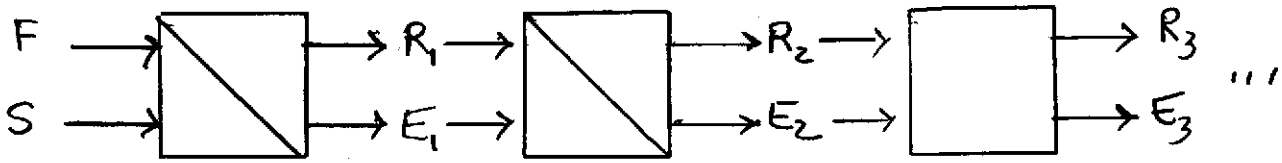
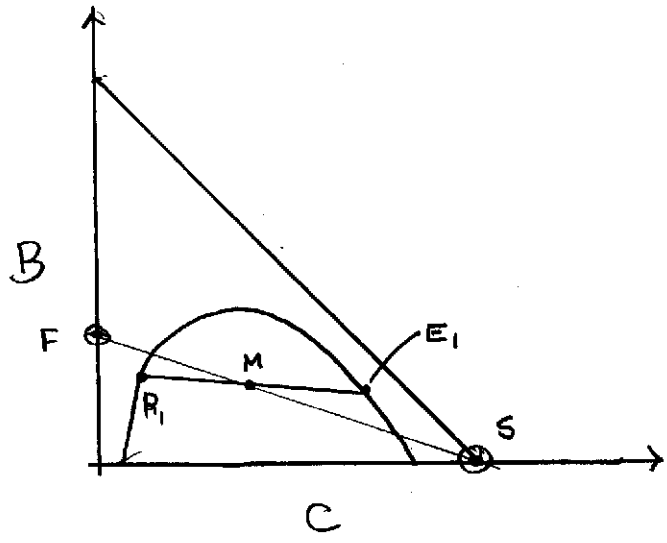
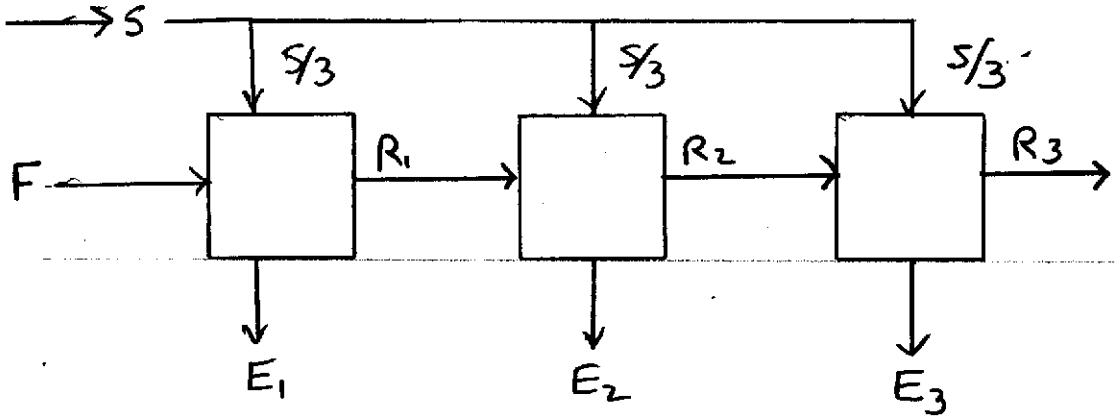
8-1 Cascades of Equilibrium Stages

Series





Cross Flow (Repeated application of solvent)



