

S.P. 62-511-01 & 27-516-01
CULVERT DIARY

STATE OF MINNESOTA
DEPARTMENT OF HIGHWAYS

MINNEAPOLIS

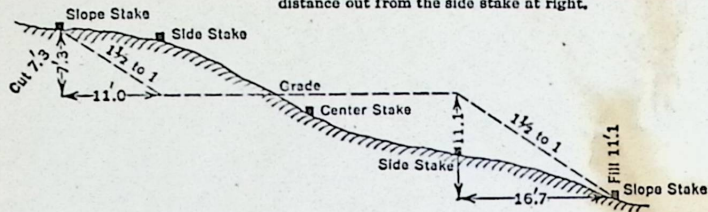
1921

7

DISTANCES FROM SIDE STAKES FOR CROSS-SECTIONING

Roadway of any Width. Side Slopes $1\frac{1}{2}$ to 1.

In the figure below: opposite 7 under "Cut or Fill" and under .3 read 11.0, the distance out from the side stake at left. Also, opposite 11 under "Cut or Fill" and under .1 read 16.7, the distance out from the side stake at right.



Cut or Fill	Distance out from Side or Shoulder Stake										Cut or Fill
	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	
0	0.0	0.2	0.3	0.5	0.6	0.8	0.9	1.1	1.2	1.4	0
1	1.5	1.7	1.8	2.0	2.1	2.3	2.4	2.6	2.7	2.9	1
2	3.0	3.2	3.3	3.5	3.6	3.8	3.9	4.1	4.2	4.4	2
3	4.5	4.7	4.8	5.0	5.1	5.3	5.4	5.6	5.7	5.9	3
4	6.0	6.2	6.3	6.5	6.6	6.8	6.9	7.1	7.2	7.4	4
5	7.5	7.7	7.8	8.0	8.1	8.3	8.4	8.6	8.7	8.9	5
6	9.0	9.2	9.3	9.5	9.6	9.8	9.9	10.1	10.2	10.4	6
7	10.5	10.7	10.8	11.0	11.1	11.3	11.4	11.6	11.7	11.9	7
8	12.0	12.2	12.3	12.5	12.6	12.8	12.9	13.1	13.2	13.4	8
9	13.5	13.7	13.8	14.0	14.1	14.3	14.4	14.6	14.7	14.9	9
10	15.0	15.2	15.3	15.5	15.6	15.8	15.9	16.1	16.2	16.4	10
11	16.5	16.7	16.8	17.0	17.1	17.3	17.4	17.6	17.7	17.9	11
12	18.0	18.2	18.3	18.5	18.6	18.8	18.9	19.1	19.2	19.4	12
13	19.5	19.7	19.8	20.0	20.1	20.3	20.4	20.6	20.7	20.9	13
14	21.0	21.2	21.3	21.5	21.6	21.8	21.9	22.1	22.2	22.4	14
15	22.5	22.7	22.8	23.0	23.1	23.3	23.4	23.6	23.7	23.9	15
16	24.0	24.2	24.3	24.5	24.6	24.8	24.9	25.1	25.2	25.4	16
17	25.5	25.7	25.8	26.0	26.1	26.3	26.4	26.6	26.7	26.9	17
18	27.0	27.2	27.3	27.5	27.6	27.8	27.9	28.1	28.2	28.4	18
19	28.5	28.7	28.8	29.0	29.1	29.3	29.4	29.6	29.7	29.9	19
20	30.0	30.2	30.3	30.5	30.6	30.8	30.9	31.1	31.2	31.4	20
21	31.5	31.7	31.8	32.0	32.1	32.3	32.4	32.6	32.7	32.9	21
22	33.0	33.2	33.3	33.5	33.6	33.8	33.9	34.1	34.2	34.4	22
23	34.5	34.7	34.8	35.0	35.1	35.3	35.4	35.6	35.7	35.9	23
24	36.0	36.2	36.3	36.5	36.6	36.8	36.9	37.1	37.2	37.4	24
25	37.5	37.7	37.8	38.0	38.1	38.3	38.4	38.6	38.7	38.9	25
26	39.0	39.2	39.3	39.5	39.6	39.8	39.9	40.1	40.2	40.4	26
27	40.5	40.7	40.8	41.0	41.1	41.3	41.4	41.6	41.7	41.9	27
28	42.0	42.2	42.3	42.5	42.6	42.8	42.9	43.1	43.2	43.4	28
29	43.5	43.7	43.8	44.0	44.1	44.3	44.4	44.6	44.7	44.9	29
30	45.0	45.2	45.3	45.5	45.6	45.8	45.9	46.1	46.2	46.4	30
31	46.5	46.7	46.8	47.0	47.1	47.3	47.4	47.6	47.7	47.9	31
32	48.0	48.2	48.3	48.5	48.6	48.8	48.9	49.1	49.2	49.4	32
33	49.5	49.7	49.8	50.0	50.1	50.3	50.4	50.6	50.7	50.9	33
34	51.0	51.2	51.3	51.5	51.6	51.8	51.9	52.1	52.2	52.4	34
35	52.5	52.7	52.8	53.0	53.1	53.3	53.4	53.6	53.7	53.9	35
36	54.0	54.2	54.3	54.5	54.6	54.8	54.9	55.1	55.2	55.4	36
37	55.5	55.7	55.8	56.0	56.1	56.3	56.4	56.6	56.7	56.9	37
38	57.0	57.2	57.3	57.5	57.6	57.8	57.9	58.1	58.2	58.4	38
39	58.5	58.7	58.8	59.0	59.1	59.3	59.4	59.6	59.7	59.9	39
40	60.0	60.2	60.3	60.5	60.6	60.8	60.9	61.1	61.2	61.4	40

For Curve Tables see end of book.

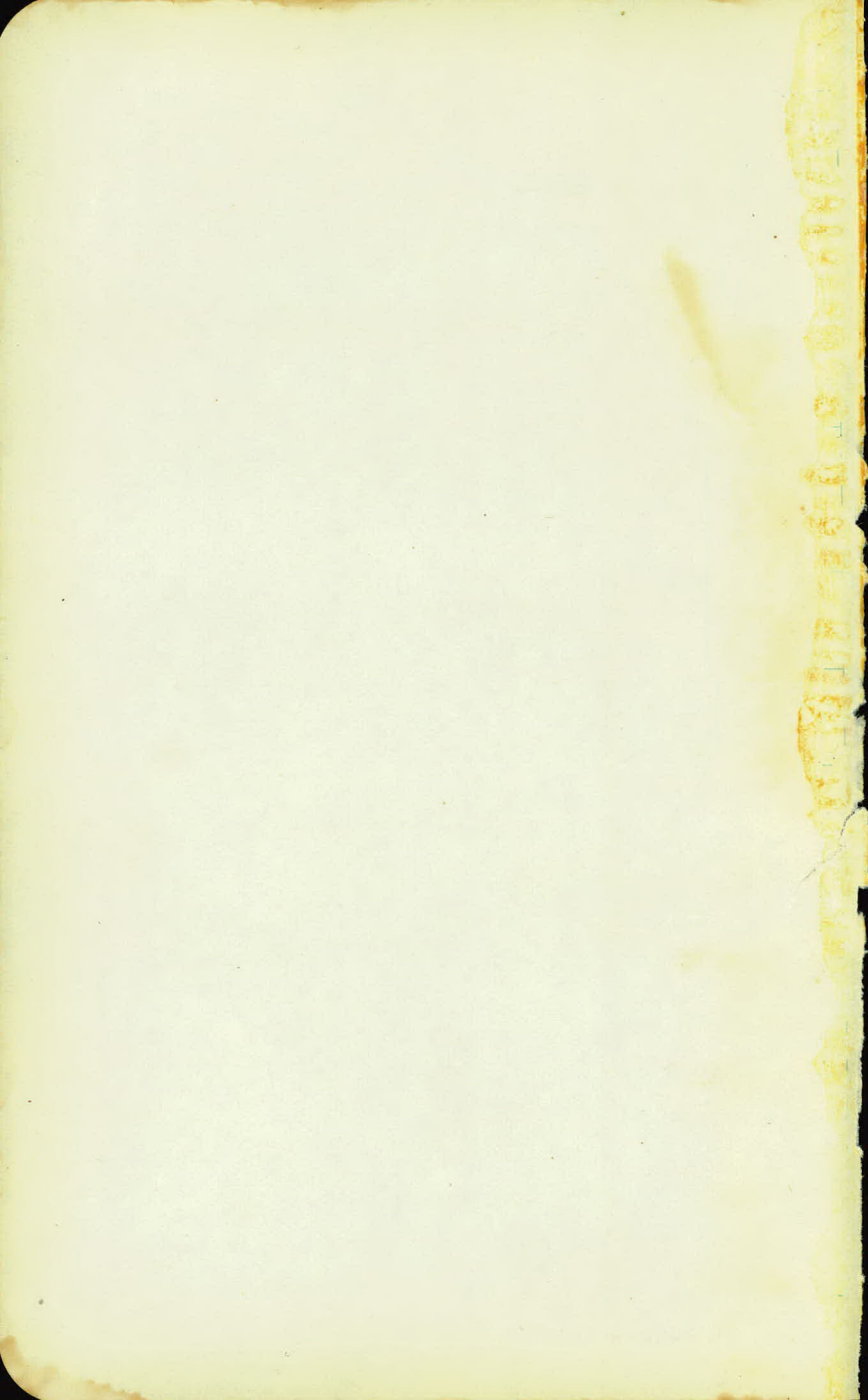
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Sewer Diddy

62-511-01,

27-516-01

Culvert



Aug. 12th Wed.

(3 Hrs)

Force

Foreman, Operator, Oiler (2 Hrs),
Truck Driver (8 Hrs),
5 Lab. (4 Hrs each)

Equip.

Link Belt Speeder (LS-50), Ford Truck,

Operator seized with attack about
noon. No work in PM on Trench.

Truck & Driver hauled pipe all day.
Started dig. at sta. 81+50 (cut lot of sand)

Aug. 13th Thu.

Force

5 Lab.; Drag Line Operator, Foreman,
Truck Driver.

Equip.

Link Belt Speeder (LS-50), Ford
Truck. (Hauling Pipe)

Laid 78' Pipe (SC 18")

Worked 9 Hrs. (8 till 6 - 1 Hr moon)

1111
Tues. Sept. 29-42 -

Clear

Started work - 10: AM. moved over
from Culv. Sta 68+58.

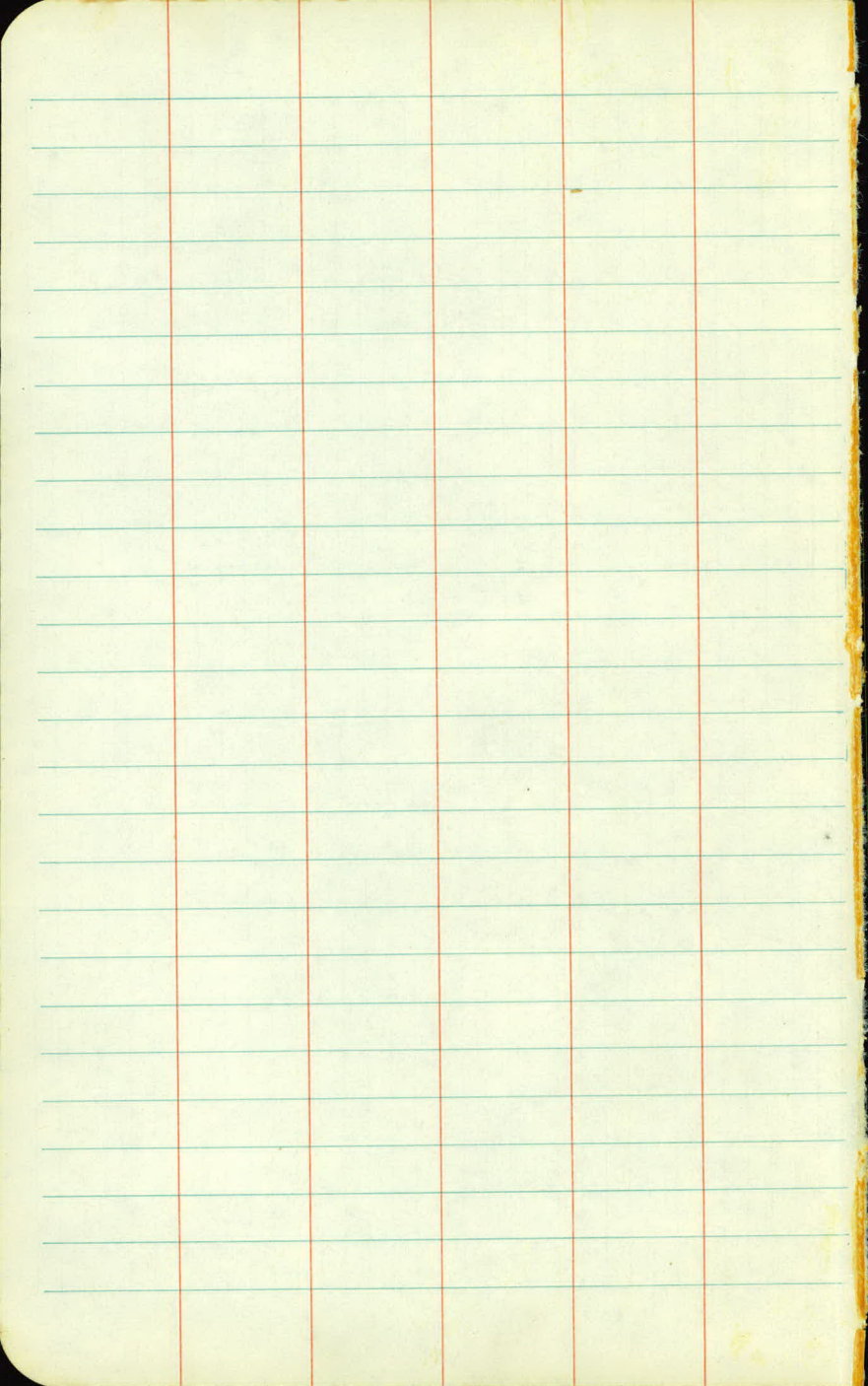
1 Speeder, 1 operator, 1 Oiler
1 Pipe layer, acting as Foreman
4 Laborers.

