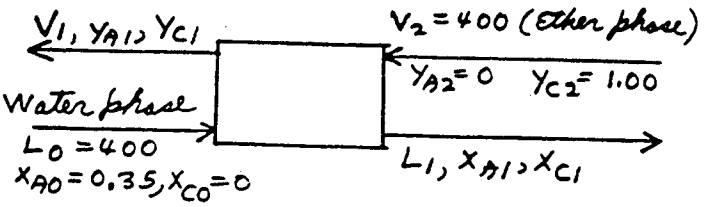
(12.5-2)

Eq.(12.5-12)

$L_0 + V_2 = M = L_1 + V_1$

$400 + 400 = 800 = M$



Eq.(12.5-13)

$L_0 x_{A0} + V_2 y_{A2} = M x_{AM}$

$400(0.35) + 400(0) = 800 x_{AM}$

$x_{AM} = 0.175$

Eq.(12.5-14)

$L_0 x_{C0} + V_2 y_{C2} = M x_{CM}$

$400(0) + 400(1.00) = 800 x_{CM}$

$x_{CM} = 0.50$

Plot point M on graph. Tie line through M gives L_1 and V_1.

L_1 Raffinate layer

$x_{A1} = 0.255$
$x_{C1} = 0.03$
$x_{B1} = 0.715$

V_1 Extract layer

$y_{A1} = 0.11$
$y_{C1} = 0.86$
$y_{B1} = 0.03$

Calculate L_1 and V_1 amounts.

Eq.(12.5-13)

$L_1 x_{A1} + V_1 y_{A1} = M x_{AM}$

$L_1(0.255) + V_1(0.11) = 800(0.175)$

Eq.(12.5-12)

