2. Pointwork

2.1 Development of the prototype

2.2.1 Historical background.

A railway is a guided system, in which pointwork is used to switch trains from one route to another. To understand why pointwork takes the form it now does you must go back briefly into the origins of railways.

A wheelbarrow can be pushed along a paved road much more easily than it can across a field, the hard surface greatly reduces the resistance to rolling. So great is this reduction that the early miners and quarrymen laid down prepared and surfaced ways along which they rolled the tubs or chaldrons which they had loaded at the working face. They found that these tubs, once they were onto the main haulage ways, rolled so easily that they could be formed into 'trains'. However, because the individual tubs in a train tended to wander, flanges were provided on the outside of the planks commonly used to surface the ways. In time wooden planks were replaced by cast iron plates, usually L-shaped sometimes U-shaped, they wore better and offered less resistance

When steam locomotives began to replace horses, their weight was found to be too great for the plate rails and so the edge rail came into general use, sometimes shaped like a T but later like an I. These rails were lighter, cheaper and stronger for a given weight because their material was used more efficiently to support the increasing weights on vehicle wheels. However, carts and other vehicles running on these edge-railways had to have flanged wheels to provide the essential guidance and so lacked the freedom to roam onto the common roads and tracks. Likewise the railways on which they ran had to be continuous from the point of loading to that of discharge and be provided with specially constructed passing places. As the wheels ran on the highest part of the rail, they were less likely to be obstructed by stones and other debris and, what was more important, with careful design of rail head and wheel tread, friction between flange and rail could be much reduced, especially on curves.

Because a plateway was a guided way on which wagons ran in trains, a method was needed at a junction to ensure that all the wagons in a train followed the chosen route. You could no longer, as on a road with a horse pulling a single cart, just pull the reins to the left or right and expect the horse to pull the wheels of each successive wagon into the diverging ruts. The 'rails' in the plateway were short iron castings, typically 3ft long. There were two types of divergence, later to be known as switches, in common use. In the first type a complete plate, pivoted at one end, was arranged so that the free end could be switched to face one or other of the two diverging roads; in the second the plate was vee-shaped with a separate cast iron blade which likewise could be moved to close off the straight road.

Since movement on these tramroads took place at the speed of a carthorse there was time to set each switch by hand while the vehicle approached. Then, at the place further on, where one wheel track crossed another, still called the 'crossing', there would be another plate with a swivel blade which could be rotated to the chosen route as above or, if the line was by then reasonably straight, an open symmetrical cross-shaped plate that allowed each wheel to pass across on its chosen route. The resemblance of this crossing to a frog may account for its other name, common in