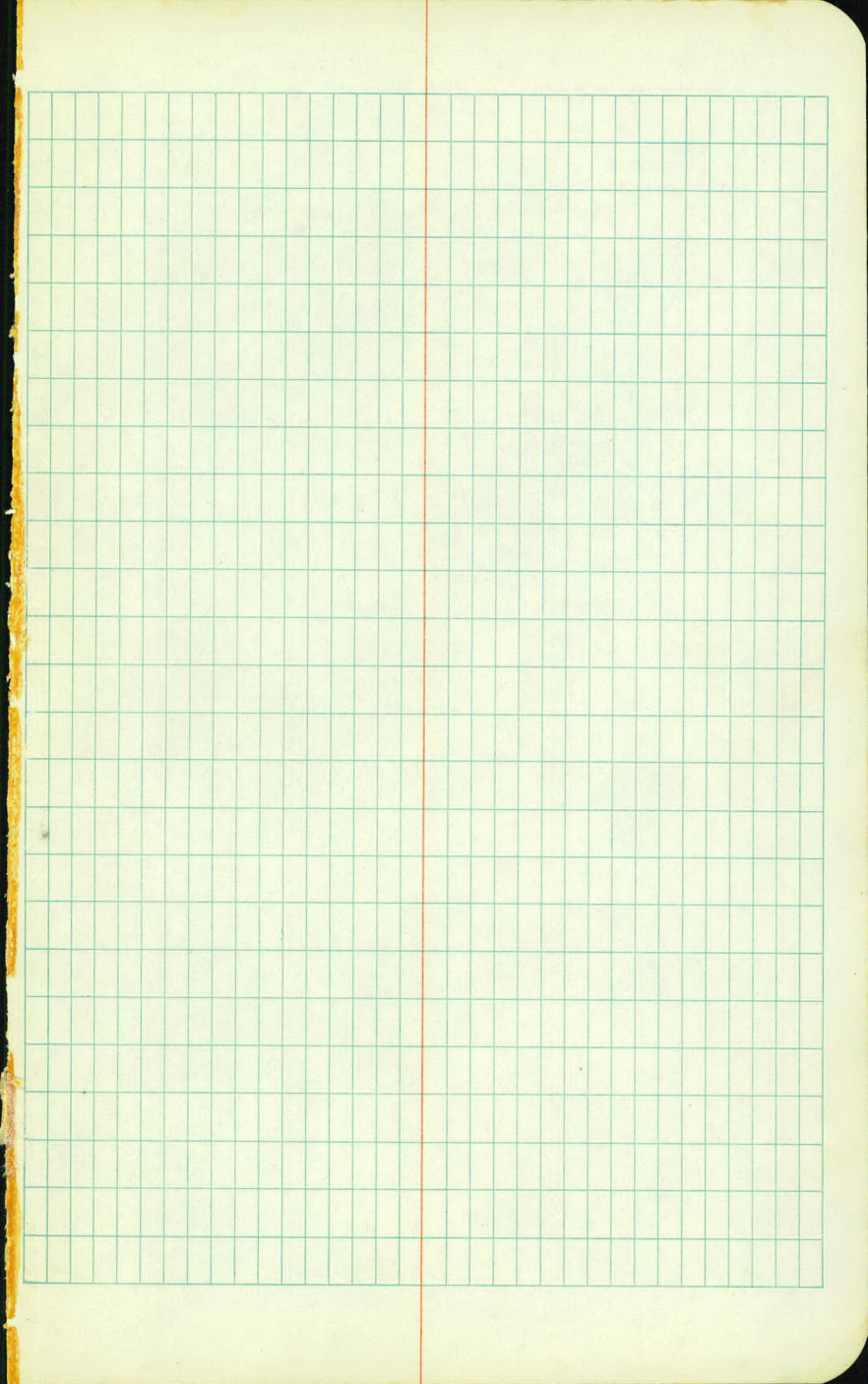
~~Laid 2 pcs - @ 6' - 12' - 24" pipe
Joints opened up and work deferred
moved to East Sta 68+58~~

A.G. Co. delivered sand in P.M.
to fill and open road on S. side

Doyne started filling about 5:30
to open roadway - on S. side

Placed 4 pcs - 6' - 24' - 24" pipe





Fri. Sept. 25-42. Fair + Cloudy

S.P. 62-511-01

Culv. at Sta 68+58

92' - 24" Conc. Pipe

Stock on hand

13 pcs @ 6' = 78'

2 " @ 4' = 8

86

Started work at 2:30

1 speeder 3h

1 foreman 3h

1 Operator + boiler 3h

1 pipe layer 2½h

3 Laborers 3h

Placed 3 pcs 6' = 18' - 24" pipe

Rec'd truck load of gravel at 4 P.M.

Placed gravel under 3rd piece.

Found only one grade stake. Cont. Erickson looked up Engineer to get check.

3-Pcs 6' = 18' - 24" pipe

Friday Aug. 14th

5 Lab. (10 Hrs.) 1 Lab 3 Hrs, Drag Line Operator
Foreman, Truck Driver, Oiler.

Link Belt Spreader (1550), Ford Truck
with Trailer.

Laid 80' Pipe (10-6'; 5-4')

Boulder on Line. Dug out to ht. side &
roller over. (50 x 30 x 2.5)

Worked 7 till 5:30 - 1/2 Hr norm)

Sat. Aug. 15th

2 Lab. Drag Line Operator, Oiler.
Laid 1-4' & 1-6' Pipe.

Foreman, 3 Lab., on 18" x 80' C.W. Sta.
Ht 50 on S.P. 6216-02.

Both crews worked till noon.
7:00 till 12:00 norm)

Monday Aug. 17th

SP 6216-02.

Foreman, 3 Lab finished laying
Pipe Sta. 4+50 7:00 till 12:00 noon.

Did not cover with roofing paper
Left. wks. exposed.

SP 62-511-01

A.M. Foreman, 2 Lab., Operator,
Oiler excavating Trench East side
New Brighton Rd. and W. side to Sta
78+00. (5:30 PM)

P.M. 2 Foreman, 5 Lab., Operator, Oiler
excavating trench W. side New Brighton
Rd. and E. side (4 Lab) starting under
slab. Excavating

D-1 Cat. & Bulldozer worked 1 hr.
on job today.

Wisconsin Pump on Job.

Tuesday Aug 18th

SP. 62-511-01.

3 Lab. excavating on E. side of New Brighton rd. preparing for jacking pipe under road.

Mr. Chand here this AM. He recommended gravel Bedkill for Trench (75766 to 79439.5)

Contractor hauled P&H shovel on Job to excavate trench.

from State Pit.

Contractor hauled one load of Pitrun Gravel & one load Pea Gravel from Shiely. Delivered by Shiely Trux

3 Lab - 1:30 P. till 5:30 P. drilling hole under road. 1 Lab. 4:30 P. till 5:30 P. same.

Back digger worked on W. side. in P.M. Cable came out 2 times. Not much accomplished

Also back filled trench on E side New Brighton Rd.

Laid 3-6' Pipe & 2-4' Pipe. in P.M.

Sta. 79407 to 78481

Foreman, 2 Lab, Operator, Oiler. till 5 P.M. on Pipe.

1 Lab. 2:30 P. till 5:30 P. New

Wednesday Aug 19th

3 Lab. Foreman on E. side New Brighton road drilling hole under Pav. 1 Lab. on W. side shoveling. 3 Lab 7:00 A till 8:30 A. Then went on W. side digging out 346 digging. 8:30 A till 10:30. Then back on E. side.

Decided to tunnel a few ft. under slab.

Back digger W side

" " Brake down moving to Exc trench.

Bull Dozer stuck in Muck.

Laying Pipe.

Foreman, Operator, Diler, 3 Lab. 7:00 till 11:30

1" 8:30 till 10:30

laid 100' Pipe - 8 lengths.

Sta. 77+81 to 77+81

Truck & Driver, 3 Lab got Load of Gravel.

11:00 A till 12:15 A.

Dry ditch Bottom 77+60 to 77+81

Thursday Aug 20TH

^{PM}
Back digger, excavating trench. Operator
Boiler. Very slow digging. One (1) Pipe in early lay
Speeder Dragline laying Pipe, Operator
Boiler.

Foreman, 4 Lab.

Laid 2' Pipe this AM so decided to put
both outlets digging. Started Speeder at Sta
75766 started Laying Pipe about 3:00 AM.
Dry bottom to Sta. 77+40. Water seeping
in again. Water at Sta 75766 also.

Laid 60' Pipe. 4' Longth.

Sta. 77+81 to 77+21

Foreman, 2 Lab working on Pipe under
Pave.

Used platform truck to haul blocking, planks &
Jacks. ^{Quotusa.}

Used Track jack for due length + then could
Back digger (P&H) broke down at 4:45 PM

Friday Aug 21st.

Back digger (PTH) not working first thing today. Speeder digging Sta 75766 toward 77+21. Digger started about 10:30A.

Moved Speeder to Esida New Bright Rd. & laid 6-4' Pipe which connect CM pipe jacked under slab
W side.

1-4' & 3-6' = 22' (To MIT) ✓

77+21 to 77+09 = 12' (2-6')

Jacking Pipe under Pavement
Foreman, 3 Lab. 7:00A till 12:00 Noon.

Use burning torch to cut at battered end ^{of CM} that was jacked under Pavement. 2' cut off & 4' Length added. Total Length of CM Pipe 22'

2 loads of Gravel hauled today.

Sat. Aug 22nd.

SP 6216-02

Foreman - 3 Lab, Laying cross Culv.
Sta. 82 + 48. 7:00 AM to 2:00 PM } 1/2 Hr. noon.

1 Lab. 9:00 AM to 2:00 PM

Using P+H Back Digger to Lay Pipe.

SP. 62-511-01

Foreman - 2 Lab, Dredge Line Operator, Diker
Laying Pipe Sta 77 + 09 to 76 + 69. 6-6 Pipe
36'; 1-4"; Total 40' 7:00 to 12:00 Noon.

2 Lab. exc. trench to grade.

Hauled 1 load Gravel

Sunday Aug 23rd

No Work.

Monday Aug 24th.

SP. 62-511-01

Foreman, Operator (LSSD) Oiler, Pipe
layer, 4 Lab. 7:00 AM till 12:00 Noon

Laid 1-6' Pipe 79+07 to 79+13

Laid 5-6' " & 18-4' Pipe 76+69 to 79+67

Above crew loading Equip.

12:30 P till - 2:00 PM moving to

SP 6216-02.

S.P. 6216-02

P & H digger began digging at Sta 51+78
and working South toward Sta 18+00

(PHH)

Foreman, Operator, Oiler, 1 Lab. worked
7:00 AM till 5:30 P.M.

