NATIONAL TRANSPORTATION SAFETY BOARD
Investigative Hearing
Washington Metropolitan Area Transit Authority Metrorail train 302 that encountered heavy smoke in the tunnel between the L'Enfant Plaza Station and the Potomac River Bridge on January 12, 2015

GROUP	H
EXHIBIT	
28	

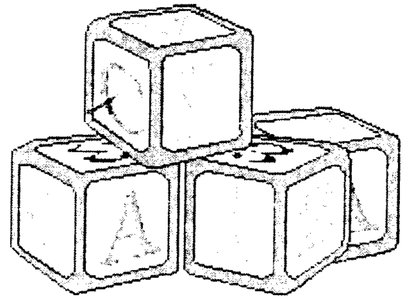
Agency / Organization

Washington Metropolitan Area Transit Authority

Title

Track Inspector Entry Level Course

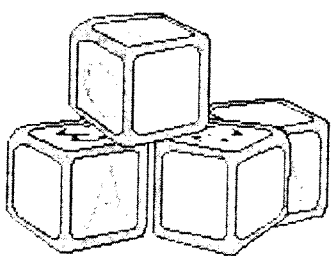
Docket ID: **DCA 15 FR 004**



Track Inspector's

Entry Level

Course



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BRAIN TEASER

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N	I	P	P	K	A	N	I	N	X	E	V	F	O	E
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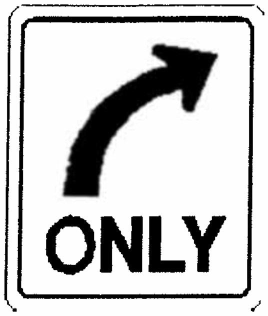
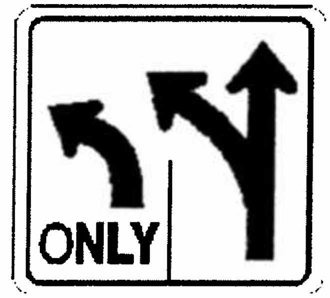
~~CHAIN~~
~~INSPECTION~~
~~MARKERS~~
~~DEFECT~~
~~FLAKING~~
~~TRACK~~

~~GAUGE~~
~~MAINLINE~~
~~CODE~~
~~FASTENERS~~
~~TIES~~

OBJECTIVES





Evaluate the measurements taken when string lining a curve.

