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Informal Working Note #42

YARD GEOMETRIC DESIGN

The purpose of this informal working note is to describe basic requirements on yard geometric design. This yard geometric design document has been derived from conversations with yard design experts in the U.S. In the future this note will be rearranged and combined with the previous working note on yard hardware.

General Considerations:

- A parallel receiving yard is good for cold weather, because cars can loosen up by the push and pull movements before humping.
- The switch to switch distance is determined simply from the center/center distance between adjacent tracks. The relationship between the distance between switches, K, and the distance between adjacent tracks, P, and the switch angle, a, is given as:

$$K = P/\sin a \quad \text{(see Figure 1)}$$

The distance between tracks, P, varies from yard to yard. At the receiving and departure yards, the appropriate P value will be 20 to 25 ft. This spacing is required for inspectors to travel along the yard tracks using a small vehicle, which also carries necessary spare parts for repairs. It is recommended that the space between the tracks be paved. The arrangement can be made in such a way that every other walkway has a wide spacing as shown in Figure 2. In this case every other walkway can be as narrow as 15 ft. between track centers.

At the class yard the recommended distance between track centers is 14 ft. A wider spacing (20 ~ 21 ft.) is considered between track groups. This wider spacing usually is a result of accommodating curvatures for the fan layout. This spacing, however, has its own use such as a space for light post installation or piling snow in winter.

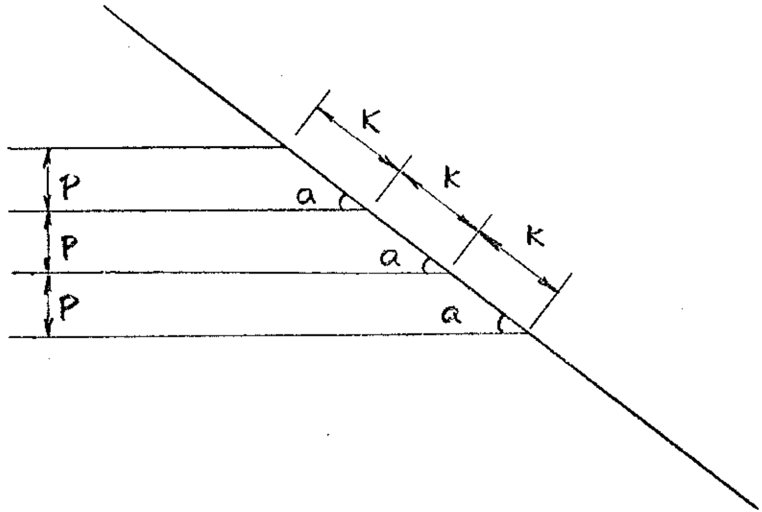


FIGURE 1. Schematic Ladder Layout

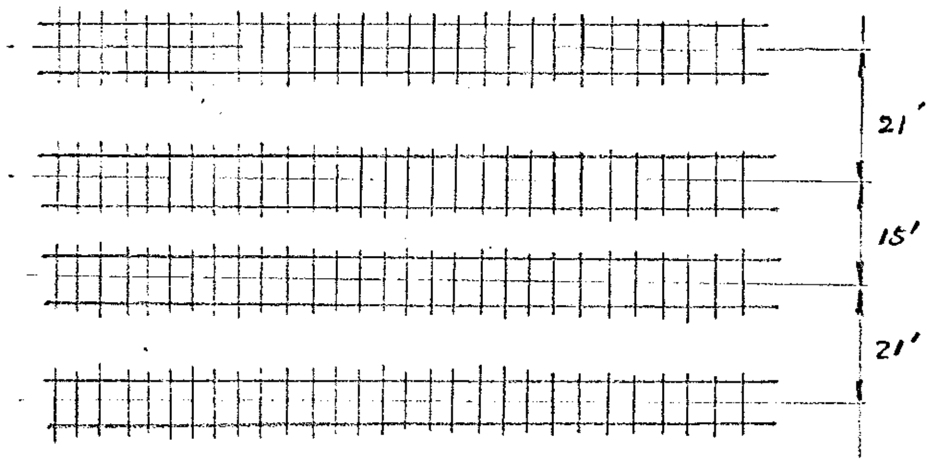


FIGURE 2 Example Walkway Arrangement

Hump Geometric Design

The hump geometry should be designed in such a manner that the distance from the hump crest to the tangent points of the classification tracks becomes as short as possible. The detailed design of hump profile is done by using a computer hump profile evaluator, such as PROFILE, as a design evaluating tool.