Foreman, Operator (LSSD), Oiler, Pipe
Layer, 4 Lab. Laying 30" Pipe Sta. 51+78
to Sta 51+10 (17-4' Pipe) 2:00 PM till
5:30 P.M.

Drag Line (LSSD) moved to end of
36" Pipe.
Ford Trux & Trailer haul 30' Pipe.

Tuesday Aug 25th

SP 6216-02

P&H digger at trench. Sta 50+90 excavating.

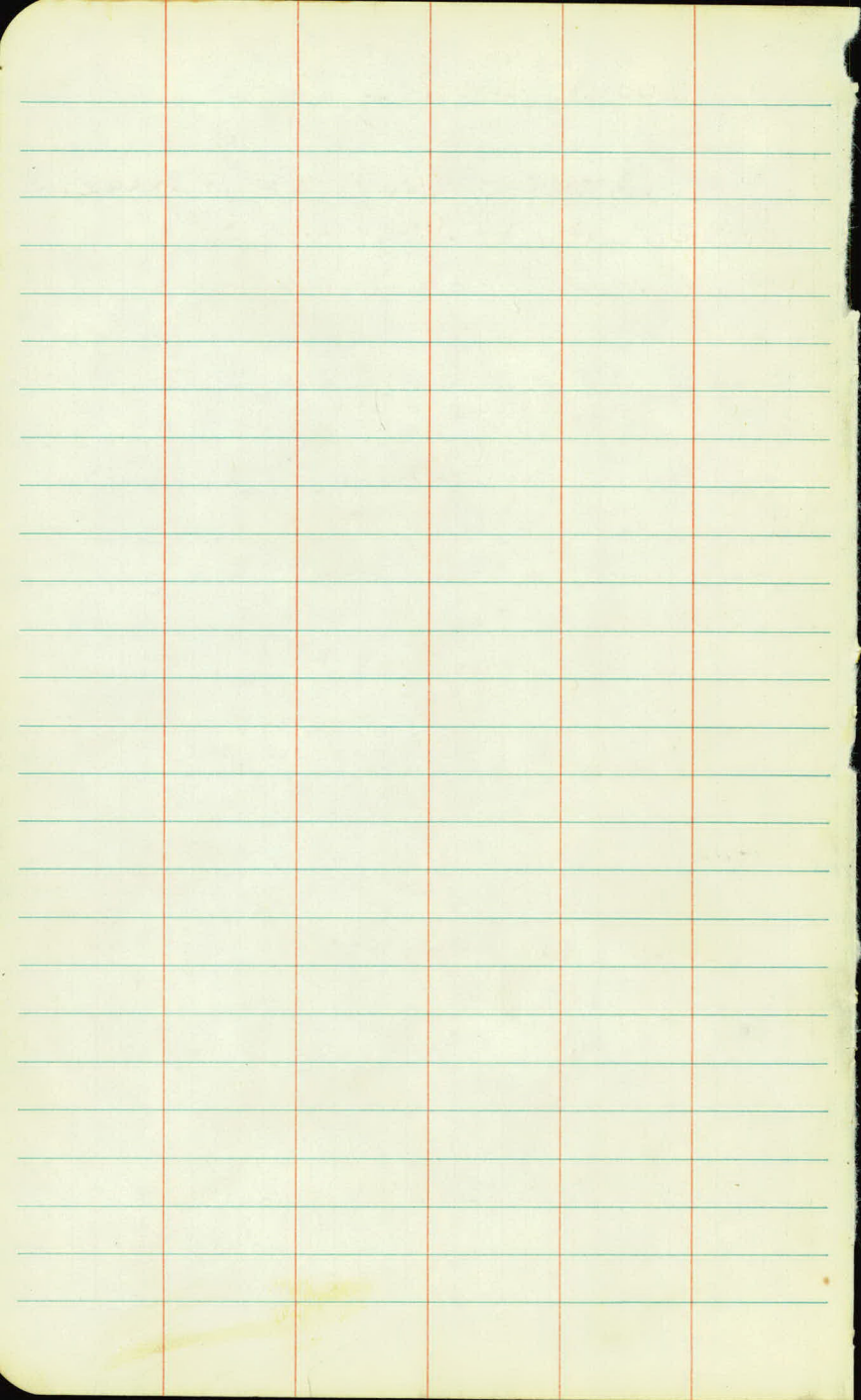
Operator, Diller, 1 Lab.

LS50 at end of 36" Pipe (Sta 2+06) excavating trench. Took out 1' below grade and back-filled with mat'l. hauled in by Guthrie and cast in place with LS50.

Sta. 2+06 to 1+46

SP 62-511-01

2 Lab. 7:00 till 10:00 excavating for Mith. base west end Sta 75+66.



Thursday Sept. 10th

P&H, Operator, Oiler, Foreman, 4 Lab.
Laying x Colv Sta. 5+57 on S.P. 27-516-01
Henn. Co.

Friday Sept. 11th

P&H, Operator, Oiler, Foreman, 4 Lab.
Finished x Colv Sta. 5757 on S.P. 27-516-01
Henn. Co.

Laying x Colv. Sta. 7+09 S.P. 62-511-01

Fri. Sept. 25-42 Cloudy + Fair
SP-62-511-01

Culv. at Sta 75+66

Started work 9:30 AM

1-Speeder 4h

1-operator + 1-boiler 4h

1 Foreman 4h

1-Pipe Layer 4h

3 Laborers 4h

Culvert 90' - 24" pipe
Manhole on S. end not
started.

Pipe stock on ground:

15 Pcs - 6' = 90 } 24" conc.
2 " - 4' = 8 }

Placed 4 pcs - 6' = 24'

Work stopped at 2:30
to get gravel to improve
foundation.

Moved to Culv. at Sta. 68+58
Truck load of gravel
delivered at 4:0 P.M.

4 pcs - @ 6' = 24' - 24" pipe

Sat. Sept. 26-42. Snow

No Work

Mon - Sept 28-42 Clear

Cul. Sta 68+50

Engr. checked elev. found
end 0.1 high - raised entire
grade across 0.1. Furnished
hub at side of fill.

1 - Speeder - 1 operator, boiler

1 - Pipe layer, acting as Foreman.

4 Laborers

1 Cat. and dozer in P.M.

7 pcs @ 6' = 42' - 24" pipe laid

Cat. making fill over section
laid.

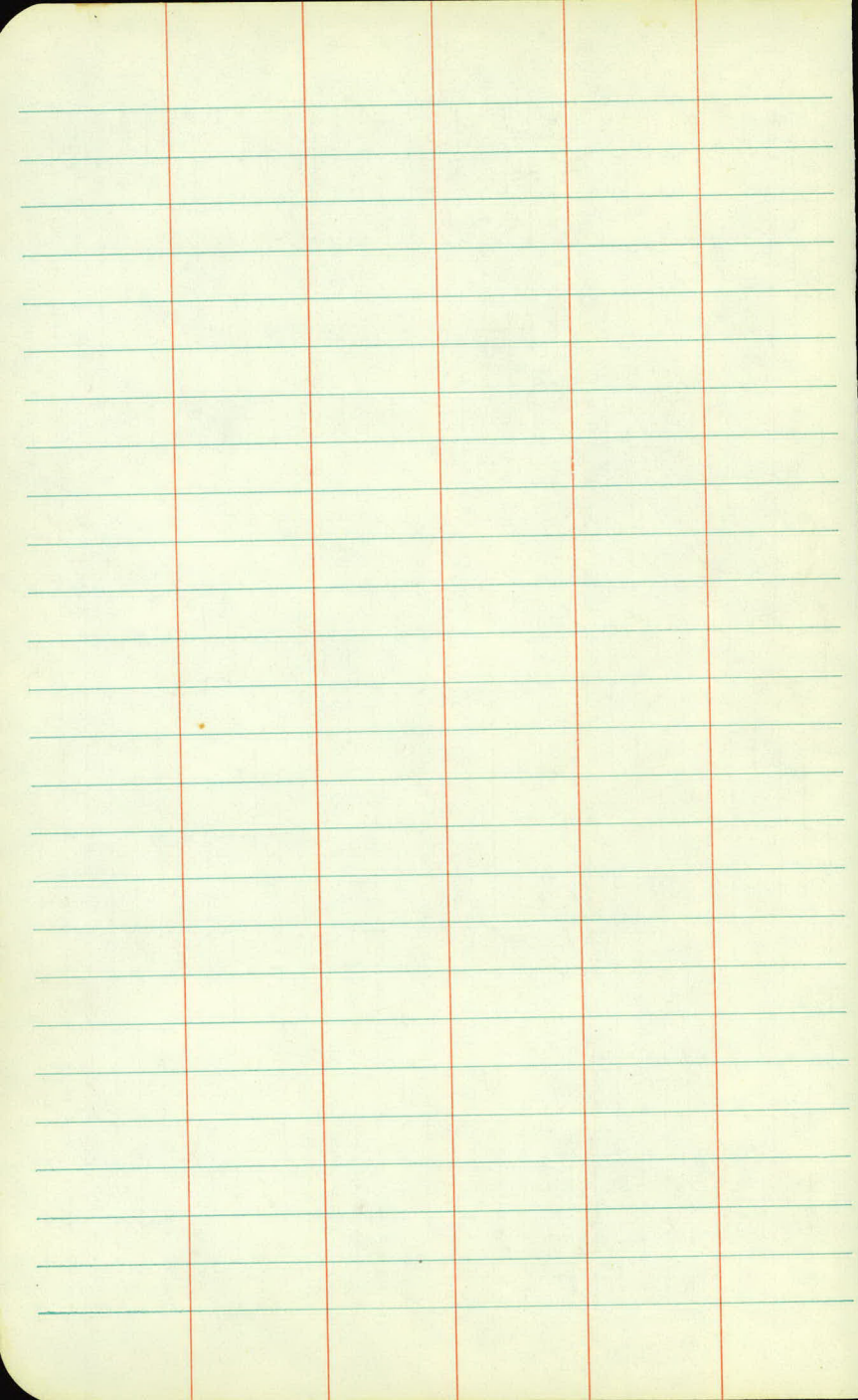
Filled with sand furnished
by A.G. Co.

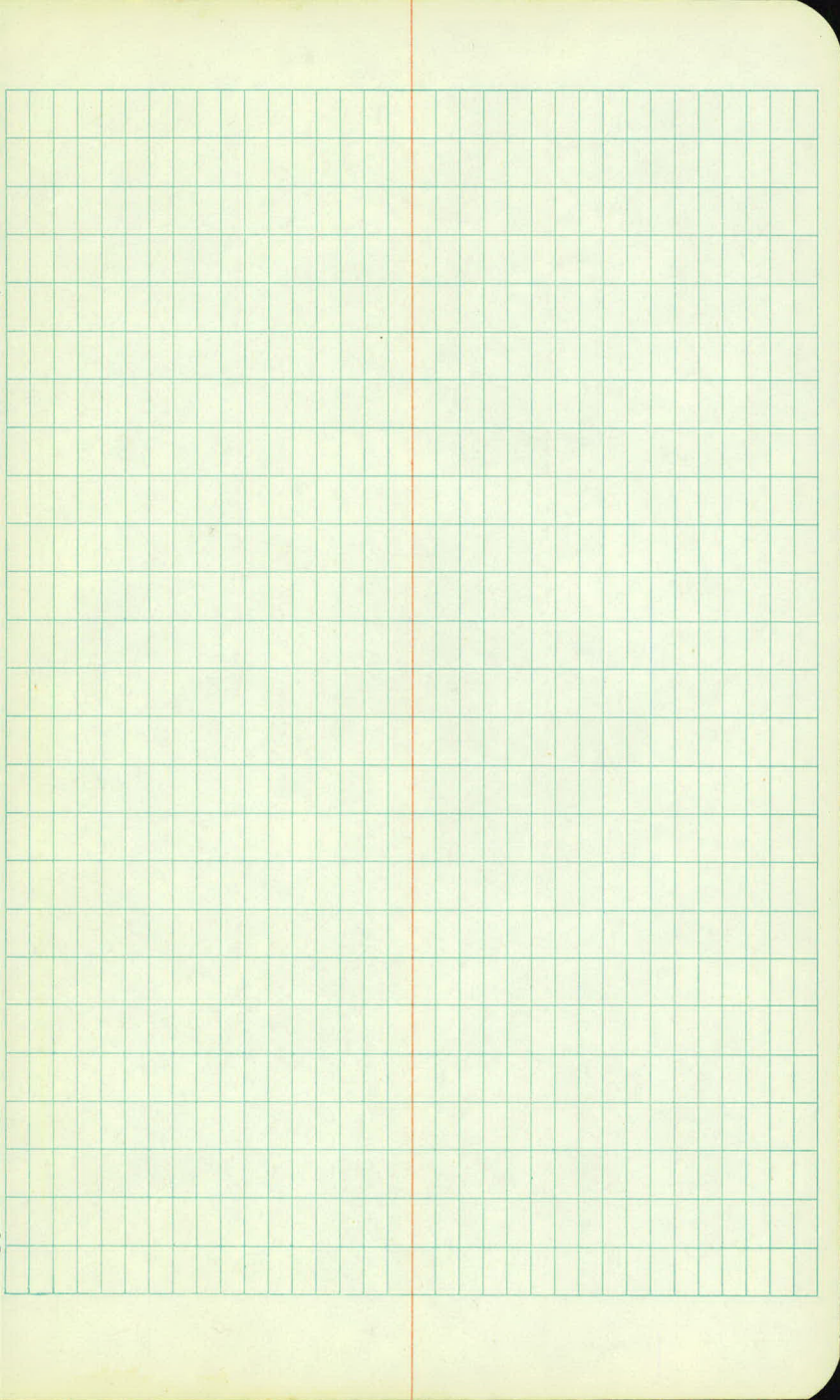
Laid 7 pcs @ 6' - 42' - 24" pipe

Tues. Sept. 29-42. Clear.

