Building a de Winton   Dave Watkins

Part 1 - Introducing IDRIS

Readers of 16mm Today with a long memory or a collection of back numbers may recall the article “Curiouser and Furiouser”. This appeared in SMT 28 and described the first steam locomotive that I constructed in 1982. It was a somewhat over scale de Winton type with pot boiler and single oscillating cylinder. “Fury” as she was called shared traffic on the Birches Barn Light Railway with two Mamods. She was so reliable that she bore the brunt of services on the line for a few years. Another pot boiler based on “Lyn” of Lynton & Barnstaple fame took over whilst “Fury” continued to give good service in a standby role. Eventually gears and bearings became so worn that the wheels would not turn when “Fury” was lifted from the track even though the cylinder might be going nineteen to the dozen. She is now in semi-permanent retirement on loan to a nephew who has hankerings after a garden line.

Over the last year or so I have missed the sight and sound of the old engine (not forgetting the smell) and so I resolved to build another. “Fury” had been grossly over scale for 16mm scale. This time I decided to build an engine much closer to scale size. Now it just so happened that when I was about to make a start, I happened upon a copy of a Computer Aided Design (CAD) package at a price I could not resist. The best way to try this out seemed to be to produce some drawings for the new de Winton. The drawings showed it to be quite possible to build a scale size locomotive with two cylinder engine driving directly onto a crank axle. This is much more realistic than the geared single cylinder arrangement of the old “Fury”.

I usually use a “back of an envelope” sketch or even no drawing at all when building locomotives. Using a CAD package has eliminated some of the hit and miss of such efforts. It also has the big advantage that I can copy and pass the drawings on to others who may be interested. Here then is “Idris”. I trust that some of our members may be tempted to have a go and build their own.

“Idris” ran in public for the first time on Thursday at the Midlands Model Engineering Exhibition in October last year. She trundled round at a steady slow speed with a train of slate wagons. The first test runs had only been the previous weekend, when “Idris” consisted of boiler, frames, wheels and cylinders only. The tests went so well that I worked late into the night for the next few days. Fly-cranks and coupling rods were made and tested. A reverser was designed and fitted. Body-work was folded and soldered ready for the West Midlands Group day at the exhibition. All the effort was made worthwhile when I talked to a gentleman admiring “Idris”. He turned out to be a trustee of the Narrow Gauge Museum Trust. He had recognised a resemblance to “George Henry”, the de Winton in the museum. It is a small world (perhaps even a narrow world). My haste to get “Idris” running shows in the paint finish. I bolted the loco together before the paint had time to harden, hence the flaking and peeling paint in the photographs. I like to feel it adds an appropriately industrial look.

You cannot expect the ultimate in haulage power from such a small engine though “Idris” will happily pull a dozen slate wagons and I can hang half a dozen peat wagons on the back for good measure. The boiler is very small. Consequently the duration on one filling is short, only 10 minutes or so. There is a water filler so you can refill whilst hot, wait a few minutes to raise a full head of steam and set off again. I have used methylated spirit firing which I find convenient, safe and reliable. The firebox is small with but little combustion space. Raising steam is quickest with a battery electric steam blower but this is not essential. I am sure a suitable gas burner could be designed which would be both hotter and raise steam quicker - any offers? Exhaust steam is directed up the chimney so that the draught draws the fire. Whilst running, steam generation matches steam consumption so well that “Idris” trundles round at a steady speed without intervention. “Idris” is manually controlled. The absence of a cab means that reverser and regulator fall easily to hand even on a ground level line. I suspect someone will rise to the challenge of trying to fit a mini-servo, receiver and batteries for radio control. There might just be enough room in and under the coal bunker. If anyone succeeds I hope they let us know how they get on!

I must give credit where credit is due. “Idris” is based somewhat loosely on “George Henry” which is in the Narrow Gauge Museum at Tywyn. I can strongly recommend a visit to the museum which is located next to Tywyn station. A friendly welcome awaits all visitors to the Talyllyn Railway. Ross Harrison began a series of articles on a 3½” gauge version of “George Henry” in Tom Cooper’s Steamlines magazine. Issue 12 carried a good photograph whilst issue 13 included a scale drawing which was my starting point for this model. The general arrangement drawing accompanying this article shows the model NOT the original de Winton.

If you want to have a go, then you can build “Idris” entirely from stock materials. The only finished components you need are bolts and nuts. You could use commercial boiler fittings should you wish to save time. I am sure it would be possible to adapt commercial oscillating cylinders and wheels. Use of a small lathe is essential if you intend to make your own wheels and cylinders. To make the boiler a suitable means of heating is similarly essential. When I first started boiler making I used a paraffin blow-lamp. For the next boiler I was lent a propane torch and would not now willingly use anything else. I currently use a Sievert propane torch. The Sievert 2941 burner produces plenty of heat for silver soldering small boilers. I also use a 3941 for general use and a 3938 burner when fabricating small parts.

I have been criticised for mixing Imperial and Metric dimensions in designs. I use British Association (BA) and Model Engineer (ME) threads. I still find it easier to obtain BA screws than metric screws even though the UK started to change to SI Metric threads over twenty-five years ago. Commercial boiler fittings generally use ME threads. Materials from model engineers' suppliers are often still in Imperial sizes. If you have Metric screwing tackle then I suggest you switch to equivalent Metric size threads. When scaling from full size dimensions it seems much easier to work in millimetres than inches. I normally use Metric for cosmetic parts and resort to Imperial for the working bits. There is really no need to apologise for this mixture, after all if you mention “16mm to the foot” scale to a modeller from Europe you can expect him or her to burst into uncontrollable laughter. All dimensions on these drawings are in millimetres unless otherwise indicated. I have tried to show sensible metric alternatives to Imperial sizes where feasible.

I am intending in these notes to concentrate on the more awkward, interesting or unusual aspects of building this steam locomotive. I will try to cover operations that the beginner may find puzzling. I will be assuming that you can use normal hand tools and know how to operate a lathe. However if there is anything I have omitted to explain or failed to make clear do not be afraid to ask.

Part 2 - Starting Construction of Idris

Frames

It seems good to start with the frames, wheels and axles when building a locomotive. Once the wheels are in place it begins to look like a railway vehicle and you get a good idea of how big (or small) the finished engine is going to be.

The frame drawing shows that the two side frames have a curved section round the boiler. The curve is there to allow for a larger boiler than would be the case if the frames were left straight. This is such a characteristic feature of “George Henry” that I felt duty bound to reproduce it. If you look at photographs of de Winton locomotives you will see that there were many different arrangements of frames. Many smaller de Winton locomotives than “George Henry” had straight frames so you could save yourself some work by making them straight. If you do decide to use straight frames you will have to work out how to support the boiler for yourself.

The first job is to cut two lengths of steel for the side frames. I used $^{1}/_{16}$” x 1” steel. They need to be two millimetres longer than shown in the drawing to allow for the curve, that is 168 rather than 166 millimetres. Make sure you have a straight edge on each strip, if not scribe a line and use a file to clean up to the line. Line up the straight edges of the strips and clamp together. Mark out the outside shape of the other edge making the centre section some 2 millimetres longer than shown in the drawing. Cut to shape leaving a little surplus to remove later. I find the best tool for cutting such complex shapes is an Abrafile. Abrafile blades fit into a standard hacksaw frame with a pair of special links. Bend the embryo frames by hand round a suitable round object - just lay the strips at right angles across your chosen cylinder and press on the ends. Get the curve close to that shown in the plan, then clamp by the straight part in the vice. Bend the ends back to produce the sharp bends at the end of the curved section. Now clamp the two side frames back to back. Carefully mark out the centres of the axle holes and drill. I use a Black & Decker drill in a vertical drill stand. Try to be as accurate as you can manage. Whilst you are at it you can also mark out and drill holes for the rivets. File to final shape. The end plates have the bottom edges bent up to form a sort of cowcatcher or snow plough shape.

The pieces of angle which are riveted along the top of the frames make them quite rigid. Use $^{3}/_{64}$” rivets or similar. I suggest you clamp the angle to the frames and drill one rivet hole into the angle through the corresponding hole in the frames. Insert a rivet, trim to length and close the rivet with a rivet snap. Now move on to the next rivet hole and proceed as before. If you know how to bend a piece of angle to a smooth curve, please pass the knowledge on to the rest of us. I gave up trying and fabricated curved angle by silver soldering a curved strip of brass to a flat strip. A few tapped holes in the angles will be used later to affix the water tank, foot-plate and coal bunker. These holes are best drilled after you made the parts to be fixed.

