

Dr 14 BK 18

B18 Dr 14

K. C. F.  
FIELD BOOK  
360 A

WHITE BEAR 1935 WPA

# KEUFFEL & ESSER CO.

DRAWING MATERIALS

AND

SURVEYING INSTRUMENTS.

NEW YORK.

CHICAGO. ST. LOUIS. SAN FRANCISCO. MONTREAL.

## TABLES FOR EXCAVATIONS AND EMBANKMENTS.

DISTANCES FROM CENTER OF ROADWAY FOR CROSS-SECTIONING.

ROADWAY 18 FEET WIDE. SIDE SLOPES 1 TO 1.

FOR SINGLE TRACK EXCAVATION.

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|    | 0    | .1   | .2   | .3   | .4   | .5   | .6   | .7   | .8   | .9   |    |
|----|------|------|------|------|------|------|------|------|------|------|----|
| 0  | 9.0  | 9.1  | 9.2  | 9.3  | 9.4  | 9.5  | 9.6  | 9.7  | 9.8  | 9.9  | 0  |
| 1  | 10.0 | 10.1 | 10.2 | 10.3 | 10.4 | 10.5 | 10.6 | 10.7 | 10.8 | 10.9 | 1  |
| 2  | 11.0 | 11.1 | 11.2 | 11.3 | 11.4 | 11.5 | 11.6 | 11.7 | 11.8 | 11.9 | 2  |
| 3  | 12.0 | 12.1 | 12.2 | 12.3 | 12.4 | 12.5 | 12.6 | 12.7 | 12.8 | 12.9 | 3  |
| 4  | 13.0 | 13.1 | 13.2 | 13.3 | 13.4 | 13.5 | 13.6 | 13.7 | 13.8 | 13.9 | 4  |
| 5  | 14.0 | 14.1 | 14.2 | 14.3 | 14.4 | 14.5 | 14.6 | 14.7 | 14.8 | 14.9 | 5  |
| 6  | 15.0 | 15.1 | 15.2 | 15.3 | 15.4 | 15.5 | 15.6 | 15.7 | 15.8 | 15.9 | 6  |
| 7  | 16.0 | 16.1 | 16.2 | 16.3 | 16.4 | 16.5 | 16.6 | 16.7 | 16.8 | 16.9 | 7  |
| 8  | 17.0 | 17.1 | 17.2 | 17.3 | 17.4 | 17.5 | 17.6 | 17.7 | 17.8 | 17.9 | 8  |
| 9  | 18.0 | 18.1 | 18.2 | 18.3 | 18.4 | 18.5 | 18.6 | 18.7 | 18.8 | 18.9 | 9  |
| 10 | 19.0 | 19.1 | 19.2 | 19.3 | 19.4 | 19.5 | 19.6 | 19.7 | 19.8 | 19.9 | 10 |
| 11 | 20.0 | 20.1 | 20.2 | 20.3 | 20.4 | 20.5 | 20.6 | 20.7 | 20.8 | 20.9 | 11 |
| 12 | 21.0 | 21.1 | 21.2 | 21.3 | 21.4 | 21.5 | 21.6 | 21.7 | 21.8 | 21.9 | 12 |
| 13 | 22.0 | 22.1 | 22.2 | 22.3 | 22.4 | 22.5 | 22.6 | 22.7 | 22.8 | 22.9 | 13 |
| 14 | 23.0 | 23.1 | 23.2 | 23.3 | 23.4 | 23.5 | 23.6 | 23.7 | 23.8 | 23.9 | 14 |
| 15 | 24.0 | 24.1 | 24.2 | 24.3 | 24.4 | 24.5 | 24.6 | 24.7 | 24.8 | 24.9 | 15 |
| 16 | 25.0 | 25.1 | 25.2 | 25.3 | 25.4 | 25.5 | 25.6 | 25.7 | 25.8 | 25.9 | 16 |
| 17 | 26.0 | 26.1 | 26.2 | 26.3 | 26.4 | 26.5 | 26.6 | 26.7 | 26.8 | 26.9 | 17 |
| 18 | 27.0 | 27.1 | 27.2 | 27.3 | 27.4 | 27.5 | 27.6 | 27.7 | 27.8 | 27.9 | 18 |
| 19 | 28.0 | 28.1 | 28.2 | 28.3 | 28.4 | 28.5 | 28.6 | 28.7 | 28.8 | 28.9 | 19 |
| 20 | 29.0 | 29.1 | 29.2 | 29.3 | 29.4 | 29.5 | 29.6 | 29.7 | 29.8 | 29.9 | 20 |
| 21 | 30.0 | 30.1 | 30.2 | 30.3 | 30.4 | 30.5 | 30.6 | 30.7 | 30.8 | 30.9 | 21 |
| 22 | 31.0 | 31.1 | 31.2 | 31.3 | 31.4 | 31.5 | 31.6 | 31.7 | 31.8 | 31.9 | 22 |
| 23 | 32.0 | 32.1 | 32.2 | 32.3 | 32.4 | 32.5 | 32.6 | 32.7 | 32.8 | 32.9 | 23 |
| 24 | 33.0 | 33.1 | 33.2 | 33.3 | 33.4 | 33.5 | 33.6 | 33.7 | 33.8 | 33.9 | 24 |
| 25 | 34.0 | 34.1 | 34.2 | 34.3 | 34.4 | 34.5 | 34.6 | 34.7 | 34.8 | 34.9 | 25 |
| 26 | 35.0 | 35.1 | 35.2 | 35.3 | 35.4 | 35.5 | 35.6 | 35.7 | 35.8 | 35.9 | 26 |
| 27 | 36.0 | 36.1 | 36.2 | 36.3 | 36.4 | 36.5 | 36.6 | 36.7 | 36.8 | 36.9 | 27 |
| 28 | 37.0 | 37.1 | 37.2 | 37.3 | 37.4 | 37.5 | 37.6 | 37.7 | 37.8 | 37.9 | 28 |
| 29 | 38.0 | 38.1 | 38.2 | 38.3 | 38.4 | 38.5 | 38.6 | 38.7 | 38.8 | 38.9 | 29 |
| 30 | 39.0 | 39.1 | 39.2 | 39.3 | 39.4 | 39.5 | 39.6 | 39.7 | 39.8 | 39.9 | 30 |
| 31 | 40.0 | 40.1 | 40.2 | 40.3 | 40.4 | 40.5 | 40.6 | 40.7 | 40.8 | 40.9 | 31 |
| 32 | 41.0 | 41.1 | 41.2 | 41.3 | 41.4 | 41.5 | 41.6 | 41.7 | 41.8 | 41.9 | 32 |
| 33 | 42.0 | 42.1 | 42.2 | 42.3 | 42.4 | 42.5 | 42.6 | 42.7 | 42.8 | 42.9 | 33 |
| 34 | 43.0 | 43.1 | 43.2 | 43.3 | 43.4 | 43.5 | 43.6 | 43.7 | 43.8 | 43.9 | 34 |
| 35 | 44.0 | 44.1 | 44.2 | 44.3 | 44.4 | 44.5 | 44.6 | 44.7 | 44.8 | 44.9 | 35 |
| 36 | 45.0 | 45.1 | 45.2 | 45.3 | 45.4 | 45.5 | 45.6 | 45.7 | 45.8 | 45.9 | 36 |

Calculated by Julien A. Hall, M. Am. Soc. C. E.

For Keith's Railroad Curve Tables see end of book.

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Birch Lake Ave.

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Division St.

Alignment.

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Notes for Blue Tops.

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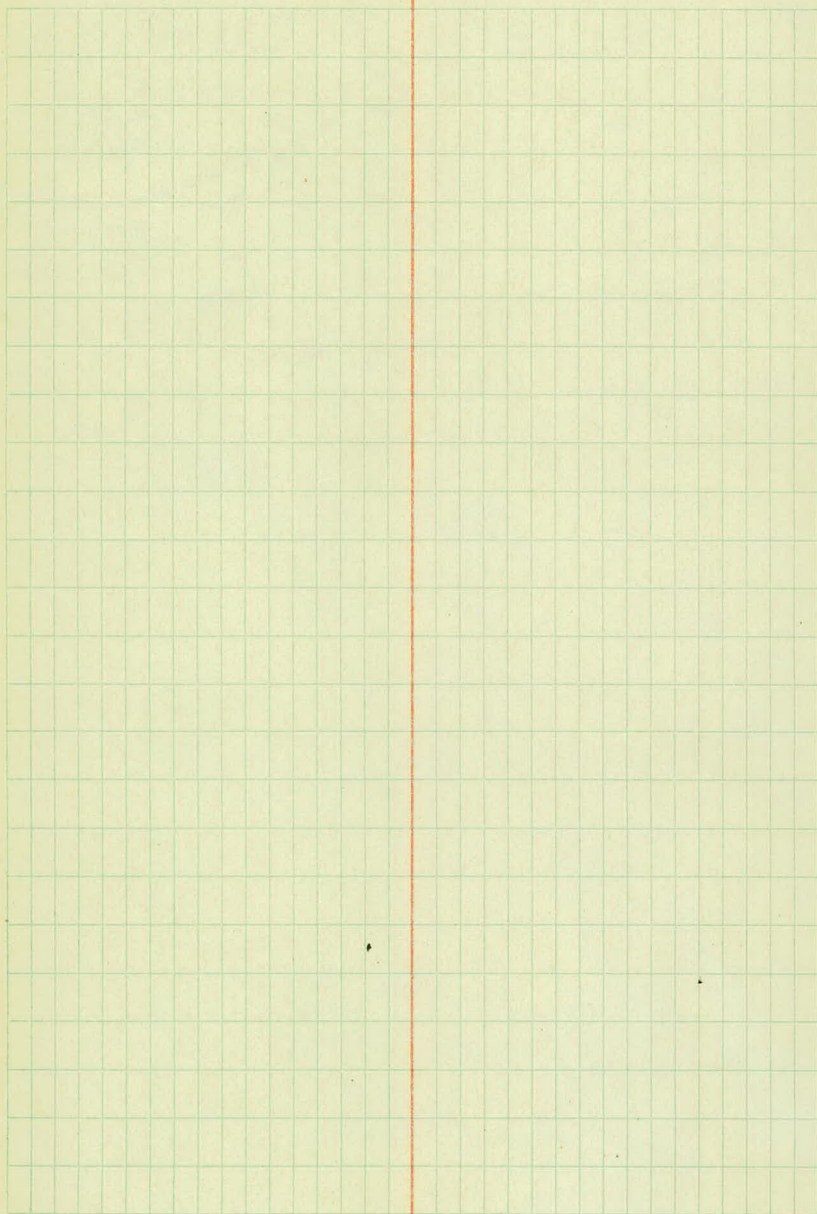
Storm Sewer 5<sup>th</sup> St

P. 53

" " 8<sup>th</sup> St

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| Sta.  | +    | $\pi$  | - | Grade  | Ground |
|-------|------|--------|---|--------|--------|
| B.M.  | 4.33 | 936.12 |   | 931.79 |        |
| 0     |      |        |   |        | 31.30  |
| +10   |      |        |   |        |        |
| +50   |      |        |   |        | 31.33  |
| 1     |      |        |   |        | 31.36  |
| +65   |      |        |   |        |        |
| +50   |      |        |   |        | 31.39  |
| +95   |      |        |   |        |        |
| 240   |      |        |   |        | 31.42  |
| 2 +25 |      |        |   |        |        |
| +50   |      |        |   |        | 31.45  |
| 3     |      |        |   |        | 31.48  |

(Spike in 24" oak 73 Lt. 0754) Moved to (0779 - Tri Oak - RT)

Dit. Gr. RT & Lt.

Shd 1r - G. Rod

Ditch G. R. - Rt. & Lt.

28.92

4.82

7.20

28.99

4.79

7.13

29.06

4.76

7.06

29.13

4.73

6.99

29.20

4.70

6.92

29.27

4.67

6.85

29.34

4.64

6.78

Ditch Gr. 10.14 - Bet. Sta. 06 - 1100

936.12

3 + 50

31.51

4

31.54

T.P.

5.04

936.58

4.58

931.54

+ 50

31.57

5

31.60

+ 50

31.63

+ 64.5

+ 94.5

6 + 0

31.66

6 + 06

Dit. Gr.

Rt. + Ct.

Shd. Gr. Rod.

Dit. Gr. Rod. Rt. + Ct.

29.41

4.61

6.71

29.48

4.58

6.64

29.55

5.01

7.03

29.62

4.98

6.97

29.69

4.95

6.90

29.76

4.92

6.83

936.58

6+50

31.69

6+60

B.M.

5.01

936.77

4.79

931.76

+90

7+0

31.72

7+50

31.75

B.M.

8

31.78

+50

31.81

9

31.84

+50

31.87

10

31.90

29.83

4.89

6.75

29.90

5.05

6.87

29.97

5.02

6.80

Spike in T.P. 25' Rt. Sta. 7+58 (931.76)

30.04

4.99

6.73

30.11

4.96

6.66

30.18

4.93

6.59

30.25

4.90

6.52

30.32

4.87

6.45

| Sta.   | +    | $\pi$  | - | Grade  |
|--------|------|--------|---|--------|
|        |      | 936.77 |   |        |
| 10 +50 |      |        |   | 31.93  |
| 11     |      |        |   | 31.96  |
| B.M.   | 1.96 | 937.20 |   | 935.24 |
| +35    |      |        |   |        |
| +50    |      |        |   | 31.99  |
| +60    |      |        |   |        |
| 12     |      |        |   | 32.02  |
| +50    |      |        |   | 32.05  |
| +89    |      |        |   |        |
| 13     |      |        |   | 32.08  |
| 13 +19 |      |        |   |        |

Dit. Gr. Rl. 27 -

30.39

484

6.38

30.46

481

6.31

Gr. Road

Ditch Gr. Should.

 $\frac{6.71}{25}$  $\frac{5.21}{15}$ 

5.21

 $\frac{5.01}{19} = \text{Top S. W. Bench.}$  $\frac{6.68}{25}$  $\frac{5.18}{15}$ 5.18 $\frac{4.98}{19}$  $\frac{6.65}{25}$  $\frac{5.15}{15}$ 5.15 $\frac{4.95}{19}$  $\frac{6.62}{25}$  $\frac{5.12}{15}$ 5.12 $\frac{4.92}{19}$

937.20

13+50

✓

32.11

14

32.14

+50

32.17

15

32.20

+50

32.23

+85

16to

32.26

16+15

+50

+45

$$\frac{6.59}{25}$$

$$\frac{5.00}{15}$$

$$5.09$$

$$\frac{4.89}{19}$$

$$\frac{6.56}{25}$$

$$\frac{5.06}{15}$$

$$5.06$$

$$\frac{4.86}{19}$$

$$\frac{6.53}{25}$$

$$\frac{5.03}{15}$$

$$5.03$$

$$\frac{4.83}{19}$$

$$10/cir = \frac{6.5}{25}$$

$$\frac{5.00}{15}$$

$$5.00$$

$$\frac{4.80}{19}$$

$$\frac{4.77}{19}$$

$$4.77$$

$$\frac{4.77}{19}$$

$$\frac{4.74}{19}$$

$$4.74$$

$$\frac{4.74}{19}$$

Rad

B.M.

