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A New Absorption Cycle: The Single-Effect Regenerative Absorption Refrigeration Cycle

Kim Dao

February 1978

Lawrence Berkeley Laboratory University of California/Berkeley

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A NEW ABSORPTION CYCLE: THE SINGLE-EFFECT REGENERATIVE ABSORPTION REFRIGERATION CYCLE

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THE SINGLE-EFFECT REGENERATIVE ABSORPTION REFRIGERATION CYCLE

ABSTRACT

A new absorption cycle, using heat as the energy source, was proposed to produce refrigeration. This proposed cycle, referred to as the single-effect regenerative absorption cycle or cycle 1R, has a performance much superior to the well-known basic absorption cycle, namely: the coefficient of performance (COP) is higher at higher input temperatures and the "cut-off" input temperature is very much lower. The cycle 1R operates with a multistage boiler and a multi-stage absorber in such a way that each stage of the heat input and heat rejection processes of the cycle occurs essentially at constant temperature rather than at constant pressure. The greatest part of the high pressure refrigerant vapor subsequently condensed is generated in an adiabatic multi-section regenerator rather than in the boiler (or the generator). The greatest part of the heat necessary to generate the high pressure refrigerant vapor comes from the absorption of the evaporator vapor by the very weak solution leaving the boiler. This absorption process occurs in the regenerator. Because the regenerator is adiabatic, the cycle receives and rejects heat at essentially constant temperatures. Therefore, the COP of the cycle approaches the Carnot COP.

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NOMENCLATURE

m = mass flow rate relative to the mass flow rate of line 1, Figure 3.

h = enthalpy, Btu/lb

X = concentration, lb NH_3/lb of mixture

T_B = highest temperature of the solution in the boiler, °F

T_E = lowest saturated temperature in the evaporator, °F

$T_C = T_O$ = lowest saturated temperature in the condenser or in the absorber, °F

COP = coefficient of performance = q_E/q_B

q_B = total heat input to the boiler

q_E = total heat input to the evaporator

P_E = evaporator pressure, psia

P_C = condenser pressure, psia

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INTRODUCTION

The single-effect regenerative absorption refrigeration cycle (or cycle 1R) is a new absorption cycle that has better performance at high input temperatures than the well-known basic absorption cycle. The cycle 1R also has a substantially lower "cut-off" generator temperature. Although the basic single-effect absorption cycle[1] has been used for decades as a means to produce refrigeration, using heat as the energy source, it has two undesirable characteristics,[1] namely, the almost constant coefficient of performance (COP) with increasing input temperatures, and the cut-off input temperatures below which the basic cycle ceases to operate. Because of these deficiencies, for solar energy applications the basic cycle cannot benefit from the development of efficient high temperature collectors, and cannot be used during considerable periods when the insolation is low. The cycle 1R's much higher COP at high input temperatures and workable COP at very low input temperatures largely eliminate the shortcomings of the basic cycle.

DESCRIPTION OF CYCLE 1R

The cycle 1R consists of nine processes (Figure 1):

1. Process B. This is an approximately constant, high temperature heat input process called the <u>boiling process</u>. In Figure 1 this process starts from station III and ends at station IV, going along the constant temperature line at T_B = 270°F. At station III the solution is

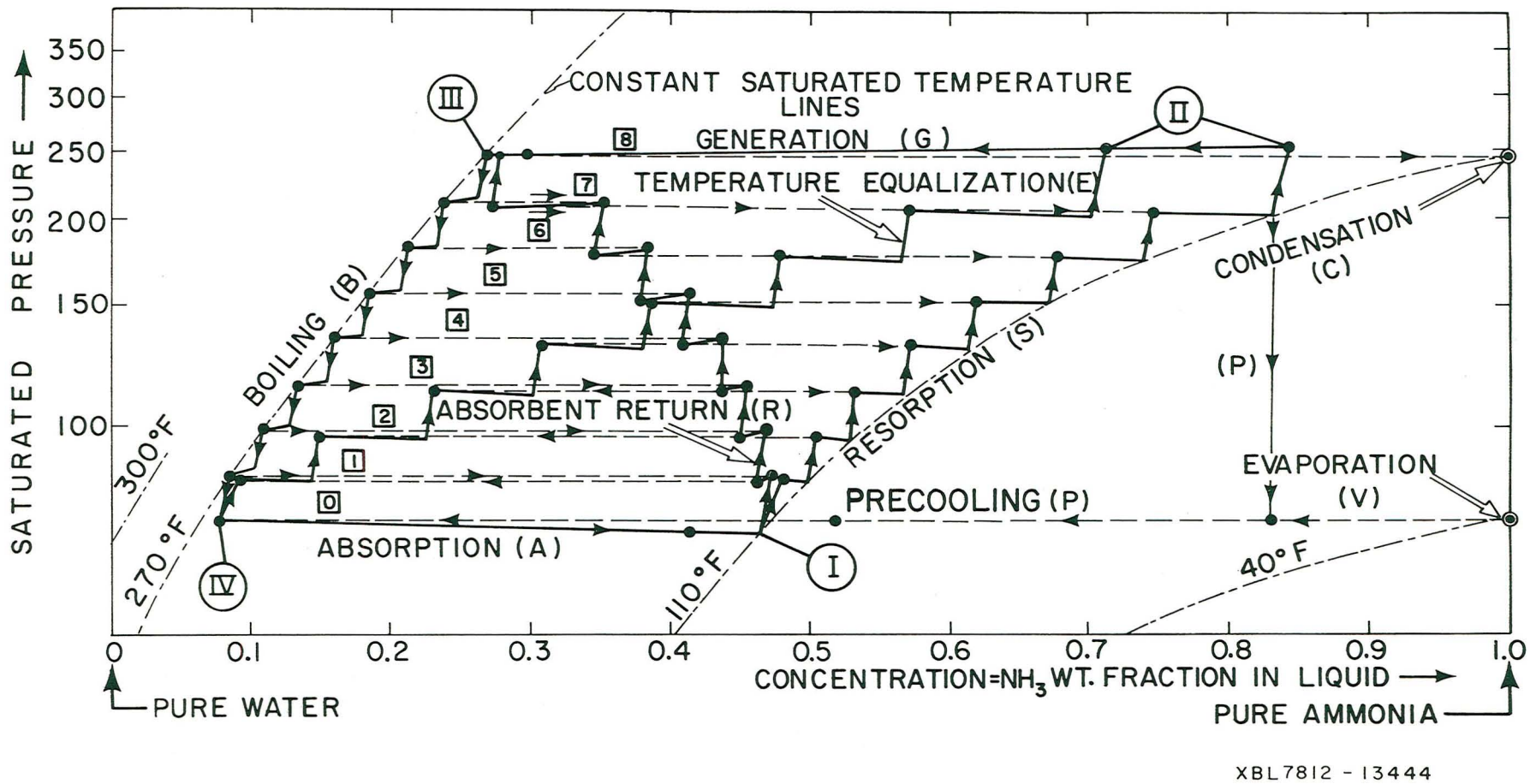

Figure 1. Thermodynamic diagram of cycle 1R.

heated to T_B at pressure level 8. No further boiling is possible at this pressure level because the temperature of the solution has reached the highest value obtainable from the heat source. Further boiling is possible only when the solution is throttled down to the successive pressure levels 7, 6, 5 ... 1. Pressure level 8 corresponds to the condenser pressure P_C, and level 0 corresponds to the evaporator pressure P_E. The temperature span through which the solution boils depends on the number of pressure levels existing between the condenser and the evaporator pressures (in Fig. 1, eight pressure levels are shown). Fewer pressure levels are needed if this temperature span is allowed to increase at the expense of the performance.

2. Process G. The generation process produces refrigerant vapor at essentially constant high pressure. In Figure 1 this process starts from station II and ends at station III, going along the essentially constant pressure line at $P_C \approx 247$ psia. The difference in pressure between stations II and III represents the pressure drop across the flow path of generation process G. The high pressure vapor generated can be collected once at station III or successively at many locations along the generation process.

3. Process A. This process occurs at essentially constant low pressure for the absorption of refrigerant vapor. The absorption process shown in Figure 1 starts from station IV and ends at station I, going along the essentially constant pressure line at $P_{Evap.} \approx 73$ psia. The difference in pressure between stations IV and I represents the pressure drop across the flow path of the absorption process. The vapor to be absorbed comes from the evaporator and is fed once at station IV or successively at many locations along the absorption process.

4. Process R. The absorbent return process is a multi-pressure-stage process for the return of the absorbent to the absorption process A via the boiling process B. In Figure 1 this process starts from station I and ends at station III, going along the multi-stage diagonal. A pressure stage of the absorbent return process R corresponds to each pressure stage of the boiling precess B. During this process R vapor can be generated or absorbed, depending on the temperatures T_B, T_C and T_E.

5. Process E. This is a multi-pressure-stage process for the absorption or generation of vapor, depending on the needs of process R. It is called temperature equalization. In Figure 1 this process starts from station IV (or from station II) and ends at station II (or at station IV), along the multi-stage diagonal.

A pressure stage of this process E corresponds to each pressure stage of the boiling process B. Pumping or expansion is required, depending on the direction of process E.

6. Process S. Occurring at approximately constant ambient temperature for heat rejection, the resorption process starts from station I and ends at station II (Figure 1), going along the constant temperature line at $T_o \approx 110°F$. Each pressure stage of this process corresponds to a pressure stage of process B. The vapors absorbed in this process come from processes B and R (or B and E).

7. Process C. This is the condensation process of the refrigerant vapor at high pressure.

8. Process V. This is the evaporation process, at low pressure, of the refrigerant liquid coming from the condenser for the production of refrigeration.

9. Process P. This is the precooling process: the very strong solution at station II is bled from high pressure to the evaporator pressure and then mixed with the cold vapor exiting the evaporator. This is used for precooling the liquid refrigerant leaving the condenser.

