

STP-S-07(317)-SE-07

27th ST

Resurfacing

E | L | A | N

Field Book

E 64.4x4

Name Black Hawk County
Engineer's Office
Address 316 E. 5th St Suite 211
Waterloo, IA 50703
Phone 319-291-2419

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DT-0659

Projects



Publishing Co., Inc.

Meredith, N.H. 03253

Projects (continued)

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PROJECT INFORMATION

PROJ. NO. STP-S-07(31)--SE-07

Prime Contractor

Aspro Inc

3613 Texas st.

Waterloo, IA 50704

Fore Person

GARY Echolm

Approved Sub Contractors

Love's Enterprises, Inc

Granular Shoulders

ALL IOWA Contracting

Pavement Markings

MANOTT'S

Paved Shoulder (MILLING)

Tri-State Signing

Traffic Control

Contract Late START Date

9-11-95

Specified Working Days

30

Actual START Date

9-11-95

Actual Completion DATE

Working Days Used

Liquidated Damages Per Day

\$ 700⁰⁰

Inspection Personnel

NAME

INT.

Robert Baldwin

R/B

Lynn Koberdane

LK

Wendell Lukes

Bud Sutherland

NE/TC FINAL AUDIT
Don Wink
12/15/95

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Line No. 0010

2121-7425020

GRANULAR SHOULDERS Type "B"

Contract Quantity 1,418 Ton

Actual Quantity 1131.18 Ton ✓

$$1131.18 \times 12^{\text{TS}} = \underline{14399}^{\text{QS}}$$

SEC. 2121.08 & 2121.09 B

Page No. 10

By RIB

Checked By LK

Line No. 0020

2122-5190300

PAVED SHOULDERS Type "B" A.C.C.

Contract Quantity 18,701 S.Y.

Actual Quantity 19,066 SY ✓

$$19,066 \times 7^{\text{TS}} = \underline{138,419}^{\text{QS}}$$

SEC. 2122.07 A & 2122.08 A.

Page No. 12

By LK

Checked By RIB

Line No. 0030

2212-0475095

CLEANING AND PREPARATION OF BASE

Contract Quantity

2.9 miles

Actual Quantity

2.92 miles

$$2.92 \times 2000^{\text{QS}} = \underline{5840}^{\text{QS}}$$

SEC. 2212.06 A & 2212.07 A

Page No. 14

By RIB

CHECKED BY LK

Line No. 0040

2303-0375010

ASPHALT CEMENT

Contract Quantity

785 TONS

Actual Quantity

763.25 Ton

$$763.25 \times 127^{\text{QS}} = \underline{96,932}^{\text{QS}}$$

SEC. 2303.25 B & 2303.26 B

Page No. 16

By RIB

CHECKED BY LK

Line No. 0050

2303-0400175

Asphalt Cement Concrete Type "A" $\frac{3}{4}$ " B_{inder}

Contract Quantity 7,960 Ton

Actual Quantity 6,780.49 tons

LK

$$6,780.49 \times 17^{\frac{73}{100}} = \underline{\underline{120,218}}^{\frac{09}{100}}$$

Sec. 2303.25 A + 2303.26 A

Page No. 18

By LK

Checked by RAB

Line No. 0060

2303-0400450

Asphalt Cement Concrete Type "A" $\frac{1}{2}$ " Surface

Contract Quantity 5,127 Ton

Actual Quantity 5,551.65 tons

LK

$$5,551.65 \times 17^{\frac{83}{100}} = \underline{\underline{98,985}}^{\frac{92}{100}}$$

Sec. 2303.25 A + 2303.26 A

Page No. 18

By LK

Checked by RAB

Line No. 0070

2303-6375000

Primer or Tack-Coat Bitumen

Contract Quantity 7,909 GNL

Actual Quantity 4,307.1 gals

LK

$$4,307.1 \times 1^{\frac{00}{100}} = \underline{\underline{4,307}}^{\frac{10}{100}}$$

Sec. 2303.25 C + 2303.26 C

Page No. 20

By LK

Checked By RAB

Line No. 0080

2303-6911222

Asphalt Cement Concrete Pavement Samples

Contract Quantity Lump Sum

Actual Quantity Lump Sum

$$\text{Lump Sum} \times 1,000^{\frac{00}{100}} = \underline{\underline{1,000}}^{\frac{00}{100}} \quad R$$

Sec. 2303.25 G + 2303.26 F

Page No. 22

By RAB

Checked By LK

Line No. 0090 2520-3350010

Field Laboratory

Contract Quantity Each

Actual Quantity Each

$$1 \text{ Each} \times \$2,000^{00} = \$2,000^{00}$$

Sec 2520.06 + 2520.07

Page No. 25

By RAB

Checked By LK

Line No. 0100 2527-9263110

Printed Pavement Marking

Contract Quantity 47610 STA.

Actual Quantity 703.87 STA

$$703.87 \times \$14^{00} = \$9,917^{53}$$

Sec. 2527.07A + 2527.08A

Page No. 26

By RAB

Checked By LK

Line No. 0110

2528-8445110

Traffic Control

Contract Quantity Lump Sum

Actual Quantity Lump Sum

$$\text{Lump Sum} \times \$5000^{00} = \$5,000^{00}$$

Sec. 2528.11A + 2528.12A

Page No. 27

By RAB

Checked By LK

Line No. 0120

2528-8445112

Flaggers

Contract Quantity 40 Day

Actual Quantity 24 Day

$$24 \times \$145^{00} = \$3,480^{00}$$

Sec. 2528.11A + 2528.12A

Page No. 28

By RAB

Checked By LK

Line No. 0130

2528-8445114

Pilot Cars

Contract Quantity 15 Day

Actual Quantity 11 DAY *W*

$$11 \times 215^{00} = \underline{\underline{2365^{00}}}$$

Sec. 2528.11 A & 2528.12 A

Page No. 29

By RIB

Checked By LK

Line No. 0140

2533-4980005

Mobilization

Contract Quantity Lump Sum

Actual Quantity Lump Sum

$$\text{Lump Sum} \times \$56,000^{00} = \underline{\underline{\$56,000^{00}}} \quad \checkmark$$

Sec. 2533.03

Page No. 30

By RIB

Checked By LK

EWO

7

EWO #1

8001

REMOVAL ASPHALT CEMENT CONCRETE
SURFACING (milling)

$$12254 @ 1^{20} = \underline{\underline{\$195^{20}}} \quad \checkmark$$

SEE PAGE 33

As per 2531.07 & 2531.08

By LK

Checked by

8002

PRICE REDUCTION FOR SMOOTHNESS
SPECIFICATION (7.1-110)

$$14 \text{ segments} @ \$50^{00} = \underline{\underline{\$700.00 \text{ CREDIT}}} \quad \checkmark$$

SEE PAGE

As per 55-5130

by LK

Checked by

8003

Smoothness Incentive 0.0"-1.0"

2 segments @ \$75⁰⁰ = \$150.00

W

SEE PAGE

As Per SS-5130

by DMC Checked by

EW0#2

8

7001

GRANULAR SHOULDERS TYPE B

DECREASE QUANTITY by 286.82 tons

W

SEE PAGE No. 10

by DMC Checked by

8004

Smoothness Incentive 2.1'-3.0'

7 segments @ \$25⁰⁰ = \$175.00

W

SEE PAGE

As Per SS-5130

by DMC Checked by

7002

Asphalt Cement Concrete, TYPE A BINDER

DECREASE QUANTITY by 1179.51 tons

W

SEE PAGE No 18

by DMC

Checked by

2003

PRIMER OR TACK COAT Bitumen

DECREASE Quantity by 3601.90 Gals

SEE PAGE No 20

by OAC

Checked by

2004

PAINTED PAVEMENT MARKINGS

INCREASE Quantity by 227.77 STA

SEE PAGE No 26

by OAC

Checked by

2005

FLAGGERS

DECREASE Quantity by 16 DAYS

SEE PAGE No. 28

by OAC

Checked by

2006

Pilot Cars

DECREASE Quantity by 4 DAYS

SEE PAGE No 29

by OAC

Checked by

Item # 0010 GRANULAR SHOULDERS 2121-7425020

Date	STATION		Side	Lmft	Tons Used	Tons Required	20	Tons To Date	Insp	Remarks
	From	To								
10/2/95	43+80	153+00	RT	10920	797.26	327.6	243%	797.26	BS	
10-6-95					125.85			923.11		
10-9-95					208.07			1131.18		

Total Div I = 1074.62, Div II = 56.56

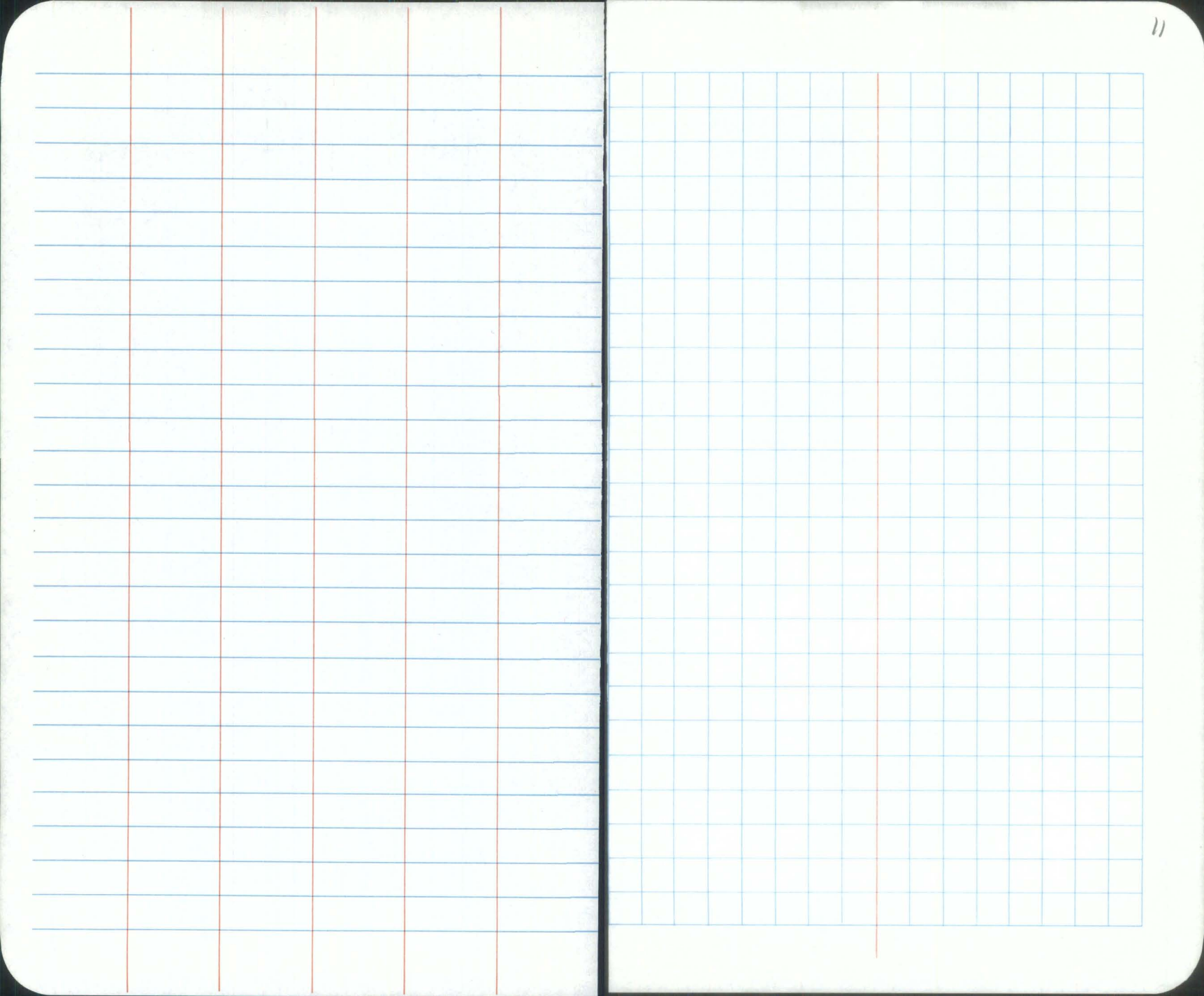
10

12 R/B

Total = 1131.18 Tons

10

12 R/B



Line No. 0020 Paved Shoulders 2122-5190300

Date	STATION		Side	Lin FT	Width
	From	To			

9/14/95	153+00	0+00	LT	15,300	5.5'
---------	--------	------	----	--------	------

9/14/95	0+00	115+00	RT	11,500	5.5'
---------	------	--------	----	--------	------

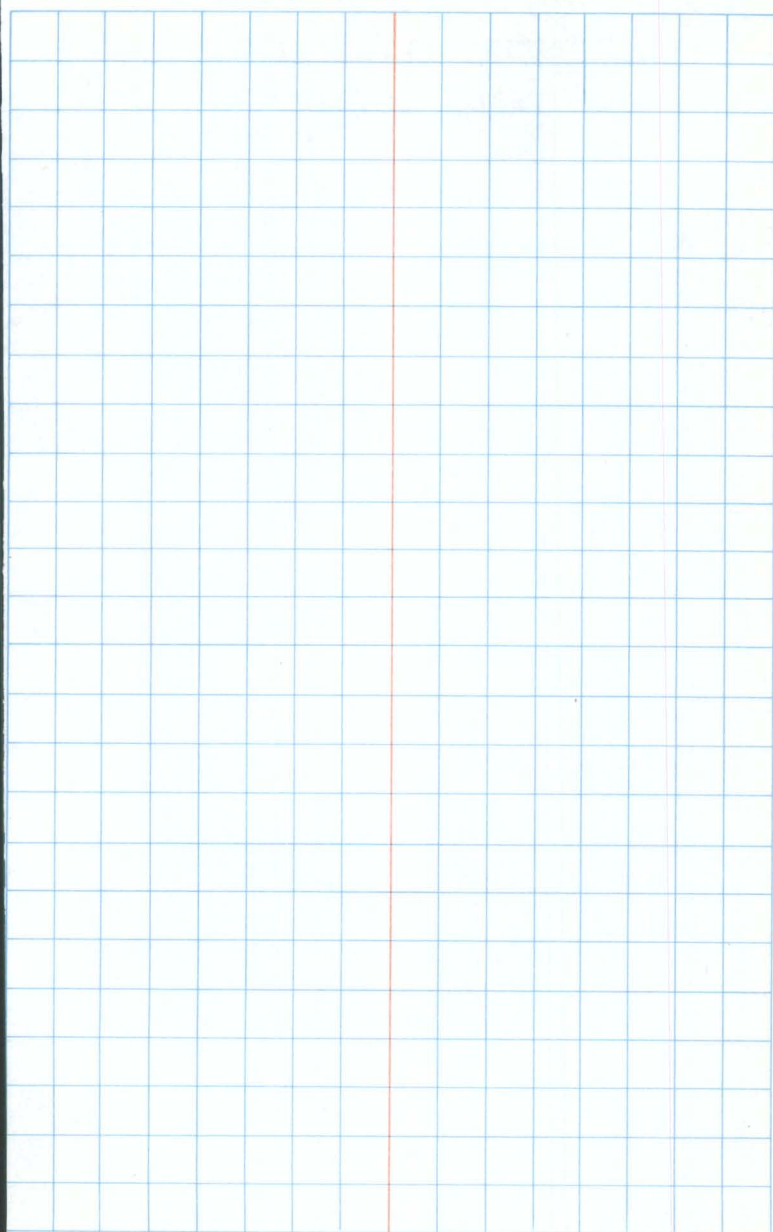
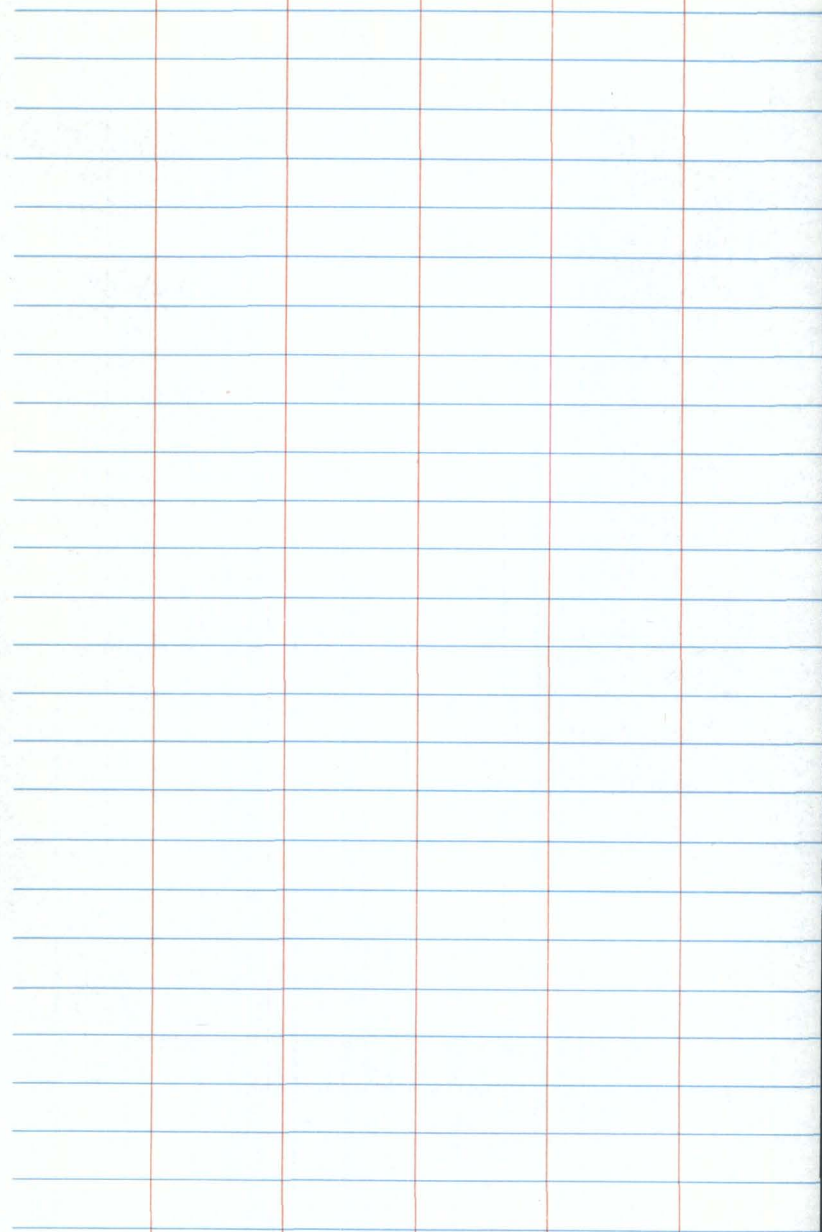
9/15/95	115+00	153+00	RT	3,800	5.5'
---------	--------	--------	----	-------	------

"	153+00	159+00	LT	600	5.5'
---	--------	--------	----	-----	------

Total DIV I = 17,954 sq yds R/B WTotal DIV II = 1,112 sq yds R/B W

Sq. Yards	Sq. Yards to date	SY		Insp.	Remarks
		DIV I	DIV II		
9,350	9,350			LK	
7,027	16,377			LK	2265.18 tons
2,322	18,699			LK	
367	19,066			LK	644.97 tons
		17,954	1,112	LK	

TOTAL SQ YDS =
19,066 LK
 R/B



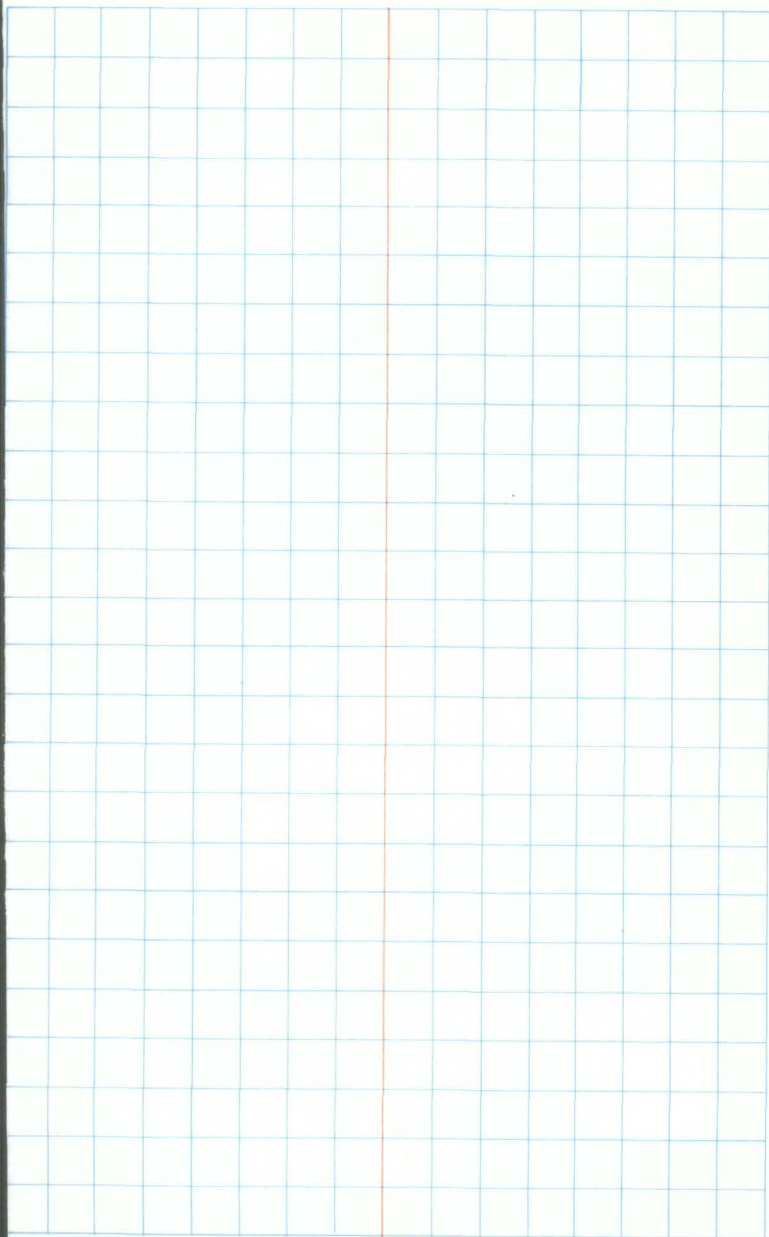
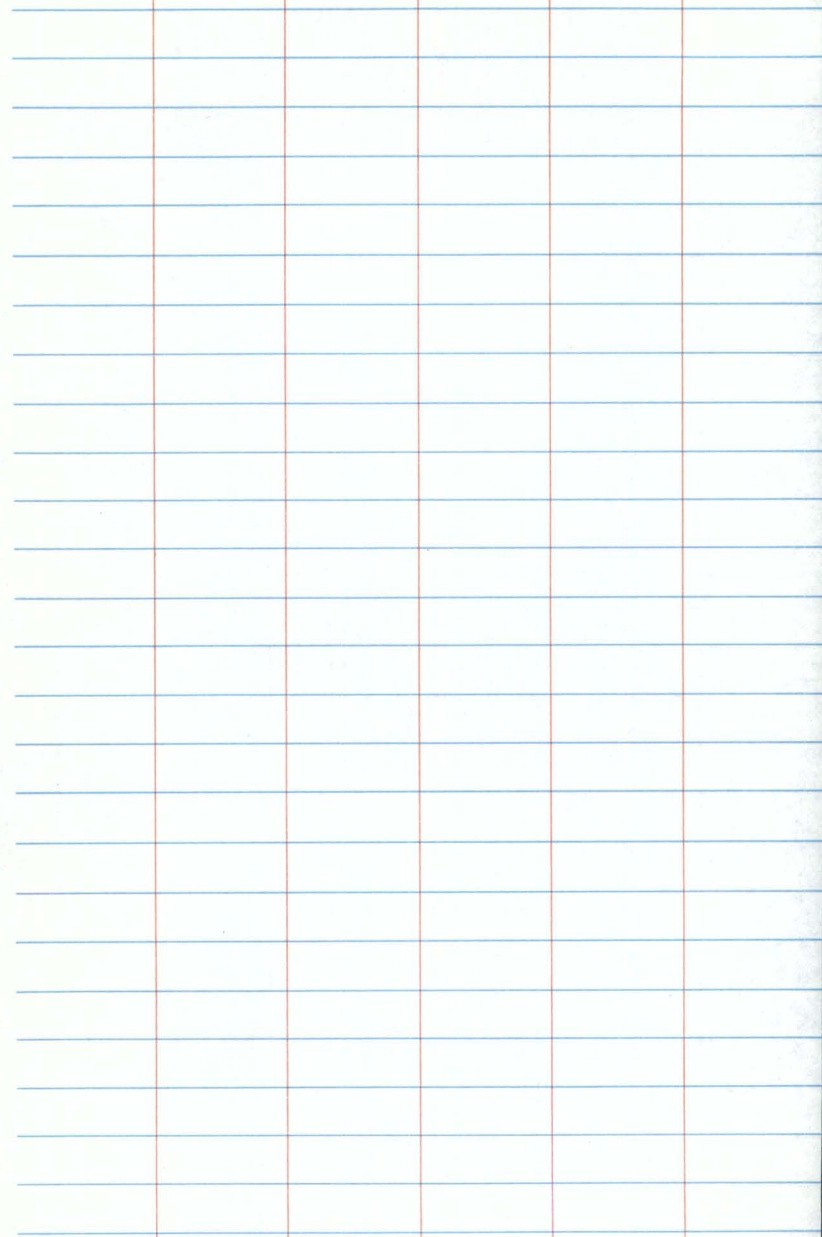
Item #0030 Clean & Preparation of Base 2212-0475095

Date	STATION		Measured		INSP
	From	To	Lin. Ft.	Miles	
9-21-95	-1+20	153+00	15420	2.92	RIB

Remarks

✓ TOTAL DIV I = 2.80 miles, Div. II 0.12 miles

✓ TOTAL - 2.92 miles RIB



*
ITEM 0040 ASPHALT CEMENT 2303-0375010

See PLANT BOOK Page For This Item R/B

TOTAL DIV I = 725.10, DIV II = 38.15 Ton

TOTAL = 763.25 Ton R/R

R/R

R/R

Item #	ACC $3\frac{1}{4}" \times \frac{1}{2}"$		Type "A"	Tons Used	Tons Regd.
DATE	From	To	Lin Ft.		
9/12/95	leveling			135.04	
9/21/95	0+00	26+80	2,680	645.17	514.56
	26+80	48+10	2,130	465.03	408.96
	48+10	82+70	3,460	674.95	669.32
	82+70	106+90	2,420	584.97	464.64
	106+90	141+50	4,150	765.08	796.80
(9/21/95 DAILY TOTAL = 3135.20)					
9/22/95	0+00	21+70	2,170	479.99	432.92
	21+70	58+80	3,710	810.00	740.14
	58+80	105+45	4,665	1034.98	930.67
	105+45	126+80	2,135	524.92	425.93
(9/22/95 DAILY TOTAL = 2849.88)					
9/23/95	141+50	153+00	1,150	195.18	220.8
	126+80	153+00	2,620	464.94	522.69
9/23/95 DAILY TOTAL = 660.12					
9/25/95	0+00	46+50	4,650	990.47	778.9
	46+50	80+50	3,400	720.27	569.5
	80+50	109+00	2,850	599.98	477.4
	109+00	153+00	4,400	885.42	737.0
9/25 DAILY TOTAL = 3196.34 2562.8					
9/26/95	0+00	70+10	7,010	975.13	1174.2
	70+10	133+50	6,340	1050.13	1061.9
	133+50	153+00	1,950	329.96	326.6
(9/26 DAILY TOTAL = 2355.22 2562.7)					

%	Type & Size	W _{th}	D _{th}	Insp	Remarks
—	"A" $3\frac{1}{4}"$	5.5		LK	for leveling
125.4	"A" $3\frac{1}{4}"$	15.7	2"	LK	tons per STA = 19.2
113.7	" "	"	2"	LK	tons per STA = 19.2
101.6	" "	"	2"	LK	" " " "
125.8	" "	"	2"	LK	" " " "
104.1	" "	"	2"	LK	" " " "
110.8	"A" $3\frac{1}{4}"$	16.3	2"	LK	tons per STA = 19.95
109.4	" "	"	"	LK	" " "
111.2	" "	"	"	LK	" " = "
123.2	" "	"	"	LK	" " "
88.4	"A" $3\frac{1}{4}"$		2"	LK	tons per STA = 19.2
88.9	"A" $3\frac{1}{4}"$	16.3	2"	LK	tons per STA = 19.95
127.1	"A" $\frac{1}{2}"$	16.3	$1\frac{1}{2}"$	LK	tons per STA = 16.75
126.5	" "	"	"	LK	" "
125.7	" "	"	"	LK	" "
120.1	" "	"	"	LK	" "
124.7					
83.0	" "	16.3	"	LK	tons per STA = 16.75
98.9	"A" $\frac{1}{2}"$	"	"	LK	
101.0	"A" $\frac{1}{2}"$	"	"	LK	

(from tape totals)

ASPHALT CONCRETE TOTALS

DATE	TYPE	TONS	to date TONS
9/12/95	3/4" BINDER	135.04	135.04
9/21/95	3/4" BINDER	3135.32	3270.36
9/22/95	3/4" BINDER	2849.97	6120.33
9/23/95	3/4" BINDER	660.16	6780.49

TOTAL BINDER = 6780.49 LK

✓RDD

9/25/95	1/2" SURFACE	3196.42	3196.42
9/26/95	1/2" SURFACE	2355.23	5551.65

TOTAL SURFACE = 5551.65 tons LK

✓RDD

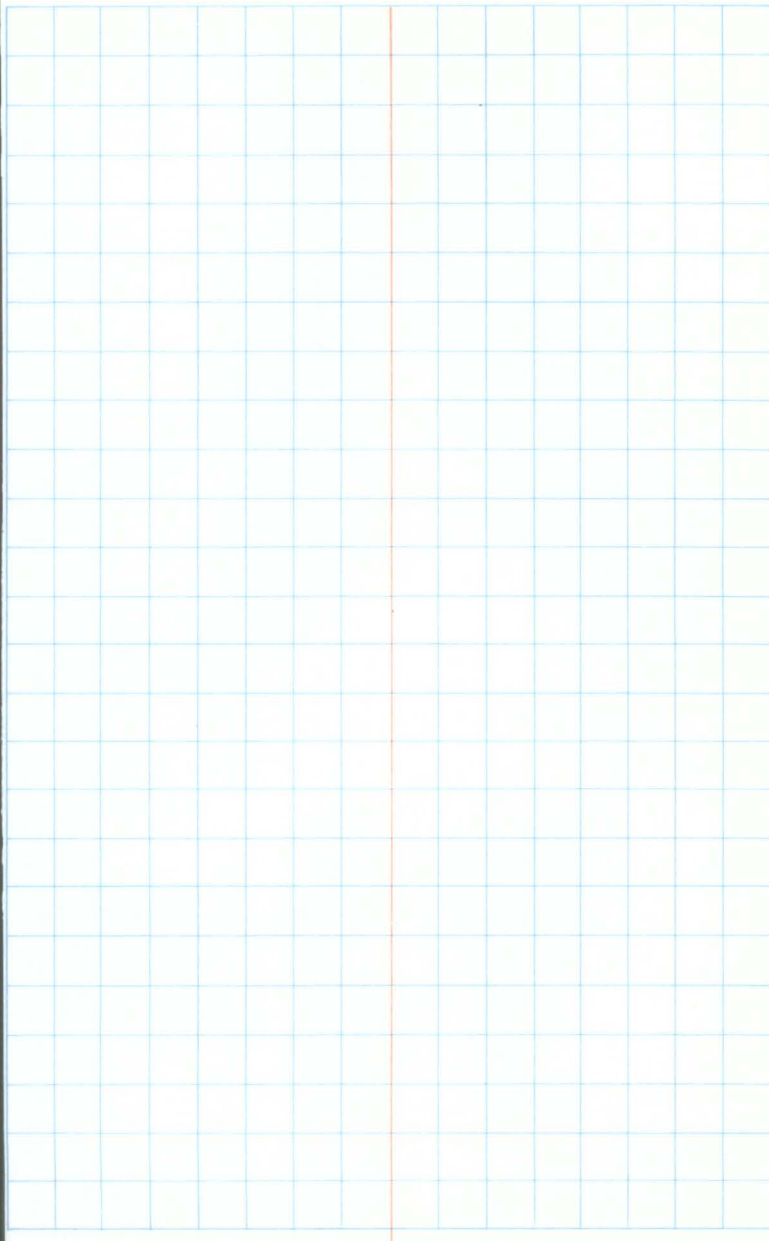
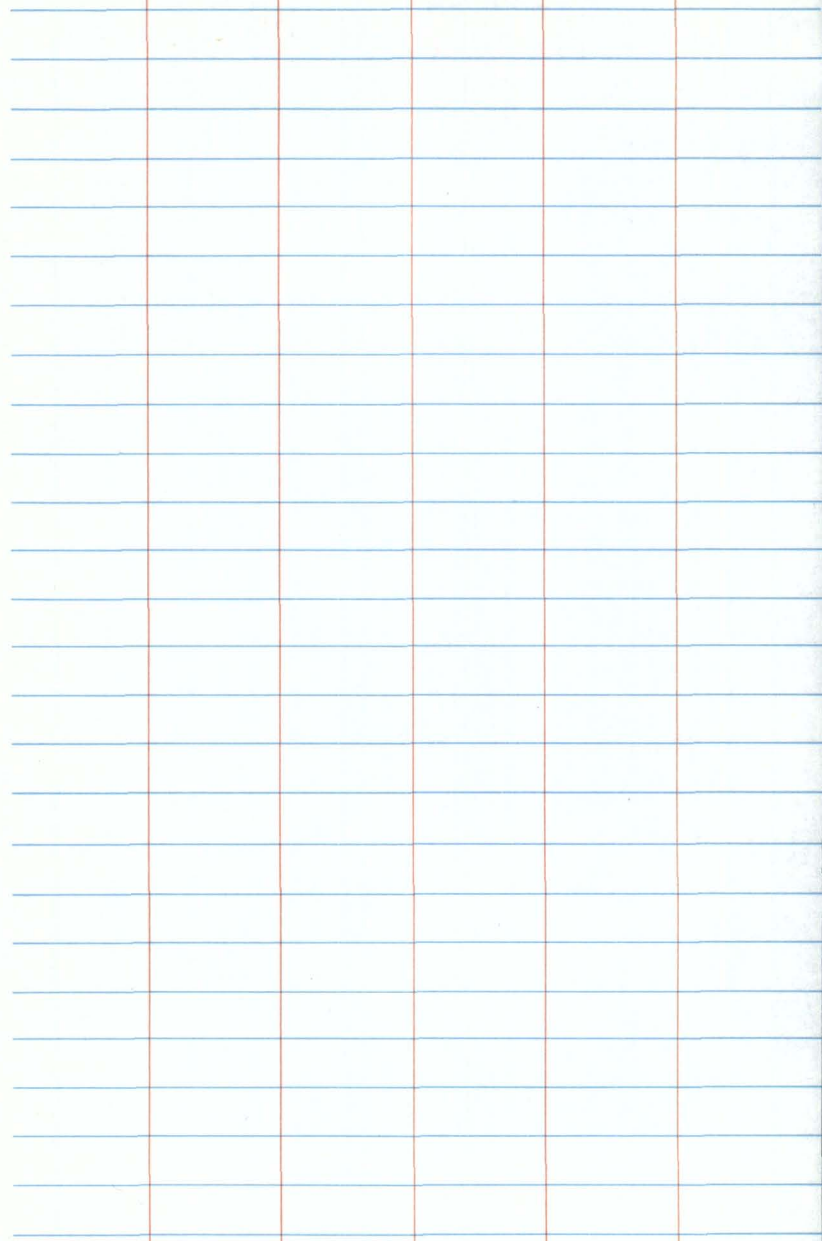
A