2.03

935.24

937.27

17

32.32 5.70

0

183

937.07

935.24

+50

32.35 5.52

18

32.38 5.49

+45

32.41

+50

5.46

+75

32.43

19

32.44 4.43

19+05

32.44

+50

32.47 4.40

20

32.50 4.37

Top Hyd 25' Lt Sta 16+65

937.07

20 +50

32.53 · 4.30

+95

32.56

21

32.56 4.31

21 +25

32.58

+50

32.59 4.28

+55

32.59

22

32.62 · 4.25

+50

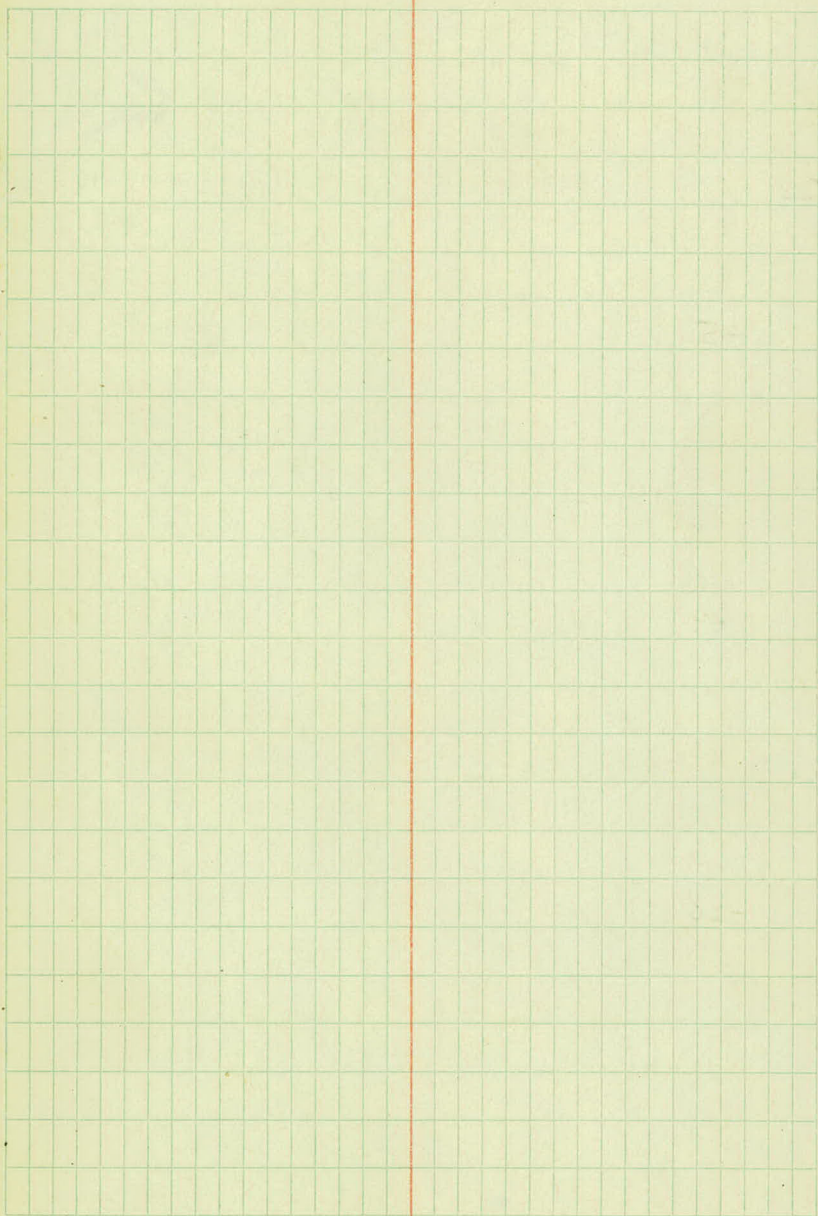
32.65 4.22

23

32.68 · 4.19

+50

32.71 · 4.16



449

93707

|    |     |        |     |        |     |
|----|-----|--------|-----|--------|-----|
| 0  | 434 | 937.78 | 363 | 933.44 |     |
| 24 |     |        |     | 32.74  | 484 |

|     |  |  |  |       |     |
|-----|--|--|--|-------|-----|
| +50 |  |  |  | 32.77 | 481 |
|-----|--|--|--|-------|-----|

|    |  |  |  |       |     |
|----|--|--|--|-------|-----|
| 25 |  |  |  | 32.80 | 479 |
|----|--|--|--|-------|-----|

|     |  |  |  |       |     |
|-----|--|--|--|-------|-----|
| +50 |  |  |  | 32.83 | 476 |
|-----|--|--|--|-------|-----|

|         |  |  |  |       |     |
|---------|--|--|--|-------|-----|
| 26 + 05 |  |  |  | 32.86 | 473 |
|---------|--|--|--|-------|-----|

|     |  |  |  |       |  |
|-----|--|--|--|-------|--|
| +20 |  |  |  | 32.87 |  |
|-----|--|--|--|-------|--|

|     |  |  |  |  |  |
|-----|--|--|--|--|--|
| +26 |  |  |  |  |  |
|-----|--|--|--|--|--|

|      |  |       |      |        |  |
|------|--|-------|------|--------|--|
| B.M. |  | 37.93 | 4.49 | 933.29 |  |
|------|--|-------|------|--------|--|

$$\begin{array}{r} \text{SW} \\ 3.96 \\ \hline 29 \end{array}$$

$$\begin{array}{r} 4.59 \\ \hline 29 \end{array}$$

$$\begin{array}{r} \text{D.C. } 1.29 \\ 4.83 \\ \hline 17.96 \end{array} \quad \begin{array}{r} 4.65 \\ \hline 9 \end{array}$$

$$\begin{array}{r} \text{C.D. } 0.31 \\ 4.76 \\ \hline 0 \end{array}$$

$$\begin{array}{r} 4.93 \\ \hline 15 \end{array}$$

$$\begin{array}{r} \text{D.C. } 1.09 \\ 4.98 \\ \hline 19.36 \end{array}$$

$$\begin{array}{r} 4.84 \\ \hline 23 \end{array}$$

$$\begin{array}{r} \text{SW} \\ 4.65 \\ \hline 30 \end{array}$$

$$\begin{array}{r} 5.07 \\ \hline 6.07 \end{array}$$

USGS in St. Mary School Yard.

| Sta.  | +    | $\pi$  | -    | Grade  | G. Root |      |
|-------|------|--------|------|--------|---------|------|
| B.M.  | 2.12 | 937.36 |      | 935.24 | 2.204   |      |
| 16+50 |      |        |      | 32.29  | 5.07    | 4.87 |
| 17    |      |        |      | 32.32  | 5.04    | 4.84 |
| +50   |      |        |      | 32.35  | 5.01    | 4.81 |
| 18    |      |        |      | 32.38  | 4.98    | 4.78 |
| +50   |      |        |      | 32.41  | 4.95    | 4.75 |
| 19    |      |        |      | 32.44  | 4.92    | 4.72 |
| +50   |      |        |      | 32.47  | 4.89    | 4.69 |
| 20    |      |        |      | 32.50  | 4.86    | 4.66 |
| +50   |      |        |      | 32.53  | 4.83    | 4.63 |
| T.D   | 1.18 | 937.59 | 0.95 | 936.41 |         |      |
| 21    |      |        |      | 32.56  | 5.03    | 4.83 |
| +50   |      |        |      | 32.59  | 5.00    | 4.80 |
| 22+0  |      |        |      | 32.62  | 4.97    | 4.77 |

Top Fire Hyd. 25' Lt. Jt. 16765

Top Fire Hyd.

937.59

22+50

~~32.65~~

32.65

4.94 4.71

23

32.68

4.91 4.71

+50

32.71

4.88 4.68

24

32.74

4.85 4.65

+50

32.77

4.82 4.62

25

32.80

4.79 4.59

+50

32.83

4.76 4.58

26

32.86

4.73 4.53

T.P.

4.73

937.79

4.53

933.06

4.50

933.29

U.S.G.S church yard.



Division St.

4th St. to N. City Limits.

A Lt.

A Rt.

Iron Mon.

4+34

R1 =  $\pm 5^{th}$  St.

0° 12' Rt

3+440

P.T.

17° 38'

19.16

+75

15° 15.4'

25° Lt.

3+0

12° 07.9'

 $\Delta 35^\circ 16'$ 

+75

9° 00.4'

T. 73.43

150

5° 52.9'

L. 141.06

75.19

+75

2° 45.4'

22.05 72.22

2+02.95

P.C.

0° 00'

0° 00'

0+00

 $\pm 4^{th}$  St.

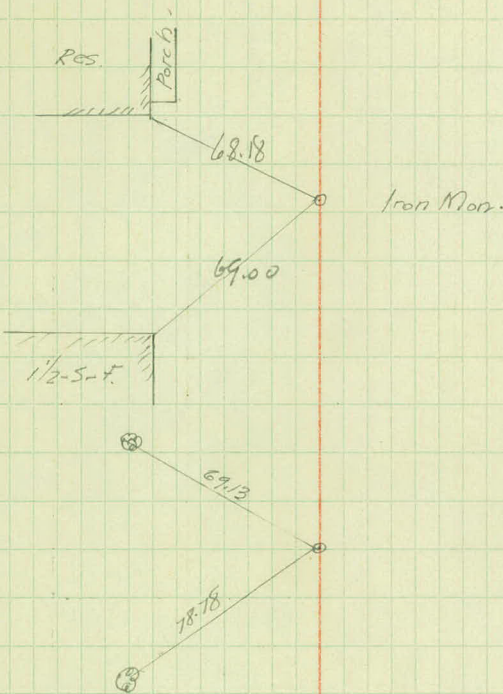
NT-6  
17.

46

W.H.C.  
Wilke  
Anter  
Hendrix

Aug. 7-1935

①



| Sta.       | +    | $\pi$  | -    | Grade |                        |
|------------|------|--------|------|-------|------------------------|
| B.M.       | 3.15 | 941.99 |      |       |                        |
| 0+18       |      |        |      | 38.3  | -0.70%                 |
| 0+50       |      |        |      | 38.25 |                        |
| 1+0        |      |        |      | 37.90 | ①                      |
| 1+50       |      |        |      | 37.60 |                        |
| 2+0        |      |        |      | 37.4  | V.C. 300'<br>H = 0.175 |
| +50        |      |        |      | 37.2  |                        |
| 3.         |      |        |      | 37.2  | ②                      |
| +44<br>+50 |      |        |      | 37.2  |                        |
| T.P.       | 4.30 | 941.71 | 4.58 |       |                        |
| 4+0        |      |        |      | 37.2  | 0.0%                   |
| +60        |      |        |      | 37.2  | ③                      |
| 5+0        |      |        |      | 37.2  |                        |

938.84- 37° Rt. Sta. 0465 N.W. Cor. sidewalk

G. Rod.

G. Rod

G. Rod.

$$\begin{array}{r} 3.34 \\ 19 \end{array}$$

$$3.74$$

$$\begin{array}{r} 3.81 \\ 19 \end{array}$$

$$\begin{array}{r} 4.09 \\ 19 \end{array}$$

$$\begin{array}{r} 3.89 \\ 19 \end{array}$$

$$\begin{array}{r} 3.69 \\ 30 \end{array}$$

$$\begin{array}{r} 4.19 \\ 19 \end{array}$$

$$\begin{array}{r} 4.39 \\ 19 \end{array}$$

$$\begin{array}{r} 4.19 \\ 19 \end{array}$$

$$\begin{array}{r} 3.99 \\ 30 \end{array}$$

$$\begin{array}{r} 4.39 \\ 19 \end{array}$$

$$\begin{array}{r} 4.59 \\ 19 \end{array}$$

$$\begin{array}{r} 4.39 \\ 19 \end{array}$$

$$\begin{array}{r} 4.19 \\ 30 \end{array}$$

$$\begin{array}{r} 4.59 \\ 19 \end{array}$$

$$\begin{array}{r} 4.79 \\ 19 \end{array}$$

$$\begin{array}{r} 4.59 \\ 19 \end{array}$$

$$\begin{array}{r} 4.39 \\ 30 \end{array}$$

$$\begin{array}{r} 4.59 \\ 19 \end{array}$$

$$\begin{array}{r} 4.79 \\ 19 \end{array}$$

$$\begin{array}{r} 4.59 \\ 19 \end{array}$$

$$\begin{array}{r} 4.39 \\ 30 \end{array}$$

$$\begin{array}{r} 4.59 \\ 19 \end{array}$$

$$4.79$$

$$\begin{array}{r} 4.59 \\ 19 \end{array}$$

$$\begin{array}{r} 4.39 \\ 30 \end{array}$$

937.41- Top Walk @ 5th

$$\begin{array}{r} 4.31 \\ 19 \end{array}$$

$$\begin{array}{r} 4.51 \\ 19 \end{array}$$

$$\begin{array}{r} 4.31 \\ 19 \end{array}$$

$$\begin{array}{r} 4.11 \\ 30 \end{array}$$

✓

$$\begin{array}{r} 4.51 \\ 19 \end{array}$$

✓

✓

✓

✓

✓

✓

| Sta. | +    | $\pi$  | -    | Grade |                        |
|------|------|--------|------|-------|------------------------|
|      |      | 941.71 |      |       |                        |
| 5+50 |      |        |      | 37.3  |                        |
| 6+0  |      |        |      | 37.3  |                        |
| +50  |      |        |      | 37.4  |                        |
| 7+0  |      |        |      | 37.5  |                        |
| T.D. | 4.25 | 941.95 | 4.01 |       | 10.20%                 |
| +50  |      |        |      | 37.6  |                        |
| 8    |      |        |      | 37.7  |                        |
| +50  |      |        |      | 37.75 |                        |
| 9    |      |        |      | 37.7  |                        |
| +50  |      |        |      | 37.65 | 900' V.C.<br>1150.1875 |
| 10   |      |        |      | 37.6  |                        |
| +50  |      |        |      | 37.45 |                        |
| 11   |      |        |      | 37.3  |                        |
| B.M. | 0.87 | 941.73 | 1.09 |       | -0.35%                 |

$$\begin{array}{r} 4.21 \\ 19 \end{array}$$

$$\begin{array}{r} 4.41 \\ 19 \end{array}$$

$$\begin{array}{r} 4.21 \\ 19 \end{array}$$

$$\begin{array}{r} 4.01 \\ 20 \end{array}$$

✓

$$\begin{array}{r} 4.41 \\ 19 \end{array}$$

✓

✓

$$\begin{array}{r} 4.11 \\ 19 \end{array}$$

$$\begin{array}{r} 4.31 \\ 19 \end{array}$$

$$\begin{array}{r} 4.11 \\ 19 \end{array}$$

$$\begin{array}{r} 3.91 \\ 20 \end{array}$$

$$\begin{array}{r} 4.01 \\ 19 \end{array}$$

$$\begin{array}{r} 4.21 \\ 19 \end{array}$$

$$\begin{array}{r} 4.01 \\ 19 \end{array}$$

$$\begin{array}{r} 3.81 \\ 20 \end{array}$$

937.70

$$\begin{array}{r} 4.15 \\ 19 \end{array}$$

$$\begin{array}{r} 4.35 \\ 19 \end{array}$$

$$\begin{array}{r} 4.15 \\ 19 \end{array}$$

$$\begin{array}{r} 3.95 \\ 20 \end{array}$$

$$\begin{array}{r} 4.05 \\ 19 \end{array}$$

$$\begin{array}{r} 4.25 \\ 19 \end{array}$$

$$\begin{array}{r} 4.05 \\ 19 \end{array}$$

$$3.85$$

$$\begin{array}{r} 4.00 \\ 19 \end{array}$$

$$\begin{array}{r} 4.20 \\ 19 \end{array}$$

$$\begin{array}{r} 4.00 \\ 19 \end{array}$$

$$3.80$$

$$\begin{array}{r} 4.05 \\ 19 \end{array}$$

$$\begin{array}{r} 4.25 \\ 19 \end{array}$$

$$\begin{array}{r} 4.05 \\ 19 \end{array}$$

$$3.85$$

$$\begin{array}{r} 4.10 \\ 19 \end{array}$$

$$\begin{array}{r} 4.30 \\ 19 \end{array}$$

$$\begin{array}{r} 4.10 \\ 19 \end{array}$$

$$3.90$$

$$\begin{array}{r} 4.15 \\ 19 \end{array}$$

$$\begin{array}{r} 4.35 \\ 19 \end{array}$$

$$\begin{array}{r} 4.15 \\ 19 \end{array}$$

$$3.95$$

$$4.3$$

$$4.50$$

$$4.30$$

$$\begin{array}{r} 4.1 \\ 19 \end{array}$$

$$\begin{array}{r} 4.45 \\ 19 \end{array}$$

$$\begin{array}{r} 4.65 \\ 19 \end{array}$$

$$\begin{array}{r} 4.45 \\ 19 \end{array}$$

$$\begin{array}{r} 4.25 \\ 20 \end{array}$$

120.86  
Top Fire Hyd

| Sta.     | +    | $\Sigma$ | -    | Grade  |
|----------|------|----------|------|--------|
|          |      | 941.73   |      |        |
| 11+50    |      |          |      | 37.15  |
| 12       |      |          |      | 37.0   |
| +50      |      |          |      | 36.85  |
| 13       |      |          |      | 36.7   |
| +50      |      |          |      | 36.6   |
| 14       |      |          |      | 36.5   |
| +50      |      |          |      | 36.4   |
| 15 14+90 |      |          |      | 36.35  |
| B.M.     | 1.87 | 941.62   | 1.98 | 939.75 |
| +50      |      |          |      | 36.4   |
| 16       |      |          |      | 36.4   |
| +50      |      |          |      | 36.45  |
| 17       |      |          |      | 36.5   |

-0.3%

400' V.C.  
M = 0.25

+0.2%

$$\begin{array}{r} 4.38 \\ 19 \end{array}$$

$$\begin{array}{r} 4.58 \\ 19 \end{array}$$

$$\begin{array}{r} 4.38 \\ 19 \end{array}$$

$$\begin{array}{r} 4.18 \\ 30 \end{array}$$

$$\begin{array}{r} 4.53 \\ 19 \end{array}$$

$$\begin{array}{r} 4.73 \\ 19 \end{array}$$

$$\begin{array}{r} 4.53 \\ 19 \end{array}$$

$$\begin{array}{r} 4.33 \\ 30 \end{array}$$

$$\begin{array}{r} 4.68 \\ 19 \end{array}$$

$$\begin{array}{r} 4.88 \\ 19 \end{array}$$

$$\begin{array}{r} 4.68 \\ 19 \end{array}$$

$$\begin{array}{r} 4.48 \\ 19 \end{array}$$

$$\begin{array}{r} 4.83 \\ 19 \end{array}$$

$$\begin{array}{r} 5.03 \\ 19 \end{array}$$

$$\begin{array}{r} 4.83 \\ 19 \end{array}$$

$$\begin{array}{r} 4.63 \\ 19 \end{array}$$

$$\begin{array}{r} 4.93 \\ 19 \end{array}$$

$$\begin{array}{r} 5.13 \\ 19 \end{array}$$

$$\begin{array}{r} 4.93 \\ 19 \end{array}$$

$$\begin{array}{r} 4.73 \\ 30 \end{array}$$

$$\begin{array}{r} 5.03 \\ 19 \end{array}$$

$$\begin{array}{r} 5.23 \\ 19 \end{array}$$

$$\begin{array}{r} 5.03 \\ 19 \end{array}$$

$$\begin{array}{r} 4.83 \\ 19 \end{array}$$

$$\begin{array}{r} 5.13 \\ 19 \end{array}$$

$$\begin{array}{r} 5.33 \\ 19 \end{array}$$

$$\begin{array}{r} 5.13 \\ 19 \end{array}$$

$$\begin{array}{r} 4.93 \\ 19 \end{array}$$

$$\begin{array}{r} 5.16 \\ 19 \end{array}$$

$$\begin{array}{r} 5.38 \\ 19 \end{array}$$

$$\begin{array}{r} 5.18 \\ 19 \end{array}$$

$$\begin{array}{r} 4.98 \\ 19 \end{array}$$

Top Fire Hyd. S.E. Cor. 8th & Div.