1 Speeder, 1 Operator, 1 Oiler
1- Pipe layer, acting as Foreman
4- Laborers

Laid 2 Pcs @ 6' = 12' - 24" Pipe
Joints opened up, and work deferred
moved to Culv. 75+66 at 10 A.M.





Aug

Operator
Speeder

operator
P&H.

oilers

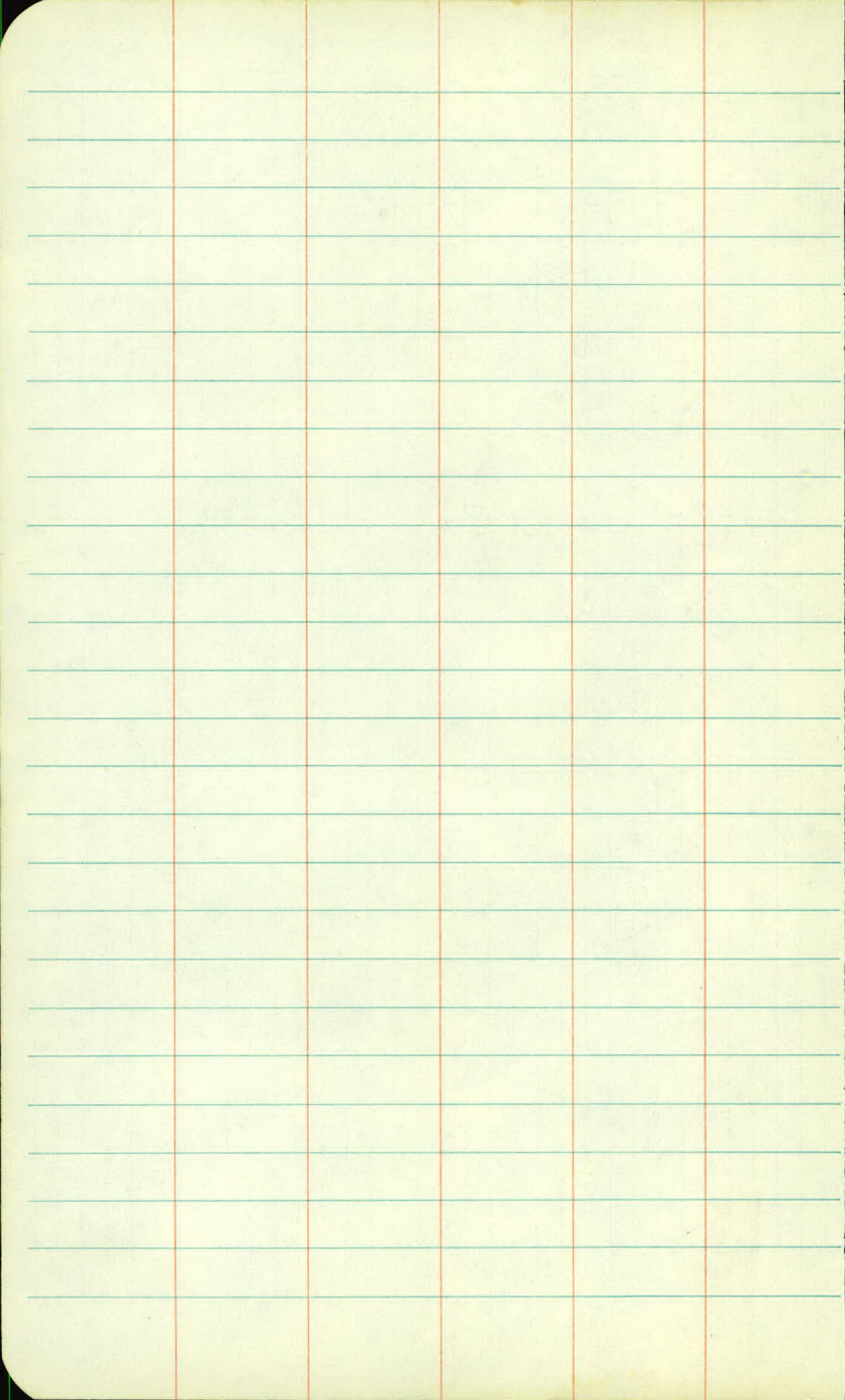
Foremen

Lab.

17th
18th

Force Acc't

- 17th Foreman 4 Lab.
- 18th Foreman, 3 Lab - 4 hrs.
1" - 1".
- 19th Foreman, 3 Lab 7:00 till 8:30 A
" " 10:30 till 4:30 P
2" 4:30 P " 5:30 P
- 20th Foreman, 2 Lab 7:00 till 11:00 A.
" 4" 11:00 till 5:30 P
- 21st " 3 Lab 7:00 till 12:00 noon.



CURVE TABLES.

HOW TO USE CURVE TABLES.

Table I. 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 External: Divide Ext. opposite the given Central Angle by the given External.

To find Nat. Tan. and Nat. Ex. Sec. for any angle by Table I.: 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.

EXAMPLE.

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

Ext. in Tab. I opposite 23° 20' = 120.87
 $120.87 \div 12 = 10.07$. Say a 10° Curve.

Tan. in Tab. I opp. 23° 20' = 1183.1
 $1183.1 \div 10 = 118.31$.

Correction for A. 23° 20' for a 10° Cur. = 0.16
 $118.31 + 0.16 = 118.47$ = corrected Tangent.

(If corrected Ext. is required find in same way)
 Ang. 23° 20' = 23.33° $\div 10 = 2.3333$ = L. C.

2° 19½' = def. for sta.	542	I. P. = sta.	542+72
4° 49½' = " " "	+50	Tan. =	1 .18.47
7° 19½' = " " "	543	B. C. = sta.	541+53.53
9° 49½' = " " "	+50	L. C. =	2 .33.33
11° 40' = " " "	543+	E. C. = Sta.	543+86.86
	86.86		

$100 - 53.53 = 46.47 \times 3'$ (def. for 1 ft. of 10° Cur.) = 139.41' = $\frac{1}{2}$
 2° 19½' = def. for sta. 542.

Def. for 50 ft. = 2° 30' for a 10° Curve.

Def. for 36.86 ft. = 1° 50½' for a 10° Curve.

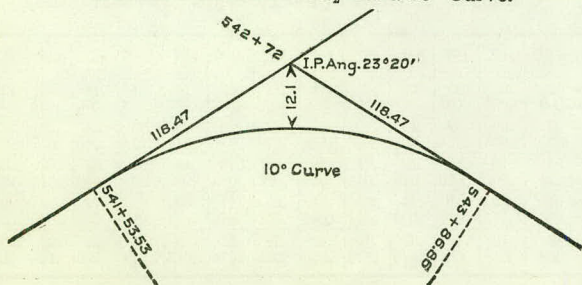


TABLE I. — Tangents and External to a 1° Curve.
Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
1°	50.00	.22	8°	400.66	13.99	15°	754.32	49.44
10'	58.34	.30	10'	409.03	14.58	10'	762.80	50.55
20	66.67	.39	20	417.41	15.18	20	771.29	51.68
30	75.01	.49	30	425.79	15.80	30	779.77	52.82
40	83.34	.61	40	434.17	16.43	40	788.26	53.97
50	91.68	.73	50	442.55	17.07	50	796.75	55.13
2	100.01	.87	9	450.93	17.72	16	805.25	56.31
10	108.35	1.02	10	459.32	18.38	10	813.75	57.50
20	116.68	1.19	20	467.71	19.06	20	822.25	58.70
30	125.02	1.36	30	476.10	19.75	30	830.76	59.91
40	133.36	1.55	40	484.49	20.45	40	839.27	61.14
50	141.70	1.75	50	492.88	21.16	50	847.78	62.38
3	150.04	1.96	10	501.28	21.89	17	856.30	63.63
10	158.38	2.19	10	509.68	22.62	10	864.82	64.90
20	166.72	2.43	20	518.08	23.38	20	873.35	66.18
30	175.06	2.67	30	526.48	24.14	30	881.88	67.47
40	183.40	2.93	40	534.89	24.91	40	890.41	68.77
50	191.74	3.21	50	543.29	25.70	50	898.95	70.09
4	200.08	3.49	11	551.70	26.50	18	907.49	71.42
10	208.43	3.79	10	560.11	27.31	10	916.03	72.76
20	216.77	4.10	20	568.53	28.14	20	924.58	74.12
30	225.12	4.42	30	576.95	28.97	30	933.13	75.49
40	233.47	4.76	40	585.36	29.82	40	941.69	76.86
50	241.81	5.10	50	593.79	30.68	50	950.25	78.26
5	250.16	5.46	12	602.21	31.56	19	958.81	79.67
10	258.51	5.83	10	610.64	32.45	10	967.38	81.09
20	266.86	6.21	20	619.07	33.35	20	975.96	82.53
30	275.21	6.61	30	627.50	34.26	30	984.53	83.97
40	283.57	7.01	40	635.93	35.18	40	993.12	85.43
50	291.92	7.43	50	644.37	36.12	50	1001.7	86.90
6	300.28	7.83	13	652.81	37.07	20	1010.3	88.39
10	308.64	8.31	10	661.25	38.03	10	1018.9	89.89
20	316.99	8.76	20	669.70	39.01	20	1027.5	91.40
30	325.35	9.23	30	678.15	39.99	30	1036.1	92.92
40	333.71	9.71	40	686.60	40.99	40	1044.7	94.46
50	342.08	10.20	50	695.06	42.00	50	1053.3	96.01
7	350.44	10.71	14	703.51	43.03	21	1061.9	97.57
10	358.81	11.22	10	711.97	44.07	10	1070.6	99.16
20	367.17	11.75	20	720.44	45.12	20	1079.2	100.75
30	375.54	12.29	30	728.90	46.18	30	1087.8	102.35
40	383.91	12.85	40	737.37	47.25	40	1096.4	103.97
50	392.28	13.41	50	745.85	48.34	50	1105.1	105.60

Corrections to be Added (T=Tangent. E=External.)

