Turnout and Crossings

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4th year Civil

Week 13

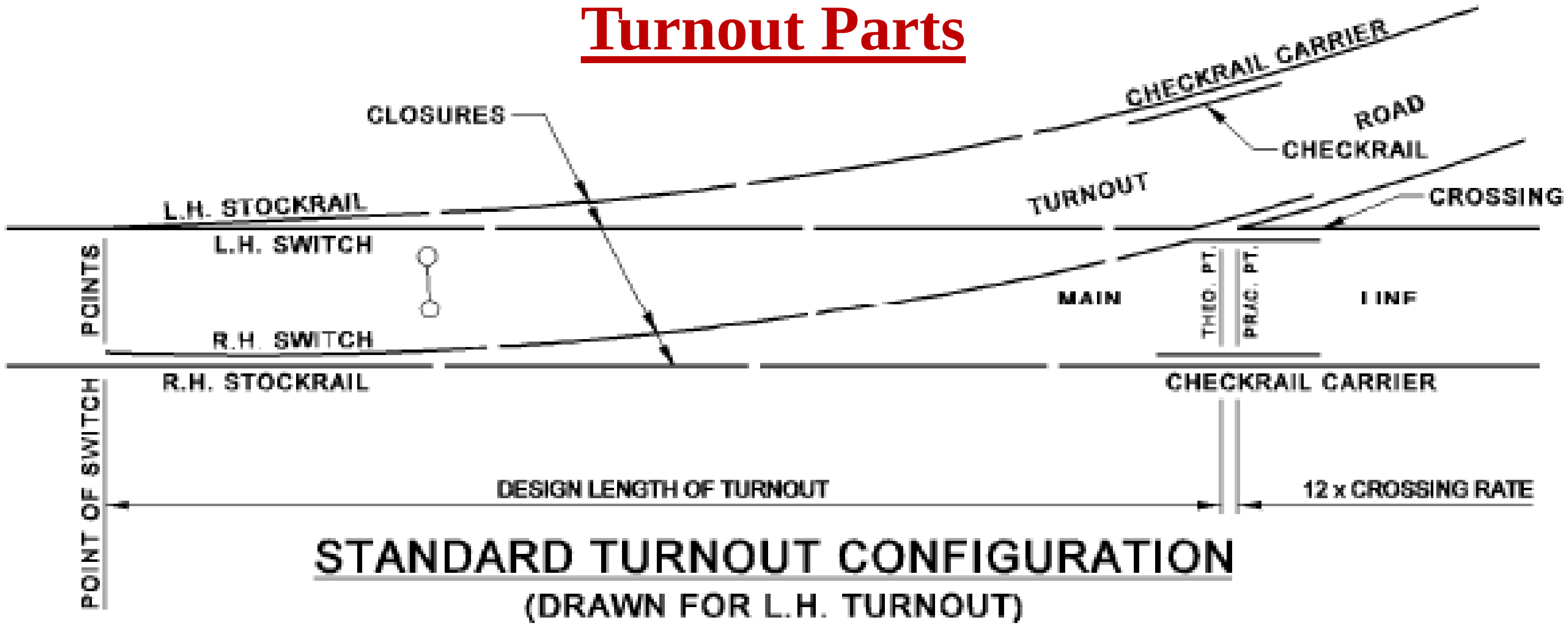
Turnouts & Crossings in a Yard

Electric Left Turnout

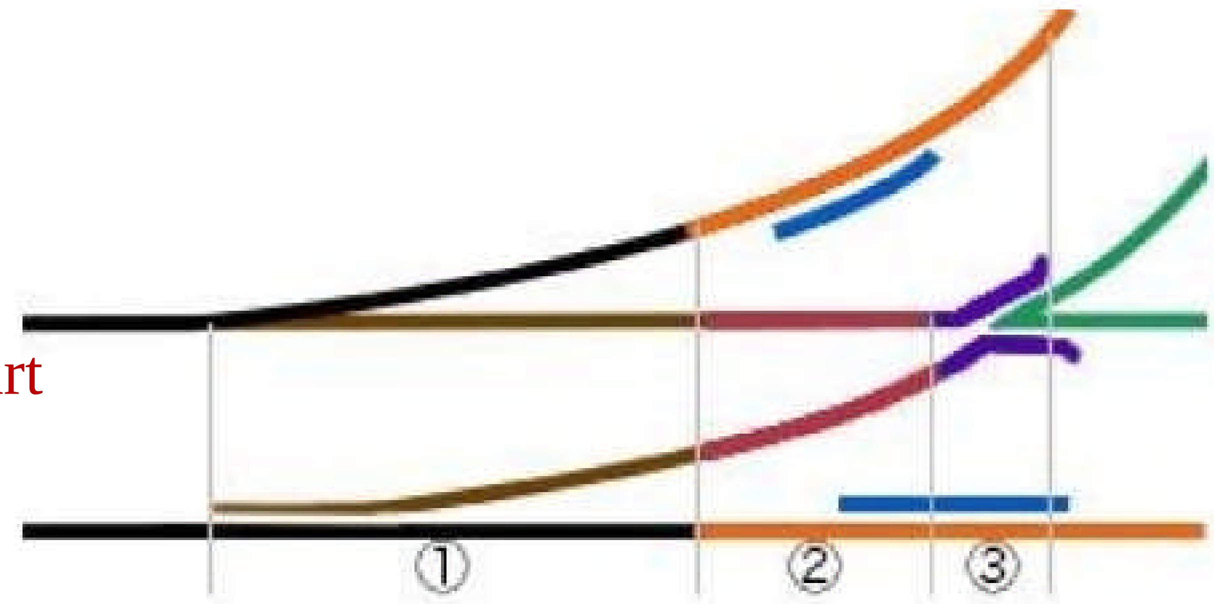
Manual Handling Right Turnout

Right and Left Turnouts

Turnout Parts



1- Switch part
2- Middle (Lead) part
3- Crossing part



-The long, continuous rails that form the outside edges of the switch are called the **stock rails**.

-The movable parts that route the trains one way or the other are called the points or **point blades**. The **throw bar** or tie bar ties the points together and controls their movement from side to side.

-The crossing in the middle where the rails meet is called the **frog**.

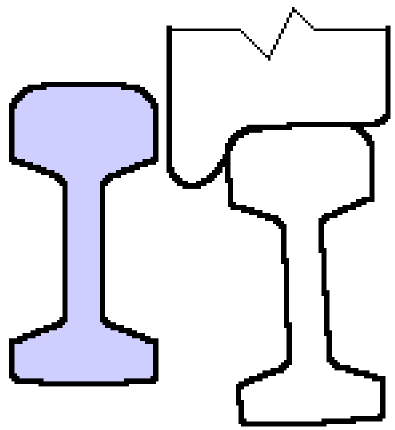
-The rails between the points and the frog are called the **closure rails**.

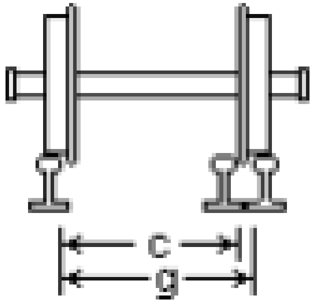
-The small lengths of rail along the stock rails (opposite the frog) are called **checkrails or guard rails**. These keep the wheels from "picking the frog" and heading the wrong way, leading to a derailment.

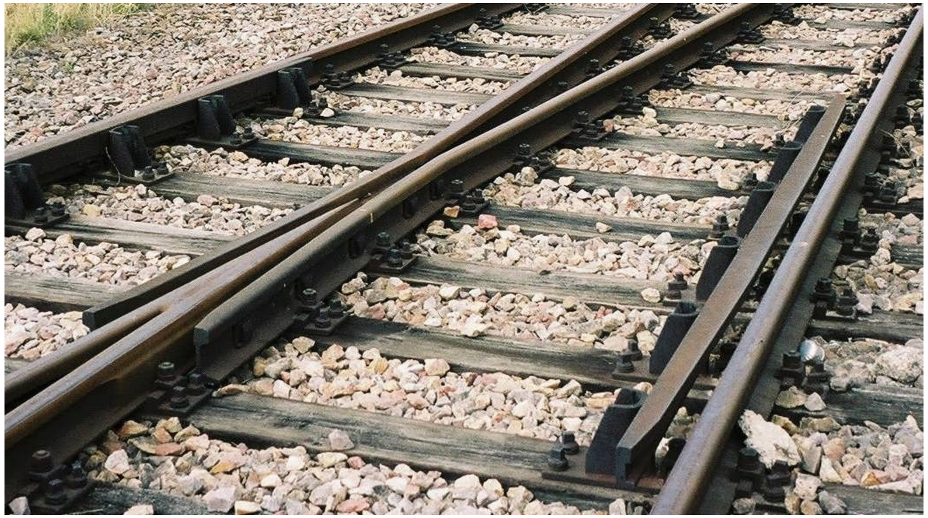
On a typical switch, the straight path is called the **main route**, and the path that curves away is called the **diverging route**.

In a railroad, the sharpness of this divergent route is identified in one of two ways: either in terms of **the radius**, or by **a number**. **The larger the frog angle, the wider is the switch.**

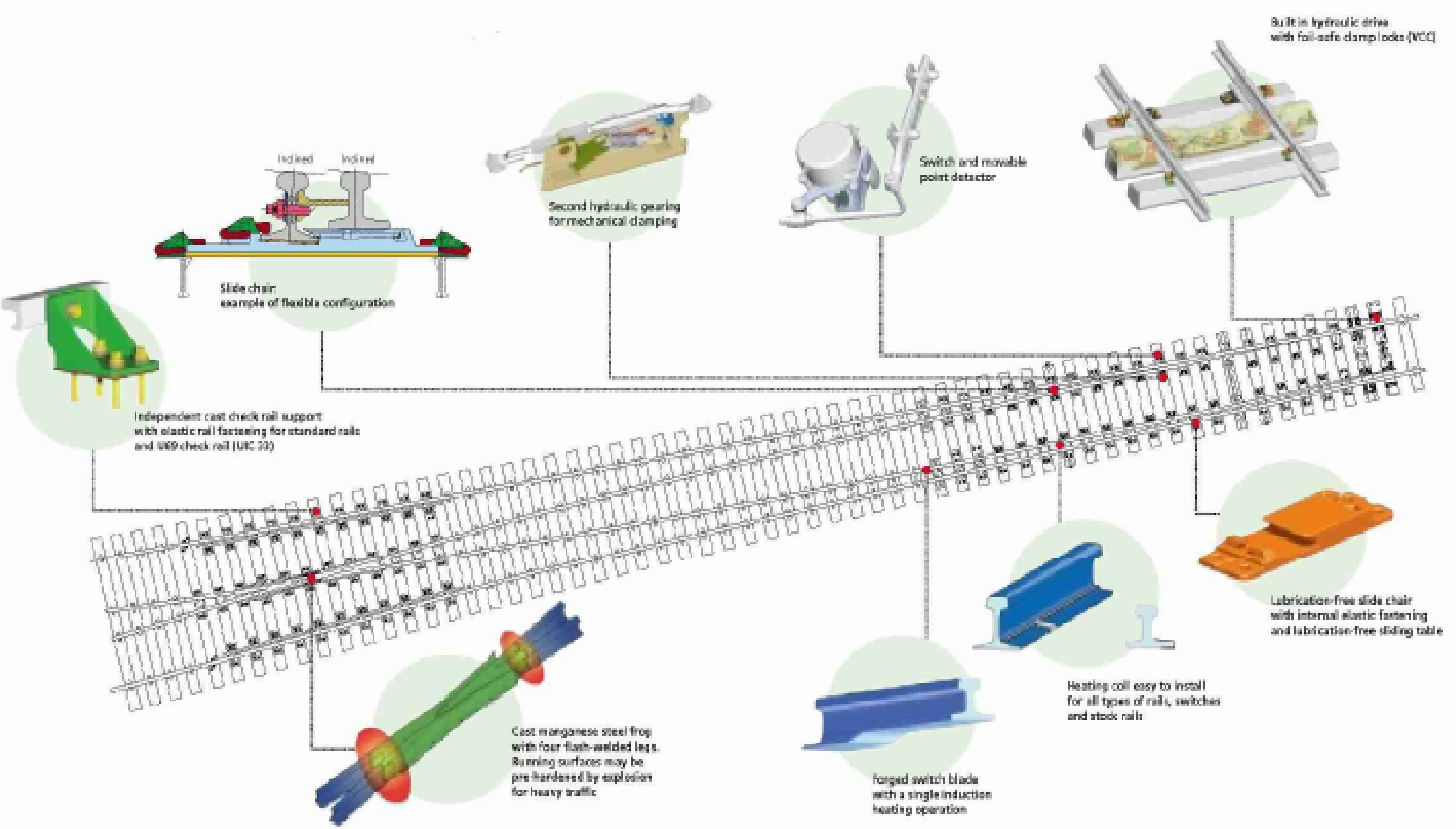
- **A guard rail** (check rail) is a short piece of rail placed alongside the main (stock) rail opposite the frog.
- These exist to ensure that the wheels follow the appropriate flangeway through the frog and that the train does not derail.
- Generally, there are two of these for each frog, one by each outer rail.