LK

Total Binder = Div I = 6441.50, Div II = 338.99 TonTotal Surface = Div I = 5274.10, Div II = 277.55 Ton

LK

LK



Item# 0070 Prime or Tack-Coat Bitumen 2303-6375000
 Date Time Distributor START STOP GALS. Temp Corr. Factor

9/12				195	105	.99085
9/14				100	103	.99131
9/14				80	103	.99131
9/15				40	107	.99039
9/21				165	105	.99085
				160	103	.99131
				320	105	.99085
				255	105	.99085
9/22				320	101	.99177
9/22				430	102	.99154
9/23				90	103	.99131
9/23				190	103	.99131
9/25				350	102	.99154
9/25				350	103	.99131
9/25				300	102	.99154
9/26				350	104	.99108
9/26				350	104	.99108
9/26				300	103	.99131

Total Div I = 4121.29 gal, Div II = 185.9 gal

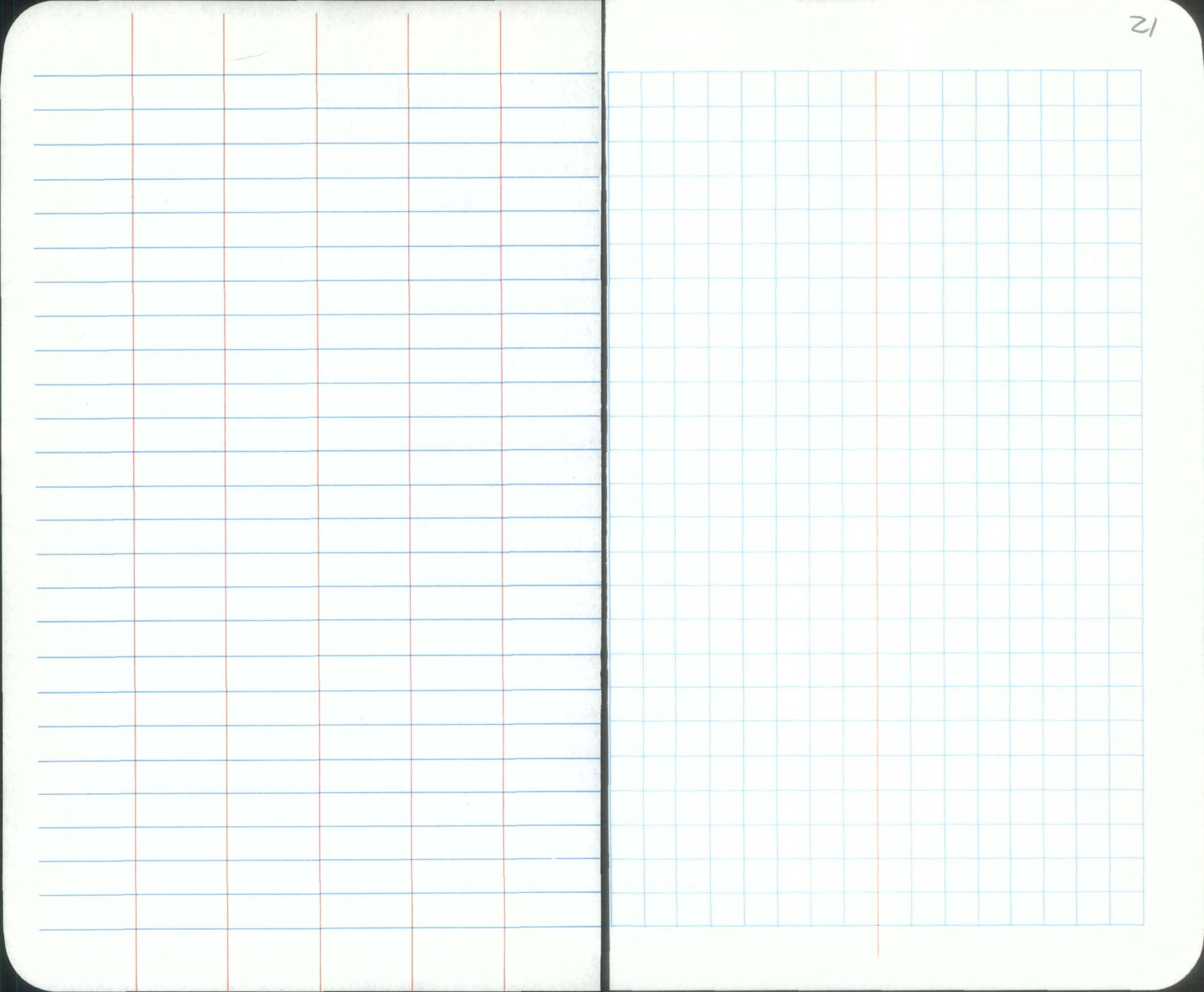
✓

✓

Gals 60°	START	STOP	Lin Ft.	Width	S.Y.	Rate	Insp
193.2				11.0'			LK
99.1	153+00	0+00	15,300	2.0'	3400	.029	LK
79.3	0+00	97+50	9,750	2.0'	2166	.036	LK
39.6	97+50	153+00	5550	2.0'	1233.3	.032	LK
163.5	0+00	26+80	2680	16.5'	4913.3	.033	LK
158.6	26+80	53+00	2620	16.5'	4803.3	.033	LK
317.1	53+00	105+00	5200	16.5'	9533.3	.033	LK
252.7	105+00	147+00	4200	16.5'	7700.0	.033	LK
317.4	0+00	53+00	5300	16.8'	9893	.032	LK
426.4	53+00	128+00	7,500	16.8'	14,000	.031	LK
89.2	147+50	153+00	1150	16.5'	2,108	.042	LK
188.3	126+80	153+00	2620	16.8'	4,891	.04	LK
347.1	0+00	53+00	5,300	16.5'	9717	.04	LK
346.9	53+00	107+00	5,400	16.5'	9900	.035	LK
297.5	107+00	153+00	4,600	16.5'	8433	.035	LK
346.9	0+00	53+00	5,300	16.5'	9717	.036	LK
346.9	53+00	107+00	5,400	16.5'	9900	.035	LK
297.4	107+00	153+00	4,600	16.5'	8433	.035	LK

1307.1 gals

LK
VRMB

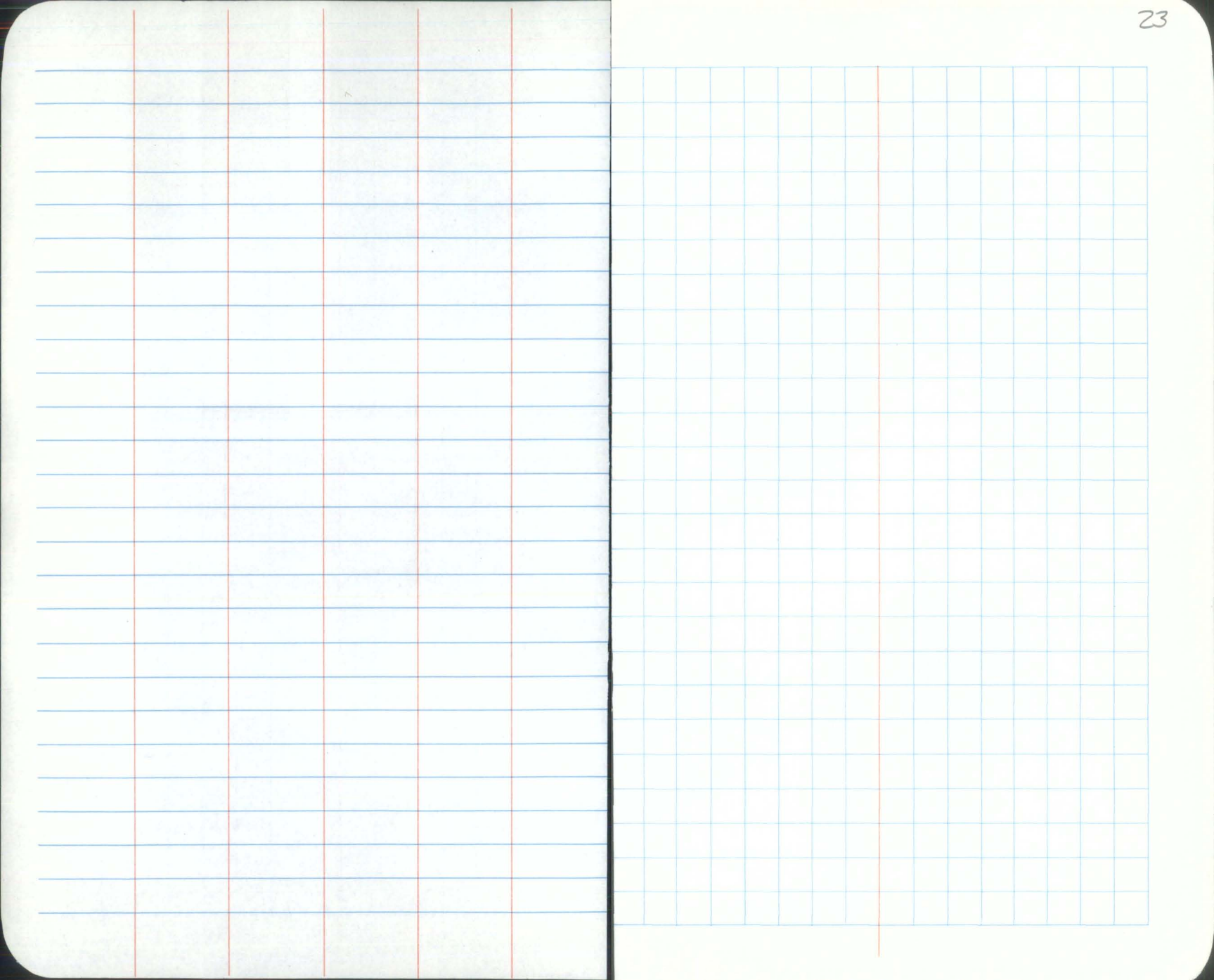


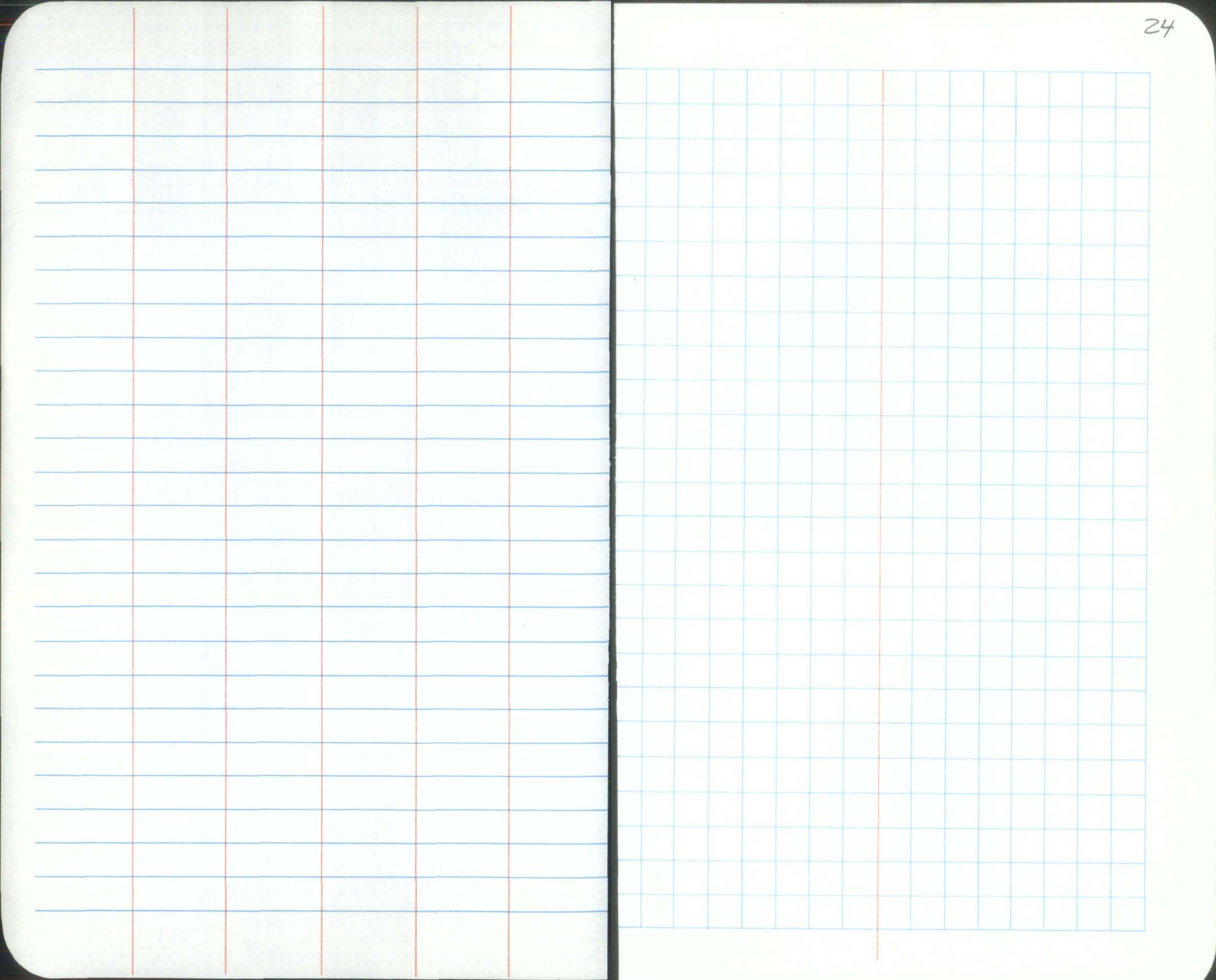
Item # 0080 PAVEMENT SAMPLES 2303-6911222

Date	STA	side	LIFT	material	Insp
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TOTAL Div I = 0.95, Div II = 0.05

TOTAL < Lump Sum R/B





Item #0090 Field Laboratory 2520-3350010

DATE

10-4-95

TOTAL - 1 EACH

RMB

Div. I = 0.95 Div. II = 0.05 RMB

Item # 0100 PAVEMENT Markings 2527-9263110

Date	4 SKIP LIN FT	No PASSING LIN. FT.	Edge Line LIN FT	TOTAL IN TATIONS	Insp	Remarks
9/21/95	3675	9504	—	131.79	LK RPB	Painting between L.FTs
9/23/95	3675	9504		131.79	LK RPB	" " "
9/26/95	3675	9504		131.79	LK RPB	
9/28/95			30850	308.5	LK RPB	

TOTAL - DIV I = 673.37, DIV II = 30.5 STA

TOTAL = 703.87 STA. RPB

ITEM # 0110 TRAFFIC CONTROL 2528-8445110

Date	% Completed	Amount Paid	Invsp
------	-------------	-------------	-------

Remarks

$$\text{Div I} = \underline{0.95}, \text{Div II} = \underline{0.05}$$

$$\text{Total} = \text{Lump Sum} \quad R40$$

Item # 6120

Flaggers

2528-8445112

Date Day Days To Date Insp.

Remarks

9/12/95 2 2 LK

9/14/95 2 4 LK

9/15/95 2 6 LK

9/21/95 2 8 LK

9/22/95 2 10 LK

9/23/95 2 12 LK

9/25/95 2 14 LK

9/26/95 2 16 LK

9/27/95 2 18 LK

10-2-95 2 20 R/B

10-3-95 2 22 R/B

10-6-95 2 24 R/B

Shouldering

Shouldering

Shouldering

Total

24 Day

R/B

Total Div I - 21 Day, Div II - 3 day

R

W

ITEM # 0130

PILOT CAR

2528-8445114

Date	Day	Days To Date	Insp	Remarks
9/14/95	1	1	LK	
9/15/95	1	2	LK	
9/21/95	1	3	LK	
9/22/95	1	4	LK	
9/23/95	1	5	LK	
9/25/95	1	6	LK	
9/26/95	1	7	LK	
9/27/95	1	8	LK	
10-2-95	1	9	R/B	Shouldering
10-3-95	1	10	R/B	Shouldering
10-6-95	1	11	R/B	Shouldering
Total - <u>11 DAY</u>				R/B
Total Div I <u>9 DAY</u>				u
Div II <u>2 DAY</u>				u

ITEM # 0140 Mobilization 2533-4980005

Date	% Completed	% Payment	Amount	Insp
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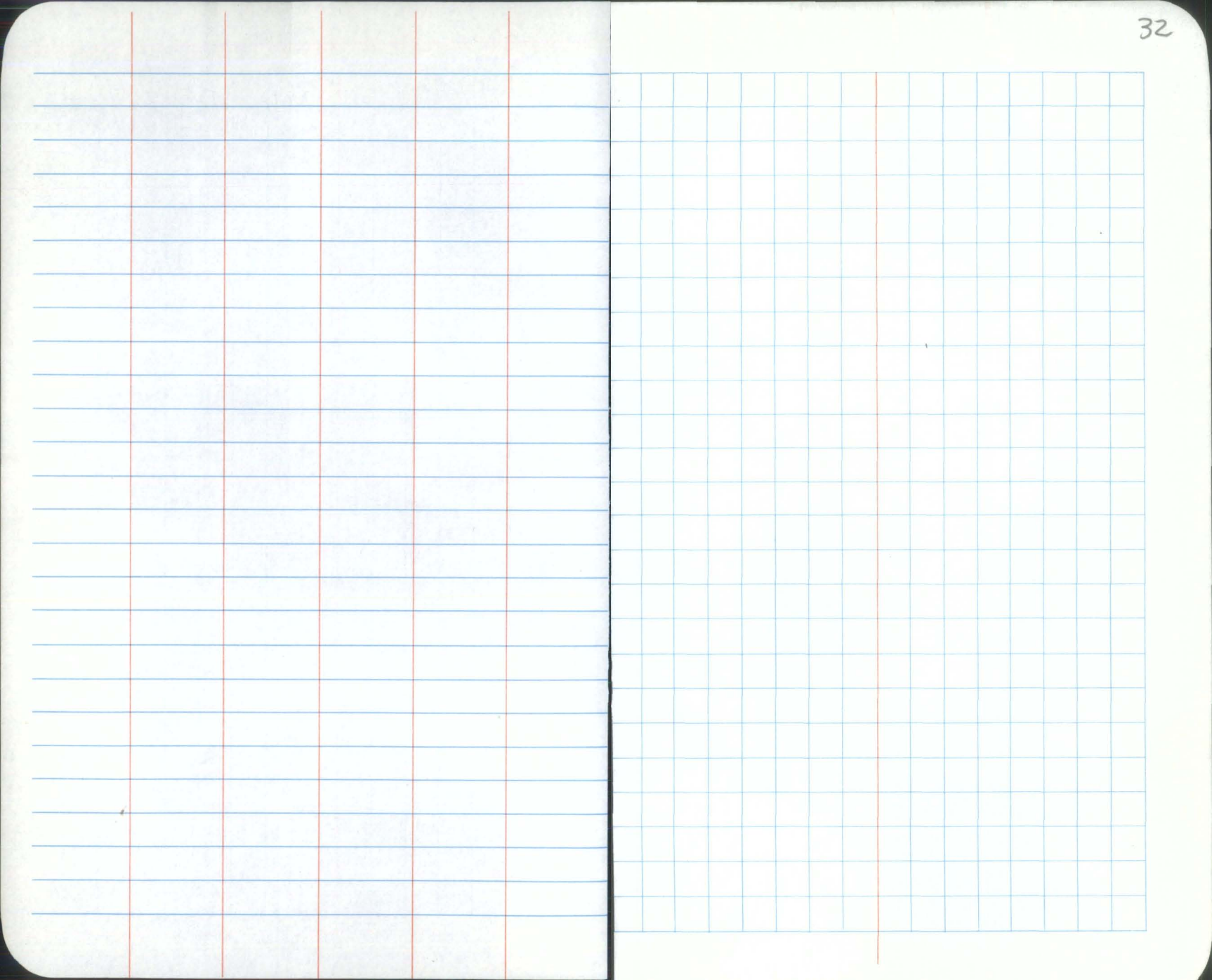
Remarks

Total Div I = 0.95, Div II = 0.05

Total = Lump Sum RB

MAT Temperatures

Date	Time	Temp	Date	Time	Temp	Date	Time	Temp	Date	Time	Temp
9/21	8:30 A	290°F	9/26/95	2:00	290°						
"	10:30 A	295°F		4:00 P	290°						
"	12:30 P	295°F									
"	2:30 P	290°F									
"	4:30 P	295°F									
9/22	8:30 A	295°F									
	10:30 A	290°F									
	12:30 A	290°F									
	2:30 P	295°F									
	4:30 P	300°F									
9/23/95	8:00 A	295°F									
	10:00 A	295°F									
	12:00 P	295°F									
9/25/95	8:00 A	300°F									
	10:00 A										
	12:00 P										
	2:00 P										
	4:00 P										
	6:00 P										
9/26/95	8:00 A	290°									
	10:00 A	290°									
	12:00 A	290°									



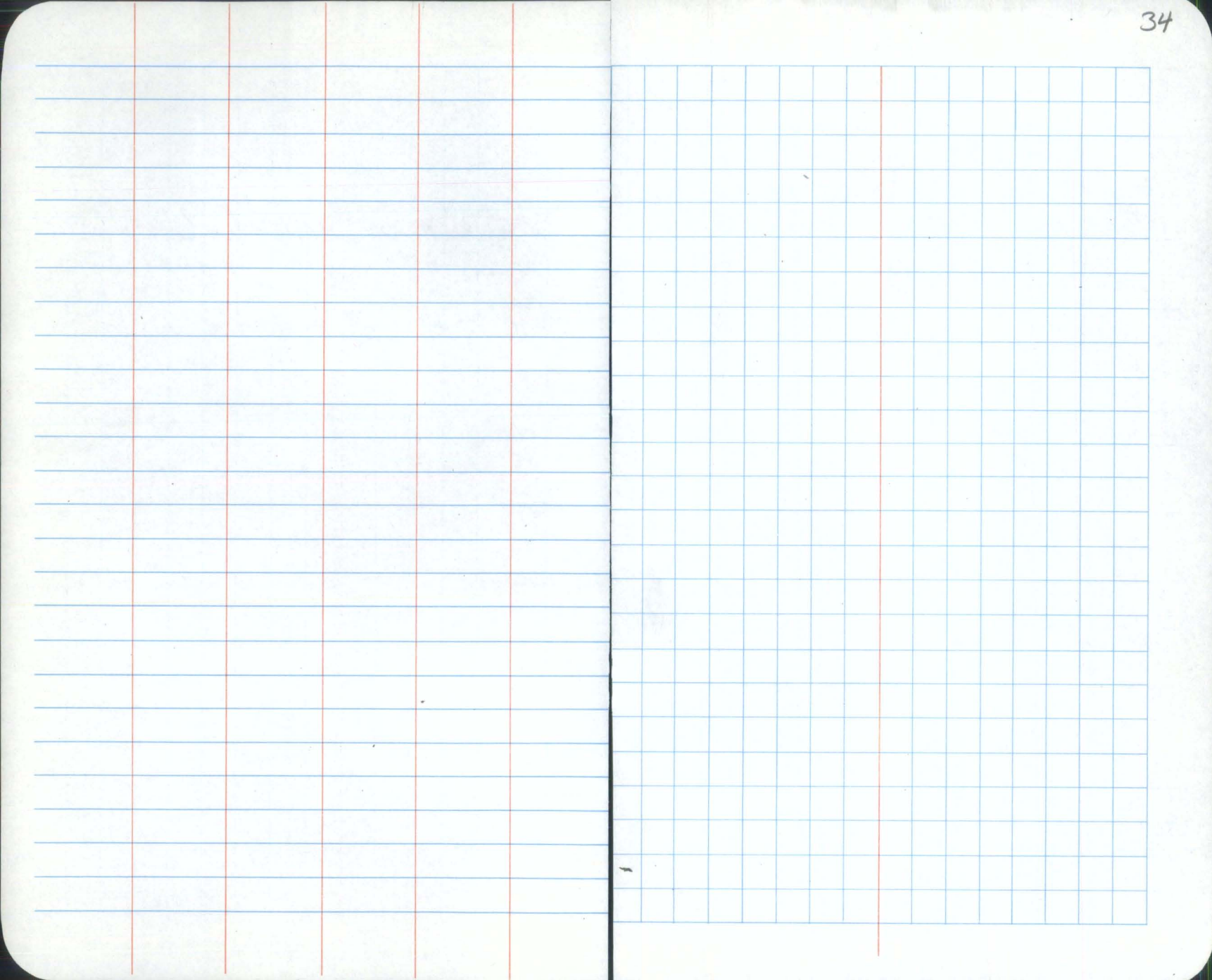
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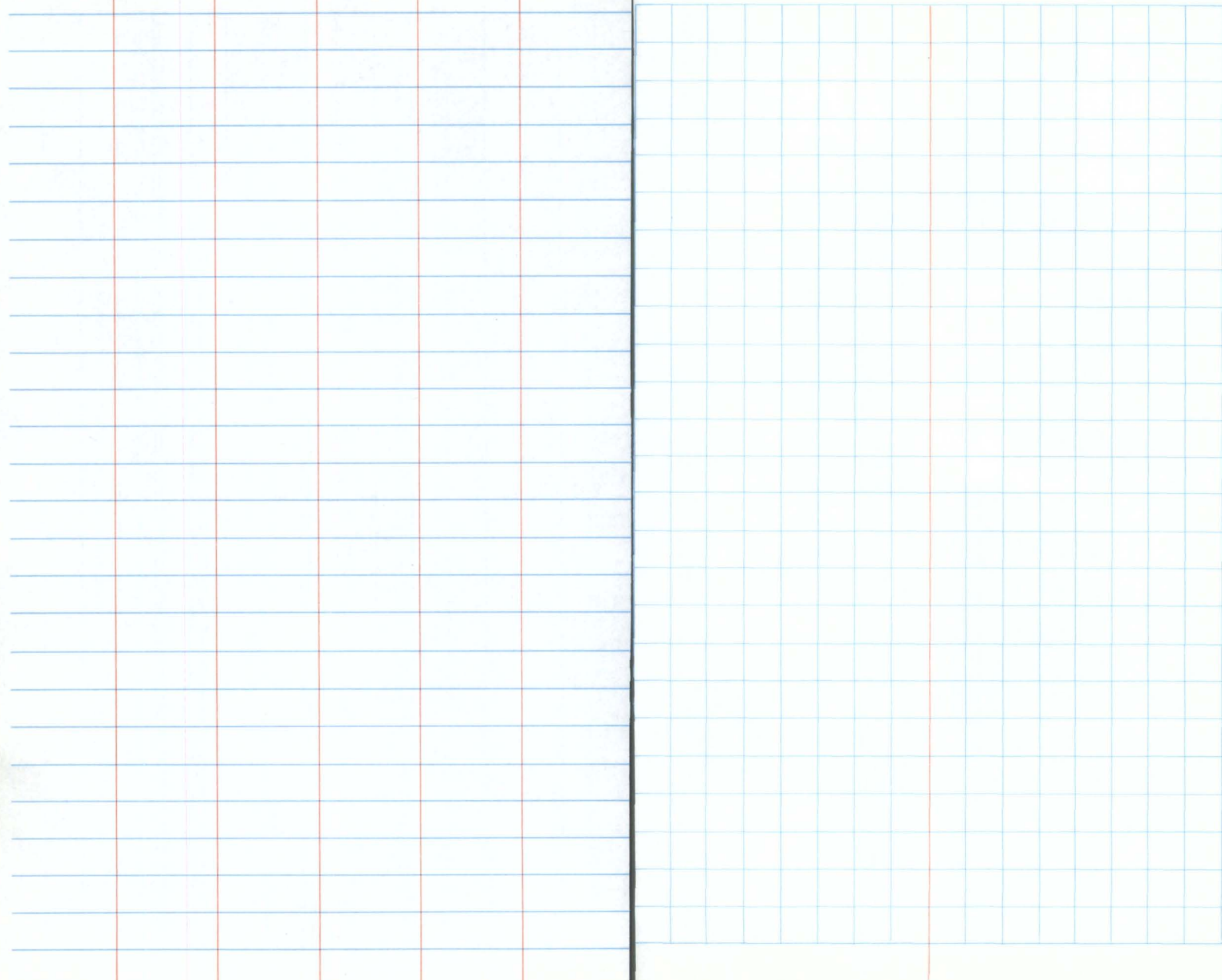
8001 ACC REMOVAL.