HEAT EXCHANGERS USED IN CYCLE 1R REFRIGERATORS

The heat exchangers used in cycle 1R refrigerators are (see Figure 2):

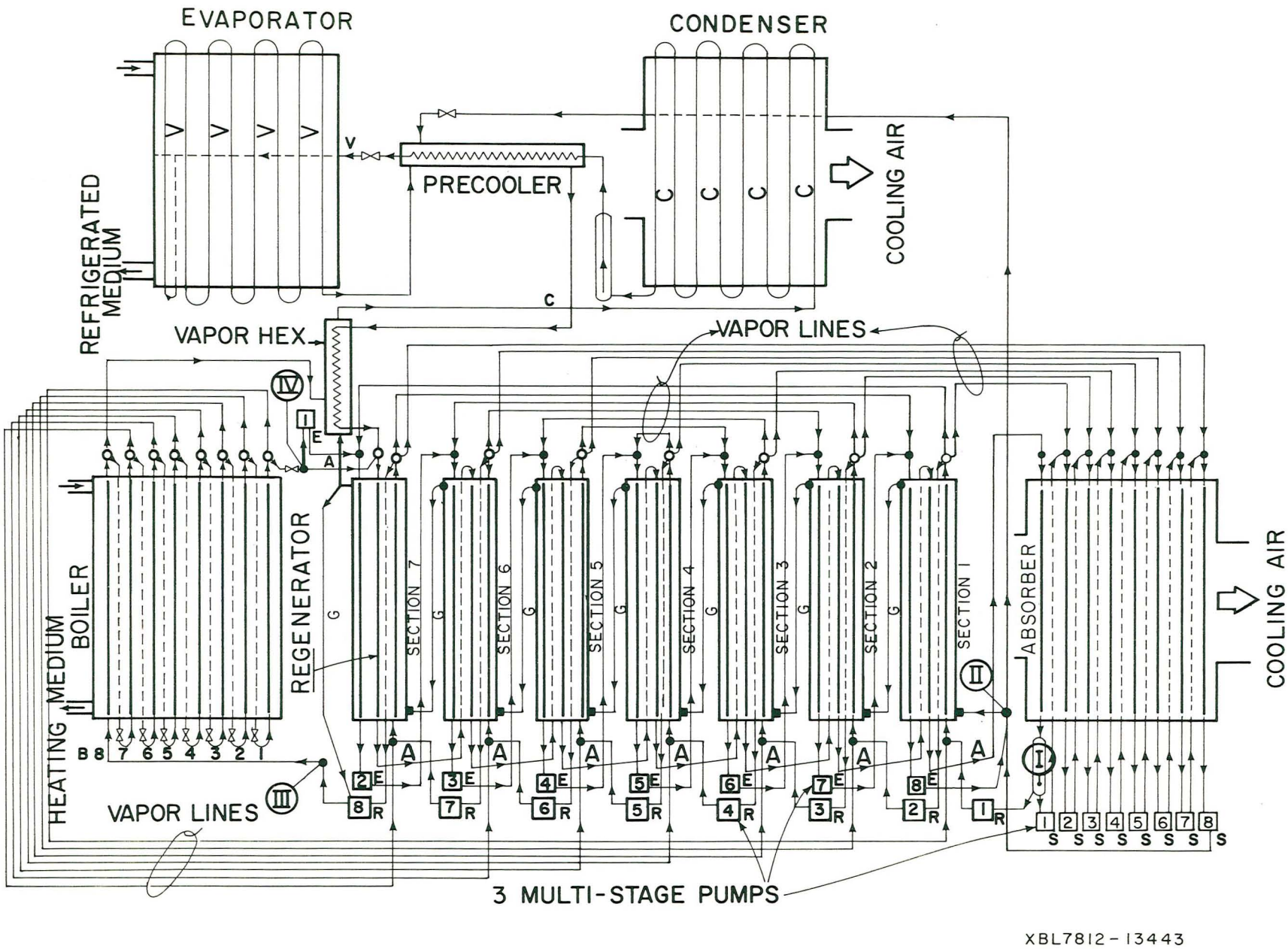

Figure 2. Schematic configuration of cycle 1R refrigerators.

1. A boiler in which the heating medium (heat source) transfers heat to boiling process B.

2. A multi-section regenerator in which the G, A, R, and E processes exchange heat. Processes R and E occur at constant pressure in each section of the regenerator. Processes G and A occur at essentially unchanged pressures throughout all the sections of the regenerator. Two multistage pumps are used to pump the products of R and E from each pressure level of each section of the regenerator to the next. The number of sections in the regenerator is equal to the number of pressure levels minus two. In Figure 2 there are nine pressure levels; therefore, the regenerator has seven sections. Eight pressure levels, labeled from 1 to 8, are located at the pump boxes while the ninth level, the lowest pressure level, is located at the evaporator (labeled O in Figure 1). Process A and (if operating temperatures permit) process E are absorption processes that reject heat to processes G and R. Depending on operating temperatures, processes R and E can be either absorption or generation processes.

3. A vapor heat exchanger (vapor HEX.) in which the hot vapors collected at the end of process G and from pressure level 8 of the boiler exchange heat with the warm vapor exiting the precooler. The condensate given up by the hot vapor is returned to station III, possibly by gravity.

4. An absorber where the resorption process S is cooled by ambient air. A multi-stage pump is used here to pump the rich solution from one pressure level to the next.
5. A condenser cooled by ambient air.
6. An evaporator.
7. A precooler.

OPERATION OF THE CYCLE 1R REFRIGERATOR

The operation of the single-effect regenerative absorption cycle is described below and can be traced by reference to labels in Figure 2. The letters A, B, C, E, G, R, S, V represent the cycle processes, the numbers 0, 1, 2, ... 8 represent the pressure levels and the roman numerals I, II, III, IV represent the main reference stations where the processes start or end.

1. Vapor generation

The very strong solution at station II is circulated through the regenerator sections in series (shell side of the heat exchangers labeled G). It receives heat from the counterflow processes A and E, and therefore starts boiling from station II to station III. At station III the vapor generated by process G is diverted to the vapor HEX., and the remaining solution expands to the suction line at stage 8R of pump R. There, it mixes with the solution at the outlet of process R. This mixture is then pumped to the boiler in which boiling process B occurs. At the end of each coil of the boiler, the solution becomes weaker and weaker. Because the boiling process is intended

to maintain constant temperature, the pressure must be reduced to allow the boiling of the weaker solution. To effect pressure reduction, restrictors are used at B7, B6, ... B1. Vapors are collected at each pressure stage of boiling process B to be diverted subsequently, at essentially the same pressure level, to the corresponding pressure level of process R (by the group of vapor lines leaving the boiler shown in Figure 2). Because the vapor collected at pressure level 8 of the boiler is at the condenser pressure, it is fed to the vapor heat exchanger. These vapor lines are in fact packed with pall rings to facilitate their rectification by direct contact with the solution bled from pump R (and/or pump S). Bleeding lines are not shown in Figure 2. Now, at the outlet of the last boiler stage (station IV), the very weak solution is separated into two flow paths in the regenerator: the first path (path A) constitutes the absorption process A and the second path (path E) constitutes the temperature equalization process E. The mass flow rate of path E is much smaller than the mass flow rate of path A. Thus, some sort of controller is needed to control the speed of pump E and vary the mass flow rate to path E. Essentially, the controller tries to keep invariable the pressure difference ($\Delta P_1 = P_8 - P_7$) between the suction and delivery sides of the last stage (stage 8E or 8S) of pump E (or pump S). Every stage of pump E has a bypass calibrated restrictor connected between the suction and the delivery tubes such that when pump E runs fast, the flow direction of path E is from station IV to station II, and when pump E runs slow, the flow direction of path E is reversed because the leakage through the bypass restrictors is more than the pump E capacity.

The reversed process E is a vapor generation process which supplies the vapors for absorption in processes R and S. An increase in ΔP_1 slows down pump E.

2. Vapor Absorption

The absorption process A begins at station IV where the very weak solution starts absorbing the vapor coming from the evaporator via the precooler and the vapor heat exchanger. The absorption process A continues throughout the regenerator sections, essentially at constant evaporator pressure. From the outlet of the last section of the regenerator, in the direction of process A, the solution flows to the absorber where it absorbs more vapor from the evaporator. Finally this solution is stored in the solution accumulator at station I.

From the accumulator at station I, the solution is pumped into two flow paths. The first path (path R) constitutes the absorbent return process R, and the second path (path S) constitutes the resorption process S. In process S, the solution is pumped through the absorber for further absorption of refrigerant vapor collected at the pressure stage outlets of process R. The solution leaving the last stage (stage 8) of the absorber is a very strong solution that can be boiled at low temperature in the first section of the regenerator (section 1). The resorption process S is a heat rejection process intended to maintain constant temperature; therefore, it occurs at a higher pressure level as the solution becomes stronger. Each pressure level of the absorber corresponds to a pressure level of the boiler, except that the highest pressure level of the boiler corresponds to the

condensation pressure and the lowest pressure level of the absorber corresponds to the evaporator pressure. The mass flow rate to the absorber at station I is controlled by the pressure difference ($\Delta P_2 = P_1 - P_0$) between the evaporator and the first stage outlet of pump S. An increase in ΔP_2 results in an increase in flow rate of S. ΔP_2 is to be kept constant.

Because each pound of absorbent contained in the solution of the generation process G is associated with a larger change in concentration ($\Delta X_G = X_{II} - X_{III}$) than a pound of absorbent contained in the solution of the absorption process A ($\Delta X_A = X_I - X_{IV}$), the amount of refrigerant generated by G into the condenser is always larger than the amount of refrigerant that can be absorbed by A from the evaporator. Therefore, some sort of absorbent compensation is needed, and this is furnished by the absorbent return process R, which provides the extra amount of absorbent necessary to completely absorb the refrigerant vapor from the evaporator. The mass flow rate of the absorbent of process R from station I is controlled by the evaporator temperature or pressure. A higher evaporator pressure means there is not enough flow rate to process R and a lower temperature means the opposite. Process R continues throughout the sections of the regenerator and in fact each section of the regenerator corresponds to a pressure stage of process R. Depending on the temperature attainable by the solution in each section of the regenerator, vapor generation or vapor absorption can occur. As a rule, when the temperature of the boiling process is greater than the cut-off generator temperature of the basic single-effect absorption

cycle, vapor generation occurs. The opposite happens when the boiling temperature is less than the cut-off temperature.

Note that the vapors collected at the pressure-stage outlets of the boiler are first rectified by direct contact with the solution bled from R, then fed to process R. From there they are fed to processes E and S via vapor-line groups. At the exit of the last section of the generator (Section 7), the solution of process R is mixed with the solution exiting process G and then pumped to the boiler.

3. Temperature equalization.

To minimize the irreversibilities of the regeneration processes caused by the unequal temperature drop across process A which rejects heat, and the temperature rise across processes R and G which absorb heat, a temperature equalization process E is needed. This process E tends to equalize the temperature drop of the heat rejecting processes A and E to the temperature rise of the heat receiving processes R and G across all the sections of the regenerator.

Process E is an absorption process when R is a generation process and vice-versa. When E is an absorption process, it starts at station IV and ends at station II. When E is a generation process, it starts from II and ends at IV. Each section of the regenerator corresponds to a pressure stage of process E. The vapors absorbed (or generated) by the solution of the temperature equalization process E come from (or are fed into) the absorbent return process R at the same pressure level. (Note that there is a complete balance between the vapor generated and the vapor absorbed by the processes B, R, E and S at each pressure level).

4a. Production of Refrigeration

The hot vapor generated by process G and by the highest pressure stage of boiling process B is collected to the inlet (shell side) of the vapor heat exchanger (vapor HEX.). This high pressure vapor is cooled and rectified by the counterflow coil of low pressure vapor coming from the precooler. It is subsequently condensed in the condenser, subcooled across the precooler, expanded to low pressure and boiled in the evaporator to produce refrigeration. At the outlet of the evaporator, the cold refrigerant vapor is mixed with the boiling cold solution that is expanded to low pressure from station II. This mixture serves as a heat sink for the precooling of the condensed liquid refrigerant.

4b. Production of Work:

Obviously, instead of condensing the hot vapor generated by process G in the condenser for the production of refrigeration, the hot vapor can be expanded into the evaporator pressure through some fluid engine for the production of work. The efficiency of cycle 1R working as a power cycle is greater than that of the Rankine cycle using the same refrigerant as working fluid. It has fewer irreversibilities, particularly at input temperatures approaching the critical temperature of the refrigerant.

PRELIMINARY ESTIMATE OF THE PERFORMANCE OF CYCLE 1R

For a preliminary estimate, Figure 3 can be used to calculate the performance of cycle 1R (a minimum of six pressure stages is needed).