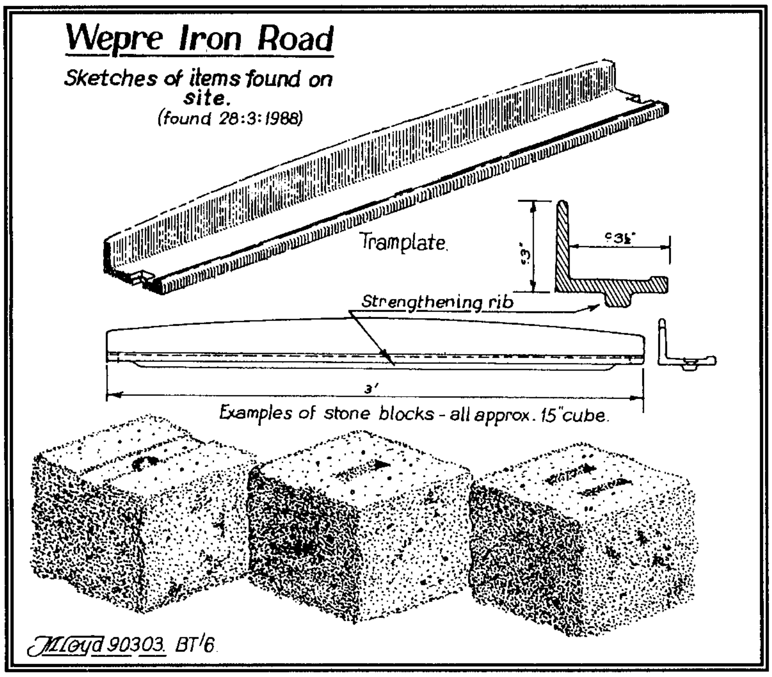

Figure 2-1 *Wepre Iron Road*

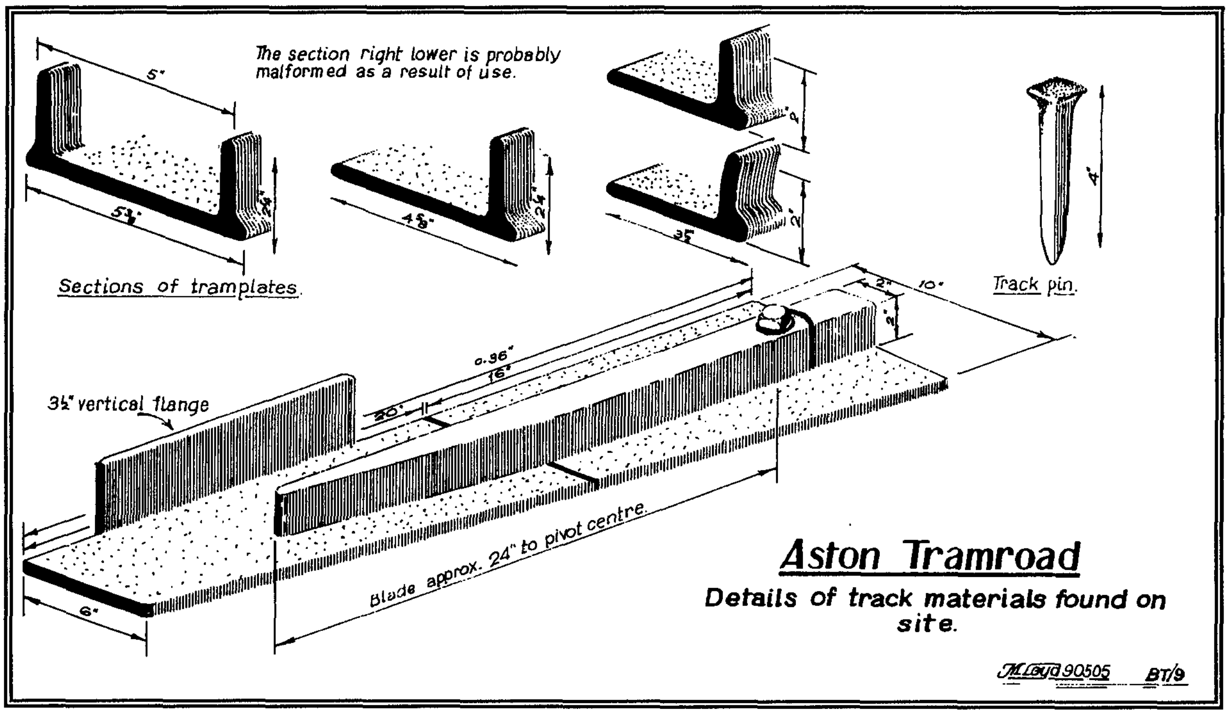

Figure 2-2 *Aston Tram Road*

North America, but introduced into UK modelling circles we think by Henry Greenly who gained his early engineering experience on the Metropolitan Railway which may have used the term by association, for the London Underground tube lines were at one time American owned.

When edge rails were adopted, despite their many benefits, two new problems emerged; not only did the rails have to support and constrain the wheels continuously in both vertical and lateral directions, they also had to remain true to gauge while carrying loads. On plain track the means were relatively simple, but at divergences cleverer solutions were needed. The earliest switches were of the 'stub' type, imitating the movable plate in the old plateways. While they could be adequately supported beneath by the surfaces on which they slid, their only lateral support came from the use of gauge ties. The stub ends were kept in place by the switching mechanism which had also to be able to resist the lateral forces occurring as each vehicle was turned through the angle of the divergence. These stubs could in consequence only be short and, being short, caused the wagons to be turned abruptly through a large angle. The switch thus experienced a large lateral thrust and if speeds were other than low, wear was rapid. Figure 2-3.

At the crossing also, a moveable piece was tried, but here the ends of a swivel had somehow to be held in alignment. In some US designs, one rail was raised so that the wheels then passed over the other rail, the wheel clattering over the gap, kept in line by means of a guard, guide, or check rail bearing on the back of the flanges of the wheels on the other diverging rail.

Such crudities lasted much longer in the USA than in Europe because US engineers accepted that track would be crude and designed rolling stock accordingly. In the American Civil War, when the locomotive *'The General'* was stolen by the Andrews Raiders, the engines used by the pursuit had to run over ties (sleepers) which the raiders had removed and laid on top of the rails, they even managed to run over rails which had been lifted and then placed across the track without capsizing. In Europe however practice quickly settled, albeit via a bewildering variety of patents, to the use of machined switch rails tapering to a point, hence the name, and crossings built up from several rails, some likewise machined. A pair of these points, together with a crossing, formed a turnout.

2.2.2 Switches.

Remember how on plateways, when negotiating their crude switches, vehicles were turned abruptly onto the new route. This feature was unavoidable with cast iron switches which, restricted to a nominal length of no more than 2ft 6in, turned the wagon through an angle of 1 in 4. By the 1940's, in