General rules:

- Ascending grade to the hump--Usually the ascending grade is somewhere between 0% (flat) to 3%.
- Descending grade from the hump--The maximum grade is considered to be approximately 6%. The grade should usually be less than the limit.
- The length of the vertical curve section at the hump crest--This should be at least 100 ft. This 100 ft. length for the curve is an empirically established value, which insures that the two tracks of a car (front and rear tracks) do not stand on the ascending grade track and the descending grade track at the same time.
- The minimum distance between an end of a curve to a beginning of another curve--This should be 50 ft.

Grade

- Receiving Yard--It is preferable to have a zero grade in the receiving yard. To avoid runaway cars from the yard, the receiving yard can have a slight grade leading toward the center of the yard at both ends. (See Figure 3) The grade for the ends of tracks should be approximately 1/10%.
- Hump Pullout Lead--In the pullback style yard, a positive grade of 1%∽1.5% is prefered in the pull direction. The vertical profile of the yard at and around the hump may look like Figure 4.

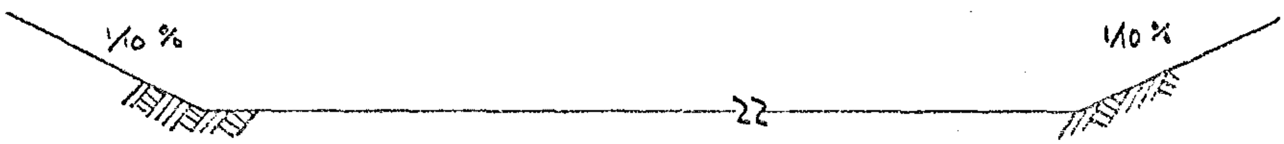


FIGURE 3 VERTICAL PROFILE OF RECEIVING YARD

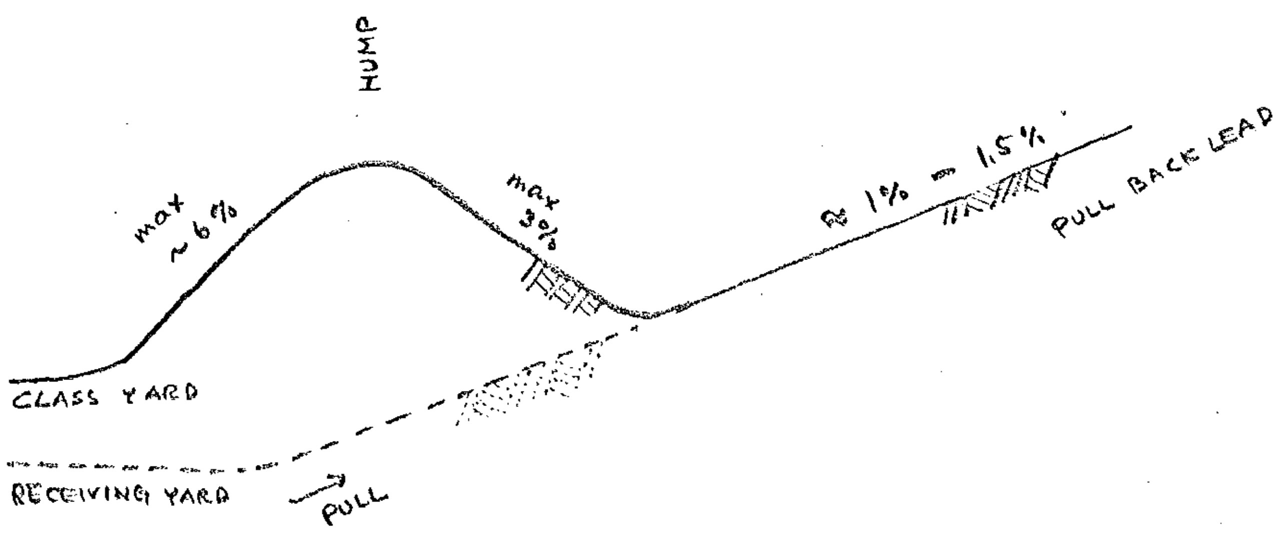


FIGURE 4 VERTICAL PROFILE OF YARD AT AND AROUND THE HUMP

- Classification Yard--It is preferable to have a zero grade in the classification yard, except in the departure end of the classification yard. There it is preferred that the last 300 ft. of the classification tracks have a positive grade toward the track ends of approximately .3%. A retarder is installed just prior to this positive grade to insure stoppage of cars in the classification tracks.
- Pullout Lead--The preferred grade is between 0 to 1/10%. If a grade is applied, it should be positive toward the spur end of the drill track.
- Departure Yard--Same as the receiving yard. The yard is preferred to be flat except at the ends. The positive grade of approximately .3% should be applied toward both track ends.

Location of the Yard Relative to the Mainline

The preferred location of the yard relative to the mainline is shown in Figure 5. The yard should be located close to the mainline as shown in the figure. The yard should be perpendicular to the mainline connected by grade separated tracks. This geometric configuration allows the most conflict free operations between yard traffic and incoming and outgoing traffic (see figure 5).

If the yard is located adjacent and parallel to the mainline, then conflicting movements of traffic can be avoided by installing tunnels or bridges. It is not recommended that the mainline or any other track cross through either the receiving or departure yards. It is often suitable to construct a tunnel under the hump. The grade separation of incoming traffic from the yard traffic otherwise can be done by the use of a bridge. A tunnel or the bridge can also be utilized for auto traffic which crosses the yard.

Swtiches and Turnouts

In general, the type of switch which is most frequently used in the railroad yard is the standard split switch. The turnout numbers used are mostly either 8 or 10. It is considered that the No. 8 turnout with a