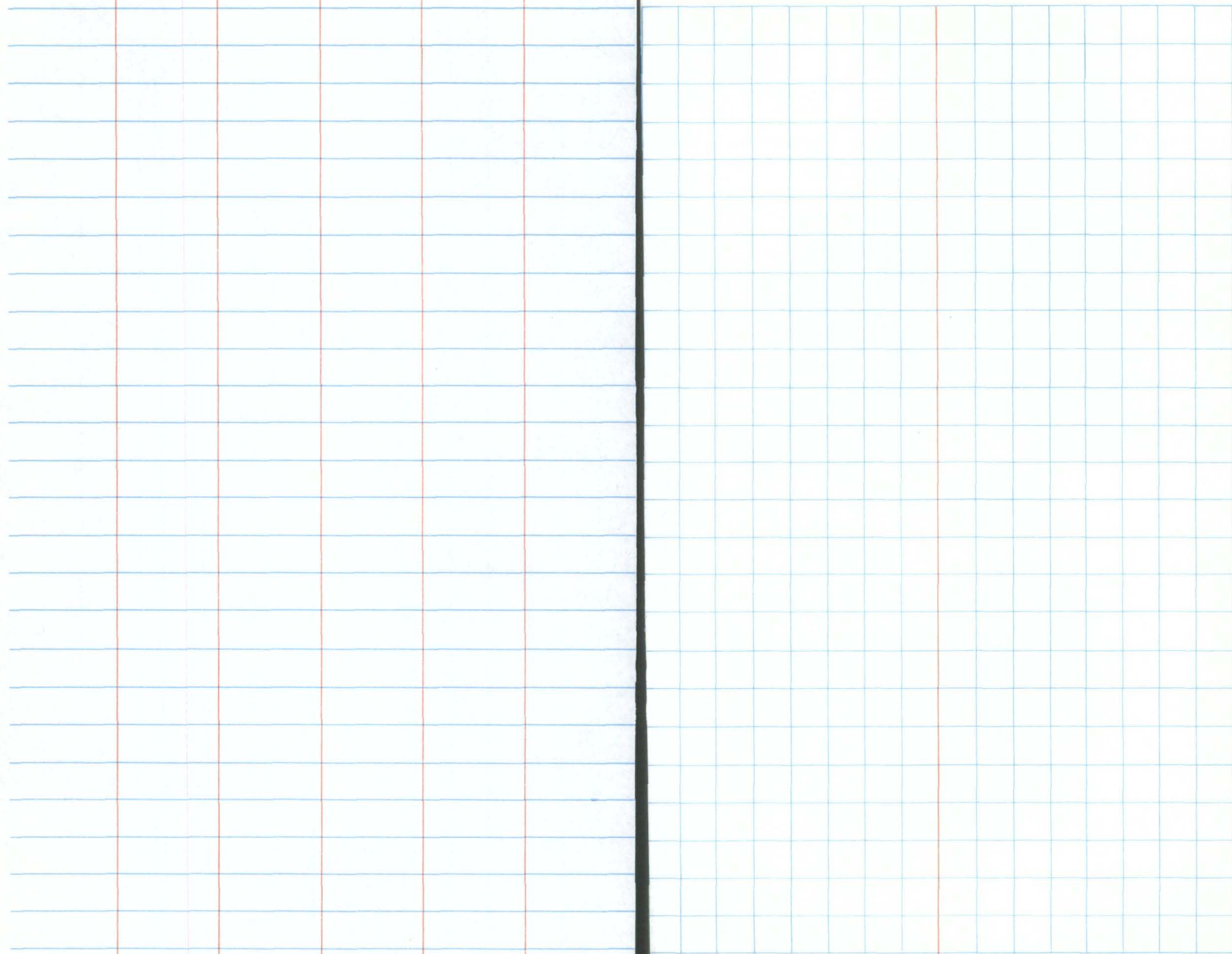
DATE	AREA	IMP.
9-20-95	122 S.Y.	R/C

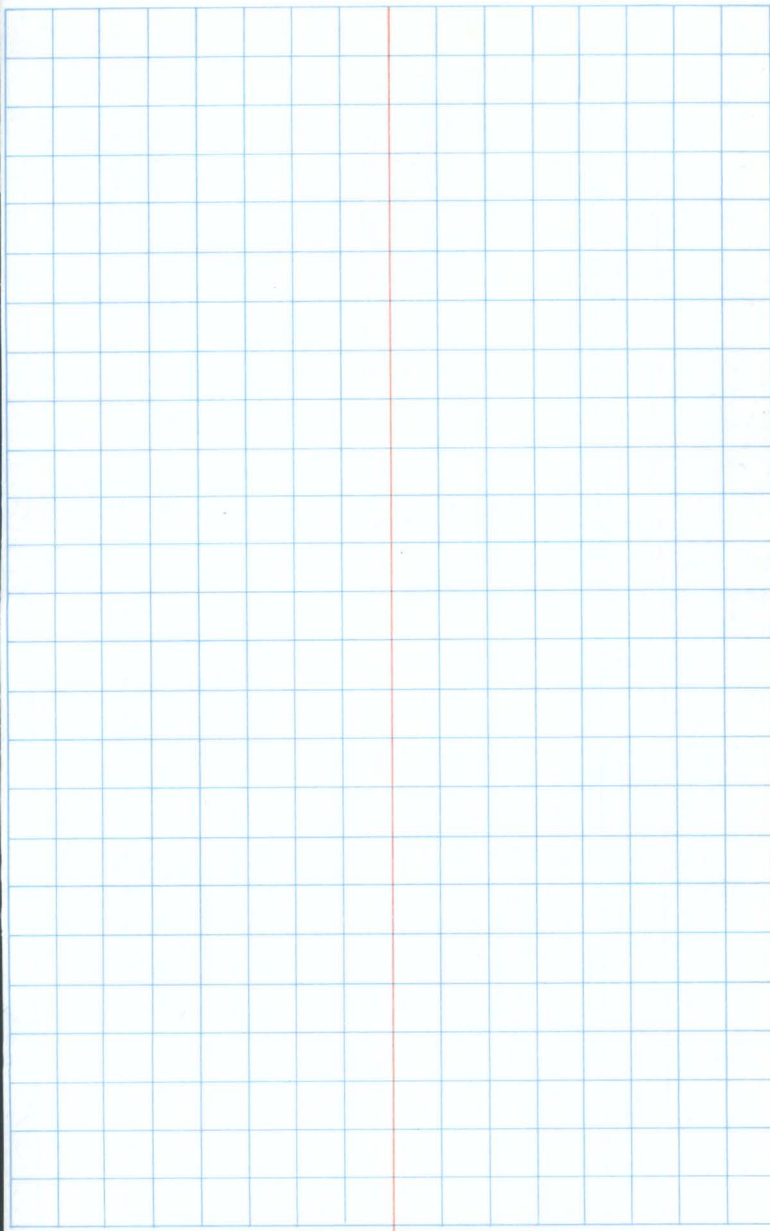
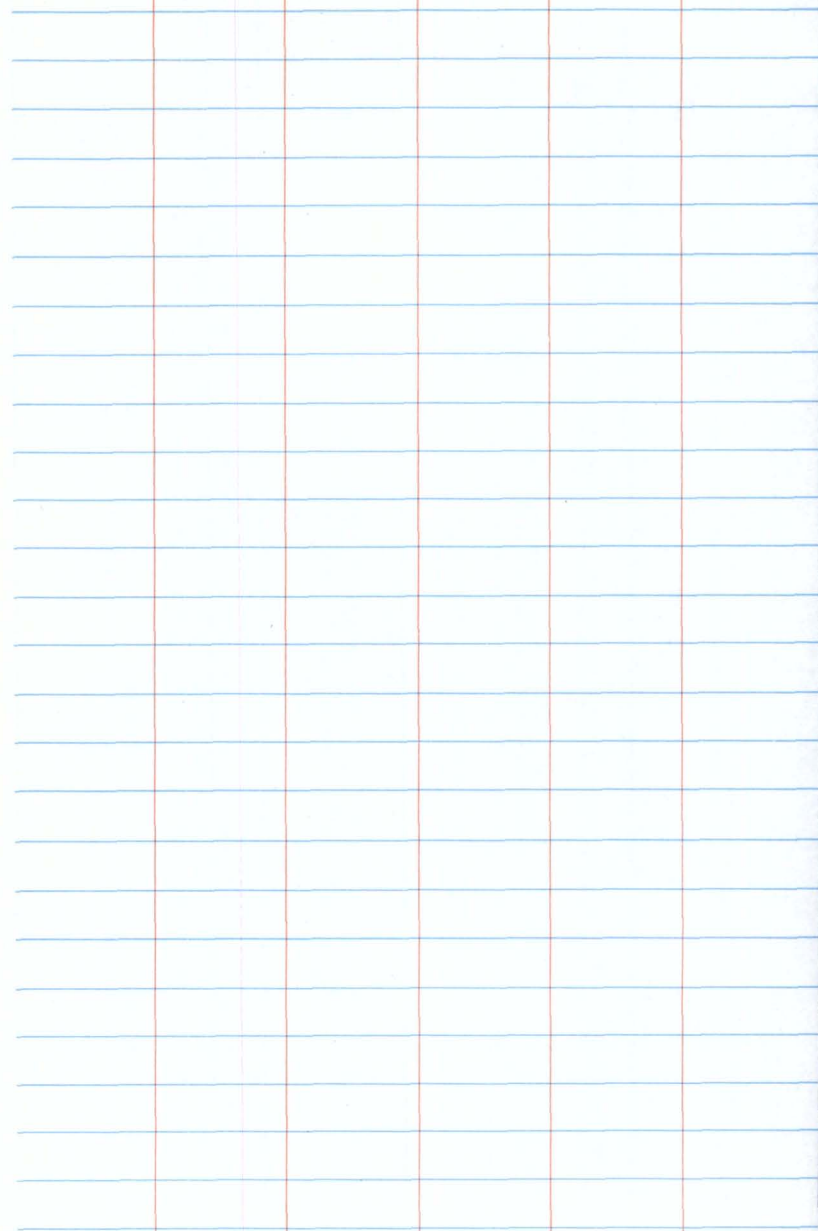
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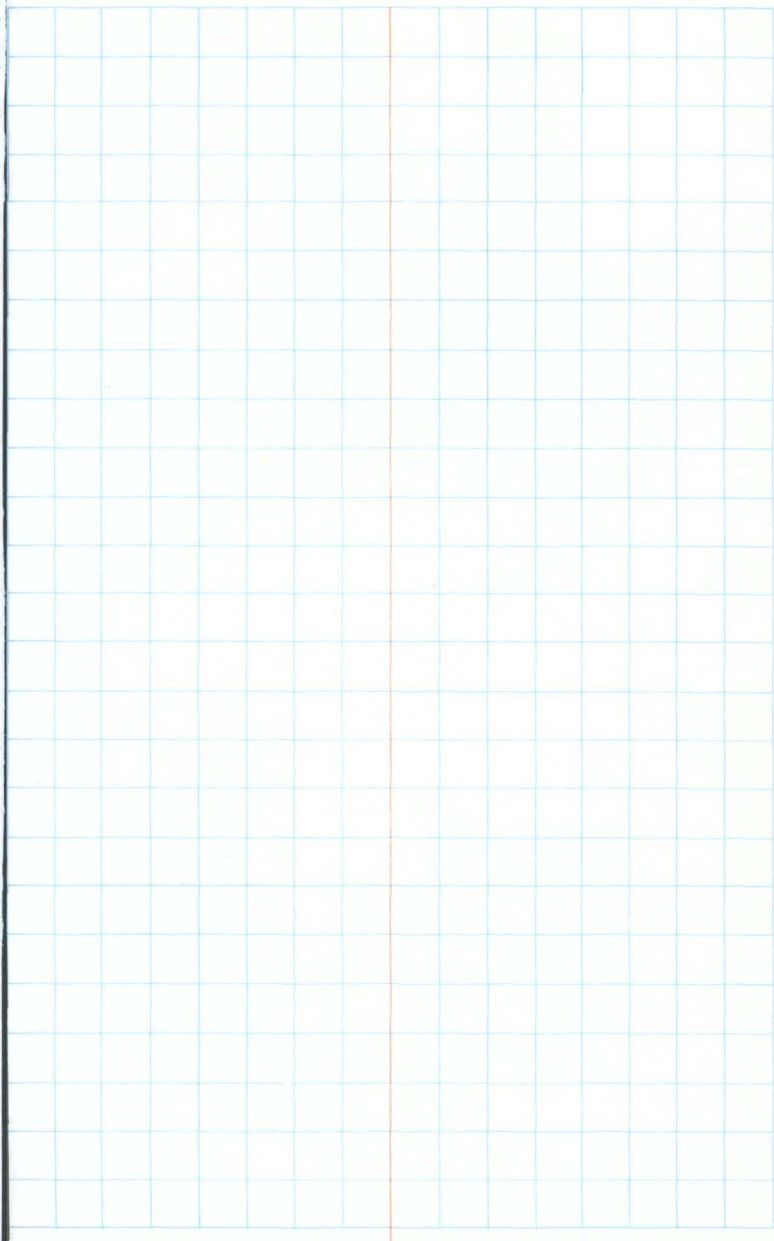
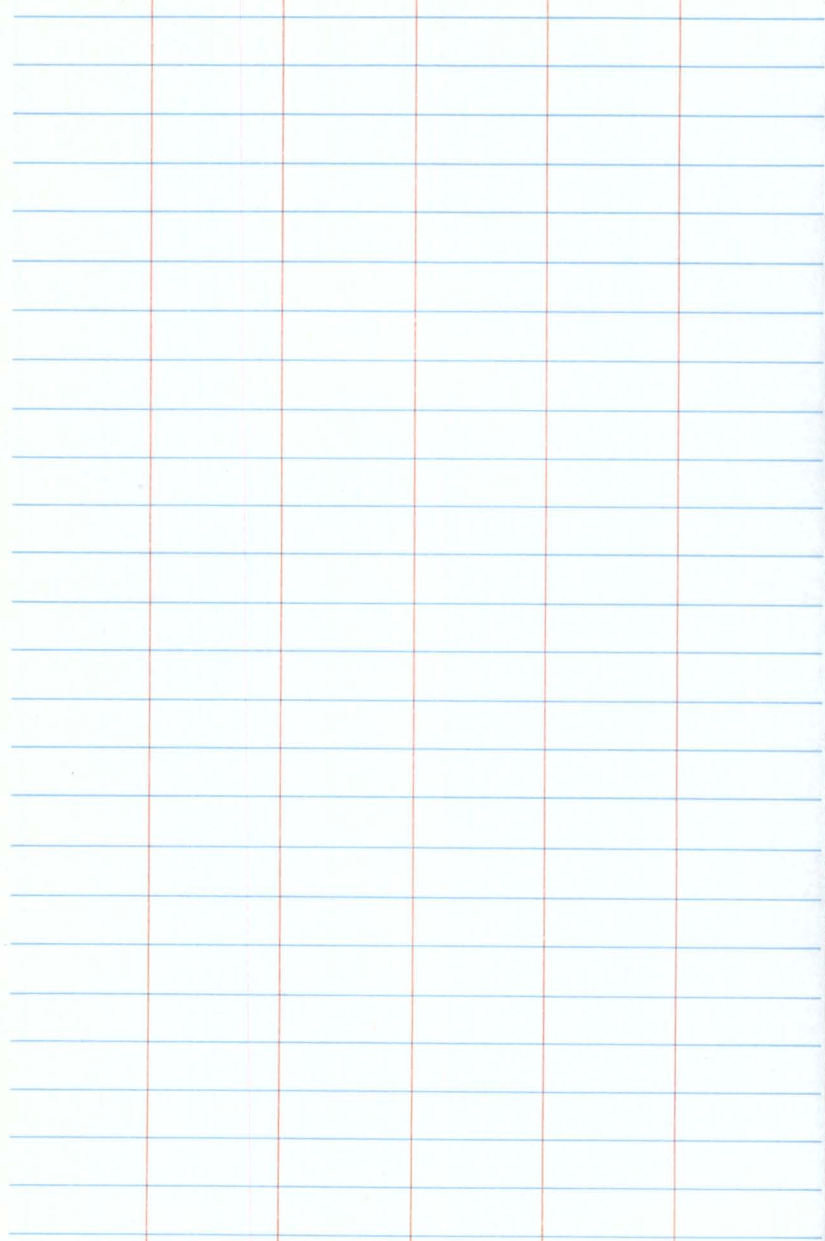
Q EAST END OF PROJECT, CEDAR
FALLS WANT EXISTING MILL
DOWN SO THAT NEW GRADE
WILL MEET OLD GRADE.

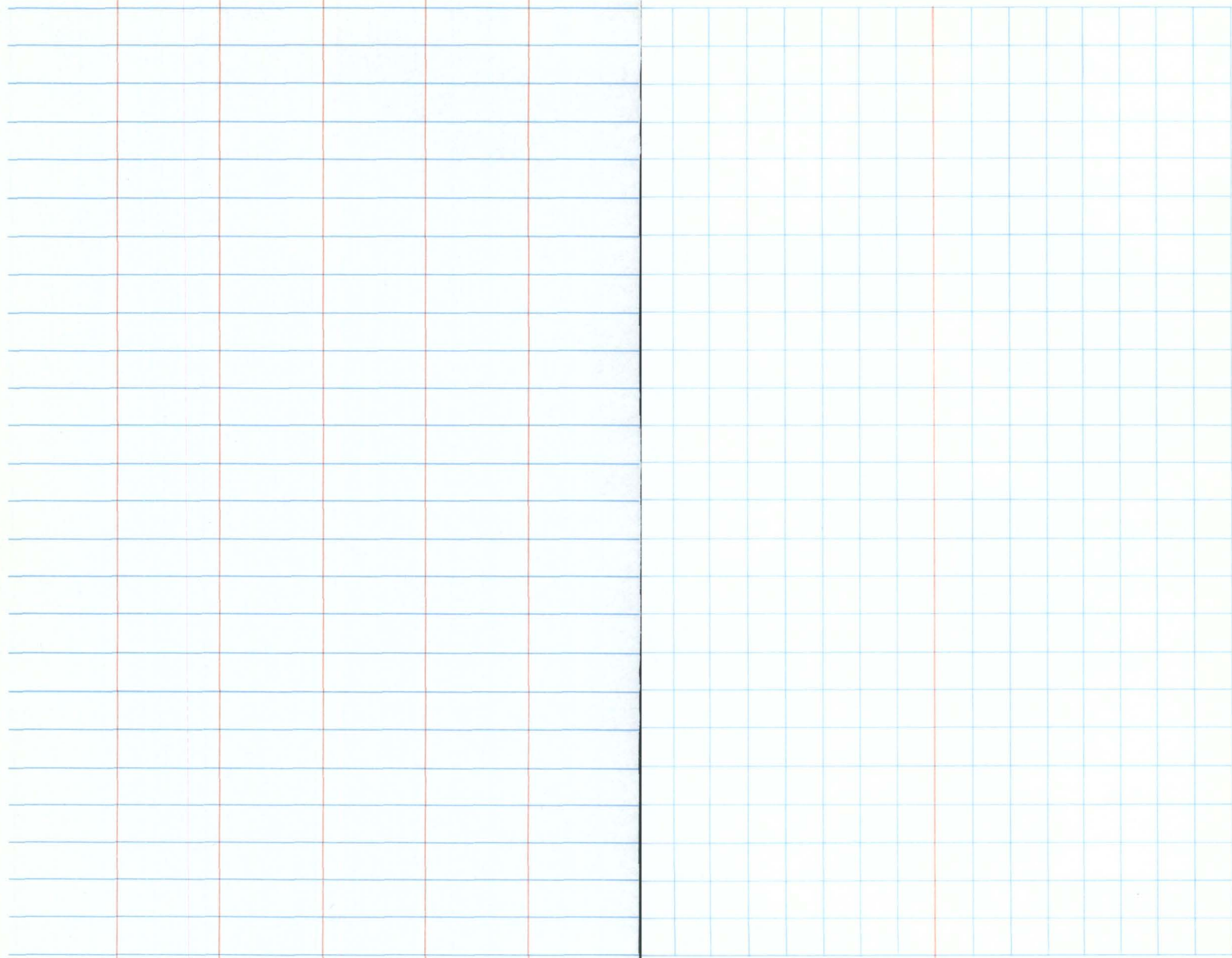












Diary

8-28-95

Monday

Pre Construction HELD IN
AFTERNOON

RB

9-11-95

Monday

Clear & mild

Tri. STATE Signers began to place
Signs. 1 day charged

RB

9-12-95

TUESDAY RAIN

Placed leveling courses
over culverts.

LK

9-13-95

WEDNESDAY

No work on project
1 day charged

LK

9-14-95

THURSDAY

Milled shoulders from
STA 153+00 to 0+00 LT and STA
0+00 to 115+00 RT and
placed 5'-6" asphalt
shoulders over 153+00 to
0+00 LT and 0+00 to 97+50 RT
(2265.17 tons)

LK

9-15-95

FRIDAY

Placed asphalt shoulder (5'-6")
from 97+50 RT to 153+00 RT
and from 159+50 to 153+00 LT.
(644.97 tons)

Milled east end asphalt
adjacent concrete roadway

Milled shoulder from
97+50 to 153+00 RT
prior to placement of asphalt.

Core cut Quantity = $60' \times 22' \div 49 = 122 \text{ s.y.}$ LK

9/18/95

MONDAY

ASPH CUT CORES IN
PREVIOUS DAY'S WORK
RANDOM SHLDR WIDTHS
MEASURED - ALL WERE OF
ADEQUATE WIDTH.

LK

9/19/95

TUESDAY

RAIN! LK

No WORK.

9/20/95

WEDNESDAY

No WORK. RAIN!

LK

9/21/95

THURSDAY

ASPRO BEGAN LAYING
BINDER 8.00 AM STA 0+00 RT.
ENDED @ STA 141+50 RT

9/22/95

FRIDAY COLD

ROAD TEMP @ 7:30 AM
37°F.

ASPRO BEGAN @ STA 0+00 LT
@ 8:00 AM, ENDED @
STA 126+80 ≈ 6:30 PM
CORES WERE CUT IN
PREVIOUS DAY'S WORK.

LK

9/23/95

SATURDAY

ROAD TEMP @ 7:15 33-34°F
by 7:45 TEMP HAD RISEN TO
38°F. ASPRO LAID FIRST
LOAD @ STA 141+50 RT @
7:55 AM, RAN TO
153+00 RT THEN BACK
TO STA 126+80 LT.
LAID FROM 126+80 LT TO
153+00 LT. ENDING
@ 1:00 PM

(Cont.)

9/23/95

ASPRO ALSO CUT
CORES FROM PREVIOUS
DAY'S WORK.

LK

9/25/95

MONDAY

ROAD TEMP ROSE TO 45° by
7:45 AM. ASPRO BEGAN
LAYING SURFACE @ STA 0+00
LEFT @ 8:00 AM, CONTINUED
THROUGH STA 153+00
ENDING APPROX 7:00 PM.
ASPRO CUT CORES FROM
9/23/95 WORK.

LK

9/26/95

TUESDAY

SUNNY, 50°

ASPRO BEGAN SURFACE LIFT
@ STA 0+00 RT @ 7:45 AM.
and COMPLETED RT LANE
@ STA 153+00 @ 4:30 PM
CENTERLINE MARKINGS
WERE APPLIED IMMEDIATELY
UPON COMPLETION OF PAVING.
CORES WERE CUT FOR
PREVIOUS DAY'S WORK.

LK

9/27/95

WEDNESDAY
SUNNY, COOLCONFERENCE - CALL SET UP FOR 10-4-95
WITH AMES-DOT-LOVE.

ASPRO CUT CORES
FOR PREVIOUS DAY'S WORK.
ASPRO BEGAN APPLYING
SHOULDER ROCK @
STA 153+00 LT @ 7:30 AM
COMPLETED TO STA 43+88
WHEN STOCKPILED ROCK WAS
DEPLETED

9/28/95

Thursday
RM

Pointed Edge Line

9/29/95

10/2/95

MONDAY

LOVE BEGAN APPLYING SHOULDER
ROCK AT 10:30. FINISHED AT 7:30 PM. HAD 5 TO
7 TRUCKS HAULING ROCK. HAD 15 MIN. TO 45 MIN
BROOM ARRIVED 4:00. NO BOBCAT OR BLADE
FOR SMOOTH SHOULDERING. NO DRESSING UP
DONE

10/3/95 2 PEOPLE SHOWED UP FOR WORK.

MR. LOVE SHOWED UP 11:00. THEN LEFT FOR
ASPRO OFFICE, FOR CONFERENCE. -

10-11-95

Wednesday

Cedar Valley moved in this A.M.
And began to correct bumps. Working
West bound Lane on East end.

RIB

10-12-95

Thursday

No Contractor on Project.

RIB

10-13-95

Friday

Cedar Valley finished This A.M.
Corrective Grinding Completed

RIB

10-25-95

Wednesday

ASPRO Sand Sealing Project

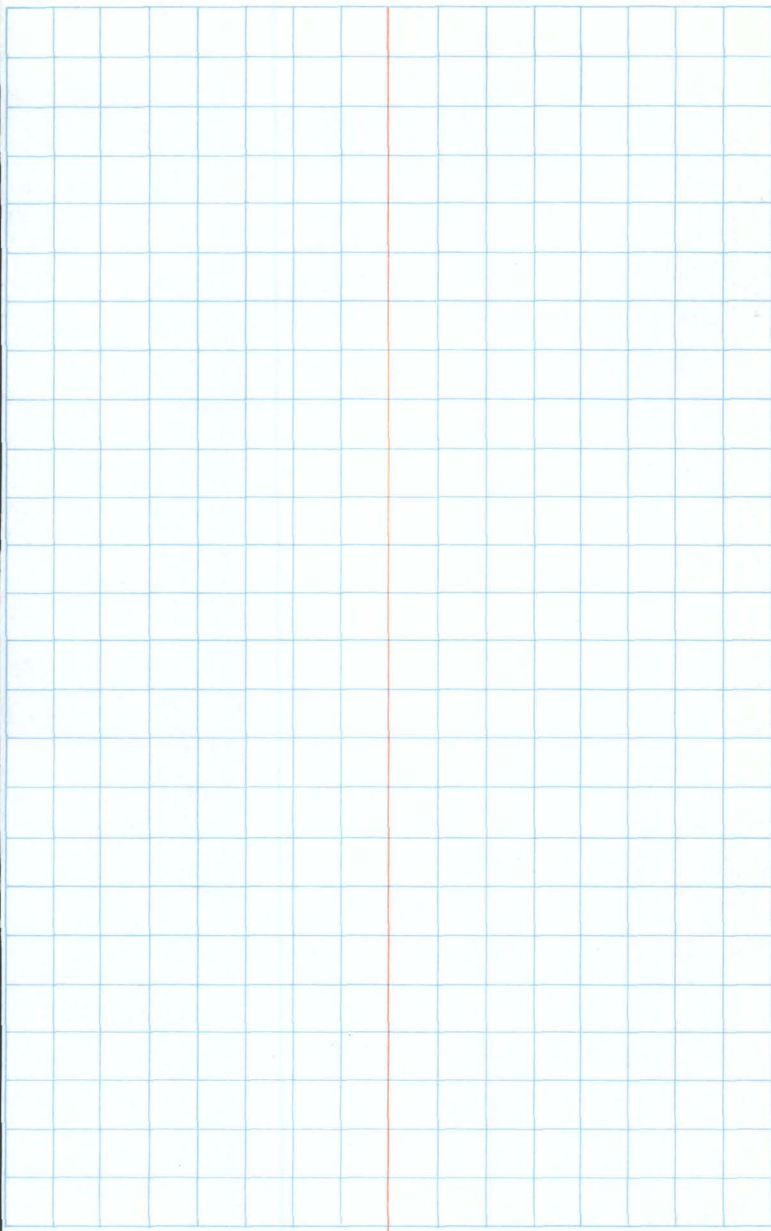
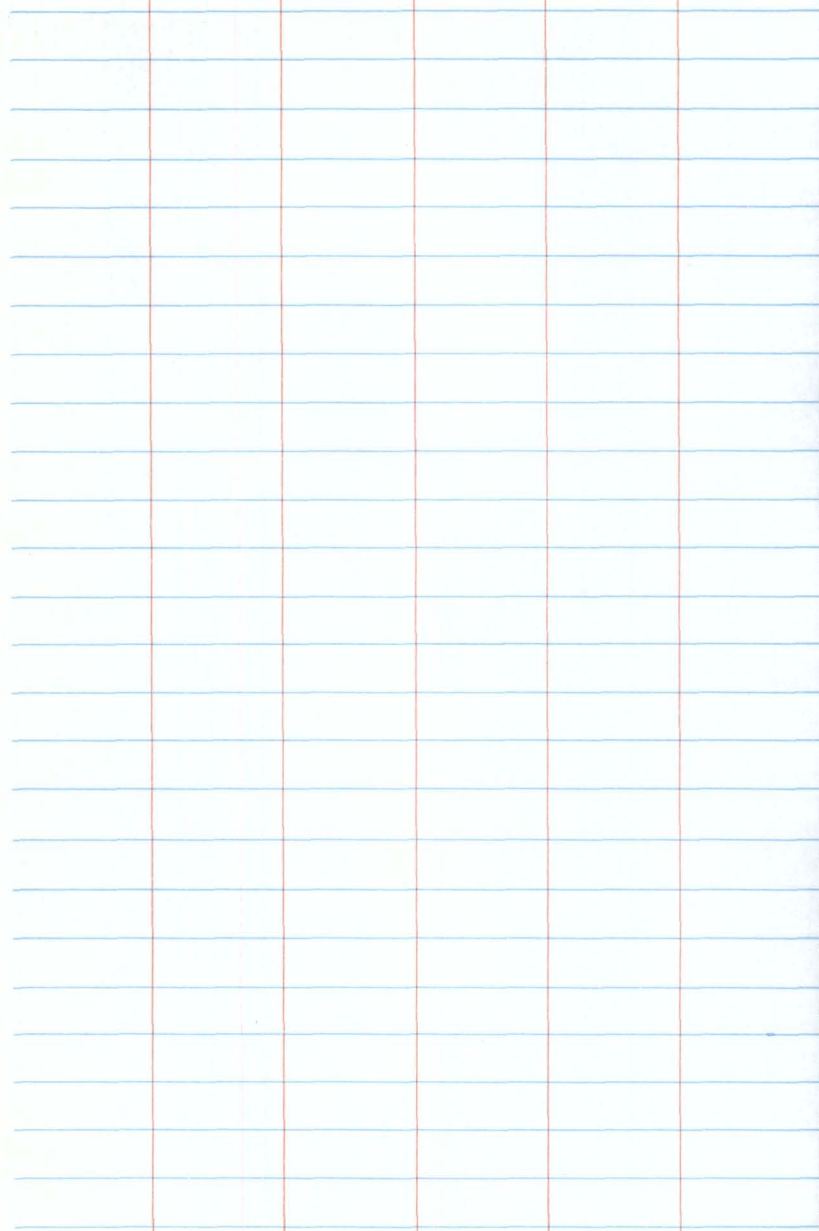
RIB

