Construction Notes2mm Finescaling kit for Graham Farish LMS Ivatt 2-6-0:

1. Introduction

This kit has been designed to convert a Graham Farish (Grafar) Ivatt 2-6-0 loco chassis to 2mm finescale. It includes etched replacement parts for most of the valve gear, and a tender chassis. The original loco chassis and motor are retained for the conversion. Significant dismantling and modification to the original model, as described below, is involved, and this will INVALIDATE ANY WARRANTY you may have. I cannot be held responsible for any damage to your model incurred during the conversion process.

Parts required to complete are: -

Graham Farish LMS Ivatt 2-6-0	1
Pony truck wheels	2x 6mm
Driving wheels	6 x 10mm
Tender wheels	6 x 7mm
Crankpins	6 flanged recommended for driving wheel
Crankpin cap washers	4
Motion pins minimum	2 packs, or use 0.25mm nickel silver rod
Frame bushes minimum	14
Wheel muffs	2 small diameter, 5 large diameter
PCB frame spacer 7mm	2" or so
Thin double-sided PCB (say 0.25mm thick)	2 sq. inches should suffice
Screws and nuts 12BA cheesehead	1
16BA washers	2

Couplings own choice

Tools required include: -

Soldering iron and solder, flux
Needle files – flat, round
Modelling knife
Broaches
12BA tap
Back to back gauges
Wet and dry paper, glass fibre brush
Set of jewellers screwdrivers
Chassis frame assembly jig
Tweezers
Flat-nosed pliers
Lathe or Minidrill (both optional)
Vice

I recommend you read and understand these instructions before you begin assembly. There are a number of small and delicate parts on the etch. It's best to leave parts on the etch until actually required. All folds are made with the half-etched line inside the fold unless otherwise
stated. Traces of tabs holding parts in the etch should be removed with a needle file prior to assembly. It is recommended that work done is cleaned periodically to remove all traces of flux.
A supplementary drawing is provided to assist you with the conversion.
I posted a topic on RMWeb showing some aspects of the construction of this kit. It can be found at
http://www.rmweb.co.uk/community/index.php?/topic/81104-finescaling-a-farish-ivatt-2-6-0/

2. Dismantling the Grafar Loco

As already mentioned, dismantling the model will INVALIDATE ANY WARRANTY you may have. As you progress through these steps, make a note of how things went together, and keep all the bits safely, labelled if you think necessary. Refer to the Grafar instruction sheet for additional guidance. Note that there are several delicate plastic parts on the model, so be as gentle as possible as you take the model apart. If you are unsure how to proceed at any given point, please get in touch and I will try to help, but I will not accept liability for any damage you inflict on your model.
2.1 I started by removing the tender top, which just clips in place on the footplate/ chassis moulding. Mind the ladder at the back of the tender and put the tender body somewhere safe.
2.2 Now unsolder the wire connections from the loco chassis to the PCB DCC panel, and then the connections at the phosphor bronze wheel frames.

2.3 Remove the screw securing the drawbar to the tender, ease out the three sets of wheels, and remove the wheel frames.
2.4 Unscrew the PCB DCC panel and drill a 1.5mm hole in the footplate/ chassis next to the water scoop, then use a piercing saw to saw round the base of the scoop. When cut away from the footplate, remove the whole of the solid base of the plastic moulding, and retain the water scoop for re-attachment later.
2.5 Unclip the drawbar from the loco chassis, trying not to damage the phosphor bronze clip.
2.6 Remove the pony truck, then the loco body fixing screw between the cylinders. Then the loco body can be hinged away from thechassis as mentioned in the Grafar instructions.
2.7 Undo the cylinder assembly securing screw and remove the cylinders.
2.8 Undo the 4 screws securing the keeper plate, then prise away the latter.
2.9 Undo the hexagonal screws attaching the connecting and coupling rods to the driving wheels and separate the parts.
2.10 Remove the driving wheels from their axles and keep the wheel bearings safe. Also remove the plastic gear from the middle axle.
2.11 Twist the expansion link away from the motion bracket. It helps if you pull the side of the motion bracket out slightly.
2.12 Cut a slot with a piercing saw in the top of the motion bracket into the rectangular hole the radius rod passes through. Pull the lifting link away from the loco chassis and ease the link away from the radius rod, taking care not to damage the 'pip' that connects the lifting link to the radius rod. Lift the radius rod out of the way via the slot cut into the motion bracket.
2.13 Ease the metal disc away from the back of the crosshead, then file around the side of the lug retaining the connecting rod to the crosshead until the connecting rod is released. Do not file the top of the lug: retain as much as possible for attaching the new connecting rod later.
2.14 File around the side of the lug retaining the union link to the crosshead until the union link released. Do not file the top of the lug: retain as much as possible for attaching the new union link later.