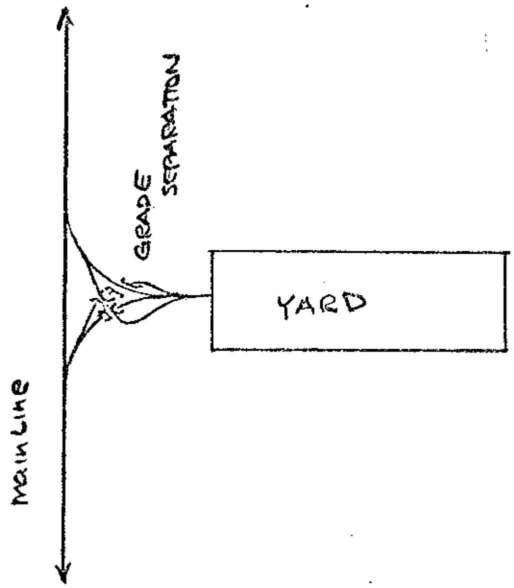


FIGURE 5. PREFERED YARD LOCATION

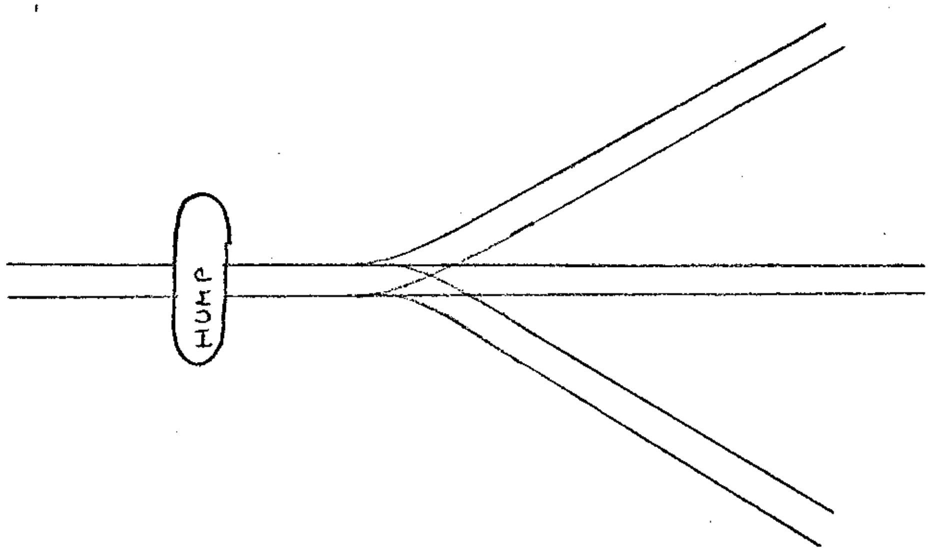


FIGURE 6 THREE-WAY LAP SWITCH

straight switch is suitable for a speed of 10 mph and the No. 10 for 15 mph. The allowable maximum speeds for these turnout numbers are slightly higher than these values. (See Informal Working Note No. 38.) The curved switch is used in the railroad yard only at the fanout part of the classification tracks. The most commonly used turnout numbers for each sub-yard are:

receiving yard	-	No. 10 turnout
classification yard		
hump end	-	No. 8 turnout
trim end	-	No. 10 turnout
departure yard	-	No. 10 turnout

The three-way lap switch is widely used between the hump and the classification yard. (See Figure 6) The turnout numbers used for this would be either 8 or 10.

The recommended minimum distance between the switch point and the retarder is 20 ft.

Curves

There are various types of curves commonly used to connect two straight segments of a track which are not horizontally tangent to each other. Among these curves are: simple circular curves, compound curves, reverse curves, curves with spiral transition segments, etc. For vertical transitions, parabolic curves are most commonly used.

