

# EngrD 2190 – Lecture 27A

Concept: Graphical Models for Mass Balances

Context: Operating Lines for Distillation, cont'd.  
The McCabe-Thiele Method.

Defining Question: How to graphically model unconventional multi-stage distillation?

Read Chapter 5 pp. 423-431.  
Dimensional Analysis & Dynamic Scaling

# Homework

- Homework 7 due today at noon.

Write team code and names of all *contributing* team members on all solutions. Indicate this week's Team Coordinator.

Submit *after* lecture or deliver to the EngrD 2190 mailbox in a cabinet in the hallway outside 116 Olin Hall (ChemE Business Office). **Not to my mailbox.**

- Homework 8 due Friday 11/14.

**4.67 & 4.68** analysis of distillation columns.

**4.108** design with distillation columns.

**4.103** design with ternary diagrams.

Download blank graphs and phase data from EngrD 2190 homepage:

Textbook → Textbook Graphs and Figures →

Graphs for Chapter 4 Exercises.

*Homework is your chief means of assessing your command of the material.*

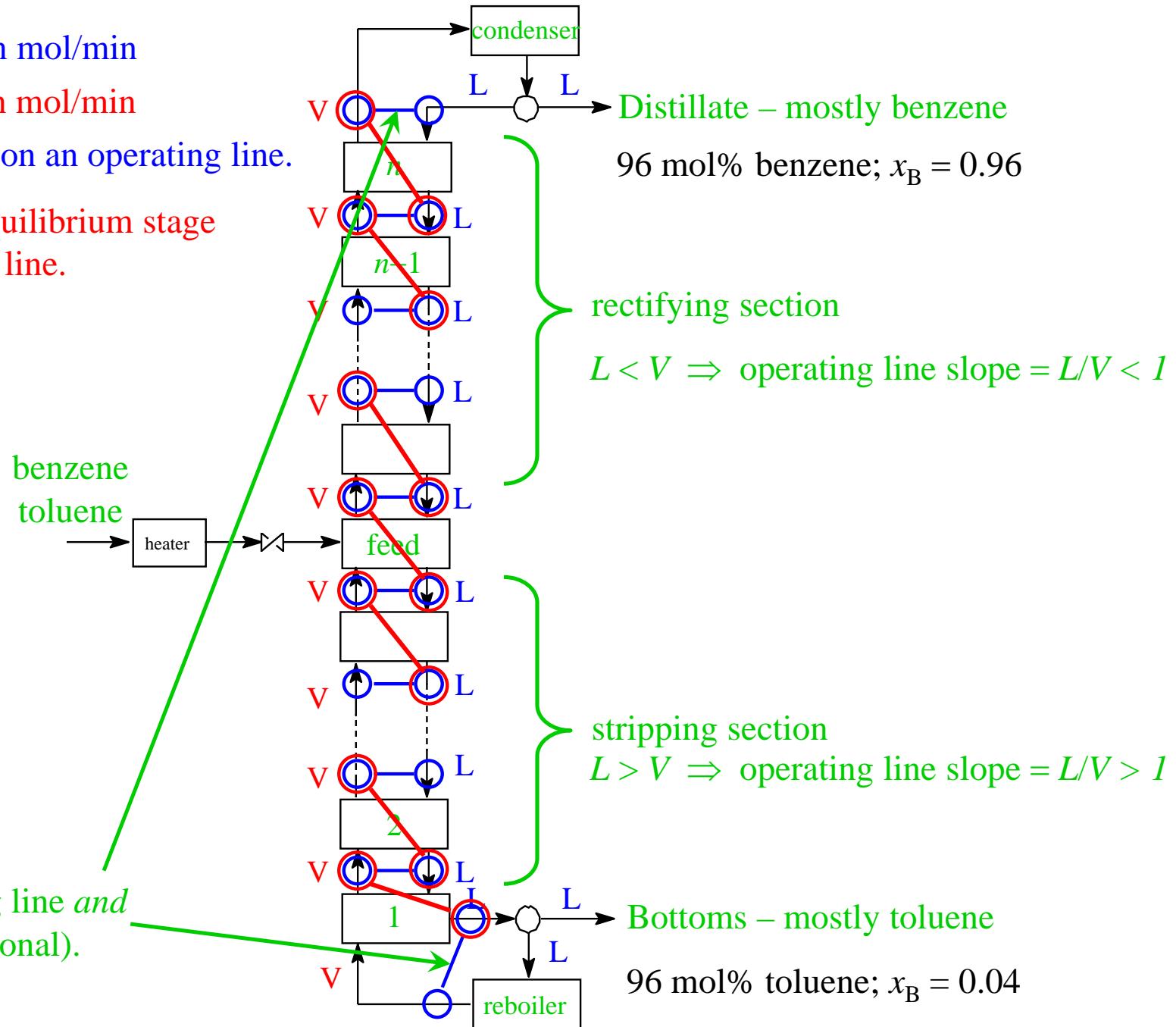
# A Distillation Column

$L$  ≡ liquid flow rate, in mol/min

$V$  ≡ vapor flow rate, in mol/min

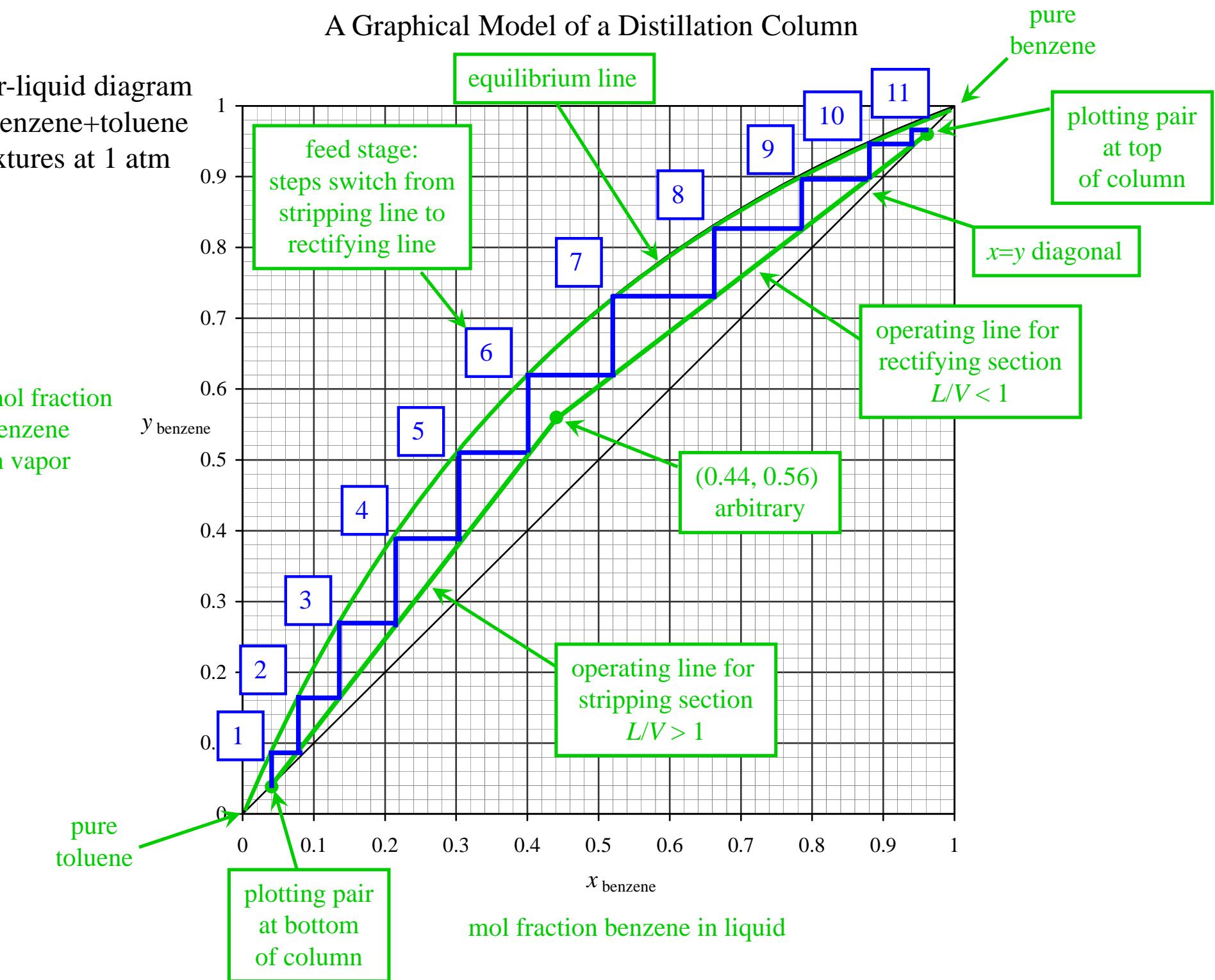
Adjacent  $x$ - $y$  pairs are on an operating line.

*x-y* pairs leaving an equilibrium stage are on the equilibrium line.



