SILVER LINK MODEL RAILWAYS VOLUME 2

THE GUIDE TO MODEL RAILWAYS

FROM BEGINNER TO EXPERT – TIPS AND ADVICE FOR ALL ABILITIES

BRIAN LAMBERT

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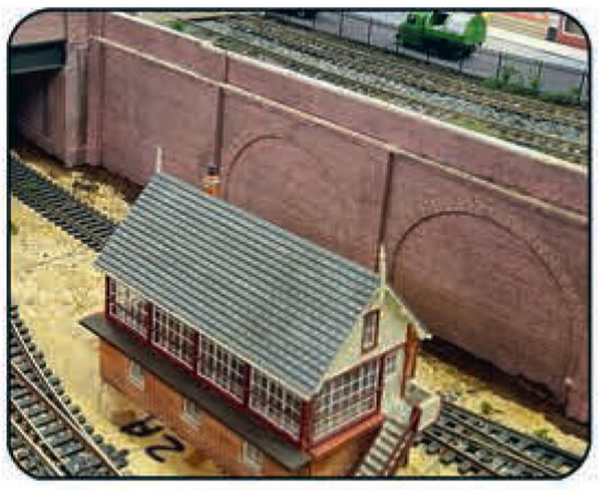

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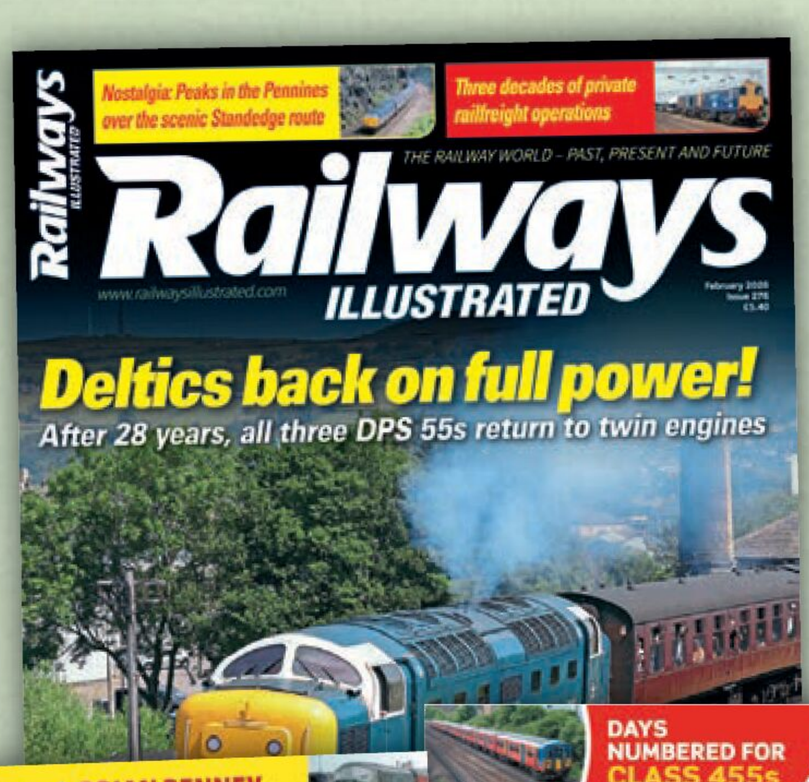

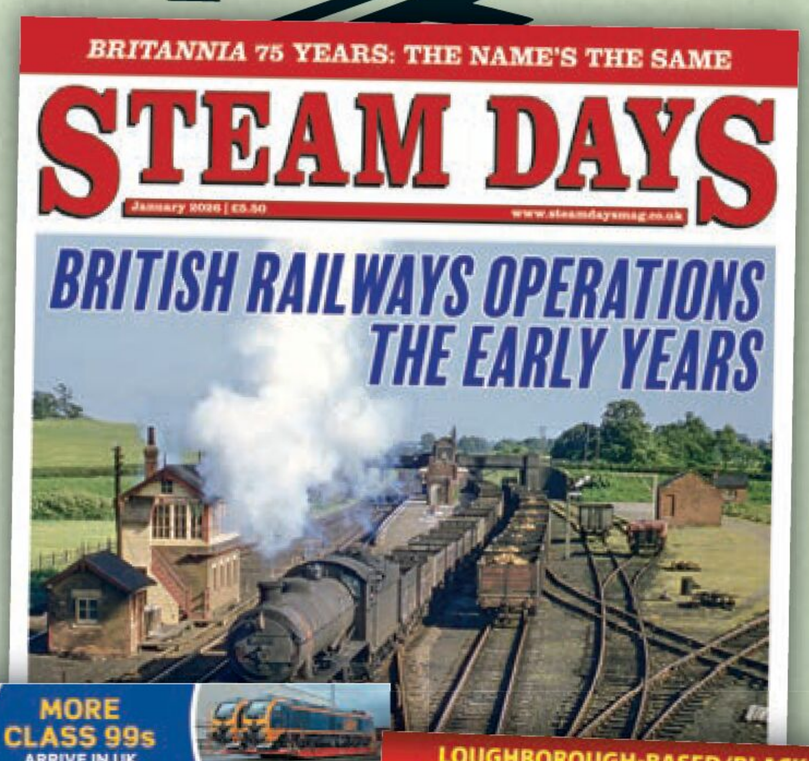

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PREFACE

My hobby has been model railways for many years, since I was given a Tri-ang Princess Elizabeth train set as a then eight-year-old schoolboy for Christmas. Over the years I have gained much modelling knowledge from practical experience and belonging to model railway clubs, not to mention the wealth of knowledge gained from working on the 'real thing' from a young post-school teenager through to my retirement.

My website – www.brian-lambert.co.uk – has helped many modellers with technical problems and given myself huge enjoyment in compiling it.

My first publication in this series, *The Guide to Model Railways*, has hopefully given many readers a great helping hand in the hobby. So, it was considered necessary that I should produce a second volume, which enhances the first, but tries not to cover the same ground too much, though some duplication cannot be avoided. While in these pages I write about generic items and often reference the real thing, there are many regional variations, and these cannot be taken into account within the confines of this publication. I would recommend that before starting any regional- or era-based project, undertake a good deal of research to gain the correct facts. Internet searches, books and perhaps visits to preserved railways or to the real places will usually reveal plenty of detail.

If you are starting out in the hobby or returning to it after several years of absence and have not obtained a copy of *The Guide to Model Railways*, I suggest it might be an advantage to obtain a copy and enjoy the contents.

A scene from the author's current OO layout – High Hopes.

I would like to take the opportunity to thank those who have given their permission to use items and images from private individuals, commercial sources and the retailers who have helped with some of the aspects of this second volume. Also, thanks must go to my wife Sue who has seen railways built in her conservatory and half of a double garage and never complains about the mess or part finished work that often lays scattered about when I'm making railway items. Bless you Sue, for your patience.

I hope you enjoy the items you are about to read and hopefully they will help and possibly nudge you into producing a great model railway layout.

All content is given in good faith. E&OE.

Contents

Preface	3
1 The Beginnings	4
2 Baseboards	10
3 Track	15
4 Wiring	22
5 Train control	25
6 Construction Kits	29
7 Point control	33
8 Digital Command Control (DCC)	36
9 Lineside detailing	45
10 Basic Electronics	53
11 Railway signalling	67
12 Electrification – Third rail and OLE	82
Bibliography	130
Acknowledgements	130

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Author: Brian Lambert

Production Director: Steve Wright

Retail Sales Director: Steve Brown

Design: Druck Media

Cover Design: Darren Hendley

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1
The beginnings

Beginning in model railway construction can be a daunting initial experience for the newcomer or returnee to the hobby looking in the hobby shop's window or when using the internet, and for those who have already obtained a train set and wish to progress further. Jargon is often used and some terminology has never been heard before! Electrical wiring petrifies many, while carrying out

Candid view of the author's layout.

scenic work appears more to belong to an artist or sculptor rather than a railway modeller! But fear not, by taking each issue in their basic sequential part of construction, this publication should lead the modeller from novice to experienced layout builder in a fairly brief time.

The aim of the chapters within this book is to guide and help the progression from the train set to a fully operational model railway.

I will cover track laying, scenery, electrical work and digital control, and much more. But before we progress further the modeller needs to understand some of the terminology and jargon used.

AC Alternating Current in the UK is at 50Hz, 60Hz in some other countries including North America. AC continually swaps polarity around the zero-voltage point as stated by the rate shown by the Hertz value. In the UK it changes 50 times per second = 50Hz.

Ballast The stones used to retain the track in place.

Cess The area between the outer ballast shoulder and the often unkempt ground or other railway boundary, such as a fence or wall.

Chair The metal plate fixed on top to the sleeper into which the rail sits. The rail being retained in place in the chair by keys (see below).

Check rail A secondary inner rail used to guide the wheel flange, preventing the wheel from riding up in the crossing area ensuring the wheels take the correct course or route.

Closure rails The fixed non-moving rails immediately after the switch rails and immediately before the points frog or crossing.

DC Direct Current. Output from all batteries and can also be from rectified AC. Using a single directional flow of current as it maintains the positive above the zero voltage

DCC Digital Command Control. A means of controlling and operating a model railway by digital data signals transmitted into the rails and then to the locomotive which has a decoder fitted.

Decoder A small electronic circuit board sometimes called a Chip which converts digital instructions into operation outputs for electric motor control, lighting, sounds or operating accessories.

Fishplate Also known as a Rail Joiner, this is the device used to connect two abutting rail ends securely together. It keeps the two rails in line both vertically and horizontally. Normally on the real railway two are used, one on each side of the rail, they are held onto the rail by bolts and nuts and depending on type they normally have four or six bolts per fishplate joint. Due to their construction, they allow a small amount of expansion and contraction to occur within the joint. In model railways they are normally a slide on fit. Their purpose on the model is normally to hold the two abutting rails in register with each other and to provide an electrical path rail to rail.

Four foot The real railways terminology for the space between the two running rails which is on Standard gauge railways actually 4ft 8½ inches (1435mm).

Frog This really isn't a true terminology and is not used on the real railway! It is actually a fixed crossing. But for some reason model railways have opted to use the term 'Frog'! This is the place where the two rails converge then separate again out to the route required.

Gauge This was covered in some detail in *The Guide to Model Railways Volume 1*, but basically… the distance between the two running rails inner faces. Often gauge is confused with scale (see below) but the two are different.

IRJ Insulated Rail Joiner This is similar to a fishplate

Another view of what can be achieved: a busy coal yard and carriage sidings with electric lights.

but this joiner is normally made from plastic or nylon and separates electrically the abutting rails.

Key The device that retains the rail in place in its chair. The key may be made of sprung steel or, on older track sections, a hardwood block. These are usually driven in place and are a tight fit onto the outside web section of the rail, but they still allow the rail to slide under expansion and contraction in the chair.

Point Motor A device that moves the points switch blades from one side to the other. Often electrically operated, but on the real railway can also be operated by air (pneumatic) or oil (hydraulic).

Point Sometimes called a turnout, this track arrangement changes the direction of a train. Points come in single turnouts to the left or right, Y (Wye), Three way, Single or Double slips. Points are made up of various components and terms and it is very handy to know the names of these and their place or use.
Points Normal, is the position of the points moving switch blades that allows the train to pass on the most used direction or route. Often, but not always, in the straight-ahead direction.
Points Reverse, is the opposite to Normal and where the point switch blade allows the train to pass in the lesser direction or route, often but not always this is in the turn out direction or route.

Rail This has three basic components: the head or top surface on which the train's wheels travel. Foot the bottom part of the rail and Web the thinner area that connects the head to the foot. In model form the size of the rail is referenced to as being a 'Code'. The word code is followed by a series of numbers which is the overall height of the rail in thousandths of an inch. i.e. Code 100 is 100 thousandth of an inch tall.

Rail Joiner See Fishplate.

Route The direction the train is to take along the track.

Scale The measurement between the model and the real life item.

Scales used, here may lie to the unwary an array of confusion. But again, the main scales found in the model shop are N, TT:120, HO, OO and O. Where N normally runs on a track gauge of 9mm between inner faces of the two rails. TT:120 runs on 12mm track gauge. HO and OO share the same track gauge and run on 16.5mm wide track, while O uses track with an inside edge rail to rail measurement of 32mm. Many are confused by HO and OO using the same track, but HO is really the nearer to correct scale and is used by all European and US modellers, while OO is a scale not normally available outside of the UK and technically the rolling stock is over sized for the track it runs on. Scale is the relevant size of the model to the real full-size item. Model railways tend to use many other scales. But the main ones found off the shelf in model shops are 4mm to the foot (UK this is OO) and 2mm to the foot (N) or given in their ratio i.e. 1:76.2 (OO) commonly referenced as 1:76, 1:86 (HO)

Industriously posed figures and carefully chosen scenery can help bring a layout to life.

and 1:148 (UK N) and TT120 which is 1:120. Note; 'TT' stands for 'Table Top'.

Signal 'off' Where the signal is displaying a proceed aspect. In the case of a semaphore signal the arm being raised or lowered to approximately 45 degrees from horizontal. Or where a colour light signal is used then Off is any aspect or aspects displayed that are a proceed.

Signal 'on' The signal is at danger or stop and for semaphore signals the arm is horizontal. In the case of a semaphore distant signals, when the arm is horizontal it means Caution the next signal is On (stop) when raised (or lowered) it means the whole of the section ahead has

all signals in their proceed positions, or for a two aspect colour light distant signal it is when it is at its lowest possible proceed aspect of one yellow, which may be passed at caution but the next signal is On (at red or stop).

Six foot The gap between two adjacent running lines on the real railway.

Sleeper The support that holds the two running rails apart. These on the real railway can be made of wood, concrete or steel and some have even been produced in plastic too!

Stock rails The two fixed outer rails of the point.

Stretcher bar or Tie bar, this in the model is the part of the point that connects the two moving switch rails together. Often it is also the place where a point motor or other point control method connects onto and moves the point switch rails over and back as required.

Switch rails The moving rail parts of the point that direct the wheels of the train to the correct direction or route.

Ten foot Another track spacing gap, but wider, between two adjacent tracks and is often used on the real railway where four or more lines are running parallel together and then the ten foot would be in the middle of the four lines, separating lines two and three.

Tip The single end of the point, more explicitly it is the moving switch rail ends.

Toe The single line or beginning of the point.

Track Fairly straightforward as it is what our trains run along. In model form it is mainly two rail but some three rail track is still sold but it is becoming rarer with the passing of each year.

Up and down This refers to the direction of travel. In the UK this is quite often referenced when travelling towards or away from London, but not always. So Up is towards London, Down is away from the city. But as I have stated there are many cases where this doesn't apply! Note: In the UK trains travel normally on the left-hand side – the same side as the UK drives cars on the road. Again, there are some exceptions to the rule, but this is the normal practice.

Wheel flange The raised inner lip on each wheel of all railway locomotives, carriages and wagons. It maintains the wheels tread on the top of the running rail and guides the wheel and train through points and crossings. (Locomotives don't have steering wheels!).

While the above is far from an exhaustive list, it should help the modeller to become more familiar with model and real railway terminology, although it applies to UK railway practice. Non-UK railways will use similar terms, but may have local terminology for specific items. e.g. Turnout for a Point. Ties for Sleepers etc.

2
BASEBOARDS

Firstly, there is a need to decide what the track is to be laid upon. This is the 'baseboard', and is not the dining room table or even worse the floor, where dust and carpet fluff will very quickly cause your new models to develop poor running or even fail stopped. It should be remembered that a baseboard is the foundation of the model railway. It is exactly like the foundations of your home. If it is poorly made, in the end it will lead to anything it supports becoming weakened and will cause poor running due to unlevel track, while any scenic work will crack or break away. So the best advice I can offer is to make the baseboard solid enough to support your own weight (Sumo wrestlers exempt!), without it flexing or buckling!

I have found plywood to be one of the best materials from which to construct a baseboard. If possible use Marine or Birch plywood, 9mm or 12mm thick, supported on a timber frame, as its relatively light in weight but equally quite rigid when well braced. 6mm plywood can be used, but needs additional underside bracing to prevent sagging. Medium Density Fibreboard (MDF) is also used, but has two main disadvantages in that it is very hard to drive track pins into and is prone to soaking up any moisture, so if used it needs all surfaces to be thoroughly sealed. It can be sealed with paint, gloss or matt, varnish or even PVA glue diluted with water, 50/50 or 60/40 water to glue. Ensure that all edges are treated, especially where the layout is in an environment where airborne moisture may be present – garages or sheds are two such examples.

OSB (Oriented Strand Board) has a flat surface, cuts, drills and accepts track pins easily. Available normally in 9mm and 11mm thickness it is a cheaper alternative to both Plywood and MDF. It should ideally be sealed to prevent ingress of moisture.

Hardboard (known as Masonite in the US) is not a suitable material as it is too thin and very hard. Chipboard has been used by many modellers, but weight is an important factor. It too needs good bracing underneath and the edges are prone to breaking away if knocked slightly. Plasterboard is totally unsuitable, as is soft board, sometimes known as insulation board. Some have use solid insulation foam sheets sold by the building trade for insulating wall cavities, etc; the 2-inch (50mm) variety is mainly used. It offers a very light weight and considerable thickness, but its main disadvantage is the thickness – installing point motors below the baseboard is virtually impossible. You will

Selecting and preparing the baseboard is a crucial first step for any layout. The edge of the author's sturdy Oriented Strand Board (OSB) baseboard can be seen here. OSB is an engineered wood, formed by adding adhesives and then compressing layers of wood strands or flakes, and makes a good alternative to plywood.

A typical trestle support. Note the chain used to hold the legs at the correct distance apart and to stop the legs doing the splits! It also has adjustable feet to overcome uneven floors.

need to mount the motors either to the points underside by creating a large hole in the foam to accommodate the motor, or use surface motors. It can also be seriously affected by contamination from some solvents.

The use of a soft sheet material known as Sundela is one that is often recommended by model shops. Sundela is technically a pin-board material made from recycled paper. It accepts track pins easily and retains

A hinged foldaway support leg with diagonal brace to lock the leg in its erected position.

them too, but is extremely prone to sagging between supporting timbers. I recommend that if Sundela is the chosen material it should be laid on top of a more stable and firmer sub-base, such as 6mm plywood or MDF, which will help to prevent any sagging. Sundela board needs to be conditioned for a few days prior to use and, if used anywhere that is slightly damp, needs to be well sealed on all edges plus top and bottom. Sundela doesn't cut too well either – a sharp large-sized craft knife or a fine-toothed saw are best. Flush doors have been used, but these tend mainly to be supplied as 6ft 6in (1,981mm) long by widths of between 24 inches (610mm) to 33 inches (838mm). While a modern internal flush hollow door may seem like an ideal baseboard, its physical size makes is not easily moved around indoors, and its thickness can be a problem too. Using internal doors might necessitate joining them together to make one reasonably sized baseboard, then there is the problem of not being able to reach the furthest places from the front or side edges – and these will always be the locations where track cleaning or derailments need to be resolved!

Having chosen the baseboard material, now comes the decision of how to support the boarding. For many years, and still used today, 2in x 1in (44mm x 21mm) Planed Square Edge (PSE) timber has been used. The timber bracing is installed with the narrow edge to the underside of the baseboard. Equally, thinner but deeper timber can be used, such as ¾in x 2¾in (18mm x 69mm) PSE. Two timbers are used, one each along the front and rear edges, and two at each end. Intermediate cross timbers are also fitted and spaced apart inside the edge framing. The distance between these internal framing timbers will depend on the number of bracing timbers used underneath. Typically the bracing is placed at 12-inch (305mm) to 16-inch (406mm) centres. Simple square-cut butt joints will suffice, though more advanced carpentry joints can be used. The simple butt joints can be PVA glued and screwed or nailed together. Screws are always better if possible; drill a pilot hole smaller than the screw's size to help stop the end of the timber splitting. Increase the timber thickness or its depth where longer timber spans are used.

Alternatives to PSE timber framing are plywood or MDF with a thickness of around ½in to ¾in (12mm to 18mm) and cut to between 3 inches and 4in (76mm to 101mm) deep. Plywood makes a very strong framing. Slotted metal angle can be used, as well as metal angle iron, but overall weight is then a problem, as also will be the cost of the material.

Now comes the decision as to how to support our baseboard. What height should the baseboard be is one question frequently asked. Unfortunately there is no hard and fast rule – it is really what suits you or the person who is to operate the layout. A low height might suit children, but can cause severe backache to taller operators, especially during the construction stages. I use a baseboard height of 39in (1,000mm) above the floor. Some layout builders prefer to have their baseboards near their eye level, and taller board heights are not uncommon – 4 or more feet is tall!

Straight fixed timber legs can be used, held to the layout with coach bolts, washers and wing nuts on semi-portable layouts, or glued and screwed to the framing on permanent layouts, screwing through the baseboard bracing into the legs. Trestles can be either

home-made or purchased as builders' trestles. Drop-down legs that are hinged to the baseboard framing are commonly used on portable layouts, but may also need additional bracing to stop any lateral movement and to hold the board level and rigid in the opened position. Whatever method is chosen, it is essential that the support is rigid and can easily take the full weight of the baseboard and possibly the operator leaning on the layout. When using timber, the very minimum for square section straight legs is 2in x 2in (50mm x 50mm) PSE, but thicker is better. I have successfully used stud walling timber called CLS (Canadian Lumber Standard) timber. I have found 1½in x 2½in (38mm x 63mm) CLS to be a good size, but using a larger size will never hurt. Any legs must be cross-braced to prevent them from moving and opening up, which would cause serious damage to the layout and possibly the user and the room too. Trestles need to have a cord, chain or other means of securing the legs at set distance apart, or they risk doing the splits!

Where a layout is fixed around the walls, the use of a lift-up flap or a removable section should be considered to allow the operator easy access to the middle area. A lift-up flap akin to a bar counter flap should have its hinges placed on blocks that raise the hinges above rail level; then the flap will open without the rails colliding along the hinged side! The hinge packing can be a suitable timber offcut or a piece of plywood – in fact, anything that raises the hinges above rail level. Small shoot bolts hold the flap in the down position. Wiring for track feeds to the flap section should use flexible stranded wire.

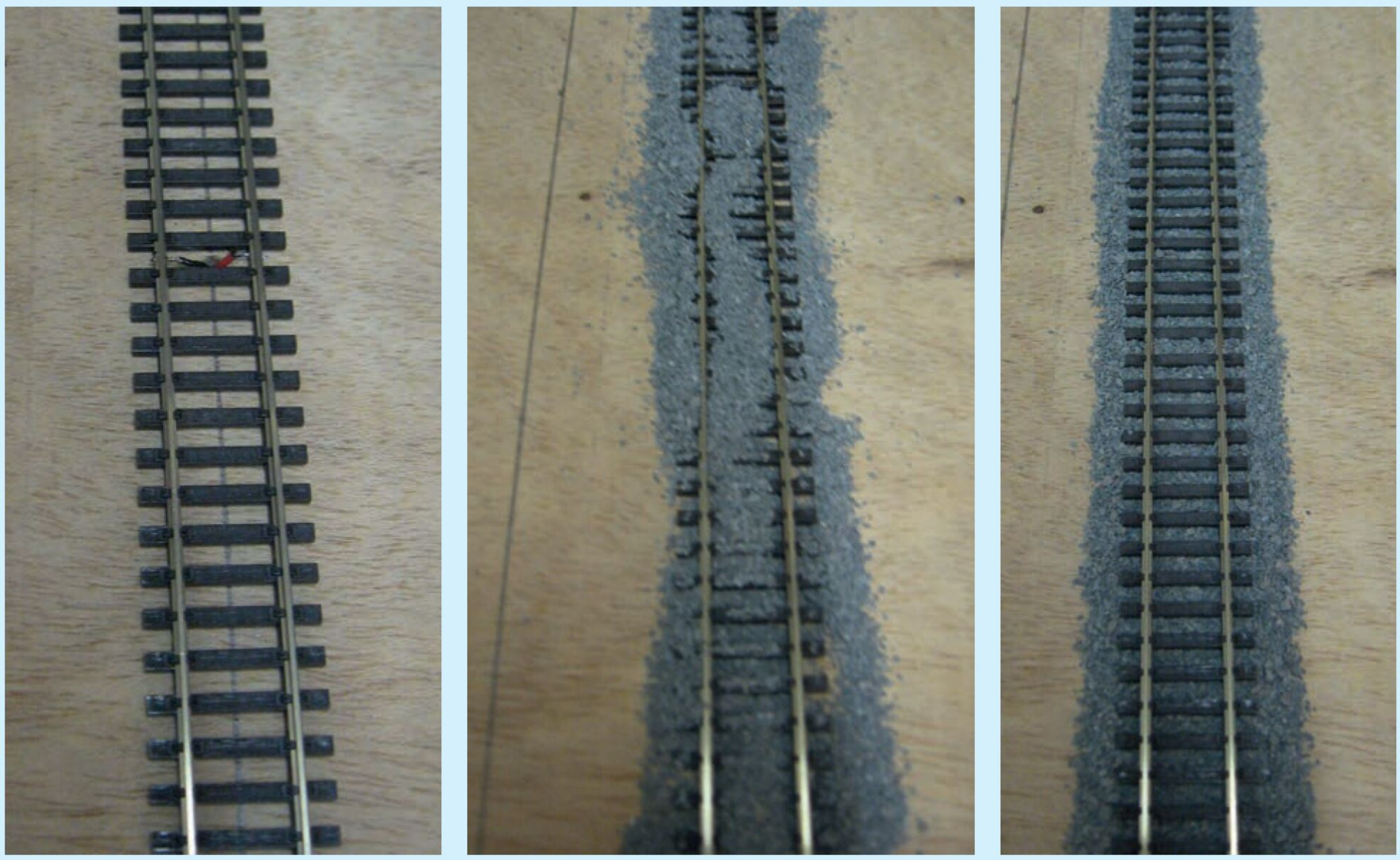
Slide-out sections need to be carefully made to obtain a reasonably tight fit but still able to be slid out. Again, a small shoot bolt or two locks will fix the removable section in place. Wiring to and from the slide-out section needs to be via a multi-pin plug and socket to allow the section to be removed. Castors fitted to the bottom of the legs will allow the sliding to happen smoothly and easily.

3
Track

Our model railway will use basically three types of track: fixed sectional track pieces; flexible track lengths with matching fixed-radius points; or hand-made track and points using pieces of ready-made rail and sleepers of plastic or a copper-clad material, or even wood!

The sectional track offers immediate track usage with nothing needed other than fixing it all together and adding the power feed. It is often supplied with train sets and pieces are available as extra individual items to allow the layout to be extended. Curves are normally available in three or four pre-set and fixed radii. Normally radius 1 is the smallest or tightest curve, with radius 4 being the largest outer curved sections. Points are usually of the insulated frog (dead frog) type, offering a simple self-isolating feature towards the unset route, i.e. the unset direction is normally electrically dead and only becomes live when the point is moved over to that direction. Typical UK sectional track is produced by Hornby, Peco in its Setrack range, and by Bachmann. Most sectional track is supplied with pre-drilled fixing holes in the sleepers. Larger-sized pins are often used and need to be either removed once ballasting is completed or their heads hidden with some suitably coloured paint to match the sleeper colouring. If removed, the holes in the sleepers can be filled with plastic modelling compound or modelling clay, or even a spot of plaster filler, then coloured with tints of paint that match the sleepers once dried. Sectional track is normally supplied with factory-fitted metal rail joiners (fishplates), two joiners per section.

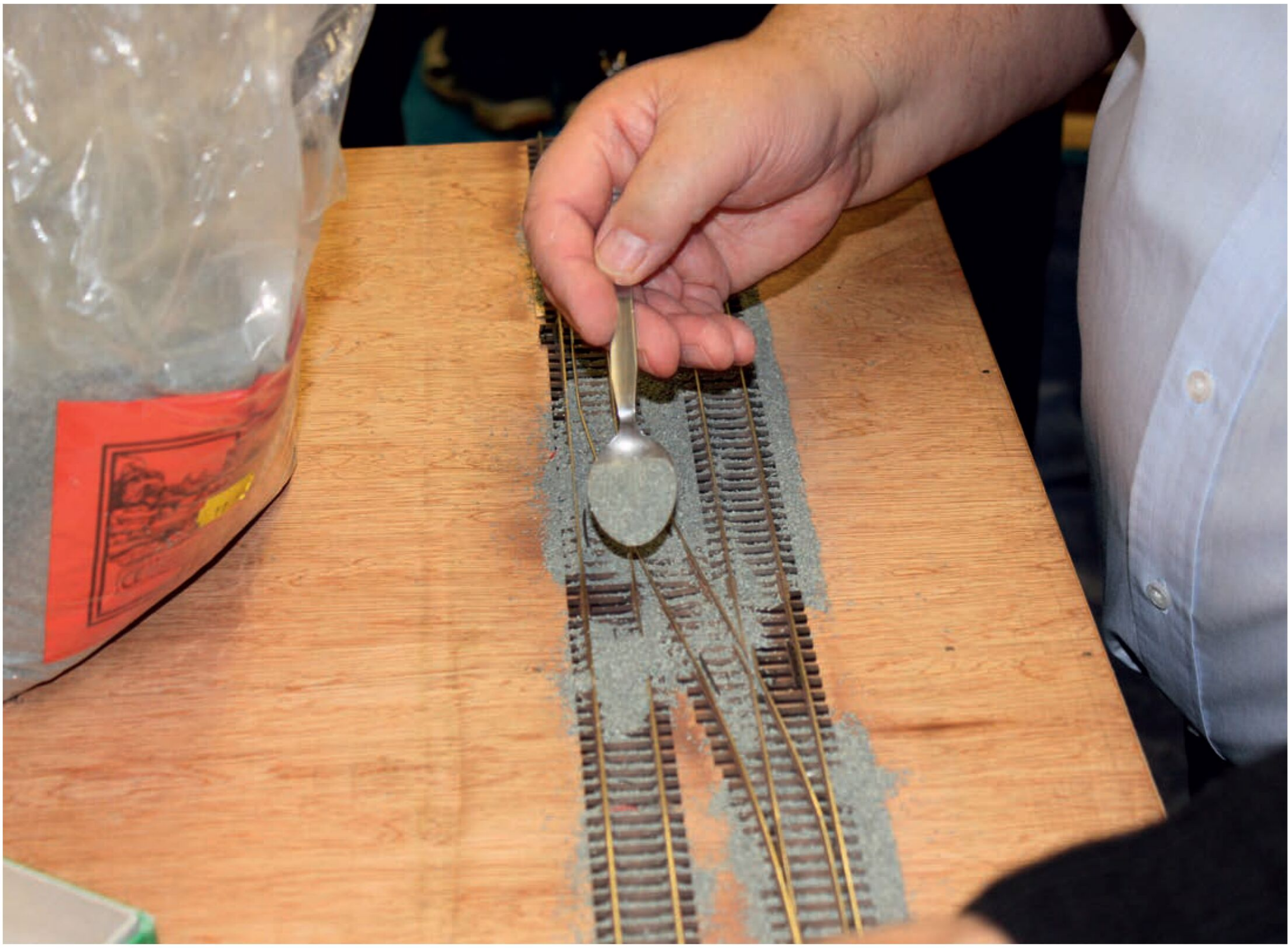
Flexible track offers the advantage of forming much larger-radius curves, and normally has its parallel track centres closer together than with sectional track, e.g., in OO the sectional track centre is at 67mm, while flexible track used with the same own-brand point



In these three pictures, a section of straight track has been laid and is to be ballasted. The first image shows the basic track section pre wired and lightly pinned into place. The second shows the same section with ballast applied and waiting to be brushed into place and any surplus removed. Finally, the ballast has been brushed into place and solution of dilute PVA/Water/IPA has been applied and allowed to dry overnight. The wiring has all but disappeared and the sleepers are no longer covered with ballast.

system provides 50mm track centres. Flexible track takes a little more skill in track-laying, as there is the need to keep the straight tracks straight and the curves to the correct chosen radius, which is often to a minimum of 24 inches, but can be tighter if wished. A steel rule placed temporarily alongside straight sections of track while pinning it in place will provide a good straight track, and the use of Tracksetta gauges can help produce an even curve. It must be noted that flexible track will require some rail cutting and probably sleeper removal and trimming of the fixing chairs at the ends of a length where the fishplates are to be fitted. Initially, during track-laying I use very fine Peco track pins pushed into the sleepers and baseboard at intervals of 4 to 6 inches; these will aid track-laying and help keep the track in its final position until it is ballasted. I never push the fixing pins in fully, only to around half their length, then bend over their top portion onto the top of the sleeper. This makes it very easy to remove them once the track has been ballasted and all securely glued in place. I don't like seeing pin heads on my finished track! Flexible track and matching points are not usually supplied with rail joiners; these have to be purchased separately.

When curving flexible track the inner rail will become longer and should be cut to match the now shorter outer rail. How you cut the rail is a personal matter, and several methods can be used: an electric mini-drill with a metal cutting disc fitted; a razor saw and a suitable block to maintain the saw upright against the block; and my personal favourite, the Xuron rail cutter, which is like a pair of wire side cutters but purely designed to cut rail cleanly on the one side. Once cut, the rails will need a light file with a flat needle file to remove any small burrs, which will aid the fitting of the rail joiner (fishplate). In addition, the rail fixing chairs on at least the first sleeper on either side of the joint will need to be removed so that the rail joiner can slide onto the rail to half its length. Note: rail joiners are a separately purchased item for flexible track, so make sure you obtain sufficient packs of joiners at the time of purchasing the track.



A teaspoon is used to initially place the ballast.

Ballast is moved around into its final position with the aid of an artist's paint brush. Extra ballast can be brushed forward to fill the track further along the layout. Ensure all ballast is removed from around the points moving stretcher (tie) bar and away from the frog and the insides of check rails.

A bottle filled with PVA, water and IPA mix is used to bond the ballast into place.

Pre-curving the rails before laying can really help on curved sections of track. Slide out the rail from the chairs and carefully between thumb and first finger stroke the side of the rail, forming a gentle and even curve along the rail's length. The rail will be slightly over curved and is then carefully rethreaded back into all the sleeper chairs. Do the same with the opposite rail. By pre-curving the track it will help hold the curve. Rail joints on curves are somewhat of a pain, but by pre-curving the rails the joiner tends to maintain the curve better. If necessary, once the joiner is in place, apply a slight twisting motion along its length with the aid of a pair of fine-nosed pliers. Some modellers solder their joiners to the rails on curves, but I have not found this necessary. Never solder all the rails to their joiners as some tiny movement is need inside the joiner to allow for rail expansion and contraction.

Adding ballast will enhance the layout. Ballast is

available in several forms for the modeller to use; very fine real granite types, while home-made ballast from canary grit or aquarium gravel is just two of the alternative options. Whichever is the chosen medium, it must be sieved or produced to represent the size of typical real railway ballast stones, which are approximately 2 inches (50mm) in size. Some ballast stones are of course smaller in size and some will be a little larger, up to a maximum of around 3 inches (60mm). So, in OO scale the largest stones would be less than 1mm, and in N around 0.5mm.

Some modellers like to add a ballast shoulder, and this is often produced by laying strips of cork under the track to act as a trackbed. The thickness of the cork is dependent on the scale being worked in, but is generally between 2mm and 3mm thick. It is cut a little wider than the sleeper ends, then the edges are trimmed to a slope to represent the shoulder. Once it is bonded to the baseboard with PVA or impact adhesive, weights are applied to keep the cork flat during the glue drying period (books, paint tins or similar heavy objects can be used as weights). Once the glue has been allowed to cure, the track can be lightly pinned onto the cork. The alternative (and my preferred method!) is to lay the track directly onto the baseboard's flat surface. When using any ballast shoulder material, the modeller needs to remember that anything adjacent to the raised track needs to be raised up by the same amount, e.g. platform surfaces, goods sheds or engine sheds that locos or wagons, etc, pass through or past. All need to be raised to allow for the added rail top height caused by the cork or other material used in raising the final rail top height.

The other method of combined trackbed and ballasting is to use a proprietary foam-style trackbed, upon which the track is laid in often pre-cut sleeper indents. Most track manufacturers produce a foam-type trackbed, and some are better than others. If used, the track that is laid into the foam must only be lightly pinned to stop it moving, but the pins are not to be pressed in so hard that they press the foam down or compress and distort the track. Poor running will result if this is allowed to occur!

Once the track is laid but before ballasting, now is the time, if desired, to paint the rail sides a rusty colour. Use blended shades of rust, brown (Burnt Umber is great!) and black to vary the shading along the rails. Use a fine artist's paintbrush to apply the rusty paint colour and do not be too bothered if the paint gets onto the rail chairs as these would often be rusty too! They can always be touched in with a darker paint colour.

The actual sleepers can be painted too if wished to highlight their woodenness; on the real railway they were soaked in creosote or pitch to a dark colour before being used in the track.

If wished, apply masking tape along the outer edges of the trackbed – the cess area – to prevent overspray where a spray paint is used if painting sleepers or rails; and it can be used during ballasting to give a neat edge to the ballast.

Having made the choice of ballast material, the modeller needs to ensure that it cannot be sucked up into any passing locomotive's gearing, which if allowed would cause serious mechanical failure. The ballast therefore should be glued in position. There are

A section of track ballasted and scenically completed.

two methods of doing this. The first and possibly the most basic is to apply a band of neat PVA glue to the trackbed or baseboard before laying the track, then, as soon as the track is lightly pinned down, sprinkle the ballast between the sleepers and along the two outside shoulders, brushing away surplus ballast as you work along the pre-glued area. The second method, and favoured by myself, as I feel it gives a far better result, is to lay the track, wire it, test-run several locos and trains, then make good any problems noted by using pieces of thin card shims placed under the track to lift up any low areas. Once all is proved to be satisfactory, sprinkle the dry ballast along the track centre and outside edges – use a teaspoon if wished as a mini 'shovel' to initially place the ballast. Then, with the aid of a 1-inch (20-25mm) paintbrush and a smaller artist's brush, move the dry ballast around until the correct profile is obtained on the outer edges and the middle of the track is correctly ballasted.

Once you are happy with the look of the ballast, take a plant mister bottle or other suitable clean spray mister-type bottle – a well-washed-out former kitchen surface spray is ideal – fill with tap water and add some Isopropanol (Isopropyl) Alcohol – known as IPA – at a strength of 99.9%, or use methylated spirit (meths) if IPA isn't readily available, mixing it to about 90% water/10% IPA or meths. Gently spray all the dry ballast to make it wet; the IPA or meths will act as a wetting agent, reducing the surface tension and allowing the next stage of water/PVA glue to seep into the ballast better. Now mix PVA glue with tap water and a few drops of the IPA or meths in a container. The strongest mix is 50/50 glue to water, but the glue can be diluted much more with water if desired, to around 75/25 water to glue, then add the IPA or meths to the mix – you only need to add a little, around four or five drops. With the aid of an eye-dropper, pipette or small bottle with a nozzle, apply the glue mix to the ballast, allowing it to soak into every part. Ensure that no glue is allowed into the tie bar or any other moving part of a set of points. Also watch out for the thinned glue mix running out through baseboard wiring holes and joints and dropping onto the best Axminster carpet! Best practice prior to starting is to lay down some temporary sheets of plastic under the layout where there is a risk of a carpet or flooring being damaged!

Once the glue mix has been applied, leave the baseboard and glued ballast alone. Don't poke at it or try to move anything once it has been glued. With a clean lint-free cloth dampened with a little of the IPA or meths, gently wipe over the rail tops to remove any glue deposits. Allow at least a full 24 hours, then carefully vacuum off any unstuck ballast – there will always be a few little spots that didn't fully glue and will come up under the vacuum's suction! Once vacuumed, go back over the area and touch in any bald areas with more ballast, then reapply the process of the PVA/glue/IPA mix. Always allow the ballast to remain untouched for a full 24 hours and then vacuum again to remove any remaining loose particles.

Safety: When using IPA or methylated spirit, always ensure that you have adequate ventilation in the room and observe all safety issues – no naked flame or smoking, etc!

Some modellers prefer to use a latex adhesive, as used in the fitting of carpets and vinyl flooring. This is diluted with water as per the PVA glue to the required consistency, and a few drops of IPA or meths can be added. Latex allows easier removal of the glued ballast and track should the track plan be changed later on.

After 24 hours or more your track should be bonded securely in place. The extra-fine track pins previously inserted through the sleepers can now be pulled out and discarded. Clean the rail tops to remove all traces of the glue mix. Use a track rubber, an ultra-fine-grit emery cloth or a fibre pencil if you have one of sufficient width to clean the rail tops. Follow up with a final clean using a lint-free cloth dampened with a little neat 99.9% IPA or meths to remove any final residue and ensure the rails are spotlessly clean.

4
Wiring

Wiring is perhaps most disliked by many modellers for fear of the unknown! However, when taken piece by piece, wire by wire, it can become much easier to understand and work with.

Firstly, let's look at the type of wire used. Conventionally it is made from a copper conductor, as copper is an excellent conductor of electricity. The copper wire needs to be isolated from coming into contact with other copper wires, so today most wire is wrapped in a PVC jacket or sleeve, as PVC is a great insulator. Other insulating mediums are used, but PVC is one of the most commonly found types.

Wire comes in two types: solid conductor, or flexible strands making up the overall conductor. Which is best? Answer – both! It really depends on what the wire is being used for. For example, if the model railway is a portable layout that is moved from room to room or even taken to exhibitions, etc., then using solid wires may well lead to the wires eventually fracturing due to continual movement; flexible wires should be able to cope far better in this situation. Layouts may use a mix of both solid and flexible wires. An example is a fixed home layout that is using Digital Command Control (DCC); ideally a DCC track feed bus pair of wires is installed and smaller dropper wires connect the bus wire to the rail above. The bus pair can be of solid wire while the droppers can be flexible wire. There are no hard and fast rules, and the bus may just as easily be made from flexible wire! Just use the wire that is most suitable for the job for which it is needed. If the wire is going to move and flex frequently or needs to bend sharply around an obstacle, consider a flexible wire as the most suitable.

By now I can already hear the groans about 'bus' and 'dropper' wires being mentioned! Well, let us talk briefly about them to ease the mind! A 'bus' is nothing more than a means of connecting power to a main feed wire – the bus wire. Generally two separate wires make up a bus pair, and these are often referred to simply as the bus. The main feed distribution device is the bus wire, which runs around the layout or wherever it is needed, providing a good low-resistance path for power to where it is required. A simple bus can be nothing more than a pair of wires used to provide layout lighting, and all road, building and platform lights are connected to this bus pair of wires. The bus is fed at one end by a suitable power source and at the far end it is terminated somehow to stop the two wire ends touching each other. Along the length of the bus smaller 'dropper' wires drop down off all the lights, etc., that need to be connected to the bus pair.

'Droppers' are normally of a smaller wire size than the bus wires. This is because the dropper wire only carries a small amount of power in amperes to whatever it feeds – e.g. a street light. Each street light is rated at, say, 70 milliamps (0.07A) for a filament lamp light. Several lights may be connected to the lighting bus pair and when power is applied the total consumption of this power in amperes is what is flowing in the bus pair. Assume there are 20 lights, so 20 times 0.07 is 1.4 amps. This power is all carried in the bus pair of wires, hence the need for them to be larger in size than the dropper wires leading to each of the lights – we don't want the bus glowing in the darkness under the baseboard due to it being too small a wire size! A very serious enemy of the bus pair is a voltage drop; this occurs due to the resistance the wire used. The larger the wire size, the lower its resistance and the less the voltage drop will be for a set distance. After all, we don't want to feed 12 volts in at the source only to have 9 or fewer volts under load at the far end! However, volt drop really only becomes a serious problem on longer wire runs.

What type of wire for what circuit? This question is asked many times and the answer is 'use what is suitable'! Modellers are often very good at saving the pennies! But at times scrimping at the wiring installation stage doesn't result in a saving later on when problems start to occur and the wiring has to be replaced! Telephone wire, bell wire and small fine speaker wire are often used. However, in the main these really are not that suitable for use over any reasonable distance due to volt drop or limited volt drop! They all have very fine strands designed for low current applications.

Below are some tried and tested examples of minimum wire sizing and their use in model railways. They are listed for DCC and DC wiring method and I have attempted to give the approximate AWG (American Wire Gauge) sizes as well, although direct conversion isn't always that accurate.

Bus wires for DCC layouts: minimum 32/0.2mm or 1.0mm² (17AWG)
Bus wires for layout lighting up to 3.0A: 16/0.2mm or 0.5mm² (20AWG)
Droppers for rail feeding DCC over 400mm in total length rail to bus: 16/0.2mm, 0.5mm² (20AWG)

Droppers for rail feeding DCC not exceeding 300mm in total length rail to bus: 7/0.2mm, 0.2mm² (24AWG)
DC rail feeding not exceeding 4 metres: 7/0.2mm, 0.20mm² (24AWG)
DC rail feeding exceeding 4 metres: 16/0.2mm, 0.5mm² (20AWG)
Solenoid point motor wiring not exceeding 4 metres: 16/0.2mm, 0.5mm² (20AWG)
Common return point wiring: 32/0.2mm, 1.0mm² (17AWG)
Stall-style point motor wiring: 7/0.2mm, 0.20mm² (24AWG)
Colour light signal wiring using LEDs: 7/0.2mm, 0.20mm² (24AWG)
Layout building and street lighting, etc: 16/0.2mm, 0.5mm² (20AWG) for the main feeds, and finer wires to the lights.

These examples are the minimum I recommend for each application to give trouble-free results. You can always install larger-sized wire without ever causing issues.

What is meant by '32/0.2mm'? This is the number of individual wires that make up the conductor and their actual wire size. Thus 32/0.2 has 32 individual wires each of 0.2mm in size, while 7/0.2 has just seven wires each of 0.2mm. These types of wire are normally referred to as their size (7/0.2, etc), and often the words 'Equipment' or 'Hook-up' wire are used.

Be a little cautious of some hobby/model shops or retailers selling so-called 'Layout wire'; this type is often the smaller 7/0.2mm equipment wire and may not be suitable for some wiring jobs! So always ask what the actual wire size is.

What is the best way to make wire connections? Without doubt the very best connection is one that has been correctly soldered. A soldered joint that has been correctly made will virtually never fail, although the emphasis has to be on 'correctly made' – see the paragraphs further on regarding soldering. Another type of connection is one that is twisted and insulated, and while this works it is not the best option as eventually the joint can become loose and a high-resistance joint then occurs, resulting in much head-scratching trying to find the problem. My advice therefore is not to use this method. Screw-down terminal blocks, sometimes called 'choc blocks', make secure and quick connections and allow differing sizes of wires to be joined together. Make sure the terminal connector used is not too large for the wires being connected into it. If at all possible choose terminal block connectors that use a small thin metal finger inside the connector and the grub screw pushes the finger down onto the wire, rather than the more conventional type where the grub screw itself tightens and twists down onto the wire, which can lead to wire distortion and even wire fracture!

Another method is to use 'suitcase' connectors sometimes called Scotchlok (the maker's name). These work by displacing and severing the wire insulation as an internal notched V blade is pushed down, making contact onto the copper wire. The downside is that most need the two wires being joined to be roughly of the same size, though there are connectors that do allow for differing wire sizes to be joined. Some of these connectors have a tap-off connection onto which a 'push-on' spade-style connector fits, thereby allowing differing wire sizes to be connected together. Suitcase connectors tend to come in three main sizes, denoted by their body colour: yellow (the largest connector) has wire size connections of around 2.5mm² to 6.0mm²; blue has 1.0mm² to 2.5mm²; and red is 0.4mm² to 1.0mm². Note that the wire sizes stated may differ between manufacturers. It is important to obtain the correct colour-coded suitcase connection to fit the wires that need to be joined. Using the wrong size can lead to the wires being cut through or the connector being too loose.

Recently, sprung-grip push-in-style terminal blocks are gaining popularity and these often come in two-, three- and five-way groups, with all terminals in that group interconnected. One such make is Wago, but there are others.

To make a soldered joint in wiring I recommend the use of 60/40 Rosen cored solder, which has a special flux suitable for electrical connection built in. Lead-free solder is now taking over from lead content 60/40 solder, but this does need a higher temperature at which to solder, and some older soldering irons are not quite able to fully reach the necessary temperature. I do not recommend adding any additional flux to electrical solder – it is not really necessary. Whatever you do, avoid fluxes sold for general-purpose soldering work, as these will contain acid and they need to be washed off after the soldering is completed. Of course this is not possible with an electrical joint. There are some fluxes sold specifically for electrical work and these can be used.

The choice of soldering iron is fairly important. If you have an old iron with a battered bit, it is probably time to replace it with a modern iron! Modern soldering iron tips are coated with a special surface finish and should never be filed. Only use a damp sponge to wipe the iron's tip. If the tip is seen to become coated in what can only be called 'surface crud', then consider using a special soldering iron tip reviver/cleaner, often made with brass particles or a paste to clean the tip. Never file it! The choice of iron will depend on what you are going to solder. For most general electrical soldering work on a model railway a 25 watt iron will suffice.

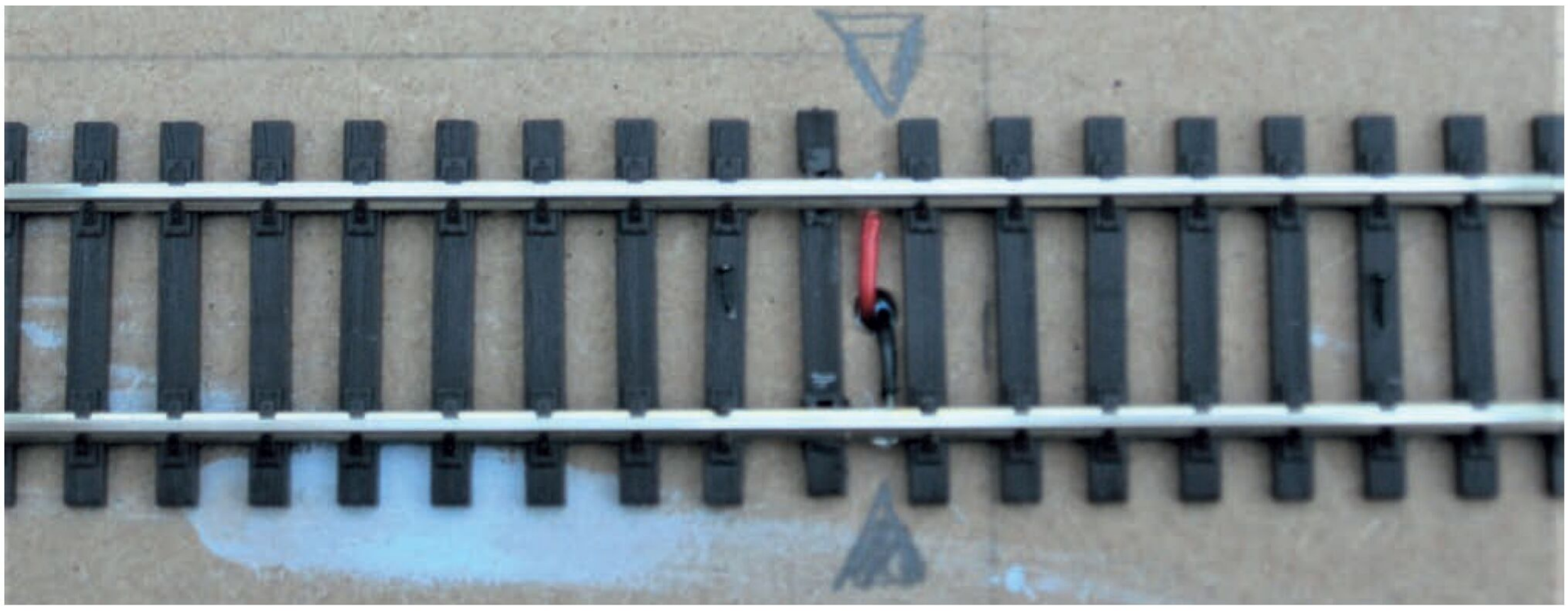
However, a higher-wattage iron will never hurt – in fact, it can be an advantage at times as the tip's temperature will be maintained or replaced faster as the heat is sucked out by whatever the iron is in direct contact with.

Tip shape is a personal choice, but I like a fine-angled chisel tip, with a tapered pointed tip coming a close second. Tip size is also a fairly important factor – too large and you will not be able to use it easily in small confined places, while too small and you do not get the transfer of heat rapidly, making soldering virtually impossible. Some irons allow their tips to be interchanged; Antex is one soldering manufacturer, but there are others. A soldering iron safety stand is really an essential item, as it keeps the hot iron's tip secure and normally comes with a built-in sponge tip-cleaning pad.

To make the joint you need to ensure that the two items to be soldered are spotlessly clean. Freshly stripped wire will be clean, but if left exposed to the air for several hours or longer it will start to tarnish and will benefit from cleaning. Rail to be soldered or to have wires attached to it should always be cleaned in the area of soldering, even if it is new track from the box. I like to use a fibre pencil for this cleaning process, but a piece of emery cloth or a craft knife blade could also be used, but do be careful if using a knife blade as a scraper as it is all too easy to damage the wire!

To join two wires together after they have been cleaned or are freshly stripped, twist the two together to form a tight but dry joint. Let the soldering iron reach full temperature, allow five minutes from switching it on. Wipe the tip on the damp sponge and then apply the Rosen cored solder to the tip, coating the tip in molten solder. Place the coated iron's tip onto the joint and allow a few seconds for the heat to transfer into the wires. Then feed the end of the cored solder onto the heated wire joint and allow the solder to melt and flow into and around the joint. Remove the iron and don't move the joint for at least five to seven seconds or until the solder is seen to take on a dull sheen as it sets. Wipe soldering iron tip on the damp sponge and place the iron back in the safety stand.

To solder a dropper wire to a rail I recommend pre coating the wire with solder – called tinning. As before, heat the iron and once it is at full temperature and the wire has been freshly stripped to remove approx. 4 to 5mm of insulation and if required it is bent to an 'L' shape, wipe the irons tip onto the damp sponge and apply a coating of solder to the tip. Hold the tip onto the bare wire and feed the end of the solder onto the heated wire, coating the whole bare wire in solder. Wipe tip on sponge and place iron in its holder. Clean the rail surface where the soldering is to occur, then place the iron with a fresh coating of solder on its tip onto the rail, once heat from the hot tip has heated the rail (a couple of seconds usually) feed the cored solder onto the rail and irons tip where it is held against the rail, when solder is seen to flow onto the rail then remove iron. Place the previously tinned wire into its final position against the tinned rail. Apply a fresh coating of solder to the iron's tip and hold the iron against the wire, pressing the wire against the rail. Allow a couple of seconds for heat to transfer from the iron into the wire and then into the rail. If necessary, angle the irons tip so as it is touching both the rail and the wire. Feed the end of the cored solder onto the wire and allow it to flow onto the rail. Once the rail and wire solders are seen to melt into one, remove the iron and maintain the joint in place. Wipe the tip on the sponge and place it in the safety stand. Allow the joint to cool before moving the wire. The wire can be held in place as soon as the iron's tip is removed by a flat blade screwdriver or tweezers etc.