Here, we will describe briefly definitions and formulas of the simple circular curves which are most often used in the railroad yard.

- Definitions Related to Simple Curves--A simple curve consists of a circular arc tangent to two straight sections of a route.
  A layout of a simple curve is given in Figure 7. In the figure, the curve starts at the left-hand side of the layout and ends at the layout and ends at the right-hand side of it. The notations used in Figure 7 are:

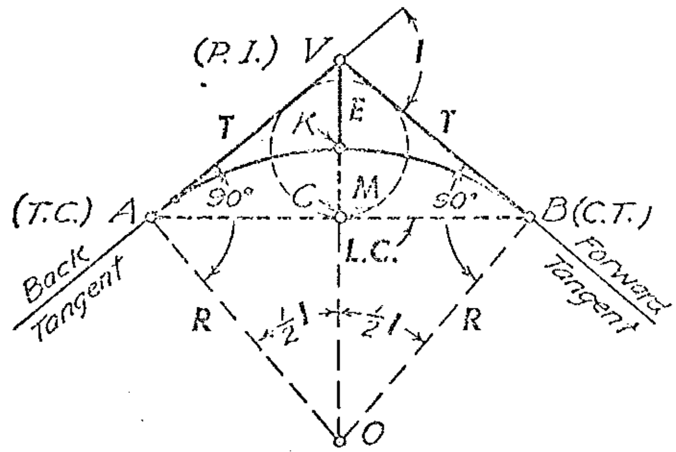


FIGURE 7. SIMPLE CURVE LAYOUT

V = vertex or point of intersection (=P.I.)

I = deflection angle between the tangents (equal to the central angle of the curve)

T.C. = the beginning of the circular arc (=tangent to curve), sometimes designated as P.C. (point of curve)

C.T. = the end of the circular arc (=curve to tangent), sometimes designated at P.T. (point of tangent) or E.C. (end of curve)

T = the tangent distance (P.I. to T.C.)

E = the external distance (P.E. to K)

R = the radius of the circular arc

L.C. = the long chord (T.C. to C.T.)

