The Spirit of Resistance.

Part one. Setting the scene.

How many of you have a resistance soldering unit (RSU) you have never even got out of the box? How many of you have tried it, put it back in the box (and cupboard) and said, "I can't get on with this"? I know there are quite a few because I have spoken with you at exhibitions and Missenden courses. The intention of this article is to encourage you (and newcomers) to set up your RSU and try this technology, to become acquainted with the benefits and techniques of this different method of soldering.

Resistance soldering is not a substitute for, but is complimentary to, 'traditional' soldering. The two work together so have them both out, side by side or, as here, one on top of the other if space is a problem.

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Some jobs are best done with a soldering iron, others with the RSU and many with a combination of both. Ultimately, you should be able to make cleaner, neater models with less cleaning up, saving time which means more time to make things. To learn a new skill, the keys to success are perseverance and experimenting.

Resistance soldering is not new - the Japanese were using it to make superb detailed models way back in the 1980s - but it is a different way of soldering. My impression is that modellers have thought it would help them make wonderful models but when faced with this tool, because of a lack of proper instruction, an unsatisfactory experience and some negative anecdotes, there were difficulties and catastrophes, so the fear factor came in to play and the units went away to gather dust in a cupboard.

What follows is based on my experience. I do not say this is 'the right way' but it works for me. I encourage you to try different ways for yourself, to experiment on scrap metal and come to your own conclusions. I also encourage you to persevere and find a way that works for you as resistance soldering can be a great benefit to your modelling.

What is Resistance Soldering?

I know very little about electricity so will describe the process in simple terms. Most people know that to get something to work with electricity, you need to complete a circuit so that the electricity can flow from start to finish through whatever it is you want to work. We put in a switch to make or break the circuit. If at some point in the circuit it is more difficult for the electricity to flow - where we have 'resistance' - then that point gets hot. We need only look at the filament in an incandescent light bulb or the element in the electric kettle.

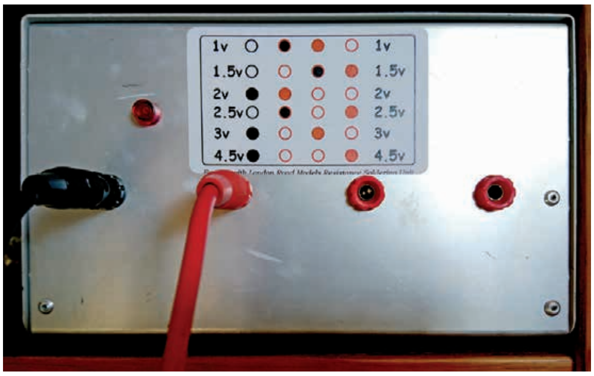
With an RSU, we have a box that sends the electricity out through one lead and allows it back through another. There is a switch (usually a foot pedal) and pressing it completes the circuit. Solder and a joint between metal parts is a point of resistance so by passing the electricity through that joint, heat is generated, sufficient to melt the solder and fix the parts together. The melting is quick and you see the solder flash through the joint. This is the original resistance soldering where one part is connected to the input lead (black) or plate, the other in contact with a hand-held probe (usually made of carbon) on the return lead (red), electricity flowing through the joint, which is best tinned beforehand.

The tip of the carbon probe is also a point of resistance and can be used on its own to generate heat with which to melt solder. With no joint between the input lead and probe, heat is generated at the probe tip but unlike a conventional iron, it is only made when you complete the circuit. The heating and cooling is quick and local.

In the second part of this article, I will be showing examples where I use the RSU and illustrate both methods.

Don’t worry about these now - the important point is to know that where there is resistance to the flow of electricity, heat is generated.

The greater the flow of electricity, the greater the resistance at the probe point and the hotter it gets. On most well-designed RSUs we vary the flow of electricity by putting the plugs into different sockets. The amount of ‘flow’ is given on the RSU in volts (v). Resistance soldering is very safe because the voltages are very low, for the modeller typically between 1 and 4.5 volts.



London Road Models Resistance Soldering Unit

We now have something akin to a temperature controlled soldering iron but instead of measuring temperature in degrees Celsius, on an RSU we use volts, the fewer the volts, the ‘cooler’ the tip of the carbon probe and the more gentle the heating. The heat produced is ample to melt solders we use in modelling, it is almost instantaneous and providing you don’t keep your foot down too long, very localised so that you don’t unsolder things nearby. Typically your foot presses the switch for no more than one or two seconds.

Safety.