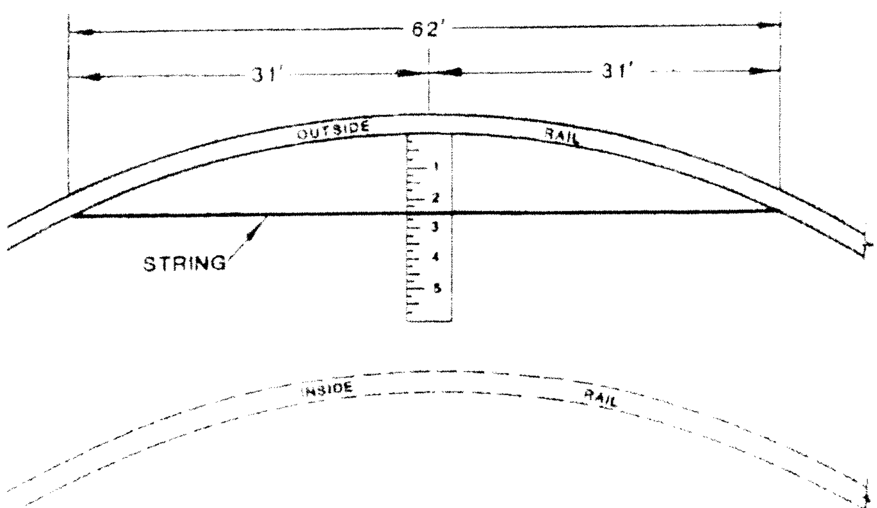
Interpret track maintenance charts

Recognize specific elements of the maintenance charts

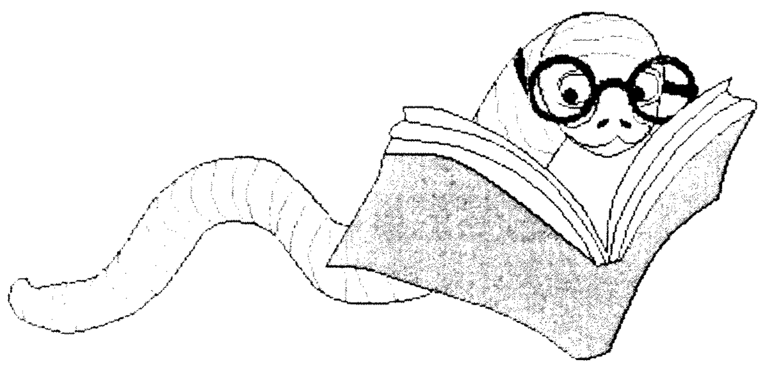
Explain a spiral in track Geometry

This week we will look at tracks charts

and making decisions from string line data.



Track Charts



INTRODUCTION TO TRACK CHARTS

Track Charts are both maps (sort of!) and pictures (sort of!) . That is, they are prepared to scale as are the maps with which we are all familiar. For example: the track charts we are using and looking at have a scale of
½" = 100 feet. Each increment is therefore 100'.

And, like a picture they exhibit many details about a subject (the track structure) with which you are already familiar.

More accurately, they are drawings— engineering drawings- composed of carefully drawn lines, thoughtfully conceived and carefully drawn symbols and abbreviations. In fact, they are a very brief but very complete portrayal (to the finest detail) of the entire track structure which include 120 symbols and abbreviations (more or less) indicating the individual and combined elements of 28 items (more or less) of the track structure.

NOTE: REFER TO YOUR TRACK CHARTS MANUAL

OPEN YOUR CHARTS

LETS LOOK AND SEE

Track Symbols

Track abbreviations

Civil abbreviations and symbols

- Horizontal
- Vertical
- General symbols
- General abbreviations

How to find a particular chart?

❑ To find a particular chart you should go to the index page and look for 3 things:

❑ Location the line (Route) that you are looking for.

Example: A-line, B-line or C-line.

❑ Sheet Number Look for TC(track chart) and then look for line(Route) letter and sheet number.

Example: TC-A-2.

- [ ] Description(Station Markers (Chain Markers CM))

These locations are found at the bottom of each track chart sheet.

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY	ROCKVILLE ROUTE	STATION 30+00 TO STATION 60+00

Every transit authority and railroad have their own peculiar organization and legend on their track charts that portray, a symbolized and diagrammatic representation of the track structure in the as—built condition. There are six basic categories into which the information about the track structure is classified. They are the following:

- Traction power and train control
- Profile
- Type of structure
- Alignment data
- General information
- Maintenance Record

TRACTION POWER AND TRAIN CONTROL DATA:

First, this is that portion of the. track chart where the Chain Markers are most easily observed and read. Chain Markers are posted every 100' on the system. Chain markers are used to pin—point locations for a variety of reasons most of which deal with problems in or on the system, e.g., track walkers notes and reports, equipment breakdowns, derailments, etc. Most important is the configuration of the beginnings and endings of the contact rail — or 3rd rail.

PROFILE:

Profile is the longitudinal section of the tracks that shows elevation (vertical curvature). Also, the chart drawings show the grade line (including percent of grade) of the track from levels taken (usually) from the top of the rail.

TYPE OF STRUCTURE:

This section of the track chart simply indicates the kind of structure in which the track is contained, e.g., a tunnel, an aerial, a cut etc. — or simply at grade.

ALIGNMENT DATA:

Alignment is the condition of the track in regard to uniformity in direction over short distances on tangents, or uniformity in variation over short distances on curves. This section of the track chart provides the very specific curve data including:

Let us look at the curve date while we go over each one of the items in the mini-chart

CURVE DATA **MINI CHART**

Civil Abbreviations		Notes
R =	Radius of curve	
Lc =	Length of curve	
Ls =	Length of spiral	
SE (Ea) =	Superelevation (Actual)	
(Eu) =	Superelevation (Un-balanced)	
Speed	Speed on the curve	

GENERAL INFORMATION:

This portion of the Track Charts provides general information by civil engineering symbols of the verticalness and horizontalness of track curvature with specific geographic locations. It also details, to scale, the precise geographic location and size of each of the stations with their platforms. In addition to the track information indicated above, this portion of the track chart also coordinates geographically with street location.