3.Tender chassis
3.1 Start by removing the tender frames from the fret and open out the bearing holes with a round file until frame bearings just fit. Solder bearings in each hole on the inside of the frames. File the outside of the bearings flush with the frames.
3.2 Open out each bearing with a broach until a tender wheel axle can be inserted and spun freely with minimum play.
3.3 Cut three lengths of 7mm PCB frame spacer, front 4mm long, middle 9mm, and rear 4mm. Drill a 1.3mm diameter hole centrally in the rear spacer, 2.5mm from the rear edge. Gap the top and bottom surfaces along their length to provide electrical isolation. For the rear spacer, remove extra copper from the top and bottom surfaces of the spacer so that a 12BA screw does not contact the remaining copper on the spacer when inserted through the hole.
3.4 Solder the spacers along the top edge of the inside of one of the frames, the front one against the front edge of the frame, the middle one centrally above the rear lightening hole, and the rear against the rear edge of the frame. Check the spacers are at right angles to theframe.
3.5 Solder frames together using a loco frame assembly jig inserted through the outer axle holes. Check after soldering that the frames are square to each other. This can be done using lengths of axle steel through the outer axle holes, viewed from one end of the chassis.
3.6 Drill a series of 1.5mm holes centrally part way through the PCB along the middle spacer so that the water scoop moulding can be re-attached. With the chassis in place under the footplate, check that the water scoop can be fitted so that its rear edge is 7.5mm from the
inside of the buffer beam, and the bottom of the scoop is no more than 0.5mm below the bottom of the frames.
3.7 Reduce the length of three 3.2mm diameter muffs so they fit between the bearings in the frames. Ream the muffs until the tender wheels fit firmly inside them. Drill 1mm diameter holes through the muffs 1.5mm either side of centre, then assemble the tender wheels and muffs in the frames. Set the back-to-back using back-to-back gauges. There is a cut out above each axle hole so that gauges may be used at the top and bottom of the wheels. Check the wheel sets rotate freely and add superglue in the 1mm holes to fix the axles to the muffs.
3.8 Open out the hole in the tender securing plate to take a 12 BA screw and solder a 12BA nut over the hole. Clear solder from the threads of the nut with a 12BA tap and glue the plate on top of the plastic footplate/chassis, lining up the hole in the plate with a hole drilled in the rear of the plastic chassis, centrally 3mm in front of the buffer beam.
3.9 Screw the etched chassis assembly to the plastic footplate/ chassis and check that the wheels line up with the axle box covers. If necessary, elongate the hole in the PCB spacer slightly to adjust the position of the wheels relative to the axle box covers.
3.10 I added a length of plasticard to the top of the footplate, a wedge fit under the PCB just in front of the blanking plate to support the PCB and stop the coiled wires on the underside of the blanking plate contacting the tender securing plate.

4.Valve gear assembly.
(Refer to supplementary drawing for general arrangement of the various parts of valve gear. If you have never assembled valve gear before, the chapter on the subjectin Pete Wright's book is well worth reading).
4.1 Solder together pairs of coupling rods, connecting rods, combination levers, eccentric and radius rods (a single layer will bend too easily), fluted sides being on the outside. There is also a backing piece for the small-holed end of the union link which may be left off if you prefer. In addition to the union link on the etch, I have produced extra union links with

small holes at either end. If you want to use these, then you can use either a single or double layer, as you prefer. The double layer is stronger but a bit chunky looking. When the parts have been soldered together, clean up any excess solder, and remove any traces of attachment tabs remaining on the parts. Do this for the single layer parts too. Form 'kinks' in the combination levers, expansion links and return crank as shown in the drawing. These bends provide clearance past adjacent parts of the motion when the loco is moving.

