1 Plain Track

1.1 Recommended Minimum Curvature

Important factors to consider when setting out model railway track are the sharpness of track curves forced by space limitations and the type of rolling stock employed. For satisfactory operation the criteria set out in Table 1 are recommended when selecting the minimum radius for a given layout. It is possible to build long vehicles to go round sharp curves, the Hornby O gauge *Princess Elizabeth* was designed for 3ft radius curves, but it is necessary to arrange increased sideplay to allow for this.

TABLE 1

ROLLING STOCK AND CURVATURE

Type of Line	Equipment	Recommended Minimum Model Radius	Group Number
Tram Route	Single 4 wheel or bogie cars.	0.15m (6 inches)	1
Dock area, industrial or factory lines.	4 wheel locos dumb buffered or with large diameter heads; 4 wheel rolling stock wheelbase 3m (10ft) or less.	0.60m (24 inches)	2
Light railway or general goods sidings.	Short wheelbase (3.3m - 12ft) locos and rolling stock. Bogie stock up to 13.6m (45ft) with lengthened couplings	0.915m (36 inches)	3
Minor branch or early period main line.	Locos with rigid wheelbase up to 4.8m (16ft); 4 wheel vehicles up to 6m (20ft) wheelbase; bogie stock up to 17m (56ft).	1.22m (48 inches)	4
Main line.	Locos with rigid wheelbase up to 6m (20ft); bogie stock up to 21m (70ft)	1.8m (72 inches)	5

Note: The above figures are based on stock being pulled. Where stock has to be propelled through curves into sidings or station areas the type of coupling employed is important. With loose couplings where the thrust is carried by buffers of scale diameter, (tighter curves need bigger buffers - up to 12mm diameter depending on wheelbase) it is recommended that the minimum be increased by at least 30% to limit the possibility of bufferlocking. Where the thrust is taken by some form of rigid centre coupling, e.g. Buckeye, single link or similar, and the buffer faces are not in contact the above recommendations should prove satisfactory.

Where stock has to be propelled through reverse curves a short length of straight track should be introduced between the two curved portions.

Prototype curves of less than 10 chains are fully checkrailed. The equivalent model radius is 4.6m (15ft). For appearance purposes it is suggested that curves less than 1.0m (40ins) be fully check railed.

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Drawn by D. Morton and G.E.J. Wheeler

1.2 Transition Curves and Superelevation

1.2.1 Introduction

In prototype practice, except in goods yards and similar locations where speeds are low, a direct change from straight track to a circular curve is avoided. On running lines a sudden change of direction at the beginning and end of a curve causes lurching (and passenger discomfort) which increases wear and causes some disturbance to the track. To minimise these effects transition curves or easements are introduced between the straight portion and the true circular curve. On large radius model curves a transition has only visual significance but where space considerations require tight curves, transitions will improve running and prevent derailments due to buffer locking.

To permit higher speeds when passing round curves, full size lines raise the outer rail to counteract the overturning effect of centrifugal force acting on the rolling stock. The amount of 'banking' or superelevation depends on the radius of the curve and the speed at which it is traversed; the higher the speed, the higher the superelevation. The maximum prototype superelevation used is 150mm (6in) and on tight curves this limits the maximum operating speed. In modelling terms there is no need for superelevation, the light weight and slow operating speeds of models do not generate the same forces as the full sized vehicles. (The fact that a Hornby No 1 clockwork tank engine, fully wound and running at a scale 200 mph will fly off a 610mm (2ft) radius tinplate curve is recognised but does not invalidate the statement). Superelevation can be used to improve the appearance of model trackwork but should not normally exceed 3.5mm (1/8in) to match prototype practice.

If it is decided to use superelevation, it must be increased gradually from zero to the maximum height chosen. This change in level is called the run-off and is usually confined to the transition curve, although if the transition curve is short it may be necessary to extend the run-off into the circular curve; extending run-off into the straight portion of the track is bad practice as it causes uneven running. Take particular care when laying the run-off track, the change in level may exaggerate any errors, so avoid rail joints here.

