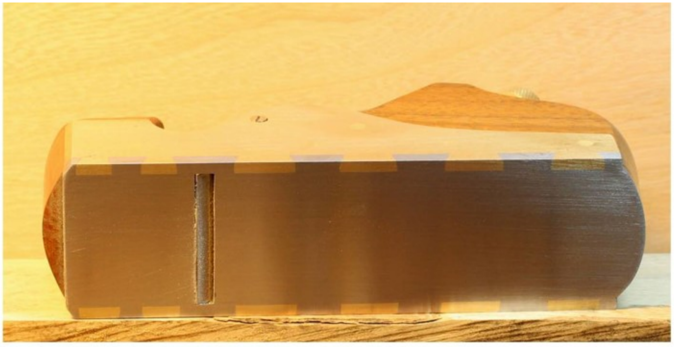
Once you have even score-marks on the entire sole, move up to the next grit size & work through progressively finer grits until you are satisfied with the level of finish. I generally stop at 240 because I find the scratches caused by use can be deeper than those left by 240 grit paper, so there is little point in going further. On a straight-sided plane I check frequently & try to keep the sides perpendicular to the sole. But with curved sides I generally concentrate on flattening the sole & only work on the sides to remove any scratches rather than trying for perfect squareness.

The question of just how flat you can get a sole by lapping on abrasive paper has been argued about for more years than I can remember & I acknowledge that this method is *never* going to get you into the flat-within-a-micron zone. But with careful lapping on tightly-stretched abrasive papers, I can get soles flat enough to take consistent 0.001" (0.025mm) shavings, which is the standard I set for a pass. If you own a lapping plate or are a dab-hand at scraping & wish to spend the time to get your soles flat to the tolerances of the Hubble telescope, by all means do so. You probably won't plane your table tops any flatter than I do, but you'll definitely have bragging rights when it comes to flat soles.

Getting those last few low areas flat on the sole of a large plane can take quite a while – as the flat areas increase, more & more metal has to be abraded away for further progress, and obviously, the wider & longer the sole, the more pronounced the effect. Someone dubbed it the "90/10 rule" i.e., it takes ninety percent of the effort to do the last 10 percent of flattening. But persistence eventually wins the day and there is great satisfaction in seeing even scratches over the entire sole. Once it is flat, it usually takes little effort to remove the scratches when you move to the next grade.

With the sole flattened to your satisfaction, you can now tweak the front of the mouth and get the blade through. I aim for a mouth of around 0.25 mm on a bench plane, though it has nearly always ended up being a little bit more rather than a little bit less than what I aimed for. I proceed very carefully; file & test, file & test, but it all too often seems to go from the blade not-quite coming through, to suddenly coming through with a wider gap than I wanted.

A small mouth is very important in controlling tear-out with single-iron planes but far less so with double-iron planes. Sharp blades with tight-fitting & closely-set cap-irons do far more to control tear-out than tight mouths. With many Australian hardwoods, a very fine mouth can actually be a nuisance. A mouth barely wide enough to let the finest shavings through causes no problems in free-planing woods, but with many of our hard, short-fibred woods, the shavings crumble as they are lifted from the surface & tend to compact in the mouth, preventing further cutting and you'll spend more time clearing it than planing.



The result of too little relief above the mouth opening. Crumbs of wood have compacted in the space & prevent the blade from cutting.

The slope of the *front* of the mouth is also important. You will need a good forward slope to let a close-set cap iron reach far enough down. Too steep a toe on the cap-iron can also block the escapement and cause shavings impaction. With tight mouths, some woods may cause impaction regardless of the mouth & cap-iron geometry so I like to test a new plane on a few different woods before making any major alterations.

For high-angle blades (~60^0), I've found that super-fine mouths clog more easily. That may be due to the woods I use them on & not necessarily a general rule. In any case, if you start with a fine mouth, you always have the option of opening it more but it's a lot more bother to fix an over-large mouth.

If a plane cuts sweetly with absolutely no tendency to chatter on hard woods & can take full-width shavings 1 to 2 thousandths of an inch thick from end to end of a board consistently, I call that success. The shavings shown in the picture are of American cherry, which is a relatively easy wood to plane, but this plane also gave a very good account of itself on ringed Gidgee, which is a stern test for any plane.

Clean shavings, 0.0015 inches (.04mm) thick

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