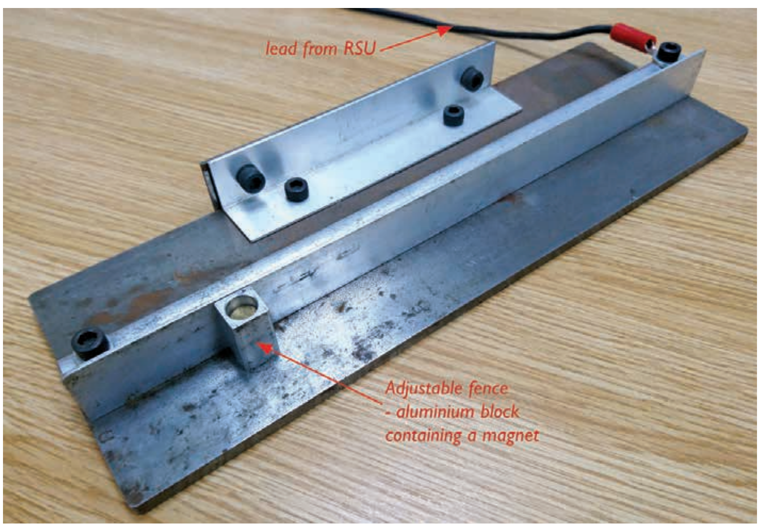
Resistance soldering is safe because the voltages are very low, typically between 1 and 4.5 volts. Current (flow), though, is high, so plugs and leads should be able to handle 35 to 40 amps. However, one still needs to be aware of potential hazards. Notwithstanding the obvious ones about hot parts, flux fumes, mains electricity and liquids, the unit generates a strong magnetic field that has been known to wipe credit cards. It would also be sensible to seek advice if you have something like a pacemaker.

Benefits of Resistance Soldering.

- Heating is virtually instantaneousand ‘on demand’.
- Efficient heating of the joint - the heat penetrates well
- Heat is localised
- Cooling is quick
- Can solder close to other items without de-soldering them
- Faster than a soldering iron
- Cleaner soldering
- ‘Third hand’. The probe is used to hold work before, during and after soldering. The foot switch leaves hands free

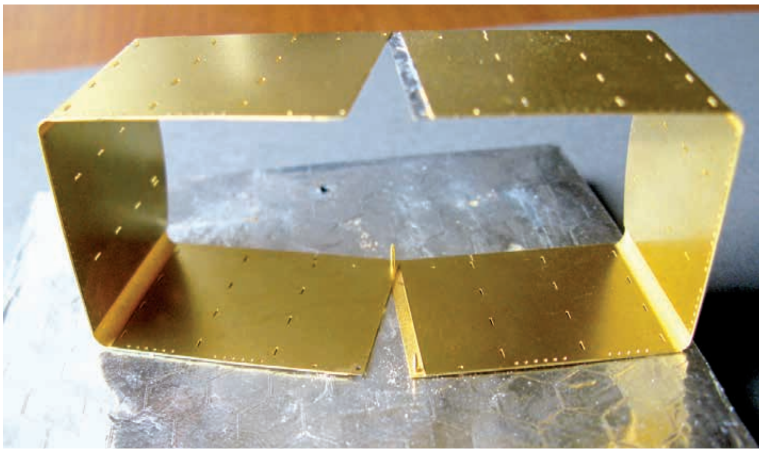
Setting up.

Most instructions recommend using the RSU with a metal base plate. The black lead is permanently connected (or bolted) to the metal plate, usually of steel or other ferrous material so parts can be held in place with magnets. Aluminium is also popular, although magnets can’t be used. Pieces of angle can be attached to the base plate, to work against and get items set at right (and correct) angles.



A lump of metal acts as a heat sink and you may need to set the RSU on a higher voltage. Whilst many people work very successfully like this, others have made modifications, putting a piece of cardboard over the steel and covering it with aluminium foil to reduce the heat sink effect. This can work well though you may find magnets less effective. Thin card on its own between the work and metal plate acts as a heat insulator.

The metal base plate does not have to be either large or thick. I have seen plates as small as 3” square let in to a work board and others of a flattened piece of tin can screwed to a piece of wood. Over time ferrous metal will begin to corrode due to the acidic fluxes and heat. You can’t prevent this but can keep it to a minimum by rubbing the surface regularly with wire wool. This reduces inhibition to the flow of electricity. Aluminium base plates often develop a bloom that needs cleaning off.



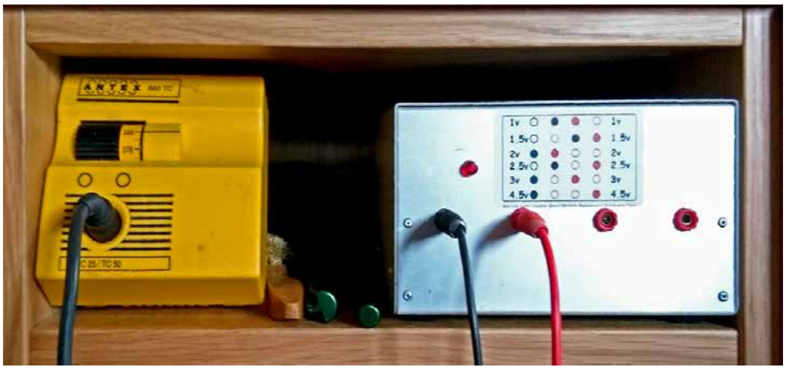
On occasions, I use a piece of MDF wrapped in aluminium foil. I drill in to the wood and insert pins to locate parts (usually tinned first). The foil acts as a conductor and prevents any charred wood fouling the brass. In the image I am soldering the body of the new Iron Mink kit available from the Scalefour Stores.

My usual method (not generally recommended) does not use a metal plate. I have soldered a crocodile clip to the end of the black lead and attach it to an appropriate part of the model. To reduce the possibility of arcing, I filed the teeth off the clip. Because the joint is not tight, there is some resistance here and the clip does get warm sometimes.