M = the middle ordinate (K to the mid-point of L.C.)

Formulas Related to Simple Curves--The most commonly used formulas regarding the simple curve are:

$$T = R \tan I/2$$

$$L.C. = 2R \sin I/2$$

$$E = R(\sec A - 1)I/2$$

$$M = R(1 - \cos A)\ I/2$$

Degree of Curve--The curvature of circular arc is often defined by a parameter which is called the degree of curve, D. Though there are several definitions for the degree of curve, the most commonly used definition by the railroads is so called chord definition of of the degree of curve; i.e., the degree of curve is the central angle subtended by a 100 ft. chord. The relationship between the degree of curve, D_c, and the radius, R, is approximated as:

$$D_c = \frac{5,370}{R}$$

Single Ladder vs. Tandem Ladder

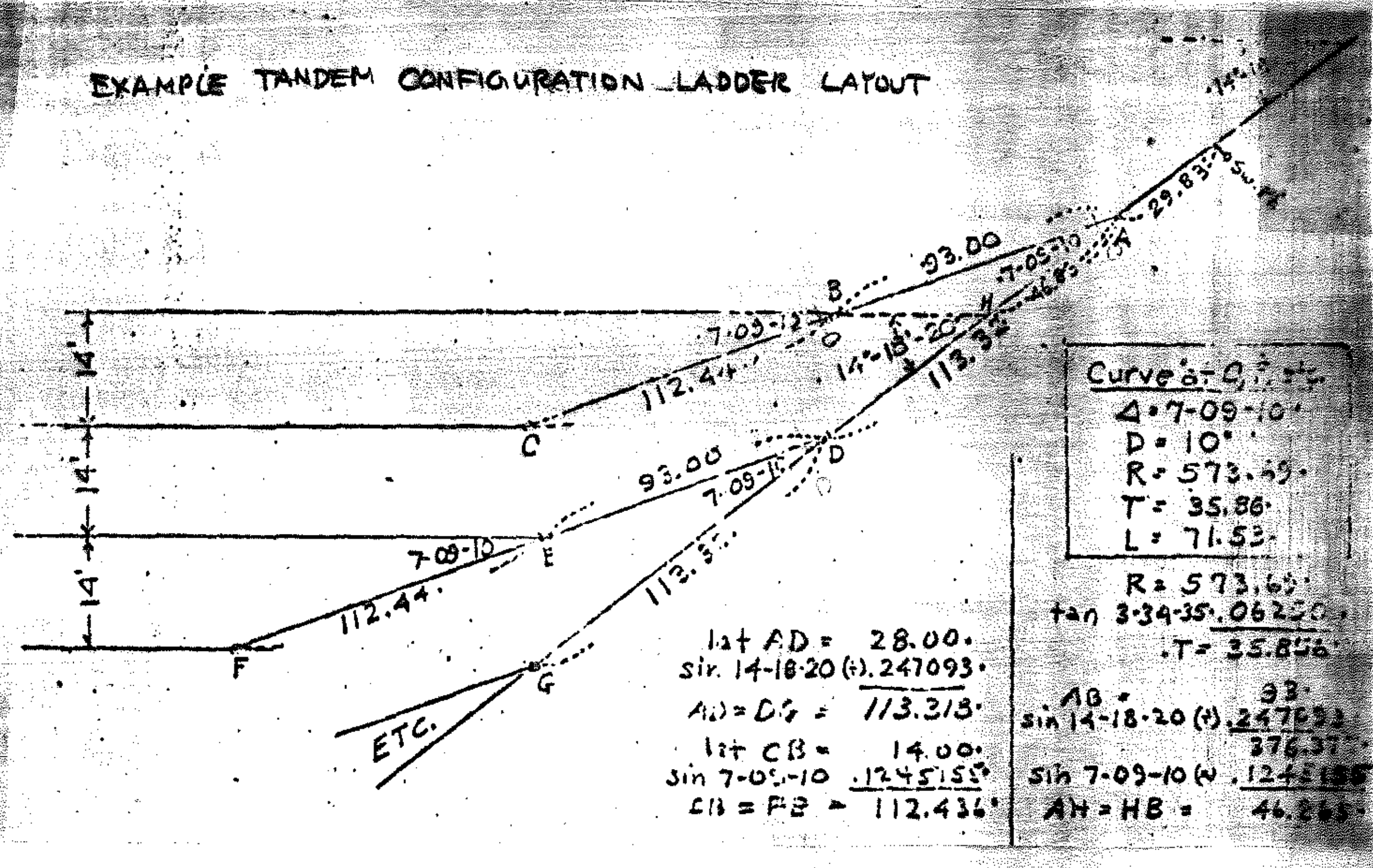
An example tandem ladder layout is given in Figure 8 (a) and an example single ladder layout is given in Figure 8 (b). In both cases, the distance between track centers is 14 ft. However, it is shown in the figure that the angle of the ladder to the track group in the tandem ladder is much sharper than that in the single ladder case (14^{o} - 18' - 20" in tandem ladder, and 10^{o} - 02" - 10" in single ladder). It should be noted that the angle between tangents is identical 7^{o} - 09' - 10" for all switches shown in both the tandem ladder and single ladder layouts (turnout number 8). It is believed by some that the single ladder is suitable for manual operations of switches, because all the switch machines can be installed on a straight line, facilitating the switchman's work. On the other hand, some designers believe that the tandem design makes the job easier for a switchman, because the walking distance is shorter.