4.2 The valve gear can be joined together using 0.31mm nickel silver rod or Association rivets. I will describe the former method, using the link between the combination lever and the union link as an example. Before starting, open out the small holes of the items to be joined, and any washers, with a 0.35mm drill, and file the areas around the holes smooth with a needle file. The bottom end of the combination lever is attached over the top of the union link, whichever version you decide to use. First then, put a 10mm length of rod vertically in a vice. Place a piece of greaseproof paper over the rod, then place the union link (small hole) upside down on the rod. Hold the union link down and solder to the rod. Place this assembly back in the vice, right way up, then put a piece of greaseproof paper on the rod over the union link. Put the combination lever on the rod, then another piece of greaseproof paper, and finally, a small etched washer. Hold the washer down on the union link etc and solder the washer to the rod with a quick dab of your soldering iron. Check that the combination lever rotates, even if stiffly. Remove the assembly from the vice and carefully pull the two bits of greaseproof paper away from the joint. Rinse flux residue away with water, dry the assembly and clean up with a glass fibre brush. File the back of the joint flush and file the other end of the rod until no more than 0.25mm protrudes above the washer. If you solder the joint up solid, you will need to dismantle the parts, clean them thoroughly to remove all traces of solder and start again. The following parts are joined together in similar fashion:

- Combination lever top end on top of the front end of the radius rod
- Eccentric rod front end on top of the expansion link
- Eccentric rod rear end on top of the return crank narrow end

4.3 Solder a short length of 0.25mm nickel silver rod in the top hole of the expansion link and file the rod back until about 0.75mm protrudes either side of the expansion link. You should end up with two separate sub-assemblies for each side: the union link, combination lever and radius rod, and the expansion link, eccentric rod and return crank.

5. Pony truck

5.1 Open out the holes in the pony truck side frames and solder frame bearings, shaped as shown in the supplementary diagram, in place on the inside of the frames. File the outside of the bearings flush with the outside of the frames. Ream the bearing holes so that a wheel spins freely in the holes.

5.2 Solder appropriately shaped pieces of 0.25mm PCB to the pony truck side frames. Form right angle bends in the pony truck spacer using the half-etched fold lines and solder the spacer to one of the side frames. Mount this on a loco frame assembly jig, then add the other side frame and the remaining part of the jig. Then solder the spacer to the side frames and with the frame spacer jig removed check that the side frames are in line with each other as viewed from the side.

5.3 Insert a small diameter muff, prepared as for the tender axle muffs, between the frames and then insert the pony truck wheels into the muff, set the gauge, and check that the wheels rotate freely. If so, glue the wheels in the muff.

5.4 Bend the guard irons as shown in the supplementary drawing.

6. Re-assembly

6.1 Solder 6 Association axle bearings onto a length of 1.5mm brass rod and turn the flanges down to c. 2.9mm so that a Grafar bearing just slides over them. Remove the bearings and solder them inside the Grafar bearings, with the Assoc bearing flange flush with the outside edge of the Grafar bearing. An alternative approach is to open out the Grafar bearings to 3.2mm diameter, preferably using a pillar drill.

6.2 Reduce two large diameter and one small diameter Assoc muffs to 4mm in length, drill 1mm holes 1mm either side of centre line right through the muffs, and ream them until the Assoc driving wheels are a firm fit inside the muffs.

6.3 Open out the hole in the Grafar gear to 2.3mm diameter so that the gear is a firm push fit on the small diameter muff, taking care not to damage the gear. Then fit the gear centrally on the muff and superglue in place.

6.4 Solder flanged crankpins into the holes in the driving wheels. Then solder or glue the driving wheel balance weights onto the wheels if you wish though you may want to leave this until the coupling rods and valve gear have been attached if you intend to glue the weights on. The larger ones go on the middle driving wheels. Refer to the Grafar wheels for positions of the weights on the wheels.