Modelling in 4mm I usually operate at 2 volts, using 1.5V with more delicate parts and 2.5V for heftier jobs. You will need to experiment to find what works best for you but always start on a low setting and work up. On some RSUs the settings are not in volts but something like ‘high’, ‘medium’ or ‘low’. The different levels of power output should be obvious. At higher voltages and if the circuit is completed for longer, the clip and handpiece can get quite warm. I don’t find this a problem especially with short bursts but do leave gaps in between to allow the probe to cool (see below).

The probe should not be too long. Sharpen it to a point with a pencil sharpener, knife or scalpel. The tip will blunten and get dirty when it can become difficult to complete the circuit, in which case re-sharpen or scrape it clean. Make sure the copper covering is clean and the probe held firmly in the holder. The holder itself should not get hot though it may get warm. If it does become hot you may not be using the unit efficiently, so re-think what you are doing. Make sure the unit is off for at least as long as it is on. If you are soldering for 2 seconds, don’t press the switch again for at least a further 2 or 3 seconds. Never run the unit continuously for more than 10 seconds on any setting. **Warm is normal; hot is not.**

When does one use Resistance Soldering?



There are some modellers who try to use the RSU for everything, abandoning the conventional soldering iron. This is not the best or most effective way. The RSU is better for some jobs and not useful in others. The most effective way is to use it in conjunction with your soldering iron, though not at the same time! On my workbench, I have my soldering iron and RSU next to each other and easily change between them.

In modelling, resistance soldering is used to attach metals such as brass, nickel silver and copper to each other. It will also attach these metals to white metal. What you can **not** do is use the RSU to solder white metal to white metal. Try it on scrap and see what happens! The RSU is very good for attaching detail parts and overlays. I also use it to put solder fillets in folds and to complete joints which have been tacked with an iron. Parts can be separated and joints undone. The probe is a third hand holding parts in place before, during and after soldering, when your foot comes foot off the switch andthe solder cools. This is not possible with a conventional iron.

Resistance soldering can be used in electronics but great care is needed with components. Attaching wires is an obvious use but heat sensitive items such as resistors and diodes requires a different method. As I have no experience in this field, I will not include any details here.

Golden Rule No.1.

There is a definite order to using an RSU once parts have been prepared:

1. position parts, hold in place and have the probe in contact with the work
2. press the foot switch. This is usually brief
3. take your foot off the switch
4. PAUSE - wait a few seconds for the solder to cool and harden
5. take the probe off the work.

Probe on, then foot on. Foot off, (pause) then probe off.

The difficult part for the new user is co-ordinating hand and foot. If you remove the probe before you take your foot off the switch, you often get a flash as the electricity arcs. This is very hot, makes a sudden noise, you jump and, if you are attaching a small detail part, can vaporise that part at worst or burn it at best.

Preparation.

I usually tin parts first with my soldering iron. Wherever possible, I do this with the parts still on the fret. It is easier to handle them and you can run the iron off on to the fret edge leaving the tinning even and the blob, which always comes where the iron is taken off, out of the way.

For other jobs I use small pieces of solder and have a pot with bits already cut or available to cut up. (*See:* 'Screwing Up', *Scalefour News 205*.) These are especially useful for fillets and seams.

My preference is a liquid flux and I use Carr's yellow which is phosphoric acid. It is important to wipe over the whole area you want solder thoroughly, not give it a token wipe. You may prefer something different.

Some modellers like solder paste or cream, its main use being for attaching components rather than seam-soldering. Not needing a flux, it is placed on the relevant area using a tool such as a cocktail stick. Tiny quantities are required and the results can be very neat. I don't use it as I find it tends to spit and splatter but as with many things in this hobby, try it out yourself. What doesn't work for me might work for you.

Try this: On a piece of scrap fret, wipe a small area thoroughly with flux, then tin it but at the same time, try to tin the adjacent, un-fluxed area. If the scrap is old or has been handled, the solder should flow easily on the fluxed part but not adhere or flow well on that which has not been fluxed.

. . and this: Tin, not too meanly, an area about an inch in diameter. Put the probe in the centre and operate the switch. Watch how the heat flows outwards, melting the solder. Leave the probe in place and take your foot off the switch. See how quickly the solder cools. Do this at different voltages. You should now have an idea of what is happening when you use the RSU on your kit.

To be continued . . . .. In the second part of the article, I will concentrate on examples of resistance soldering in use.

