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A computer program to calculate sonic velocities in two phase vapor-liquid systems

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A COMPUTER PROGRAM TO CALCULATE SONIC VELOCITIES IN TWO PHASE VAPOR-LIQUID SYSTEMS

by

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A THESIS

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Head of the Department

Date

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ABSTRACT

A Computer program was developed to calculate sonic velocity in the two phase region for a pure fluid using the Royal Mc Bee LGP 30 Digital Computer. This program was used to calculate sonic velocities for ten pressures at all qualities in increments of 10 per cent for Freon 12 and Freon 22. Figs 3 and 4 are plots of this data.

The purpose of this study is to investigate sonic velocity in two phase systems in order to determine whether a sonic choke exists at any intermediate qualities. For the range of pressures for which velocities were calculated no choke was found to be exhibited.

If a choke region does occur for the Freon 12 or Freon 22 systems, it appears from the shape of the isobars that it would exist at lower pressures than those investigated.

INTRODUCTION

It has been proposed that a limiting sonic velocity, or choke effect, may occur at some intermediate quality for a two phase vapor-liquid mixture (3). If a sonic choke does exist at some quality other than the expected saturated vapor condition, this information would be of significance in the design of many systems where the flow of two phase mixtures is encountered.

The purpose of this report is to present a general computer program for the calculation of sonic velocities within the two phase region from saturated vapor and liquid properties. It is also the specific purpose of this report to develop a sonic velocity curve for the two phase Freon 22 system. A similar curve for Freon 12 was also obtained for comparison with the earlier work of Vaillancourt (8).

THEORETICAL BACKGROUND

It is a well established fact that the limiting velocity for a fluid in flow through a duct of uniform cross section is the velocity of sound. This can be shown from thermodynamic principals by examining a Mollier diagram for a high velocity vapor.

Considering the pressure-enthalpy diagram in Fig. 1, assume that a superheated vapor at high pressure is flowing through a uniform duct at low velocity (point 1). As the vapor expands adiabalically, the change in enthalpy is described by the equation

$$dH = -\frac{UdU}{g_c}$$

$$\text{or } \Delta H = -\frac{(U_2^2 - U_1^2)}{2\, g_c} = -\Delta KE$$

Initially, at low velocity, the change in enthalpy will be very small for a moderate change in pressure. However, as the pressure decreases and the volume increases, the increase in velocity becomes more rapid for a given change in pressure. Finally as the pressure becomes very low, a small pressure decrement results in a very large increment in volume, velocity and kinetic energy, so that the enthalpy drops rapidly (point 3).

The path of a typical adiabatic expansion is shown in Fig. 1 by the broken line. At point 2 the curve passes through a maximum value of entropy and the entropy decreases through the balance of the expansion process. Since there is no work done and no heat transfer, it is obvious that the minimum change possible in entropy is zero and therefore a maximum velocity is reached when the differential change in entropy becomes zero.

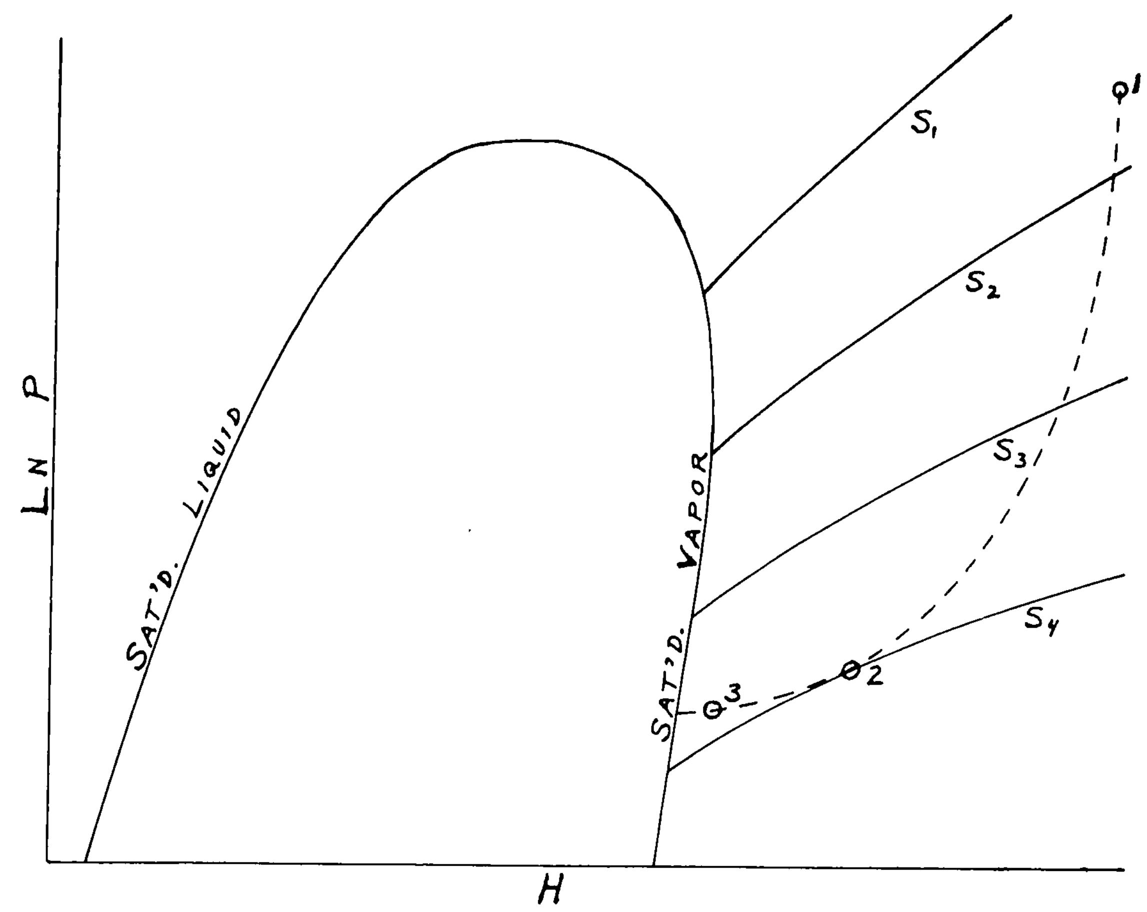


Figure 1 Mollier Diagram

By definition:

$$dH = dE + d(PV) = dE + PdV + VdP$$

But in the limit as the change in entropy approaches zero, a reversible process is being approached and $PdV = dW = 0$. Since dE is zero for an ideal gas and $dH = \frac{-UdU}{g_c}$,

$$\frac{-UdU}{g_c} = VdP \qquad (1)$$

Since the gas is flowing at a constant mass flow rate through a constant cross section,

$$dG = 0 = d\left(\frac{U}{V}\right)$$

$$\text{or} \qquad 0 = \frac{VdU - UdV}{V^2}$$

$$\text{or} \qquad dU = \frac{UdV}{V} \qquad (2)$$

Substituting equation 2 into equation 1 we obtain,

$$-\frac{U^2\,dV}{g_c\,V} = VdP$$

Rearranging, and recalling that this applies only for the condition of constant entropy, which also is the necessary condition for maximum velocity, we have,

$$U^2_{Max} = -g_c\,V^2\left(\frac{\partial P}{\partial V}\right)_s$$

$$\text{or } G_{Max} = \sqrt{-g_c\left(\frac{\partial P}{\partial V}\right)_s}$$

This is the common equation for sonic velocity in fluid flow. It applies strictly only to ideal gasses, since there was assumed to be no energy change for the adiabatic expansion. A second order term has been cited in the literature, however this has been assumed negligible (7).

This same equation is considered to hold true for liquids, where the isentropic compressibility of the fluid is very high and sonic velocities of the order of 5000 ft/sec. or 300,000 lbs./ft.^{2}sec. are considered typical (1 & 7). Since this is far above practical operating velocities, there has been very little interest in this region.

The two phase region has also lacked investigation in the past, since the assumption that the liquid volume is negligible compared to the vapor volume for most qualities of vapor leads people to assume that maximum velocity can be approximated by considering only the vapor velocities.

Since little work has been done on two phase fluids, and since there has been some reason to predict unexpectedly low maximum velocities in this region, a study of the sonic velocities of vapor-liquid mixtures might prove profitable at this time.

COMPUTER PROGRAM

Discussion

A program was developed for the Royal McBee LGP-30 digital computer to calculate the velocity of sound for a vapor-liquid mixture. The program requires as input five values of saturated liquid and vapor enthalpy, entropy and specific volume with the corresponding pressures. Any number of pressures up to ten for which it is required to calculate sonic velocities may also be read in as input.

From the input data coefficients are calculated for a fourth order polynomial to solve for the saturated liquid and vapor properties at any pressure. A semi-log polynomial is used for the liquid properties and log-log for vapor properties.

After calculating the coefficients, headings are printed and the first isobar for which velocities are to be obtained is generated. The specific volume and entropy of saturated liquid and vapor are calculated for the isobar (P) and also for .975 times this pressure (P_1) and 1.025 times this pressure (P_2).

Setting the quality equal to zero, the entropy is calculated using the equation:

$$S_Q = QS_V + (1-Q)S_L$$

at P. The quality at P_1 for which the mixture has the same entropy, S_Q, is obtained by rearranging the above equation to

$$Q_1 = \frac{S_Q - S_{L1}}{S_{V1} - S_{L1}}$$

From this value the specific volume for the mixture at P_1 is calculated from

$$V_{Q1} = Q_1 V_{V1} + (1-Q_1)V_{L1}$$

The same equations are repeated for P_2 except that at 0% and 100% quality the specific volume is calculated for P, since Q_2 would become negative and greater than 100% respectively

Since two values of pressure and the corresponding values of specific volume are now available, the equation

$$G_{Max} = \sqrt{-g_c \left(\frac{\partial P}{\partial V}\right)_s}$$

may be used in difference form

$$G_{Max} \simeq 68.07 \sqrt{-\left(\frac{P_2-P_1}{V_2-V_1}\right)_S}$$

to calculate the sonic velocity at P and Q. The average mixture properties and the fictitions linear velocity, Vmax, are calculated and the data are printed out.

The quality is increased by 10% and the calculations repeated for this new point. When the 100% quality point is completed, this procedure is repeated for the next isobar. When the last results are printed out for the last isobar, the computer will stop at break point 16, at which point one additional isobar may be entered. The computer always finishes at break point 16 so that an additional isobar may be read in at any time.

Reasonably accurate results have been obtained using this program to develop sonic velocity curves for Freon 12 and Freon 22. The critical step in this program is in obtaining constants for the polynomial for the physical properties.

For this purpose the Curve Fit Subroutine on page 68 of the appendix was written. It is important to note that this is not a true curve fit, but so titled for lack of a more descriptive term. This routine solves for the coefficients of a fourth order polynomial and therefore requires smoothed data. The routine also has the obvious limitation that if care is not used in the choice of data points, excessive fluctuation will occur in the resulting polynomial.