Above shows 7/0.2mm dropper wires soldered to the rails undersides before laying the track. The two dropper wires pass to the underside of the baseboard via a hole drilled centrally between the rails and two sleepers. Soldering dropper wires to the rails underside prior to track laying ensures the wires are almost inviable when the track is ballasted.

5
Train control

The two main methods used currently are DC (Analogue) and DCC (Digital). AC control also exists but is now very much being replaced by these two methods.

For many years our model railways were operated by analogue control – DC (Direct Current). This works by applying a variable DC voltage to the rails; typically the voltage varies between 0 (zero) volts and the maximum, which is a nominal 12 volts. The more volts applied to the rails the faster the locomotive moves, as the electric motor inside the loco increases its revolutions in line with the volts being fed to it.

In the early days of ready-made off-the-shelf train sets, the speed control was from dry cells – batteries – with a simple set of resistances connected in series with the output to provide slow and medium speed settings and the full battery volts fed to the rails when the controller was in the third maximum speed setting. To reverse the direction of travel the output polarity was swapped around, that is positive on one rail being replaced by negative and the opposite on the other rail, causing the electric motor to turn the other way.

In the 1930s to 1950s more UK homes changed their mains power from DC to AC (Alternating Current) and mains-powered controllers became more common. Inside their casing is an isolating transformer that reduces the mains 240 volts to around 16 volts AC, and electrically isolates the lethal 240-volt mains power from the low-voltage outputs. For train control the 16-volt AC is fed into a device called a bridge rectifier, and this converts the AC into DC, a small amount of voltage being lost in the process. The DC is then fed onto one end of a large resistance mat, and a wiper arm moves in an arc or up and down over the mat. The arm's movement is controlled by turning the speed control knob on the front or top of the controller. As the speed knob is moved from the off position towards the full-speed position, less and less resistance is inserted into the output by the wiper arm moving over the resistance mat, until eventually at full speed no resistance is left in circuit and the full 12 volts flow out to the rails and the loco's motor. Note that 12 volts is nominal and may be higher if read on a multimeter. Being a variable resistance, much finer speed control can be obtained compared with the earlier three-speed step controller. It should be noted that the three-step controller continued in production alongside the variable controller, and three-step mains-powered controllers were supplied in train sets for many years.

With the advent of the transistor the variable resistance mat controller became virtually redundant, as now there was no need for it or the wiper arm. Speed control is now arranged from a small low-power 'volume'-type potentiometer, which allows the transistors to be turned on by varying their control volts, which in turn allows larger voltages and current to be passed by the output transistors. Controllers of this style will use a power transistor in the main output, while smaller lower-powered transistors feed the larger power transistor, varying the output set by the position of the speed knob. Today many DC controllers have moved away from direct power feeding to what is called Pulse Width Modulation (PWM) control. Here full voltage is available all the time that the speed setting is on, but it is only fed to the output and rails in microsecond bursts, with 'off' gaps in between the 'on' periods. The time length of the 'on' to 'off' gaps, or spaces in the output, determines how fast the motor will turn for a given pulse/space ratio. For example, for full power the full 12 volts is allowed to pass out to the rails, even though in reality there are likely to be some very small 'off' periods in the output, but they are so small that they can be discounted. To allow our loco to move at half speed, the full power to the rails is turned 'on' and 'off' in equal spacings. For quarter-speed running the power is turned 'off' for longer than the 'on' period. All this is occurring at a very high speed or frequency, so the motor, while receiving full voltage with every 'on' pulse, only ever rotates at the setting provided, due to the 'off' periods interrupting the supply. This works very well with most locomotive motors, but some do not like PWM and can overheat; this particularly applies to coreless motors. Therefore the modeller will have to revert to the transistor-controlled type of train speed controller. But in the main most locomotive motors produced today are happy to work with PWM, as this is how DCC loco decoders feed their motors!

DCC (Digital Command Control)

This is the second most commonly used system. As the name suggests, digital information is sent to our locomotives and line side accessories. But nothing will work if it is directly connected to the DCC rails! 'Decoders' are needed to interface between the rails or DCC bus pair and the device to be operated, be this the locomotives motor or an accessory like a point motor or signal. There are two basic types of decoder:

mobile, as used in locomotives and carriages etc., and static. Static decoders are normally fitted to the layouts baseboard and operate accessories like the point motors. The decoder is basically an interface device that receives digital commands sent from the DCC base unit and converts the commands into analogue outputs to power electric motors or light lamps etc.

An example of how DCC works is that each item connected to the DCC system is given a unique address number which is user set and is usually between 1 and 9999. Only when that unique number is sent as part of a coded sequence or broadcast from the DCC base or command unit will that decoder act upon the next stream of information to be sent in that broadcast. All other decoders, while connected and 'listening' to what is being sent, will ignore it, as their unique address number hasn't been sent in the broadcast – so they remain doing whatever they were told to do last time their broadcast was sent; for example, it might be stopped, running or powering some other device. It should be noted that some basic or budget ranges of DCC systems only allow a small amount of address numbers to be used.

Put very simply, think of DCC addressing as like a postman on his round delivering a letter with instructions in it. There are up to 9999 houses in the street. The postman only puts the letter through No 38's letterbox (the unique address in this case) and the occupant of No 38 reads the instruction and acts upon it. All the other house numbers, 1 to 37 and 39 to 9999, have seen the postman on his rounds but haven't got the letter, so they carry on doing what they were last doing! But No 38 now does something different.

The introduction of wi-fi train and accessory control via a smart phone or tablet is becoming increasingly popular with some DCC users. With free-to-use downloaded applications for most mobile phones or tablets being readily available. Wi-fi connections to the DCC command system are either via the home internet router or a dedicated router that connects directly to the DCC system.

A third system and relatively new to the model railway scene is full Bluetooth control. Each locomotive has an onboard Bluetooth decoder fitted, much like DCC. An 'app' (application) is downloaded from the internet to a smartphone, tablet or other smart device with Bluetooth capability. The smart device communicates directly to the loco's decoder via Bluetooth radio signals and control of the loco is via a throttle control on the smart device. There is virtually no limit to the number of Bluetooth locos or other devices that can be controlled, so long as each has a unique address number or other reference detail. Bluetooth control is still very much in its infancy at the time of writing, but it is looking to become a serious contender to model railway train control over wi-fi. Bluetooth uses a constant voltage applied to the rails, and the Bluetooth decoder uses this voltage to control whatever it is connected to, as it receives commands that are sent wirelessly by the controlling device. There is no need for a router, computer or any other peripheral items to allow the Bluetooth device to connect to the Bluetooth decoder fitted in the loco or somewhere on the baseboard.

As previously mentioned, the DC or analogue controller varies the volts on the rails (between nominally 0 and 12 volts) while DCC has full voltage on the rails continually (nominally 12 to 16 volts AC). With DCC you drive all the individual locos on the same track, while with DC you normally only drive one loco per controller per track.

Which is best DC or DCC? Both are! There is no one system better than the other! DC has a well-established following and a proven record. DCC is making serious inroads into the hobby and now has a good following with currently a significant percentage of all new train set sales being DCC sets.

Basically, a DC system needs one controller per track loop or running line. So, a twin tracked layout would use two DC controllers. This gives better control of each line and allows two or more locos to run, each under the control of their own dedicated DC controller. To hold locos in platforms or sidings, isolating sections of track are installed and their rails connected to on/off switches.

Many consider changing from DC to DCC but are put off by the high cost of having to install DCC decoders in all of their DC locos. It isn't always necessary to convert all of them all at once – convert three or four at a time or as your budget allows, keeping the non-converted locos in isolated sidings or completely off the DCC-powered rails until they are converted. Only convert those that run faultlessly on DC power, as converting a poor DC running loco will result in it becoming far worse on DCC! Either service a poor running DC loco and retry it on DC to see if it is now a faultless runner, or sell it and put the money gained towards the cost of a new DCC-ready or DCC-fitted loco. If you can't part with it, put it in a display case!

DC control

How does DC work? A variable speed and direction of travel controller is used to vary the output voltage and polarity to the rails. Controllers come in ready-made units with one, two or four or more built-in throttles, or each throttle can be of the hand-held type, where just one control is used. Many controllers will offer auxiliary power outlets to feed lighting, point motors, etc. These auxiliary outputs are normally 12 volts DC and 16 volts AC. Most N, OO and HO controllers will provide around a 1.0-ampere output to the track terminals, while larger-gauge controllers will provide substantially more current (ampere) output. Each controller will have

its own pair of 'Track' terminals or pre-fitted track feed wires, and these allow the power to be connected to the rails from the controller's terminals or direct from the controller. By varying the speed control knob or switch, the track output voltage is varied. Direction of travel is altered by a switch or a centre-off speed knob, where turning the knob one way produces forward travel and, after passing through the centre off position to the other direction, varies the speed in the opposite direction of travel. But many controllers today will use a single-speed knob and a separate direction-of-travel switch.

Forward direction on DC is gained by applying a positive voltage to the right-hand rail – that is the rail beneath the right-hand side of the locomotive and on a stream outline loco this is when looking along the loco towards the chimney. To reverse a DC locomotive the power to the rails is swapped around, resulting in the electric motor turning in the opposite direction.

The locomotive's wheels collect the power in the rails and transfer it to the electric motor inside the model. The motor will turn faster the more voltage is applied to the rails from the controller. The motor then turns a gear train, which ultimately turns the driving wheels, thereby producing the movement forward or backwards.

Connections to the rail are made in several ways, perhaps by plug-in power clip or a power track section. Probably the very best way is by soldering the feed wire directly to the rail. Ideally, solder the wire to the underside of the rail before laying the track; however, if the track is already laid, soldering the feed wire to the rail's outer web area will be the second-best option. Take the feed wires below the baseboard via small, drilled holes.

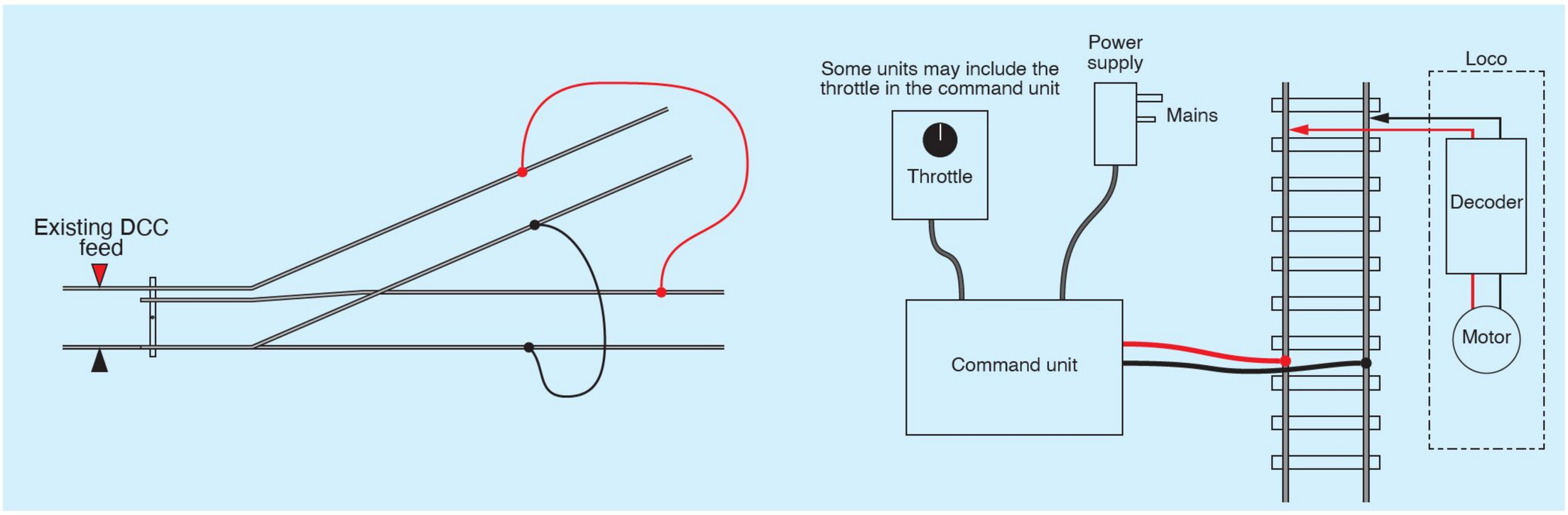
From DC to DCC

With DCC, full rail volts are applied to the rails all the time and are transferred to the locomotive's decoder. A digital signal is also carried in the rail power. The decoder acts upon the digital commands issued to it and uses the full rail power to drive the motor by using the Pulse Width Modulation method of motor control, as discussed earlier. Lighting and other separately controllable features are also provided by the decoder, again using the full rail voltage, but converted to DC. To reverse a DCC locomotive the decoder swaps around the feed to the motor, while the rail power remains always the same. Also, it is AC.

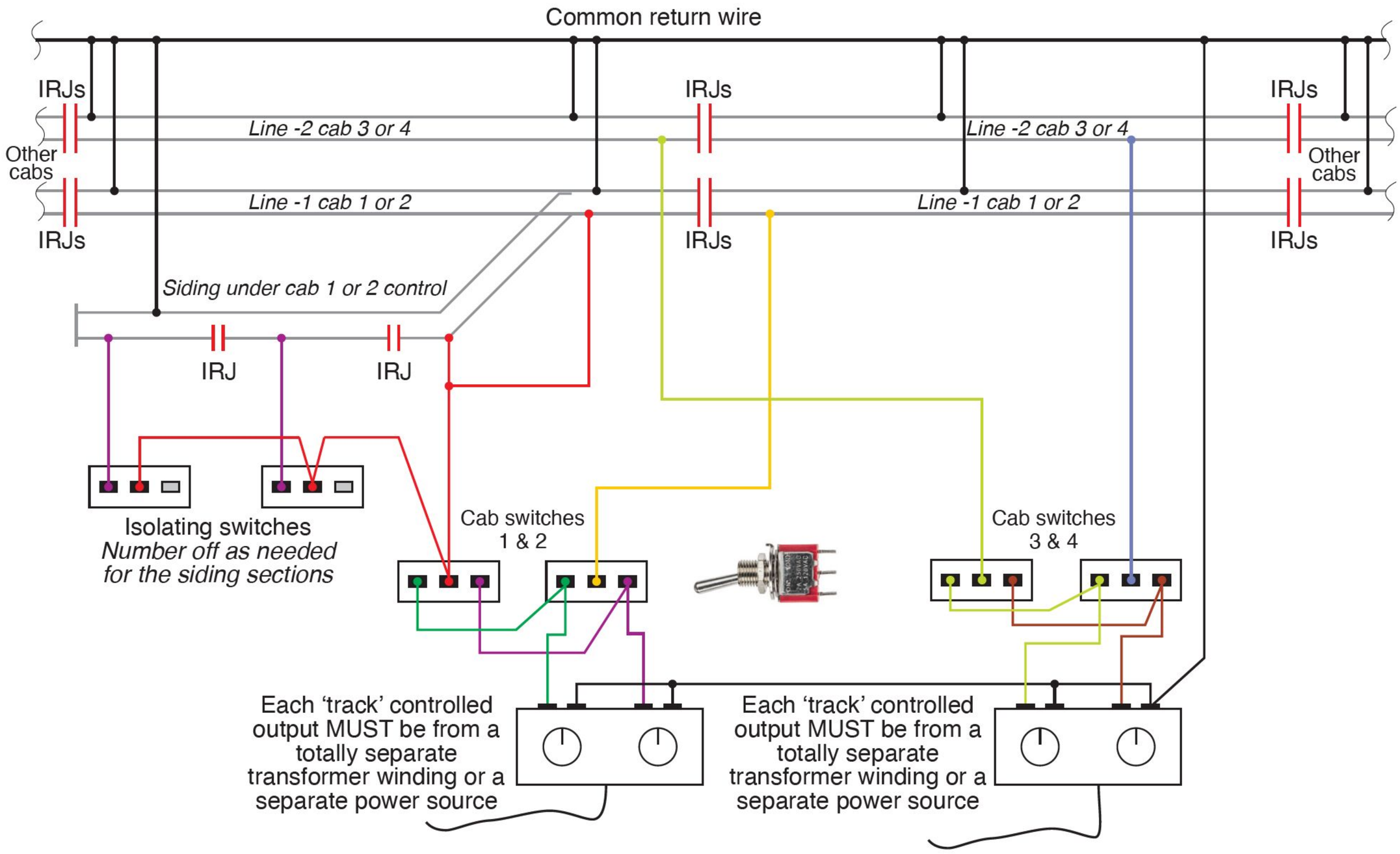
A question often asked is, 'My layout is DC – how do I convert it to DCC?' In the simplest form, take all the controller wires off the DC controller's 'Track' terminals and connect them together into two bunches, ensuring that all wires going to the left-hand rails are together and all the wires going to the right-hand rails are together. Connect the now pairs of wires to the 'Track' output of a DCC control system. If you have isolating sections, turn on all the isolating switches. Your layout, if wired correctly, should now work on DCC. Ensure that all your locos have decoders fitted.

If your DC layout uses analogue point operation for the solenoid motors, can they still be used? Yes of course. There is no reason why analogue point motor operation cannot be used with the DCC just operating the locos. You will need a suitable power supply to feed the motors and the passing contact levers or switches, but that is all. However, do keep analogue loco controls and operations totally separate from all DCC wiring.

Will points need to be modifying for DCC operation? No. There is really no such thing as a DCC point. If the point works on DC rail power, it will do the same on DCC. There are things that can be done to improve the point for both DCC and DC! Adding rail feeds to the points' two outside stock rails will ensure that power and data for DCC are directly fed to the point. Installing additional rail feeds after the point will ensure that the self-isolating feature of points will be overcome. Or if your points are Hornby examples, fitting two Hornby Electro point clips (R8232) per point will overcome the points' self-isolating feature for the DCC user.



Left shows how the self-isolation is overcome on an insulated frog point by using two link wires. Right, a basic idea of how DCC is connected to the rails and the loco decoder.



A section of dual track which has been divided up into sections or blocks by the use of IRJs (Insulated Rail Joiners) and the cabs (DC Controllers) are only permitted to feed the section of track depending on that sections cab switch position. Using the central Off type of switch allows that section to be isolated. Note: the DC controllers use a common return wiring method and these controllers MUST be fed from totally separate power supplies or via separate windings on a dual wound transformer. You cannot use one power feed for both controllers.

DC cab control: with cab-control wiring, a DC layout using two (or more) separate DC controllers is divided into several electrically isolated sections called 'blocks' or sometimes called 'cab sections'. Each block is independent of all the others, so a train in Block A can be operated by Controller 1, and a train in Block B can be operated by Controller 2. Equally each block can be fed from Controller 1 or Controller 2 depending on the position of the cab switch for that block.

Each section's block starts and ends with an IRJ (Insulated Rail Joiner) or a narrow slit cut through the same handed rail. While a cab-controlled layout looks to be like a continuous track, electrically it is several separate track sections.

Single-pole double-throw (SPDT) and ideally centre off type switches connect one cab to a specific block at a time, there's no option available for both operators to connect their individual controllers to the same block at the same time. The only time problems can occur is if Operator A allows his train to pass over the IRJs into the section that's being controlled by Operator B.

6
Construction kits

Kits have for many years been the backbone of model railway rolling stock and buildings. Traditionally made from card, plastic or wood, today laser-cut wooden and card kits are rapidly expanding. Kits are generally fairly simple to put together and provide a great range of buildings, locos, wagons and carriages, and virtually all types of model railway scales are catered for.

Today there is also a vast range of cast resin ready-built and painted buildings available. But why leave your buildings to look like hundreds of other similar examples?

Enhancing a kit or a ready-made resin building beyond its basic form is a really good way of improving and individualising it. Adding either purchased or handmade detailing parts, will really improve the building. There are many suppliers of additional detailing components, or you could even use parts left over from other kits or parts recovered from older dismantled buildings. Many ready-made detailing parts are made from plastic, white metal and brass; perhaps the white metal and brass examples are the better choice for providing fine detail. But modern plastic detailing parts now hold their own too.
The simplest forms of added detailing are:

- new and various-sized chimney pots
- lead flashing around the chimney stack or roof joints
- guttering and down pipes together with the down pipe wall fixings
- waste water pipes for WCs, sinks or baths in the building
- 'S'- or 'X'-shaped wall tie bracing plates often found on older buildings
- street name plates on the corners of buildings, etc.

On steam locos, tools such as fire irons and shovels, and oil lamps to show the designation of the train or loco – e.g. Fast Passenger, Stopping Passenger, Goods, etc – all add to the realism, not forgetting the crew in the cab who drive the train!

Weathering a building or rolling stock item will enhance it more. Weathering is adding those streaks of dirty colour that are seen on real buildings and items of rolling stock, such as staining running down the wall from an overflow pipe or leaking down pipe. General road dirt splashes onto the lower levels of a building where heavy traffic passes by, and railway brake dust film collects on locos, etc.

Domestic buildings can benefit from garden detail. Boundary fencing and gates together with garden details, such as a lawn, borders with flowers, and paths with drain and manhole inspection pit covers, all add that little extra detail.

Some card kits can have their windows replaced by etched brass frets, which provide a greater level of detail than the 'as supplied' transparent plastic printed window frames. Even if etched parts are not readily available, by using fine plastic microstrip frames and other window detail can be constructed.

Adding internal detail to rooms will make a building look lived-in or, where a commercial property is represented, at least look used and inviting. Adding people to carriage interiors will improve their look – far better than running empty trains!

Domestic rooms can be easily constructed from painted card, or use some of the readily available pre-printed sheets or downloadable sheets of interior detail. Scalescenes.com is one such supplier, which produces sheets for those who wish to print them off themselves.

Commercial properties can be made to look more realistic by adding extra detail. Shop windows can be enhanced by using printed items from real commercial adverts. For example, visiting an electrical retailer's website might produce many pictures of washing machines, TVs, fridges, etc., which can be copied and reduced in size to suit the scale, then carefully cut out and arranged to look as though the window is actually containing these items. Periodical magazines offer another good selection, but getting the correct scale size may be a little difficult unless a photocopier or scanner is used to reduce them. Try to aim for a semi-3D effect, by not only copying the flat front view but adding side and top detail to make the appliance or item truly stand out. Offices could contain filing cabinets, desks and even computer monitors, especially where a modern office is being depicted. Again much of this detail can be taken or copied from magazines or downloaded from web pages, etc.

A quick note on using and copying items displaying a particular real-life manufacturer, retailer's name or other trade mark that can be clearly distinguished, there should not be any problems in copying or using the items. If you believe there could be a copyright issue, contact the original owner of the picture and ask permission to use it, explaining that you wish to use the picture in a model building and not for trade or any other use; 99 times out of 100 they will be more than

happy for you to use their pictures. But please don't just copy a product picture then openly use it to show brand names, especially where a model may be on the exhibition circuit or used in photographic settings for any commercial or other financial gain.

By adding some lighting to the interiors of buildings you can then see the interior detail through the windows. However, do be cautious of using filament lamps inside buildings as these get very hot in use and can easily melt or soften plastic! LEDs (Light Emitting Diodes) offer a good level of illumination, but do ensure that those used are either warm or sunny white types. Many so-called 'white' LEDs are in fact tinged with blue and can give a very strange-looking level of illumination. In fact, all white LEDs are basically blue and they have phosphors added to give the white light. The use of LED strips is also a boon to illuminate the insides of buildings. These often come in strips of three or multiples of three with very small surface-mounted LEDs together with a series resistor all on the one strip. Applying 12 volts DC to the strip's connection pads the correct way round immediately provides great internal lighting.

However, do not illuminate every room. Ensure that there are some rooms unlit, achieving this by fitting internal walls, floors and ceilings to act as separators to prevent light spreading from area to area. Paint the inside faces of any external walls black or a suitable dark colour to prevent any light bleeding through the walls.

Before starting to construct a kit or your own building from scratch, you will need some basic tools. I recommend the following be obtained as a minimum:

- self-healing cutting mat
- scalpel or craft knife with spare blades – you'll use plenty of blades
- 12-inch (300mm) steel rule or safety rule
- engineer's square, 120mm or 150mm type
- small scissors – I find nail scissors ideal
- suitable adhesive for the medium being used, e.g. PVA glue or specialist glue for gluing cardboard
- needle files or a fine grade of glass paper
- solvent weld for plastics
- superglue (cyanoacrylate, also known as cyano) for bonding etched parts if they are not soldered together, and the cyano for bonding etched parts to the building structure
- small artist's paint brush for applying the solvent weld adhesive
- suitable coffee mug

No, it is not time for a cup of tea! The mug is used for the solvent weld bottle. It keeps it more stable and helps prevent it being accidentally knocked over, which will almost certainly happen if the bottle is left free standing and opened!

Some other 'nice to have' tools are:

- small sheet (approximately 300mm x 300mm) of 6mm or thicker float glass or a similar-sized mirror to be used as a level surface to build on. **Important:** get your local glass merchant to bevel all the edges
- razor saw with suitable handle
- pin vice drill and selection of small drill bits
- wooden cocktail sticks
- heavy-duty utility knife with spare blades and masking tape

Making a start with kit construction

Always read the instruction leaflet, then read it again! Carefully check all the parts of the kit against the list of parts or any other detailed item listing. Once you have ascertained that all the component parts are present, ensure that all smaller and loose items are placed on a tray or in a small box to keep them safe. Following the instructions, remove the first parts to be assembled from their sprue or retainer. Carefully cut away the item from the moulding sprue with the aid of the craft knife or a special sprue cutting tool, then clean away any moulding remaining using a needle file or glass paper wrapped around a small flat square of timber. When cutting brass etching away from its retainer by using a knife, use a flat piece of hardwood or other hard surface underneath on which to push and cut down through the securing brass tabs. Do not use a cutting mat for cutting brass etchings as it has a soft surface and will allow the etch to bend under the cutting knife's downward pressure. An alternative with brass etching is to use a fine, small pair of scissors – a sharp pair of nail scissors is the best option here. However, I have found it best to use special sprue cutters!

If the kit is a plastic building, normally the first two major pieces to be joined are walls – the end wall and one longer front or rear wall. It may be easier to fit doors and windows before proceeding further. Place the two walls together, as a dry fit, on the glass sheet. If you are satisfied that they are correct, hold them together by applying a small strip of masking tape around the outside on the two pieces. This will temporarily hold them in place, allowing you to open the bottle of solvent (in its mug!) and dip the artist's brush into it. Apply the brush to the inside of the corner and run it up and down the seam. The solvent will be drawn into the joint by capillary action. Check and ensure that the two surfaces are still correctly in line, then take the engineer's square and check that the two walls are at the correct 90-degree angle (assuming that is what the angle of the joint should be). Carefully place the bonded surfaces to one side to allow the bond to cure, ideally overnight, and make sure the joint is still at the correct angle.

Proceed with the construction of the opposite pair of walls, and again leave them overnight to set. Once set, remove the masking tape. The two cured wall sections can now be bonded together to form the basic 'box' shape of the building. Use the glass sheet to ensure that the walls are level along their bottom edges and apply strips of masking tape to each corner before gluing. Check all is square and, once correct, apply the solvent to the two joints using the artist's brush. Again, ideally allow the solvent to cure overnight. Remove the tape and a solid box shape should be the result.

Remember, when test dry assembling the components together before gluing, any irregularities preventing a close fit of the two items can be gently removed with a flat needle file or fine glass paper wrapped around, for example, a solid piece of wood.

Where card kits are to be constructed I use either neat PVA wood-working adhesive or a special card bonding glue such as Roket. The PVA is applied with a small artist's-style brush or, in very small areas, with the tip of a cocktail stick.

Once the building has been constructed and painted as necessary, it needs to be brought to life. Super-detailing areas around the building will vastly improve its appearance and make it that little bit different from all the other similar models produced from the same kit. The following detailing can be carried out on all types of buildings – card, plastic or resin, etc.

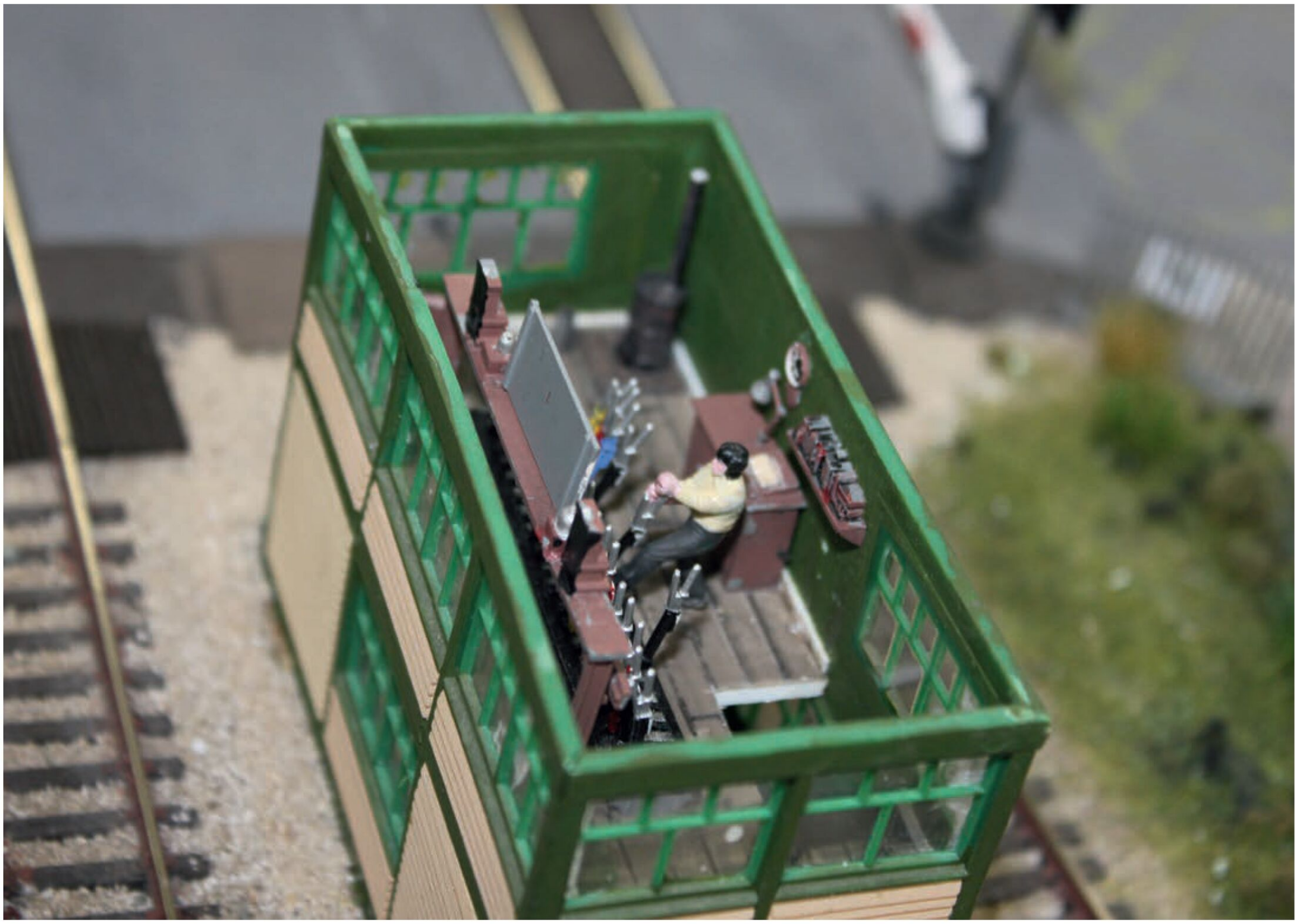
Always ensure the building sits *into* its surroundings and does not sit on top of the land or area, as a visible building-to-land joint line is unsightly and unrealistic. Place the building into its final location, then add the surroundings – earth, pavements, road surface, concrete, etc – up to the wall of the building. If your building needs to be removable, consider making a small sub-base onto which the building is bonded, the sub-base being larger than the building. The joints between the main layout landscape and the sub-base can be disguised by walls, paving, fencing, hedges, etc – in fact, anything that would normally be found around the outer area of the building.

Adding creeper growth to the sides of some buildings will make them look more part of the landscape. Grass tufts, flowers or any rough undergrowth can help disguise the building-to-landscape interface, especially with older or more derelict and unkempt buildings.

Look carefully at real-life buildings, and note the way in which they seem normally to blend into their setting. Exceptions will be found, and many newly constructed buildings can look out of place until their surroundings mature. This 'new-build' look can be modelled and can often form a focal point of a small cameo setting. Add sections of soil pipes, timber, bricks, piles of earth, etc, all of which are all found on new-build sites, together with scaffolding and ladders, of course. Mechanical diggers and mobile compressors for pneumatic drills are also found on modern building sites. A 'hole in the earth' (a baseboard hole) where pipes or cables can be seen with a workman digging will also add to the illusion of realism. Almost all the items needed for adding super-detailing to a building or its surroundings can be purchased ready-made or made by the modeller using odd items from the scrap box. An example is pipes, which can be produced by cutting up lengths of plastic tubing. Cables laid on the ground or air pipes for pneumatic drills, etc, can be produced from fine electrical wire or the insulation stripped from small wires.

Ground cover can be produced using several materials. A hanging basket liner is one such, and can be used to represent grass on larger areas. Glue it with PVA to the sub-base structure, then, once the glue has fully dried, the liner is pulled off the sub-base, leaving behind tufts or hairs of the liner which, once touched in with suitably coloured paint, represent undergrowth. Scenic mat can be glued over a pre-shaped former. Flocks and scatters, sold by model shops or war game stores, are used to represent grass and earth, etc – they are simply sprinkled onto a coating of neat PVA glue either onto previously painted areas or onto the scenic mat. Static grass can be used to produce grass and weeds that are able to stand up from the surface to which they are glued; they are applied onto neat PVA glue using either an electric static grass application tool or a puffer bottle. Both produce strands of grass that stand upright in the PVA and, once the glue has dried, they can, if need be, be trimmed with small scissors to the height required. Adding spots of neat PVA glue to the tops of some static grass tufts, then sprinkling on lighter shades of ground cover material or scatters of a completely different colour, can add to the illusion of weeds, flowers and other undergrowth.

We are no longer limited to producing kits from ready-produced parts sold in a box or packet. There are now downloadable construction kits available from the internet. You normally buy the download, though some are free, and once it has been downloaded and saved to your PC you then print off as many copies as you need, or a part of an item to enhance or alter other buildings. There is no limit to the number of times the item can be printed. These are all card and printed paper constructions, and during and after construction it is well worthwhile to spray the freshly printed papers once the ink has dried and before they are cut up into individual parts or glued onto the card backing; use an artist's matt varnish from an aerosol can, or if you have an air brush use artist's matt varnish diluted by 50% with IPA (Isopropanol Alcohol). This seals the printer ink and paper from any moisture in the glue being used to construct the item. Also, overspray the whole completed structure once the final building work has



Detailing applied to an 'ready-made' signal box. Unseen is that a warm white LED has been wired into the removed roof and will gently illuminate the inside detail when its powered.

finished and it has fully dried; this will prevent moisture in the air causing damage to the printed papers and card surfaces. Cover any glazed windows with cut strips of repositionable note-type pre-glued paper, which will act as a mask to prevent the varnish being applied to the window glazing during the spraying process; then strip these off once the varnish has dried.

On plastic, metal and laser cut wooden models the use of fine-finish modelling putty is highly recommended for infilling any gaps or visible joins in the completed but unpainted model. By spraying the area with a light coat of car primer paint or a similar primer paint that is suitable for models, the spray paint application can quickly reveal misaligned parts or other areas that require the application of the modelling putty to correct bad joints and other defects etc. Work the soft putty into the gaps and uneven areas, leave to set then scrape, sand or file off the surplus until a correct profile is obtained. Overspray lightly with the primer again to double-check that the repair or correction is now good.

3D printing has become some modellers' choice for producing detailing parts for buildings or even whole buildings. While producing excellent results, it can be quite expensive to set up initially.

7
Point control

To operate the layouts points over and back there are several methods available.

Manually by finger: This is OK but isn't ideal where points are located remotely from the operation position or are just not easily reached.

Wire in tube or rod: Flexible wire or a flexible nylon rod is threaded inside a protective tube and by push/pull operation of the wire or rod the point is moved over and back. The operation can be from mechanical-signalling-type levers or by basic push/pull rods emerging from the side frame of the baseboard with little more than a cork or wooden round ball on the end. The same can be used for solid rod operation, but here right-angled cranks are used to transfer movement around any corners or right-angles.

Electrically by a solenoid: This has been used for many years and is still the most popular means of moving the point blades. Two coils of wire are formed and inside the coils a metal iron core is free to move between them. A drive pin is fitted onto the iron core, passing the core's movement to the points' stretcher or tie bar. Applying power to one coil momentarily energises it and causes a magnetic field to be produced, which pulls the iron core into the energised coil's centre. Energising the opposite coil pulls the iron core into that coil's centre. It is very important that the coil is only energised momentarily, normally for no longer than half a second. If the power is left on for too long there is a great risk of the coil burning out, rendering the motor defective. Thus the normal means of switching the power to the coils are: passing contact levers; non-locking sprung-to-centre-off toggle switches; press-to-make non-locking push buttons; or a stud and probe. DCC accessory point decoders can also be used to operate solenoid point motors. Solenoids work on either AC or DC power, and normally their operating voltage is between 12 and 20 volts, but they do draw a considerable current when operated, typically around 3 amps instantaneously.

Electrically by an electric motor: These are often called 'slow motion' or 'stall' motors, although some are not of the stall type. Both types use a small electric motor and gearing to slowly move a drive pin from one end of the motor's body to the other, the pin being connected to the points' stretcher or tie bar. Normally the points' over-centre spring fitted to most ready-made points is removed to allow the motor to reproduce a more realistic slow-motion drive of the points' switch blades. Unlike solenoids, these motors do not use passing contact levers or switches; instead, they require the operating power to be left on even when they have finished their travel. Stall types, via their internal circuitry, put the motor into a stalled condition at the end of its travel, with low-current power continually being applied to the motor. The non-stall types drive to the end of their travel and, via internal contacts, cut off the operating power; the drive remains in the end position of travel locked by the gearing, preventing further free movement.

To make either type of motor drive to the opposite end the power to the motor is reversed and causes the motor to drive to the other end of its travel and again stall or be disconnected and remain in position. These motors usually operate on DC power, though half wave rectified AC can also be used. Some will work on AC power too. They draw a very small current when running and normally even less when stalled for the stall type, of course the non-stall type has a zero-power consumption when stopped at the end of their travel. Typical running current is between 15 and 35 milliamps (0.015 to 0.035A) and 5 to 15 milliamps when stalled. The operating voltage varies with make, but can be between 7 to 20 volts. Typical manufacturers are Tortoise, Cobalt, with Conrad producing an AC operating motor. As usual there are other manufacturers.

Electrically by a servo: Servos were predominately the preserve of the radio-control modeller — planes, boats and cars, etc. Simply put, the servo is an electric motor controlled by a series of power pulses. The length and frequency of the pulse determines the movement of the motor. Normally a servo turns a maximum of 90 degrees left or right of its neutral position (180 degrees overall) — these are positional rotation servos, and their movement can be controlled to be less than 90 degrees each way. They require external electronic circuitry to provide the operating pulses. They do occasionally suffer from what is known as 'servo twitch' or 'buzzing', which is often caused by having the control wiring too long or running too close to interference sources, or the servo is being driven too hard against the stop position. Keep the control cables as short as possible and try not to exceed a 2-metre length, as beyond that you risk the possibility of interference and possible volt

drop. Advancements in servo design and their operating circuitry are making them more cost effective for the model railway user. Servos can be analogue or digital styles, but digital servos tend to draw more current. Servos operate at around 4.5 to 6 volts.

Which switch?

Which switches are used for electrical operation of the point motors? This depends on the motor. As previously stated, solenoid motors must only have a brief momentary pulse of power applied to the coil, so it is vital that the power is removed quickly. This is achieved by using passing contact levers. As the lever is moved from one end to the other, contacts inside break the connection to the motor coil, thereby providing the momentary pulse needed. Levers tend to be costly, so the canny modeller will look for suitable alternatives! These are mainly (On)-Off-(On) toggle switches, where the bracketed (On) cannot remain in that position when the switch's toggle lever is released. These switches are under sprung tension and return to the centre Off position after being at either end of its travel. Toggle switches are often used in control panels where banks of switches are positioned to operate the points, or they are placed on the mimic track plan where the point they are to operate is drawn. These switches are of the Single Pole Double Throw (SPDT) type of non-locking sprung-to-centre-off style for solenoids.

Next is the push-to-make non-locking press button. Two of these are needed for each motor, one for each feed to the coil. When pressed they apply power to the coil and once released the switch returns to the off position.

Finally comes 'stud and probe' operation. This system is normally used with a mimic control panel where a simple representation of the actual layout track is reproduced, with the points shown. Two studs are fitted into the panel's board for each set of points, and by applying the probe momentarily to the appropriate stud, power is sent to the motor's coil.

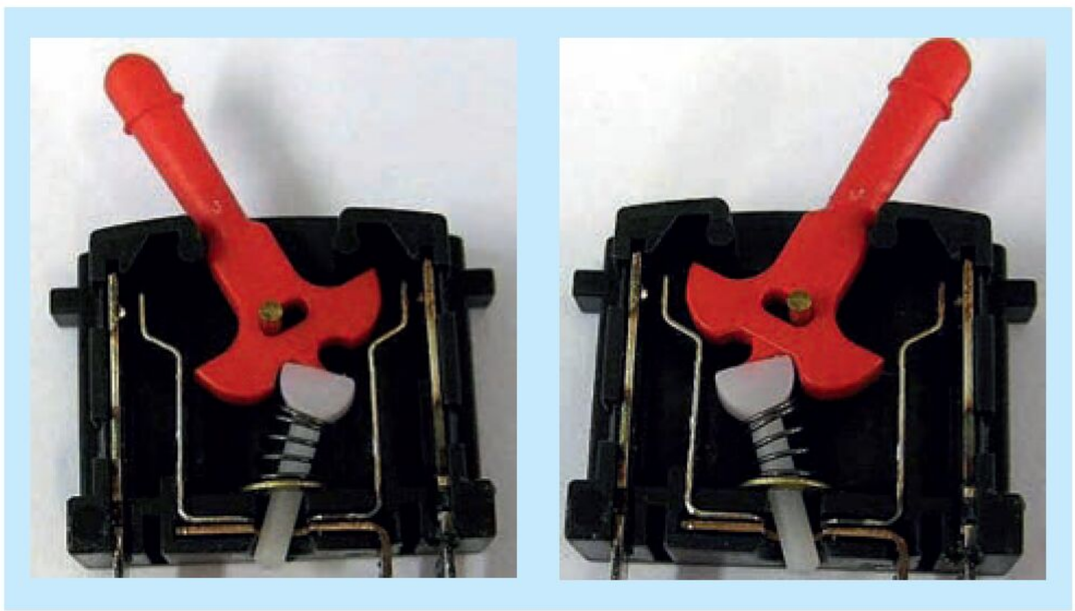
For slow motion (stall and non-stall) switches, conventionally locking On–On switches are used. Slow motion motors need to have the power polarity reversible, allowing the motor to move one way under one polarity, then in the opposite direction by reversing the polarity. For DC operation of slow motion motors, a Double Pole Double Throw (DPDT) switch is used.

Servos normally use a locking On–Off Single Pole Single Throw (SPST) or Single Pole Double Throw (SPDT) switch. Double-throw switches can be used instead of single-throw ones if they are more readily available. One end tab and the middle tab are used for single throw operation; the remaining tab at the other end of the switch is not used.

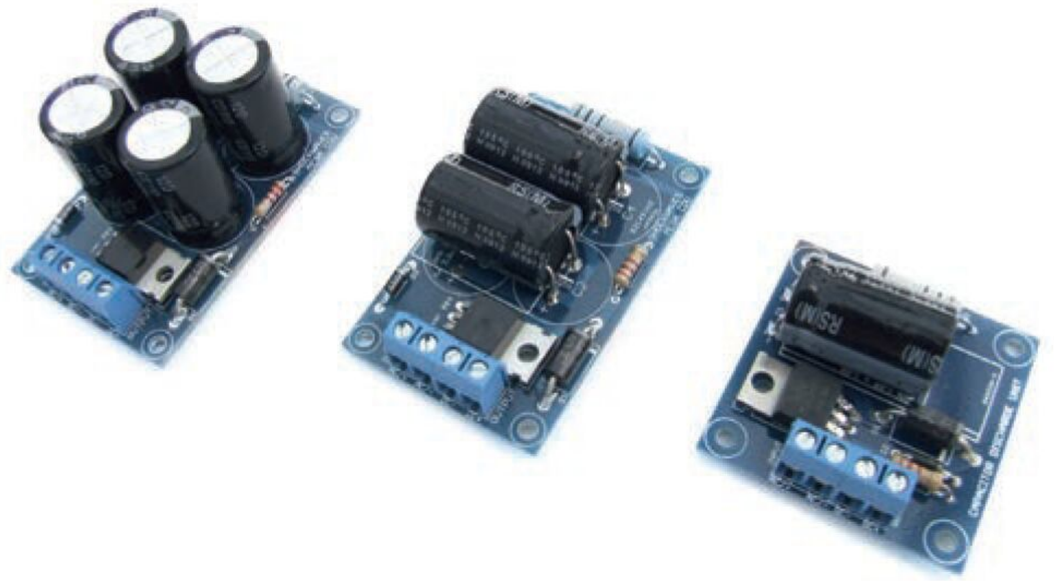
Solenoid point motors have fairly low resistance coils, typically 3 to 5 ohms. This means that the current flowing in the coil at our applied voltage is fairly high, but it is only a momentary pulse. Ohm's law comes into play here, so if our supply volts are DC and at 15 volts and the coil is 4 ohms, the current flow is 3.75 amps. AC will be a little higher! While this power is momentary, it needs to be considered when designing your circuit, allowing the correct wire sizing to be used.

You may wish to operate signals or have indication lights relating to the points' position. Therefore you will need some form of point- or point-motor-operated change-over switch. Some point motors allow an optional extra switch to be bonded onto the motor and as the motor moves over and back the switch changes too. A typical example is the Peco PL10 motor fitted with the SPDT Peco PL13 switch or the DPDT Peco PL15 micro-switch; via the switch's contacts accessories are fed from a separate power source or the switch is used to feed live-frog point frogs. Seep PM1 and the self-locking PM4 have a built-in SPDT switch that can be used to switch accessories or provide the power to a live frog point frog.

Tortoise and some Cobalt motors usually have a minimum of two separate change-over contacts fitted internally, so there are two SPDT switches provided.



A Peco PL-26 passing contact lever.

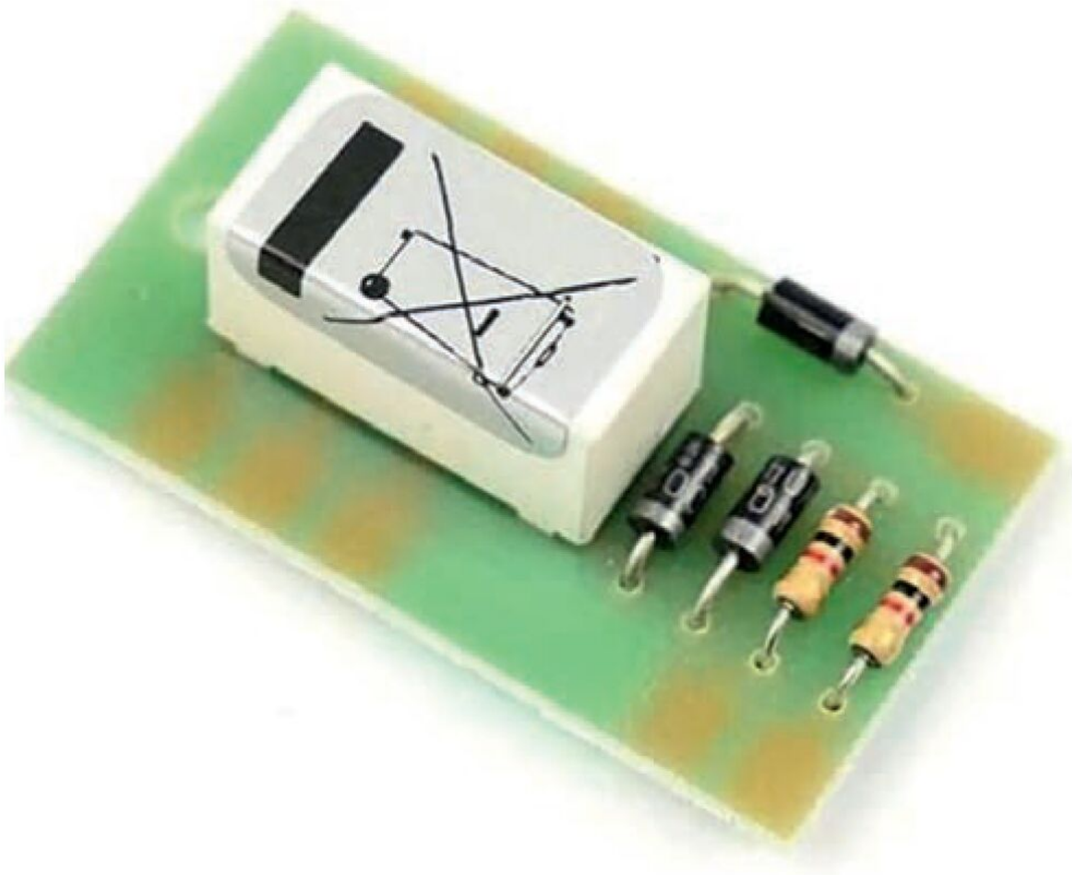


Three CDUs. On the right is a high-powered CDU; in the middle is a medium powered one and on the left is a standard device. The choice of type is dependent on how many solenoids are to be operated from the one switch or lever. Usually only one CDU is needed for the layout, though larger layouts with two or more operating areas may use one for each area.

Some Cobalts have an output that is for frog polarity or LED indication operation, but this is internally wired to the drive input power for the motor and provides a low-current supply to external devices, these are fitted to the Cobalt iP motor range.

If you use surface-mounted solenoid motors like the Peco PL11, Hornby R8243 or Gaugemaster PM20, currently there are no means of fitting an accessory switch directly to them. You therefore have two choices. One is to use a micro-switch fitted to the opposite side of the point, with its lever worked by the point's moving stretcher or tie bar. If this is visually unacceptable, I recommend using a twin coil latching relay, which is wired to the motor's three operation wires and is mechanically latched in one position by one relay coil being energised momentarily as the point motor receives a pulse of power to operate it. The mechanical latch is released by the point motor coil for the other direction, receiving a pulse to the point motor coil and the other latching relay's coil being momentarily energised. Only a pulse is needed to latch and unlatch the coils of the relay, so it is ideal for use with solenoid motors. The relay coil requires a DC power source to work, so the point motors should ideally be fed from a DC supply or from the output of a CDU (Capacitor Discharge Unit), which is DC even if the input to the CDU is AC. However, by adding diodes to the feed paths to the relay coils, these latching relays work happily on AC power feeds to the point motor. By means of the latching relay's contacts, accessories are switched and fed.

Most twin-coil latching relays have two separate change-over contacts DPDT; one contact set can be used for live frog switching, or both used for other applications such as point position panel indications or signalling controls, etc. Where home-made latching relays are produced, the relays will have fine connection pins and are ideally plugged into an Integrated Circuit Dual In Line (IC DIL) socket with the correct number of ways to accommodate the relay's pins i.e. a 16-way DIL socket is normal for a DPDT twin coil latching relay. Alternatively the relays can be directly soldered to suitable PCB (Printed Circuit Board) tracks. Where a DIL socket or direct relay fitting is used, it is soldered to a circuit board — copper-tracked stripboard being ideal — and all the wires are soldered to the board's copper strips. Don't forget to gap the copper tracks between adjacent pins! These simple relay sets can be pre-made on the workbench, then fitted to the layout.



The GM500 latching relay. Photo courtesy of Gaugemaster.

Ready-made latching relay units are also available such as those from Gaugemaster – GM500.

A CDU (Capacitor Discharge Unit) provides the solenoid point motor with a 'beefy' pulse of power. The pulse is pre-stored in the capacitor and is released as soon as the point lever or switch is operated. Normally only one CDU is needed for the whole layout, although on very large layouts or where there is more than one control position, it may require a second or even a third CDU.

The CDU not only provides the heavy-duty pulse of power to the point motor coil, but also helps stop accidental solenoid coil burn-out occurring, should a point switch accidently remain on for too long, as the CDU cannot recharge until all the point switches are back in their off position. Only a few milliamps flow through the point motor coil in the event of a switch remaining on after the initial discharge has occurred. A CDU is installed after the point motor power source and before the first switch or lever. Note that a CDU does not work very well with the existing Hornby R044 black point lever, due to the lever's internal switching arrangements, but one does work well with all other passing contact levers and switches. CDUs work best with a 16-volt AC input; this is converted to DC via on-board diodes and they always give a DC output. You can feed the CDU with DC power, but this is then best increased to around 19 to 22 volts DC. Always check that your CDU can operate at this voltage and, if visible, that the capacitor is rated at 25 volts or higher. Most should be!

8
Digital Command Control (DCC)

As mentioned in an earlier chapter, DCC is the newer control method and is becoming increasingly popular. It will probably never replace DC, as many modellers prefer to use DC control, but DCC has gained many supporters and often those taking up the hobby afresh will opt to go down the DCC route from the beginning.

So what is so special about DCC? It enables you to control (up to 9,999) locomotives all on one layout (if you can get that many on one layout!), each sharing the same power and rails as all the others; to move one loco while next to it another loco remains stationary; to turn on or off lighting on locos or inside carriages; and to have sounds playing that are recordings taken from the real locomotives represented on the model, following what the model loco does so that the exhaust (chuff) rate increases as a steam loco pulls away or the engine revs build up on a diesel loco.

Notice that I mentioned 9,999. This is the conventional range of address numbers used by most DCC systems, starting at 1 and going through to 9999 (note that some basic DCC control systems do not allow the full range of address numbers to be used and only offer 1 to 9 or 1 to 59 or similarly low digit address numbers). You, as the end user, set the unique address number for each item (decoder) that you have connected to your DCC system. Once set, the decoder remembers this address number until you change it. For example, taking a loco with address number 10 to another DCC-operated layout, it will still only respond to a command when address number 10 is sent to it on the other system. If you have two or more items with the same address number, they will all do whatever you request when that address number is sent out by the system. For example, two locomotives given the same address number will both move off together in the same direction and at the same speed. Speed is also governed by other external factors such as gearing and friction, so no two locomotives will perform exactly the same. Running trains with more than one locomotive is called 'double heading' in the UK or a 'consist' in the US.