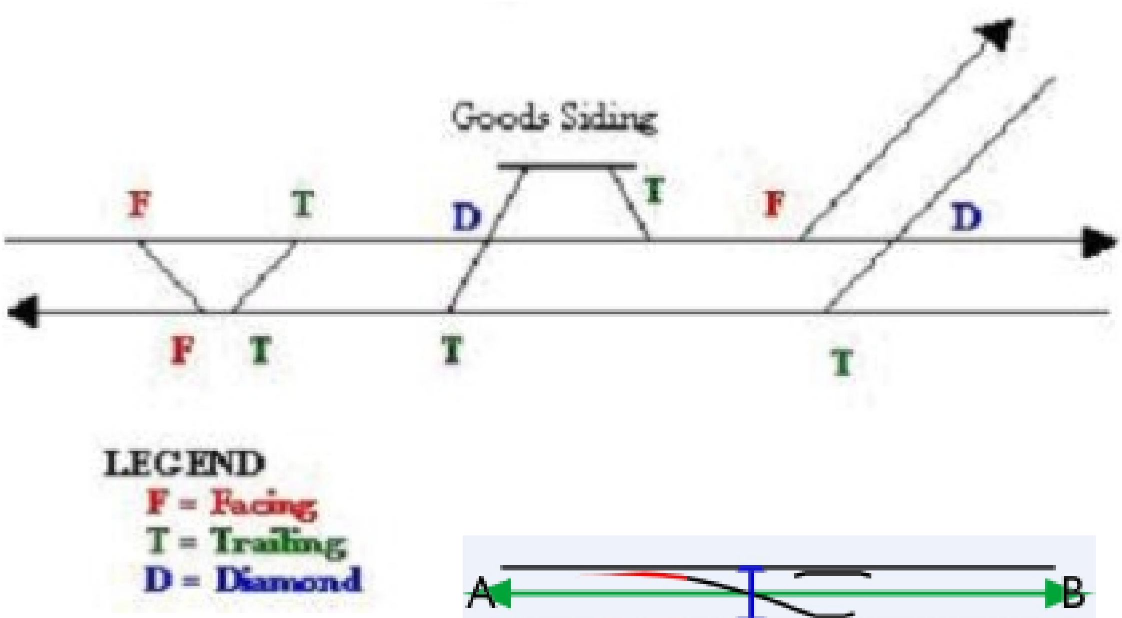


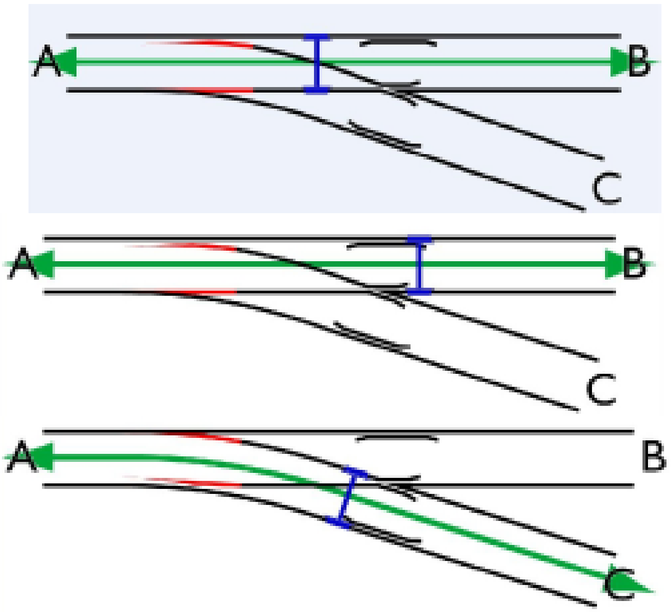


Turnout Operation



Facing and Trailing



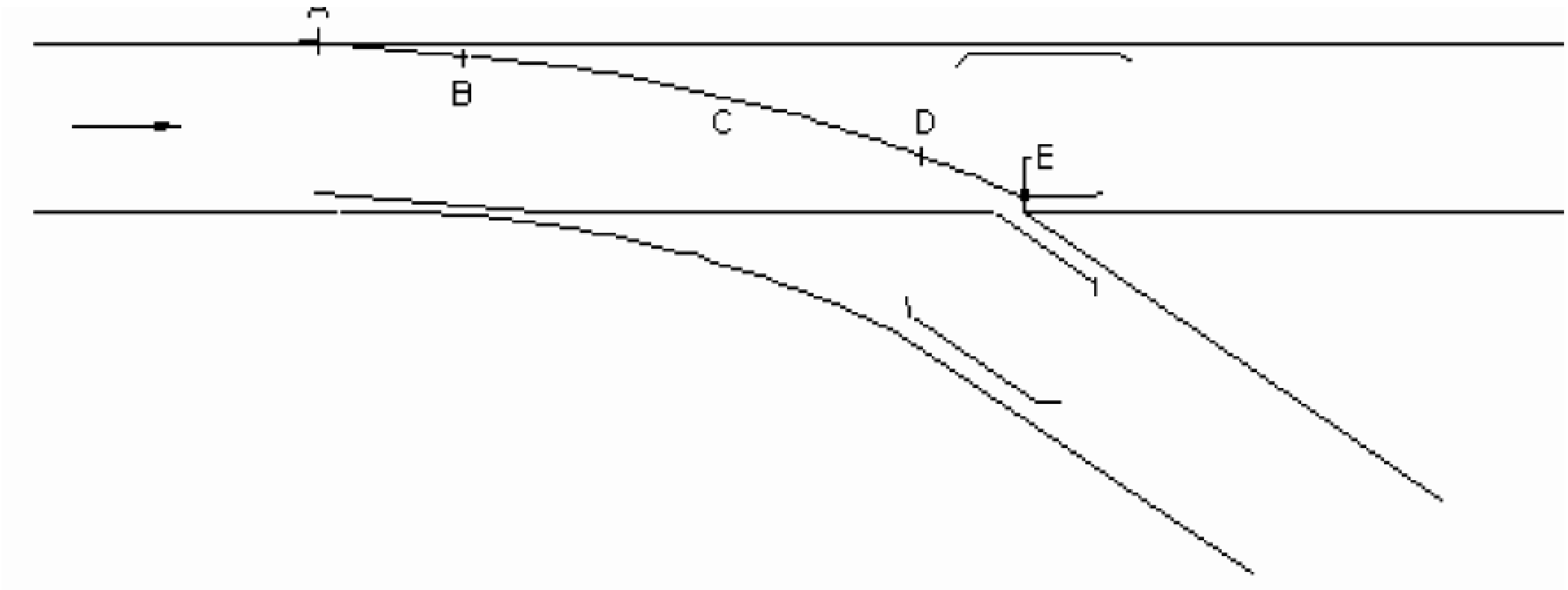


- Points can be moved laterally into one of two positions so as to determine whether a train coming from the narrow end will be led towards the straight path or towards the diverging path.
- A train moving from the narrow end towards the point blades is said to be executing a facing-point movement.

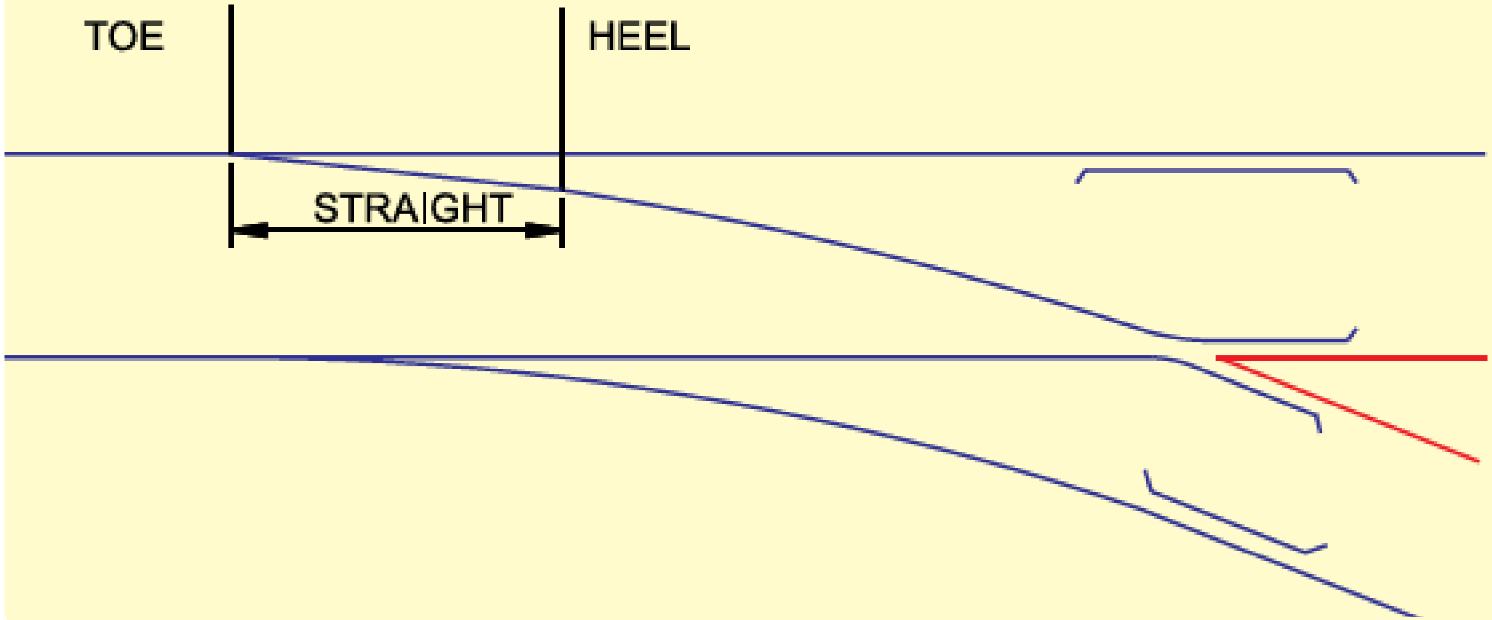
Unless the switch is locked, a train coming from either of the converging directs will pass through the points onto the narrow end, regardless of the position of the points, as the vehicle's wheels will force the points to move. Passage through a switch in this direction is known as a trailing-point movement.

Various factors limiting speeds over turnouts are as follows

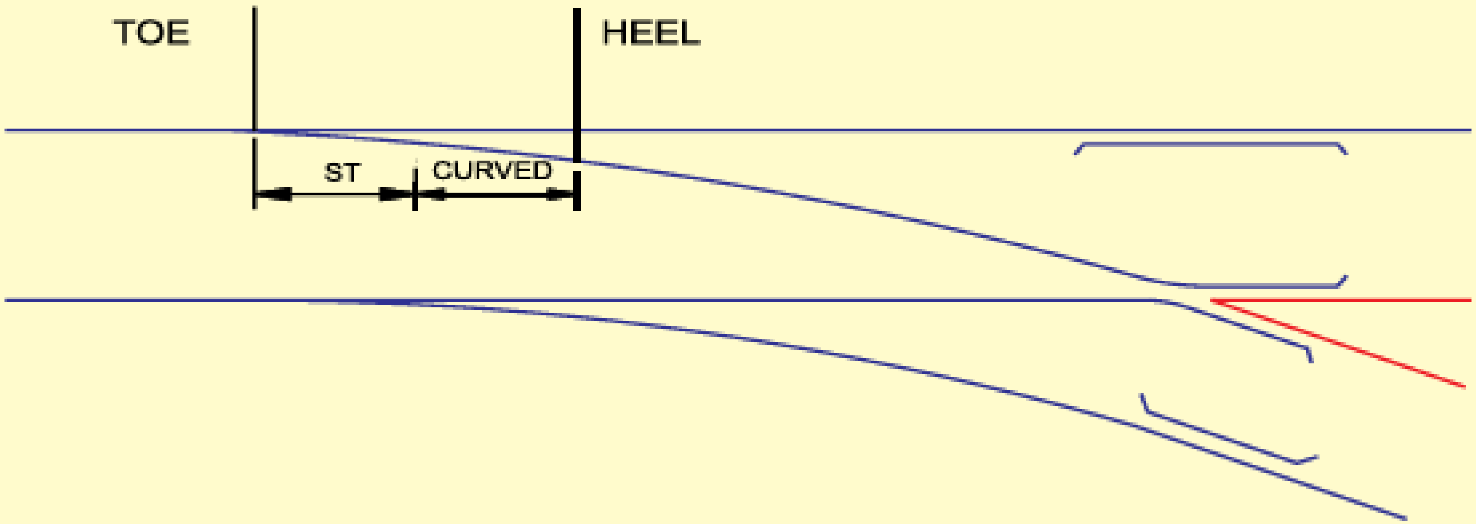
A-Kink in the turnout route at the toe of switch rail
B-Entry from straight to curve without transition
C- Lead curve without super-elevation
D-Entry from curve to straight without transition
E-Gap at the V of crossing