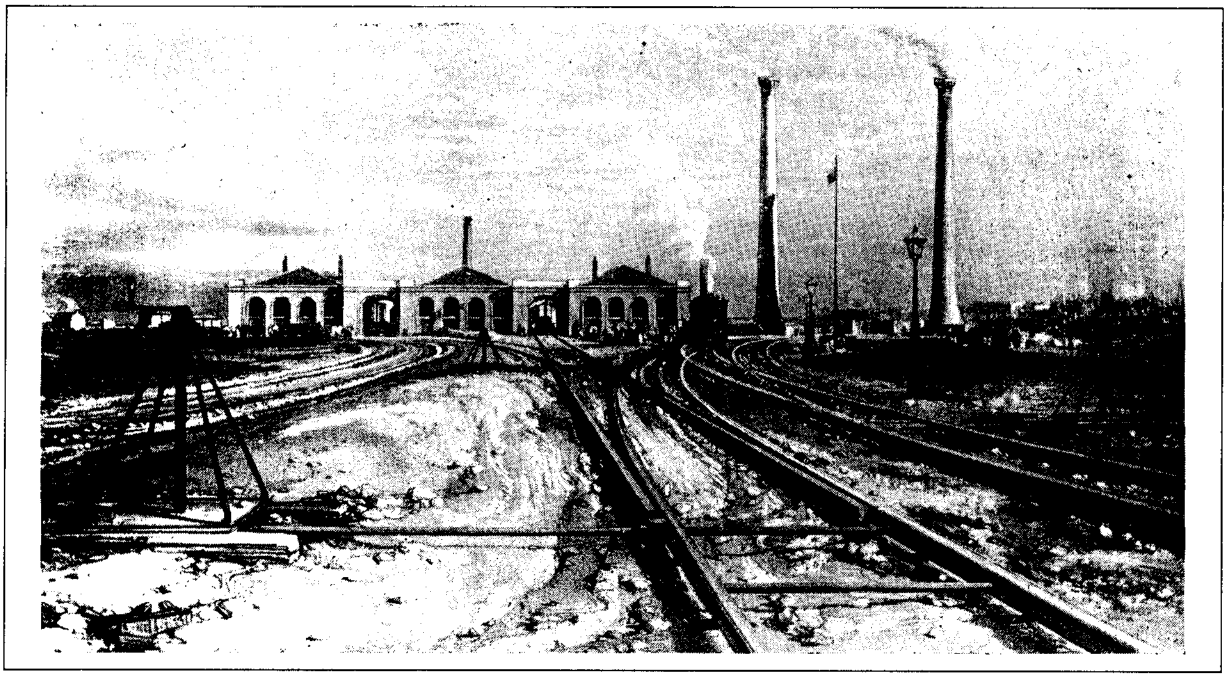

Figure 2-3 *Early Switches at Camden Town Engine Shed*

track made up from rolled steel edge rails, switches were commonly 30ft long and so turned the vehicle through no more than 1 in 80 onto a curve that allowed a theoretical speed of 80mph. Each switch blade was however still machined such that, in plan view, it still appeared triangular, the two long sides being straight as shown in Figure 2-4. It is this form, the straight-cut switch, that is all that modellers need be able to copy.

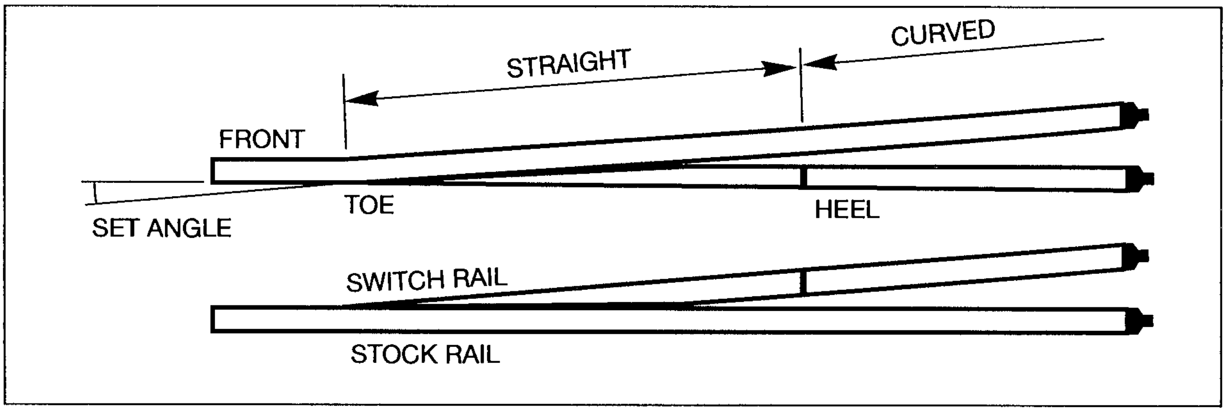

Figure 2-4 *Straight-cut switches*

In the USA, where as stated earlier they accept different behaviour, until recently such switches remained in general use. On this side of the Atlantic however, from about 1920, in order to provide smoother running and reduce wear, the tapered portion of the blade began to be machined to a curve. Though more difficult to form, these curved switch blades cause much less of a lurch, having entry angles which range from 1 in 59 up to 1 in 604.5 when used for 125mph running. These curved switches entail the cutting of chamfers under the head of the adjacent stock rails so that the slender toes of the blades fit in and serve initially solely to guide the flange, carrying significant weight only when they have become thick enough to bear it.

Note however that there still has to be an entry angle and tip of finite width, it is impossible to machine to infinity. The tip of the toe of our straight-cut switch was 1/4in thick, today the toe of a 125mph switch is 6mm, it is however tucked into the stock rail. In operation, the machined blade closes against and is supported laterally by the stock rail. When open, wheels run along the stock rail: closed, they are turned on to the blade. Like their plateway equivalents, the earliest edge rails were made from cast iron. Because they broke so often, railways changed to using wrought iron and then to steel. The typical rail section throughout Europe was at first symmetrical in the form of an I with top and bottom similar in shape and size. It was however found that in general, by the time the wear on the top was such that the rail needed turning, the underside had become so galled at the points where it rested in the chairs as to make it unsuitable for further use. This experience lead to the adoption of the bullheaded rail. Though both the top and bottom of the BH section had the same width, the depth of the top was much greater, giving it a longer service life.