In order to check the choice of data points, a subroutine is included in the main program to calculate the coefficients and from these to calculate properties at any pressure to compare with published data. A description of this routine is given beginning on page 104 of the appendix.

DESCRIPTION OF PROGRAM

Function:

To compute the sonic velocity of a mixture of saturated vapor and liquid for various pressures and vapor qualities. (a)

Input:

5 reference pressures followed by the corresponding values of saturated liquid and vapor enthalpy in sequence in locations 6100 through 6114 followed by an exit code. 5 reference pressures followed by the corresponding values of saturated liquid and vapor entropy in 6115 through 6129 followed by an exit code. 5 reference pressures followed by the corresponding values of saturated liquid and vapor specific volume in 6130 through 6144 and up to 10 pressures starting in 6146 for which it is required to calculate sonic velocities. An exit code at this point completes the input data. (See sample data load sheets, pgs. 118 to 121).

Operation:

Halt and transfer to 4200 with data tape in reader. Depress break point 4 if there is no error on the data tape. Depress break point 8 when ready for print out. When the calculations and print out are completed the computer stops at break point 16. At this point an additional pressure may be entered in 6146. An exit code will result in computing sonic velocities at this pressure.

(a) See pgs. 104 to 106 of Appendix for the function of the routine for checking the curve fit of the data points.

Output:

P, Q, H, V, S, G_{max} and V_{max} for 0% to 100% quality at increments of 10% for each pressure read into 6146 to 6155. These values will also be printed out for each additional pressure read into 6146.

Storage:

Locations 4200 through 5454

Temporary storage in 5900 through 6162

Program Stops:

4434 - No pressures read into 6146 to 6155

4029 - Constant or Y value for polynomial too large to hold at q = 12.

Subroutines:

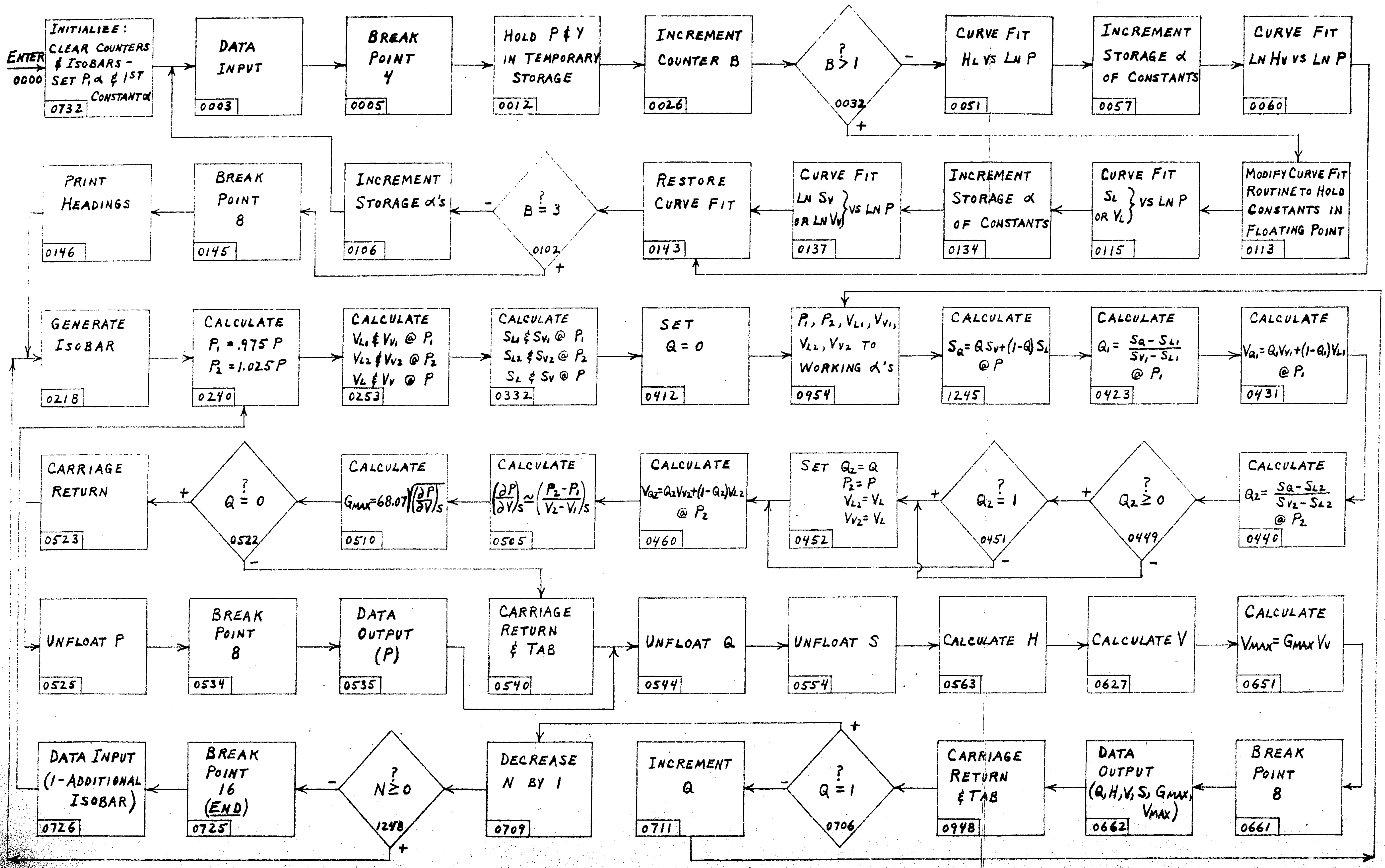
Data Input Routine #3	(11.2)	0300 to 0563
Data Out put Routine #2	(12.1A)	0600 to 0850
Extended Range Floating Point Interpretive Routine	(24.1)	0900 to 1963
Curve Fit		2000 to 3316
Data Output Driver		3332 to 3363
Logarithm	(18.2)	3419 to 3463
Exponential	(17.2)	3500 to 3663
Alphanumeric	(19.0)	3700 to 3757
Float and Unfloat	(25.1)	3800 to 4143
Decimal Memory Print Out	(21.0)	5500 to 5863

Time:

Approximately two hours for first print-out.

Approximately twenty minutes for each additional isobar.

FIGURE 2 SONIC VELOCITY - BLOCK DIAGRAM



LGP-30 CODING SHEET

PREPARED FOR:	PAGE 1 OF 29
NO.: — PROGRAM NO.: — PROGRAM PREPARED BY: — PROGRAM CHECKED BY:	DATE 4/26/63
PROBLEM: SONIC VELOCITY	TRACK 42

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
00042000	·						
00042000	·	[X]					
		0000		U0730	·		INITIALIZE
		01		B0914	·	α OF "A" FOR	H_L VS LN P (0750)
		02		H0850	·		
		03		XR0308	·	[X] } DATA	(0112)
		04		XU0300	·	} INPUT	
		05		XZ0400	·		
		06		B0849	·	P_1 α	
		07		Y0012	·	[X]	
		08		B0913	·	P_1 TEMP. α	
		09		Y0013	·		
		10		A0905	·	10 @ 29	
		11		Y0014	·	[X]	
		12		B[ ]	·	P's & Y's @12	(0043)
		13		H[ ]	·		
		14		H[ ]	·		
		15		B0825	·	[X] COUNTER A	
		16		A0900	·	1@29	
		17		H0825	·	COUNTER A	
		18		S0904	·	5 @ 29	
		19		T0034	·	[X]	
		20		S0904	·	5@ 29	
		21		T0044	·		
		22		S0900	·	1 @ 29	
		23		T0047	·	[X]	
		24		S0903	·	4 @ 29	
		25		T0034	·		
		26		XC6300	·		
		27		C0825	·	[X] COUNTER A	
		28		B0826	·	COUNTER B	
		29		A0900	·	1@29	
		30		H0826	·	COUNTER B	
		31		S0901	·	[X] 2@29	

LP-10 · = CONDITIONAL STOP CODE [X] CARRIAGE RETURN

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2	29	4/26/63	42

PROGRAM NO.: PROGRAM PREPARED BY: PROGRAM CHECKED BY:

SONIC VELOCITY

INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	X						
		0032	T	0051	·		
		33	U	0113	·	MODIFIED CURVE FIT	
		34	B	0012	·		(0019, 0025, 0046)
		35	A	0900	X	1@29	
		36	Y	0012	·		
		37	B	0013	·		
		38	A	0900	·	1@29	
		39	Y	0013	X		
		40	B	0014	·		
		41	A	0900	·	1@29	
		42	Y	0014	·		
		43	U	0012	X		
		44	B	0013	·		(0021, 0050)
		45	Y	0014	·		
		46	U	0034	·		
		47	B	0013	X		(0023)
		48	A	0904	·	5@29	
		49	Y	0013	·		
		50	U	0044	·		
		51	XC	6300	X		(0032)
		52	XC	3303	·	FLAG	
		53	B	0829	·	P_1	CURVE FIT
		54	B	0850	·	"a"	H_L VS LN P
		55	XR	2855	X		
		56	XU	2000	·		
		57	B	0850	·	"a" α	
		58	A	0904	·	5@29	
		59	H	0850	X	"a" α	
		60	B	0900	·	1@29	
		61	XH	3303	·	FLAG	
		62	B	0839	·	P_1	CURVE FIT
		63	B	0850	X	"a"	LN H_V VS LN P

· = CONDITIONAL STOP CODE X = CARRIAGE RETURN

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...ED FOR: | PROGRAM NO. | PROGRAM PREPARED BY: | PROGRAM CHECKED BY:

...M: SONIC VELOCITY

...RAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·					
	·	☒				
		0100	XR2855	·		}
		01	XU2000	·		}
		02	B0826	·	COUNTER B	(0937)
		03	S0902	·	☒ 3 @ 29	
		04	T0106	·		
		05	U0145	·		
		06	B0850	·	"a" α	(0104)
		07	A0904	·	☒ 5 @ 29	
		08	H0850	·	"a" α	
		09	B0849	·	P_1 α	
		10	A0906	·	15 @ 29	
		11	H0849	·	☒ P_1 α	
		12	U0003	·		
		13	B0915	·	U0122	(0033)
		14	XH2837	·		
		15	XC6300	·	☒	}
		16	XC3303	·	FLAG	}
		17	B0829	·	P_1	} CURVE FIT
		18	B0850	·	"a"	} S_L OR V_L VS LN P
		19	XR2855	·	☒	}
		20	XU2000	·		}
		21	U0134	·		
		22	XE0000	·		(X2837)
		23	XB2842	·	☒ "a" α (FIXED POINT)	
		24	S0911	·	XZ5910	
		25	M0930	·	2 @ 2	
		26	D0931	·	1 @ 2	
		27	A0912	·	☒ XZ6024	
		28	Y0131	·		
		29	XR0900	·	} ERFP	
		30	XU0900	·	}	
		31	800H[ ]	·	☒ CONSTANTS (ERFP)	

· = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

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...: SONIC VELOCITY				TRACK 43

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	·	☒				
		0132	XE0000	·		
		33	XU2838	·		
		34	B0850	·	"a" α	(0121)
		35	A0904	·	☒ 5 @ 29	
		36	H0850	·	"a" α	
		37	B0900	·	1 @ 29	}
		38	XH3303	·	FLAG	}
		39	B0839	·	☒ P_1	} CURVE FIT
		40	B0850	·	"a"	} LN S_V OR LN V_V
		41	XR2855	·		} VS LN P
		42	XU2000	·		}
		43	B0132	·	☒ XE0000	
		44	U0936	·		
		45	XZ0800	·	B.P. 8	(0105)
		46	XR3700	·	} ALPHANUMERIC	
		47	XU3700	·	☒ }	
00000034	'	48	20104206	·	CR, UC, P, SPACE	}
		49	4J427F22	·	(, P, S, I	}
		50	72043074	·	A,), TAB, Q	}
		51	064J2J06	·	☒ SPACE, (, %, SPACE	}
		52	3A087242	·	V, LC, A, P	}
		53	461F1004	·	O, R, UC,)	}
		54	3062064J	·	TAB, H, SPACE, (	}
		55	0F5F5208	·	☒ B, T, U, LC	}
		56	26100J08	·	/, UC, L, LC	}
		57	0F100430	·	B, UC,), TAB	}
		58	3A064J6F	·	V, SPACE, (, C	}
		59	08520610	·	☒ LC, U, SPACE, UC	} PRINT
		60	54085F26	·	F, LC, T, /	} HEADINGS
		61	100J080F	·	UC, L, LC, B	}
		62	1004307F	·	UC,), TAB, S	}
		63	064J0F5F	·	☒ SPACE, (, B, T	}

☒ CARRIAGE RETURN

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SONIC VELOCITY

Program Input Codes	Stop	Location	Operation	Address	Stop	Contents of Address	Notes
	☒						
		0200	5208	2610	·	U, LC, /, UC	
		01	0308	0F0A	·	L, LC, B, -	
		02	2F4F	5310	·	D, E, G, UC	
		03	0654	0430	·	☒ SPACE, F,), TAB	
		04	5J06	083F	·	G, SPACE, LC, M	
		05	724A	0610	·	A, X, SPACE, UC	
		06	4J0J	080F	·	(, L, LC, B	
		07	2610	7F08	·	☒ /, UC, S, LC	
		08	7406	1054	·	Q, SPACE, UC, F	
		09	085F	0A10	·	LC, T, -, UC	
		10	7F08	4F6F	·	S, LC, E, C	
		11	1004	303A	·	☒ UC,), TAB, V	
		12	0608	3F72	·	SPACE, LC, M, A	
		13	4A06	104J	·	X, SPACE, UC, (	
		14	5408	5F26	·	F, LC, T, /	
		15	107F	084F	·	☒ UC, S, LC, E	
		16	6F10	0420	·	C, UC,), CR	
		17	08VQ	0000	·	LC, EXIT	
		18	X	B6155	·	LAST ISOBAR	
		19	S	0932	·	☒ 1@30	(0239)
		20	T	0229	·		
		21	U	1251	·		
		22	B	0905	·	10@29	(1254)
		23	S	0827	·	☒ COUNTER C	
		24	X	H5930	·	N@29	
		25	B	L J	·	N^{TH} ISOBAR	(0724)
		26	X	C6156	·	P@12	(0729)
		27	C	0827	·	☒ COUNTER C	
		28	U	0240	·		
		29	B	0827	·	COUNTER C	(0220)
		30	A	0900	·	1@29	
		31	H	0827	·	☒ COUNTER C	

· = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

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SONIC VELOCITY

INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	☒						
		0232	S	0905		10 @29	
		33	T	0235			
		34	XZ	0000		STOP - DATA ERROR	
		35	B	0910	☒	XZ6155	(0233)
		36	S	0827		COUNTER C	
		37	Y	0238			
		38	B	[ ]		ISOBAR	
		39	U	0219	☒		
		40	XB	6156		P @ 12	(0228)
		41	XR	3816			FLOAT P
		42	XU	3800			
		43	XZ	0900	☒		
		44	XZ	0012			
		45	XR	0900		ERFP	
		46	XU	0900			
		47	80XH	5932	☒	P(ERFP)	
		48	80XP	5932		P	
		49	800M	0926		.975	
		50	80XH	6012		P_1	
		51	800M	0924	☒	1.025	
		52	80XH	6014		P_2	
		53	80XC	6262			
		54	E	0708		SET FLAG @0	
		55	XY	3303	☒		
		56	80XB	6044		"a"	MODIFIED SOLN. OF POLY.
		57	R	0824			
		58	U	0751			
		59	80XH	6018	☒	V_{L2}	
		60	80XB	6012		P_1	
		61	80XC	6262			
		62	80XB	6044		"a"	MODIFIED SOLN. OF POLY.
		63	R	0824	☒		

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SONIC VELOCITY

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	· ☒						
		0300		U0751	·		
		01	80X	H6016	·	V_{L1}	
		02	80X	B6014	·	P_2	
		03	80X	C6262	· ☒		
		04		E0900	·	} SET FLAG @ 1	
		05		XY3303	·	}	
		06	80X	B6054	·	"a"	} MODIFIED SOLN. OF POLY.
		07		R0824	· ☒		
		08		U0751	·		
		09	80X	H6022	·	V_{V2}	
		10	80X	B6012	·	P_1	
		11	80X	C6262	· ☒		
		12	80X	B6054	·	"a"	} MODIFIED SOLN. OF POLY.
		13		R0824	·		
		14		U0751	·		
		15	80X	H6020	· ☒	V_{V1}	
		16	80X	B5932	·	P	
		17	80X	C6262	·		
		18		E0708	·	} SET FLAG @ 0	
		19		XY3303	· ☒	}	
		20	80X	B6044	·	"a"	} MODIFIED SOLN OF POLY
		21		R0824	·		
		22		U0751	·		
		23	80X	H5946	· ☒	V_L	
		24	80X	B5932	·	P	
		25	80X	C6262	·		
		26		E0900	·	} SET FLAG @ 1	
		27		XY3303	· ☒	}	
		28	80X	B6054	·	"a"	} MODIFIED SOLN OF POLY
		29		R0824	·		
		30		U0751	·		
		31	80X	H5948	· ☒	V_V	

· = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

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SONIC VELOCITY

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION / ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·					
	· ☒					
		0332	80XB6014	·	P2	
		33	80XC6262	·		
		34	E0708	·	} SET FLAG @ 0	
		35	XY3303	· ☒		
		36	80XB6024	·	"a"	} MODIFIED SOLN OF POLY
		37	R0824	·		
		38	U0751	·		
		39	80XH5952	· ☒	S_{L2}	
		40	80XB6012	·	P_1	
		41	80XC6262	·		
		42	80XB6024	·	"a"	} MODIFIED SOLN OF POLY
		43	R0824	· ☒		
		44	U0751	·		
		45	80XH5950	·	S_{L1}	
		46	80XB6014	·	P_2	
		47	80XC6262	· ☒		
		48	E0900	·	} SET FLAG @ 1	
		49	XY3303	·		
		50	80XB6034	·	"a"	} MODIFIED SOLN OF POLY
		51	R0824	· ☒		
		52	U0751	·		
		53	80XH5956	·	S_{V2}	
		54	80XB6012	·	P_1	
		55	80XC6262	· ☒		
		56	80XB6034	·	"a"	} MODIFIED SOLN OF POLY
		57	R0824	·		
		58	U0751	·		
		59	80XH5954	· ☒	S_{V1}	
		60	80XB5932	·	P	
		61	80XC6262	·		
		62	E0708	·	} SET FLAG @ 0	
		63	XY3303	· ☒		

· CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

LGP-30 CODING SHEET

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SONIC VELOCITY				TRACK 46

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	·	☒					
		0400	80XB	6024	·	"a"	Modified Soln of Poly
		01	R	0824	·		
		02	U	0751	·		
		03	80XH	5958	·	☒ S_L	
		04	80XB	5932	·	P	
		05	80XC	6262	·		
		06	E	0900	·		Set Flag @ 1
		07	XY	3303	·	☒	
		08	80XB	6034	·	"a"	Modified Soln of Poly
		09	R	0824	·		
		10	U	0751	·		
		11	80XH	5960	·	☒ S_V	
		12	800B	0920	·	0	
		13	80XH	5962	·	Q	(0718)
		14	U	0954	·		
		15	80XM	5960	·	☒ S_V	(1246)
		16	800H	0851	·	$Q S_V$	
		17	800B	0922	·	1	
		18	80XS	5962	·	Q	
		19	XU	0000	·	☒	
		20	80XM	5958	·	S_L	
		21	800A	0851	·	$Q S_V$	
		22	80XH	6000	·	S_a	
		23	80XS	5950	·	☒ S_{L_1}	
		24	800H	0853	·	$S_a - S_{L_1}$	
		25	80XB	5954	·	S_{V_1}	
		26	80XS	5950	·	S_{L_1}	
		27	800H	0855	·	☒ $S_{V_1} - S_{L_1}$	
		28	800B	0853	·	$S_a - S_{L_1}$	
		29	800D	0855	·	$S_{V_1} - S_{L_1}$	
		30	80XH	6002	·	Q_1	
		31	XU	0000	·	☒	

· = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

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PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	PAGE 10 OF 29
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SONIC VELOCITY			TRACK 46

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	☒						
		0432	80XM	5942		V_{V_1}	
		33	800H	0851		$Q_1 V_{V_1}$	
		34	800B	0922		1	
		35	80XS	6002	☒	Q_1	
		36	X	U0000			
		37	80XM	5938		V_{L_1}	
		38	800A	0851		$Q_1 V_{V_1}$	
		39	80XH	6006	☒	V_{Q_1}	
		40	80XB	6000		S_Q	
		41	80XS	5952		S_{L_2}	
		42	800H	0853		$S_Q - S_{L_2}$	
		43	80XB	5956	☒	S_{V_2}	
		44	80XS	5952		S_{L_2}	
		45	800H	0855		$S_{V_2} - S_{L_2}$	
		46	800B	0853		$S_Q - S_{L_2}$	
		47	800D	0855	☒	$S_{V_2} - S_{L_2}$	
		48	80XH	6002		Q_2	
		49	T	0452		(Q_2 NEG?)	
		50	800S	0922		1	
		51	T	0460	☒	($Q_2 \geq 1$?)	
		52	80XB	5962		Q	(0449)
		53	80XH	6004		Q_2	
		54	80XB	5932		P	
		55	80XH	5936	☒	P_2	
		56	80XB	5946		Y_L	
		57	80XH	5940		Y_{L_2}	
		58	80XB	5948		V_V	
		59	80XH	5944	☒	V_{V_2}	
		60	80XP	6004		Q_2	(0451)
		61	80XM	5944		V_{V_2}	
		62	800H	0851		$Q_2 V_{V_2}$	
		63	800B	0922	☒	1	