## A Graphical Model of a Distillation Column

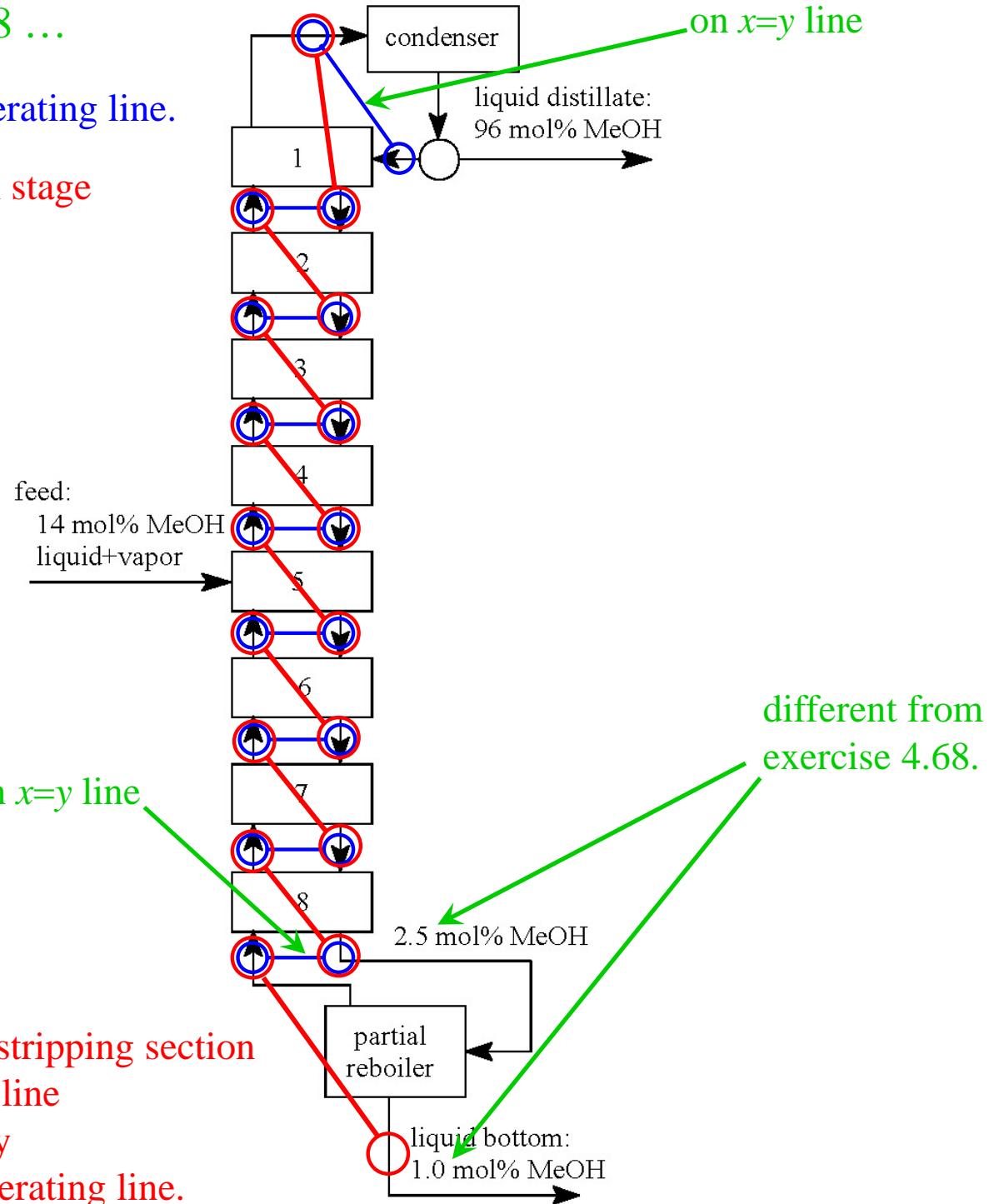
# vapor-liquid diagram for benzene+toluene mixtures at 1 atm

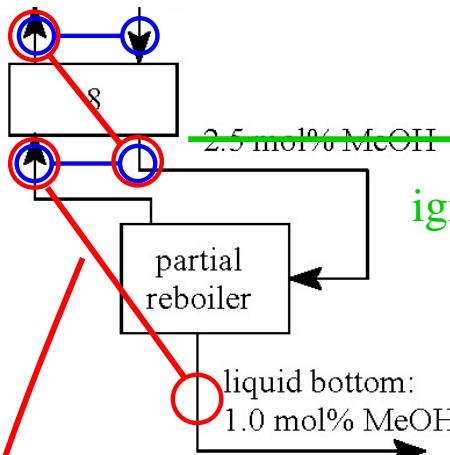


## Some hints for exercise 4.68 ...

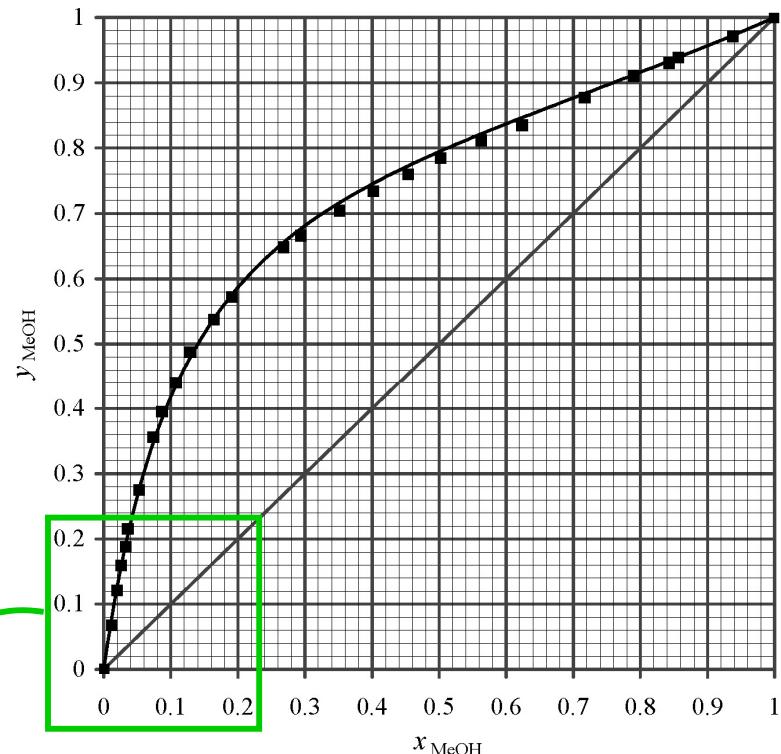
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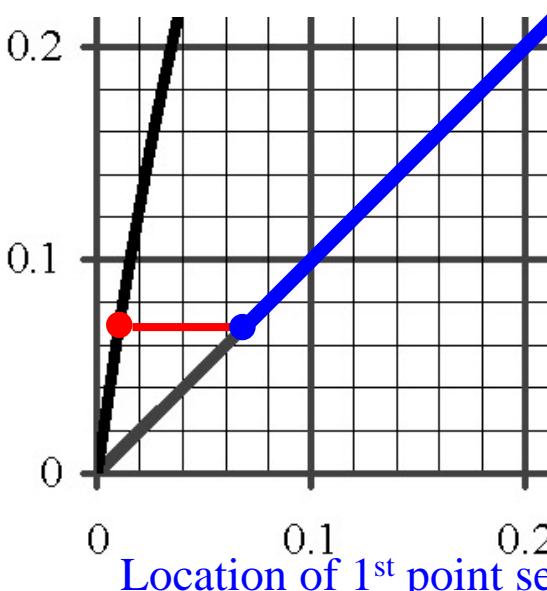
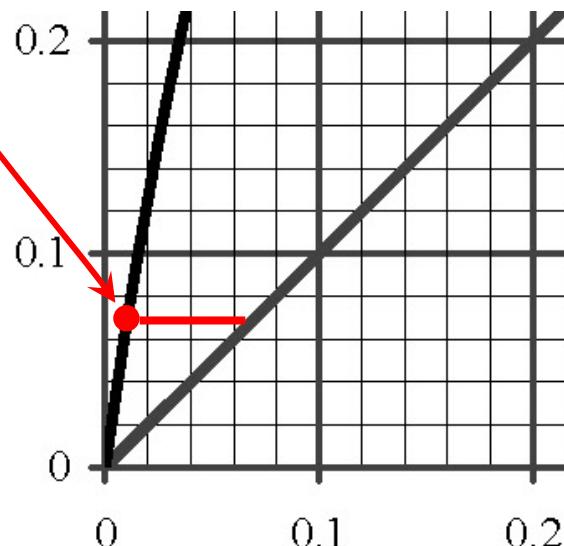




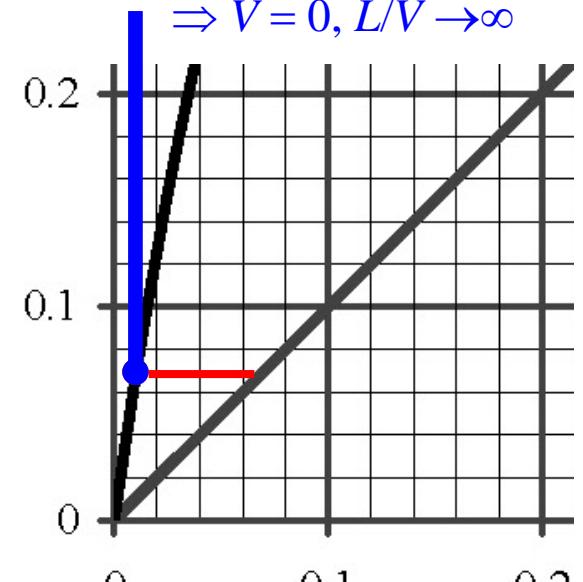
graphical analysis for the stripping section  
begins on the equilibrium line  
and then steps horizontally  
to the first point on the operating line.