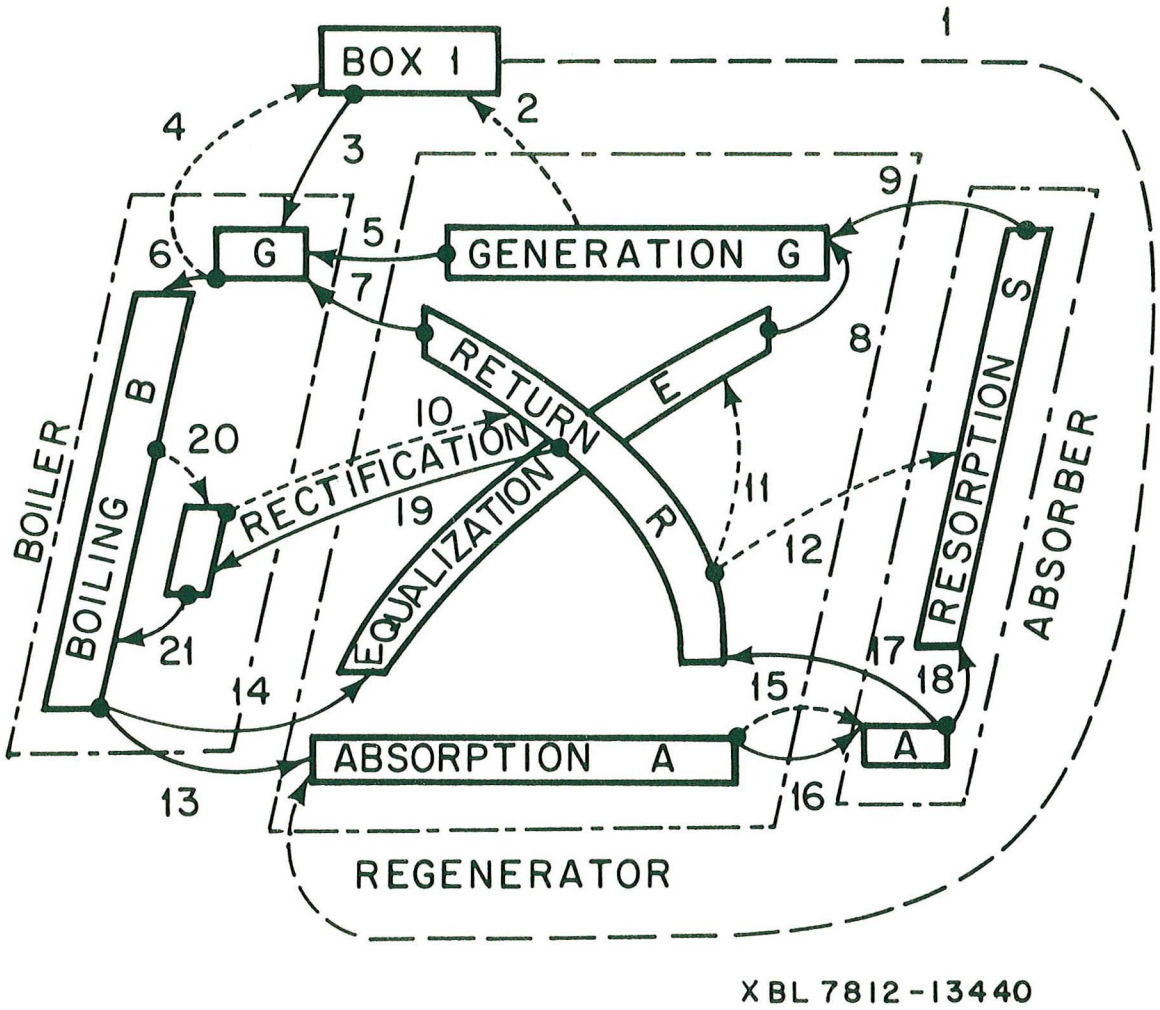

Figure 3. Schematic of system used for estimating the performance of cycle 1R. The solid lines represent solution lines, and the dotted lines represent vapor lines. Box 1 represents the ensemble of heat exchangers including: condenser, precooler, evaporator, and vapor HEX.

Assumptions:

1. The vapors generated by the boiler are at different pressure levels but are lumped together at one vapor line: line 20. These vapor lines are rectified by bleeding lines from pump R (represented by line 19 in Figure 3 but not shown in Figure 2). The properties of line 20 are taken to be the weighted average properties of lines 6 and 13. The properties of line 19 are taken to be the weighted average of lines 7 and 17: the weight factors are 0.33 for line 7 and 0.67 for line 17. The properties of line 21 are the weighted averages between lines 6 and 13 with weight factors of 0.17 for line 6 and 0.83 for line 13.
2. The vapors generated by process R are lumped into lines 11 and 12.
3.

Table 1. Weight factors of average properties.

Properties of line	Average of lines	Respective weight factors
20	6 and 13	0.29 and 0.71
19	7 and 17	0.33 and 0.67
21	6 and 13	0.17 and 0.83
10	7 and 17	0.33 and 0.67
12	7 and 17	0.33 and 0.67
11 (From R to E)	7 and 17	0.33 and 0.67
11 (From E to R)	Evaluated at $P = P_{C1}$ and $T = T_C + 25$.	

4. The refrigerant-absorbent pair used is NH_3/H_2O (properties are taken from Reference 2).

5. The line pressure drops are neglected.

6. The pumping works are neglected.

7.

Table 2. The saturated temperatures and pressures from which the properties of the lines are found.

Line No.	Temperature (°F)	Pressure (psia)
Evaporator	T_E	P_E = Saturated pressure at T_E of NH_3
Condenser	T_C	P_C = Saturated pressure at T_C of NH_3
6	T_B	P_C
13	T_B	$P_{E1} = P_E(P_C/P_E)^{0.125}$, or $= P_E + 10.$
4	T_B	P_C
3	T_B-15	P_C
5	T_B-15	P_C
7	T_B-20	$P_{C1} = P_E(P_C/P_E)^{0.875}$, or $= P_C - 30.$
9	T_C	P_{C1}
15	T_C+15	P_E
16	T_C+15	P_E
17	T_C	P_E
18	T_C	P_E
8 from E to G	T_C+15	P_{C1}
8 from G to E	T_C	P_{C1}
14 from B to E	T_B	P_{E1}
14 from E to B	T_B-20	P_{E1}
2	$T_C+(T_B-T_C)/3$	P_C

8. We propose to calculate the COP as a function of the boiler temperature T_B and compare it to the Carnot COP defined as:

$$\text{Carnot COP} = \frac{T_B - T_O}{T_B + 460} \times \frac{T_E + 460}{T_O - T_E}$$

9. One pound of vapor generated at line 1 produces 500 Btu of cooling. Therefore:

$$\text{COP} = 500\ m_1/q_B\ ,$$

where

$$q_B = m_4 h_4 + m_{10} h_{10} + m_{13} h_{13} + m_{14} h_{14}$$
$$- m_7 h_7 - m_5 h_5 - m_3 h_3 - m_{19} h_{19}\ .$$

The m's are the mass flow rates, the h's are the specific enthalpies. The concentration is defined as:

$$X = \frac{\text{mass of refrigerant}}{\text{Total mass of solution (or vapor)}}\ .$$

10. The second law of thermodynamics is assumed to be satisfied for the processes in the adiabatic regenerator; that is, heat transfer is possible so that the enthalpies used in the energy balance for the regenerator are correct.

The following equations can be written for the system:

<u>Msss balances</u>:

$$m_1 = 1.0$$

$$m_3 + m_5 + m_7 = m_6 + m_4$$

$$m_9 + m_8 = m_5 + m_2$$

$$m_6 = m_{13} + m_{14} + m_{10} - m_{19}$$

$$m_{17} + m_{10} = m_7 + m_{11} + m_{12} + m_{19}$$

$$m_{14} + m_{11} = m_8$$

$$m_{18} + m_{12} = m_9$$

$$m_{13} + 1 = m_{16} + m_{15}$$

$$m_{13} + 1 = m_{17} + m_{18}$$

$$m_{20} + m_{19} = m_{10} + m_{21}$$

<u>NH_3 Mass balances:</u>

$$m_3X_3 + m_5X_5 + m_7X_7 = m_6X_6 + m_4X_4$$

$$m_9X_9 + m_8X_8 = m_5X_5 + m_2X_2$$

$$m_6X_6 = m_{13}X_{13} + m_{14}X_{14} + m_{10}X_{10} - m_{19}X_{19}$$

$$m_{17}X_{17} + m_{10}X_{10} = m_7X_7 + m_{11}X_{11} + m_{12}X_{12} + m_{19}X_{19}$$

$$m_{14}X_{14} + m_{11}X_{11} = m_8X_8$$

$$m_{18}X_{18} + m_{12}X_{12} = m_9X_9$$

$$m_{13}X_{13} + X_1 = m_{16}X_{16} + m_{15}X_{15}$$

$$m_{13}X_{13} + X_1 = m_{17}X_{17} + m_{18}X_{18}$$

$$m_{20}X_{20} + m_{19}X_{19} = m_{10}X_{10} + m_{21}X_{21}$$

$$m_{20}h_{20} + m_{19}h_{19} = m_{10}h_{10} + m_{21}h_{21}$$

<u>Energy balance for the adiabatic regenerator:</u>

$$m_1h_1 + m_{13}h_{13} - m_{16}h_{16} - m_{15}h_{15}$$
$$+ m_{17}h_{17} + m_{10}h_{10} - m_7h_7 - m_{12}h_{12} - m_{19}h_{19}$$
$$+ m_{14}h_{14} + m_9h_9 - m_5h_5 - m_2h_2 = 0$$

For a given set T_B, T_C, T_E, the X's and the h's are known saturated properties, therefore the solution of the above 20 equations gives the mass flow rates from which the COP can be calculated.

[NOTE: The enthalpy h_1 at the outlet of the vapor heat exchanger is taken to be $h_1 = 580 + 0.7\ (T_B-150)$ and $X_1=0.998$]

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The COP's are plotted approximately in Figures 4, 5 and 6. Calculated results are given the Appendix. (Negative mass flow rates indicate reversed flow, opposite to the arrows in Figure 3).

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2. Physical and Thermodynamic Properties of Ammonia-Water Mixtures. Research Bulletin No. 34, I.G.T. - A.G.A., September 1964.