Front-end of Classification Yard

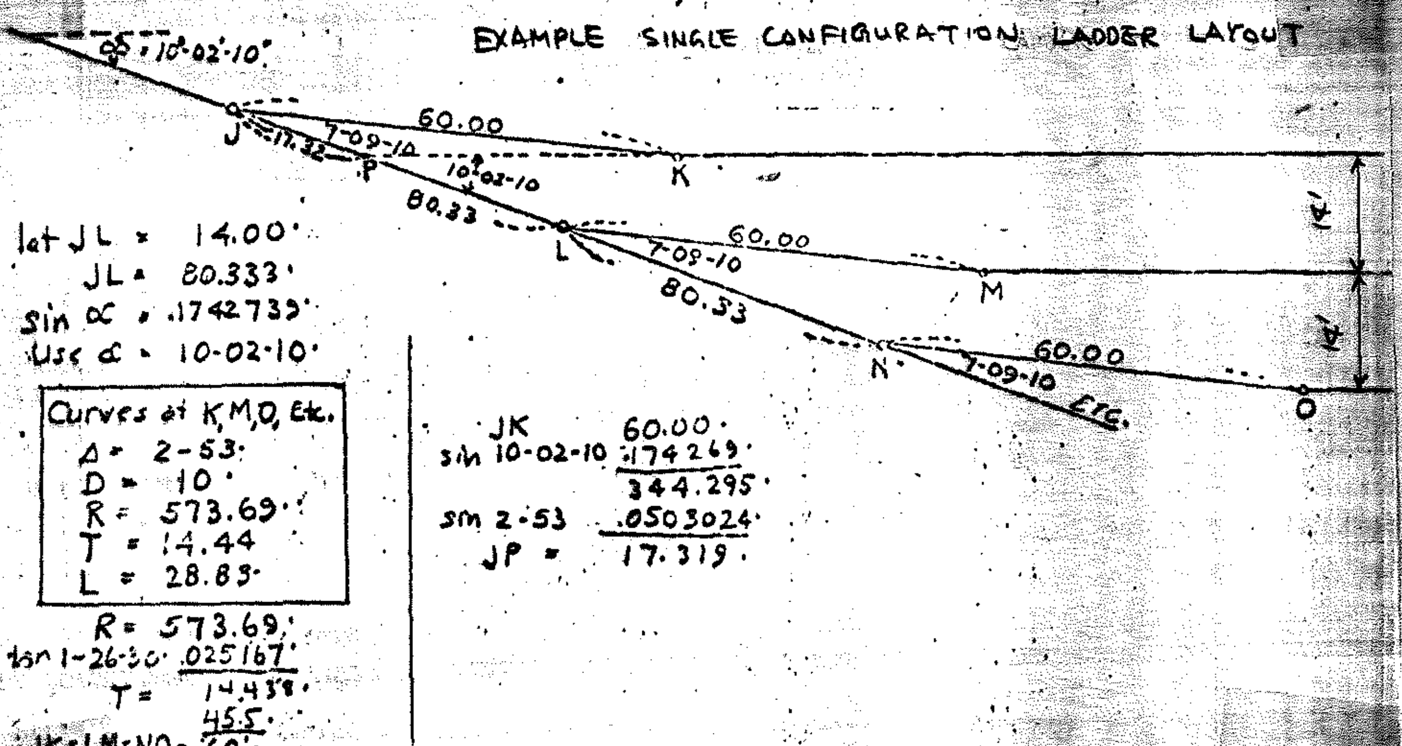
An example track layout of classification yard front end is given in figure 9. The figure shows a fanning out layout of a classification track group which is located at the center of the yard. Each major point is identified by X-Y coordinates and by the distance from the 0+00 point. The degrees of a curve used is 10^{o} except just prior to the tangent points of the two center tracks. The points of intersection for non switch track segments are denoted by a P.I., and the points of intersection for swtiches are denoted by an F.P.I. The points of switches are denoted by a P.S. The turnout numbers and the types of switch to be used (C = curved switch; S = straight switch) are given for each switch.