The length of a transition curve is a complex calculation using a number of factors including the radius of the circular curve that it connects to, the maximum train speed through the curve and the superelevation. Taking the recommended minimum curvatures listed in Table 1 and assigning nominal figures for speed and superelevation, lengths of model transition curves can be derived. Because tram tracks are laid in roadways and operating speeds are low Group 1 lines have not been included in the calculations.

TABLE 2

RECOMMENDED MAXIMUM SUPER ELEVATION AND MINIMUM LENGTH FOR TRANSITION CURVES

Type of line (see Table 1)	2	3	4	5
Superelevation (mm)	2.0	3.5	3.5	3.5
Superelevation (in)	0.08	0.14	0.14	0.14
Length of transition (mm)	210	700	980	1400
Length of transition (in)	8.25	27.5	38.5	55.0

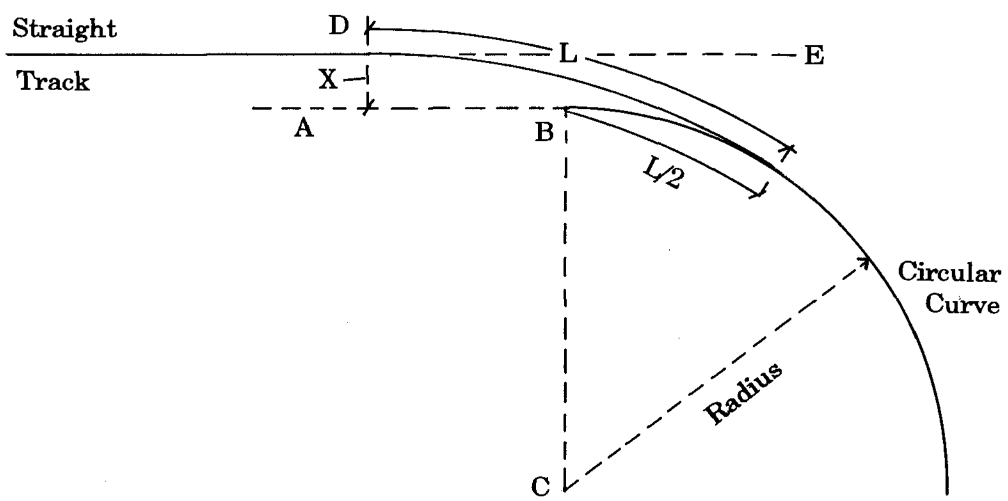


FIGURE 1-1 *Transition curve*

In Figure 1-1 a transition with a length L is shown joining straight track to a circular curve with a radius of R and a centre at C. The line AB is the tangent to the circular curve while DE is the line of the straight track. If there were no transition curve then AB and DE would coincide but, if one is added then DE must be offset from AB by a distance X which varies with the length of the transition and the radius of the circular curve. Recommended offset distances are shown in Table 3.

TABLE 3
RECOMMENDED OFFSET DISTANCES

Curve Radii (BC)	0.7m (27.5in)	0.915m (36in)	1.0m (40in)	1.22m (48in)	1.52m (60in)	1.83m (72in)	2.44m (96in)
Transition length (L) 210mm (8.25in)	3mm 0.125in	3mm 0.125in	3mm 0.125in	2mm 0.0625in	2mm 0.0625in		
700mm (27.5in)	32mm 1.25in	25mm 1.0in	22mm 0.875in	19mm 0.75in	16mm 0.625in	13mm 0.5in	10mm 0.375in
980mm (38.5in)			38mm 1.5in	38mm 1.5 in	29mm 1.25 in	25mm 1.0in	19mm 0.75in
1400mm (55in)					57mm 2.25in	50mm 2.0in	38mm 1.5in

1.2.2 Setting out transition curves

One of the easiest methods of setting out a transition curve which requires the minimum of calculation is to make use of a guide stick, i.e. a flexible piece of material that will take up a natural curve under light pressure. If the transition is short enough a piece of straight undamaged rail can be used. Alternatively, a length of whippy straight grained wood, free of knots and cracks, or a piece of plastic curtain rail from the local DIY store would be equally satisfactory.