Short pieces of angle join the side frames to the end plates. Fix the angle to the side frames with $^{1}/_{16}$" rivets. Bolt the end plates to the angle rather than riveting so that you can dismantle things for painting or maintenance. For the top pair of fixings at each end use countersunk screws that will be hidden by the buffing plates later (see drawings and photograph). 10 BA hex bolts look reasonable for the lower fixings, though a 10 BA screw is actually quite massive when scaled up. It is the equivalent of somewhere around a 1½" bolt in full size.

The axle bushes are a straightforward turning operation. These are retained in the frames with adhesive. I used Loctite 641, available from good tool stores. Loctite engineering adhesives are expensive but a little goes a long way. Many grades are available, different strengths being sold for locking screws, fitting bearings and retaining. A similar range is manufactured by Permabond. If you can only afford one grade I suggest buying Loctite 601 high strength retainer or equivalent. You will need such a strong adhesive later for the crank axle.

Fit the bushes to the frames and push a length of axle rod through each. Get your head down level with the axles and squint along the frames to make sure that both rods are in line. If they line up, congratulations - ignore the rest of this paragraph. You will have trouble later if there is any twist in the frames. If the rods do not line up try to find out why and put things right now. When you cut a piece of steel you release internal stresses that are an inevitable consequence of the way steel strip is made. This often means that even with the most careful workmanship things do not line up as they ought. Cutting away chunks from only one side of steel strip as we have just done has given the steel an ideal chance to move a bit. You can probably correct things by easing and re-tightening the bolts holding the end plates. If all else fails clamp one end of the frames in the vice and twist the other end using brute force to get the axles to line up. If the late L.B.S.C. were writing this article he would tell you to look over your shoulder first to make sure that Inspector Meticulous is not watching.

Wheels and Axles

Wheels can be made by sawing off a blank from round bar some 17 millimetres long or so and making a pair of wheels back to back. Hold one end in the lathe chuck with sufficient of the blank projecting to turn the tread after facing and recessing the end. Now grip the blank by the tread you have just turned. Face the second end, recess and turn the tread for the second wheel. Swing the tool round to cut the slope of the flange. Reverse the blank in the chuck and repeat on the other flange.

For good running it is worth rounding off the tip of the wheel flange. This can be done using a file with the wheel spinning in the lathe. Be very careful when filing in the lathe. Keep your hands clear of the chuck. The spinning chuck jaws at best will give you a nasty jolt. Also remember that the file you are holding is likely to be at chest height. You do not want a sharp file being jerked into your heart!

Separate the two wheels by sawing through with a hacksaw. I do not recommend trying to separate the wheels with a parting tool. Parting off involves considerable stress on the lathe and work-piece. Your wheels will probably jump out of the chuck damaging the tread you have just turned.

Grip each wheel by the tread to face the back of the wheel and drill the axle hole. Always use a centre drill when starting holes in the lathe and start first with a smaller drill than the final size. This helps ensure an accurate, true sized hole. If you have an appropriate sized reamer use it by all means but this is not strictly necessary. Once again it is best to round the top edge of the flange with a file.

Fix one pair of wheels to an axle using Loctite 601. Adhesives work best on clean surfaces so try to get rid of any grease, oil or cutting fluid before assembly. Put a drop of Loctite in the axle hole of each wheel and push onto the axle. Twist back and forth to ensure an even distribution of adhesive and finally leave to set with a back to back gauge between the wheels. Wipe off surplus adhesive with a tissue before it sets. The back to back dimension should be 28 millimetres.

The crank axle is built up similarly with Loctite. After turning the two crank disks, mark out and drill the crank holes using a vertical drill. Use a short length of axle rod as a jig to locate a crank disk on top of a wheel. Glue together with super-glue. Drill through the crank into the wheel. Repeat with the other crank and wheel. Separate by tapping lightly to break the glue bond. Keep the crank and wheel pairs together to ensure that everything goes together square. Assemble cranks, spacer and wheels with Loctite on a full length axle. Leave overnight to set and then saw away the chunks of axle between wheels and cranks. The resulting axle is surprisingly strong. It will stand working stresses but it will not stand sudden shock. I dropped mine onto a concrete surface and bent the crank. If this happens to you or if you make a mistake, take the axle apart by heating until the Loctite softens.

Unbolt the frames, insert the wheels and axles and then bolt together again. Check that the axles spin freely and the wheels run true.

Fly-Cranks and Coupling Rods

Mark out the four fly-cranks in a row on a suitable strip of steel. Drill the larger holes to fit the axles before sawing the cranks apart. Also drill the smaller hole for the crank-pin in one fly-crank only. When sawing around the fly-cranks, leave some surplus material to remove with a file later. Use the crank with two holes as a jig when drilling the crank-pin holes in each of the remaining three fly-cranks in turn. That way all four fly-cranks should be the same. I suggest you line up the two fly-cranks you are working on with a short piece of axle steel. Use super-glue to hold them together whilst drilling. When they have all been drilled, clamp all four fly-cranks together using pieces of axle steel and crank-pin steel to line them up. File round the outside to the final profile.

Crank-pins are a simple turning and threading job. Secure to the fly-cranks with Loctite 601.

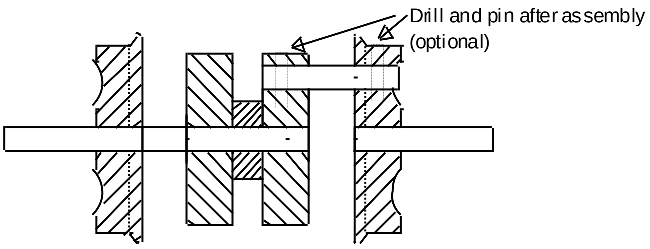
Before marking out the coupling rods, check the exact distance between the axles. Mark out the holes in the coupling rods to match. Drill the holes. Bolt the two coupling rods back to back with 8 BA bolts. File the outside to profile.

Fix fly-cranks on one side with Loctite and one fly-crank only on the other side. Remember to set the opposite sides at 90 degrees. You do not need to be too precise with the angle. Setting to 89 degrees or 91 degrees will not matter so long as both fly-cranks on the same side are the same. Leave aside for the adhesive to set.

Fit a coupling rod to the side with both fly-cranks. Retain in place with nuts and washers. Check the wheels still revolve and if not find out why and put it right. Problems at this stage are probably caused by the coupling rods being too long or too short. Now fit the last fly-crank. Line it up by eye then drop on a coupling rod. Wait a few moments for the adhesive to catch before checking again that the wheels revolve easily and smoothly. If not check that you have the fly-crank at the correct angle and check again the length of the coupling rod. Once you have the quartering correct the wheels should spin freely with no tight spots.

A Late Design Change

I broke a crank axle joint by dropping "Idris" off the bench onto the floor. You will guess that it was not 'butterfingers' I said. The crank axle as shown can be made stronger by pinning through the cranks into the crank-pin. Similarly a pin can go through the tread of the wheel into the crank-pin. Use short pieces of 1 mm silver steel as pins. Drill a 1 mm hole through the crank disk as shown below. Coat the pin with Loctite 601 and tap it into place.



Next installment

In the next part of this series I intend to present drawings of the cylinders and describe how to make them. At present I am scratching my head trying to remember how I fabricated the cylinders. I hope I will not have to take "Idris" apart to find out how I did it. Further parts will cover the boiler and boiler fittings. The "body-work" which is only cosmetic will come last.

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Part 3 - Mechanical Parts

In the previous instalment we dealt with the frames, wheels, cranks and coupling rods. It seems sensible to press on with the remaining moving parts. Then at the end of this section we will have a complete chassis which runs on an air supply. Watching the wheels turn round is very satisfying and a spur to encourage one to complete the project.

I chose a twin cylinder arrangement for "Idris" because I wanted the loco to be self starting. The cylinders are arranged back to back on a common port block. A loose trunnion pin allows them to rotate freely whilst pressed against the port block by a single simple spring. I first saw this arrangement on a de Winton made by Colin Binnie several years ago. Having tried it myself, I was pleasantly surprised at how easy it was to get the engine running smoothly. There seems to be less friction than with the more conventional coil spring arrangement.