The Spirit of Resistance

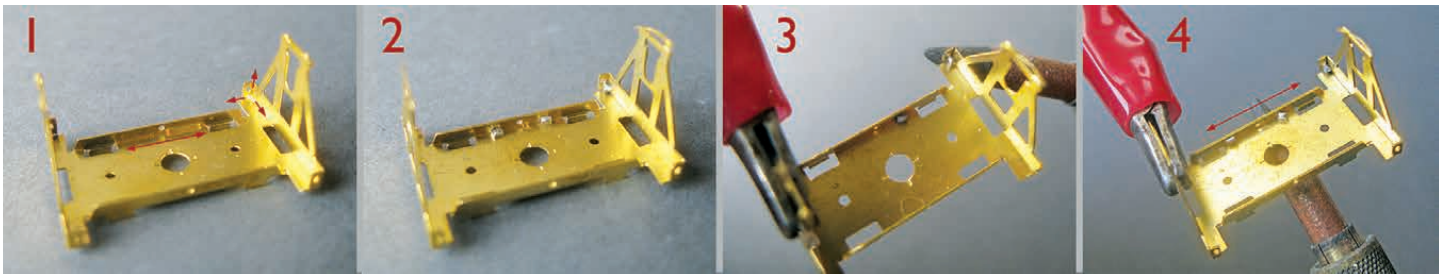
Part two. Getting down to work.

In the first part of this article, I went through the principles of resistance soldering, highlighting the benefits and practical considerations. In this second part, we will look at some applications of resistance soldering. These are a selection and I am sure you will find more situations where resistance soldering can be used effectively. However, do not try to use it for every soldering job. Resistance soldering is a tool to be used appropriately alongside a conventional iron. Like a screwdriver, you might try using it for a lot of jobs but there are many for which it is neither designed nor very effective.

If you are unsure which setting to use, begin on a low voltage and work up. This way you should avoid burning or even vapourising parts. Practising on scrap etch is always time usefully spent.

Examples of using resistance soldering.

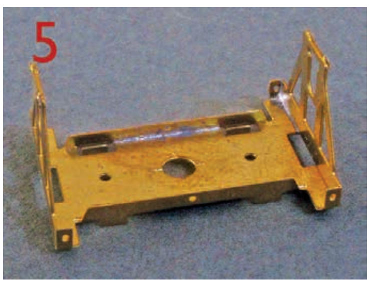
Reinforcing folds



1. Wipe a little flux along each fold. You do not need much.

2. Place small pieces of solder in contact with each surface.

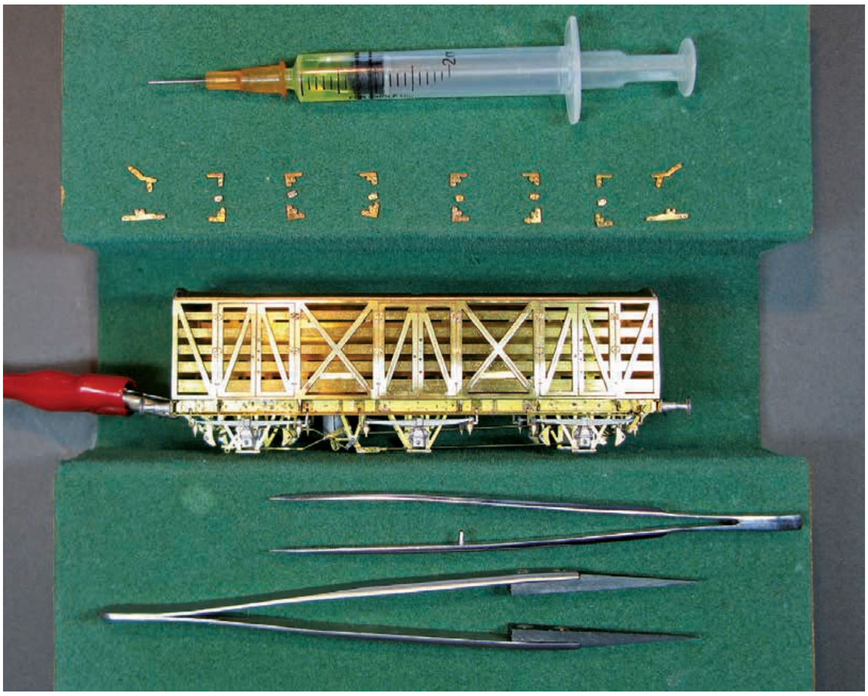
3. With the probe on the ***outside*** of the fold, put your foot down. The solder flashes in all 3 planes. The boiling flux sometimes pings the solder off, in which case put it or another bit back and heat again. I have not found it necessary to re-flux. Pinging the solder off might be avoided if you do not put the probe directly behind the solder.



4. For longer folds try sliding the probe along the edge. Solder will follow the heat.

5. The solder has flashed along the fold and the result is much neater than using a conventional iron. A little solder covers quite a length and gets right in to the fold. The whole fold does not have to be reinforced - ends and middle are usually sufficient.

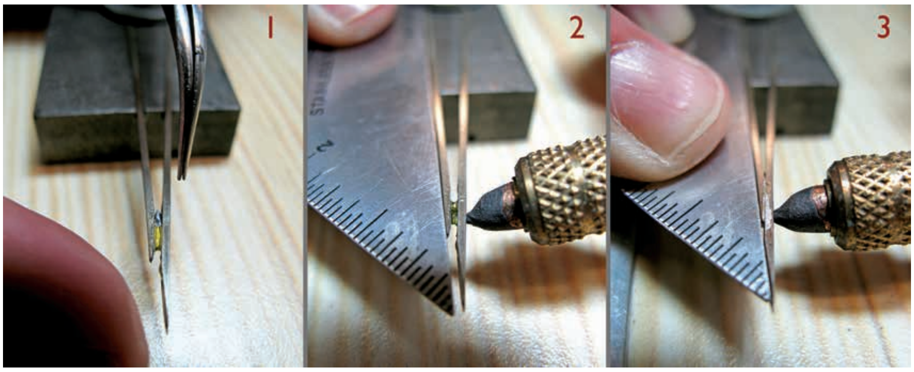
Small parts



I used this image in S4 News 199 but it illustrates where the RSU is a real boon. There are 40 pieces of metalwork (18 hinges are already on) to be added to each side of this GWR Siphon, a D&S kit. The parts were tinned whilst still on the fret, cut out and laid out as seen. The croc clip has been attached to the coupling hook.