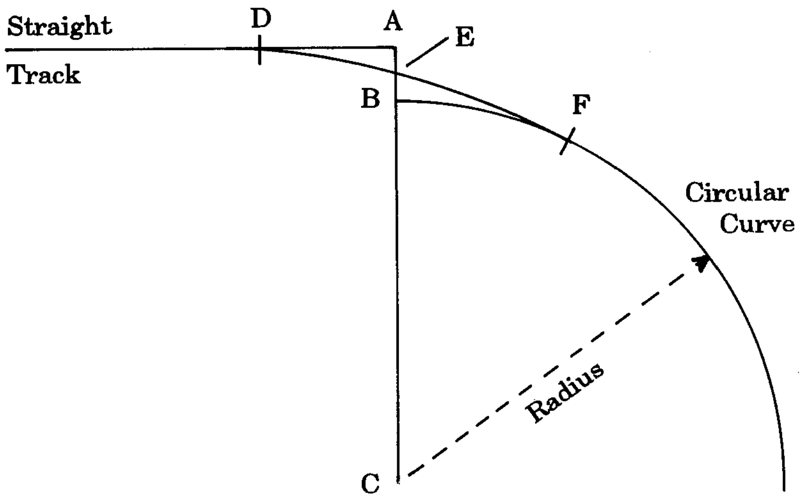


FIGURE 1-2 *Setting out a transitional curve*

Referring to Figure 1-2, once the radius of the circular curve and the length of the transition have been decided setting out the curve is as follows:

a) Draw the straight track line extended to point A and mark off a line AC at right angles.
b) Locate C, the centre of the circular curve, where AB is the offset distance read from Table 3 and BC is the radius of the circular curve.
c) Draw the circular curve round to the point B.
d) Mark the point E in the middle of AB and measure off ED and EF, each equal to half the transition length.
e) Clamp the guide stick along the line of the straight track so that it is held rigid up to the point D.
f) Steadily bend the other end of the guide stick until it touches the line of the circular curve at F. Secure the end along the line of the circular curve and check that the centre falls on the point E.
g) Mark off the line of the transition.

If the same transition length and circular curve radius are used a number of times on a layout the above method can be used to draw the transition on a piece of heavy card which can be cut to form a transition template. A selection of two or three standard transition templates can often be sufficient for a layout.

1.3 Double Track Clearances

The Guild recommended track centres are 80mm for standard track and 90mm for sidings. The increase for sidings follows prototype practice where additional space is allowed to provide safe access for staff. These dimensions are satisfactory for straight track and for long modern rolling stock on curves greater than 2 metre radius but, if space considerations require the use of sharper radii then the possibility of vehicles striking one another when passing on curves must be taken into account.

Assuming that the maximum model vehicle width is 65mm (2.82m or 9ft 3in prototype width), the clearance on parallel straight tracks is 15mm. If a safety margin of 3mm is retained then the maximum throw-over that can be allowed is 12mm. A throw-over greater than this requires the track clearances to be increased. A graphical method of working out the extra clearance required is shown in Figure 1.5.