All mobile decoders (loco decoders) are supplied new with a default address of 3, and the purchaser should always change this number to whatever is required. Keeping the decoder at 3 can lead to minor problems, especially when other new locos are obtained and have the same address number. I always recommend changing it. Many operators use all or some element of the loco's actual running number.

DCC allows for two ranges of address numbers, 'short address' and 'long address'. Short address, or two digit addressing, is in the range 1 to 127. I can hear you now saying '127' – that's three digits! DCC use the binary coding system and numbers from 1 to 127 are classed as being in the two-digit range. Long numbers or four-digit addressing is in the 1 to 9999 range. Technically four-digit address numbering can go to 10238, but the vast majority of control systems stop at 9999. It should also be noted that some DCC systems use 1 to 99 and 10 to 9999, while others can use 1 to 127 and have four-digit addresses starting at 128! There is no defined method, so read your DCC system's manual!

If you have up to 20 or 30 locos, consider two-digit addressing. Some makes of DCC control systems and some mobile decoders do not accept four-digit addressing, though mobile decoders that are restricted to two-digit addressing are now quite rare! But some can still be found, so be cautious if you specifically want four-digit addressing.

You can technically have 9,999 locos all sitting on your tracks with only one moving! In reality this isn't going to happen, but the option is there if ever needed. Note that address 0 (Zero) is reserved on some DCC systems to enable one DC locomotive without a decoder fitted to be operated by the DCC command unit; however, not every DCC system allows this, and it does come with a serious word of caution: allowing a DC loco without a decoder fitted to remain on DCC-powered rails while stationary risks the loco's motor being burned out very quickly. This is due to the high-frequency DCC arriving at the motor and causing the motor's armature coils to rapidly swap polarity. This will cause the motor's coil windings to eventually overheat; there is even a risk of them getting so hot that they eventually burn out! So be warned, and if at all possible avoid using a DC loco on DCC, even under address number 0. Always fit a decoder and no harm will then come to the loco. Normally a DCC-fitted loco can be used on DC systems as long as DC operation hasn't been disabled.

DCC provides a constant voltage to the rails all of the time, so unlike DC, where the rail volts vary, DCC is always on and ideally fed to all parts of the railway. Self-isolation of points should be overcome to allow unset routes to be powered even when the point is set to the opposite direction. Rail volts are typically in the

range of 12 to 16 volts and are a sort of AC though not a sine wave. The AC used is not of the conventional sine wave format like mains power — 50Hz in the UK. DCC tends to be in the 8,000Hz to 10,000Hz range (8kHz–10kHz) or around that frequency. Its wave form is more akin to being bipolar or square wave, but neither of those terminologies are 100% correct. To accurately read DCC rail volts you need a multimeter that can read True RMS voltage at 10kHz. A standard domestic multimeter set to its AC voltage range can be used, but the reading shown will not be accurate; however, it is a good indication and should be the same all around the layout. The other accurate measuring means are to use a RRamp meter, which is specifically made to measure DCC voltage, or an oscilloscope.

Once the decoder receives its package of data and the data has arrived correctly, the decoder will perform whatever instruction is contained in that package. This might, for example, be 'stop', 'move forwards at half speed', 'change direction of travel', or 'turn on lighting and/or sounds'. Once the instruction has been acted upon, the decoder continues to do that action until it is told to do something else. It is like the postman analogy earlier: this is the simplest description, and is repeated here in case you missed it... Think of DCC instructions or packets of data as being like a postman delivering a letter with instructions in it. The postman only puts the letter through the letterbox of No 38, and the occupant of No 38 reads the instruction and acts upon it. All the other house numbers from 1 to 9,999 have seen the postman on his round, but haven't received the letter, so they carry on doing what they were last doing!

There are two main types of DCC decoder: mobile decoders designed to fit inside locomotives or carriages etc, and static decoders known as accessory decoders. The latter are stationary and operate devices like point motors and signals, or simply turn lineside lighting on or off, etc.

Mobile decoders come in three styles.

Function only These have no motor control circuitry and are normally fitted into carriages or the rear unpowered carriages of diesel multiple units (DMUs) or electric multiple units (EMUs) to provide rear directional lighting and internal lighting, etc.

Motor control with additional function outputs These offer full motor control but additionally have function outputs that are used to feed and control other loco devices such as front and rear directional lighting, firebox fire flicker, smoke generator and cab lighting, etc. These additional outputs are called 'functions', and are switched on or off by the DCC system's 'F' keys. Decoders can have one function output or many; currently ten is about the maximum. Mainstream mid-price decoders will normally offer three or four function outputs.

Sound decoders These are normally manufactured as combined sound, motor and function output all in the one package, although sound-only decoders are available. Basically, they are the same as motor decoders but are frequently larger in size and may well have two wires provided to connect to a suitable loudspeaker. Four function outputs are common, but some makes offer six and even ten function outputs.

Decoder outputs (functions), as previously stated, are used to operate lights or other features fitted into the locomotive. All decoders with wiring harnesses use a common wiring colour coding, as shown below. A decoder's function output is nominally at 12 volts DC and is switched on the negative function wires. Common to all the functions, the blue wire is used to feed positive DC to all features connected to the function wires; all other function wires are switched negatives. The actual DC voltage on the function output will depend on the DCC rail volts minus about 2 volts; hence DCC rail volts of 14 volts will proved around 12 volts DC on the function outputs.

The most commonly used function outputs are the two direction-of-travel outputs, which on wired decoders are found on the white and yellow wires. These are normally turned on and off by the command station's F0 key. They will automatically swap power between the white and yellow wires when the direction of travel button is pressed. For forward moves the white wire is on, and when the loco is travelling in reverse the yellow wire is on, both in relation to the common positive blue wire.

Additional function outputs are typically a green wire operated on non-sound decoders by the F1 key, and the purple or violet wire operated by the F2 key. Note that some decoders may differ in their functions and their F key numbers and which decoder wires control them can be different. Refer to the decoder manual or leaflet to determine which function output is controlled by which F key.

At this stage it should be mentioned that there are other connection styles of decoders, mainly 6 pin, 8 pin and 21 pin. 6 and 21 pin decoders plug directly into special sockets in the loco and normally do not have any wires attached. All the connections are carried through the pins onto the loco's printed circuit board where they are distributed as required around the circuit board and finally off to the item they are needed to power.

Another style of mobile decoder is called PluX and was originally intended to replace all UK 6, 8, and 21pin decoder connections, but for whatever reason so far the

main UK train manufacturers have not adopted this standard. They may well do so in the future, so here are the PluX details. PluX has been designed to be available in 22, 16, and 8 pin configuration, the latter two being able to directly plug into a 22 PluX socket. A 12 pin version has also been mooted but hasn't appeared on the NMRA listing as yet (NMRA is the National Model Railroad Association in North America, which sets standards for DCC and other model railway features, offering a common ground approach for manufacturers to follow.

Just to add confusion, a further style of mobile decoder called NEXT18 is being considered for use by some manufacturers. This is an 18 pin direct plug-in decoder. It is therefore very wise to double-check when purchasing a DCC-ready loco to find out what type and style of DCC socket it has been fitted with.

When a DCC loco is placed on the track, assuming forward direction is selected on the command station, the loco will move forwards. If it is removed from the track, turned through 180 degrees and returned to the DCC power rails it will still move in the forward direction, unlike a DC loco, which will run in the opposite direction when turned through 180 degrees. This is easy to relate to if using a steam locomotive, as the chimney is normally at the front — but what about diesel-outline models? In the UK the No 1 end is conventionally the front, but it's always worth double-checking the real locomotive, pictures and its build details.

There are basically three types of locomotive manufactured that the DCC user needs to be aware of:

DCC-fitted or DCC on board: These all come with a decoder pre-fitted by the manufacturer or in some cases by the retailer.

DCC-ready: As sold, this is a DC-only locomotive. It has inside a special socket fitted to enable a DCC decoder to be plugged in, but as sold the socket is occupied by a DC-operation-only plug. To convert to DCC, open the loco, or its tender, ease out the DC plug from the socket and remove it, keeping it safe as you may want to revert back to DC-only operation should you ever sell the loco or wish to test it on DC power. Plug in a DCC decoder of a suitable choice and size, ensuring that the decoder's plug, or the decoder itself for direct-pin-fitting versions, is installed the correct way around.

Non-DCC-ready: These will mainly be older pre-DCC-era locomotives and will require some rewiring and electrical testing to ensure that the wheels and metal chassis are not making contact with either of the two motor connections before the decoder's wires are soldered in. Decoders use red wire to the right-hand wheel pick-ups, and black wire to the left-hand wheel pick-ups, with orange and grey wires to the motor connections. On no account must the red and black wires or their connection places make connection with the orange and grey wires. Once converted, test the loco on the programming track, then, assuming all is correct, place the loco onto the main DCC-powered tracks and test it. If it runs the opposite way to the console's direction setting, either reverse the orange and grey wires on the motor or, if you wish, change the value of CV29, increase it by 1 if the existing value is an even number, or reduce it by 1 if it is currently an odd number. e.g. read 6 make it 7, or read 7 then make it 6.

What is CV (Configuration Variable)? Put simply, this is specific 'tuning' data that is adjusted by altering the coded number in the CV's value; it alters how the decoder will perform a specific task assigned to that CV. Think of a CV as being like a radio station setting. You tune the radio to receive the station, then fine tune it more to make the station clearer. The CV is the radio station and the value is the fine tuning. The easiest to understand is CV1, which is the address number of the decoder. By adjusting the value of CV1 the loco's address number is changed.

There can be many hundreds of CVs in advanced decoders and not all makes of decoder are allocated the same CV numbers for the same features, though these basic CVs are all common.

Static or non-mobile accessory decoders offer the DCC user an interface to allow the operation by DCC of all other accessories, such as point motors, signalling and anything else power-operated on the layout. These are normally referred to as accessory decoders, or point decoders if they only operate point motors. They all take data from the DCC system and provide one or more switched outputs. Some use the DCC as a power source, while others allow connection to a separate power supply to feed the item(s) connected to the decoder. Typically accessory decoders come in single, twin, four, six or eight outputs per decoder. Some have fixed outputs that are pulse only for operating solenoid motors, such as the DCC Concepts ADS-2sx or ADS-8sx decoders, while other styles can have their outputs set between pulse or continuous – Hornby's R8247 and the ESU SwitchPilot are two examples. A pulse output is used for solenoid motors while a continuous output is used for powered colour light signals, lighting, or stall point motors. A third type is the continuous-output-only decoder. Mostly these are designed to work with stall point motors. One such is the DCC Concepts AD2-fx – note that the 'S' is missing from this part number compared to the earlier one referred to, as this decoder is not suitable for solenoid motors, only stall motors.

Accessory decoders that offer a pulse output will have three connections per output. Most will use the

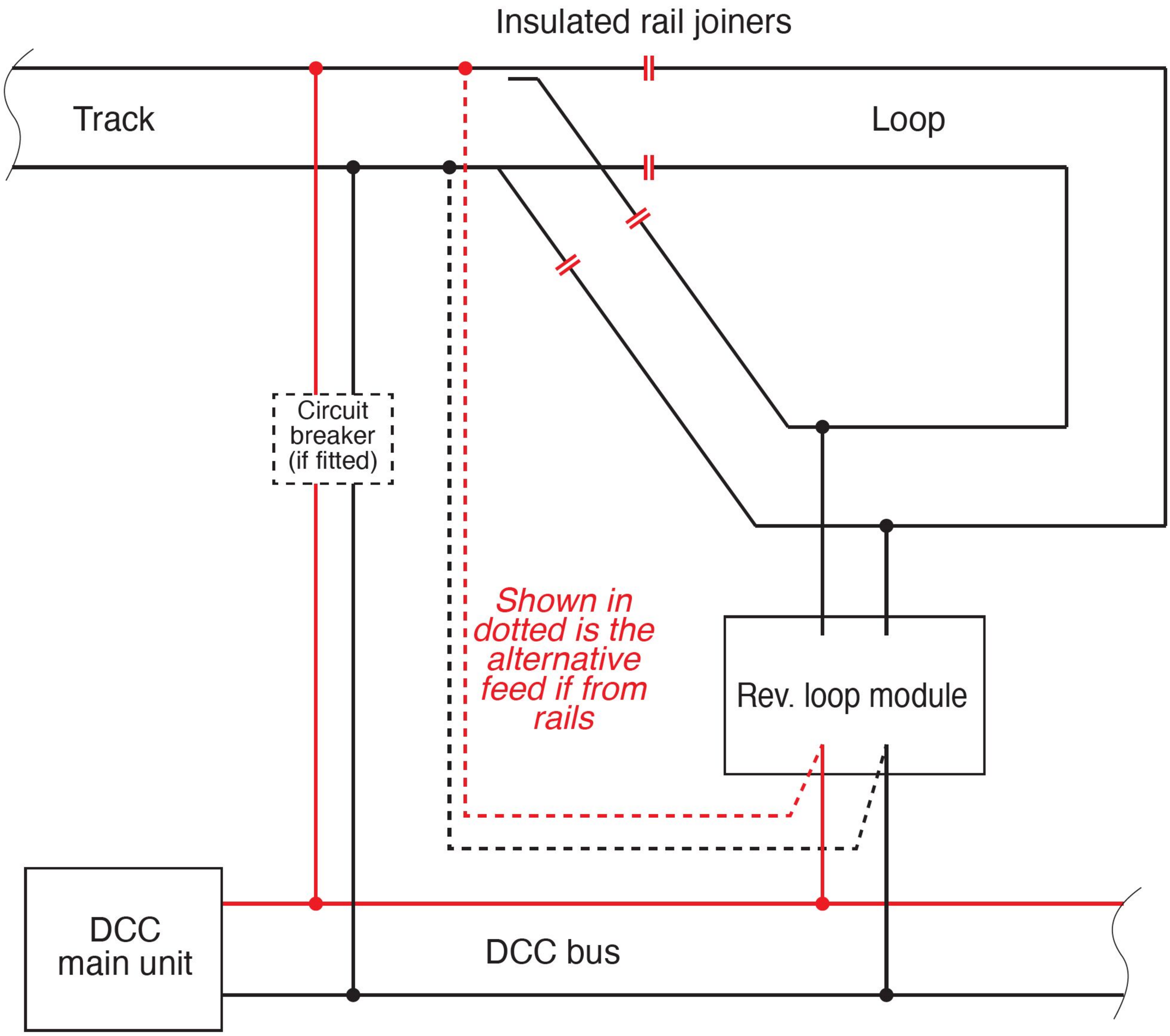
DCC Solenoid (Pulse) decoder. Image courtesy of DCC Concepts.

markings '+' 'C' and '–', while others will use 'L', 'C' and 'R' for Left, Common and Right. The C is the common connection and is positive to the switched '+' and '–' or 'L' and 'R' connections, which are both negative regardless of being marked '+'! A conventional solenoid point motor will connect to the three terminals of the one output. An example is the Seep PM1 connecting its pad A to '+', pad B to '–' and pad C to 'C'. Decoders designed solely for continuous output may have either three or just two terminals per output depending on the make.

On our DCC layout there are a few other items that will not normally be found on the DC layout. One such is the Reverse Loop Module (RLM). As the name suggests this is used on a single-line reverse loop of track or a 'Y' point track configuration. A reverse loop is where the left-hand rail at one end of the loop becomes the right-hand rail at the other end, and thereby meets a rail that is at the opposite polarity. If left without some form of action, this will result in a full short circuit occurring. Initially the entrance and exit places of the loop are electrically separated from the main lines by inserting Insulated Rail Joiners (IRJs) into both rails opposite each other at both locations, leaving the reverse loop's rails totally isolated from the rest of the railway, and only designed to be operated off the RLM's output. The RLM is designed to detect a short circuit, and instantly swaps over its output pair of connections. So, our train entering a reverse loop finds that the loop's rails are at the same polarity and carries on as normal; however, as it exits the loop the main-line rails are at opposite polarity, which produces a momentary short circuit as the loco's metal wheels bridge the exit IRJs. The RLM detects the short and flips the reverse loop's rails polarity over before the main console detects the short occurring. This of course removes the shorting problem, and all happens in microseconds. Now the loop's rails are at opposite polarity at the entrance IRJs! When another train enters the loop from the main-line end and its metal wheels bridge the entrance IRJs, the RLM again detects the short and instantly flips over the loop rails polarity to match that of the incoming rails. The short circuit is thus removed and the train carries on as though nothing has occurred, then as it exits the loop the rails will be out of phase again with the main line and the RLM flips the loop rails back to match the exit track's polarity.

One thing to remember with a reverse loop is that the entrance and exit IRJs need to be further apart than the longest train to travel over the loop section, i.e. the whole train, loco, wagons or carriages, should all fit in between the entrance and exit pairs of IRJs. The size of the loop can easily be increased by moving one or both IRJs further out along the main line. The reason this is important is we do not want the metal wheels of our rolling stock to be able to cause the RLM to flip should the loco be exiting while the rear is still travelling over the entrance IRJs. The RLM will be continually flipping over its output polarity and eventually the main console will detect the shorting and cause the entire system to shut down – not a helpful situation! Thus the reverse loop between the IRJs needs to be longer than the longest ever train to travel over that loop.

There are some 'workarounds' to prevent this. Having all rolling stock fitted with plastic wheels is one. This is not a recommended procedure, as plastic wheels are renowned for collecting and spreading rail-generated 'muck' and cause more poor running problems than they are worth. I highly recommend not fitting plastic wheel sets! Alternatively the rails at the entrance and exit to the loops can be isolated for a few millimetres by fitting additional IRJs or cutting through the rails and inserting an insulating material into the gap, then profiling it to the rail shape. This insulating material – plastic normally or an epoxy resin allowed to set, then shaped to the rail profile – prevents the rails touching each other, especially when the air temperature increases and rails expand a little. The idea is that the insulated gap stops the metal wheels of a carriage or wagon being able to bridge the main-line rails to the loop's rails by the insulated rail, which is only a couple of millimetres in length. The main disadvantage of this option is that any rolling stock with interconnected wheel sets (carriages with lighting, where multi-wheel pick-up is used, or metal bogies on wagons or carriages, etc.) will still cause the RLM to continually flip, as too will a loco with a long wheelbase, so while it works generally it is not foolproof and can still lead to problems. Therefore really it is best to ensure that the actual length of the loop between IRJs is always longer than the longest complete train to travel over that loop.



Our RLM can also be used on some makes of turntable where a continuous feed to the rotating bridge rail is provided.

Another option for reverse loop control on DCC is to use a Frog Juicer with two outputs (Dual Juicer). These two outputs feed the loop's rails and flip the loop's polarity as required. Again the loop should be longer than the longest train to use it.

Some DCC (and DC for that matter) users will employ a Double Pole Double Throw (DPDT) switch, either fitted to the points that control entrance to and exit from the reverse loop. By means of the DPDT switch's contacts, the loop rail polarity is changed over with the movement of the point itself.

The next item found on DCC layouts but not on DC ones is the Booster. This device provides a secondary source of power output to the DCC console, or is used to feed a totally separate section of track that is isolated from the main-line feed from the main DCC console.

The Booster can be used (depending on make) to increase the current (amperes) available from a standard DCC system or to feed a totally isolated separate area of the layout. Here all rails leading into and out of the Booster-controlled section are insulated from all other areas by fitting Insulated Rail Joiners (IRJs) to all rails.

Some Boosters can take DCC commands directly from the rails or the DCC bus pair of wires fed from the main command station, but many have to use a dedicated output socket on the command station via a special data cable that connects command station to Booster; again this is type dependent. Boosters will have their own power supplies to feed them and provide the output to the Booster-fed rails. A Booster will have its own internal overload protection, which

will cut off its output to the rails in the event of a short circuit, but will still leave the main command station operating correctly.

Asymmetric Brake Control (ABC Braking)

ABC is used for fully automatic non-computer-controlled stopping at and pulling away from certain places such as signals or platforms or wherever an automatic stop is required. ABC can be employed anywhere so long as the loco decoder supports it. Note that not all decoders support ABC, so the user should check. Zimo, Lenz, ESU v4 and and their higher numbers support ABC, as do several other manufacturers. Most decoders require CV27 to be configured to a value of 1 to permit the ABC feature, but Lenz uses CV51 value 2, so always check the decoder's leaflet or manufacturer's specification list for that decoder.

How does it work? Put simply, one rail — always the right-hand rail depending on direction of travel — is isolated at both ends of the stopping section by inserting two plastic Insulated Rail Joiners (IRJs) or cutting the rail. The isolated section must be long enough to be able to bring the loco to a halt at the pre-set deceleration rate, and is fed via a network of five diodes, these being ideally Ultra-Fast versions such as UF4001 or UF4002. As the DCC loco moves into the section, the DCC wave form is reduced on the positive side via four of the diodes, each diode reducing the volts by 0.7 volts so that the four will reduce the rail volts by 2.8 volts; the other half of the cycle, the negative side, is reduced by 0.7 volts via the single fifth diode. This now asymmetric DCC signal causes the pre-set deceleration to take place and the loco slows to a stop. All lights and sounds, if fitted, remain operational.

When the distorted DCC wave form is replaced with the correct full value DCC wave form, the loco, under the control of its decoder's pre-set acceleration rate, moves off and gains speed. The diodes are removed from circuit by the operation of a conventional on/off switch or even a relay contact linking them out and restoring normal DCC. If a train approaches from the opposite direction, it simply continues as normal as the detection of the asymmetric DCC is dependent on the direction of travel.

Wiring

How do you wire the command station or booster to the rails? There are several methods, from simple plug-in power clips or powered track sections. But these must be designed for use with DCC, as some that are produced for DC operation have an internal capacitor fitted across their two input connections. These can be used with DCC, but must be converted or they will cause running problems. It is a simple matter to use a small flat-blade screwdriver and carefully flip open the plastic cover on either the plug-in power clip or the cover on the power track section and snip off the two wires from the capacitor and discard the capacitor, then close the cover; the clip is now able to operate with DCC. This is especially true for Hornby R602 and R8206 power connectors designed for DC.

However, best of all is to use dropper wires soldered to the rails. These wires can be soldered to the undersides of the rails before track-laying commences, or to the outer web area of the rails if the track has

already been laid. The wire size used for droppers is normally a flexible single-core type – 16/0.2mm equipment wire is recommended. Smaller 7/0.2mm wire can also be used but with the proviso that the smaller wire's overall length from rail to bus wire is no more than 300mm.

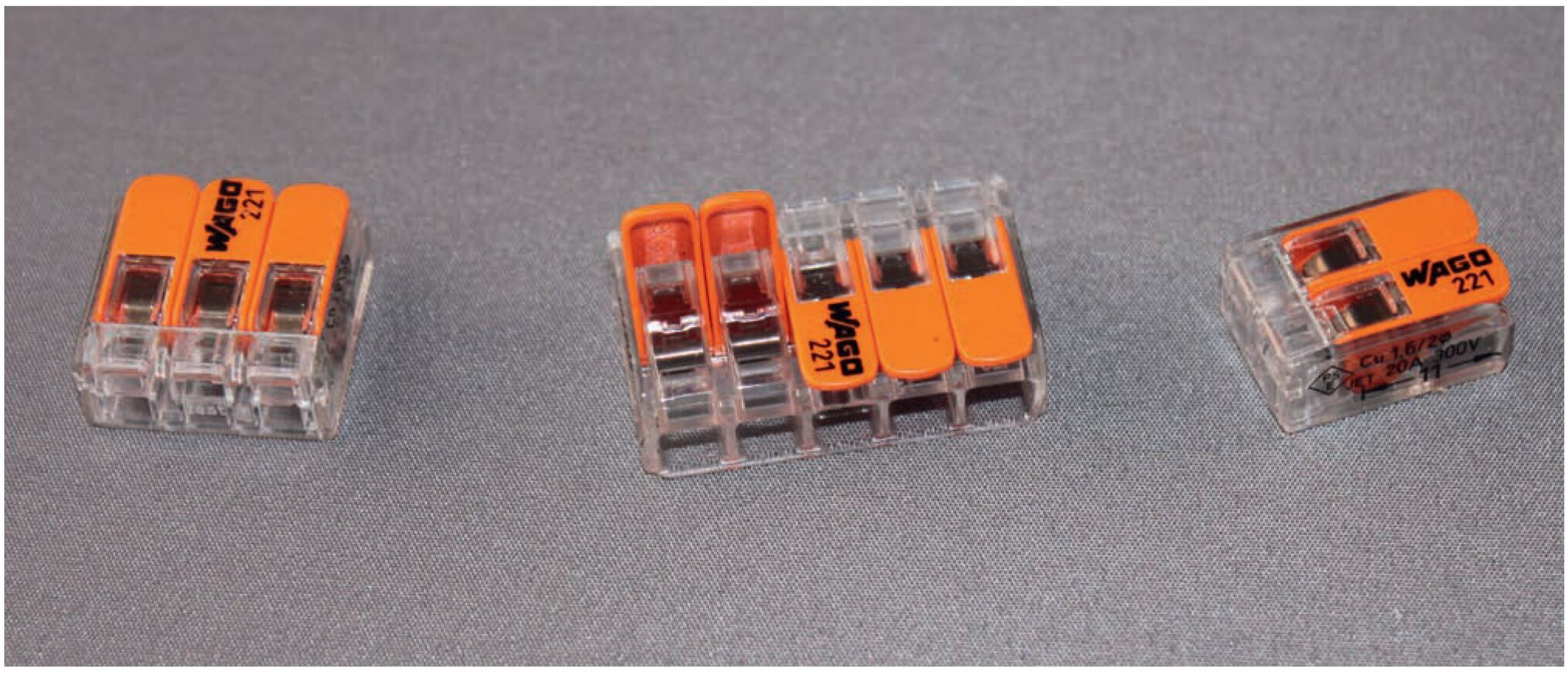
A DCC bus pair is normally employed to feed all the rails, and runs around under the layout with the smaller 'dropper wires' tapped off it and connected to the rails above. The input to the bus from the command station can be of a flexible type of wire, where the bus wire itself is solid. The minimum bus wire size I recommend is flexible 32/0.2mm equipment wire or 1.5mm² solid core. Of course, larger wire sizes can be used and will never cause harm. In fact, it is often better to use a larger wire size if available, and an increase in size will be needed for larger layouts where the length of the bus wire is greater, or where the command station or Booster offers a higher output current. The main objective of the DCC bus pair is to provide the rails above with as many connection places as required, and to allow fault currents to rapidly return to the command station or Booster and cause the system to shut off the rail power. A coin dabbed momentarily on and off across the two powered running rails should immediately cause the DCC system to trip and cut off the rail power. If this doesn't happen when the coin is touched across the rails, the cause should be investigated immediately and the system not used until the problem is corrected and the coin is proved to cause the system to trip.

How the connection is made between bus and dropper is entirely at the discretion of the layout builder. The best method is to twist or wrap the dropper around the bared bus wire, then solder the two wires together. Terminal block connectors, snap-lock splice connectors or tag strips are also often used. Common-connected two-, three- or five-way push-in-to-insert connectors are also making a headway, but these tend to be on the more expensive side. One such push-in is the Wago 221 connector, which accepts wires from 0.14mm to 6.0mm, so the bus and dropper wires can be connected to them without fear of loose connections. The bus not only feeds the rails but all DCC accessory decoders too. *See next paragraph regarding twin bus system.*

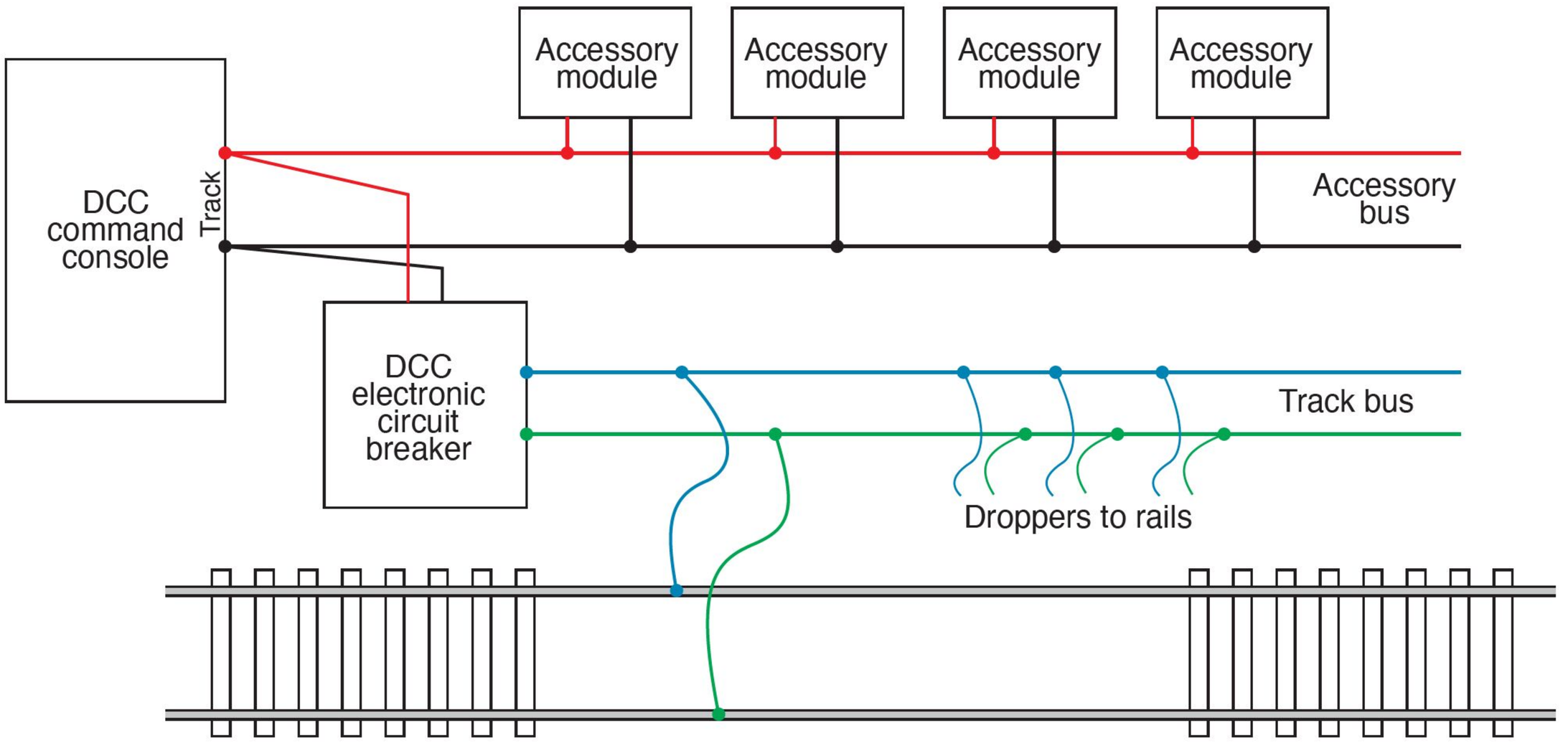
The DCC layout can have two separate DCC bus wire pairs and doing this offers better control protection for the locos and rail feeds. Basically, the feed from the command station or Booster is taken to the input terminals of an all-electronic DCC circuit breaker. A second pair of wires connects in with the pair from the command station or is taken from the main console's Track terminals and these two wires connect to the second bus pair of wires onto which all accessory decoders are connected.

The output of the all-electronic circuit breaker connects to the main rail bus pair of wires. Should a problem occur on the rails i.e. a train is accidently driven into an unset point and causes a short, the circuit breaker cuts off the rail power, but the command station is still working, and the accessory decoder can be accessed and the point moved over to remove the short. The train can then be driven onto the point or backed away as required.

Without the twin bus system and circuit breaker, the entire system would have shut down until the offending loco was manually pushed clear or the point operated by finger to remove the short. One such DCC all-electronic circuit breaker is the PSX1 which can have its trip current adjusted to allow it to trip at lower current than a main command station is set to. It has various tripping current levels from 1.27 amp to a whopping 19.1 amps. The trip current settings available will cover most DCC systems, except the very basic systems that offer less than 1.3 amp output.



DCC Dual Bus



Some layouts will be improved by fitting DCC filters to the ends of the bus pair of wires that feed the rails. The filter consists of just two simple components: a ceramic 0.1uF capacitor and a resistor of a value of 120 to 150 ohms and rated at 2 or 3 watts. The two components cost less than £1 and are connected together in series with each other, one end of the resistor to one wire of the capacitor – it doesn't matter which way round they are connected as they are not polarity-conscious devices. The remaining end of the resistor and the capacitor wire are connected directly to the end of the track bus feed pair of wires, with one filter at all bus wire ends.

Some DCC problems and the fixes

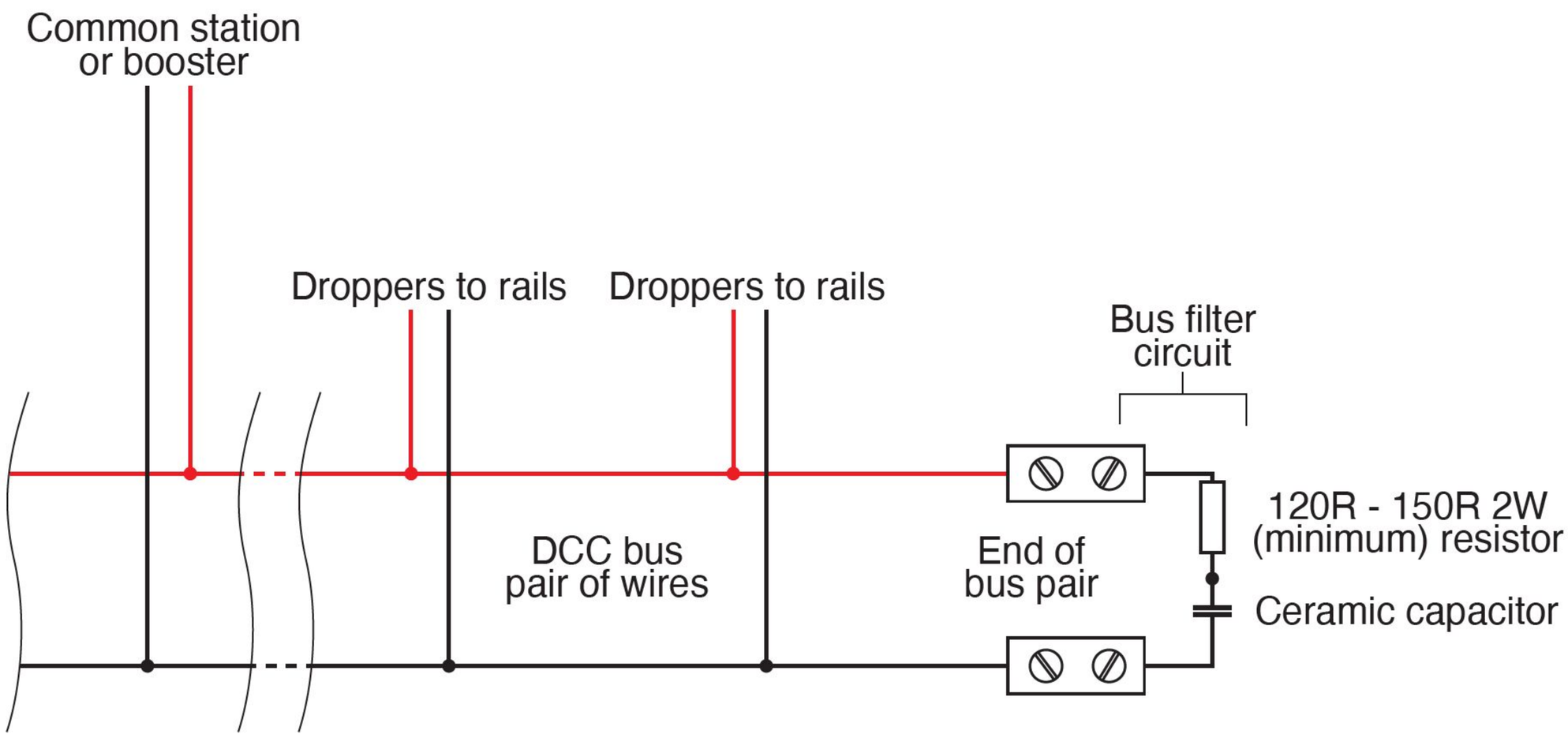
• Loco runs the opposite way to other locos or the DCC consoles direction setting: There are two methods available to correct this. 1) Reverse the two motor feed wires on the actual motor terminals or 2) Without opening the loco, adjust CV29 increase by 1 (one) if the existing value is an even number or reduce it by 1 if it is currently an odd number. e.g. read 6 then make it 7. Or read 7 then make it 6. This permanently sets the direction of travel to the opposite way from what it was previously.

• Loco suddenly takes off at full speed and is uncontrollable: The decoder has 'seen' the full DCC rail volts as being DC and at full voltage. The decoder is 'confused' and applies full DCC rail voltage, minus a little for conversion to DC, to the motor. As decoders act on the last received instruction until they receive another instruction the decoder continues to apply full power to the motor. The only way often to stop the errant loco is to remove rail power or physically take the loco off the rails. This runaway problem is corrected via CV29 and turning off the DC operation mode. This of course means the loco can no longer be operated on DC layouts, but it does overcome the runaway problem. To turn off DC operation in a decoder, access CV29 read current value then reduce that by 4 (Four) to that read. e.g. existing CV29 is at 6 reduce it to 2.

• Loco is seen to skip or jump suddenly or gives generally poor running: This is often due to the requirement to adjust CV54 and CV55. Try CV55 first as this is more likely to solve the problem. On

Approx conversion		
AWG	Area mm2	Metric standard
13	2.5mm2	50/0.25mm
15	1.5mm2	30/0.25mm
17	1.0mm2	32/0.2mm
20	0.5mm2	16/0.2mm
24	0.20mm2	7/0.2mm

This chart shows the approximate conversion sizes of some of the more commonly used wire sizes found in DCC wiring.



some locos CV55 should be reduced if the loco has a big flywheel (or large worm drives with a lot of mass) or increased if it has no flywheel and/or smaller worm drives. The CV value would be in the range 0-63.

Adjust the CV setting by units of 5 or 10 at a time and then check the results.

To further fine tune the running of a loco's motor, CV54 can also be changed. Back EMF (Back Electro Motive Force) basically reads the voltage produced by the motor when free running and puts pulses of power to the motor to try and keep it running at a continuous speed. If these are too strong, this too can lead to hunting or hesitancy. I would recommend initially trying to reducing this number. The CV value must be in the range 0-63. Initially, I would suggest setting CV54 to about 10 and CV55 to around 60. If all else fails, then remove all motor suppression capacitors (there may be more than one!).

• Loco takes longer than expected time to stop: CV4 deceleration value is set high. Reduce CV4 to 1 (One) and retest loco. If deceleration is required, then increase CV4 value to 5 and retry and then going up in units of 5 until deceleration rate is correct or near to that wanted. Then adjust CV4 up or down from that setting in single units of 1 (one) until at the required level is reached

• Loco is slow to pull away: CV3 Acceleration is set to high. Set CV3 to 1 (one) and retest loco. As for CV4, if acceleration is required increase CV3 by units of five and fine tune after reaching the level needed by adjusting up or down by single units.

• Loco is too slow at maximum throttle: Set CV5 top speed control to the decoder's maximum; this can be 63 or more normally 255, depending on the make of decoder. If it is too fast at full throttle setting, reduce CV5 value. Once CV5 is set, CV6 should be set to ideally 1/3 and no more than 1/2 (one-third to half maximum) of the value set in CV5 to ensure a smooth throttle range.
For example, CV5 is set to 200, therefore CV6 needs to be set to around 67 to 100 maximum. Note that some decoders do not offer CV5 or CV6 adjustments.

• Loco is unresponsive or just will not start but was working previously: Try a decoder reset. This resets the decoder back to the 'as manufactured' default settings including address number back to 3 and any other CVs back to their default settings too. Many loco decoders are reset by CV8 entering a value of 8, but do check with the decoder manufacturers leaflet or web site, as some use differing CV number and value for a reset.

9
Special Scenic Effects

From anti flicker carriage lighting to static grass, special effects help make the model come alive!

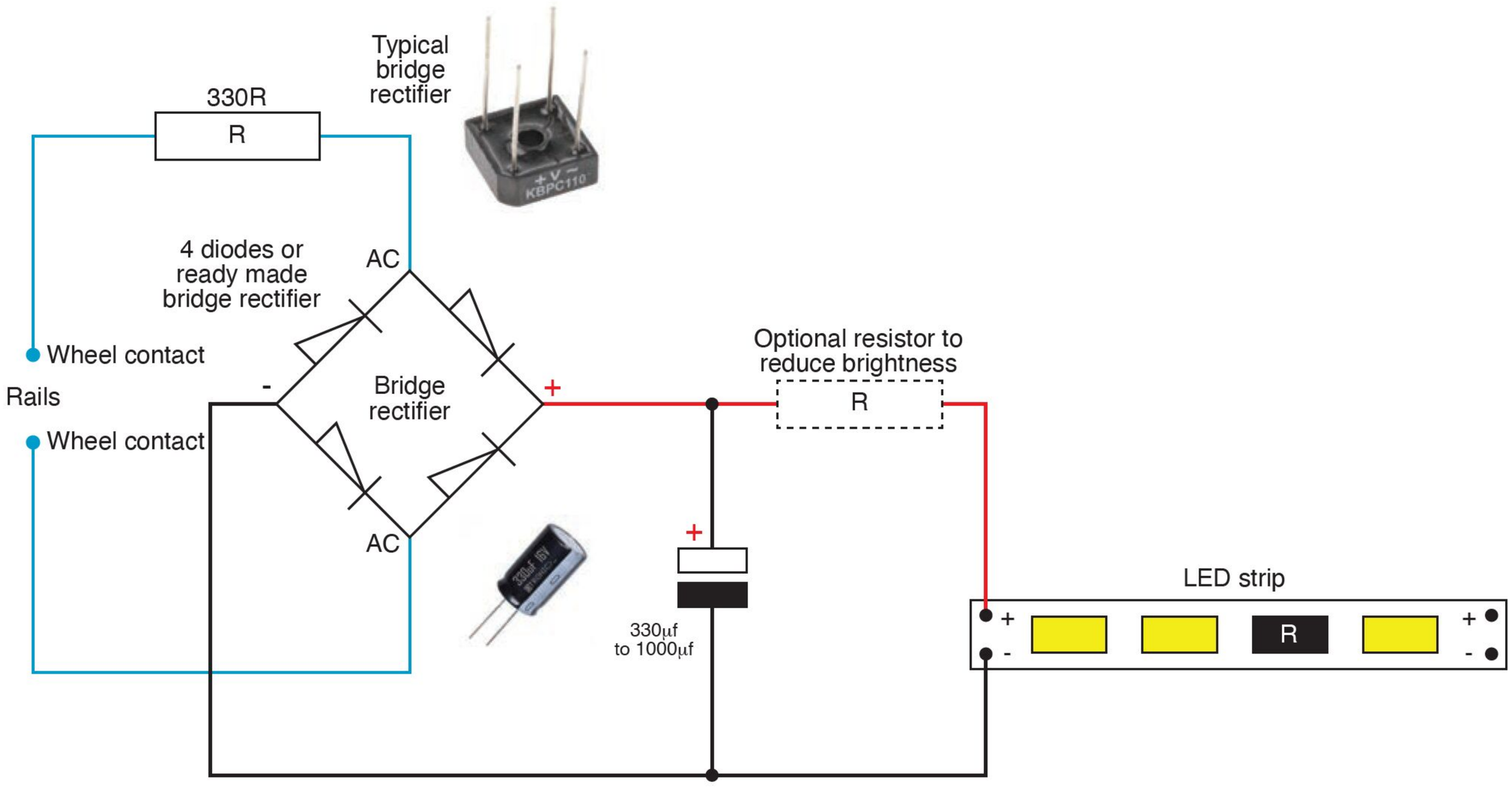
Carriage lighting

Carriage lighting or brake van rear lighting with anti-flicker can be produced for DC or DCC operation with the aid of a few readily available electronic components. The idea is that as the carriage or guard's van on a passenger or goods train passes over a section of track that may not be as clean as it should be or over the plastic frog area of insulated-frog points, the lighting remains on should the power be momentarily lost.

An electrolytic capacitor is charged and acts as a 'reservoir of power,' releasing the stored power when no input is available from the rails/wheels. However, the problem is that on DC the rail polarity reverses with direction of travel, and on DCC it's a sort of AC, so the capacitor could be fed with the wrong polarity if directly connected across the rails/wheels, and this could cause the electrolytic capacitor to possibly explode! The answer is to add a bridge rectifier between the capacitor and the wheel pick-ups; this ensures that its output is always the correct way round to feed the capacitor, regardless of the DC direction of travel or the DCC supply.

Another problem can be encountered where several lighting units are used in more than one carriage, causing an in-rush of current drawn by all the capacitors trying to charge up at once at power switch-on. This in-rush current could cause the control system to see a large current flow and consider it as a short circuit or overload, and in turn this can cause the system's over-current device to operate. By adding a series resistor in one wire going to the bridge rectifier AC input, the in-rush current can be better controlled, and a 330-ohm (330R) resistor will aid this. The capacitor can now charge and act as the reservoir and feed the lighting.

Ideally the lighting itself is of the LED style, either a small red LED acting as a rear tail lamp on a brake van or as a group of white LEDs acting as the interior



A typical arrangement for carriage illumination using an LED strip. The strip can be longer than shown and is normally made up into units of three LEDs. The circuit is suitable for both DC and DCC operation. The builder may wish to replace the bridge rectifier with four diodes and for the DCC user it would then be wise to use fast operation diodes such as UF4002 or other fast recovery diodes.

A typical roll of 5-metre long warm white LED strip, in every group of three LEDS a resistor is factory fitted to the strip. A cut line is usually marked and is located between the four copper solder pad dots after every third LED. When uncut each three LED section is automatically connected to the next section.

illumination of a passenger carriage. The interior illumination can be by several single white LEDs or by using an LED strip, often three LEDs, and a series resistor on a self-adhesive strip. These strips can also be supplied in multiple groups of three. Use warm white LEDs to represent filament lighting and white LEDs for fluorescent lighting in modern coaching stock. Do remember that LEDs are polarity-conscious devices and must be connected to the supply the correct way around. On single LEDs the longer lead is the anode or positive lead, and on strips this is normally marked by a plus (+) symbol. If dimming of the lighting level is required, add a 3,300 to 5,000-ohm (3K3 to 5K0) resistor in series with the LEDs in the positive feed wire. The final value of resistor in ohms will need to be found by trial and error, testing with various values of resistor used in series until the desired level of illumination is reached.

An example of random lighting is illustrated in these three pictures, which show a 'Scout Hut Disco Dance' in full swing. Note the colour changing internally.

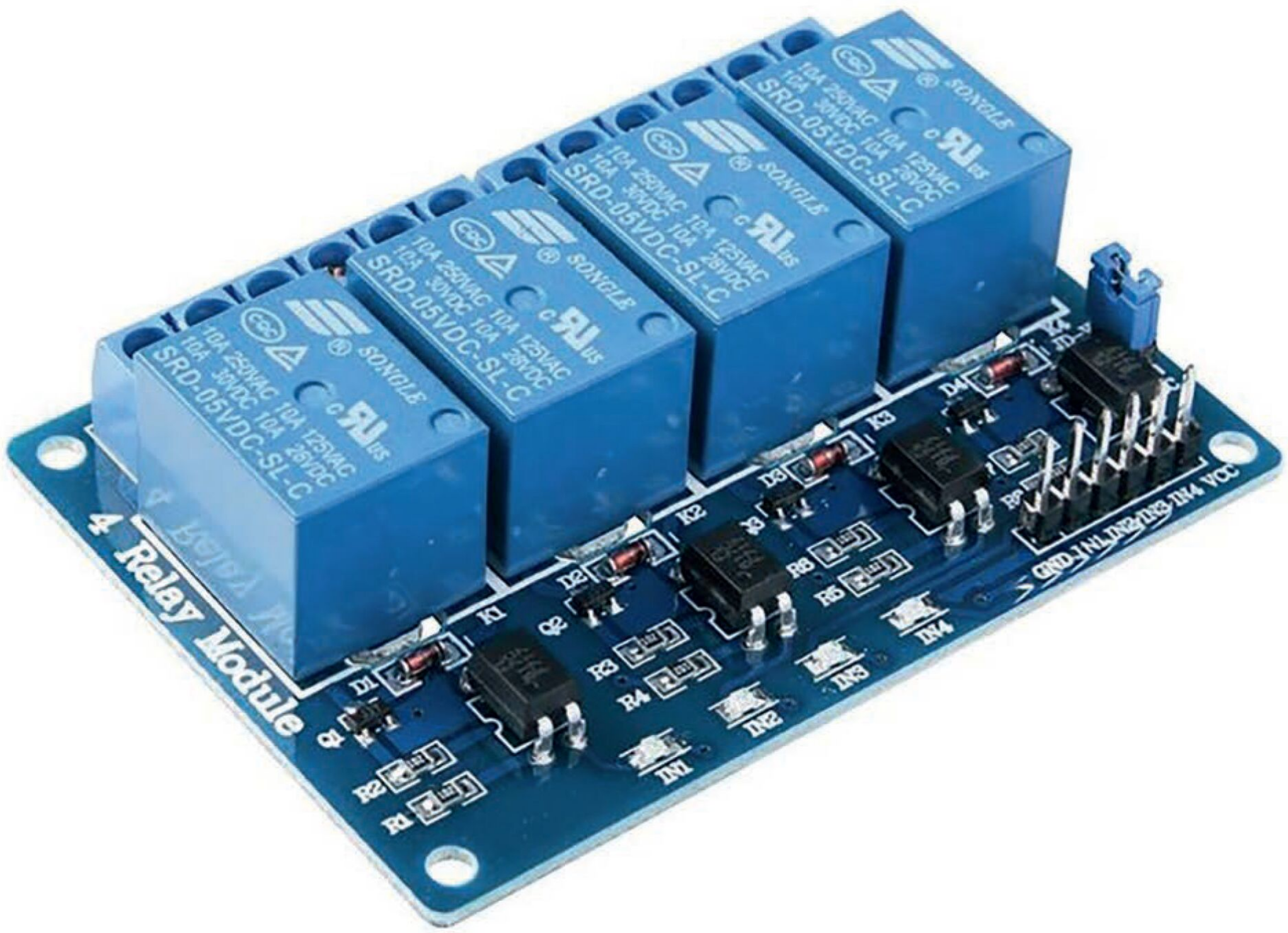
The connection between the metal wheel and the wiring can be by fine phosphor bronze strips lightly rubbing on the wheel's rear face, or by specially produced wheel lighting connectors. From this wheel connection, run fine flexible wires taking the rail power (DC or DCC) to the bridge rectifier's AC pair of terminals. Wiring from the capacitor is to the bridge rectifier's DC terminals. If possible, use a 25-volt-rated capacitor of around 1000µF minimum, but if you are absolutely sure that your rail voltage will never exceed 16, use a smaller (in physical size) 16-volt-rated capacitor.

Commercially made lighting units can be purchased for those who do not wish to make their own units. But making your own is a very cost-effective method per unit for the basic electronic components needed, excluding the wheel connection wipers.

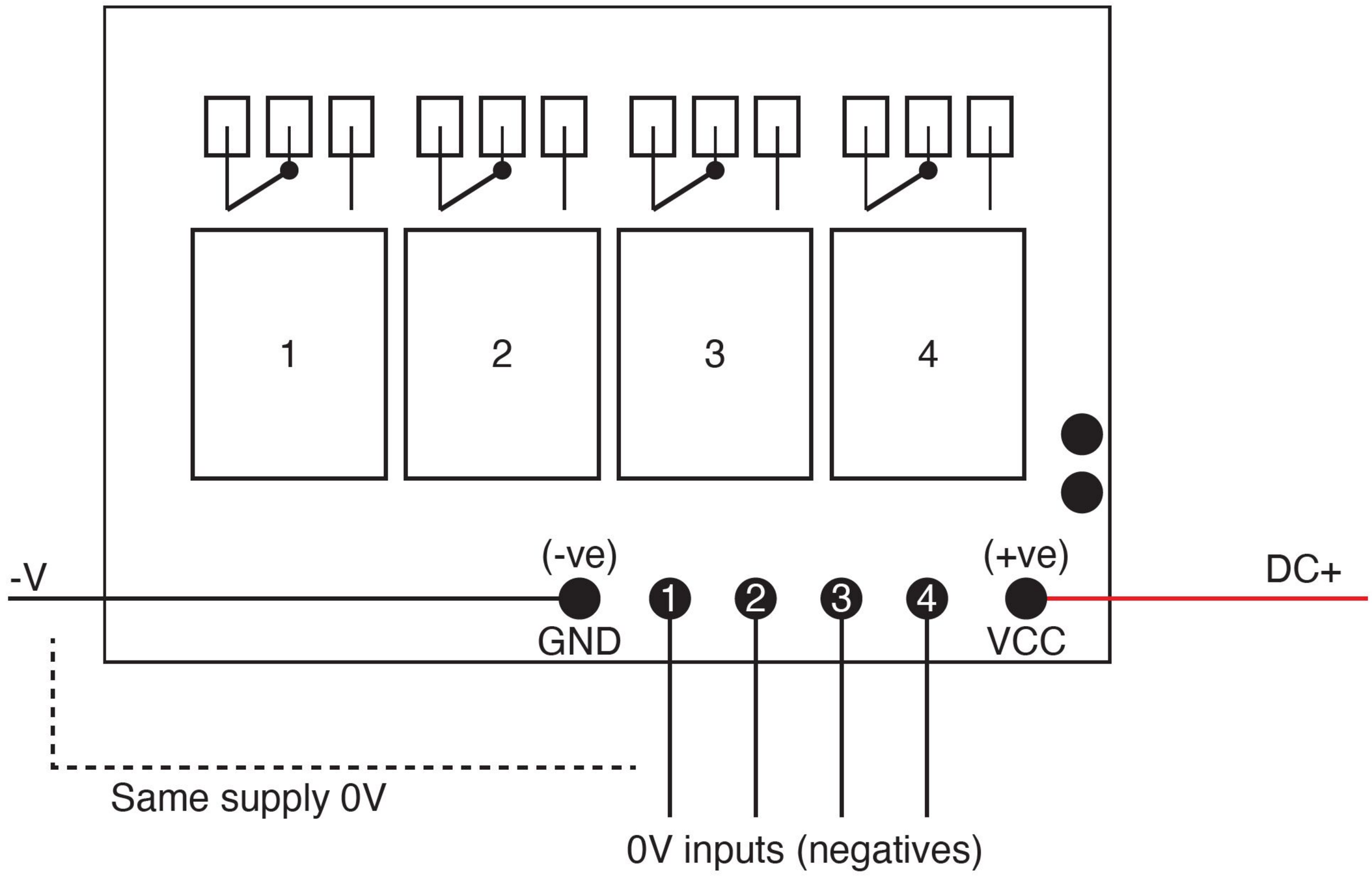
Building lighting

Building lighting can be added to most buildings, whether card, plastic or cast resin. The main thing with lighting is not to light every room and to ensure that no light can escape through the walls (light bleed). The latter can be prevented quite often by applying a coat of paint to the inside of the building, and the former by sectioning off the inside of the building with light-resistance material; this can be thick card or painted plastic, etc., ensuring that no light bleed occurs through the material or where any joints are made with other surfaces.