If you want to make construction easier then a double acting single cylinder geared two to one to the driving axle would give equal power. You would however need to nudge it to get it going. You can get similar results using a single acting cylinder geared four to one. If you do want to try an alternative cylinder layout you should find no insuperable problems. The cylinder would probably have to be set somewhat higher to allow space for the gear train. If you wish to build a geared engine I suggest you read Peter Jones article “Bunty A First Project” in SMT 51 and 52.

Cylinders - a boring job

The cylinders are fabricated from brass rod and sections which can be obtained from model engineering suppliers. I suggest using a gas torch to soft solder the parts together. The keys to successful soft soldering are cleanliness, using the right flux and adequate heat. The fluxes sold by hardware shops and do-it-yourself stores for use on copper pipe work well on brass.

Start by cutting off a length of 12 mm brass rod a little longer than the finished cylinder. Grip in the lathe chuck and face both ends to correct length. The cylinder bore needs to be as true and as smooth as you can get it. I drilled through with an 8 mm drill, followed up with a small boring tool held in the tool post to give an accurate but somewhat rough bore around 9.5 mm. The final finish is probably most easily achieved with a reamer but if you are careful you can get a very good finish with a boring tool. I was very pleased when I found an adjustable reamer at a model engineering exhibition which allows me to get a fine finish on cylinders from around 9.5 mm to 11 mm bore.

It is worth pointing out that the exact size of the bore is not important. It is far more important that the surface is smooth. Should the bore finish under or over size, do not worry since you can always machine the pistons to fit. If you do not have a suitable reamer, I suggest lapping the surface. A hardwood lap is simple to make and the process is much easier than it sounds. Find a piece of wooden dowel slightly larger than your cylinder. Hold it in the lathe chuck and turn down a couple of inches length to a size onto which you can slide the cylinder on. Coat the wooden lap with a small quantity of valve grinding paste. Set the lathe spinning at a moderate speed. Then slide the cylinder by hand to and fro along the lap. This will soon take off any remaining roughness in the bore. To get a really fine finish, clean away the valve grinding paste, coat the lap with metal polish and repeat the process. When you have finished clean away all trace of abrasive.

The port face of the cylinder is made from a chunk of 5 mm thick brass. Cut it to size and make a curved recess along the length for the cylinder proper to fit. You can cut the groove fairly quickly with a half round file. If you prefer machining, clamp the brass under the tool post and use a boring tool held in the lathe chuck. For jobs like this I find it quicker to use a file than to spend time setting up the lathe.

If you have any doubt about the flatness of the port face, clamp in the four jaw chuck in the lathe and face the surface. Mark out the centre hole for the trunnion pin and the two ports. Drill the holes and if possible ream the trunnion pin hole. File a shallow recess across the centre of the port face. When you assemble the cylinders, this increases the pressure on the metal round the ports so improving the steam seal. When ready, solder the port face and cylinder together with soft solder. After soldering, clean up any solder from the trunnion hole and drill the ports right through into the cylinder. Be sure to clean off any burrs around the drilled holes.

A length of spring steel wire is used to hold the cylinders onto the port block. Aim for smooth rounded ends to the wire to avoid them cutting into the cylinders. The ends of the spring locate in centre dimples in the cylinders. Put a length of trunnion rod in the lathe chuck. Place the cylinder on the end of the rod. With a centre drill in the tail-stock chuck, bring the tail-stock up to press the centre on the cylinder. Turn the cylinder round by hand to drill the dimple.

The cylinder end covers are simple turning jobs. The bottom cover has a recess for an ‘O’ ring to seal round the piston rod. Use a silicon rubber ‘O’ ring of $^{1}/_{4}$" OD, $^{1}/_{8}$" bore. The retaining plate for the ‘O’ ring is again a simple turning job. It has a spigot to locate in the recess. The spigot length should be such that the ‘O’ ring is free to move up and down a little. The retaining plate is fixed to the bottom cover by two 10 BA screws. I used soft solder to hold the top cover to the cylinder whilst the bottom cover is retained with Loctite after making and fitting the piston.

Pistons - straightforward turning

The piston itself is again a simple turning job. Aim for a free fit in the cylinder with no slop. Use the cylinder itself as a test gauge. The bores of the two cylinders may be slightly different. If so, make each piston to fit its respective cylinder and mark them so that you put the correct pairs together when it is time for final assembly.

Use a parting tool to cut the ‘O’ ring groove. A silicon rubber ‘O’ ring of $^{3}/_{8}$" OD by $^{1}/_{4}$" ID provides a low friction seal. The groove depth is critical, too shallow and friction will be high, too deep and steam will leak. Aim for 1.6 mm deep as shown in the drawing. The piston rod is made from $^{1}/_{8}$" stainless steel, threaded 5 BA at both ends. The piston screws onto the piston rod and is again retained with Loctite.

Big Ends - a fiddly job

The big ends have to be made in two pieces so they can be bolted round the crank-pins. They are a fiddle to make but the end result is rather satisfying. Start with a piece of 12 mm brass rod about 23 mm long to make both upper parts, one for each side, back to back. Face the end, drill and tap 5 BA to a depth of 5 or 6 mm, turn down to 6 mm diameter for a length of 8 mm. Then reverse in the chuck, repeat for the other end. File the sides down to give an overall 5 mm thickness. Cut across to separate the two parts and face each down to a length of 10 mm. Cut the end caps from 5 mm brass, soft solder in place, then drill and tap for the 10 BA screws. Drill and ream the hole for the crank-pin. Finally heat up to unsolder the two parts. Mark the matching parts so that when you put them together again the correct end cap goes on its matching big end and goes on the right way round.

Spilt big ends do have one major advantage. It is possible to take up wear by removing the bearing cap and filing away a little metal before reassembly. I first saw this technique in the handbook for my first car. They don’t make cars like they used to (Chorus - and a good thing too!).

Port Block

Use 5 mm brass for the main part of the port block. The cylinders fit either side sharing common port and steam passage drillings. Marking out and drilling is straightforward but careful workmanship is needed to ensure accurate positioning of the holes. Drill the trunnion and port holes first. Plug the port holes temporarily with short lengths of brass wire before drilling the long steam passageways from the top of the block. Plugging the holes helps stop the drill from wandering (or worse still breaking!) when it cuts into the ports. The centre hole at the top is drilled and tapped for an 8 BA stud which forms the pivot for the reversing valve.

A slice turned from 20 mm diameter brass sits on top of the port block. Steam passageways and ports for the reversing valve are drilled as in the drawing. The live steam inlet side is threaded $^{3}/_{16}$" x 40 tpi to take a male threaded union fitting. On the exhaust side I have shown a plain $^{1}/_{8}$" hole. Since the exhaust pipe is not under any great pressure it can be retained with adhesive. There is usually no need for screwed fittings on the exhaust side of this sort of engine.

The two parts of the port block are soft soldered together. Use the 8 BA stud with a nut and washers to locate the two parts in line whilst soft soldering. When soldering parts like this there is always a risk that soft solder will flow into the passageways hence blocking them. A little typewriter correction fluid (such as Tipp-ex) on such surfaces will stop soft solder sticking. Once things have cooled down you can remove any remaining Tipp-ex from the passageways with a drill bit twirled between the fingers or by poking with a piece of wire.

Reversing Valve

Most readers will be familiar with the reversing valve used on the Mamod loco. This type of valve has been used for many many years. It looks and is simple to make and works well. Such a brilliant idea yet I have no idea who first thought of it. The key to success is minimising steam leakage by keeping the working surface smooth and flat. I make such valves in two pieces. The port face can be made from a slice parted from the end of a length of brass rod. Drill the centre hole and four radial holes. Join up the radial holes with a piercing saw or a needle file to make the curved slots. The top piece is soft soldered on. Make sure the projecting arm is in line with the uncut metal between the curved slots as in the drawing. You can if you like file the top to size after soldering the parts together.

Anyone with a milling machine and rotary table will probably prefer to make the reversing valve in one piece. They can use an end-mill to cut the curved slots.

Fitting Flat Surfaces

Here is one way to get a good flat surface on components like the cylinder and reverser port faces. You will need a piece of flat glass and the finest wet & dry abrasive paper you can find. Place the wet & dry on the glass. Gently rub the part you want to finish on the wet & dry with a circular motion. Try to keep the part pressed down flat to avoid ending up with a convex surface. Treat both mating surfaces this way. To check that the surfaces fit together smear one with marking blue then press the parts together. When you separate them there should be an even coating of marking blue on both. Any high spots show up as bright spots.