MAINTENANCE RECORD:

The year installed proceeds any code. For example, this portion of the chart provides historical and geographic data concerning:

a. Grinding of both rails of the track — inbound and outbound — indicating the number of passes. No other code.
b. Ties: that is, the year that they were installed. No other code.
c. Surface: that is, inches of lift (no other code) , keeping in mind that <u>surface</u> is the condition of the track as to the vertical evenness or smoothness over short distances.
d. Ballast: this is indicated by (C)leaned, (R)enewed and (N)ew.
e. Rail: all rail is 115#.
f. Fasteners: all fasteners are indicated by either "L" , "H" or "F", the beginning letter of the manufacturers: Landis, Lord, Hixon or L. B. Foster

The track charts also lay out in precise detail all of the engineering information in all categories of all WMATA's yards.

SOMETHING TO THINK ABOUT

Circle the correct answer

✓ Are track charts usefull to a person inspecting track ?

Yes No

✓ The scale of WMATA's track charts is ½" = 100 feet ?

True False

✓ The speed limit of a curve on the rail system can be found in the curve data box ?

True Flase

✓ What is the name of the page used to find a particular track chart ?

Cover Page Index Page

Put the learning to work

TRACK AND CIVIL ABBREVIATIONS

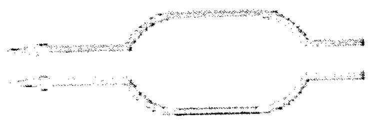
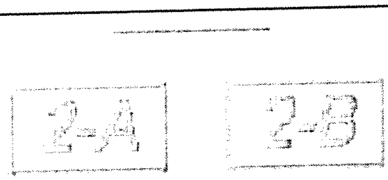
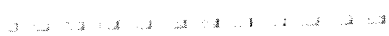
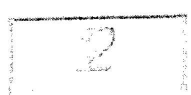
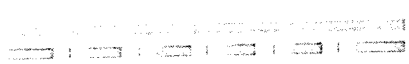
Pair up with a partner and answer the following. Fill in the blank space with the correct answer.

TRY THIS EXERCISE WITH THE TRACK CHARTS MANUAL CLOSED

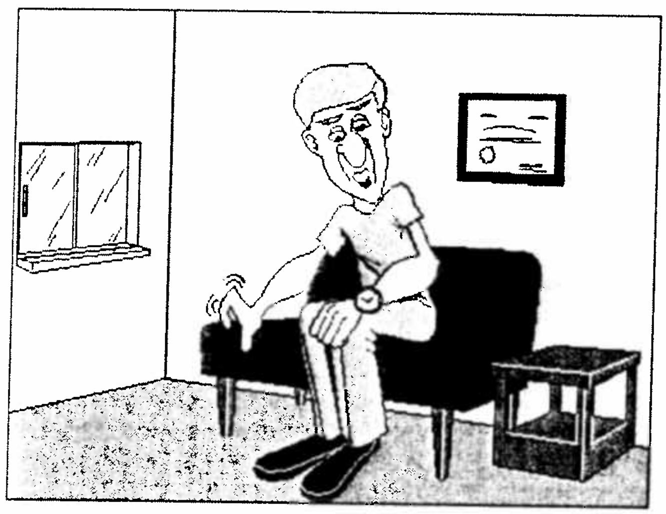
ABBREVIATIONS	ANSWER	TRACK	CIVIL
T/R	TOP OF RAIL		✓
BAL	BALLASTED	✓	
CWR	CONTINUOS WELDED RAIL	✓	
PVC	POINT OF VERTICAL CURVE		✓
PGL	PROFILE GAGE LINE		✓
R	RADIUS OF CIRCULAR CURVE		✓
MPH	MILES PER HOUR		✓
LUB	LUBRICATOR	✓	
D	DEGREE OF CURVE		✓
DF	DIRECT FIXATION	✓	

USE YOUR TRACK CHARTS

Identify the track symbols in column "A". Write your answer in column "B"

A	B
	LEFT / RIGHT HAND CURVE
	SPIRAL #
	CONTINUOUS WELDED RAIL
	CURVE #
	RESTRAINING RAIL TRACK

NEXT 4 PAGES DO ALONE



Use the drawing labeled Branch Route Sheet T C F-18 to answer the following questions. Use curve # 260