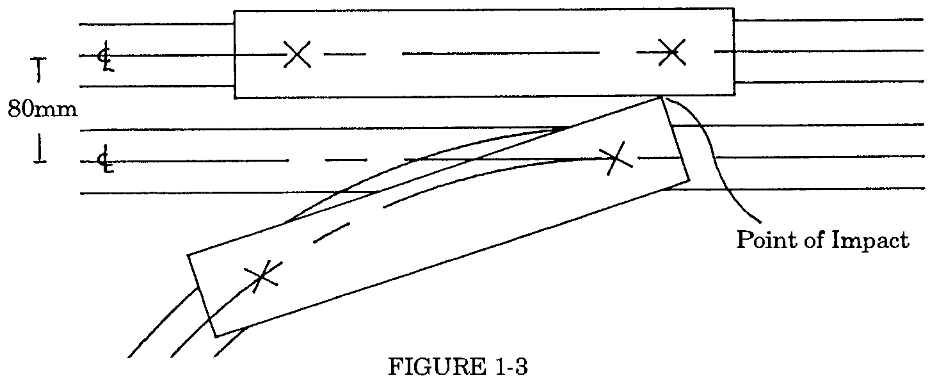


FIGURE 1-3
Simple throw-over when a branch or a crossover approaches a parallel track

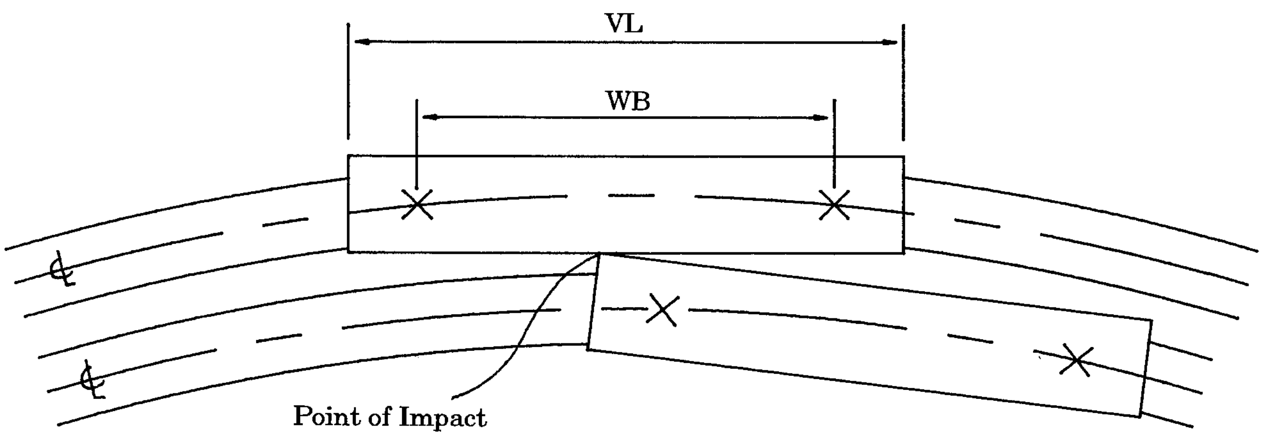


FIGURE 1-4
Compound throw-over when long vehicles pass on curved tracks.
In the sketch VL = Vehicle length and WB = the rigid wheelbase or the bogie centre distance.