Int. Angle	Curve 5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
5°	T=.02	.03	.05	.06	.08	.10	.11	.13	.15	.16	.18	.20	.21	.23
	E=.000	.000	.001	.001	.002	.002	.002	.003	.003	.004	.004	.004	.005	.005
10°	T=.03	.06	.09	.13	.16	.19	.22	.25	.28	.31	.34	.38	.42	.46
	E=.001	.003	.004	.006	.007	.008	.009	.011	.012	.014	.015	.017	.018	.020
15°	T=.04	.10	.14	.19	.24	.29	.34	.39	.45	.51	.53	.58	.63	.68
	E=.003	.007	.010	.014	.018	.023	.027	.029	.032	.035	.039	.043	.047	.051
20°	T=.06	.13	.19	.26	.32	.39	.45	.51	.58	.65	.72	.79	.84	.90
	E=.006	.011	.017	.022	.028	.034	.038	.045	.051	.057	.063	.070	.076	.083
25°	T=.08	.16	.24	.33	.40	.49	.58	.67	.75	.83	.90	.99	1.06	1.14
	E=.009	.018	.027	.036	.046	.056	.065	.074	.083	.093	.106	.120	.127	.135

TABLE I. — Tangents and External to a 1° Curve.
Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
22°	1113.7	107.24	29°	1481.8	188.51	36°	1861.7	294.9
10'	1122.4	108.90	10'	1490.7	190.74	10'	1870.9	297.7
20	1131.0	110.57	20	1499.6	192.99	20	1880.1	300.6
30	1139.7	112.25	30	1508.5	195.25	30	1889.4	303.5
40	1148.4	113.95	40	1517.4	197.53	40	1898.6	306.4
50	1157.0	115.66	50	1526.3	199.82	50	1907.9	309.3
23	1165.7	117.38	30	1535.3	202.12	37	1917.1	312.2
10	1174.4	119.12	10	1544.2	204.44	10	1926.4	315.2
20	1183.1	120.87	20	1553.1	206.77	20	1935.7	318.1
30	1191.8	122.63	30	1562.1	209.12	30	1945.0	321.1
40	1200.5	124.41	40	1571.0	211.48	40	1954.3	324.1
50	1209.2	126.20	50	1580.0	213.86	50	1963.6	327.1
24	1217.9	128.00	31	1589.0	216.3	38	1972.9	330.2
10	1226.6	129.82	10	1598.0	218.7	10	1982.2	333.2
20	1235.3	131.65	20	1606.9	221.1	20	1991.5	336.3
30	1244.0	133.50	30	1615.9	223.5	30	2000.9	339.3
40	1252.8	135.35	40	1624.9	226.0	40	2010.2	342.4
50	1261.5	137.23	50	1633.9	228.4	50	2019.6	345.5
25	1270.2	139.11	32	1643.0	230.9	39	2029.0	348.6
10	1279.0	141.01	10	1652.0	233.4	10	2038.4	351.8
20	1287.7	142.93	20	1661.0	235.9	20	2047.8	354.9
30	1296.5	144.85	30	1670.0	238.4	30	2057.2	358.1
40	1305.3	146.79	40	1679.1	241.0	40	2066.6	361.3
50	1314.0	148.75	50	1688.1	243.5	50	2076.0	364.5
26	1322.8	150.71	33	1697.2	246.1	40	2085.4	367.7
10	1331.6	152.69	10	1706.3	248.7	10	2094.9	371.0
20	1340.4	154.69	20	1715.3	251.3	20	2104.3	374.2
30	1349.2	156.70	30	1724.4	253.9	30	2113.8	377.5
40	1358.0	158.72	40	1733.5	256.5	40	2123.3	380.8
50	1366.8	160.76	50	1742.6	259.1	50	2132.7	384.1
27	1375.6	162.81	34	1751.7	261.8	41	2142.2	387.4
10	1384.4	164.86	10	1760.8	264.5	10	2151.7	390.7
20	1393.2	166.95	20	1770.0	267.2	20	2161.2	394.1
30	1402.0	169.04	30	1779.1	269.9	30	2170.8	397.4
40	1410.9	171.15	40	1788.2	272.6	40	2180.3	400.8
50	1419.7	173.27	50	1797.4	275.3	50	2189.9	404.2
28	1428.6	175.41	35	1806.6	278.1	42	2199.4	407.6
10	1437.4	177.55	10	1815.7	280.8	10	2209.0	411.1
20	1446.3	179.72	20	1824.9	283.6	20	2218.6	414.5
30	1455.1	181.89	30	1834.1	286.4	30	2228.1	418.0
40	1464.0	184.08	40	1843.3	289.2	40	2237.7	421.4
50	1472.9	186.29	50	1852.5	292.0	50	2247.3	425.0

Corrections to be Added (T = Tangent. E = External.)

Int. Angle	Curve 5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
20°	T=.06 E=.006	.13 .011	.19 .017	.26 .022	.32 .028	.39 .034	.45 .038	.51 .045	.58 .051	.65 .057	.72 .063	.79 .070	.84 .076	.90 .083
25°	T=.08 E=.009	.16 .018	.24 .027	.33 .036	.40 .046	.49 .056	.58 .065	.67 .074	.75 .083	.83 .093	.90 .106	.99 .120	1.06 .127	1.14 .135
30°	T=.10 E=.013	.19 .025	.29 .039	.39 .051	.49 .065	.59 .078	.69 .090	.79 .103	.89 .116	.99 .129	1.09 .149	1.20 .170	1.29 .179	1.39 .188
35°	T=.11 E=.018	.22 .035	.34 .054	.47 .072	.58 .086	.69 .109	.80 .131	.93 .153	1.05 .175	1.17 .197	1.29 .213	1.42 .230	1.54 .247	1.66 .264
40°	T=.13 E=.023	.26 .046	.40 .070	.53 .093	.67 .117	.80 .141	.93 .172	1.06 .203	1.20 .234	1.34 .265	1.49 .277	1.64 .290	1.79 .315	1.94 .341
45°	T=.15 E=.030	.30 .060	.44 .093	.60 .119	.76 .153	.91 .184	1.06 .216	1.21 .254	1.37 .289	1.52 .325	1.70 .351	1.87 .378	2.04 .411	2.21 .445

TABLE I. — Tangents and Externals to a 1° Curve.
Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
43°	2257.0	428.5	50°	2671.8	592.3	57°	3110.9	790.1
10'	2266.6	432.0	10'	2681.9	596.6	10'	3121.7	795.2
20	2276.2	435.6	20	2692.1	600.9	20	3132.6	800.4
30	2285.9	439.2	30	2702.3	605.3	30	3143.4	805.6
40	2295.6	442.8	40	2712.5	609.6	40	3154.2	810.9
50	2305.2	446.4	50	2722.7	614.0	50	3165.1	816.1
44	2314.9	450.0	51	2732.9	618.4	58	3176.0	821.4
10	2324.6	453.6	10	2743.1	622.8	10	3186.9	826.7
20	2334.3	457.3	20	2753.4	627.2	20	3197.8	832.0
30	2344.1	461.0	30	2763.7	631.7	30	3208.8	837.3
40	2353.8	464.6	40	2773.9	636.2	40	3219.7	842.7
50	2363.5	468.4	50	2784.2	640.7	50	3230.7	848.1
45	2373.3	472.1	52	2794.5	645.2	59	3241.7	853.5
10	2383.1	475.8	10	2804.9	649.7	10	3252.7	858.9
20	2392.8	479.6	20	2815.2	654.3	20	3263.7	864.3
30	2402.6	483.4	30	2825.6	658.8	30	3274.8	869.8
40	2412.4	487.2	40	2835.9	663.4	40	3285.8	875.3
50	2422.3	491.0	50	2846.3	668.0	50	3296.9	880.8
46	2432.1	494.8	53	2856.7	672.7	60	3308.0	886.4
10	2441.9	498.7	10	2867.1	677.3	10	3319.1	892.0
20	2451.8	502.5	20	2877.5	682.0	20	3330.3	897.5
30	2461.7	506.4	30	2888.0	686.7	30	3341.4	903.2
40	2471.5	510.3	40	2898.4	691.4	40	3352.6	908.8
50	2481.4	514.3	50	2908.9	696.1	50	3363.8	914.5
47	2491.3	518.2	54	2919.4	700.9	61	3375.0	920.2
10	2501.2	522.2	10	2929.9	705.7	10	3386.3	925.9
20	2511.2	526.1	20	2940.4	710.5	20	3397.5	931.6
30	2521.1	530.1	30	2951.0	715.3	30	3408.8	937.3
40	2531.1	534.2	40	2961.5	720.1	40	3420.1	943.1
50	2541.0	538.2	50	2972.1	725.0	50	3431.4	948.9
48	2551.0	542.2	55	2982.7	729.9	62	3442.7	954.8
10	2561.0	546.3	10	2993.3	734.8	10	3454.1	960.6
20	2571.0	550.4	20	3003.9	739.7	20	3465.4	966.5
30	2581.0	554.5	30	3014.5	744.6	30	3476.8	972.4
40	2591.0	558.6	40	3025.2	749.6	40	3488.3	978.3
50	2601.1	562.8	50	3035.8	754.6	50	3499.7	984.3
49	2611.2	566.9	56	3046.5	759.6	63	3511.1	990.2
10	2621.2	571.1	10	3057.2	764.6	10	3522.6	996.2
20	2631.3	575.3	20	3067.9	769.7	20	3534.1	1002.3
30	2641.4	579.5	30	3078.7	774.7	30	3545.6	1008.3
40	2651.5	583.8	40	3089.4	779.8	40	3557.2	1014.4
50	2661.6	588.0	50	3100.2	784.9	50	3568.7	1020.5

Corrections to be Added (T = Tangent. E = External.)

Int. Angle	Curve 5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
40°	T = .13	.26	.40	.53	.67	.80	.93	.106	1.20	1.34	1.49	1.64	1.79	1.94
	E = .023	.046	.070	.093	.117	.141	.172	.203	.234	.265	.277	.290	.315	.341
45°	T = .15	.30	.44	.60	.76	.91	1.06	1.21	1.37	1.52	1.70	1.87	2.04	2.21
	E = .030	.060	.093	.119	.153	.184	.216	.254	.289	.325	.351	.378	.411	.445
50°	T = .17	.34	.51	.68	.85	1.02	1.19	1.36	1.54	1.72	1.91	2.10	2.29	2.48
	E = .037	.075	.116	.151	.189	.227	.266	.305	.345	.384	.425	.467	.508	.550
55°	T = .19	.38	.57	.76	.95	1.14	1.32	1.52	1.72	1.92	2.14	2.35	2.56	2.77
	E = .046	.093	.142	.188	.236	.283	.332	3.81	.420	.479	.530	.582	.641	.700
60°	T = .21	.42	.63	.84	1.05	1.27	1.49	1.71	1.94	2.17	2.38	2.60	2.83	3.07
	E = .056	.112	.168	.225	.283	.340	.398	.457	.516	.575	.636	.697	.774	.851
65°	T = .23	.46	.69	.93	1.16	1.40	1.64	1.88	2.13	2.38	2.63	2.88	3.13	3.39
	E = .067	.135	.204	.273	.343	.412	.483	.554	.625	.697	.771	.845	.922	1.01

TABLE I. — Tangents and External to a 1° Curve.
Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
64°	3580.3	1026.6	71°	4086.9	1308.2	78°	4639.8	1643.0
10'	3591.9	1032.8	10'	4099.5	1315.6	10'	4653.6	1651.7
20	3603.5	1039.0	20	4112.1	1322.9	20	4667.4	1660.5
30	3615.1	1045.2	30	4124.8	1330.3	30	4681.3	1669.2
40	3626.8	1051.4	40	4137.4	1337.7	40	4695.2	1678.1
50	3638.5	1057.7	50	4150.1	1345.1	50	4709.2	1686.9
65	3650.2	1063.9	72	4162.8	1352.6	79	4723.2	1695.8
10	3661.9	1070.2	10	4175.6	1360.1	10	4737.2	1704.7
20	3673.7	1076.6	20	4188.5	1367.6	20	4751.2	1713.7
30	3685.4	1082.9	30	4201.2	1375.2	30	4765.3	1722.7
40	3697.2	1089.3	40	4214.0	1382.8	40	4779.4	1731.7
50	3709.0	1095.7	50	4226.8	1390.4	50	4793.6	1740.8
66	3720.9	1102.2	73	4239.7	1398.0	80	4807.7	1749.9
10	3732.7	1108.6	10	4252.6	1405.7	10	4822.0	1759.0
20	3744.6	1115.1	20	4265.6	1413.5	20	4836.2	1768.2
30	3756.5	1121.7	30	4278.5	1421.2	30	4850.5	1777.4
40	3768.5	1128.2	40	4291.5	1429.0	40	4864.8	1786.7
50	3780.4	1134.8	50	4304.6	1436.8	50	4879.2	1796.0
67	3792.4	1141.4	74	4317.6	1444.6	81	4893.6	1805.3
10	3804.4	1148.0	10	4330.7	1452.5	10	4908.0	1814.7
20	3816.4	1154.7	20	4343.8	1460.4	20	4922.5	1824.1
30	3828.4	1161.3	30	4356.9	1468.4	30	4937.0	1833.6
40	3840.5	1168.1	40	4370.1	1476.4	40	4951.5	1843.1
50	3852.6	1174.8	50	4383.3	1484.4	50	4966.1	1852.6
68	3864.7	1181.6	75	4396.5	1492.4	82	4980.7	1862.2
10	3876.8	1188.4	10	4409.8	1500.5	10	4995.4	1871.8
20	3889.0	1195.2	20	4423.1	1508.6	20	5010.0	1881.5
30	3901.2	1202.0	30	4436.4	1516.7	30	5024.8	1891.2
40	3913.4	1208.9	40	4449.7	1524.9	40	5039.5	1900.9
50	3925.6	1215.8	50	4463.1	1533.1	50	5054.3	1910.7
69	3937.9	1222.7	76	4476.5	1541.4	83	5069.2	1920.5
10	3950.2	1229.7	10	4489.9	1549.7	10	5084.0	1930.4
20	3962.5	1236.7	20	4503.4	1558.0	20	5099.0	1940.3
30	3974.8	1243.7	30	4516.9	1566.3	30	5113.9	1950.3
40	3987.2	1250.8	40	4530.4	1574.7	40	5128.9	1960.2
50	3999.5	1257.9	50	4544.0	1583.1	50	5143.9	1970.3
70	4011.9	1265.0	77	4557.6	1591.6	84	5159.0	1980.4
10	4024.4	1272.1	10	4571.2	1600.1	10	5174.1	1990.5
20	4036.8	1279.3	20	4584.8	1608.6	20	5189.3	2000.6
30	4049.3	1286.5	30	4598.5	1617.1	30	5204.4	2010.8
40	4061.8	1293.6	40	4612.2	1625.7	40	5219.7	2021.1
50	4074.4	1300.9	50	4626.0	1634.4	50	5234.9	2031.4

Corrections to be Added (T = Tangent. E = External.)