1. What should the gauge be? 56 1/4 Why RADIUS IS GREATER THAN 1425

2. What is the meaning of Lc? LENGTH OF CIRCULAR CURVE What is its measurement? 148.02'

3. What is the meaning of Ls? LENGTH OF SPIRAL What is its measurement? 304.55'

4. Superelevation 6"

5. Un-balance elevation 0.74"

6. What track is curve 260 on'? TK#2

   Is that inbound or out bound? INBOUND

7. List the other curves that can be read on this sheet and their track numbers

a. 257 TK#2	e. 262 TK# 1
b. 258 TK#1	f.
c. 259 TK#2	g.
d. 261 TK# 2	h.

8. Is this area direct fixation track or ballasted track? DIRECT FIXATION

9. What section of the sheet help you make the decision in question 8 above? MAINTENANCE RECORD

Use the drawing labeled Huntington Route Sheet T C C-20 to answer the following questions. Use curve # 24

1. What should the gauge be? 56 1/4 Why RADIUS GREATER THAN 1425

2. What is the measurement for Lc ? 679.54'

3. What is the measurement for Ls? 220.00'

4. What is the superelevation for curve 24? 4 1/2"

5. What track is curve 24 on? TK #1

   Is that inbound or out bound? INBOUND

6. Is this curve on ballast track or direct fixation(DF)? BALLAST TRACK

   If DF, what fastener is used? ________

7. What section of the chart can you find the station platform name ?

   GENERAL INFORMATION

8. What is the maximum speed through this curve? 65 MPH

Use the drawing labeled Greenbelt Route Sheet T C E-21 to answer the following questions. Use curve # 128

1. What should the gauge be? 56 1/4 Why RADIUS GREATER THAN 1425
2. What is the maximum speed through this curve? 75 MPH
3. What line and what track is this curve on? E-LINE TK#2

   Is that inbound or out bound? INBOUND
4. Is this curve on ballast track or direct fixation? BALLAST
5. If DF, what fastener is used? ______
6. Under normal flow of train traffic, is the curve before or after the platform? BEFORE
7. What is the length of the curve? 299.10'
8. What is the length of the spiral? 100.00'
9. Under normal flow of train traffic, is the crossover before or after the station?

   AFTER

Use the drawing labeled Vienna Route Sheet T C K-1 to answer the following questions. Use curve # 13

1. What should the gauge be? 56 1/2" Why RADIUS BETWEEN 350 TO 1425
2. Length of the curve? 868.33'
3. Length of the spiral? 220.00'
4. Superelevation 4"
5. Un-balance elevation 4.50"
6. What is the speed on this curve? 40 MPH

G. What track is curve 13 on, is that in or out bound? TK#2 OUTBOUND

8. Name the transition points and their chain makers:(normal flow of traffic)
   a. TS - 146+16.25
   b. SC - 148+74.98
   c. CS - 157+46.34
   d. ST - 159+66.34
9. What line is this curve on, in the system ? K-LINE
10. Is this curve on ballast track or direct fixation(DF)? DIRECT FIXATION

    If DF, what fasteners is used and when was it placed in service? HIXON, 1978

MEASURING TRACK

When measuring track, track geometry describes the position that each rail, or the track center line, occupies in space.

By placing track geometry into several planes, track geometry parameters can be specialized. These planes are Horizontal, Longitudinal Vertical, Transverse Vertical and the Track Plane.

The Horizontal Track Geometry

The horizontal track geometry is called Alignment. Alignment is the projection of the track geometry of each rail or the track center line onto the horizontal plane. When alignment describes a rail, a line along the rail gage side, 5/8" below the top of the rail, is used for the projection. The following terms are used when describing alignment:

(1) Curvature
(2) Line
(3) Degree of Curve
(4) Curve Radius
(5) Horizontal Space Curve
(6) Versine

The Longitudinal Vertical Track Geometry

The longitudinal vertical track geometry is called Longitudinal Profile.