From such rails turnouts could easily be constructed since only the switch blade had to be machined, the stock rail readily being given the slight joggle needed to accommodate the toe of the blade. Rails of the Vignoles or flat-bottom type, which came into use quite early because they could be laid directly onto sleepers without the use of chairs and were stronger for a given weight, could not easily be joggled. Consequently it was much harder to construct turnouts from them, both blade and stock rail usually having to be machined. Much later, in high speed turnouts made from BH section rail, the joggle was replaced by machined chamfer and undercut of switch and stock rail, as noted above.

2.2.3 Switch chairs.

Remember the two problems faced by the designers of switches ?

1. Vertical support.
2. Lateral support.

Also 3. Preventing wheels from hitting the toe of the open switch blade.

1 and 2 are overcome by providing slide chairs to support both stock and blade from beneath and to give side support to the stock by bolting it to their heavy outer lugs. Spacing blocks are also bolted between the two rails which support the blade when closed, as shown on Figure 2-5. Whereas, to help guide the wheel sets, the rails in conventional plain track are tilted towards each other at 1 in 20, in turnouts in bullhead track, to ensure support where stock and blade meet, both rails are twisted into the vertical plane. In older flat bottom track only the blade is vertical being machined to fit against the tilted stock rail. The loads imposed by model rolling stock are however so small as to make it unnecessary to reproduce these details of construction in model pointwork.

Formerly, in full size practice, only one chair, the heel chair, ensured that the blade remained upright yet could still swivel. As this chair had so much to do, it was very heavy. It linked and supported both the blade and the stock rail keeping them spaced correctly at an important place in the set-up. Here a blade when open came closest to the

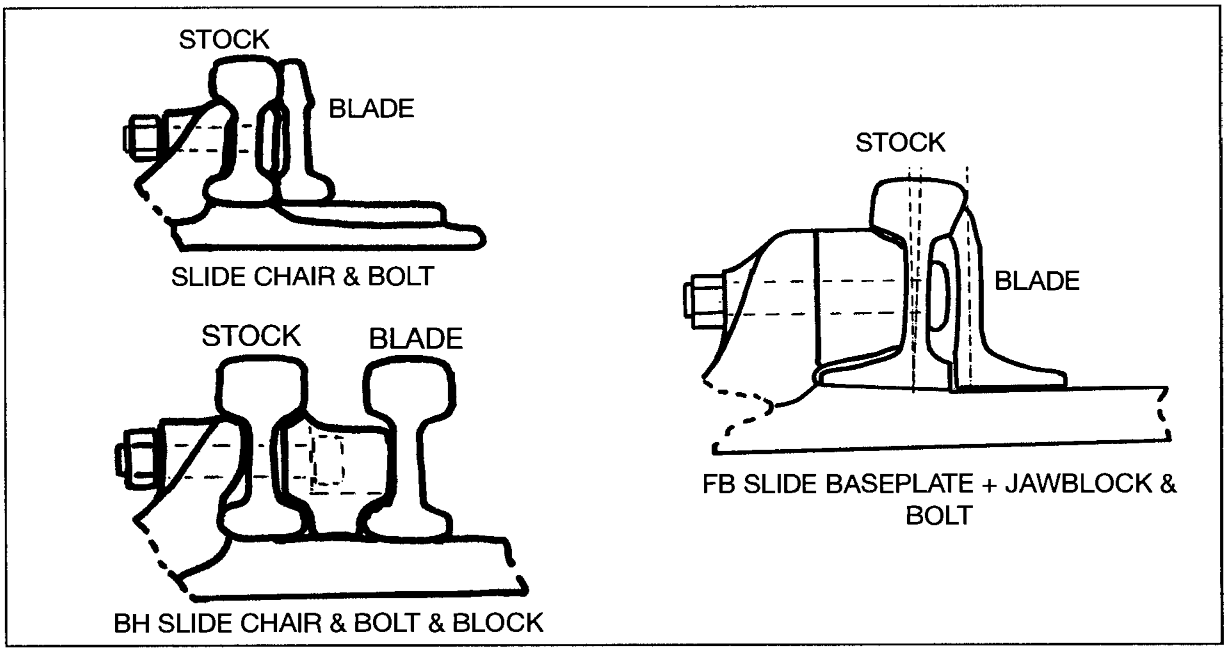

Figure 2-5 *How blades fit against stock rails.*

stock rail, with perhaps only flangeway clearance between them (2in). The swivel could be a pin in the chair or a fishplate in front of or behind it. See Figure 2-6.

The third problem, to prevent wheels either hitting the toe of an open blade or pushing through the gap between the stock and the toe of an incompletely closed blade, was dealt with by joining both blades together with connecting rods at their toes. At the same time the two stock rails were held to gauge with a steel plate, or by gauge tie-bars. The point mechanism is designed to ensure a minimum distance between the toe of the open blade and the adjacent stock rail of 4¼in.