$$\begin{array}{r} 5.02 \\ 19 \end{array}$$

$$\begin{array}{r} 5.22 \\ 19 \end{array}$$

$$\begin{array}{r} 5.02 \\ 19 \end{array}$$

$$\begin{array}{r} 4.82 \\ 30 \end{array}$$

$$\begin{array}{r} 5.02 \\ 19 \end{array}$$

$$\begin{array}{r} 5.22 \\ 19 \end{array}$$

$$\begin{array}{r} 5.02 \\ 19 \end{array}$$

$$\begin{array}{r} 4.82 \\ 19 \end{array}$$

$$\begin{array}{r} 4.97 \\ 19 \end{array}$$

$$\begin{array}{r} 5.17 \\ 19 \end{array}$$

$$\begin{array}{r} 4.97 \\ 19 \end{array}$$

$$\begin{array}{r} 4.77 \\ 19 \end{array}$$

$$\begin{array}{r} 4.92 \\ 19 \end{array}$$

$$\begin{array}{r} 5.12 \\ 19 \end{array}$$

$$\begin{array}{r} 4.92 \\ 19 \end{array}$$

$$\begin{array}{r} 4.72 \\ 19 \end{array}$$

| Sta   | +    | $\pi$  | -    | Grade  |                        |
|-------|------|--------|------|--------|------------------------|
|       |      | 941.62 |      |        |                        |
| 17+50 |      |        |      | 36.6   |                        |
| 18    |      |        |      | 36.7   |                        |
| +50   |      |        |      | 36.8   |                        |
| 19    |      |        |      | 36.9   | 10.2%                  |
| +50   |      |        |      | 37.0   |                        |
| 20    |      |        |      | 37.1   |                        |
| T.P.  | 5.44 | 942.74 | 4.32 |        | 937.30                 |
| +50   |      |        |      | 37.2   |                        |
| 21    |      |        |      | 37.3   | ⊙                      |
| +50   |      |        |      | 37.4   |                        |
| 22    |      |        |      | 37.4   |                        |
| +50   |      |        |      | 37.3   | 200' V.C.<br>M = 0.125 |
| B.M.  | 2.01 | 941.56 | 3.19 | 939.55 |                        |
| 23    |      |        |      | 37.2   | ⊙                      |
|       |      |        |      |        | -0.37%                 |

|                   |                   |             |                   |                   |
|-------------------|-------------------|-------------|-------------------|-------------------|
|                   | <u>4.82</u>       | 5.02        | <u>4.82</u>       | 4.62              |
| <u>4.52</u><br>30 | <u>4.72</u><br>19 | 4.92        | <u>4.72</u><br>19 | <u>4.52</u><br>30 |
| <u>4.42</u>       | 4.62              | <u>4.82</u> | 4.62              | 4.42              |
| <u>4.32</u>       | <u>4.52</u>       | <u>4.72</u> | <u>4.52</u>       | <u>4.32</u>       |
| <u>4.22</u>       | <u>4.42</u>       | 4.62        | 4.42              | <u>4.22</u>       |
| <u>4.12</u>       | <u>4.32</u>       | 4.52        | <u>4.32</u>       | <u>4.12</u>       |
| <u>5.14</u>       | <u>5.34</u>       | 5.54        | <u>5.34</u>       | <u>5.14</u>       |
| <u>5.04</u>       | <u>5.24</u>       | 5.44        | <u>5.24</u>       | <u>5.04</u>       |
| <u>4.94</u>       | 5.14              | <u>5.34</u> | <u>5.14</u>       | <u>4.94</u>       |
| <u>4.94</u><br>30 | <u>5.14</u><br>19 | 5.34        | <u>5.14</u><br>19 | <u>4.94</u><br>30 |
| <u>5.04</u>       | 5.24              | 5.44        | <u>5.24</u>       | <u>5.04</u>       |

Top Fire Hyd Rt. 22+

|             |             |      |             |      |
|-------------|-------------|------|-------------|------|
| <u>3.96</u> | <u>4.16</u> | 4.36 | <u>4.16</u> | 3.96 |
|-------------|-------------|------|-------------|------|

941.56

23+50

37.1

24

36.9

-0.3%

+40  
+50

36.8

25

36.6

①

+50

36.5

26

36.3

200' V.O.  
M = 0.138

+50

36.3

27

36.3

T.P.

522

941.71

5.07

936.49

+50

36.4

①

28

36.5

+50

36.6

+0.25%

29

36.8

$$\begin{array}{r} 4.06 \\ \hline 30 \end{array}$$

$$\begin{array}{r} 4.26 \\ \hline 19 \end{array}$$

$$4.46$$

$$\begin{array}{r} 4.26 \\ \hline 19 \end{array}$$

$$\begin{array}{r} 4.06 \\ \hline 30 \end{array}$$

$$\begin{array}{r} 4.76 \\ \hline \end{array}$$

$$\begin{array}{r} 4.46 \\ \hline \end{array}$$

$$4.66$$

$$\begin{array}{r} 4.46 \\ \hline \end{array}$$

$$\begin{array}{r} 4.26 \\ \hline \end{array}$$

$$\begin{array}{r} 4.86 \\ \hline \end{array}$$

$$\begin{array}{r} 4.56 \\ \hline \end{array}$$

$$4.76$$

$$\begin{array}{r} 4.56 \\ \hline \end{array}$$

$$\begin{array}{r} 4.36 \\ \hline \end{array}$$

$$\begin{array}{r} 4.86 \\ \hline \end{array}$$

$$\begin{array}{r} 4.76 \\ \hline \end{array}$$

$$4.96$$

$$\begin{array}{r} 4.76 \\ \hline \end{array}$$

$$\begin{array}{r} 4.56 \\ \hline \end{array}$$

$$4.66$$

$$4.86$$

$$5.06$$

$$\begin{array}{r} 4.86 \\ \hline \end{array}$$

$$4.66$$

$$\begin{array}{r} 4.86 \\ \hline \end{array}$$

$$\begin{array}{r} 5.06 \\ \hline \end{array}$$

$$5.26$$

$$5.06$$

$$4.86$$

$$\begin{array}{r} 4.86 \\ \hline \end{array}$$

$$\begin{array}{r} 5.06 \\ \hline \end{array}$$

$$5.26$$

$$\begin{array}{r} 5.06 \\ \hline \end{array}$$

$$4.86$$

$$\begin{array}{r} 4.86 \\ \hline \end{array}$$

$$\begin{array}{r} 5.06 \\ \hline \end{array}$$

$$5.26$$

$$\begin{array}{r} 5.06 \\ \hline \end{array}$$

$$\begin{array}{r} 4.86 \\ \hline \end{array}$$

$$\begin{array}{r} 4.91 \\ \hline 30 \end{array}$$

$$\begin{array}{r} 5.11 \\ \hline 19 \end{array}$$

$$5.31$$

$$\begin{array}{r} 5.11 \\ \hline 19 \end{array}$$

$$\begin{array}{r} 4.91 \\ \hline 30 \end{array}$$

$$\begin{array}{r} 4.81 \\ \hline \end{array}$$

$$\begin{array}{r} 5.01 \\ \hline \end{array}$$

$$5.21$$

$$\begin{array}{r} 5.01 \\ \hline \end{array}$$

$$4.81$$

$$\begin{array}{r} 4.71 \\ \hline \end{array}$$

$$\begin{array}{r} 4.91 \\ \hline \end{array}$$

$$5.11$$

$$\begin{array}{r} 4.91 \\ \hline \end{array}$$

$$4.71$$

$$\begin{array}{r} 4.51 \\ \hline \end{array}$$

$$\begin{array}{r} 4.71 \\ \hline \end{array}$$

$$4.91$$

$$\begin{array}{r} 4.71 \\ \hline \end{array}$$

$$4.51$$

941.71

79+50

36.9

30

37.0

+50

37.2

21+00

37.3

B.M.

131

940.40

W.H.C.  
Wilke Aug. 8-1935 52  
Parker  
Hendrix Finish

4.41  
30

4.61  
19

4.81

4.61  
19

4.41  
30

4.31

4.51

4.71

4.51

4.31

4.11

4.31

4.51

4.31

4.11

4.01

4.21

4.41

4.21

4.01

Top Fire Hydrant. Rt. Sta. 30+



Storm Sewer 5th St.  
Bald Eagle Ave to Div. St.

| Sta.                        | T    | A              | Rod                | Elev.  | Grade  |
|-----------------------------|------|----------------|--------------------|--------|--------|
| B.M.                        | 2.82 | 939.80         |                    | 936.98 |        |
| 0+00 = 2 M.H. FA Line Sewer |      |                | 11.12              |        | 928.68 |
| 0+00                        |      |                | 6.14               | 33.66  | 928.68 |
| 0+50                        |      |                | 5.80               | 934.0  | 928.78 |
| 1+0                         |      |                | 5.93               | 33.87  | 928.88 |
| 1+50                        |      |                | 5.47               | 34.33  | 28.98  |
| 2+0                         |      |                | 4.63               | 35.17  | 29.08  |
| 2+50                        |      |                | 4.26               | 35.54  | 29.18  |
| 3+0                         |      |                | 4.30               | 35.50  | 29.28  |
| 3+50                        |      |                | 4.48               | 35.32  | 29.38  |
| 3+90                        |      |                | 4.20               | 35.60  | 29.46  |
| 4+50                        |      |                | 4.20               | 35.60  | 29.58  |
| 5+0                         | 5.51 | H.I.<br>941.28 | 4.03 <sup>70</sup> | 35.77  | 29.68  |
| 5+50                        |      |                | 5.32               | 35.96  | 29.78  |
| 6+10                        |      |                | 4.28               | 37.00  | 29.90  |
| 6+50                        |      |                | 4.55               | 36.73  | 29.98  |
| 7+0                         |      |                | 4.59               | 36.69  | 30.08  |
| 7+50                        |      |                | 4.41               | 36.87  | 30.18  |
| 8+0                         |      |                | 4.40               | 36.88  | 30.28  |
| 8+50                        |      |                | 4.67               | 36.61  | 30.38  |
| 9+0                         |      |                | 4.66               | 36.62  | 30.48  |
| 9+50                        | 5.12 | 40.51          | 5.89               | 35.39  | 30.58  |

Out.

W.H.C.

H.A.W.

K.A.

L.P.

Sept. 3, 1935

4.98 ✓

5.22 ✓

4.99 ✓

5.35 ✓

6.09 ✓

6.36 ✓

6.22 ✓

5.94 ✓

6.14 ✓

6.02 ✓

6.09 ✓

6.18 ✓

7.10 ✓

6.75 ✓

6.61 ✓

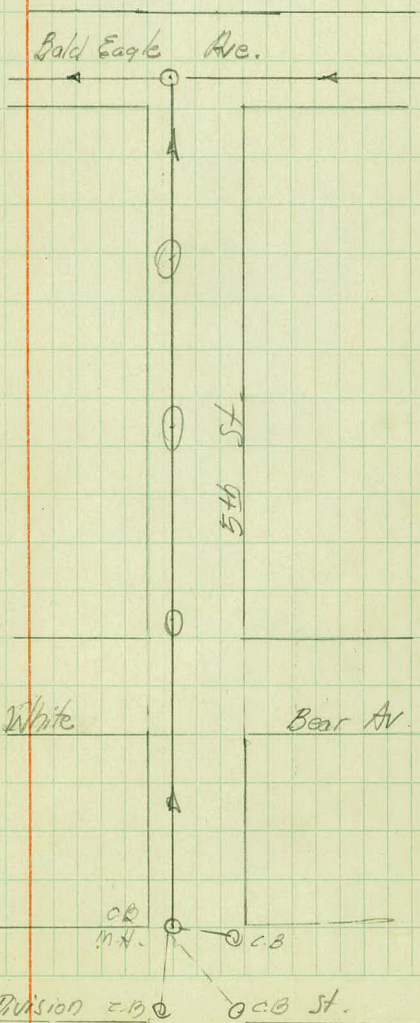
6.69 ✓

6.60 ✓

6.23 ✓

6.14 ✓

4.81 ✓





5.37<sup>✓</sup>5.22<sup>✓</sup>5.12<sup>✓</sup>4.86<sup>✓</sup>5.60<sup>✓</sup>5.98<sup>✓</sup>5.91<sup>✓</sup>

6.07



Storm Sewer 8<sup>th</sup> Str.  
White Bear Av. to Div. Str.



W.H.C.  
H.A.W.  
K.A.  
L.B.H.

9/10/35

57

Cot.

36.4  
1.8  
35.6

36.3  
1.8  
35.5

40.54  
3.76  
49.4

40.54  
35.5  
5.04

3.77

Div. Str.

4.72

Grate 35.6 19.5' 35.5-Grate  
32.8  
2.7

4.71

Grate 35.6 32.5' 35.5-Grate  
32.7  
2.8

4.23

4.35

4.36

4.38

4.35

3.84

3.29

19.5'

⊥

8th St.

15' ⊙ →

White Bear Ave.

# X. Sections to Determine Drainage

| Sta.  | +    | $\pi$  | -    | Elev   |
|-------|------|--------|------|--------|
|       |      | 940.91 |      |        |
| 28+00 |      |        |      | 36.5   |
| 27+50 |      |        |      | 36.4   |
| 27+0  |      |        |      | 36.3   |
| I.P.  | 3.08 | 941.44 | 3.55 | 938.36 |
| 26+50 |      |        |      | 36.3   |
| 26+00 |      |        |      | 36.3   |

H.

L

Rt.

| Finished          |                   |                  | Ground            |                   |                   |
|-------------------|-------------------|------------------|-------------------|-------------------|-------------------|
| $\frac{5.01}{30}$ | $\frac{5.21}{19}$ | $\frac{5.41}{0}$ | $\frac{5.21}{19}$ | $\frac{5.01}{30}$ | $\frac{6.24}{40}$ |
|                   |                   |                  |                   |                   | $\frac{6.2}{80}$  |
|                   |                   |                  |                   |                   | $\frac{6.4}{130}$ |

- Ground -

|                   |                  |                  |                   |                   |                  |                   |                   |                  |                  |                   |
|-------------------|------------------|------------------|-------------------|-------------------|------------------|-------------------|-------------------|------------------|------------------|-------------------|
| $\frac{6.5}{130}$ | $\frac{6.5}{80}$ | $\frac{6.0}{30}$ | $\frac{5.11}{30}$ | $\frac{5.31}{19}$ | $\frac{5.51}{0}$ | $\frac{5.31}{19}$ | $\frac{5.11}{30}$ | $\frac{6.2}{40}$ | $\frac{6.7}{80}$ | $\frac{6.7}{130}$ |
|-------------------|------------------|------------------|-------------------|-------------------|------------------|-------------------|-------------------|------------------|------------------|-------------------|

|                   |                  |                  |                   |                   |                  |                   |                   |                  |                  |                  |                   |
|-------------------|------------------|------------------|-------------------|-------------------|------------------|-------------------|-------------------|------------------|------------------|------------------|-------------------|
| $\frac{6.7}{130}$ | $\frac{6.6}{80}$ | $\frac{6.1}{30}$ | $\frac{5.21}{30}$ | $\frac{5.41}{19}$ | $\frac{5.61}{0}$ | $\frac{5.41}{19}$ | $\frac{5.21}{30}$ | $\frac{344}{30}$ | $\frac{6.5}{30}$ | $\frac{7.0}{80}$ | $\frac{7.0}{130}$ |
|-------------------|------------------|------------------|-------------------|-------------------|------------------|-------------------|-------------------|------------------|------------------|------------------|-------------------|

|                   |                  |                  |                   |                   |                  |                   |                   |                   |                  |                  |                   |
|-------------------|------------------|------------------|-------------------|-------------------|------------------|-------------------|-------------------|-------------------|------------------|------------------|-------------------|
| $\frac{6.4}{130}$ | $\frac{6.3}{80}$ | $\frac{5.8}{30}$ | $\frac{4.74}{30}$ | $\frac{4.94}{19}$ | $\frac{5.14}{0}$ | $\frac{4.94}{19}$ | $\frac{4.74}{30}$ | $\frac{35.2}{30}$ | $\frac{6.2}{30}$ | $\frac{6.9}{80}$ | $\frac{7.1}{130}$ |
|-------------------|------------------|------------------|-------------------|-------------------|------------------|-------------------|-------------------|-------------------|------------------|------------------|-------------------|

|                   |                  |                  |                   |                   |                  |                   |                   |                  |                  |                   |
|-------------------|------------------|------------------|-------------------|-------------------|------------------|-------------------|-------------------|------------------|------------------|-------------------|
| $\frac{6.4}{130}$ | $\frac{6.3}{80}$ | $\frac{5.9}{30}$ | $\frac{4.94}{30}$ | $\frac{4.94}{19}$ | $\frac{5.14}{0}$ | $\frac{4.94}{13}$ | $\frac{4.74}{30}$ | $\frac{5.7}{30}$ | $\frac{5.6}{80}$ | $\frac{6.0}{130}$ |
|-------------------|------------------|------------------|-------------------|-------------------|------------------|-------------------|-------------------|------------------|------------------|-------------------|



# KEITH'S RAILROAD CURVE TABLES.

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## HOW TO USE KEITH'S TABLES.

### EXAMPLE.

Wanted a Curve with an Ext. of about 12 ft. Angle  
of Intersection or I. P.= $23^{\circ} 20'$  to the R. at Station  
542+72.

Ext. in Tab. IV opposite  $23^{\circ} 20' = 120.87$

$120.87 \div 12 = 10.07$ . Say a  $10^{\circ}$  Curve.

Tan. in Tab. IV opp.  $23^{\circ} 20' = 118.1$

$118.1 \div 10 = 11.81$ .