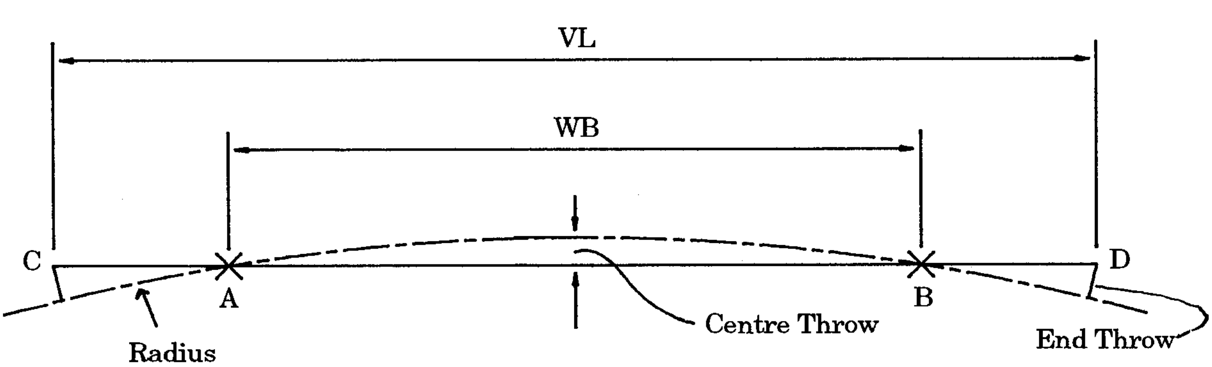


FIGURE 1-5
Measuring throw-over graphically.

1.3.1 Graphical solution

For drawing convenience the measurements shown in Figure 1-5 can be scaled down from full size. The procedure is as follows:

a) Draw a curve representing the centreline of the smallest radius curve on the layout where two or more tracks are adjacent to one another.
b) Draw a straight line cutting the curve at points A and B such that the distance AB is equal to the rigid wheelbase or bogie centres of the longest vehicle planned for the layout. (See also Part 3, Section 5 which deals with sideplay in locomotive chassis)
c) Extend the line at either end to C and D so that CD is equal to the overall length of the vehicle including buffers, etc.
e) Measure the centre and end throw-over distances as indicated in Figure 1-5.
f) For a simple throw-over (Figure 1-3), if the end throw is greater than 12mm increase the track centre distance by the difference, e.g. end throw is 15mm, increase the track centres to 83mm.
g) For compound throw-over (Figure 1-4), if the combined throws are greater than 12mm increase the track centre distance by the difference, e.g. end throw 8mm, centre throw 10mm, 8 + 10 - 12 = 6mm, increase track centres to 86mm.

1.3.2 Calculated solution

For those who prefer to calculate the clearances rather than draw them, it is relatively simple to find the minimum track centres necessary for vehicles to pass by using the following formulae. (It is convenient to make the calculation with all dimensions in cm and convert the centre distance to mm at the end). Table 4 gives the calculated minimum track centres for typical coaches assuming 3mm clearance.

Distance between the track centres = VDi + VDo + VW + Cl

where: VDi = Vehicle centre displacement to the inside of the curve.
VDo = Vehicle end displacement to the outside of the curve.
VW = Vehicle overall width.
Cl = Clearance between passing trains, (taken as 3mm minimum).

Note: For vehicles with tapered ends the calculation must be made for both the full width and the reduced end width using the correspond ing lengths from the centre. (see table 4) Cl should be not less than 3mm.

$$VDi = Rc - R'$$

where: Rc = Curve radius.

$$R' = \sqrt{Rc^2 - Bc^2}$$

Bc = Half the bogie centre distance or rigid wheelbase.

$$VDo = \sqrt{R'^2 + LV^2} - Rc$$

where: LV = The greater of the lengths from the bogie or rigid wheelbase centre to the end of the vehicle. (Half the overall length of a symmetrical vehicle).

Note: For those who prefer trial and error, make up card templates of the longest vehicles, set them with their bogie centres on the curve(s) and move the track until they just clear by about 3mm. The technique is also useful to check that the graphical or calculated solution has provided satisfactory clearance.

TABLE 4

TYPICAL CURVED TRACK CLEARANCES

Minimum track centres for typical coaches to pass on curves

BR Mk 1 Coach: length 444mm (at the full width), Bogie centres 325mm, Overall width 63mm.

Curve radius (m)	0.9	1.2	1.5	1.8
Minimum track centres (mm)	94	87	83	80

LMS 57ft Coach: length 399mm, Bogie centres 285mm, Overall width 60mm.