Filament lamps were used inside buildings for many years and can still be used, but their main disadvantages are the heat they generate and the power needed to feed them, especially where many lamps are lit at one time. Many filament lamps – 'grain of rice' (GoR) or 'grain of wheat' (GoW) – are rated at around 60 to 70 milliamps each. When all the lamps are added together to provide several lit areas, this soon mounts up! Therefore, LEDs have taken over the major role in illumination. Much like the carriage lighting mentioned previously, either single LEDs or the strip types can be used and, when used with suitable series resistors, they can be adjusted in brightness. Many LEDs will consume just a few



A typical four-way 5-volt interface board. Each relay has one set of change-over contacts. On this board the input is 5 volts DC and is made via the row of pins along the front right-hand edge. Opto isolators, one for each input/relay, separate the relay coil's operation voltage from the inputs for each relay. Normally the inputs are negative, but by moving a selector link they can be positive at the rated voltage, in this case 5 volts. Pins marked GND and VCC have a permanent 5 volts on them, GND being negative and VCC being positive. IN1 to IN4 pins are the inputs to operate each relay. The relays' contact connections are at the rear on the blue terminal blocks.
They are frequently sold with a choice of 5-volt, 12-volt or 24-volt operation. Mainly the 5 -and 12-volt versions will be used. Their operating voltage is marked on each relay's top.



An example of how they can be wired.

milliamps, typically 10 milliamps per lit LED or less. Therefore many more can be connected to the power supply without overloading it.

I always recommend using a regulated power supply rather than the uncontrolled output of a 'train controller'.

The reason is that a regulated supply voltage remains at the stated constant level regardless of loading, whereas the train controller or an unregulated supply can vary widely in its output voltage. For example, a 12-volt DC supply that is unregulated can be 18 volts or more with no loading or very little load, and reduce to below 12 volts when loaded towards its maximum rating!

Always make sure that a series resistor is installed with any LED, as this will limit current to the LED and ensure that it operates correctly. Normally strip LEDs (see the accompanying illustration) will have a series resistor built into each group of three, but there is no reason why an additional resistor cannot be added to further reduce the brightness of the strip.

Obtaining LED strips in 3- or 5-metre rolls from auction websites or direct from China retailers is about the cheapest way I have found to obtain a good quantity. The strip is pre-marked with cut lines to allow three LEDs plus a built-in resistor to be used, or multiples of three can be used. Once cut into the required number of ways, solder the feed wires to the tabs at one end. These are usually marked '+' and '–' and polarity must be observed. Unless you are fitting them outside, I would avoid the waterproof LED strips sold as being suitable for outdoor use, as they are covered with a clear coating that makes cutting them and soldering feed wires more difficult.

Sequential or random building lighting can add to the overall effect whereby lights are switched on or off automatically suggesting dusk and dawn periods, or they can randomly switch on or off, all controlled by an electronic master circuit board onto which they are wired. Such control items can be a simple timer unit offering variable on and off periods, Arduino or Raspberry Pi micro-controllers, or complex computer-controlled DMX lighting effect controllers. Discussion of how these operate is not a part of this book, but further details can be obtained via internet searches.

Other lighting effects

Simple lighting controls for a one-off effect are readily available, and can represent, for example, an arc welder at work, the arcing from the third rail as a train's pick-up shoe passes, or a camp fire flicker effect. Vehicle emergency beacon lights and road traffic light controllers are available in UK and continental styles. In fact, if it lights there is probably a module produced that will represent it! Ready-built modules are the simplest to use; however, more ambitious modellers who wish to dabble in electronics can build their own

A static grass applicator I made a few years ago – it runs off of a couple of AA batteries in the handle.

A commercially produced static grass applicator.

Above is a good example of static grass applied to the embankment and hill side the static grass fibres can be seen standing up. Image courtesy of Steve Mumford.

modules using programmable Peripheral Interface Controller (PIC) microchips.

(PIC) micro-controller circuits. The output current available is low, coming directly from a PIC, but by allowing a transistor to be switched from that output the PIC's output can be increased via the transistor; an alternative is to use a relay, then its contacts to switch a load. Ready-made relay interface boards, ideally with an on-board Opto-coupler connection between the input and the relay coil, are cheaply available for direct operation from a PIC or micro-controller. Look for the 5-volt versions for general use with PIC or micro-controllers.

Electrically lit shop signs, whether static, flashing or scrolling are manufactured in various scales and are a simple 'plug and play' concept with the controlling electronics either built in or provided as a small circuit board onto which the sign connects.

Lighting on station platforms, goods yards, loco stabling areas and of course road street lighting all adds to the character of the model when the railway room lights are dimmed and the layout illumination is turned on. Street and station area lighting is sold in many forms, from modern street and platform lights to representations of gas lights. Many are LED lit and draw low power (current) from the supply. However, there are still a large number of ready-made filament lit lamps available and the user should be aware of what they are obtaining, as filament lamps will need far more power (current) to allow multiples to operate. They also are prone to run very hot too. See the previous section regarding GoW and GoR lamps. A separate power supply, which could also feed building lighting, is the ideal way of suppling power to these. I would always recommend opting for a DC Regulated power source.

Electro-mechanically operated effects are also used – for example, a rabbit popping out of its burrow. Moving semaphore signal arms are common too. Both can be obtained ready-made or can be home-made to operate via a servo motor and control circuit board.

Static grass

Static grass is growing in popularity as the process helps to truly represent grass. In its simplest form it is applied to a base of wet PVA glue via a 'puffer bottle'; the bottle is filled with fibres and, when pressed, produces a puff and a static charge is generated as the puffer emits the grass fibres. However, a better effect is achieved by using a special static grass applicator tool. This normally looks either like a tea strainer, or a more expensive tubular

device. Special static grass is sold in various lengths, and loaded into the 'tea strainer' or the hopper of the tubular device. PVA glue is spread over the area to be treated, and a pin or nail is inserted into the baseboard, ensuring that it passes through the wet PVA. The crocodile clip of the static grass device is connected to the pin or nail and when the button is operated to power the device a static charge is produced. As the fibres fall into the glue they stand mainly upright in it. By varying the length of the fibres long grasses can be represented with shorter grasses applied in other areas. When the PVA dries the grass fibres are held securely upright.

Homemade static grass application tools can be made from former converted electric fly swats or using negative ion generators and a metal mesh tea strainer or similar small mesh. YouTube has several videos of how to make these. On page 50 is one I made a few years ago – it runs off of a couple of AA batteries in the handle.

I would err on the side of caution for DCC users and recommend when using a static grass generator that any DCC-fitted locos are removed from the rails and kept off the layout – it may also be advisable to earth the rails. Certainly, do not have a DCC system powered up! But remember to remove the earth as soon as grassing work has ended! I haven't found any issues with static grass applicators, but I feel caution may be the better option than losing a loco's decoder or a static accessory decoder due to possible static charge leakage!

10
Basic Electronics

I must at the outset advise the reader that I am by no means an electronics engineer, but I have an understanding of the basics and build items that help with train control and automation. For more detailed electronic circuits I would direct the reader to specialist books written in their entirety for railway modellers and hobbyists.

Some basics first.

Power source

Most electronics requires a stable and smooth DC power source. This can be from a battery, a regulated DC power supply or, at times, a USB connection. AC can be used, but will need to be converted to DC via a full wave rectifier, then a smoothing capacitor is added across the DC output. Many circuits will also add a voltage regulator to ensure that the output volts are "clamped" to whatever the regulator is set to. Voltage regulators are explained later in this chapter.

Our power is normally referenced in wiring diagrams as VCC and zero (0) volts. VCC is the positive full voltage of the circuit, while zero volts, or 0 volts, is frequently the negative. Note that the negative can also be referenced as VSS. However, where a split or dual supply is used it can have a +VCC (positive) and a -VCC (minus negative) with a common zero volts, which is occasionally referred to as 'ground' – note that this is not the earth. The basic two styles are shown later under the regulated power supply heading.

Resistors

This is a device that has an ohm or resistance value and is added to a circuit to reduce current and voltage to a predetermined level as calculated. The ohm value of resistors is set in predefined value steps known as 'E' values, which were agreed in the 1950s and are still upheld today. The ohm value of an available resistor is therefore set by its E ranges of E3, E6, E12, E24 and E48, E96 and E192. The higher the E range number the more resistor values are available in that range. Additionally, the E number also denotes the tolerance values allowed for a resistor. E3 is 50% tolerance, while E6 is 20%, E12 is 10%, E24 is 5% and E48 is 1%. That is the amount by which the resistor's ohm value is permitted to be above or below the stated value. As an example, an E12 range resistor of 100 ohms has a 10% tolerance, so its actual value can be anywhere between 90 and 110 ohms. These tolerance ranges are normally 1%, 2%, 5%, 10% and 20%, and are denoted by a coloured band at the end of the resistor — 1% is brown, 2% red, 5% gold, 10% silver, and 20% has no markings.

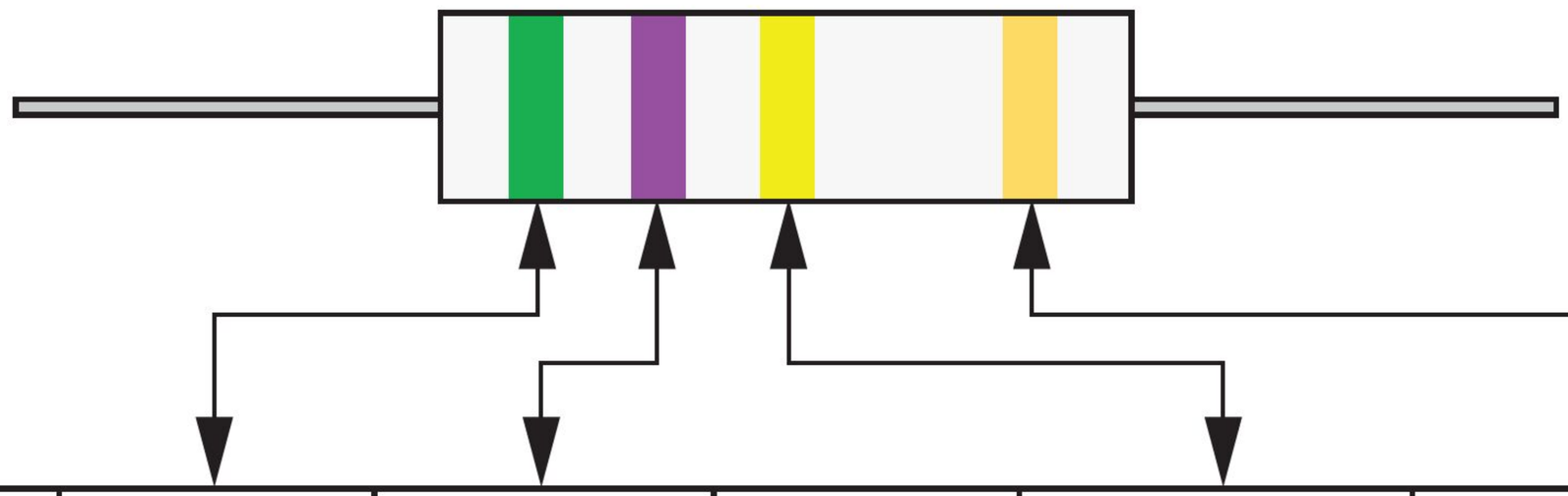
In most uses the modeller can ignore E3, which is now generally no longer available, and the E6 range, which are very limited in the values available and are now considered mainly out of date. All resistors in each E range are to a decade value. For example E12 range resistors will be found in ohm values of 1.0, 1.2, 1.5, 1.8, 2.2, 2.7, 3.3, 3.9, 4.7, 5.6, 6.8 and 8.2 (12 set ranges). These then increase in decades, so for example 2.2 ohms also in its E12 range as 22, 220, 2200, 22000, 220000 and 2200000 ohms. Therefore the largest E12 value resistor in that E12 decade range is 2.2 million ohms, or 2M2.

Circuits will then use either the letter 'K' or 'M' to help prevent long digits having to be written. K is Kilo or a thousand and M is for Mega for a million, so for example 3300 ohms will be shown as 3K3. A 33,000-ohm resistor would be shown as 33K and 330,000 is shown as 330K; finally, 3.3 million ohms is shown as 3M3.

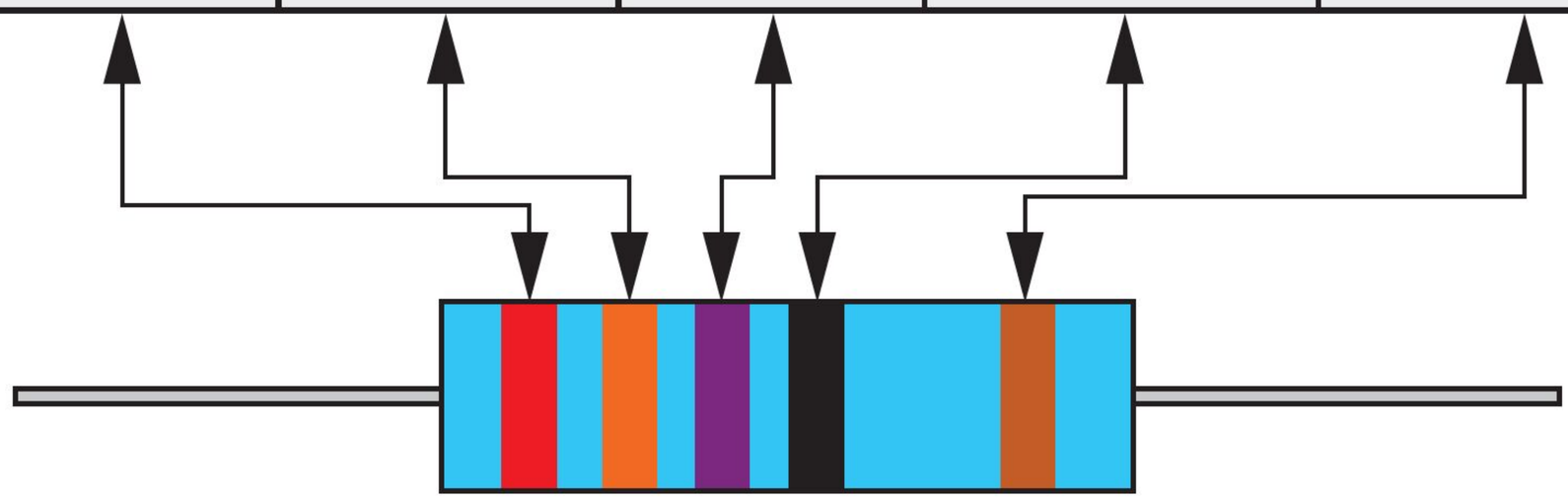
Resistors will normally be colour-coded and reference to the banding is essential to ensure the correct value of resistance is being used. Equally a resistor can be quickly checked by the use of a multimeter set to its continuity (ohms) range and the leads connected to the resistor.

E12 values							
1R0	10R	100R	1K0	10K	100K	1M0	10M
1R2	12R	120R	1K2	12K	120K	1M2	
1R5	15R	150R	1K5	15K	150K	1M5	
1R8	18R	180R	1K8	18K	180K	1M8	
2R2	22R	220R	2K2	22K	220K	2M2	
2R7	27R	270R	2K7	27K	270K	2M7	
3R3	33R	330R	3K3	33K	330K	3M3	
3R9	39R	390R	3K9	39K	390K	3M9	
4R7	47R	470R	4K7	47K	470K	4M7	
5R6	56R	560R	5K6	56K	560K	5M6	
6R8	68R	680R	6K8	68K	680K	6M8	
8R2	82R	820R	8K2	82K	820K	8M2	

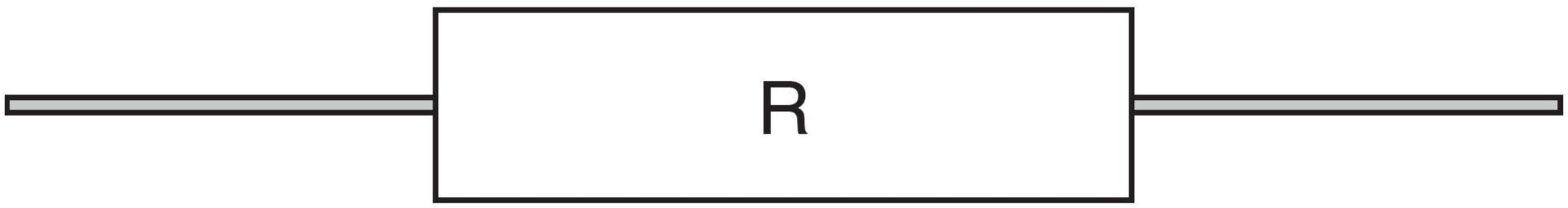
Table showing the common E12 resistor values.



COLOUR	1st BAND	2nd BAND	3rd BAND	MULTIPLIER	TOLERANCE
Black		0	0	1Ω	
Brown	1	1	1	10Ω	±1%
Red	2	2	2	100Ω	±2%
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	±0.5%
Blue	6	6	6	1MΩ	±0.25%
Violet	7	7	7	10MΩ	±0.10%
Grey	8	8	8	100MΩ	±0.05%
White	9	9	9	1GΩ	
Gold				0.1Ω	±5%
Silver				0.01Ω	±10%



The standard resistor colour coding.

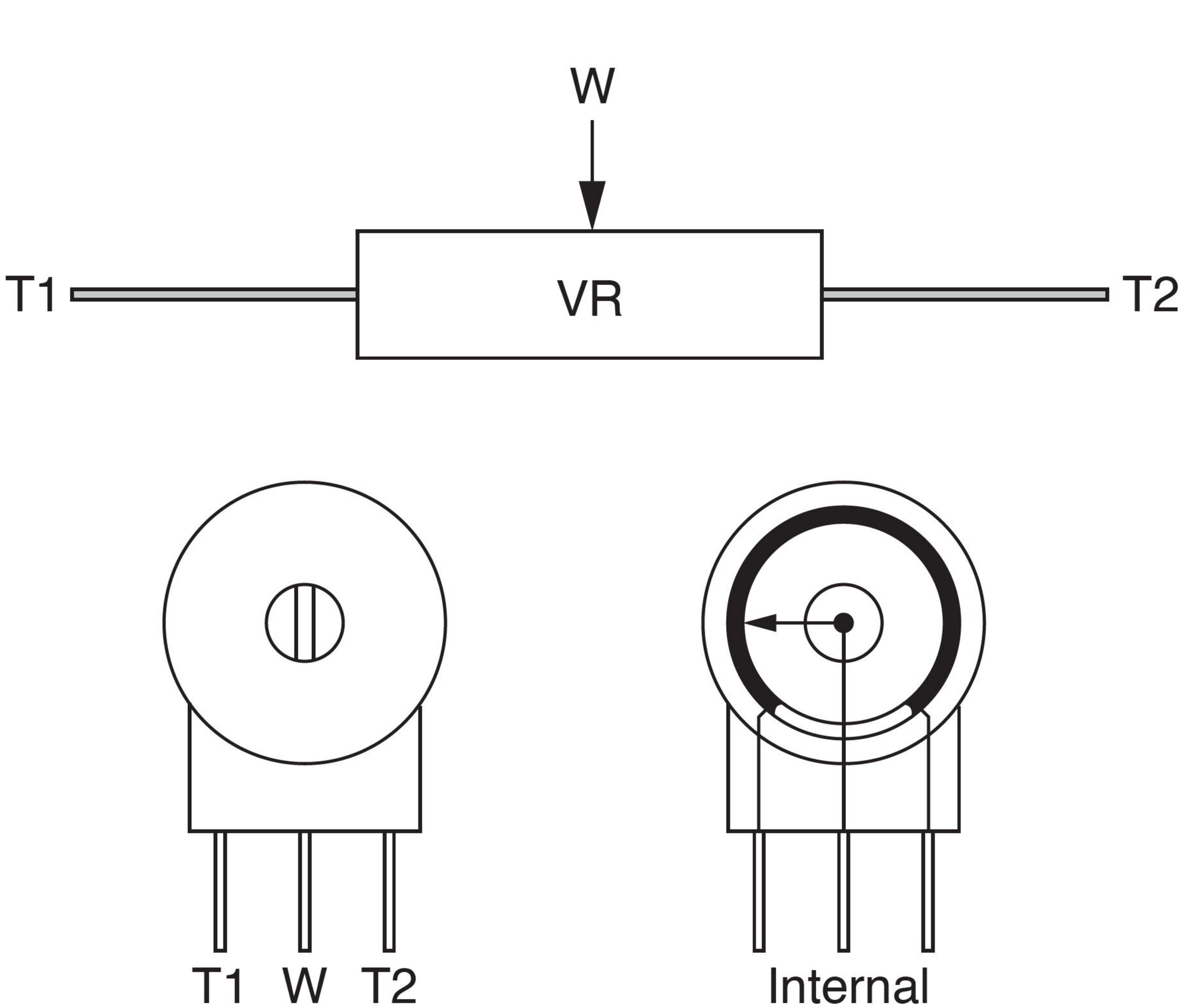


Fixed value Resistor symbol.

Note that this is best done with the resistor removed from the circuit, as it is very easy to get false readings from other components on a circuit board! Never try to check a resistor's value with a circuit powered up!

Resistors come in two main styles, fixed value and variable value. The latter is usually known as a potentiometer, or "pot" for short, and will have a set top value ohm range; by turning the shaft or moving a slider up or down the resistance is adjusted from minimum to maximum.

The adjustable wiper's position on the variable potentiometer sets the resistance value on the 'W' pin connection. By turning the wiper, more or less resistance is inserted into the circuit. The resistance value of the variable resistor is that measured across T1 to T2. So, for example a 5K variable resistor can be set to anywhere in the range of 0 (zero) to 5000 Ohms. Variable resistors come in two defined resistor adjustment types: linear and logarithmic. The linear resistor has a constant resistance all along the track, so the wiper's position is proportional in ohms to its position. These are usually referred to as Type A. The other style is 'log' or logarithmic, and is Type B, more suited to audio applications.



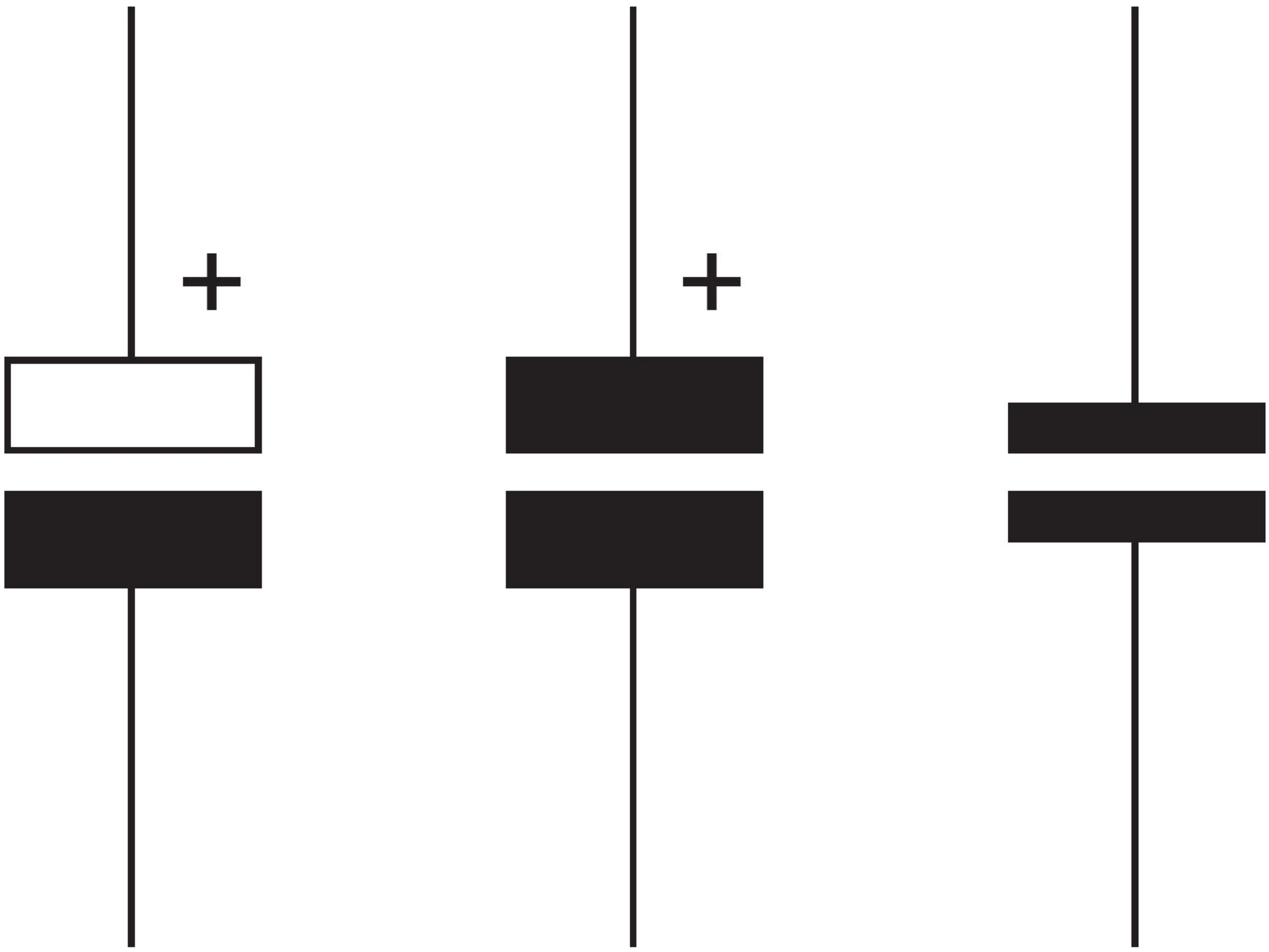
Variable value resistor symbol.

Capacitors

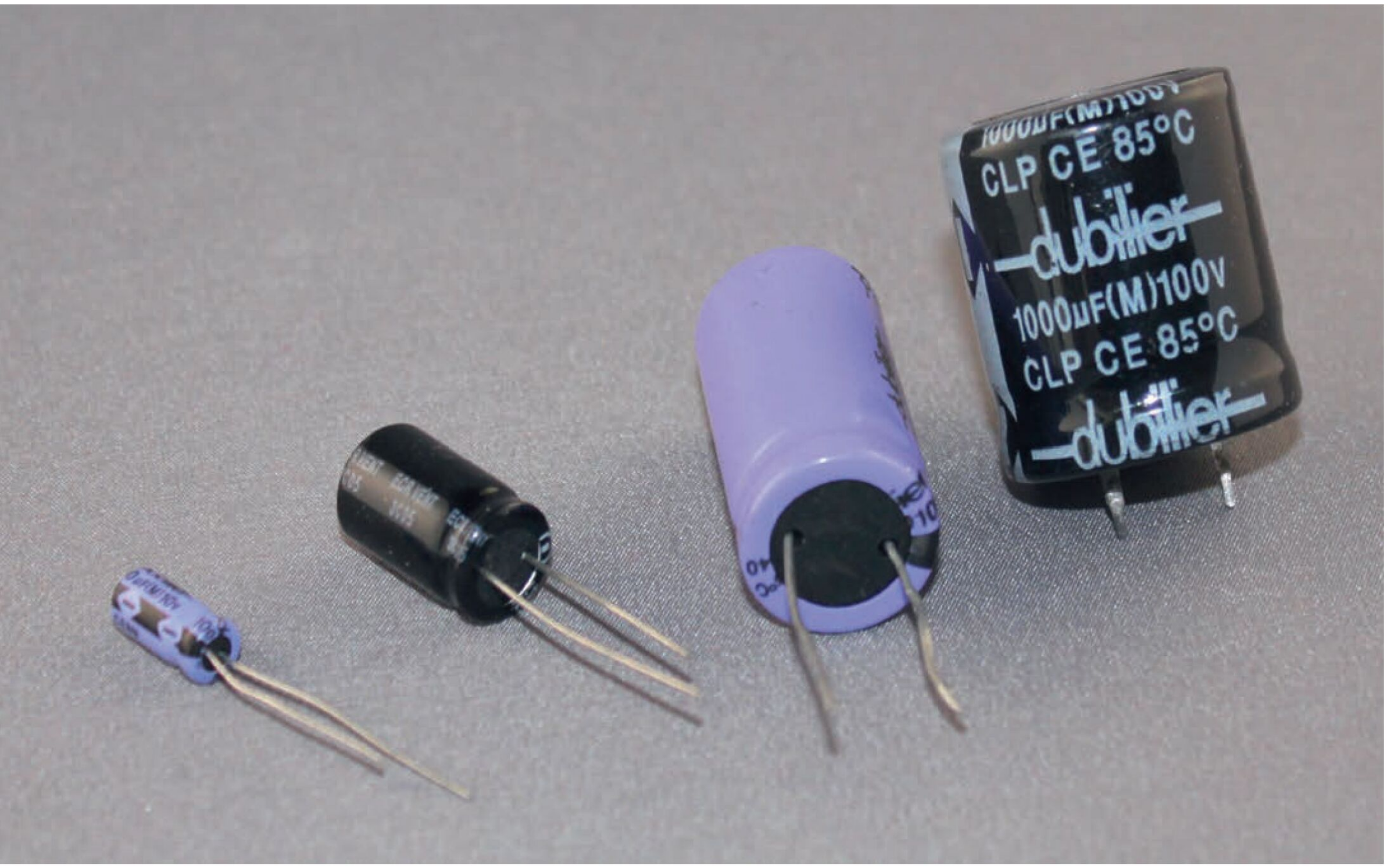
Again, much like resistors, capacitors are available in preset ranges, and are sold in values of a Farad. A Farad is a fairly large amount of capacitance and is rarely used except in so-called Super Capacitors, where values are often found in Farads. The values of capacitors are normally in micro-Farads (µF – 1 millionth of a Farad), nano-Farads (nF – 1,000 millionth of a Farad), and Pico Farads (pF – 1 million millionth of a Farad). Capacitor values can be marked in one of two ways. For example, 100nF is the same as 0.1µF.

The working voltage of a capacitor is usually of great importance, and if exceeded can result in failure of the capacitor. The working voltage of a capacitor defines the maximum continuous voltage that may be applied across it. This is normally printed on the case, or will be in the datasheet. The voltage normally refers to the largest DC voltage that can be applied to that capacitor. Be aware that when a capacitor is operating on a circuit with an AC waveform superimposed on a DC voltage, the voltages experienced may be well above the DC rated value, in which case the capacitor's rated DC voltage needs to be increased to at least 1.4 times that of the RMS measured AC voltage.

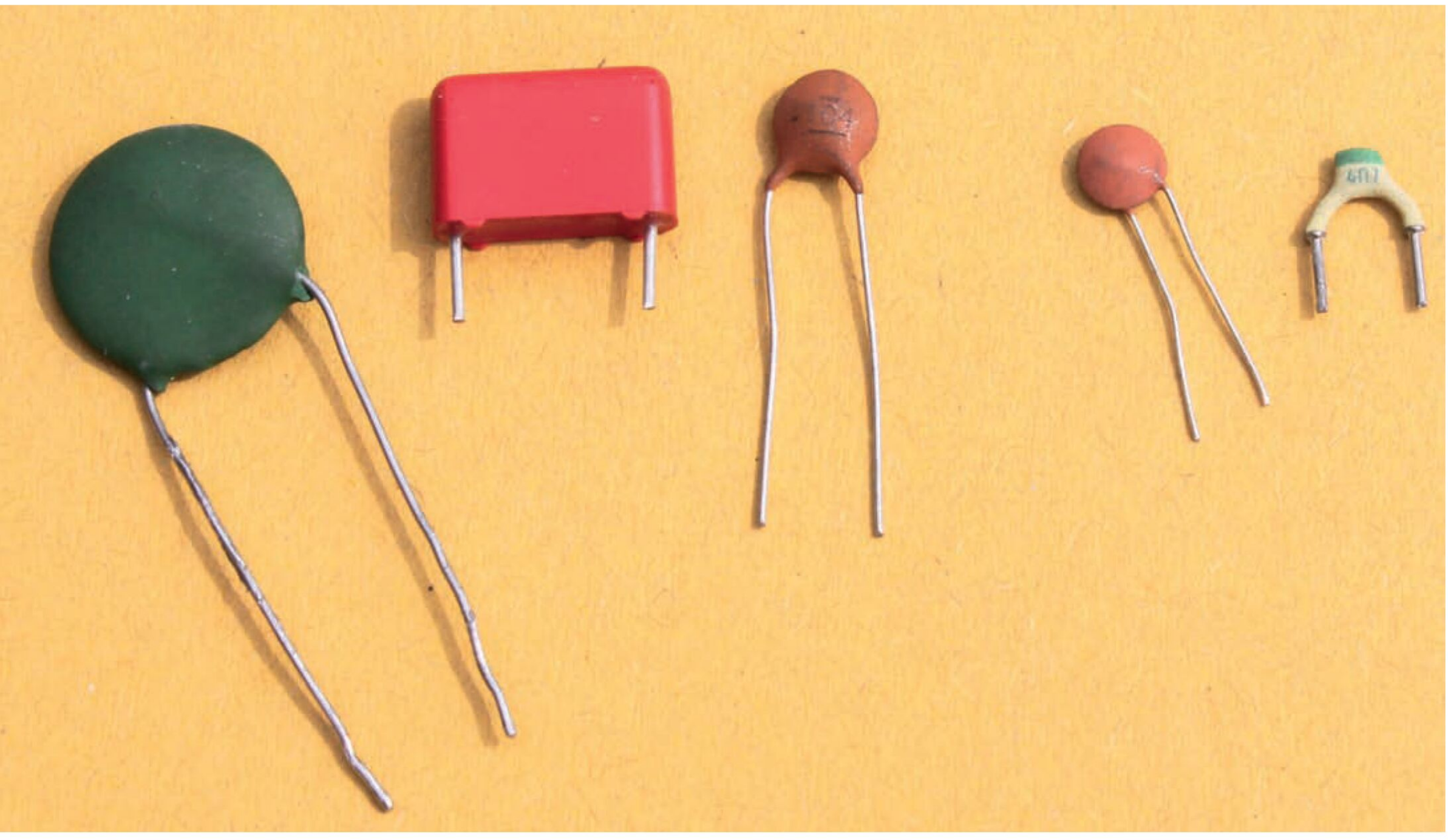
The two major types of capacitors that will be encountered are the electrolytic (polarised) and ceramic or mica (non-polarised) styles. Polarised capacitors have to be connected the correct way around on the circuit, but non-polarised can be fitted either way around. Generally, electrolytic capacitors are used to smooth AC ripple on a DC circuit or to store power for short periods. Typical examples in the model railway field would be as a power supply used to feed electronics where as much of the AC ripple part of the supply is



Typical schematic drawing symbols for electrolytic (polarised) and non-polarised capacitors. The left-hand symbol is mainly used in the UK and European circuit diagrams while the middle version tends to be more frequently used in US wiring diagrams. The plus symbol can at times be omitted on the electrolytic European version. To add to confusion and very similar is the version on the right shown with thinner solid plates but without the plus symbol, which is used for non-electrolytic capacitors such as Ceramic types or other non-polarised capacitors, occasionally the lower plate of the non-polarised symbol is shown as a crescent or the ends are slightly in a downward curve.

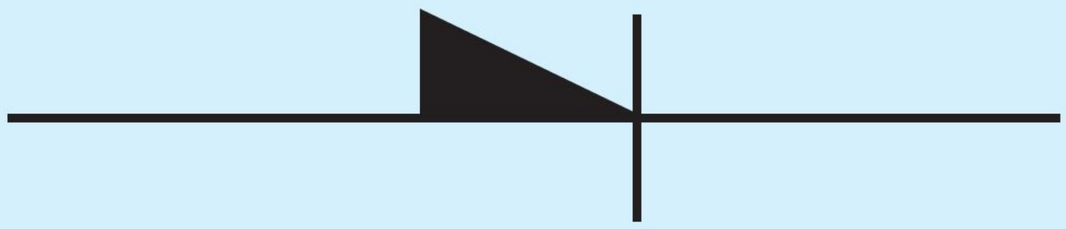


Above is a selection of electrolytic capacitors.

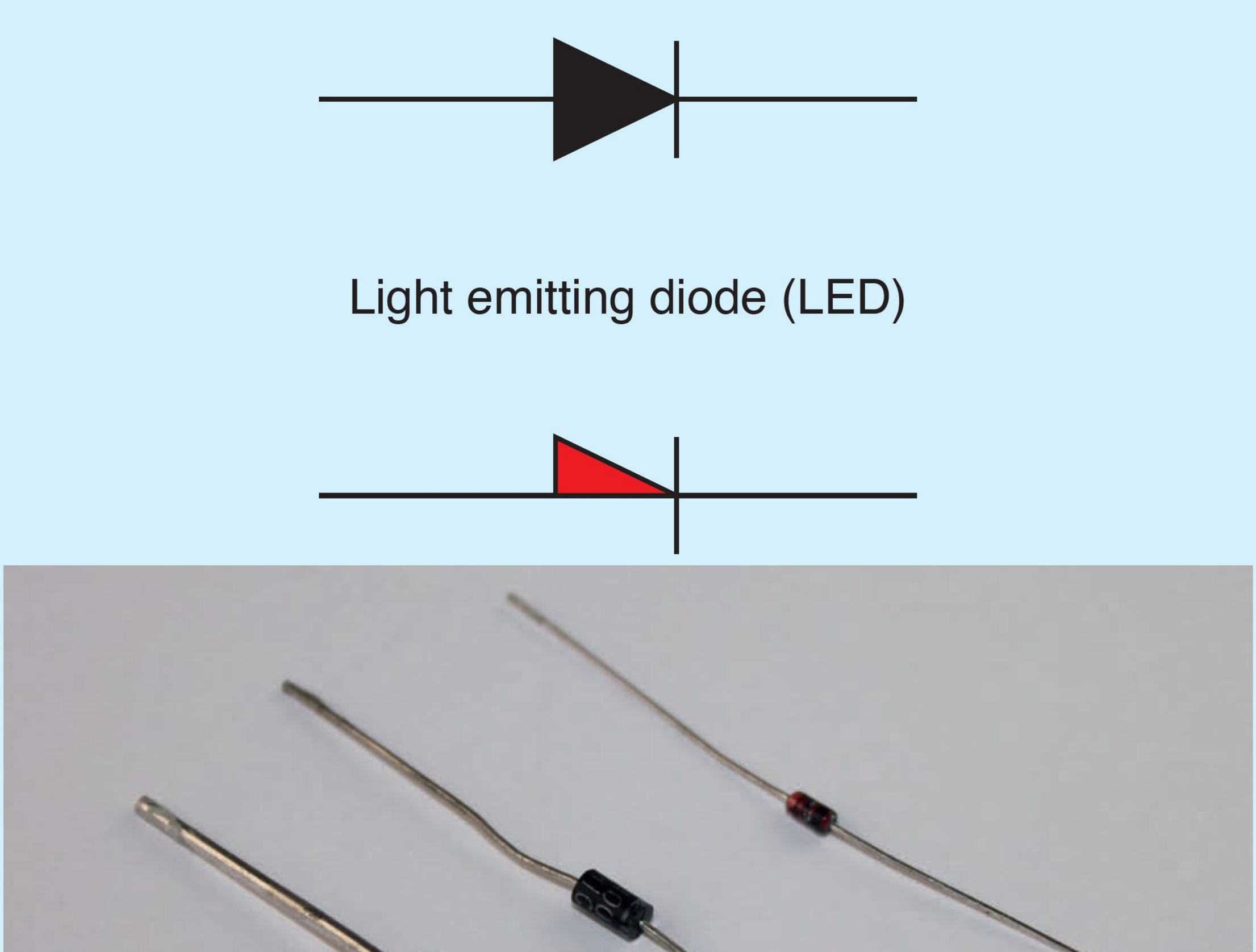


Above is a selection of non-polarised capacitors.

Standard Diode Symbols



Light emitting diode (LED)



A selection of diodes. Nearest is a 1N5401. Middle a 1N4001 and furthest from the camera is a 1N4148 all do the same job but they handle different voltages and currents. The silver banded end denotes the cathode (Negative) end of the diode.

needed to be removed after rectification or in a Capacitor Discharge Unit (CDU) used to operate solenoid point motors where power is stored and released as a pulse when required.

Ceramic non-polarised capacitors are frequently used across a loco's electric motor to help remove Radio Frequency (RF) interference caused by the sparking of the motor brushes on the motor commutator. Or they can be fitted inside a DC track power connector to help prevent any arcing interference that has occurred between rail and wheels and then being able to use the rails and associated wiring as a long antenna (aerial).

As stated, a standard electrolytic capacitor must be connected to the supply the correct way around. Failure to observe this will normally lead to the capacitor exploding! The negative lead is normally the shorter one and the side of the electrolytic capacitor case is usually marked with a 'negative' marking directly next to the negative lead. Never connect a standard electrolytic capacitor directly onto an AC power supply.

Diodes

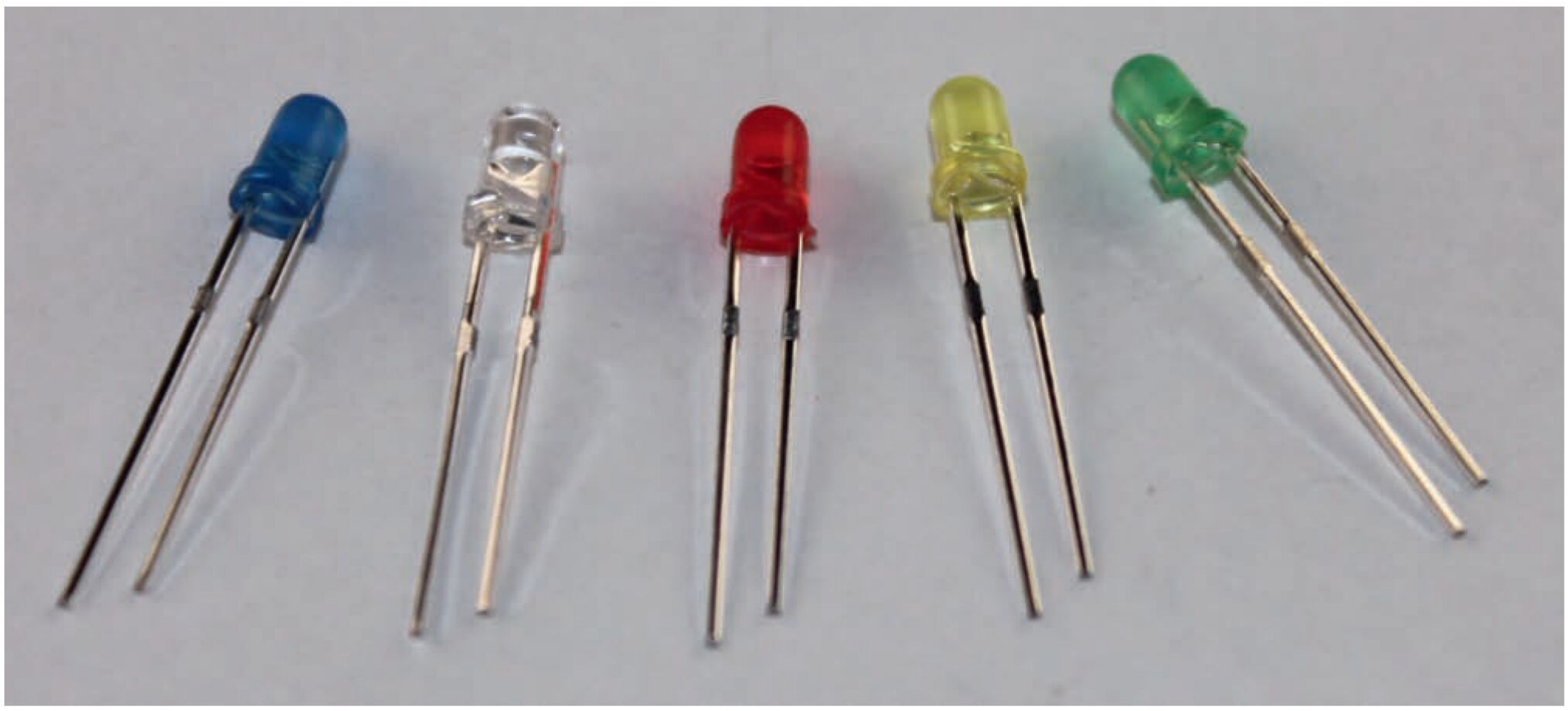
A diode in its most basic form can be considered like a one-way valve to the flow of electrons. Current flows through the diode in one direction only, from anode to cathode. If the flow is reversed the current is blocked. It is important not to exceed the diode's rated voltage or current as it will quickly become stressed and fail.

For use on model railways two types of diode will usually be encountered, conventional and light-emitting. Conventional diodes can be broken down into two main styles, standard silicon and high-speed. High-speed will be able to deal with high-frequency operations such as those encountered on a DCC (digital) layout, while the standard diode is frequently used to convert AC to DC, either by half wave or full wave rectification. Diodes are normally marked at their cathode end by a band of colour, frequently a silver or white band on an all-black body.

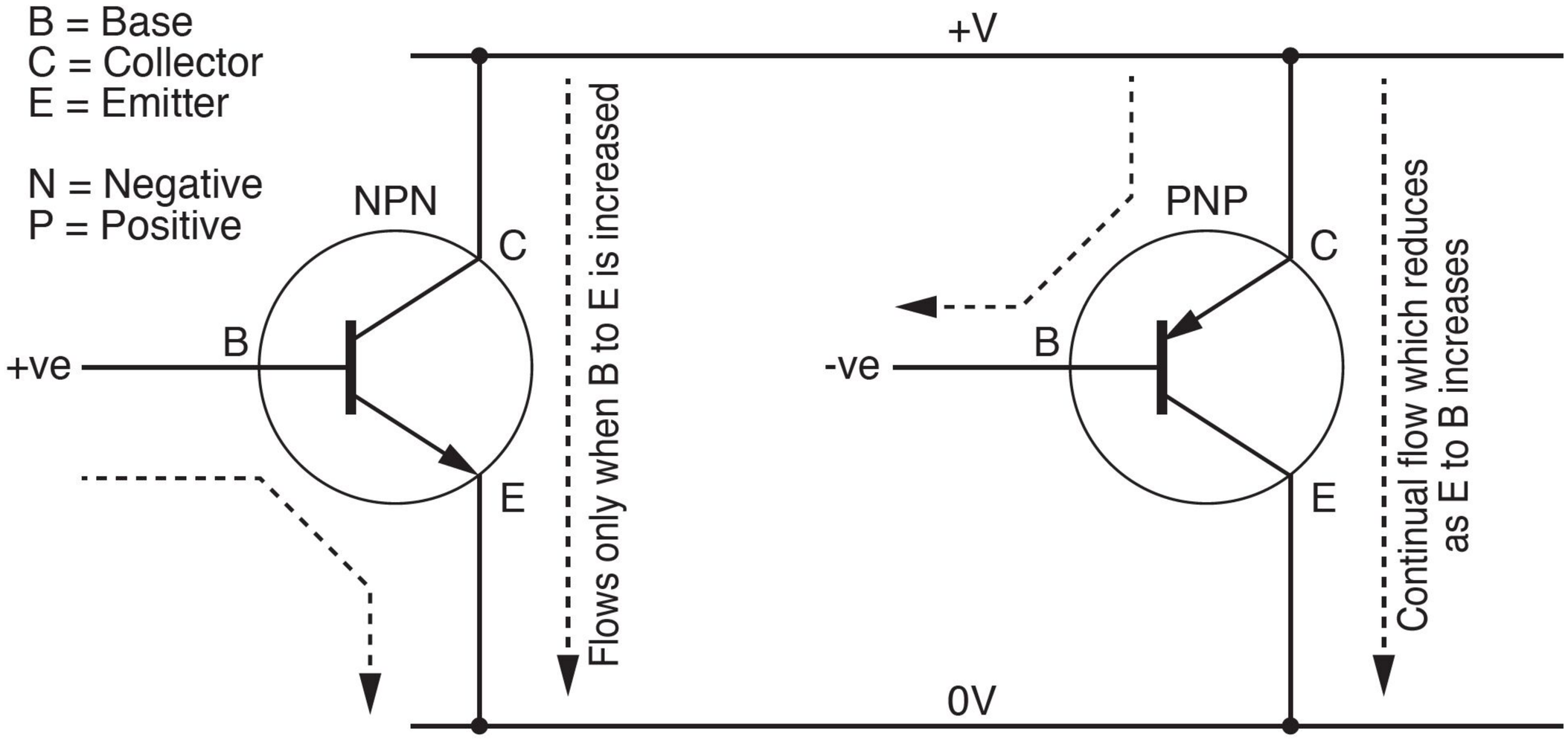
Light Emitting Diodes, or LEDs, are similar, but emit light – visible or infrared. However, they are not very good at blocking reverse current flow and have a much lower threshold for this than a standard diode. Their advantages are a low operating current, reasonably adjustable light output, cool running temperature and longevity when compared to filament lamps. The longer lead on an LED is normally the Positive or Anode connection.

Transistors and integrated circuits

The transistor has been with us since around 1950 and gained a major hold in the electronics industry from around the mid-1960s. It can switch a current on or off or operate as an amplifier; it is also used to increase the gain in a circuit by adjusting the base voltage. There are far too many variations of transistor to begin making comparisons here, but they fall into two major types – NPN or PNP – that is Negative/Positive/Negative or the opposite, Positive/Negative/Positive. Both do similar work and the choice is determined by how the transistor is connected into its overall circuit. Generally the standard transistor will have three leads: collector, base, and emitter. Basically, the collector 'collects' the charge, the emitter 'emits' the charge, and the base is the control by which the transistor is switched on or off. With the NPN transistor, when a positive current flows through the base emitter junction electrons leave the emitter and flow into the base. As a result, most of the electrons are then able to flow through from the emitter into the collector, attracted by the positive overall. The



Assorted 3mm LEDs. Note the longer lead is the anode (positive).



These are the standard diagrammatic symbols for both type NPN and PNP transistors.

more the base is supplied with potential, the harder the transistor turns on. This description is very basic and is not meant to form a tutorial on the workings of a transistor! Electrons flow in the opposite direction to current! However, unfortunately it is not quite that simple, as you need to calculate the base resistor value to allow the point of saturation to fully turn on the transistor. The PNP transistor requires a negative base to allow it to turn off.

Integrated Circuits

Integrated Circuits (ICs) are simply many transistors placed inside a package. How they work and what they operate will depend on the type of IC. Some are used for switching, some for amplification, and others for inverting their input to the output. Some store messages such as data and keep it stored even when powered off, while others simply operate only when the power is turned on. Again, what and how ICs operate is too a vast field for this book to cover, so if the reader wishes to gain more knowledge a wealth of information is available on the Internet or in specialist electronics books.

A simple circuit that the modeller may find useful is a voltage regulator, which keeps the output voltage at a constant level. It uses a bridge rectifier, electrolytic capacitors, a ceramic capacitor and a fixed-voltage regulator. It should also use a heat sink of suitable metal – aluminium is frequently used for this purpose.

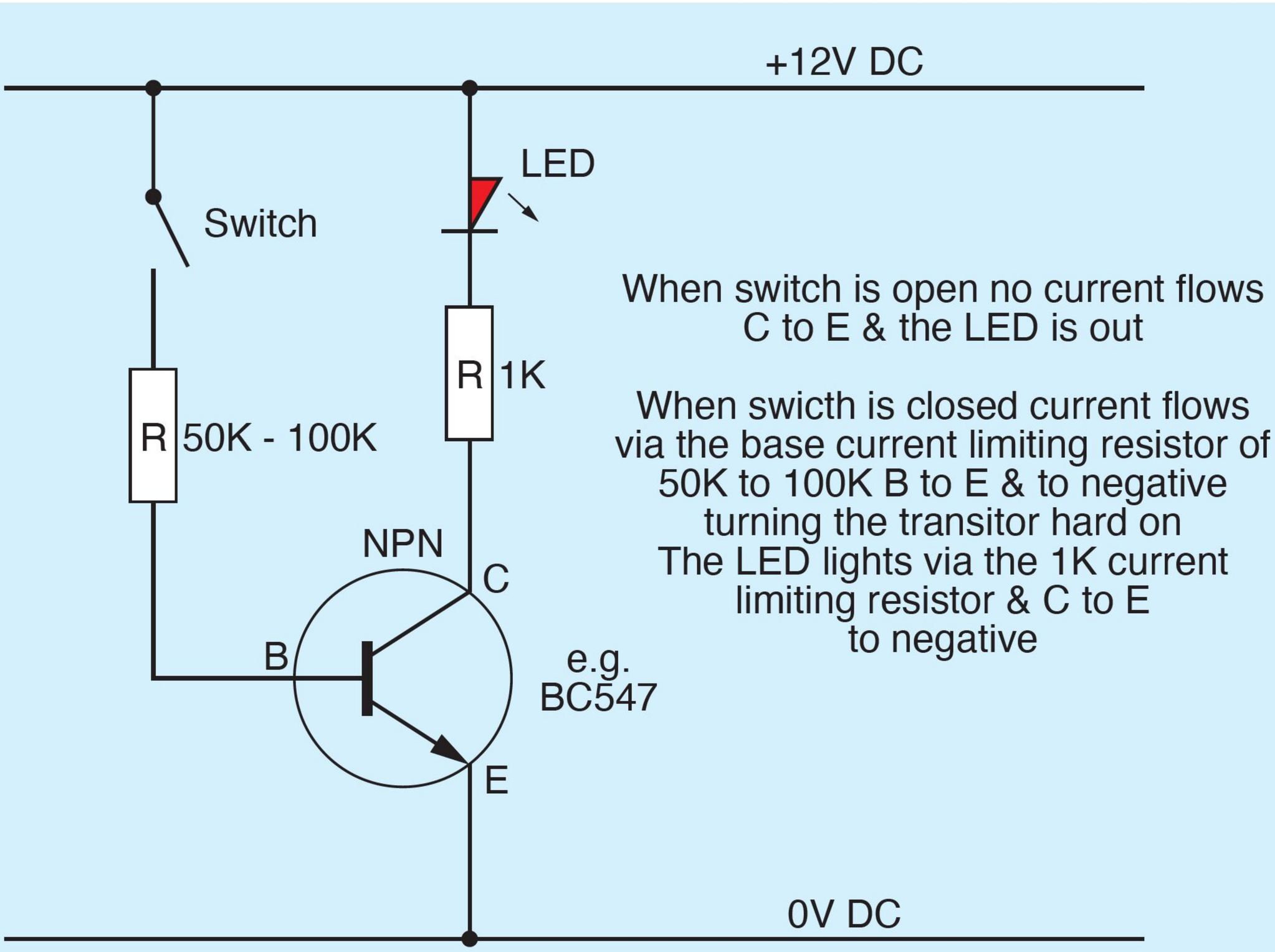
I would highly recommend that the electronic experimenter obtain a 'bread board', which is used to easily assemble components and carry out checks and tests before building the final circuit on stripboard or similar PCB material. When using stripboard, the copper tracks will need to be cut through at strategic locations to stop current flowing into that part of the circuit where it is not required. The copper needs careful cutting and ideally a Spot face cutter tool is used, but a 3.0mm sharp twist drill bit can also be used with care.