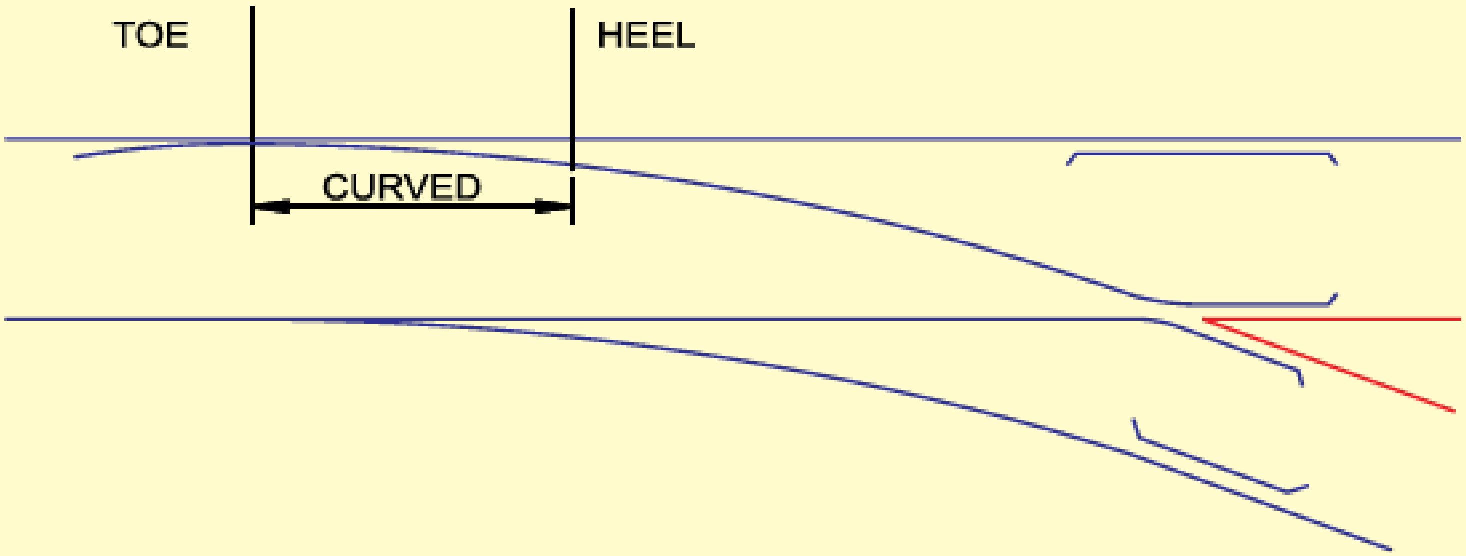
Straight switches



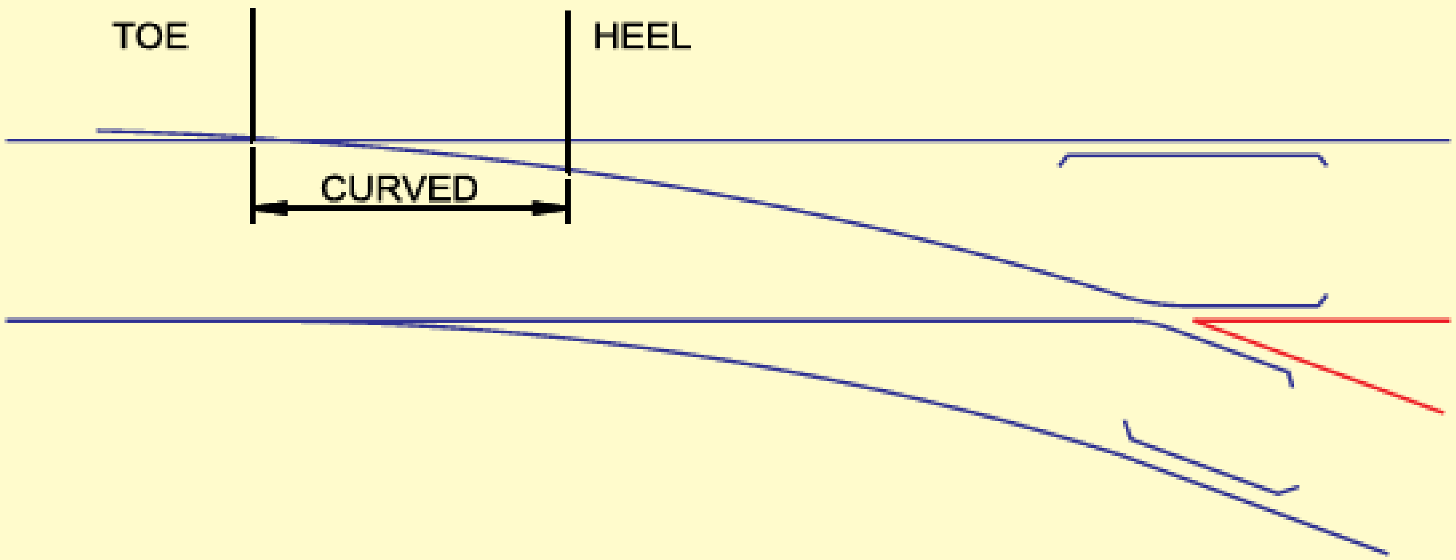
Partly curved switches



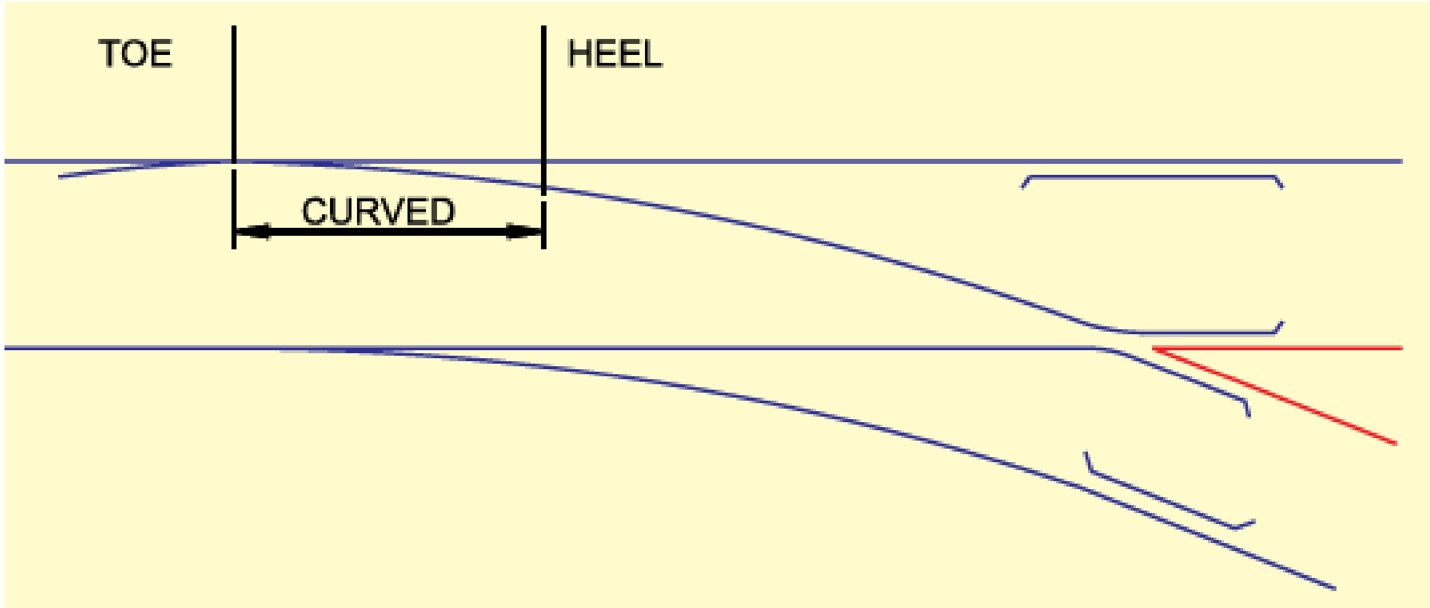
Non- intersecting type



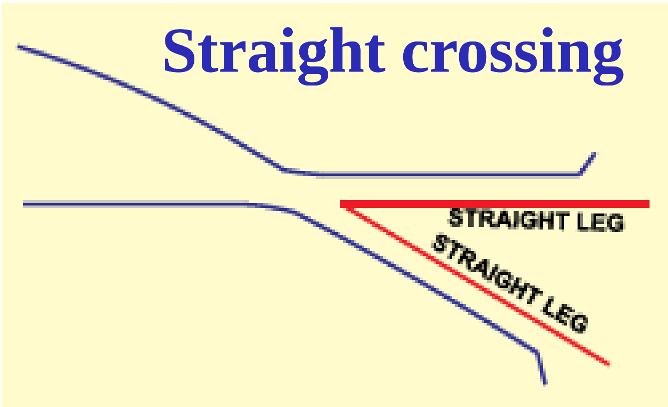
Intersecting type

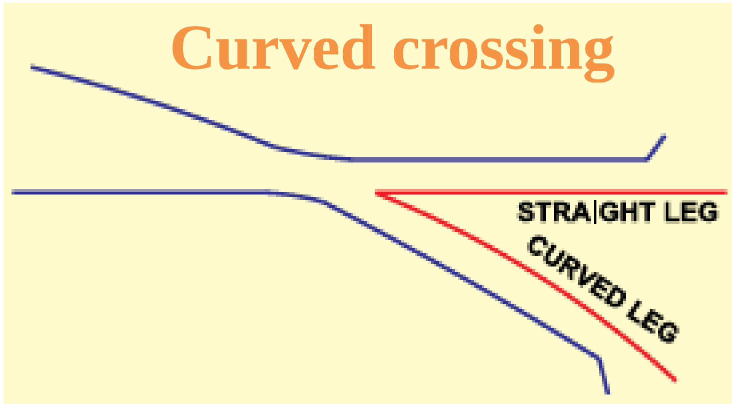


Tangential type



Type s of crossing (Frog)



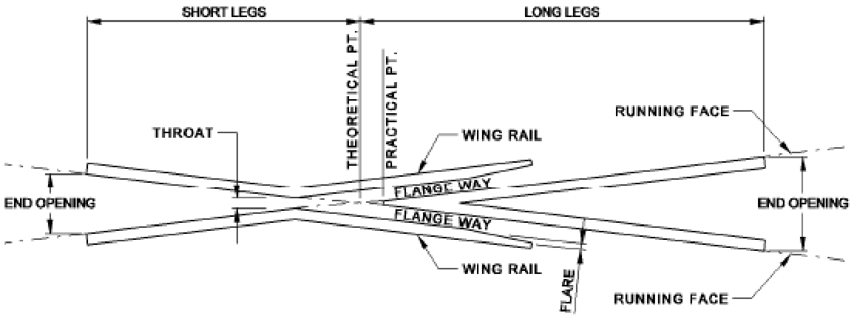


lead curve may take one of the following forms:

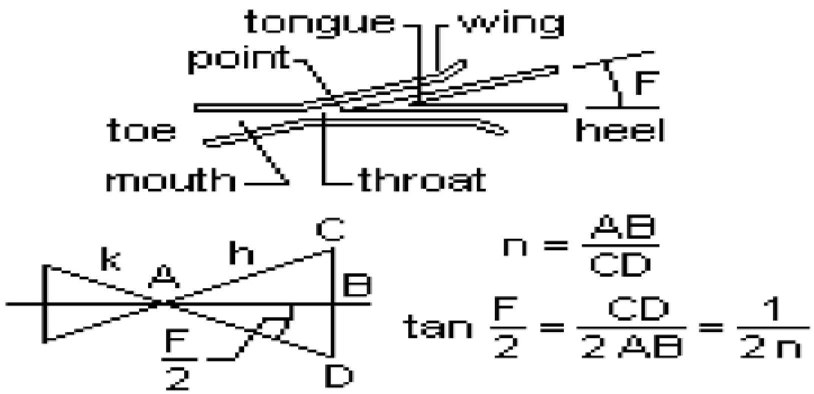
1- Simple Circular Curve

2- Partly Curved, having a straight length near the crossing

3- Transition Curve

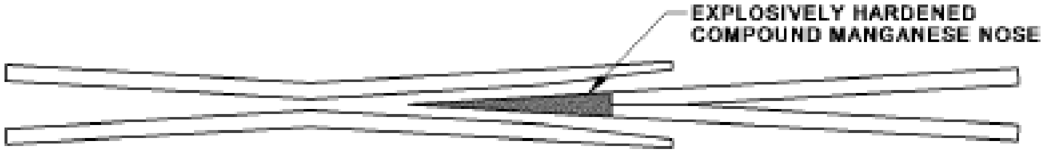


'V' CROSSING

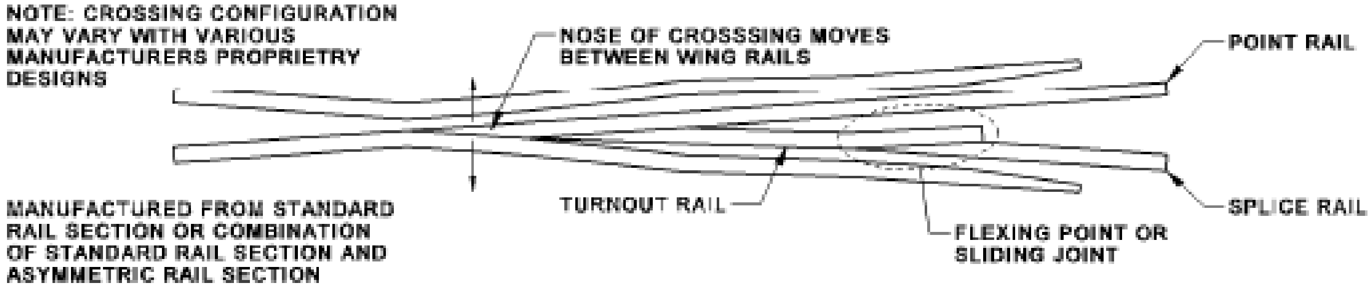


FABRICATED CROSSING

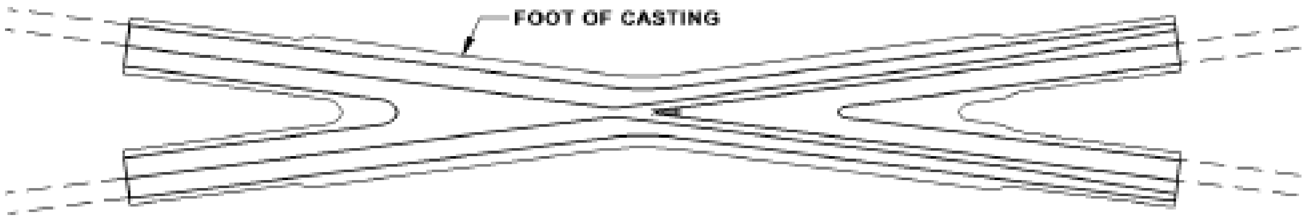
DRAWN FOR R.H. POINT RAIL



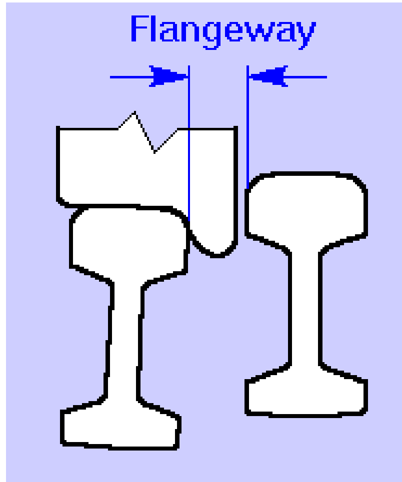
COMPOUND MANGANESE NOSE CROSSING



FABRICATED SWING NOSE CROSSING



SOLID CAST MANGANESE CROSSING

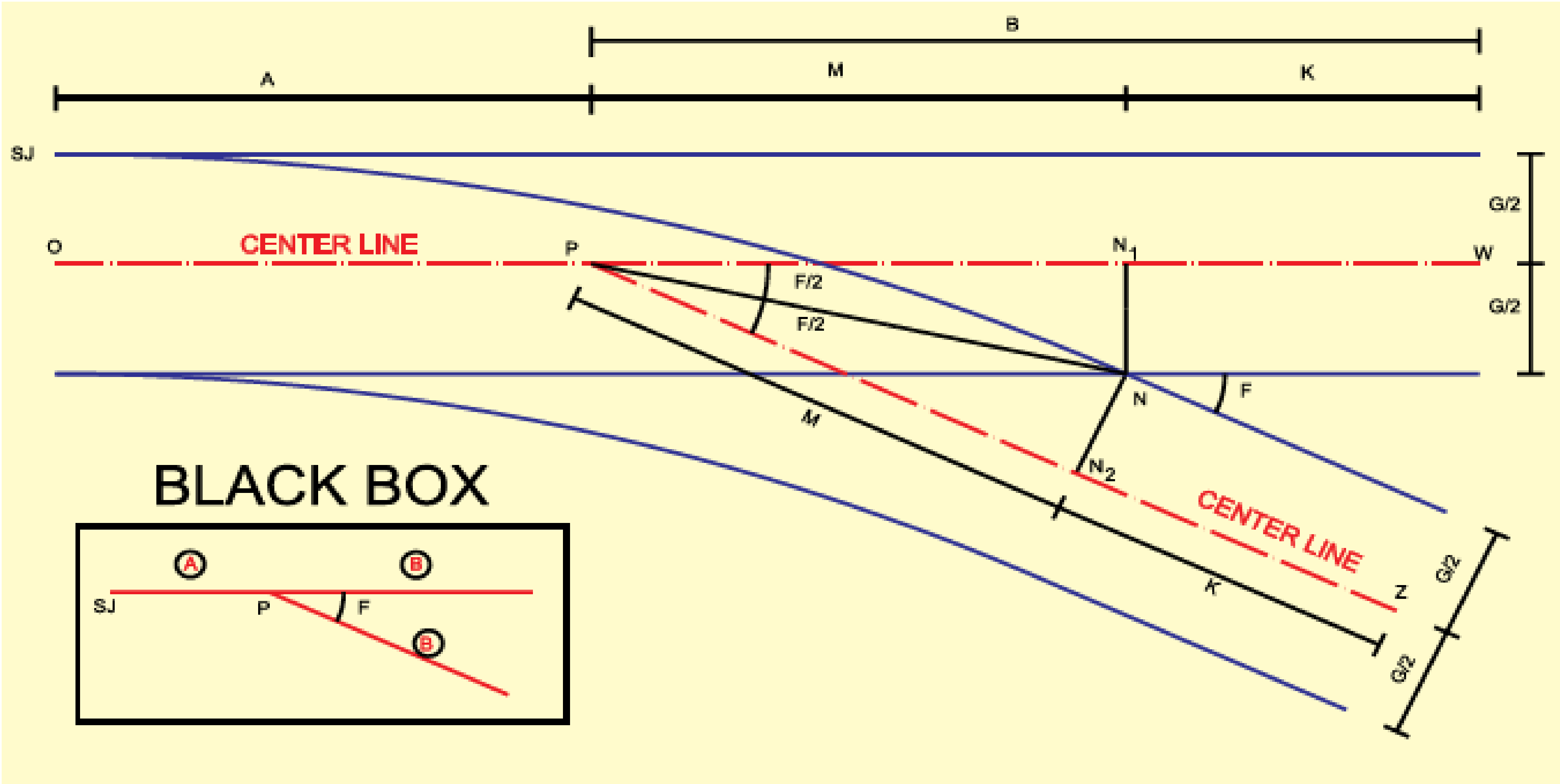


- Abbreviations to be used

SJ/SRJ	Stock joint/stock rail joint
TTS	Theoretical toe of switch
ATS	Actual toe of switch
β	Switch angle
SL	Actual switch length
TSL	Theoretical switch length
t	Designed thickness of the switch at toe
d	Heel divergence
ANC	Actual nose of crossing
TNC	Theoretical nose of crossing
HOC	Heel of crossing
w	Length of straight leg of crossing ahead of TNC upto the tangent point of lead curve
F	Crossing angle
G	Gauge of the track
D	Distance between the track
R_m	Radius of the outer rail of curved main line
R_c	Radius of the outer rail of the turn in curve/ connecting curve
R	Radius of the outer rail of the lead curve

OL	Over all length of the layout
S	Length of straight portion outside the turnout
A	Distance from 'SJ' to the point of intersection in a turnout measured along the straight
B	Distance from the point of intersection to the heel of crossing measured along the straight
K	Distance from TNC of the crossing to the heel of crossing measured along the straight

Representation of a turnout on centre line



On the centre line the turnout is represented by two lines OPN1 W and PN2 Z. In this OW represents the overall length of turnout from SJ to the heel of crossing along the gauge line on which the crossing lies. To locate the turnouts on centre line method, it will be necessary to knowthe different components of centre line representation.

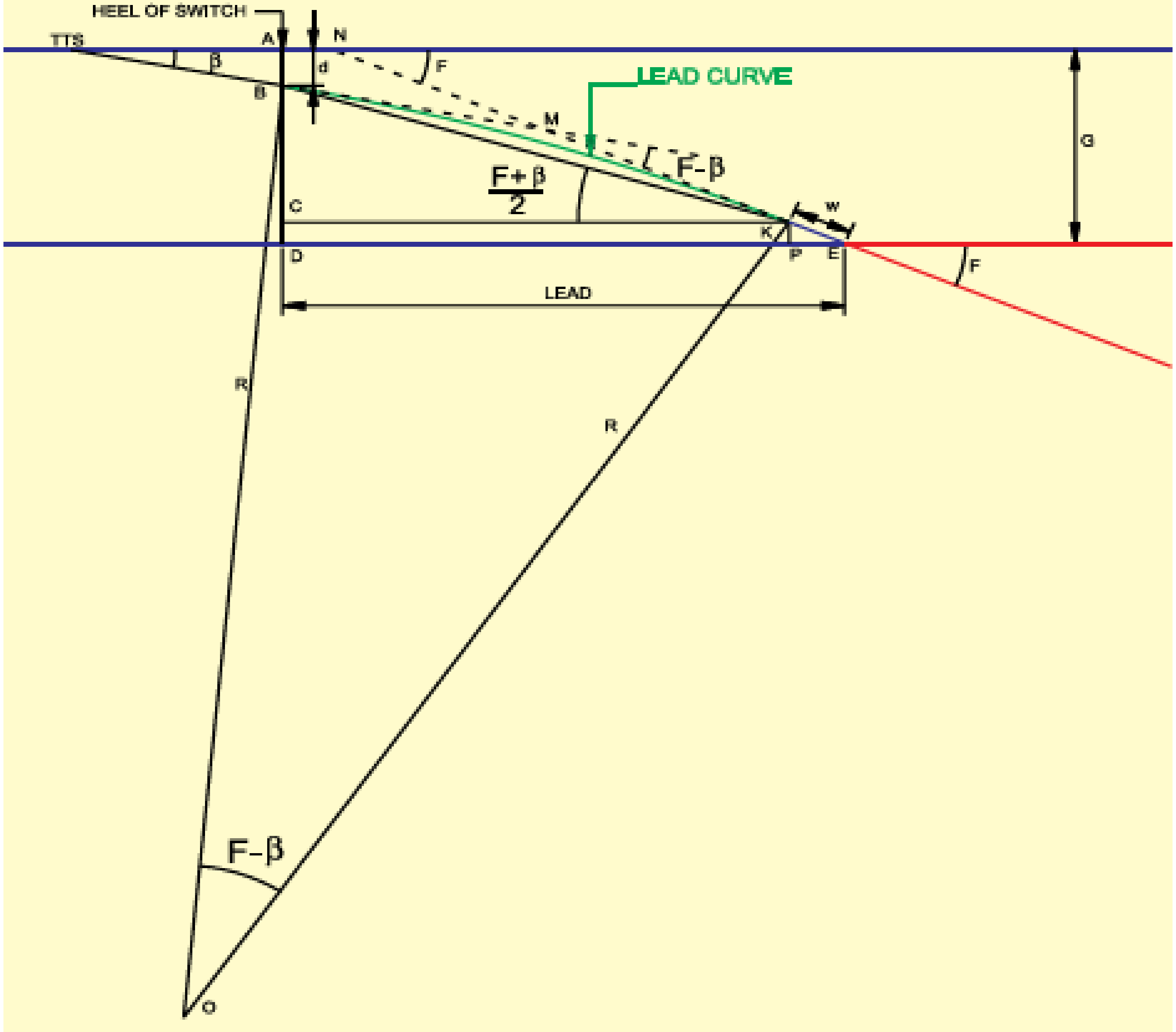
OP=A
PN1 =PN2 =M
N1 W=N2 Z=K
PW=PZ=B=M+K
Where A, M & K are known as turnout parameters

'M' is the distance from 'P' to the stock joint and can be found out as explained below:

$$\Delta PN_1N, \qquad \tan F/2 = \frac{NN_1}{PN_1} = \frac{G/2}{M}$$

$$\therefore \qquad M = G/2 \cot F/2$$

1- Turnout with straight switches



In Δ BMK; BM = MK (Each being tangent length)

$$\angle MBK = \angle MKB = \frac{F - \beta}{2}$$

$$\text{In } \Delta \text{ BKC}; \quad \angle BKC = F - \left(\frac{F - \beta}{2}\right) = \frac{F + \beta}{2}$$

$$BC = AD - AB - CD = AD - AB - KP = G - d - wSinF$$

$$KC = BCCot\frac{F + \beta}{2} = (G - d - wSinF)Cot\frac{F + \beta}{2}$$

$$Lead = DE = DP + PE = KC + PE$$

$$Lead = (G - d - wSinF)Cot\frac{F + \beta}{2} + wCosF \qquad (2.1)$$

$$\text{In } \Delta OBK; \quad \angle BOK = F - \beta, \ \ OB = OK = R$$

$$BK = 2RSin\frac{F - \beta}{2} \qquad (2.1a)$$

also in ΔBKC; $\quad BK = \dfrac{BC}{\operatorname{Sin}\dfrac{F+\beta}{2}} = \dfrac{G-d-w\operatorname{Sin}F}{\operatorname{Sin}\dfrac{F+\beta}{2}} \qquad (2.1b)$

equating Eq 2.1a & 2.1b; $\quad 2R\operatorname{Sin}\dfrac{F-\beta}{2} = \dfrac{G-d-w\operatorname{Sin}F}{\operatorname{Sin}\dfrac{F+\beta}{2}}$

$$\therefore \quad R = \frac{G-d-w\operatorname{Sin}F}{2\operatorname{Sin}\dfrac{F+\beta}{2}\operatorname{Sin}\dfrac{F-\beta}{2}} \qquad (2.2)$$

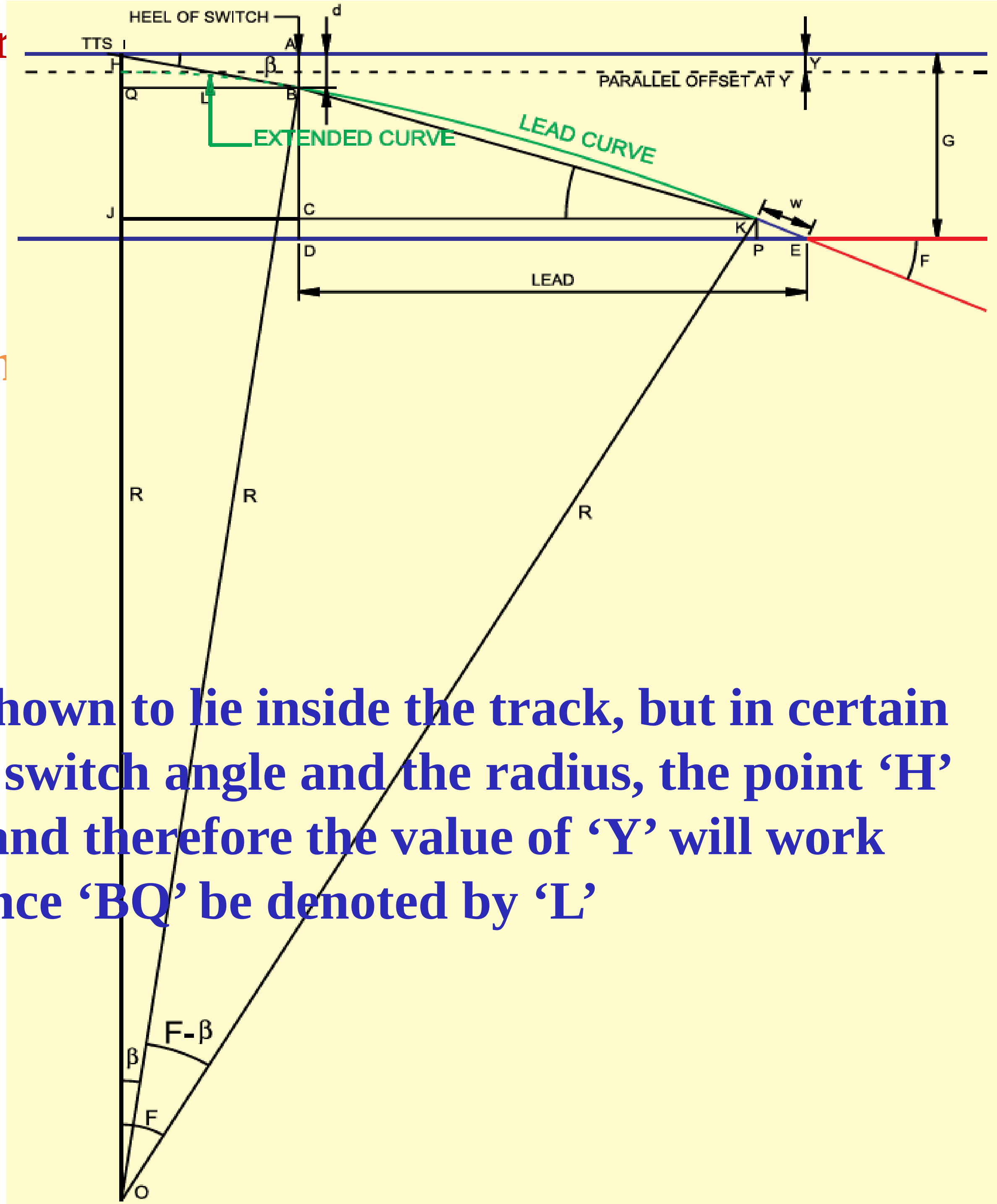
Where $\quad R$ = radius of lead curve, d = heel divergence

w = straight leg of crossing ahead of TNC, β = switch angle

Offsets to Lead Curves for Turnout with Straight Switches

- The lead curve is extended from heel at point 'B' to a point 'H' so that the tangent to the curve runs parallel to the gauge line at a distance 'Y'