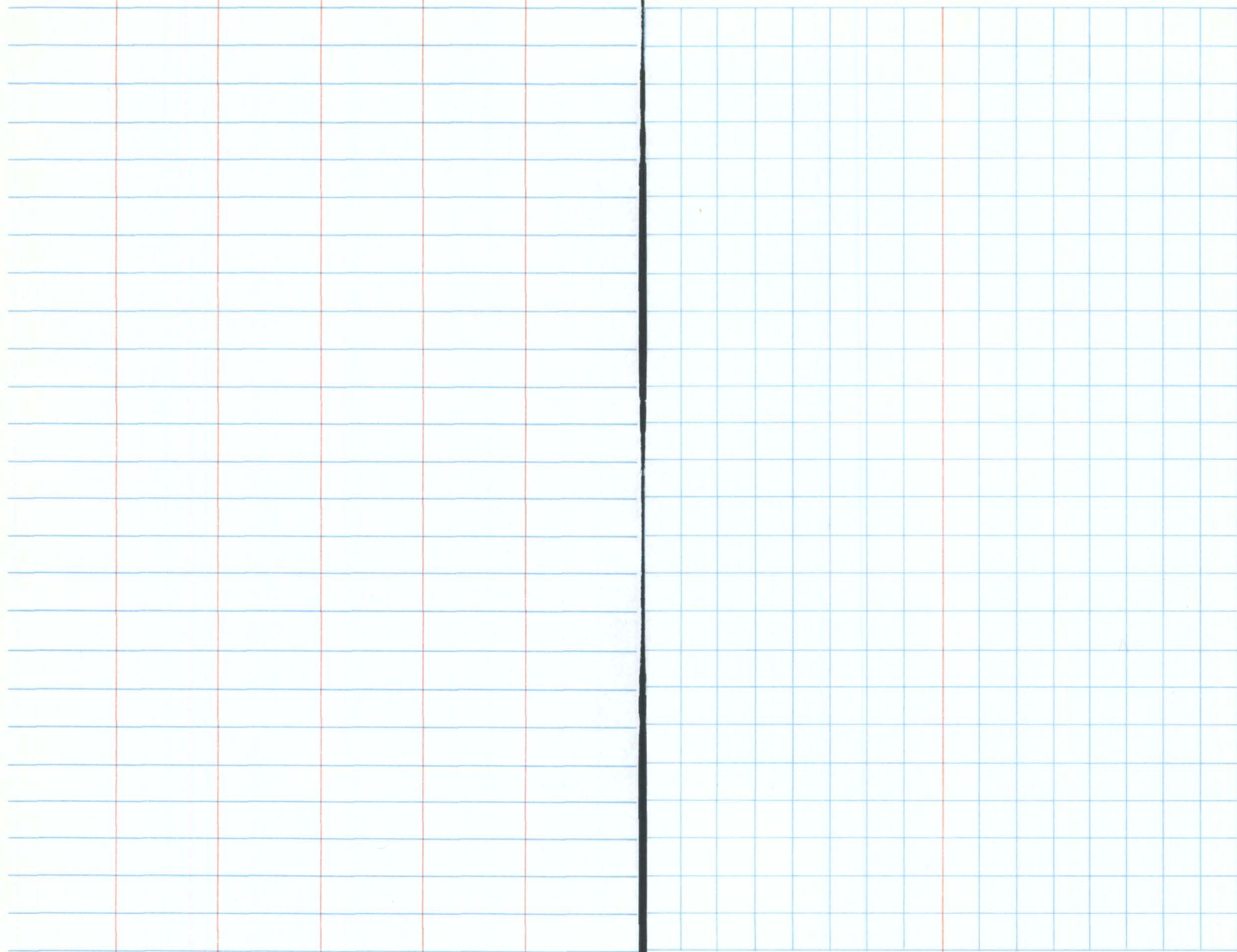
11-8-95

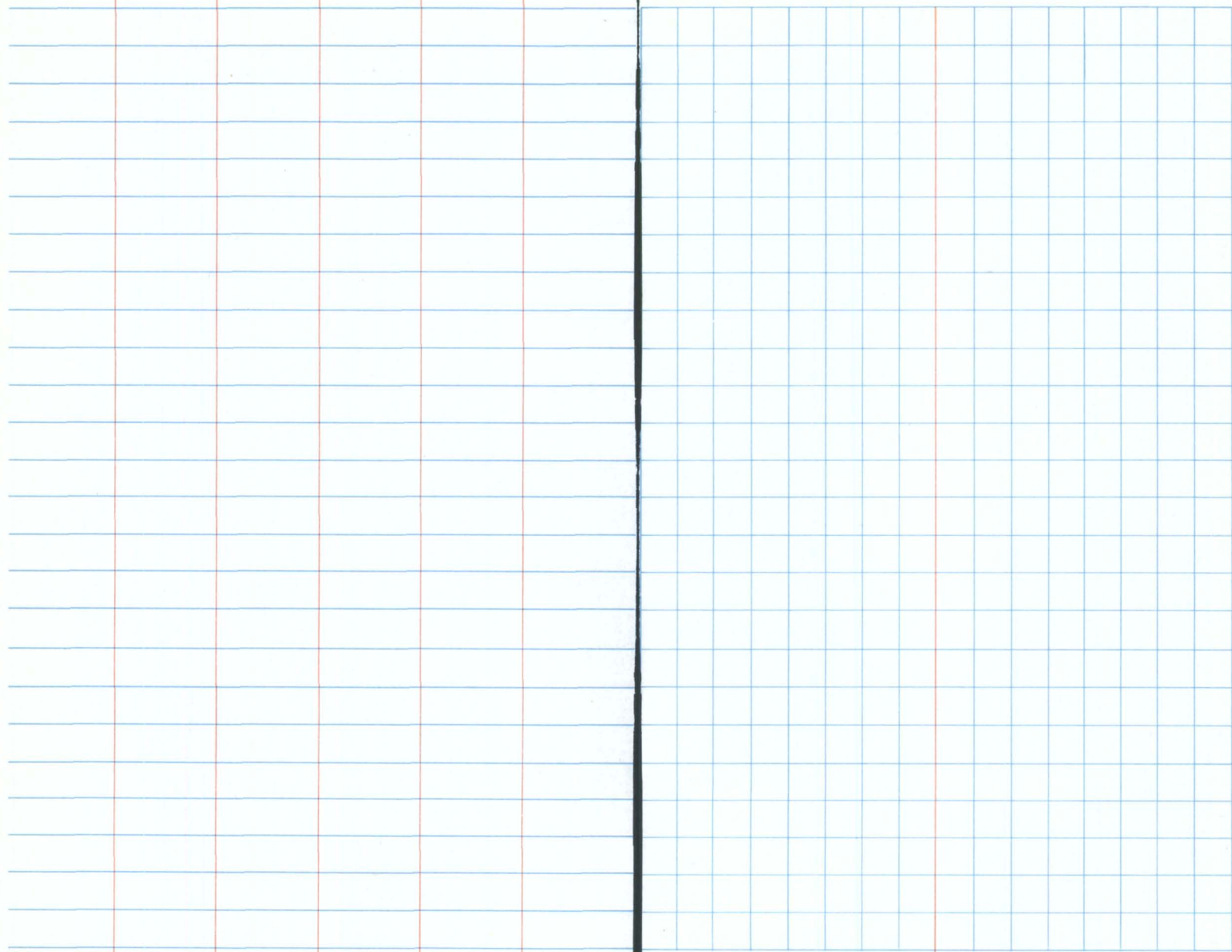
Wednesday

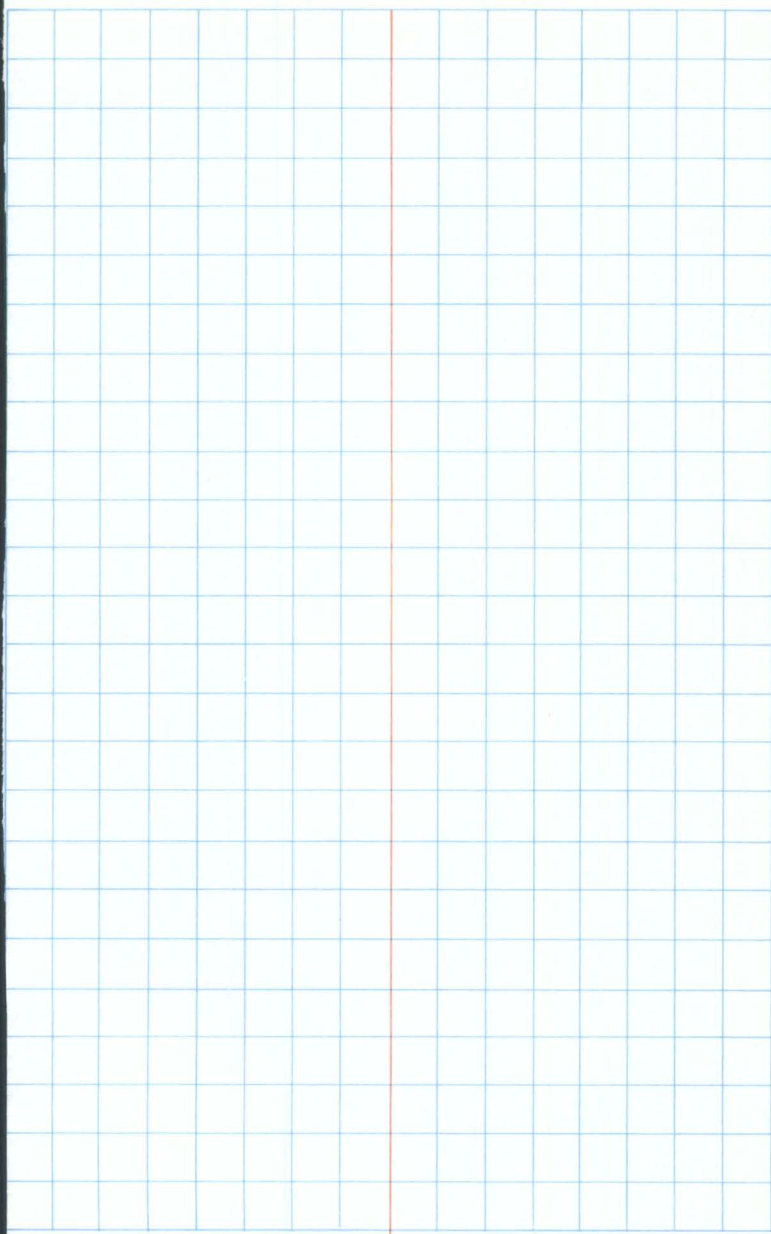
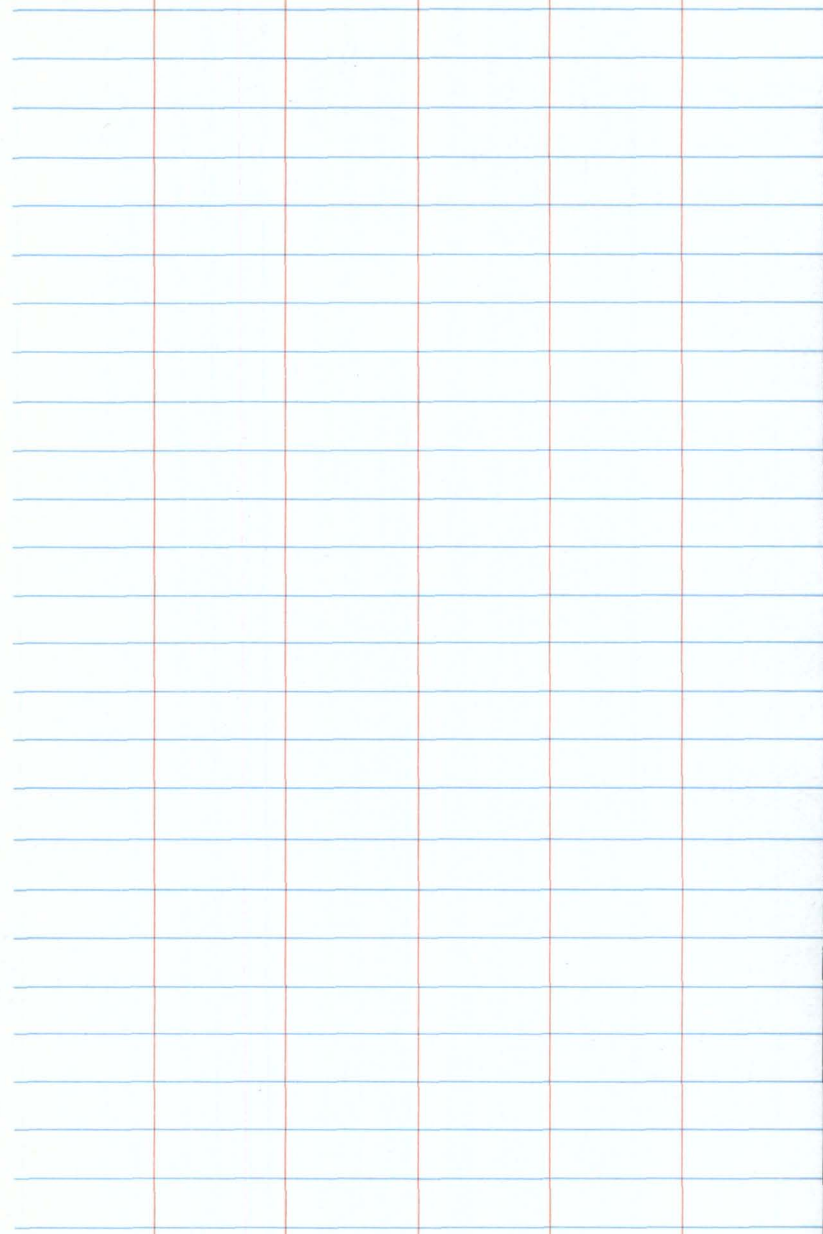
ALL IOWA Restriped Project
Project Complete

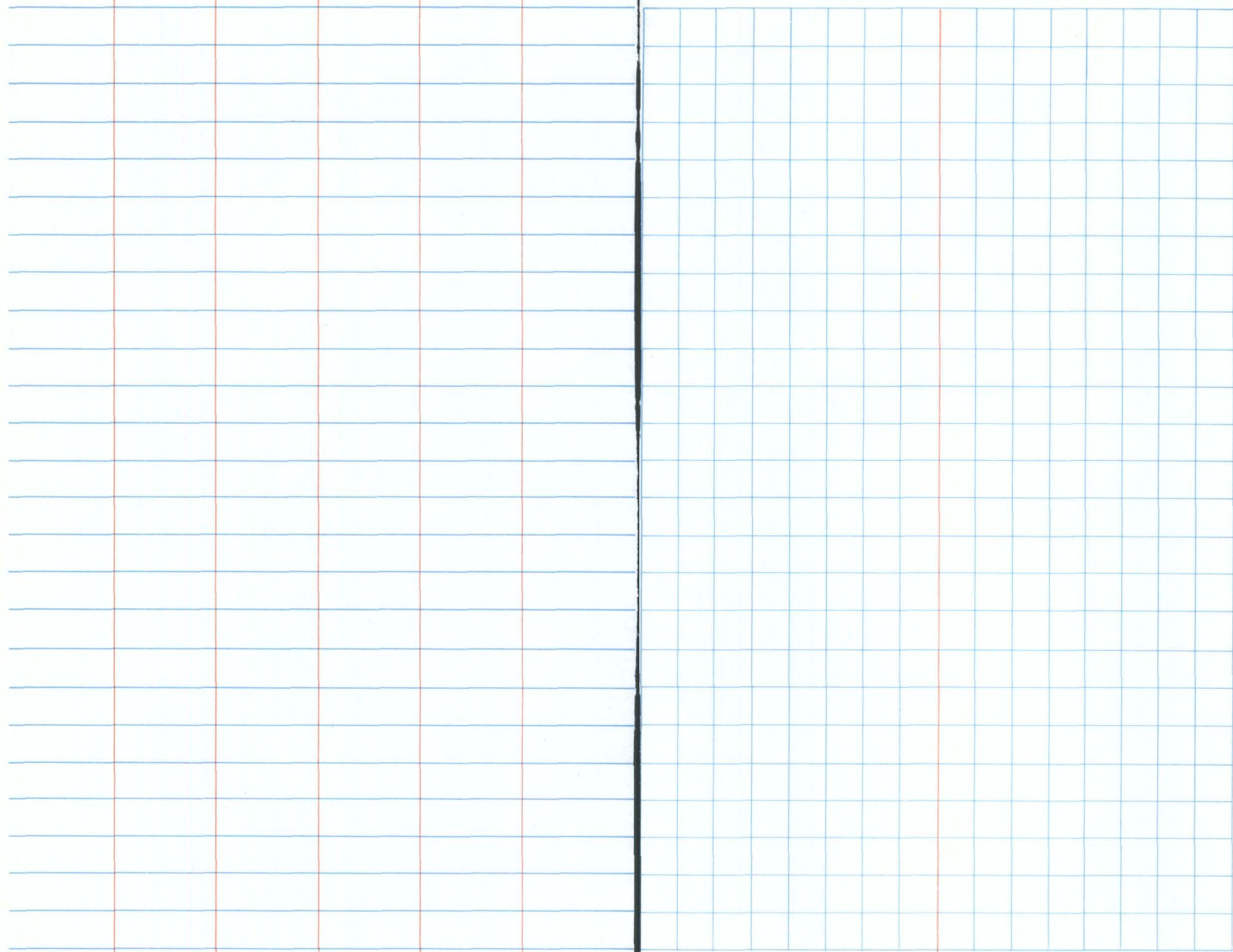
RIB

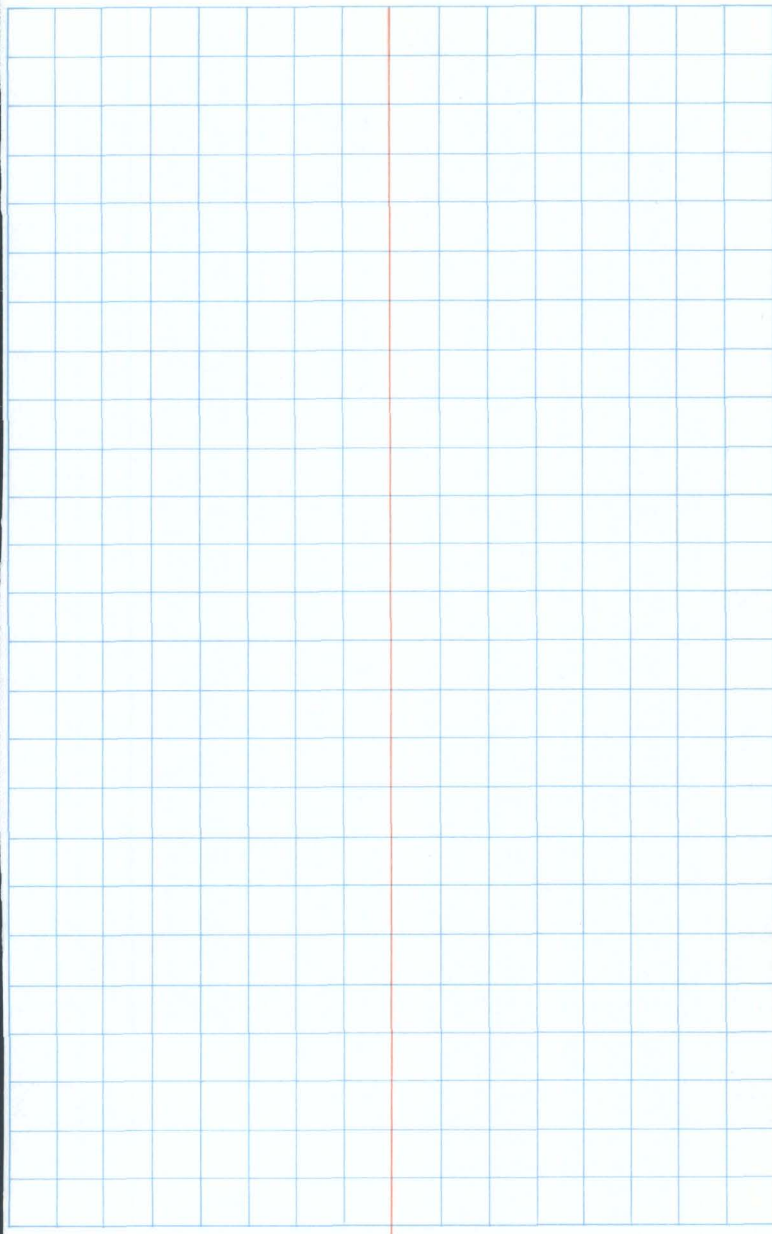
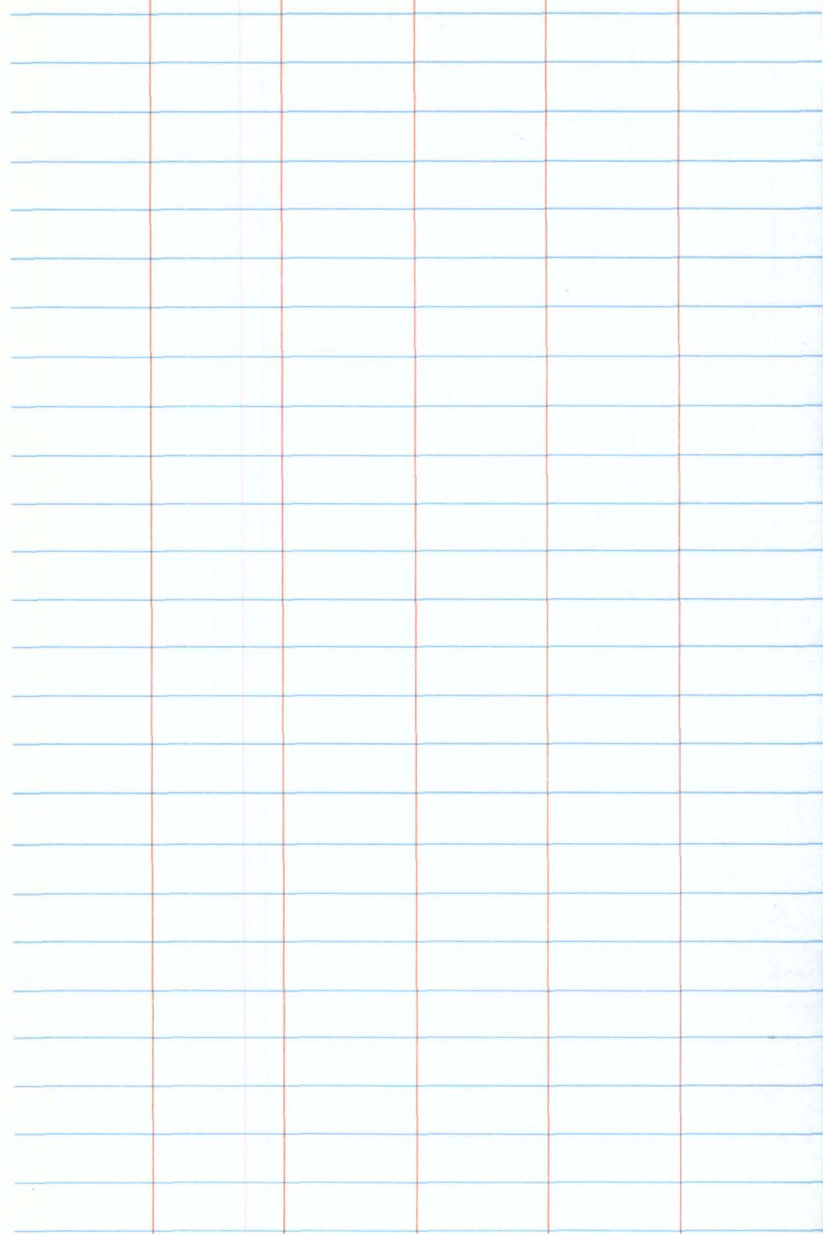


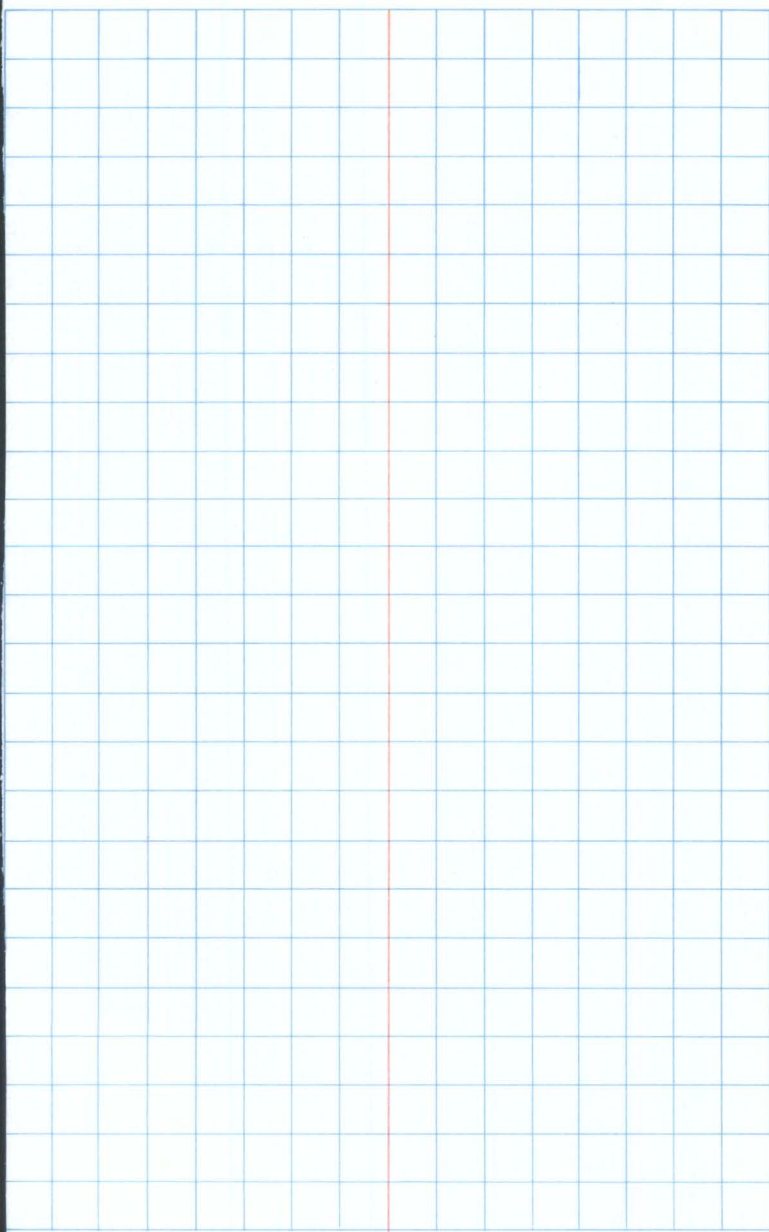
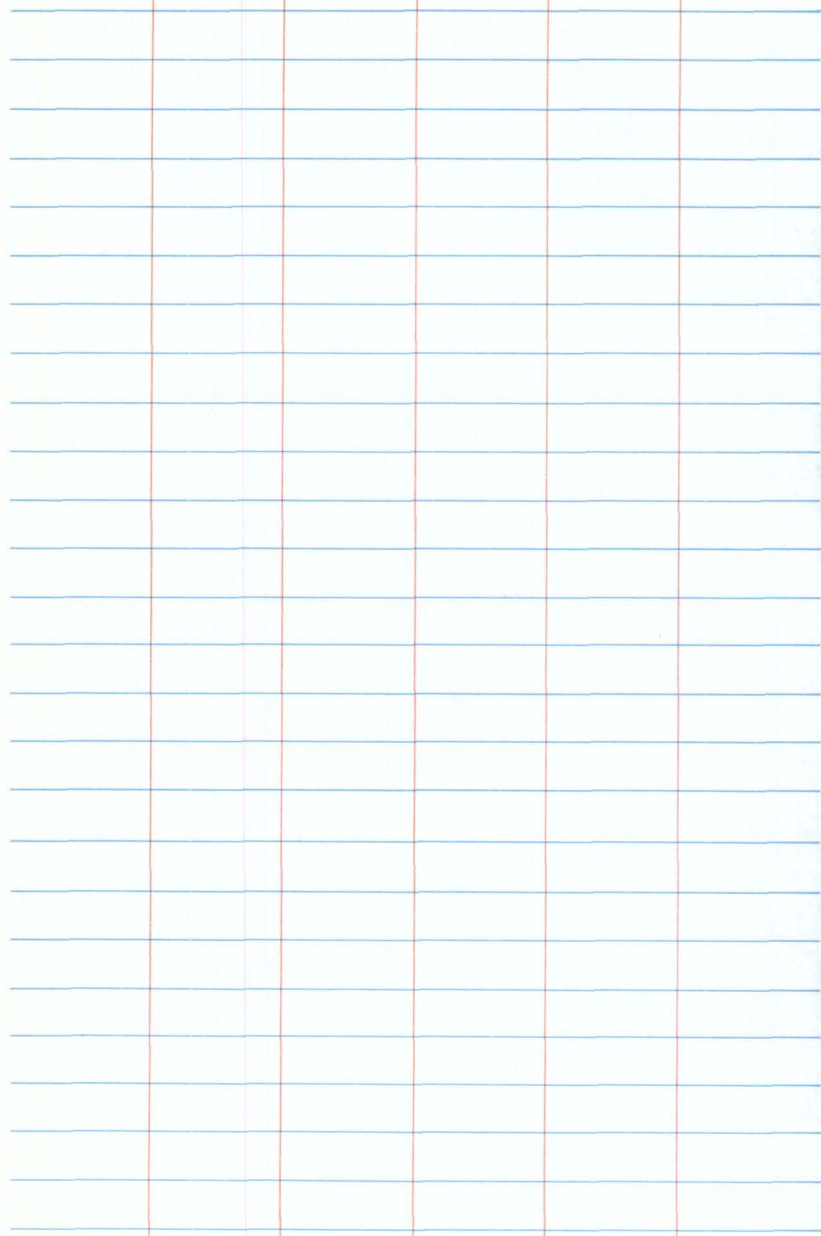