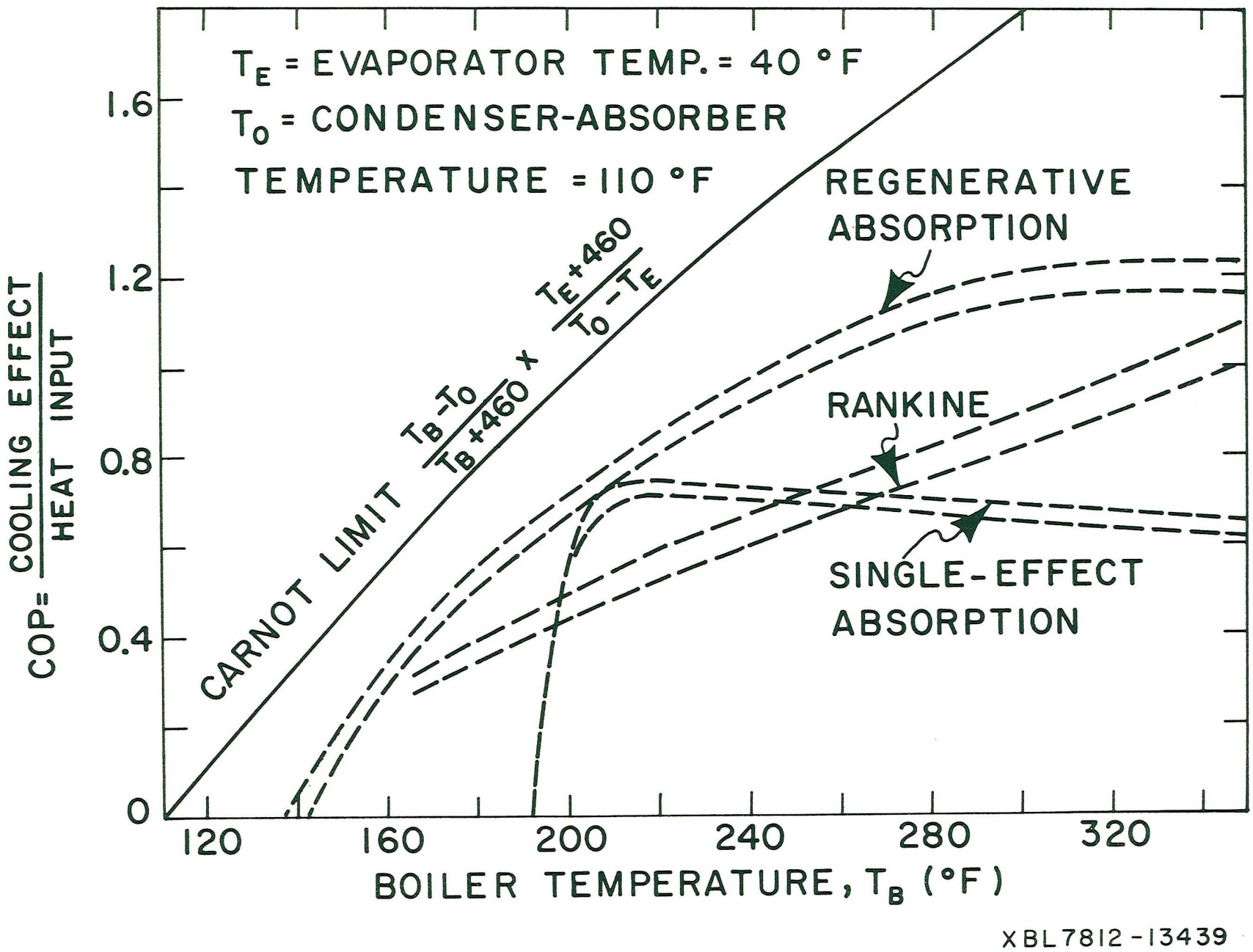

Figure 4. Calculated performance of cycle 1R (regenerative absorption) using NH_3/H_2O mixtures.

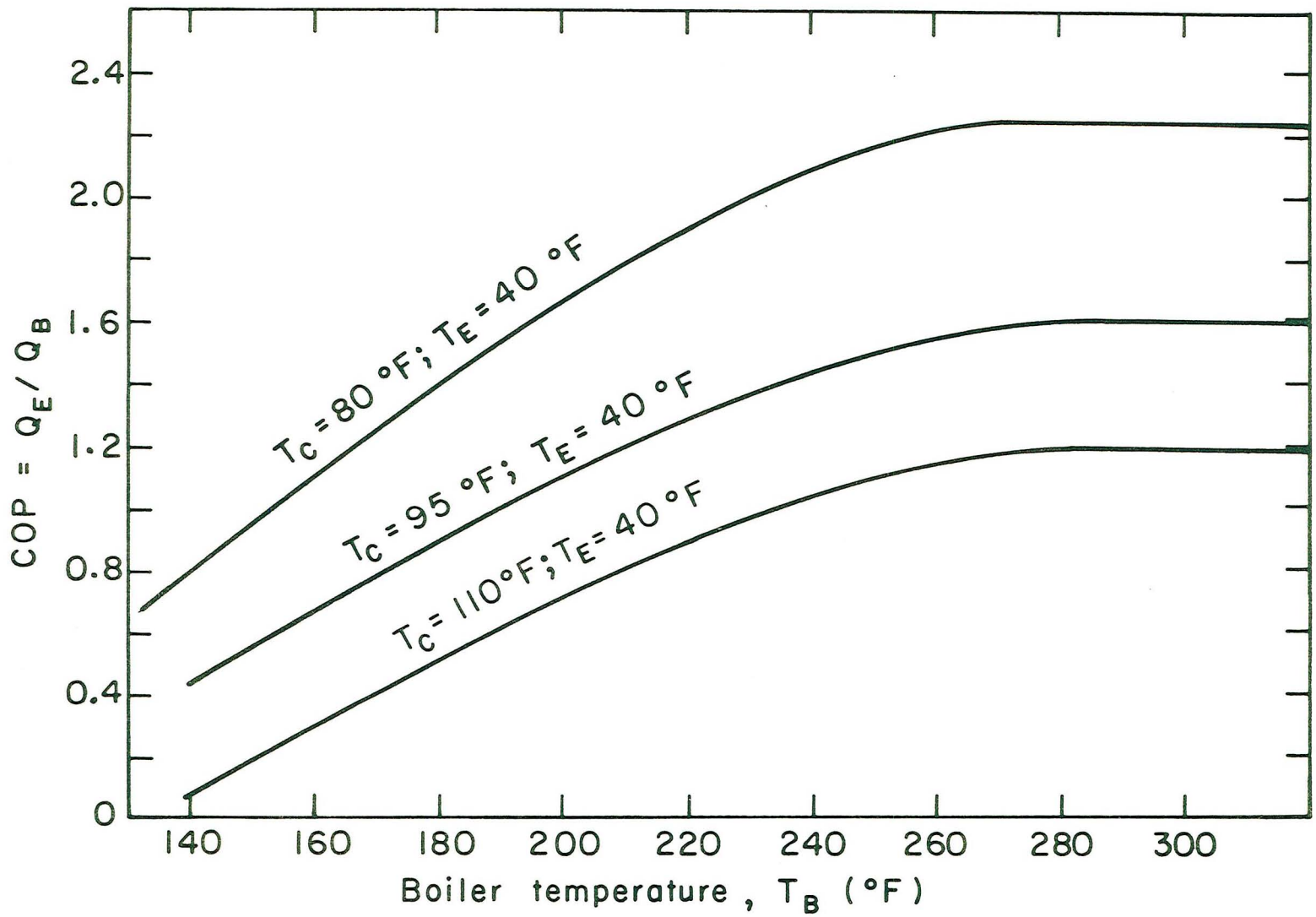

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Figure 5. Calculated performance of cycle 1R using NH_3/H_2O mixtures.

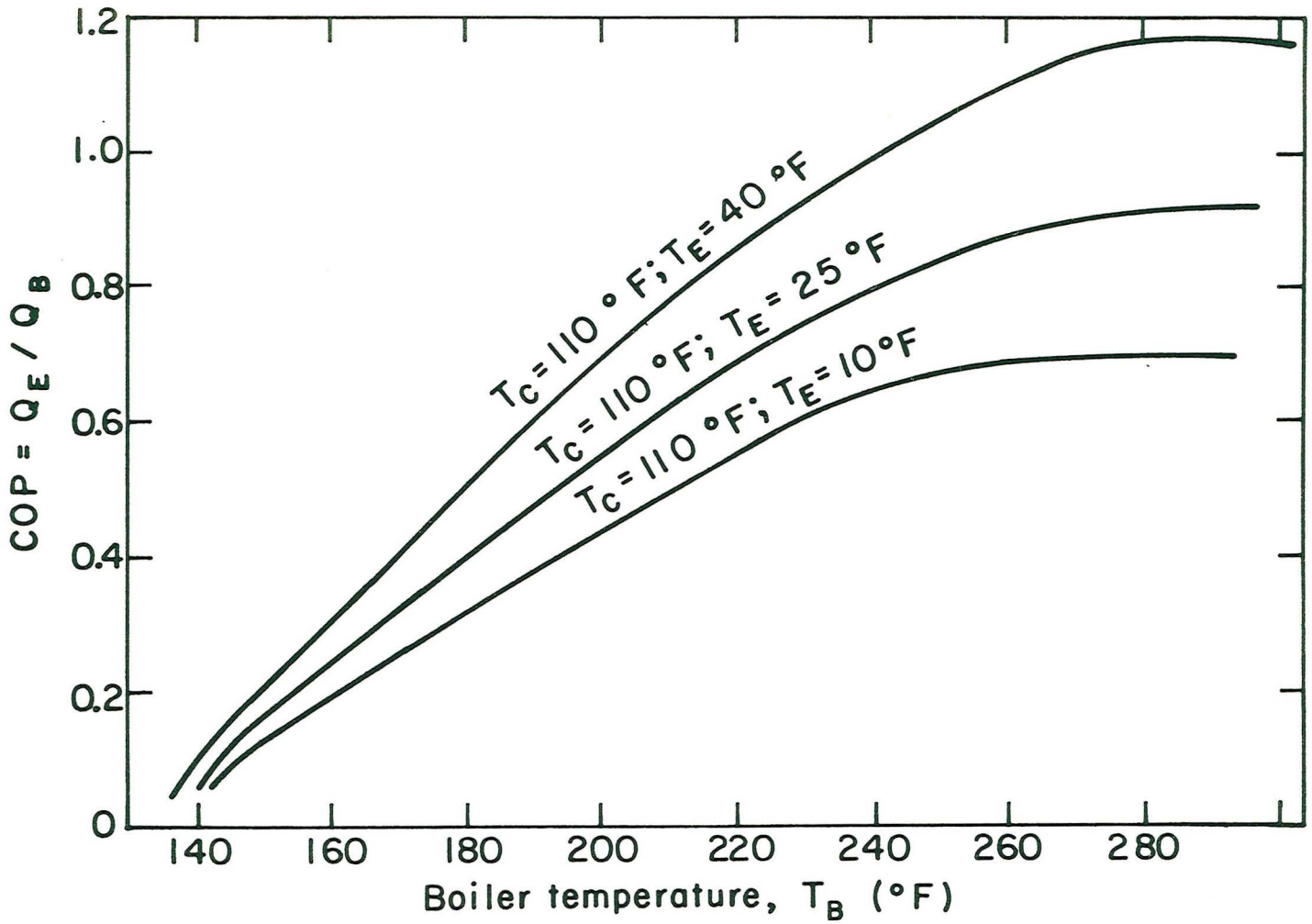

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Figure 6. Calculated performance of cycle 1R using NH_3/H_2O mixtures.

