CE407 SEPARATIONS

Lecture 25b

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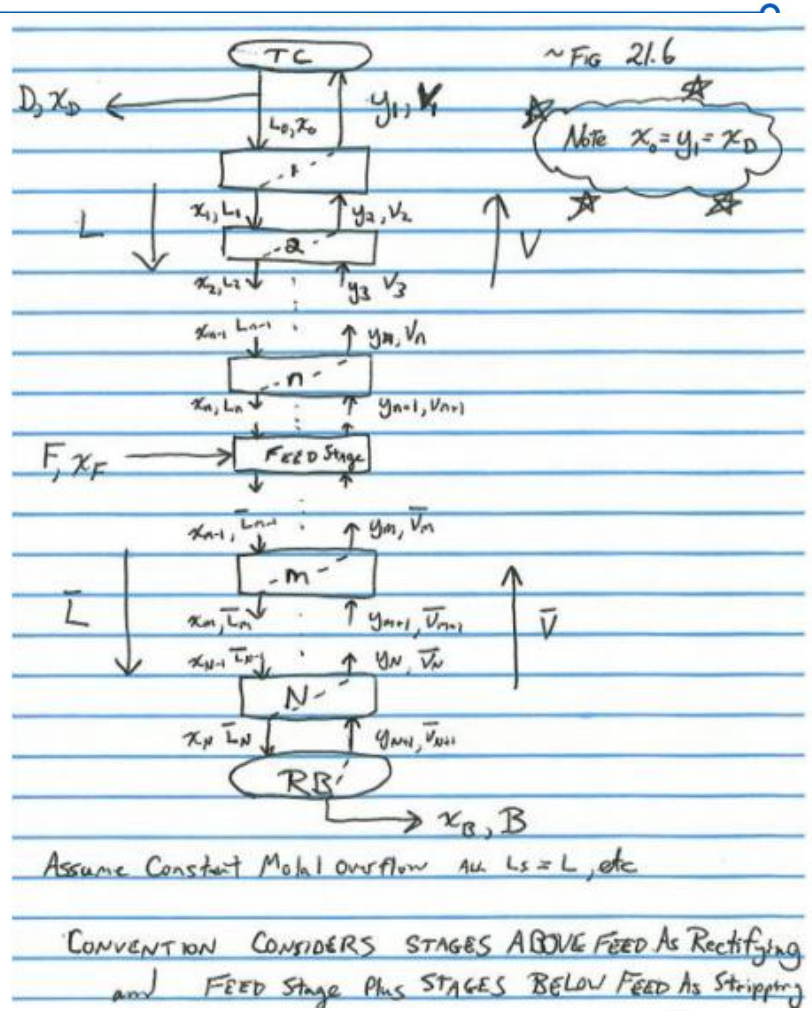
Control Schemes for Distillation Columns

- We have looked at distillation columns quite a bit in this course
- We have looked at mass balances between the feed and the distillate and bottoms streams
- We have calculated the number of stages required to achieve the separation desired
- We have studied the effect of different reflux ratios on the required number of stages
- We have calculated the heat (as well as cooling water and steam) requirements of the column