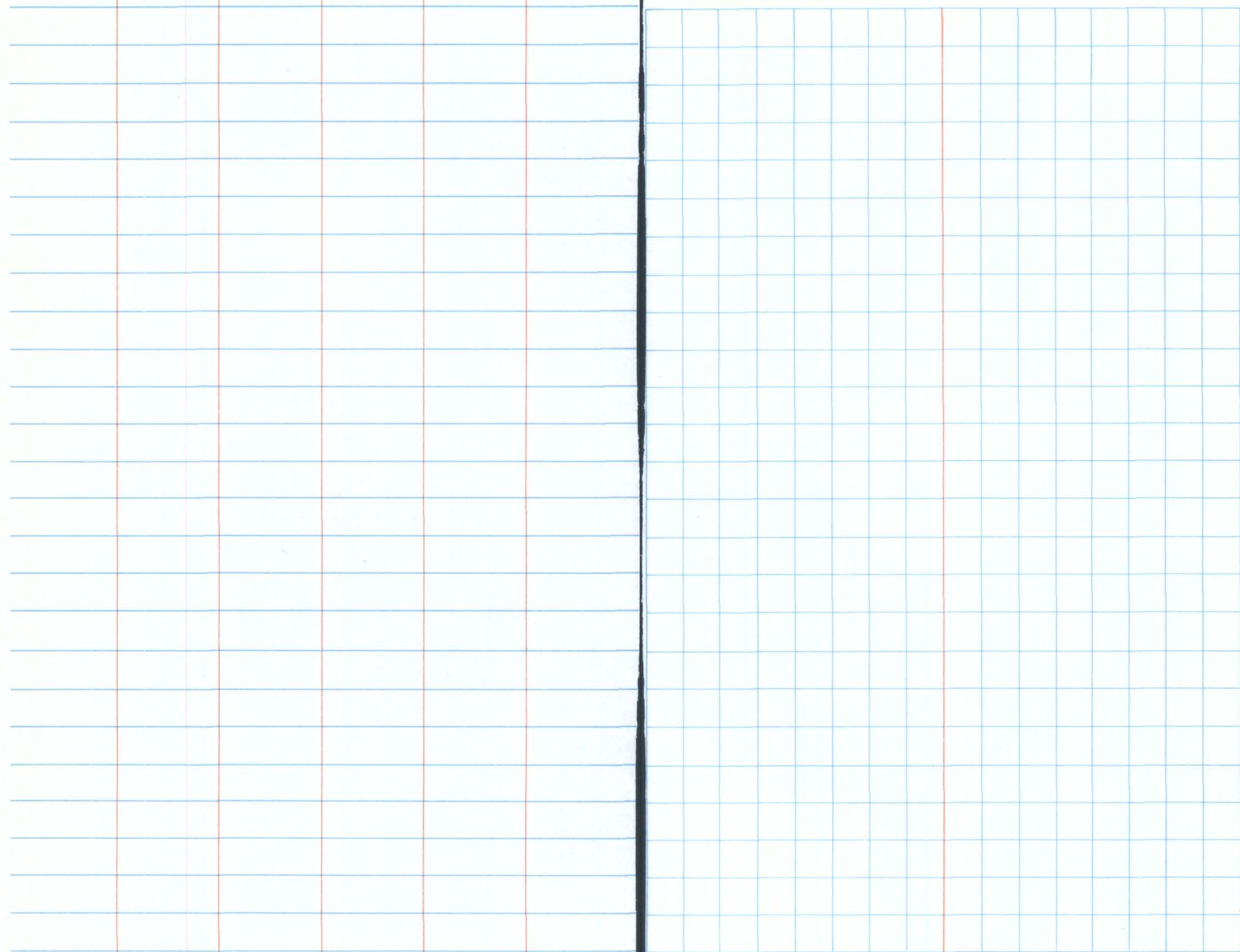


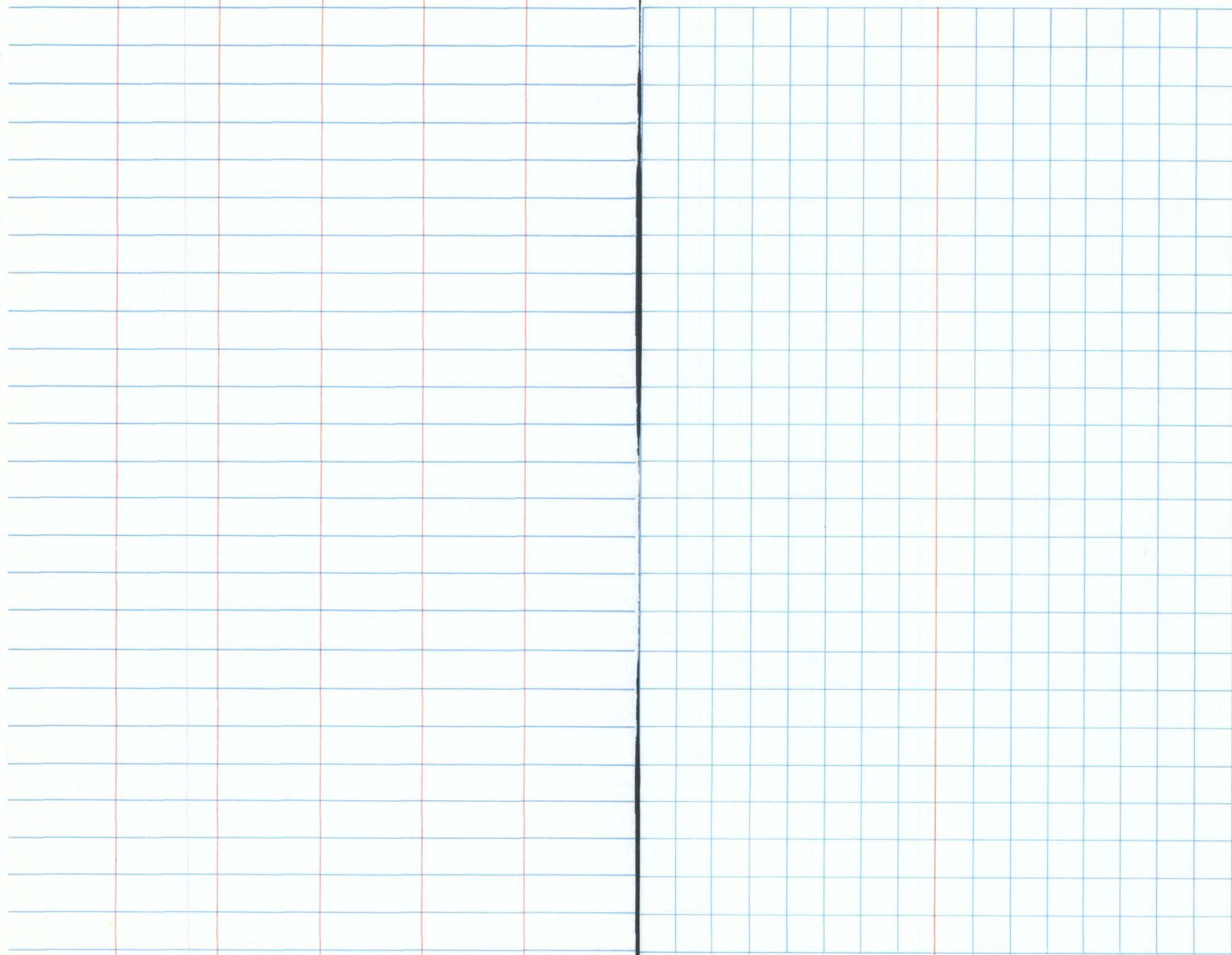


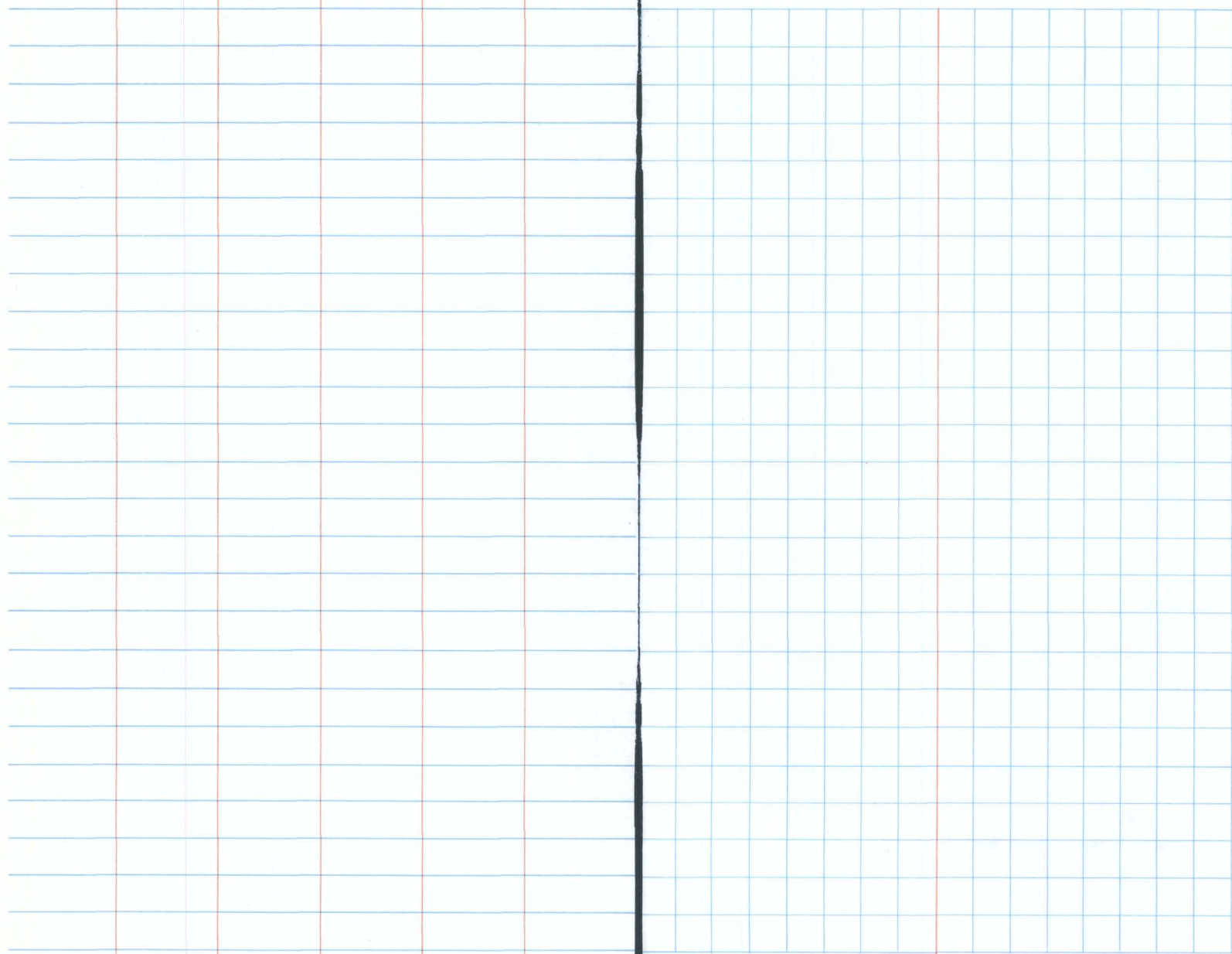


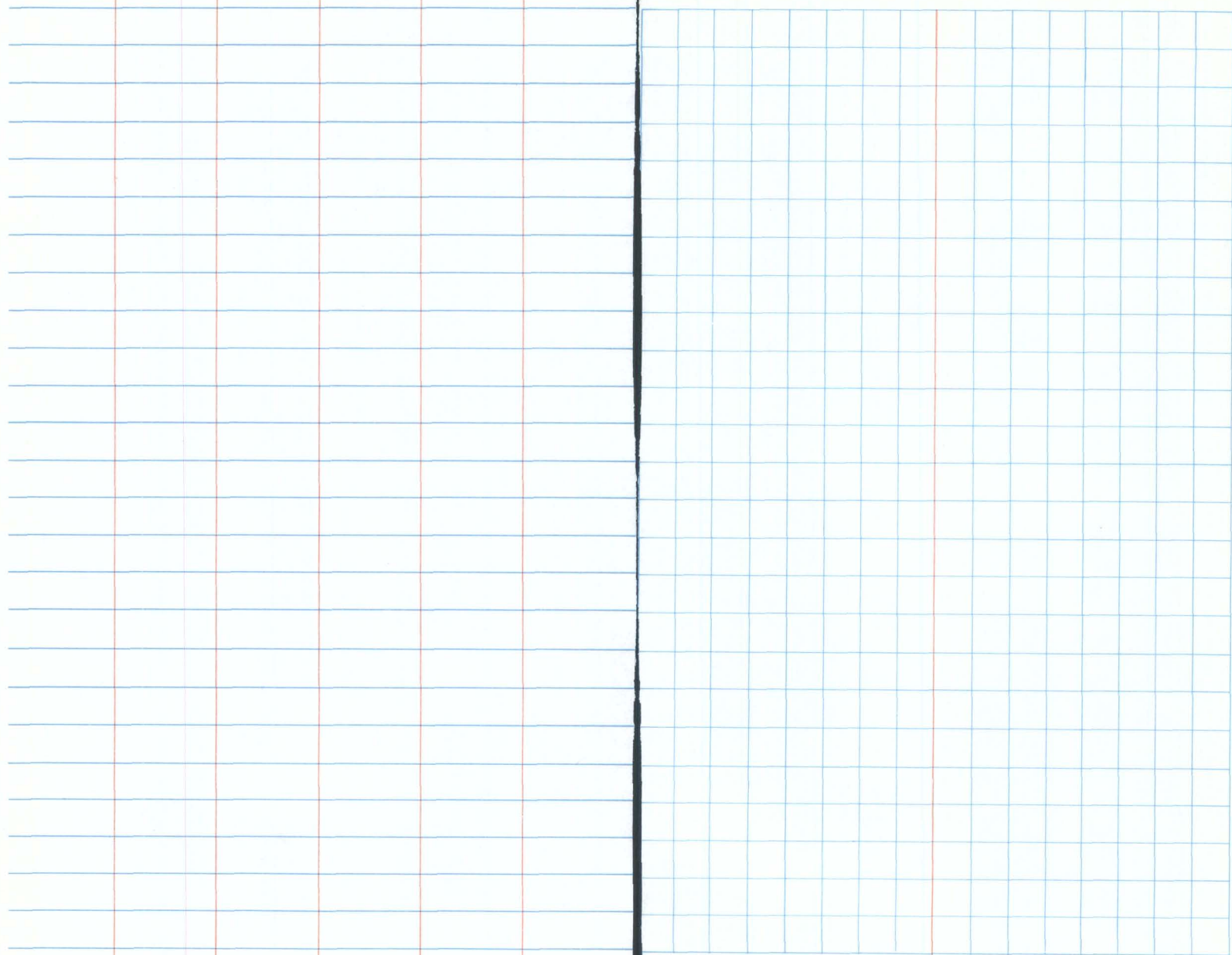


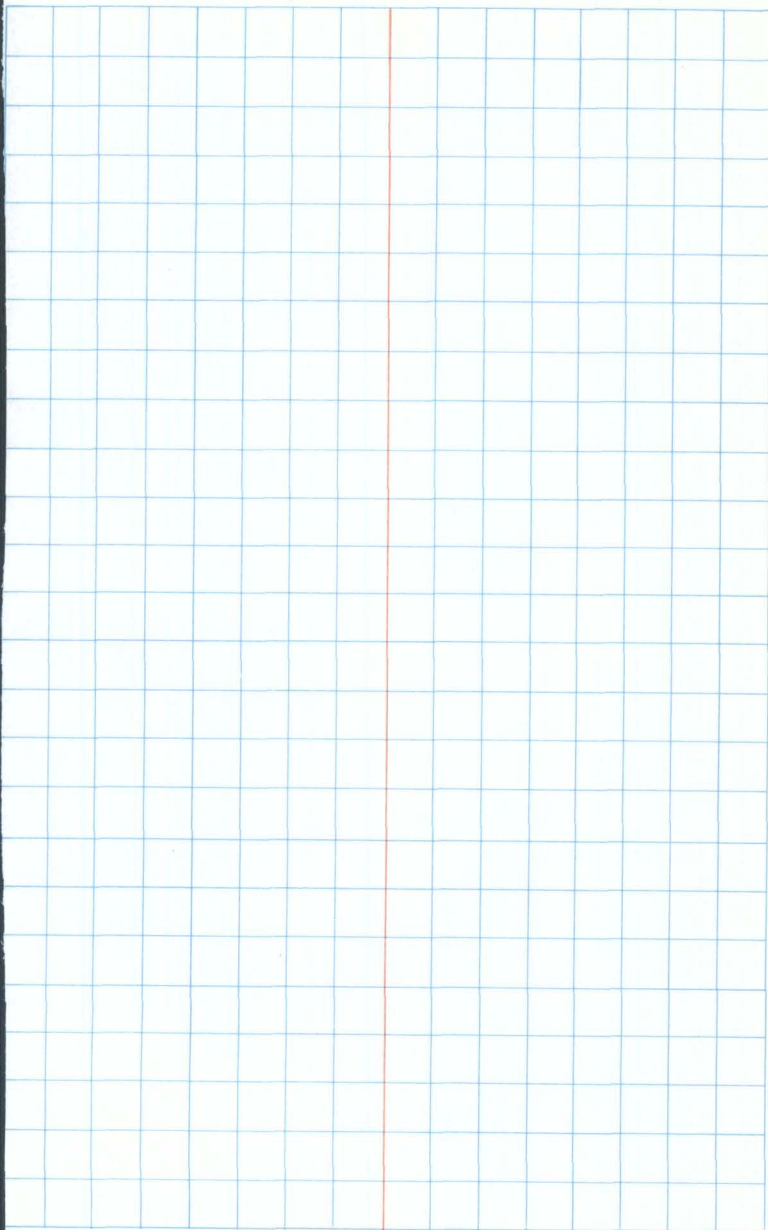
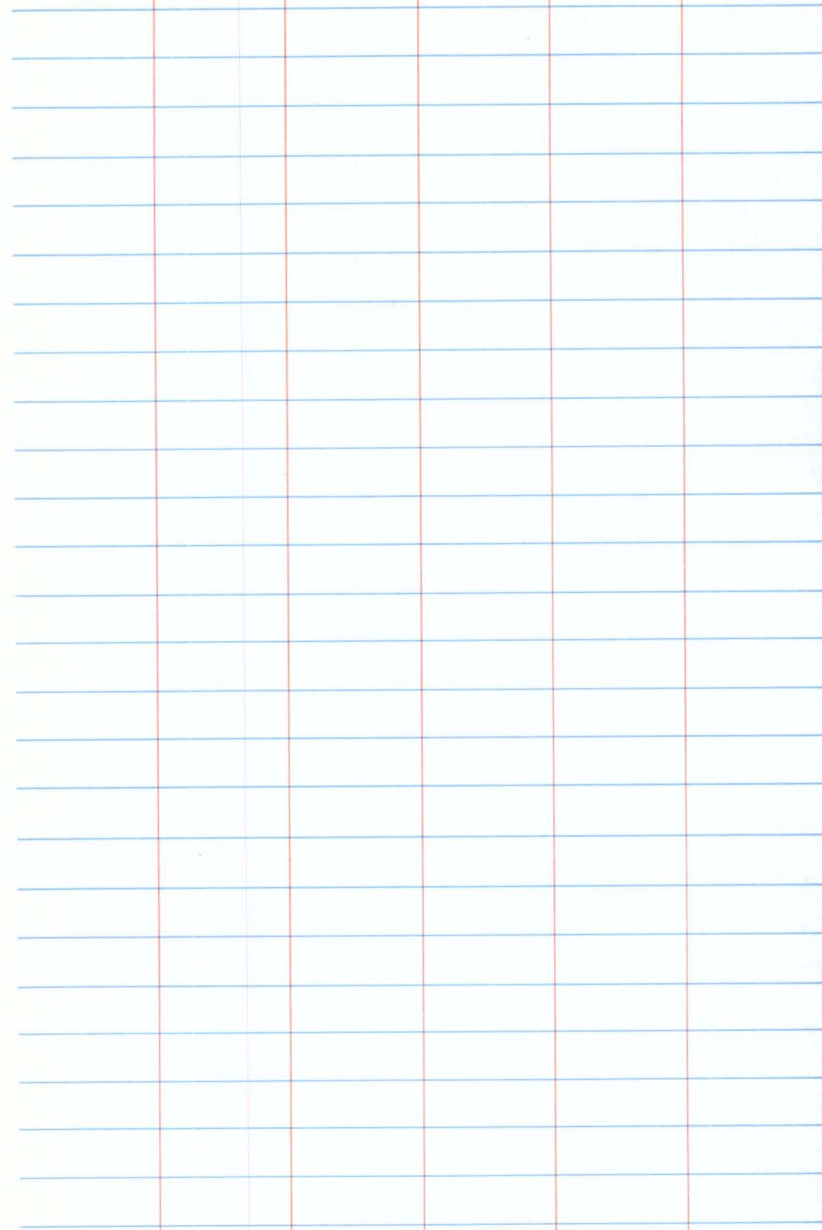


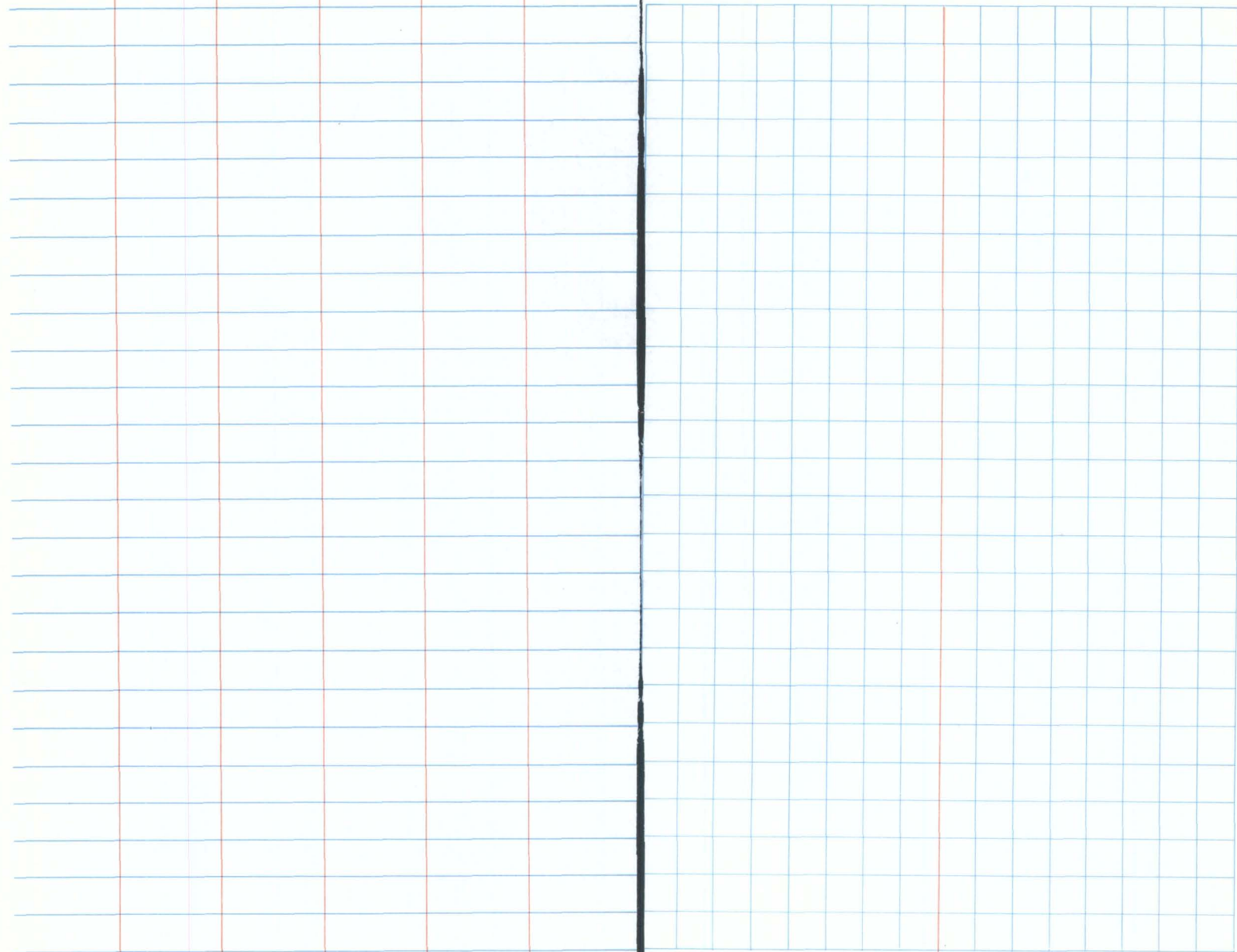


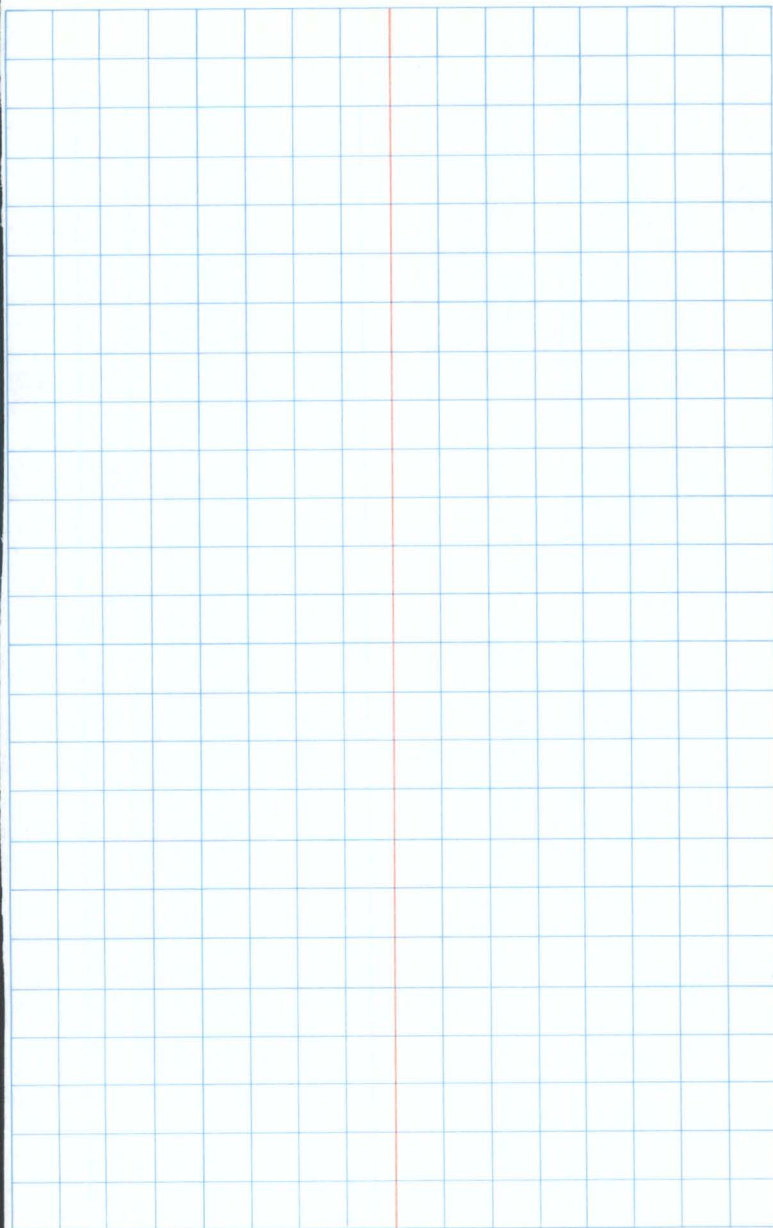
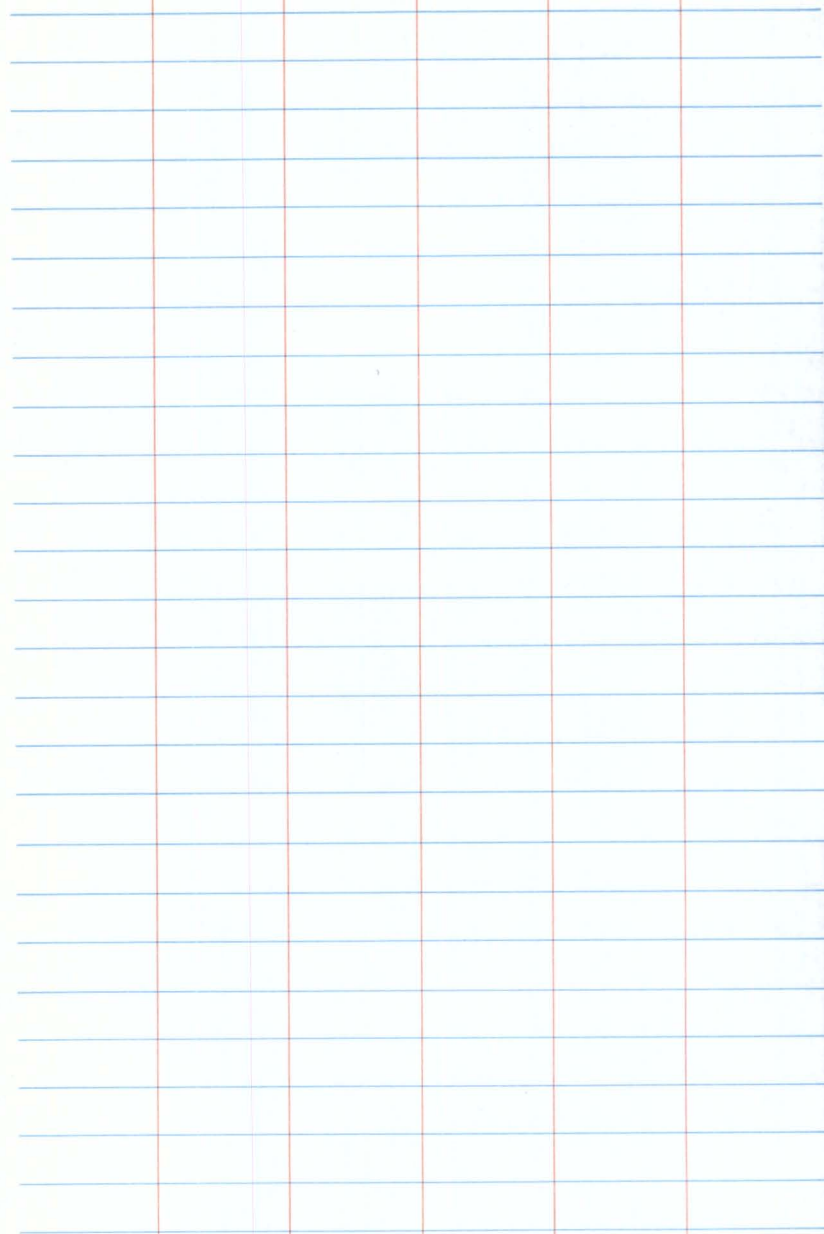


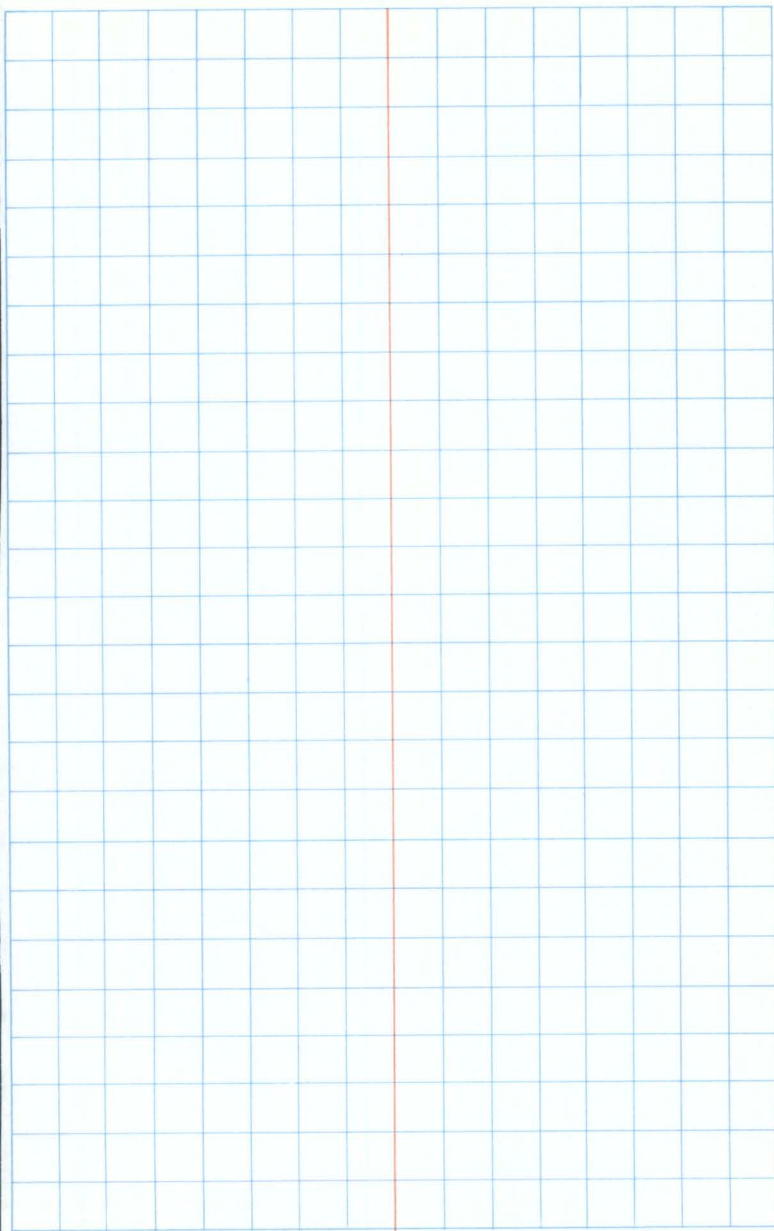
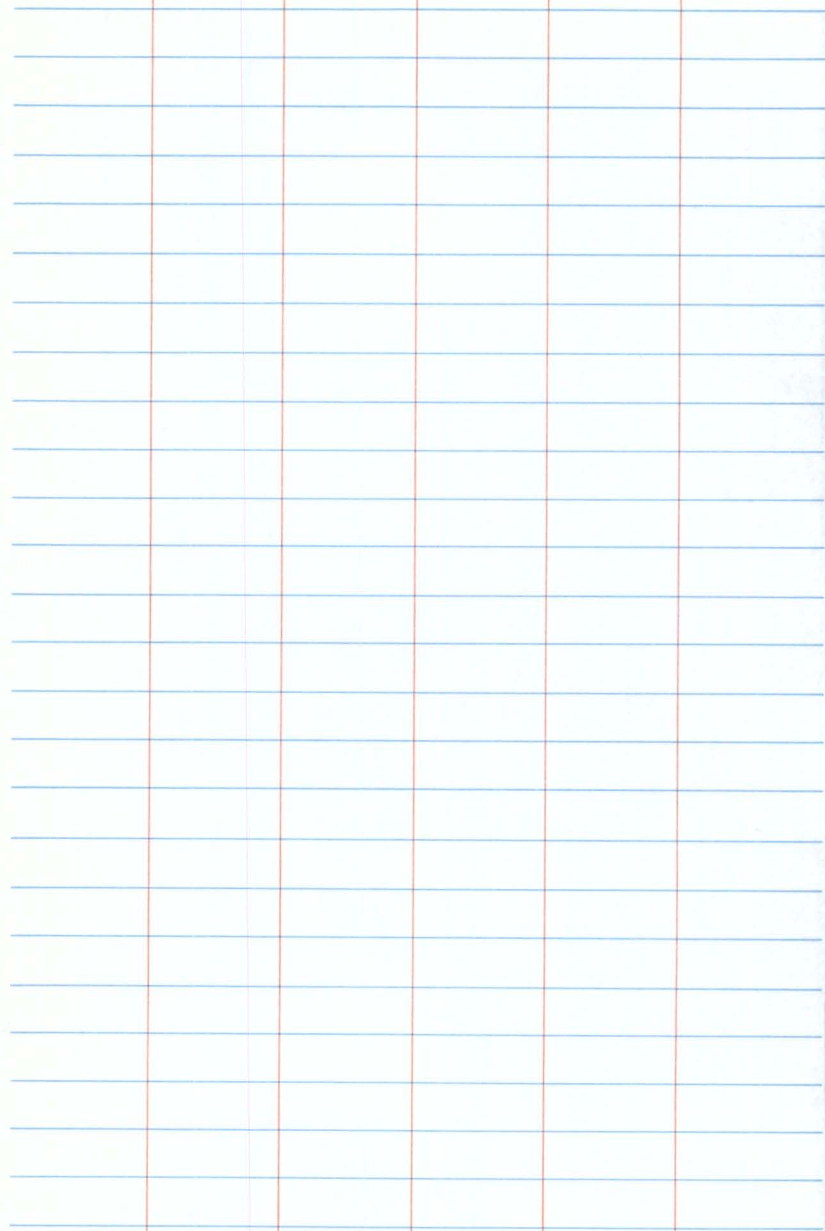


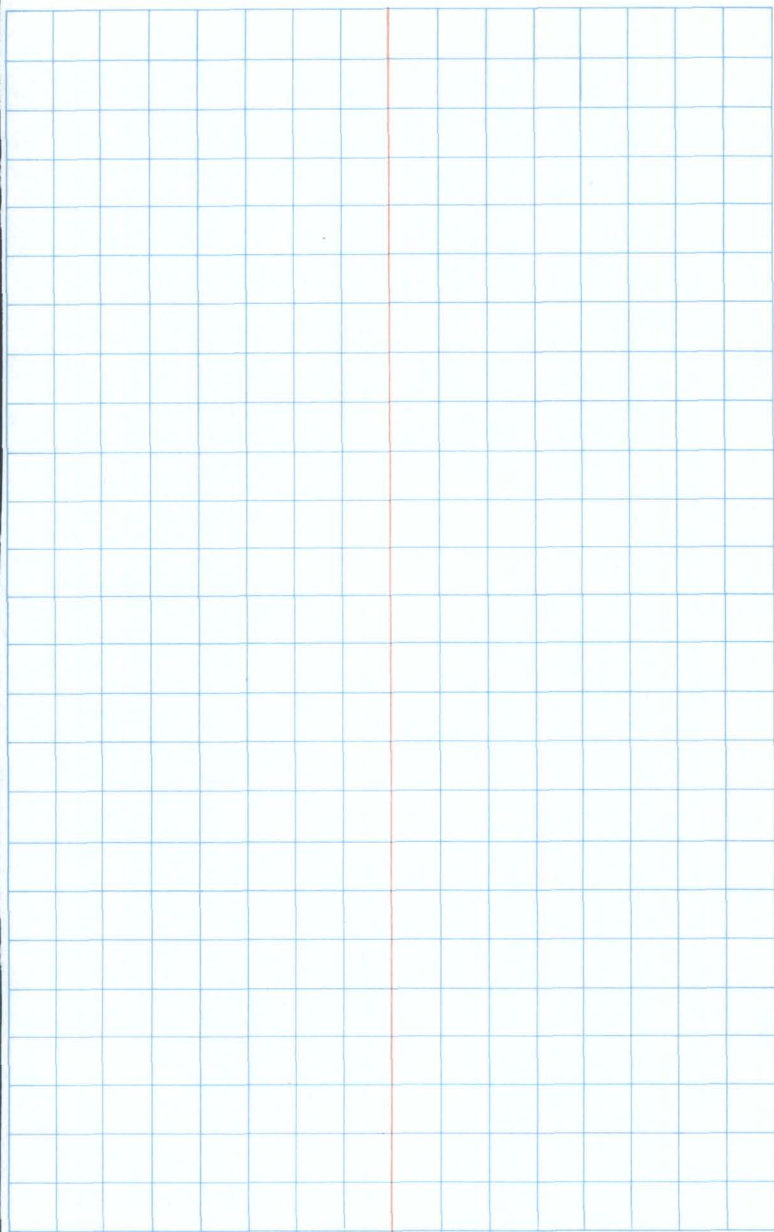
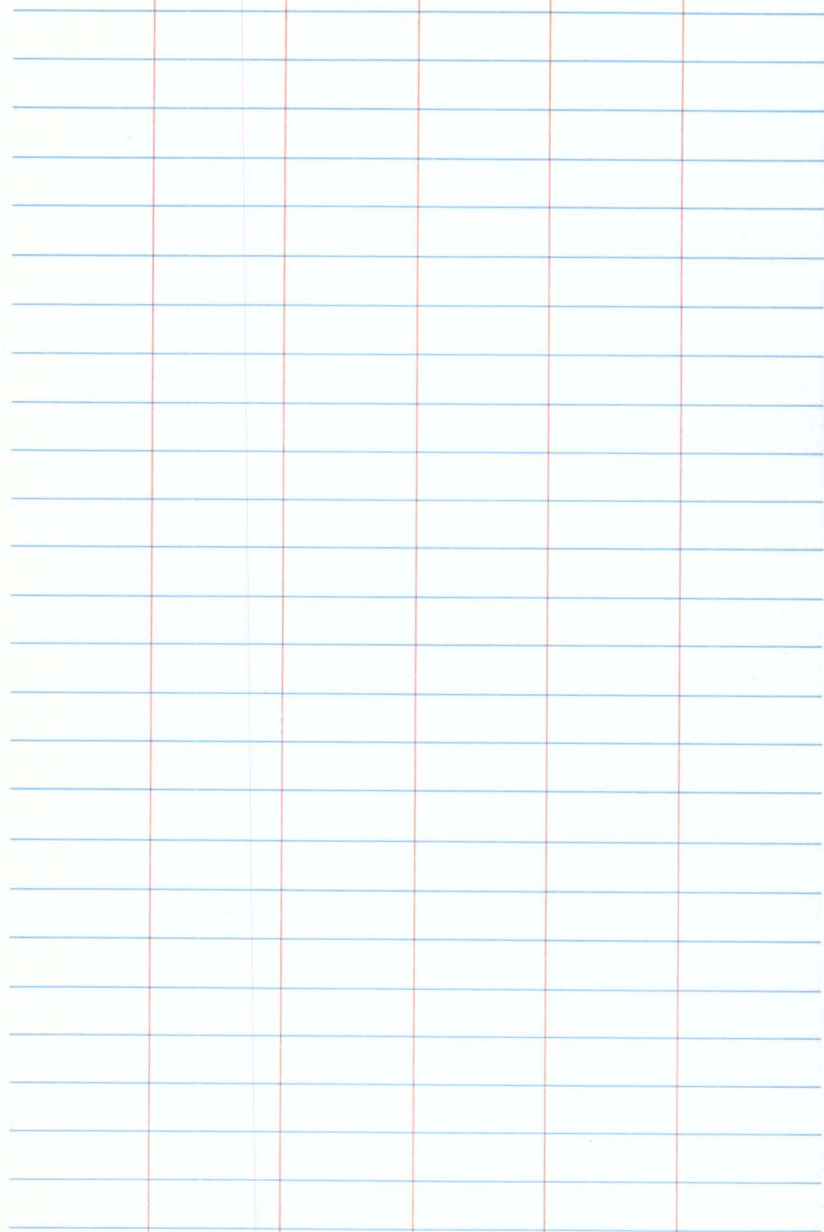