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APPENDIX

CALCULATED MASS FLOW RATES

AND OTHER RESULTS

TB= 150.0F TC=110.0F TE= 10.0F
COP= .131 FRACTION OF CARNOT=.425

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	593.00
2	.3207	.9985	574.17
3	.0090	.7313	40.83
4	.6883	.9943	589.76
5	.8204	.7313	40.83
6	9.9396	.6401	38.68
7	9.7985	.6572	18.40
8	-7.4370	.8064	30.25
9	8.5781	.8064	30.25
10	5.6493	.9885	597.10
11	-5.2976	.9954	586.72
12	6.0674	.9912	593.70
13	8.1901	.2820	40.29
14	-2.1394	.3385	6.57
15	.6236	.9680	616.76
16	8.5666	.3157	5.56
17	6.6794	.3599	-17.90
18	2.5107	.3599	-17.90
19	1.7605	.4590	-5.80
20	5.5023	.9733	619.40
21	1.6135	.3590	15.30

TB= 170.0F TC=110.0F TE= 10.0F
COP= .251 FRACTION OF CARNOT=.561

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	606.00
2	.7661	.9975	577.12
3	.0073	.6142	40.12
4	.2412	.9881	604.45
5	.7615	.6142	40.12
6	5.8104	.5494	49.30
7	5.2828	.5599	27.06
8	-2.6872	.8064	30.25
9	4.2149	.8064	30.25
10	2.8256	.9828	604.42
11	-1.9754	.9954	586.72
12	3.0014	.9869	600.57
13	4.8487	.2283	74.29
14	-.7118	.2820	40.29
15	.3969	.9680	616.76
16	5.4519	.3157	5.56
17	4.6353	.3599	-17.90
18	1.2134	.3599	-17.90
19	1.1521	.4266	-2.91
20	2.7394	.9508	643.08
21	1.0660	.2993	47.37

TB= 190.0F TC=110.0F TE= 10.0F
COP= .377 FRACTION OF CARNOT=.651

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	619.00
2	.8913	.9965	581.12
3	.0082	.5307	53.42
4	.1169	.9766	623.06
5	.6145	.5307	53.42
6	3.9671	.4796	67.71
7	3.4613	.4872	45.03
8	-1.1826	.8064	30.25
9	2.6884	.8064	30.25
10	1.8079	.9777	610.41
11	-.8913	.9954	586.72
12	1.9300	.9819	607.14
13	3.4537	.1752	108.54
14	-.2913	.2283	74.29
15	.3022	.9680	616.76
16	4.1515	.3157	5.56
17	3.6953	.3599	-17.90
18	.7584	.3599	-17.90
19	1.0033	.4023	3.08
20	1.7434	.9141	674.93
21	.9388	.2447	81.18

TB= 210.0F TC=110.0F TE= 10.0F
COP= .491 FRACTION OF CARNOT=.699

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	632.00
2	.9359	.9954	585.35
3	.0102	.4637	72.97
4	.0743	.9569	644.28
5	.5162	.4637	72.97
6	3.0166	.4184	89.86
7	2.5645	.4247	67.24
8	-.5457	.8064	30.25
9	1.9979	.8064	30.25
10	1.3265	.9720	617.05
11	-.4200	.9954	586.72
12	1.4453	.9771	612.80
13	2.7735	.1299	141.14
14	-.1257	.1752	108.54
15	.2560	.9680	616.76
16	3.5174	.3157	5.56
17	3.2208	.3599	-17.90
18	.5526	.3599	-17.90
19	.9576	.3815	10.48
20	1.2811	.8581	712.89
21	.9122	.1921	114.89

TB= 230.0F TC=110.0F TE= 10.0F
COP= .602 FRACTION OF CARNOT=.737

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	645.00
2	.9649	.9943	589.76
3	.0111	.4039	95.81
4	.0462	.9336	666.59
5	.3811	.4039	95.81
6	2.4095	.3636	114.37
7	2.0635	.3688	92.03
8	-.2335	.6871	18.86
9	1.5794	.8064	30.25
10	1.0392	.9656	624.24
11	-.1580	.9719	618.92
12	1.1523	.9719	618.92
13	2.3677	.0904	172.52
14	-.0754	.0904	172.52
15	.2285	.9680	616.76
16	3.1392	.3157	5.56
17	2.9406	.3599	-17.90
18	.4271	.3599	-17.90
19	.9220	.3629	18.74
20	1.0260	.7834	745.34
21	.9089	.1485	146.72

TB= 250.0F TC=110.0F TE= 10.0F
COP= .673 FRACTION OF CARNOT=.726

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	658.00
2	.9768	.9929	594.28
3	.0130	.3507	120.77
4	.0363	.9020	695.28
5	.3905	.3507	120.77
6	1.9097	.3129	142.13
7	1.5425	.3168	119.94
8	-.0353	.6871	18.86
9	1.4025	.8064	30.25
10	.8855	.9583	631.99
11	-.0245	.9660	625.61
12	1.0332	.9660	625.61
13	2.0805	.0532	203.75
14	-.0108	.0532	203.75
15	.2090	.9680	616.76
16	2.8715	.3157	5.56
17	2.7112	.3599	-17.90
18	.3694	.3599	-17.90
19	1.0455	.3456	28.05
20	.8838	.6794	810.22
21	1.0438	.1084	177.97

TB= 140.0F TC=110.0F TE= 25.0F
COP= .103 FRACTION OF CARNOT=.362

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	586.50
2	-.2941	.9989	572.18
3	.0160	.8171	50.88
4	1.3101	.9960	583.21
5	-2.6285	.8171	50.88
6	12.0151	.6978	38.96
7	15.9377	.7418	25.59
8	-13.9482	.8354	38.16
9	11.0247	.8354	38.16
10	7.2050	.9937	588.92
11	-10.0837	.9956	585.58
12	7.9925	.9949	586.56
13	10.3140	.3583	15.37
14	-3.8646	.4174	-11.24
15	.8372	.9788	608.06
16	10.4768	.3698	-2.35
17	8.2819	.4149	-22.26
18	3.0322	.4149	-22.26
19	1.6394	.5239	-6.31
20	7.0336	.9867	604.59
21	1.4680	.4353	-.69

TB= 165.0F TC=110.0F TE= 25.0F
COP= .275 FRACTION OF CARNOT=.547

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	602.75
2	.5953	.9977	576.16
3	.0097	.6401	38.68
4	.4144	.9901	600.38
5	.4947	.6401	38.68
6	5.5661	.5692	45.60
7	5.4760	.5945	25.42
8	-2.7341	.8354	38.16
9	3.8241	.8354	38.16
10	2.5220	.9892	597.56
11	-2.0618	.9956	585.58
12	2.7886	.9915	594.23
13	4.6199	.2886	55.13
14	-.6723	.3440	22.43
15	.4159	.9788	608.06
16	5.2040	.3698	-2.35
17	4.5843	.4149	-22.26
18	1.0355	.4149	-22.26
19	.9035	.4747	-6.36
20	2.4447	.9651	629.72
21	.8262	.3553	32.27

TB= 190.0F TC=110.0F TE= 25.0F
COP= .468 FRACTION OF CARNOT=.666

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	619.00
2	.8439	.9965	581.12
3	.0103	.5307	53.42
4	.1664	.9766	623.06
5	.4463	.5307	53.42
6	3.6018	.4796	67.71
7	3.3117	.4975	45.47
8	-.8128	.8354	38.16
9	2.1030	.8354	38.16
10	1.4243	.9835	605.70
11	-.6321	.9956	585.58
12	1.5447	.9873	601.68
13	3.0451	.2234	96.82
14	-.1808	.2752	63.51
15	.2993	.9788	608.06
16	3.7457	.3698	-2.35
17	3.4868	.4149	-22.26
18	.5582	.4149	-22.26
19	.6867	.4424	.32
20	1.3707	.9319	662.56
21	.6332	.2849	72.26

TB= 215.0F TC=110.0F TE= 25.0F
COP= .660 FRACTION OF CARNOT=.744

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	635.25
2	.9211	.9952	586.44
3	.0127	.4483	78.43
4	.0916	.9505	649.81
5	.3200	.4483	78.43
6	2.5480	.4039	95.81
7	2.3070	.4192	72.99
8	-.1802	.7060	23.07
9	1.4213	.8354	38.16
10	.9612	.9773	613.10
11	-.1197	.9820	609.21
12	1.0538	.9820	609.21
13	2.2937	.1606	138.43
14	-.0606	.1606	138.43
15	.2437	.9788	608.06
16	3.0499	.3698	-2.35
17	2.9262	.4149	-22.26
18	.3674	.4149	-22.26
19	.6463	.4163	9.49
20	.9214	.8718	707.83
21	.6065	.2192	113.75

TB= 240.0F TC=110.0F TE= 25.0F
COP= .792 FRACTION OF CARNOT=.747

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	651.50
2	.9509	.9936	592.01
3	.0148	.3768	108.07
4	.0640	.9194	680.01
5	.3715	.3768	108.07
6	2.0436	.3379	127.28
7	1.7213	.3507	104.41
8	.1537	.7060	23.07
9	1.1686	.8354	38.16
10	.7662	.9709	620.64
11	.1059	.9758	616.56
12	.8761	.9758	616.56
13	1.9027	.1084	177.98
14	.0478	.1084	177.98
15	.2148	.9788	608.06
16	2.6879	.3698	-2.35
17	2.6102	.4149	-22.26
18	.2925	.4149	-22.26
19	.6731	.3935	19.96
20	.7485	.7811	752.15
21	.6554	.1611	153.96

TB= 265.0F TC=110.0F TE= 25.0F
COP= .884 FRACTION OF CARNOT=.725

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	667.75
2	.9724	.9912	597.84
3	.0183	.3129	142.13
4	.0459	.8689	721.59
5	.3610	.3129	142.13
6	1.5805	.2769	164.78
7	1.2470	.2878	141.57
8	.2872	.7060	23.07
9	1.0463	.8354	38.16
10	.6569	.9634	629.07
11	.2039	.9696	623.73
12	.7932	.9696	623.73
13	1.6476	.0609	217.08
14	.0833	.0609	217.08
15	.1959	.9788	608.06
16	2.4517	.3698	-2.35
17	2.3945	.4149	-22.26
18	.2531	.4149	-22.26
19	.8074	.3725	32.35
20	.6499	.6469	833.31
21	.8004	.1104	192.97

TB= 150.0F TC=110.0F TE= 40.0F
COP= .205 FRACTION OF CARNOT=.438

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	593.00
2	-.1003	.9985	574.17
3	.0159	.7313	40.83
4	1.1162	.9943	589.76
5	-.1017	.7313	40.83
6	6.6566	.6401	38.68
7	7.8586	.6914	25.67
8	-5.3901	.8640	46.32
9	5.1881	.8640	46.32
10	3.1742	.9942	588.50
11	-4.1199	.9958	584.50
12	3.8868	.9953	586.35
13	5.5448	.3771	24.77
14	-1.2703	.4565	-.73
15	.5621	.9862	601.75
16	5.9827	.4236	-5.92
17	5.2434	.4720	-23.53
18	1.3013	.4720	-23.53
19	.7920	.5451	-7.13
20	3.0858	.9841	609.56
21	.7036	.4440	10.39

TB= 180.0F TC=110.0F TE= 40.0F
COP= .507 FRACTION OF CARNOT=.649

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	612.50
2	.7400	.9970	579.08
3	.0110	.5692	45.60
4	.2711	.9832	613.33
5	.3338	.5692	45.60
6	3.5835	.5130	57.90
7	3.5097	.5437	37.10
8	-.7779	.8640	46.32
9	1.8517	.8640	46.32
10	1.2844	.9901	597.36
11	-.6194	.9958	584.50
12	1.3956	.9921	594.20
13	2.9637	.2945	70.20
14	-.1585	.3489	38.47
15	.3404	.9862	601.75
16	3.6233	.4236	-5.92
17	3.5077	.4720	-23.53
18	.4561	.4720	-23.53
19	.5062	.4959	-3.32
20	1.2362	.9562	640.26
21	.4579	.3523	49.18