Tab. V. correction for A.  $23^{\circ} 20'$  for a  $10^{\circ}$  Cur.=0.16

$11.81 + 0.16 = 11.97 = \text{corrected Tangent.}$

(If corrected Ext. is required find in same way)

Ang.  $23^{\circ} 20' = 23.33^{\circ} \div 10 = 2.3333 = \text{L. C.}$

|                                                   |       |            |           |
|---------------------------------------------------|-------|------------|-----------|
| $2^{\circ} 19\frac{1}{2}' = \text{def. for sta.}$ | 543   | I. P.=sta. | 542+72    |
| $4^{\circ} 49\frac{1}{2}' = \text{" " "}$         | +50   | Tan.=      | 1.18.47   |
| $7^{\circ} 19\frac{1}{2}' = \text{" " "}$         | 543   | B. C.=sta. | 541+53.53 |
| $9^{\circ} 49\frac{1}{2}' = \text{" " "}$         | +50   | L. C.=     | 2 33.33   |
| $11^{\circ} 40' = \text{" " "}$                   | 543+  | E. C.=sta. | 543+86.86 |
|                                                   | 86.86 |            |           |

$100 - 53.53 = 46.47 \times 3' (\text{def. for 1 ft. of } 10^{\circ} \text{ Cur.}) = 139.41' =$   
 $2^{\circ} 19\frac{1}{2}' = \text{def. for sta. 542.}$

Def. for 50 ft.= $2^{\circ} 30'$  for a  $10^{\circ}$  Curve.

Def. for 36.86 ft.= $1^{\circ} 50\frac{1}{2}'$  for a  $10^{\circ}$  Curve

(These tables are published in Field Books of  
KEUFFEL & ESSER Co., New York, N. Y.)

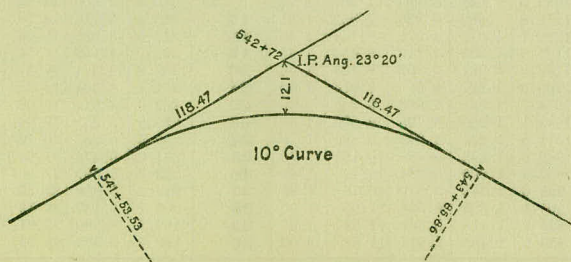


TABLE I. — Minutes in Decimals of a Degree.

|    |       |     |       |     |       |     |       |     |       |     |        |
|----|-------|-----|-------|-----|-------|-----|-------|-----|-------|-----|--------|
| 1' | .0167 | 11' | .1833 | 21' | .3500 | 31' | .5167 | 41' | .6833 | 51' | .8500  |
| 2  | .0333 | 12  | .2000 | 22  | .3667 | 32  | .5333 | 42  | .7000 | 52  | .8667  |
| 3  | .0500 | 13  | .2167 | 23  | .3833 | 33  | .5500 | 43  | .7167 | 53  | .8833  |
| 4  | .0667 | 14  | .2333 | 24  | .4000 | 34  | .5667 | 44  | .7333 | 54  | .9000  |
| 5  | .0833 | 15  | .2500 | 25  | .4167 | 35  | .5833 | 45  | .7500 | 55  | .9167  |
| 6  | .1000 | 16  | .2667 | 26  | .4333 | 36  | .6000 | 46  | .7667 | 56  | .9333  |
| 7  | .1167 | 17  | .2833 | 27  | .4500 | 37  | .6167 | 47  | .7833 | 57  | .9500  |
| 8  | .1333 | 18  | .3000 | 28  | .4667 | 38  | .6333 | 48  | .8000 | 58  | .9667  |
| 9  | .1500 | 19  | .3167 | 29  | .4833 | 39  | .6500 | 49  | .8167 | 59  | .9833  |
| 10 | .1667 | 20  | .3333 | 30  | .5000 | 40  | .6667 | 50  | .8333 | 60  | 1.0000 |

TABLE II. — Inches in Decimals of a Foot.

|       |       |               |       |               |       |               |               |               |               |               |
|-------|-------|---------------|-------|---------------|-------|---------------|---------------|---------------|---------------|---------------|
| 1-16  | 3-32  | $\frac{1}{8}$ | 3-16  | $\frac{1}{4}$ | 5-16  | $\frac{3}{8}$ | $\frac{1}{2}$ | $\frac{5}{8}$ | $\frac{3}{4}$ | $\frac{7}{8}$ |
| .0052 | .0078 | .0104         | .0156 | .0208         | .0260 | .0313         | .0417         | .0521         | .0625         | .0729         |
| 1     | 2     | 3             | 4     | 5             | 6     | 7             | 8             | 9             | 10            | 11            |
| .0833 | .1667 | .2500         | .3333 | .4167         | .5000 | .5833         | .6667         | .7500         | .8333         | .9167         |

TABLE III. — Radii, Ordinates and Deflections.

| Deg.   | Radius | Mid. Ord. | Tan. Def. | Chd. Def. | Def. for 1 Foot | Deg. | Radius | Mid. Ord. | Tan. Def. | Chd. Def. | Def. for 1 Foot |
|--------|--------|-----------|-----------|-----------|-----------------|------|--------|-----------|-----------|-----------|-----------------|
| 0° 10' | 34377. | .036      | .145      | .291      | 0.05'           | 7°   | 819.0  | 1.528     | 6.105     | 12.21     | 2.10'           |
| 20     | 17189. | .073      | .291      | .582      | 0.10            | 20'  | 781.8  | 1.600     | 6.395     | 12.79     | 2.20            |
| 30     | 11459. | .109      | .436      | .873      | 0.15            | 30   | 764.5  | 1.637     | 6.540     | 13.08     | 2.25            |
| 40     | 8594.4 | .145      | .582      | 1.164     | 0.20            | 40   | 747.9  | 1.673     | 6.685     | 13.37     | 2.30            |
| 50     | 6875.5 | .182      | .727      | 1.454     | 0.25            | 8    | 716.8  | 1.746     | 6.976     | 13.95     | 2.40            |
| 1      | 5729.6 | .218      | .873      | 1.745     | 0.30            | 20   | 688.2  | 1.819     | 7.266     | 14.53     | 2.50            |
| 10     | 4911.2 | .255      | 1.018     | 2.036     | 0.35            | 30   | 674.7  | 1.855     | 7.411     | 14.82     | 2.55            |
| 20     | 4297.3 | .291      | 1.164     | 2.327     | 0.40            | 40   | 661.7  | 1.892     | 7.556     | 15.11     | 2.60            |
| 30     | 3819.8 | .327      | 1.309     | 2.618     | 0.45            | 9    | 637.3  | 1.965     | 7.846     | 15.69     | 2.70            |
| 40     | 3437.9 | .364      | 1.454     | 2.909     | 0.50            | 20   | 614.6  | 2.037     | 8.136     | 16.27     | 2.80            |
| 50     | 3125.4 | .400      | 1.600     | 3.200     | 0.55            | 30   | 603.8  | 2.074     | 8.281     | 16.56     | 2.85            |
| 2      | 2864.9 | .436      | 1.745     | 3.490     | 0.60            | 40   | 593.4  | 2.110     | 8.426     | 16.85     | 2.90            |
| 10     | 2644.6 | .473      | 1.891     | 3.781     | 0.65            | 10   | 573.7  | 2.183     | 8.716     | 17.43     | 3.00            |
| 20     | 2455.7 | .509      | 2.036     | 4.072     | 0.70            | 30   | 546.4  | 2.292     | 9.150     | 18.30     | 3.15            |
| 30     | 2292.0 | .545      | 2.181     | 4.363     | 0.75            | 11   | 521.7  | 2.402     | 9.585     | 19.16     | 3.30            |
| 40     | 2148.8 | .582      | 2.327     | 4.654     | 0.80            | 30   | 499.1  | 2.511     | 10.02     | 20.04     | 3.45            |
| 50     | 2022.4 | .618      | 2.472     | 4.945     | 0.85            | 12   | 478.3  | 2.620     | 10.45     | 20.91     | 3.60            |
| 3      | 1910.1 | .655      | 2.618     | 5.235     | 0.90            | 30   | 459.3  | 2.730     | 10.89     | 21.77     | 3.75            |
| 10     | 1809.6 | .691      | 2.763     | 5.526     | 0.95            | 13   | 441.7  | 2.839     | 11.32     | 22.64     | 3.90            |
| 20     | 1719.1 | .727      | 2.908     | 5.817     | 1.00            | 30   | 425.4  | 2.949     | 11.75     | 23.51     | 4.05            |
| 30     | 1637.3 | .764      | 3.054     | 6.108     | 1.05            | 14   | 410.3  | 3.058     | 12.18     | 24.37     | 4.20            |
| 40     | 1562.9 | .800      | 3.199     | 6.398     | 1.10            | 30   | 396.2  | 3.168     | 12.62     | 25.24     | 4.35            |
| 50     | 1495.0 | .836      | 3.345     | 6.689     | 1.15            | 15   | 383.1  | 3.277     | 13.05     | 26.11     | 4.50            |
| 4      | 1432.7 | .873      | 3.490     | 6.980     | 1.20            | 30   | 370.8  | 3.387     | 13.49     | 26.97     | 4.65            |
| 10     | 1375.4 | .909      | 3.635     | 7.271     | 1.25            | 16   | 359.3  | 3.496     | 13.92     | 27.84     | 4.80            |
| 20     | 1322.5 | .945      | 3.781     | 7.561     | 1.30            | 30   | 348.5  | 3.606     | 14.35     | 28.70     | 4.95            |
| 30     | 1273.6 | .982      | 3.926     | 7.852     | 1.35            | 17   | 338.3  | 3.716     | 14.78     | 29.56     | 5.10            |
| 40     | 1228.1 | 1.018     | 4.071     | 8.143     | 1.40            | 18   | 319.6  | 3.935     | 15.64     | 31.29     | 5.40            |
| 50     | 1185.8 | 1.055     | 4.217     | 8.433     | 1.45            | 19   | 302.9  | 4.155     | 16.51     | 33.01     | 5.70            |
| 5      | 1146.3 | 1.091     | 4.362     | 8.724     | 1.50            | 20   | 287.9  | 4.374     | 17.37     | 34.73     | 6.00            |
| 10     | 1109.3 | 1.127     | 4.507     | 9.014     | 1.55            | 21   | 274.4  | 4.594     | 18.22     | 36.44     | 6.30            |
| 20     | 1074.7 | 1.164     | 4.653     | 9.305     | 1.60            | 22   | 262.0  | 4.814     | 19.08     | 38.16     | 6.60            |
| 30     | 1042.1 | 1.200     | 4.798     | 9.596     | 1.65            | 23   | 250.8  | 5.035     | 19.94     | 39.87     | 6.90            |
| 40     | 1011.5 | 1.237     | 4.943     | 9.886     | 1.70            | 24   | 240.5  | 5.255     | 20.79     | 41.58     | 7.20            |
| 50     | 982.6  | 1.273     | 5.088     | 10.18     | 1.75            | 25   | 231.0  | 5.476     | 21.64     | 43.28     | 7.50            |
| 6      | 955.4  | 1.309     | 5.234     | 10.47     | 1.80            | 26   | 222.3  | 5.697     | 22.50     | 44.99     | 7.80            |
| 10     | 929.6  | 1.346     | 5.379     | 10.76     | 1.85            | 27   | 214.2  | 5.918     | 23.35     | 46.69     | 8.10            |
| 20     | 905.1  | 1.382     | 5.524     | 11.05     | 1.90            | 28   | 206.7  | 6.139     | 24.19     | 48.38     | 8.40            |
| 30     | 881.9  | 1.418     | 5.669     | 11.34     | 1.95            | 29   | 199.7  | 6.360     | 25.04     | 50.07     | 8.70            |
| 40     | 859.9  | 1.455     | 5.814     | 11.63     | 2.00            | 30   | 193.2  | 6.583     | 25.88     | 51.76     | 9.00            |

TABLE IV. — Tangents and Externals to a 1° Curve.

| Angle     | Tangent | External | Angle      | Tangent | External | Angle      | Tangent | External |
|-----------|---------|----------|------------|---------|----------|------------|---------|----------|
| <b>1°</b> | 50.00   | .22      | <b>11°</b> | 551.70  | 26.50    | <b>21°</b> | 1061.9  | 97.57    |
| 10'       | 58.34   | .30      | 10'        | 560.11  | 27.31    | 10'        | 1070.6  | 99.16    |
| 20        | 66.67   | .39      | 20         | 568.53  | 28.14    | 20         | 1079.2  | 100.75   |
| 30        | 75.01   | .49      | 30         | 576.95  | 28.97    | 30         | 1087.8  | 102.35   |
| 40        | 83.34   | .61      | 40         | 585.36  | 29.82    | 40         | 1096.4  | 103.97   |
| 50        | 91.68   | .73      | 50         | 593.79  | 30.68    | 50         | 1105.1  | 105.60   |
| <b>2</b>  | 100.01  | .87      | <b>12</b>  | 602.21  | 31.56    | <b>22</b>  | 1113.7  | 107.24   |
| 10        | 108.35  | 1.02     | 10         | 610.64  | 32.45    | 10         | 1122.4  | 108.90   |
| 20        | 116.68  | 1.19     | 20         | 619.07  | 33.35    | 20         | 1131.0  | 110.57   |
| 30        | 125.02  | 1.36     | 30         | 627.50  | 34.26    | 30         | 1139.7  | 112.25   |
| 40        | 133.36  | 1.55     | 40         | 635.93  | 35.18    | 40         | 1148.4  | 113.95   |
| 50        | 141.70  | 1.75     | 50         | 644.37  | 36.12    | 50         | 1157.0  | 115.66   |
| <b>3</b>  | 150.04  | 1.96     | <b>13</b>  | 652.81  | 37.07    | <b>23</b>  | 1165.7  | 117.38   |
| 10        | 158.38  | 2.19     | 10         | 661.25  | 38.03    | 10         | 1174.4  | 119.12   |
| 20        | 166.72  | 2.43     | 20         | 669.70  | 39.01    | 20         | 1183.1  | 120.87   |
| 30        | 175.06  | 2.67     | 30         | 678.15  | 39.99    | 30         | 1191.8  | 122.63   |
| 40        | 183.40  | 2.93     | 40         | 686.60  | 40.99    | 40         | 1200.5  | 124.41   |
| 50        | 191.74  | 3.21     | 50         | 695.06  | 42.00    | 50         | 1209.2  | 126.20   |
| <b>4</b>  | 200.08  | 3.49     | <b>14</b>  | 703.51  | 43.03    | <b>24</b>  | 1217.9  | 128.00   |
| 10        | 208.43  | 3.79     | 10         | 711.97  | 44.07    | 10         | 1226.6  | 129.82   |
| 20        | 216.77  | 4.10     | 20         | 720.44  | 45.12    | 20         | 1235.3  | 131.65   |
| 30        | 225.12  | 4.42     | 30         | 728.90  | 46.18    | 30         | 1244.0  | 133.50   |
| 40        | 233.47  | 4.76     | 40         | 737.37  | 47.25    | 40         | 1252.8  | 135.35   |
| 50        | 241.81  | 5.10     | 50         | 745.85  | 48.34    | 50         | 1261.5  | 137.23   |
| <b>5</b>  | 250.16  | 5.46     | <b>15</b>  | 754.32  | 49.44    | <b>25</b>  | 1270.2  | 139.11   |
| 10        | 258.51  | 5.83     | 10         | 762.80  | 50.55    | 10         | 1279.0  | 141.01   |
| 20        | 266.86  | 6.21     | 20         | 771.29  | 51.68    | 20         | 1287.7  | 142.93   |
| 30        | 275.21  | 6.61     | 30         | 779.77  | 52.89    | 30         | 1296.5  | 144.85   |
| 40        | 283.57  | 7.01     | 40         | 788.26  | 53.97    | 40         | 1305.3  | 146.79   |
| 50        | 291.92  | 7.43     | 50         | 796.75  | 55.13    | 50         | 1314.0  | 148.75   |
| <b>6</b>  | 300.28  | 7.86     | <b>16</b>  | 805.25  | 56.31    | <b>26</b>  | 1322.8  | 150.71   |
| 10        | 308.64  | 8.31     | 10         | 813.75  | 57.50    | 10         | 1331.6  | 152.69   |
| 20        | 316.99  | 8.76     | 20         | 822.25  | 58.70    | 20         | 1340.4  | 154.69   |
| 30        | 325.35  | 9.23     | 30         | 830.76  | 59.91    | 30         | 1349.2  | 156.70   |
| 40        | 333.71  | 9.71     | 40         | 839.27  | 61.14    | 40         | 1358.0  | 158.72   |
| 50        | 342.08  | 10.20    | 50         | 847.78  | 62.38    | 50         | 1366.8  | 160.76   |
| <b>7</b>  | 350.44  | 10.71    | <b>17</b>  | 856.30  | 63.63    | <b>27</b>  | 1375.6  | 162.81   |
| 10        | 358.81  | 11.22    | 10         | 864.82  | 64.90    | 10         | 1384.4  | 164.86   |
| 20        | 367.17  | 11.75    | 20         | 873.35  | 66.18    | 20         | 1393.2  | 166.95   |
| 30        | 375.54  | 12.29    | 30         | 881.88  | 67.47    | 30         | 1402.0  | 169.04   |
| 40        | 383.91  | 12.85    | 40         | 890.41  | 68.77    | 40         | 1410.9  | 171.15   |
| 50        | 392.28  | 13.41    | 50         | 898.95  | 70.09    | 50         | 1419.7  | 173.27   |
| <b>8</b>  | 400.66  | 13.99    | <b>18</b>  | 907.49  | 71.42    | <b>28</b>  | 1428.6  | 175.41   |
| 10        | 409.03  | 14.58    | 10         | 916.03  | 72.76    | 10         | 1437.4  | 177.55   |
| 20        | 417.41  | 15.18    | 20         | 924.58  | 74.12    | 20         | 1446.3  | 179.72   |
| 30        | 425.79  | 15.80    | 30         | 933.13  | 75.49    | 30         | 1455.1  | 181.89   |
| 40        | 434.17  | 16.43    | 40         | 941.69  | 76.86    | 40         | 1464.0  | 184.08   |
| 50        | 442.55  | 17.07    | 50         | 950.25  | 78.26    | 50         | 1472.9  | 186.29   |
| <b>9</b>  | 450.93  | 17.72    | <b>19</b>  | 958.81  | 79.67    | <b>29</b>  | 1481.8  | 188.51   |
| 10        | 459.32  | 18.38    | 10         | 967.38  | 81.09    | 10         | 1490.7  | 190.74   |
| 20        | 467.71  | 19.06    | 20         | 975.96  | 82.53    | 20         | 1499.6  | 192.99   |
| 30        | 476.10  | 19.75    | 30         | 984.53  | 83.97    | 30         | 1508.5  | 195.25   |
| 40        | 484.49  | 20.45    | 40         | 993.12  | 85.43    | 40         | 1517.4  | 197.53   |
| 50        | 492.88  | 21.16    | 50         | 1001.7  | 86.90    | 50         | 1526.3  | 199.82   |
| <b>10</b> | 501.28  | 21.89    | <b>20</b>  | 1010.3  | 88.39    | <b>30</b>  | 1535.3  | 202.12   |
| 10        | 509.68  | 22.62    | 10         | 1018.9  | 89.89    | 10         | 1544.2  | 204.44   |
| 20        | 518.08  | 23.38    | 20         | 1027.5  | 91.40    | 20         | 1553.1  | 206.77   |
| 30        | 526.48  | 24.14    | 30         | 1036.1  | 92.92    | 30         | 1562.1  | 209.12   |
| 40        | 534.89  | 24.91    | 40         | 1044.7  | 94.46    | 40         | 1571.0  | 211.48   |
| 50        | 543.29  | 25.70    | 50         | 1053.3  | 96.01    | 50         | 1580.0  | 213.86   |