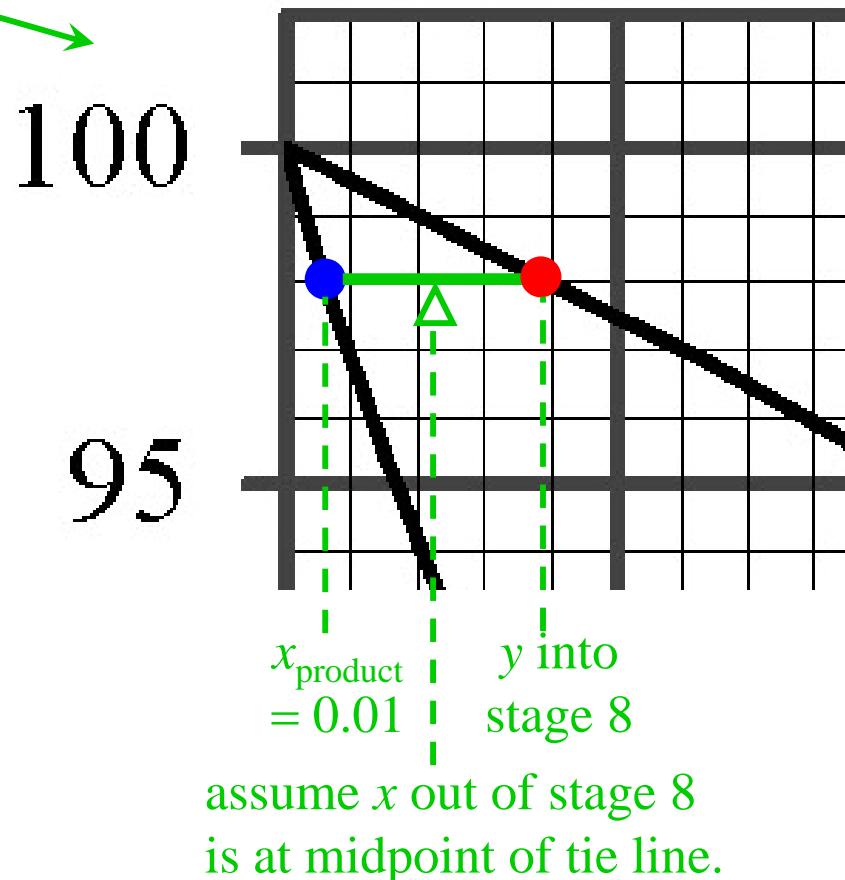
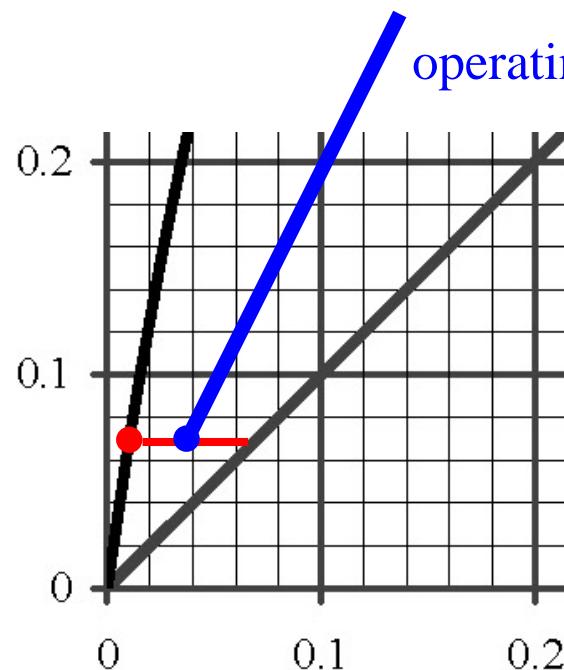
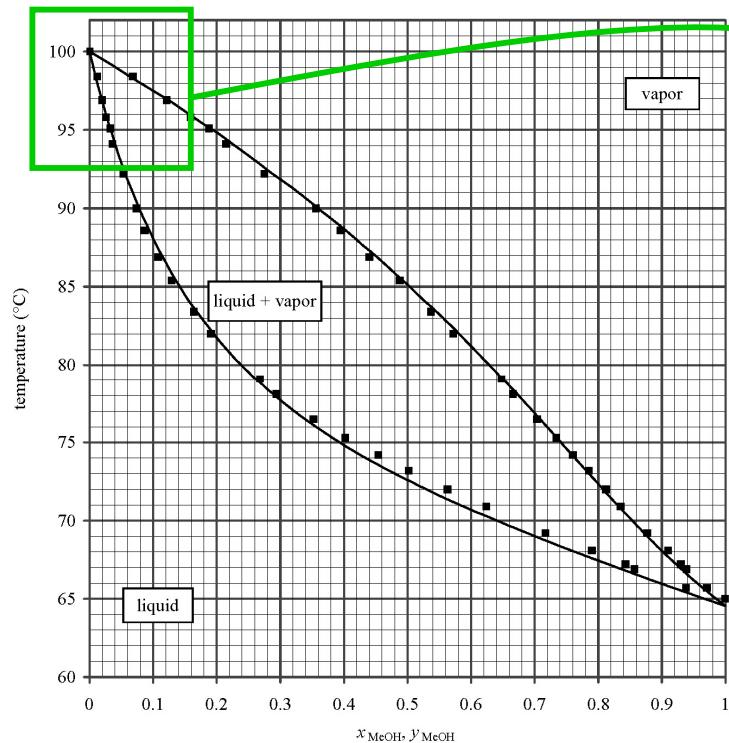


One extreme: no output  
 $\Rightarrow x = y, L = V, L/V = 1$



Another extreme: no reflux  
 $\Rightarrow V = 0, L/V \rightarrow \infty$





$\Rightarrow V \text{ into stage 8} = \frac{1}{2}L \text{ out of stage 8}$

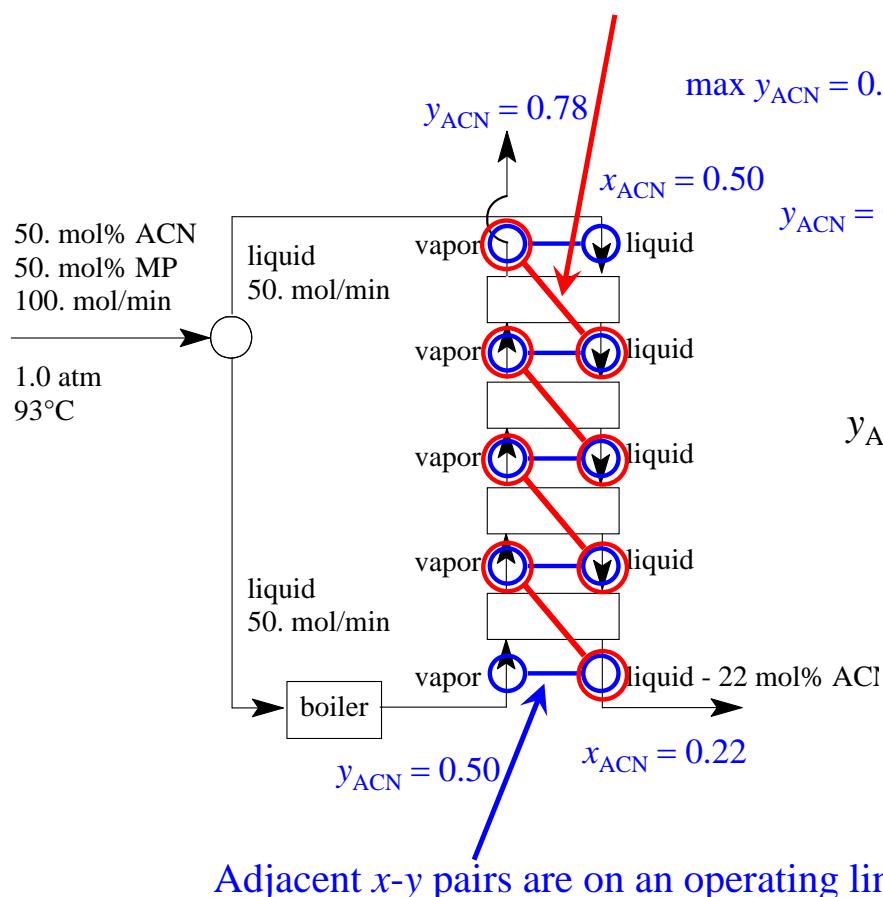
$\Rightarrow L/V = L/(\frac{1}{2}L) = 2$

$x$  out of stage 8 determines the operating line slope.

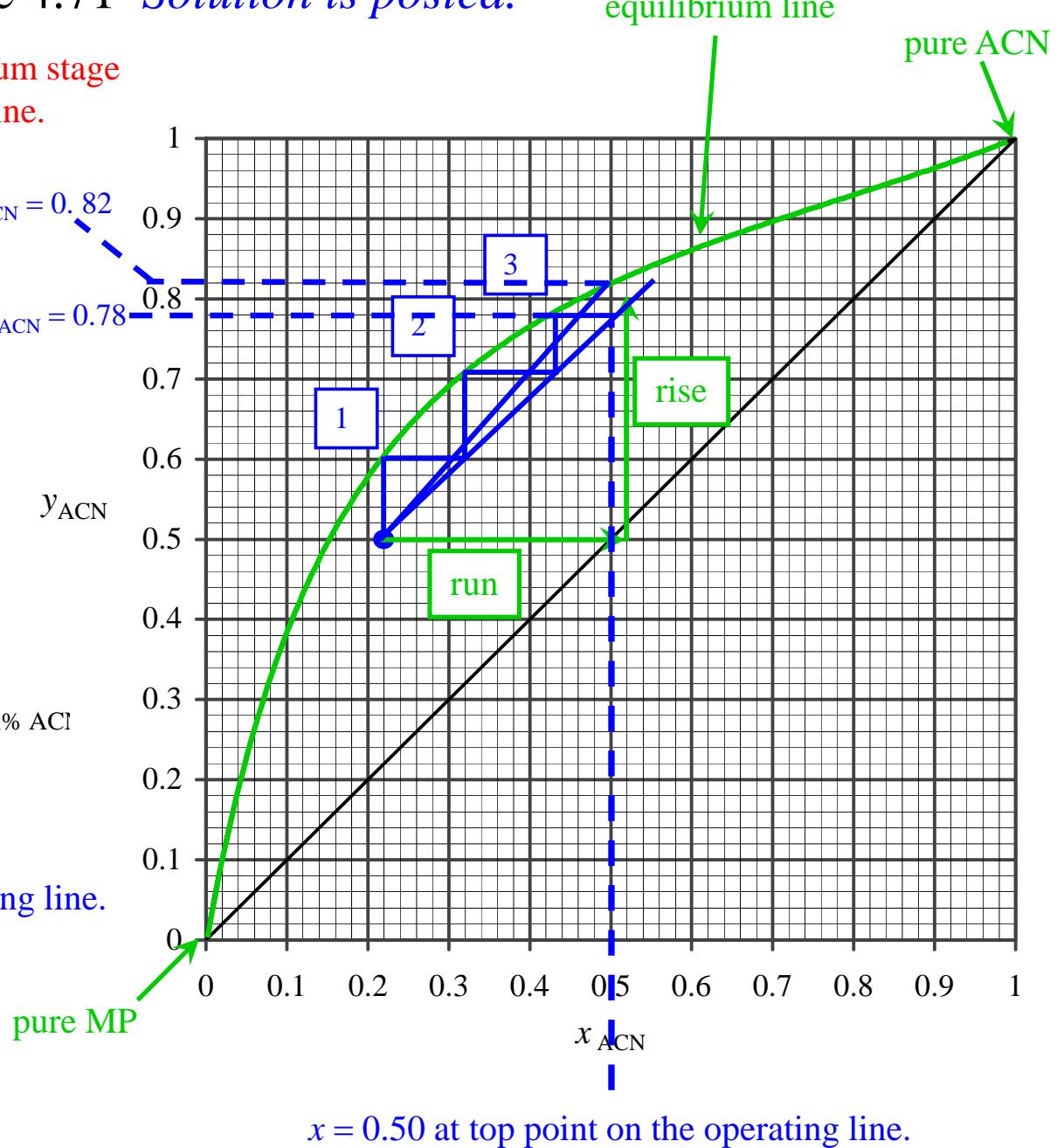
and vice versa.