$L_1 + V_1 = M = 800$

Solving,

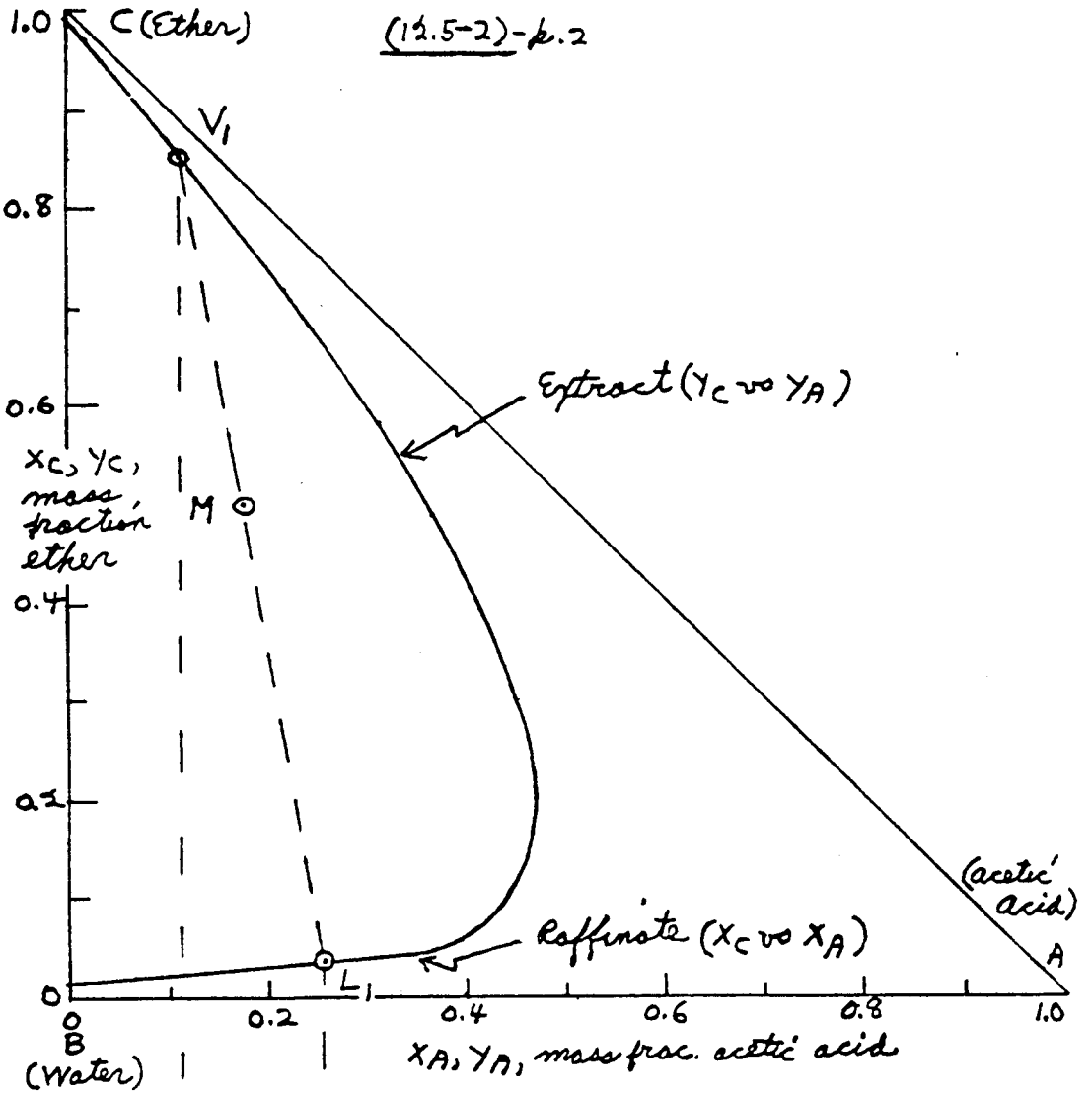
$L_1 = 358$ kg
$V_1 = 442$ kg

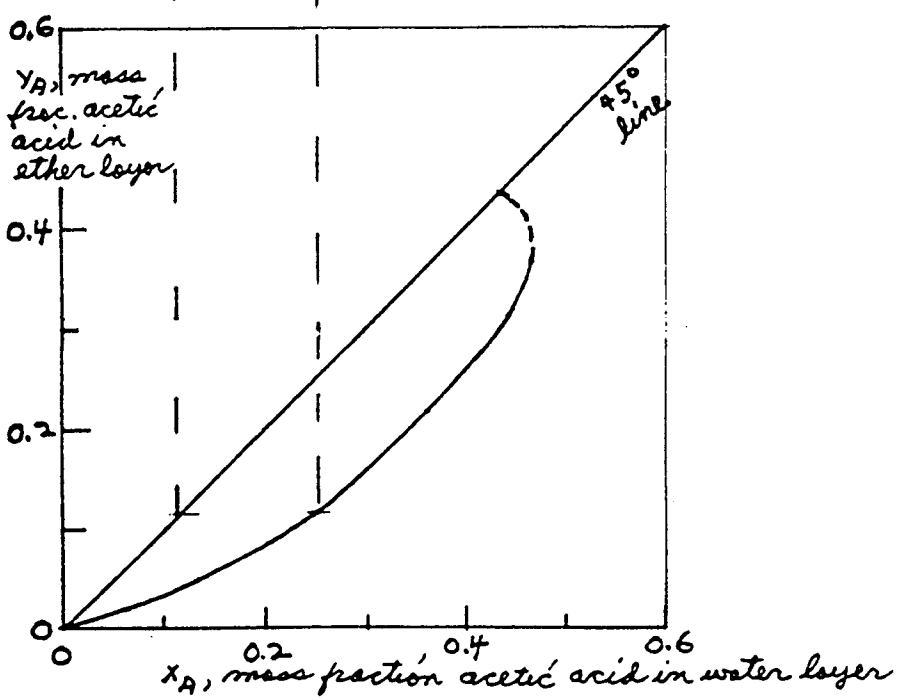
Original amount of A = 0.35(400) = 140 kg

Recovered in V_1 = 0.11(442) = 48.62 kg

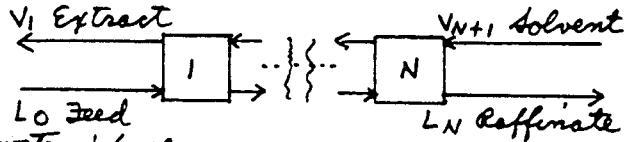
% recovered = $\frac{48.62}{140} \times 100 =$ **34.7% recovered**

(12.5-2)-p.2


1.0
C (Ether)
V1
0.8
0.6
Extract (Y_C vs Y_A)
X_C, Y_C, mass fraction ether
M
0.4
0.2
0
L1
Raffinate (X_C vs X_A)
(acetic acid)
A
0
0.2
0.4
0.6
0.8
1.0
B
(Water)
X_A, Y_A, mass frac. acetic acid


0.6
Y_A, mass frac. acetic acid in ether layer
45° line
0.4
0.2
0
0
0.2
0.4
0.6
X_A, mass fraction acetic acid in water layer

(12.7-2)



$L_0 = 200$ kg/h (feed)

$x_{A0} = 0.25$ acetic acid $\quad x_{C0} = 0$

$x_{B0} = 0.75$ H_2O $\quad x_{AN} = 0.03$ in exit water phase.