6.5. Assemble the driving wheels on the muffs with the bearing assemblies either side of the muffs, and the raised ridge on the bearing nearer the centre. Set the back to backs of the three sets of drivers and drop into the slots in the loco chassis. Check the wheels spin freely. For the geared axle, use one of the outer chassis holes for test purposes.

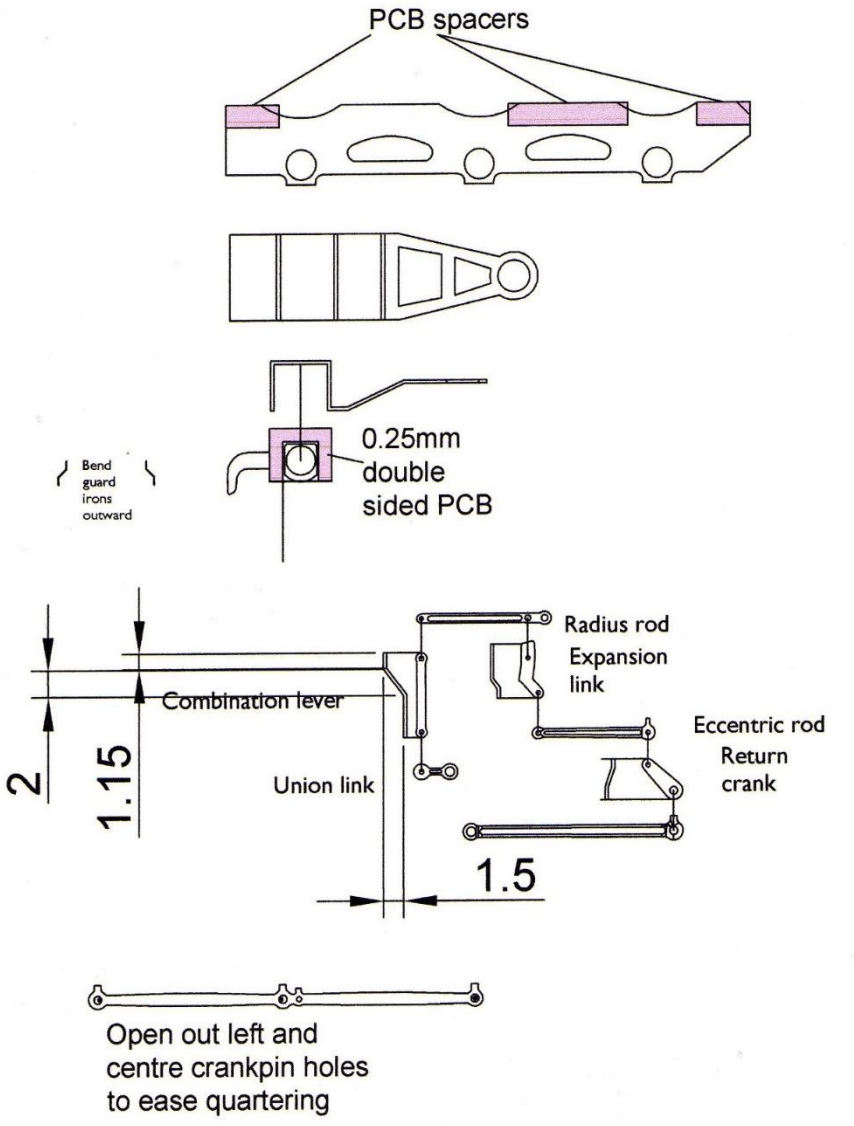
6.6 Remove the three sets of drivers, and quarter them approximately by eye, then put them back in the chassis. Line up the crankpins on one side of the chassis, then turn the wheels on the other side until the crankpins are in a line on that side. Attach the coupling rods temporarily, and check that the rod on each side is horizontal.

6.7 Re-attach the keeper plate and apply power to the motor via the leads running along the top of the chassis block. Run the motor slowly and observe the position of the crankpins in the coupling rod holes at any point where binding occurs. Open out the crankpin holes where binding occurs, and re-test. If all appears OK on one side of the chassis, repeat the process as you inspect the other side until the driving wheels rotate without any binding.