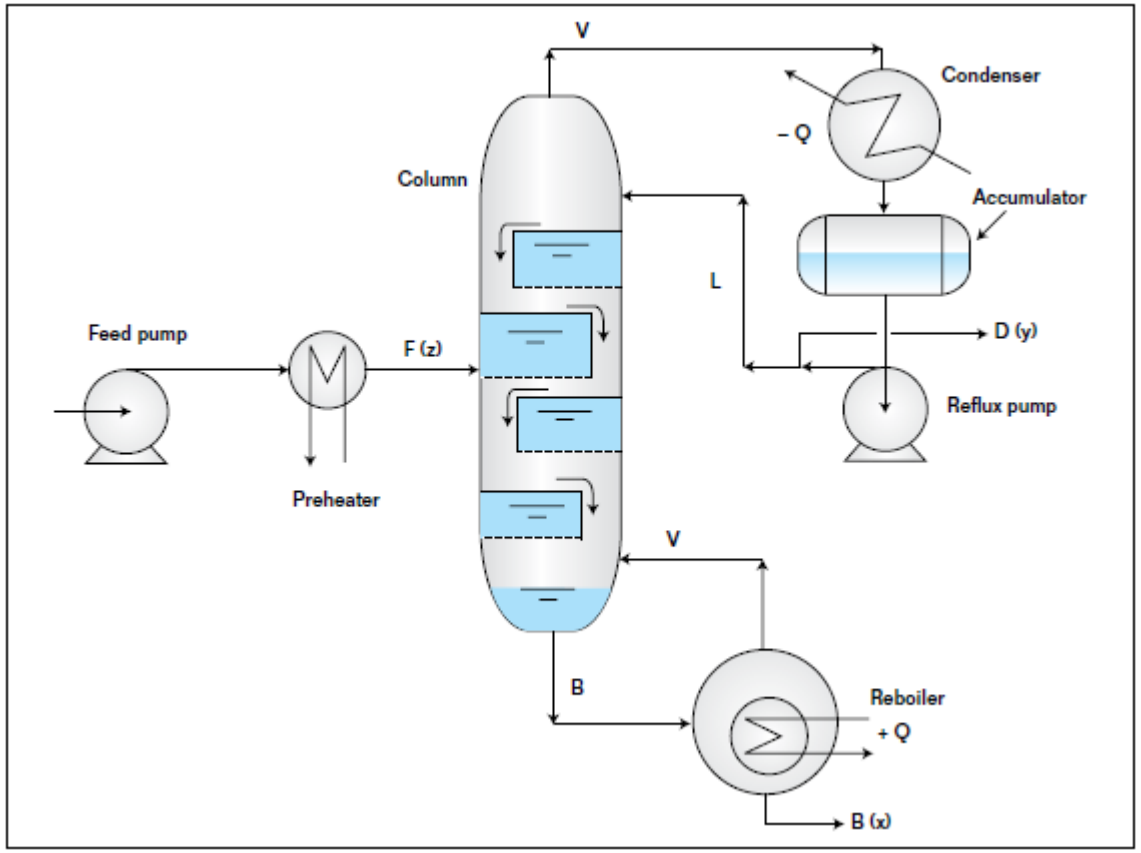
- What we HAVEN'T Discussed:
  - How do we control the column to achieve the desired outcomes…



Most Common Variables to Control

- Composition of Top Product (x_D)
- Composition of Bottom Product (x_B)
- Level in Column Base
- Level in Accumulator (Distillate Drum)
- Column Pressure

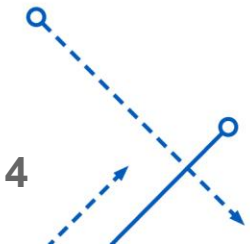
- Obviously, we are controlling the following, as well:
  - Feed Flow Rate
  - Feed Temperature (and quality)