Longitudinal Profile is the track geometry of each rail or the track center line projected onto the longitudinal vertical plane. When Longitudinal Profile describes a rail, a line along the top of the rail is used for the projection. The following terms are used when describing Longitudinal Profile:

(1) Profile, Surface, Top, Vertical Alignment
(2) Dip, Sag, Hump
(3) Grade, Slope
(4) Ramps, Runoff
(5) Vertical Space Curve
(6) Vertical Curve

The Track Geometry in the Transverse Vertical Plane

Superelevation: The difference in elevation between the top of one rail and the top of the other rail measured along a line perpendicular to the track center line.
The following terms are synonyms for superelevation:

(1) Elevation
(2) Cant
(3) Crosslevel

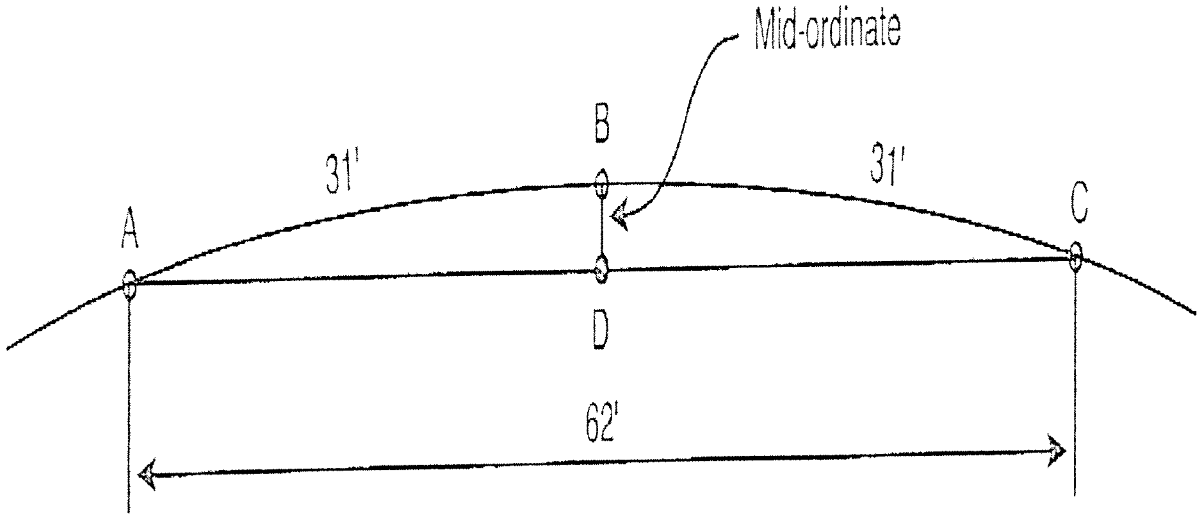
The Track Geometry in the Track Plane

Two parameters are used to describe track geometry in the track plane.

Gage (Gauge): The distance (measured normal to the track axis) between the inside of the rail heads.

Flangeway Width (Gap): The distance (measured normal to the track axis) between the running rail and the restraining or guard rail.
In the next section we will be looking at measuring curves in the horizontal plane.

String Lining of Curves



String Lining of Curves

Track personnel can determine the degree of a curve by stretching a string between two points 62 feet apart on the gage of the outer rail of the curve and measuring the offset or ordinate (number of inches between the string and the rail) at the midpoint (31 ft.). Each inch of offset (measurement) indicates one degree of curvature.

When string measurements are made on a curve which has not been lined recently, the ordinates will not be uniform on the body of the curve. They also will not increase or decrease at a smooth, gradual rate on the spirals, but will vary, some above and others below the average values. The line on such curves can be improved very much by throwing the track inwardly where the ordinates are larger than the average and outwardly where the ordinates are smaller than the average. Ordinarily you have no way of knowing just how much to shift the track at each point.

A string is stretched tightly between the first and third stations which are twice the station length apart. A ruler is used to measure the midordinate. Mid-ordinates should be measured to the gage side of the string in sixteenths (16ths) of an inch. The mid-ordinate is the distance between the string and the station point on the gage line which is 5/8" below the top of the high rail. This measurement is recorded and the procedure is used at all stations around the curve. String line holders or offset blocks should be used to position the string a distance of one (1) inch away from the gage line of the rail, so as to permit measurement of any reverse curvature.