TABLE IV. — Tangents and Externals to a 1° Curve.

| Angle      | Tangent | External | Angle      | Tangent | External | Angle      | Tangent | External |
|------------|---------|----------|------------|---------|----------|------------|---------|----------|
| <b>31°</b> | 1589.0  | 216.3    | <b>41°</b> | 2142.2  | 387.4    | <b>51°</b> | 2732.9  | 618.4    |
| 10'        | 1598.0  | 218.7    | 10'        | 2151.7  | 390.7    | 10'        | 2743.1  | 622.8    |
| 20         | 1606.9  | 221.1    | 20         | 2161.2  | 394.1    | 20         | 2753.4  | 627.2    |
| 30         | 1615.9  | 223.5    | 30         | 2170.8  | 397.4    | 30         | 2763.7  | 631.7    |
| 40         | 1624.9  | 226.0    | 40         | 2180.3  | 400.8    | 40         | 2773.9  | 636.2    |
| 50         | 1633.9  | 228.4    | 50         | 2189.9  | 404.2    | 50         | 2784.2  | 640.7    |
| <b>32</b>  | 1643.0  | 230.9    | <b>42</b>  | 2199.4  | 407.6    | <b>52</b>  | 2794.5  | 645.2    |
| 10         | 1652.0  | 233.4    | 10         | 2209.0  | 411.1    | 10         | 2804.9  | 649.7    |
| 20         | 1661.0  | 235.9    | 20         | 2218.6  | 414.5    | 20         | 2815.2  | 654.3    |
| 30         | 1670.0  | 238.4    | 30         | 2228.1  | 418.0    | 30         | 2825.6  | 658.8    |
| 40         | 1679.1  | 241.0    | 40         | 2237.7  | 421.4    | 40         | 2835.9  | 663.4    |
| 50         | 1688.1  | 243.5    | 50         | 2247.3  | 425.0    | 50         | 2846.3  | 668.0    |
| <b>33</b>  | 1697.2  | 246.1    | <b>43</b>  | 2257.0  | 428.5    | <b>53</b>  | 2856.7  | 672.7    |
| 10         | 1706.3  | 248.7    | 10         | 2266.6  | 432.0    | 10         | 2867.1  | 677.3    |
| 20         | 1715.3  | 251.3    | 20         | 2276.2  | 435.6    | 20         | 2877.5  | 682.0    |
| 30         | 1724.4  | 253.9    | 30         | 2285.9  | 439.2    | 30         | 2888.0  | 686.7    |
| 40         | 1733.5  | 256.5    | 40         | 2295.6  | 442.8    | 40         | 2898.4  | 691.4    |
| 50         | 1742.6  | 259.1    | 50         | 2305.2  | 446.4    | 50         | 2908.9  | 696.1    |
| <b>34</b>  | 1751.7  | 261.8    | <b>44</b>  | 2314.9  | 450.0    | <b>54</b>  | 2919.4  | 700.9    |
| 10         | 1760.8  | 264.5    | 10         | 2324.6  | 453.6    | 10         | 2929.9  | 705.7    |
| 20         | 1770.0  | 267.2    | 20         | 2334.3  | 457.3    | 20         | 2940.4  | 710.5    |
| 30         | 1779.1  | 269.9    | 30         | 2344.1  | 461.0    | 30         | 2951.0  | 715.3    |
| 40         | 1788.2  | 272.6    | 40         | 2353.8  | 464.6    | 40         | 2961.5  | 720.1    |
| 50         | 1797.4  | 275.3    | 50         | 2363.5  | 468.4    | 50         | 2972.1  | 725.0    |
| <b>35</b>  | 1806.6  | 278.1    | <b>45</b>  | 2373.3  | 472.1    | <b>55</b>  | 2982.7  | 729.9    |
| 10         | 1815.7  | 280.8    | 10         | 2383.1  | 475.8    | 10         | 2993.3  | 734.8    |
| 20         | 1824.9  | 283.6    | 20         | 2392.8  | 479.6    | 20         | 3003.9  | 739.7    |
| 30         | 1834.1  | 286.4    | 30         | 2402.6  | 483.4    | 30         | 3014.5  | 744.6    |
| 40         | 1843.3  | 289.2    | 40         | 2412.4  | 487.2    | 40         | 3025.2  | 749.6    |
| 50         | 1852.5  | 292.0    | 50         | 2422.3  | 491.0    | 50         | 3035.8  | 754.6    |
| <b>36</b>  | 1861.7  | 294.9    | <b>46</b>  | 2432.1  | 494.8    | <b>56</b>  | 3046.5  | 759.6    |
| 10         | 1870.9  | 297.7    | 10         | 2441.9  | 498.7    | 10         | 3057.2  | 764.6    |
| 20         | 1880.1  | 300.6    | 20         | 2451.8  | 502.5    | 20         | 3067.9  | 769.7    |
| 30         | 1889.4  | 303.5    | 30         | 2461.7  | 506.4    | 30         | 3078.7  | 774.7    |
| 40         | 1898.6  | 306.4    | 40         | 2471.5  | 510.3    | 40         | 3089.4  | 779.8    |
| 50         | 1907.9  | 309.3    | 50         | 2481.4  | 514.3    | 50         | 3100.2  | 784.9    |
| <b>37</b>  | 1917.1  | 312.2    | <b>47</b>  | 2491.3  | 518.2    | <b>57</b>  | 3110.9  | 790.1    |
| 10         | 1926.4  | 315.2    | 10         | 2501.2  | 522.2    | 10         | 3121.7  | 795.2    |
| 20         | 1935.7  | 318.1    | 20         | 2511.2  | 526.1    | 20         | 3132.6  | 800.4    |
| 30         | 1945.0  | 321.1    | 30         | 2521.1  | 530.1    | 30         | 3143.4  | 805.6    |
| 40         | 1954.3  | 324.1    | 40         | 2531.1  | 534.2    | 40         | 3154.2  | 810.9    |
| 50         | 1963.6  | 327.1    | 50         | 2541.0  | 538.2    | 50         | 3165.1  | 816.1    |
| <b>38</b>  | 1972.9  | 330.2    | <b>48</b>  | 2551.0  | 542.2    | <b>58</b>  | 3176.0  | 821.4    |
| 10         | 1982.2  | 333.2    | 10         | 2561.0  | 546.3    | 10         | 3186.9  | 826.7    |
| 20         | 1991.5  | 336.3    | 20         | 2571.0  | 550.4    | 20         | 3197.8  | 832.0    |
| 30         | 2000.9  | 339.3    | 30         | 2581.0  | 554.5    | 30         | 3208.8  | 837.3    |
| 40         | 2010.2  | 342.4    | 40         | 2591.0  | 558.6    | 40         | 3219.7  | 842.7    |
| 50         | 2019.6  | 345.5    | 50         | 2601.1  | 562.8    | 50         | 3230.7  | 848.1    |
| <b>39</b>  | 2029.0  | 348.6    | <b>49</b>  | 2611.2  | 566.9    | <b>59</b>  | 3241.7  | 853.5    |
| 10         | 2038.4  | 351.8    | 10         | 2621.2  | 571.1    | 10         | 3252.7  | 858.9    |
| 20         | 2047.8  | 354.9    | 20         | 2631.3  | 575.3    | 20         | 3263.7  | 864.3    |
| 30         | 2057.2  | 358.1    | 30         | 2641.4  | 579.5    | 30         | 3274.8  | 869.8    |
| 40         | 2066.6  | 361.3    | 40         | 2651.5  | 583.8    | 40         | 3285.8  | 875.3    |
| 50         | 2076.0  | 364.5    | 50         | 2661.6  | 588.0    | 50         | 3296.9  | 880.8    |
| <b>40</b>  | 2085.4  | 367.7    | <b>50</b>  | 2671.8  | 592.3    | <b>60</b>  | 3308.0  | 886.4    |
| 10         | 2094.9  | 371.0    | 10         | 2681.9  | 596.6    | 10         | 3319.1  | 892.0    |
| 20         | 2104.3  | 374.2    | 20         | 2692.1  | 600.9    | 20         | 3330.3  | 897.5    |
| 30         | 2113.8  | 377.5    | 30         | 2702.3  | 605.3    | 30         | 3341.4  | 903.2    |
| 40         | 2123.3  | 380.8    | 40         | 2712.5  | 609.6    | 40         | 3352.6  | 908.8    |
| 50         | 2132.7  | 384.1    | 50         | 2722.7  | 614.0    | 50         | 3363.8  | 914.5    |

TABLE IV. — Tangents and Externals to a 1° Curve.

| Angle      | Tangent | External | Angle      | Tangent | External | Angle      | Tangent | External |
|------------|---------|----------|------------|---------|----------|------------|---------|----------|
| <b>61°</b> | 3375.0  | 920.2    | <b>71°</b> | 4086.9  | 1308.2   | <b>81°</b> | 4893.6  | 1805.8   |
| 10'        | 3386.3  | 925.9    | 10'        | 4099.5  | 1315.6   | 10'        | 4908.0  | 1814.7   |
| 20         | 3397.5  | 931.6    | 20         | 4112.1  | 1322.9   | 20         | 4922.5  | 1824.1   |
| 30         | 3408.8  | 937.3    | 30         | 4124.8  | 1330.3   | 30         | 4937.0  | 1833.6   |
| 40         | 3420.1  | 943.1    | 40         | 4137.4  | 1337.7   | 40         | 4951.5  | 1843.1   |
| 50         | 3431.4  | 948.9    | 50         | 4150.1  | 1345.1   | 50         | 4966.1  | 1852.6   |
| <b>62</b>  | 3442.7  | 954.8    | <b>72</b>  | 4162.8  | 1352.6   | <b>82</b>  | 4980.7  | 1862.2   |
| 10         | 3454.1  | 960.6    | 10         | 4175.6  | 1360.1   | 10         | 4995.4  | 1871.8   |
| 20         | 3465.4  | 966.5    | 20         | 4188.5  | 1367.6   | 20         | 5010.0  | 1881.5   |
| 30         | 3476.8  | 972.4    | 30         | 4201.2  | 1375.2   | 30         | 5024.8  | 1891.2   |
| 40         | 3488.3  | 978.3    | 40         | 4214.0  | 1382.8   | 40         | 5039.5  | 1900.9   |
| 50         | 3499.7  | 984.3    | 50         | 4226.8  | 1390.4   | 50         | 5054.3  | 1910.7   |
| <b>63</b>  | 3511.1  | 990.2    | <b>73</b>  | 4239.7  | 1398.0   | <b>83</b>  | 5069.2  | 1920.5   |
| 10         | 3522.6  | 996.2    | 10         | 4252.6  | 1405.7   | 10         | 5084.0  | 1930.4   |
| 20         | 3534.1  | 1002.3   | 20         | 4265.6  | 1413.5   | 20         | 5099.0  | 1940.3   |
| 30         | 3545.6  | 1008.3   | 30         | 4278.5  | 1421.2   | 30         | 5113.9  | 1950.3   |
| 40         | 3557.2  | 1014.4   | 40         | 4291.5  | 1429.0   | 40         | 5128.9  | 1960.2   |
| 50         | 3568.7  | 1020.5   | 50         | 4304.6  | 1436.8   | 50         | 5143.9  | 1970.3   |
| <b>64</b>  | 3580.3  | 1026.6   | <b>74</b>  | 4317.6  | 1444.6   | <b>84</b>  | 5159.0  | 1980.4   |
| 10         | 3591.9  | 1032.8   | 10         | 4330.7  | 1452.5   | 10         | 5174.1  | 1990.5   |
| 20         | 3603.5  | 1039.0   | 20         | 4343.8  | 1460.4   | 20         | 5189.3  | 2000.6   |
| 30         | 3615.1  | 1045.2   | 30         | 4356.9  | 1468.4   | 30         | 5204.4  | 2010.8   |
| 40         | 3626.8  | 1051.4   | 40         | 4370.1  | 1476.4   | 40         | 5219.7  | 2021.1   |
| 50         | 3638.5  | 1057.7   | 50         | 4383.3  | 1484.4   | 50         | 5234.9  | 2031.4   |
| <b>65</b>  | 3650.2  | 1063.9   | <b>75</b>  | 4396.5  | 1492.4   | <b>85</b>  | 5250.3  | 2041.7   |
| 10         | 3661.9  | 1070.2   | 10         | 4409.8  | 1500.5   | 10         | 5265.6  | 2052.1   |
| 20         | 3673.7  | 1076.6   | 20         | 4423.1  | 1508.6   | 20         | 5281.0  | 2062.5   |
| 30         | 3685.4  | 1082.9   | 30         | 4436.4  | 1516.7   | 30         | 5296.4  | 2073.0   |
| 40         | 3697.2  | 1089.3   | 40         | 4449.7  | 1524.9   | 40         | 5311.9  | 2083.5   |
| 50         | 3709.0  | 1095.7   | 50         | 4463.1  | 1533.1   | 50         | 5327.4  | 2094.1   |
| <b>66</b>  | 3720.9  | 1102.2   | <b>76</b>  | 4476.5  | 1541.4   | <b>86</b>  | 5343.0  | 2104.7   |
| 10         | 3732.7  | 1108.6   | 10         | 4489.9  | 1549.7   | 10         | 5358.6  | 2115.8   |
| 20         | 3744.6  | 1115.1   | 20         | 4503.4  | 1558.0   | 20         | 5374.2  | 2126.0   |
| 30         | 3756.5  | 1121.7   | 30         | 4516.9  | 1566.3   | 30         | 5389.9  | 2136.7   |
| 40         | 3768.5  | 1128.2   | 40         | 4530.4  | 1574.7   | 40         | 5405.6  | 2147.5   |
| 50         | 3780.4  | 1134.8   | 50         | 4544.0  | 1583.1   | 50         | 5421.4  | 2158.4   |
| <b>67</b>  | 3792.4  | 1141.4   | <b>77</b>  | 4557.6  | 1591.6   | <b>87</b>  | 5437.2  | 2169.2   |
| 10         | 3804.4  | 1148.0   | 10         | 4571.2  | 1600.1   | 10         | 5453.1  | 2180.2   |
| 20         | 3816.4  | 1154.7   | 20         | 4584.8  | 1608.6   | 20         | 5469.0  | 2191.1   |
| 30         | 3828.4  | 1161.3   | 30         | 4598.5  | 1617.1   | 30         | 5484.9  | 2202.2   |
| 40         | 3840.5  | 1168.1   | 40         | 4612.2  | 1625.7   | 40         | 5500.9  | 2213.2   |
| 50         | 3852.6  | 1174.8   | 50         | 4626.0  | 1634.4   | 50         | 5517.0  | 2224.3   |
| <b>68</b>  | 3864.7  | 1181.6   | <b>78</b>  | 4639.8  | 1643.0   | <b>88</b>  | 5533.1  | 2235.5   |
| 10         | 3876.8  | 1188.4   | 10         | 4653.6  | 1651.7   | 10         | 5549.2  | 2246.7   |
| 20         | 3889.0  | 1195.2   | 20         | 4667.4  | 1660.5   | 20         | 5565.4  | 2258.0   |
| 30         | 3901.2  | 1202.0   | 30         | 4681.3  | 1669.2   | 30         | 5581.6  | 2269.3   |
| 40         | 3913.4  | 1208.9   | 40         | 4695.2  | 1678.1   | 40         | 5597.8  | 2280.6   |
| 50         | 3925.6  | 1215.8   | 50         | 4709.2  | 1686.9   | 50         | 5614.2  | 2292.0   |
| <b>69</b>  | 3937.9  | 1222.7   | <b>79</b>  | 4723.2  | 1695.8   | <b>89</b>  | 5630.5  | 2303.5   |
| 10         | 3950.2  | 1229.7   | 10         | 4737.2  | 1704.7   | 10         | 5646.9  | 2315.0   |
| 20         | 3962.5  | 1236.7   | 20         | 4751.2  | 1713.7   | 20         | 5663.4  | 2326.6   |
| 30         | 3974.8  | 1243.7   | 30         | 4765.3  | 1722.7   | 30         | 5679.9  | 2338.2   |
| 40         | 3987.2  | 1250.8   | 40         | 4779.4  | 1731.7   | 40         | 5696.4  | 2349.8   |
| 50         | 3999.5  | 1257.9   | 50         | 4793.6  | 1740.8   | 50         | 5713.0  | 2361.5   |
| <b>70</b>  | 4011.9  | 1265.0   | <b>80</b>  | 4807.7  | 1749.9   | <b>90</b>  | 5729.7  | 2373.8   |
| 10         | 4024.4  | 1272.1   | 10         | 4822.0  | 1759.0   | 10         | 5746.3  | 2385.1   |
| 20         | 4036.8  | 1279.3   | 20         | 4836.2  | 1768.2   | 20         | 5763.1  | 2397.0   |
| 30         | 4049.3  | 1286.5   | 30         | 4850.5  | 1777.4   | 30         | 5779.9  | 2408.9   |
| 40         | 4061.8  | 1293.6   | 40         | 4864.8  | 1786.7   | 40         | 5796.7  | 2420.9   |
| 50         | 4074.4  | 1300.9   | 50         | 4879.2  | 1796.0   | 50         | 5813.6  | 2432.9   |