Variables Used to Control the Variables Mentioned on Previous Slide

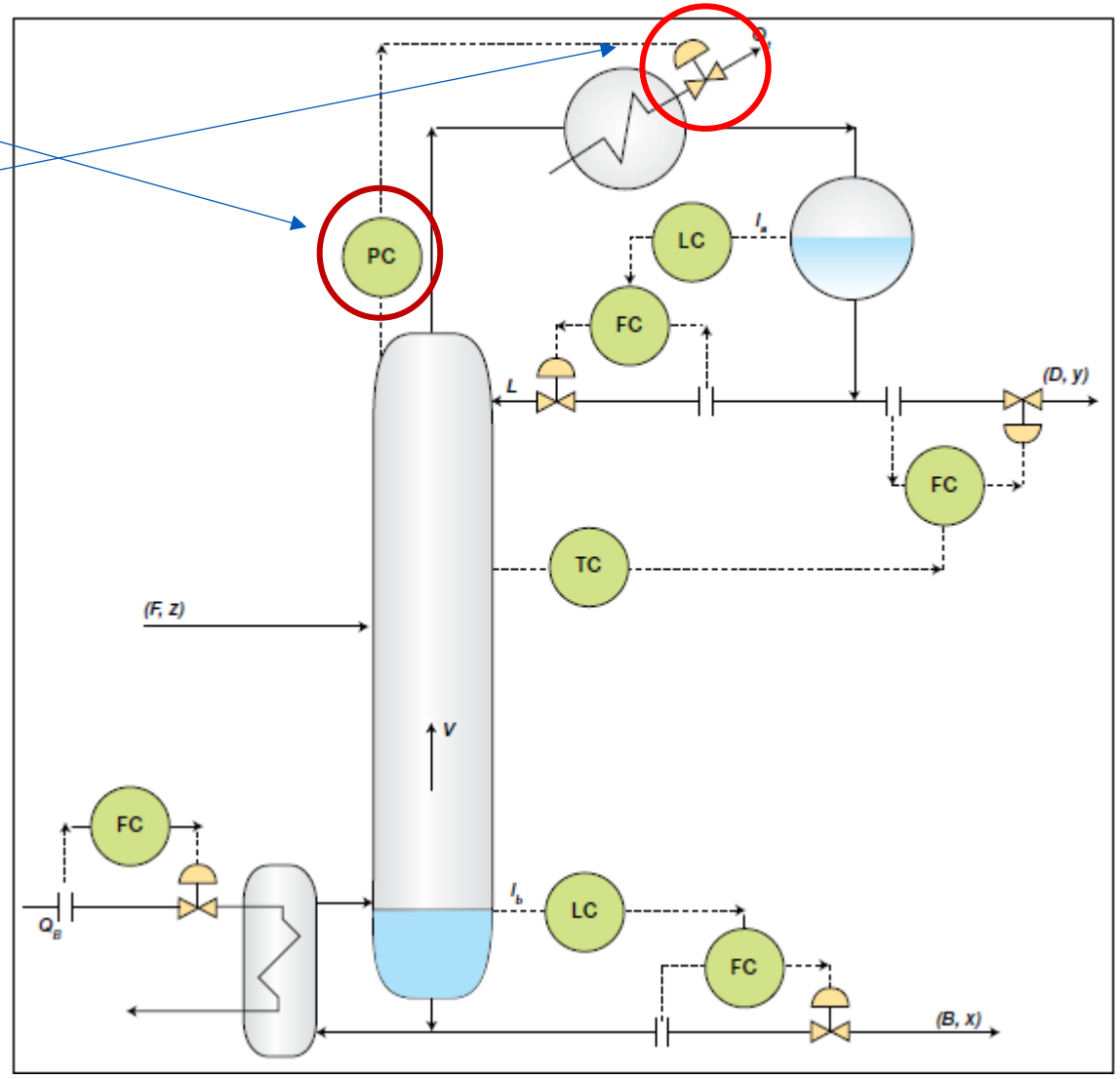
- Distillate Flow (D)
- Bottoms Flow (B)
- Reflux Ratio (L/D)
- Vapor Boilup Rate (V)
  - Controlled via heat input (Q_R)
- Heat Removal (Q_C)
  - Used to control Column Pressure

- There will be five control loops
- This lecture will not deal with dynamics or loop tuning parameters