Should a blade come loose it might be moved forward by a train and thus cause a derailment. To prevent this a flat steel anchor, attached near the heel of the blade, maintains the blade in its correct position relative to the stock rail.

type, one of which is required in each turnout, is called, unsurprisingly, the common crossing. Crossings used to be built up from a combination of rails, some machined and some bent, clamped by bolts and spaced with cast iron blocks. Today steel castings can replace some or all of the separate rails in the older type. The compromise of a gap in the running surface is accepted provided that check rails are fitted alongside the opposite running rails to guide wheelsets through, minimum flangeway clearance being provided on both sides. At sensible angles of crossing the wheel tread is still being carried by the rail it is leaving as it passes onto the tip or nose of the crossing, only fully transferring its weight where the rail becomes strong enough to carry it. If the alignment of the elements of the crossing is good the wheel will take a natural path, if not the check rail will constrain it to do so but the ride is then rough

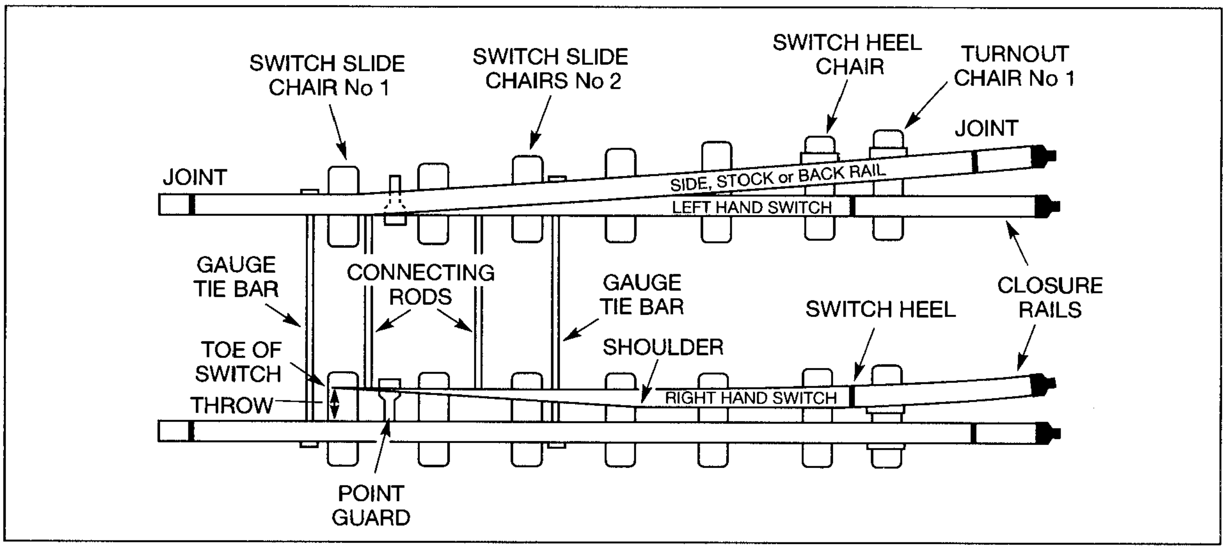

Figure 2-6 Switches
(The point guards, if fitted, prevented the toes from rising).

More recently, once the use of longer switches became normal, it was realised that the flexibility of the switch rail was sufficient to make special pins or bolts unnecessary, thus making the heel chair redundant. The latter was replaced by pairs of large cast iron blocks which also replaced the anchor strip. These blocks are bolted between blade and stock rails at positions far enough from the switch toe to provide the requisite flexibility. This longer blade was still however fishplated to its neighbour, the closure rail, beyond the anchor block.

2.2.4 Crossings.

You will recall that the crossing was at the location where the diverging rails cross. The commonest

as the wheels are having to be pushed in to the correct path. See Figure 2-7

2.2.5 Terminology; Names of Components.

The names of the main components of switches and crossings are shown on Figures 2-6 and 2-7. Formerly, as with plain track, turnouts were built up on sleepers of standard length width and depth. These were interlaced and located on the centre-lines of the diverging tracks. Gradually they came to be replaced by specially cut 'timbers', supporting both tracks to some distance beyond the crossing. These timbers were wider and deeper than sleepers to accept chairs or baseplates on the skew and were cut to length. For some time after concrete sleepered track became standard, pointwork