# Exercise 4.71 Solution is posted.

x-y pairs leaving an equilibrium stage  
are on the equilibrium line.

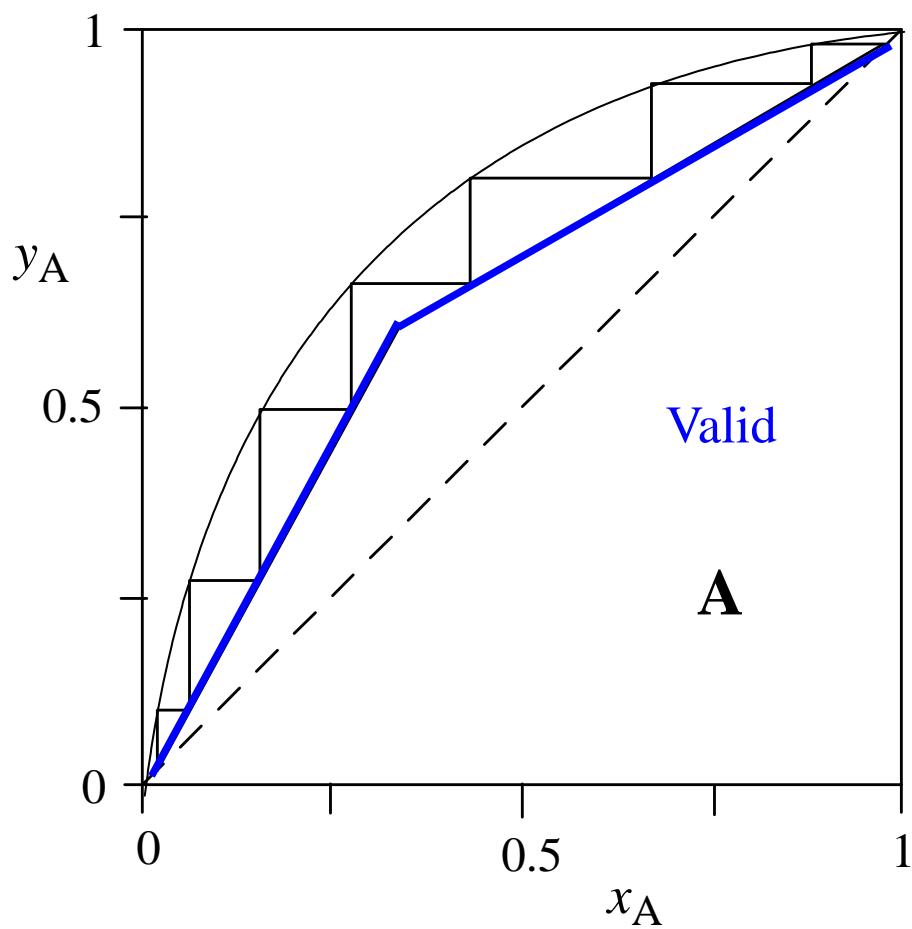


$$\text{operating line slope} = \frac{L}{V} = \frac{50 \text{ mol/min}}{50 \text{ mol/min}} = 1$$

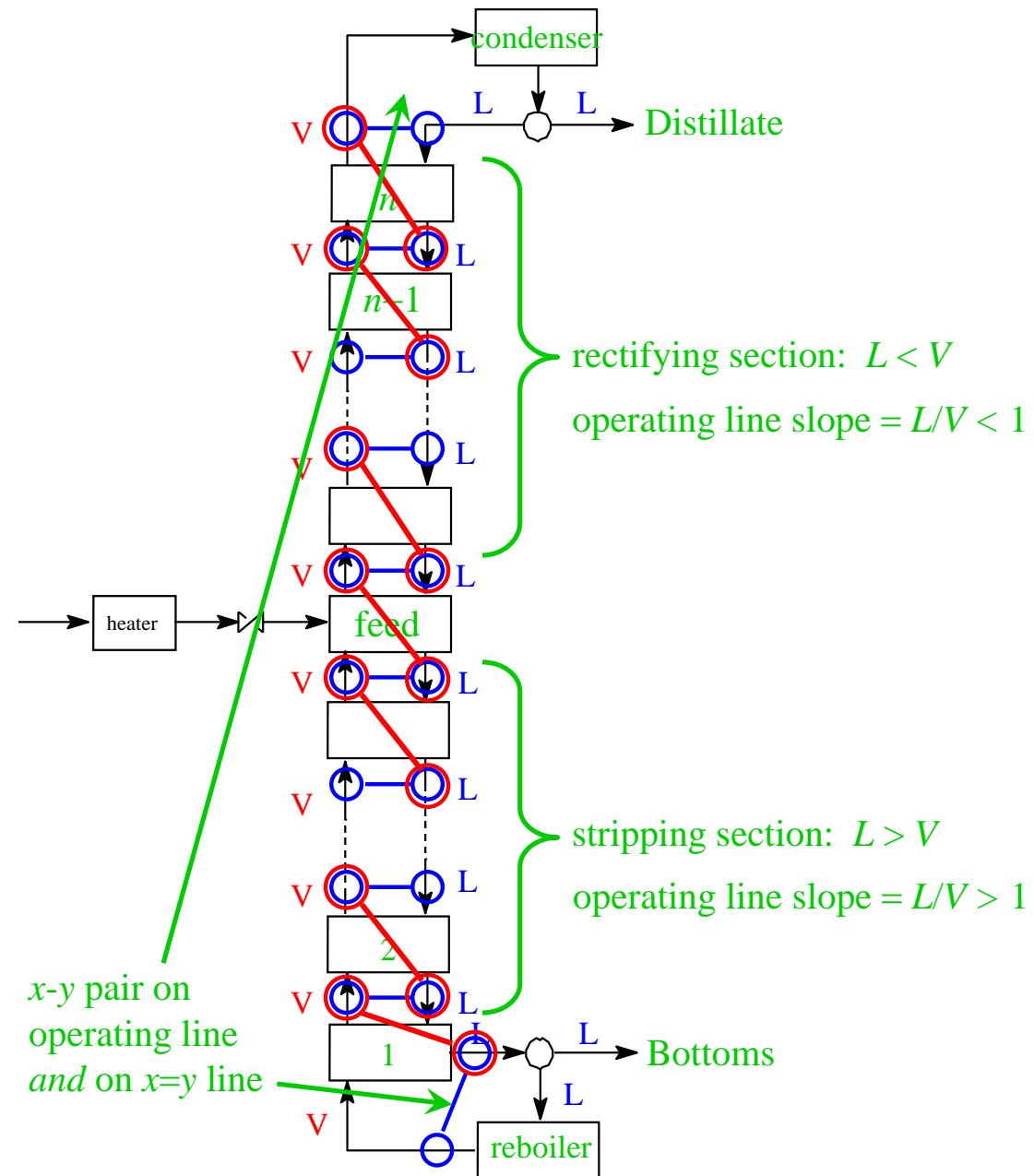


## Exercise 4.60 *Solution is posted.*

### A Distillation Column

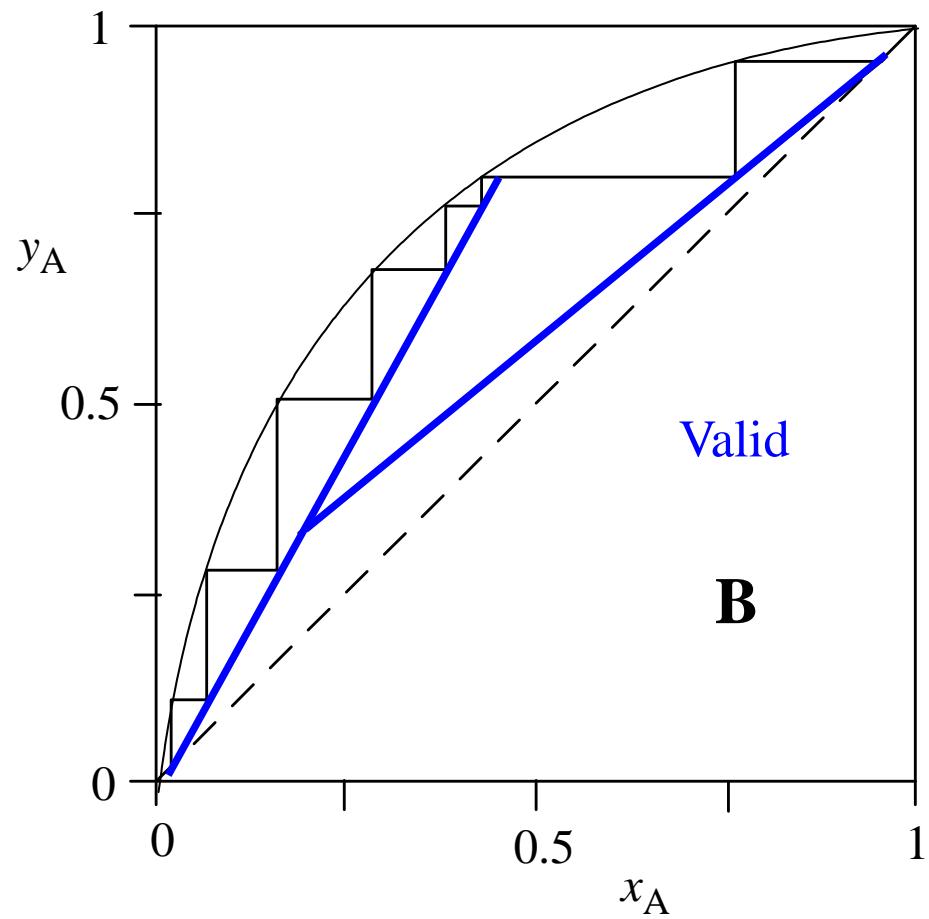


Decide if the operating lines and the steps are consistent with a distillation column with one feed stage and finite output from both the top and the bottom.