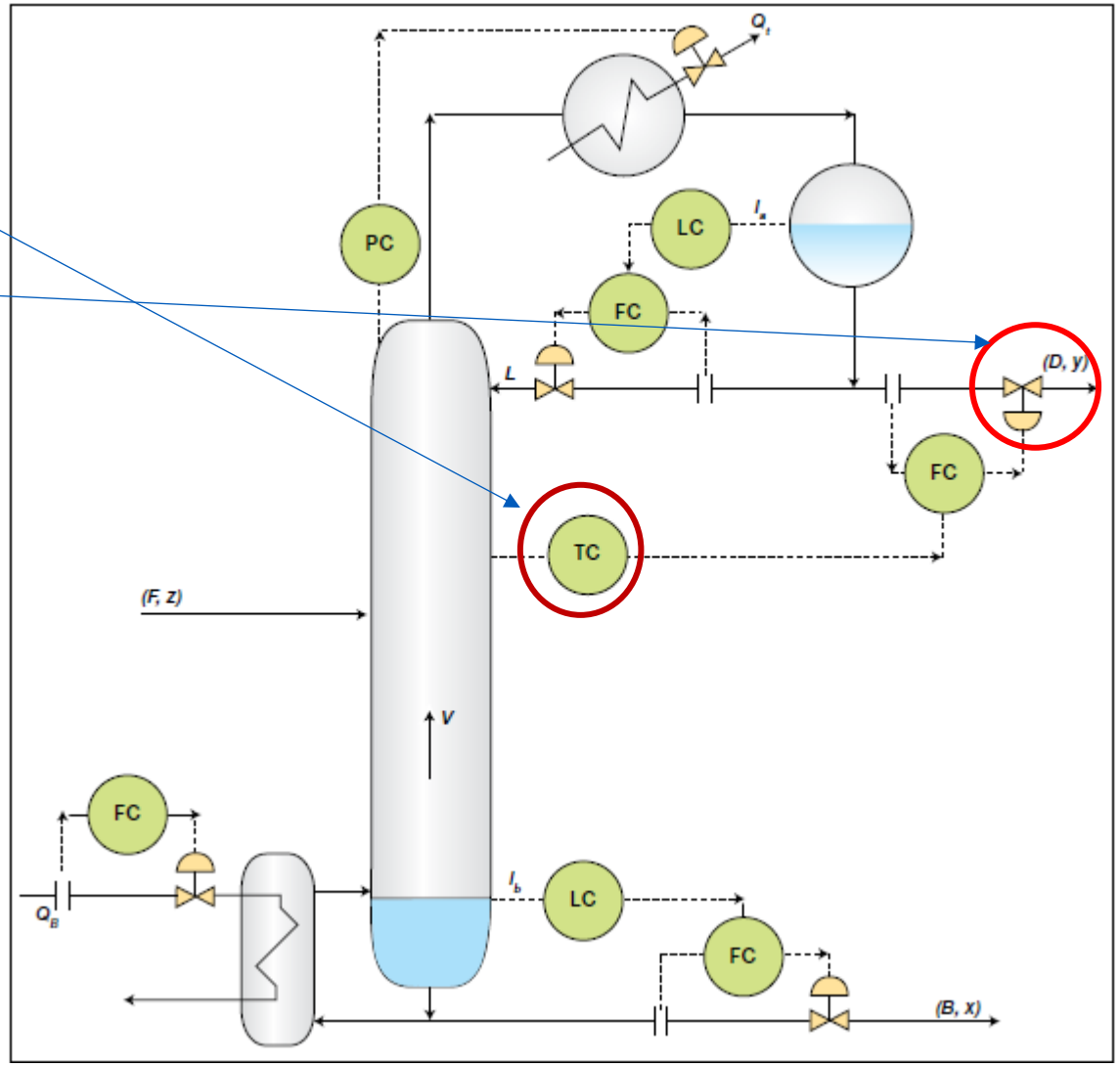
Control Loops

- **Column Pressure Control**
  - Column Pressure measured
  - Control Valve on Cooling Water manipulated
  - Pressure is built via the vapors generated in the reboiler
  - The cooling in the condenser counteracts this by converting the vapors back to liquid
  - Increase in cooling flow allows more vapor to be condensed