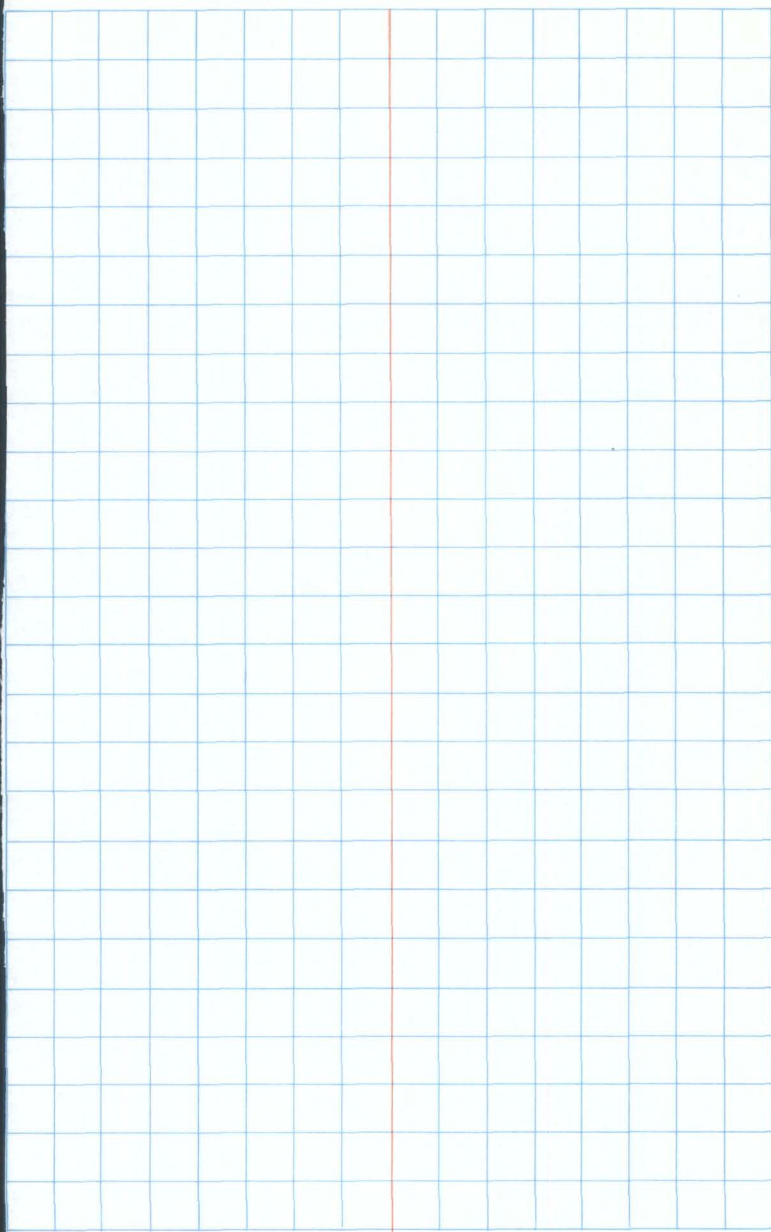
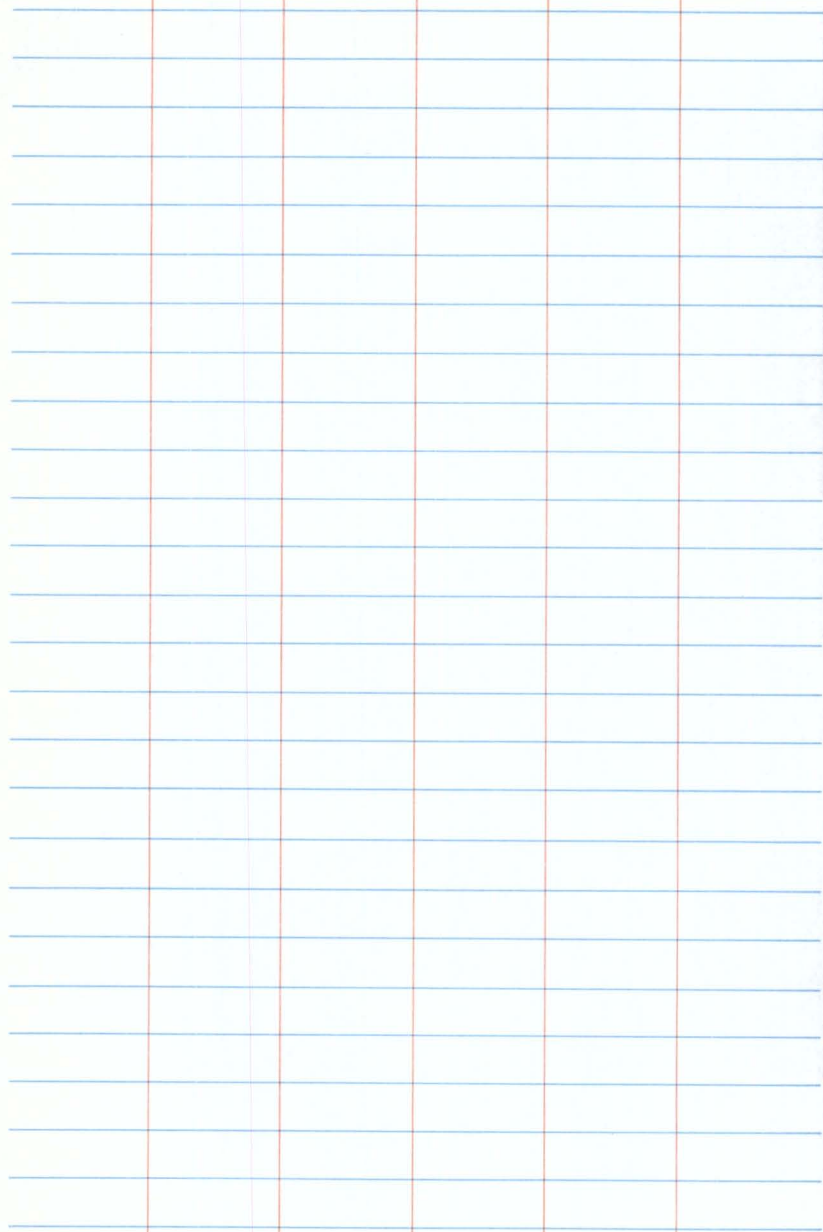


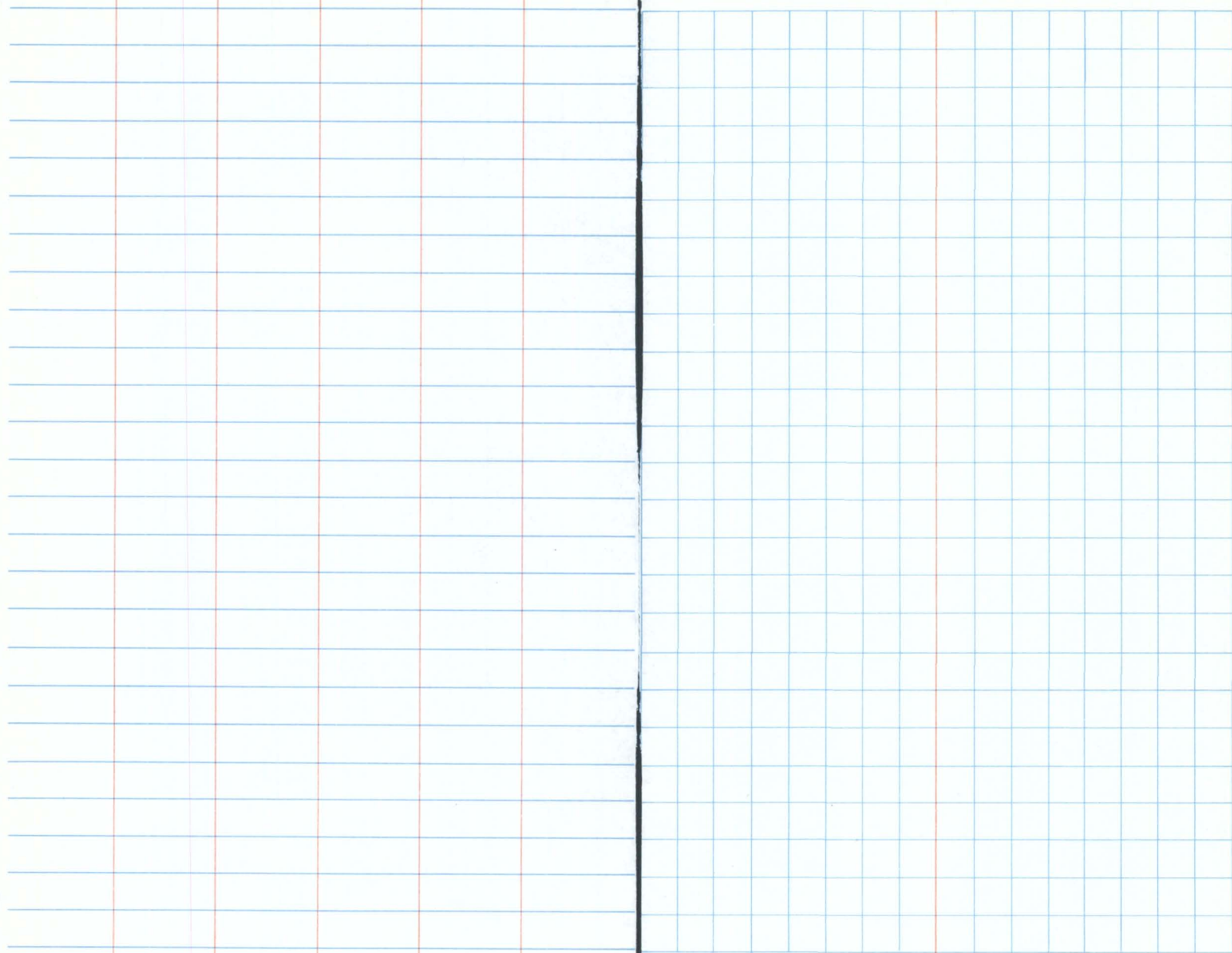


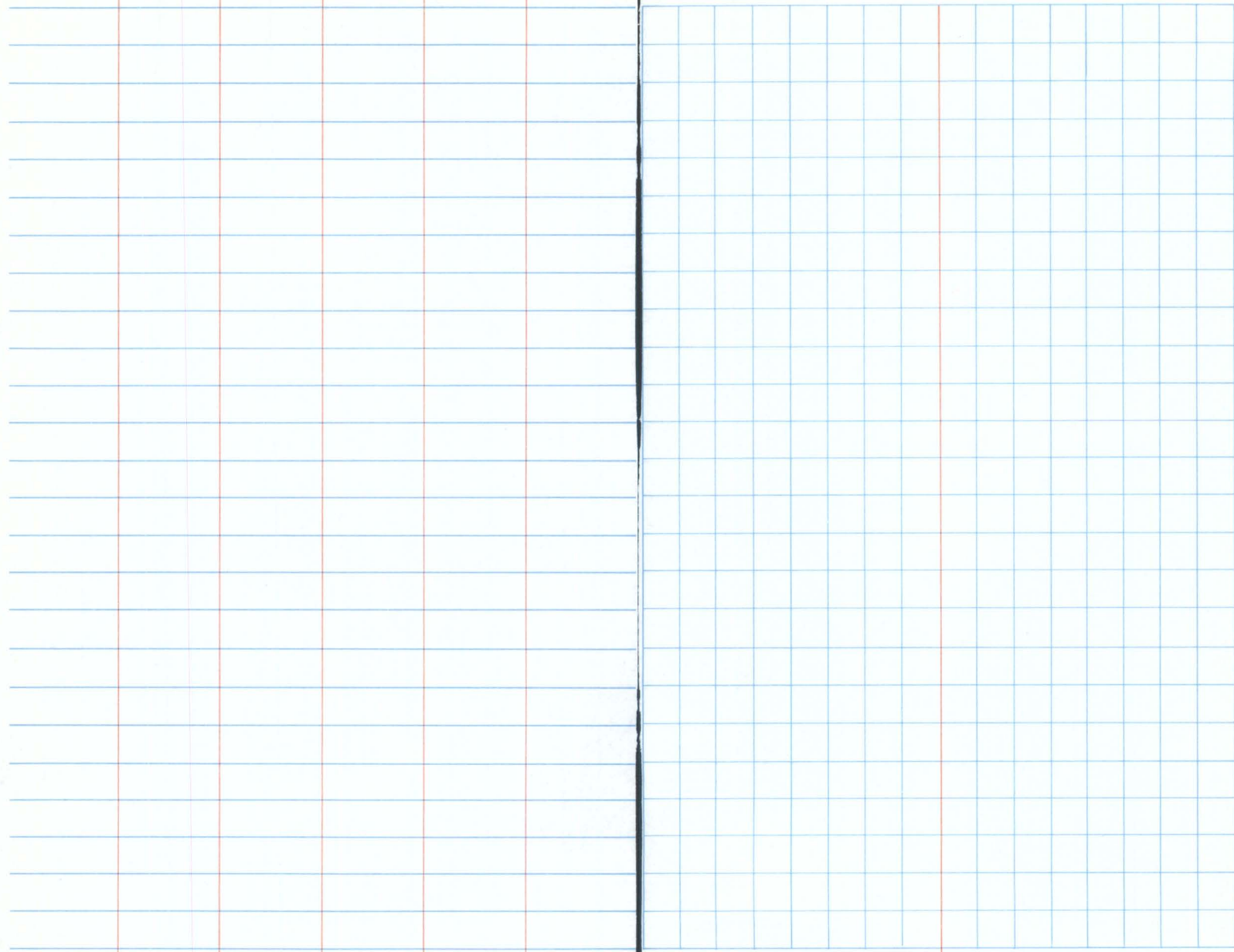


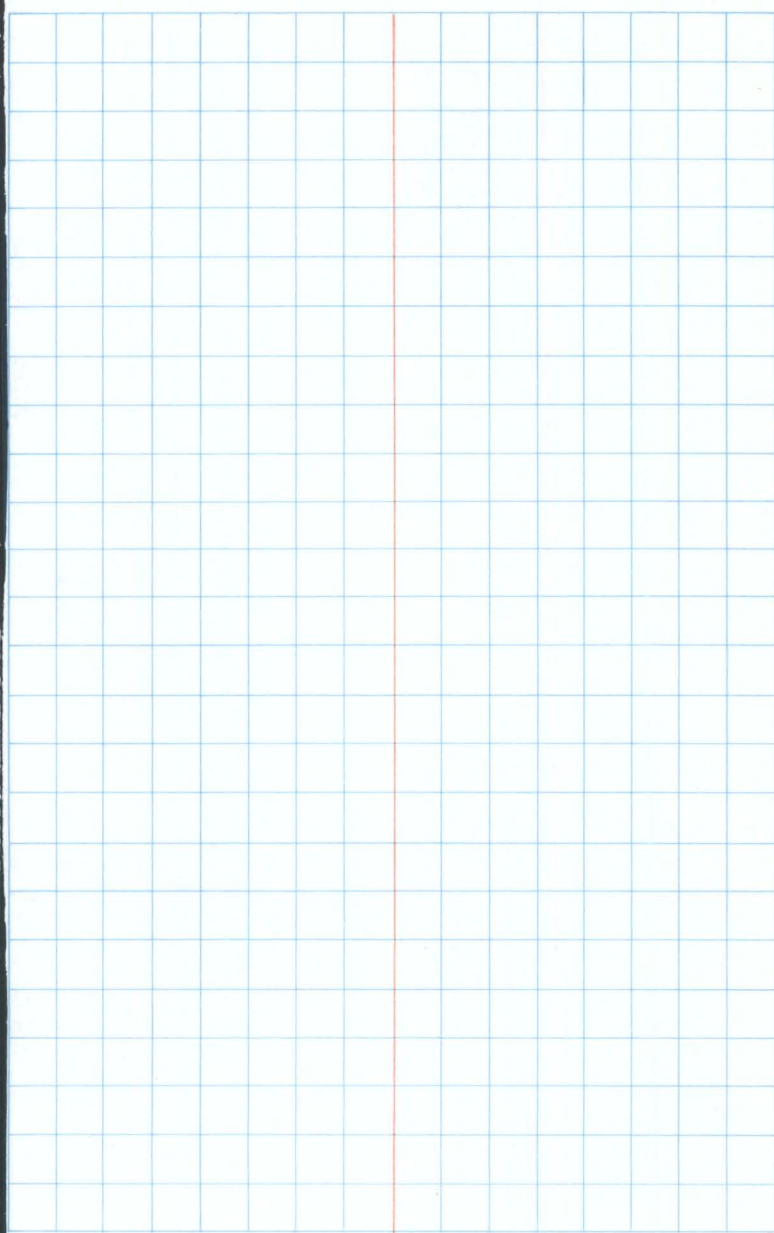
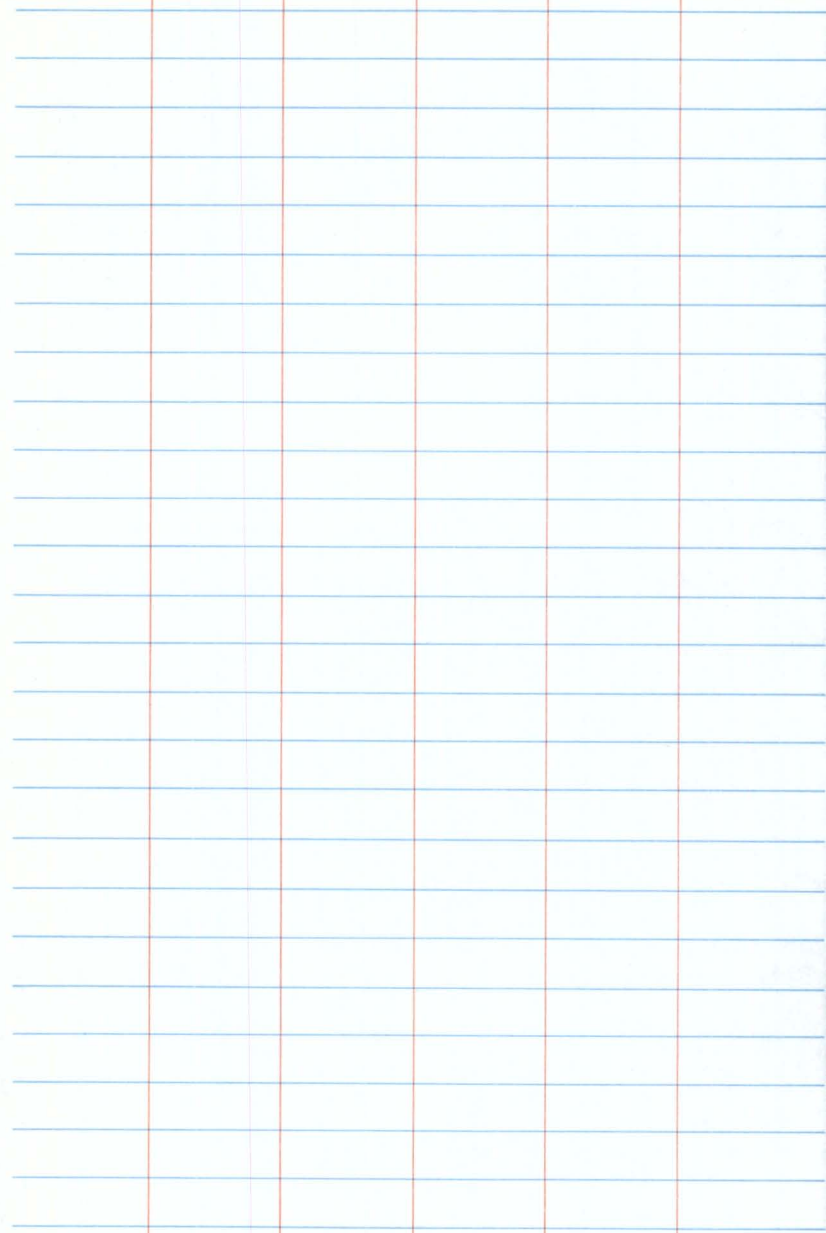


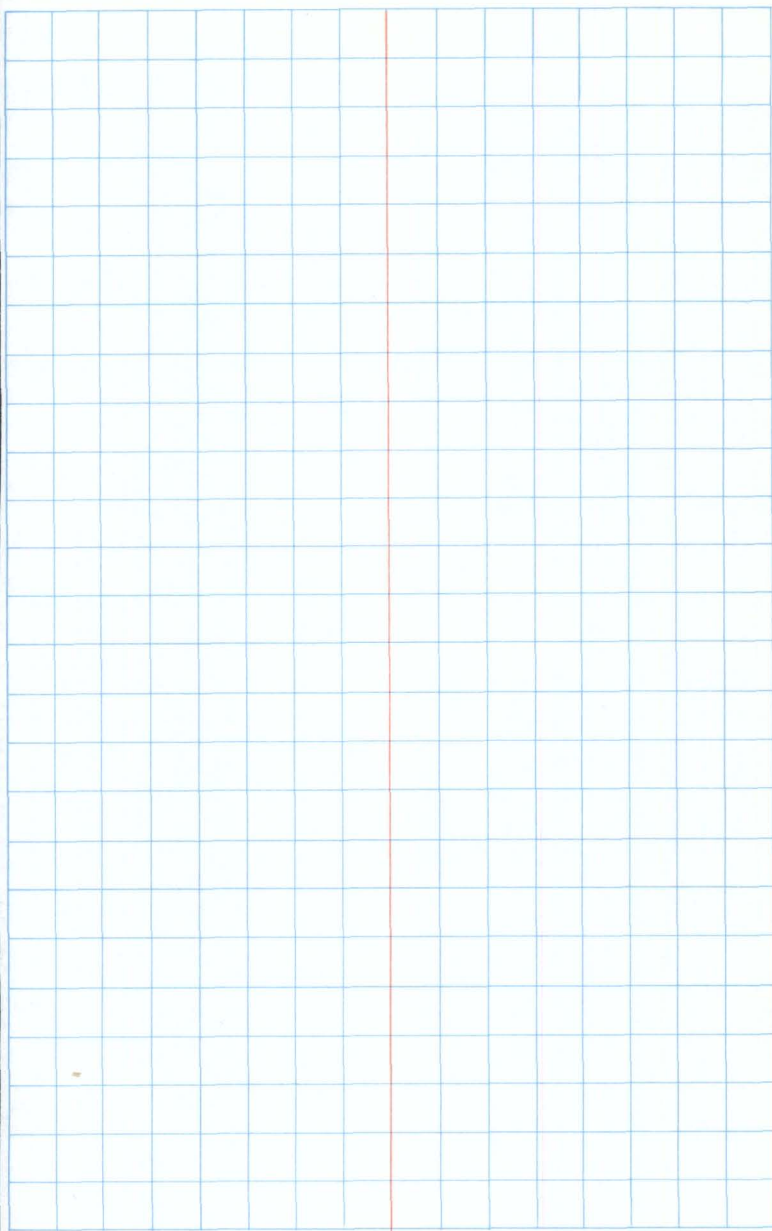
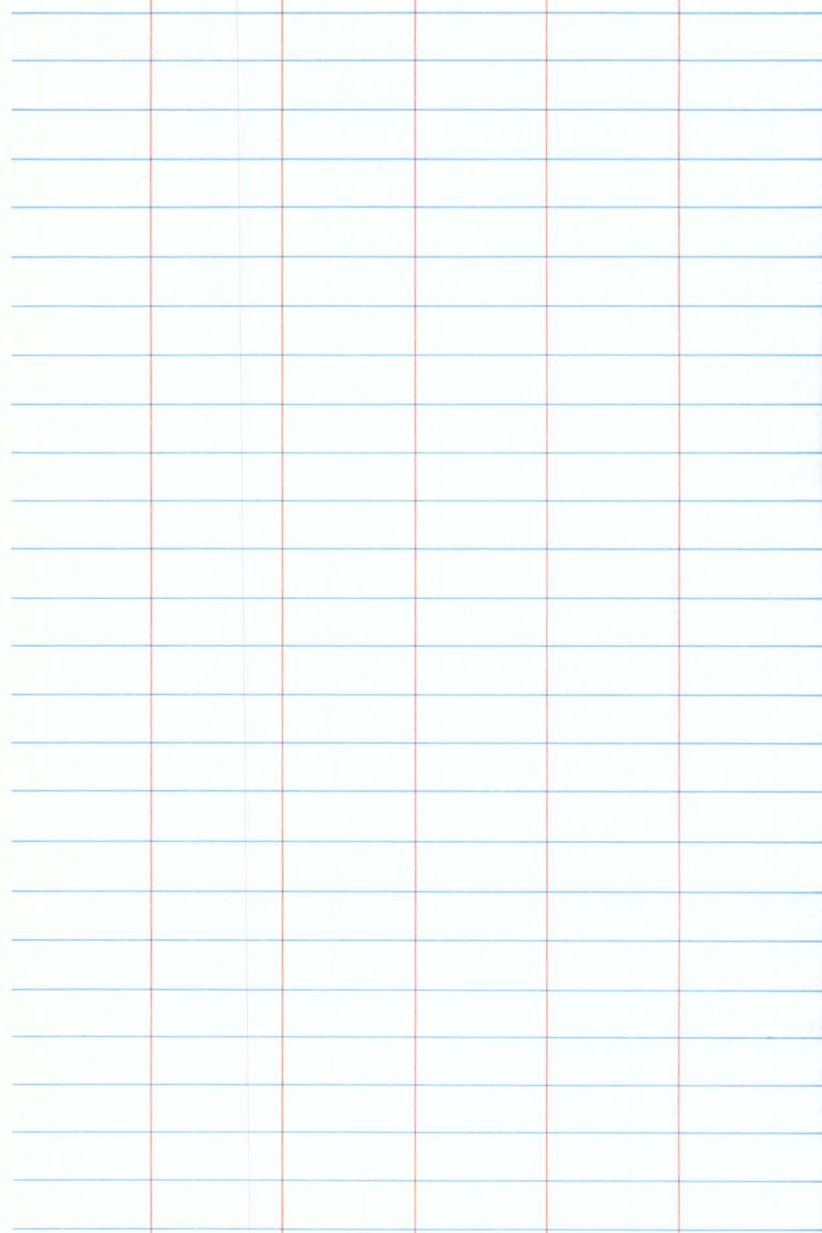


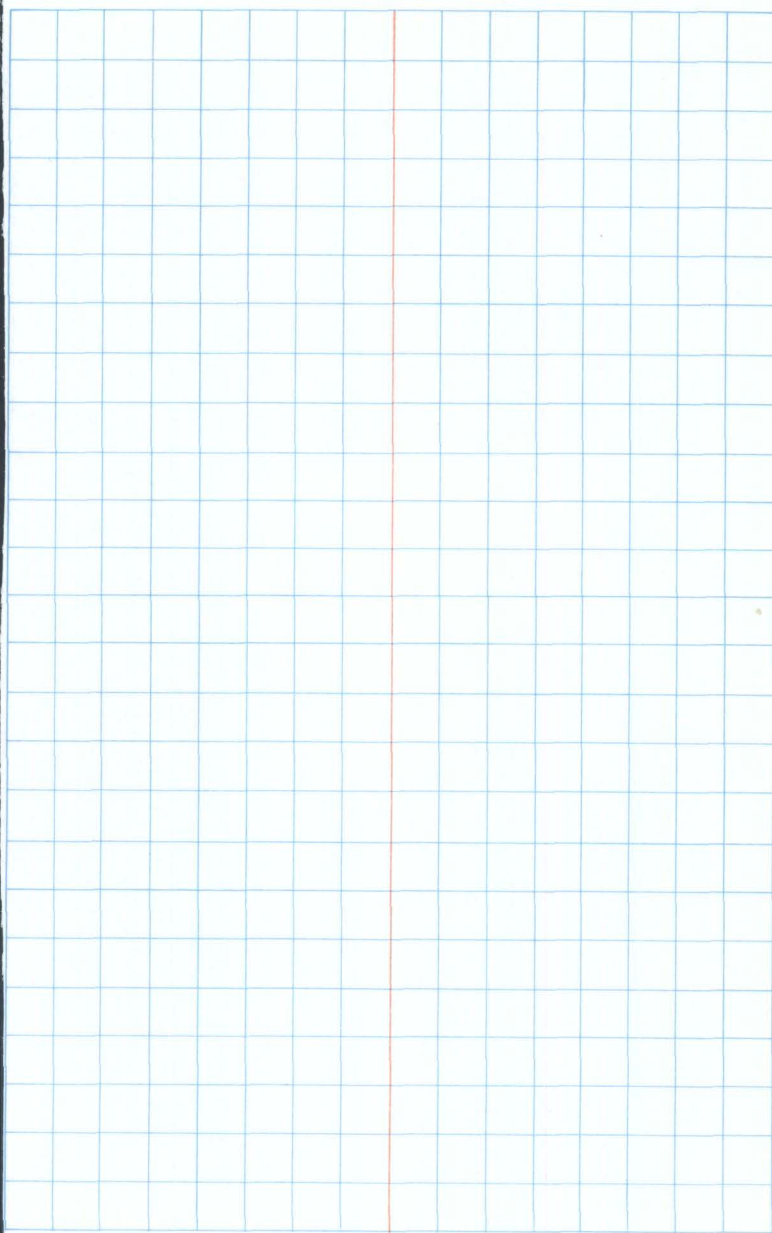
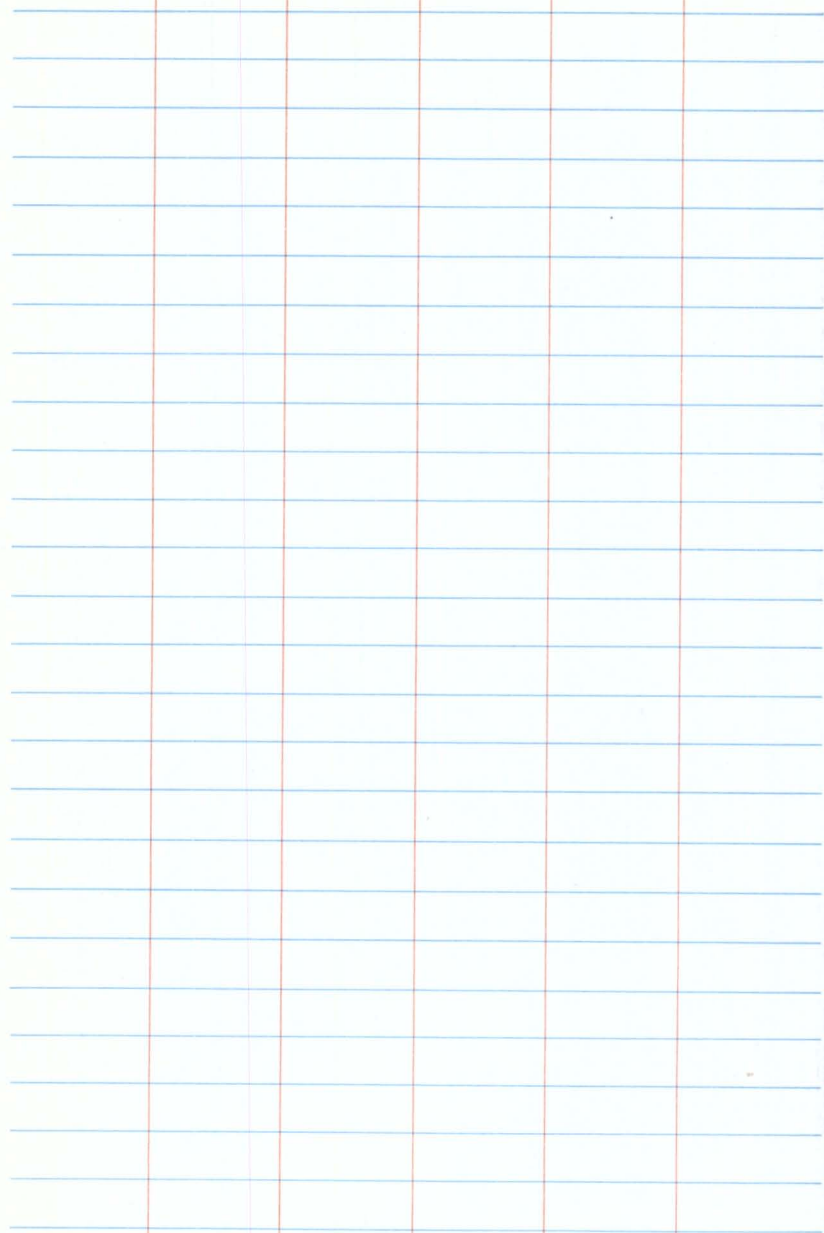