TABLE IV. — Tangents and Externals to a 1° Curve.

| Angle      | Tangent | External | Angle       | Tangent | External | Angle       | Tangent | External |
|------------|---------|----------|-------------|---------|----------|-------------|---------|----------|
| <b>91°</b> | 5830.5  | 2444.9   | <b>101°</b> | 6950.6  | 3278.1   | <b>111°</b> | 8336.7  | 4386.1   |
| 10'        | 5847.5  | 2457.1   | 10'         | 6971.3  | 3294.1   | 10'         | 8362.7  | 4407.6   |
| 20         | 5864.6  | 2469.3   | 20          | 6992.0  | 3310.1   | 20          | 8388.9  | 4429.2   |
| 30         | 5881.7  | 2481.5   | 30          | 7012.7  | 3326.1   | 30          | 8415.1  | 4450.9   |
| 40         | 5898.8  | 2493.8   | 40          | 7033.6  | 3342.3   | 40          | 8441.5  | 4472.7   |
| 50         | 5916.0  | 2506.1   | 50          | 7054.5  | 3358.5   | 50          | 8468.0  | 4494.6   |
| <b>92</b>  | 5933.2  | 2518.5   | <b>102</b>  | 7075.5  | 3374.9   | <b>112</b>  | 8494.6  | 4516.6   |
| 10         | 5950.5  | 2531.0   | 10          | 7096.6  | 3391.2   | 10          | 8521.3  | 4538.8   |
| 20         | 5967.9  | 2543.5   | 20          | 7117.8  | 3407.7   | 20          | 8548.1  | 4561.1   |
| 30         | 5985.3  | 2556.0   | 30          | 7139.0  | 3424.3   | 30          | 8575.0  | 4583.4   |
| 40         | 6002.7  | 2568.6   | 40          | 7160.3  | 3440.9   | 40          | 8602.1  | 4606.0   |
| 50         | 6020.2  | 2581.3   | 50          | 7181.7  | 3457.6   | 50          | 8629.3  | 4628.6   |
| <b>93</b>  | 6037.8  | 2594.0   | <b>103</b>  | 7203.2  | 3474.4   | <b>113</b>  | 8656.6  | 4651.3   |
| 10         | 6055.4  | 2606.8   | 10          | 7224.7  | 3491.3   | 10          | 8684.0  | 4674.2   |
| 20         | 6073.1  | 2619.7   | 20          | 7246.3  | 3508.2   | 20          | 8711.5  | 4697.2   |
| 30         | 6090.8  | 2632.6   | 30          | 7268.0  | 3525.2   | 30          | 8739.2  | 4720.3   |
| 40         | 6108.6  | 2645.5   | 40          | 7289.8  | 3542.4   | 40          | 8767.0  | 4743.6   |
| 50         | 6126.4  | 2658.5   | 50          | 7311.7  | 3559.6   | 50          | 8794.9  | 4766.9   |
| <b>94</b>  | 6144.3  | 2671.6   | <b>104</b>  | 7333.6  | 3576.8   | <b>114</b>  | 8822.9  | 4790.4   |
| 10         | 6162.6  | 2684.7   | 10          | 7355.6  | 3594.2   | 10          | 8851.0  | 4814.1   |
| 20         | 6180.2  | 2697.9   | 20          | 7377.8  | 3611.7   | 20          | 8879.3  | 4837.8   |
| 30         | 6198.3  | 2711.2   | 30          | 7399.9  | 3629.2   | 30          | 8907.7  | 4861.7   |
| 40         | 6216.4  | 2724.5   | 40          | 7422.2  | 3646.8   | 40          | 8936.3  | 4885.7   |
| 50         | 6234.6  | 2737.9   | 50          | 7444.6  | 3664.5   | 50          | 8965.0  | 4909.9   |
| <b>95</b>  | 6252.8  | 2751.3   | <b>105</b>  | 7467.0  | 3682.3   | <b>115</b>  | 8993.8  | 4934.1   |
| 10         | 6271.1  | 2764.8   | 10          | 7489.6  | 3700.2   | 10          | 9022.7  | 4958.6   |
| 20         | 6289.4  | 2778.3   | 20          | 7512.2  | 3718.2   | 20          | 9051.7  | 4983.1   |
| 30         | 6307.9  | 2792.0   | 30          | 7534.9  | 3736.2   | 30          | 9080.9  | 5007.8   |
| 40         | 6326.3  | 2805.6   | 40          | 7557.7  | 3754.4   | 40          | 9110.3  | 5032.6   |
| 50         | 6344.8  | 2819.4   | 50          | 7580.5  | 3772.6   | 50          | 9139.8  | 5057.6   |
| <b>96</b>  | 6363.4  | 2833.2   | <b>106</b>  | 7603.5  | 3791.0   | <b>116</b>  | 9169.4  | 5082.7   |
| 10         | 6382.1  | 2847.0   | 10          | 7626.6  | 3809.4   | 10          | 9199.1  | 5107.9   |
| 20         | 6400.8  | 2861.0   | 20          | 7649.7  | 3827.9   | 20          | 9229.0  | 5133.3   |
| 30         | 6419.5  | 2875.0   | 30          | 7672.9  | 3846.5   | 30          | 9259.0  | 5158.8   |
| 40         | 6438.4  | 2889.0   | 40          | 7696.3  | 3865.2   | 40          | 9289.2  | 5184.5   |
| 50         | 6457.3  | 2903.1   | 50          | 7719.7  | 3884.0   | 50          | 9319.5  | 5210.3   |
| <b>97</b>  | 6476.2  | 2917.3   | <b>107</b>  | 7743.2  | 3902.9   | <b>117</b>  | 9349.9  | 5236.2   |
| 10         | 6495.2  | 2931.6   | 10          | 7766.8  | 3921.9   | 10          | 9380.5  | 5262.3   |
| 20         | 6514.3  | 2945.9   | 20          | 7790.5  | 3940.9   | 20          | 9411.3  | 5288.6   |
| 30         | 6533.4  | 2960.3   | 30          | 7814.3  | 3960.1   | 30          | 9442.2  | 5315.0   |
| 40         | 6552.6  | 2974.7   | 40          | 7838.1  | 3979.4   | 40          | 9473.2  | 5341.5   |
| 50         | 6571.9  | 2989.2   | 50          | 7862.1  | 3998.7   | 50          | 9504.4  | 5368.2   |
| <b>98</b>  | 6591.2  | 3003.8   | <b>108</b>  | 7886.2  | 4018.2   | <b>118</b>  | 9535.7  | 5395.1   |
| 10         | 6610.6  | 3018.4   | 10          | 7910.4  | 4037.8   | 10          | 9567.2  | 5422.1   |
| 20         | 6630.1  | 3033.1   | 20          | 7934.6  | 4057.4   | 20          | 9598.9  | 5449.2   |
| 30         | 6649.6  | 3047.9   | 30          | 7959.0  | 4077.2   | 30          | 9630.7  | 5476.5   |
| 40         | 6669.2  | 3062.8   | 40          | 7983.5  | 4097.1   | 40          | 9662.6  | 5504.0   |
| 50         | 6688.8  | 3077.7   | 50          | 8008.0  | 4117.0   | 50          | 9694.7  | 5531.7   |
| <b>99</b>  | 6708.6  | 3092.7   | <b>109</b>  | 8032.7  | 4137.1   | <b>119</b>  | 9727.0  | 5559.4   |
| 10         | 6728.4  | 3107.7   | 10          | 8057.4  | 4157.3   | 10          | 9759.4  | 5587.4   |
| 20         | 6748.2  | 3122.9   | 20          | 8082.3  | 4177.5   | 20          | 9792.0  | 5615.5   |
| 30         | 6768.1  | 3138.1   | 30          | 8107.3  | 4197.9   | 30          | 9824.8  | 5643.8   |
| 40         | 6788.1  | 3153.3   | 40          | 8132.3  | 4218.4   | 40          | 9857.7  | 5672.3   |
| 50         | 6808.2  | 3168.7   | 50          | 8157.5  | 4239.0   | 50          | 9890.8  | 5700.9   |
| <b>100</b> | 6828.3  | 3184.1   | <b>110</b>  | 8182.8  | 4259.7   | <b>120</b>  | 9924.0  | 5729.7   |
| 10         | 6848.5  | 3199.6   | 10          | 8208.2  | 4280.5   | 10          | 9957.5  | 5758.6   |
| 20         | 6868.8  | 3215.1   | 20          | 8233.7  | 4301.4   | 20          | 9991.0  | 5787.7   |
| 30         | 6889.2  | 3230.8   | 30          | 8259.3  | 4322.4   | 30          | 10025.0 | 5817.0   |
| 40         | 6909.6  | 3246.5   | 40          | 8285.0  | 4343.6   | 40          | 10059.0 | 5846.5   |
| 50         | 6930.1  | 3262.3   | 50          | 8310.8  | 4364.8   | 50          | 10093.0 | 5876.1   |

Table V. Corrections for use with table IV,

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| $\Delta$<br>ANGLE | For Tangents Add |     |      |      |      |      |      |      |      |      |      |      |      |      |     |
|-------------------|------------------|-----|------|------|------|------|------|------|------|------|------|------|------|------|-----|
|                   | CURVE            | 5°  | 10°  | 15°  | 20°  | 25°  | 30°  | 35°  | 40°  | 45°  | 50°  | 55°  | 60°  | 65°  | 70° |
| 10°               | .03              | .06 | .09  | .13  | .16  | .19  | .22  | .25  | .28  | .31  | .34  | .38  | .42  | .46  |     |
| 15°               | .04              | .10 | .14  | .19  | .24  | .29  | .34  | .39  | .45  | .51  | .53  | .58  | .63  | .68  |     |
| 20°               | .06              | .13 | .19  | .26  | .32  | .39  | .45  | .51  | .58  | .65  | .72  | .79  | .84  | .90  |     |
| 25°               | .08              | .16 | .24  | .33  | .40  | .49  | .58  | .67  | .75  | .83  | .90  | .99  | 1.06 | 1.14 |     |
| 30°               | .10              | .19 | .29  | .39  | .49  | .59  | .69  | .79  | .89  | .99  | 1.09 | 1.20 | 1.29 | 1.39 |     |
| 35°               | .11              | .22 | .34  | .47  | .58  | .69  | .79  | .81  | .92  | 1.04 | 1.29 | 1.42 | 1.54 | 1.66 |     |
| 40°               | .13              | .26 | .40  | .53  | .67  | .80  | .93  | 1.06 | 1.20 | 1.34 | 1.49 | 1.64 | 1.79 | 1.94 |     |
| 45°               | .15              | .30 | .44  | .60  | .76  | .91  | 1.06 | 1.21 | 1.37 | 1.52 | 1.70 | 1.87 | 2.04 | 2.21 |     |
| 50°               | .17              | .34 | .51  | .68  | .85  | 1.02 | 1.19 | 1.36 | 1.54 | 1.72 | 1.91 | 2.10 | 2.29 | 2.48 |     |
| 55°               | .19              | .38 | .57  | .76  | .95  | 1.14 | 1.32 | 1.52 | 1.72 | 1.92 | 2.14 | 2.35 | 2.56 | 2.77 |     |
| 60°               | .21              | .42 | .63  | .84  | 1.05 | 1.27 | 1.49 | 1.71 | 1.94 | 2.17 | 2.38 | 2.60 | 2.83 | 3.07 |     |
| 65°               | .23              | .46 | .69  | .93  | 1.16 | 1.40 | 1.64 | 1.88 | 2.13 | 2.38 | 2.63 | 2.88 | 3.13 | 3.39 |     |
| 70°               | .25              | .51 | .76  | 1.02 | 1.28 | 1.54 | 1.80 | 2.06 | 2.33 | 2.60 | 2.88 | 3.16 | 3.44 | 3.72 |     |
| 75°               | .27              | .56 | .83  | 1.12 | 1.40 | 1.69 | 1.98 | 2.27 | 2.57 | 2.87 | 3.16 | 3.47 | 3.78 | 4.09 |     |
| 80°               | .30              | .61 | .91  | 1.22 | 1.53 | 1.84 | 2.15 | 2.46 | 2.78 | 3.10 | 3.44 | 3.78 | 4.12 | 4.46 |     |
| 85°               | .33              | .66 | 1.00 | 1.33 | 1.68 | 2.02 | 2.36 | 2.70 | 3.05 | 3.40 | 3.77 | 4.14 | 4.55 | 4.89 |     |
| 90°               | .36              | .72 | 1.09 | 1.45 | 1.83 | 2.20 | 2.57 | 2.94 | 3.32 | 3.70 | 4.10 | 4.50 | 4.91 | 5.32 |     |
| 95°               | .39              | .79 | 1.19 | 1.55 | 2.00 | 2.40 | 2.80 | 3.20 | 3.61 | 4.02 | 4.49 | 4.98 | 5.38 | 5.83 |     |
| 100°              | .43              | .86 | 1.30 | 1.74 | 2.18 | 2.62 | 3.06 | 3.50 | 3.95 | 4.40 | 4.88 | 5.37 | 5.85 | 6.34 |     |

## For Externals Add

| ANGLE | CURVE | 5°   | 10°  | 15°  | 20°  | 25°  | 30°  | 35°  | 40°  | 45°  | 50°  | 55°  | 60°  | 65°  | 70° |
|-------|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----|
| 10°   | .001  | .003 | .004 | .006 | .007 | .008 | .009 | .011 | .012 | .014 | .015 | .017 | .018 | .020 |     |
| 15°   | .003  | .007 | .010 | .014 | .018 | .023 | .027 | .029 | .032 | .035 | .039 | .043 | .047 | .051 |     |
| 20°   | .006  | .011 | .017 | .022 | .028 | .034 | .038 | .045 | .051 | .057 | .063 | .070 | .076 | .083 |     |
| 25°   | .009  | .018 | .027 | .036 | .046 | .056 | .065 | .074 | .083 | .093 | .106 | .120 | .127 | .135 |     |
| 30°   | .013  | .025 | .038 | .051 | .065 | .078 | .090 | .103 | .116 | .129 | .149 | .170 | .179 | .188 |     |
| 35°   | .018  | .035 | .054 | .072 | .086 | .109 | .131 | .153 | .175 | .197 | .213 | .230 | .247 | .264 |     |
| 40°   | .023  | .046 | .070 | .093 | .117 | .141 | .172 | .203 | .234 | .265 | .277 | .290 | .315 | .341 |     |
| 45°   | .030  | .060 | .093 | .119 | .153 | .184 | .216 | .254 | .289 | .325 | .351 | .378 | .411 | .445 |     |
| 50°   | .037  | .075 | .116 | .151 | .189 | .227 | .266 | .305 | .345 | .384 | .425 | .467 | .508 | .550 |     |
| 55°   | .046  | .093 | .142 | .188 | .236 | .283 | .332 | .381 | .420 | .479 | .530 | .582 | .641 | .700 |     |
| 60°   | .056  | .112 | .168 | .225 | .283 | .340 | .398 | .457 | .516 | .575 | .636 | .697 | .774 | .851 |     |
| 65°   | .067  | .135 | .204 | .273 | .343 | .412 | .483 | .554 | .625 | .697 | .711 | .845 | .922 | 1.01 |     |
| 70°   | .080  | .159 | .240 | .321 | .403 | .485 | .568 | .652 | .735 | .819 | .906 | .994 | 1.08 | 1.17 |     |
| 75°   | .095  | .182 | .286 | .383 | .480 | .578 | .678 | .777 | .877 | .977 | 1.07 | 1.18 | 1.29 | 1.39 |     |
| 80°   | .110  | .220 | .332 | .445 | .558 | .671 | .787 | .903 | 1.02 | 1.13 | 1.25 | 1.38 | 1.50 | 1.62 |     |
| 85°   | .128  | .259 | .391 | .524 | .657 | .790 | .926 | 1.06 | 1.20 | 1.34 | 1.47 | 1.62 | 1.76 | 1.91 |     |
| 90°   | .149  | .299 | .450 | .603 | .756 | .910 | 1.07 | 1.22 | 1.38 | 1.54 | 1.70 | 1.87 | 2.03 | 2.20 |     |
| 95°   | .174  | .350 | .522 | .706 | .985 | 1.06 | 1.25 | 1.43 | 1.62 | 1.80 | 1.99 | 2.18 | 2.38 | 2.58 |     |
| 100°  | .200  | .401 | .604 | .809 | 1.01 | 1.22 | 1.43 | 1.64 | 1.85 | 2.06 | 2.28 | 2.50 | 2.73 | 2.96 |     |