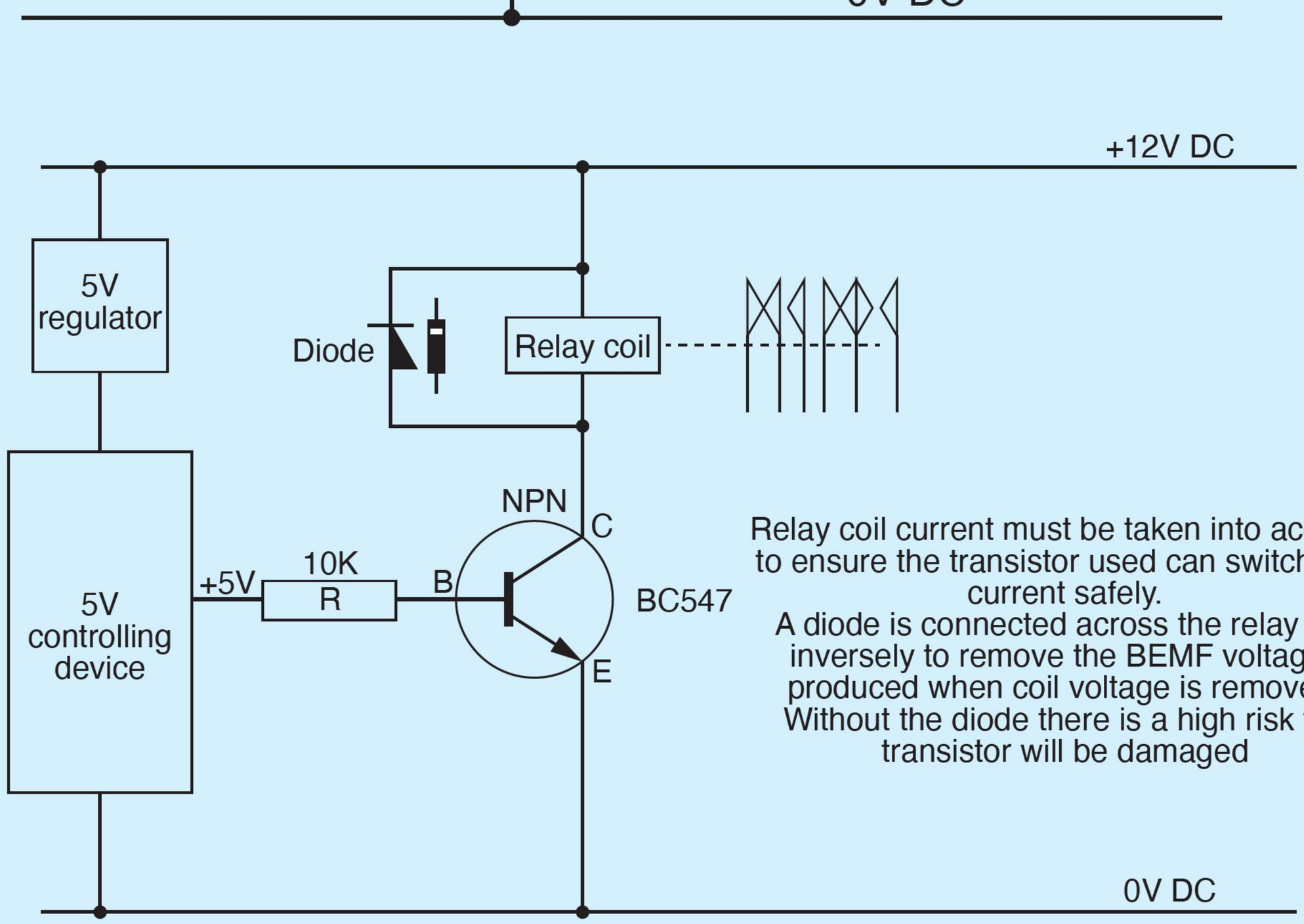
A CDU is relatively easy to produce at home. The circuit requires an input diode to ensure that the positive is always correctly presented to the capacitor(s), or use a bridge rectifier and a transistor that can handle the instantaneous discharge current from the capacitor(s). Note the reference to capacitors in the plural, as more than one may be used to allow greater storage capacity and a larger discharge, especially where two or more solenoid motors are to move from one switch operation. The input volts to the CDU can be 16 to 22 volts AC or 22 to 30 volts DC. If a bridge rectifier is used, both AC and DC inputs can be connected either way round to the input terminals. Please be aware that with any electrolytic capacitor circuit the capacitor, once charged, retains that charge for a long time once power is turned off. If working on the circuit, turn off the power and operate a point switch to discharge the capacitor(s) safely.

The rated working voltage of an electrolytic capacitator should always be at least 1.5 times that of the input voltage and ideally 2.0 times the input volts.

PIC micro-controllers

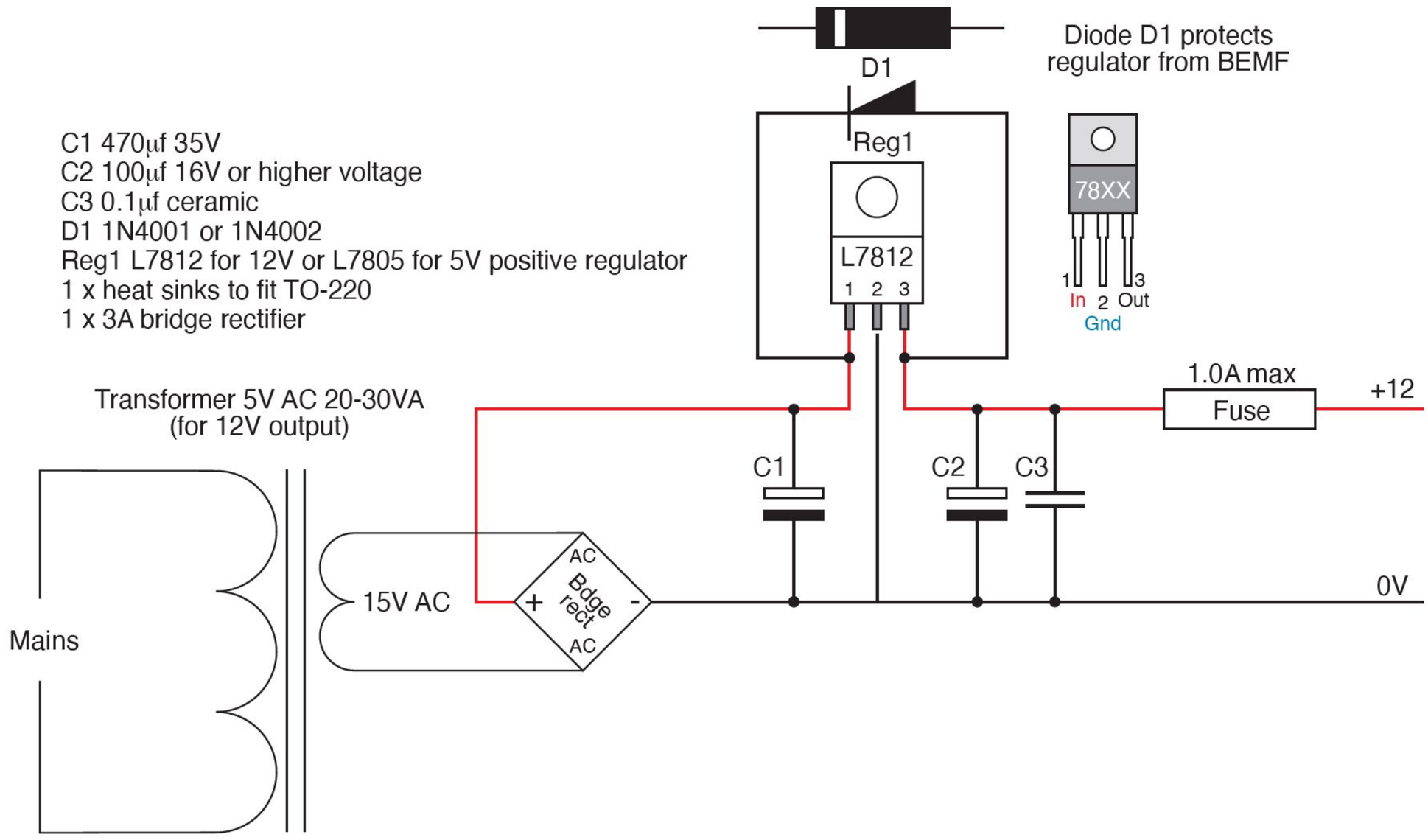
These little ICs are programmable and can be used over and over again for different types of circuit, although the user should obtain the best Peripheral



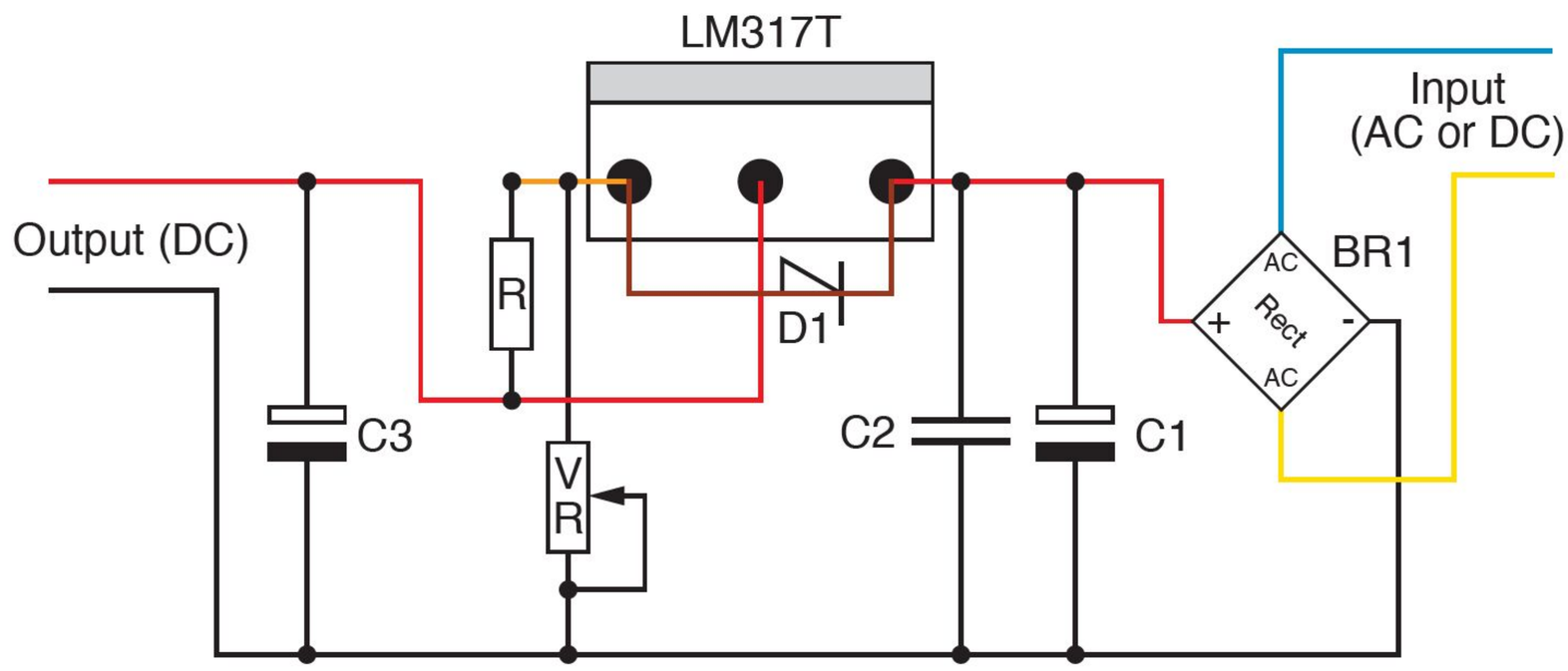


Simple examples of a transistor doing the same job – switching a device on or off. Here they are used to operate an LED and a relay.

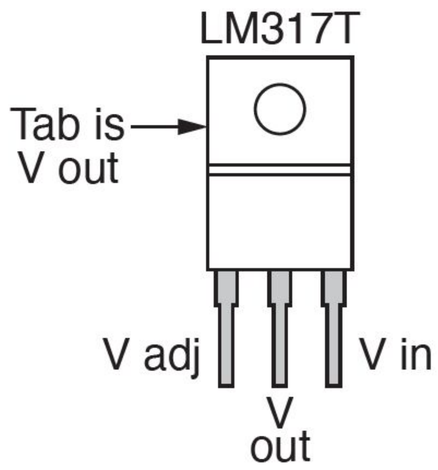
C1 470µf 35V
C2 100µf 16V or higher voltage
C3 0.1µf ceramic
D1 1N4001 or 1N4002
Reg1 L7812 for 12V or L7805 for 5V positive regulator
1 x heat sinks to fit TO-220
1 x 3A bridge rectifier



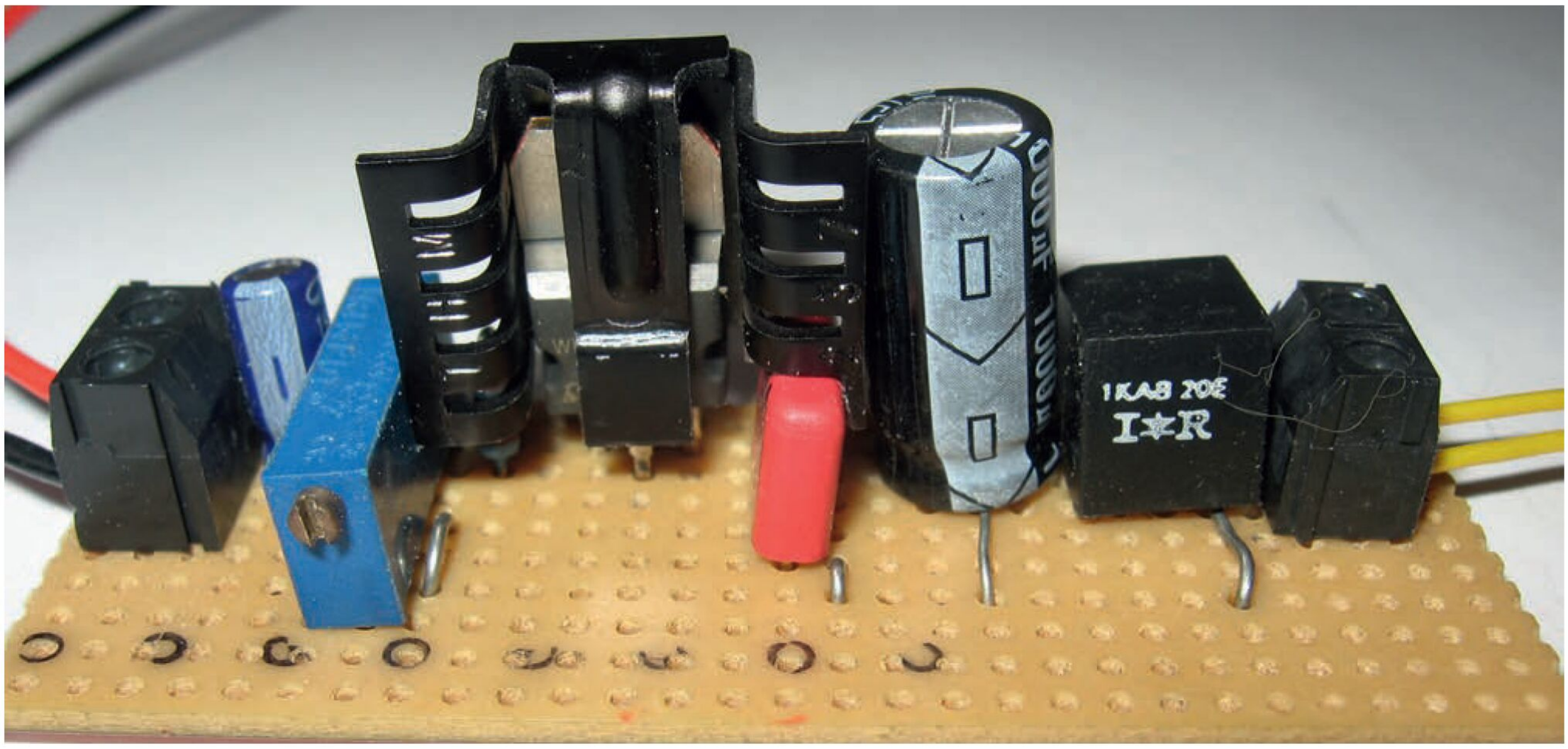
This basic 12-volt voltage regulator circuit provides 12 volts DC at up to 1.0 amp when a suitable heat sinking is fitted. It needs an input of around 14 to 16 volts AC or more and can also be DC at a higher voltage than the output required. When AC input is used, the rectifier converts it to a DC output. Note that fixed-output regulators are available in several fixed-output voltages, and 9- or 5-volt regulators are also frequently used. The bridge rectifier converts the AC to DC, and the first electrolytic capacitor smoothes the ripples after rectification. The DC positive is then fed to the input pin 1 of the regulator, and its output pin 3 feeds out to provide the stable 12 volts DC. Another electrolytic capacitor provides even further smoothing. Finally, a ceramic capacitor provides added stability by removing much of the high frequencies that may appear on the output to finally provide a near perfect DC supply. Negative (0V) DC flows directly through from the bridge rectifier. Pin 2 of the voltage regulator also connects to this negative.



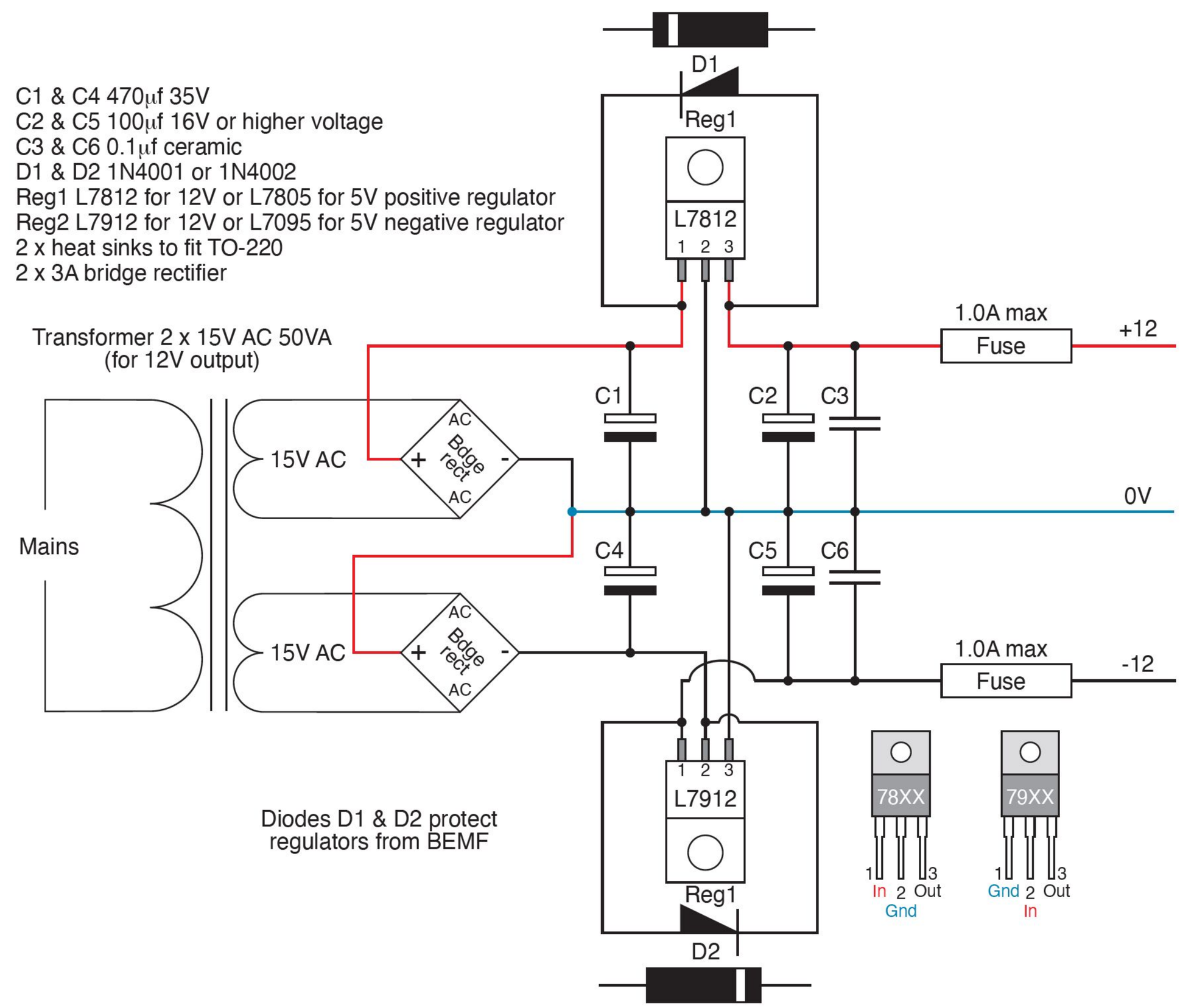
Notes:
C1 100µf 25V minimum
C2 0.1µf ceramic
C3 100µf 25V minimum
D1 1N4001
R 220R 0.25W
VR 5K multi turn Cermet
Voltage reg. LM317T
BR1 bridge rectifier
Heatsink for T220 case device



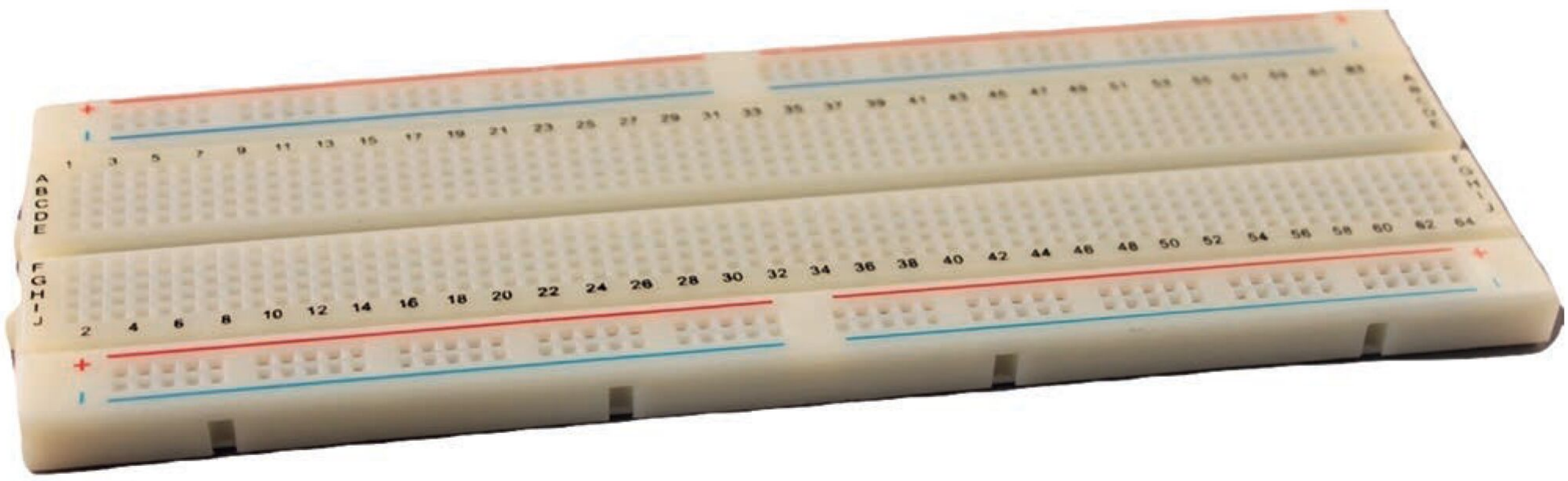
By altering a few components, the fixed-voltage regulator circuit shown previously can be made to become voltage-adjustable on its output, depending on the setting of a variable resistor, or potentiometer. Here a different regulator is used, and added to the circuit is a fixed-value resistor and a potentiometer to adjust the output volts.



This is the above circuit is shown below build onto a piece of stripboard. Voltage adjustment is via the small grub screw on the blue coloured potentiometer. In both cases above the input voltage must be around 2.0 volts greater than the required output volts. E.g. for 12 volts output an input of a minimum 14 volts is required.



For those needing a dual output supply offering a positive, zero and negative voltage, a dual-wound power supply is required, and the use of a negative voltage regulator is recommended. The circuit is shown here and is similar to that of the fixed regulator but with added components.

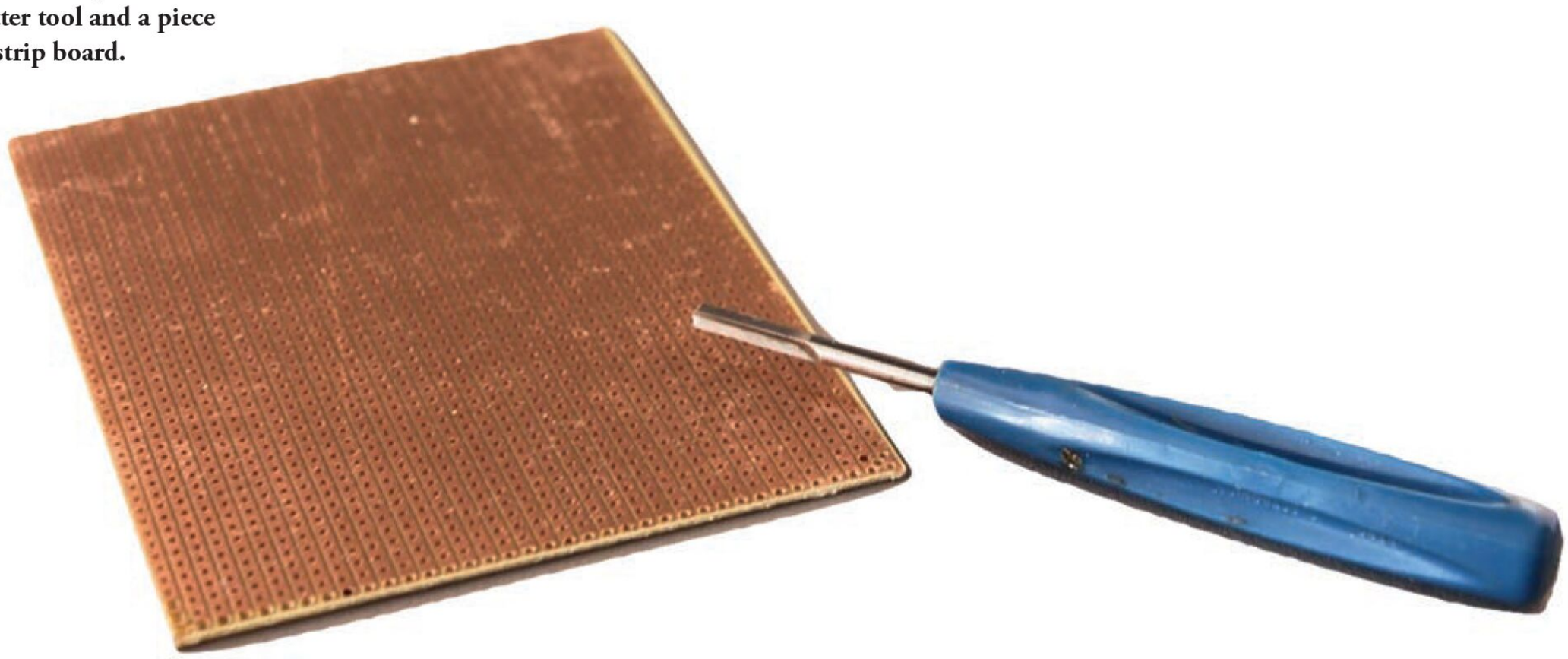


Above a small breadboard is shown. This makes an excellent project board for constructing and testing a circuit before soldering it to a strip board.

Interface Controller (PIC) for the job it is required for. A PIC programming board is almost an essential part of the setting-up process, and I have found using a software programme like PICAXE makes the understanding, testing and final downloading of the finished programme very simple. PICAXE Editor 6 version 6.1 is the latest version at the time of writing, but is well worth checking for later updates or newer issues, all of which are free. Once it is installed on a computer, it is very simple to use. The built in flow charts and menus make assembling a circuit simple. No knowledge of computer programming or BASIC is needed.

These circuits can make effective lighted items such as to control dot matrix theatre lights, infrared train detection, railway signalling, and much more that are simple to assemble and use.

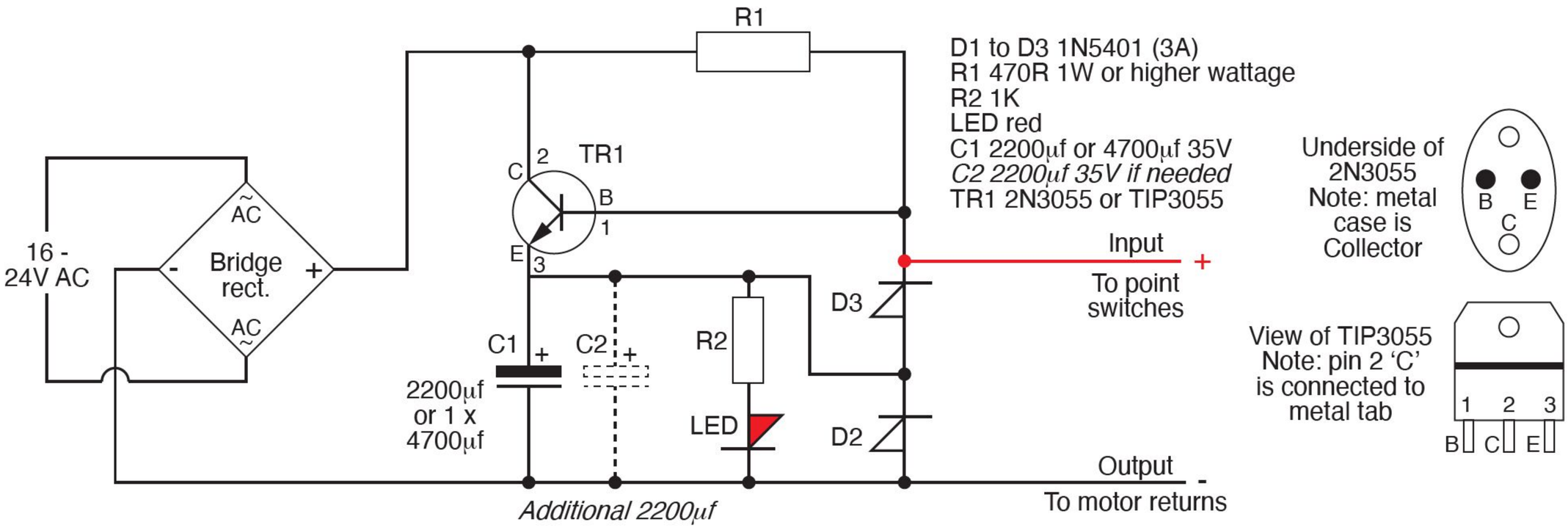
Above is a spot face cutter tool and a piece of strip board.



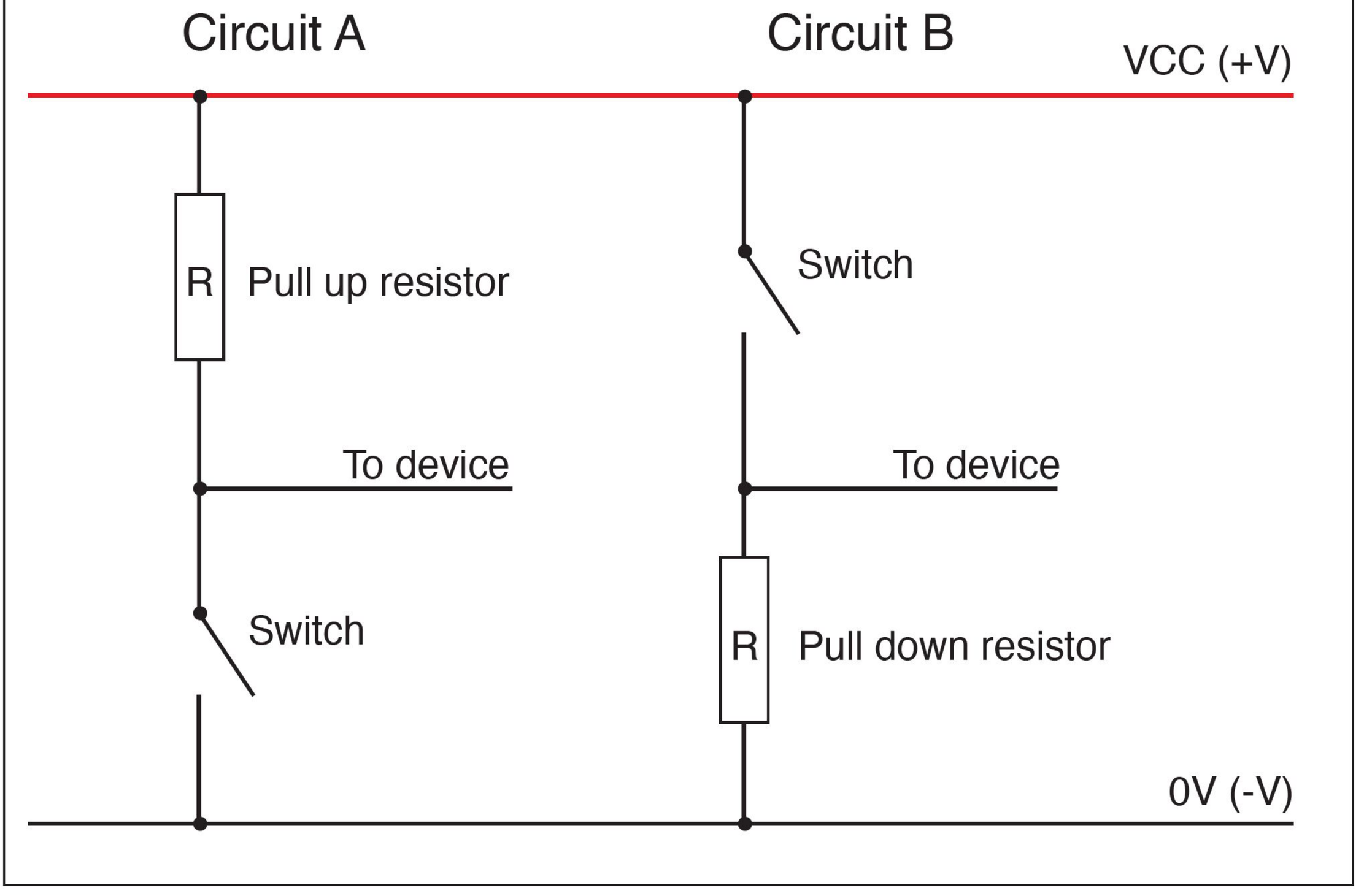
Infrared

Mentioning infrared (IR) provides the opportunity to discuss this a little bit more. Infrared sends out invisible light, which is reflected back to an infrared receiver. When the reflected IR signal is received it causes the receiver electronics to alter state, and that alteration can be used to switch other devices such as a transistor or the input to a PIC or other IC device. The great advantage is that IR does not require any alterations to be made to rolling stock, and works with whatever passes over or in front of it. IR transmitters and receiver LEDs are readily available and can cost very little. I personally like the dual-packed RPR220 device, which, once working in a circuit, can simply sit between two OO-scale sleepers in a hole drilled into the baseboard.

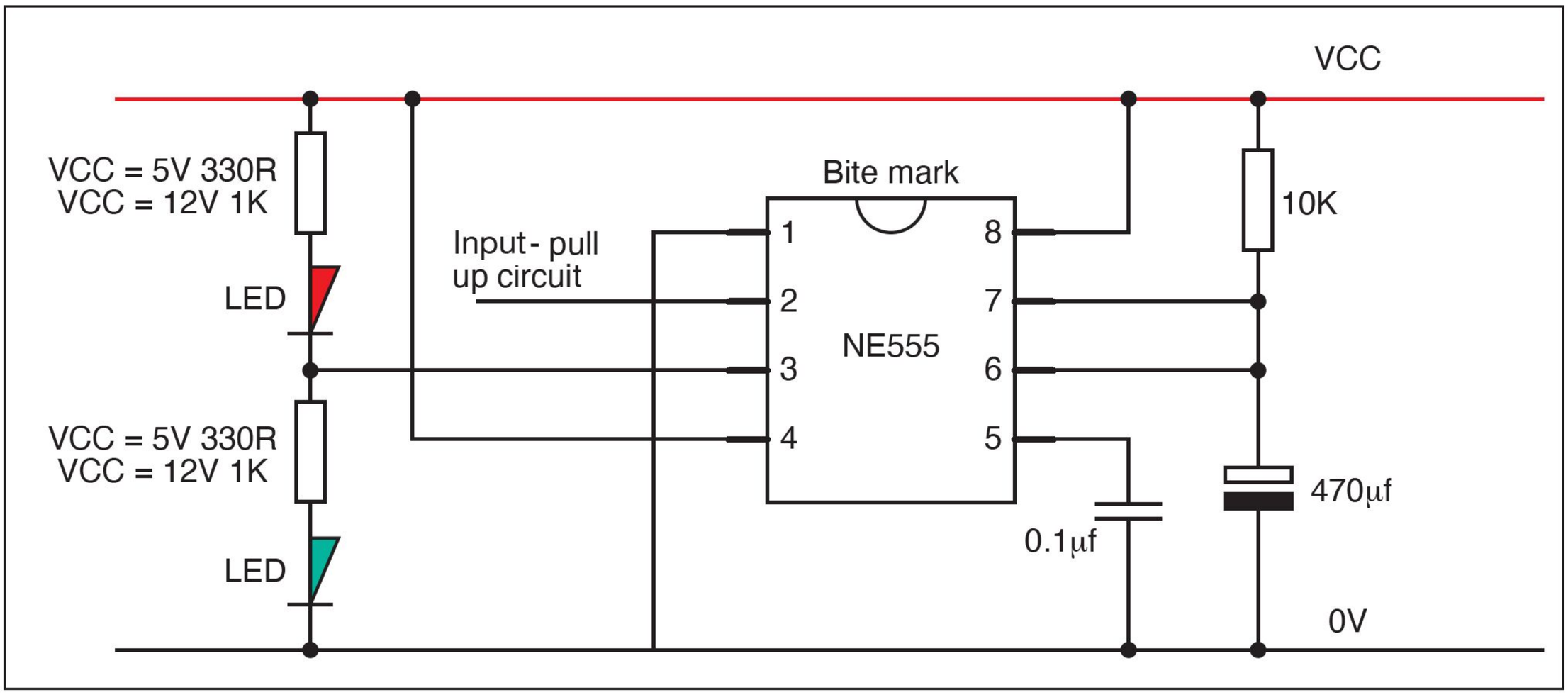
In the RPR220 package is an infrared transmitter (Tx) LED and an infrared receiver (Rx) LED (transistor). By



Capacitor Discharge Unit - CDU (with bridge rectifier)



The basic idea of biasing the input for both states VCC or 0. Circuit A is a pull up and the 'device' receives VCC all the while the switch is open. When it closes the 'device' is connected to 0 volts. While the opposite occurs in Circuit B. The 'device' is connected to 0v all the while the switch is open via the resistor. When the switch closes, VCC appears to the 'device'. The 'device' can be anything required, e.g. a micro controller's input pin or a transistor base etc. The value of R can be whatever is required but frequently 10K or more is used.



In this simplistic diagram, using an NE555 IC, it can be seen how, depending on the IC's input setting (high or low) on pin 2, an LED can be controlled, which will time for a preset period once the switch is opened. The timing period is determined by the value of the resistor and electrolytic capacitor on pins 6 and 7. Use Circuit A (pull up) for the input, then try Circuit B (pull down). Values of resistors for the LEDs will need to be calculated and will depend on VCC supply volts and the LEDs' forward voltage rating. The diagram is shown purely as an example and not necessarily as a working prototype, although it will work as shown with the component values. The two LEDs with their series resistors are connected to the IC's single output pin, then one LED will light when the output is positive and the other when it is negative (0 or 1 state).

feeding the Tx with a constant supply via a suitable series resistor, the infrared light is constantly being emitted. As an item such as a loco or carriage passes over, or in front of the device, the infrared beam is reflected off it and the Rx then 'sees' the infrared and causes the circuit to which it is connected to operate. While to the human eye the infrared LED cannot be seen to be lit, if a camera, such as one built into a cell phone, is used, the pinkish colour of the lit infrared LED can clearly be seen.

By designing the PIC micro-controller to carry out various functions, when one of its input pins is triggered the outputs can directly turn on or off via a suitable series resistor and LED such as a signal aspect. Note that the outputs of a PIC are relatively low current rated and, while they can easily feed a single LED, any larger current that needs to be switched should be via a transistor fed from the output. Where a relay is switched, always add an inverse diode across the relay coil to remove the back electro-motive force (EMF) created as the coil is turned off, as this can easily damage the transistor.

When using any electronics, and you are switching a supply to an input pin, always connect the pin via typically a 10K resistor to either the positive supply (VCC) or the negative (0 volts), then the switch to the other supply rail. This then biases the pin, ensuring that it will not operate randomly and will only operate as intended when the switch closes or opens. This is called 'pull up' or 'pull down'.

11
Lineside Detailing

From the boundary fence to telegraph poles, cable routes to point rodding and everything else railway.

Fencing

UK railways fence in all the railway to prevent easy access, something not found in many European countries or in the Americas. Fencing comes in many styles from five-stranded open wire and post to chain link or palisade wooden fencing through to metal fencing. Its purpose is to keep animals and trespassers off the railway, so its style is very much dependant on what it is to be used for. In country areas five-strand wire fencing is the norm. This simple fencing often has wooden or concrete posts and five single-stranded wires running between them, and is a cheap option where human trespass is not a problem. It is still frequently used, but not ideal where sheep or other livestock are occupying the field adjacent to the railway; they tend to get between the strands and are able to then gain access to the running line or lineside areas where the grass is always greener!

Five-wire fencing can be modelled by using proprietary plastic moulded posts and fine nylon line or fishing line to represent the strands of wire. Posts can be made from matchsticks or strips of small square-section wood, balsa or plastic strip. When positioned in pre-drilled holes and the posts glued in place, they make a good representation of the real thing.

Chain link fencing is used in more urban areas where human trespass is likely. It can vary in height and may even have a strand or two of barbed wire on the top. It is harder to reproduce, but the use of an open-weave metal fabric such as that used in the plastering trade for bridging plasterboard joints makes a good representation. Posts for the model fence are again made from wood or plastic and are frequently coloured to represent concrete.

Palisade fencing is frequently used on platforms in country areas and along the sides of level crossings of both the gated and barrier form. It is much more involved to make and perhaps the best option is to use one of the many commercial styles produced in plastic. This can be painted in the railway company's colours on platforms or white at level crossings. Palisade can be upright struts spaced roughly one strut apart, or angled to around 45 degrees and at times also interlaced with spacing in the opposite 45-degree angle.

Anti-climb steel fencing is used mainly to protect industrial sites or railway workshop areas, where trespass and theft is likely. Some have a curved top, while other styles are straight bars with spiked tops. I haven't tried to reproduce this style, and believe it may be quite hard and tedious to undertake! Commercially produced anti-climb fencing is available in most scales.

Telegraph poles

These are usually associated with railways that represent the pre-1970s era, but examples can still be found on some UK railway lines, especially in rural areas. The telegraph pole is or was used to transmit telephone signals and signalling circuits on open copper wires, although towards the latter part of their life when the copper wire was renewed it was often covered in a PVC jacket.

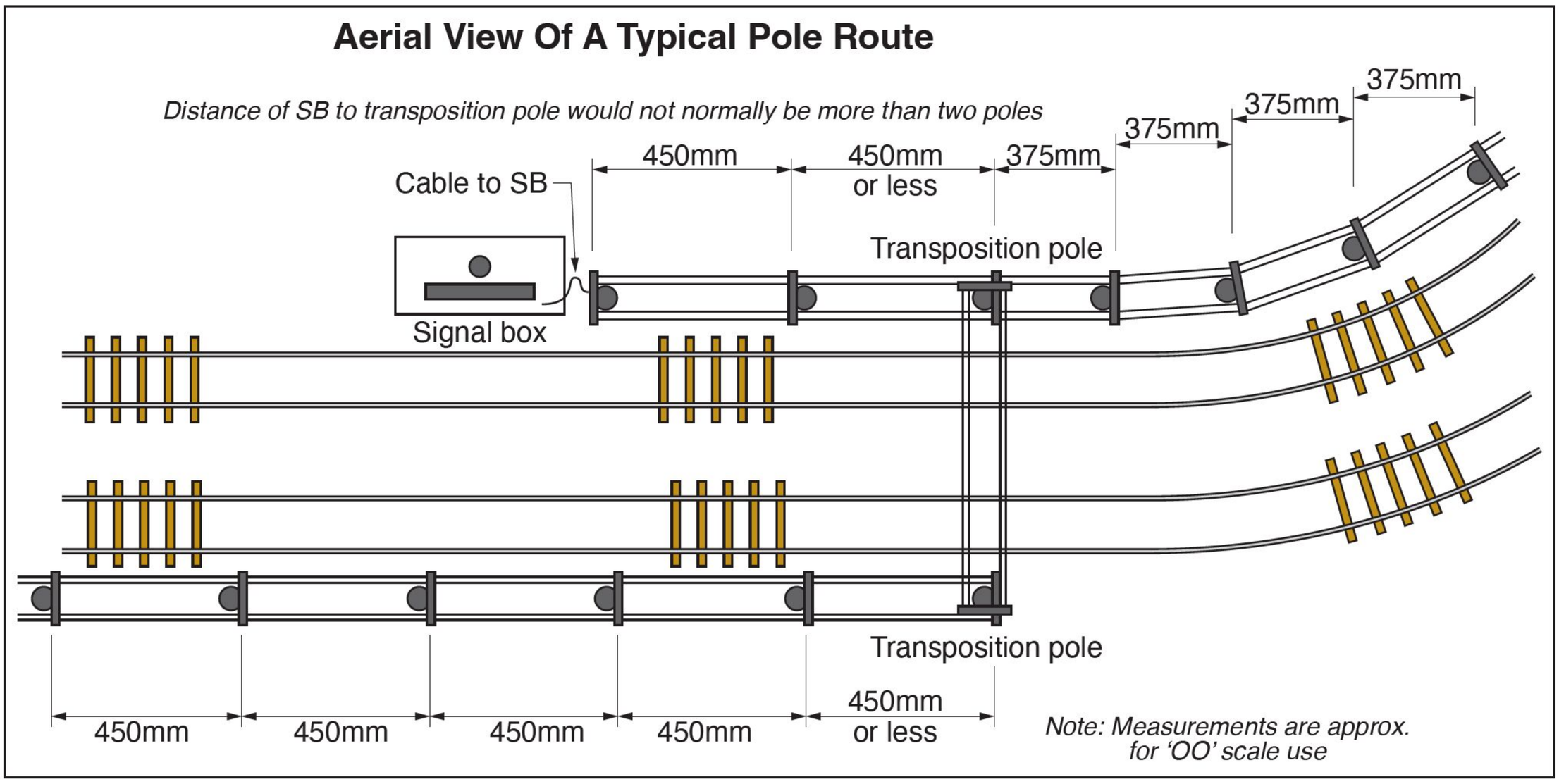
Telegraph poles were placed clear of the running line and normally on the inside of a curve. They had 'arms' at the top that carried insulated ceramic (usually china) pots to which the wires were attached. How many arms and pots used on the post depended on the area and type of line; a main-line telegraph pole might have ten or more arms each with four pots/wires on each side of the post, while on more rural lines it might only have a couple of arms and four pots/wires per arm.

Pole circuits were used for block bell and block section control from signal box to signal box, as well as telephone circuits. In addition, it was not unusual to have some wires used for actual signalling purposes, especially for distant signals where an electric indication confirming the signal's aspect was sent back to the controlling signal box, also indicating whether or not the signal was lit correctly. Some wires carried a higher voltage of 110 volts, usually on red-coloured pots, and this was used to charge batteries located at distant signals.

Some poles had double arms fitted, the arms being aligned on either side of the post, while others had just single arms on one side of the post. It is recorded that where single arms were used they were normally fitted to the side of the pole that was closer to London! Double-armed poles often had transposition crossovers in their wire circuits to overcome the possibility of induced noise and cross talk. Here a top pair of wires were transposed by jumpers to lower arms and were often also twisted around to make the upper left wire become the lower right one, etc.

Tall poles were produced to allow the wires to pass over roads or across the railway. Poles and their wires were installed so that a minimum clearance was achieved;

A painting of a typical multi arm telegraph pole. Courtesy of www.1900s.org.uk



An overview of how telegraph poles would be situated alongside the railway.

over the railway the minimum clearance was deemed to be 17 feet above rail top. At rural farm crossings, 16 feet above the road surface was the norm, and when passing over a main road the lowest wire would be at least 20 feet above the road.

Poles were stayed on curves to stop them being pulled in towards the curve, and also stayed at termination posts to act against the natural pull of the wires. Stays were made of twisted galvanised wire, the galvanised coating helping to prevent rusting. More than one stay might be used to help support a post. Generally, telegraph poles were spaced 60 to 65 yards apart, being closer on curves. In 4mm scale, 60 yards (180 feet) is equal to 720mm, which would probably not look correct, so compression is used. In OO 4mm/foot, a pole spacing of around 400-450mm seems to look about right, but of course spacings can be increased as wished.

Posts usually have a cap on top made of galvanised zinc or lead in a sort of inverted V shape. This helped to prevent premature rot at the top of the pole. Pole steps were normally fitted from around 10–12 feet above ground to just below the lowest arm, and these generally alternated on each side of the pole; quite often the last top step also had a diagonally mating step to allow the linesman to stand on the top pair of steps while working on lower wires.

Goods yards

Yard lights can be either on wooden poles (such as telegraph poles) or on concrete or steel posts. They are used to provide footpath lighting for loco crews and shunters, etc., and were originally lit by either oil or gas. More modern ones will use filament lamps and the latest possibly high-powered flood lighting from large tungsten filament lamps, mercury vapour tubes or, most recently, banks of high-brightness power-saving LEDs. There are several manufacturers of ready-made yard and station lights in all scales, and you can also buy kits to make them. With some skill, home-made yard lamps can be produced from plastic or brass tubing or rodding of a suitably size, and the shade fashioned from a small washer fitted over an LED. The rod and washer can be painted to suit, then 'planted' in a hole drilled in the baseboard and wired to a low-voltage DC power supply.

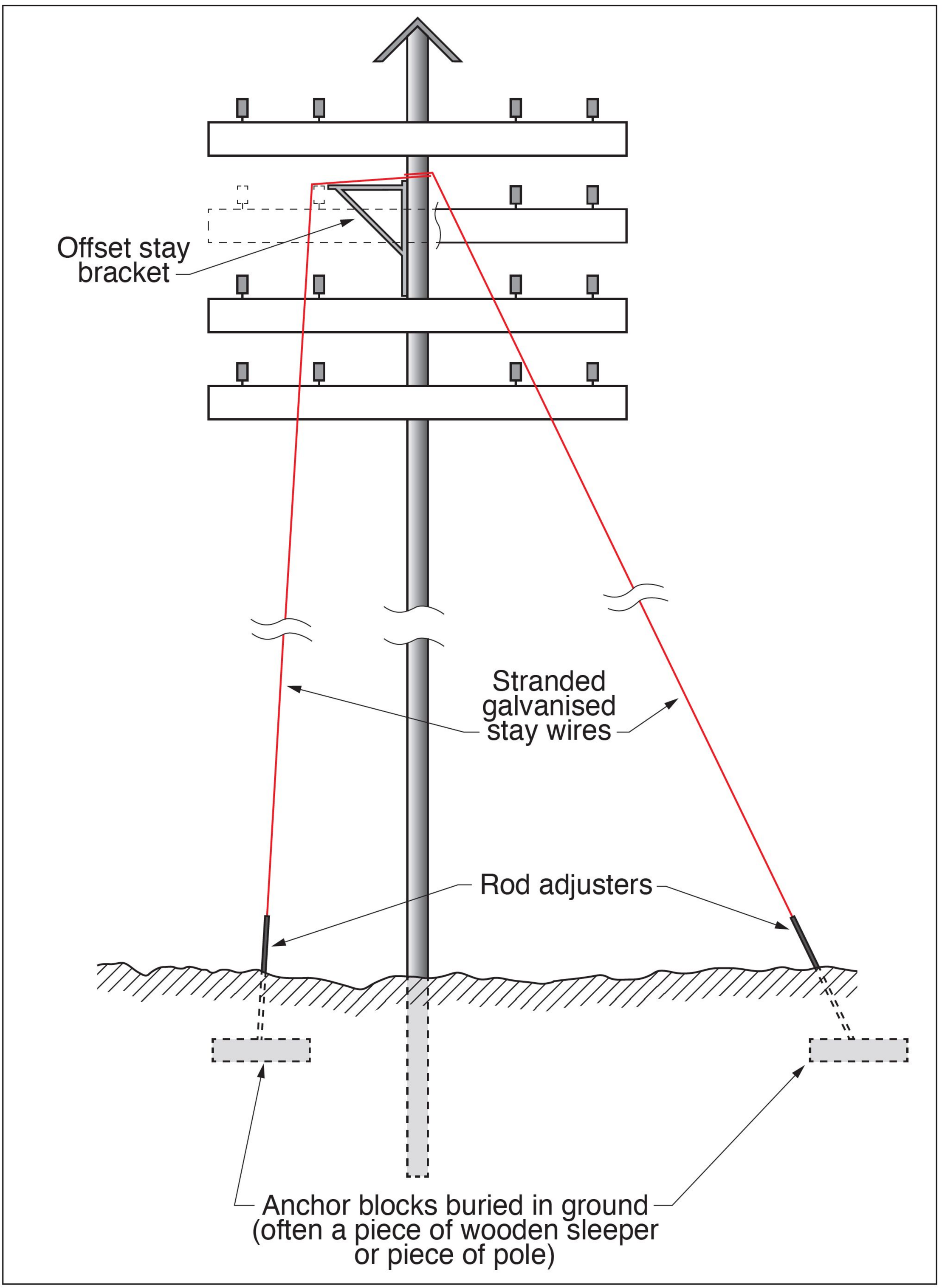
Tower-style yard floodlights are more difficult to make at home, so perhaps a ready-made item might be the more cost-effective solution. However, if you feel like the challenge, use brass or plastic L- and H-shaped sections with fine flat sections used for other areas.