A small dab of flux is applied where the part is to go, the part put in place and held with the probe. This is an example where the electric current passes through the solder joint and on through the probe. A quick 'zap', the flux fizzes and you feel the part drop slightly as the solder melts. Foot off the switch, pause and the job is done. The rate of work is quite fast and I had all 40 pieces on the model in a matter of minutes.

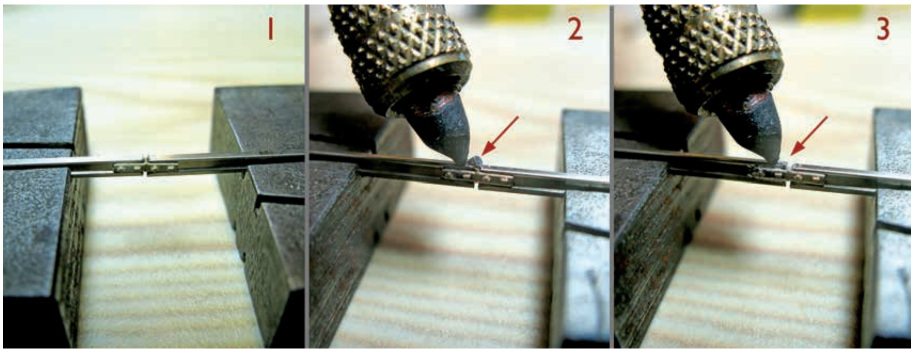
Track *(Thanks to Andrew Eaton)*



1. The rail for making a vee has been set in to the jig, the points prised apart and a drop of flux inserted together with a small piece of solder.

2. A metal straight edge is held firmly against one rail with the probe of the RSU on the opposite side.

3. Foot down, the solder melts and pressure from the probe pushes the two rails together. Foot off, the solder cools and . . . job done!



1. The track is lined up using filing jigs, a cast Exactoscale fishplate (cleaned with fine wet and dry) is fitted and a drop of flux added.

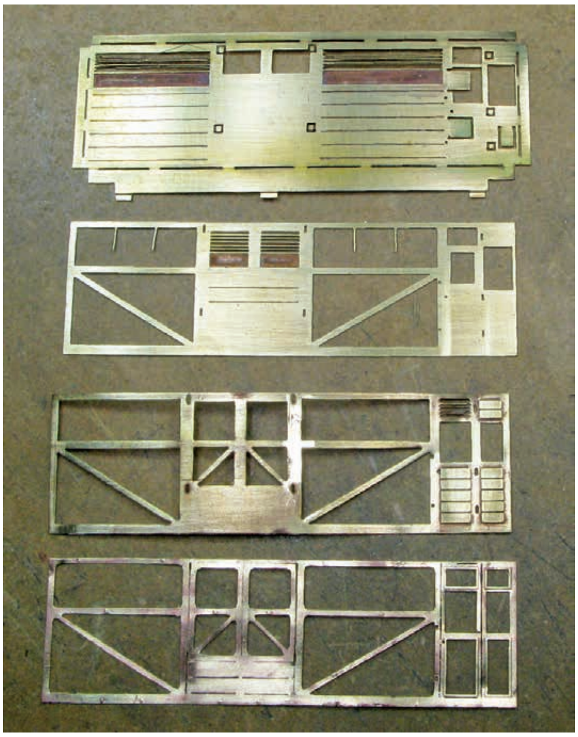
2. A small piece of solder is put on the gap between the rails, the probe applied then foot down. Now you see it . . .

3. . . . now you don't. The solder has flashed in to the joint on both rails and fixed the fishplate.

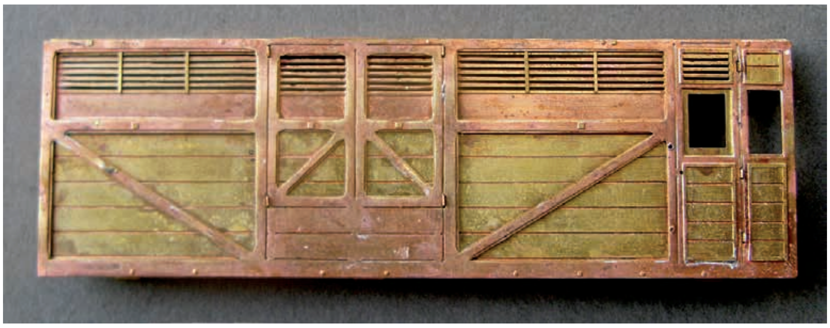
Fixing dropper wires to rail. Tinned wire is held against the rail with the probe. Heating is quick and local, as is cooling, so much so that nearby plastic chairs should not be melted unless you keep your foot down for too long.