TB= 210.0F TC=110.0F TE= 40.0F
COP= .794 FRACTION OF CARNOT=.744

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	632.00
2	.8832	.9954	585.35
3	.0143	.4637	72.97
4	.1311	.9569	644.28
5	.3277	.4637	72.97
6	2.4584	.4184	89.86
7	2.2475	.4429	67.06
8	.1083	.7249	27.44
9	1.1026	.8640	46.32
10	.7794	.9847	606.14
11	.0713	.9880	602.21
12	.8376	.9880	602.21
13	2.0735	.2183	119.26
14	.0370	.2183	119.26
15	.2640	.9862	601.75
16	2.8096	.4236	-5.92
17	2.8086	.4720	-23.53
18	.2650	.4720	-23.53
19	.4316	.4623	6.66
20	.7427	.9090	683.72
21	.3949	.2713	96.78

TB= 240.0F TC=110.0F TE= 40.0F
COP= .995 FRACTION OF CARNOT=.750

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	651.50
2	.9351	.9936	592.01
3	.0170	.3768	108.07
4	.0819	.9194	680.01
5	.3736	.3768	108.07
6	1.8744	.3379	127.28
7	1.5658	.3586	103.78
8	.4370	.7249	27.44
9	.8716	.8640	46.32
10	.5946	.9775	615.19
11	.3022	.9825	610.61
12	.6693	.9825	610.61
13	1.6192	.1471	167.89
14	.1348	.1471	167.89
15	.2249	.9862	601.75
16	2.3943	.4236	-5.92
17	2.4169	.4720	-23.53
18	.2023	.4720	-23.53
19	.4741	.4342	18.90
20	.5666	.8172	744.28
21	.4461	.1965	145.41

TB= 270.0F TC=110.0F TE= 40.0F
COP= 1.148 FRACTION OF CARNOT=.733

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	671.00
2	.9645	.9906	599.09
3	.0219	.3007	149.71
4	.0574	.8557	731.24
5	.3570	.3007	149.71
6	1.4730	.2653	172.27
7	1.1516	.2832	147.77
8	.5675	.7249	27.44
9	.7540	.8640	46.32
10	.4987	.9701	623.63
11	.4075	.9753	619.39
12	.5873	.9753	619.39
13	1.3673	.0872	214.81
14	.1600	.0872	214.81
15	.2033	.9862	601.75
16	2.1640	.4236	-5.92
17	2.2006	.4720	-23.53
18	.1667	.4720	-23.53
19	.5530	.4090	33.57
20	.4856	.6774	816.30
21	.5399	.1320	192.45

TB= 300.0F TC=110.0F TE= 40.0F
COP= 1.128 FRACTION OF CARNOT=.632

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	690.50
2	.9890	.9867	607.30
3	.0270	.2320	194.62
4	.0380	.7476	797.81
5	.3003	.2320	194.62
6	1.0161	.2007	216.79
7	.7268	.2152	193.12
8	.4919	.7249	27.44
9	.7974	.8640	46.32
10	.4877	.9618	632.92
11	.3644	.9676	627.80
12	.6307	.9676	627.80
13	1.1925	.0308	262.85
14	.1275	.0308	262.85
15	.1883	.9862	601.75
16	2.0042	.4236	-5.92
17	2.0258	.4720	-23.53
18	.1667	.4720	-23.53
19	.7916	.3864	48.69
20	.4817	.4588	951.26
21	.7856	.0735	239.45

TB= 150.0F TC= 95.0F TE= 10.0F
COP= .273 FRACTION OF CARNOT=.547

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	602.75
2	.6101	.9982	573.83
3	.0062	.6299	19.20
4	.3961	.9919	596.64
5	.5426	.6299	19.20
6	5.5466	.5601	27.07
7	5.3939	.5847	6.68
8	-2.6880	.8248	17.76
9	3.8407	.8248	17.76
10	2.4729	.9908	591.68
11	-1.9915	.9966	582.23
12	2.7404	.9930	588.64
13	4.6056	.2774	41.34
14	-.6965	.3338	7.13
15	.4151	.9813	601.17
16	5.1905	.3599	-17.90
17	4.5054	.4059	-38.34
18	1.1002	.4059	-38.34
19	.8354	.4655	-23.33
20	2.3991	.9687	623.35
21	.7616	.3448	16.83

TB= 170.0F TC= 95.0F TE= 10.0F
COP= .424 FRACTION OF CARNOT=.644

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	615.75
2	.8205	.9975	577.46
3	.0070	.5404	31.00
4	.1865	.9832	613.25
5	.4980	.5404	31.00
6	3.8730	.4873	45.03
7	3.5544	.5057	22.86
8	-1.0323	.8248	17.76
9	2.3508	.8248	17.76
10	1.5457	.9868	597.96
11	-.7858	.9966	582.23
12	1.6857	.9901	594.36
13	3.2505	.2238	75.38
14	-.2465	.2774	41.34
15	.3147	.9813	601.17
16	3.9358	.3599	-17.90
17	3.5854	.4059	-38.34
18	.6651	.4059	-38.34
19	.6767	.4392	-17.94
20	1.4911	.9435	648.86
21	.6221	.2872	50.01

TB= 190.0F TC= 95.0F TE= 10.0F
COP= .569 FRACTION OF CARNOT=.704

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	628.75
2	.8969	.9966	581.43
3	.0090	.4710	50.28
4	.1121	.9668	633.10
5	.4354	.4710	50.28
6	2.8967	.4248	67.24
7	2.5645	.4405	44.39
8	-.3604	.8248	17.76
9	1.6927	.8248	17.76
10	1.1092	.9826	603.54
11	-.2803	.9966	582.23
12	1.2213	.9865	600.14
13	2.5159	.1706	109.69
14	-.0801	.2238	75.38
15	.2604	.9813	601.17
16	3.2555	.3599	-17.90
17	3.0445	.4059	-38.34
18	.4714	.4059	-38.34
19	.6482	.4175	-10.76
20	1.0651	.9014	682.61
21	.6042	.2332	83.84

TB= 210.0F TC= 95.0F TE= 10.0F
COP= .701 FRACTION OF CARNOT=.738

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	641.75
2	.9353	.9956	585.63
3	.0105	.4101	73.24
4	.0753	.9452	654.24
5	.3763	.4101	73.24
6	2.3248	.3688	92.03
7	2.0132	.3825	68.96
8	-.0284	.6951	3.12
9	1.3400	.8248	17.76
10	.8705	.9780	609.16
11	-.0189	.9822	605.97
12	.9741	.9822	605.97
13	2.1152	.1260	142.16
14	-.0095	.1260	142.16
15	.2307	.9813	601.17
16	2.8845	.3599	-17.90
17	2.7493	.4059	-38.34
18	.3659	.4059	-38.34
19	.6514	.3981	-2.58
20	.8417	.8381	718.86
21	.6225	.1820	117.38

TB= 230.0F TC= 95.0F TE= 10.0F
COP= .798 FRACTION OF CARNOT=.738

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	654.75
2	.9536	.9946	590.01
3	.0125	.3556	98.52
4	.0589	.9169	681.11
5	.3947	.3556	98.52
6	1.9621	.3169	119.93
7	1.6138	.3290	95.94
8	.1800	.6951	3.12
9	1.1684	.8248	17.76
10	.7371	.9729	615.38
11	.1228	.9780	611.20
12	.8556	.9780	611.20
13	1.8559	.0869	173.49
14	.0571	.0869	173.49
15	.2115	.9813	601.17
16	2.6444	.3599	-17.90
17	2.5431	.4059	-38.34
18	.3128	.4059	-38.34
19	.6880	.3803	6.42
20	.7259	.7570	757.89
21	.6768	.1390	149.17

TB= 250.0F TC= 95.0F TE= 10.0F
COP= .865 FRACTION OF CARNOT=.716

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	667.75
2	.9703	.9929	594.30
3	.0151	.3044	127.68
4	.0448	.8746	715.32
5	.3806	.3044	127.68
6	1.5716	.2680	150.78
7	1.2207	.2785	127.44
8	.2697	.6951	3.12
9	1.0812	.8248	17.76
10	.6576	.9670	622.18
11	.1885	.9731	617.01
12	.7984	.9731	617.01
13	1.6627	.0499	204.73
14	.0812	.0499	204.73
15	.1972	.9813	601.17
16	2.4655	.3599	-17.90
17	2.3800	.4059	-38.34
18	.2827	.4059	-38.34
19	.8299	.3635	16.92
20	.6508	.6392	835.41
21	.8230	.0993	180.44

TB= 140.0F TC= 95.0F TE= 25.0F
COP= .249 FRACTION OF CARNOT=.480

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	596.25
2	.1992	.9986	572.44
3	.0086	.6873	18.90
4	.8094	.9946	590.01
5	.1716	.6873	18.90
6	5.8336	.6043	20.97
7	6.4628	.6508	5.48
8	-3.7807	.8546	26.08
9	4.1515	.8546	26.08
10	2.5454	.9948	584.68
11	-2.8611	.9967	581.26
12	3.0505	.9959	582.61
13	4.8766	.3534	15.88
14	-.9197	.4123	-10.99
15	.4943	.9882	595.63
16	5.3823	.4149	-22.26
17	4.7755	.4631	-40.30
18	1.1011	.4631	-40.30
19	.6686	.5257	-25.04
20	2.4721	.9829	608.75
21	.5954	.4184	-.11

TB= 165.0F TC= 95.0F TE= 25.0F
COP= .497 FRACTION OF CARNOT=.641

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	612.50
2	.7438	.9976	576.52
3	.0079	.5601	27.07
4	.2641	.9859	608.74
5	.3614	.5601	27.07
6	3.6103	.5042	40.05
7	3.5051	.5346	18.95
8	-.7939	.8546	26.08
9	1.8990	.8546	26.08
10	1.2737	.9918	591.69
11	-.6222	.9967	581.26
12	1.4014	.9936	588.83
13	2.9843	.2838	56.18
14	-.1716	.3391	23.00
15	.3351	.9882	595.63
16	3.6492	.4149	-22.26
17	3.4867	.4631	-40.30
18	.4976	.4631	-40.30
19	.4760	.4869	-20.55
20	1.2271	.9603	633.91
21	.4295	.3424	33.66

TB= 190.0F TC= 95.0F TE= 25.0F
COP= .739 FRACTION OF CARNOT=.729

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	628.75
2	.8726	.9966	581.43
3	.0105	.4710	50.28
4	.1379	.9668	633.10
5	.3178	.4710	50.28
6	2.5904	.4248	67.24
7	2.4001	.4496	44.34
8	-.0144	.7140	7.36
9	1.2048	.8546	26.08
10	.8244	.9878	598.73
11	-.0093	.9906	595.22
12	.8940	.9906	595.22
13	2.1889	.2187	97.92
14	-.0052	.2187	97.92
15	.2682	.9882	595.63
16	2.9207	.4149	-22.26
17	2.8781	.4631	-40.30
18	.3107	.4631	-40.30
19	.4177	.4586	-12.09
20	.7878	.9228	669.12
21	.3811	.2734	74.73