☒ CARRIAGE RETURN

PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	PAGE 11 OF 29
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SONIC VELOCITY			TRACK 47

INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·	☒					
		0500	80XS	6004	·	Q_2	
		01	XU	0000	·		
		02	80XM	5940	·	V_{L2}	
		03	800A	0851	·	☒ $Q_2 V_{V2}$	
		04	80XH	6008	·	V_{a2}	
		05	80XS	6006	·	V_{a1}	
		06	800H	0853	·	$V_{a2} - V_{a1}$	
		07	80XB	5936	·	☒ P_2	
		08	80XS	5934	·	P_1	
		09	800D	0853	·	$V_{a2} - V_{a1}$	
		10	XY	0000	·	CHANGE SIGN	
		11	XR	0000	·	☒ √	
		12	XU	0000	·		
		13	800M	0928	·	68.07	
		14	80XH	6010	·	G_{MAX}	
		15	XE	0000	·	☒	
		16	XR	3851	·		} UNFLOAT G_{MAX}
		17	XU	4008	·		
		18	XZ	0900	·		
		19	XZ	0014	·	☒	
		20	XC	6161	·	G_{MAX}@14	
		21	XS	5962	·	Q	
		22	T	0544	·		
		23	XP	1600	·	☒ } C.R.	
		24	XZ	0000	·		
		25	XR	0900	·	} ERFP	
		26	XU	0900	·		
		27	80XB	5932	·	☒ P	
		28	XE	0000	·		
		29	XR	3851	·		} UNFLOAT P
		30	XU	4008	·		
		31	XZ	0900	·	☒	

· = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

DATE 4/26/63

TRACK 47

PROGRAM NO. | PROGRAM PREPARED BY: | PROGRAM CHECKED BY:

SONIC VELOCITY

Input Codes	Stop	Location	Operation	Address	Stop	CR	Contents of Address	Notes
						⊠		
		0532	XZ	0012				
		33	XH	6156			P @ 12	
		34	XZ	0800			B.P. 8	
		35	XB	6156		⊠	P@12	
		36	XR	0605			} DATA OUTPUT	
		37	XU	0600				
		38	XZ	0112				
		39	U	0544		⊠		
		40	XP	1600			} C.R.	
		41	XZ	0000				
		42	XP	2400			} TAB	
		43	XZ	0000		⊠		
		44	XR	0900			} ERFP	(0522,0539)
		45	XU	0900				
		46	80XB	5962			Q	
		47	XE	0000		⊠		
		48	XR	3851				} UNFLOAT Q @ 1
		49	XU	4008				
		50	XZ	0900				
		51	XZ	0001		⊠		
		52	M	0933			100 @ 11	
		53	XH	6157			Q@12	
		54	XR	0900			} ERFP	
		55	XU	0900		⊠		
		56	80XB	6000			S_Q	
		57	XE	0000				
		58	XR	3851				} UNFLOAT S
		59	XU	4008		⊠		
		60	XZ	0900				
		61	XZ	0012				
		62	XH	6160			S@12	
		63	XB	6156		⊠	P@12	

⊠ CARRIAGE RETURN

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SONIC VELOCITY

INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	☒						
		0600	XC	6262	·	} SET FLAG @ 0	
		01	XC	3303	·	}	
		02	U	0603	·		
		03	XB	5900	·	☒ "a"	} SOLN OF POLY
		04	XR	3231	·		}
		05	XU	3132	·		}
		06	H	0859	·	H_L@12	
		07	XB	6156	·	☒ P@12	
		08	XC	6262	·		
		09	B	0900	·	1@29	
		10	XC	3303	·	FLAG	
		11	XB	5905	·	☒ "a"	} SOLN OF POLY
		12	XR	3231	·		}
		13	XU	3132	·		}
		14	H	0860	·	H_v@12	
		15	XB	6157	·	☒ Q@12	
		16	D	0933	·	100@11	
		17	H	0861	·	Q @ 1	
		18	M	0860	·	H_v @12	
		19	D	0930	·	☒ 1@1	
		20	H	0851	·	QH_v@ 12	
		21	B	0930	·	1@1	
		22	S	0861	·	Q@1	
		23	M	0859	·	☒ H_L@12	
		24	D	0930	·	1@1	
		25	A	0851	·	QH_v@ 12	
		26	XH	6158	·	H @12	
		27	XB	6156	·	☒ P@ 12	
		28	XC	6262	·	} SET FLAG @ 0	
		29	XC	3303	·	}	
		30	XB	5920	·	"a"	} SOLN OF POLY
		31	XR	3231	·	☒	}

· = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

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SONIC VELOCITY

INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CARRIAGE RETURN	CONTENTS OF ADDRESS	NOTES
		☒						
		0632	XU	3132				
		33	H	0857			VL @12	
		34	XB	6156			P @12	
		35	XC	6262		☒		
		36	B	0900			1@29	
		37	XC	3303			FLAG	
		38	XB	5925			"a"	} SOLN OF POLY
		39	XR	3231		☒		}
		40	XU	3132				}
		41	H	0858			VV @12	
		42	M	0861			Q @1	
		43	D	0930		☒	1@1	
		44	H	0851			QVV @12	
		45	B	0930			1@1	
		46	S	0861			Q@1	
		47	M	0857		☒	VL @12	
		48	D	0930			1@1	
		49	A	0851			QVV @12	
		50	XH	6159			V @ 12	
		51	XR	0900		☒	} ERFP	
		52	XU	0900			}	
		53	80XP	6010			GMAX	
		54	80XM	5948			VV	
		55	XE	0000		☒		
		56	XR	3851				} UNFLOAT VMAX
		57	XU	4008				}
		58	XZ	0900				}
		59	XZ	0014		☒		}
		60	XH	6162			VMAX @14	
		61	XZ	0800			B.P. 8	
		62	XB	6157				} DATA OUTPUT
		63	XR	0605		☒	COUNTER A	}

' CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

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PROGRAM NO. | PROGRAM PREPARED BY: | PROGRAM CHECKED BY:

SONIC VELOCITY

INPUT CODES	STOP	LOCATION	INSTRUCTION (OPERATION / ADDRESS)	STOP	CONTENTS OF ADDRESS	NOTES
	·					
	·	[X]				
		0700	XU0600	·		}
		01	XZ0412	·		}
		02	XZ0214	·		}
		03	U0948	·	[X]	
		04	D0933	·	100@11	(Q@1) (0953)
		05	S0930	·	1@1	
		06	T0711	·		
		07	XP1600	·	[X] } C.R	
		08	XZ0000	·	}	
		09	XB5930	·	N@29	
		10	U0719	·		
		11	A0935	·	[X] 1.1@1	(0706)
		12	XR3816	·		} FLOAT NEW Q
		13	XU3800	·		}
		14	XZ0900	·		}
		15	XZ0001	·	[X]	}
		16	XR0900	·	} ERFP	
		17	XU0900	·	}	
		18	U0413	·		
		19	S0900	·	[X] 1@29	(0710)
		20	XH5930	·	N@29	
		21	U1247	·		
		22	A0909	·	XZ6145	(1250)
		23	Y0225	·	[X]	
		24	U0225	·		
		25	XZ1600	·	B.P. 16	(1248)
		26	XR0308	·	} DATA	1 ADDITIONAL
		27	XU0300	·	[X] } INPUT	ISOBAR
		28	XB6146	·		
		29	U0226	·		
		30	XC6300	·		} (0000)
		31	C0025	·	[X] COUNTER A	}

· = CONDITIONAL STOP CODE [X] CARRIAGE RETURN

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TRACK 49

PROGRAM NO.: | PROGRAM PREPARED BY: | PROGRAM CHECKED BY:

SONIC VELOCITY

INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
		☒					
		0732		C0826		COUNTER B	INITIALIZE (locations 0732–0750)
		33		C0827		COUNTER C	
		34		C0828		COUNTER D	
		35		XC6145		☒	
		36		XC6146		ISOBAR #1	
		37		XC6147		" 2	
		38		XC6148		" 3	
		39		XC6149		☒ " 4	
		40		XC6150		" 5	
		41		XC6151		" 6	
		42		XC6152		" 7	
		43		XC6153		☒ " 8	
		44		XC6154		" 9	
		45		XC6155		" 10	
		46		B0907		XZ6100	
		47		H0849		☒ P_1 α	
		48		B0132			
		49		XH2837			
		50		U0001			
		51		XE0000		☒	MODIFIED SOLN OF POLY (0816) (locations 51–63)
		52		B0908		XZ6252	
		53		Y0762			
		54		B0824		EXIT α	
		55		S0902		☒ 3@29	
		56		Y0757			
		57		B[ ]			
		58		Y0761			
		59		XR0900		☒ } ERFP (locations 59–60)	
		60		XU0900			
		61	800B	[ ]		CONSTANTS	
		62	800C	[ ]			
		63		XE0000		☒	

CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

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SONIC VELOCITY

INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	☒						
		0800	B	0828	·	COUNTER D	
		01	A	0900	·	1@29	
		02	H	0828	·	COUNTER D	
		03	S	0904	·	☒ 5@29	
		04	T	0810	·		
		05	B	0916	·	XU3213	
		06	XH	3249	·		
		07	B	0917	·	☒ U0817	MODIFIED
		08	XH	3226	·		SOLN OF POLY
		09	U	0941	·		
		10	B	0761	·		(0804)
		11	A	0901	·	☒ 2@29	
		12	Y	0761	·		
		13	B	0762	·		
		14	A	0901	·	2@29	
		15	Y	0762	·	☒	
		16	U	0759	·		
		17	B	0918	·	U3239	(X3226)
		18	XH	3249	·		
		19	B	0919	·	☒ XR3851	
		20	XC	3226	·		
		21	C	0828	·	COUNTER D	
		22	XR	0900	·	} ERFP	
		23	XU	0900	·	☒	
		24	U	[ ]	·	EXIT	
		25	[	]	·	COUNTER A	
		26	[	]	·	COUNTER B	
		27	[	]	·	☒ COUNTER C	
		28	[	]	·	COUNTER D	
		29	[	]	·	P_1 @ 12	
		30	[	]	·	P_2 @ 12	
		31	[	]	·	☒ P_3 @ 12	

· = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

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SONIC VELOCITY

INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	☒						
		0832	[	]		P_4 @ 12	
		33	[	]		P_5 @ 12	
		34	[	]		Y_{L1} @ 12	
		35	[	]	☒	Y_{L2} @ 12	
		36	[	]		Y_{L3} @ 12	
		37	[	]		Y_{L4} @ 12	
		38	[	]		Y_{L5} @ 12	
		39	[	]	☒	P_1 @ 12	
		40	[	]		P_2 @ 12	
		41	[	]		P_3 @ 12	
		42	[	]		P_4 @ 12	
		43	[	]	☒	P_5 @ 12	
		44	[	]		Y_{V1} @ 12	
		45	[	]		Y_{V2} @ 12	
		46	[	]		Y_{V3} @ 12	
		47	[	]	☒	Y_{V4} @ 12	
		48	[	]		Y_{V5} @ 12	
		49	[	]		P_1 ∝ FOR CURVE FIT	
		50	[	]		"a" ∝ FOR CURVE FIT	
		51	[		☒	QY_V	
		52	[	]			
		53	[			$S_Q - S_L$	
		54	[	]			
		55	[		☒	$S_V - S_L$	
		56	[	]			
		57	[	]		V_L @ 12	
		58	[	]		V_V @ 12	
		59	[	]	☒	H_L @ 12	
		60	[	]		H_V @ 12	
		61	[	]		Q @ 1	
		62				101	
		63			☒	102	

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TRACK 51

SONIC VELOCITY

INPUT CODES	STOP	LOCATION	INSTRUCTION: OPERATION / ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
		☒				
		0900	XZ0001			
		01	XZ0002			
		02	XZ0003			
		03	XZ0004		☒	
		04	XZ0005			
		05	XZ0010			
		06	XZ0015			
		07	XZ6100		☒	
		08	XZ6252			
		09	XZ6145			
		10	XZ6155			
		11	XZ5910		☒	
		12	XZ6024			
		13	Z0829		P_1 TEMP α	
		14	XZ5900			
		15	U0122		☒	
		16	XU3213			
		17	U0817			
		18	XU3239			
		19	XR3851		☒	
00016'		20	0		} 0	
		21	0		}	
		22	40000000		} 1	
		23	4		☒ }	
		24	4199999F		} 1.025	
		25	4		}	
		26	7JJJJ000		} .975	
		27	0		☒ }	
		28	4411QG80		} 68.07	
		29	1J		}	
		30	40000000		1@1 OR 2@2	
		31	20000000		☒ 1@2	

' = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

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20	29	4/26/63	51

PROGRAM NO. | PROGRAM PREPARED BY: | PROGRAM CHECKED BY:

SONIC VELOCITY

INPUT CODES	STOP	LOCATION	INSTRUCTION (OPERATION / ADDRESS)	STOP	CONTENTS OF ADDRESS	NOTES
		⊠				
		0932	2		1@30	
		33	6400000		100@11	
		34	100000		1@11	
		35	46666668	⊠	1.1@1	
		36	XH2837			(0144)
		37	U0102			
		38	OPEN			
		39	OPEN	⊠		
		40	OPEN			
		41	XR0900		} ERFP	(0809)
		42	XU0900		}	
		43	80XB6262	⊠	P	
		44	XN0000		LOG	
		45	80XC6262		P	
		46	XE0000			
		47	XU3160	⊠		
		48	XP1600		} C.R.	(0703)
		49	XZ0000		}	
		50	XP2400		} TAB	
		51	XZ0000	⊠	}	
		52	XB6157		Q@12 (%)	
		53	U0704			
		54	80XB6012		P_1	(0414)
		55	80XH5934	⊠		
		56	80XB6014		P_2	
		57	80XH5936			
		58	80XB6016		V_{L1}	
		59	80XH5938	⊠		
		60	80XB6018		V_{L2}	
		61	80XH5940			
		62	80XB6020		V_{V1}	
		63	U1242	⊠		

⊠ CARRIAGE RETURN

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PROGRAM NO. | PROGRAM PREPARED BY: | PROGRAM CHECKED BY:

SONIC VELOCITY

LOCATION	OPERATION	ADDRESS	STOP	CARRIAGE RETURN	CONTENTS OF ADDRESS	NOTES
				⊠		
1000	B	1232	·		U1013	
01	XH	2837	·			
02	B	1233	·		XU3613	
03	XH	3249	·	⊠		
04	U	1006	·			
05			·			
06	XR	0308	·		} DATA	
07	XU	0300	·	⊠	} INPUT	
08	B	1205	·		}	
09	B	1031	·		} CURVE	
10	XR	2855	·		} FIT	
11	XU	2000	·	⊠	}	
12	U	1025	·			
13	XE	0000	·			(X2837)
14	XB	2842	·			
15	S	1037	·	⊠	Z1225	
16	M	0930	·		2@2	
17	D	0931	·		1@2	
18	A	1039	·		XZ1215	
19	Y	1022	·	⊠		
20	XR	0900	·		} ERFP	
21	XU	0900	·		}	
22	800H	[ ]	·		CONSTANTS	
23	XE	0000	·	⊠		
24	XU	2838	·			
25	XZ	0800	·		B.P. 8	(1012)
26	B	1205	·		}	
27	XR	0605	·	⊠	} DATA	(P's)
28	XU	0600	·		} OUTPUT	
29	XZ	0512	·		}	
30	XP	1600	·		} C.R	
31	Z	1225	·	⊠		

· = CONDITIONAL STOP CODE ⊠ CARRIAGE RETURN

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SONIC VELOCITY

INPUT CODES	STOP	LOCATION	INSTRUCTION (OPERATION / ADDRESS)	STOP	CONTENTS OF ADDRESS	NOTES
		☒				
		1032	B1210		DATA	
		33	XR0605		DATA	(Y's)
		34	XU0600		OUTPUT	
		35	XZ0512		☒	
		36	XP1600		C.R.	
		37	Z1225			
		38	XP1600		C.R.	
		39	Z1215		☒	
		40	B1225			
		41	XR0605		DATA	(CONSTANTS)
		42	XU0600		OUTPUT	
		43	XZ0512		☒	
		44	XR3700		ALPHA.	
		45	XU3700			
2000004'		46	30106F08		TAB, UC, C, LC	
		47	46327F5F		☒ O, N, S, T	
		48	72325F7F		A, N, T, S	
		49	2020VQ00		CR, CR, EXIT	
		50	B1039		Z1215	(1139)
		51	Y1063		☒	
		52	B1120		XZ6252	
		53	Y1100			
		54	B1126		Z1210	
		55	Y1109		☒	
		56	XC6300			
		57	C1230		COUNTER 1	
		58	C1231		COUNTER 2	
		59	B1240		☒ B1205	
		60	U1239			
		61	XR0900		ERFP	(1160)
		62	XU0900			
		63	800B[[illegible]]		☒ CONSTANTS	(1204)

' CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

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PROGRAM NO.:
PROGRAM PREPARED BY:
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SONIC VELOCITY

INPUT CODES	STOP	LOCATION	INSTRUCTION: OPERATION / ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	.					
	. ☒					
		1100	800C[ ]	.		
		01	XE0000	.		
		02	B1230	.	COUNTER 1	
		03	A0900	.	☒ 1@29	
		04	H1230	.	COUNTER 1	
		05	S0904	.	5@29	
		06	T1154	.		
		07	XR3231	.	☒ } SOLN	
		08	XU3160	.	} OF POLY	
		09	H[ ]	.	Y	
		10	B1231	.	COUNTER 2	
		11	A0900	.	☒ 1@29	
		12	H1231	.	COUNTER 2	
		13	S0904	.	5@29	
		14	T1140	.		
		15	B1205	.	☒ }	
		16	XR0605	.	} DATA	P's
		17	XU0600	.	} OUTPUT	
		18	XZ0512	.	}	
		19	XP1600	.	☒ } C.R.	
		20	XZ6252	.	}	
		21	B1210	.	}	
		22	XR0605	.	} DATA	Y's
		23	XU0600	.	☒ } OUTPUT	
		24	XZ0512	.	}	
		25	XP1600	.	} C.R.	
		26	XZ1210	.	}	
		27	XP1600	.	☒ } C.R.	
		28	XZ0000	.	}	
		29	B1234	.	XE0000	
		30	XH2837	.		
		31	[illegible]1235	.	☒ XU3639	

. = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

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SONIC VELOCITY

INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION / ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
		[X]				
		1132	XH3249			
		1133	U1135			
		1134	OPEN			
		1135	XR0308	[X]	} DATA	
		1136	XU0300		} OUTPUT	
		1137	B1233		XU3613	
		1138	XH3249			
		1139	U1050	[X]		
		1140	B1109			(1114)
		1141	U1236			
		1142	B1145			(1238)
		1143	A0900	[X]	1@29	
		1144	Y1145			
		1145	B[ ]		P	
		1146	XR3816		}	
		1147	XU3800	[X]	} FLOAT	
		1148	XZ0900		}	
		1149	XZ0012		}	
		1150	XU3209			
		1151	OPEN	[X]		
		1152	OPEN			
		1153	OPEN			
		1154	B1063			(1106)
		1155	A0901	[X]	2@29	
		1156	Y1063			
		1157	B1100			
		1158	A0901		2@29	
		1159	Y1100	[X]		
		1160	U1061			
		1161	XR3816		}	(1241)
		1162	XU3800		} FLOAT	
		1163	XZ0900	[X]	}	

[X] CARRIAGE RETURN

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PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:

SONIC VELOCITY

INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	· ☒						
		1200	XZ	0012	·		
		01	XR	0900	·	} ERFP	
		02	XU	0900	·		
		03	80XH	6262	· ☒		
		04	U	1063	·		
		05	[	]	·	P_1 @ 12	
		06	[	]	·	P_2 @ 12	
		07	[	]	· ☒	P_3 @ 12	
		08	[	]	·	P_4 @ 12	
		09	[	]	·	P_5 @ 12	
		10	[	]	·	Y_1 @ 12	
		11	[	]	· ☒	Y_2 @ 12	
		12	[	]	·	Y_3 @ 12	
		13	[	]	·	Y_4 @ 12	
		14	[	]	·	Y_5 @ 12	
		15	[	]	· ☒	a	
		16	[	]	·		
		17	[	]	·	b	
		18	[	]	·		
		19	[	]	· ☒	c	
		20	[	]	·		
		21	[	]	·	d	
		22	[	]	·		
		23	[	]	· ☒	e	
		24	[	]	·		
		25	[	]	·	a @ 12	
		26	[	]	·	b @ 12	
		27	[	]	· ☒	c @ 12	
		28	[	]	·	d @ 12	
		29	[	]	·	e @ 12	
		30	[	]	·	COUNTER 1	
		31	[	]	· ☒	COUNTER 2	

· = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN.