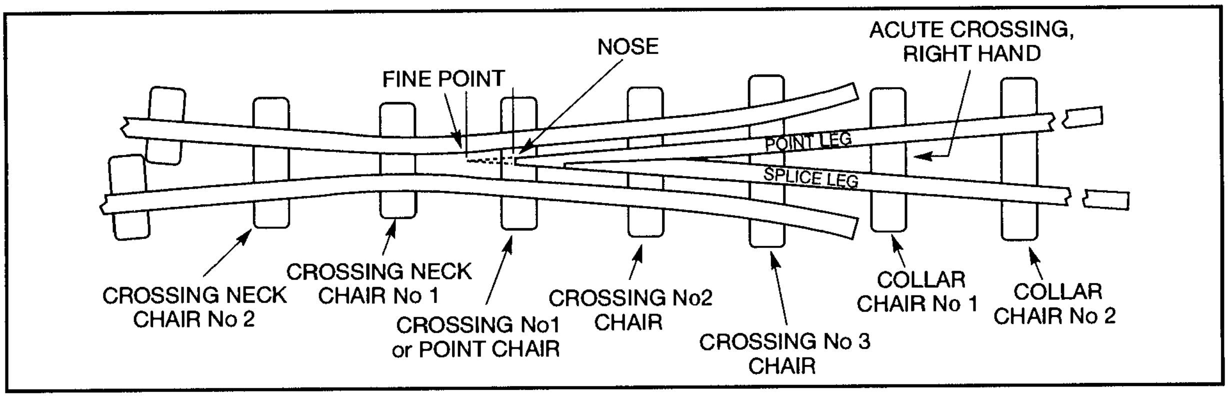

Figure 2-7 *Common crossing*

remained on timbers, only recently have concrete 'bearers', the equivalent of timbers, appeared.

The size of an item of built-up pointwork, especially when constructed from BH rail, was commonly described by the length of the switch blades and the angle of the crossing. The length of switch blades is indicated by letters, the crossing angle by a number, viz. B-8. This turnout would have switch blades 22ft-6in long and a crossing angle of 1 in 8. Figure 2.8 gives a more complete picture of the range of choice available to the installer of traditional trackwork.

2.2.6 Variety of prototype pointwork.

Bullhead rail, with its foot no wider than its head, is inherently more flexible laterally than Flat Bottom rail. It thus lends itself to variety in pointwork configurations. Originally, the only rails which needed to be machined and kept as standard items in stores, were the switch blades and the two pieces of rail forming the nose of the crossing. These were all made as short as possible for ease of handling. All the others could be cut, bent and drilled by the men on site using hand tools. Individual lengths of rail, after careful heating, were bent using a giant screw clamp known as a Jim Crow or jimmie. A great range of combinations is thus possible, Figure 2-8 demonstrates this variety, being a table of switch and crossing dimensions as used on the North British Railway. Combinations of these could even be superimposed one upon another.

Progressively, with the demise of horse and capstan shunting and changing traffic patterns, these wonders began to disappear. Higher speeds, standardisation of locomotives and particularly the advent of FB rail capable of carrying higher axle loads, led to standardisation of FB switch and crossing (S&C) components. BH S&C work, however, has continued in use at some BR stations long after the FB alternative became the standard because it allows awkward layouts to be fitted into tight spaces, it also takes curves better. Such layouts could not be replaced by FB equivalents piecemeal, the only way was to remodel the whole station in a 'big bang' closure, such as at Crewe in 1985.

2.2.7 Refinement of the design of Pointwork.

Thus far this introduction has sketched in the early history of switches and crossings in Britain, but for a fuller understanding the story needs to be brought up to date.

Speed through turnouts was limited by the lack of super-elevation (also known as cant, the raising of the outer rail, see Part 2 page 2.1.2), and, through double junctions, by the angle of the diamond. The latter problem was overcome in the 1920s by flattening the angle of the crossing and using switch diamonds. The former was first dealt with on the LMS in the 1930's, where chairs of varying height were introduced into S&C work to provide cant and at the same time including transition curves in the design of such high-speed junction layouts.

These turnouts required many different chairs, including complex ones with rail seats at different levels known as two-level chairs. The same approach was also used with FB rail after 1950 which, with other changes, allowed 70mph on both routes at some junctions. However the vast array of components cost a great deal and necessitated keeping large stocks or accepting delays when repairs were needed.

The current BR design has simplified all that, with a limited range of flat baseplates using the Pandrol clip to fasten the 113lb rail. A lot of that simplification resulted from setting the rails vertical throughout, instead of at the traditional 1 in 20 inward tilt. This meant acceptance of a poorer ride which was made acceptable by other simplifications, accompanying major changes in design conventions, that the turnout curves should be transitioned and be of such radii as to allow

NORTH BRITISH RAILWAY. PERMANENT WAY.

TABLE OF SWITCH AND CROSSING LEADS WITH RADII OF CURVES.