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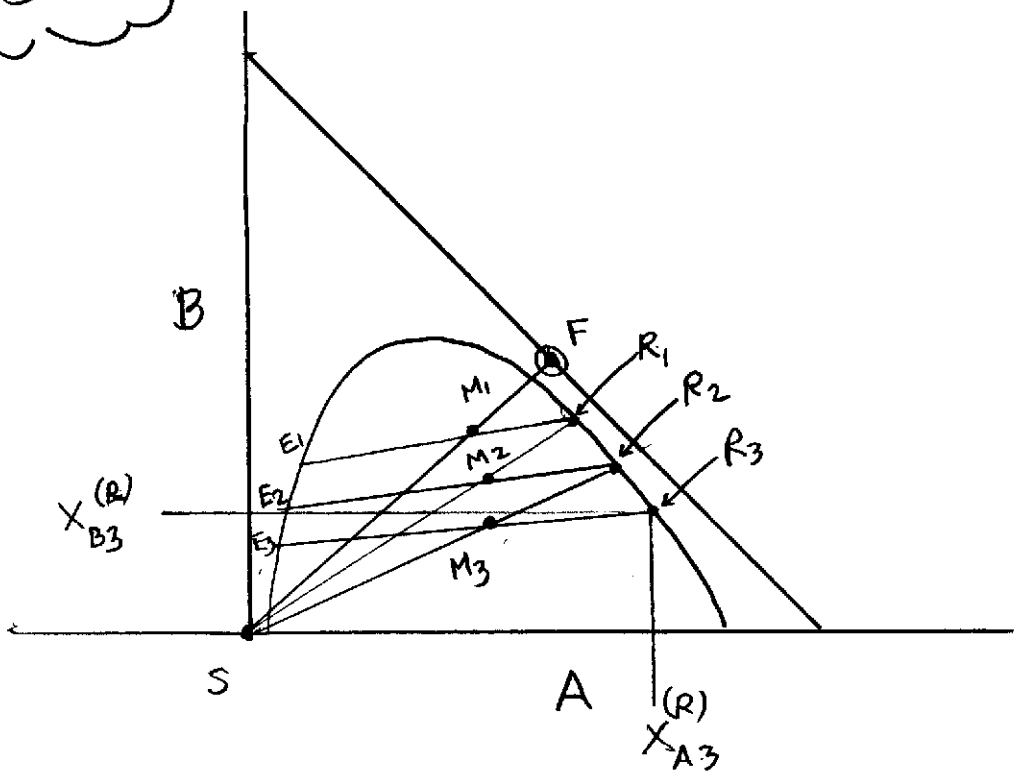


Notes and comments

(1) $n = 2, 3, 4, \ldots$

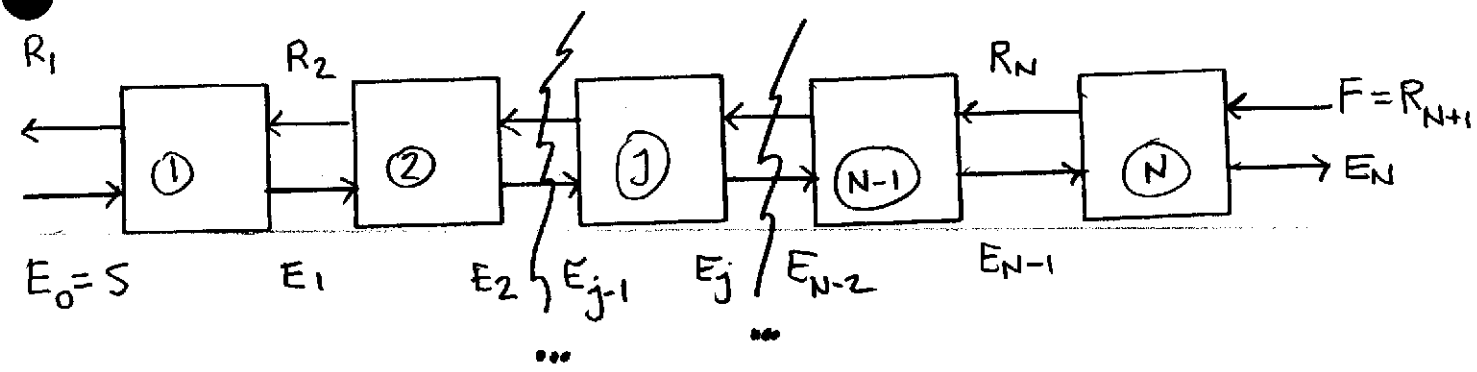
(2) Solvent does not need to be equally partitioned