Curve radius (m)	0.6	0.9	1.2	1.5
Minimum track centres (mm)	99	88	83	79

1.4 Prototype Rail Sections

Prototype rail sections vary widely from the early top hat and Tee sections through bullhead rail to flat bottom rail. Most British main lines used bullhead until about 1950 and it can still be seen in sidings and certain special locations like the London Underground. Flat bottom rail was preferred overseas and also found use in light railway practice in Britain. Modern British main line practice is to use a heavy section flat bottom rail resting on pads and mounted on concrete sleepers.

The code numbers shown below are based on the system used by model manufacturers to identify the sizes of model rail. The figures represent the height of the model rail in thousandths of an inch, e.g. code 124 model bullhead rail is 0.124 ins high and could represent 80 lb/yd rail. The heavy section (Code 200) model rail has no prototype equivalent in O scale but could represent a 100 lb/yd rail in 10mm scale narrow gauge (1n3) or 60 lb/yd rail in 16mm scale narrow gauge (SM32).

Note: The code can only be used as a guide as it does not indicate the width of the head, web or foot of the model rail. A full table of prototype rail dimensions is found in Data Sheet T1/1. A list of currently available model rail sections and their prototype equivalents is given in Data Sheet T1/2. *(In preparation).*

TABLE 5

PROTOTYPE RAIL HEIGHTS
and their model equivalent code numbers.

Bullhead Rails BS9 1935		
BS Reference Number	Actual Height mm	Equivalent Model Code No
60	121	109
65	124	112
70	127	115
75	130	118
80	136	124
85R	139	126
90R	141	128
95R	145	131
100	136	136

Flat Bottomed Rails BS11 1985		
BS Reference Number	Actual Height mm	Equivalent Model Code No.
50 'O'	100	90
60A&R	114	104
70A	124	112
75A&R	129	116
80A&R	133	120
80 'O'	127	115
90A&R	143	129
95A, R&N	148	133
95RBH	145	131
100A&R	152	138
110A	159	144
113A	159	144

1.5 Track Making

Although 'Ready to lay' track is available commercially many modellers prefer to build their own using material available from the model trade. Track construction methods fall into three main categories; pinned, soldered or glued.

Pinned track consists of separate chairs, usually whitemetal, which slide onto bullhead rail and are secured to wooden sleepers with track pins. A flat bottomed version using spikes is also available. This system is popular where heavy section rail (Code 200) is used but is less frequently used in the smaller rail sizes.

Soldered track comes in two versions. The simpler uses copperclad printed circuit board (PCB) cut to sleeper size with the rail soldered directly to the copper. For two rail power supply the copper has an insulation gap cut between the two rails. It is extremely quick to manufacture track using this system but the finished appearance, particularly of bullhead track, is not as realistic as with some of the other systems.

The more elaborate soldered track system consists of wooden sleepering with brass rivets inserted at the rail positions. Bullhead rail is soldered to the rivets and the joint disguised with plastic cosmetic chairs glued in position. Manufacturing track with this system is relatively slow but, with care, the finished work is very realistic.

Glued track is a distant relation to pinned track in that separate plastic chairs slide onto bullhead rail and are glued to plastic sleepers with one of the plastic-welding solvents. The finish appearance is very realistic.

Note 1: Some plastics have suffered from embrittlement due to the action of sunlight and are not suitable for long term use in the garden. Check before purchase.

Note 2: Where live steam locomotives are to be run, especially if of the externally fired type, plastic sleepered track should be avoided if possible.

1.5.1 Track making jig

The type of track making jig illustrated in Figure 1-6 first appeared in the model press in the late 20s and early 30s. The design has changed little over the years, the main variation being the introduction of double sided tape to hold the sleepers in position over a track drawing instead of using fixed spacers. There is little to choose between the methods, the former allows greater flexibility in positioning sleepers but the latter allows the finished track to be removed easily without damage.