The use of white or warm white LEDs is ideal for all types of lighting, as they run virtually cold. But do ensure that you add a series current limiting resistor in the LED feed line unless the LED is produced as working at the voltage being used, e.g. a 12-volt LED on a 12-volt DC supply. Otherwise use a 610- to 1,000-ohm (610R to 1K0) resistor in series on a 12 volts DC supply. Increase the resistor's ohms value to reduce the brightness, or lower the value to brighten the LED. I have found that warm white LEDs offer a light similar to filament (tungsten) lighting, while white LEDs are more likely to represent fluorescent or high-powered LED outside lighting.

Lineside buildings

Permanent way (p.way) huts were used by the track

A telegraph pole located lineside and just before a tunnel portal. Note usually the wires are not modelled as they are too fine and easily break.


Offset stay bracket
Stranded galvanised stay wires
Rod adjusters
Anchor blocks buried in ground (often a piece of wooden sleeper or piece of pole)

A modelled p.way hut adds detail to the scene. Picture courtesy of Steve Mumford.

length gangs until BR modernised track maintenance and used mobile track gangs. P.way huts were placed along the trackside at intervals of roughly 2 to 4 miles, although they could be closer or further apart depending on locality. They were the 'base camp' for the gang of men who maintained a specific length of track, hence the term 'length gangs'. The gangs were often six to eight men strong, and a chargehand called a 'ganger' took overall responsibility for the track section and his men. The hut provided them with shelter, a place to sit and eat their food, store their tools and other equipment, as well as a place where the ganger could do his office duties — daily time sheets and work completed sheets, etc.

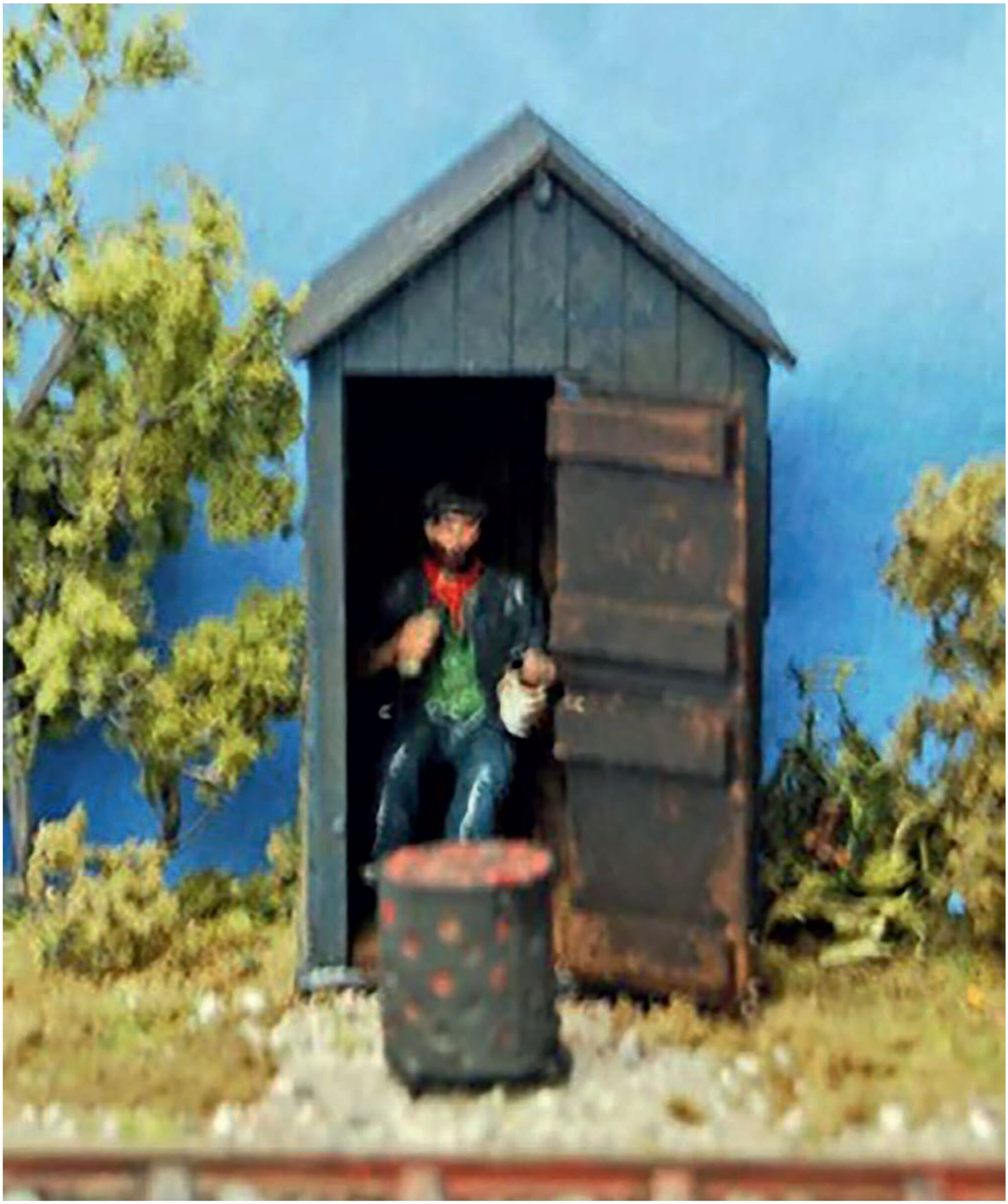
The hut frequently had a brick-built chimney and hearth where the 'tea boy' would heat hot water for the gang's brew at lunchtime, and more often on a wet day!

Many huts were built from wooden sleepers with a tar or pitch covered roof, a dirt floor and a long wooden table with two benches each side, with possibly a further bench along a wall. The ganger had a high-legged chair and a tall Dickensian-style writing desk. No one was normally allowed to use this chair and desk except the ganger or someone he nominated!

The gangs were fiercely competitive of each other and used to keep their track section in tiptop condition. In my very early days on the railway I saw ballast stones aligned in a neat row along the edges of the ballast shoulder and the fishplates and rails shone due to being polished by the men's oily rags. The gangs were well known for riding their bicycles along the cess to reach their section and hut. Modelling of the flat, narrow cess area should be carried out wherever possible.

P.way huts are readily available pre-built and painted in all scales or as kits in plastic, laser-cut wood or card. They could of course also be made from card and printed paper or even produce them from plastic embossed sheets and scrap box items.

Another hut often seen on pre-modernisation railways usually located at strategic signals, and positioned at distant signals, was the 'fogging hut'. They were smaller than p.way huts and normally a one-man unit, much like a sentry box, and were used by operations or, more frequently, trained p.way staff for fogging and falling snow duties. During fog (smog too) and falling snow,



A typical fogging hut. Courtesy of Rail Model.

the railway operators would send a trained person to just beyond the distant or other signal, and they were instructed to place one detonator on the running rail on the approach side of the signal when the signal was 'on' (at danger). The train would run over the detonator producing a very loud 'bang', and the train driver was instantly made aware of the approaching invisible signal being at danger. The detonator was replaced with a new one pending the arrival of the next train while the signal remained 'on'. The hut also provided some

Adding detail to the platform helps bring the model to life.

Above is a 1960s style of sectional concrete Permanent Way hut, as installed on the Southern Region during electrification of the line.

A water crane located on the end of a platform. Note the brazier just behind the crane which is used in the winter to help stop the water from freezing.

A goods shed receiving the day's wagons for unloading and then onward road transport to their destination.

protection from the flying fragment from the exploding detonators. Quite often a small brazier for holding an open fire would be located at the hut. Again, ready-made or kit-built items are available, and home-made huts are fairly easy to construct.

Don't forget platform items – Water cranes, Running in (name board), Bench seats, Lamps, Barrows, Sacks and cases, Milk churns, Weighing machine, Chocolate vending machine and of course the passengers and station staff themselves, strategically placed along the platform.

Goods sheds

Goods sheds were used predominantly up until the mid-1960s to load and unload produce and materials that came from or were going to local businesses. After this time most goods were taken by road rather than rail, as Dr Beeching's cuts closed many smaller lines where such sheds would have been in daily use.

The typical goods shed offered a covered area of a single track running inside along one side of the building, and usually a raised stage above the track. The shed helped to keep goods being loaded or unloaded dry. The wagons would be pushed or pulled into the shed for easy unload or loading, then the local goods yard staff would move the wagons to the main sidings for assembly into a goods train ready to go out onto the main line and its final destination. The side of the goods shed had access from the road to the platform to aid moving the goods from the raised platform to or from a road vehicle. When heavy items were to be moved onto or off a road vehicle, a small hand-operated crane was frequently used and was located outside the shed on a raised platform of its own.

Models of goods sheds are available in all scales, either ready built or in kit form. There are some lovely examples available in assorted finishes to represent brick or stone, and even wood.

A similar shed, known as a 'provender store', was also used by some regions and these generally held goods

such as grain, cattle food and other produce. They were usually raised off the ground on short stilts of brick or concrete pillars. Many provender stores were made of pre-fabricated concrete slabs. There are several kits and ready-made examples available for the modeller.

Signal boxes

Signal boxes are the control centre of the railway, in which one or more signallers operate levers or control buttons on a panel, or today computer screens and keyboards to control train movements. Early signal boxes usually had the signaller and signalling equipment at least one level above ground. Some were built much higher, or even spanned the tracks. This raised position provided the signaller with a better view of approaching and passing trains, while all the mechanical interlocking, signal wires and point rodding were housed in the area below the signaller's floor, affording good access to this equipment for the signal maintenance staff.

Some signal boxes were located at ground level, and these were often found at level crossings, controlling both crossing protection signals and the crossing gates; some were located on the station platform. Many signal boxes where constructed either from all wood or the lower portion of brick and the upper portion wood. Later signal boxes where mainly all-electric signalling panels are installed were built from all brick or other suitable solid building materials.

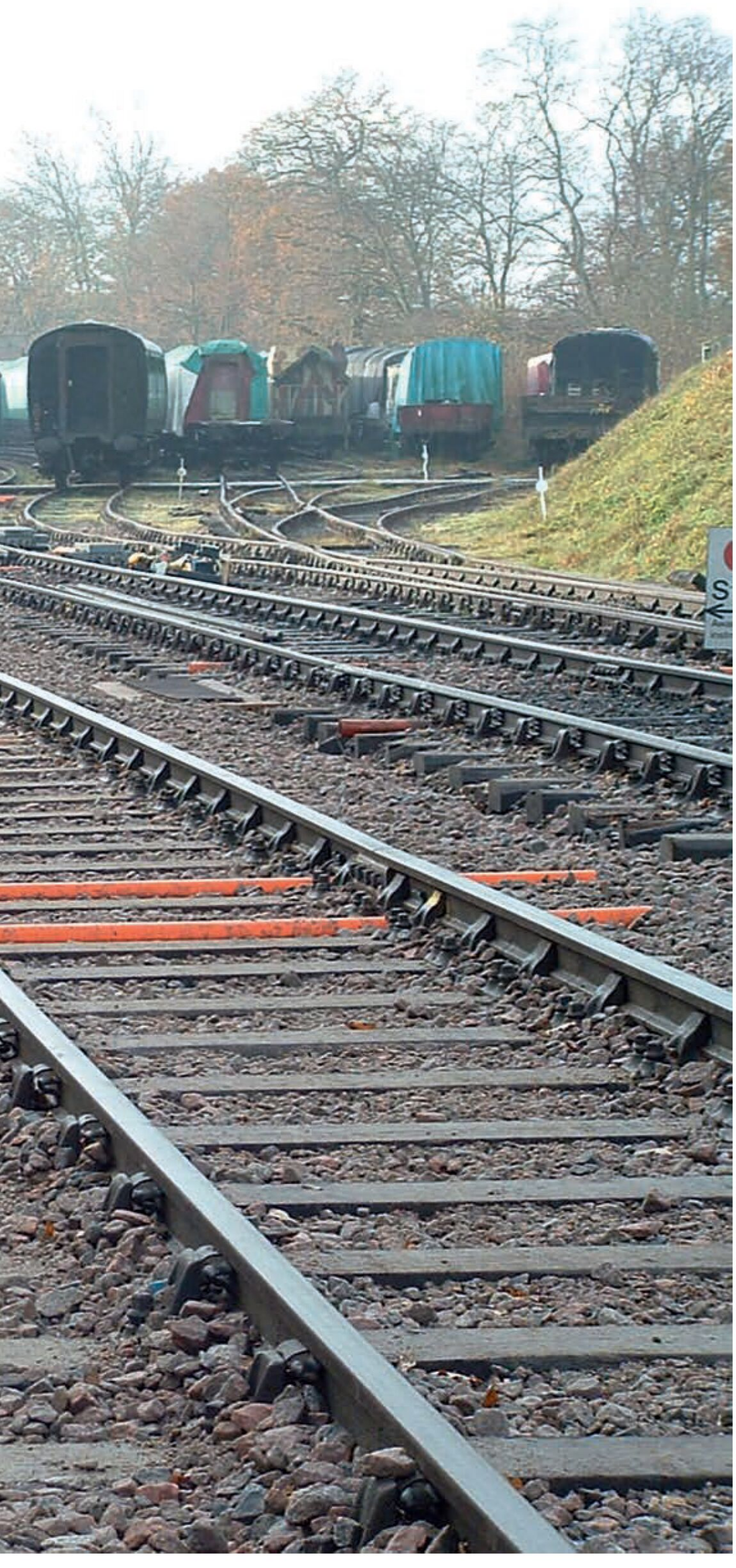
Largely made from steel framing with suitable cladding applied to the frames. Modern IECCs (Integrated Electronic Control Centres) house work stations containing computer screens and keyboards and have several signallers operating individual large sections of the railway, the whole IECC being responsible for controlling many hundreds of track miles. Most IECCs have fully automatic computer-controlled route setting and signalling and the signaller only needs to take over control in the event of a problem occurring that the computer is unable to deal with.

Engine sheds, or for the modern era modeller maintenance depots, are a great feature to model. Steam era engine sheds would be dark dingy places, often poorly lit inside, wash out areas and pits on the approach lines and coaling and watering sites too. Lots of ash, coal and oil around the track(s) leading into the sheds. Yard lighting could be gas lights or electrically lit lamps,

Point rodding – nearest the camera is more modern channel rodding while further along it transfers to round rodding.

A fine example of Wills non-working OO scale point rodding kits. Image courtesy of Railway Modeller/Peco.

BUCKLEIGH SIGNAL BOX
XP



An example of concrete cable troughing (ducting). Further along the route the lids are removed exposing the cables laid inside the troughing. Image courtesy of Adrian Lee.

but they would not offer much general illumination. Modern maintenance depots would possibly have a diesel refuelling site, loco washing machine and generally be a cleaner area than steam engine sheds. They would have good lighting both inside the depot and in the yard areas outside. Often the building's entrance to the depot would have doors that usually remain closed and were opened electrically as needed to allow access in and out of the depot building.

Point rodding is used where mechanically operated points are operated from levers in the signal box. Early installations used a round rod, while later installations, or where the old rod run has been upgraded, used inverted U-channel made of galvanised steel. Whichever type is modelled is fairly easy to represent using plastic tubing, plastic square or U-sections, and kits are also available for most gauges.

The harder parts to make yourself are the right-angle cranks that were used to change the rodding's direction from the main rod run to the actual point. There are some smaller manufacturers who produce brass etch items for producing your own rod runs and these include cranks and compensator cranks, all found in conventional rod runs. A well-laid model from the signal box to all points looks great, but does take a lot of planning and care when installing the runs. Easier to use is the plastic non-working point rodding such as the Wills SS89 kit, but this is unfortunately only available in OO scale.

Concrete cable ducting, or 'troughing', is seen everywhere on the modern railway and carries signalling cables, telecommunication cables and, where the line is electrified, traction power cables. High-voltage power cables used for traction are kept separate and their own route is frequently seen on the opposite side of the railway or, where space is limited, the two troughings run alongside each other. This ducting is usually made of concrete in various widths and heights. The main body is U-shaped, into which the cables are laid and a separate flat concrete lid fits on top to provide a fully covered cable enclosure.

Along the side of the railway will be found lineside apparatus cabinets which the troughing allows cables to enter or leave the cabinet. Frequently a T-shaped trough is inserted in the run where cables in the troughing enter and leave lineside apparatus cabinets. These mainly contain signalling items, such as track circuit feed and relay and equipment, axle counter components and signalling controls, either via relays or electronic modules, together with their rows of terminals to which the cables are connected. Telecoms cabinets are usually smaller but are still fed by T-shaped troughing.

12
Railway Signalling

Semaphore signalling

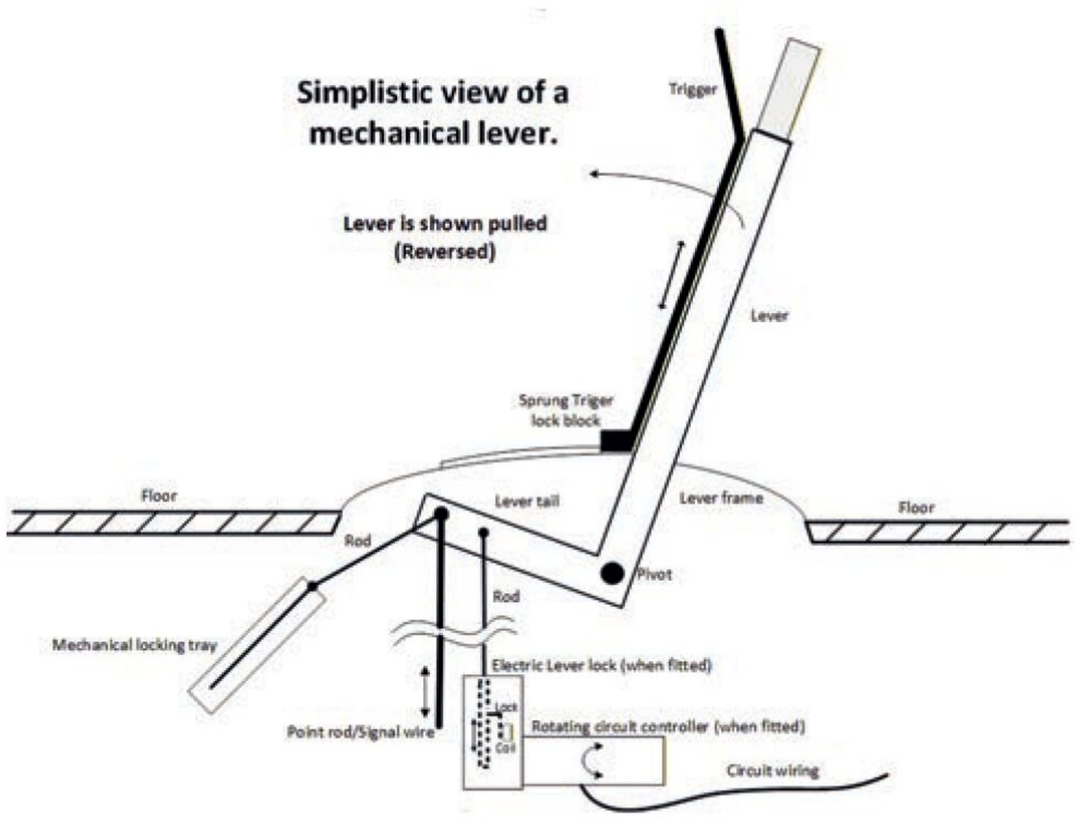
Originally trains were dispatched from place 'A' and expected to arrive at place 'B' within a certain time limit. Once this set time had elapsed, a second train could be dispatched from A and was expected to arrive at B. All this worked well until the first train didn't arrive at B inside the expected time frame; anything could have caused it to be delayed or stopped between A and B. The second train, having been dispatched, proceeded and eventually found the first train sitting in its path. Results could be catastrophic!

Clearly some form of communication between A and B and vice versa was needed. Thus the telegraph system was developed and the signaller at A could advise the signaller at B that a train had left and B could then tell A that it had arrived and A could then dispatch another train safe in the knowledge that the line ahead was clear. From this simple system 'block working' evolved, and visible indicators were used to remind the signaller of the presence of a train and also lock the exit signals, preventing accidental clearing of a signal to allow the passage of a train before the section between the two signal boxes was clear. This system is still in use in some areas today but is generally on the decline where resignalling works are undertaken.

While I mention specific styles of BR signals, there are regional variations and it becomes impossible to include every variant. These descriptions are general, and if you are modelling a specific region and time period the best option is to research that era and location from dedicated books or the Internet.

The signalling of a train evolved from the basic signalman (sometimes called a 'bobby') standing with a red flag to a signaller working in a specially built cabin, or signal box. In the box were levers used to operate the signals and points remotely. Eventually levers were mechanically interlocked to stop conflicting moves being made. Later the mechanical interlocking was improved by electrical lever locks, adding to the protection of trains. The inside of a typical small signal box is shown left.

The signal levers are usually painted red for stop signals and yellow for distant signals. The lever, which is either straight or L-shaped, pivots at over three quarters along its length, and for the L-shaped lever the



This image shows the two red and white banded signals are at Stop, one for each line and are protecting the entrance to the single track line in the distance. Also, in the distance can be seen the rear view of a bracket signal. The rear of each arm is white with a black band. Each arm protects the line where it diverges into the two tracks. The right-hand arm as seen by an approaching train would control moves onto the right-hand line while the left-hand arm controls moves onto the left-hand line.

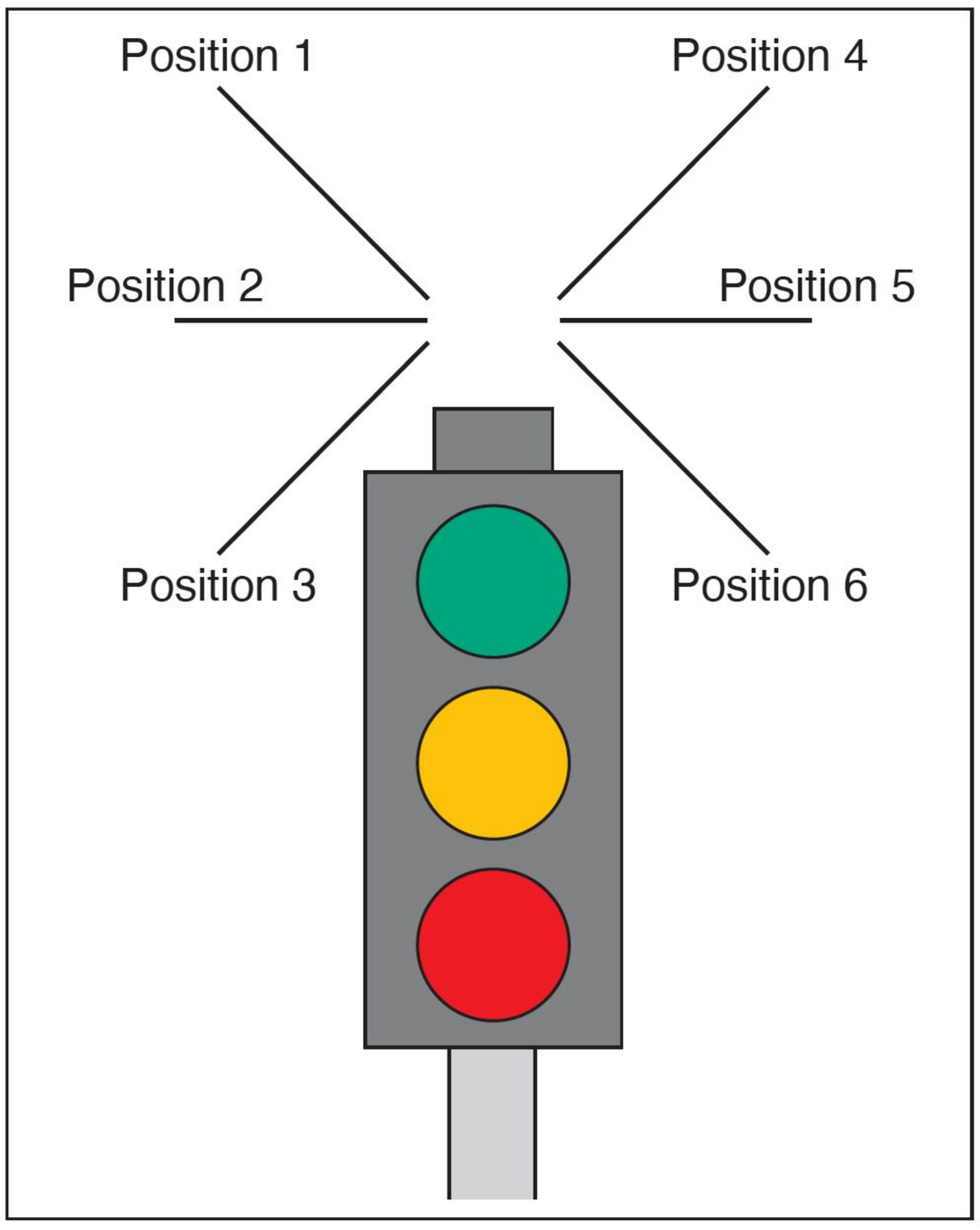
A modern four aspect LED lit signalhead. Note this is displaying its second (Top) yellow aspect. The lower aspect is able to show all three main aspects of Red, Yellow and Green. Image courtesy of Unipart Dorman.

pivot is at the right-angle. The signal lever frequently had a chain connected to its end and this was taken via pulley wheels to where it eventually connected to a multi-strand wire, which led away to where the signal was located. The movement of the lever allowed the signal arm to be moved to the 'proceed' ('off') position, giving the train driver a good and clear indication that he could proceed. This formed the basics of semaphore railway signalling.

Two types of semaphore signals are used, upper quadrant or lower quadrant. Both types have the signal arm in the horizontal position for stop (signal is 'on'). The upper quadrant arm moved from the horizontal to go upward 45 degrees above horizontal to give a proceed ('off') indication to the driver, while the lower quadrant arm dropped below horizontal by approximately 45 degrees to give the proceed aspect. The two styles were rarely ever intermingled, a whole section or region would usually have one type of semaphore signal. If the wire to the signal arm broke while the arm was 'off', the arm would return to the 'on' position under the weight of the arm and counterweights would return it to the 'on' position, so the system was fail safe in the main. Of course, it was not unknown occasionally for the arm not to return to 'on' for some reason, possibly due to ice or snow holding the arm 'off', which resulted in a 'wrong side' signalling failure, an extremely serious event.

When facing a semaphore signal an approaching train driver would see the signal arm was painted red with a white vertical line towards its outer end; the reverse side of the arm was white with a black horizontal band in line with the front white band. Glasses or spectacles, called 'specs', were fitted to the pivot end of the signal arm; one was red and the other green (the green had a distinct blue shade that, when combined

Above shows both left- and right-hand junction indicators. The left hand one is position 1 while the right hand is position 4. Both images courtesy of Train Tech (Gaugemaster).



The six possible positions are shown here.

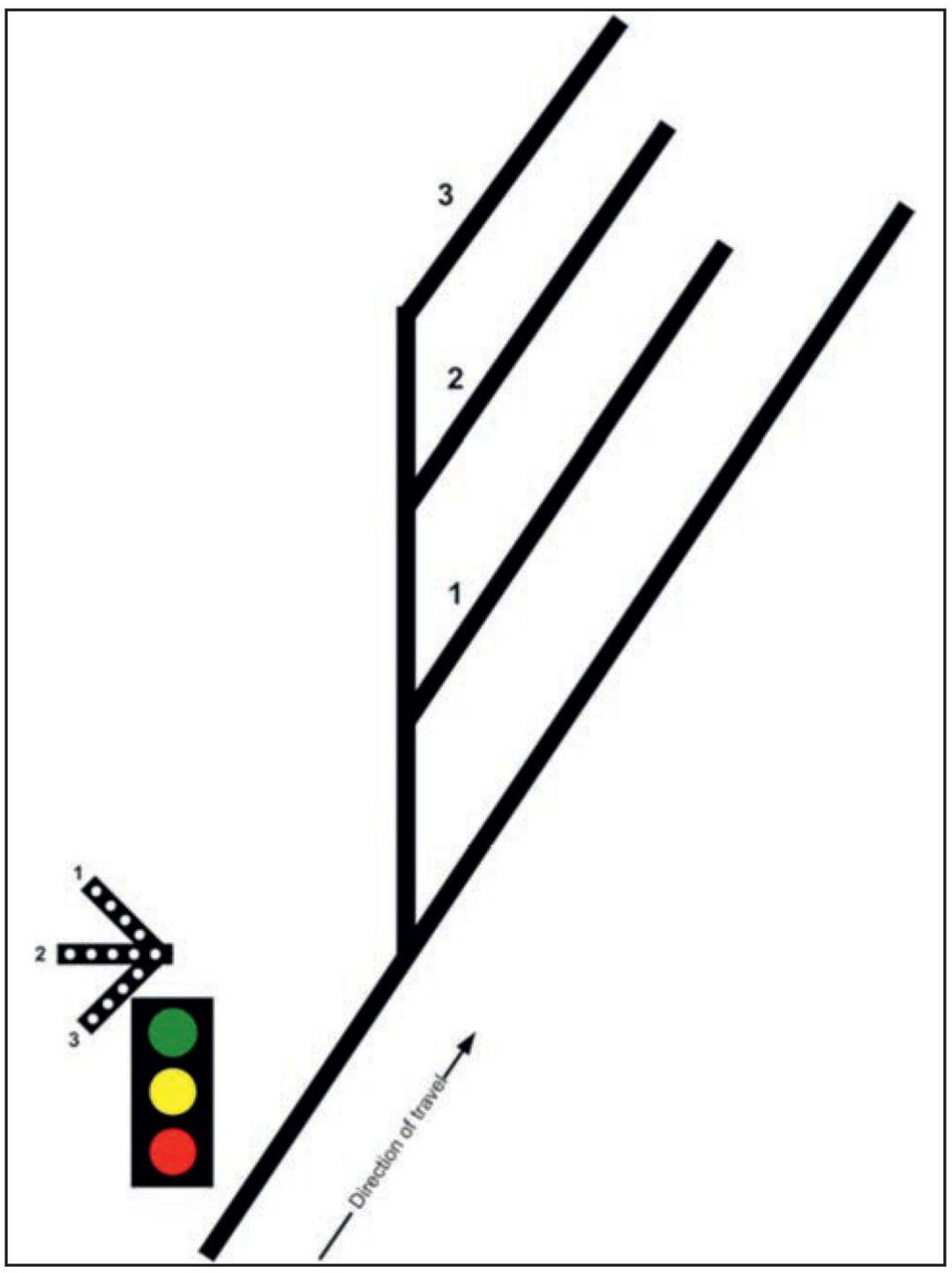
with the yellowish flame of the illuminating oil lamp, produced a better green colour). Originally a paraffin oil lamp was used to illuminate the spectacles. The lamps had a clear glass dome lens and the lamp's flame was adjusted to brightly illuminate the lens. The lamps were for many years paraffin-powered and had to be regularly maintained by a signal lamp tender, but were used for many years. Today semaphore signals tend to have electric lamps for night-time use, though there are still some areas using paraffin oil lamps!

Where the signal is positioned out of view of the signaller in the signal box an arm position indicator is used, which is electrically operated and shows visually what the actual signal arm is displaying to the drivers by means of a swinging arm indicator, usually mounted above the lever controlling that signal. These indicators show 'Off', 'On' or 'Wrong'. 'Wrong' indicating that the arm isn't fully 'off' or 'on'; they normally have a white face with a red or black pointer.

Long wire runs from signal box to the actual signal frequently had rachet style wire adjusters in the signal box and these allowed the signaller to slacken or tension the wire as required due to temperature changes effecting the wire. Some long wire runs had compensators, with a weight on one end, fitted in the wire run to allow for semi-automatic wire tensioning and these also helped the signaller somewhat with the heavy load placed on the lever and the 'hard pull' required to move the lever over to operate the signal arm to the 'off' position. A 'lamp out' indicator could also be found for the lamps not seen directly by the signaller. These were simple bi-metal strips, heated by the oil lamp's flame and heat, and the heat of the lamp made the bi-metal make an electrical contact. If the strip bent due to a lack of flame, due to the lamp being out, the bi-metal contact in the signal lamp's housing broke the contact, and the 'lamp out' indicator in the signal box showed 'Out'.

As well as the red 'stop' signal there was the 'distant' signal. If this was 'off' it indicated to the train driver that the section of signalling ahead had all signals cleared to proceed; if 'on' — horizontal — the signal could be passed but warned the driver that the next signal or the whole route ahead hadn't been cleared to proceed. The distant signal arm was either upper or lower quadrant style and differed from the stop arm in that the arm was yellow facing the oncoming train with a 'fishtail' V-shape cut into the outer end. There was a black V-shaped chevron band on the front of the arm, matching the V notch in the arm.

There was generally one distant signal for each direction or route approaching the signalling section. As with the stop signal, the distant two spectacles that were lit during the hours of darkness, but showed yellow when 'on' and green when 'off'. On the approach to junctions two or more distant arms indicated which



In this drawing the three routes 1 to 3 leading off the main line are shown.

A OO scale 'theatre' indicator. Image courtesy of Train Tech/Gaugemaster.

route ahead had been selected and whether the whole section for that route was clear or not. The distant signal levers in the signal box are usually at the outer ends of the row of red levers and were painted yellow. Note that the distant arm could not be cleared to 'off' until all signals in that route ahead were also cleared.

Distant signals were generally placed at least about half a mile before the stop signal, and exceptionally long wire runs of a mile or more were not unusual. Later years saw the advent of the motorised mechanical distant signal, whereby an electric motor was operated by the lever in the signal box and the motor in turn powered the signal arm to the 'off' position; on removing the power the arm returned to 'on' by the weight of the counterbalance. Indications of the position of the arm was again relayed back to the signal box, with a swinging pointer indicator, located above the lever controlling that signal. This indicator usually had a black dial face and a white or yellow pointer.

Main-line junctions were signalled using multiple posts and arms bracketed on one main post, the posts arranged side by side in a 'stepping' arrangement. The main-line route was signalled by the taller post and diverging lines by lower posts arranged to the left or right of the main post depending on which way the lines diverged from the main line. Where arms were placed one above the other on the same post, usually on sidings or goods lines, this was called 'stacking'. Where a bracketed signal had the arms at the same height, each one was considered to be as important a route as the other.

Colour light signals

Colour light signals first appeared around the early 1930s and slowly progressed around British Railways, replacing semaphore signalling. They could be intermixed with semaphores and one of the most common examples is a colour light distant signal in an otherwise totally semaphore section.

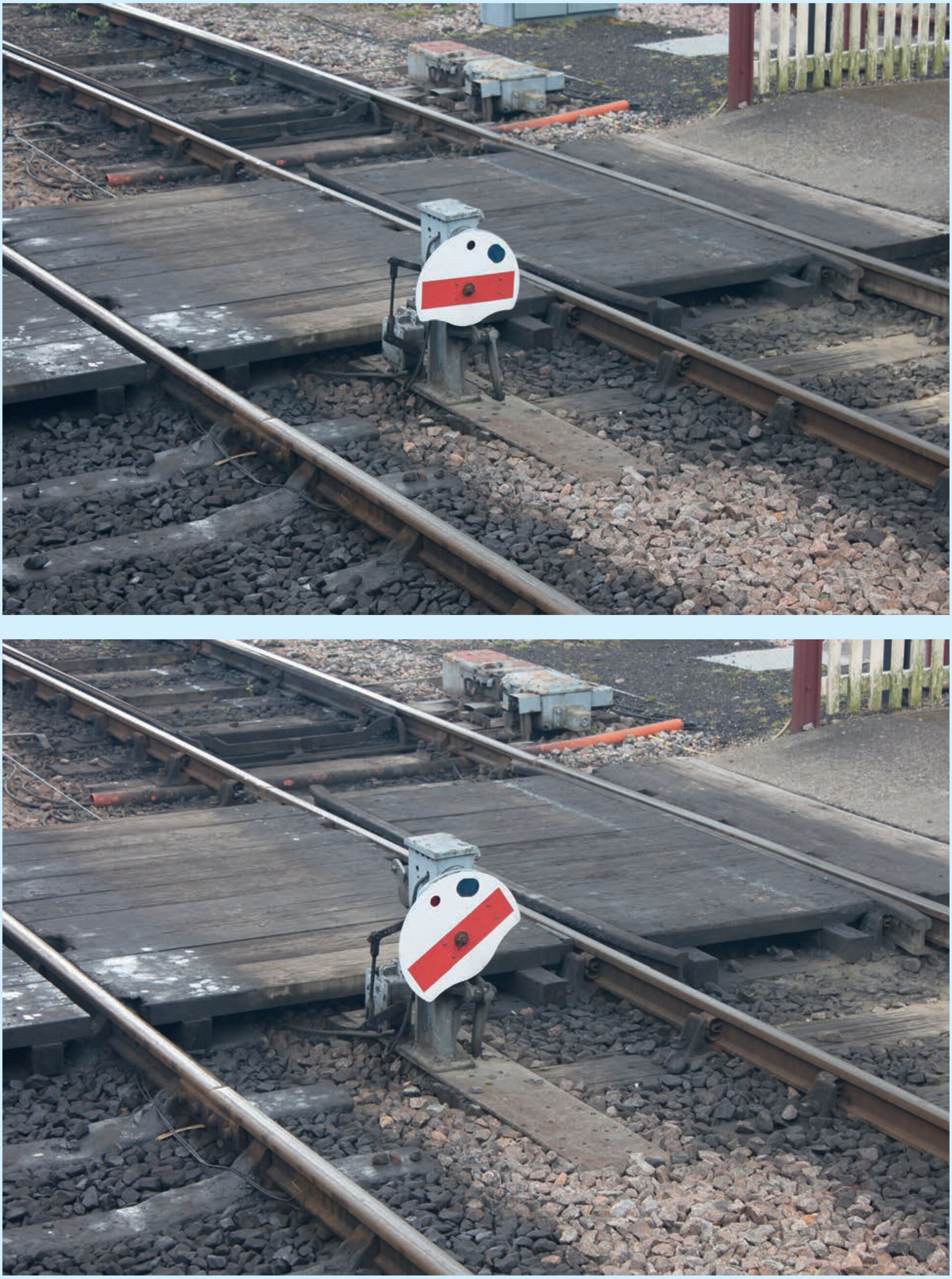
A colour light distant signal would only show a yellow or green aspect. In early days they were battery powered from lead acid cells fitted in the cabinet at the base of the signal, and charging of the batteries was via dedicated pole route wires that carried nominally 110 volts DC supplied from a local power supply within the signal box. The batteries ensured that the signal was always lit, even when power outages were experienced.

The aspects of the colour light distant work exactly as per the semaphore distant signal, in that the green aspect could only be illuminated if the whole section ahead was all clear, otherwise the distant remained at yellow.

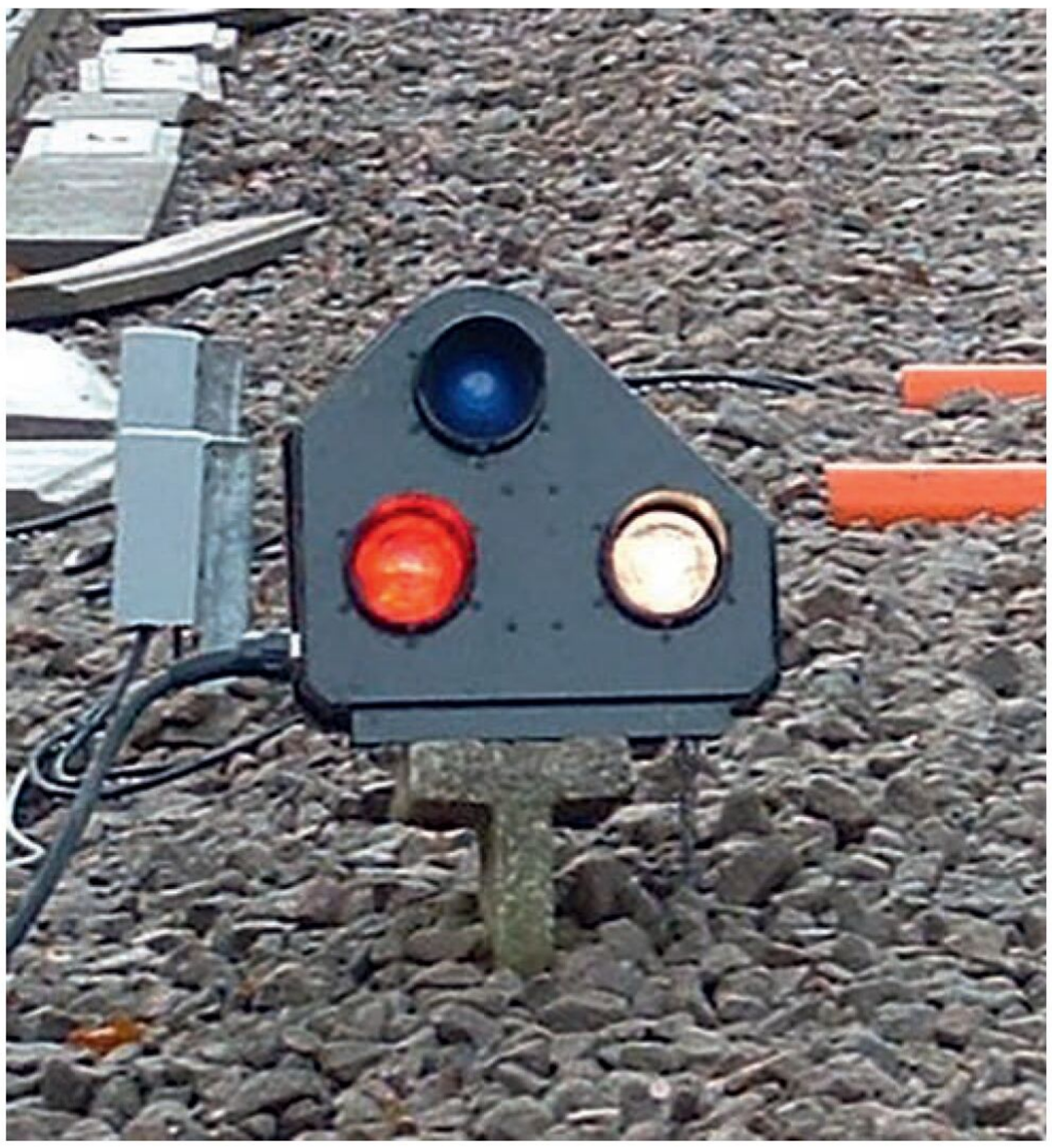
Two-aspect signalling is used where the train traffic is exceptional light, typically on branch lines or lines where train density is low. Such signals display red or green, red and yellow, or yellow and green depending on their position in the signalling area. Three-aspect signalling is used where train density is greater, the line speed is frequently lower, and braking and stopping distances are longer between signals. Three-aspect signals normally display red, yellow or green aspects. In four-aspect signalling – 2nd yellow, green, 1st yellow and red, from top to bottom – the top yellow lit with the middle yellow indicates that the next signal is yellow and the next but one is at red.

All colour light signals are arranged so that the red aspect is closest to the driver's eye-line. Thus, for post- or gantry-mounted signals this means that red aspect is at the bottom of all the aspects, the first colour that the driver would see on approach. Where signals are tunnel-mounted – normally inside tunnels – the red swaps position to the top, keeping it nearest to the driver's eye-line. So, from bottom up, a tunnel ground-mounted colour light signal would read second yellow if four aspect, green, 1st yellow, and red at the top.

BR colour light signals used filament lamps to illuminate the aspects. Usually the lamps had twin filaments, and these are employed with one or both filaments illuminated depending on the lamp style in use in that particular signalling area. The idea was that should one filament fail, the other would be able to take over until the lamp could be replaced.



In the first picture a mechanical shunt signal is shown in the 'on' (stop) position, and in the second in the 'off' (proceed) position.



A filament illuminated shunt signal in the 'on' position. Note the upper light is unlit.

The same signal is now in the 'off' position. Note the right-hand white light (called the 'pivot') remains illuminated.

More modern signalling now employs LED (Light Emitting Diode) illumination, and as the LEDs can produce three colours in one lens, signal heads are reduced to one lens for the red, yellow and green. Where four-aspect signalling is used a second lens and LED light is fitted above the first and lights only to show a yellow when the second yellow aspect is required, otherwise it stays unlit. The use of LED lighting has improved signalling tremendously as it offers virtually fail-free illumination and a much clearer and brilliant visible aspect.

In our model form signalling can be of either type – semaphore or colour light. But don't intermix them, except if the colour light distant is required on semaphore signalling.

Semaphores and colour light signals can be purchased readymade, in kit form or built from scratch. Semaphores can be operated mechanically via fine line (fishing line is often used) from a lever frame. They can be electrically operated via solenoid coils, stepper motors or servos. Or just left fixed in the 'off' or 'on' position as required.

Currently Dapol produces a working semaphore signal of various styles in OO and 'N' scale. These are 'planted' into a hole drilled in the baseboard and wired to a simple push-to-make push button or switch and of course a suitable power supply. At the time of writing there are no off-the-shelf working semaphore signals for other scales, though there are a small number of specialist manufacturers that can undertake orders for working signals. Older modellers may recall the Hornby Dublo working semaphore signals, which at times can still be found second hand, but their size is rather over scale for OO railways and are somewhat toy-like in their appearance.

Colour light signalling is available in most scales and is produced as both working or non-working signals. Typical examples of OO scale non-working colour light signals are the items produced by Knightwing and Bachmann in the UK. Working colour lights are produced by several manufacturers, and the Eckon and Berko range offer a good choice for the kit-builder. Ready-made ranges of colour light signals are also produced by specialist producers such as Train-Tech, CR Signals and Absolute Aspects, to name but three. In addition, in OO scale there is the Hornby range, which are now LED-lit rather than the filament lamps formerly used. But I find these to be somewhat overscale and toy-like in appearance. Most colour light signals use LEDs as the light source for illumination. They offer cool running, good colour rendition and are long lasting and dependable if fed correctly with power.

Where a junction is signalled by colour lights, a Junction Route Indicator (JI), also known as a 'feather', is used. This usually sits on top of the main signal head and illuminates with rows of five white lights. There are six positions for UK JIs and each indicates the route to be taken left or right from the main line. The six positions are numbered 1 to 6; position 1 is top left, position 2 middle left and position 3 lower left, while 4 to 6 are top right, middle right and lower right respectively. The upper and lower positions are

approximately at 45 degrees to the horizontal. Eckon produces an OO scale JI, but this is only available in position 1 or position 4. Wire the signal via the signal post to below the baseboard, then the choice is to use a manual switch to operate it or perhaps have automatic illumination via a point-operated position switch. Here I would be inclined to ensure that the red aspect is not lit when the JI is to become lit; a relay or some form of electronics can be used to prevent this, i.e. the J/I only illuminates with a proceed aspect.

Another means of advising the train driver of the direction to be taken is the use of 'theatre' lights, which illuminate a letter or number relating to a track ahead. Originally these used a dot matrix display of small pigmy lamps, but these have been replaced by LED theatre lights that show white letters or numbers. They are reproduced in the model form mainly by specialist manufacturers such as Absolute Aspects and Train Tech (Gaugemaster) while home-made units can be produced using commercial small seven-segment LED matrix units. However, obtaining white LED types is a little harder as many of the readily available ones are yellow or other colours such as red or green. But white can be found with a little searching. They need very careful wiring and the use of ultra-fine wires.

Ground or shunt signals

One other type of signal used is the shunt or ground signal. These are either mechanical disc-style shunt signals or the electrically lit aspect type. Two distinct styles are used, as for main signals. The mechanically operated discs have a horizontal red band on a white background; the disc, known as a 'target', indicates stop when horizontal or proceed when angled to around 45 degrees. There is also the caution type, which uses a white background and a yellow horizontal band, or at times a black background with a yellow band. This position or when angled to 45 degrees ('off'), and are mainly used where shunt moves can be made along a siding without interfering with the main line. Although called ground signals, they can at times be mounted on posts or signal posts.

The modern version is the illuminated shunt signal, also known as a Position Light Signal (PLS). This has two types. The early version used a white 'pivot' lamp and a red horizontal light to signify stop ('on'); when 'off' the pivot remained lit at white and another white light was lit diagonally at 45 degrees and the red extinguished – thus two diagonal whites were shown for proceed. The latest type, used from around the early to mid-1990s uses LEDs and has the pivot lamp as a dual colour. When 'on' the signal displays two red horizontal lights. When set to proceed ('off') the pivot red changes colour to white and the diagonal white is also illuminated, again producing two white lights at around 45 degrees.

Shunt signals are produced in mechanical form by a few kit manufacturers for the user to assemble and paint, or the electric type readymade in the two versions. Several manufacturers produce these and are easy to install and wire.

Mechanical ground shunt signals are usually replaced during resignalling or upgrading works with colour light shunt signals. There are also shunt signals that display a yellow light instead of the red, in which case these could be passed by a train even when 'on' (horizontal yellow and white lit). Often this route was towards a stabling siding usually within a siding.

LED PLS. Image courtesy Unipart Domain

13
Electrification – Third Rail and OLE

Railway electrification falls into two main areas, 'third rail' (conductor rail) or Overhead Line Equipment (OLE). I am deliberately excluding fourth rail electrification schemes as used on many underground railways, as this book deals with systems seen usually on main lines.

Both styles of electrification can be modelled. Modern image modellers or those wishing to portray the UK's Southern Region from around 1930 to the present day have ample opportunities and will find plenty of documentation about these systems of traction power supply. Merseyrial also uses third rail traction. Conductor rail is available in OO scale from Peco, which produces insulated third rail "pots" and a Code 60 rail to fit into the pots to represent third and even fourth rail systems. C&L Finescale produces a range of pots, ramp ends and guard boards together with a special gauge to aid pot placement. The Scalefour Society commissioned Exacoscale (now C&L) to produce a range of third rail pots, which were sold to society members or via the society's sales stand at exhibitions, but it is unclear if these components are still available. OLE is available ready to use from Peco, Dapol and Summerfield, although the latter has a more continental bias. Summerfield OLE is available in N, HO and OO scales, while Dapol OLE is produced in both N and OO scales. There are a few small 'cottage industry' manufacturers that produce OLE masts, often in brass etch self-assembly kits.

Third rail

Installing third rail means that the layout really has to be permanent and the track well secured. At the time of writing there is no commercially produced ready-to-use third rail for N gauge, but OO, EM and S4/P4 are well covered by the products mentioned previously.

The use of a pot-drilling template is well worth the cost, as it is necessary to fit a pot to the end of every fourth sleeper. A small 0.8mm-diameter hole is drilled, ideally by means of a template (home-made if necessary), and the required number of pots are slid onto the Code 60 rail. This is aided by filing a slight chamfer in the foot of the rail to allow the pots to slide on more easily. Position them in line with the pre-drilled sleeper-end holes, apply a spot of glue (UHU is ideal) to the spigot and insert it into the sleeper-end hole, threading the remaining pots along carefully and gluing each, then positioning them into the holes. A craft knife blade, a jeweller's flat-blade screwdriver and tweezers are all helpful in fitting the rail.

On curves it is best by far to pre-curve the Code 60 rail to the radius required before trying to thread the pots onto it and assembling on the sleepers; the pre-curving will assist the rail to align. Once laid and the glue has had chance to set, try several third rail locos over the area to ensure that the third rail doesn't cause the loco to be lifted on one side and lose contact with the running rail. One thing I've found when using the Peco system on Code 100 OO track is not to use the spacers, as they raised the third rail a little and caused several steam locos to stop operating due to their outside motion rods fouling the third rail.

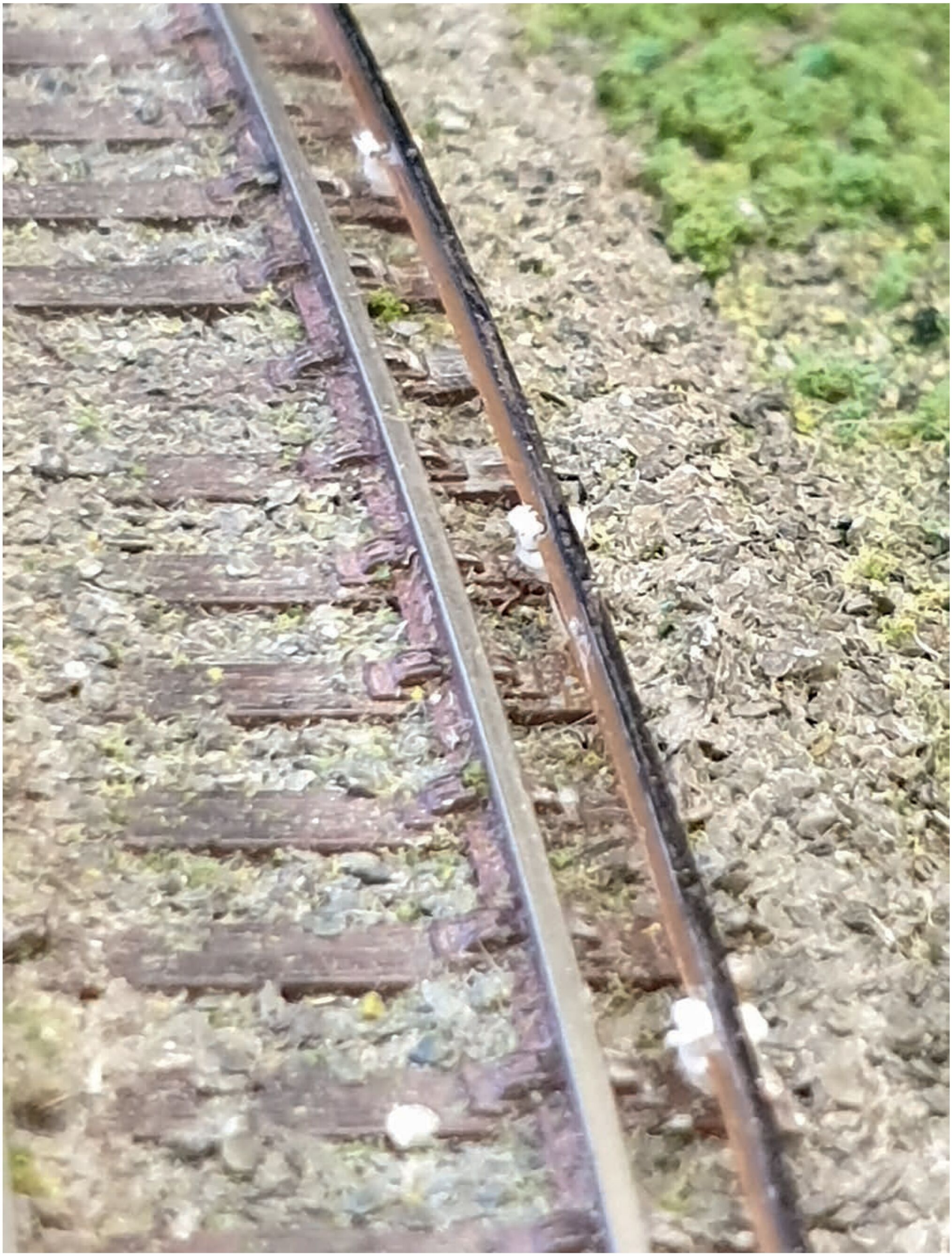
Third rail is conventionally installed on the sleeper ends between adjacent tracks, in the space that is known as the 'six foot'. At times it will move over to the outermost edges of the sleepers where required by sub-stations or tighter curves. It is always placed on the six-foot side or the opposite side across the track from platforms for passenger safety. Where pointwork occurs, shorter 'floater' sections of third rail are laid, and these can swap sides to maintain a continuous traction supply to the train or loco. The ramped ends of the rail slope downwards, and on the real thing have shallower pots fitted to the ends of the ramp, allowing the train's pick-up shoe to smoothly glide up onto or off of the third rail's top surface. There are very many types of ramp ends, and frequently those used by the modeller are of one style covering all applications.