6.8 Once you are happy with the quartering, the coupling rods can be attached, with washers on the front and rear wheel crankpins only. Put larger washers on each of the three crankpins, then put a piece of greaseproof paper the outer pins, then the coupling rod, more greaseproof on the outer pins, and another washer. Solder the top crankpin washer to the crankpin while holding the washer down, but not too firmly. Check the two wheels rotate, then remove the greaseproof paper and do the other side of the chassis.
6.9 Rinse the four crankpins with water to remove any traces of flux and dry thoroughly. Avoid getting any water near the motor. Trim the crankpins to about 0.5mm above the washers and clean up any stray solder with a glass fibre brush.
6.10 Mount a connecting rod on the lug on the inside of the crosshead, then ease the round metal Grafar discs over the lug and press the disc down on the inside face of the connecting rod. Carefully hold the crosshead with a pair of smooth jawed pliers, squeeze down on the lug, gently at first, and look to see if it has started to splay out at the top. Check that the connecting rod swings around the lug. Carry on squeezing down on the lug with increasing pressure until you are satisfied that the splayed lug is holding the disc and connecting rod firmly in place but allowing the connecting rod to swing easily. Insert the crosshead assembly between the slidebars and check the crosshead slides smoothly along the slidebars. Repeat this for the other crosshead and connecting rod.
6.11 Remove the crosshead assembly from the slidebars, and if you are using the original union link parts with one large and one small end, then ease the large-holed end of the union link over the lug at the bottom of the crosshead. Squeeze the lug down gently with smooth-jawed pliers to splay the lug over the union link. Check the union link swings freely then apply slightly more pressure until the union link is secured over the lug, and swings without too much slop. Be careful not to press the lug down too much otherwise the union link can end up locked solid against the crosshead. Repeat for the other crosshead and union link. If you are using the alternative union link, file the stub at the bottom of the crosshead down to almost nothing, then mark the centre of the remaining lug and drill through the crosshead with a 0.35mm drill. File any remaining lug away. Bend a 10mm long length of 0.31mm nickel silver rod into an 'L' shape with one leg about 1.5mm long. Insert the long leg through the back of the crosshead, then place a square of greaseproof paper around the rod onto the base of the crosshead. Then thread the loose end of the union link onto the rod, another layer of greaseproof paper, and finally a small etched washer. Hold the washer down on the union link etc and solder the washer to the rod with a quick dab of your soldering iron. Check that the union link rotates, even if stiffly. Remove the greaseproof paper layers, rinse the assembly and clean up with files and a glass fibre brush. Repeat for the other crosshead and union link.
6.12 You should now have the crosshead connected to the union link, combination lever and radius rod. The final stages of assembly of the motion can now be dealt with. Things start to get a bit fiddly from now on! Clearance between the upper end of the combination lever and the slidebars is limited and it is worth filing the inside face of the cosmetic plastic valve spindle guide away slightly so that the join between the combination lever and the radius rod is kept as far away from the centre of the chassis as possible. It is also a good idea to file a slight chamfer along the top edge of the crosshead, especially at the front end. This will give extra clearance for the combination lever where it kinks outwards past the crosshead.
6.13 Insert both crosshead assemblies inside the slide bars and mount the cylinder block on the Grafar chassis. Ease the slide bars between the apertures in the plastic slide bar brackets and screw the cylinder block in place on the Grafar chassis using the original screw.
6.14 Thread the rear end of the radius rod through the small rectangular opening at the top of the motion bracket, then ease the plastic lifting link assembly onto the rear hole in the radius rod using the lug on the inside of the lifting link. Then insert the lifting link into its locating hole in the Grafar chassis. Check again that the crossheads slide freely along the slidebars. Secure the lifting link in the chassis with a drop of superglue.
6.15. Twist the expansion link into place between the motion bracket and the radius rod so that the pin in the expansion link engages in the holes in the motion bracket and the radius rod, and check that the expansion link swings back and forth freely.
6.16 Place a 16BA washer over the middle driving wheel crankpin, then a piece of greaseproof paper, then the connecting rod, another piece of greaseproof paper and finally the return crank.
6.17 Position the return crank so that the join between it and the eccentric rod is just forward (c. 1mm) of the centre of the driving wheel boss when the crankpin is in the bottom centre position. Have a look at prototype photographs if you need to clarify this. Then solder the return crank to the crankpin with the upper end of the return crank held angled outwards away from the driving wheel. Check driving wheels still rotate back and forth slightly. If you have soldered the join up solid you will need to unsolder the return crank and connecting rod, thoroughly clean away all traces of solder from the crankpin, connecting rod and return crank and start again.
6.18 If the driving wheels are now moveable, remove the greaseproof paper, rinse the join with water to remove any flux residue, and clean up the joint with a glass fibre brush and a needle file. The crankpin should be filed almost flush with the return crank so that the top of the crankpin passes under the inside of the return crank as the wheels rotate.
6.19 Repeat 6.14 to 6.18 for the other side of the chassis.
6.20 The running of the chassis can now be tested. Run the loco slowly under power. If the wheels stop rotating suddenly, it's likely some part of the valve gear is catching. Cut the power and inspect the valve gear carefully to identify the problem. Possible causes could be the bottom of the expansion link catching against the connecting rod, the middle crankpin catching the return crank or the combination lever catching the crosshead. It's possible to correct any of these possibilities by filing or sanding away with wet and dry paper the relevant parts to create more clearance. If the wheels rotate without any