⇨ Mid-ordinate measurements should be taken with the string line pulled taut, not affected by the wind, and with the string line holders and the scale held horizontal and perpendicular to the gage.

Alignment Defects on Curves

To measure for alignment defects on curves, we have a new twist added to our procedure from tangent. All curves have what is known as design alignment. If we just measure the amount of offset as you do on tangent track, the measurement would not be the amount of misalignment, but the amount of design alignment plus any misalignment. An alignment defect on a curve is the amount that the mid-point offset measurement exceeds the amount of design offset for the curve.

For example, if you take an offset measurement on a 2 degree curve that is not out of line, you should read 2". To find this reading, you need to know the work area you are in. Note that for every 1 degree of curve, you will measure 1" of offset when using an (62') chord. To measure for misalignments on curves, we need to take the design measurement, then subtract the amount of design offset from that value to determine the out-of-line measurement.

11.11 Measuring Alignment in Curves:

11.11.1
11.11.2

Stop and think about where we are!

Use what you have and know to answer each question

What can you use to measure curve alignment? 62' CORD

How can actual curvature on a curve be checked in the field? STRING LINING

If variations of alignment are within or not within tolerances, where would you find the guidelines for correction of the problem? (Be specific)

CHART 11-4 IN TRACK STANDARD BOOK.

Explain superelevation VERTICAL DISTANCE THAT THE OUTER RAIL IS ABOVE THE INNER RAIL IN A CURVE.

HORIZONTAL ALINGNMENT DEVIATION FROM DESIGN

⇨ The curve you are measuring has a 60 mph speed limit. You obtain a mid point measurement of 5" using a 62' string, on a 6" curve.

What is the out - of - line measurement? 1"

✓None, deviation does not exceed limits
Arrange to take track out of service.
Slow train to next lower speed. (What speed is that
What priority code should be used: GREEN

⇨ The curve you are measuring has a 60 mph speed limit. You obtain a mid point measurement of 5" using a 62' string, on a 6" curve.

What is the out - of - line measurement? 1"

✓None, deviation does not exceed limits
Arrange to take track out of service.
Slow train to next lower speed. (What speed is that
What priority code should be used: GREEN

⇨ The curve you are measuring has a 60 mph speed limit. You obtain a mid point measurement of 3 ½" using a 62' string, on a 6" curve.

What is the out - of - line measurement? 2 1/2"

None, deviation does not exceed limits
Arrange to take track out of service.
✓Slow train to next lower speed. (What speed is that 35 MPH
What priority code should be used: YELLOW

⇨ The curve you are measuring has a 40 mph speed limit. You obtain a mid point measurement of 2" using a 62' string, on a 4" curve.

What is the out - of - line measurement? 2"

None, deviation does not exceed limits
Arrange to take track out of service.
✓Slow train to next lower speed. (What speed is that 35 MPH
What priority code should be used: YELLOW

Graphing a Curve by Hand

Not long ago, track personnel would check curves and provide transition point indicators and superelevation markers for curves. More and more we are required to perform work without the advantage of previous support crews. Curves are normally measured by hand during walking inspections, or following a derailment.
Having access to a curve graph is of limited use if worker do not understand what information is contained within the graph.

Benefits of a Curve Graph

From a curve graph you can determine:

- existing alignment throughout a curve
- desired alignment throughout a curve
- transition points of a curve
- design offset for any point on a curve
- required superelevation for any point on a curve

To accurately measure irregularities for alignment, superelevation and runoff in the spirals of a curve, you must refer to information provided by a curve chart. To graph a curve, the first step is to stringline the entire curve from entering tangent to leaving tangent. Refer back to the early lesson on stringlining a curve.

Plotting the Curve

Next we take the listing of offset measurements for each Station, and plot them on a sheet of graph paper.

- Start near the bottom of the graph paper by drawing a horizontal baseline and labeling it 0 on the left side.
- Next, mark each horizontal line above the baseline in mm or 1/8" increments, again depending on the measurement base you are using.
- Only mark as many increments as is necessary to plot the numbers obtained in your list.
- You may have to tape an additional piece of graph paper on top or to the right side to enable you to graph the entire curve.
- If necessary, mark a few lines below the baseline to plot any negative readings you may have taken.
- Now mark station numbers on each of the vertical lines below the baseline until you have enough stations to plot the entire curve.
- Plot the curve by marking a dot where the appropriate measurement line meets for each station.