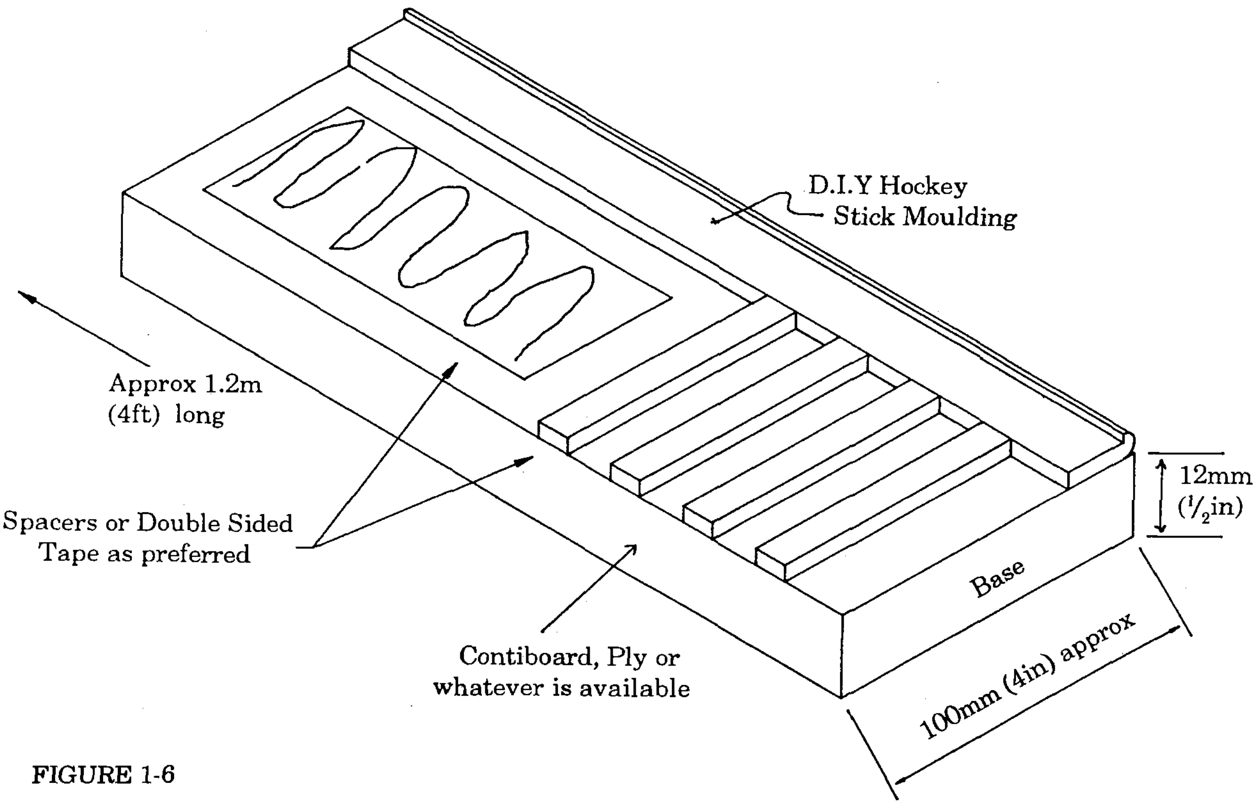


FIGURE 1-6

Basic track making jig.

1.5.2 Track making jig in use

FIGURE 1-7

Rail locator - holds rail in position while it is being fixed. If used with pinned slide-on chairs, the end of the angle (shown dotted) can be cut away to allow access for a pin punch.