Overlays and Laminating

Overlays and laminating are eminently suitable for resistance soldering. I tin only one surface so as not to overload the joint, wipe flux across the whole of the un-tinned area and, where possible, apply the probe from the back. This is not always possible and you will probably get some discolouration of the face side which looks worse than it really is and cleans off easily. It does not affect painting unless you have burned and pitted the brass.

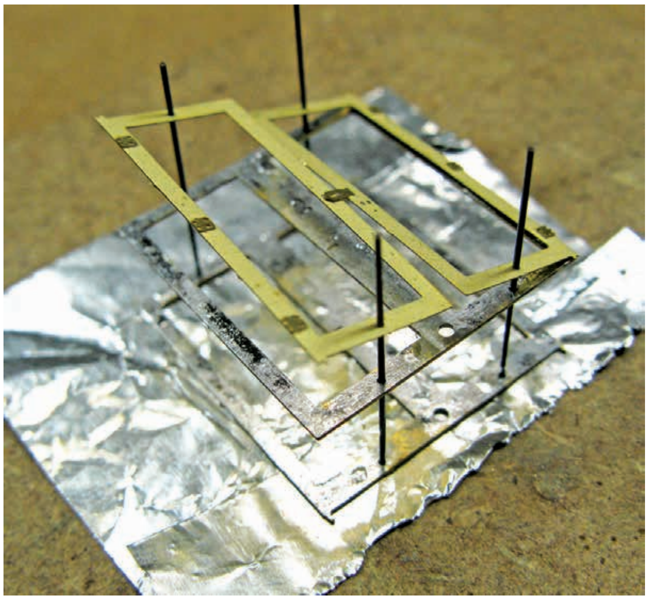


It is important to remember that metal expands when heated, so do not fix the ends first. Start in the middle and work outwards in a straight line for things like solebars or radially for more complex overlays and layers.



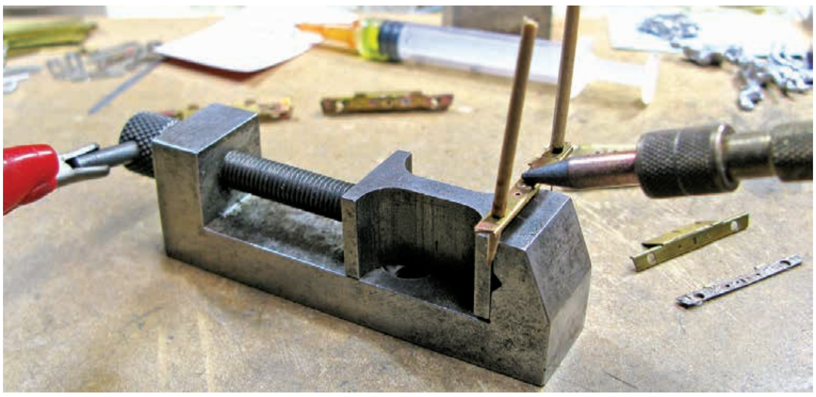
This is a PC Kits LNWR Cattle Box where the sides are made of 4 layers plus detail of iron reinforcements on corners, these still to be added. I have tinned the back of the top 3 layers (the lower 3 on the image), assembled them - the hinges are used to locate each layer - and worked from the centre outwards with short bursts of the RSU. I fluxed with Carr's yellow label as I went along.

The doors of the new Iron Mink kit I assembled on MDF covered with foil. One side of the bottom and middle layers was tinned and the layers assembled on 0.3mm brass wire, convenient holes being considerately provided in the design. The wire got soldered in, was cut off and filed flush.



This was a case where I decided a different technique with a conventional iron was preferable as I had a number of doors to make. Nevertheless, it illustrates how several layers can be assembled all at once. Do not be afraid to try different way of doing things. Sometimes they work and on others you find it may not be so good. The RSU is not a golden wand which will solve your soldering problems.

It is important not to work too quickly. Leave time for the probe to cool between bursts. **Remember - warm if normal; hot is not.**



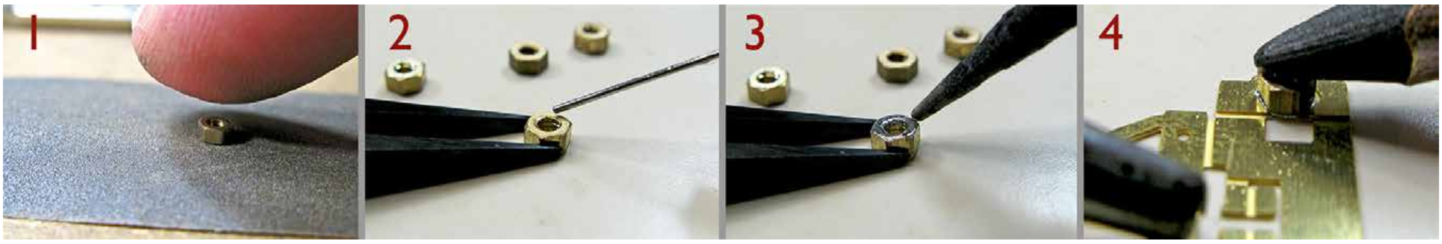
Detail overlays such as solebars and buffer beams are easy to apply with resistance soldering. In this example I have held the tab of this buffer beam in a vice (to which I have attached the croc clip). I have left a small air gap underneath so that the metal vice does not act as a heat sink. The back of the overlay has been tinned and located with cocktail sticks through the buffer holes. The first 'zap' is in the middle of the beam, the next to the left, then the right, left and right, working outwards.