Int. Angle	Curve 5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
60°	T = .21	.42	.63	.84	1.05	1.27	1.49	1.71	1.94	2.17	2.38	2.60	2.83	3.07
	E = .056	.112	.168	.225	.283	.340	.398	.457	.516	.575	.636	.697	.774	.851
65°	T = .23	.46	.69	.93	1.16	1.40	1.64	1.88	2.13	2.38	2.63	2.88	3.13	3.39
	E = .067	.135	.204	.273	.343	.412	.483	.554	.625	.697	.771	.845	.922	1.01
70°	T = .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
	E = .080	.159	.240	.321	.403	.485	.568	.652	.735	.819	.906	.994	1.08	1.17
75°	T = .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
	E = .095	.182	.286	.383	.480	.578	.678	.777	.877	.977	1.07	1.18	1.29	1.39
80°	T = .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
	E = .110	.220	.332	.445	.558	.671	.787	.903	1.02	1.13	1.25	1.38	1.50	1.62
85°	T = .33	.66	1.00	1.33	1.63	2.02	2.36	2.70	3.05	3.40	3.77	4.14	4.55	4.89
	E = .128	.259	.391	.524	.657	.790	.926	1.06	1.20	1.34	1.47	1.62	1.76	1.91

TABLE I. — Tangents and Externals to a 1° Curve.
Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
85°	5250.3	2041.7	92°	5933.2	2518.5	99°	6708.6	3092.7
10'	5265.6	2052.1	10'	5950.5	2531.0	10'	6728.4	3107.7
20	5281.0	2062.5	20	5967.9	2543.5	20	6748.2	3122.9
30	5296.4	2073.0	30	5985.3	2556.0	30	6768.1	3138.1
40	5311.9	2083.5	40	6002.7	2568.6	40	6788.1	3153.3
50	5327.4	2094.1	50	6020.2	2581.3	50	6808.2	3168.7
86	5343.0	2104.7	93	6037.8	2594.0	100	6828.3	3184.1
10	5358.6	2115.3	10	6055.4	2606.8	10	6848.5	3199.6
20	5374.2	2126.0	20	6073.1	2619.7	20	6868.8	3215.1
30	5389.9	2136.7	30	6090.8	2632.6	30	6889.2	3230.8
40	5405.6	2147.5	40	6108.6	2645.5	40	6909.6	3246.5
50	5421.4	2158.4	50	6126.4	2658.5	50	6930.1	3262.3
87	5437.2	2169.2	94	6144.3	2671.6	101	6950.6	3278.1
10	5453.1	2180.2	10	6162.6	2684.7	10	6971.3	3294.1
20	5469.0	2191.1	20	6180.2	2697.9	20	6992.0	3310.1
30	5484.9	2202.2	30	6198.3	2711.2	30	7012.7	3326.1
40	5500.9	2213.2	40	6216.4	2724.5	40	7033.6	3342.3
50	5517.0	2224.3	50	6234.6	2737.9	50	7054.5	3358.5
88	5533.1	2235.5	95	6252.8	2751.3	102	7075.5	3374.9
10	5549.2	2246.7	10	6271.1	2764.8	10	7096.6	3391.2
20	5565.4	2258.0	20	6289.4	2778.3	20	7117.8	3407.7
30	5581.6	2269.3	30	6307.9	2792.0	30	7139.0	3424.3
40	5597.8	2280.6	40	6326.3	2805.6	40	7160.3	3440.9
50	5614.2	2292.0	50	6344.8	2819.4	50	7181.7	3457.6
89	5630.5	2303.5	96	6363.4	2833.2	103	7203.2	3474.4
10	5646.9	2315.0	10	6382.1	2847.0	10	7224.7	3491.3
20	5663.4	2326.6	20	6400.8	2861.0	20	7246.3	3508.2
30	5679.9	2338.2	30	6419.5	2875.0	30	7268.0	3525.2
40	5696.4	2349.8	40	6438.4	2889.0	40	7289.8	3542.4
50	5713.0	2361.5	50	6457.3	2903.1	50	7311.7	3559.6
90	5729.7	2373.3	97	6476.2	2917.3	104	7333.6	3576.8
10	5746.3	2385.1	10	6495.2	2931.6	10	7355.6	3594.2
20	5763.1	2397.0	20	6514.3	2945.9	20	7377.8	3611.7
30	5779.9	2408.9	30	6533.4	2960.3	30	7399.9	3629.2
40	5796.7	2420.9	40	6552.6	2974.7	40	7422.2	3646.8
50	5813.6	2432.9	50	6571.9	2989.2	50	7444.6	3664.5
91	5830.5	2444.9	98	6591.2	3003.8	105	7467.0	3682.3
10	5847.5	2457.1	10	6610.6	3018.4	10	7489.6	3700.2
20	5864.6	2469.3	20	6630.1	3033.1	20	7512.2	3718.2
30	5881.7	2481.5	30	6649.6	3047.9	30	7534.9	3736.2
40	5898.8	2493.8	40	6669.2	3062.8	40	7557.7	3754.4
50	5916.0	2506.1	50	6688.8	3077.7	50	7580.5	3772.6

Corrections to be Added (T = Tangent. E. = External.)

Int. Angle	Curve	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
85°	T = .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	
	E = .128	.259	.391	.524	.657	.790	.926	1.06	1.20	1.34	1.47	1.62	1.76	1.91	
90°	T = .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	
	E = .149	.299	.450	.603	.756	.910	1.07	1.22	1.38	1.54	1.70	1.87	2.03	2.20	
95°	T = .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	
	E = .174	.350	.522	.706	.985	1.06	1.25	1.43	1.62	1.80	1.99	2.18	2.38	2.58	
100°	T = .43	.86	1.30	1.74	2.18	2.62	3.06	3.50	3.95	4.40	4.83	5.37	5.85	6.34	
	E = .200	.401	.604	.809	1.01	1.22	1.43	1.64	1.85	2.06	2.28	2.50	2.73	2.96	
105°	T = .46	.94	1.42	1.90	2.38	2.87	3.34	3.84	4.35	4.84	5.35	5.87	6.40	6.93	
	E = .230	.470	.700	.938	1.17	1.42	1.65	1.90	2.14	2.39	2.64	2.90	3.16	3.41	

TABLE I. — Tangents and External to a 1° Curve.
Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
106°	7603.5	3791.0	111°	8336.7	4386.1	116°	9169.4	5082.7
10'	7626.6	3809.4	10'	8362.7	4407.6	10'	9199.1	5107.9
20	7647.9	3827.9	20	8388.9	4429.2	20	9229.0	5133.3
30	7672.9	3846.5	30	8415.1	4450.9	30	9259.0	5158.8
40	7696.3	3865.2	40	8441.5	4472.7	40	9289.2	5184.5
50	7719.7	3884.0	50	8468.0	4494.6	50	9319.5	5210.3
107	7743.2	3902.9	112	8494.6	4516.6	117	9349.9	5236.2
10	7766.8	3921.9	10	8521.3	4538.8	10	9380.5	5262.3
20	7790.5	3940.9	20	8548.1	4561.1	20	9411.3	5288.6
30	7814.3	3960.1	30	8575.0	4583.4	30	9442.2	5315.0
40	7838.1	3979.4	40	8602.1	4606.0	40	9473.2	5341.5
50	7862.1	3998.7	50	8629.3	4628.6	50	9504.4	5368.2
108	7886.2	4018.2	113	8656.6	4651.3	118	9535.7	5395.1
10	7910.4	4037.8	10	8684.0	4674.2	10	9567.2	5422.1
20	7934.6	4057.4	20	8711.5	4697.2	20	9598.9	5449.2
30	7959.0	4077.2	30	8739.2	4720.3	30	9630.7	5476.5
40	7983.5	4097.1	40	8767.0	4743.6	40	9662.6	5504.0
50	8008.0	4117.0	50	8794.9	4766.9	50	9694.7	5531.7
109	8032.7	4137.1	114	8822.9	4790.4	119	9727.0	5559.4
10	8057.4	4157.3	10	8851.0	4814.1	10	9759.4	5587.4
20	8082.3	4177.5	20	8879.3	4837.8	20	9792.0	5615.5
30	8107.3	4197.9	30	8907.7	4861.7	30	9824.8	5643.8
40	8132.3	4218.4	40	8936.3	4885.7	40	9857.7	5672.3
50	8157.5	4239.0	50	8965.0	4909.9	50	9890.8	5700.9
110	8182.8	4259.7	115	8993.8	4934.1	120	9924.0	5729.7
10	8208.2	4280.5	10	9022.7	4958.6	10	9957.5	5758.6
20	8233.7	4301.4	20	9051.7	4983.1	20	9991.0	5787.7
30	8259.3	4322.4	30	9080.9	5007.8	30	10025.0	5817.0
40	8285.0	4343.6	40	9110.3	5032.6	40	10059.0	5846.5
50	8310.8	4364.8	50	9139.8	5057.6	50	10093.0	5876.1

Corrections to be Added (T = Tangent. E = External.)

Int. Angle	Curve 5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
100°	T=.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
	E=.200	.401	.604	.809	1.01	1.22	1.43	1.64	1.85	2.06	2.28	2.50	2.73	2.96
105°	T=.46	.94	1.42	1.90	2.38	2.87	3.34	3.84	4.35	4.84	5.35	5.87	6.40	6.93
	E=.230	.470	.700	.938	1.17	1.42	1.65	1.90	2.14	2.39	2.64	2.90	3.16	3.41
110°	T=.50	1.03	1.55	2.08	2.60	3.14	3.66	4.21	4.76	5.31	5.86	6.43	7.01	7.59
	E=.260	.535	.808	1.08	1.36	1.63	1.91	2.19	2.49	2.61	3.05	3.35	3.65	3.95
115°	T=.54	1.13	1.70	2.29	2.86	3.45	4.03	4.63	5.23	5.83	6.44	7.07	7.70	8.35
	E=.307	.624	.939	1.26	1.57	1.89	2.21	2.54	2.87	3.20	3.53	3.88	4.23	4.58
120°	T=.61	1.25	1.89	2.52	3.16	3.81	4.44	5.11	5.78	6.44	7.11	7.80	8.51	9.21
	E=.339	.720	1.08	1.45	1.82	2.20	2.56	2.95	3.33	3.72	4.10	4.50	4.91	5.32

TABLE II. — Radii, Ordinates and Deflections. Chord = 100 ft.

Deg.	Radius	Mid. Ord.	Tan. Dist.	Def. Dist.	Def. for 1 Ft.	Deg.	Radius	Mid. Ord.	Tan. Dist.	Def. Dist.	Def. for 1 Ft.
	ft.	ft.	ft.	ft.	'		ft.	ft.	ft.	ft.	'
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	3.718	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

The middle ordinate in inches for any cord of length (C) is equal to .0012 C² multiplied by the middle ordinate taken from the above table. Thus, if it desired to bend a 30 ft. rail to fit a 10 degree curve, its middle ordinate should be .0012×900×2.183 or 2.36 inches.

TABLE III. Deflections for Sub Chords for Short Radius Curves.