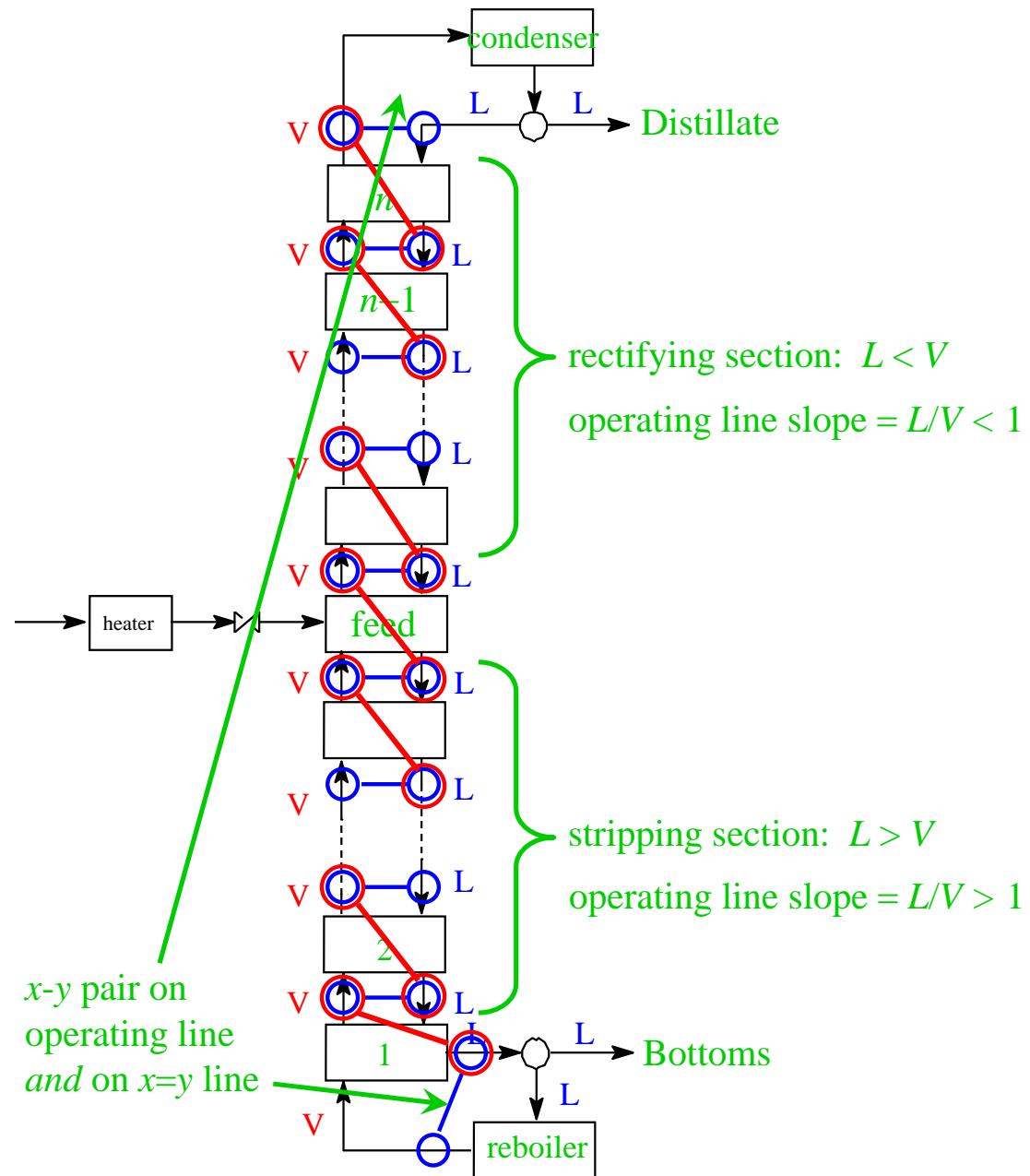


Exercise 4.60 *Solution is posted.*

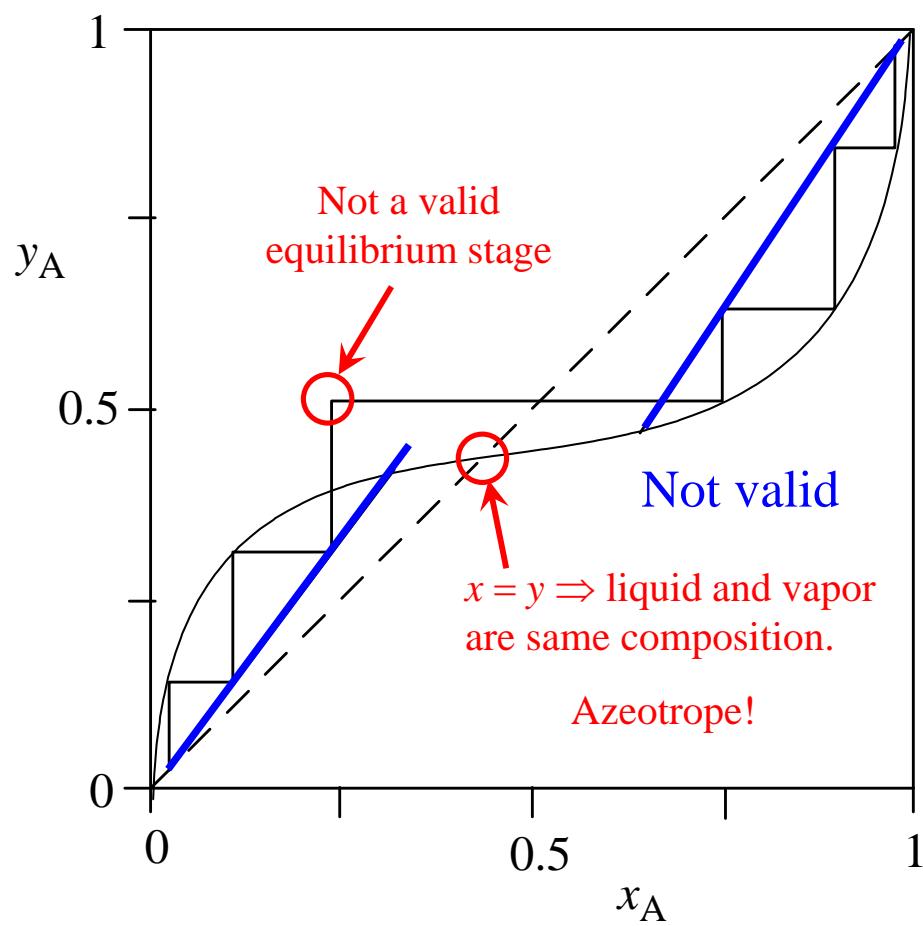
## A Distillation Column



Decide if the operating lines and the steps are consistent with a distillation column with one feed stage and finite output from both the top and the bottom.