Table VI. Deflections for Sub Chords for Short Radius Curves.

| Degree<br>of<br>Curve | Radius<br>50<br>sin. def. ang. | $\frac{1}{2}$ sub chord<br>R = sin of def. angle |        |        |        | Length<br>of arc<br>for 100 ft. |
|-----------------------|--------------------------------|--------------------------------------------------|--------|--------|--------|---------------------------------|
|                       |                                | 12.5 Ft.                                         | 15 Ft. | 20 Ft. | 25 Ft. |                                 |
| 30°                   | 193.18                         | 1° 51'                                           | 2° 17' | 2° 58' | 3° 43' | 101.15                          |
| 32°                   | 181.39                         | 1° 59'                                           | 2° 25' | 3° 10' | 3° 58' | 101.33                          |
| 34°                   | 171.01                         | 2° 06'                                           | 2° 33' | 3° 21' | 4° 12' | 101.48                          |
| 36°                   | 161.80                         | 2° 13'                                           | 2° 41' | 3° 33' | 4° 26' | 101.66                          |
| 38°                   | 153.58                         | 2° 20'                                           | 2° 49' | 3° 44' | 4° 40' | 101.85                          |
| 40°                   | 146.19                         | 2° 27'                                           | 2° 57' | 3° 55' | 4° 54' | 102.06                          |
| 42°                   | 139.52                         | 2° 34'                                           | 3° 05' | 4° 07' | 5° 08' | 102.29                          |
| 44°                   | 133.47                         | 2° 41'                                           | 3° 13' | 4° 18' | 5° 22' | 102.53                          |
| 46°                   | 127.97                         | 2° 48'                                           | 3° 21' | 4° 29' | 5° 36' | 102.76                          |
| 48°                   | 122.92                         | 2° 55'                                           | 3° 29' | 4° 40' | 5° 50' | 103.00                          |
| 50°                   | 118.31                         | 3° 02'                                           | 3° 38' | 4° 51' | 6° 04' | 103.24                          |
| 52°                   | 114.06                         | 3° 09'                                           | 3° 46' | 5° 02' | 6° 17' | 103.54                          |
| 54°                   | 110.11                         | 3° 16'                                           | 3° 54' | 5° 13' | 6° 31' | 103.84                          |
| 56°                   | 106.50                         | 3° 22'                                           | 4° 02' | 5° 23' | 6° 44' | 104.14                          |
| 58°                   | 103.14                         | 3° 29'                                           | 4° 10' | 5° 34' | 6° 57' | 104.43                          |
| 60°                   | 100.00                         | 3° 35'                                           | 4° 18' | 5° 44' | 7° 11' | 104.72                          |

## CURVE FORMULAS.

$$T = R \tan \frac{1}{2} I$$

$$T = \frac{50 \tan \frac{1}{2} I}{\sin. D}$$

$$\sin. D = \frac{50}{R}$$

$$\sin. D = \frac{50 \tan \frac{1}{2} I}{T}$$

$$R = T \cot. \frac{1}{2} I$$

$$R = \frac{50}{\sin. D}$$

$$E = R \text{ ex. sec. } \frac{1}{2} I$$

$$E = T \tan \frac{1}{4} I$$

$$\text{Chord def.} = \frac{\text{chord}^2}{R}$$

$$\text{No. chords} = \frac{\frac{1}{2} I}{D}$$

$$\text{Tan. def.} = \frac{1}{2} \text{ chord def.}$$

The square of any distance, divided by twice the radius, will equal the distance from tangent to curve, very nearly.

Table IV. contains Tangents and External to a 1° curve. Tan. and Ext. to any other radius may be found, nearly enough, by dividing the Tan. or Ext. opposite the given Central Angle by the given degree of curve.

To find Deg. of Curve, having the Central Angle and Tangent: Divide Tan. opposite the given Central Angle by the given Tangent.

To find Deg. of Curve, having the Central Angle and Tangent: Divide Ext. opposite the given Central Angle by the given External.

To find, Nat. Tan. and Nat. Ex. Sec. for any angle by Table IV.: Tan. or Ext. of twice the given angle divided by the radius of a 1° curve will be the Nat. Tan. or Nat. Ex. Sec.

To find angle for a given distance and deflection.

Rule 1. Multiply the given distance by .01745 (def. for 1° for 1 ft.), and divide given deflection by the product.

Rule 2. Multiply given deflection by 57.3, and divide the product by the given distance.

To find deflection for a given angle and distance: Multiply the angle by .01745, and the product by the distance.

RIGHT ANGLE TRIANGLES.—Square the altitude, divide by twice the base. Add quotient to base for hypotenuse.

Given Base 100, Alt 10.  $10^2 \div 200 = .5$ .  $100 + .5 = 100.5$  hyp.

Given Hyp. 100, Alt. 25.  $25^2 \div 200 = 3.125$ .  $100 - 3.125 = 96.875 = \text{Base}$ .

Error in first example, .002; in last, .045.

To find Tons of Rail in one mile of track: multiply weight per yard by 11, and divide by 7.

## Natural Sines

| DEG. | 0'   | 10'  | 20'  | 30'  | 40'  | 50'  | DEG. | DEG. | 0'   | 10'  | 20'  | 30'  | 40'  | 50'  | DEG. |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 0    | 0000 | 0029 | 0058 | 0087 | 0116 | 0145 | 89   | 40   | 6428 | 6450 | 6472 | 6494 | 6517 | 6539 | 49   |
| 1    | 0175 | 0204 | 0233 | 0262 | 0291 | 0320 | 88   | 41   | 6561 | 6583 | 6604 | 6626 | 6648 | 6670 | 48   |
| 2    | 0349 | 0378 | 0407 | 0436 | 0465 | 0494 | 87   | 42   | 6691 | 6713 | 6734 | 6756 | 6777 | 6799 | 47   |
| 3    | 0523 | 0552 | 0581 | 0610 | 0640 | 0669 | 86   | 43   | 6820 | 6841 | 6862 | 6884 | 6905 | 6926 | 46   |
| 4    | 0698 | 0727 | 0756 | 0785 | 0814 | 0843 | 85   | 44   | 6947 | 6967 | 6988 | 7009 | 7030 | 7050 | 45   |
| 5    | 0872 | 0901 | 0929 | 0958 | 0987 | 1016 | 84   | 45   | 7071 | 7092 | 7112 | 7133 | 7153 | 7173 | 44   |
| 6    | 1045 | 1074 | 1103 | 1132 | 1161 | 1190 | 83   | 46   | 7193 | 7214 | 7234 | 7254 | 7274 | 7294 | 43   |
| 7    | 1219 | 1248 | 1276 | 1305 | 1334 | 1363 | 82   | 47   | 7314 | 7333 | 7353 | 7373 | 7392 | 7412 | 42   |
| 8    | 1392 | 1421 | 1449 | 1478 | 1507 | 1536 | 81   | 48   | 7431 | 7451 | 7470 | 7490 | 7509 | 7528 | 41   |
| 9    | 1564 | 1593 | 1622 | 1650 | 1679 | 1708 | 80   | 49   | 7547 | 7566 | 7585 | 7604 | 7623 | 7642 | 40   |
| 10   | 1736 | 1765 | 1794 | 1822 | 1851 | 1880 | 79   | 50   | 7660 | 7679 | 7698 | 7716 | 7735 | 7753 | 39   |
| 11   | 1908 | 1937 | 1965 | 1994 | 2022 | 2051 | 78   | 51   | 7771 | 7790 | 7808 | 7826 | 7844 | 7862 | 38   |
| 12   | 2079 | 2108 | 2136 | 2164 | 2193 | 2221 | 77   | 52   | 7880 | 7898 | 7916 | 7934 | 7951 | 7969 | 37   |
| 13   | 2250 | 2278 | 2306 | 2334 | 2363 | 2391 | 76   | 53   | 7986 | 8004 | 8021 | 8039 | 8056 | 8073 | 36   |
| 14   | 2419 | 2447 | 2476 | 2504 | 2532 | 2560 | 75   | 54   | 8090 | 8107 | 8124 | 8141 | 8158 | 8175 | 35   |
| 15   | 2588 | 2616 | 2644 | 2672 | 2700 | 2728 | 74   | 55   | 8192 | 8208 | 8225 | 8241 | 8258 | 8274 | 34   |
| 16   | 2756 | 2784 | 2812 | 2840 | 2868 | 2896 | 73   | 56   | 8290 | 8307 | 8323 | 8339 | 8355 | 8371 | 33   |
| 17   | 2924 | 2952 | 2979 | 3007 | 3035 | 3062 | 72   | 57   | 8387 | 8403 | 8418 | 8434 | 8450 | 8465 | 32   |
| 18   | 3090 | 3118 | 3145 | 3173 | 3201 | 3228 | 71   | 58   | 8480 | 8496 | 8511 | 8526 | 8542 | 8557 | 31   |
| 19   | 3256 | 3283 | 3311 | 3338 | 3365 | 3393 | 70   | 59   | 8572 | 8587 | 8601 | 8616 | 8631 | 8646 | 30   |
| 20   | 3420 | 3448 | 3475 | 3502 | 3529 | 3557 | 69   | 60   | 8660 | 8675 | 8689 | 8704 | 8718 | 8732 | 29   |
| 21   | 3584 | 3611 | 3638 | 3665 | 3692 | 3719 | 68   | 61   | 8746 | 8760 | 8774 | 8788 | 8802 | 8816 | 28   |
| 22   | 3746 | 3773 | 3800 | 3827 | 3854 | 3881 | 67   | 62   | 8829 | 8843 | 8857 | 8870 | 8884 | 8897 | 27   |
| 23   | 3907 | 3934 | 3961 | 3987 | 4014 | 4041 | 66   | 63   | 8910 | 8923 | 8936 | 8949 | 8962 | 8975 | 26   |
| 24   | 4067 | 4094 | 4120 | 4147 | 4173 | 4200 | 65   | 64   | 8988 | 9001 | 9013 | 9026 | 9038 | 9051 | 25   |
| 25   | 4226 | 4253 | 4279 | 4305 | 4331 | 4358 | 64   | 65   | 9063 | 9075 | 9088 | 9100 | 9112 | 9124 | 24   |
| 26   | 4384 | 4410 | 4436 | 4462 | 4488 | 4514 | 63   | 66   | 9135 | 9147 | 9159 | 9171 | 9182 | 9194 | 23   |
| 27   | 4540 | 4566 | 4592 | 4617 | 4643 | 4669 | 62   | 67   | 9205 | 9216 | 9228 | 9239 | 9250 | 9261 | 22   |
| 28   | 4695 | 4720 | 4746 | 4772 | 4797 | 4823 | 61   | 68   | 9272 | 9283 | 9293 | 9304 | 9315 | 9325 | 21   |
| 29   | 4848 | 4874 | 4899 | 4924 | 4950 | 4975 | 60   | 69   | 9336 | 9346 | 9356 | 9367 | 9377 | 9387 | 20   |
| 30   | 5000 | 5025 | 5050 | 5075 | 5100 | 5125 | 59   | 70   | 9397 | 9407 | 9417 | 9426 | 9436 | 9446 | 19   |
| 31   | 5150 | 5175 | 5200 | 5225 | 5250 | 5275 | 58   | 71   | 9455 | 9465 | 9474 | 9483 | 9492 | 9502 | 18   |
| 32   | 5299 | 5324 | 5348 | 5373 | 5398 | 5422 | 57   | 72   | 9511 | 9520 | 9528 | 9537 | 9546 | 9555 | 17   |
| 33   | 5446 | 5471 | 5495 | 5519 | 5544 | 5568 | 56   | 73   | 9563 | 9572 | 9580 | 9588 | 9596 | 9605 | 16   |
| 34   | 5592 | 5616 | 5640 | 5664 | 5688 | 5712 | 55   | 74   | 9613 | 9621 | 9628 | 9636 | 9644 | 9652 | 15   |
| 35   | 5736 | 5760 | 5783 | 5807 | 5831 | 5854 | 54   | 75   | 9659 | 9667 | 9674 | 9681 | 9689 | 9696 | 14   |
| 36   | 5878 | 5901 | 5925 | 5948 | 5972 | 5995 | 53   | 76   | 9703 | 9710 | 9717 | 9724 | 9730 | 9737 | 13   |
| 37   | 6018 | 6041 | 6065 | 6088 | 6111 | 6134 | 52   | 77   | 9744 | 9750 | 9757 | 9763 | 9769 | 9775 | 12   |
| 38   | 6157 | 6180 | 6202 | 6225 | 6248 | 6271 | 51   | 78   | 9781 | 9787 | 9793 | 9799 | 9805 | 9811 | 11   |
| 39   | 6293 | 6316 | 6338 | 6361 | 6383 | 6406 | 50   | 79   | 9816 | 9822 | 9827 | 9833 | 9838 | 9843 | 10   |
| DEG. | 60'  | 50'  | 40'  | 30'  | 20'  | 10'  | DEG. | DEG. | 60'  | 50'  | 40'  | 30'  | 20'  | 10'  | DEG. |

| DEG. | 0'   | 10'  | 20'  | 30'  | 40'    | 50'    | DEG. |
|------|------|------|------|------|--------|--------|------|
| 80   | 9848 | 9853 | 9858 | 9863 | 9868   | 9872   | 9    |
| 81   | 9877 | 9881 | 9886 | 9890 | 9894   | 9899   | 8    |
| 82   | 9903 | 9907 | 9911 | 9914 | 9918   | 9922   | 7    |
| 83   | 9925 | 9929 | 9932 | 9936 | 9939   | 9942   | 6    |
| 84   | 9945 | 9948 | 9951 | 9954 | 9957   | 9959   | 5    |
| 85   | 9962 | 9964 | 9967 | 9969 | 9971   | 9974   | 4    |
| 86   | 9976 | 9978 | 9980 | 9981 | 9983   | 9985   | 3    |
| 87   | 9986 | 9988 | 9989 | 9990 | 9992   | 9993   | 2    |
| 88   | 9994 | 9995 | 9996 | 9997 | 9997   | 9998   | 1    |
| 89   | 9998 | 9999 | 9999 | 9999 | I.0000 | I.0000 | 0    |
| DEG. | 60'  | 50'  | 40'  | 30'  | 20'    | 10'    | DEG. |