- Using a pencil, lightly connect the dots to graph the curve.
- Any part of the graph that follows the baseline indicates tangent track.
- Any part of the graph which basically follows a horizontal line, other than the baseline, indicates that portion of track is part of a circular curve or forms the "body" of the curve.

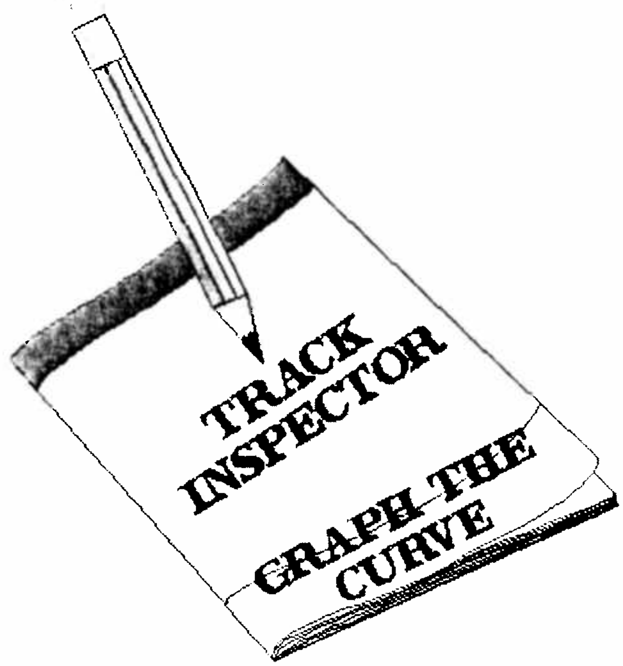
Remember the definition of a curve: Any uniform change in direction that forms part of a circle. The uniform change is the constant offset measurement reading plotted as a straight line on any horizontal line other than the baseline. Finally, any points on the graph that form a diagonal line indicate that this portion of track is a spiral; an ever-changing curve.
That covers the basic procedures for graphing a curve to determine the existing alignment and the transition points.

Summary

the resulting curve graphs may look a little different, but will provide you with same critical information in the field to check and balance.

You can use any measurement base when taking readings:

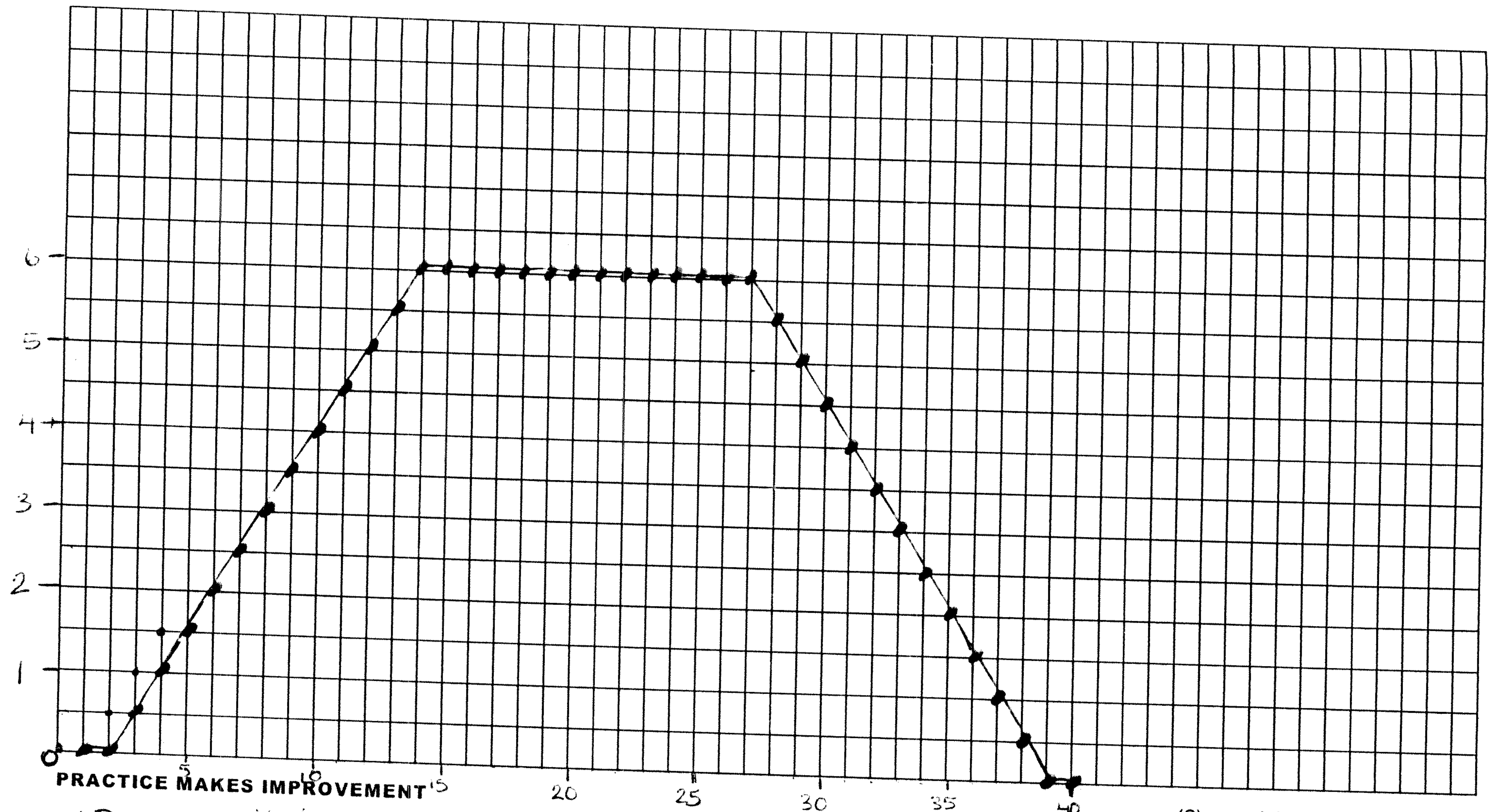
- (1/2, 1/4, 1/8, 1/16).
- A geometry car provides a continuous plot of the alignment of track. This information is very useful in planning work programs and verifying the quality of work done.


TRACK
INSPECTOR
GRAPH THE
CURVE

Use the following data to Plot this Curve (designed)

In the columns below, is a list of readings taken from string lining. Enter these readings on the standard graph paper in their proper locations.

STATIONS	MEASUREMENTS	STATIONS	MEASUREMENTS
1	0"	21	6"
2	0"	22	6"
3	1/2"	23	6"
4	1	24	6"
5	1 1/2"	25	6"
6	2 "	26	6"
7	2 1/2"	27	6"
8	3 "	28	5 1/2"
9	3 1/2"	29	5"
10	4 "	30	4 1/2"
11	4 1/2"	31	4 "
12	5 "	32	3 1/2"
13	5 1/2"	33	3 "
14	6"	34	2 1/2 "
15	6"	35	2 "
16	6"	36	1 1/2"
17	6"	37	1"
18	6"	38	1/2"
19	6"	39	0"
20	6"	40	0"



PRACTICE MAKES IMPROVEMENT

1 BLOCK = 1/2"

BLACK = DESIGNED

ELLOW = ACTUAL

Use the following data to Plot this Curve (actual)
2nd graph

In the columns below, is a list of readings taken from string lining. Enter these readings on the standard graph paper in their proper locations.

STATIONS	MEASUREMENTS	STATIONS	MEASUREMENTS
1	0"	21	6 1/2"
2	0"	22	6 1/2"
3	-1/4"	23	6 1/2"
4	3/4"	24	6"
5	2"	25	6"
6	2 "	26	6"
7	2 1/4"	27	5 1/2"
8	3 1/4"	28	5"
9	3 1/4"	29	4 1/2"
10	4 "	30	4"
11	4 1/2"	31	3 1/2"
12	4 1/2 "	32	3"
13	4 1/2"	33	2 1/2"
14	5 1/2"	34	2 "
15	5 1/2"	35	1 1/2 "
16	5 1/2"	36	1 1/2"
17	5 1/2"	37	1"
18	6 1/2"	38	1/2"
19	6 1/2"	39	0"
20	6 1/2"	40	0"