- The point 'H' has been shown to lie inside the track, but in certain layouts, depending on the switch angle and the radius, the point 'H' may lie outside the track and therefore the value of 'Y' will work out as negative. The distance 'BQ' be denoted by 'L'



In Δ KOJ,

$$OK = R, \quad \angle KOJ = F, \quad \angle OJK = 90^0$$

$$JK = OKSinF = RSinF$$

$$CK = (G - d - wSinF)Cot\frac{F+\beta}{2}$$

$$CJ = BQ = L = JK - CK$$

$$\therefore\ CJ = RSinF - (G - d - wSinF)Cot\frac{F+\beta}{2} \qquad (2.3)$$

$$OI = OH + HI = R + Y \qquad (2.4)$$

$$\text{also,}\ OI = OJ + JI = RCosF + G - wSinF \qquad (2.5)$$

equating (2.4) & (2.5),

$$R + Y = RCosF + G - wSinF$$

$$\therefore\ Y = G - wSinF - R(1 - CosF) \qquad (2.6)$$

Note : It is also possible to work out values of 'L' & 'Y'

directly from Δ OBQ,

$$L = RSin\beta \qquad (2.7)$$

2'

$$Y = d - R(1 - Cos\beta) \qquad (2.8)$$

$$L = RSin\beta$$

Example Calculate the lead and the radius of a 1 in 8 turnout with straight switches.

Given: G= mm, d=136mm, w=864mm

$$F = 7^0 7' 30.06'' \qquad \beta = 1^0 34' 27''$$

$$\text{Lead} = (G - d - w\operatorname{Sin}F)\operatorname{Cot}\frac{F+\beta}{2} + w\operatorname{Cos}F$$

$$= \left(1435 - 136 - 864 \times \operatorname{Sin}7^0 7' 30.06''\right)\operatorname{Cot}\frac{7^0 7' 30.06'' + 1^0 34' 27''}{2}$$

$$+ 864 \times \operatorname{Cos}7^0 7' 30.06''$$

$$= 16526.8 \text{ mm} \approx 16527 \text{ mm}$$

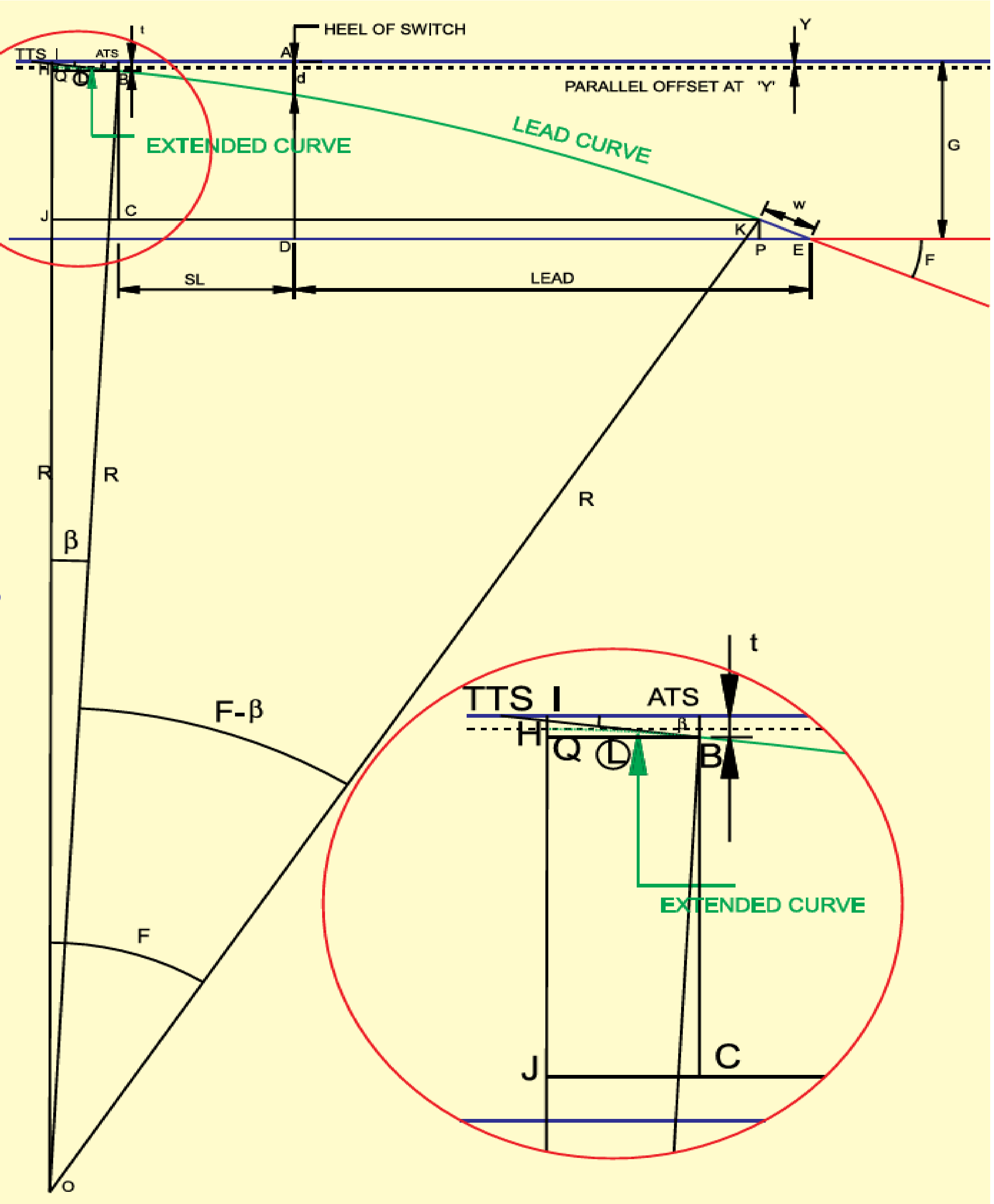
$$R = \frac{G - d - w\operatorname{Sin}F}{2\operatorname{Sin}\frac{F+\beta}{2}\operatorname{Sin}\frac{F-\beta}{2}}$$

$$= \frac{1435 - 136 - 864 \times \operatorname{Sin}7^0 7' 30.06''}{2 \times \operatorname{Sin}\frac{7^0 7' 30.06'' + 1^0 34' 27''}{2}\operatorname{Sin}\frac{7^0 7' 30.06'' - 1^0 34' 27''}{2}}$$

$$= 162270.707 \text{ mm} \approx 162271 \text{ mm}$$

2- Turnout with Curved Switches

The lead curves in these layouts at toe of switches are tangential to the switch angle and meets the straight leg of crossing at a distance ‘w’ from the TNC of the crossing.



At toe of switch, thickness of tongue rail is ‘t’. Derivation for lead curve radius will be same as for straight switches. The same can be derived by substituting ‘t’ (toe thickness) for ‘d’ (the heel divergence).

$$CK = (G - t - wSinF)Cot\frac{F+\beta}{2} \tag{2.9}$$

$$\text{Radius of Lead Curve, } R = \frac{G - t - wSinF}{2Sin\frac{F+\beta}{2}Sin\frac{F-\beta}{2}} \tag{2.10}$$

$$L = BQ = CJ = KJ - CK = RSinF - (G - t - wSinF)Cot\frac{F+\beta}{2} \tag{2.11}$$

$$or, \quad \text{from } \Delta\, OQB,$$

$$L = BQ = RSin\beta \tag{2.12}$$

$$Y = G - wSinF - R\left(1 - CosF\right) \tag{2.13}$$

$$\text{Switch Length,} \quad SL = \sqrt{2R(d - Y) - (d - Y)^2} - L \tag{2.14}$$

$$Lead = (G - t - wSinF)Cot\frac{F+\beta}{2} - SL + wCosF \tag{2.15}$$

- Example

Calculate the lead and the radius of a 1 in 12 turnout with curved switches.

Given: G=1435 mm, d=175mm, w=1877mm

$$F = 4^0 45' 49'' \quad , \quad \beta = 0^0 20' 0''$$

$$R = \frac{G - t - wSinF}{2Sin\frac{F+\beta}{2}Sin\frac{F-\beta}{2}}$$

$$= \frac{1435 - 0 - 1877 \times Sin4^0 45' 49''}{2Sin\frac{4^0 45' 49'' + 0^0 20' 0''}{2}Sin\frac{4^0 45' 49'' - 0^0 20' 0''}{2}}$$

$= 3721333$ mm

In 1 in 12 turnout with curved switches, Stock Rail is machined to house the tongue rail so that there is no projection of thickness of the tongue rail. Hence 't' is taken as zero.

$$Lead = (G - t - wSinF)Cot\frac{F+\beta}{2} + wCosF - Switch\ Length$$

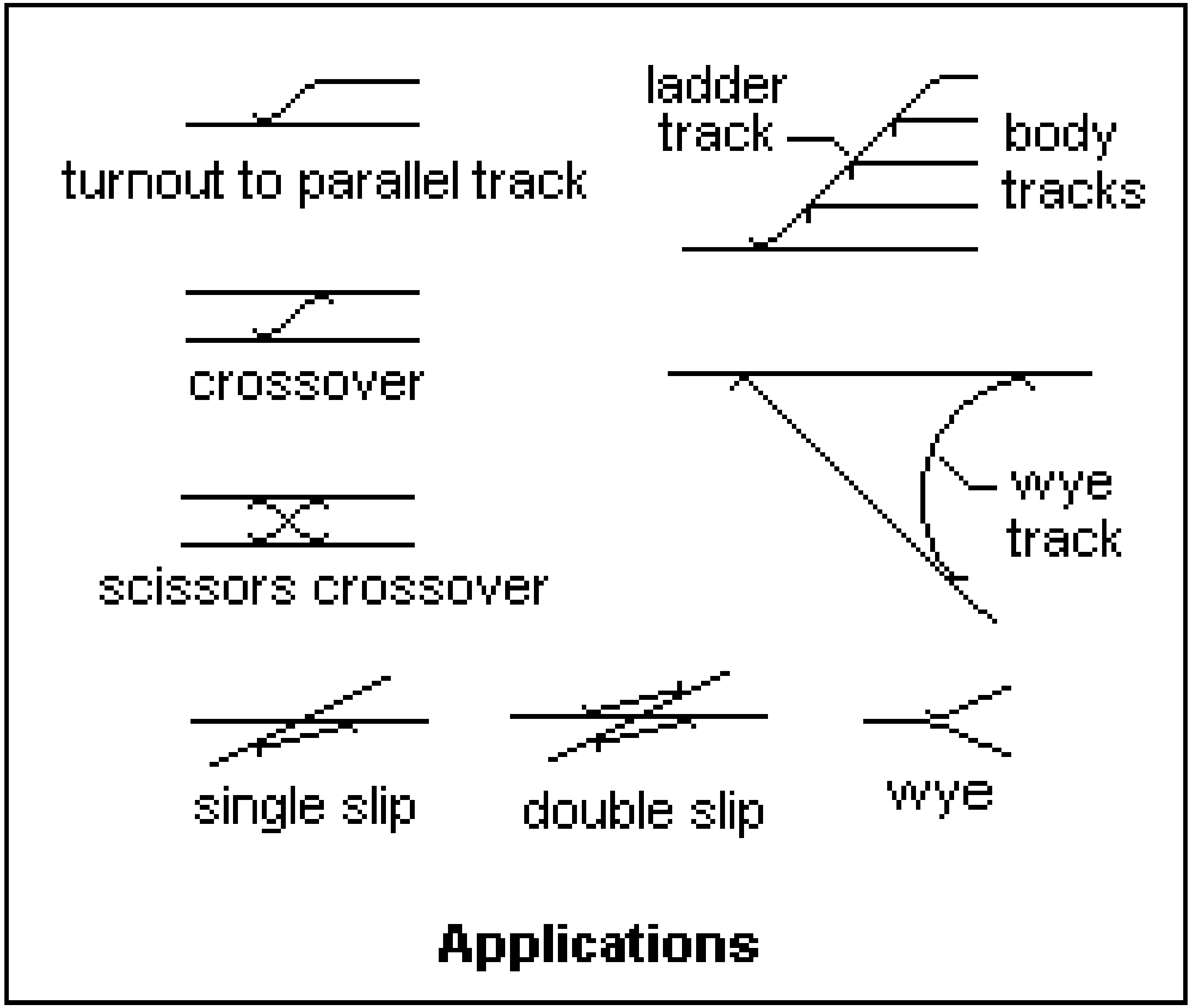
$$= (1435 - 0 - 1877 \times Sin4^0 45' 49'')Cot\frac{4^0 45' 49'' + 0^0 20' 0''}{2}$$