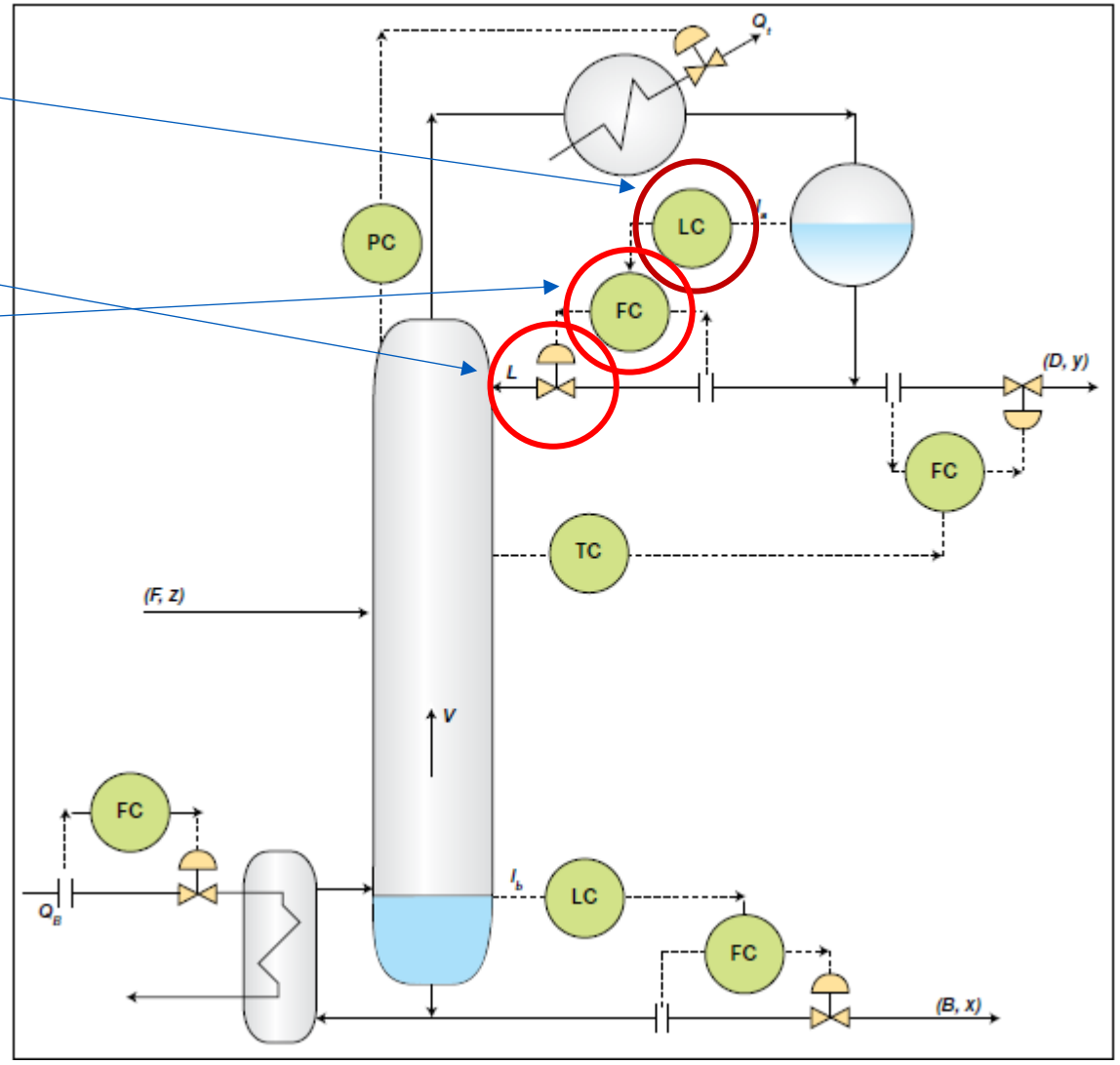
Control Loops

- **Distillate Composition Control**
- **Indirect Control**
  - Column Temperature is measured
  - Control Valve on Distillate Stream is manipulated
  - By controlling the Distillate Flow Rate, we are influencing the material balances and affecting the composition of the distillate
  - By measuring the temperature at a certain tray location, we are inferring the composition
    - Remember the T_{XY} diagram!
    - We pick a tray location where temperature is sensitive to changes in composition
  - If we control the composition at a given tray, we control the composition of the distillate



