A.I.Ch.E. ANNUAL STUDENT COMPETITION

Foreword

Under the direction of the Advisory Committee on Student Chapters of which Professor Edwin M. Baker of the University of Michigan is Chairman, the American Institute of Chemical Engineers sponsored, in 1933, its second national competition on the solution of a Contest Problem, among members of the student chapter groups. Twenty-eight solutions of the current year's problem were submitted from members of eleven individual chapters.

On the recommendation of the Sub-Committee on Awards of which Dr. L. A. Pridgeon of the General Foods Corporation, Fairport, N. Y., was Chairman, Council awarded to Roy S. Arrandale of the University of Illinois, Urbana, Illinois, 1st prize—honorarium $100.00; to W. M. Yates, Washington University, St. Louis, Mo., 2d prize—honorarium $50.00; and to F. C. Schroeder, Iowa State College, Ames, Iowa, 3d prize—honorarium $25.00.

Following the practice approved by Council last year the 1st prize winning solution is published in the Transactions.

Frederic J. LeMaistre,
Secretary.

CONTEST PROBLEM

A.I.Ch.E. 1933 National Student Competition Sponsored by the Advisory Committee on Student Chapters. Open to Undergraduates Only

Statement

A producer of apple cider proposes to install evaporating equipment for the production of "Boiled Cider." After receiving an estimate of the cost of a horizontal tube single effect evaporator, the engineering department points out that a multiple effect evaporator should be considered. The manager requests the engineering department to prepare a proposal showing why he is justified in making any additional investment, with the stipulation that the added capital expenditure should be written off in four years. You, as Junior Engineer of the department, are requested to present

to receive assistance from others. (Handbooks and textbooks allowable.) Submission of a report for the competition implies adherence to this condition.

Solutions must be received by local Chapter Councillor fourteen days after statements of problems are issued at that chapter.

Solutions should be mailed by the Councillor of the Student Chapter before March 1, 1933 to

L. A. Pridgeon,
General Foods Corporation,
Fairport, New York.

FIRST PRIZE WINNING SOLUTION

CONTEST PROBLEM

1933

Student Chapters
American Institute of Chemical Engineers

Roy S. Arrandale
University of Illinois

Calculations for evaporating equipment for the production of "Boiled Cider"; concerning the choice of 1, 2, or 3 effects, the heating surface required, and the choice of copper, aluminum, or KA_2 evaporator tubes.

Data

Data on sugar solutions apply to cider with sufficient accuracy for this problem.

	Corresponding sugar soln.* Sp. grav.	Per cent sucrose
Initial conc. of cider 8 Bé.	1.0575	14.1
Final conc. of cider 32 Bé.	1.2787	58.1

Spec. Heats of Sugar Solutions †

Per cent	C (abs. joules/g. soln./deg. C.)
5	4.0
10	3.8
15	3.7
20	3.6
30	3.3
40	3.1
50	2.9
60	2.8

1 abs. joule equals 0.000948 B.T.U.

* Brown's Sugar Handbook.
† Int. Crit. Tables.

to the Senior Engineer calculations showing solution of the following questions:

Question 1: Should a single effect, a double effect or a triple effect evaporator be installed?

Question 2: How much heating surface is required when using 16 gage copper tubes; when using 16 gage aluminum tubes and when using 16 gage KA_2 tubes?

Question 3: Which tubes will be the most economical to use?

Data

Initial concentration of cider ..... 8° Bé.
Final concentration of cider ..... 32° Bé.
Data on sugar solutions for specific gravity, total solids, and boiling points apply to cider with sufficient accuracy for this problem.
Feed temperature is 125° F.
Available steam—15 lbs. gage pressure; quality 97 per cent; cost 40 cents per 1,000 pounds.
Available water at an average temperature of 50° F. at a cost of 10 cents per 1,000 gallons.
The plant will operate 24 hours per day for 100 days each year. It is to produce 7,500 gallons concentrated cider per day.
The tubes are to be of 16 B. and S. gage. It has been determined by experiment that copper tubes give an overall coefficient in a single effect evaporator of $U = 150$; in a double effect, 1st effect $U = 200$, 2d effect $U = 100$; in a triple effect, 1st effect $U = 200$, 2d effect $U = 150$, 3d effect $U = 100$. Experiments have also shown that aluminum tubes last 200 days, copper tubes 300 days and KA_2 tubes 500 days or more.
Copper tubes cost 30 cents per pound; aluminum tubes cost 45 cents per pound and KA_2 tubes cost $1.00 per pound.
Each body equipped with copper tubes costs $12,000.
Radiation equals 2 per cent of the heat transmitted through the heating surface of each effect.
Operation—continuous feed, forward flow.

Problem Arrangement

The exact arrangement of the report as to form and context are left to the contestant's judgment of how he can best meet the above requirements. It is understood that the contest problem is to represent the work of the individual student and that he is not

B. & S. ga.		Temp. F.	K	Sp. grav.	Av. wt. lb./cu. ft.	Thickness
16	Aluminum	212	119	2.55–2.8	165	0.051"
16	Copper	212	220	8.8–9.0	556	0.051
16	Steel	212	25.9	7.86–7.90	489	0.051

Data from Mark's Mech. Eng. Handbook.
K for KA_2 was assumed to be the same as for 1 per cent C steel.

Production—7,500 gals. conc. cider per day
Plant operation—24 hrs. per day; 100 days per yr. continuous feed, forward flow
Available steam—15 lbs. ga.; qual. 97 per cent; 249.85° F.; r equals 947.42 B.T.U. per lb.; cost 40 cents per 1,000 lbs.
Available water—av. temp. 50° F.: cost 10 cents per 1,000 gals.
Feed temp.—125° F.
Radiation—2 per cent of the heat transmitted through the heating surface of each effect

Each body equipped with copper tubes costs $12,000.

Tubes

	Copper	Aluminum	KA_2
Single effect U_1	150	149.8	147
Double effect U_1	200	199.3	196.3
U_2	100	99.8	98.5
Triple effect U_1	200	199.3	194.3
U_2	150	149.6	147
U_3	100	99.8	98.5
Life, in days	300	200	500
Cost per lb.	30¢	45¢	$1

U values for Al and KA_2 were calculated from the expression—$1/U = L/k + K$; values for Cu already known.

1. Assuming a 26" Hg. vac. in the last effect—30" bar. abs. pres. in last effect of 101.6 mm. Hg.
2. Assuming an av. static head of 3 ft. of solution in each effect.