Degree of Curve	Radius 50	$\frac{1}{2}$ sub chord R = sin of $\frac{1}{2}$ def. angle				Length of arc for 100 ft.
	sin. $\frac{1}{2}$ def. ang.	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

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

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

$$\text{Sin. } \frac{1}{2} D = \frac{50}{R}$$

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

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

$$R = \frac{\text{Sin. } \frac{1}{2} D}{50}$$

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

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

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

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

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

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

To find angle for a given distance and deflection.

Rule 1. Multiply the given distance by .01745 (def. for 1° for 1 ft. see Table II.), 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.

GENERAL DATA

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.

LEVELING. The correction for curvature and refraction, in feet and decimals of feet is equal to $0.574 d^2$, where d is the distance in miles. The correction for curvature alone is closely, $\frac{2}{3} d^2$. The combined correction is negative.

PROBABLE ERROR. If d_1, d_2, d_3 , etc. are the discrepancies of various results from the mean, and if $\sum d^2$ = the sum of the squares of these differences and n = the number of observations, then the probable error of the

$$\text{mean} = \pm 0.6745 \sqrt{\frac{\sum d^2}{n(n-1)}}$$

TABLE IV. — 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 V. — 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

Natural Trigonometrical Functions

Angle. Sin. Tan. Sec. Cosec. Cotg. Cosin.							Angle. Sin. Tan. Sec. Cosec. Cotg. Cosin.									
°	0	0	1.	∞	∞	1.	90	°	8	1392	1405	1.0098	7.185	7.115	.99027	82
10	.0029	.0029		343.8	343.8	1.	50	10	.1421	.1435	1.0102	7.040	6.968	.98986		50
20	.0058	.0058		171.9	171.9	.99998	40	20	.1449	.1465	1.0107	6.900	6.827	.98944		40
30	.0087	.0087		114.6	114.6	.99996	30	30	.1478	.1495	1.0111	6.766	6.691	.98902		30
40	.0116	.0116	1.0001	85.94	85.94	.99993	20	40	.1507	.1524	1.0115	6.636	6.561	.98858		20
50	.0145	.0145	1.0001	68.76	68.75	.99989	10	50	.1536	.1554	1.0120	6.512	6.435	.98814		10
1	.0175	.0175	1.0002	57.30	57.29	.99985	89	9	.1564	.1584	1.0125	6.394	6.314	.98769		81
10	.0204	.0204	1.0002	49.11	49.10	.99979	50	10	.1593	.1614	1.0129	6.277	6.197	.98723		50
20	.0233	.0233	1.0003	42.98	42.96	.99973	40	20	.1622	.1644	1.0134	6.166	6.084	.98676		40
30	.0262	.0262	1.0003	38.20	38.19	.99966	30	30	.1650	.1673	1.0139	6.059	5.976	.98629		30
40	.0291	.0291	1.0004	34.38	34.37	.99958	20	40	.1679	.1703	1.0144	5.955	5.871	.98580		20
50	.0320	.0320	1.0005	31.26	31.24	.99949	10	50	.1708	.1733	1.0149	5.855	5.769	.98531		10
2	.0349	.0349	1.0006	28.65	28.64	.99939	88	10	.1736	.1763	1.0154	5.759	5.671	.98481		80
10	.0378	.0378	1.0007	26.45	26.43	.99929	50	10	.1765	.1793	1.0160	5.665	5.576	.98430		50
20	.0407	.0407	1.0008	24.56	24.54	.99917	40	20	.1794	.1823	1.0165	5.575	5.485	.98378		40
30	.0436	.0437	1.0010	22.93	22.90	.99905	30	30	.1822	.1853	1.0170	5.488	5.396	.98325		30
40	.0465	.0466	1.0011	21.49	21.47	.99892	20	40	.1851	.1883	1.0176	5.403	5.309	.98272		20
50	.0494	.0495	1.0012	20.23	20.21	.99878	10	50	.1880	.1914	1.0181	5.320	5.226	.98218		10
3	.0523	.0524	1.0014	19.11	19.08	.99863	87	11	.1908	.1944	1.0187	5.241	5.145	.98163		79
10	.0552	.0553	1.0015	18.10	18.07	.99847	50	10	.1937	.1974	1.0193	5.164	5.066	.98107		50
20	.0581	.0582	1.0017	17.20	17.17	.99831	40	20	.1965	.2004	1.0199	5.089	4.989	.98050		40
30	.0610	.0612	1.0019	16.38	16.35	.99813	30	30	.1994	.2035	1.0205	5.016	4.915	.97992		30
40	.0640	.0641	1.0020	15.64	15.60	.99795	20	40	.2022	.2065	1.0211	4.945	4.843	.97934		20
50	.0669	.0670	1.0022	14.96	14.92	.99776	10	50	.2051	.2095	1.0217	4.877	4.773	.97875		10
4	.0698	.0699	1.0024	14.34	14.30	.99756	86	12	.2079	.2126	1.0223	4.810	4.705	.97815		78
10	.0727	.0729	1.0027	13.76	13.73	.99736	50	10	.2108	.2156	1.0230	4.745	4.638	.97754		50
20	.0756	.0758	1.0029	13.23	13.20	.99714	40	20	.2136	.2186	1.0236	4.682	4.574	.97692		40
30	.0785	.0787	1.0031	12.75	12.71	.99692	30	30	.2164	.2217	1.0243	4.620	4.511	.97630		30
40	.0814	.0816	1.0033	12.29	12.25	.99668	20	40	.2193	.2247	1.0249	4.560	4.449	.97566		20
50	.0843	.0846	1.0036	11.87	11.83	.99644	10	50	.2221	.2278	1.0256	4.502	4.390	.97502		10
5	.0872	.0875	1.0038	11.47	11.43	.99619	85	13	.2250	.2309	1.0263	4.445	4.331	.97437		77
10	.0901	.0904	1.0041	11.10	11.06	.99594	50	10	.2278	.2339	1.0270	4.390	4.275	.97371		50
20	.0929	.0934	1.0043	10.76	10.71	.99567	40	20	.2306	.2370	1.0277	4.336	4.219	.97304		40
30	.0958	.0963	1.0046	10.43	10.39	.99540	30	30	.2334	.2401	1.0284	4.284	4.165	.97237		30
40	.0987	.0992	1.0049	10.13	10.08	.99511	20	40	.2363	.2432	1.0291	4.232	4.113	.97169		20
50	.1016	.1022	1.0052	9.839	9.788	.99482	10	50	.2391	.2462	1.0299	4.182	4.061	.97100		10
6	.1045	.1051	1.0055	9.567	9.514	.99452	84	14	.2419	.2493	1.0306	4.133	4.011	.97030		76
10	.1074	.1080	1.0058	9.309	9.255	.99421	50	10	.2447	.2524	1.0314	4.086	3.962	.96959		50
20	.1103	.1110	1.0061	9.065	9.010	.99390	40	20	.2476	.2555	1.0321	4.039	3.914	.96887		40
30	.1132	.1139	1.0065	8.834	8.777	.99357	30	30	.2504	.2586	1.0329	3.994	3.867	.96815		30
40	.1161	.1169	1.0068	8.614	8.556	.99324	20	40	.2532	.2617	1.0337	3.949	3.821	.96742		20
50	.1190	.1198	1.0072	8.405	8.345	.99290	10	50	.2560	.2648	1.0345	3.906	3.776	.96667		10
7	.1219	.1228	1.0075	8.206	8.144	.99255	83	15	.2588	.2679	1.0353	3.864	3.732	.96593		75
10	.1248	.1257	1.0079	8.016	7.953	.99219	50	10	.2616	.2711	1.0361	3.822	3.689	.96517		50
20	.1276	.1287	1.0082	7.834	7.770	.99182	40	20	.2644	.2742	1.0369	3.782	3.647	.96440		40
30	.1305	.1317	1.0086	7.661	7.596	.99144	30	30	.2672	.2773	1.0377	3.742	3.606	.96363		30
40	.1334	.1346	1.0090	7.496	7.429	.99106	20	40	.2700	.2805	1.0386	3.703	3.566	.96285		20
50	.1363	.1376	1.0094	7.337	7.269	.99067	10	50	.2728	.2836	1.0394	3.665	3.526	.96206		10

Cosin. Cotg. Cosec. Sec. Tan. Sin. Angle

Cosin. Cotg. Cosec. Sec. Tan. Sin. Angle

Natural Trigonometrical Functions

Angle. Sin. Tan. Sec. Cosec. Cotg. Cosin.							Angle. Sin. Tan. Sec. Cosec. Cotg. Cosin.						
° /						74	° /						66
16	.2756	.2867	1.0403	3.628	3.487	.96126	24	.4067	.4452	1.0946	2.459	2.246	.91355
10	.2784	.2899	1.0412	3.592	3.450	.96046	10	.4094	.4487	1.0961	2.443	2.229	.91236
20	.2812	.2931	1.0423	3.556	3.412	.95964	20	.4120	.4522	1.0975	2.427	2.211	.91116
30	.2840	.2962	1.0429	3.521	3.376	.95882	30	.4147	.4557	1.0989	2.411	2.194	.90996
40	.2868	.2994	1.0438	3.487	3.340	.95799	40	.4173	.4592	1.1004	2.396	2.177	.90875
50	.2896	.3026	1.0448	3.453	3.305	.95715	10	.4200	.4628	1.1019	2.381	2.161	.90753
17	.2924	.3057	1.0457	3.420	3.271	.95630	73	.4226	.4663	1.1034	2.366	2.145	.90631
10	.2952	.3089	1.0466	3.388	3.237	.95545	50	.4253	.4699	1.1049	2.351	2.128	.90507
20	.2979	.3121	1.0476	3.357	3.204	.95459	40	.4279	.4734	1.1064	2.337	2.112	.90383
30	.3007	.3153	1.0485	3.326	3.172	.95372	30	.4305	.4770	1.1079	2.323	2.097	.90259
40	.3035	.3185	1.0495	3.295	3.140	.95284	20	.4331	.4806	1.1095	2.309	2.081	.90133
50	.3062	.3217	1.0505	3.265	3.108	.95195	10	.4358	.4841	1.1110	2.295	2.066	.90007
18	.3090	.3249	1.0515	3.236	3.078	.95106	72	.4384	.4877	1.1126	2.281	2.050	.89879
10	.3118	.3281	1.0525	3.207	3.048	.95015	50	.4410	.4913	1.1142	2.268	2.035	.89752
20	.3145	.3314	1.0535	3.179	3.018	.94924	40	.4436	.4950	1.1158	2.254	2.020	.89622
30	.3173	.3346	1.0545	3.152	2.989	.94832	30	.4462	.4986	1.1174	2.241	2.006	.89493
40	.3201	.3378	1.0555	3.124	2.960	.94740	20	.4488	.5022	1.1190	2.228	1.991	.89363
50	.3228	.3411	1.0566	3.098	2.932	.94646	10	.4514	.5059	1.1207	2.215	1.977	.89232
19	.3256	.3443	1.0576	3.072	2.904	.94552	71	.4540	.5095	1.1223	2.203	1.963	.89101
10	.3283	.3476	1.0587	3.046	2.877	.94457	50	.4566	.5132	1.1240	2.190	1.949	.88968
20	.3311	.3508	1.0598	3.020	2.850	.94361	40	.4592	.5169	1.1257	2.178	1.935	.88835
30	.3338	.3541	1.0608	2.996	2.824	.94264	30	.4617	.5206	1.1274	2.166	1.921	.88701
40	.3365	.3574	1.0619	2.971	2.798	.94167	20	.4643	.5243	1.1291	2.154	1.907	.88566
50	.3393	.3607	1.0631	2.947	2.773	.94068	10	.4669	.5280	1.1308	2.142	1.894	.88431
20	.3420	.3640	1.0642	2.924	2.747	.93969	70	.4695	.5317	1.1326	2.130	1.881	.88295
10	.3448	.3673	1.0653	2.900	2.723	.93869	50	.4720	.5354	1.1343	2.119	1.868	.88158
20	.3475	.3706	1.0665	2.878	2.699	.93769	40	.4746	.5392	1.1361	2.107	1.855	.88020
30	.3502	.3739	1.0676	2.856	2.675	.93667	30	.4772	.5430	1.1379	2.096	1.842	.87882
40	.3529	.3772	1.0688	2.833	2.651	.93565	20	.4797	.5467	1.1397	2.085	1.829	.87743
50	.3557	.3805	1.0700	2.811	2.628	.93462	10	.4823	.5505	1.1415	2.073	1.816	.87603
21	.3584	.3839	1.0711	2.790	2.605	.93358	69	.4848	.5543	1.1434	2.063	1.804	.87462
10	.3611	.3872	1.0723	2.769	2.583	.93253	50	.4874	.5581	1.1452	2.052	1.792	.87321
20	.3638	.3906	1.0736	2.749	2.560	.93148	40	.4899	.5619	1.1471	2.041	1.780	.87178
30	.3665	.3939	1.0748	2.729	2.539	.93042	30	.4924	.5658	1.1490	2.031	1.767	.87036
40	.3692	.3973	1.0760	2.709	2.517	.92935	20	.4950	.5696	1.1509	2.020	1.756	.86892
50	.3719	.4006	1.0773	2.689	2.496	.92827	10	.4975	.5735	1.1528	2.010	1.744	.86748
22	.3746	.4040	1.0785	2.670	2.475	.92718	68	.5000	.5774	1.1547	2.000	1.732	.86603
10	.3773	.4074	1.0798	2.650	2.455	.92609	50	.5025	.5812	1.1566	1.990	1.720	.86457
20	.3800	.4108	1.0811	2.632	2.434	.92499	40	.5050	.5851	1.1586	1.980	1.709	.86310
30	.3827	.4142	1.0824	2.613	2.414	.92388	30	.5075	.5890	1.1606	1.970	1.698	.86163
40	.3854	.4176	1.0837	2.595	2.394	.92276	20	.5100	.5930	1.1626	1.961	1.686	.86015
50	.3881	.4210	1.0850	2.577	2.375	.92164	10	.5125	.5969	1.1646	1.951	1.675	.85866
23	.3907	.4245	1.0864	2.559	2.356	.92050	67	.5150	.6009	1.1666	1.942	1.664	.85717
10	.3934	.4279	1.0877	2.542	2.337	.91936	50	.5175	.6048	1.1687	1.932	1.653	.85567
20	.3961	.4314	1.0891	2.525	2.318	.91822	40	.5200	.6088	1.1707	1.923	1.643	.85416
30	.3987	.4348	1.0904	2.508	2.300	.91706	30	.5225	.6128	1.1728	1.914	1.632	.85264
40	.4014	.4383	1.0918	2.491	2.282	.91590	20	.5250	.6168	1.1749	1.905	1.621	.85112
50	.4041	.4417	1.0932	2.475	2.264	.91472	10	.5275	.6208	1.1770	1.896	1.611	.84959