By the way an old lipstick makes a good substitute for marking “blue” even though it is red. Readers expecting a rather corny sexist joke at this point will be disappointed. My “political correctness” advisor has politely suggested that I ought to remove it from the text. I judge it politic to comply.

Cylinder Assembly

The trunnion pin is a short length of silver-steel. Watch the length carefully. If too long the port faces will stand proud of the port block preventing a steam tight seal.

Slide the piston rod through the bottom cover and screw into the big end. Adjust the length by screwing in and out to get the 45 mm dimension correct. Secure the big end with Loctite. Now push the piston in the cylinder and fix the bottom cover in place. Expect things to be a little stiff. Dribble a little light oil through the ports and on the piston rod. Slide the rod to and fro and the piston should free up. Test for steam tightness by covering the each port in turn with your fingers whilst pulling the piston too and fro. It should feel as if you are pulling against a return spring.

Cylinder Support Plate

The most important point here is to get the height of the port block correct. Make the support plate from steel or brass and fix a length of angle across the bottom. I suggest soldering a piece of angle right across, cutting away the unwanted part in the middle later. There is quite a lot of strain at these joints so it is sensible to back up the soldered joint with a couple of small rivets. Drill and countersink the two fixing holes for the port block.

To get the cylinder height right, I suggest mounting the support plate on the frames and then fixing the port block to the support with super-glue. Slide up or down to get the trunnion exactly 45 mm from the axle centre then hold for a few seconds whilst the glue sets. If you have stuck your fingers on as well peel them away now. Take the support plate complete with port block off the frames. Drill and tap the holes in the port block for the fixing screws whilst still glued together. The correct cylinder height is fairly important. If too high then the ports will not open fully and if too low the cylinders will swing through an excessive angle.

First Test

If you have a suitable air supply, now is a good time for a test. Assemble everything making sure the parts move readily and freely as you do so. If anything sticks find out why and rectify the problem before moving on. An electric car tyre pump provides a good air supply for testing small steam engines. You can also use it as compressor for an air brush. A cycle pump or car tyre foot pump will also give enough air to turn the engine over. You will need to make an adapter to fit the steam inlet to the port block. Lubricate everything with light oil, connect the air supply, switch on and the engine should run like a sewing machine.

Reverse Lever

Since you can reverse the engine using the projecting arm of the reverse valve you may well wish to leave making the reverse lever until after you have made and fitted the boiler. I did.

The reverse lever and reach rod can be made from $^{1}/_{16}$" x $^{1}/_{8}$" steel. My stock of such steel ran out before I started “Idris” and I have not yet found any more. I ended up sawing down the length of a piece of $^{1}/_{4}$" x $^{1}/_{8}$". The most tricky job is to get a nice clean bend across the width of the reach rod. One way to do this is to file a ‘V’ groove most of the way across the rod. Bend the rod through 90° at the apex of the ‘V’ then silver-solder the joint. Once it has cooled and you have removed any excess solder with a file the joint is all but invisible. I will say a bit more about silver-soldering when we come to boiler making in the next instalment.

The reverser stand is again fairly straightforward to make. You will not be able to fit it permanently to the chassis until the boiler and footplate are in place. Once you have the stand mounted on the frames, check that the reversing valve swings through an adequate arc. You may find you need to bend the reach rod a little to ensure the valve moves an equal distance for forward and backward travel.

Lubricator

I have specified a simple displacement lubricator. The steam pipe passes through the top of the lubricator. It has a very small cross hole to allow steam out. Steam condenses in the cold oil and the resulting water which is heavier than oil sinks to the bottom. A little oil is then displaced into the steam pipe and carried by the steam into the cylinders. A simple engine like this will actually work without a lubricator, after all Mamod engines do not have one. A lubricator gives smoother more powerful running and reduces wear.

I found it difficult to know where to put the lubricator on “Idris”. Since we use much larger lubricators than those on full size engines I feel obliged to try to hide them away. The position chosen between the right hand cylinder and the boiler is not too obvious and allows the steam pipe to follow a similar path to that on full size de Wintons. If the sight of a lubricator offends you, I suggest tucking it out of sight below the foot-plate at the rear.

Do please remember that a displacement lubricator is subject to steam pressure. It must be strongly made. I suggest silver-solder to hold the parts together. The main steam pipe is a length of $^{3}/_{32}$" copper pipe. Allow plenty of length on one end of the steam pipe to allow it to pass round the boiler to the regulator. You will need to wait till you have the boiler in place before bending and cutting to length. The other end connects into the threaded hole in the port block mentioned earlier. This end has to have a tight bend. Before bending copper tube, heat to cherry red and cool. This softens the copper. You can either plunge the copper in water to cool or let it cool naturally. I find it useful when bending small copper tubes to bend them round a small pulley wheel. This helps get an even bend with less tendency for the tube to collapse as it is bent.

The male union fitting to connect to the port block is made from $^1/_4$" hex brass. Make a tiny olive from brass. Silver-solder the olive to the end of the tube. Do not forget to put the union fitting on first!

The cross hole in the steam pipe can be drilled after assembly. A 1 mm hole is actually too large letting through far too much oil. Bend a piece of copper or brass wire into a 'U' shape and drop one leg into the cross hole. This will restrict the oil flow. If when running you feel more oil is needed, just file a flat on the wire. To reduce oil flow use a thicker piece of wire.

I have shown a simple ball valve at the bottom which is fairly quick to make though a little obtrusive. At the end of a run open the valve a quarter turn and then open the regulator to blow out the condensate. If you do not fancy making a valve fit a small screw into the side of the lubricator at the bottom and remove the screw to drain.

The filler cap is sealed with yet another 'O' ring. The cap need only be finger tight to achieve a pressure tight seal. I suggest knurling the outside of the cap to give a good finger grip. If you do not have a knurling tool then you could cut a screwdriver slot. To make it easy to remove the cap whilst still hot, I use a hex key. To make a hexagonal hole, first use a drill the same size as the across flats size of the key. Then drive a short length of hex key into the hole with a light hammer. You can use still use the remainder of the key to release and tighten the cap.

Next Instalment

I hope to cover the boiler and boiler fittings in the next part. After that I am planning a final instalment to cover the burner and plate-work.

Building a de Winton   Dave Watkins

Part 4 - Boiler and Fittings

When I first started to build steam engines, I found many of the engineering tasks somewhat intimidating. My worst fears were about making a boiler. There are a number of skills to be learnt but really a boiler is no more difficult than any other part of the work. With appropriate tools, good materials and a sensible attitude to safety there is really no need to worry.

Materials

Small boilers are best made from copper. A well-made copper boiler should last a lifetime. It is best to steer clear of brass, if you were to use the wrong grade the resulting boiler would be brittle or porous. You will need solid drawn copper tube for the boiler shell which can be obtained from model engineering suppliers or sometimes more cheaply as off-cuts from plumbing firms. The centre flue in Idris's boiler can be a length of ordinary domestic copper water pipe. End plates are made from copper sheet. Bushes to take boiler fittings should be made from gunmetal or phosphor bronze. Once again avoid brass.

Assemble the boiler with silver-solder. This is sold in "sticks" of 2 mm diameter. You will need a couple of sticks for this project. If you can find it 0.5 mm silver-solder wire is extremely useful for small jobs such as small boiler fittings. I can thoroughly recommend Easiflo No 2. This has a somewhat lower melting point than some other silver-solders. It flows readily into joints and forms a nice smooth fillet. A suitable flux is essential. Buy this at the same time as the solder. Easiflo flux comes as a powder. Mix a small amount with water to a thin cream and coat the joints before putting the parts together and heating. Silver-solder will not stick readily to areas that have not been fluxed.

Silver-Soldering Technique

You will need some sort of hearth on which to place the boiler whilst heating. For a long time I used to prop up parts being soldered on a few old fire-bricks. Eventually I bought three new fire-bricks from a hardware store and followed Peter Jones advice in SMT 26 to make a proper hearth. This was definitely worth doing since the hearth is now always ready for use and I don't drop the fire bricks on my toes any more. Plenty of heat is needed. A propane torch is ideal. You will also need a pair of tongs to pick up the hot boiler. These can be made from a couple of strips of steel. Use a bolt or rivet as a hinge. Mine are made from part of an old pushchair frame. Another useful tool is a length of steel rod sharpened to a point. This is used whilst silver-soldering to persuade solder to flow into odd corners. I use an old steel knitting needle.