Turnout Number vs. Deflection Angle Between Tangents

There is a one-to-one relationship between the turnout number (identified by the frog number) and the deflection angle between tangents. The relationship between the two is given below.



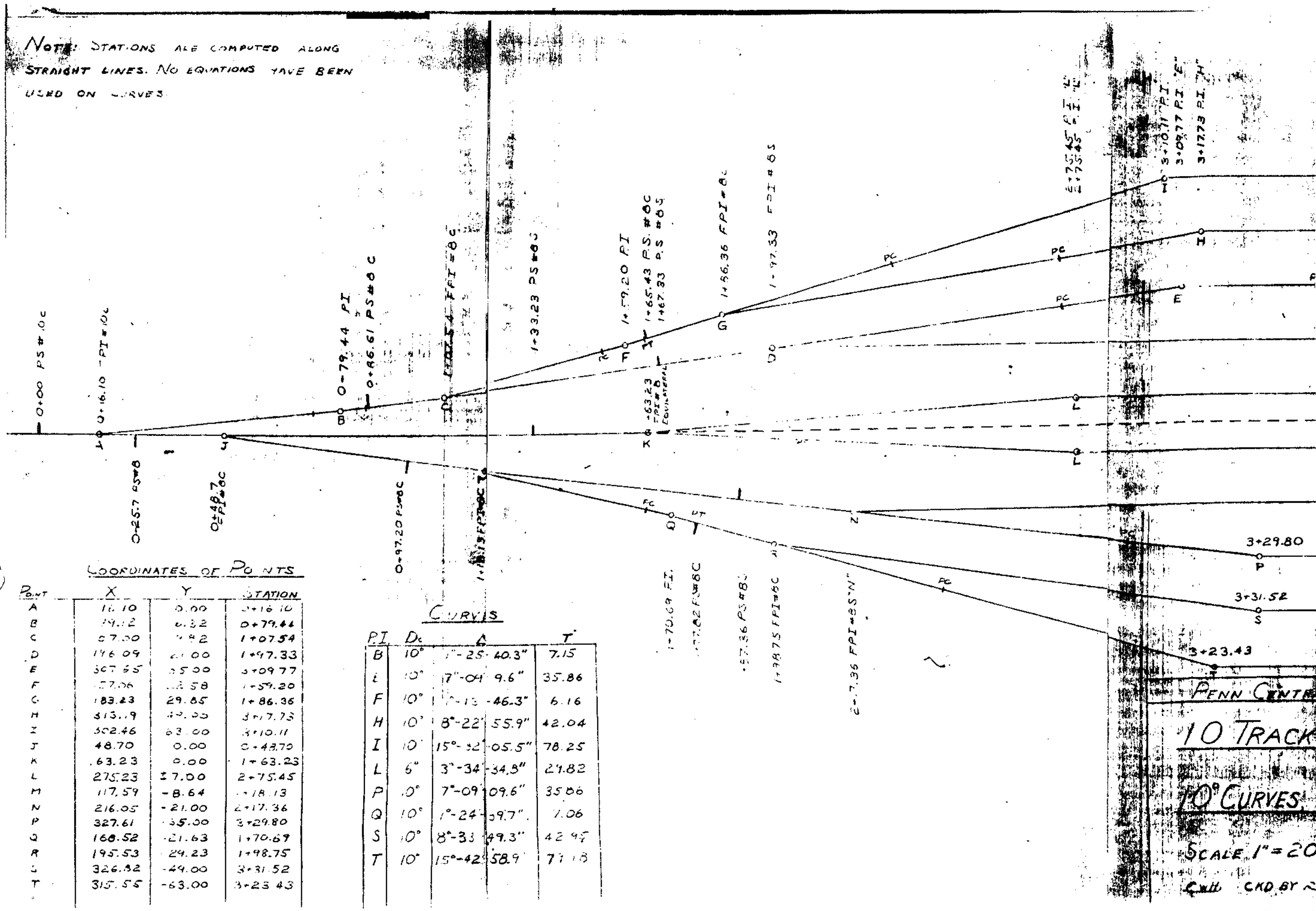
8-(a)