Cosin. Cotg. Cosec. Sec. Tan. Sin. Angle

Cosin. Cotg. Cosec. Sec. Tan. Sin. Angle

Natural Trigonometrical Functions

Angle. Sin. Tan. Sec. Cosec. Cotg. Cosin.							Angle. Sin. Tan. Sec. Cosec. Cotg. Cosin.						
°	′	″	‴	‵	‶	‷	°	′	″	‴	‵	‶	‷
32	.5299	.6249	1.1792	1.887	1.600	.84805	58	.6293	.8098	1.2868	1.589	1.235	.77715
10	.5324	.6289	1.1813	1.878	1.590	.84650	50	.6316	.8146	1.2898	1.583	1.228	.77531
20	.5348	.6330	1.1835	1.870	1.580	.84495	40	.6338	.8195	1.2929	1.578	1.220	.77347
30	.5373	.6371	1.1857	1.861	1.570	.84339	30	.6361	.8243	1.2959	1.572	1.213	.77162
40	.5398	.6412	1.1879	1.853	1.560	.84182	20	.6383	.8292	1.2991	1.567	1.206	.76977
50	.5422	.6453	1.1901	1.844	1.550	.84025	10	.6406	.8342	1.3022	1.561	1.199	.76791
33	.5446	.6494	1.1924	1.836	1.540	.83867	57	.6428	.8391	1.3054	1.556	1.192	.76604
10	.5471	.6536	1.1946	1.828	1.530	.83708	50	.6450	.8441	1.3086	1.550	1.185	.76417
20	.5495	.6577	1.1969	1.820	1.520	.83549	40	.6472	.8491	1.3118	1.545	1.178	.76229
30	.5519	.6619	1.1992	1.812	1.511	.83389	30	.6494	.8541	1.3151	1.540	1.171	.76041
40	.5544	.6661	1.2015	1.804	1.501	.83228	20	.6517	.8591	1.3184	1.535	1.164	.75851
50	.5568	.6703	1.2039	1.796	1.492	.83066	10	.6539	.8642	1.3217	1.529	1.157	.75661
34	.5592	.6745	1.2062	1.788	1.483	.82904	56	.6561	.8693	1.3251	1.524	1.150	.75471
10	.5616	.6787	1.2086	1.781	1.473	.82741	50	.6583	.8744	1.3284	1.519	1.144	.75280
20	.5640	.6830	1.2110	1.773	1.464	.82577	40	.6604	.8796	1.3318	1.514	1.137	.75088
30	.5664	.6873	1.2134	1.766	1.455	.82413	30	.6626	.8847	1.3352	1.509	1.130	.74896
40	.5688	.6916	1.2158	1.758	1.446	.82248	20	.6648	.8899	1.3386	1.504	1.124	.74703
50	.5712	.6959	1.2183	1.751	1.437	.82082	10	.6670	.8952	1.3421	1.499	1.117	.74509
35	.5736	.7002	1.2208	1.743	1.428	.81915	55	.6691	.9004	1.3456	1.494	1.111	.74314
10	.5760	.7046	1.2233	1.736	1.419	.81748	50	.6713	.9057	1.3492	1.490	1.104	.74120
20	.5783	.7089	1.2258	1.729	1.411	.81580	40	.6734	.9110	1.3527	1.485	1.098	.73924
30	.5807	.7133	1.2283	1.722	1.402	.81412	30	.6756	.9163	1.3563	1.480	1.091	.73728
40	.5831	.7177	1.2309	1.715	1.393	.81242	20	.6777	.9217	1.3600	1.476	1.085	.73531
50	.5854	.7221	1.2335	1.708	1.385	.81072	10	.6799	.9271	1.3636	1.471	1.079	.73333
36	.5878	.7265	1.2361	1.701	1.376	.80902	54	.6820	.9325	1.3673	1.466	1.072	.73135
10	.5901	.7310	1.2387	1.695	1.368	.80730	50	.6841	.9380	1.3711	1.462	1.066	.72937
20	.5925	.7355	1.2413	1.688	1.360	.80558	40	.6862	.9435	1.3748	1.457	1.060	.72737
30	.5948	.7400	1.2440	1.681	1.351	.80386	30	.6884	.9490	1.3786	1.453	1.054	.72537
40	.5972	.7445	1.2466	1.675	1.343	.80212	20	.6905	.9545	1.3824	1.448	1.048	.72337
50	.5995	.7490	1.2494	1.668	1.335	.80038	10	.6926	.9601	1.3863	1.444	1.042	.72136
37	.6018	.7536	1.2521	1.662	1.327	.79864	53	.6947	.9657	1.3902	1.440	1.036	.71934
10	.6041	.7581	1.2549	1.655	1.319	.79688	50	.6967	.9713	1.3941	1.435	1.030	.71732
20	.6065	.7627	1.2577	1.649	1.311	.79512	40	.6988	.9770	1.3980	1.431	1.024	.71529
30	.6088	.7673	1.2605	1.643	1.303	.79335	30	.7009	.9827	1.4020	1.427	1.018	.71325
40	.6111	.7720	1.2633	1.636	1.295	.79158	20	.7030	.9884	1.4061	1.422	1.012	.71121
50	.6134	.7766	1.2661	1.630	1.288	.78980	10	.7050	.9942	1.4101	1.418	1.006	.70916
38	.6157	.7813	1.2690	1.624	1.280	.78801	52	.7071	1.	1.414	1.414	1.	.70711
10	.6180	.7860	1.2719	1.618	1.272	.78622	50						
20	.6202	.7907	1.2748	1.612	1.265	.78442	40						
30	.6225	.7954	1.2778	1.606	1.257	.78261	30						
40	.6248	.8002	1.2808	1.601	1.250	.78079	20						
50	.6271	.8050	1.2838	1.595	1.242	.77897	10						

Cosin. Cotg. Cosec. Sec. Tan. Sin. Angle

Cosin. Cotg. Cosec. Sec. Tan. Sin. Angle

West side C ^{10.36}~~12.36~~ Sta. 79+39.5

East ✓ C ^{10.73}~~12.73~~ Sta 79+59.5

78 - c 9.3

+su 10.0

77 10.1

+su 10.7

76 10.1

75766 10.1

3-6
2-4

No

E

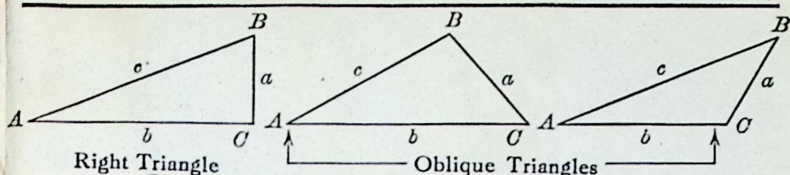
W

α

So

464-982

TRIGONOMETRIC FORMULÆ



Solution of Right Triangles

For Angle A . $\sin = \frac{a}{c}$, $\cos = \frac{b}{c}$, $\tan = \frac{a}{b}$, $\cot = \frac{b}{a}$, $\sec = \frac{c}{b}$, $\operatorname{cosec} = \frac{c}{a}$

Given Required

a, b A, B, c

$$\tan A = \frac{a}{b} = \cot B, c = \sqrt{a^2 + b^2} = a \sqrt{1 + \frac{b^2}{a^2}}$$

a, c A, B, b

$$\sin A = \frac{a}{c} = \cos B, b = \sqrt{(c+a)(c-a)} = c \sqrt{1 - \frac{a^2}{c^2}}$$

A, a B, b, c

$$B = 90^\circ - A, b = a \cot A, c = \frac{a}{\sin A}$$

A, b B, a, c

$$B = 90^\circ - A, a = b \tan A, c = \frac{b}{\cos A}$$

A, c B, a, b

$$B = 90^\circ - A, a = c \sin A, b = c \cos A,$$

Solution of Oblique Triangles

Given Required
 A, B, a b, c, C

$$b = \frac{a \sin B}{\sin A}, C = 180^\circ - (A + B), c = \frac{a \sin C}{\sin A}$$

A, a, b B, c, C

$$\sin B = \frac{b \sin A}{a}, C = 180^\circ - (A + B), c = \frac{a \sin C}{\sin A}$$

a, b, C A, B, c

$$A + B = 180^\circ - C, \tan \frac{1}{2}(A - B) = \frac{(a - b) \tan \frac{1}{2}(A + B)}{a + b},$$

$$c = \frac{a \sin C}{\sin A}$$

a, b, c A, B, C

$$s = \frac{a + b + c}{2}, \sin \frac{1}{2}A = \sqrt{\frac{(s - b)(s - c)}{bc}},$$

$$\sin \frac{1}{2}B = \sqrt{\frac{(s - a)(s - c)}{ac}}, C = 180^\circ - (A + B)$$

a, b, c Area

$$s = \frac{a + b + c}{2}, \text{area} = \sqrt{s(s - a)(s - b)(s - c)}$$

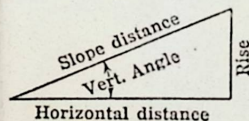
A, b, c Area

$$\text{area} = \frac{bc \sin A}{2}$$

A, B, C, a Area

$$\text{area} = \frac{a^2 \sin B \sin C}{2 \sin A}$$

REDUCTION TO HORIZONTAL



Horizontal distance = Slope distance multiplied by the cosine of the vertical angle. Thus: slope distance = 319.4 ft. Vert. angle = $5^\circ 10'$. From Table, Page IX. $\cos 5^\circ 10' = .9959$. Horizontal distance = $319.4 \times .9959 = 318.09$ ft.

Horizontal distance also = Slope distance minus slope distance times (1 - cosine of vertical angle). With the same figures as in the preceding example, the following result is obtained. $\cos 5^\circ 10' = .9959$. $1 - .9959 = .0041$. $319.4 \times .0041 = 1.31$. $319.4 - 1.31 = 318.09$ ft.

When the rise is known, the horizontal distance is approximately:—the slope distance less the square of the rise divided by twice the slope distance. Thus: rise = 14 ft., slope distance = 302.6 ft. Horizontal distance = $302.6 - \frac{14 \times 14}{2 \times 302.6} = 302.6 - 0.32 = 302.28$ ft.