A "pickle bath" is highly desirable to clean the copper after soldering and remove most traces of flux. Model engineers usually suggest using dilute sulphuric acid. Citric acid works just as well, is cheap, non-toxic and readily available from chemist's shops. Small local shops will just sell you citric acid over the counter. Large multiple chemists give you funny looks and point you at their home brew counters. What makes some assistants in large shops so supercilious? A 100 gram packet of citric acid crystals in half a bucket of water will suffice.

Apply flux to the joint area before putting the parts together. Heat gently until the water has been driven out of the flux, then turn up the heat as the flux melts. Keep heating until the parts are glowing a dull red. Then touch the joint with the tip of the stick of silver solder and the solder will flash into the joint. Look for a clean bright line of molten solder along the joint. Turn off the heat and allow the job to cool to black heat. Then quench in the pickle bath. Leave there for a quarter of an hour or so. Usually most of the flux will have been cleaned off and the copper will now be a delightful gummy pink colour. You may find some flux has formed a solid glass like deposit, if so chip it off with a sharp point.

Boiler Parts

Cut off a length of boiler tube for the outer shell a little longer than you need with a hacksaw. Make the ends square either by filing or by turning in the lathe. Filing is fairly quick. You can check the end is square by standing the embryo boiler on its end on a flat surface whilst holding a set square against it. If you use the lathe, first plug the ends of the boiler with wooden discs. Hold one end in the lathe chuck whilst supporting the other with the tail-stock centre. Take light cuts at a medium speed. Mark out and drill the holes.

The photos of Idris in SMT 70 show a boiler made with plain discs of copper for the ends. Whilst this form of construction is perfectly adequate, flanged end plates are even stronger. They take only a little longer to make, silver-soldering is easier and they give a much more substantial joint area. You will need a former to flange the plates. This can be a disc of plywood. Measure the inside diameter of the boiler shell, deduct twice the thickness of the end plates and make the disc that size. Cut out discs of copper and mark out the centres for the holes. Leave drilling the holes until after flanging. Use dividers to scribe a circle showing the size of the centre flue and scribe another circle the size of the former. Soften the embryo plate by heating to bright red before quenching in water or the pickle bath. Clamp the plate and former together and use a hammer to tap the edges down towards the former. The copper will be soft to start with and the initial hammer blows will sound dull. When the metal starts to ring as you hit it, soften again by heating and quenching. You will probably have to repeat the softening three or four times before the flange is fully formed. Check the plate from time to time in the boiler shell to make sure it is going to fit snugly in place. The end plates should be a tight fit so that they do not move whilst heating later. Drill all the holes in the plates once you have finished flanging. The centre hole is rather large to drill. You can either file this to size or set up the plates in the lathe and bore to size.

The various bushes are a straightforward turning and threading job. If using gunmetal you will find the job easy. Turning phosphor bronze is hard work unless you use a cutting fluid.

I have shown some two dozen “hedgehog” spikes in the bottom of the boiler. These are to assist heat transfer by increasing the surface area. The number is not critical. I used short lengths of copper wire cut from a scrap length of heavy duty electric earth cable.

Assembling the Boiler

Clean all the parts thoroughly before starting assembly. Dunking them in the pickle bath will help. Assemble the boiler in stages. Start with the bottom plate. Place this flange down on a fire-brick. Flux round the holes, insert the hedgehog prickles and try you skills at silver soldering by fixing them in place. After pickling, take a good hard look at your work. Check there is a ring of solder round every prickle on both sides of the plate. If you have any doubts about any joints, flux again and re-heat applying more solder to the suspect area.

Next affix the centre flue to the bottom plate. If the flue is not a tight fit you may need to wedge it up with a small chunk of fire-brick underneath whilst heating. Once the bottom plate and flue have been quenched and checked you can insert them in the boiler and fit the top plate. You will need to juggle things a bit to get the flue through the centre hole in the top plate. Insert the bushes as well at this stage.

Stand the boiler upright on its base. Heat up again and solder round the top edge. Apply solder to the bushes as you pass them and then apply to the joint round the centre flue. You will find that silver-solder tends to follow the heat. It tries to run towards the hottest point. By moving the torch you can draw solder round and into joints. Bring the torch down the side of the boiler and put a touch of solder round the two water tube bushes.

Now grab the boiler with the tongs and turn it upside down to balance on the top end. Heat from outside the boiler shell and finish off with the joint round the bottom end plate. Leave to cool to black before quenching in the pickle bath. Rinse well in water before handling.

Check all the joints carefully, be prepared to heat everything up again if any joint is suspect. Once you are happy you can proceed to a hydraulic test.

Boiler Testing

It is important (make that essential) that boilers are tested. If you are a member of a Model Engineering society then they will have rules that you should follow. These rules are drawn up for larger boilers at higher pressures than we use. Nonetheless there is a lot of stored energy in superheated water even when the boiler is small. You can see why testing is so important.

To carry out a boiler test you need a hand pump and a pressure gauge. Testing is carried out by pumping water into the boiler to twice the normal working pressure. Hydraulic testing is perfectly safe. Water is virtually incompressible so that even if the boiler should burst, pressure will drop immediately. The worst that can happen is that you get a little wet. This would not be the case if the boiler were full of steam!

The boiler for “Idris” is designed for a maximum pressure of 40 pounds per square inch that is 2.75 BAR. The normally acceptable test pressure is twice working pressure that is 80 pounds per square inch or 5.5 BAR. You will need to make screwed plugs for all the boiler bushes not used for connecting the pump and gauge. Remove a plug, fill the boiler with water, then replace the plug. Start pumping and then slacken the plug again to release any trapped air. Once you are sure all air has been expelled, tighten the plug. Dry the outside of the boiler. Raise the pressure steadily, checking from time to time for any sign of leaks. If all seems well raise the pressure to 80 pounds per square inch and hold it there for a few minutes.

It is unlikely that you will see any leaks if you have checked your silver-soldering thoroughly earlier. However if any joint does leak you will need to redo it.

Normal model engineering practice is to follow the hydraulic test with a steam test to one and a quarter or one and a half times working pressure. A check that the safety valve can release all the steam at the maximum steaming rate for the boiler follows.

Mounting Flange

To fix the boiler to the frames another piece of curved angle is needed as shown in the plan.

John Wenlock suggests making “curved angle” by soldering the “bent” part of the “L” section to an uncut, flat strip. Then cut the flat strip to shape after. This avoids having to get everything lined-up.

Keith Bucklitch has made “curved angle” by turning from brass in the lathe. He made curved angle for the joint between a saddle tank and smoke-box this way. If you were to turn the angle from a large circular blank it would be very expensive. Keith suggests using a block of brass just big enough for the piece of angle you wish to make. Hold the block of brass to be turned at the right distance from the lathe centre by soldering to a sacrificial piece of brass held in the lathe chuck.

I used the former method for “Idris”. An odd scrap of the tube you used for your boiler shell makes an ideal jig to get the right bend in the curved strip. You can also use it to hold the curved strip there whilst soldering.

Boiler fittings - Regulator

The regulator is a simple screw down valve. To achieve fine control, aim for a long taper to the end of the regulator spindle. Most parts of the regulator are fabricated from brass rod with the exception of the spindle which is from stainless-steel. The main body is first turned and threaded and a 4 mm hole drilled for the side piece. The side piece which connects to the main steam pipe is threaded $^{3}/_{16}$” x 40 at one end and turned down to 4 mm at the other. Silver-solder the parts together. I find that 0.5 mm silver-solder is much easier to use for jobs like this than the normal 2 mm sticks.

The inner part of the body is designed so that the regulator spindle cannot easily be unscrewed completely. The inside is threaded just half way through. The outside is threaded at both ends. Cutting the thread on the outside of one end is easy. To turn and thread the other end make a holder from a short length of brass rod. Drill and tap the holder whilst held in the three-jaw chuck. Having cut a thread on one end of the part it can be screwed into the holder so you can work on the other end. Do mark the holder so you can put it back the same way in the chuck each time you use it.

Turning the regulator spindle is tricky. Take small cuts and use a cutting fluid. Polish the surface. Gland nuts can be purchased if you do not want to spend time making them. Pack the spindle gland with a couple of twists of graphited string round the spindle before screwing on the gland nut.