obvious catching, but with a degree of stiffness, you can try further cleaning of the soldered joints with a glass fibre brush. A likely candidate causing stiffness is the joint between the return crank and the middle crankpin.
Some modellers frown on this, but an alternative method to improve the running is to put small amounts of CIF on the soldered joint of the valve gear and crankpins, and run the chassis under power, slowly at first, then gradually increasing the speed, and reversing the direction of movement now and then. You must be careful to keep any moisture away from the motor while running the chassis and when you clean the CIF away, which must be done thoroughly to avoid continuing wear in any of the joints.
6.21. Once you are happy with the running of the chassis, lubricate all the joints, the gear wheel and the axle bearings with lubricating oil and re-test the running. The oiling round should make a difference to the smoothness of running.
6.22 Now the loco and tender chassis can be re-united. Firstly, the phosphor bronze pickup wires on the drawbar need reducing in length and bending in slightly so that when the drawbar is screwed back into place on the underside of the tender footplate, the pickup wires still spring against the inside edges of the new chassis unit to maintain pickup between the loco and tender chassis but allow the drawbar to swing freely. Start by cutting off 5mm from the rear end of the wires and then test and adjust the fit until it works satisfactorily.
6.23 Solder the free ends of the rearmost wires attached to the tender PCB to the top of the tender chassis frames in front of the middle axle. Thread these wires through the hole in the plastic footplate above the middle axle. I opened out the these holes slightly to make it easier to get the wire back to the PCB. Screw the chassis to the footplate using the attachment point at the rear of the tender. Then screw the drawbar back onto the tender footplate.
6.24 Re-attach the tender to the loc chassis by twisting the front end of the drawbar back over the bottom projections of the loco chassis, and check that the phosphor bronze pickup wire still spring against the loco chassis projections.
6.25 Thread the two wires from the loco chassis back along the drawbar to the tender and up through the hole in front of the PCB. Solder the wires to the front connections of the PCB, remembering to which side each wire needs attaching.
6.26 Replace the loco body, then the pony truck, and finally the tender body and that's it for the construction work!

7. Painting etc
7.1 The tender chassis, tender wheels and loco driving and pony truck wheels and pony truck can be painted after any soldering work has been completed and prior to final assembly. You may find that the valve gear paintwork gets chipped during final assembly so you might consider painting the valve gear once it's assembled and fully tested.
7.2 Once all the paintwork has been completed, you can re-attach any other bits you may have removed, such as the sand pipes on the side of the loco chassis, and the various accessories included with the model.



References
1 Historic Locomotive Drawings in 4mm Scale, F.J. Roche
2 Stanier Locomotive Classes, A.J. Powell
3 Loco Bits and Pieces, Pete Wright