## Natural Cosines

## Natural Tangents

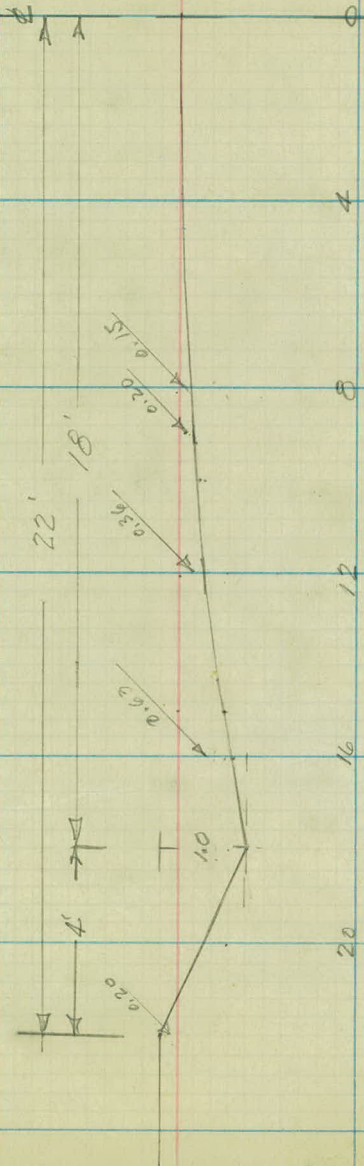
| deg. | 0'   | 10'  | 20'  | 30'  | 40'  | 50'  | deg. | 0'  | 10'    | 20'    | 30'    | 40'    | 50'    | deg.   |    |
|------|------|------|------|------|------|------|------|-----|--------|--------|--------|--------|--------|--------|----|
| 0    | 0000 | 0029 | 0058 | 0087 | 0116 | 0145 | 89   | 40  | 8391   | 8441   | 8491   | 8541   | 8591   | 8642   | 49 |
| 1    | 0175 | 0204 | 0233 | 0262 | 0291 | 0320 | 88   | 41  | 8693   | 8744   | 8796   | 8847   | 8899   | 8952   | 48 |
| 2    | 0349 | 0378 | 0407 | 0437 | 0466 | 0495 | 87   | 42  | 9004   | 9057   | 9110   | 9163   | 9217   | 9271   | 47 |
| 3    | 0524 | 0553 | 0582 | 0612 | 0641 | 0670 | 86   | 43  | 9325   | 9380   | 9435   | 9490   | 9545   | 9601   | 46 |
| 4    | 0699 | 0729 | 0758 | 0787 | 0816 | 0846 | 85   | 44  | 9657   | 9713   | 9770   | 9827   | 9884   | 9942   | 45 |
| 5    | 0875 | 0904 | 0934 | 0963 | 0992 | 1022 | 84   | 45  | 1.0000 | 1.0058 | 1.0117 | 1.0176 | 1.0235 | 1.0295 | 44 |
| 6    | 1051 | 1080 | 1110 | 1139 | 1169 | 1198 | 83   | 46  | 1.0355 | 1.0416 | 1.0477 | 1.0533 | 1.0599 | 1.0661 | 43 |
| 7    | 1228 | 1257 | 1287 | 1317 | 1346 | 1376 | 82   | 47  | 1.0724 | 1.0786 | 1.0850 | 1.0913 | 1.0977 | 1.1041 | 42 |
| 8    | 1405 | 1435 | 1465 | 1495 | 1524 | 1554 | 81   | 48  | 1.1106 | 1.1171 | 1.1237 | 1.1303 | 1.1369 | 1.1436 | 41 |
| 9    | 1584 | 1614 | 1644 | 1673 | 1703 | 1733 | 80   | 49  | 1.1504 | 1.1571 | 1.1640 | 1.1708 | 1.1778 | 1.1847 | 40 |
| 10   | 1763 | 1793 | 1823 | 1853 | 1883 | 1914 | 79   | 50  | 1.1918 | 1.1988 | 1.2059 | 1.2131 | 1.2203 | 1.2276 | 39 |
| 11   | 1944 | 1974 | 2004 | 2035 | 2065 | 2095 | 78   | 51  | 1.2349 | 1.2423 | 1.2497 | 1.2572 | 1.2647 | 1.2723 | 38 |
| 12   | 2126 | 2156 | 2186 | 2217 | 2247 | 2278 | 77   | 52  | 1.2799 | 1.2876 | 1.2954 | 1.3032 | 1.3111 | 1.3190 | 37 |
| 13   | 2309 | 2339 | 2370 | 2401 | 2432 | 2462 | 76   | 53  | 1.3270 | 1.3351 | 1.3432 | 1.3514 | 1.3597 | 1.3680 | 36 |
| 14   | 2493 | 2524 | 2555 | 2586 | 2617 | 2648 | 75   | 54  | 1.3764 | 1.3848 | 1.3934 | 1.4019 | 1.4106 | 1.4193 | 35 |
| 15   | 2679 | 2711 | 2742 | 2773 | 2805 | 2836 | 74   | 55  | 1.4281 | 1.4370 | 1.4460 | 1.4550 | 1.4641 | 1.4733 | 34 |
| 16   | 2867 | 2899 | 2931 | 2962 | 2994 | 3026 | 73   | 56  | 1.4826 | 1.4919 | 1.5013 | 1.5108 | 1.5204 | 1.5301 | 33 |
| 17   | 3057 | 3089 | 3121 | 3153 | 3185 | 3217 | 72   | 57  | 1.5399 | 1.5497 | 1.5597 | 1.5697 | 1.5798 | 1.5900 | 32 |
| 18   | 3249 | 3281 | 3314 | 3346 | 3378 | 3411 | 71   | 58  | 1.6003 | 1.6107 | 1.6212 | 1.6319 | 1.6426 | 1.6534 | 31 |
| 19   | 3443 | 3476 | 3508 | 3541 | 3574 | 3607 | 70   | 59  | 1.6643 | 1.6753 | 1.6864 | 1.6977 | 1.7090 | 1.7205 | 30 |
| 20   | 3640 | 3673 | 3706 | 3739 | 3772 | 3805 | 69   | 60  | 1.7321 | 1.7437 | 1.7556 | 1.7675 | 1.7797 | 1.7917 | 29 |
| 21   | 3839 | 3872 | 3906 | 3939 | 3973 | 4006 | 68   | 61  | 1.8040 | 1.8165 | 1.8291 | 1.8418 | 1.8546 | 1.8676 | 28 |
| 22   | 4040 | 4074 | 4108 | 4142 | 4176 | 4210 | 67   | 62  | 1.8807 | 1.8940 | 1.9074 | 1.9210 | 1.9347 | 1.9486 | 27 |
| 23   | 4245 | 4279 | 4314 | 4348 | 4383 | 4417 | 66   | 63  | 1.9626 | 1.9768 | 1.9912 | 2.0057 | 2.0204 | 2.0353 | 26 |
| 24   | 4452 | 4487 | 4522 | 4557 | 4592 | 4628 | 65   | 64  | 2.0503 | 2.0655 | 2.0809 | 2.0965 | 2.1123 | 2.1283 | 25 |
| 25   | 4663 | 4699 | 4734 | 4770 | 4806 | 4841 | 64   | 65  | 2.1445 | 2.1609 | 2.1775 | 2.1943 | 2.2113 | 2.2286 | 24 |
| 26   | 4877 | 4913 | 4950 | 4986 | 5022 | 5059 | 63   | 66  | 2.2460 | 2.2637 | 2.2817 | 2.2998 | 2.3183 | 2.3369 | 23 |
| 27   | 5095 | 5132 | 5169 | 5206 | 5243 | 5280 | 62   | 67  | 2.3559 | 2.3750 | 2.3945 | 2.4142 | 2.4342 | 2.4545 | 22 |
| 28   | 5317 | 5354 | 5392 | 5430 | 5467 | 5505 | 61   | 68  | 2.4751 | 2.4960 | 2.5172 | 2.5386 | 2.5605 | 2.5826 | 21 |
| 29   | 5543 | 5581 | 5619 | 5658 | 5696 | 5735 | 60   | 69  | 2.6051 | 2.6279 | 2.6511 | 2.6746 | 2.6985 | 2.7228 | 20 |
| 30   | 5774 | 5812 | 5851 | 5890 | 5930 | 5969 | 59   | 70  | 2.7475 | 2.7725 | 2.7980 | 2.8239 | 2.8502 | 2.8770 | 19 |
| 31   | 6009 | 6048 | 6088 | 6128 | 6168 | 6208 | 58   | 71  | 2.9042 | 2.9319 | 2.9600 | 2.9887 | 3.0178 | 3.0475 | 18 |
| 32   | 6249 | 6289 | 6330 | 6371 | 6412 | 6453 | 57   | 72  | 3.0777 | 3.1084 | 3.1397 | 3.1716 | 3.2041 | 3.2371 | 17 |
| 33   | 6494 | 6536 | 6577 | 6619 | 6661 | 6703 | 56   | 73  | 3.2709 | 3.3052 | 3.3402 | 3.3759 | 3.4124 | 3.4495 | 16 |
| 34   | 6745 | 6787 | 6830 | 6873 | 6916 | 6959 | 55   | 74  | 3.4874 | 3.5261 | 3.5656 | 3.6059 | 3.6470 | 3.6891 | 15 |
| 35   | 7002 | 7046 | 7089 | 7133 | 7177 | 7221 | 54   | 75  | 3.7321 | 3.7760 | 3.8208 | 3.8667 | 3.9136 | 3.9617 | 14 |
| 36   | 7265 | 7310 | 7355 | 7400 | 7445 | 7490 | 53   | 76  | 4.0108 | 4.0611 | 4.1126 | 4.1653 | 4.2193 | 4.2747 | 13 |
| 37   | 7536 | 7581 | 7627 | 7673 | 7720 | 7766 | 52   | 77  | 4.3315 | 4.3897 | 4.4494 | 4.5107 | 4.5736 | 4.6382 | 12 |
| 38   | 7813 | 7860 | 7907 | 7954 | 8002 | 8050 | 51   | 78  | 4.7046 | 4.7729 | 4.8430 | 4.9152 | 4.9894 | 5.0658 | 11 |
| 39   | 8098 | 8146 | 8195 | 8243 | 8292 | 8342 | 50   | 79  | 5.1446 | 5.2257 | 5.3093 | 5.3955 | 5.4845 | 5.5764 | 10 |
| deg. | 0'   | 50'  | 40'  | 30'  | 20'  | 10'  | deg. | 60' | 50'    | 40'    | 30'    | 20'    | 10'    | deg.   |    |

| deg. | 0'     | 10'    | 20'    | 30'     | 40'     | 50'     | deg. |
|------|--------|--------|--------|---------|---------|---------|------|
| 80   | 5.6713 | 5.7694 | 5.8708 | 5.9758  | 6.0844  | 6.1970  | 9    |
| 81   | 6.3138 | 6.4348 | 6.5606 | 6.6912  | 6.8269  | 6.9682  | 8    |
| 82   | 7.1154 | 7.2687 | 7.4287 | 7.5958  | 7.7704  | 7.9530  | 7    |
| 83   | 8.1443 | 8.3450 | 8.5555 | 8.7769  | 9.0098  | 9.2553  | 6    |
| 84   | 9.5144 | 9.7882 | 10.078 | 10.385  | 10.711  | 11.059  | 5    |
| 85   | 11.430 | 11.826 | 12.250 | 12.706  | 13.197  | 13.727  | 4    |
| 86   | 14.300 | 14.924 | 15.605 | 16.350  | 17.169  | 18.075  | 3    |
| 87   | 19.081 | 20.206 | 21.470 | 22.903  | 24.542  | 26.432  | 2    |
| 88   | 28.636 | 31.242 | 34.368 | 38.189  | 42.964  | 49.104  | 1    |
| 89   | 57.290 | 68.750 | 85.940 | 114.588 | 171.885 | 343.770 | 0    |

deg. 60' 50' 40' 30' 20' 10' deg.

## Natural Cotangents

Subgrade A



$$\frac{7.5}{18}$$

$$\frac{15}{10}$$

$$\begin{array}{r} 935.24 \\ 2.06 \\ \hline 937.30 \end{array}$$

$$\begin{array}{r} 37.30 \\ 32.41 \\ \hline 4.89 \end{array}$$

$$\begin{array}{r} 37.30 \\ 32.38 \\ \hline 4.92 \end{array}$$

$$\begin{array}{r} 16.40 \end{array}$$

$$\begin{array}{r} 37.30 \\ 32.29 \\ \hline 5.01 \\ 4.81 \end{array}$$

$$\begin{array}{r} 37.30 \\ 32.76 \\ \hline 5.04 \end{array}$$

$$\begin{array}{r} 15.40 \\ 37.30 \\ 32.20 \\ \hline 5.10 \\ 4.90 \end{array}$$

$$\begin{array}{r} 5.1 \\ 5.0 \\ \hline 6.0 \end{array}$$

$$\begin{array}{r} 14.50 \\ 37.30 \\ 32.17 \\ \hline 5.13 \end{array}$$

$$\begin{array}{r} 15.40 \\ 37.30 \\ 32.04 \\ \hline 5.26 \\ 4.96 \end{array}$$

$$\begin{array}{r} 37.30 \\ 32.35 \\ \hline 4.95 \end{array}$$

$$\begin{array}{r} 15.40 \end{array}$$

$$\begin{array}{r} 37.30 \\ 32.23 \\ \hline 5.07 \\ 4.87 \end{array}$$

$$\begin{array}{r} 37.30 \\ 32.32 \\ \hline 4.98 \end{array}$$

$$\begin{array}{r} 4.78 \end{array}$$

$$\begin{array}{r} 14.86 \\ \hline 4.78 \\ 6.48 \\ \hline 10.84 \end{array}$$

C-0.6

4.64  
933.29  
127.93

DISTANCES FROM CENTER OF ROADWAY FOR CROSS-SECTIONING.

ROADWAY 14 FEET WIDE. SIDE SLOPES 1½ TO 1.

FOR SINGLE TRACK EMBANKMENT.

|    | 0    | .1   | .2   | .3   | .4   | .5   | .6   | .7   | .8   | .9   |    |
|----|------|------|------|------|------|------|------|------|------|------|----|
| 0  | 7.0  | 7.2  | 7.3  | 7.5  | 7.6  | 7.8  | 7.9  | 8.1  | 8.2  | 8.4  | 0  |
| 1  | 8.5  | 8.7  | 8.8  | 9.0  | 9.1  | 9.3  | 9.4  | 9.6  | 9.7  | 9.9  | 1  |
| 2  | 10.0 | 10.2 | 10.3 | 10.5 | 10.6 | 10.8 | 10.9 | 11.1 | 11.2 | 11.4 | 2  |
| 3  | 11.5 | 11.7 | 11.8 | 12.0 | 12.1 | 12.3 | 12.4 | 12.6 | 12.7 | 12.9 | 3  |
| 4  | 13.0 | 13.2 | 13.3 | 13.5 | 13.6 | 13.8 | 13.9 | 14.1 | 14.2 | 14.4 | 4  |
| 5  | 14.5 | 14.7 | 14.8 | 15.0 | 15.1 | 15.3 | 15.4 | 15.6 | 15.7 | 15.9 | 5  |
| 6  | 16.0 | 16.2 | 16.3 | 16.5 | 16.6 | 16.8 | 16.9 | 17.1 | 17.2 | 17.4 | 6  |
| 7  | 17.5 | 17.7 | 17.8 | 18.0 | 18.1 | 18.3 | 18.4 | 18.6 | 18.7 | 18.9 | 7  |
| 8  | 19.0 | 19.2 | 19.3 | 19.5 | 19.6 | 19.8 | 19.9 | 20.1 | 20.2 | 20.4 | 8  |
| 9  | 20.5 | 20.7 | 20.8 | 21.0 | 21.1 | 21.3 | 21.4 | 21.6 | 21.7 | 21.9 | 9  |
| 10 | 22.0 | 22.2 | 22.3 | 22.5 | 22.6 | 22.8 | 22.9 | 23.1 | 23.2 | 23.4 | 10 |
| 11 | 23.5 | 23.7 | 23.8 | 24.0 | 24.1 | 24.3 | 24.4 | 24.6 | 24.7 | 24.9 | 11 |
| 12 | 25.0 | 25.2 | 25.3 | 25.5 | 25.6 | 25.8 | 25.9 | 26.1 | 26.2 | 26.4 | 12 |
| 13 | 26.5 | 26.7 | 26.8 | 27.0 | 27.1 | 27.3 | 27.4 | 27.6 | 27.7 | 27.9 | 13 |
| 14 | 28.0 | 28.2 | 28.3 | 28.5 | 28.6 | 28.8 | 28.9 | 29.1 | 29.2 | 29.4 | 14 |
| 15 | 29.5 | 29.7 | 29.8 | 30.0 | 30.1 | 30.3 | 30.4 | 30.6 | 30.7 | 30.9 | 15 |
| 16 | 31.0 | 31.2 | 31.3 | 31.5 | 31.6 | 31.8 | 31.9 | 32.1 | 32.2 | 32.4 | 16 |
| 17 | 32.5 | 32.7 | 32.8 | 33.0 | 33.1 | 33.3 | 33.4 | 33.6 | 33.7 | 33.9 | 17 |
| 18 | 34.0 | 34.2 | 34.3 | 34.5 | 34.6 | 34.8 | 34.9 | 35.1 | 35.2 | 35.4 | 18 |
| 19 | 35.5 | 35.7 | 35.8 | 36.0 | 36.1 | 36.3 | 36.4 | 36.6 | 36.7 | 36.9 | 19 |
| 20 | 37.0 | 37.2 | 37.3 | 37.5 | 37.6 | 37.8 | 37.9 | 38.1 | 38.2 | 38.4 | 20 |
| 21 | 38.5 | 38.7 | 38.8 | 39.0 | 39.1 | 39.3 | 39.4 | 39.6 | 39.7 | 39.9 | 21 |
| 22 | 40.0 | 40.2 | 40.3 | 40.5 | 40.6 | 40.8 | 40.9 | 41.1 | 41.2 | 41.4 | 22 |
| 23 | 41.5 | 41.7 | 41.8 | 42.0 | 42.1 | 42.3 | 42.4 | 42.6 | 42.7 | 42.9 | 23 |
| 24 | 43.0 | 43.2 | 43.3 | 43.5 | 43.6 | 43.8 | 43.9 | 44.1 | 44.2 | 44.4 | 24 |
| 25 | 44.5 | 44.7 | 44.8 | 45.0 | 45.1 | 45.3 | 45.4 | 45.6 | 45.7 | 45.9 | 25 |
| 26 | 46.0 | 46.2 | 46.3 | 46.5 | 46.6 | 46.8 | 46.9 | 47.1 | 47.2 | 47.4 | 26 |
| 27 | 47.5 | 47.7 | 47.8 | 48.0 | 48.1 | 48.3 | 48.4 | 48.6 | 48.7 | 48.9 | 27 |
| 28 | 49.0 | 49.2 | 49.3 | 49.5 | 49.6 | 49.8 | 49.9 | 50.1 | 50.2 | 50.4 | 28 |
| 29 | 50.5 | 50.7 | 50.8 | 51.0 | 51.1 | 51.3 | 51.4 | 51.6 | 51.7 | 51.9 | 29 |
| 30 | 52.0 | 52.2 | 52.3 | 52.5 | 52.6 | 52.8 | 52.9 | 53.1 | 53.2 | 53.4 | 30 |
| 31 | 53.5 | 53.7 | 53.8 | 54.0 | 54.1 | 54.3 | 54.4 | 54.6 | 54.7 | 54.9 | 31 |
| 32 | 55.0 | 55.2 | 55.3 | 55.5 | 55.6 | 55.8 | 55.9 | 56.1 | 56.2 | 56.4 | 32 |
| 33 | 56.5 | 56.7 | 56.8 | 57.0 | 57.1 | 57.3 | 57.4 | 57.6 | 57.7 | 57.9 | 33 |
| 34 | 58.0 | 58.2 | 58.3 | 58.5 | 58.6 | 58.8 | 58.9 | 59.1 | 59.2 | 59.4 | 34 |
| 35 | 59.5 | 59.7 | 59.8 | 60.0 | 60.1 | 60.3 | 60.4 | 60.6 | 60.7 | 60.9 | 35 |
| 36 | 61.0 | 61.2 | 61.3 | 61.5 | 61.6 | 61.8 | 61.9 | 62.1 | 62.2 | 62.4 | 36 |

Calculated by Julien A. Hall, M. Am. Soc. C. E.

MADE IN GERMANY.

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