$$+ 1877 \times Cos4^0 45' 49'' - 10125$$

$= 20484$ *mm*

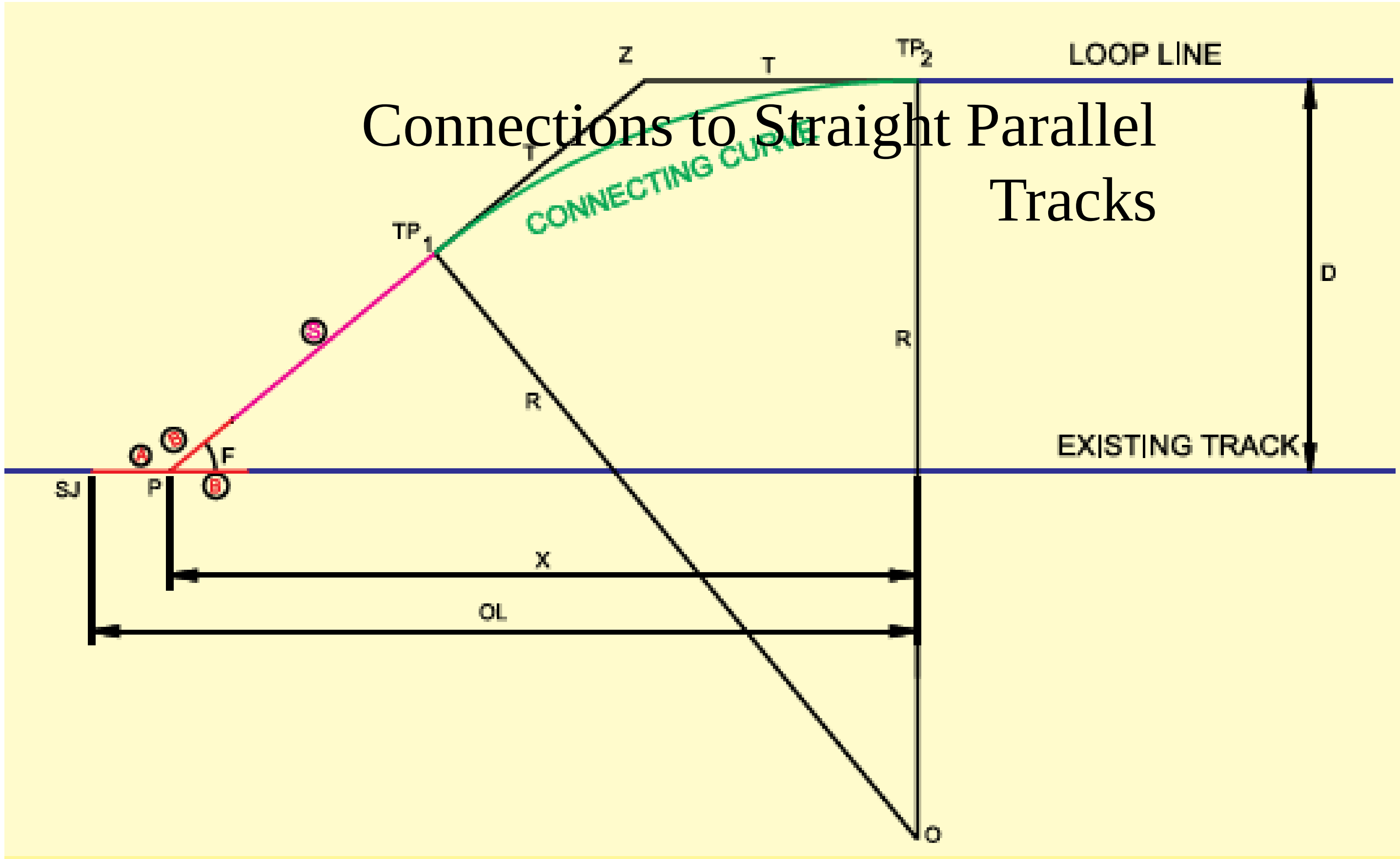
NOTE : Switch Length is 10125*mm*

Applications



Connections to Straight Parallel Tracks

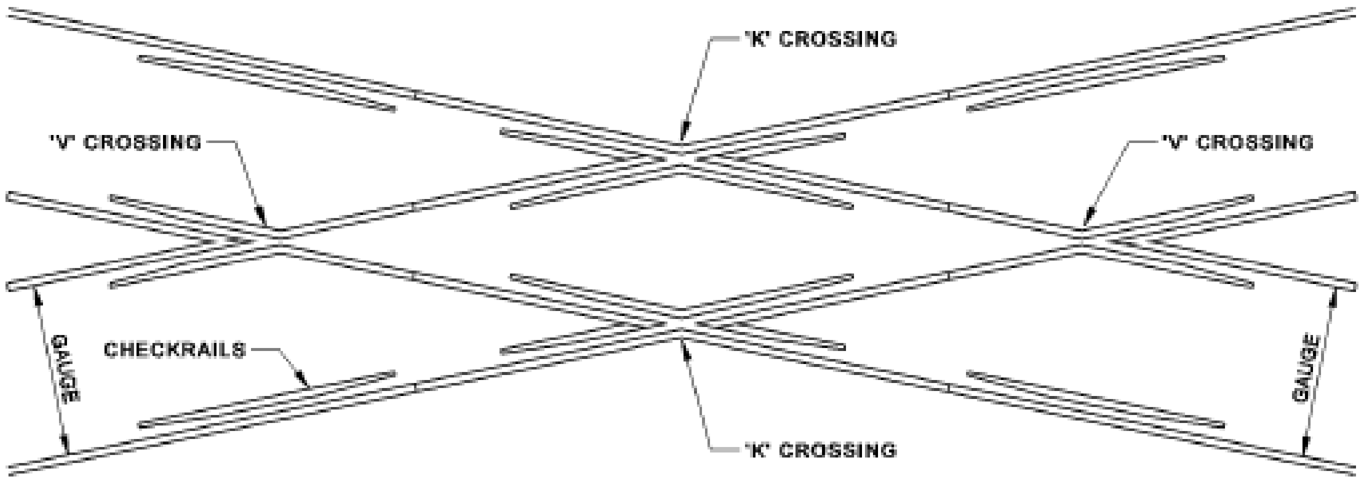
Type of Layout connections between the straight parallel tracks will be dependent upon the distance between the two tracks and the space availability in the yard. Accordingly distance between the two tracks may be treated as Normal or Large distance.



Connections to Straight Parallel Tracks

Diamond Crossing

Diamond crossings



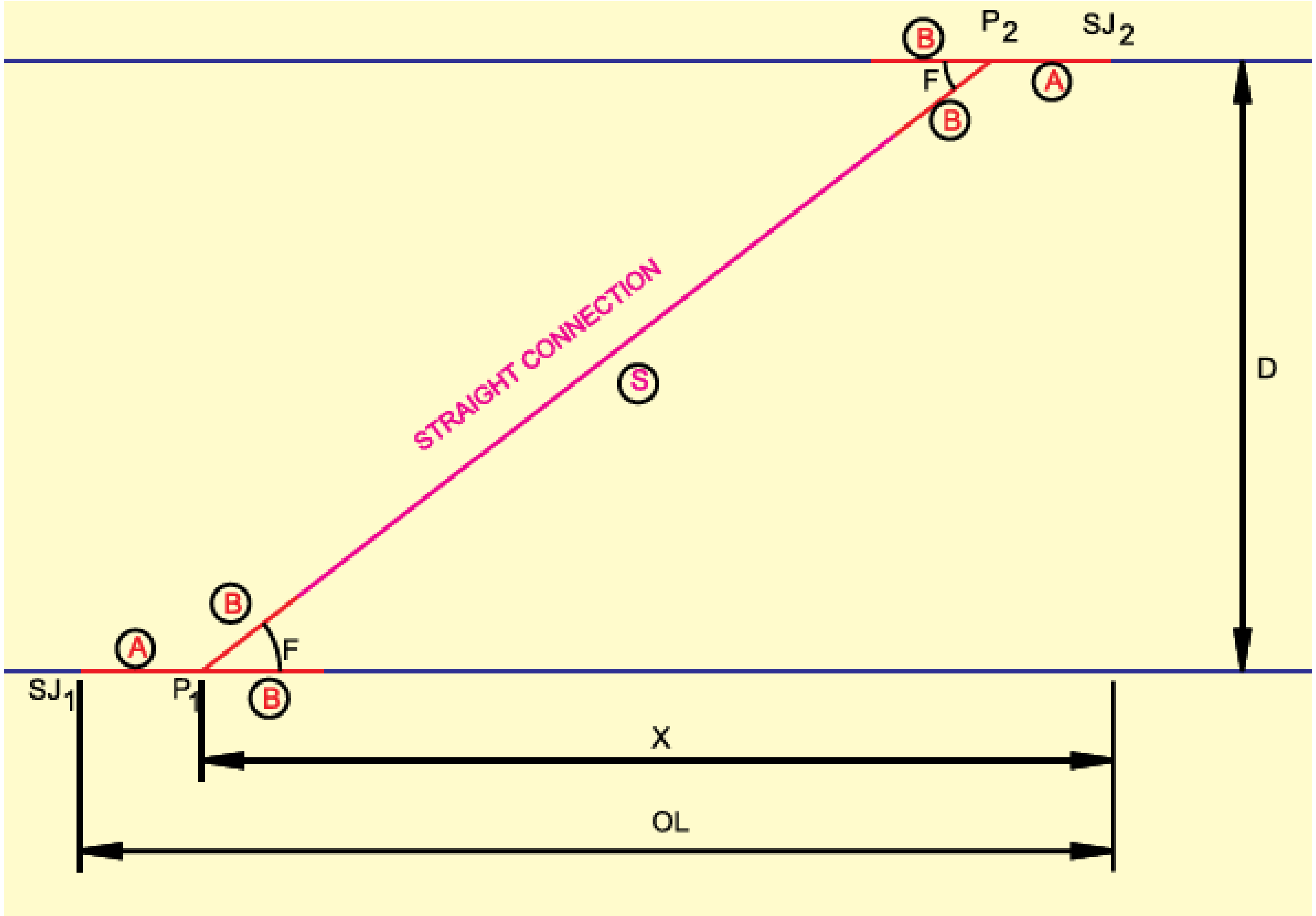
DIAMOND CONFIGURATION

Crossover

- A crossover is a pair of switches that connects two parallel rail tracks, allowing a train on one track to cross over to the other. Like the switches themselves, crossovers can be described as either facing or trailing.

- When two crossovers are present in opposite directions, one after the other, the four-switch configuration is called a double crossover.

<u>**Crossover Connection between Straight Parallel Tracks**</u>



$$(B + S + B)\mathrm{Sin}F = D$$

$$\therefore S = \frac{D}{\mathrm{Sin}F} - 2B \qquad (5.1)$$

$$X = D\mathrm{Cot}F = DN \qquad (5.2)$$

where N is the number of Xing. $(\mathrm{Cot}F = N)$

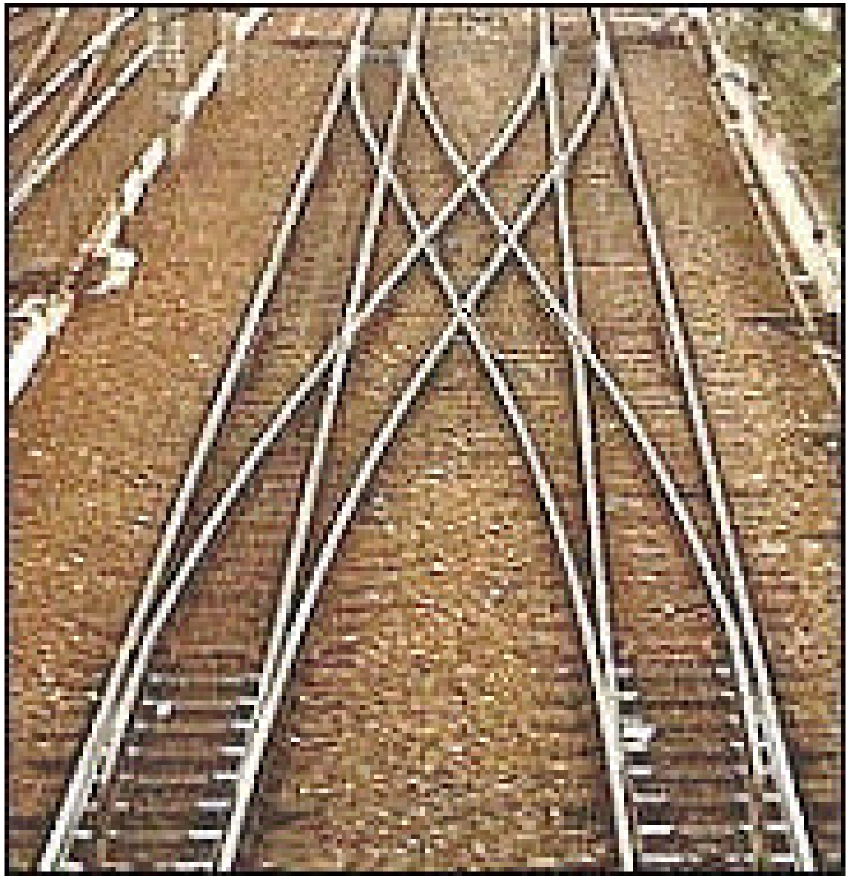
$$OL = X + 2A \qquad (5.3)$$

First of all the value of 'D' will be known from the field surveying. Turnout prarameters 'A', 'B' will be known once we have decided the type of turnout. Then from Eq 5.2 & 5.3, the values of 'X' & finally 'OL' will be calculated. Now with these values in the hand, location of one of 'SJ' can be fixed by keeping it at a distance 'OL' apart in reference to another 'SJ'.