TB= 215.0F TC= 95.0F TE= 25.0F
COP= .910 FRACTION OF CARNOT=.739

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	645.00
2	.9216	.9954	586.71
3	.0129	.3959	79.39
4	.0914	.9392	660.26
5	.3855	.3959	79.39
6	2.0476	.3556	98.52
7	1.7406	.3770	74.86
8	.3348	.7140	7.36
9	.9722	.8546	26.08
10	.6459	.9826	606.01
11	.2248	.9868	601.93
12	.7267	.9868	601.93
13	1.7432	.1562	139.54
14	.1099	.1562	139.54
15	.2307	.9882	595.63
16	2.5124	.4149	-22.26
17	2.4977	.4631	-40.30
18	.2455	.4631	-40.30
19	.4514	.4344	-1.92
20	.6158	.8547	716.55
21	.4213	.2083	116.29

TB= 240.0F TC= 95.0F TE= 25.0F
COP= 1.061 FRACTION OF CARNOT=.739

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	661.25
2	.9483	.9937	592.11
3	.0162	.3296	112.15
4	.0680	.8979	697.31
5	.3871	.3296	112.15
6	1.6934	.2921	135.41
7	1.3581	.3112	110.21
8	.5069	.7140	7.36
9	.8285	.8546	26.08
10	.5367	.9773	612.68
11	.3522	.9818	608.96
12	.6253	.9818	608.96
13	1.4919	.1045	179.01
14	.1547	.1045	179.01
15	.2096	.9882	595.63
16	2.2823	.4149	-22.26
17	2.2887	.4631	-40.30
18	.2032	.4631	-40.30
19	.4899	.4125	9.87
20	.5218	.7557	763.24
21	.4750	.1513	156.42

TB= 265.0F TC= 95.0F TE= 25.0F
COP= 1.136 FRACTION OF CARNOT=.699

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	677.50
2	.9706	.9914	597.86
3	.0201	.2680	150.78
4	.0495	.8303	745.62
5	.3562	.2680	150.78
6	1.3273	.2336	173.64
7	1.0005	.2501	149.21
8	.5413	.7140	7.36
9	.7855	.8546	26.08
10	.4880	.9712	619.95
11	.3869	.9761	615.87
12	.5994	.9761	615.87
13	1.3183	.0573	218.14
14	.1544	.0573	218.14
15	.1950	.9882	595.63
16	2.1233	.4149	-22.26
17	2.1322	.4631	-40.30
18	.1861	.4631	-40.30
19	.6333	.3921	22.87
20	.4768	.6051	859.14
21	.6222	.1012	195.45

TB= 150.0F TC= 95.0F TE= 40.0F
COP= .470 FRACTION OF CARNOT=.573

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	602.75
2	.4962	.9982	573.83
3	.0082	.6299	19.20
4	.5120	.9919	596.64
5	.2221	.6299	19.20
6	3.7216	.5601	27.07
7	4.0034	.6113	10.36
8	-1.1889	.8843	34.78
9	1.9072	.8843	34.78
10	1.2433	.9956	583.94
11	-.9524	.9969	580.35
12	1.4524	.9963	582.22
13	3.0499	.3719	25.19
14	-.2365	.4310	-.57
15	.4242	.9930	589.49
16	3.6257	.4720	-23.53
17	3.5952	.5265	-38.58
18	.4547	.5265	-38.58
19	.3350	.5548	-22.27
20	1.2007	.9804	613.47
21	.2925	.4282	10.75

TB= 180.0F TC= 95.0F TE= 40.0F
COP= .867 FRACTION OF CARNOT=.718

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	622.25
2	.8175	.9970	579.41
3	.0101	.5042	40.05
4	.1926	.9762	622.86
5	.3430	.5042	40.05
6	2.4847	.4552	55.74
7	2.3242	.4909	33.69
8	.2526	.7331	11.79
9	.9079	.8843	34.78
10	.6716	.9928	591.13
11	.1590	.9942	588.54
12	.6945	.9942	588.54
13	1.9891	.2895	71.25
14	.0936	.2895	71.25
15	.3131	.9930	589.49
16	2.6760	.4720	-23.53
17	2.7757	.5265	-38.58
18	.2134	.5265	-38.58
19	.2696	.5146	-14.49
20	.6404	.9511	644.83
21	.2384	.3400	50.47

TB= 210.0F TC= 95.0F TE= 40.0F
COP= 1.160 FRACTION OF CARNOT=.743

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	641.75
2	.8999	.9956	585.63
3	.0139	.4101	73.24
4	.1140	.9452	654.24
5	.4226	.4101	73.24
6	1.9334	.3688	92.03
7	1.6110	.3984	68.09
8	.6626	.7331	11.79
9	.6599	.8843	34.78
10	.4835	.9891	598.76
11	.4425	.9914	595.42
12	.5079	.9914	595.42
13	1.5062	.2135	120.36
14	.2200	.2135	120.36
15	.2625	.9930	589.49
16	2.2437	.4720	-23.53
17	2.3542	.5265	-38.58
18	.1520	.5265	-38.58
19	.2763	.4838	-3.02
20	.4558	.8979	691.08
21	.2486	.2602	99.16

TB= 240.0F TC= 95.0F TE= 40.0F
COP= 1.393 FRACTION OF CARNOT=.740

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	661.25
2	.9391	.9937	592.11
3	.0178	.3296	112.15
4	.0786	.8979	697.31
5	.3996	.3296	112.15
6	1.5422	.2921	135.41
7	1.2034	.3186	108.79
8	.7861	.7331	11.79
9	.5526	.8843	34.78
10	.3912	.9840	606.84
11	.5494	.9875	602.85
12	.4289	.9875	602.85
13	1.2284	.1427	169.00
14	.2368	.1427	169.00
15	.2334	.9930	589.49
16	1.9950	.4720	-23.53
17	2.1046	.5265	-38.58
18	.1237	.5265	-38.58
19	.3142	.4572	10.54
20	.3715	.7970	747.39
21	.2945	.1860	147.89

TB= 270.0F TC= 95.0F TE= 40.0F
COP= 1.538 FRACTION OF CARNOT=.706

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	680.75
2	.9663	.9909	599.12
3	.0236	.2563	158.43
4	.0574	.8127	756.56
5	.3599	.2563	158.43
6	1.2351	.2225	181.21
7	.9089	.2455	155.44
8	.8137	.7331	11.79
9	.5125	.8843	34.78
10	.3507	.9772	615.40
11	.5881	.9823	610.80
12	.4023	.9823	610.80
13	1.0637	.0833	215.91
14	.2256	.0833	215.91
15	.2161	.9930	589.49
16	1.8475	.4720	-23.53
17	1.9535	.5265	-38.58
18	.1102	.5265	-38.58
19	.4049	.4329	26.09
20	.3357	.6411	837.86
21	.3899	.1225	194.93

TB= 300.0F TC= 95.0F TE= 40.0F
COP= 1.400 FRACTION OF CARNOT=.571

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	700.25
2	.9875	.9868	607.28
3	.0311	.1896	204.05
4	.0436	.6766	826.09
5	.2918	.1896	204.05
6	.8547	.1569	227.24
7	.5754	.1779	201.67
8	.6715	.7331	11.79
9	.6078	.8843	34.78
10	.3768	.9703	623.44
11	.4998	.9756	619.18
12	.4843	.9756	619.18
13	.9438	.0270	264.05
14	.1717	.0270	264.05
15	.2036	.9930	589.49
16	1.7402	.4720	-23.53
17	1.8203	.5265	-38.58
18	.1235	.5265	-38.58
19	.6376	.4103	41.50
20	.3646	.3953	987.25
21	.6254	.0641	242.20

TB= 150.0F TC= 80.0F TE= 10.0F
COP= .488 FRACTION OF CARNOT=.634

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	612.50
2	.7484	.9982	573.34
3	.0052	.5509	8.80
4	.2568	.9883	603.82
5	.3905	.5509	8.80
6	3.6247	.4954	22.40
7	3.4858	.5254	1.05
8	-.8082	.8449	6.12
9	1.9472	.8449	6.12
10	1.2635	.9932	585.85
11	-.6237	.9975	577.56
12	1.4073	.9948	583.28
13	2.9943	.2725	42.45
14	-.1845	.3288	8.19
15	.3296	.9899	589.37
16	3.6646	.4059	-38.34
17	3.4544	.4541	-56.80
18	.5399	.4541	-56.80
19	.4485	.4779	-37.52
20	1.2184	.9638	627.46
21	.4034	.3318	18.53

TB= 170.0F TC= 80.0F TE= 10.0F
COP= .687 FRACTION OF CARNOT=.716

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	625.50
2	.8613	.9976	577.08
3	.0071	.4786	27.59
4	.1457	.9753	622.21
5	.2987	.4786	27.59
6	2.7250	.4313	44.52
7	2.5650	.4566	21.62
8	-.1565	.7033	-12.36
9	1.3165	.8449	6.12
10	.8732	.9904	591.27
11	-.0980	.9928	588.17
12	.9550	.9928	588.17
13	2.3131	.2190	76.53
14	-.0586	.2190	76.53
15	.2734	.9899	589.37
16	3.0397	.4059	-38.34
17	2.9516	.4541	-56.80
18	.3615	.4541	-56.80
19	.4027	.4550	-30.66
20	.8367	.9352	654.84
21	.3662	.2754	52.62

TB= 190.0F TC= 80.0F TE= 10.0F
COP= .825 FRACTION OF CARNOT=.726

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	638.50
2	.9065	.9968	581.12
3	.0093	.4164	50.55
4	.1028	.9557	642.25
5	.3877	.4164	50.55
6	2.2333	.3741	69.51
7	1.9391	.3963	45.81
8	.2004	.7033	-12.36
9	1.0938	.8449	6.12
10	.7075	.9869	596.87
11	.1307	.9902	593.30
12	.7972	.9902	593.30
13	1.8868	.1659	110.90
14	.0698	.1659	110.90
15	.2382	.9899	589.37
16	2.6486	.4059	-38.34
17	2.5902	.4541	-56.80
18	.2966	.4541	-56.80
19	.4308	.4349	-22.60
20	.6757	.8869	690.44
21	.3991	.2216	86.58

TB= 210.0F TC= 80.0F TE= 10.0F
COP= .952 FRACTION OF CARNOT=.731

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	651.50
2	.9315	.9959	585.38
3	.0115	.3606	76.08
4	.0800	.9305	667.32
5	.4061	.3606	76.08
6	1.9144	.3209	97.49
7	1.5768	.3414	72.36
8	.3952	.7033	-12.36
9	.9424	.8449	6.12
10	.5955	.9833	601.91
11	.2656	.9871	598.65
12	.6909	.9871	598.65
13	1.6377	.1220	143.22
14	.1296	.1220	143.22
15	.2177	.9899	589.37
16	2.4200	.4059	-38.34
17	2.3862	.4541	-56.80
18	.2515	.4541	-56.80
19	.4483	.4165	-13.75
20	.5774	.8185	720.81
21	.4302	.1717	119.94

TB= 230.0F TC= 80.0F TE= 10.0F
COP= 1.062 FRACTION OF CARNOT=.727

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	664.50
2	.9513	.9947	589.19
3	.0142	.3081	105.41
4	.0629	.8920	699.78
5	.3990	.3081	105.41
6	1.6281	.2707	129.04
7	1.2778	.2892	103.80
8	.5059	.7033	-12.36
9	.8443	.8449	6.12
10	.5237	.9791	607.25
11	.3486	.9831	604.21
12	.6236	.9831	604.21
13	1.4663	.0832	174.52
14	.1573	.0832	174.52
15	.2035	.9899	589.37
16	2.2628	.4059	-38.34
17	2.2456	.4541	-56.80
18	.2207	.4541	-56.80
19	.5193	.3991	-3.27
20	.5112	.7259	775.87
21	.5067	.1293	151.70