(3) Solvent concentration may vary from stage to stage

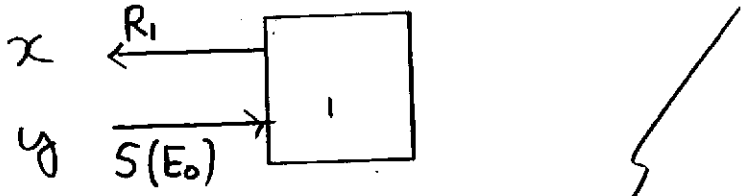
(4) Multiple solvents could be employed (Stage 1 use S1, Stage 2 use S2, etc).

8-3

Countercurrent extractions



$x_{A1}^{(R)} = x_{A1}$ ← simplex nomenclature



$x_{A0}^{(S)} = y_{A0}$ ←

External Balances

(1) $E_0 + R_{N+1} = R_1 + E_N$

$(S + F = R_1 + E_N)$

(2) $E_0 y_{A0} + R_{N+1} x_{AN+1} = R_1 x_{A1} + E_N y_{AN}$

(3) $E_0 y_{B0} + R_{N+1} x_{BN+1} = R_1 x_{B1} + E_N y_{BN}$

(or "C")

8-4

Equilibrium Relationships

(1) Each stage is an equilibrium contact so streams leaving a stage are at equilibrium.

$\therefore \quad E_1 = EE(R_1) \quad E_2 = EE(R_2)$ etc.

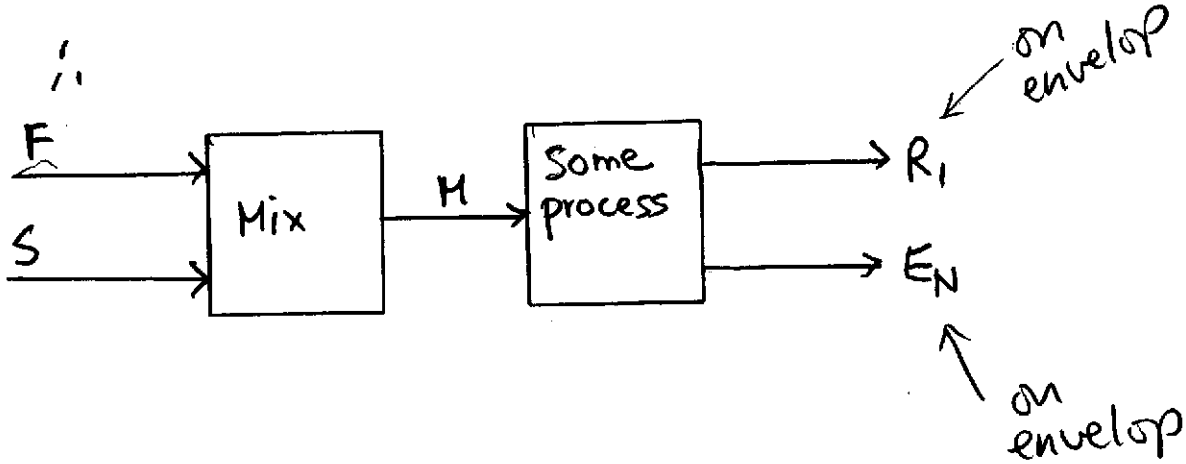
(same subscript)

(2) Streams at equilibrium must lie on phase envelop.

E_1, R_1, E_2, R_2, etc

(3) streams leaving the process are equilibrium streams, but not at equilibrium with each other.

$\therefore$



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This "black box" separation process has a mixing point M and its own balances.