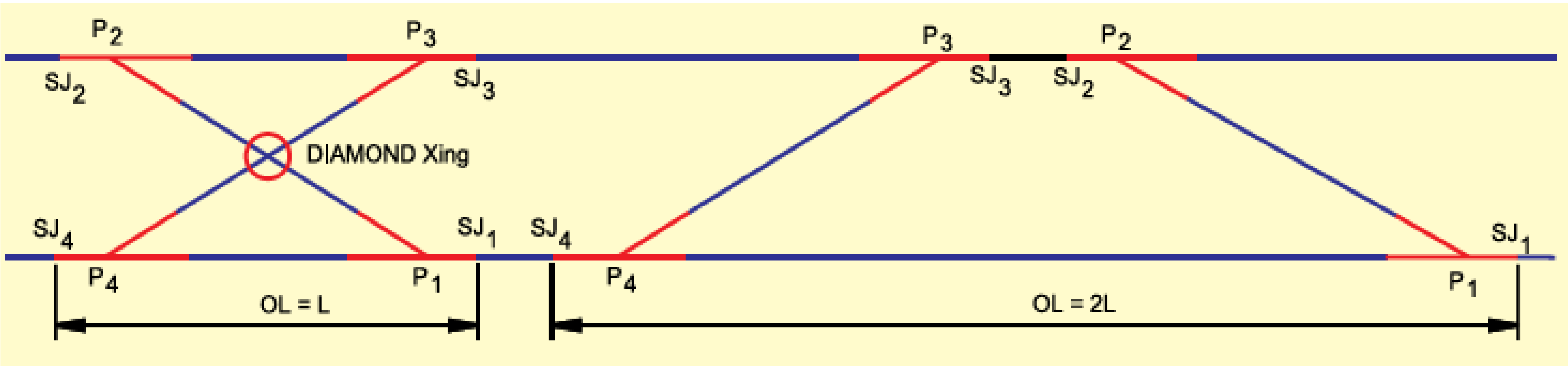
After fixing the location of 'SJ', rest of the turnout can be set out by field surveying.

Scissors

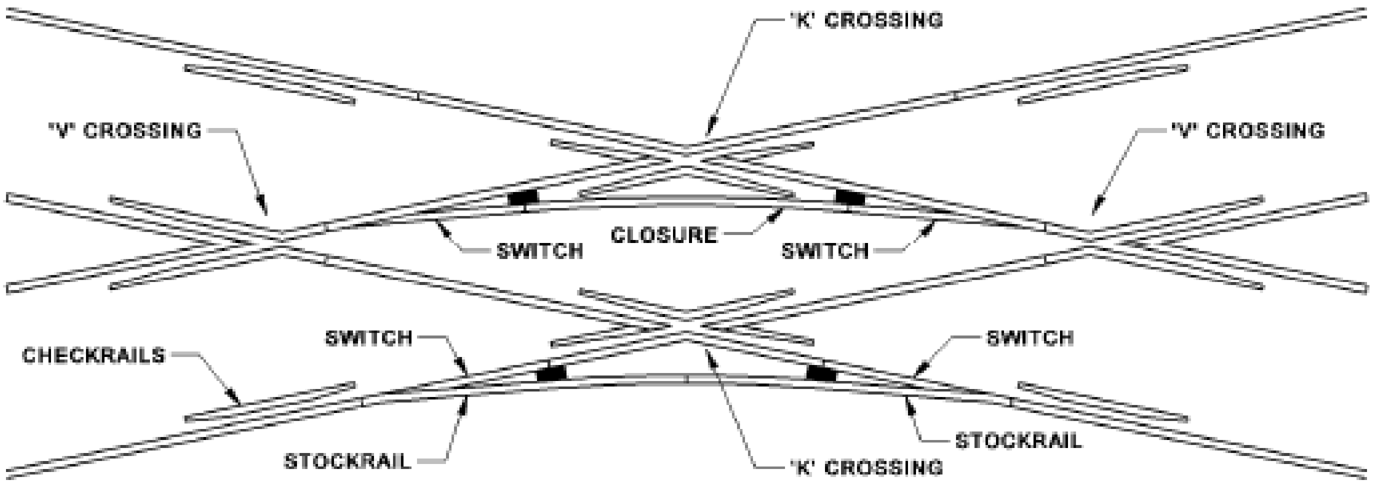
If the crossovers overlap in the shape of the letter X, it is dubbed a ‘scissors crossover or diamond crossover’ in reference to the diamond crossing in the centre. This makes for a very compact track layout at the expense of using a level junction.



The same function can be achieved by two crossovers Facing each other.