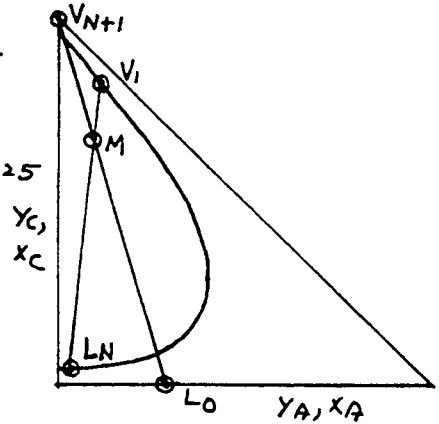
$V_{N+1} = 600$ kg/h (pure i pr. ether) $\quad y_{AN+1} = 0 \quad y_{CN+1} = 1.00$

Eq (12.7-3)

$$x_{CM} = \frac{L_0 x_{C0} + V_{N+1} y_{CN+1}}{L_0 + V_{N+1}} = \frac{200(0) + 600(1.0)}{200 + 600} = 0.75$$

Eq. (12.7-4)

$$x_{AM} = \frac{L_0 x_{A0} + V_{N+1} y_{AN+1}}{L_0 + V_{N+1}} = \frac{200(0.25) + 600(0)}{200 + 600} = 0.0625$$



Plot points V_{N+1}, L_0, and M. L_N on phase b. Locate V_1 by drawing line $L_N M$ to intersect extract phase boundary at V_1.

V_1	$y_{A1} = 0.070$
	$y_{C1} = 0.905$

L_N	$x_{AN} = 0.030$
	$x_{CN} = 0.017$

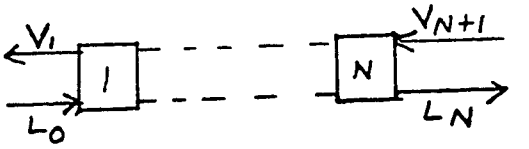
Eq. (12.7-1) $\quad L_0 + V_{N+1} = 200 + 600 = 800 = L_N + V_1 = M$

Eq. (12.7-2) $\quad L_0 x_{C0} + V_{N+1} y_{CN+1} = M x_{CM} = L_N x_{CN} + V_1 y_{C1}$

$$200(0) + 600(1.00) = 800(0.75) = L_N(0.017) + (800 - L_N)(0.905)$$

$L_N = 139.6$ kg/h $\quad V_1 = 660.4$ kg/h

(12.7-4)



$L_0 = 1000$ kg/h, $x_{AN} = 0.02$

$x_{A0} = 0.30$ $\quad V_{N+1} = 2,500$ kg/h

$x_{C0} = 0$ $\quad y_{AN+1} = 0$, $y_{CN+1} = 1.00$

(a) Minimum solvent

Tie line through L_0 gives $V_{1\,min}$. Line $L_N V_{N+1}$ and $L_0 V_{1\,min}$ (tie line) gives Δ pt. min. Draw line $L_N V_{1\,min}$ and $L_0 V_{N+1}$ and intersection gives M_{min}. $x_A = 0.114$

Eq (12.7-4) $x_{AM\,min} = 0.114 = \dfrac{L_0 x_{A0} + V_{N+1} y_{AN+1}}{L_0 + V_{N+1}} = \dfrac{1000(0.30) + V_{N+1}(0)}{1000 + V_{N+1}}$

$V_{N+1} = \boxed{V_{N+1\,min} = 1630 \text{ kg/h}}$

(b) Number of stages

Use $V_{N+1} = 2500$ kg/h

$x_{AM} = \dfrac{1000(0.30) + 2500(0)}{1000 + 2500} = 0.0857$ $\quad x_{CM} = \dfrac{1000(0) + 2500(1.0)}{1000 + 2500} = 0.714$

This point checks graphical determination of M on lines $L_N V_1$ and $L_0 V_{N+1}$

Draw line $L_N V_{N+1}$ and $L_0 V_1$ to obtain Δ op. point graphically.

Algebraic calculation of Δ op. point

$x_{AN} = 0.02$, $x_{CN} = 0.015$, $y_{A1} = 0.10$ (off graph), $x_{C1} = 0.863$

Eq. (12.7-1) $L_0 + V_{N+1} = L_N + V_1 = M$ $\quad 1000 + 2500 = 3500 = L_N + V_1$

Eq. (12.7-4) $x_{AM} = \dfrac{L_N x_{AN} + V_1 y_{A1}}{L_N + V_1}$ $\quad$ Solving, $L_N = 626$ $\quad V_1 = 2874$

Eq. (12.7-10) $x_{\Delta C} = \dfrac{L_0 x_{C0} - V_1 y_{C1}}{L_0 - V_1} = \dfrac{1000(0) - 2874(0.863)}{1000 - 2874} = +1.32$

$x_{\Delta A} = \dfrac{L_0 x_{A0} - V_1 y_{A1}}{L_0 - V_1} = \dfrac{1000(0.30) - 2874(0.10)}{1000 - 2874} = -0.0067$