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PROGRAM NO. | PROGRAM PREPARED BY: | PROGRAM CHECKED BY:

SONIC VELOCITY

INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	[X]						
		1232	U	1013			
		33	XU	3315			
		34	XE	0000			
		35	XU	3239	[X]		
		36	A	0900		1@29	(1141)
		37	Y	1109			
		38	U	1142			
		39	Y	1145	[X]		(1060)
		40	B	1205		P_1	
		41	U	1161			
		42	80XH	5942			(0963)
		43	80XB	6022	[X]	V_{v_2}	
		44	80XH	5944			
		45	80XP	5962		Q	
		46	U	0415			
		47	S	0900	[X]	1@29	(0721)
		48	T	0725			
		49	A	0900		1@29	
		50	U	0722			
		51	B	0910	[X]	XZ6155	(0221)
		52	S	0827		COUNTER C	
		53	Y	0225			
		54	U	0222			
		55			[X]		
		56					
		57					
		58					
		59			[X]		
		60					
		61					
		62					
		63			[X]		

[X] CARRIAGE RETURN

SONIC VELOCITY

Track 59

Sector	Quantity		Q
00	a	H_L VS LN P	12
01	b		12
02	c		12
03	d		12
04	e		12
05	a	LN H_V VS LN P	12
06	b		12
07	c		12
08	d		12
09	e		12
10	a	S_L VS LN P	12
11	b		12
12	c		12
13	d		12
14	e		12
15	a	LN S_V VS LN P	12
16	b		12
17	c		12
18	d		12
19	e		12
20	a	V_L VS LN P	12
21	b		12
22	c		12
23	d		12
24	e		12
25	a	LN V_V VS LN P	12
26	b		12
27	c		12
28	d		12
29	e		12
30	N		24
31			

Sector	Quantity	Q
32	[P	
33	]	
34	[P_1	
35	]	
36	[P_2	
37	]	
38	[V_{L1}	
39	]	
40	[V_{L2}	
41	]	
42	[V_{V1}	
43	]	
44	[V_{V2}	
45	]	
46	[V_L	
47	]	
48	[V_V	
49	]	
50	[S_{L1}	
51	]	
52	[S_{L2}	
53	]	
54	[S_{V1}	
55	]	
56	[S_{V2}	
57	]	
58	[S_L	
59	]	
60	[S_V	
61	]	
62	[Q	
63	]	

SONIC VELOCITY

Track 60

Sector	Quantity	Q	Group
	S_a		
	Q_1		
	Q_2		
	V_{a1}		
	V_{a2}		
0	G_{MAX}		
2	P_1		
3			
4	P_2		
5			
6	V_{L1}		
7			
8	V_{L2}		
9			
0	V_{V1}		
1			
2	V_{V2}		
3			
4	a		S_L vs LN P
5			
6	b		
7			
8	c		
9			
0	d		
1			

Sector	Quantity	Q	Group
32	e		
33			
34	a		LN S_V vs LN P
35			
36	b		
37			
38	c		
39			
40	d		
41			
42	e		
43			
44	a		V_L vs LN P
45			
46	b		
47			
48	c		
49			
50	d		
51			
52	e		
53			
54	a		LN V_V vs LN P
55			
56	b		
57			
58	c		
59			
60	d		
61			
62	e		
63			

SONIC VELOCITY

Track 61

INPUT & OUTPUT DATA

Sector	Quantity	Q	Sector	Quantity	Q
00	P_1	12	32	P_3	12
01	P_2	12	33	P_4	12
02	P_3	12	34	P_5	12
03	P_4	12	35	V_{L1}	12
04	P_5	12	36	V_{L2}	12
05	H_{L1}	12	37	V_{L3}	12
06	H_{L2}	12	38	V_{L4}	12
07	H_{L3}	12	39	V_{L5}	12
08	H_{L4}	12	40	V_{V1}	12
09	H_{L5}	12	41	V_{V2}	12
10	H_{V1}	12	42	V_{V3}	12
11	H_{V2}	12	43	V_{V4}	12
12	H_{V3}	12	44	V_{V5}	12
13	H_{V4}	12	45	XZ0000	
14	H_{V5}	12	46	ISOBAR # 1	12
15	P_1	12	47	" 2	12
16	P_2	12	48	" 3	12
17	P_3	12	49	" 4	12
18	P_4	12	50	" 5	12
19	P_5	12	51	" 6	12
20	S_{L1}	12	52	" 7	12
21	S_{L2}	12	53	" 8	12
22	S_{L3}	12	54	" 9	12
23	S_{L4}	12	55	" 10	12
24	S_{L5}	12	56	P (LB/SQ IN)	12
25	S_{V1}	12	57	Q (%)	12
26	S_{V2}	12	58	H (BTU/LB)	12
27	S_{V3}	12	59	V (CU FT/LB)	12
28	S_{V4}	12	60	S (BTU/LB-°F)	12
29	S_{V5}	12	61	G_{MAX} (LB/SQ FT-SEC)	12
30	P_1	12	62	V_{MAX} (FT/SEC)	12
31	P_2	12	63		

Sectors 56–62: OUTPUT

RESULTS

Pages 43 to 47 are the computer print out sheets for the Sonic Velocity Program for the two phase Freon 12 system. They contain results for 10 pressures - 225, 150, 100, 60, 45, 30, 20, 14.7, 10 and 5 psia for all vapor qualities from 0% to 100% at 10% intervals. In addition to the pressure, quality and sonic mass velocity the program also prints the average physical properties - enthalpy, specific volume and entropy - and the fictitious linear sonic velocity, V_{max}.

Fig. 3 is the sonic velocity curve obtained from plotting the data from the print out sheets.

Similarly, this information was obtained for the Freon 22 system and is presented on pages 49 to 53 and in Fig. 4.

The maximum velocity for 0% quality was obtained by projecting into the two-phase region. Since there is an abrupt change in the isentropic compressibility as the mixture approaches the pure liquid state, the velocities calculated for saturated liquid are very low - in fact, several orders of magnitude. Other than this discrepency in the saturated liquid region, the results are reasonably accurate.

A brief explanation of the last column of the print out sheet, V_{max}, seems in order since this could be a misleading term. V_{max} is a term invented by the author to express the linear velocity which would result if the sonic mass flow rate at any pressure and quality were to remain the same for the flow of saturated vapor at the same pressure i, e,

$$V_{max} = G_{max} \times V_v.$$

P (PSIA)	Q (% Vapor)	H (BTU/Lb)	V (Cu Ft/Lb)	S (BTU/Lb-deg F)	G max (Lb/Sq Ft-Sec)	V max (Ft/Sec)
225.00000	.00000	41.56118	.01379	.08083	3860.082	673.4776
	10.00000	46.40607	.02985	.08890	3614.185	630.5753
	20.00000	51.25097	.04592	.09696	3374.145	588.6950
	30.00000	56.09586	.06199	.10502	3176.349	554.1850
	40.00000	60.94076	.07806	.11309	3009.702	525.1097
	50.00000	65.78565	.09413	.12115	2866.802	500.1776
	60.00000	70.63055	.11019	.12922	2742.497	478.4899
	70.00000	75.47544	.12626	.13728	2633.076	459.3988
	80.00000	80.32034	.14233	.14534	2535.786	442.4245
	90.00000	85.16523	.15839	.15341	2448.5410	427.2027
	100.00000	90.01013	.17447	.16147	2341.4272	408.5143
150.00000	.00000	33.43080	.01292	.06726	2848.216	767.1808
	10.00000	38.86436	.03855	.07681	2606.863	702.1713
	20.00000	44.29793	.06419	.08636	2394.4169	644.9478
	30.00000	49.73150	.08984	.09591	2226.6676	599.7637
	40.00000	55.16506	.11548	.10546	2089.8614	562.9143
	50.00000	60.59863	.14113	.11501	1975.5231	532.1167
	60.00000	66.03220	.16677	.12456	1878.1073	505.8773
	70.00000	71.46576	.19241	.13411	1793.8133	483.1723
	80.00000	76.89933	.21806	.14366	1719.9373	463.2735
	90.00000	82.33290	.24371	.15321	1654.4962	445.6466
	100.00000	87.76647	.26935	.16276	1577.2843	424.8492

100.00000	.00000	26.51649	.01228	.05504	2094.6424	852.6863
	10.00000	32.40196	.05175	.06593	1873.3811	762.6153
	20.00000	38.28743	.09123	.07682	1694.5167	689.8032
	30.00000	44.17290	.13071	.08770	1558.7157	634.5214
	40.00000	50.05837	.17019	.09859	1451.0765	590.7037
	50.00000	55.94384	.20967	.10948	1363.0427	554.8669
	60.00000	61.82931	.24915	.12037	1289.3046	524.8497
	70.00000	67.71478	.28863	.13126	1226.3697	499.2301
	80.00000	73.60025	.32811	.14214	1171.8339	477.0297
	90.00000	79.48572	.36759	.15303	1123.9813	457.5499
	100.00000	85.37119	.40707	.16392	1068.9876	435.1631
60.00000	.00000	19.16436	.01170	.04120	1412.7614	947.8668
	10.00000	25.48073	.07761	.05362	1226.6358	822.9892
	20.00000	31.79710	.14354	.06604	1089.6186	731.0599
	30.00000	38.11347	.20947	.07846	990.1835	664.3457
	40.00000	44.42984	.27539	.09089	913.7919	613.0922
	50.00000	50.74621	.34132	.10331	852.7287	572.1230
	60.00000	57.06258	.40723	.11573	802.4701	538.4028
	70.00000	63.37895	.47315	.12815	760.1647	510.0188
	80.00000	69.69533	.53908	.14057	723.9142	485.6972
	90.00000	76.01170	.60500	.15299	692.3997	464.5531
	100.00000	82.32807	.67093	.16542	656.9770	440.7869

45.00000	.00000	15.54924	.01146	.03401	1127.2291	995.5271
	10.00000	22.06073	.09862	.04725	962.3046	849.8719
	20.00000	28.57222	.18579	.06048	846.6413	747.7224
	30.00000	35.08371	.27296	.07372	764.6533	675.3136
	40.00000	41.59520	.36014	.08695	702.6413	620.5469
	50.00000	48.10670	.44730	.10018	653.6213	577.2542
	60.00000	54.61819	.53447	.11342	613.6103	541.9180
	70.00000	61.12968	.62164	.12665	580.1489	512.3661
	80.00000	67.64117	.70882	.13989	551.6253	487.1751
	90.00000	74.15266	.79598	.15312	526.9334	465.3682
	100.00000	80.66415	.88316	.16635	499.4296	441.0778