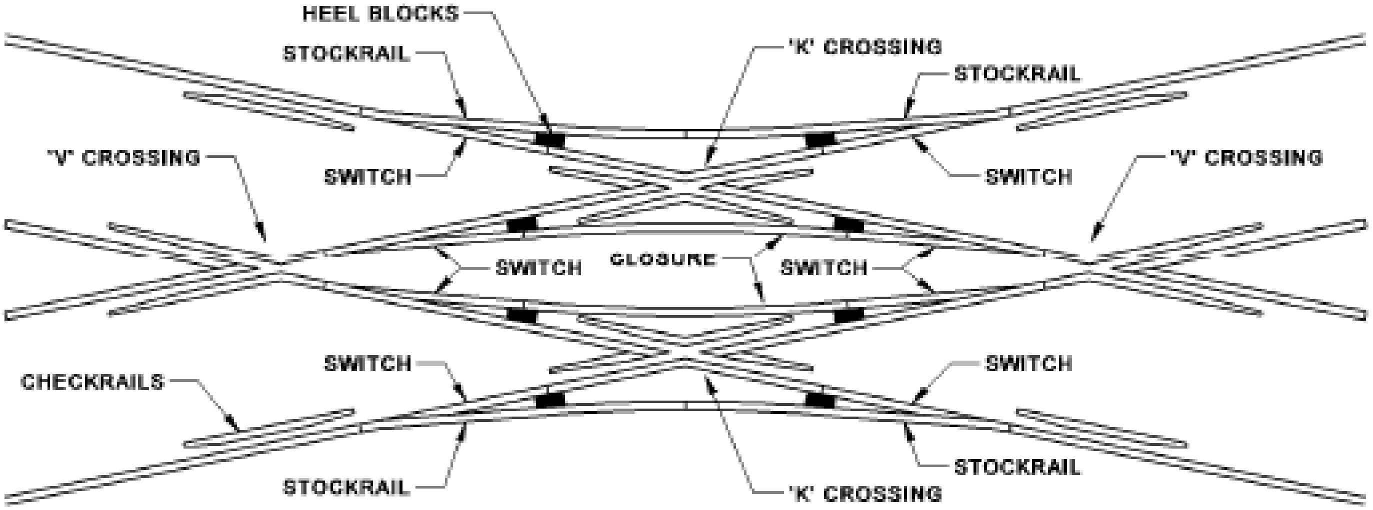


Single Slip



SINGLE SLIP CONFIGURATION

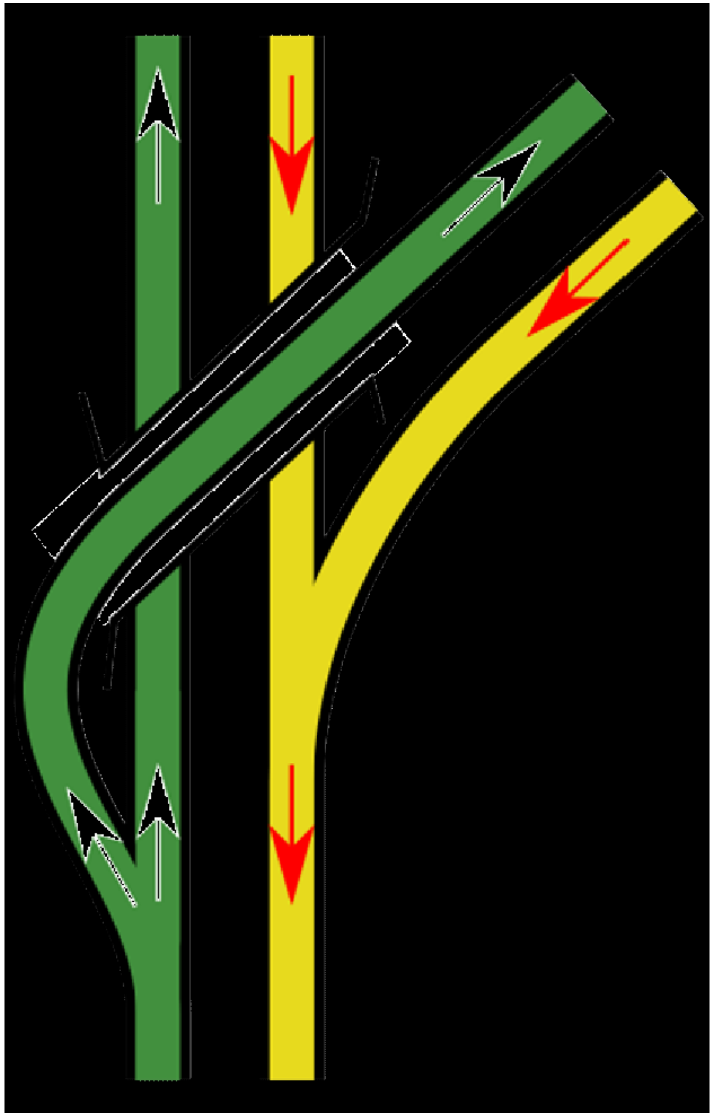
Double Slip

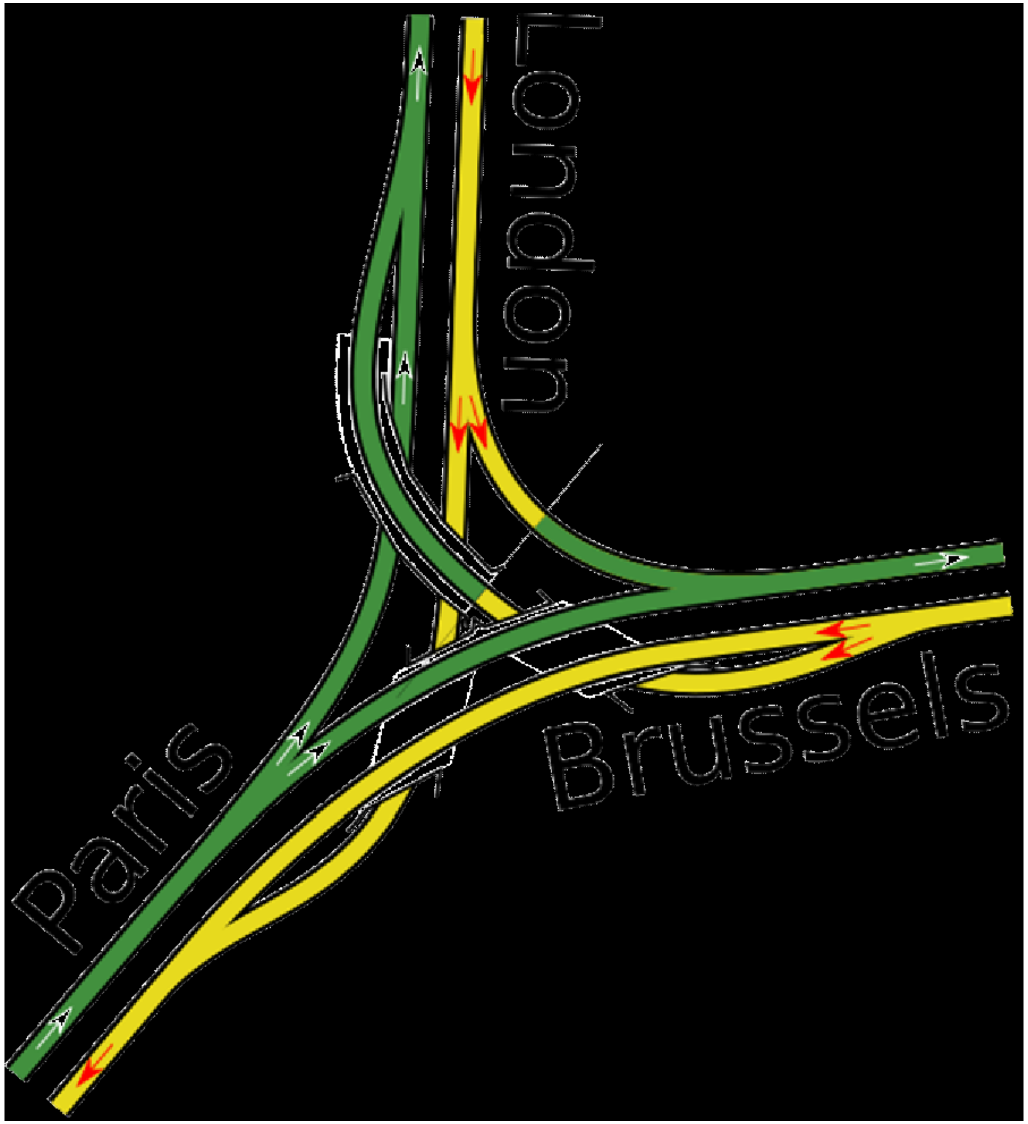


DOUBLE SLIP CONFIGURATION

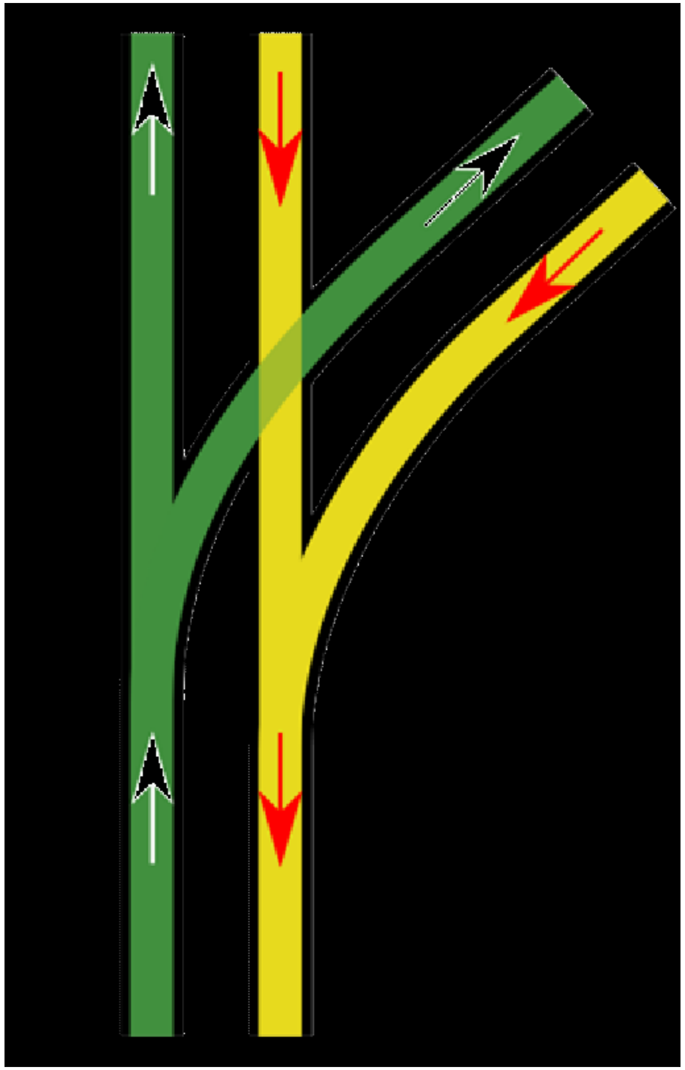
Typical Yard Depot Ladder Tracks

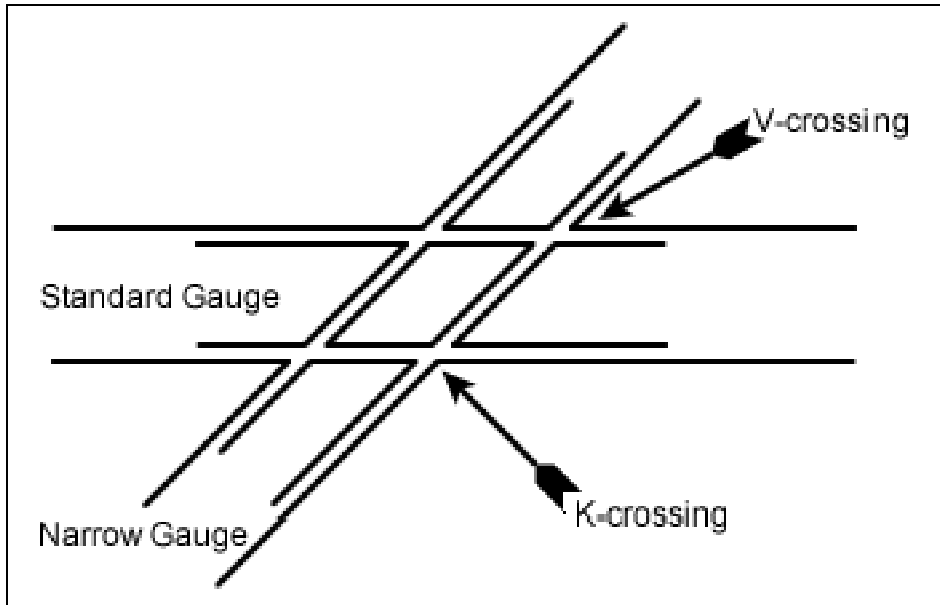
Flying Junctions
Bridges



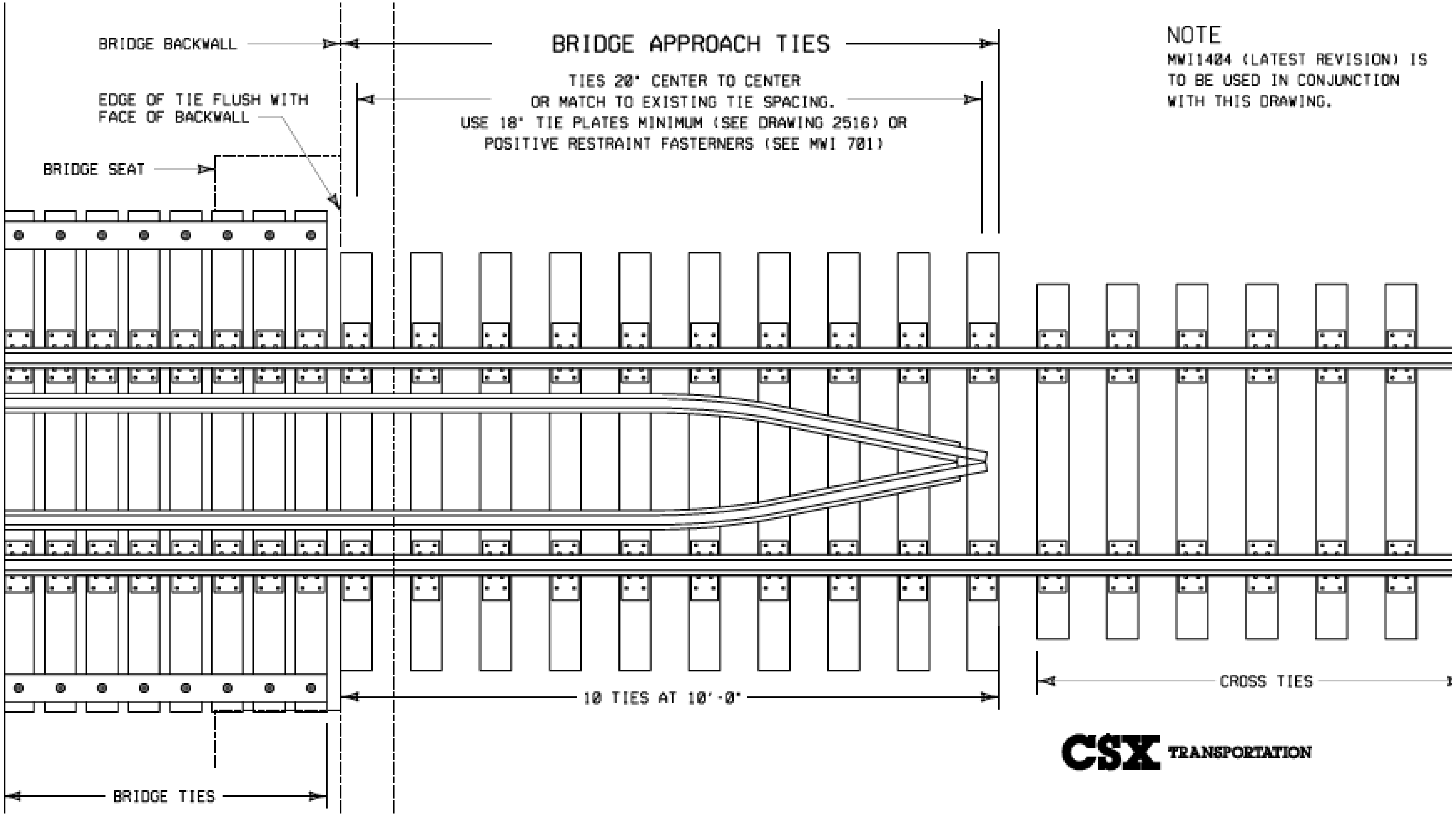


Level Junctions
Diamond Crossings





Bridge Guard Rail



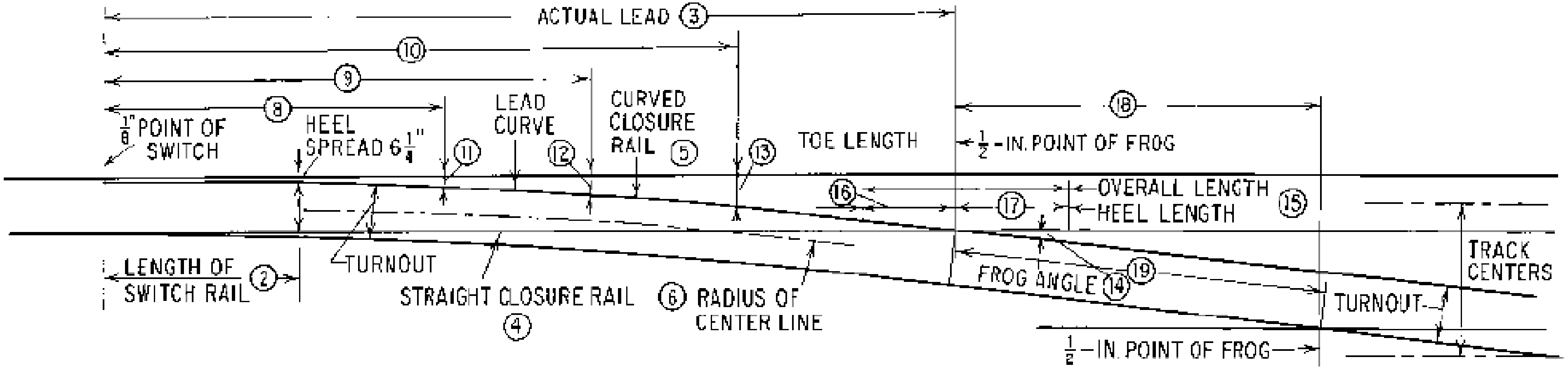


Table 19.4 Turnout and Crossover Data for Straight Split Switches*

1	2		3		4		5		6	7			8		9		10		11	12	13		14			15		16		17		18		19						
					Closure distance				Lead curve				Gage line offsets										Properties of frogs										Crossover data							
																																					For change of 12 in in track centers			
Frog No.	Length of switch rail		Actual; lead		Straight closure rail		Curved closure rail		Radius of center line, ft	Degree of curve													Frog angle			Overall length		Toe length		Heel length		Straight track, 13-ft track centers		Cross-over track, 13-ft track centers		Straight track		Cross-over track		Com-fort-able speed, mi/h
	Ft	In	Ft	In	Ft	In	Ft	In		Deg	Min	Sec	Ft	In	Ft	In	Ft	In	In	In	Ft	In	Deg	Min	Sec	Ft	In	Ft	In	Ft	In	Ft	In	Ft	In	Ft	In	Ft	In	
5	11	0	42	6½	28	0	28	4	177.80	32	39	56	18	0	25	0	32	0	11 13/16	20⅝	2	8⅞	11	25	16	9	0	3	6½	5	5½	16	10 9/16	18	1⅞	4	11 7/16	5	0⅝	12
6	11	0	47	6	32	9	33	0	258.57	22	17	58	19	2¼	27	4½	35	6¾	12⅜	21⅜	2	10	9	31	38	10	0	3	9	6	3	20	5½	21	6½	5	11½	6	0½	13
7	16	6	62	1	40	10½	41	1¼	365.59	15	43	16	26	2¼	35	10½	45	6¾	11⅜	19 9/16	2	6⅞	8	10	16	12	0	4	8½	7	3½	24	0⅜	24	11⅜	6	11 9/16	7	0 7/16	17
8	16	6	68	0	46	5	46	7½	487.28	11	46	44	27	7¼	38	8½	49	9¾	11⅞	20 9/16	2	8 5/16	7	9	10	13	0	5	1	7	11	27	7⅛	28	4⅞	7	11⅝	8	0⅝	19
9	16	6	72	3½	49	5	49	7¼	615.12	9	19	30	28	10¼	41	2½	53	6¾	12 5/16	21⅜	2	9 7/16	6	21	35	16	0	6	4½	9	7½	31	1⅝	31	10⅜	8	11 11/16	9	0 9/16	21
10	16	6	78	9	55	10	56	0	779.39	7	21	24	29	11¾	43	5½	56	11¼	12¼	21	2	8⅝	5	43	29	16	6	6	5	10	1	34	8⅛	35	3⅞	9	11 11/16	10	0 9/16	24
11	22	0	91	10¼	62	10¼	63	0	927.27	6	10	56	37	8½	53	5	69	1½	12¼	21⅜	2	9¾	5	12	18	18	8½	7	0	11	8½	38	2½	38	9½	10	11¾	11	0¼	26
12	22	0	96	8	66	10½	67	0	1,104.63	5	11	20	38	8½	55	5	72	1½	12 7/16	21⅝	2	9⅞	4	46	19	20	4	7	9½	12	6½	41	8¾	42	3¼	11	11¾	12	0¼	28
14	22	0	107	0¾	76	5¼	76	6¾	1,581.20	3	37	28	41	1¼	60	2½	79	3¾	12⅞	22 5/16	2	10½	4	5	27	23	7	8	7½	14	11½	48	9¼	49	2 3/16	13	11 13/16	14	0¼	34
15	30	0	126	4½	86	11½	87	0¾	1,720.77	3	19	48	51	9	73	6	95	3	12⅛	21¼	2	9¾	3	49	6	24	4½	9	5	14	11½	52	3 7/16	52	8⅝	14	11 13/16	15	0 3/16	35
16	30	0	131	4	91	11	92	0	2,007.12	2	51	18	53	0	76	0	99	0	12 7/16	21 13/16	2	10 5/16	3	34	47	26	0	9	5	16	7	55	9⅝	56	2½	15	11 13/16	16	0 3/16	38
18	30	0	140	11½	99	11	100	0	2,578.79	2	13	20	55	0	80	0	105	0	12¾	22⅛	2	10 7/16	3	10	56	29	3	11	0½	18	2½	62	9⅞	63	2 3/16	17	11 13/16	18	0 3/16	40
20	30	0	151	11½	110	11	111	0	3,289.29	1	44	32	57	9	85	6	113	3	13 1/16	22 11/16	2	11 3/16	2	51	51	30	10½	11	0½	19	10	69	10	70	2	19	11⅞	20	0⅛	40

* Adapted from AREA Trackwork Plans. Comfortable speed added. Column numbers refer to dimensions in Fig. 19.15.
Calculated for turnouts from straight track for 4-ft 8½-in gage.

Turnouts and crossovers recommended: for main-line high-speed movements, No. 16 or No. 20; for mainline slow-speed movements, No. 12 or No. 10; for yards and sidings to meet general conditions, No. 8.