TB= 250.0F TC= 80.0F TE= 10.0F
COP= 1.106 FRACTION OF CARNOT=.688

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	677.50
2	.9688	.9931	593.55
3	.0172	.2586	136.86
4	.0483	.8341	739.42
5	.3686	.2586	136.86
6	1.3155	.2236	160.17
7	.9781	.2400	135.55
8	.6121	.7033	-12.36
9	.8253	.8449	6.12
10	.4906	.9744	613.14
11	.3606	.9793	609.18
12	.6141	.9793	609.18
13	1.3335	.0463	205.78
14	.1515	.0463	205.78
15	.1926	.9899	589.37
16	2.1410	.4059	-38.34
17	2.1223	.4541	-56.80
18	.2112	.4541	-56.80
19	.6601	.3828	7.31
20	.4793	.5921	865.25
21	.6488	.0900	182.99

TB= 140.0F TC= 80.0F TE= 25.0F
COP= .533 FRACTION OF CARNOT=.604

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	606.00
2	.6093	.9985	571.61
3	.0050	.5944	2.16
4	.3957	.9921	595.94
5	.2655	.5944	2.16
6	3.4613	.5314	12.95
7	3.5865	.5775	-5.72
8	-.7635	.8759	15.05
9	1.6383	.8759	15.05
10	1.0817	.9961	579.83
11	-.6061	.9977	576.75
12	1.2249	.9969	578.18
13	2.8406	.3482	16.45
14	-.1574	.4069	-10.70
15	.3927	.9942	583.77
16	3.4479	.4631	-40.30
17	3.4272	.5174	-55.82
18	.4134	.5174	-55.82
19	.3035	.5374	-39.12
20	1.0437	.9788	612.45
21	.2656	.4037	.64

TB= 165.0F TC= 80.0F TE= 25.0F
COP= .845 FRACTION OF CARNOT=.704

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	622.25
2	.8186	.9977	576.12
3	.0074	.4954	22.40
4	.1888	.9794	617.33
5	.3522	.4954	22.40
6	2.5138	.4466	38.67
7	2.3429	.4821	16.26
8	.2232	.7224	-8.04
9	.9477	.8759	15.05
10	.6712	.9941	585.59
11	.1382	.9954	583.28
12	.7108	.9954	583.28
13	2.0142	.2788	57.30
14	.0850	.2788	57.30
15	.3082	.9942	583.77
16	2.7061	.4631	-40.30
17	2.7773	.5174	-55.82
18	.2369	.5174	-55.82
19	.2507	.5056	-31.79
20	.6410	.9551	638.40
21	.2265	.3300	35.41

TB= 190.0F TC= 80.0F TE= 25.0F
COP= 1.080 FRACTION OF CARNOT=.724

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	638.50
2	.8893	.9968	581.12
3	.0106	.4164	50.55
4	.1213	.9557	642.25
5	.4318	.4164	50.55
6	2.0319	.3741	69.51
7	1.7108	.4044	45.40
8	.5919	.7224	-8.04
9	.7292	.8759	15.05
10	.5102	.9915	591.69
11	.3861	.9934	588.77
12	.5492	.9934	588.77
13	1.5831	.2138	99.08
14	.2057	.2138	99.08
15	.2641	.9942	583.77
16	2.3190	.4631	-40.30
17	2.4031	.5174	-55.82
18	.1800	.5174	-55.82
19	.2672	.4797	-22.08
20	.4827	.9125	675.93
21	.2397	.2621	77.24

TB= 215.0F TC= 80.0F TE= 25.0F
COP= 1.273 FRACTION OF CARNOT=.722

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	654.75
2	.9265	.9957	586.32
3	.0134	.3472	82.78
4	.0869	.9223	674.74
5	.4196	.3472	82.78
6	1.6632	.3081	105.41
7	1.3171	.3358	78.44
8	.7222	.7224	-8.04
9	.6239	.8759	15.05
10	.4220	.9879	598.16
11	.4913	.9908	594.67
12	.4725	.9908	594.67
13	1.3140	.1516	140.70
14	.2310	.1516	140.70
15	.2366	.9942	583.77
16	2.0775	.4631	-40.30
17	2.1627	.5174	-55.82
18	.1514	.5174	-55.82
19	.3038	.4568	-11.06
20	.4000	.8344	723.32
21	.2818	.1974	118.90

TB= 240.0F TC= 80.0F TE= 25.0F
COP= 1.455 FRACTION OF CARNOT=.722

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	671.00
2	.9509	.9939	591.30
3	.0177	.2830	121.19
4	.0669	.8659	718.72
5	.3962	.2830	121.19
6	1.4081	.2467	144.66
7	1.0610	.2716	118.17
8	.7992	.7224	-8.04
9	.5479	.8759	15.05
10	.3658	.9832	605.03
11	.5605	.9873	601.01
12	.4181	.9873	601.01
13	1.1529	.1005	180.10
14	.2387	.1005	180.10
15	.2201	.9942	583.77
16	1.9328	.4631	-40.30
17	2.0230	.5174	-55.82
18	.1299	.5174	-55.82
19	.3493	.4355	2.18
20	.3511	.7257	779.56
21	.3347	.1414	158.95

TB= 265.0F TC= 80.0F TE= 25.0F
COP= 1.480 FRACTION OF CARNOT=.658

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	687.25
2	.9704	.9915	597.18
3	.0234	.2236	160.17
4	.0530	.7744	769.51
5	.3509	.2236	160.17
6	1.1199	.1895	183.49
7	.7986	.2123	157.46
8	.7599	.7224	-8.04
9	.5614	.8759	15.05
10	.3539	.9782	611.44
11	.5470	.9828	607.67
12	.4325	.9828	607.67
13	1.0360	.0535	219.25
14	.2129	.0535	219.25
15	.2082	.9942	583.77
16	1.8279	.4631	-40.30
17	1.9071	.5174	-55.82
18	.1289	.5174	-55.82
19	.4830	.4157	15.27
20	.3391	.5553	889.90
21	.4681	.0916	198.07

TB= 150.0F TC= 80.0F TE= 40.0F
COP= .958 FRACTION OF CARNOT=.668

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	612.50
2	.7297	.9982	573.34
3	.0056	.5509	8.80
4	.2760	.9883	603.82
5	.3996	.5509	8.80
6	2.3691	.4954	22.40
7	2.2398	.5461	2.61
8	.4597	.7417	-3.53
9	.6695	.9074	24.56
10	.5335	.9969	578.97
11	.2734	.9974	577.82
12	.5208	.9974	577.82
13	1.7961	.3665	25.67
14	.1864	.3665	25.67
15	.3916	.9965	579.37
16	2.4045	.5265	-38.58
17	2.6475	.5924	-49.34
18	.1487	.5924	-49.34
19	.1469	.5769	-32.02
20	.5105	.9763	616.99
21	.1239	.4142	11.28

TB= 180.0F TC= 80.0F TE= 40.0F
COP= 1.387 FRACTION OF CARNOT=.710

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	632.00
2	.8603	.9972	579.07
3	.0102	.4466	38.67
4	.1499	.9651	632.39
5	.5115	.4466	38.67
6	1.8753	.4018	56.74
7	1.5035	.4424	33.04
8	.9561	.7417	-3.53
9	.4157	.9074	24.56
10	.3630	.9951	584.79
11	.6144	.9960	582.88
12	.3245	.9960	582.88
13	1.3166	.2843	72.38
14	.3417	.2843	72.38
15	.3245	.9965	579.37
16	1.9921	.5265	-38.58
17	2.2254	.5924	-49.34
18	.0912	.5924	-49.34
19	.1459	.5424	-21.88
20	.3416	.9453	649.79
21	.1246	.3279	52.34

TB= 210.0F TC= 80.0F TE= 40.0F
COP= 1.750 FRACTION OF CARNOT=.721

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	651.50
2	.9159	.9959	585.38
3	.0133	.3606	76.08
4	.0973	.9305	667.32
5	.4713	.3606	76.08
6	1.5169	.3209	97.49
7	1.1297	.3565	70.91
8	1.0658	.7417	-3.53
9	.3214	.9074	24.56
10	.2811	.9928	591.22
11	.7233	.9942	588.61
12	.2520	.9942	588.61
13	1.0567	.2085	121.54
14	.3426	.2085	121.54
15	.2881	.9965	579.37
16	1.7686	.5265	-38.58
17	1.9873	.5924	-49.34
18	.0694	.5924	-49.34
19	.1635	.5137	-9.26
20	.2608	.8849	698.89
21	.1431	.2491	101.62

TB= 240.0F TC= 80.0F TE= 40.0F
COP= 2.053 FRACTION OF CARNOT=.719

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	671.00
2	.9471	.9939	591.30
3	.0186	.2830	121.19
4	.0714	.8659	718.72
5	.4202	.2830	121.19
6	1.2566	.2467	144.66
7	.8893	.2786	116.73
8	1.0885	.7417	-3.53
9	.2788	.9074	24.56
10	.2408	.9894	598.29
11	.7697	.9916	595.01
12	.2200	.9916	595.01
13	.8930	.1381	170.17
14	.3188	.1381	170.17
15	.2651	.9965	579.37
16	1.6279	.5265	-38.58
17	1.8343	.5924	-49.34
18	.0588	.5924	-49.34
19	.1961	.4878	6.02
20	.2253	.7738	754.96
21	.1805	.1754	150.45

TB= 270.0F TC= 80.0F TE= 40.0F
COP= 2.148 FRACTION OF CARNOT=.660

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	690.50
2	.9678	.9910	598.45
3	.0273	.2124	167.88
4	.0595	.7518	779.37
5	.3657	.2124	167.88
6	1.0278	.1780	191.36
7	.6943	.2077	163.73
8	1.0455	.7417	-3.53
9	.2880	.9074	24.56
10	.2292	.9849	605.88
11	.7619	.9882	601.98
12	.2293	.9882	601.98
13	.7904	.0791	217.08
14	.2835	.0791	217.08
15	.2508	.9965	579.37
16	1.5396	.5265	-38.58
17	1.7316	.5924	-49.34
18	.0588	.5924	-49.34
19	.2753	.4641	21.68
20	.2129	.5973	864.74
21	.2589	.1126	197.56

TB= 300.0F TC= 80.0F TE= 40.0F
COP= 1.766 FRACTION OF CARNOT=.488

LINE NO.	MASS FLOW	CONC.	ENTHALPY
1	1.0000	.9980	710.00
2	.9903	.9867	606.66
3	.0354	.1457	214.71
4	.0451	.5786	880.95
5	.2892	.1457	214.71
6	.7151	.1155	238.04
7	.4356	.1409	210.81
8	.8555	.7417	-3.53
9	.4240	.9074	24.56
10	.2891	.9789	613.98
11	.6400	.9836	609.50
12	.3415	.9836	609.50
13	.7124	.0230	265.33
14	.2154	.0230	265.33
15	.2398	.9965	579.37
16	1.4726	.5265	-38.58
17	1.6299	.5924	-49.34
18	.0825	.5924	-49.34
19	.5019	.4419	37.38
20	.2702	.3247	1025.53
21	.4830	.0548	244.96

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