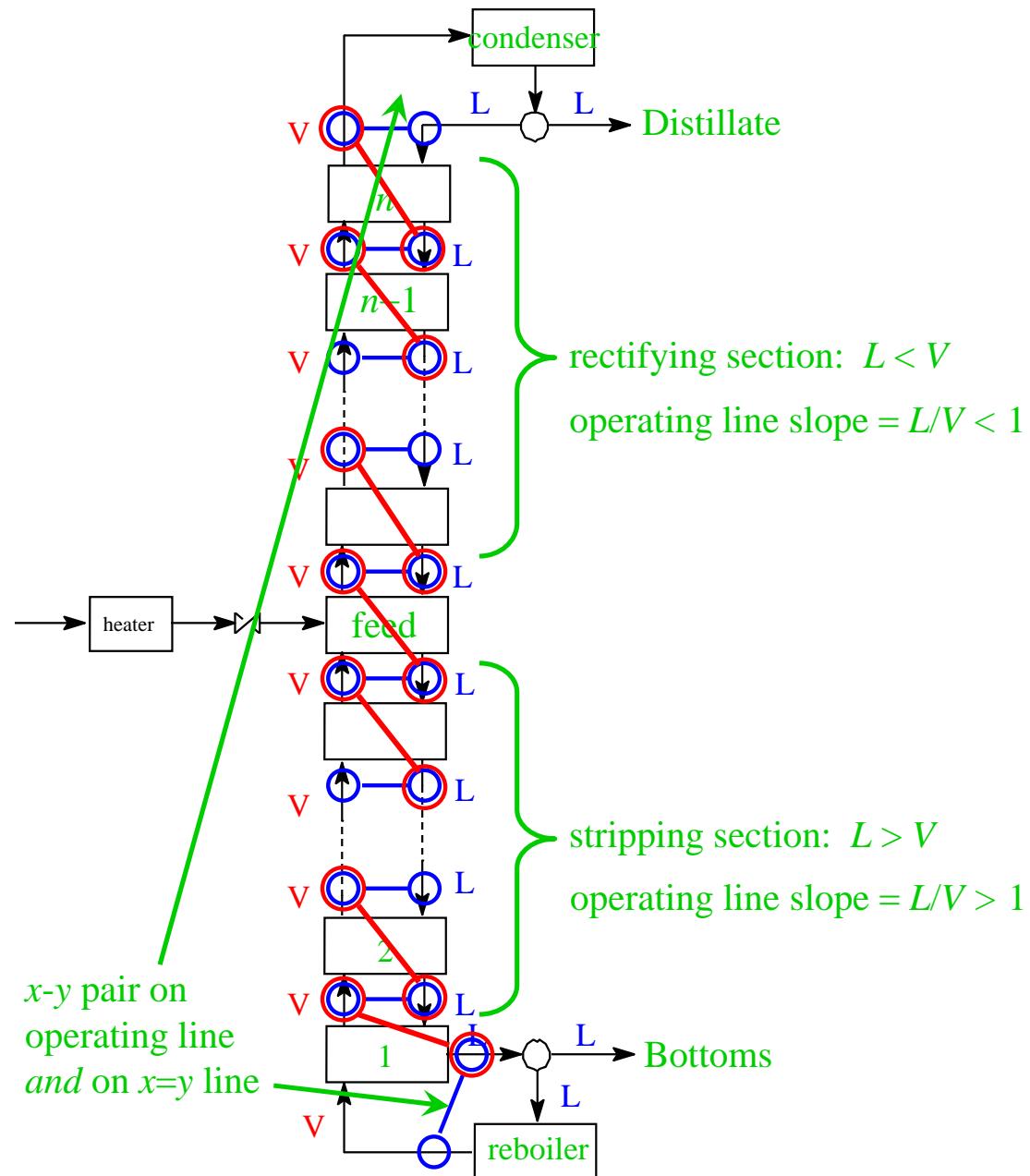


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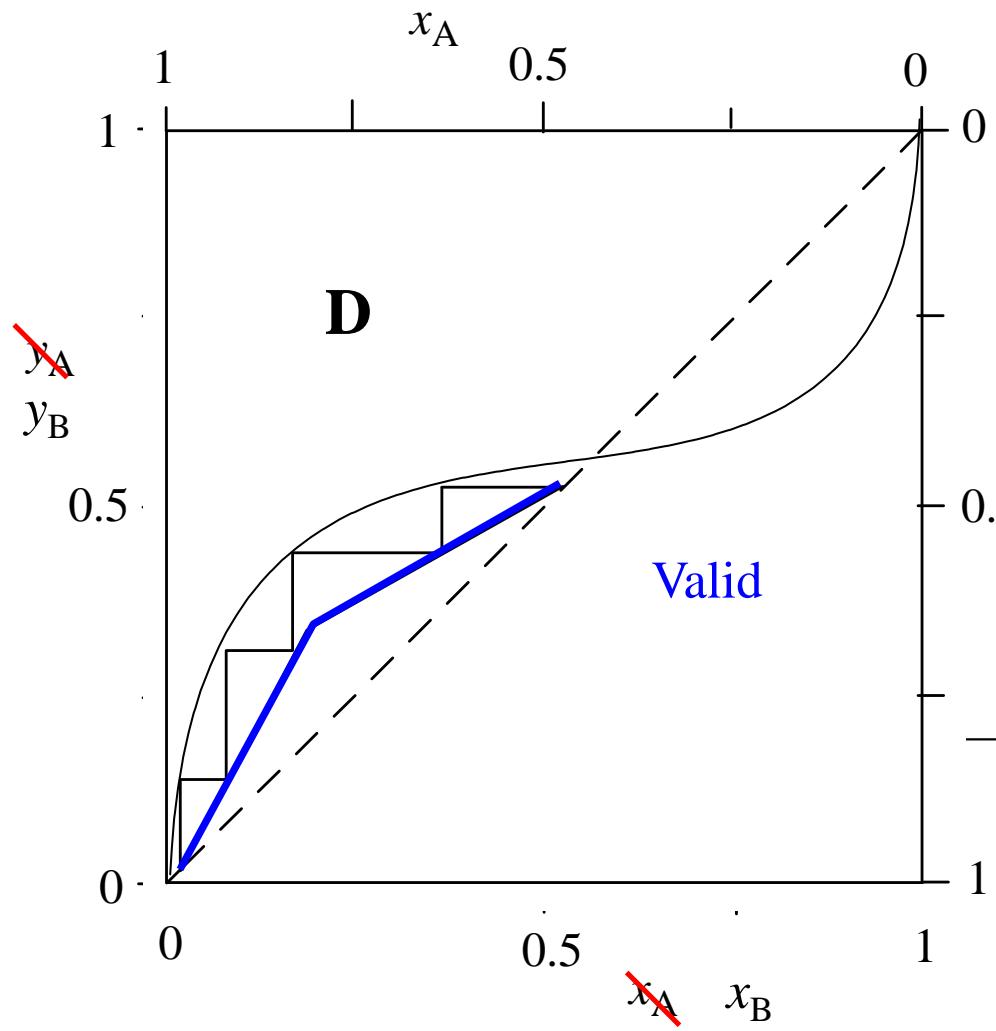


Decide if the operating lines and the steps are consistent with a distillation column with one feed stage and finite output from both the top and the bottom.

### A Distillation Column

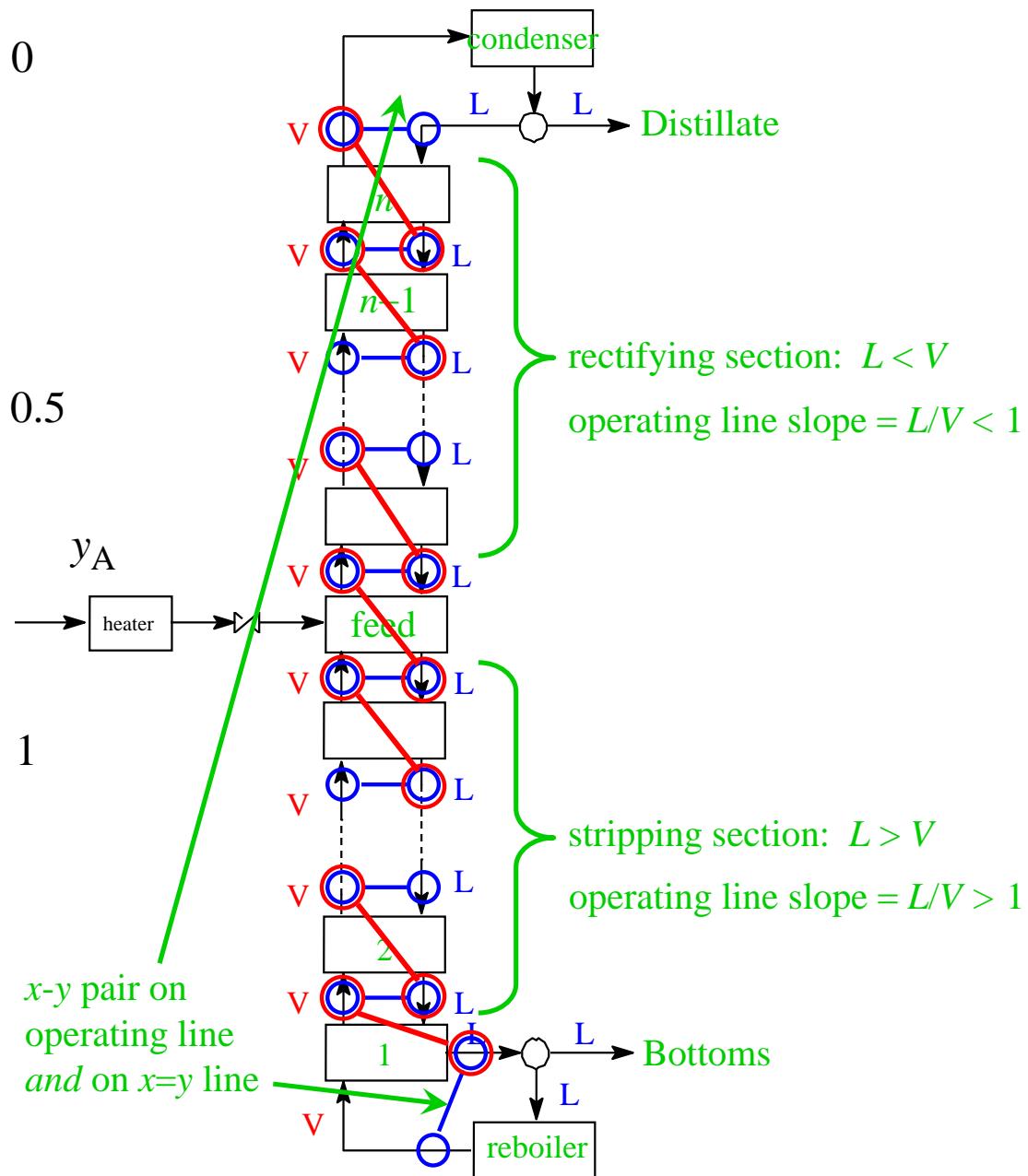


## Exercise 4.60 *Solution is posted.*



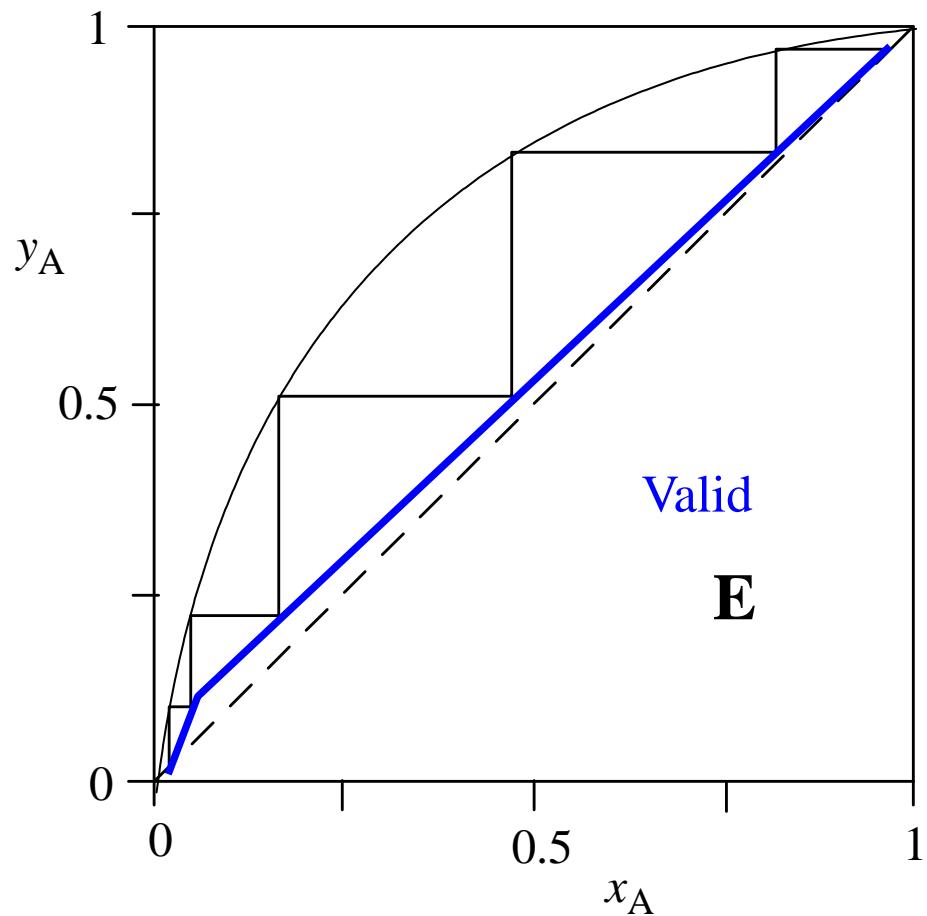
Decide if the operating lines and the steps are consistent with a distillation column with one feed stage and finite output from both the top and the bottom.