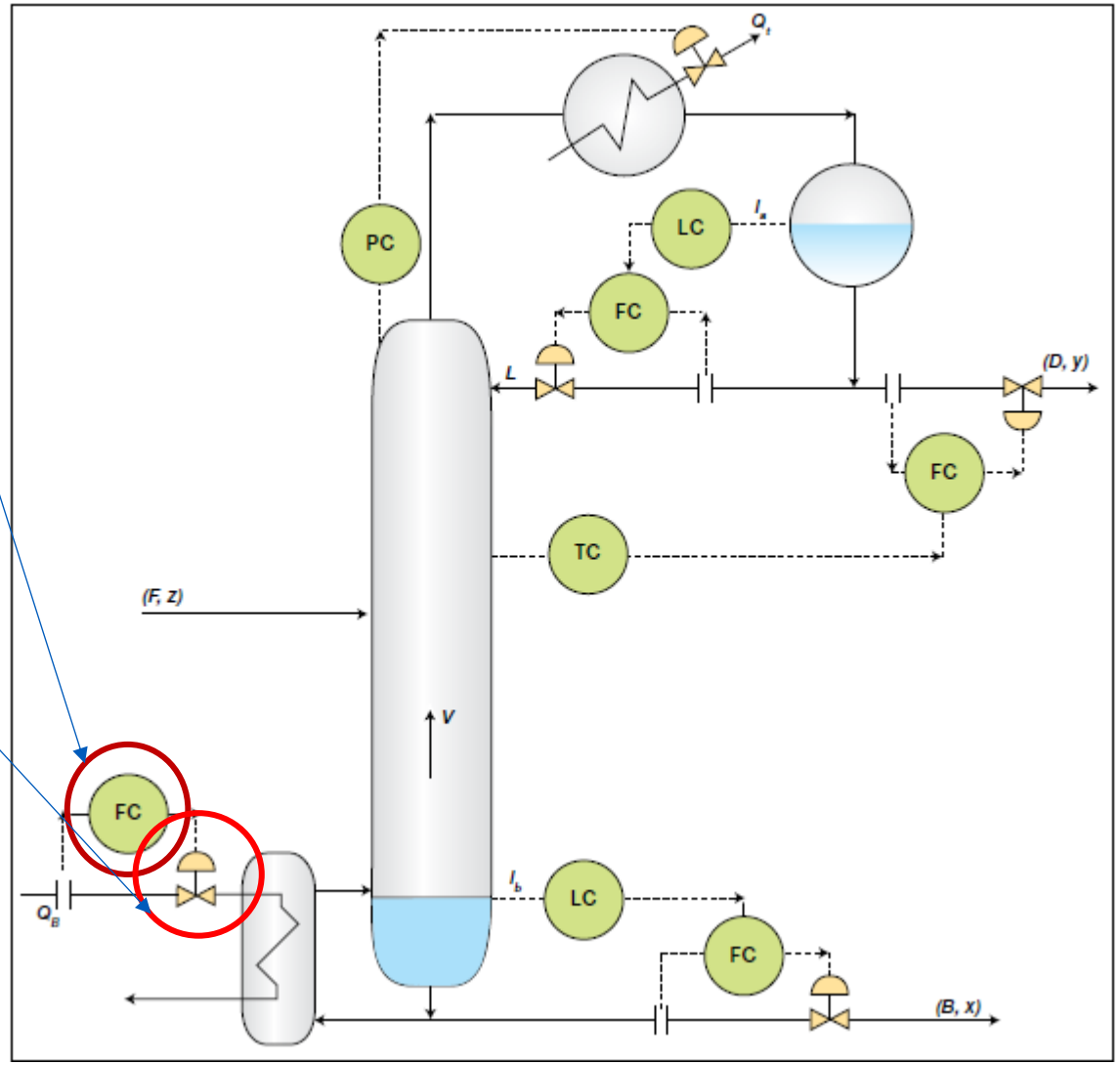
Control Loops

- **Column Reflux Control**
  - Distillate Drum level measured
  - Control Valve on Reflux Flow manipulated
  - Reflux Flow can be measured and Cascade Control Used
    - Level Control Loop manipulates setpoint on Flow Control Loop
  - This assumes a constant flow V coming from the Reboiler and D from loop on last slide
  - The various loops described in this lecture will necessarily interact with one another and care must be taken to make the system stable