It is at these ramps that most arcing is seen on the real thing, and this can be modelled by the use of a blue or blueish-white small high-brightness LED, operated perhaps by an ultra-small reed switch fitted in the track and a magnet on the train that closes the contact of the reed switch as the train passes over the reed. Then by means of a suitable small electronic circuit and power supply, the LED can be caused to rapidly flicker as if an electrical arc is being produced. The arc LED is hidden between the third rail and the running rail.

Once the third rail positioning has been checked, the Code 60 rail needs to be coloured to a dark brown and black finish. The use of a semi-gloss finish on the rail top can represent the de-icing fluid used on the real rail in wintertime.

Guard boarding – generally of wood, although a plastic version is also used on the real railway – can be fashioned from thin plastic strip or thin balsa strip and painted a deep brown or yellow colour. Paper staples can

Two views of Third rail Ramp Ends. Note in the lower image one ramp end has had the rail itself bent downwards, often seen where the train is always leaving the rail (train travelling right to left) while the nearer ramp end rail has a welded on flat section leading up onto the top of the rail. Often used where a train is approaching the rail, allowing for a smoother pick-up connection.



The Peco third rail and insulating pots installed on a section of OO track. The rail has been darkened to represent the spray form de-icing fluid applied to the rails in winter months. The top surface has been painted with a dark gun metal colour.

The real thing: third rail installed here on the outside of the two lines as a substation is nearby and this is one of the occasions the third rail moves to the out sides of the track.

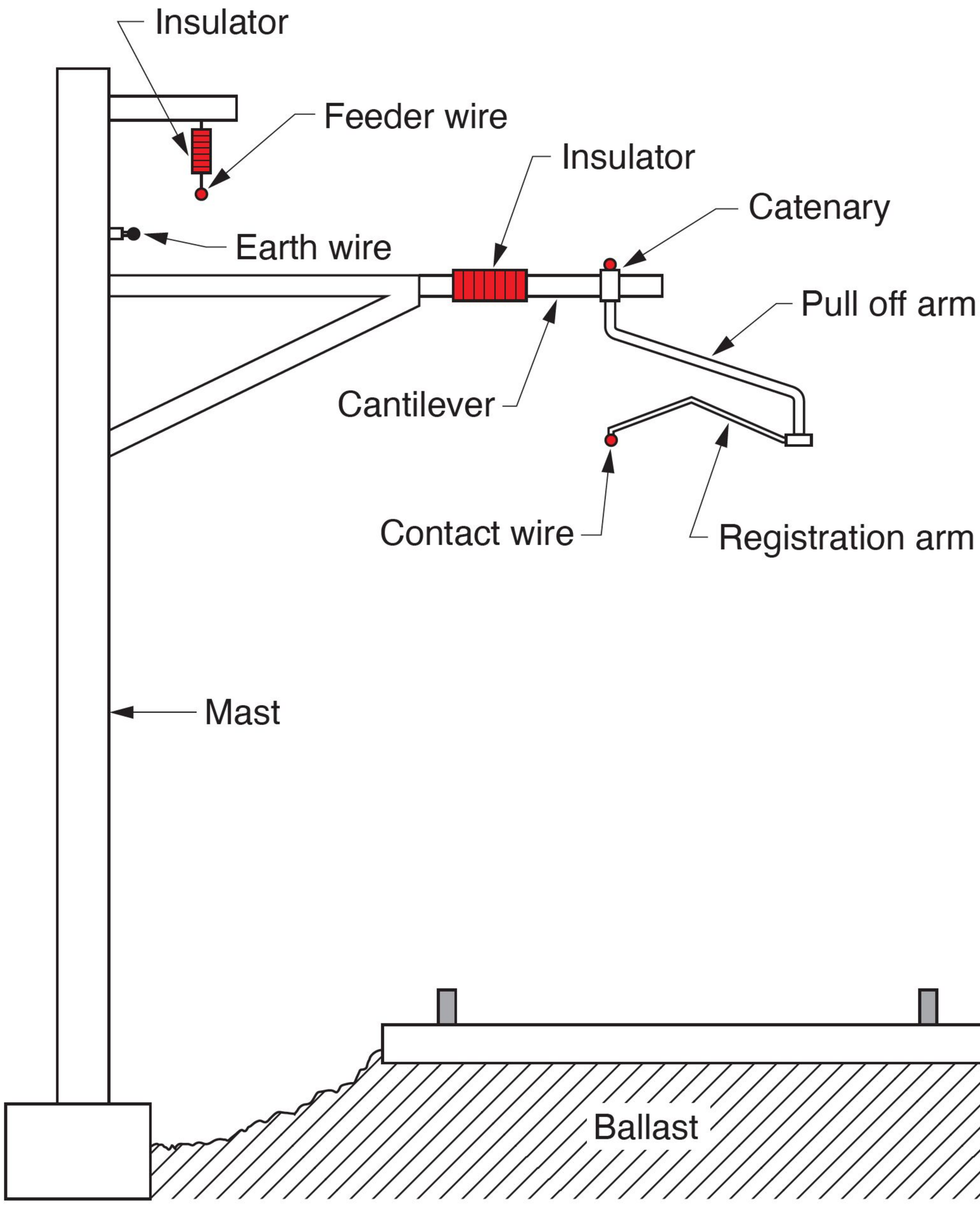
A longer view of the same area as above, Note in the distance the third rails move back to in between the tracks (in the six foot)

be fashioned and used as guard board supports. Guard boards are fitted on both sides of the conductor rail in station areas and the approaches to level crossings. Where there is a possibility of public trespass. They are also fitted to the inside (running rail side) of conductor rails in areas where rail staff are at risk of falling or tripping – in electrified sidings etc. Conductor rails in open country or rural areas are not usually boarded. A more recent location for additional boarding is under road or pedestrian bridges where vandalism is a nuisance; the throwing of metal items off the bridge causes severe damage to the third rail and the running rail due to the heat generated by the arcing created by the metal short circuiting the running rail to the conductor rail.

Heavy duty cables used for traction supply are connected to each conductor rail and lead off to link one conductor rail to another or to a sub-station. They are easily represented by using black insulated wire of a suitable insulation thickness.

For information, the third rail on former Southern Region routes is at a nominal 750 volts DC with some minor sections running at a slightly lower voltage.

Fourth rail, for those modelling an Underground railway line, can be added by the same methods as described for third rail installation. If using the Peco insulating pots, I would recommend not fitting the spacers to the pot's spigot. Fourth rail is installed exactly between the two running rails.



Overhead Line Equipment (OLE)

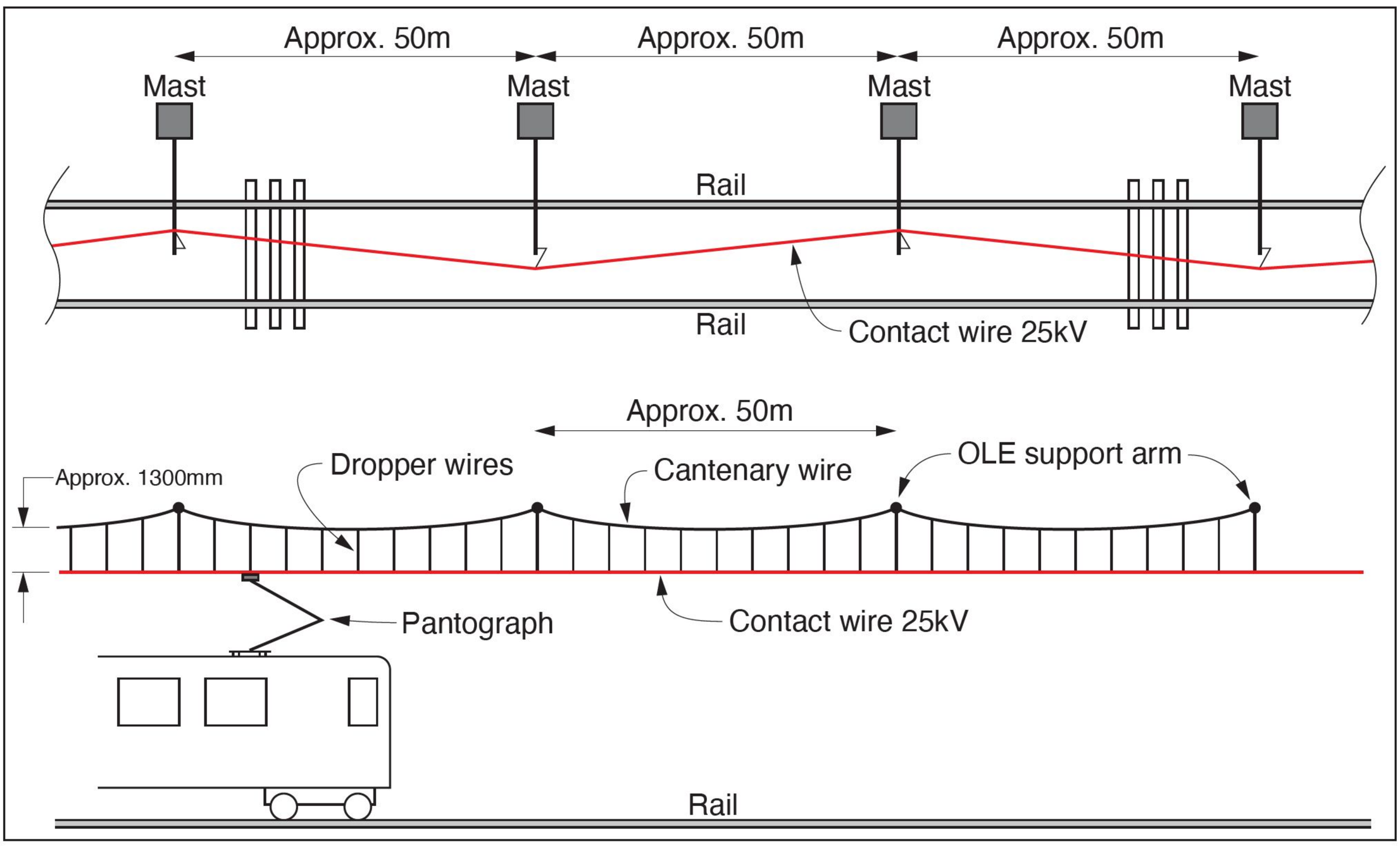
Overhead Line Equipment (OLE) is the preferred electrification method in the UK today. It was not used on BR's Southern Region main lines, as some of the system had already been laid to third rail before the outbreak of the Second World War, so it was considered more economical to continue the third rail programme into the late 1950s and beyond. The other factor was that tunnels and bridges did not have to be raised to provide the extra clearance that would be needed for OLE.

UK OLE is now standardised at 25,000 volts AC (25KV). For a short time, the Southern Region used 750-volt DC OLE in sidings where it was deemed to be hazardous to install third rail. This system was quickly removed once diesel locomotive traction was used, and much of the 750-volt OLE was taken down and the masts reduced to nothing more than a flush cut-off tube in a concrete ground fitting. A small amount of 1,500-volt and 6,600-volt DC OLE was used between London, Colchester and Southend on the former Eastern Region and in the north of England (the Woodhead route), but has now been removed. This system mainly used a gantry (portal) supporting system rather than the single mast/post type.

Electrification of the UK rail network is a slow process, with many areas still to be electrified and currently operated by diesel-powered trains. Where electrification has taken place, the contact wire is supported by what is known as the catenary (the whole work is also known locally as 'the knitting'!), and this is supported on usually galvanised steel masts with arms at right-angles and registration arms holding the main contact wire in either a 'pull off' or 'pull on' mode to provide a zigzag course. Insulators keep the mast and support arm electrically isolated from the main catenary and contact wire. Today, masts are positioned around 50 metres apart, but become closer together on curves.

On multi-track configurations an OLE gantry spans the lines and has several arms supporting the wires above each track. All the wires are held under tension by strategically placed weights located at the ends of the masts. These weights allow the contact wire tension to be maintained due to expansion and contraction in the wire. On the outsides of the masts at high level are generally one or two wires and these carry the power and where a second wire is seen, an electrical earth return. On a UK Mark 3 OLE installation the contact wire is at 4.7 metres above rail top, although this height will often vary at level crossings, overbridges and depots.

The locos and trains have wiper contacts fitted to their roofs, known as 'pantographs', and the contact arms rub on the underside of the contact wire and take the 25KV power down into the loco or train where it is used to turn the traction motors and provide train



Below are two simple drawings of OLE. The upper drawing showing the zigzag of the contact wire while the lower drawing shows a side view of the contact wire, the supporting droppers and the catenary that holds the whole lot in place

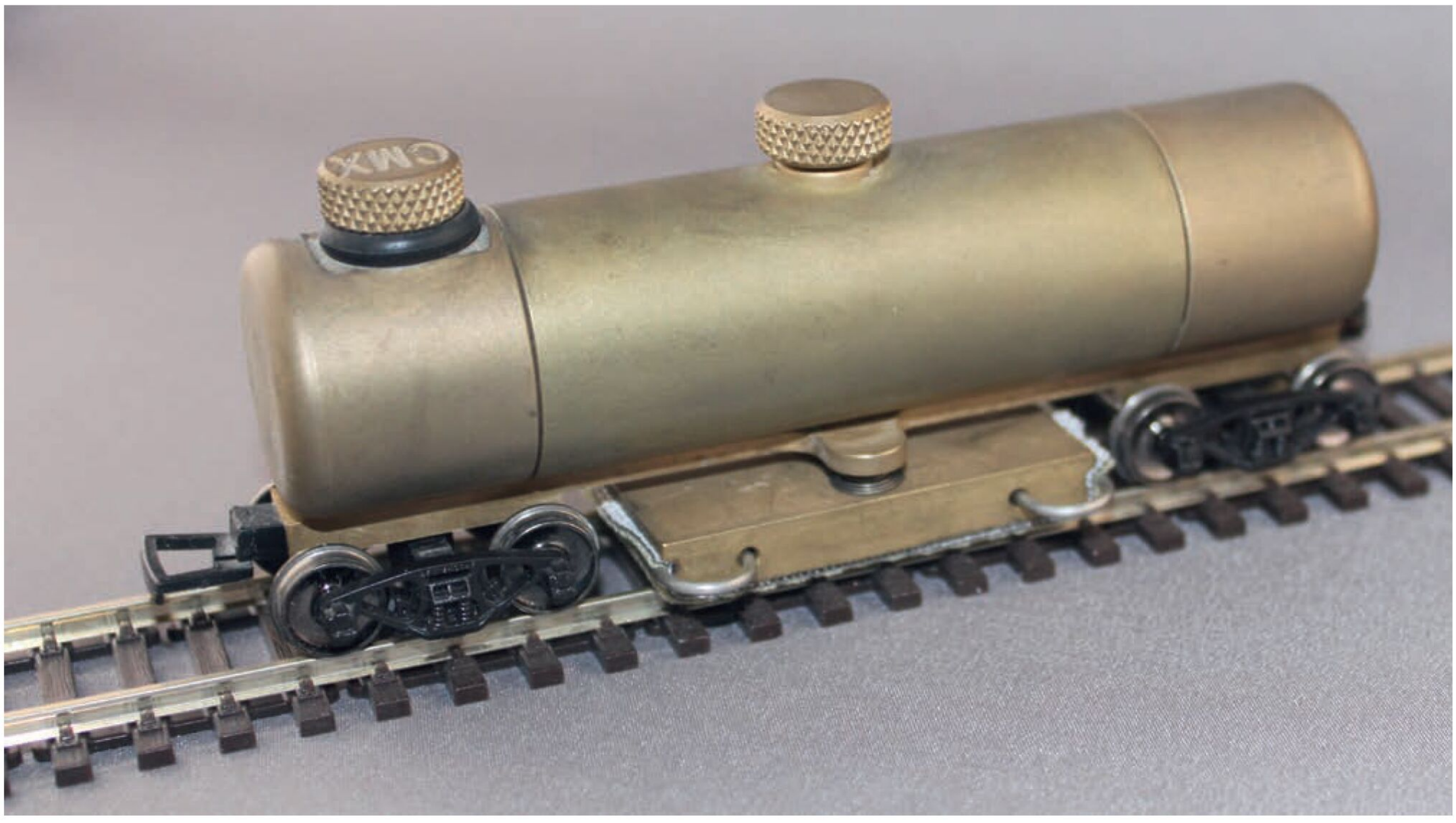
Peco OLE on a OO layout. Courtesy of Peco

A manual track cleaning pad that can be dampened with fluid such as Isopropyl Alcohol (IPA) or a proprietary track cleaning fluid and pushed along the rail tops under OLE

heating and lighting, etc. The contact wire zigzags slightly above the track's centre line to prevent wearing a ridge in the pantograph.

In model form, frequently OLE masts and wires are installed but are not operational, just a dummy system to represent the real thing. Trains run with the pantographs raised and look as though they are picking up power, but are in fact still using the conventional two-rail power supply. However, catenary systems can be made able to carry power and if the loco's pantograph is able to collect the power the system can be used separately from the two running rails. On DC layouts this offers the ability to run two trains on the same rails, with one using the two running rails for power, and the other using the OLE and one running rail. This is in fact a common return wiring method. It is not recommended to mix the two methods for DCC. Unfortunately, many ready-made locos fitted with pantographs are non-operational and to convert them would need a lot of skill and work together with the electrical wiring to the motor. It is in my view better to have dummy OLE if it is required. But do remember, installing OLE means rail cleaning becomes that much harder where manual hand rail cleaning is used!

When installing OLE, a few things should be remembered. If your track is lifted above baseboard level on, say, cork strips or foam underlay, the mast bases need to be raised by the same thickness to keep the contact wire at the correct height – without this added lift it could become too low, causing the pantograph to fold down under its own spring.



The use of a rail cleaning tanker wagon saves a lot of manual cleaning and one such is CMX tanker shown below. This is pushed or pulled around by a large loco and applied cleaning fluid to the rail tops and the cleaning pad wetted by the fluid dripping down from the tank and 'skids' along the rails.

Of course, manual track cleaning 'Rubbers' are readily available and work well too. Image courtesy of *Model Railroad* magazine

Where the OLE goes off scene into a tunnel or siding, etc., and the OLE is not required in these locations, an upward 'ramp' will be needed to allow the pantograph to lift, then at the other end a downward one is required to press down the pantograph to its correct height before appearing on the scenic side of the layout. A ramp can be fashioned from Code 55 rail or similar, or a slightly thicker contact wire. A rough idea of the angle of the slope would be around 10 degrees from the scenic-side OLE upwards and downwards to the wire's correct height on exiting the siding or tunnel back to the OLE height.

One thing to remember if installing OLE is that it means rail cleaning becomes much harder where manual rail cleaning is used, as the wires cause a problem in getting a hand under them to allow cleaning, which is an essential job to be regularly undertaken. Thought therefore needs to be given to how rails will be cleaned where the catenary is installed. Consider using a rail cleaning wagon pulled or pushed by a large heavy loco, with its cleaning pad dampened by Isopropyl Alcohol (IPA), methylated spirit (meths) or other proprietary rail-cleaning fluid. Alternatively use a long-arm cleaning tool with a fixed track rubber fitted to its end or a suitable pad that can be moistened with rail cleaner fluid.

14
High Hopes (365 Challenge Build)

My latest layout, 'High Hopes', is semi portable. It's not based on any real place but does have a 1960-1970 BR LNER theme. It occupies half of a double garage and the track plan is shown below.

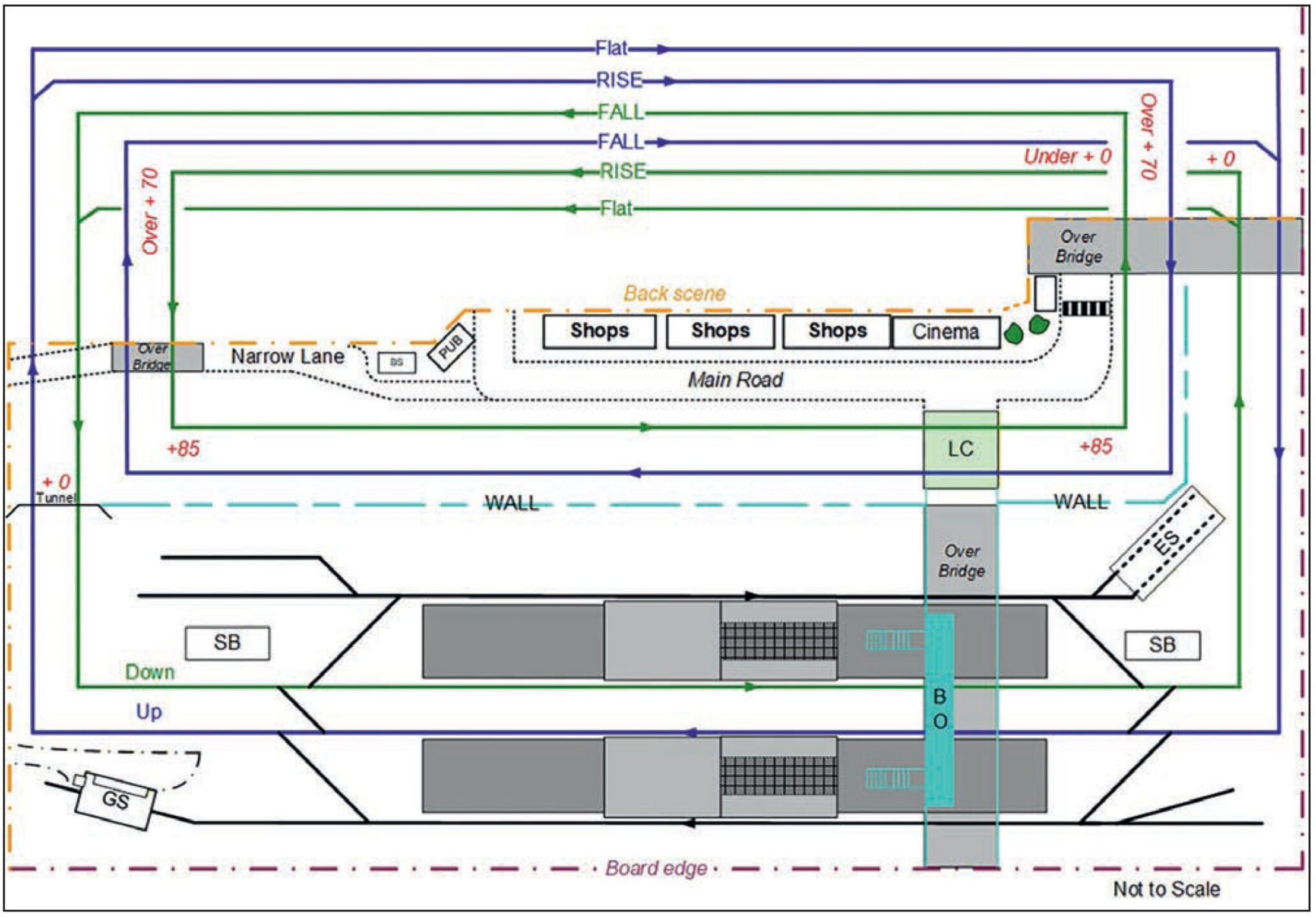
I would have liked for the two sets of crossover points at either end of the station to have been further out, but space restrictions prevented this.

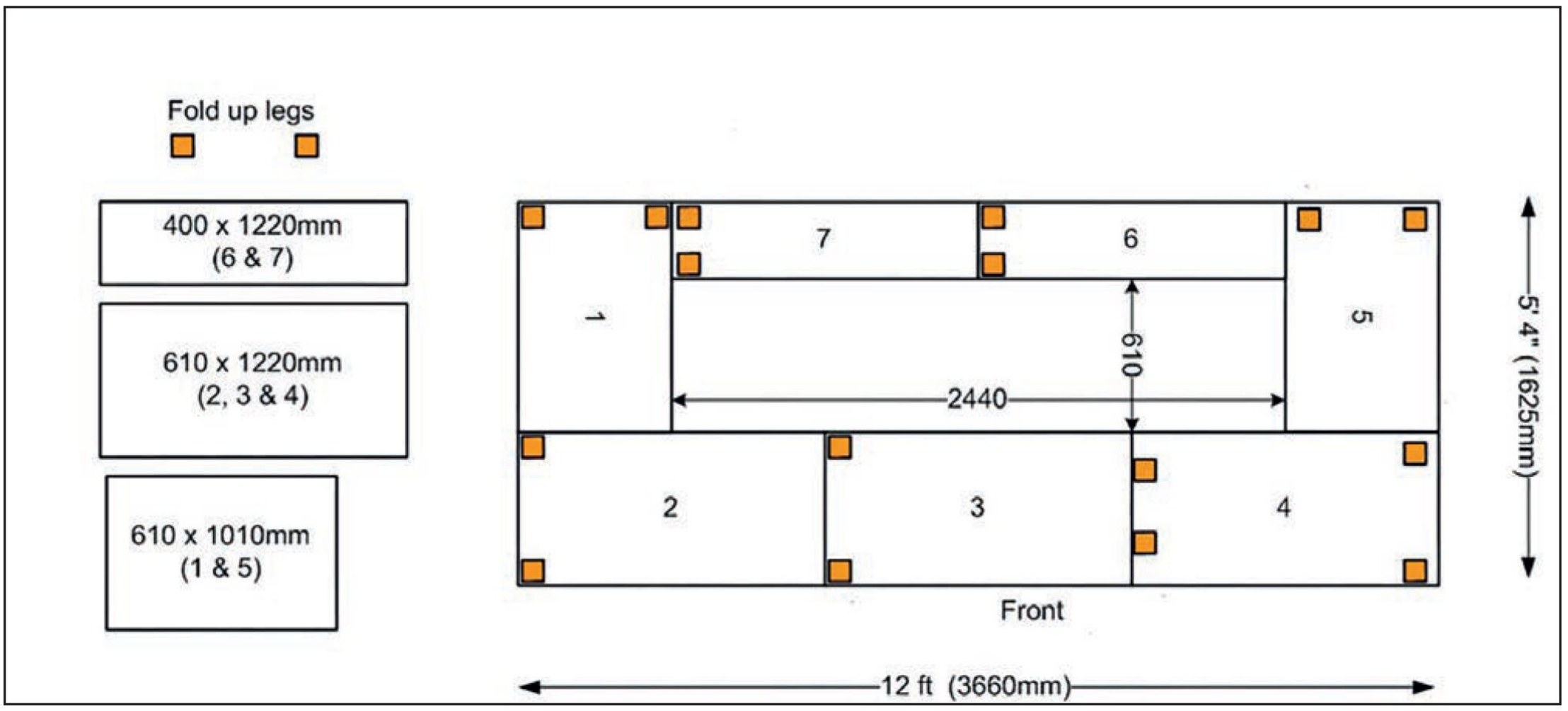
I gave myself one year to build the layout and get it operational, hence this being a '365' challenge. Did I succeed? Find out later!

Construction was commenced with ordering two 2,400mm by 1,200mm (approx. 8ft by 4ft) 11mm thick sheets of OSB (Orientated Strand Board) which is frequently used for shuttering-up purposes, especially boarding up of broken windows etc. It is very flat and easily cut with a hand saw, but I take the ultra-easy option and use an electric circular saw. Where detailed cutting is required, I used an electric jig saw! OSB holds screws and nails readily and is less expensive then plywood of a similar size. It doesn't produce carcinogenic dust when cut either, as MDF tends to do. As always though, when cutting any man-made board, wear a suitable face mask and work outside.

As the layout was to be semi portable, I decided to use deeper outside framing timbers with smaller internal cross bracing timber. So, I opted for 69mm by 18mm PSE (Planed Square Edge) timber for the outer frames and 21mm by 44mm PSE for the internal bracing timbers. While waiting for delivery of all the timber and boards, plus three boxes of various sizes of wood screws and a bottle of PVA woodworking glue, time was spent producing a cutting list for the baseboards to try and maximise the OSB boards and save waste.

Legs to support the layout were to be of the same 21mm by 44mm PSE and would be permanently attached to the larger outer framing by T-hinges. One board would have four legs, while all the other boards had one set and 'piggy backed' onto the abutting board.





The baseboards configuration.

Cabinet maker's dowels would ensure 100% alinement of the abutting boards, while suitcase latches would be used to pull the boards together and lock them securely in place.

Delivery of the OSB sheets and timber eventually occurred, after a couple of weeks' delay due to supply issues, and then the previously produced cutting list was drawn out onto the two large OSB sheets. Supporting these sheets on two portable work benches, the electric circular saw was put to use. The seven boards were very quickly cut and ready for edge smoothing with some sandpaper. Each cut section was marked with its unique number taken again from the pre-drawn cutting list. Seven panels of various sizes where produced. Three were 1,220mm by 610mm, two 1,010mm by 610mm and two more at 1,220mm by 400mm. The two 400mm wide boards were then cut into four equal widths and each is of the same length, these producing eight approx. 100mm wide boards by 1,200mm long. Two of these narrow boards would produce the up ramps between lower and upper track sections. The other two narrow boards producing the down ramp, with four more boards producing the flat hidden storage areas two on each side of the ramps at the rear of the layout.

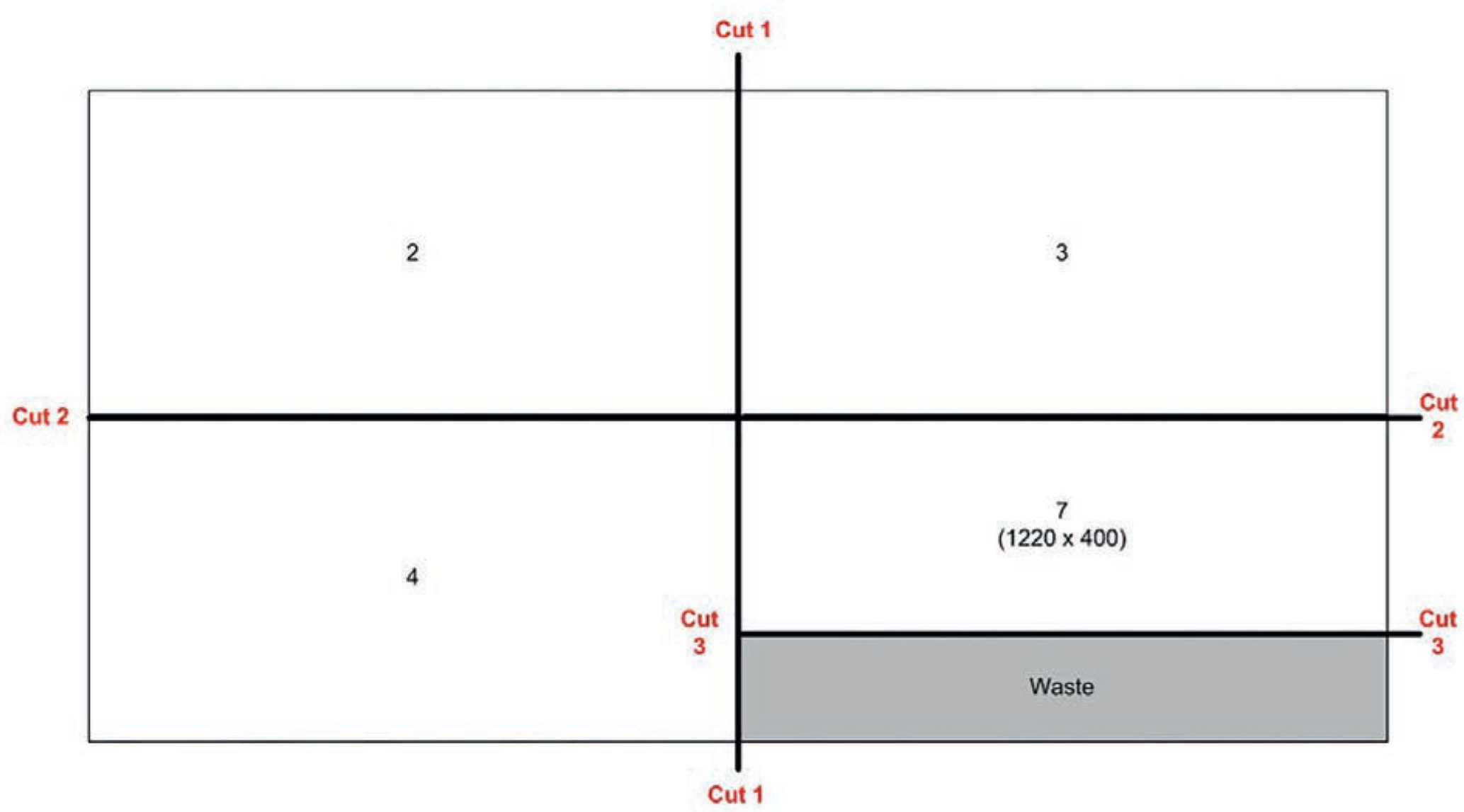
A 210mm wide strip was cut off the longer edges of the two wider boards, which would be used for the front higher level section. At each end corner board on the high level an angle cut was made to allow the curvature of the upper level tracks.

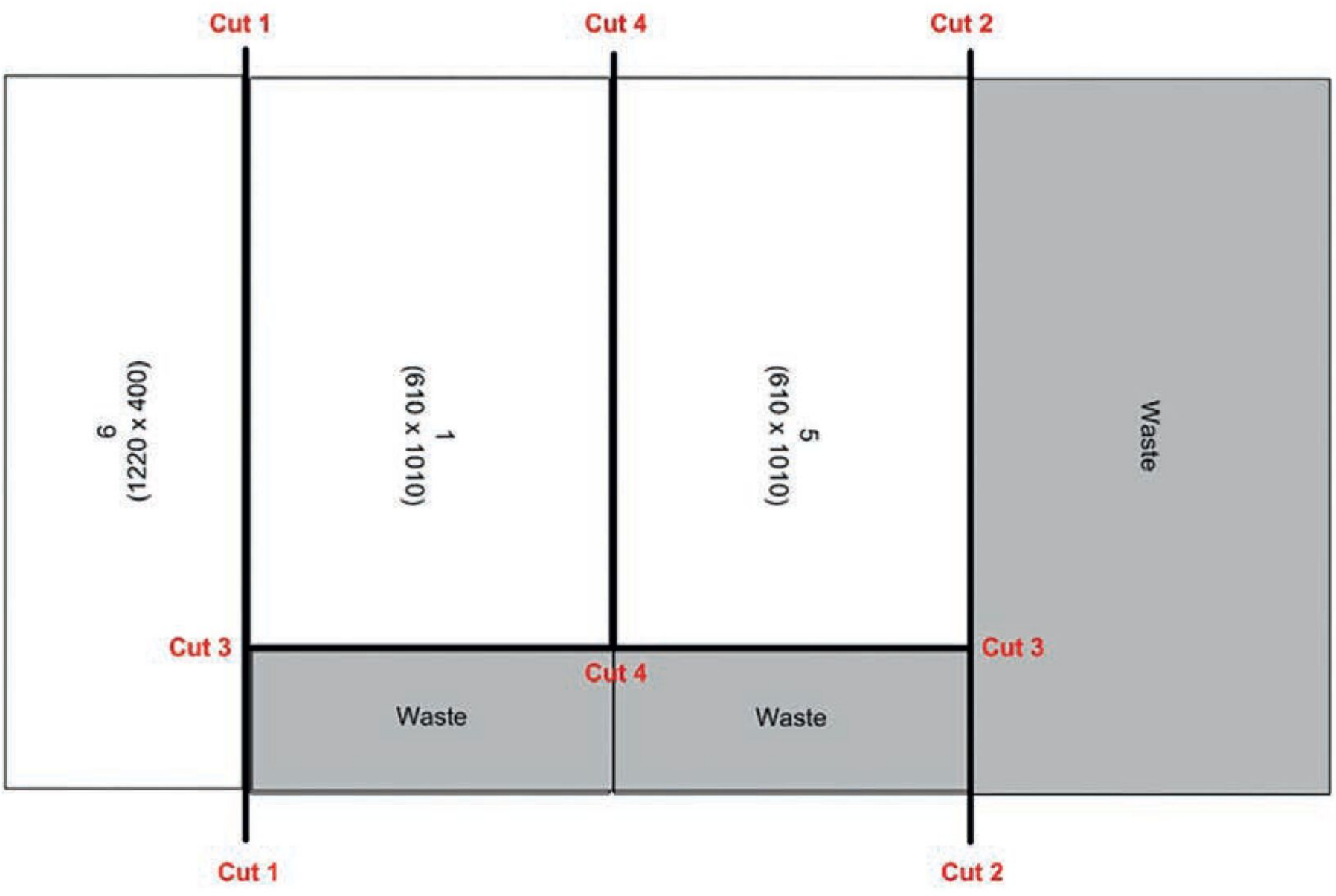
As the layout is to be semi portable I decided that the supporting legs would all be hinged and fold up into the deeper outer framing. As previously mentioned, these legs are hinged using 200mm long T-hinges. The legs allow the baseboard lower level to be at 39 inches (1m) above floor level. Each leg has two horizontal cross braces fitted, one towards the upper end of the legs and some 300mm down from the top and the other cross brace is around 150mm up from the bottom of the legs, these lock the legs rigid and prevent sideways movement.

To maintain the legs, diagonal but removeable braces were constructed, these fit onto the middle of the lower cross bracing timber and also to one of the narrow cross braces underneath the baseboards' surface. They are held in place by back flap hinges that have been modified by removing their pivot pin and using a split pin to hold the two halves of the back flap together. This arrangement allows quick assembly and disassembly of the layout. To prevent losing the split pins a short length of chain is connected to the split pin and the other end of the chain fixed to a timber bracing.

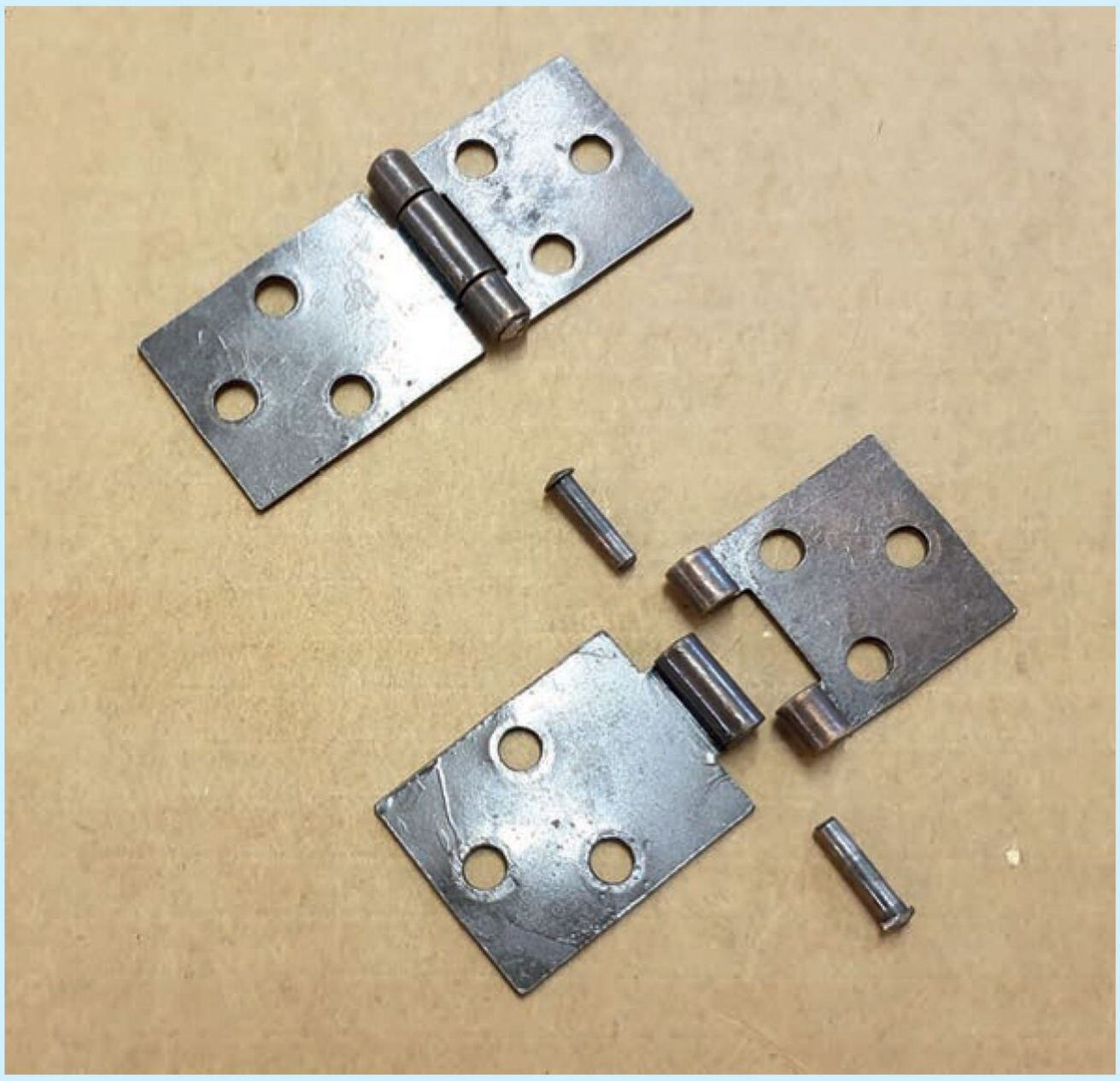
All carpentry cutting of the timbers (if you can really call it carpentry!) was undertaken using mainly an electric chop saw to provide a square cut. Square butt joints were used and all joints were woodworking PVA glued, then secured together with suitable wood screws inserted into predrilled pilot holes to avoid the timber splitting. Once the basic frame had been produced, the baseboard top was PVA glued and screwed onto the narrower edges of the outer timbers. Then the shallower cross bracing timbers where added. But before they were fitted, they were each drilled with three 15mm diameter holes in their wider surfaces, the holes being as close to the top edge as practical. These holes are to allow future wiring to pass around under the baseboard.

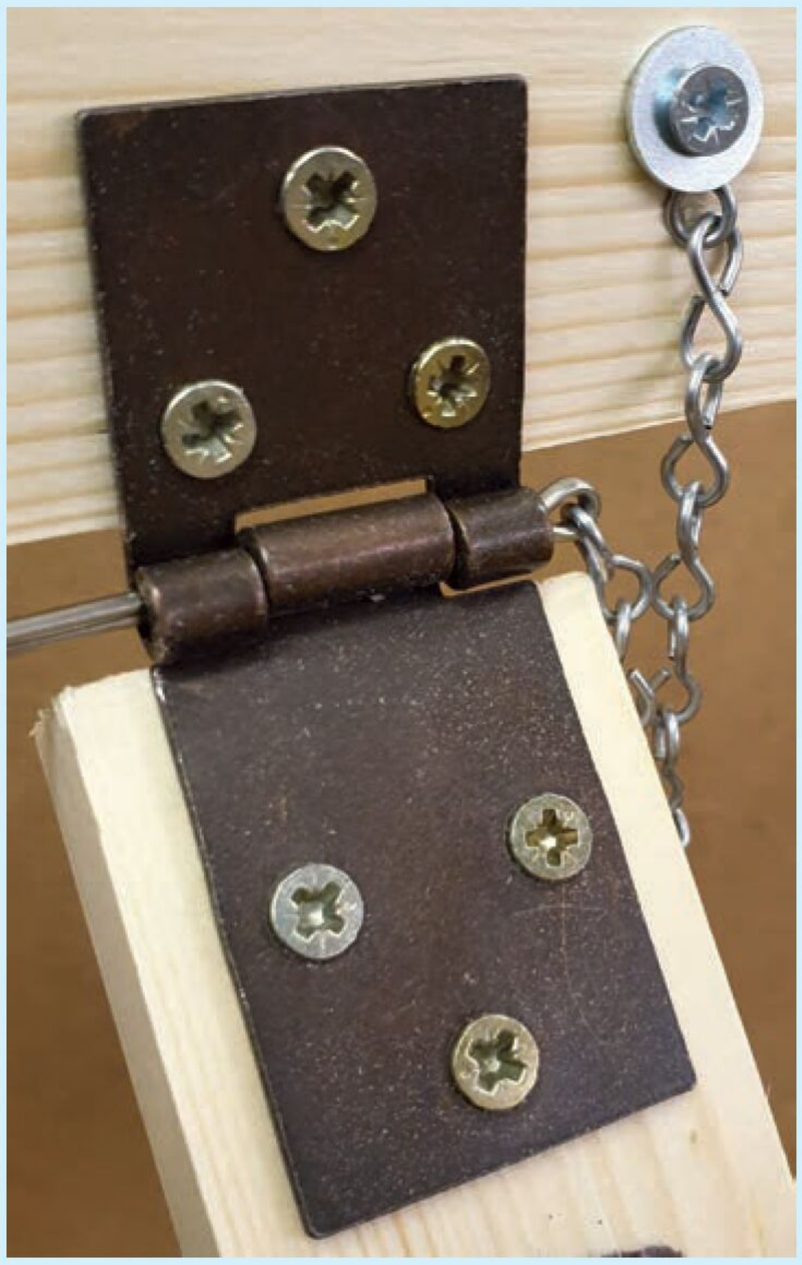
The boards are held in register with each other by the use of two cabinet maker's dowels fitted into the end framing and the boards are pulled up tight together with the use of strong suitcase latches. Finally, a dilute coat of water and PVA glue was painted onto all surfaces





Cutting plans for the OSB sheets. The waste sections were later put to use in reinforcing back scenes or raised areas.





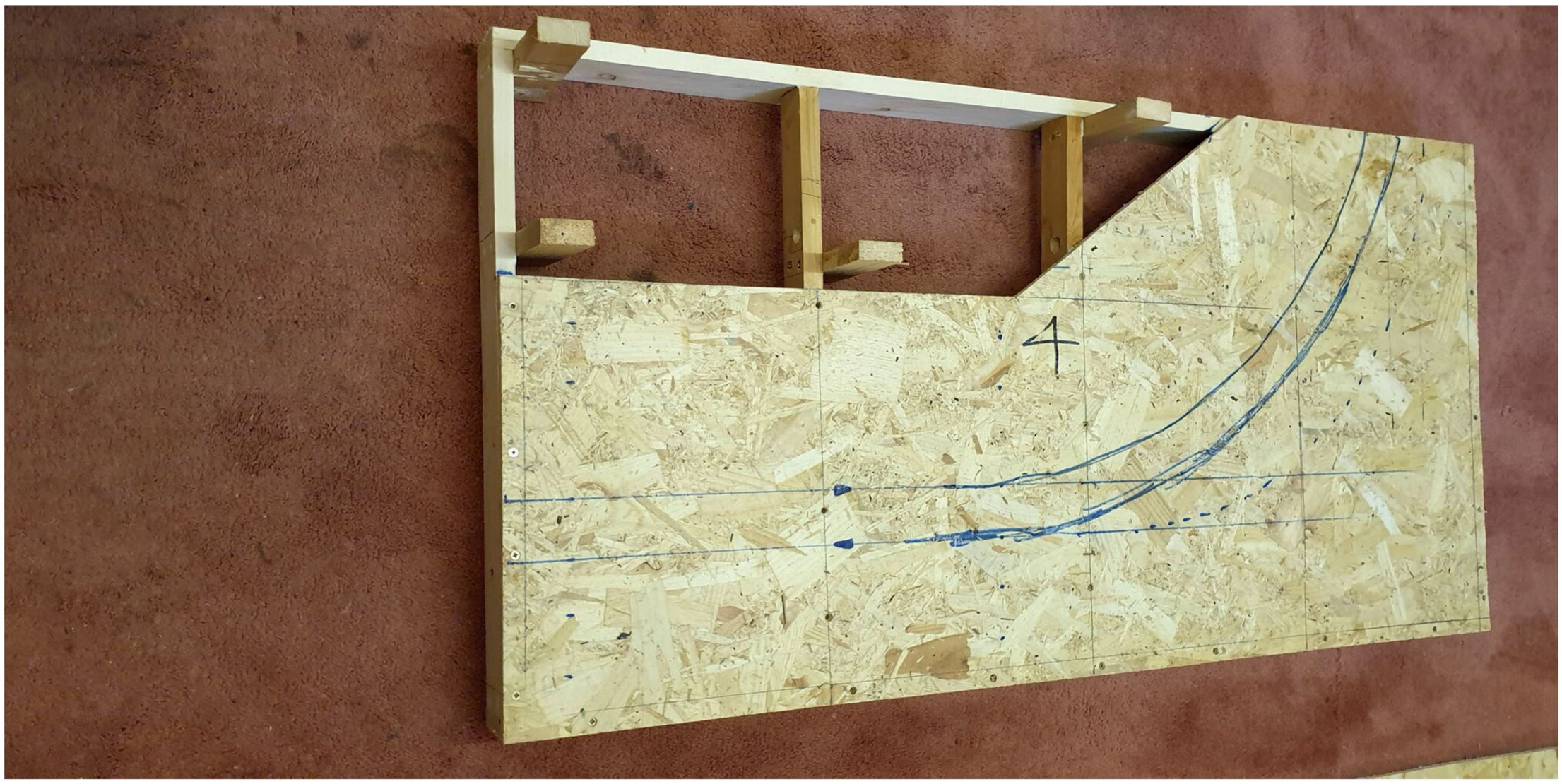
The converted backflap hinges and split pins.

to help prevent any possible later moisture ingress. This was allowed 24 hours to fully dry before any further work was undertaken.

Thoughts turned to track laying, drilling holes for point motors to operate the point blades and connecting wiring board to board. As DCC (Digital) is being used and my DCC system can produce around 4.0Amps – I opted to use 20mm 'aviation'-style four-pin plugs and mating sockets to transfer the DCC and 12 volts DC power, board to board. Plus 16mm aviation plugs and sockets in 4-way configuration for the pair of data wires and a pair of spare wires should something extra be needed (more on this later).

Track laying commenced with drawing onto the

The underside of a baseboard with the shallower cross bracing installed. Note the predrilled holes for future wiring runs.

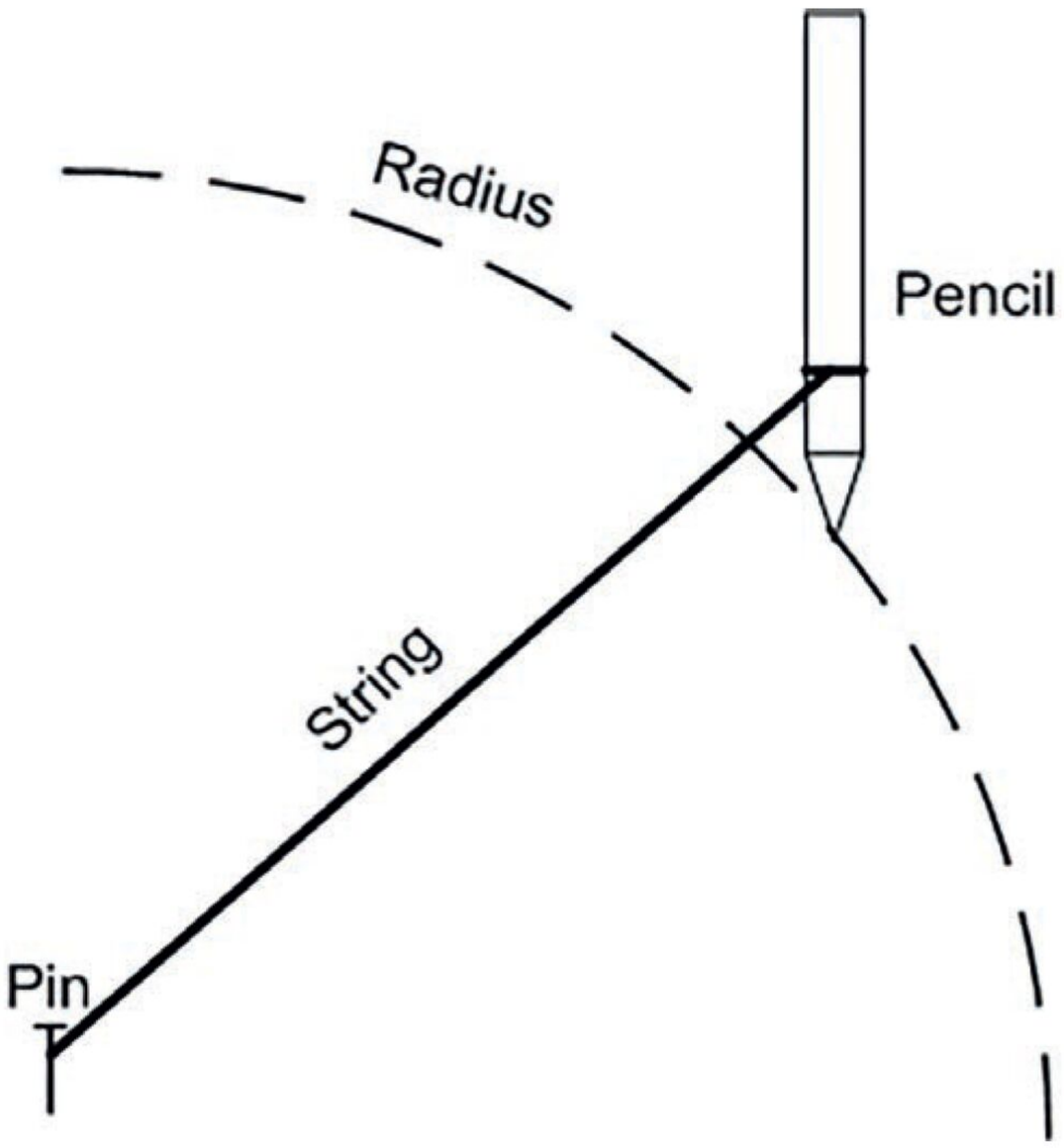


A section of a corner baseboard showing the cut away which will be used on the upper track level. Riser blocks have been installed ready to support the upper section.