Golden Rule No.2

Whether you're soldering with an RSU or a conventional iron, apply heat, whenever possible, to the larger, heavier component – the thick brass smokebox door casting rather than the thin lamp iron you need to attach to it is a case in point. When sufficient heat has been transferred to the smaller, lighter component, the solder will melt and make the joint. Leave the parts where they are until they have cooled off – the main component will retain heat for longer once the joint has been made. If you accidentally move the workpiece it could still be hot enough for the joint to come apart.

There are exceptions to this rule - when adding detail with the RSU and when white metal (with its lower melting point) is involved. This is covered separately but when soldering small brass details to large white metal lumps, touch the probe against the brass or nickel part, not the white metal component. See the notes on '*Small and delicate bits*'.

Nuts



1. A nut is cleaned by rubbing one side on some wet and dry.

2. Flux is put on the clean surface, carefully avoiding the thread . . .

3. . . . then tinned, not too generously, keeping the thread clean.

4. The area where the nut is to go is fluxed, the nut placed and held in place with the probe. Foot down. As soon as the solder melts, foot off. The nut is firmly held with little or no solder in the thread.

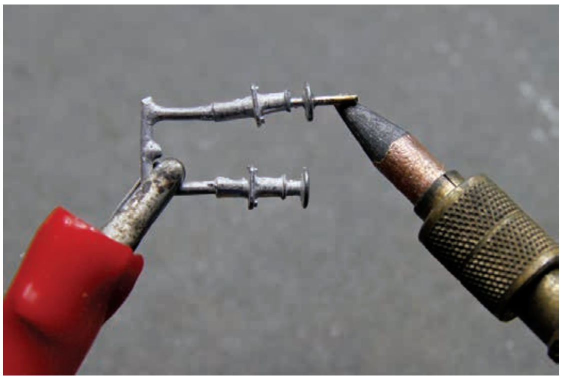
Delicate bits

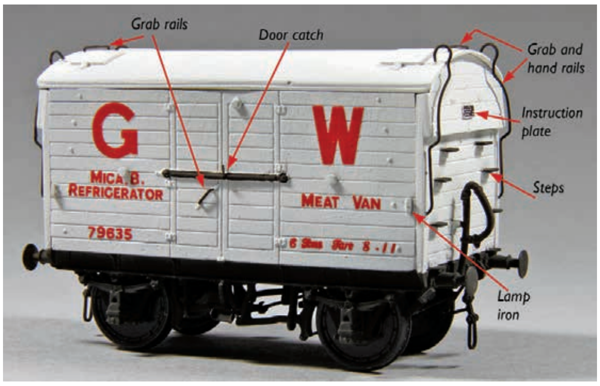
Resistance soldering can be used for quite delicate work. In this image, I am making a Southwark Bridge Models kit of an SDJR platform barrow The leg braces are half-etched, 1mm wide and 7mm long. They were bent to shape and the ends tinned. The area on the legs where they were to be soldered was scraped clean and a small drop of flux applied. The brace was put in place and held there with the probe. For this work, the voltage was reduced to 1.5v and a quick burst was enough to melt the solder without unsoldering the leg. The probe kept the brace in place whilst the solder cooled.

Hard metals to white metal

Low melt, 70^{o} solder does not adhere well to brass or nickel silver which first need to be tinned with 145^{o} or similar solder. This forms a coat that the low melt solder can bond to. 100^{o} solder (from C&L) overcomes this need to tin as it sticks directly to brass and nickel silver.

This process applies to soldering any brass or nickel silver to white metal. In the illustration, I am repairing a broken white metal buffer. The brass wire (0.7mm) was tinned with 100º solder and a hole drilled in the white metal, slightly over-size so that the tinned wire fitted snugly. A small amount of flux was put in the hole and the brass wire inserted. The voltage was reduced (I used 1.5v here) and the probe put on to the brass. The heat flowed along the brass until it melted the solder when I took my foot off the switch. The solder melted inside the hole, securing the wire cleanly and there was no surplus solder to remove. The (drilled) buffer head was added and the process repeated. Surplus wire was cut off and filed flush.