30.00000	.00000	10.95418	.01118	.02449	815.6691	1056.3539
	10.00000	17.70186	.13956	.03883	679.7745	880.3601
	20.00000	24.44955	.26795	.05317	590.4457	764.6724
	30.00000	31.19724	.39634	.06750	529.0532	685.1644
	40.00000	37.94492	.52473	.08184	483.5334	626.2128
	50.00000	44.69262	.65311	.09617	448.0471	580.2553
	60.00000	51.44030	.78151	.11051	419.3784	543.1271
	70.00000	58.18799	.90990	.12484	395.5912	512.3208
	80.00000	64.93568	1.03828	.13918	375.4407	486.2245
	90.00000	71.68337	1.16667	.15352	358.0858	463.7486
	100.00000	78.43106	1.29507	.16785	338.9478	438.9634

20.00000	.00000	6.82453	.01094	.01556	586.7008	1111.3096
	10.00000	13.77807	.19926	.03096	477.2194	903.9336
	20.00000	20.73162	.38758	.04637	409.5513	775.7588
	30.00000	27.68517	.57590	.06178	364.3534	690.1465
	40.00000	34.63872	.76422	.07718	331.4305	627.7849
	50.00000	41.59226	.95255	.09259	306.0735	579.7546
	60.00000	48.54581	1.14086	.10799	285.7679	541.2924
	70.00000	55.49935	1.32919	.12340	269.0323	509.5923
	80.00000	62.45290	1.51750	.13881	254.9299	482.8800
	90.00000	69.40645	1.70583	.15421	242.8355	459.9712
	100.00000	76.36000	1.89416	.16962	229.6036	434.9078
14.70000	.00000	3.93755	.01077	.00910	455.2620	1150.4308
	10.00000	11.03422	.26239	.02531	363.4705	918.4770
	20.00000	18.13091	.51401	.04151	309.2457	781.4528
	30.00000	25.22759	.76562	.05772	273.7528	691.7636
	40.00000	32.32428	1.01724	.07392	248.2135	627.2266
	50.00000	39.42096	1.26886	.09013	228.7043	57.9275
	60.00000	46.51764	1.52048	.10633	213.1734	538.6815
	70.00000	53.61433	1.77210	.12254	200.4298	506.4790
	80.00000	60.71101	2.02371	.13874	189.7286	479.4373
	90.00000	67.80769	2.27533	.15495	180.5766	456.3107
	100.00000	74.90438	2.52696	.17115	170.6151	431.1381

10.00000	.00000	.57809	.01058	.00137	330.4629	1197.9930
	10.00000	7.84246	.37203	.01857	257.6552	934.0506
	20.00000	15.10685	.73350	.03576	216.9664	786.5457
	30.00000	22.37124	1.09496	.05295	190.9616	692.2733
	40.00000	29.63563	1.45642	.07015	172.5109	625.3858
	50.00000	36.90002	1.81788	.08734	158.5470	574.7641
	60.00000	44.16441	2.17934	.10454	147.5040	534.7308
	70.00000	51.42879	2.54079	.12173	138.4875	502.0445
	80.00000	58.69318	2.90226	.13892	130.9451	474.7018
	90.00000	65.95757	3.26372	.15612	124.5144	451.3894
	100.00000	73.22196	3.62518	.17331	117.5555	426.1619
5.00000	.00000	-4.82829	.01028	-.01162	185.3602	1286.5730
	10.00000	2.70676	.70333	.00732	138.1883	959.1560
	20.00000	10.24182	1.39639	.02626	114.3329	793.5771
	30.00000	17.77689	2.08946	.04520	99.6857	691.9115
	40.00000	25.31194	2.78253	.06414	89.5272	621.4027
	50.00000	32.84700	3.47559	.08307	81.9517	568.8212
	60.00000	40.38205	4.16865	.10201	76.0223	527.6655
	70.00000	47.91712	4.86172	.12095	71.2179	494.3189
	80.00000	55.45217	5.55478	.13989	67.2227	466.5879
	90.00000	62.98723	6.24784	.15883	63.8322	443.0550
	100.00000	70.52229	6.94091	.17777	60.2008	417.8496

FIGURE 3

SONIC VELOCITY IN FREON-12 SYSTEM

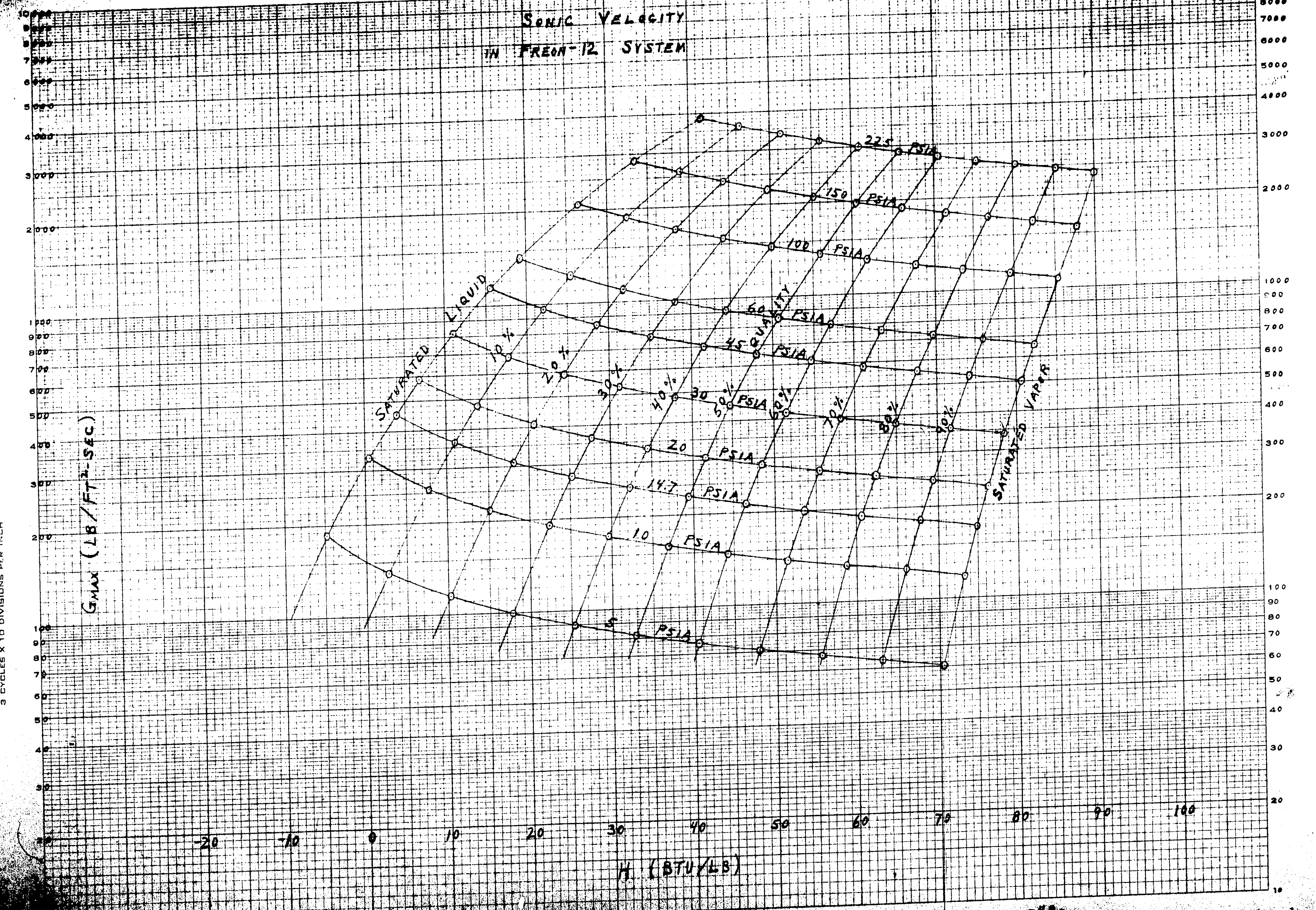


TABLE 2

P (PSIA)	Q (% Vapor)	H (BTU/Lb)	V (Cu Ft/Lb)	S (BTU/Lb-deg F)	G max (Lb/Sq Ft-Sec)	V max (Ft/Sec)
225.00000	.00000	42.30810	.01415	.08507	3648.151	862.4993
	10.00000	49.38848	.03637	.09763	3362.615	794.9927
	20.00000	56.46888	.05859	.11020	3104.848	734.0510
	30.00000	63.54926	.08083	.12276	2898.516	685.2699
	40.00000	70.62965	.10305	.13533	2728.515	645.0780
	50.00000	77.71005	.12528	.14790	2585.298	611.2185
	60.00000	84.79044	.14750	.16046	2462.4975	582.1860
	70.00000	91.87083	.16973	.17303	2355.6831	556.9328
	80.00000	98.95121	.19196	.18559	2261.6621	534.7043
	90.00000	106.03160	.21419	.19816	2178.0691	514.9412
	100.00000	113.11200	.23642	.21072	2077.9104	491.2615
150.00000	.00000	32.84031	.01338	.06817	2714.692	989.8249
	10.00000	40.73957	.04851	.08293	2428.7558	885.5674
	20.00000	48.63884	.08363	.09769	2197.7969	801.3557
	30.00000	56.53810	.11875	.11245	2022.2559	737.3503
	40.00000	64.43737	.15387	.12722	1883.0117	686.5795
	50.00000	72.33664	.18900	.14198	1769.0648	645.0324
	60.00000	80.23591	.22411	.15674	1673.5793	610.2167
	70.00000	88.13517	.25924	.17150	1592.0544	580.4913
	80.00000	96.03444	.29436	.18626	1521.3893	554.7255
	90.00000	103.93371	.32948	.20103	1459.3691	532.1118
	100.00000	111.83298	.36462	.21579	1387.9208	506.0605

100.00000	.00000	24.88832	.01281	.05315	2010.2088	1106.8610
	10.00000	33.39838	.06659	.06984	1745.6578	961.1940
	20.00000	41.90843	.12037	.08653	1551.1267	854.0812
	30.00000	50.41848	.17415	.10322	1409.8495	776.2912
	40.00000	58.92854	.22793	.11991	1301.2588	716.4990
	50.00000	67.43859	.28171	.13661	1214.4266	668.6875
	60.00000	75.94865	.33549	.15329	1142.9394	629.3252
	70.00000	84.45870	.38927	.16998	1082.7518	596.1847
	80.00000	92.96876	.44305	.18667	1031.1701	567.7828
	90.00000	101.47881	.49683	.20336	986.3211	543.0881
	100.00000	109.98887	.55061	.22005	935.9075	515.3293
60.00000	.00000	16.54166	.01228	.03644	1366.9255	1239.7134
	10.00000	25.61727	.10174	.05530	1142.8738	1036.5129
	20.00000	34.69289	.19120	.07415	994.5816	902.0214
	30.00000	43.76852	.28067	.09300	892.2000	809.1679
	40.00000	52.84415	.37013	.11185	816.0692	740.1223
	50.00000	61.91977	.45960	.13070	756.6006	686.1880
	60.00000	70.99538	.54907	.14956	708.4866	642.5517
	70.00000	80.07101	.63853	.16841	668.5203	606.3049
	80.00000	89.14663	.72799	.18726	634.6344	575.5726
	90.00000	98.22225	.81746	.20612	605.4287	549.0848
	100.00000	107.29788	.90693	.22497	573.2498	519.9007