Angle of Crossing.	6 Feet Switches. Lead. Ft.	Ins.	Radius of Curve or Turn-out. Feet.	Chains.	9 Feet Switches. Lead. Ft.	Ins.	Radius of Curve or Turn-out. Feet.	Chains.	12 Feet Switches. Lead. Ft.	Ins.	Radius of Curve or Turn-out. Feet.	Chains.	15 Feet Switches. Lead. Ft.	Ins.	Radius of Curve or Turn-out. Feet.	Chains.	16 or 24 Feet Switches. Lead. Ft.	Ins.	Radius of Curve or Turn-out. Feet.	Chains.	18 or 29 Feet Switches. Lead. Ft.	Ins.	Radius of Curve or Turn-out. Feet.	Chains.
1 in 2	21	6	37·5	0·57	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 in 2¼	23	2	47	0·71	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 in 2½	24	11	58	0·88	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 in 2¾	26	6	70	1·06	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 in 3	28	1	83	1·26	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 in 3¼	29	8	98	1·48	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 in 3½	31	2	113	1·72	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 in 3¾	32	8	131	1·98	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 in 4	34	2	150	2·27	39	1	145	2·20	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 in 4¼	35	6	169	2·57	40	8	164	2·48	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 in 4½	37	0	192	2·91	42	4	184	2·80	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 in 4¾	38	4	215	3·26	43	9	205	3·11	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 in 5	39	8	240	3·64	45	4	228	3·45	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 in 5¼	40	11	267	4·04	46	11	253	3·84	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 in 5½	42	2	295	4·47	48	4	278	4·21	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 in 5¾	...	...	...	...	49	10	306	4·63	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 in 6	...	...	...	...	51	3	333	5·05	56	5	325	4·92	...	...	...	...	...	...	...	...	...	...	...	...
1 in 6¼	...	...	...	...	52	8	364	5·51	58	0	354	5·36	...	...	...	...	...	...	...	...	...	...	...	...
1 in 6½	...	...	...	...	54	1	395	5·99	59	6	383	5·81	...	...	...	...	...	...	...	...	...	...	...	...
1 in 6¾	...	...	...	...	55	6	429	6·50	61	1	415	6·29	...	...	...	...	...	...	...	...	...	...	...	...
1 in 7	...	...	...	...	56	10	461	6·99	62	7	448	6·78	...	...	...	...	...	...	...	...	...	...	...	...
1 in 7¼	...	...	...	...	58	1	498	7·55	64	0	480	7·27	...	...	...	...	...	...	...	...	...	...	...	...
1 in 7½	...	...	...	...	59	5	537	8·14	65	6	515	7·81	...	...	...	...	...	...	...	...	...	...	...	...
1 in 7¾	...	...	...	...	60	9	578	8·75	67	0	553	8·38	...	...	...	...	...	...	...	...	...	...	...	...
1 in 8	...	...	...	...	62	0	620	9·39	68	5	592	8·96	73	8	580	8·78	75	5	577	8·74	...	...	...	...
1 in 8¼	...	...	...	...	...	...	...	...	69	10	631	9·57	75	3	618	9·36	76	10	615	9·32	...	...	...	...
1 in 8½	...	...	...	...	...	...	...	...	71	3	672	10·18	76	8	656	9·95	78	4	654	9·91	...	...	...	...
1 in 8¾	...	...	...	...	...	...	...	...	72	8	716	10·86	78	3	699	10·59	79	11	696	10·55	...	...	...	...
1 in 9	...	...	...	...	...	...	...	...	74	0	757	11·47	79	8	738	11·18	81	4	734	11·13	...	...	...	...
1 in 9¼					...	...	...	...	75	3	802	12·15	81	1	780	11·82	82	10	776	11·76	...	...	...	...
1 in 9½	21 or 31 Feet 6 Inch Switches.				...	...	...	...	76	8	850	12·88	82	7	826	12·51	84	4	822	12·45	...	...	...	...
1 in 9¾	Lead. Feet	Ins.	Radius of Curve or Turn-Out. Feet.	Chains.	...	...	...	...	78	1	903	13·69	84	2	876	13·27	85	11	871	13·20	...	...	...	...
1 in 10	95	7	897	13·59	...	...	...	...	79	3	950	14·39	85	6	919	13·93	87	3	914	13·85	90	6	905	13·71
1 in 10¼	97	2	943	14·29	...	...	...	...	80	8	1007	15·25	87	0	972	14·73	89	0	965	14·63	92	4	955	14·47
1 in 10½	98	9	991	15·02	...	...	...	...	82	0	1062	16·09	88	5	1023	15·51	90	5	1016	15·39	93	10	1004	15·22
1 in 10¾	100	3	1041	15·78	...	...	...	...	83	2	1114	16·87	89	8	1072	16·24	91	7	1066	16·15	95	0	1052	15·94
1 in 11	101	10	1092	16·55	...	...	...	...	84	6	1178	17·85	91	3	1131	17·14	93	2	1124	17·03	96	8	1110	16·81
1 in 11¼	103	4	1143	17·31	...	...	...	...	...	...	...	...	92	5	1179	17·87	94	4	1171	17·74	97	11	1156	17·51
1 in 11½	104	11	1197	18·13	...	...	...	...	...	...	...	...	93	10	1240	18·78	96	0	1228	18·61	99	11	1216	18·43
1 in 11¾	106	5	1250	18·95	...	...	...	...	...	...	...	...	95	4	1305	19·77	97	4	1294	19·61	101	0	1276	19·33
1 in 12	107	11	1306	19·78	...	...	...	...	...	...	...	...	96	8	1365	20·68	98	8	1353	20·51	102	5	1333	20·20
1 in 12¼	109	6	1364	20·67	...	...	...	...	...	...	...	...	98	0	1429	21·65	99	10	1417	21·46	103	11	1394	21·13
1 in 12½	110	11	1422	21·54	...	...	...	...	...	...	...	...	99	2	1486	22·52	101	5	1470	22·27	105	2	1449	21·96
1 in 12¾	112	6	1483	22·48	...	...	...	...	...	...	...	...	100	5	1547	23·44	102	5	1533	23·22	106	5	1507	22·83
1 in 13	114	0	1546	23.42	...	...	...	...	...	...	...	...	101	11	1625	24·63	103	11	1609	24·38	108	0	1581	23·95

NOTE.—Angles of Crossings are measured to intersection point of running faces. Leads are measured along running faces.