Overall Balance

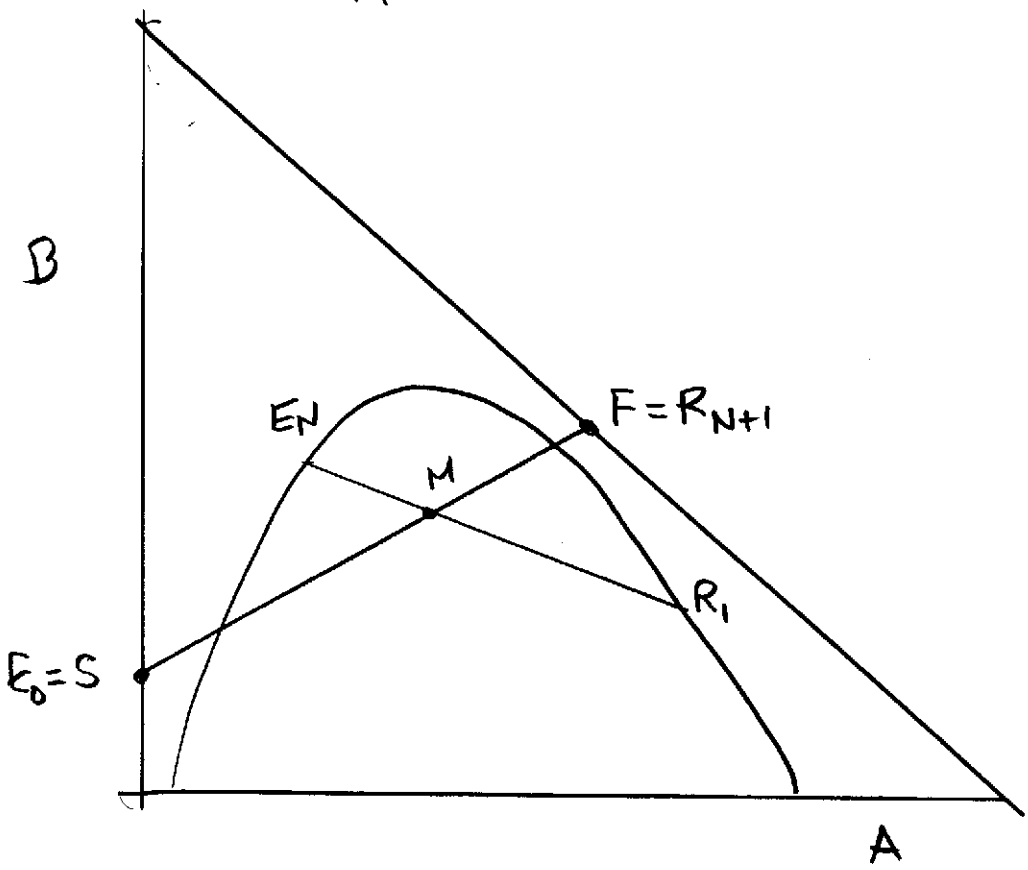
$$E_0 + R_{N+1} = M = E_N + R_1$$

Imaginary Mixing Op

$$S + F \equiv M \equiv E_0 + R_{N+1}$$

Imaginary Separation Process (Non Eq)

$$M \equiv E_N + R_1$$



The coordinates of "M" can be found by ILAR or analytically.

$$X_{AM} = \frac{E_0 y_{A0} + R_{N+1} X_{AN+1}}{E_0 + R_{N+1}}$$

$$X_{BM} = \frac{E_0 Y_{B0} + R_{N+1} X_{BN+1}}{E_0 + R_{N+1}}$$

Difference points and stage by stage calculations.

In the "real" process, we will need to do stage by stage calculations (in order to learn the number of stages required).

Given F, X_{AN+1}, X_{BN+1} (or C)

S, y_{A0}, y_{B0} (or C)

* , X_{A1}, X_{B1} (or C)

① Find y_{AN}, y_{BN}, E_N, R_1

* Assume specification for exit raffinate given in problem.

8-7

Note, these are external balances

(2) Start at stage 1.

E_1 is in equilibrium with R_1
(like $x_1 = f(y_1)$ in BD)
i.e. on same tie line

(3) Streams E_1 and R_2 are passing streams
(like $y_{j+1} = f(x_j)$)

Relate compositions by material balance.

Note Stream R_2 is in equilibrium with E_2 and therefore lies on phase envelop. (Find R_2)

(4) Stream E_2 relates to R_2 by equilibrium (tie-line)

(5) Streams E_2 and R_3 are passing streams