Another gland nut holds the main steam pipe. Turn up a tiny olive from $^{5}/_{32}$” or 4 mm brass and silver solder to the end of the pipe before assembly. Note that the steam pipe is tucked away below the water gauge glass. It needs to be in place before you assemble the water gauge.

Water Filler

This is basically the same as I described in SMT 46. The boiler can be filled using a syringe or hand pump. A cheap garden sprayer makes a fine pump. To fill the boiler the hollow stem of the filler is pressed down so the cross hole is below the ‘O’ ring. A spring returns the stem after filling so the cross hole is above the ‘O’ ring.

An “O” ring of $^{3}/_{8}$” OD, $^{1}/_{4}$” ID is used to seal the filler to the boiler. With an “O” ring you need only screw the filler in finger tight to get a steam tight seal.

Water Gauge

This is another turning and fabricating job. The top and bottom fittings are fabricated in a simlar fashion to the regulator body.

Water gauge glass size is nominal. Do measure yours and check that it will fit easily in the 4.1 mm hole specified. The glass is retained with gland nuts. For the water gauge the seal can be made from a slice of silicon rubber tube. Model aeroplane shops sell this tube for fuel lines. To cut off a neat sealing ring slide a short piece of tube onto a length of 4 mm rod. Spin the rod in the lathe and touch the tube with a sharp craft knife. You can make a number of rings about 1 mm wide very quickly this way. I used tube of about $^1/_8$" (3 mm) bore.

Make a couple of thin nuts threaded $^3/_{16}$"x40 and use these to lock the two fittings in place when screwing them to the boiler. Loctite 638 works well as a seal for boiler fittings or you could use a twist of plumbers PTFE tape. Line up the top and bottom fittings with a length of $^5/_{32}$" rod. Fit the gauge glass after everything is secure. Gauge glass can be cut to length by nicking the tube where you want it to break with a file. You only need a nick on one side. Protect your fingers, grasp the glass tube firmly and bend away from the nick. Nine times out of ten the glass will break cleanly leaving a tidy edge.

Safety Valve

The safety valve shown is quite adequate for this little boiler. The spindle and spring come from a car tyre valve. Rather than buy a valve, ask at the tyre dealer when changing your car tyres. Tyre dealers seem ready enough to give away a handful of used valves for the asking. The spring is usually either phosphor-bronze or stainless-steel. Both are fine for our purpose. The spindle needs to be modified. You will find a cup half way along the spindle. Cut off the spindle below the cup. Grip in the lathe and tidy up the bottom of the cup to sit neatly on the ball valve. You will need to shorten the spring.

Steam escapes from the valve through slots cut in the side of the spring retainer with a junior hacksaw. This arrangement is fine for this small boiler. For larger boilers a safety valve with larger escape passages should be used.

The most tricky part of safety valves is making them steam tight. You need to get a good seat for the ball valve. The traditional approach described by LBSC is to place a ball bearing of the same size on the valve seat and to hit it with a hammer. Sometimes it even works for me!

Pipe Work

As mentioned earlier a tiny olive is used to form a seal between the steam pipe and the regulator. A similar olive is needed at the other end where the pipe connects to the port block. Do not forget to thread the nuts onto the pipe before you silver-solder the olives in place.

Bending small pipes can be tricky. Soften the copper first by heating to red heat and quenching in water. One way to get a neat tidy bend is first to turn a former in the lathe. This will look like a small pulley. You can then pull the pipe round the former by hand.

The exhaust pipe is a push fit in the port block. At the other end a nozzle directs the steam up the chimney to draw the fire when running. Make a right angled nozzle from $^3/_{32}$" copper pipe and solder this into the end of the exhaust pipe. To get a sharp right angle bend in a pipe first file away a “V” shaped groove almost all the way through the pipe. Fold across the “V” to form a right angle and silver-solder the joint. This is easier to do than it sounds. Go easy on the solder so you don’t fill the whole thing solid.

Next Instalment

We have now completed virtually all the working parts except for the burner. Next time I will cover the meths burner and the plate-work such as it is.

Building a de Winton Dave Watkins

Part 5 - Chimney, Spirit Burner & Platework

Those of you who have been following the series so far and have kept pace with construction will have a complete working chassis and boiler. Once the methylated spirit burner and tank are complete you will be able to boil water and give the chassis a steam test. Do not be discouraged if it does not run first time. Typical teething problems in a new loco are steam leaks and tight spots.

With such a small boiler a slight steam leak has much more effect than on a larger engine. You may find it easier to track down leaks using an air supply than when the engine is in steam. Brush a little soapy water round any suspect points (regulator spindle, water gauge gland nuts, pipe joints, safety valve etc.). If there is a leak you will get a stream of bubbles.

Tight spots will usually ease as the loco is run. If you have a compressed air supply, running the chassis on air for half an hour or so will usually help.

The methylated spirit burner described here was the best of a number of variations I tried. I was somewhat surprised to discover that I got better results with a burner with two wick tubes than when I used one with three. I also tried an annular burner and a sort of half hearted vaporising burner but none of these worked as well as the burner shown here.

Chimney

The chimney should by rights have been on the drawing sheet for the boiler but I could not find room to fit it in. You can find it on the drawing sheet for the platework. It is worth making the chimney before steam testing since it does have an effect on steam generation. The chimney for “Idris” is a bit easier than usual since it does not have to fit the usual curved smoke-box top. You can produce the shape by straightforward turning without any need for clever milling set ups or resorting to hand filing. The chimney has a spigot to plug into the top of the boiler flue. You will need to notch the spigot to clear the exhaust pipe. Do check that the exhaust ends up in the centre of the chimney.

I was lucky to find a suitable piece of thick walled tube to machine up for my chimney. You can easily machine one up from a length of brass rod. You could even forget the machining and use a length of tube.

If you wish to machine a chimney I suggest starting with a length of solid 18 mm brass rod around 60 mm long or so. This gives you some excess length to hold the rod by in the chuck whilst you machine the chimney. You can of course shape your own chimney to taste. I went for a simple flared top as on “George Henry” in the Towyn Museum. If you are skilled at hand turning you will not need me to suggest how to make the flare. When machining from solid you can cut shapes like this by judicious twiddling of the top slide and cross slide hand-wheels. With a bit of practice you can co-ordinate the movement of both hands to achieve a smooth shape. Don’t despair if the outside ends up with ridges. You can always smooth the ridges away with a fine file whilst the chimney is spinning in the lathe. Do remember to take care when filing work in the lathe!

Methylated Spirit Tank

The methylated spirits (meths) tank fits between the frames, and is held in place by a couple of springy brass clips. It is positioned where on “George Henry” the water tank hangs down between the frames so it is quite inconspicuous.

The tank may be fabricated from thin sheet brass. For tanks and bodywork I usually use the brass sheet which model engineers suppliers stock for boiler cladding. This sheet is typically about 0.4 mm (.014”) thick. It is fairly easy to bend round a suitable former for curved parts like saddle tanks. At the same time it is stiff enough to form cab sides and bunkers, provided it is reinforced at the edges with beading.

I recommend silver soldering meths tanks and burners rather than soft soldering. This is not absolutely essential but it does give an extra safety margin. I have had soft soldered joints fail on meths tanks. Meths leaking from a cracked joint can easily catch fire and cause a flare-up.

Silver soldering a tank like this is not much more difficult than soft soldering. The tank is made from two pieces of brass sheet. Mark these out, then drill the holes for the filler, for the feeder pipe to the burner and for the overflow. Cut to size and bend each piece into a ‘U’ shape by folding along the dotted lines. The two pieces should fit together to make a rectangular tank, the top and ends fitting between the bottom and sides. You will probably need to trim the edges with a fine file to get a good fit.

Tie the two parts together with a loop of wire so they do not move whilst soldering. Coat the edges with flux. Heat gently at first to drive the water from the flux then turn up the heat. With thin sheet you need to work fairly quickly. If you overheat thin sheet you might burn a hole in it! Do not expect to get the whole tank up to red heat at the same time. Concentrate on one part of the joint. As soon it begins to glow dull red try touching it with the silver solder stick. If the work is hot enough the solder should melt and flash into the joint. Move the torch on and as you bring another part of the joint to red heat the solder will follow, flowing towards the hottest part. Once you have completed all the joints, allow to cool to black heat and quench in your “pickle” bath.