Distance x = y + z where:

> *y = the distance from the inside face of the rail to the end of the sleeper.*
>
> *z = the width of the hockey stick moulding.*

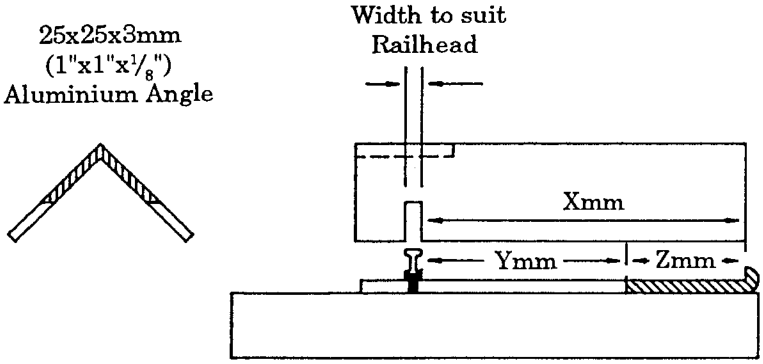
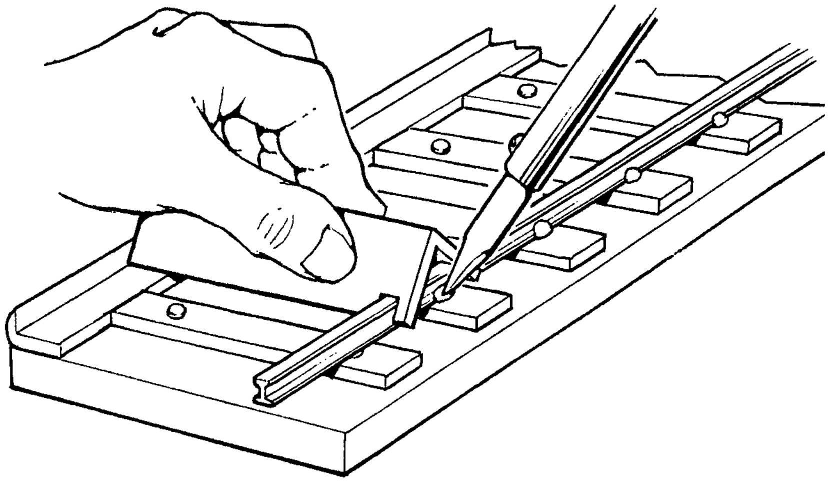


FIGURE 1-8

The track making jig in use for soldered construction. By lightly pressing the end of the rail locator against the hockey stick moulding, the rail is held at a set distance from the end of the sleeper. When a second rail is fitted in the jig using a four legged track gauge, the finished track is dead straight. For curved track, remove the single rail and sleepers from the jig and place in position on the baseboard. Fix the second rail using a three legged track gauge.



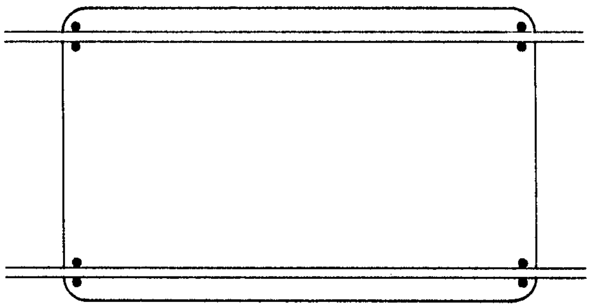


FIGURE 1-9

A four legged track gauge of the type preferred for straight track.

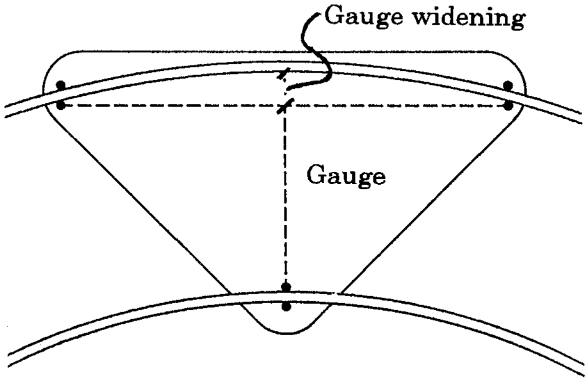


FIGURE 1-10

A three legged track gauge which provides automatic gauge widening on curve if this is desired.