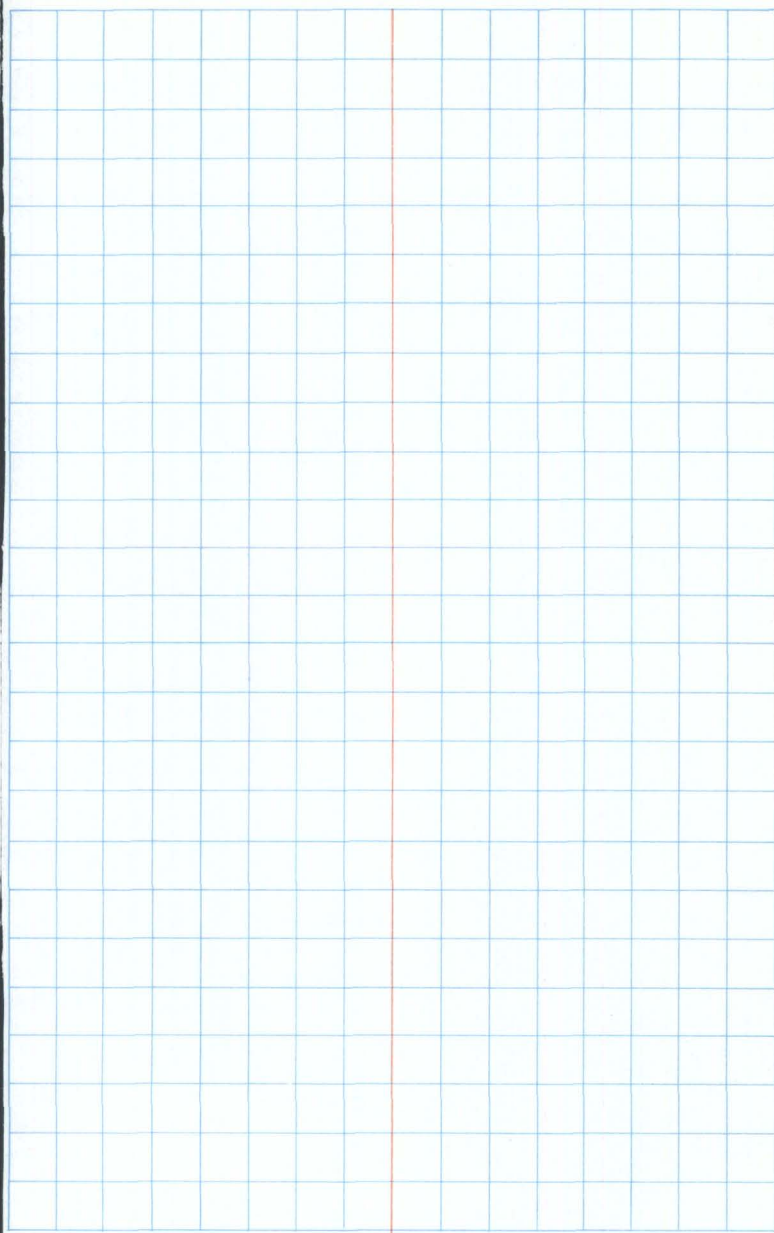
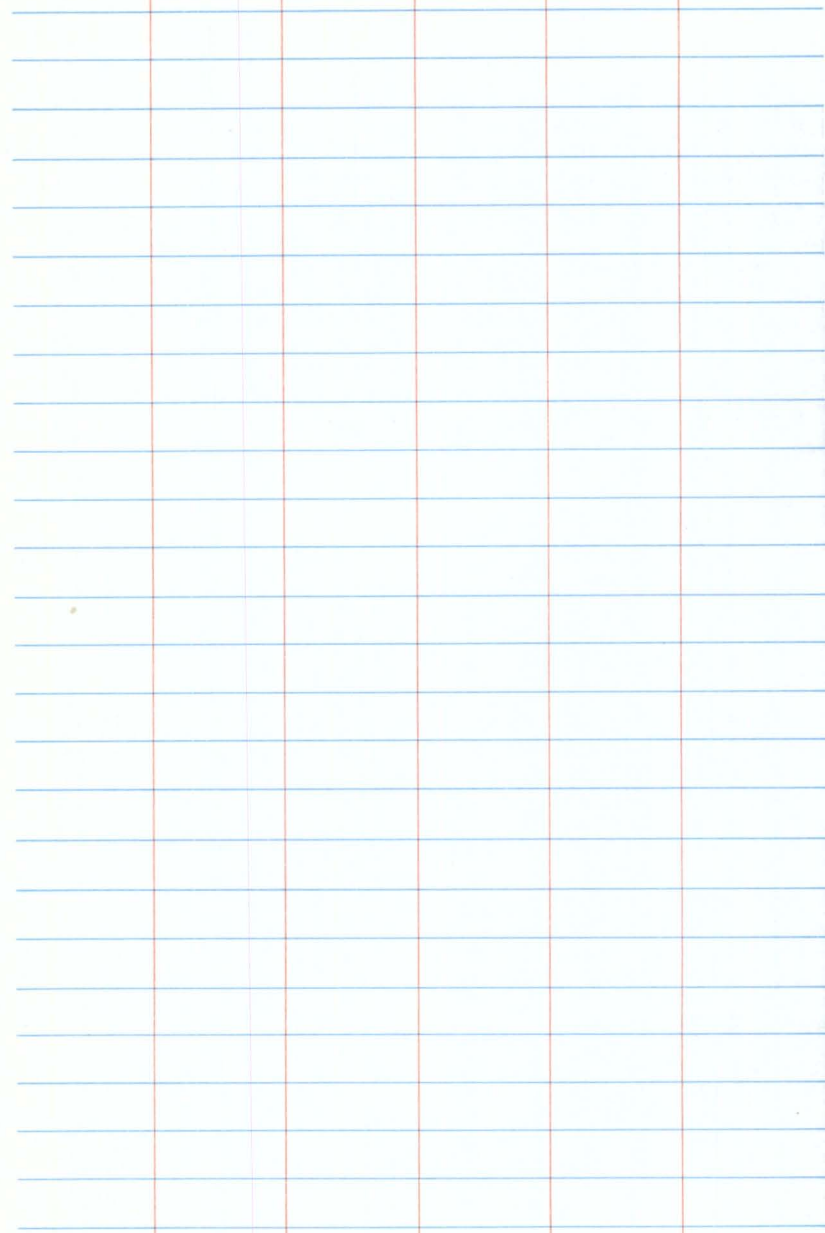


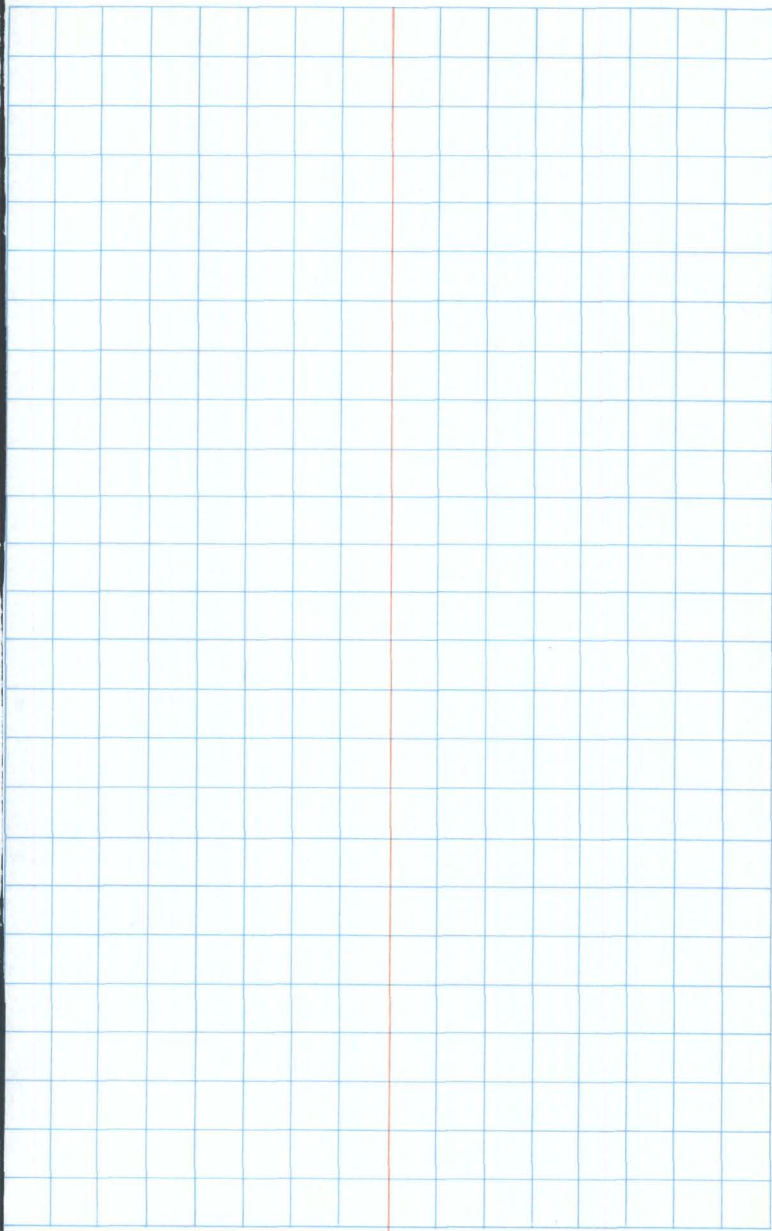
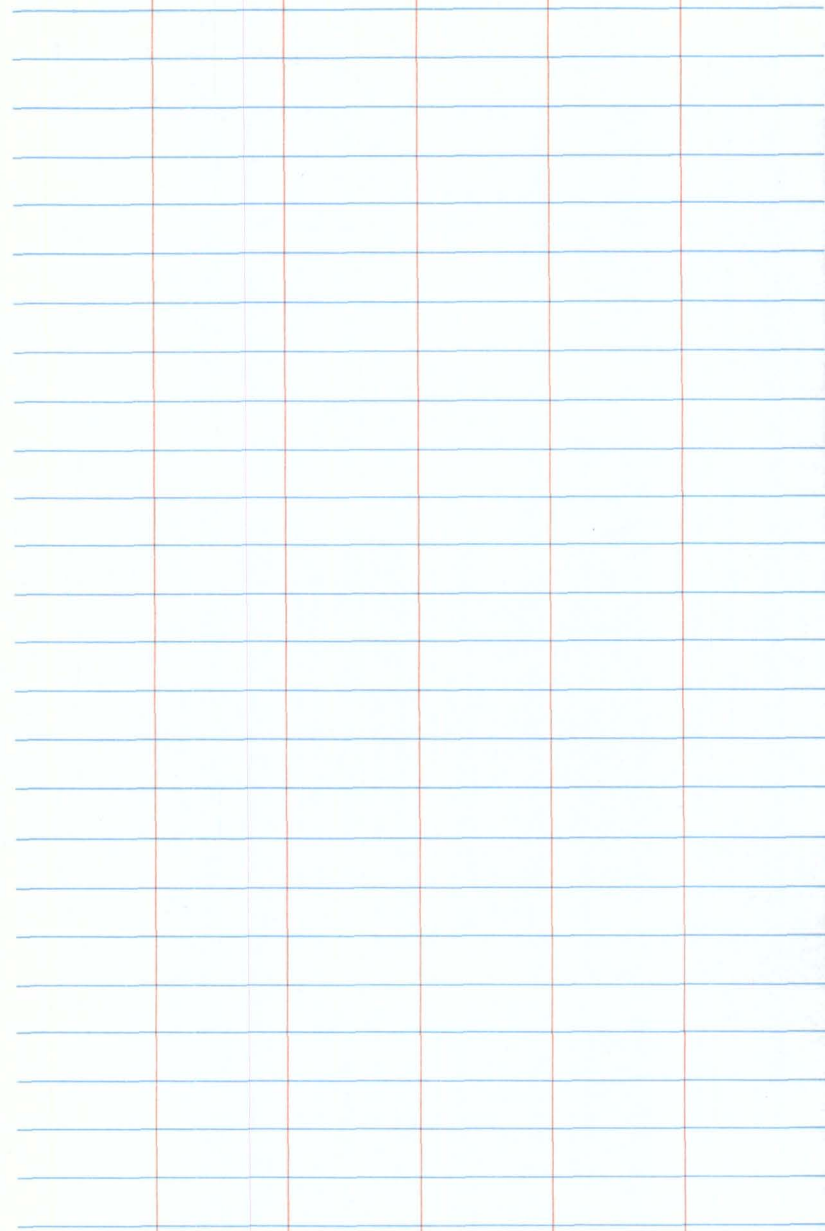


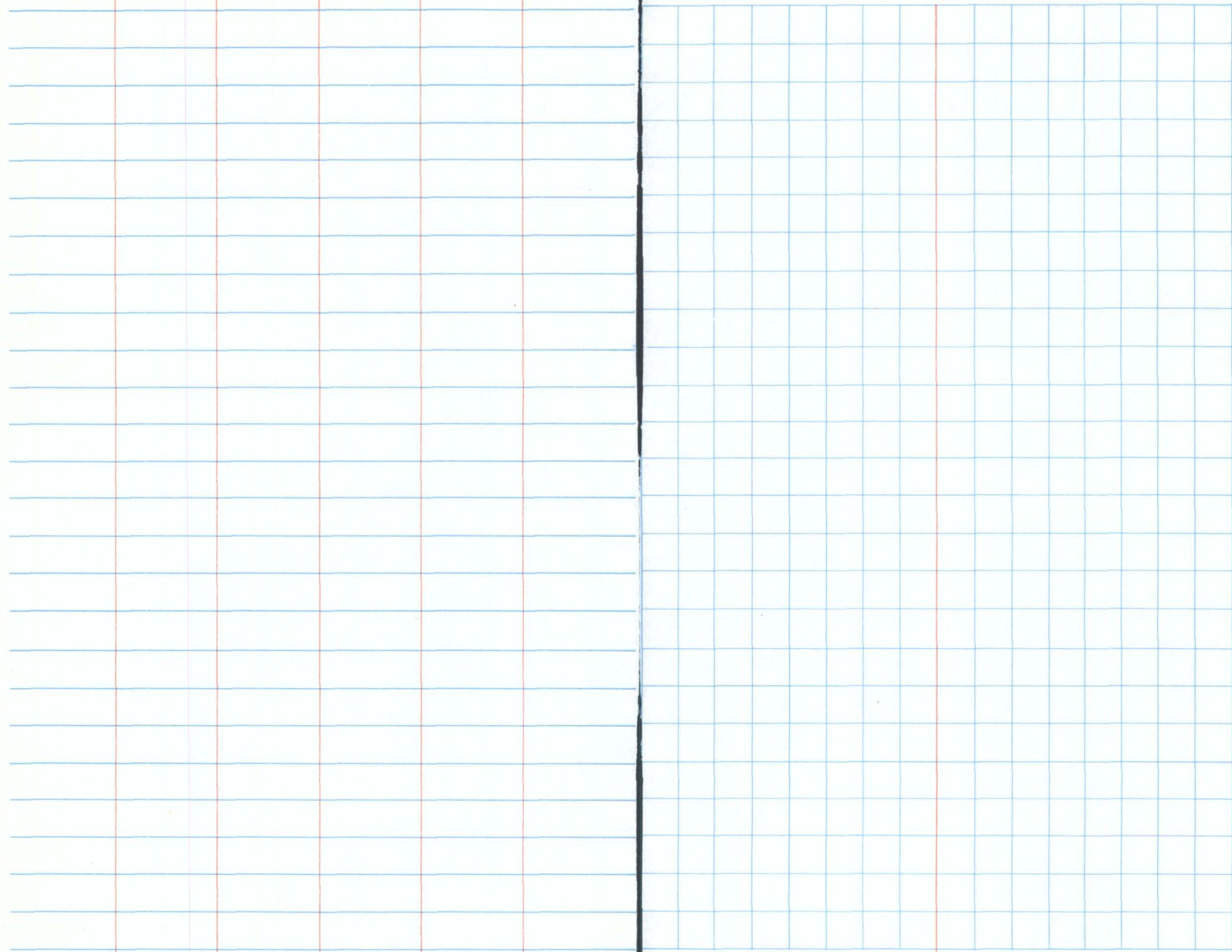


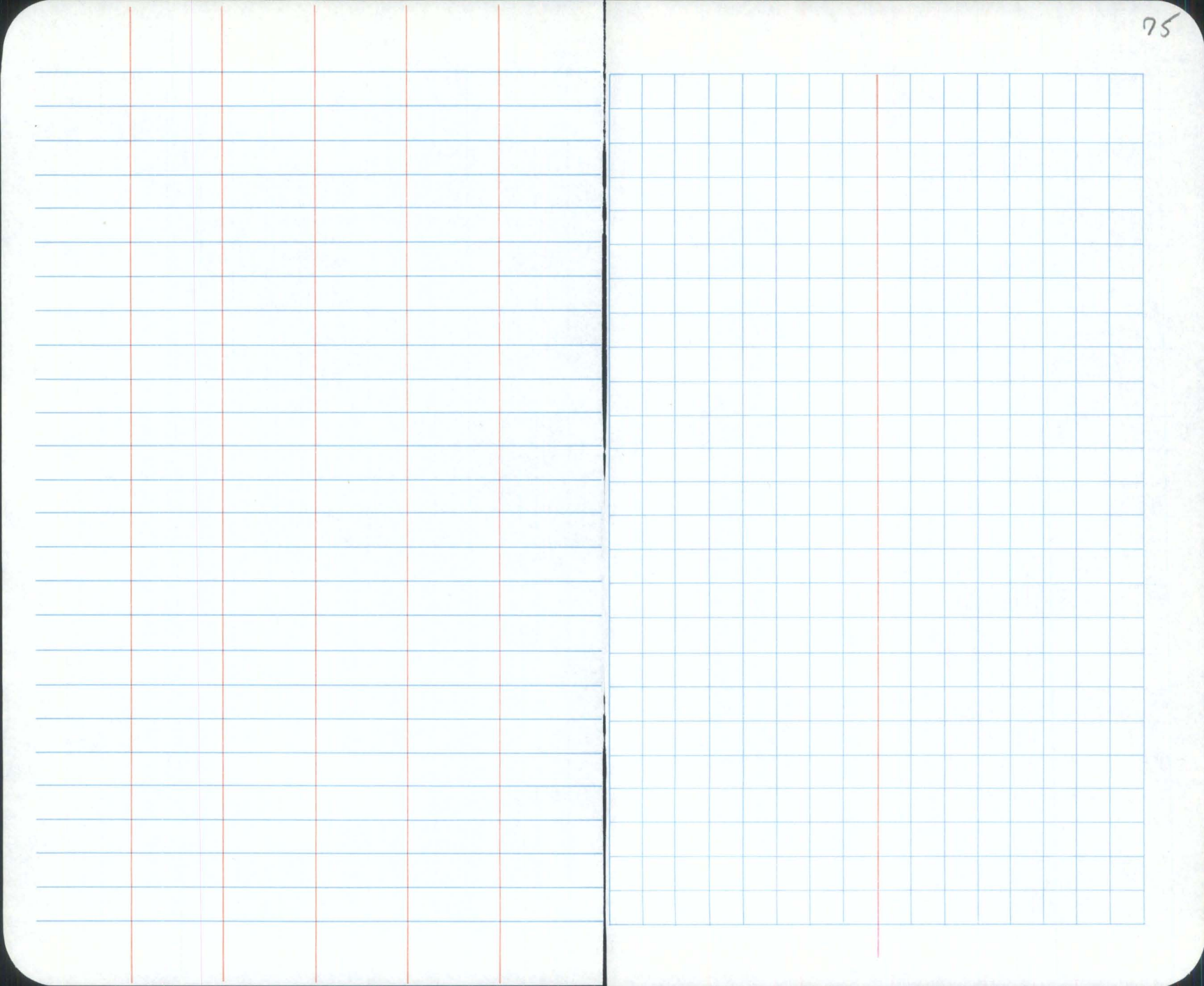


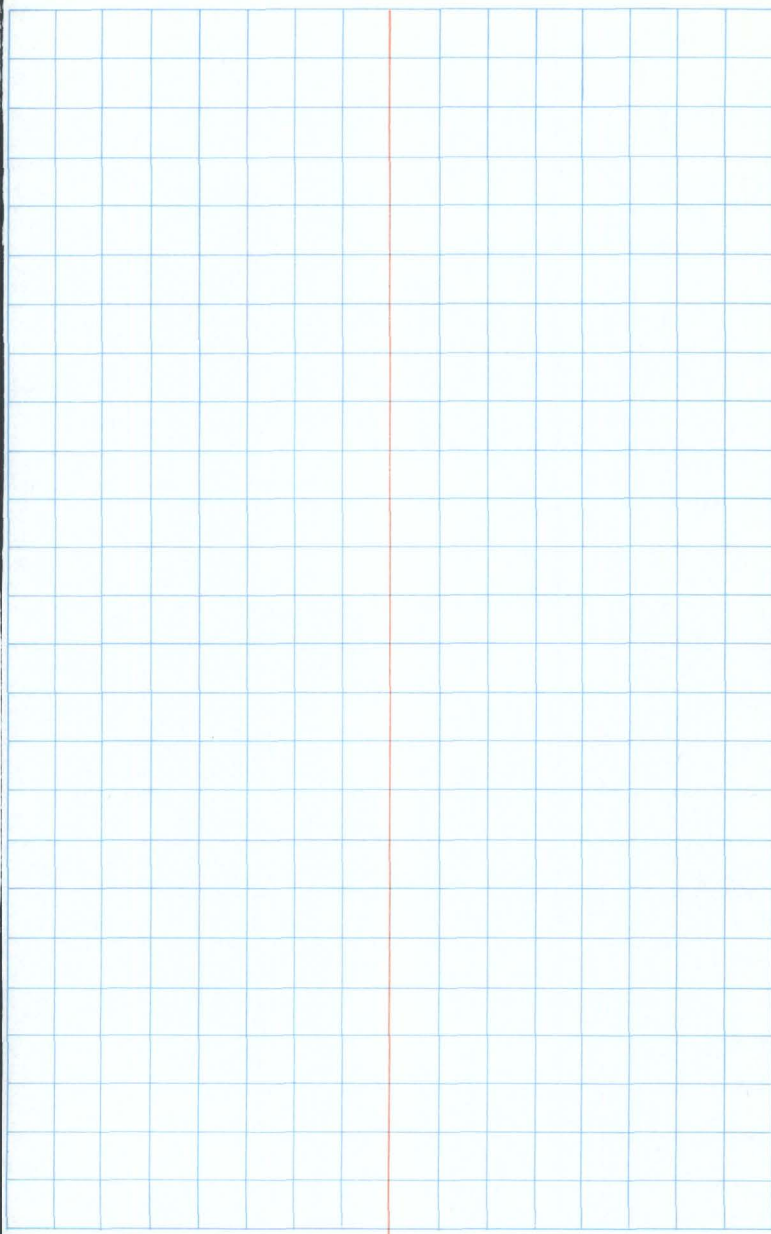
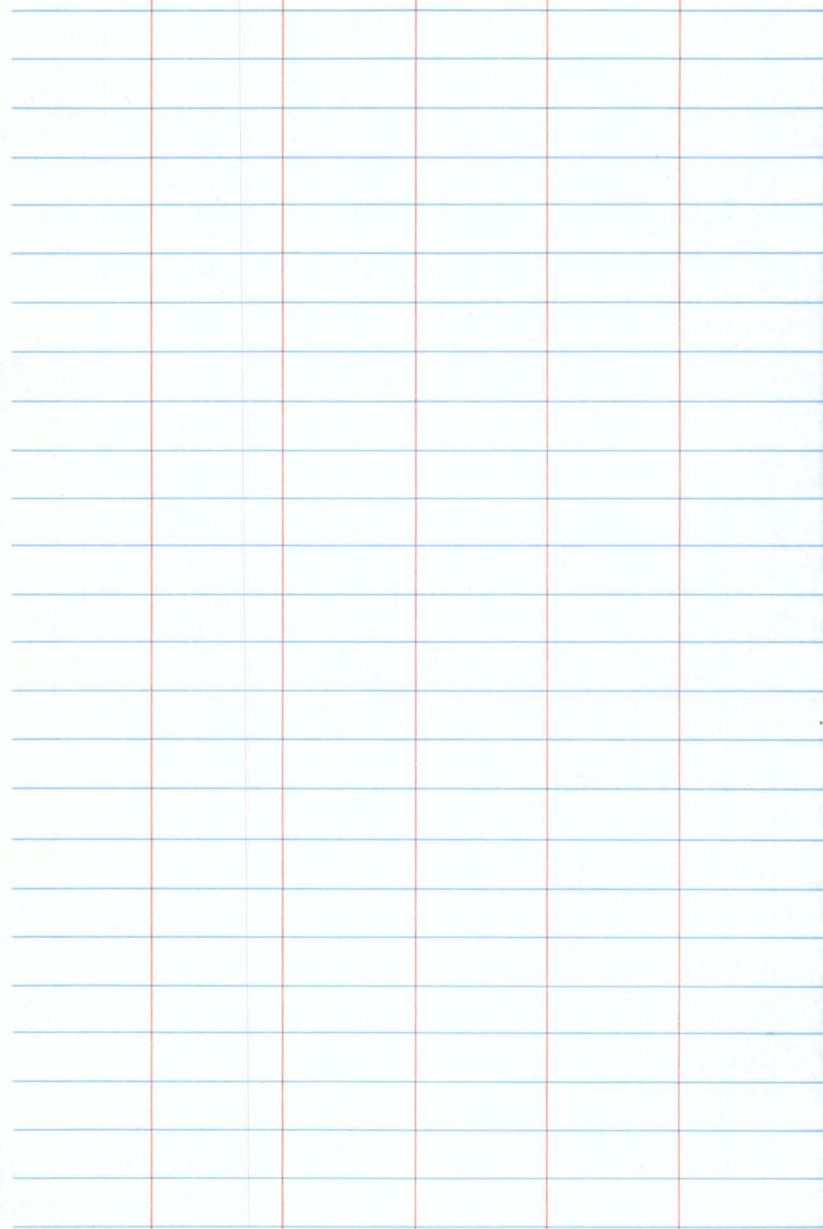


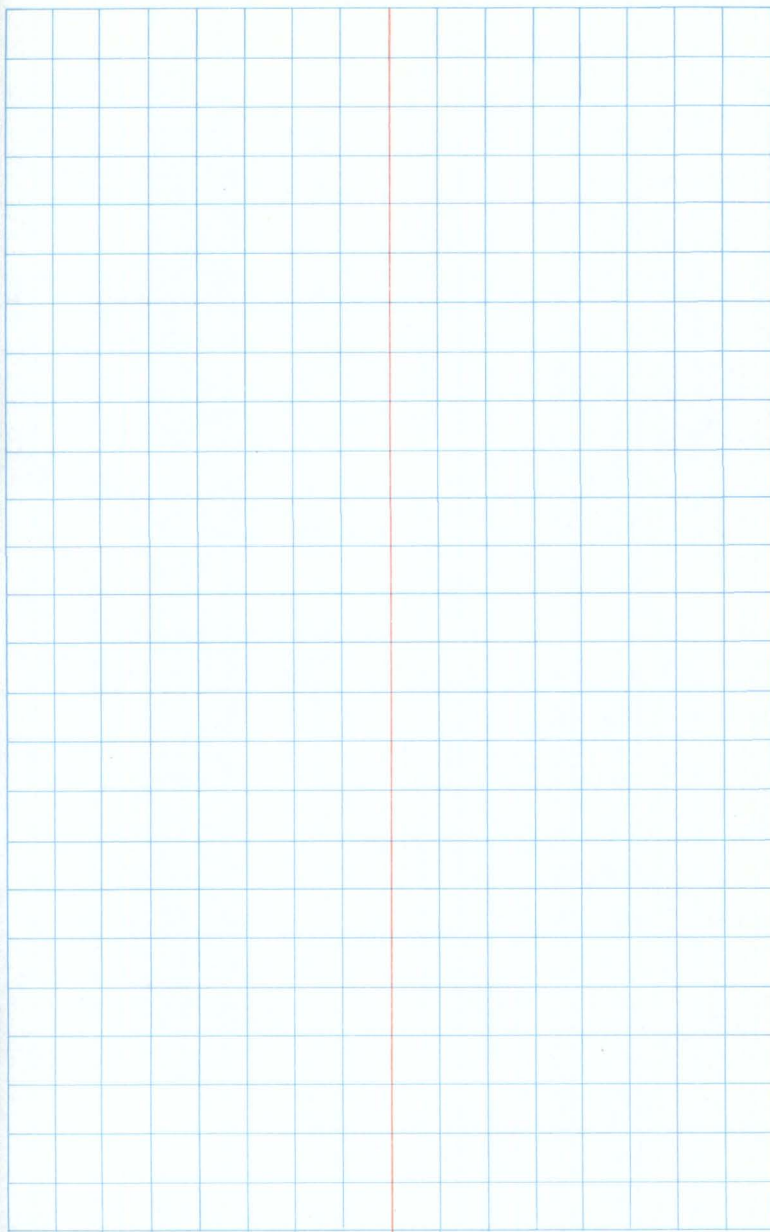
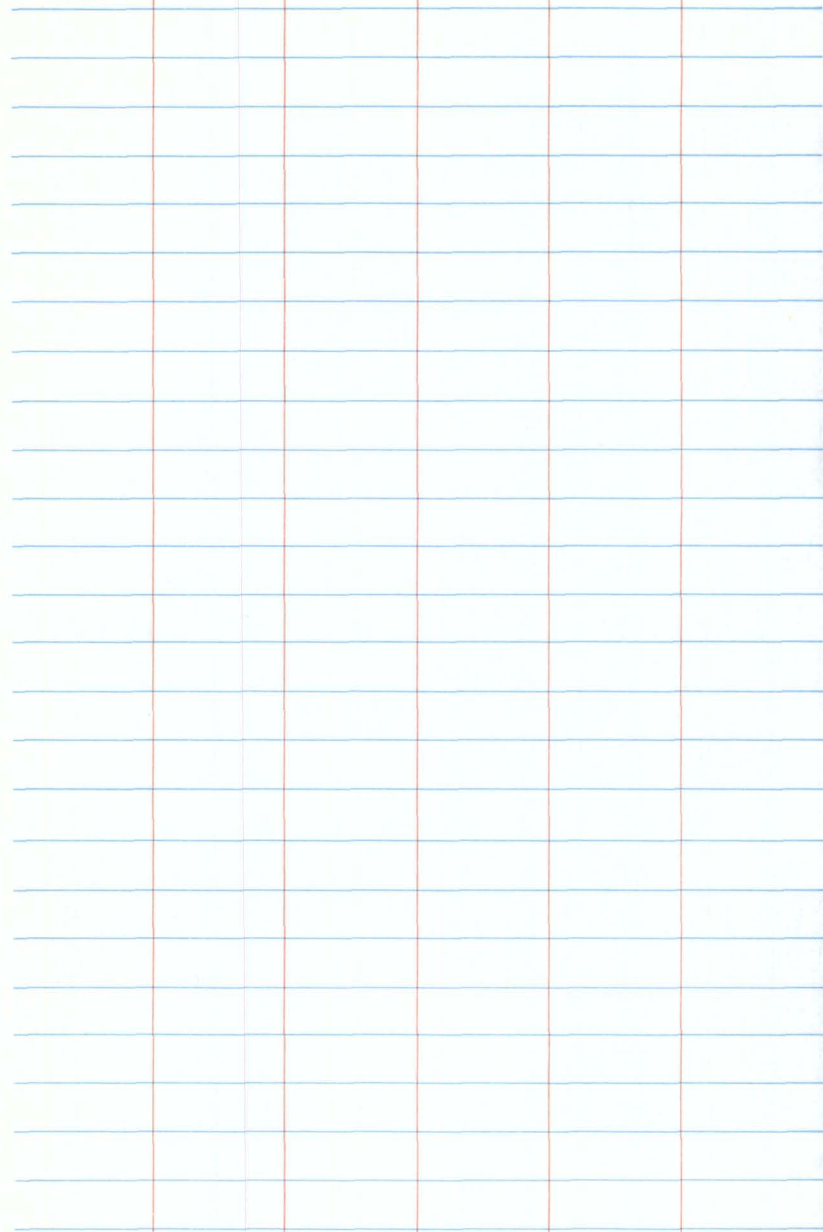


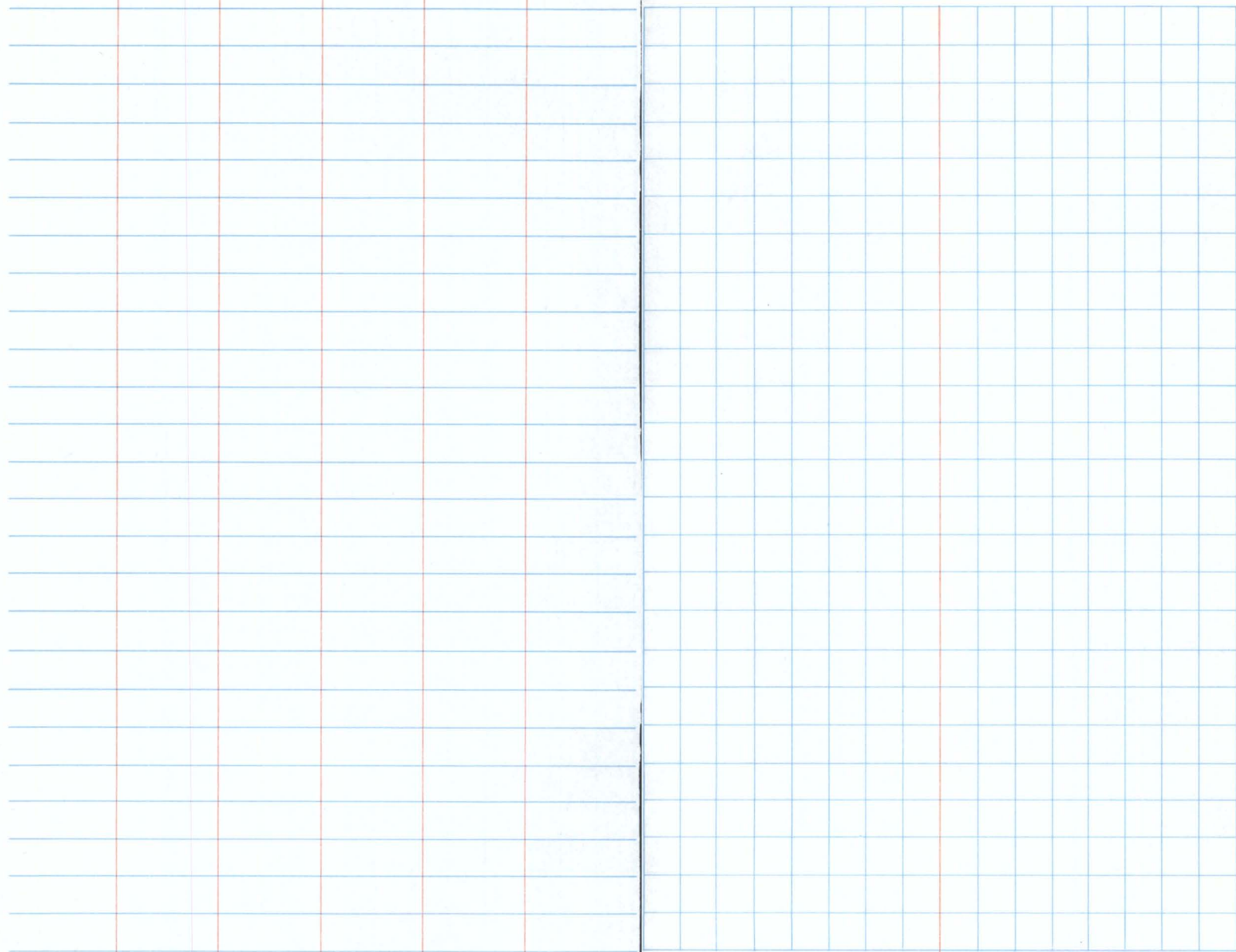












CURVE TABLES

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 ÷ 12 = 10.07. Say a 10° Curve.