The filler tube is a short length of thin wall brass tube. As with the sharp bend in the exhaust pipe, cut away a ‘V’ shaped nick using a fine saw or file. Fold up to shape and insert in the side of the tank. You can silver solder this joint which forms the bend whilst you are soldering the filler pipe into the tank.

Methylated Spirit Burner

The burner itself consists of two thin brass wick tubes joined by a smaller feeder tube. At the bottom the wick tubes are blocked by pieces of brass sheet. The two burner tubes are positioned clear of the centre flue so that the fire is not put out by hot water and oil dribbling down the flue. The tubes are filled loosely with your chosen wick material. This may be one of the modern ceramic fibre or glass fibre wicks or the traditional asbestos string. I have not had a lot of success with modern materials here and normally stick to asbestos string. I find that whilst glass or ceramic fibre wicks work well when new, the ends of fibres soon fuse or burn away whereupon the burner loses efficiency. Asbestos string wicks seem to last years. If you choose asbestos do remember that it is a hazardous material. Damp it with a little meths before cutting and handling. Avoid breathing the dust.

You may find it easier to work on the burner tubes if you fit them over a piece of wooden dowel turned down to fit. This gives some support whilst drilling holes for the feeder tube and whilst cutting to length. Once again the parts of the burner should be silver soldered together. Burners get very hot!

I suggest making the feeder tube over length to start with. Silver solder the burner parts together. After it has cooled, fit the tank and burner together in the chassis. Note how much of the feeder tube should stick out of the tank. Now you can reassemble the burner and tank before silver soldering the final joint between the feeder pipe and the tank.

To retain the burner and tank in the frames I bent up a couple of spring clips from thin brass as shown. The tops of these are bent outwards so that the tank is held reasonably firmly between the frames. The base of the spring clips may be soft soldered to the tank. The clips ought to hold the tank adequately. For belt and braces support you could add a little bracket from the firebox to support the burner as well.

Fill the burner tubes loosely with strands of your chosen wick material, fill the tank with meths, light up and check that you have a nice hot flame. If the flame looks too large, pack the wick tubes tighter with a few extra strands. Conversely remove a few strands if the flame seems too small. The tighter you pack the wicks, the less space there is for the meths to flow and hence the smaller the flame.

Once you are happy insert the burner under the boiler and try a steam test. You will find that the flame burns somewhat differently with the burner under the boiler. I find it useful to place the engine on blocks over a mirror to see how well the fire is burning. If too much meths is flowing through the burner the fire will not have enough air and will flutter and go out. Aim for a nice steady blue flame licking over the hedgehog prickles in the base of the boiler.

By the way the air holes shown on the boiler plans do help stabilise the flame. I added these to “Idris” after finding it difficult to raise steam. The chimney also has some effect on the flow of heat. You may even find that removing the chimney helps raise steam from cold. Once the loco is running the exhaust directed up the chimney helps to draw the fire. Again with the engine on blocks over a mirror you can watch the effect on the fire when you open the regulator.

Buffer Beams

The arrangement of buffer beams and the steel plates behind them are copied from "George Henry" in the Towyn Museum. I guess the steel plates are there to limit damage should the loco hit something solid. They certainly provide protection for the driver and for the water tank. These front and rear plates sit up on top of the frames. In our model they are fixed to the top of the buffer beams using countersunk rivets or screws.

The buffer coupling arrangement is a simplified version of the buffing blocks on "George Henry". I used chunks of Tufnol since I expected to need something insulated to grab the loco by if it were to get hot. In practice I find the ends of "Idris" stay quite cool so there is no reason why you should not make them from a block of metal if you choose. Fix the buffer coupling to the buffer beam with a couple of countersunk screws from behind.

The buffer beams can be bolted to the chassis end plates. A couple of 10 BA bolts each side looks quite effective though one each side would be enough to hold.

Many readers will have their own ideas on couplings. "George Henry" has three links of chain retained by a coupling pin. I have copied this arrangement on "Idris" using a shortened 25 mm nail for the pin. The chain can be home made from wire. The steel wire used to tie the end of potato sacks makes excellent chain links.

Dummy Water Tank

The top of the water tank is dummy on "Idris". It could be used as a reservoir for a chick feed arrangement for the meths burner. If you feel really enthusiastic you could use it as a water tank and add a water pump.

The sides of the water tank are folded up from thin brass sheet with a lap joint. Add embossed rivets (or real rivets if you insist) to taste. Make the tank top from an oversize piece of sheet. Solder in place before trimming to size with a fine file. Lengths of brass angle soldered around the bottom of the tank, again as on "George Henry" locate the tank on the frames. You can fix the tank to the loco by a bolt each side down through this thin angle round the tank into the angle used to edge the frames.

A dummy tank filler turned up from brass rod completes the job.

Foot-plate

The foot-plate is cut from steel sheet. The foot-plate projects out either side beyond the frames. This must make it easier for the driver to get on or off the foot-plate without getting caught up in the coupling rods. There is a trap-door in the foot-plate of real de Winton locos for the driver to feed fuel to the fire. This can be simulated by fixing a piece of sheet to the foot-plate. You can secure the foot-plate by a couple of bolts into the angle edging the frames. I used the same bolts that hold the coal bunker in place.

Coal Bunker

More thin brass sheet can be cut and bent to form the coal bunker. "George Henry" has beading round the edge of the bunker and round the coal hole. Model engineers suppliers sell half-round beading $^{1}/_{16}$" wide which is ideal. This beading takes solder readily and is soft enough to bend round tight corners. You could use strip or wire instead.

"Idris" like some other de Winton engines has a wooden seat over the coal bunker. My driver can relax without resting on the sharp front edge of the bunker or the lumpy coal. However a trustee from the Towyn Museum has pointed out that "George Henry" does not have a seat and there is no evidence that it ever had one.

Brake Handle

De Winton locomotives generally have large wooden brake blocks operated by a screw down hand brake which projects up through the coal bunker. If you wish it would not be difficult to make working brakes. I have not yet got round to adding brakes to "Idris" so these are not shown in the drawing. I have shown the brake handle in the general arrangement. If you solder a short length of brass tube inside the back of the coal bunker you can arrange for a dummy brake handle to rotate.

Nameplates

Our suppliers sell excellent etched brass nameplates at reasonable prices. These are photo etched and very good. It is possible to make plates yourself using rub-down letter transfers (Letraset for example). As well as a sheet of letters you need a sheet of plain lines. To remove the brass between the letters you can use the etching fluid sold by electronics suppliers. This is made from ferric chloride and is sold for etching the thin copper sheet from printed circuit board. It works just as well on brass.

Take a piece of sheet brass somewhat larger than the finished nameplate. Clean it up well with fine wet and dry paper or with an abrasive block. Apply your chosen name and frame it with lines from the plain line transfer sheet. Rub the letters down well. Place the plate in a glass pot and cover with etching fluid. You will need to leave the plate for several minutes to get a good deep etch. I find I need to leave the plate for around 40 minutes to an hour. Keep an eye on it. If you leave the plate too long it will be etched right through. Wash the plate thoroughly in water. Give it a couple of coats of paint and allow to dry before rubbing the paint off the letters with wet & dry paper.

Painting

Ordinary car aerosol paint sprays are ideal for most of the loco including the frames tank and bunker. The boiler though does get a bit too hot to expect ordinary paint to survive. Car accessory shops sell paint intended to stand up to high temperatures for use on car engines which is a much better bet for boiler and cylinders. "George Henry" is finished in all over black with the buffer coupling, "snow plough" ends, cranks and coupling rods in dull red. This gives an authentic industrial look to the loco.

Building a de Winton   Dave Watkins

Part 6 - Gas Tank, Control Valve and Burner

At the beginning of the "Idris" saga I suggested that it ought to be possible to fit a gas burner. Here is my attempt at a design for those of you who are averse to methylated spirit firing. Personally I do not much like the smell of butane but then again I cannot say I am enamoured of the smell of meths either. The burner is intended for butane gas. It seems to work well in such weather conditions as one would care to operate a full size locomotive like "Idris". I would not personally like to stand on the foot-plate of a full size de Winton in a howling gale. This burner does not like strong winds either. On the other hand it will cope with a few degrees of frost. Just a few days before writing this article, I ran "Idris" with this gas burner on a calm winter's day when the garden was covered with a fine white coating of hoar frost. She ran well with nice plumes of steam from the chimney and safety valve. I have to admit that I kept the gas bottle cosy and warm in a lukewarm water bath. Without this butane will not even come out of the can in really cold weather.