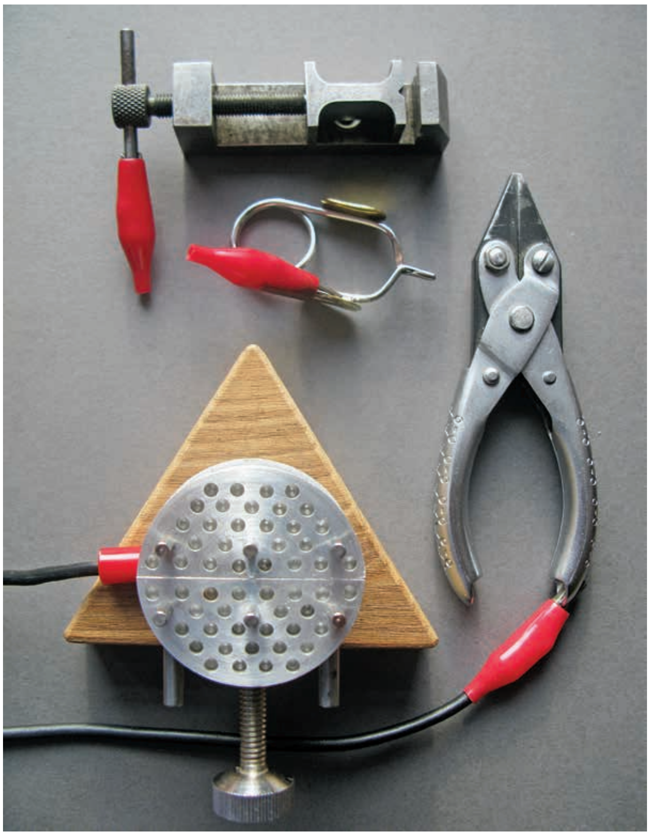
Some time ago, I made this kit of David Geen's GWR Mica. All the labelled brass parts were applied with an RSU using the same method described above. Start on a low voltage and work up or you might melt the white metal. Apply the probe to the brass and let it conduct the heat to the solder. As soon as the solder melts (you can often see a silvery flash in the hole or around the edges), switch off and let the solder cool. The result is very neat and tidy.

In all cases, the brass was tinned first with 100º solder and a conventional iron and no more solder added.

Unsoldering

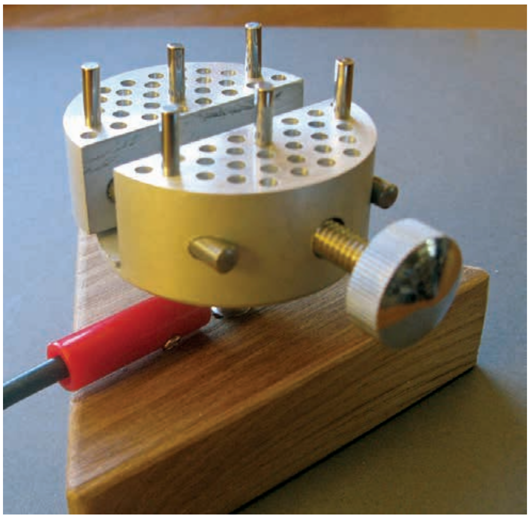
We have all added a bit to a kit, sat back and eyed up the job only to see it is not quite right. Because you control the heating with your foot, with an RSU it becomes a simple job to unsolder a part completely or melt solder sufficiently to allow you to adjust it. You can nudge bits with the probe or move them with a combination of probe and forceps. All the time, you have the probe to hold the part in place after your foot comes off the switch. Laminated parts can be unsoldered by applying heat and gently levering layers apart with a scalpel.

Holding devices



Ways of holding parts whilst being soldered are legion but for resistance soldering it is useful if you can use the holding device as part of the electrical circuit. In the image are a few I have employed.

The multi-pin holder I mounted on a block of scrap wood with a 5/16" UNC bolt through which I drilled a 4mm hole to take the plug.



All those things you have not yet thought about.

I am sure you will find many more occasions when you can use your RSU. Don't be afraid to experiment but do use scrap materials first if you are at all unsure. Sometimes you might use the RSU for a whole fix but on other occasions to finish and tidy up something you used a conventional iron for. Many jobs can be done with a conventional soldering iron, but not always as quickly or cleanly as with an RSU. You can't hold bits in place before, during and after soldering with a conventional iron.

Conclusion

My aim in writing this article is to show what a useful, versatile tool the RSU can be. There are numerous occasions when it can help you make a better job than with a conventional soldering iron. However, please do not look on the RSU as something that will solve all your soldering problems or as a replacement for that conventional iron. The two tools are complimentary and sometimes one is better for a job than the other.

I know there are modellers who like the idea of using resistance soldering but have yet to get to grips with the technique. I hope this article will spur you in to giving it a go. I have stressed the need to experiment to which I add the need to persevere. Once you get the hang of the technique, you will wonder how you ever managed without it!

What is described in this article is not necessarily the "correct" way or only way. It is based on what I have found works for me but there are other ways of achieving the same end. You need to try things out and develop your own way of working, something I am still doing.

I made two big investments in my hobby, neither of which were cheap - a temperature controlled soldering iron and a resistance soldering unit. These were my best investments and I have never regretted them.

Useful sources

Resistance soldering unit: London Road Models
traders.scalefour.org/LondonRoadModels/various/soldering-materials-and-tools/

Swanage Models (the 'Graskop' unit originally designed by Dick Ganderton)
roywoodmodels.co.uk/swanage-models

100 degree solder: C&L www.finescale.org.uk

Parallel pliers: Tools 'n' Tools www.toolsntoolsuk.co.uk

Ceramic tipped tweezers (heat-resistant): Ebay www.ebay.co.uk