### A Distillation Column

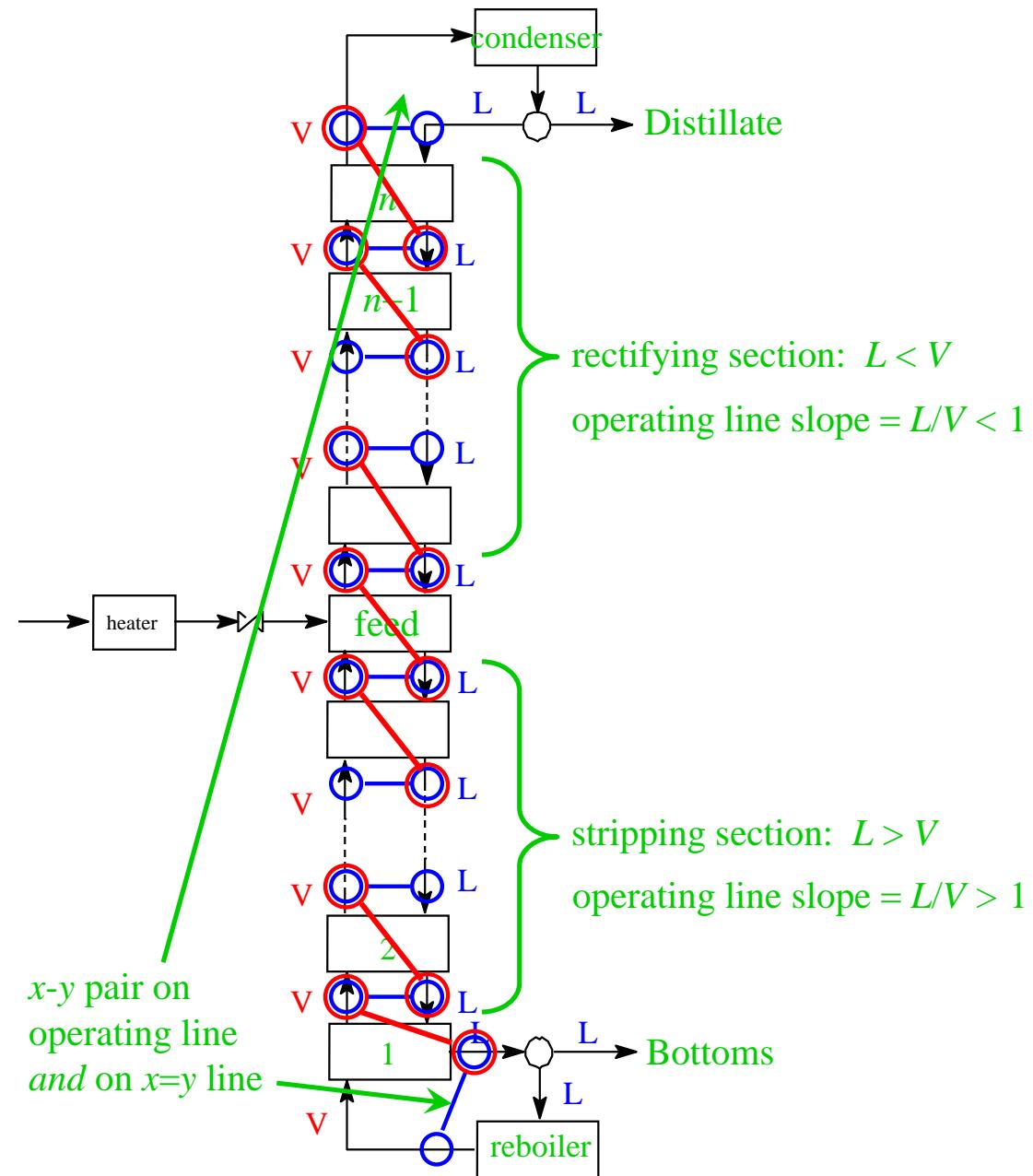


## Exercise 4.60 *Solution is posted.*

### A Distillation Column

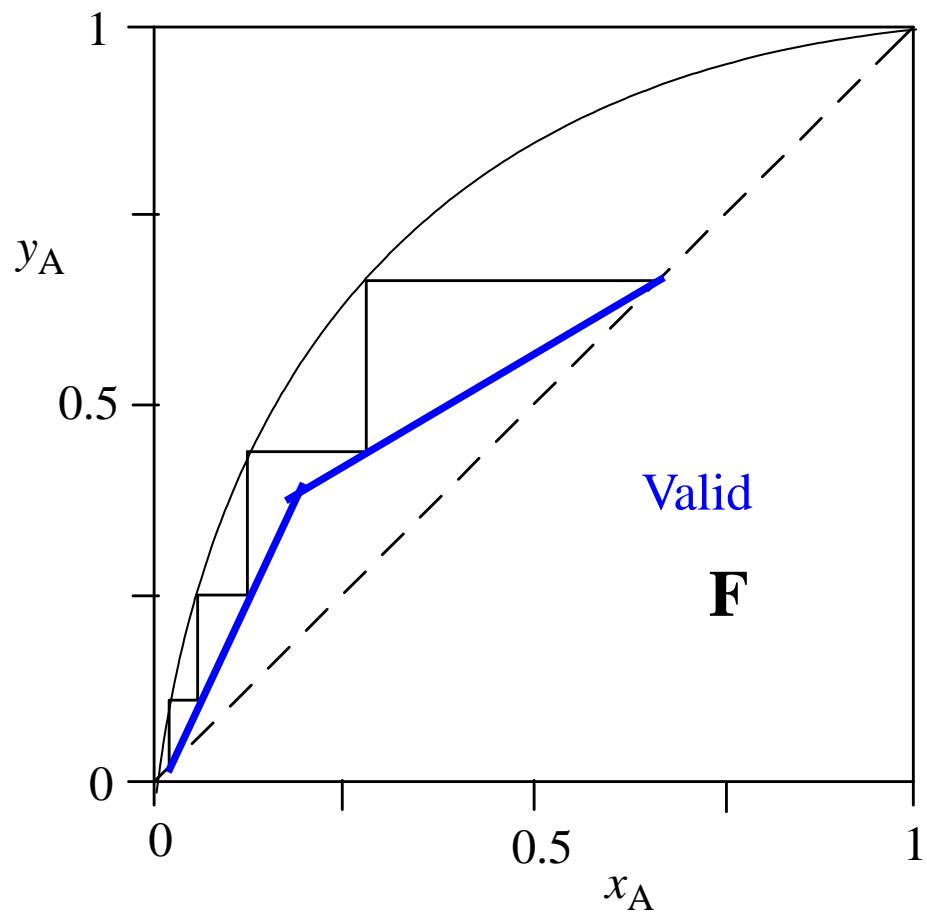


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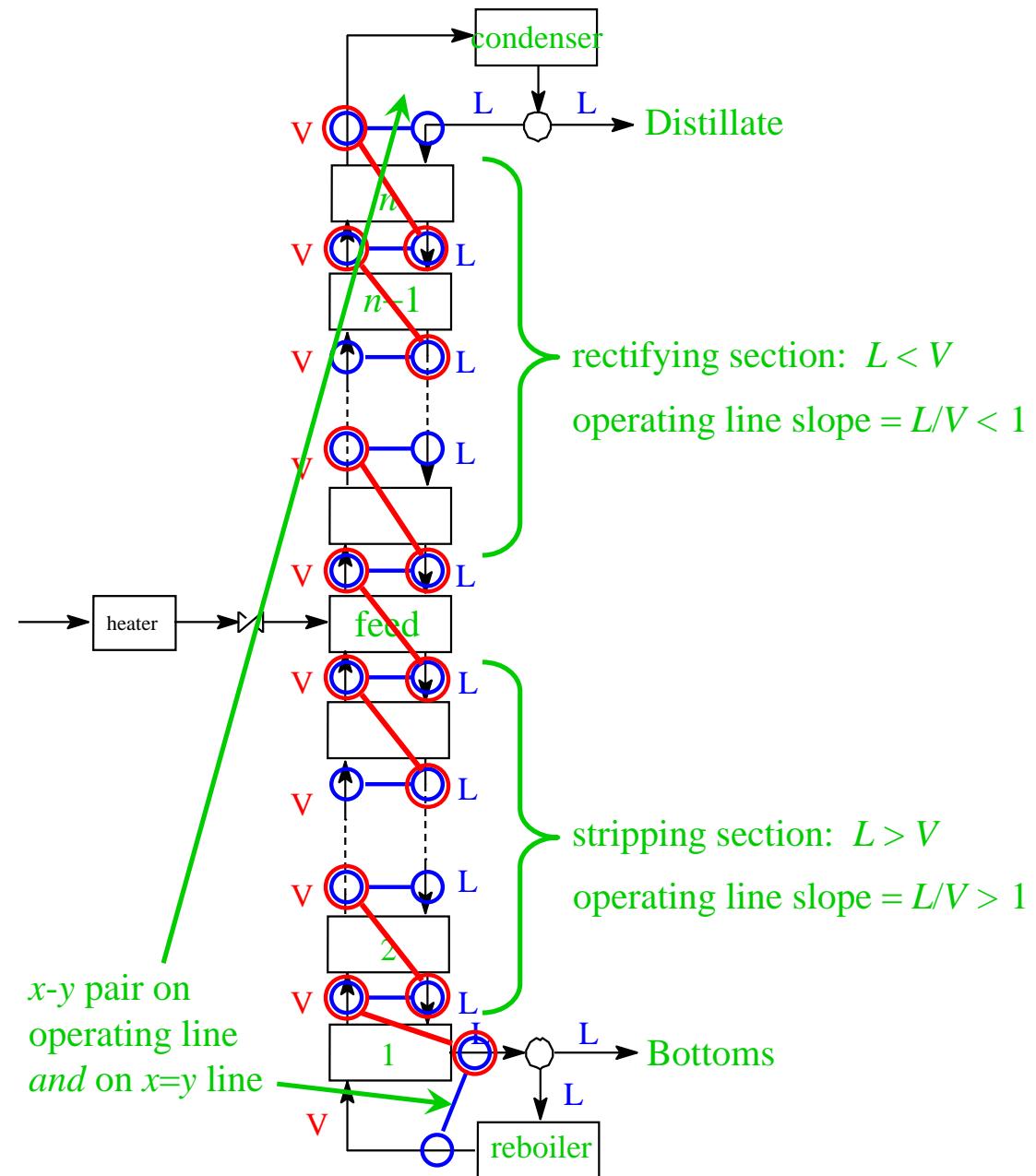