8-(b)

FIGURE 8 EXAMPLE LAYOUTS OF CLASS TRACK LADDERS

(Source: Consolidated Rail Corporation)



COORDINATES OF POINTS

POINT	X	Y	STATION
A	16.10	0.00	0+16.10
B	79.12	6.32	0+79.44
C	107.00	9.82	1+07.54
D	196.09	21.00	1+97.33
E	307.55	35.00	3+09.77
F	157.06	22.58	1+59.20
G	183.23	29.85	1+86.36
H	313.19	49.00	3+17.73
I	302.46	63.00	3+10.11
J	48.70	0.00	0+48.70
K	163.23	0.00	1+63.23
L	275.23	17.00	2+75.45
M	117.59	-8.64	1+18.13
N	216.05	-21.00	2+17.36
P	327.61	-35.00	3+29.80
Q	168.52	-21.63	1+70.69
R	195.53	-29.23	1+98.75
S	326.42	-49.00	3+31.52
T	315.55	-63.00	3+23.43

CURVES

P.I.	Dc	Δ	T
B	10°	1°-25'-40.3"	7.15
C	10°	7°-09'-9.6"	35.86
F	10°	1°-13'-46.3"	6.16
H	10°	8°-22'-55.9"	42.04
I	10°	15°-32'-05.5"	78.25
L	6°	3°-34'-34.3"	29.82
P	10°	7°-09'-09.6"	35.86
Q	10°	1°-24'-59.7"	7.06
S	10°	8°-33'-49.3"	42.97
T	10°	15°-42'-58.9"	71.[illegible]

FIGURE 9 EXAMPLE 10 TRACK LAYOUT

(Source: Consolidated Rail Corporation)

No. 4	Frog	- Angle	14° 15' 00"
No. 5	Frog	- Angle	11° 25' 16"
No. 6	Frog	- Angle	9° 31' 38"
No. 7	Frog	- Angle	8° 10' 16"
No. 8	Frog	- Angle	7° 09' 10"
No. 9	Frog	- Angle	6° 21' 35"
No. 10	Frog	- Angle	5° 43' 29"
No. 11	Frog	- Angle	5° 12' 18"
No. 12	Frog	- Angle	4° 46' 19"
No. 14	Frog	- Angle	4° 05' 27"
No. 16	Frog	- Angle	3° 34' 47"
No. 18	Frog	- Angle	3° 10' 56"
No. 20	Frog	- Angle	2° 51' 51"

Distribution

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