Gas tanks should always be solidly constructed. The pressure inside the tank whilst barely above atmospheric in cold weather increases extremely rapidly as the tank temperature rises. The pressure in a hot gas tank would be higher than in your boiler. To make the tank strong I made it with flanged ends and a central stay. This construction may look like overkill but adding the stay is not a lot of work and it provides something to support the tank with. All joints are silver soldered as with boiler construction. Careful workmanship is necessary. A gas burner does require rather more work than a meths burner but anyone who has got this far with the project should have no difficulty making the burner described here.

The control valve is basically similar to the regulator shown in part 4 of this series (see SMT 73) and so I have not drawn out the individual parts again. For simplicity I silver soldered the body of the control valve directly into the top of the gas tank. The bottom end of the valve body should be turned down to 5 mm diameter rather than being threaded as for the regulator. Also to keep things simple the draw-off pipe is silver soldered directly into the side of the control valve body. I used $^{1}/_{8}$" tube for this pipe. To control gas flow I used a knurled wheel on the end of the valve spindle but you could use a handle if you wish.

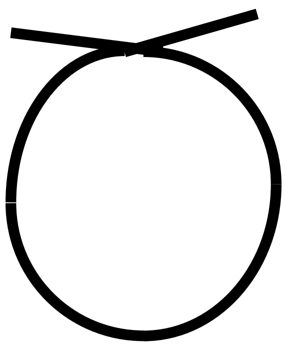
The tank is made from a length of 22 mm copper water pipe. Cut off a length of pipe, clean up the ends, drill holes for the control valve body and for the filler valve bush. Use a 5 mm hole for the control valve. The filler valve I used required a 6 mm hole for the bush. The tank ends are flanged from discs of copper sheet just like the boiler ends. In this case I turned up a steel disc to act as a former whilst flanging the ends. Hardwood or plywood could be used instead. The centre stay is a length of $^{3}/_{32}$" phosphor bronze with the ends turned down to 2.3 mm diameter. The shoulders thus formed help to hold the ends in place whilst silver soldering. I suggest silver soldering the job in stages. I secured the ends to the tube and fixed the central stay first. Then I fitted the valve body and filler bush, finally adding the draw-off pipe. Make the pipe over length at this stage. After silver soldering the pipe will be quite soft so it should be fairly easy to bend to shape. Cut the pipe to length when you are ready to fit the jet housing.

The gas jet was a commercial item. I do not know how small the hole in a gas jet should be but it is certainly small. I find trying to drill such small holes bad for the nerves and prefer to let someone else have the worry. The jet housing is turned up from brass as shown. Silver solder the housing in place on the end of the draw-off pipe.

Now is the time to test the tank. Please do not skimp this stage of the proceedings. Check all the joints carefully. If you see any signs of cracks or pinholes clean up, flux the joints and re-heat. When you are happy pressure test the tank just as you would a boiler with a hydraulic test. Do remember that high pressures may be involved and use a high test pressure. My test pressure gauge goes up to 160 PSI so this was the maximum pressure I could use. It would not be unreasonable to use a test pressure of up to 400 PSI or 27.5 BAR.

The shield (don't know what else to call it) is turned from brass and threaded to fit onto the outside of the jet housing. The gas emerges from the jet at high speed and is directed into a length of $^1/_8$" tube which feeds a mixture of gas and air into the burner proper. Air enters the shield through the cross hole which is 6 mm diameter. Do not fix the feed pipe into the shield just yet.

The ring burner proved rather easier to make than I had expected. Soften a length of $^3/_{16}$" copper tube by heating to red heat then quenching in water. Bend the tube round a suitable cylindrical object so the ends overlap like:



Cut across both ends where they cross with a junior hacksaw, clean up the edges with a fine file and bend into alignment. You should now have a near perfect ring. Drill a hole on the opposite side from the joint and fit the feed pipe to carry the incoming gas and air mixture. Flux the joints, heat up and silver solder. Try not to use too much solder since we do not want to block the tubes. I suggest using 0.5 mm silver solder wire for this sort of job. The fine wire makes it easy to control how much you put in to the joint.

I have shown a little bracket silver soldered to the burner ring to support the burner in the firebox. This prevents the burner dropping down and falling out. The bracket is a short length of brass sheet with a 10 BA screw which locates in a clearance hole in the firebox. The position of the bend in the bracket can be found by offering up the burner to the firebox. The location of the clearance hole (1.8 mm diameter) in the firebox shell can judged by eye. If you have already built the loco then to get at the firebox shell with a bench drill you would have to remove the boiler from the chassis. If you have a miniature electric drill you can probably manage without dismantling anything. Another possibility is to hold the drill in a pin vice and spin it between your fingers. Drilling holes this way does take quite a while but it works.

Some 16 holes of 1 mm diameter are shown in the top of the burner. The number of holes is not critical and they can be placed by eye. For small holes it is best to have the drill running as fast as possible. Use a depth stop if you have one to avoid drilling right through the bottom of the burner as well.

The gas tank fits between the frames in the same place as the meths tank. The upper section of the dummy water tank now covers the control valve and gas filler valve. I modified the upper section so that it would lift on and off to allow the tank to be filled and the gas flow to be adjusted. I had to file away part of the bottom flange to clear the port block and I replaced the holding down bolts with locating pegs made from brass wire.The gas tank itself is held in place by a piece of brass sheet bent into a “U” shape which fits over the ends of the centre stay. This piece of sheet has dummy rivets to disguise it as the water tank of the full size engine. I had to cut the ends away on mine to fit round the frame angles as sketch in the drawing. A couple of bolts through the frames into this dummy water tank will hold the tank and burner securely in place. Make sure the bolts clear the gas tank though!

After arranging fixings for the dummy water tank/gas tank support you can make a trial assembly. Check the length of the feed pipe and cut to length. Finally silver solder the feed pipe to the shield.

Now assemble the parts properly. Put a fibre washer between the gas jet and housing to get a good seal. You may need to trim the outside of the fibre washer to clear the inside of the shield. Don’t forget to put packing round the control valve spindle. I used a thin slice of silicon rubber tube. It makes a very effective seal, the only snag with it being a tendency to stick to the valve spindle. This makes fine adjustment of the gas flow tricky unless the spindle is lubricated.

You will probably find as I did that this burner is far easier to light from underneath than in the more traditional manner across the chimney. Close the control valve before filling the gas tank. This is rather obvious I know but I have seen a few near accidents. Make sure any spilled gas has dispersed before lighting up. Open the control valve so you can hear the gas hissing gently. Lift the loco with one hand and light the burner from below with a cigarette lighter. Now adjust the burner to get a nice ring of blue flames. If you open the valve too much then the gas will come out too fast, the flames will lift off the burner and probably go out. Similarly the burner will go out if you turn the gas flow down too far. Find a happy medium and remember the setting for next time. I found it helpful to light up above a mirror laid on the bench the first few times.

This is actually the first gas fired engine I have owned and I have enjoyed comparing and contrasting meths and butane gas firing. This gas burner is almost silent with just a barely audible hiss. I have found noisy gas burners somewhat off putting in the past. In contrast to the meths burner, steam can be raised quickly when gas firing with no need for any assistance from a blower. Steam trials have shown that the gas burner keeps up a higher boiler pressure when running too. The gas burner seems to be hotter. As I said at the beginning I do not like the smell of either fuel. Meths has the advantage that a burner uses much simpler engineering and is both quicker and easier to make. Gas burners are hotter and cleaner. Both fuels are dangerous and I really do not consider that either one is safer than the other. They each have their own risks. To me the major advantage of meths firing is that the burner can be topped up regularly so that the engine can be kept in steam for long periods.

The performance of “Idris” on gas has been a revelation. One afternoon when the Birches Barn Light Railway was covered by the wrong sort of snow I spent a happy afternoon running “Idris” up and down the workbench in my shed pushing a Mamod truck holding a 2 kilogram weight. She would even push this weight up a length of inclined track.

Finally thanks to all the people who knowingly or unknowingly have contributed to my understanding of gas firing. I have picked up a lot from contributors to SMT over the years. I have also gleaned much from talking to other loco builders at garden meets and exhibitions. The gas jet and gas filler valve I used were puchased from John Prescott Engineering. I must give a particular thank you to Mike O’Neill who contacted me soon after the first “Idris” article to talk about burner design.