Engineer's Office,
Edinburgh, *July* 1908.

Figure 2-8: *Table of Standard Turnout Dimensions, NBR.*

design speeds on all routes with the same cant throughout. Thus the main line should if possible be straight with no cant or be on a circular curve with constant cant. This tends to make S&C extremely long, particularly on high speed lines, with successive crossovers rather than diamonds. Cost considerations keep layouts to the simplest that will serve. Since 1987 a further development has been the use of concrete bearers instead of timbers below S&C (a concrete timber is an oxymoron). Apart from the slide baseplates below the switches all other ironwork is directly secured as on concrete sleepers. (Back to the situation with lots of special components). These switches have at least five heel blocks to transmit welded rail stresses.

Another recent change, on very heavily run points, is the use of UIC asymmetrical switch rails which are shallower, needing raised slide baseplate surfaces. BR 113lb rail is weaker, too thin when planed to stand the bashing, whereas UIC switches have plenty of meat even at their toes, as shown in Photo 2.1

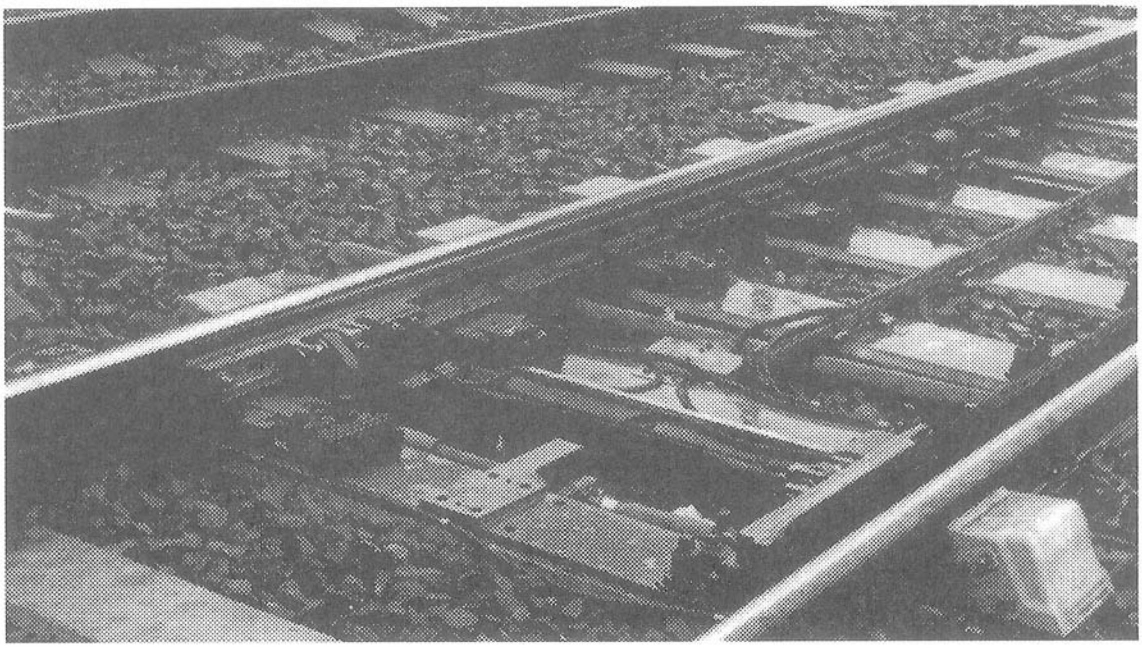

Photo 2.1 UIC assymetrical switches on concrete bearers with electro-hydraulic clamp lock drive and facing point lock combined.

2.2.8 Material to be found in typical British station layouts.

Before 1935: Except on light railways, War Department systems and the Rhymney Railway, all plain track and pointwork was assembled from bullhead rail.

1935 - 1950: Experimental lengths of FB plain track began to appear, also plain track laid on steel sleepers. During the war, from 1940, 39' lengths of FB rail imported from the US appeared, mostly in yards. Concrete pot-type rail bearers with steel ties were used in sidings under BH rail. FB rail was adopted as the future mainline standard in 1948, having appeared extensively from 1940 onwards in the plain track of all four groups, the first mainline FB pointwork being installed, both on the LMS and the LNER, before 1945.

1950 -1965: British Railways adopted 109lb and 98lb FB rail as standards. 109lb FB rail began to be used in pointwork, but only where most needed. Broadly, on lines which were closed by Dr. Beeching S&C would still have been made up from BH components. By the end of this period main line crossovers and junctions would be made up from FB S&C, but not at terminals for the reasons given in 2.6 above.

1965 - 1985: The current design of 113lb BR FB rail was introduced, being used in every rationalisation or renewal thereafter. Displaced 109lb FB turnouts then went into such sidings and yards as remained, which until then would still have been bullhead. Continuous Welded Rail (CWR) became the norm on new plain track.

1985 - to date: Pointwork on concrete bearers begins to appear, layouts are highly standardised, diamond crossings are rare, being replaced by sequences of turnouts. Components are generally heavier, using cast-steel crossings and switches with multiple heel blocks.