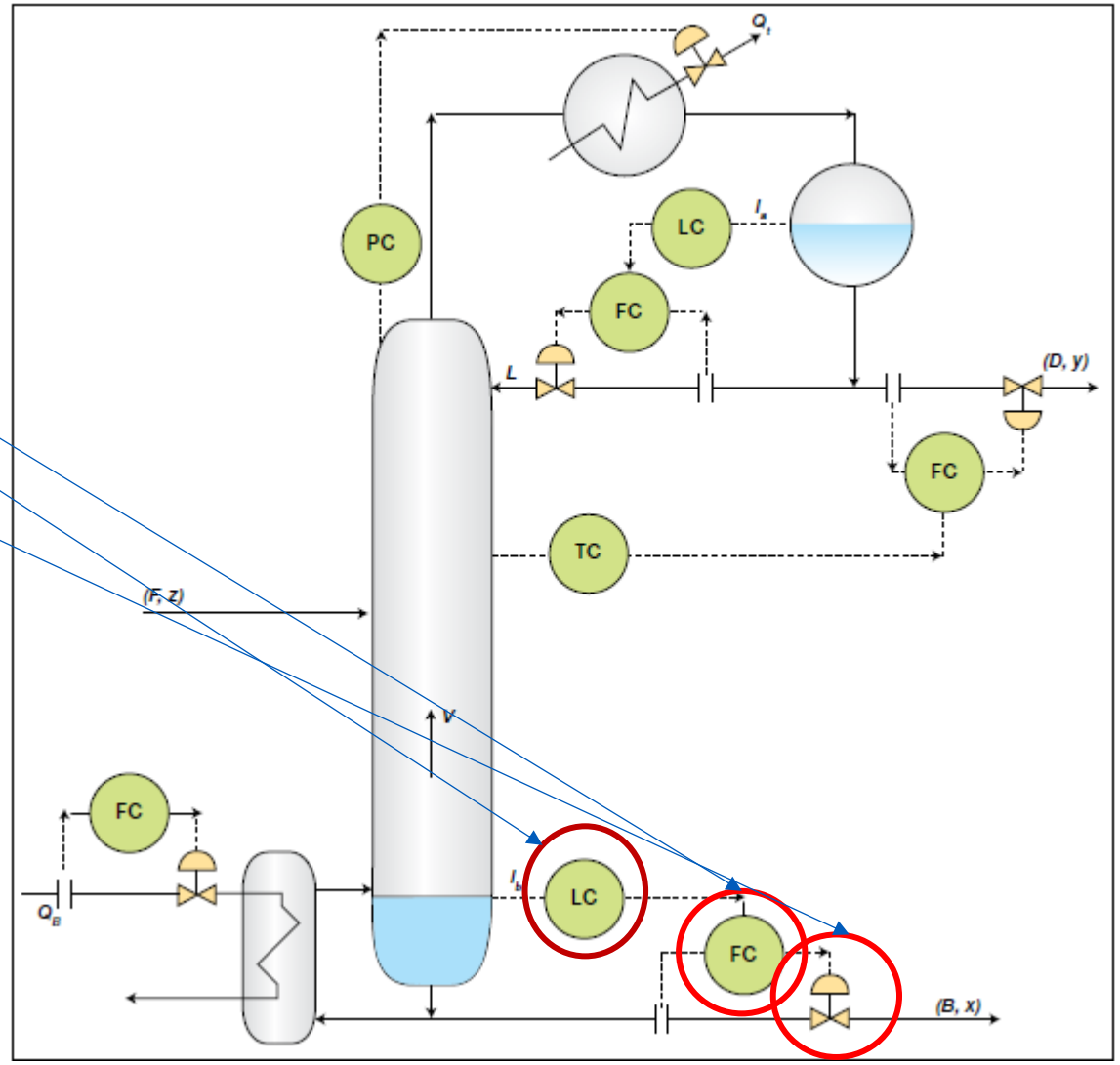
Control Loops

- **Boil Up Rate Control**
  - Steam Flow Rate is Measured
  - Control Valve on Steam Flow manipulated
  - Steam Flow Rate Sets Q_R
  - For a given composition this translates into the rate at which material is vaporized and thus sets V
  - Note that the composition at the bottom of the column is fairly pure heavy component, so heat of vaporization is relatively constant



Control Loops

- **Bottoms Rate Control**
  - Liquid Level in Column Base is Measured
  - Cascade Control Manipulates Setpoint on Bottoms Flow Rate Loop
  - Bottoms Flow Rate is Measured
  - Control Valve is Manipulated
  - This assumes that the loops on the previous slides are behaving stabily



Notes

- The previous example is just one of very many schemes for controlling the column
- For example, one could measure temperature at bottom of column to infer the bottoms composition
- Need to avoid over-specifying the variables
- Upsets to rate and composition of feed will place loads on all of these loops
- Stability is a challenge!