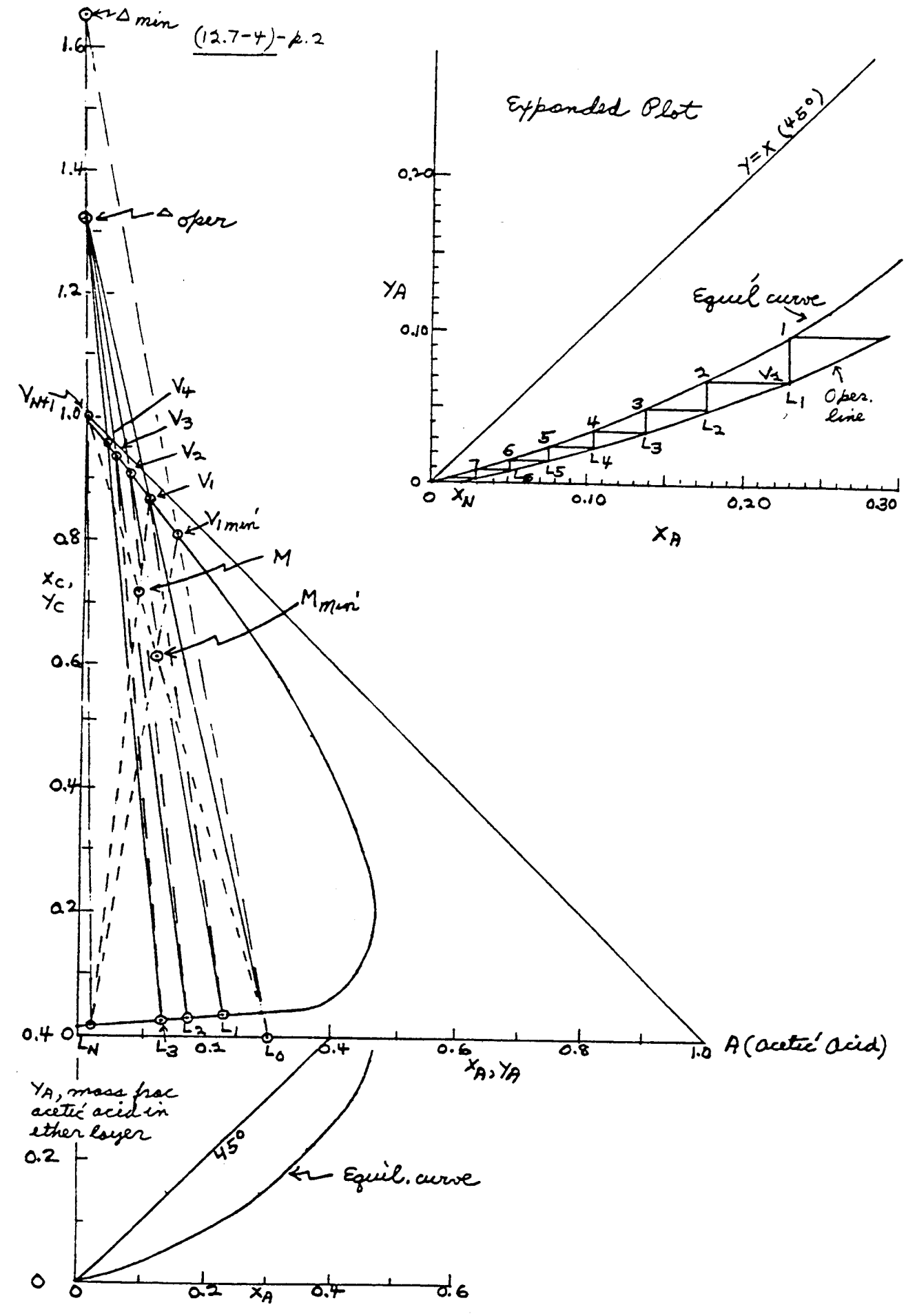
This checks the graphical Δ op. point.

Use Δ op. point to determine number of stages.

Plot stages up to V_4. Then, plot expanded scale as shown.

The operating points on expanded scale are $L_1 V_2$, $L_2 V_3$, etc., determined by lines from L to Δ op. point.

$\boxed{\text{Need } 7.5 \text{ stages}}$


(12.7-4)-p.2
Δ min
Δ oper
V4
V3
V2
V1
V1 min
M
M min
VN+1
1.0
1.6
1.4
1.2
0.8
0.6
0.4
0.2
0
xC, yC
LN
L3
L2
L1
L0
0.2
0.4
0.6
0.8
1.0
A (acetic acid)
xA, yA
Expanded Plot
y=x (45°)
Equil curve
Oper. line
yA
xA
xN
0.10
0.20
0.30
yA, mass frac acetic acid in ether layer
45°
Equil. curve