Tan. in Tab. I opp. 23° 20' = 1183.1
1183.1 ÷ 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° ÷ 10 = 2.3333 = L. C.

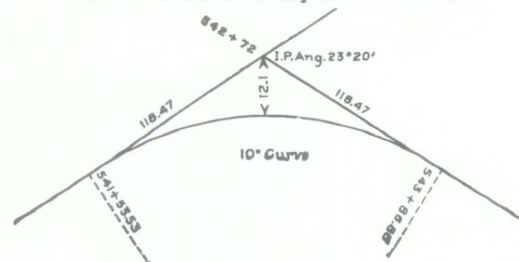
2° 19½' = def. for sta.	542	I. P. = sta.	542 + 72
4° 49½' = " " "	+50	Tan. =	118.47
7° 19½' = " " "	543	B. C. = sta.	541 + 53.53
9° 49½' = " " "	+50	L. C. =	233.33
11° 40' = " " "	543 +	E. C. = Sta.	543 + 86.86
	86.86		

100 - 53.53 = 46.47 × 3' (def. for 1 ft. of 10° Cur.) = 139.41' =

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.



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	7.86	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 E=.000	.03 .000	.05 .001	.06 .001	.08 .002	.10 .002	.11 .002	.13 .003	.15 .003	.16 .004	.18 .004	.20 .005	.21 .005	.23 .005
10°	T=.03 E=.001	.06 .003	.09 .004	.13 .006	.16 .007	.19 .008	.22 .009	.25 .011	.28 .012	.31 .014	.34 .015	.38 .017	.42 .018	.46 .020
15°	T=.04 E=.003	.10 .007	.14 .010	.19 .014	.24 .018	.29 .023	.34 .027	.39 .032	.45 .035	.51 .039	.55 .043	.58 .047	.63 .051	.68 .055
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	.41 .045	.49 .054	.58 .063	.67 .072	.75 .081	.83 .090	.91 .099	.99 .108	1.06 .117	1.14 .126

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'	1121.4	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 .040	.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 .045	.49 .054	.58 .063	.67 .072	.75 .081	.83 .090	.90 .099	.99 .108	1.06 .117	1.14 .126
30°	T=.10 E=.013	.19 .025	.29 .038	.39 .051	.49 .065	.59 .078	.69 .090	.79 .103	.89 .116	.99 .129	1.09 .142	1.20 .155	1.29 .168	1.39 .181
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 .219	1.42 .240	1.54 .261	1.66 .283
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 .296	1.64 .327	1.79 .358	1.94 .389
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 .361	1.87 .398	2.04 .435	2.21 .472

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	.28	.40	.53	.67	.80	.93	1.06	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 = .040	.093	.142	.188	.236	.283	.332	.381	.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

Tangents and Externals 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	3888.9	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	.150	.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	.266	.353	.440	.528	.617	.707	.797	.887	.977	1.07	1.18	1.29
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	1.68	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

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 E = .128	.66 .259	1.00 .391	1.33 .524	1.68 .657	2.02 .790	2.36 .926	2.70 1.06	3.05 1.20	3.40 1.34	3.77 1.47	4.14 1.62	4.55 1.76	4.89 1.91
90°	T = .36 E = .149	.72 .299	1.09 .450	1.45 .603	1.83 .756	2.20 .910	2.57 1.07	2.94 1.22	3.32 1.38	3.70 1.54	4.10 1.70	4.50 1.87	4.91 2.03	5.32 2.20
95°	T = .39 E = .174	.79 .350	1.19 .522	1.55 .706	2.00 .985	2.40 1.06	2.80 1.25	3.20 1.43	3.61 1.62	4.02 1.80	4.49 1.99	4.98 2.18	5.38 2.38	5.83 2.58
100°	T = .43 E = .200	.86 .401	1.30 .604	1.74 .809	2.18 1.01	2.62 1.22	3.06 1.43	3.50 1.64	3.95 1.85	4.40 2.06	4.88 2.28	5.37 2.50	5.85 2.73	6.34 2.96
105°	T = .46 E = .230	.94 .470	1.42 .700	1.90 .938	2.38 1.17	2.86 1.36	3.34 1.57	3.82 1.78	4.30 2.00	4.78 2.21	5.26 2.42	5.75 2.63	6.23 2.84	6.73 3.06
110°	T = .50 E = .260	1.03 .535	1.55 .808	2.08 1.08	2.60 1.36	3.14 1.63	3.66 1.91	4.21 2.19	4.76 2.49	5.31 2.81	5.86 3.05	6.43 3.35	7.01 3.65	7.50 3.95
115°	T = .54 E = .307	1.13 .624	1.70 .939	2.29 1.28	2.88 1.57	3.45 1.89	4.03 2.21	4.63 2.54	5.23 2.87	5.83 3.20	6.44 3.53	7.07 3.88	7.70 4.23	8.35 4.58
120°	T = .61 E = .339	1.25 .720	1.89 1.09	2.52 1.45	3.16 1.82	3.81 2.20	4.44 2.56	5.11 2.95	5.78 3.33	6.44 3.72	7.11 4.10	7.80 4.50	8.51 4.91	9.21 5.32

Tangents and Externals 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	7649.7	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	5672.2
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 E = .200	.86 .401	1.30 .604	1.74 .809	2.18 1.01	2.62 1.22	3.06 1.43	3.50 1.64	3.95 1.85	4.40 2.06	4.88 2.28	5.37 2.50	5.85 2.73	6.34 2.96
105°	T = .46 E = .230	.94 .470	1.42 .700	1.90 .938	2.38 1.17	2.86 1.36	3.34 1.57	3.82 1.78	4.30 2.00	4.78 2.21	5.26 2.42	5.75 2.63	6.23 2.84	6.73 3.06
110°	T = .50 E = .260	1.03 .535	1.55 .808	2.08 1.08	2.60 1.36	3.14 1.63	3.66 1.91	4.21 2.19	4.76 2.49	5.31 2.81	5.86 3.05	6.43 3.35	7.01 3.65	7.50 3.95
115°	T = .54 E = .307	1.13 .624	1.70 .939	2.29 1.28	2.88 1.57	3.45 1.89	4.03 2.21	4.63 2.54	5.23 2.87	5.83 3.20	6.44 3.53	7.07 3.88	7.70 4.23	8.35 4.58
120°	T = .61 E = .339	1.25 .720	1.89 1.09	2.52 1.45	3.16 1.82	3.81 2.20	4.44 2.56	5.11 2.95	5.78 3.33	6.44 3.72	7.11 4.10	7.80 4.50	8.51 4.91	9.21 5.32

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	11159.	.109	.436	.873	0.15	30	764.5	1.637	6.590	13.08	2.20
40	859.4	.145	.582	1.164	0.20	40	747.9	1.673	6.685	13.37	2.30
50	687.5	.182	.727	1.454	0.25	8	716.8	1.746	6.975	13.95	2.40
1	572.0	.218	.873	1.745	0.30	8	688.2	1.819	7.266	14.53	2.50
10	491.1	.255	1.018	2.036	0.35	30	674.8	1.887	7.547	14.82	2.50
20	429.7	.291	1.164	2.327	0.40	40	661.7	1.952	7.836	15.11	2.60
30	381.9	.327	1.309	2.618	0.45	9	637.3	1.965	7.846	15.69	2.70
40	343.7	.364	1.454	2.909	0.50	20	614.6	2.037	8.136	16.27	2.80
50	312.5	.400	1.600	3.200	0.55	30	603.8	2.074	8.281	16.56	2.85
2	286.9	.436	1.745	3.490	0.60	40	593.4	2.110	8.426	16.85	2.90
10	264.6	.473	1.891	3.781	0.65	10	573.7	2.183	8.716	17.43	3.00
20	245.7	.509	2.036	4.072	0.70	30	546.4	2.292	9.150	18.30	3.15
30	229.0	.545	2.181	4.363	0.75	11	521.7	2.402	9.585	19.16	3.30
40	214.8	.582	2.327	4.654	0.80	30	499.1	2.511	10.02	20.04	3.45
50	202.2	.618	2.472	4.945	0.85	12	478.3	2.620	10.45	20.91	3.60
1	191.0	.655	2.618	5.235	0.90	13	459.3	2.730	10.89	21.77	3.75
10	180.9	.691	2.763	5.526	0.95	40	441.7	2.839	11.32	22.64	3.90
20	171.9	.727	2.908	5.817	1.00	30	425.4	2.949	11.75	23.51	4.05
30	163.7	.764	3.053	6.108	1.05	14	410.3	3.058	12.13	24.37	4.20
40	156.2	.800	3.199	6.398	1.10	30	396.3	3.168	12.62	25.24	4.35
50	149.5	.836	3.345	6.689	1.15	15	383.1	3.277	13.05	26.11	4.50
4	133.7	.873	3.490	6.980	1.20	30	370.8	3.387	13.49	26.97	4.65
10	137.5	.909	3.635	7.271	1.25	16	359.3	3.496	13.92	27.84	4.80
20	132.2	.945	3.718	7.561	1.30	30	348.5	3.606	14.35	28.70	4.95
30	127.6	.982	3.926	7.852	1.35	17	338.3	3.716	14.78	29.56	5.10
40	122.8	1.018	4.071	8.143	1.40	18	319.6	3.935	15.64	31.29	5.40
50	118.5	1.055	4.217	8.433	1.45	19	302.9	4.155	16.51	33.01	5.70
5	114.6	1.091	4.362	8.724	1.50	20	287.9	4.374	17.37	34.73	6.00
10	110.7	1.127	4.507	9.014	1.55	21	274.4	4.594	18.22	36.44	6.30
20	107.4	1.165	4.653	9.313	1.60	22	262.0	4.814	19.08	38.16	6.60
30	104.2	1.200	4.798	9.606	1.65	23	250.8	5.035	19.94	39.87	6.90
40	101.5	1.237	4.943	9.896	1.70	24	240.5	5.255	20.78	41.57	7.20
50											

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

Degree of Curve	Radius 50	$\frac{1}{2}$ sub chord = $\sin$ of $\frac{1}{2}$ def. angle R				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

$T = R \tan \frac{1}{2} I$	$R = T \cot. \frac{1}{2} I$	Chord def. = $\frac{\text{chord}^2}{R}$
$T = \frac{50 \tan \frac{1}{2} I}{\sin. \frac{1}{2} D}$	$R = \frac{50}{\sin. \frac{1}{2} D}$	No. chords = $\frac{I}{D}$
$\sin. \frac{1}{2} D = \frac{50}{R}$	$E = R \text{ ex. sec } \frac{1}{2} I$	Tan. def. = $\frac{1}{2} \text{ chord def.}$
$\sin. \frac{1}{2} D = \frac{50 \tan \frac{1}{2} I}{T}$	$E = T \tan \frac{1}{4} I$	

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

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, $\frac{1}{2}d^2$. 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 Σd^2 = the sum of the squares of these differences and n = the number of observations, then the probable error of the mean = $\pm 0.6745 \sqrt{\frac{\Sigma d^2}{n(n-1)}}$

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

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	0	1.	∞	∞	1.	0	0	0	1.	∞	∞	1.
10	.0029	.0029		343.8	343.8	1.	10	.1421	.1435	1.0102	7.040	6.968	.98986
20	.0058	.0058		171.9	171.9	.99998	20	.2840	.2899	1.0412	3.592	3.450	.96046
30	.0087	.0087		114.6	114.6	.99996	30	.4258	.4467	1.0961	2.443	2.229	.91236
40	.0116	.0116	1.0001	85.94	85.94	.99993	40	.5675	.6080	1.1724	1.713	1.511	.85718
50	.0145	.0145	1.0001	68.76	68.75	.99989	50	.7092	.7771	1.3412	1.103	1.000	.70711
1	.0175	.0175	1.0002	57.30	57.29	.99985	60	.8509	.9514	1.5557	.831	.831	.50000
2	.0204	.0204	1.0002	49.11	49.10	.99979	70	.9801	1.1071	1.8197	.600	.600	.26181
3	.0233	.0233	1.0003	42.98	42.96	.99973	80	1.1071	1.3050	2.2361	.433	.433	.07175
4	.0262	.0262	1.0003	38.20	38.19	.99966	90	1.2361	1.5557	3.4641	.262	.262	.00000
5	.0291	.0291	1.0004	34.38	34.37	.99958							
6	.0320	.0320	1.0005	31.26	31.24	.99949							
7	.0349	.0349	1.0006	28.65	28.64	.99939							
8	.0378	.0378	1.0007	26.45	26.43	.99929							
9	.0407	.0407	1.0008	24.56	24.54	.99917							
10	.0436	.0436	1.0010	22.93	22.90	.99905							
11	.0465	.0466	1.0011	21.49	21.47	.99892							
12	.0494	.0495	1.0012	20.23	20.21	.99878							
13	.0523	.0524	1.0014	19.11	19.08	.99863							
14	.0552	.0553	1.0015	18.10	18.07	.99847							
15	.0581	.0582	1.0017	17.20	17.17	.99831							
16	.0610	.0612	1.0019	16.38	16.35	.99813							
17	.0640	.0641	1.0020	15.64	15.60	.99795							
18	.0669	.0670	1.0022	14.96	14.92	.99776							
19	.0698	.0699	1.0024	14.34	14.30	.99756							
20	.0727	.0729	1.0027	13.76	13.73	.99736							
21	.0756	.0758	1.0029	13.23	13.20	.99714							
22	.0785	.0787	1.0031	12.75	12.71	.99692							
23	.0814	.0816	1.0033	12.29	12.25	.99668							
24	.0843	.0846	1.0036	11.87	11.83	.99644							
25	.0872	.0875	1.0038	11.47	11.43	.99619							
26	.0901	.0904	1.0041	11.10	11.06	.99594							
27	.0929	.0934	1.0043	10.76	10.71	.99567							
28	.0958	.0963	1.0046	10.43	10.39	.99540							
29	.0987	.0992	1.0049	10.13	10.08	.99511							
30	.1016	.1022	1.0052	9.839	9.788	.99482							
31	.1045	.1051	1.0055	9.567	9.514	.99452							
32	.1074	.1080	1.0058	9.309	9.255	.99421							
33	.1103	.1110	1.0061	9.065	9.010	.99390							
34	.1132	.1139	1.0065	8.834	8.777	.99357							
35	.1161	.1169	1.0068	8.614	8.556	.99324							
36	.1190	.1198	1.0072	8.405	8.345	.99290							
37	.1219	.1228	1.0075	8.206	8.144	.99255							
38	.1248	.1257	1.0079	8.016	7.953	.99219							
39	.1276	.1287	1.0082	7.834	7.770	.99182							
40	.1305	.1317	1.0086	7.661	7.596	.99144							
41	.1334	.1346	1.0090	7.496	7.429	.99106							
42	.1363	.1376	1.0094	7.337	7.269	.99067							

Natural Trigonometrical Functions

Angle.	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.	Angle.	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.
16	.2756	.2867	1.0403	3.623	3.487	.96126	74	.4067	.4452	1.0946	2.459	2.246	.91355
17	.2784	.2899	1.0412	3.592	3.450	.96046	80	.4094	.4487	1.0961	2.443	2.229	.91236
18	.2812	.2931	1.0423	3.556	3.412	.95964	90	.4120	.4522	1.0975	2.427	2.211	.91116
19	.2840	.2962	1.0429	3.521	3.376	.95882	30	.4147	.4557	1.0989	2.411	2.194	.90996
20	.2868	.2994	1.0438	3.487	3.340	.95799	40	.4173	.4592	1.1004	2.396	2.177	.90875
21	.2896	.3026	1.0448	3.453	3.305	.95715	50	.4200	.4628	1.1019	2.381	2.161	.90753
22	.2924	.3057	1.0457	3.420	3.271	.95630	60	.4226	.4663	1.1034	2.366	2.145	.90631
23	.2952	.3089	1.0466	3.388	3.237	.95545	70	.4253	.4699	1.1049	2.351	2.128	.90507
24	.2979	.3121	1.0476	3.357	3.204	.95459	80	.4279	.4734	1.1064	2.337	2.112	.90383
25	.3007	.3153	1.0485	3.326	3.172	.95372	90	.4305	.4770	1.1079	2.323	2.097	.90259
26	.3035	.3185	1.0495	3.295	3.140	.95284	30	.4331	.4806	1.1095	2.309	2.081	.90133
27	.3062	.3217	1.0505	3.265	3.108	.95195	40	.4358	.4841	1.1110	2.295	2.066	.90007
28	.3090	.3249	1.0515	3.236	3.078	.95106	50	.4384	.4877	1.1126	2.281	2.050	.89879
29	.3118	.3281	1.0525	3.207	3.048	.95015	60	.4410	.4913	1.1142	2.268	2.035	.89752
30	.3145	.3314	1.0535	3.179	3.018	.94924	70	.4436	.4950	1.1158	2.254	2.020	.89623
31	.3173	.3346	1.0545	3.152	2.989	.94832	80	.4462	.4986	1.1174	2.241	2.006	.89493
32	.3201	.3378	1.0555	3.124	2.960	.94740	90	.4488	.5022	1.1190	2.228	1.991	.89363
33	.3228	.3411	1.0566	3.098	2.932	.94646	10	.4514	.5059	1.1207	2.215	1.977	.89232
34	.3256	.3443	1.0576	3.072	2.904	.94552	20	.4540	.5095	1.1223	2.203	1.963	.89101
35	.3283	.3476	1.0587	3.046	2.877	.94457	30	.4566	.5132	1.1240	2.190	1.949	.88968
36	.3311	.3508	1.0598	3.020	2.850	.94361	40	.4592	.5169	1.1257	2.178	1.935	.88835
37	.3338	.3541	1.0608	2.996	2.824	.94264	50	.4617	.5206	1.1274	2.166	1.921	.88701
38	.3365	.3574	1.0619	2.971	2.798	.94167	60	.4643	.5243	1.1291	2.154	1.907	.88566
39	.3393	.3607	1.0631	2.947	2.773	.94068	70	.4669	.5280	1.1308	2.142	1.894	.88431
40	.3420	.3640	1.0642	2.924	2.747	.93969	80	.4695	.5317	1.1326	2.130	1.881	.88295
41	.3448	.3673	1.0653	2.900	2.723	.93869	90	.4720	.5354	1.1343	2.119	1.868	.88158
42	.3475	.3706	1.0665	2.878	2.699	.93769	10	.4746	.5392	1.1361	2.107	1.855	.88020
43	.3502	.3739	1.0676	2.856	2.675	.93667	20	.4772	.5430	1.1379	2.096	1.842	.87882
44	.3529	.3772	1.0688	2.833	2.651	.93565	30	.4797	.5467	1.1397	2.085	1.829	.87743
45	.3557	.3805	1.0700	2.811	2.628	.93462	40	.4823	.5505	1.1415	2.073	1.816	.87603
46	.3584	.3839	1.0711	2.790	2.605	.93358	50	.4848	.5543	1.1434	2.063	1.804	.87462
47	.3611	.3872	1.0723	2.769	2.583	.93253	60	.4874	.5581	1.1452	2.052	1.792	.87321
48	.3638	.3906	1.0736	2.749	2.560	.93148	70	.4899	.5619	1.1471	2.041	1.780	.87178
49	.3665	.3939	1.0748	2.729	2.539	.93042	80	.4924	.5658	1.1490	2.031	1.767	.87036
50	.3692	.3973	1.0760	2.709	2.517	.92935	90	.4950	.5696	1.1509	2.020	1.756	.86892
51	.3719	.4006	1.0773	2.689	2.496	.92827	10	.4975	.5735	1.1528	2.010	1.744	.86748
52	.3746	.4040	1.0785	2.670	2.475	.92718	20	.5000	.5774	1.1547	2.000	1.732	.86603
53	.3773	.4074	1.0798	2.650	2.455	.92609	30	.5025	.5812	1.1566	1.990	1.720	.86457
54	.3800	.4108	1.0811	2.632	2.434	.92499	40	.5050	.5851	1.1586	1.980	1.709	.86310
55	.3827	.4142	1.0824	2.613	2.414	.92388	50	.5075	.5890	1.1606	1.970	1.698	.86163
56	.3854	.4176	1.0837	2.595	2.394	.92276	60	.5100	.5930	1.1626	1.961	1.686	.86015
57	.3881	.4210	1.0850	2.577	2.375	.92164	70	.5125	.5969	1.1646	1.951	1.675	.85866
58	.3907	.4245	1.0864	2.559	2.356	.92050	80	.5150	.6009	1.1666	1.942	1.664	.85717
59	.3934	.4279	1.0877	2.542	2.337	.91936	90	.5175	.6048	1.1687	1.932	1.653	.85567
60	.3961	.4314	1.0891	2.525	2.318	.91822	10	.5200	.6088	1.1707	1.923	1.643	.85416
61	.3988	.4348	1.0904	2.508	2.300	.91706	20	.5225	.6128	1.1728	1.914	1.632	.85264
62	.4014	.4383	1.0918	2.491	2.282	.91590	30	.5250	.6168	1.1749	1.905	1.621	.85112
63	.4041	.4417	1.0932	2.475	2.264	.91472	40	.5275	.6208	1.1770	1.896	1.611	.84959

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

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

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 1.2969 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	
20 .6202 .7907 1.2748 1.612 1.265 .78442	
30 .6225 .7954 1.2778 1.606 1.257 .78261	
40 .6248 .8002 1.2808 1.601 1.250 .78079	
50 .6271 .8050 1.2838 1.595 1.242 .77897	

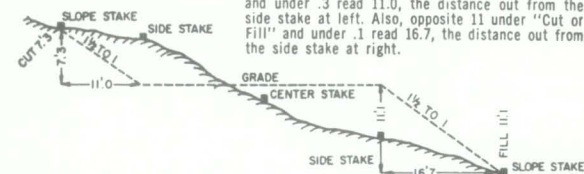
Cosin. Cotg. Cosec. Sec. Tan. Sin. Angle

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

DISTANCES FROM SIDE STAKES FOR CROSS-SECTIONING

Roadway of any Width. Side Slopes 1½ 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	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	Cut or Fill
Distance out from Side or Shoulder Stake											
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

USEFUL RELATIONS

Lineal feet	×.00019	= miles
Lineal yards	×.0006	= miles
Square inches	×.007	= square feet
Square feet	×.111	= square yards
Square yards	×.0002067	= acres
Acres	×4840	= square yards
Cubic inches	×.00058	= cubic feet
Cubic feet	×.03704	= cubic yards
Links	×.22	= yards
Links	×.66	= feet
Feet	×1.5	= links
360° = 21600' = 1296000"		
Radius = arc of 57.2957790"		
Arc of 1° (radius = 1) = .017453292		
Arc of 1' (radius = 1) = .000290888		
Arc of 1" (radius = 1) = .000004848		

Curvature of Earth's surface = about 0.7 feet in 1 mile

Curvature in feet = 0.667 (Dist. in miles)³

Difference between arc and chord length, 0.05 feet in 11½ miles

Probable error of a single observation = $0.6754 \sqrt{\frac{M}{n-1}}$

Error in chaining of 0.01 feet in 100 feet:

Due to—

1. Length of tape error of 0.01 feet
2. Alignment. One end 1.4 feet out of line
3. Sag of tape at center of 0.61 feet.
4. Temperature difference of 15°
5. Difference of pull of 15 lbs.

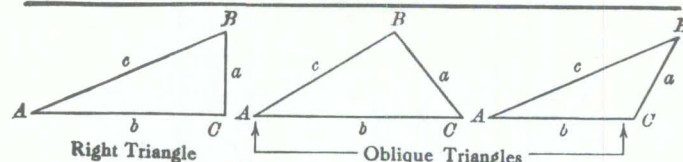
SQUARE MEASURE

144 sq. inches	= 1 sq. ft.
9 sq. ft.	= 1 sq. yard
30¼ sq. yds.	= 1 sq. rd.
40 sq. rds.	= 1 rood.
4 roods	= 1 acre
640 acres	= 1 sq. mile.

SURVEYORS' MEASURE

7.92 inches	= 1 link.
25 links	= 1 rod.
4 rds.	= 1 chain.
10 sq. chains or 160 sq. rods	= 1 acre.
640 acres	= 1 sq. mile.
36 sq. miles (6 miles sq.)	= 1 township.

TRIGONOMETRIC FORMULÆ



Solution of Right Triangles

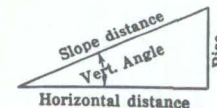
For Angle A. $\sin = \frac{a}{c}$, $\cos = \frac{b}{c}$, $\tan = \frac{a}{b}$, $\cot = \frac{b}{a}$, $\sec = \frac{c}{a}$, $\csc = \frac{c}{b}$

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

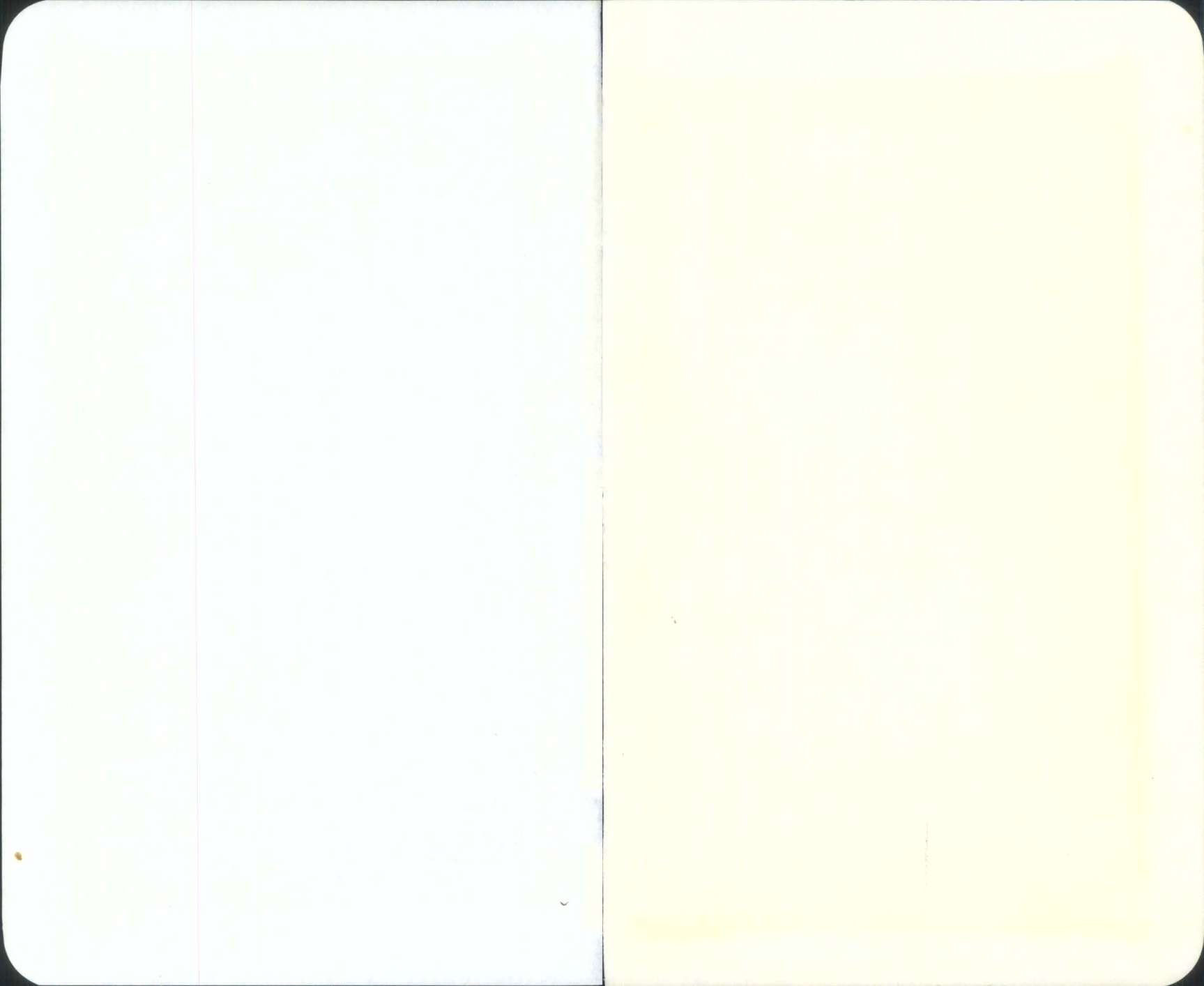
Given	Required	
A, B, a	b, c, C	$b = \frac{a \sin B}{\sin A}$, $C = 180^\circ - (A + B)$, $c = \frac{a \sin C}{\sin A}$
A, a, b	B, c, C	$\sin B = \frac{b \sin A}{a}$, $C = 180^\circ - (A + B)$, $c = \frac{a \sin C}{\sin A}$
a, b, C	A, B, c	$A + B = 180^\circ - C$, $\tan \frac{1}{2}(A - B) = \frac{(a - b) \tan \frac{1}{2}(A + B)}{a + b}$, $c = \frac{a \sin C}{\sin A}$
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°10'. From the table, $\cos 5^\circ 10' = .9959$. Horizontal distance = 319.4 × .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.



January 1981

T-108A

OFFICE OF MATERIALS - INSTRUCTIONAL MEMORANDUM

TEMPERATURE---VOLUME

CORRECTIONS FOR DILUTED EMULSIFIED ASPHALT

Applies only for 1 to 1 dilution

LEGEND: t = observed temperature in degrees Fahrenheit
m = multiplier for correcting volumes to the basis of 60°F

t	M	t	M	t	M
60	1.00000	90	.99422	121	.98700
61	.99982	91	.99400	122	.98675
62	.99964	92	.99378	123	.98650
63	.99948	93	.99356	124	.98625
64	.99930	94	.99334	125	.98600
65	.99912	95	.99312	126	.98575
66	.99894	96	.99290	127	.98550
67	.99877	97	.99268	128	.98524
68	.99858	98	.99245	129	.98498
69	.99840	99	.99222	130	.98473
70	.99822	100	.99200	131	.98447
71	.99802	101	.99177	132	.98420
72	.99783	102	.99154	133	.98394
73	.99764	103	.99131	134	.98368
74	.99744	104	.99108	135	.98341
75	.99725	105	.99085	136	.98314
76	.99706	106	.99062	137	.98288
77	.99686	107	.99039	138	.98262
78	.99666	108	.99016	139	.98235
79	.99647	109	.98992	140	.98208
80	.99628	110	.98969	141	.98182
81	.99608	111	.98945	142	.98154
82	.99587	112	.98921	143	.98126
83	.99566	113	.98896	144	.98099
84	.99546	114	.98872	145	.98072
85	.99526	115	.98848	146	.98044
86	.99505	116	.98823	147	.98016
87	.99484	117	.98798	148	.97989
88	.99464	118	.98774	149	.97962
89	.99942	119	.98750	150	.97934
		120	.98725		