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### A Distillation Column

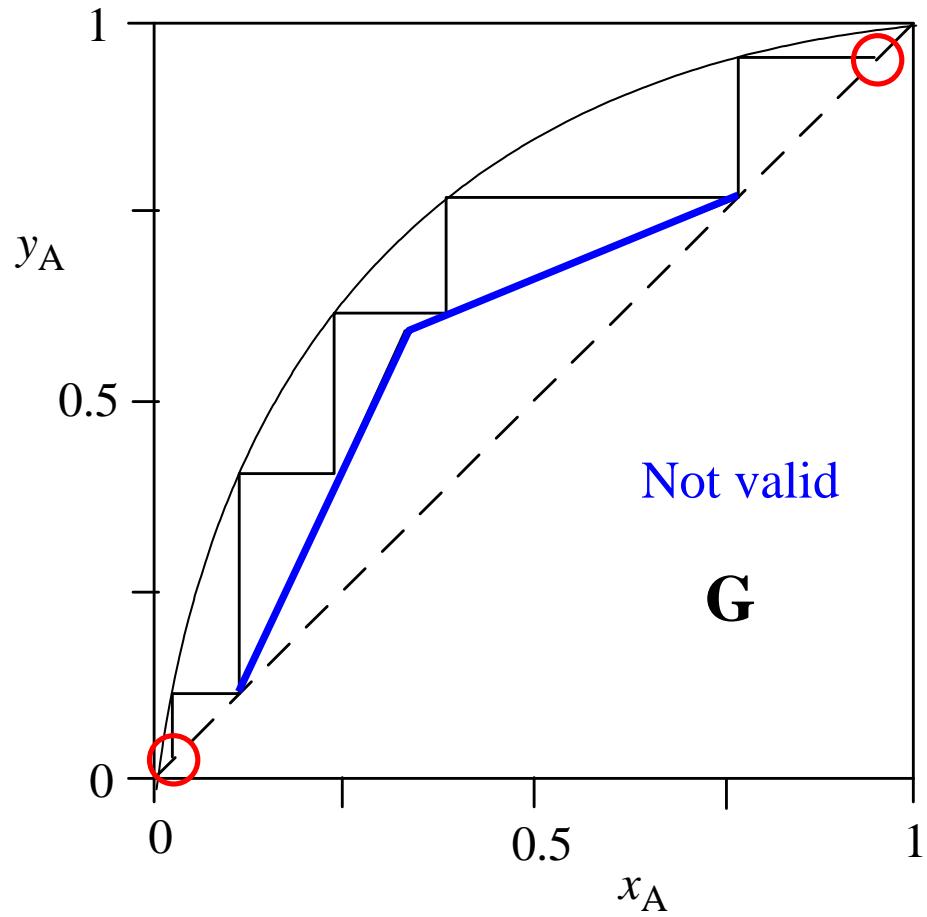


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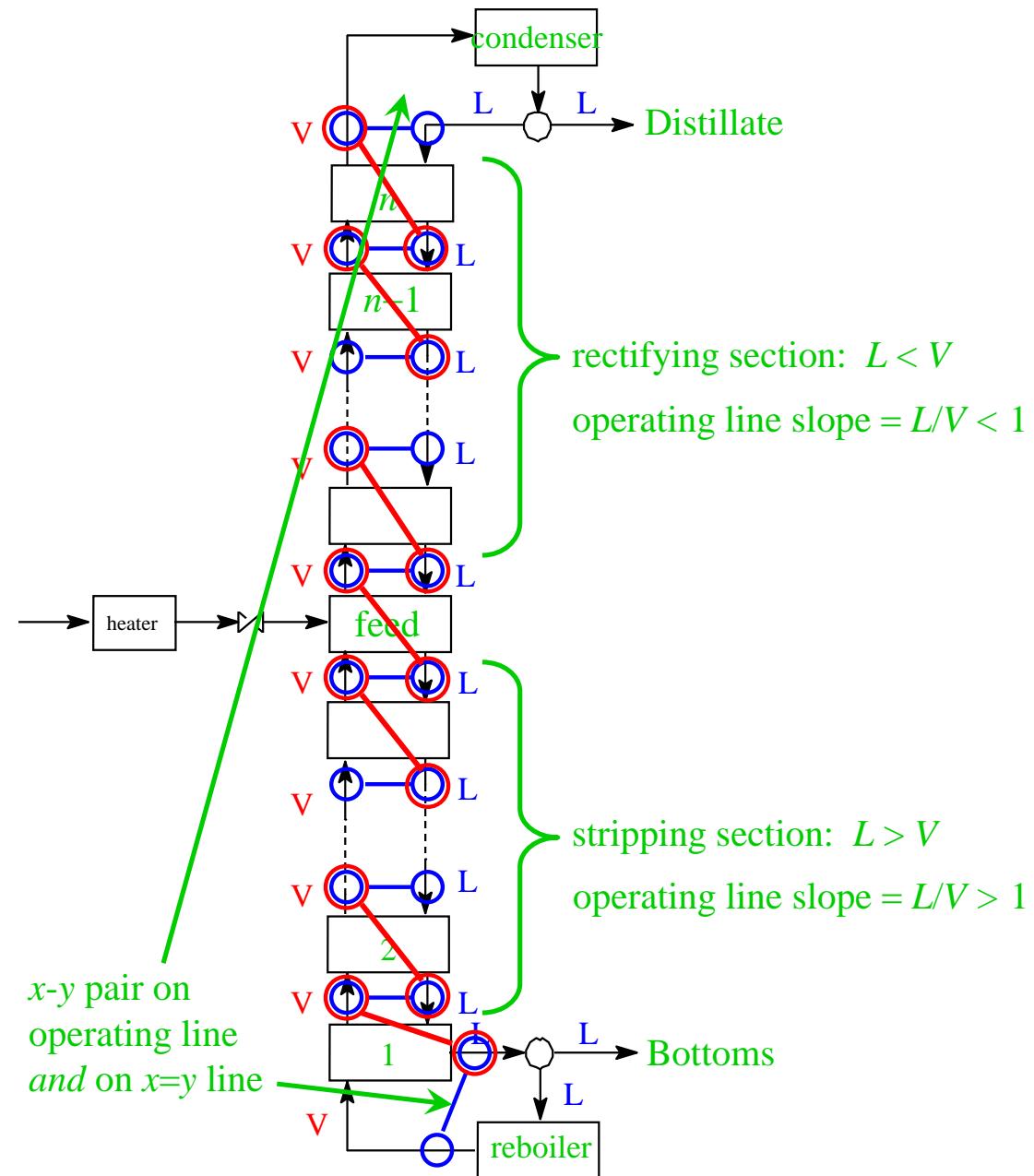


## Exercise 4.60 *Solution is posted.*

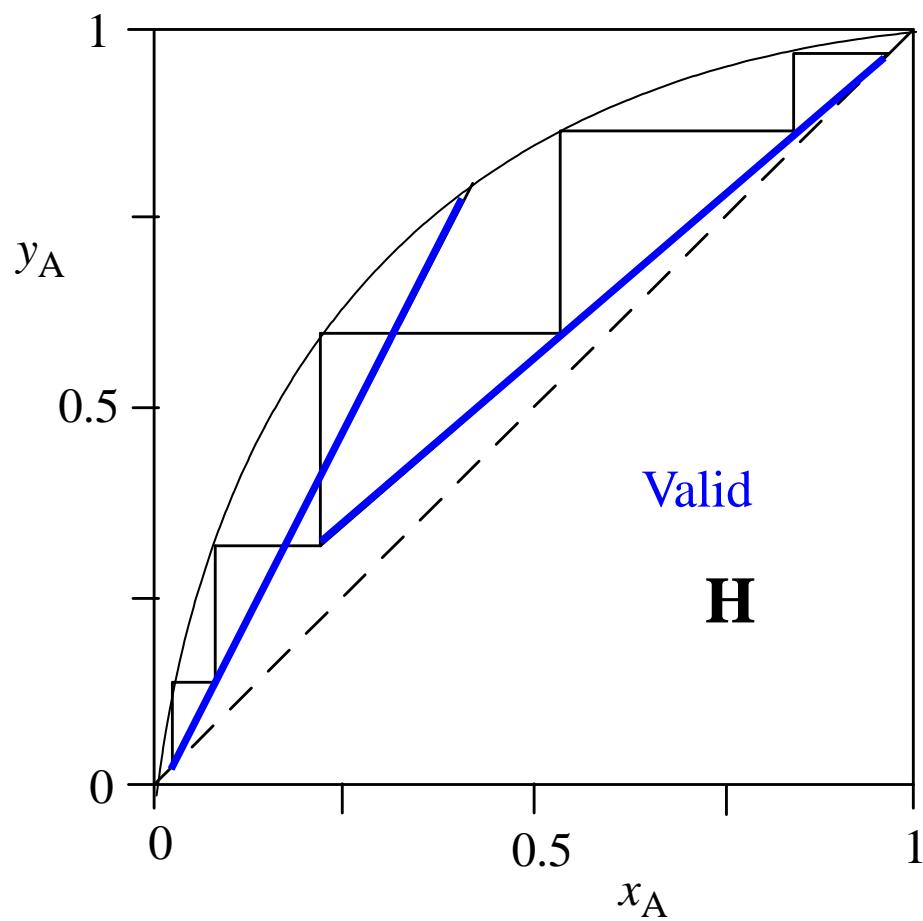
### A Distillation Column



Decide if the operating lines and the steps are consistent with a distillation column with one feed stage and finite output from both the top and the bottom.



## Exercise 4.60 *Solution is posted.*



Decide if the operating lines and the steps are consistent with a distillation column with one feed stage and finite output from both the top and the bottom.

A Distillation Column