The legs fold up within the baseboard's framing and look like this when ready for transportation. On the left is the only board with two sets of legs.

The diagonal brace that is used to maintain the legs in their open position.

The upper track and scenic level was then added using timber off cuts acting as 'risers' to support the upper level.



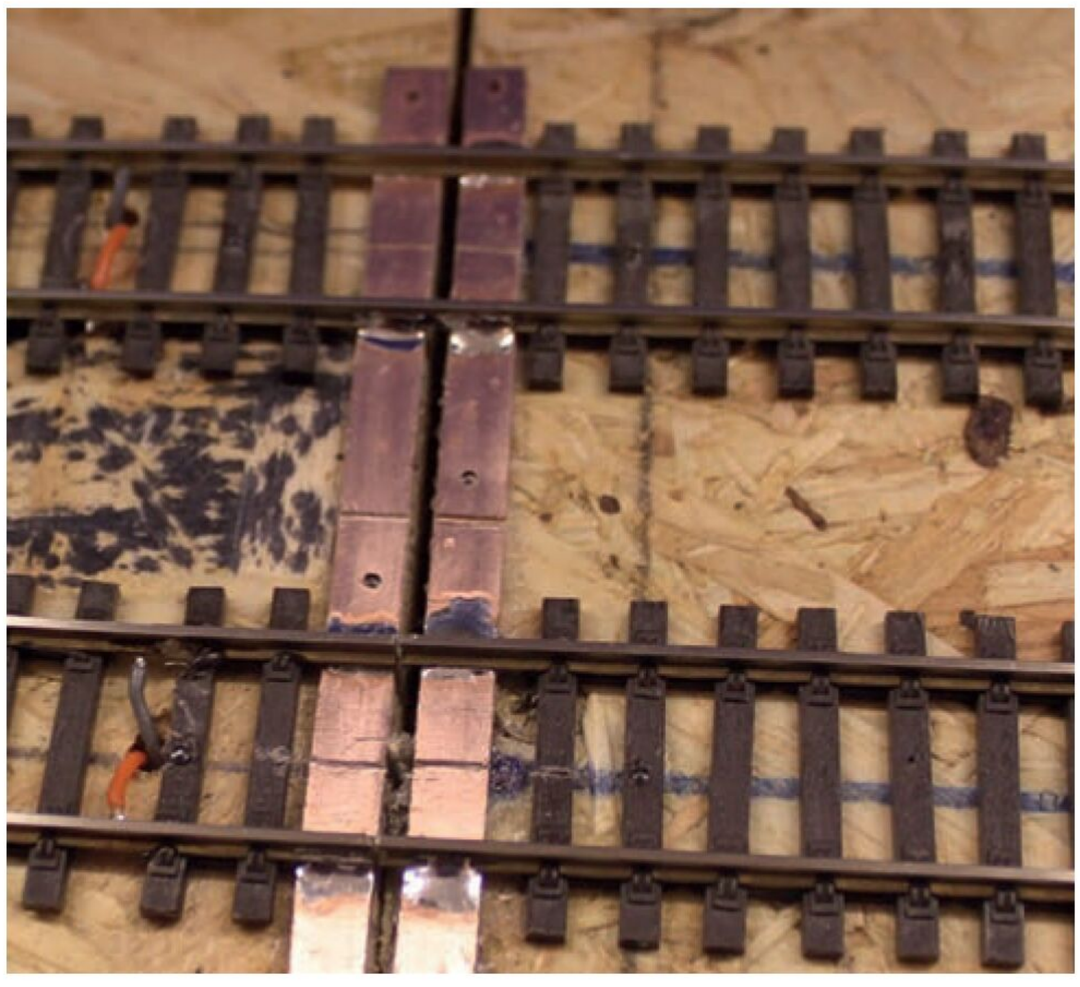
baseboard, the centre line of each track. I'm using Peco Code 100 Streamline flexible track throughout laid directly onto the OSB surface. Once the straight track centre lines were drawn, with the aid of a Peco track spacing tool and a three-foot steel rule, the curve's centre lines were plotted using a pivot pin, string and pencil acting as a radius. Then the track laying commenced.

The track is supplied in 36-inch (914mm) lengths and is cut to length and curved as required. I used Peco fine track pins to initially hold the track in place. These pins are not driven in fully, but are bent over at 90 degrees and each pin's head lays along the sleeper it's located into. Once the track has been ballasted and glued and all has set hard, the Peco pins are pulled out. At each board joint support is needed to hold the track firmly in place so I decided to use 1.6mm thick single sided copper printed circuit board (PCB) laid copper side up. A sheet of the PCB was obtained and cut into strips of approximately 4mm or 5mm wide, doing this by using a slitting disc in an electric Dremel drill.

Two lengths were cut. One set was wide enough to span a single piece of track, while the others were double track lengths. Holes of 0.8mm diameter were drilled through the PCBs, one hole at each end and one roughly just off centre. The copper track of the PCB was carefully cut through using a razor saw. A slit was made in the middle of the single PCB and three cuts were made on the double track PCBs – one centrally and two in the middle of where each track would lay. These cuts in the copper track stop rail to rail short-circuits occurring and track to track connections where the double track width PCBs were used.

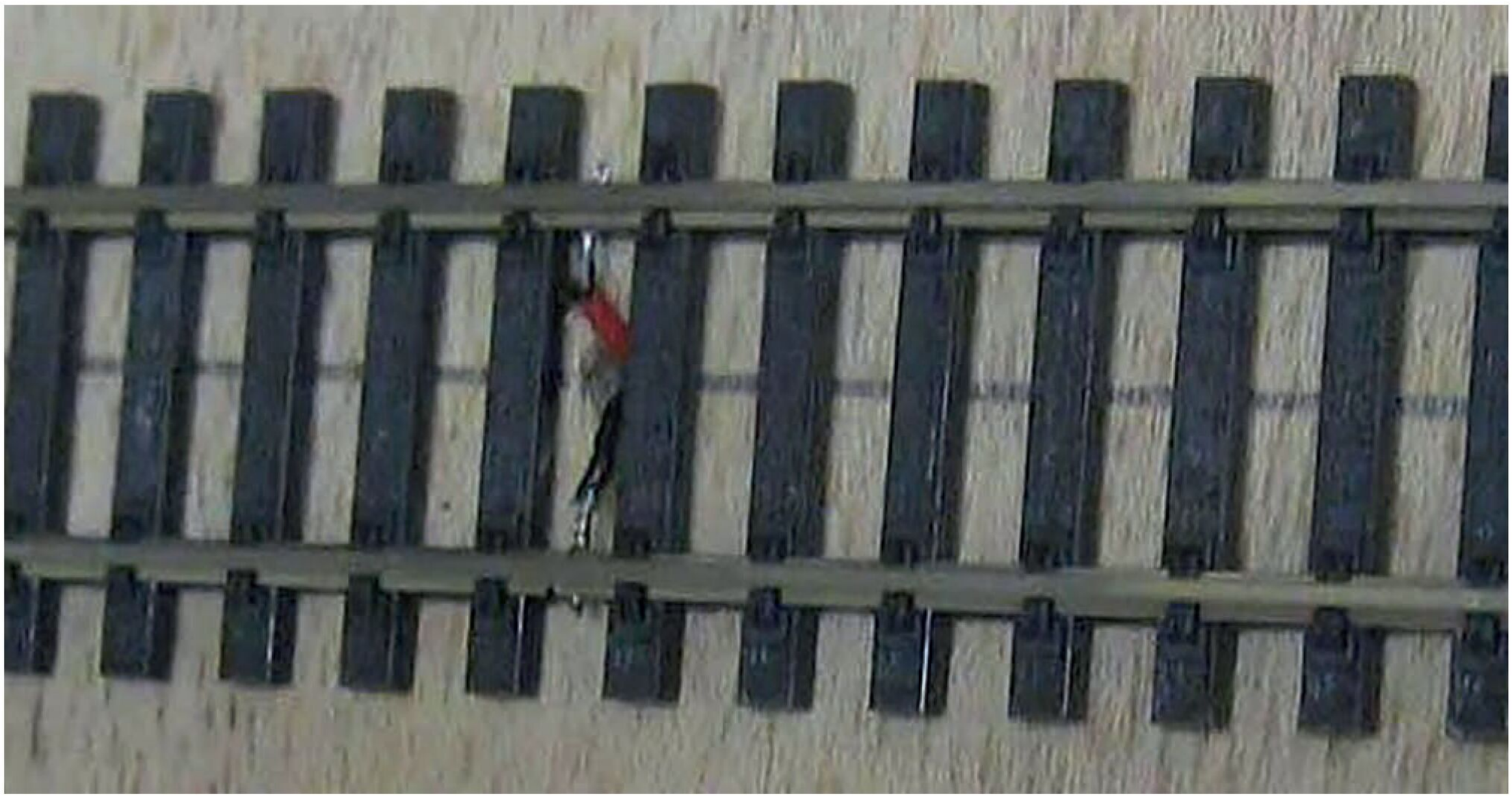
The PCBs were glued onto the edges of the OSB and positioned where the track would lay. Impact adhesive was used to glue them in place, then Peco fine track pins were tapped into the OSB surface via the predrilled 0.8mm holes. Tracks were laid and straights of track were kept as straight as possible with the aid of a steel rule being placed along the outer rail's edge. The tracks were taken over the board joints and prior to laying the track, the sleepers were removed where the PCBs were positioned. The rail's outer foot was then soldered to the copper of the PCB. Once all rails were soldered at a joint and it was allowed to cool; a razor saw was used to slice through each rail directly in line with the two abutting boards joint, thereby allowing the boards to be separated as required, but retaining the rails in register.

Points were laid in position and their drive pin holes marked through onto the surface of the OSB. The point was then removed and a pair of 4.5mm holes drilled side by side across the points' moving tie bars position. The two holes were opened up to form a slot 4.5mm wide and some 9mm long, which is sufficient for a drive rod to operate the point over and back from the motor fitted below baseboard. Before refitting the point, and as all the points used are Electrofrog, a small 1.5mm diameter hole was drilled directly in line with the factory fitted frog wire to allow the frog feed wire to pass down to below baseboard. Additionally, I soldered two dropper feed wires to the undersides of each point. Once laid and lightly pinned in place, each point had two further 1.5mm diameter holes drilled directly adjacent to the outer stock rails right through the OSB where the dropper wires were fitted. These allow the dropper wires to pass



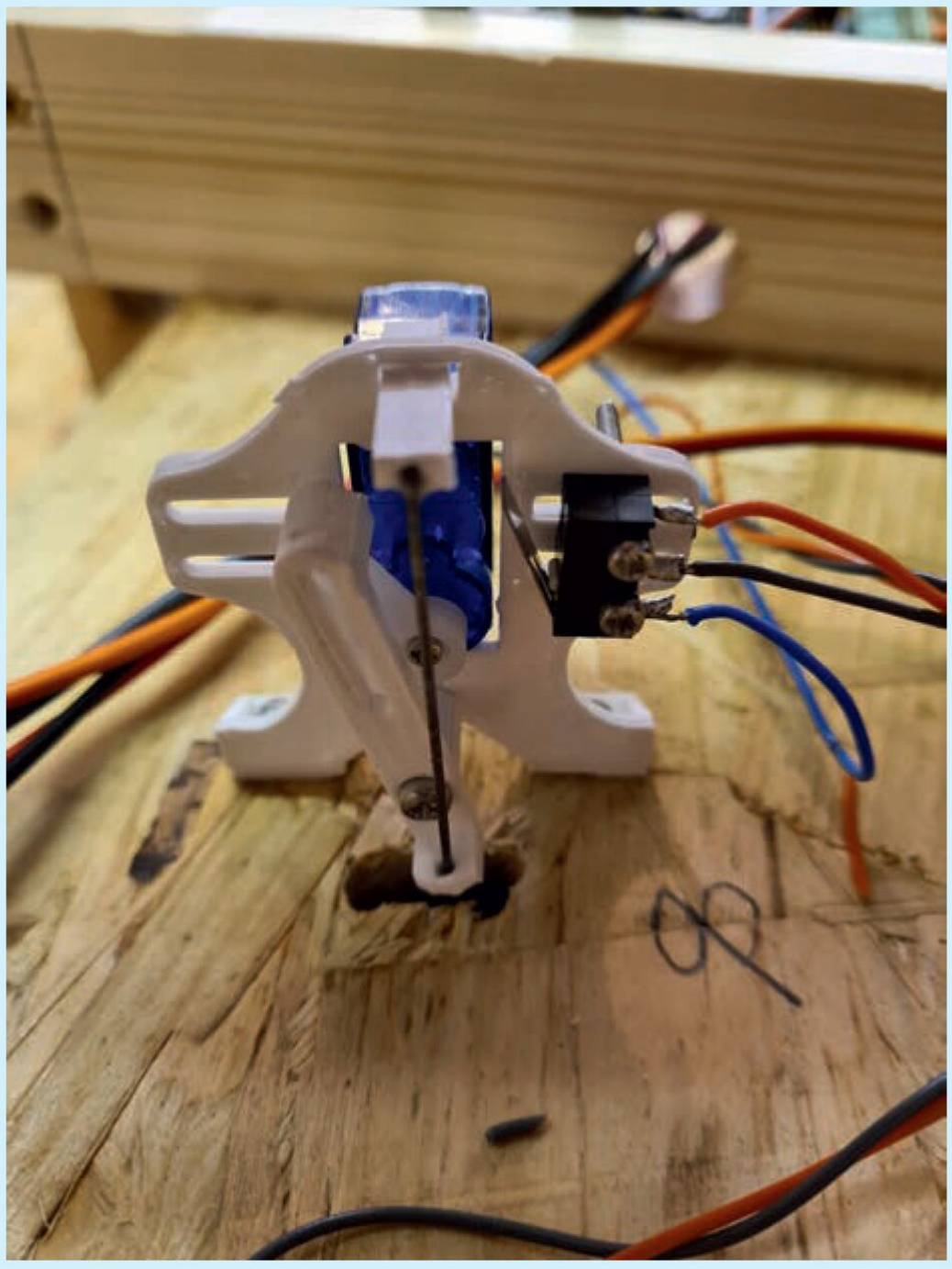
The copper PCBs fitted in place and the rails cut through. Note the small heads of the Peco track pins and the cuts in the PCB's copper. In this case the PCBs are retaining two parallel tracks across a board joint and therefore these PCBs have three slits in their copper tracks. One is in the middle of each track and a third in between the two tracks Once the track is ballasted, these PCBs become all but inviable.

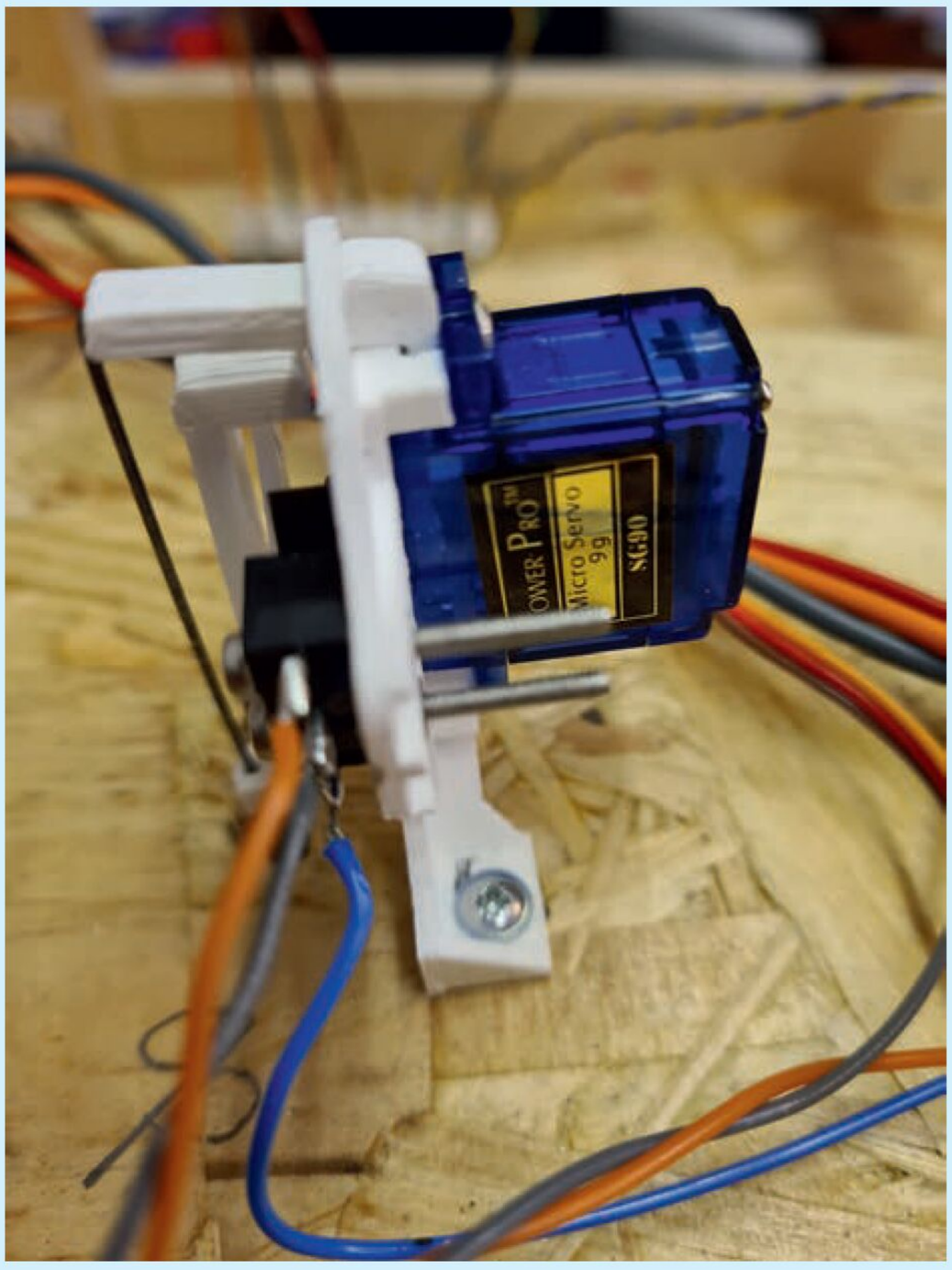
Track laying nears completion.



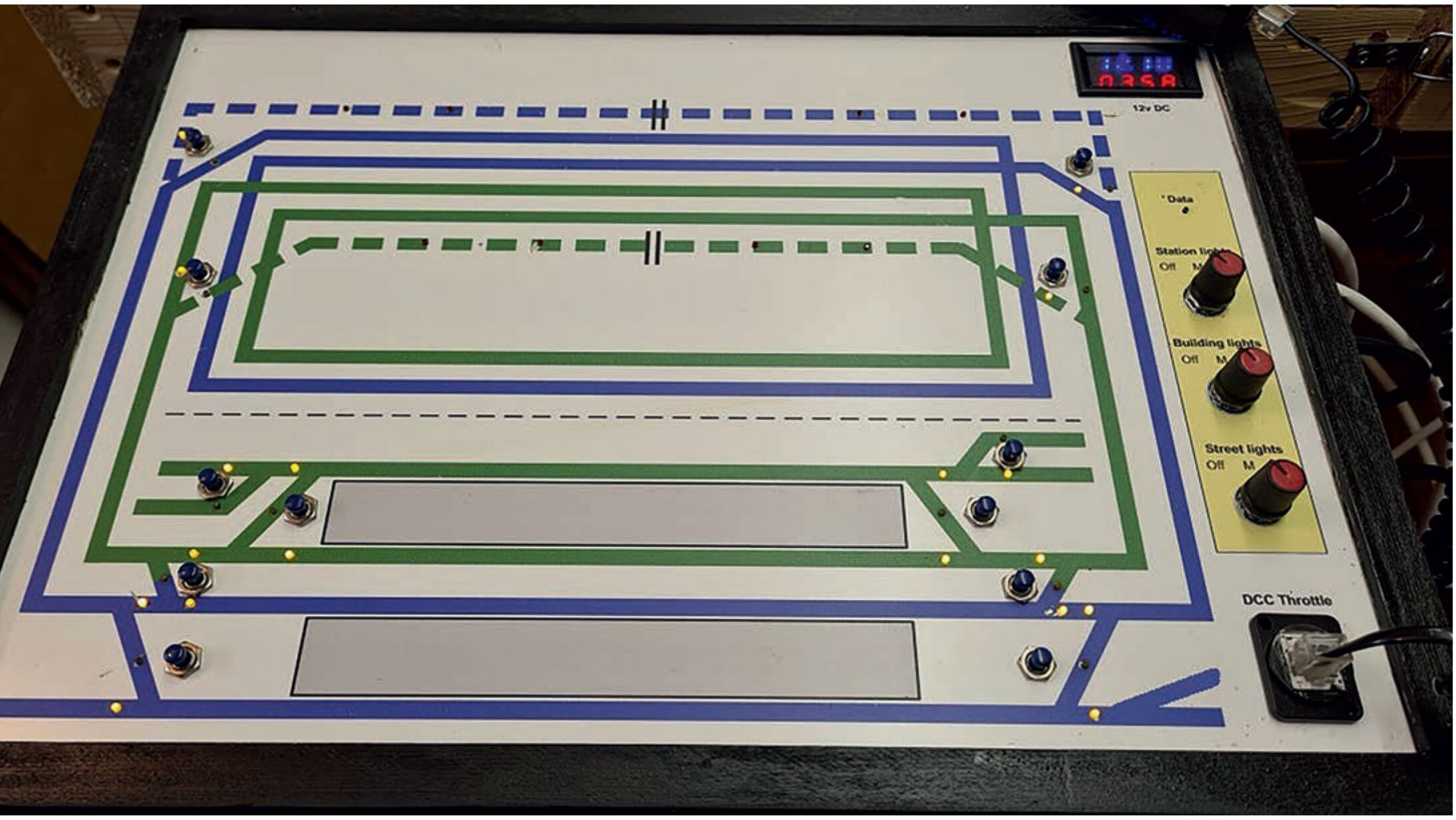
Dropper wires soldered to the rails underside are then passed down to below baseboard via a centrally drilled hole.

The mounting plate and aviation sockets.





Side and front views of two servos, which are operating the points above the baseboard. The servos operating rod, which is made from piano wire, holds the point blades over under light tension. All the points have had their over-centre springs removed to allow slow movement of the switch blades. In the left hand image the micro switch can be seen fitted onto the right of the mounting bracket.



Construction of the station overbridge.

The station entrance and booking office

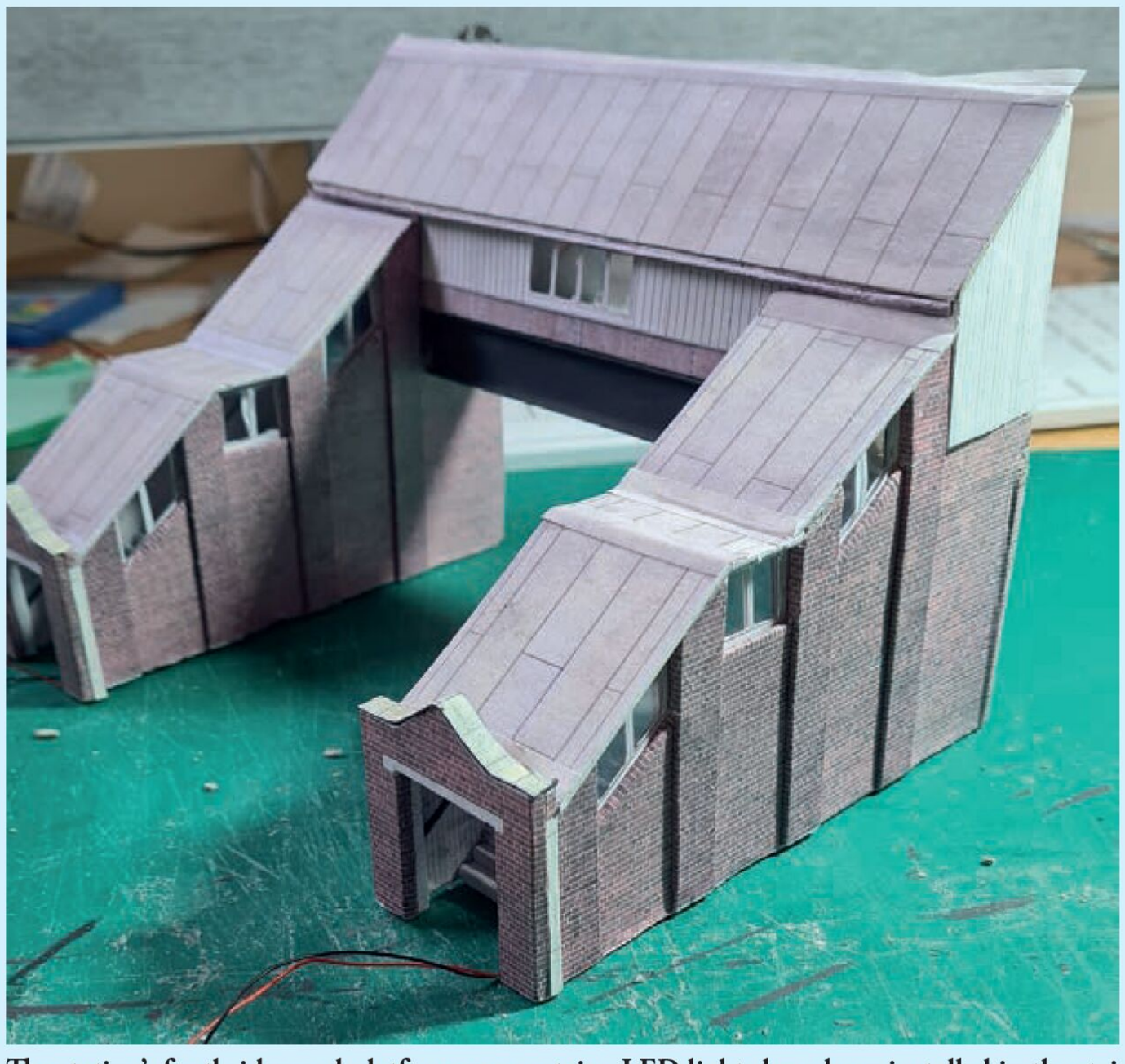
down to the boards underside and eventually connect to the DCC Bus pair of feed wires, under the layout. All my points had a full conversion with the closure rails linked to the adjacent outer stock rail and either a gap cut in each closure rail near the frog or where these rails were pre-cut, the factory fitted fine bonding wire across the two gaps was cut away. The conversion ensures that a) the open switch rail is at the same polarity as the adjacent stock rail – preventing any metal wheels from causing a possible short circuit where the conversion is not carried out, and b) removes the reliance on the closed switch rail making good electrical contact with its outer stock rail.

Prior to installing lengths of track, each section is prewired with two dropper wires soldered to the rail's undersides. A 2mm diameter hole is drilled centrally between the running rails and between sleepers, which allows these dropper wires to pass to below baseboard where they connect to the DCC Bus pair of wires. Once ballasted, the droppers are invisible.

As there are very many dropper wires under each board, and more in the station area, I opted to use a simple bus bar connection. The main DCC bus wire arrives and is connected into a four-way piece of terminal block. The mating outgoing bus wire connects into the next terminal along, and the same for the other bus wire, using position three and four of the terminal block. On the opposite side of the terminal block two short pieces of stripped copper wire are made into a sort of 'U' shape; one is inserted into blocks 1 and 2 and the other into blocks 3 and 4. This allows the DCC to come in on 1 and 3 and leave via 2 and 4 terminals. See image on page 110.

The copper wires have several dropper wires soldered to them from the rails above. Numerous four-way blocks are fitted per board and many droppers soldered to each, keeping the overall length of each dropper to around a maximum of 300mm from rail to bus. I have used 32/0.2mm equipment wire for the bus pair in grey and orange colours, and the droppers are all 7/0.2mm wire in the same two insulation colours.

As previously mentioned, to connect all the electrics board-to-board I used 'aviation' style connectors, as these offer a screw-on locking ring that clamps the plug securely in place, and their current carrying capacity is much higher than I am likely to require. They do have one small problem in that their fixed socket, if mounted onto the front surface of the support framing timbers, extends beyond the front edge and makes it likely to be knocked or damaged during transportation of the layout. I decided to drill holes for each socket in the side frames and make them large enough to allow finger room for tightening and removal of the plugs. A hole of 32mm diameter was drilled for the 16mm socket, while a 45mm-diameter hole for the 20mm socket. The sockets were mounted onto 6mm-thick ply, which was secured to the rear of the bracing timbers, thereby



The station's footbridge and platform access stairs. LED lights have been installed in the staircase's roof and the over track walkway.

allowing the socket to be recessed and prevent any accidental damage occurring.

Point operation, point position indications plus detection of locos on the hidden storage lines are all carried out by MERG CBUS data units. MERG (Model Electronic Railway Group) is a producer and supplier of electronic kits for home assembly, and they can only be obtained if you are a MERG member, which I am. I decided at an early stage to use CBUS as the main accessory operating method as it involves just two data wires and a regulated 12-volt DC power supply. The trains are controlled by DCC (Digital Command Control).

I purchased many MERG CBUS and other electronic kits over a period. Some of these are servo drive modules, while others provide outputs to operate, for example, relays for controlling lighting etc. and some accept inputs from the points to be used as panel indication. I chose to operate all the points via servos, as these are fairly inexpensive and can provide slow motion operation of the point blades.

The servos are connected to electronic servo modules that are set up with the aid of a laptop computer. This allows each servo and its module to be given electronic instructions on speed of movement and amount of throw of the servo. Once the module has been set up, the laptop is no longer required. The servos are fitted onto MERG servo mounts and these mounts have the availability to fit micro switches onto the mount. These micro switches are operated by the servos moving arm and in turn provide positive feedback to the operating panel and LEDs are lit to show the points actual position. All again via the two wire MERG CBUS modules.

A control panel was designed using drawing software on my PC and the image saved as an A3 size. The file was then sent to a commercial printer, who printed the design onto a 3mm thick aluminium sheet, called 'Dibond', which is a sandwich of two very thin aluminium sheets coloured white and a black plastic middle filling. It has been mounted into a rectangular timber box, which has a 3mm grove router cut all around and some 5mm down from the top edges; the aluminium panel then slots into the groves.

The panel was carefully drilled to accept push buttons for point operation and smaller 1.8mm holes for 'tower'-style LEDs for point position indications. It also had a trio of three position rotary switches fitted for lighting controls and a digital meter showing voltage and current drawn by the servos and other 12 volt accessories. An RJ45 socket was fitted to allow the plug connection that comes from the DCC throttle. Several aviation sockets of varying pin numbers were installed in the side framing, these are for 12v DC power in. DCC power in and out plus outputs to the various modules and accessories and a DCC programming track output.

Construction of the two platforms. I used plastic 15mm cable trunking minus their lids as the main supports. The edges of which were covered in brick paper.

Construction of the long over bridge is show above. Working street lights were later installed.

Inside is a MERG CBUS CANPAN module that provides 32 LED outputs and 32 Push button inputs, CANUSB for computer connection to allow setting up of all the modules, and a CANGIZMO that monitors activity on the CBUS data lines and provides an LED indication of such activity.

Over the winter months and especially January and February it was too cold to work out in the garage. I could have used an electric heater, but that seemed wasteful and needed to be switched on a long time while before I ventured out to the garage. So these two months were lost to layout building. But I used this time to construct card kits for the low relief street scene along the upper layout area and to build and paint a laser-cut station building, all carried out indoors and in the warm! The weather improved a little in early March and it was possible to once again work in the garage. All the electrics for track and CBUS modules were installed.

By mid-March the moment of truth had come – it was switch-on time! I pushed the mains power socket switch to 'on' and the servos sprang into life, moving to their required positions. Pressing push buttons on the panel allowed the appropriate servo(s) to drive over the points and the panel LEDs showed the routes set direction. Wonderful – it worked!

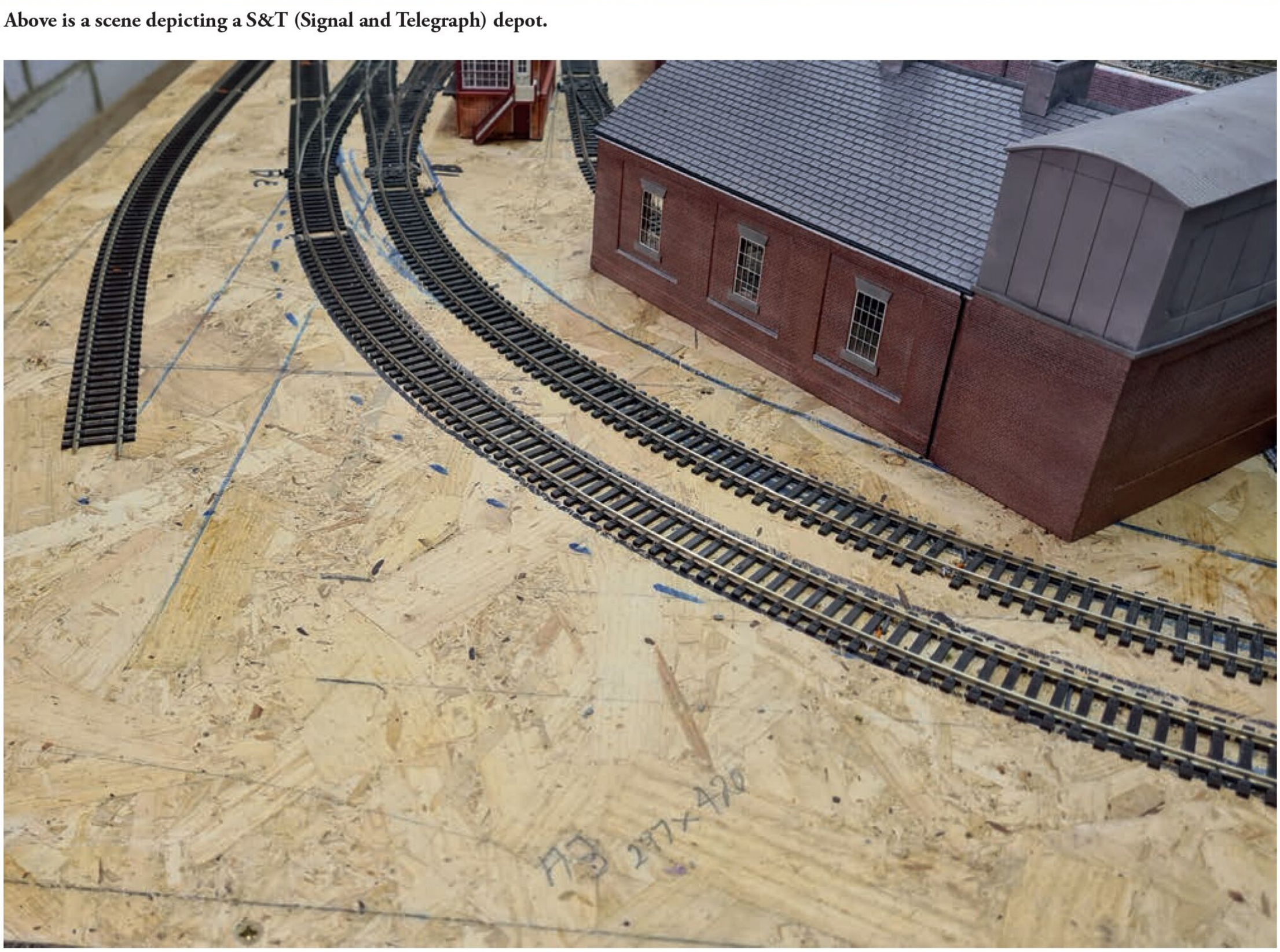
Next came powering up of the DCC system. The power was applied and the handset lit and showed a normal display, as expected. Wow, that was working too! Some fine tuning of servo modules was carried out to obtain correct operation. A DCC fitted loco was placed onto the rails and its address entered into the handset. Turning up the speed control knob saw the loco judder forwards then stop! Ah – a problem! In fact, it was only dirty rail tops, which in my eagerness to get things operational I had completely forgotten to clean.

Out came the rail cleaner and after about half an hour every rail head had been cleaned. Regardless of whether it was new or older track, it all got cleaned. Back to the DCC throttle and the same loco, the speed knob was turned up a little, but not too much in case any rail joints were incorrectly aligned. The loco ran well, faltering only on a couple of points, which I discovered still had a small amount of ballast in their flangeways. It also derailed at the transition between level and climb, which occurred on a curve on the upper level.

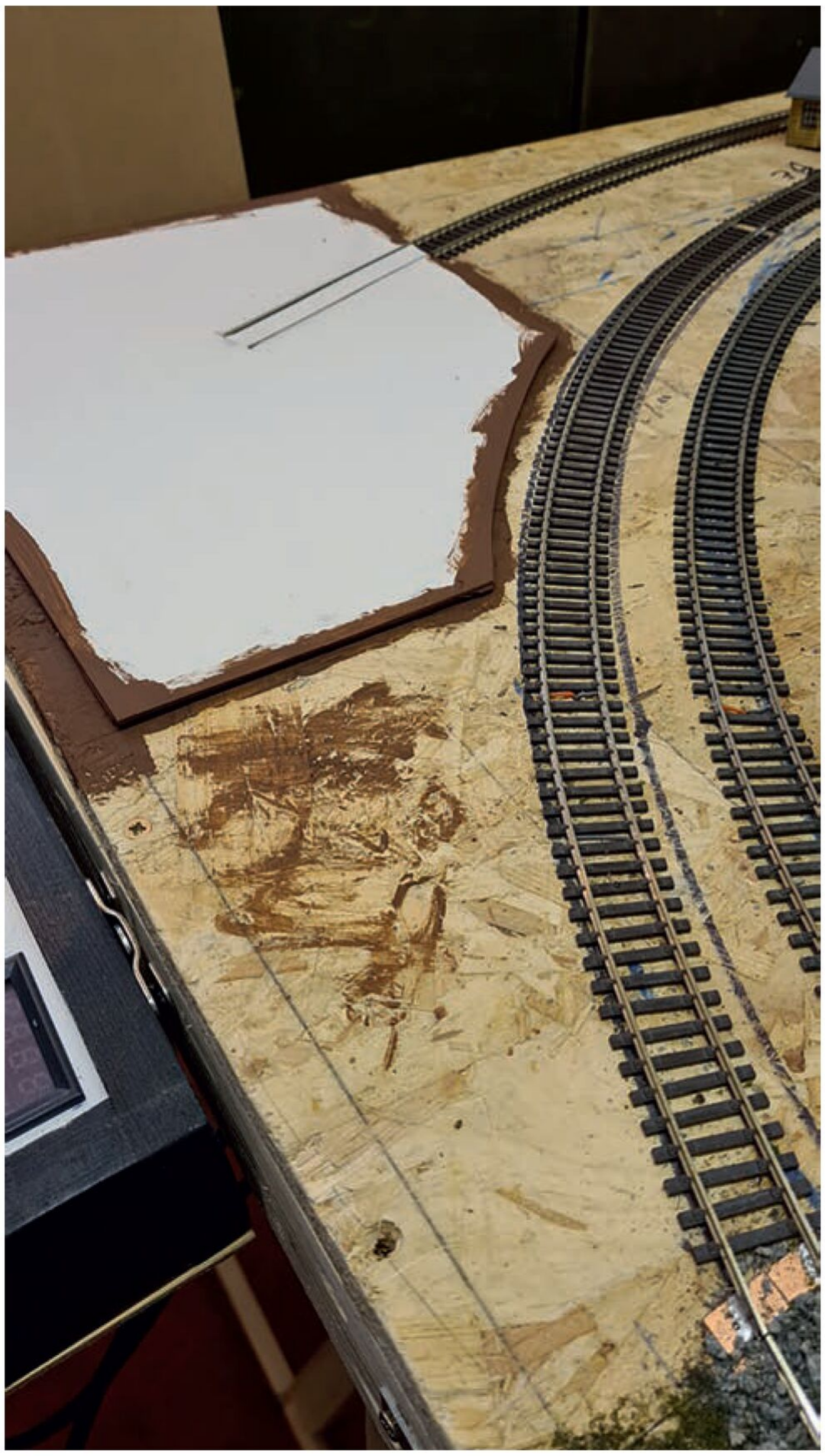
Close inspection revealed that the rails were not quite aligned; one rail needed raising and moving slightly inwards. Soldering iron heated and the rail's solder was melted. The rail was then correctly aligned with the aid of a pair of long nosed pliers. The rail was held in position for a few seconds until the solder had solidified. Once it had cooled, I passed my finger along the rails and over the joint to ensure it was a smooth transition. The loco was again run around and all was good at the former problem joint.

Another loco was then placed on the tracks, but on the other line and direction of travel. A couple of carriages were attached and it was set off, along with the former loco travelling in the opposite direction. Points were moved and the locos traversed these without any issues. The rear storage lines were next to be tested and as the locos proceeded along these, red 'track occupied' LEDs on the panel indicated their presence.

Above is a scene depicting a S&T (Signal and Telegraph) depot.



A Bachmann Scenecraft engine shed was installed to the left of the S&T depot and a small Permanent Way depot was to be created in the corner opposite the engine shed.



A subbase of 2mm thick card was laid and a slot cut for the track to be inset. A second layer of 2mm card was used over the first piece which had been covered in printed cobblestone effect paper; this raised up the final surface to bring it in line with the siding's rail tops.

A view of the chief civil engineer's private car, a Morris Minor Traveller affectionally known as a 'Moggy'. The Wickham trolly and its match wagon sits in the siding waiting to go out on a late-night line possession.

My time had been well spent and I still had a month left before the 365 days were up! Work now turned to scenics. Two platforms were constructed using 3mm thick mounting card as the surface. These were covered in Scalescenes papers representing slabs. Prior to this, construction of a station overbridge began. 3mm mounting card was used for the brick work pillars which were covered in Scalescenes inkjet-printed brick paper. Plastic H-girders were painted a dark grey and when they were dry they were imbedded into the brick pillars. More mounting card was then used to make a road surface and support for the station building. You will note that I like using mounting card as it offers a reasonable size sheet of card (A2 size) which has a lovely smooth finish. It cuts easily with a sharp craft knife and is easily bonded to either itself or other items with the aid of, in my case, UHU glue.

The station booking office and entrance had previously been built and that was then glued to the card road surface, so as its rear wall was directly in line with a baseboard joint below. Abutting this wall and mounted on the next baseboard was a card-built stairway structure leading down onto the platforms. The stairway was produced from a slightly modified Scalescenes card kit. A cunning plan was devised to hide the joint between the station building and the stairway; I used a strip of carbon paper, glued to the rear edge of the over track walkway of the stairway. This presses onto the rear wall of the station building and represents lead flashing along the stairs roof line. It worked and it looks good!

I needed a means of road access from the overbridge to the rear of the upper level so that road traffic and

A Bachmann Scenecraft building and a Wills plastic building were added along with two working LED-lit lampposts. A wooden fence added all around the perimeter along with rail and road access gates.

Finally, the approach road and siding track together with the surrounding area was scenically treated with suitable scatters, a tree added and the track ballasted.

The later extended canopy, with the two newspaper kiosks under the canopies.

A signal box and an engine shed, plus oil store hut and a grounded wagon were installed together with working yard lamps.

Final item…

The sharp-eyed reader will note that a new siding has appeared. This was installed as an afterthought and holds the breakdown crane and its match wagons.

The station building before the additional canopies were installed.

The construction of the embankment and bridge and tunnel.

people could safely cross the two main lines on the upper level where shops and houses were to be installed. A level crossing was the answer and I chose to use a gated crossing rather than barriers, as gates were more in keeping with my modelling era (1950s to 1960s). A suitable kit was procured and using Wills timber decking plastic card I constructed a road and pedestrian crossing that abutted the overbridge roadway.

A backscene of 6mm-thick MDF was cut to a height of approximately 300mm/12 inches and given two coats of sky-blue matt emulsion paint. Once dried, the backscene were fixed to the rear of the layout with the aid of 30mm-long M6 bolts, large washers and M6 tee nuts fitted into the insides of the layout's wooden frame. A main road was laid, again produced from 2mm thick mounting card and covered with printed tarmac paper. Footpaths were produced on 1mm thick card and covered in more printed papers. Then low relief buildings that had previously been constructed were glued to the pavements and back boards. LED lights were installed into some of the buildings during construction and these, along with LED lit street lights, were wired to special voltage

adjustable power sources. All of the low relief shops and other buildings are from Metcalfe card kits.

A scenic break was needed where the front scenic areas meet the rear storage tracks and the change in height track slops. A long road bridge was constructed using more mounting card and brick papers for the support pillars. Peco girder bridge sides were painted a dark grey and with three on each side they were used to make up the over-track spans and the over-roadway span leading off scene. Its construction is shown in the series of images on page 117.

It was now time to construct the retaining wall covering the whole of the front and right hand side sections, covering the lower to upper levels of the baseboards. The wall, mostly arches and a small amount in plain brick, was once again made from mounting card and covered with Scalescenes inkjet-printed brick papers. Once glued in place, it was sprayed with artist's matt varnish to protect the papers and then treated to a light spray of a dirty wash colour. Some areas had ivy and other undergrowth added to improve the overall look. The wall is some 11ft long and took around two weeks to complete!

On the lower level and to the left of the long bridge I constructed a Signal & Telegraph (S&T) depot. The base for this was again card covered with an inkjet-printed sheet of block effect paper. A main office and covered storage are from Bachman Scenecraft plus smaller detailing parts were used to make the depot come to life.

My attention now turned to the station platform buildings and here I chose to use Scalescenes platform buildings. Two buildings were constructed – one for each platform. Later, two additional roof sections were built; these extend the roof on each platform and are supported on canopy pillars. Two newspaper kiosks were added under the open section of the canopies. Hand-painted figures are positioned on both platforms along with sack barrows, parcel sacks, chocolate vending machine and fire buckets. The end of one platform has a twin head colour light signal while the opposite side has individual colour lights signalheads, one mounted on the retaining wall and the other suspended from the over-track footway linking the two platforms. LED strip lights have been fitted to the canopy undersides and illuminate the whole canopy length.

The left-hand end of the layout has both an over bridge on the upper level and a tunnel leading off-scene on the lower level. As of course tunnels are cut through steep hillsides and bridges take roads over the railway, a raised country lane and embankment was produced. There are two sidings at the foot of the embankment for loco stabling and a goods shed is to be installed along the front siding.

My 365 days are up! I have completed 96% of the layout and have everything electrically operating, all track down and tested. I have succeeded in my challenge and there is just some scenic detailing to complete around the goods shed. This will involve a cobbled area outside the shed, a gated entrance at the very rear of the diorama and a small section of track to ballast and I need to infill a small section of the track at the goods shed. I also need to paint more people and fit station lampposts on both platforms. But none of these will impact on the layout's operation. So I'm rather pleased with myself (he says smugly!).

I hope you have enjoyed the layout build and perhaps it may ignite a small spark inside you, that spurs you on to build one for yourself. Small, medium or large sized, it doesn't matter. What's important is the enjoyment of constructing something that gives you pleasure.

Real Feet	N Scale 2mm/foot	TT:120 2.54mm/foot	HO Scale 3.5mm/foot	OO Scale 4mm/foot	Real Feet	N Scale 2mm/foot	TT:120 2.54mm/foot	HO Scale 3.5mm/foot	OO Scale 4mm/foot
1	2	2.54	3.5	4	26	52	66.04	91	104
2	4	5.08	7	8	27	54	68.58	94.5	108
3	6	7.62	10.5	12	28	56	71.12	98	112
4	8	10.16	14	16	29	58	73.66	101.5	116
5	10	12.7	17.5	20	30	60	76.2	105	120
6	12	15.24	21	24	31	62	78.74	108.5	124
7	14	17.78	24.5	28	32	64	81.28	112	128
8	16	20.32	28	32	33	66	83.82	115.5	132
9	18	22.86	31.5	36	34	68	86.36	119	136
10	20	25.4	35	40	35	70	88.9	122.5	140
11	22	27.94	38.5	44	36	72	91.44	126	144
12	24	30.48	42	48	37	74	93.98	129.5	148
13	26	33.02	45.5	52	38	76	96.52	133	152
14	28	35.56	49	56	39	78	99.06	136.5	156
15	30	38.1	52.5	60	40	80	101.6	140	160
16	32	40.64	56	64	41	82	104.14	143.5	164
17	34	43.18	59.5	68	42	84	106.68	147	168
18	36	45.72	63	72	43	86	109.22	150.5	172
19	38	48.26	66.5	76	44	88	111.76	154	176
20	40	50.8	70	80	45	90	114.3	157.5	180
21	42	53.34	73.5	84	46	92	116.84	161	184
22	44	55.88	77	88	47	94	119.38	164.5	188
23	46	58.42	80.5	92	48	96	121.92	168	192
24	48	60.96	84	96	49	98	124.46	171.5	196
25	50	63.5	87.5	100	50	100	127	175	200

BIBLIOGRAPHY

Further information and recommended reading is available from the following:

Suggested websites to visit
www.brian-lambert.co.uk (my own website)
www.model railway forum.com (general model railway forum)
www.new railwaymodellers.co.uk (general model railway forum)
www.MERG.co.uk (Model Electronics Railway Group)
www.uk model shops.co.uk (details of UK model clubs and retailers)
www.2mm.org.uk (2mm scale modellers)
www.n gauge society.com (N gauge society)
www.double o gauge.com (OO Gauge Association)

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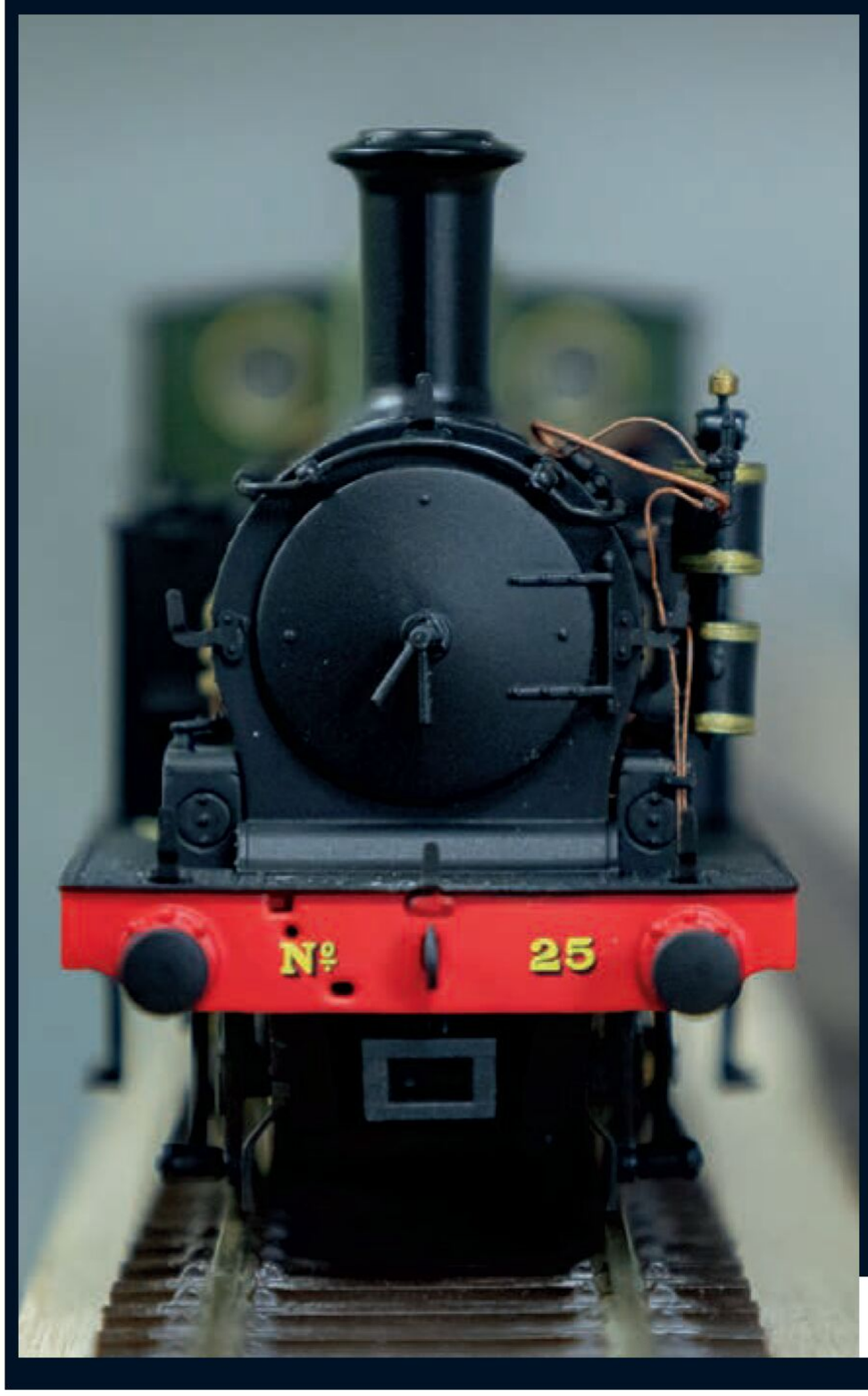

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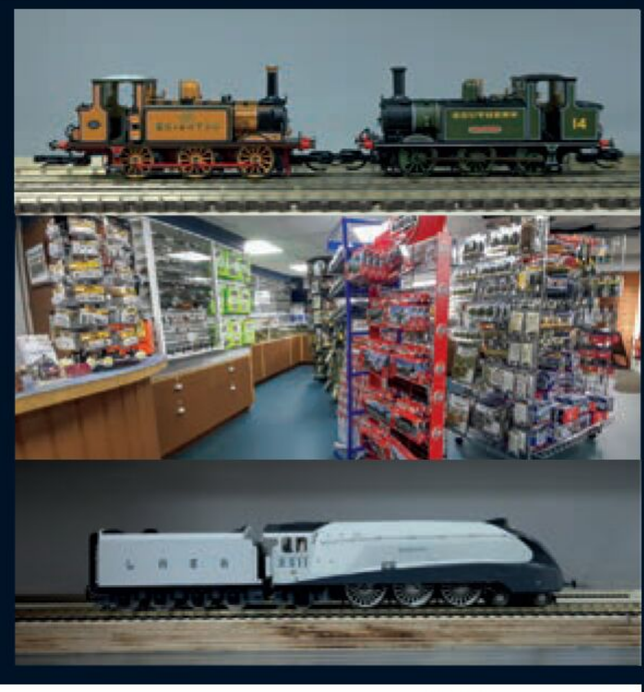

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