45.00000	.00000	12.47868	.01203	.02792	1095.5099	1307.5195
	10.00000	21.80544	.13017	.04790	896.4770	1069.9685
	20.00000	31.13222	.24833	.06788	771.7883	921.1493
	30.00000	40.45899	.36648	.08787	687.8832	821.0065
	40.00000	49.78577	.48462	.10785	626.4855	747.7268
	50.00000	59.11253	.60277	.12783	579.0512	691.1126
	60.00000	68.43932	.72093	.14782	540.9810	645.6749
	70.00000	77.76608	.83907	.16780	509.5508	608.1621
	80.00000	87.09286	.95721	.18778	483.0307	576.5096
	90.00000	96.41963	1.07536	.20777	460.2623	549.3350
	100.00000	105.74641	1.19352	.22775	435.3752	519.6316
30.00000	.00000	7.35094	.01174	.01678	797.2223	1394.7696
	10.00000	16.97904	.18552	.03829	632.9835	1107.4279
	20.00000	26.60716	.35929	.05980	537.3440	940.1030
	30.00000	36.23528	.53307	.08131	475.0687	831.1501
	40.00000	45.86340	.70685	.10282	430.3968	752.9950
	50.00000	55.49151	.88063	.12433	396.3429	693.4164
	60.00000	65.11961	1.05441	.14585	369.2733	646.0571
	70.00000	74.74773	1.22819	.16736	347.0864	607.2404
	80.00000	84.37586	1.40196	.18887	328.4714	574.6728
	90.00000	94.00397	1.57575	.21038	312.5624	546.8394
	100.00000	103.63209	1.74953	.23189	295.3219	516.6766

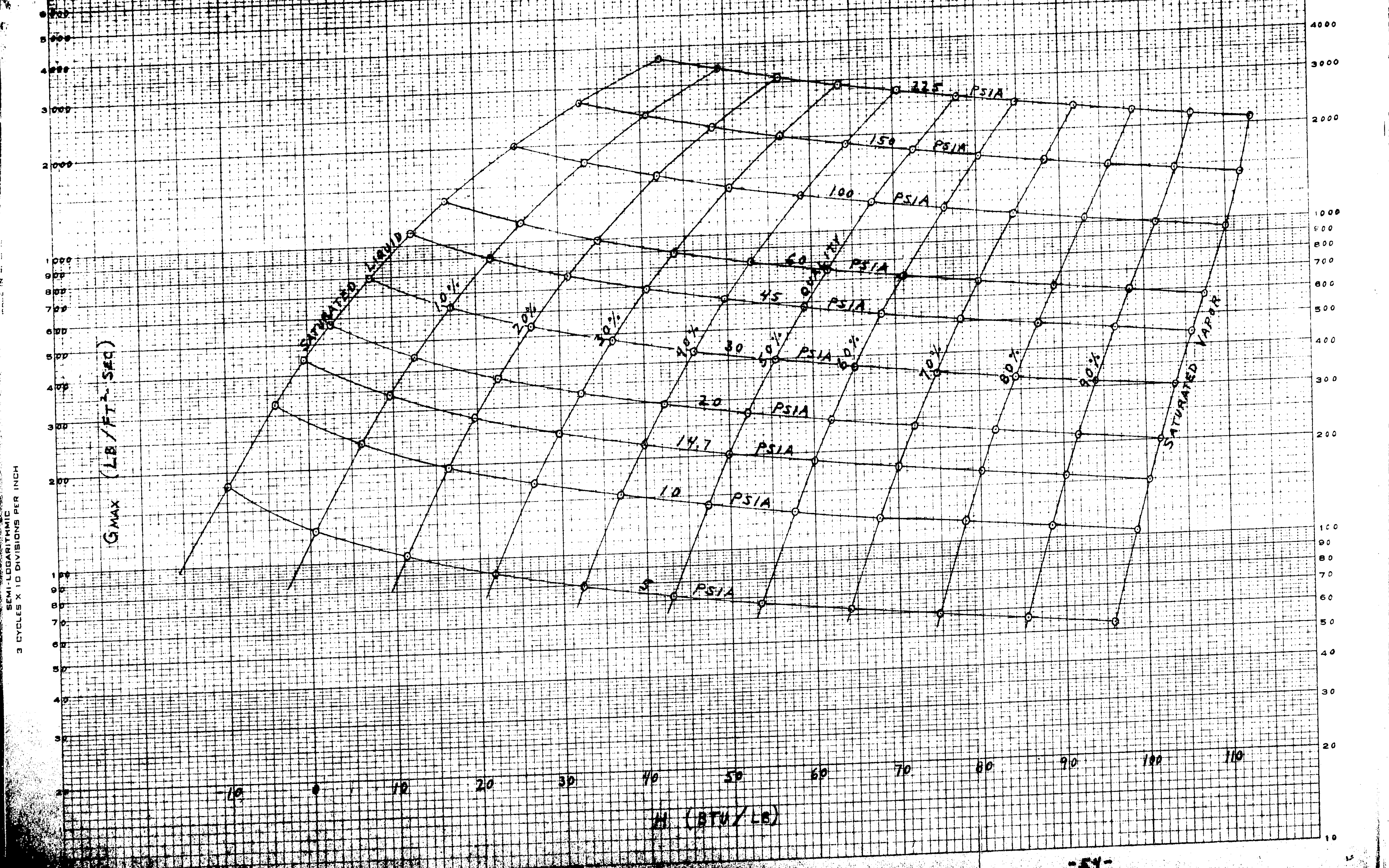
20.00000	.00000	2.77512	.01149	.00647	575.8634	1472.5610
	10.00000	12.66433	.26604	.02947	443.8732	1135.0441
	20.00000	22.55354	.52061	.05246	372.0697	951.4329
	30.00000	32.44276	.77518	.07545	326.6582	835.3094
	40.00000	42.33198	1.02974	.09844	294.6329	753.4164
	50.00000	52.22119	1.28431	.12143	270.4914	691.6833
	60.00000	62.11041	1.53886	.14443	251.4528	642.9991
	70.00000	71.99963	1.79343	.16742	235.9405	603.3319
	80.00000	81.88884	2.04800	.19041	222.9850	570.2031
	90.00000	91.77806	2.30256	.21340	211.9533	541.9935
	100.00000	101.66728	2.55713	.23639	200.0751	511.6194
14.70000	.00000	-.40502	.01132	-.00090	447.5835	1525.4569
	10.00000	9.66421	.35100	.02319	337.5546	1150.4558
	20.00000	19.73343	.69068	.04729	280.5126	956.0450
	30.00000	29.80266	1.03037	.07138	245.1397	835.4868
	40.00000	39.87189	1.37006	.09548	220.4711	751.4110
	50.00000	49.94111	1.70975	.11957	202.0092	688.4891
	60.00000	60.01034	2.04944	.14366	187.5233	639.1180
	70.00000	70.07957	2.38913	.16776	175.7646	599.0419
	80.00000	80.14880	2.72881	.19185	165.9724	565.6681
	90.00000	90.21803	3.06850	.21595	157.6534	537.3152
	100.00000	100.28725	3.40820	.24004	148.7311	506.9062

10.00000	.00000	-4.08073	.01112	-.00970	324.6660	1584.1892
	10.00000	6.19467	.49795	.01575	238.5662	1164.0702
	20.00000	16.47009	.98478	.04120	196.3472	958.0649
	30.00000	26.74551	1.47161	.06665	170.7288	833.0617
	40.00000	37.02092	1.95844	.09210	153.0769	746.9301
	50.00000	47.29634	2.44527	.11755	139.9675	682.9634
	60.00000	57.57175	2.93211	.14300	129.7361	633.0400
	70.00000	67.84716	3.41893	.16845	121.4636	592.6747
	80.00000	78.12258	3.90576	.19390	114.5953	559.1612
	90.00000	88.39800	4.39259	.21935	108.7742	530.7575
	100.00000	98.67342	4.87943	.24479	102.5568	500.4200
5.00000	.00000	-9.89189	.01090	-.02460	179.9204	1668.1387
	10.00000	.68339	.93696	.00317	126.7759	1175.4077
	20.00000	11.25867	1.86302	.03093	102.8727	953.7885
	30.00000	21.83395	2.78908	.05869	88.8174	823.4736
	40.00000	32.40924	3.71514	.08646	79.2952	735.1887
	50.00000	42.98452	4.64121	.11422	72.2982	670.3155
	60.00000	53.55980	5.56726	.14199	66.8770	620.0530
	70.00000	64.13509	6.49333	.16975	62.5171	579.6294
	80.00000	74.71037	7.41939	.19751	58.9119	546.2039
	90.00000	85.28565	8.34544	.22528	55.8662	517.9654
	100.00000	95.86094	9.27152	.25304	52.6341	487.9991

FIGURE 4

SONIC VELOCITY

IN FREON-22 SYSTEM



DISCUSSION OF RESULTS

Pages 122 to 127 of the Appendix are the computer print-out sheets used to check the accuracy of the program for the Freon 12 and Freon 22 systems investigated. They represent computer results for 5 saturation pressures very close to 5 of the 10 pressures listed in the "Results", but are values for which saturated liquid and vapor data are tabulated in Properties of Commonly Used Refrigerants (2). This choice of pressures was made to eliminate inter-polation of data for hand calculations.

Sonic velocity was calculated by hand for all 5 pressures at 0%, 50% and 100% quality by the same method and with the same equations used in the computer program, using the next higher tabulated pressure for P_2 and the next lower for P_1. The results of these hand calculations and the equivalent computer values are listed in Tables 3 and 4 along with the percentage deviation of the computer values.

The maximum deviation for Freon 12 was found to be approximately 4% and for Freon 22 approximately 6.5%. Some of this deviation is due to the inherent error in using difference methods to approximate a derivative, since the differences are greater for the hand calculations and the accuracy of the differences is less than for the computer calculations.

However, the main reason for the deviation is the error in the physical properties resulting from the inaccuracy of the polynomials. Tables 5 and 6 show a comparison between published data and computer values for saturated liquid and vapor properties.

The maximum deviation in entropy or specific volume is 1.8%. Although the deviations are generally much smaller than this, the maximum velocity is a function of the slope of the entropy and volume curves and is therefore affected by the oscillations of the polynomials, even though the equations may accurately reproduce the properties for a given point.

A comparison of the results from this report with those of Vaillancourt (8) for the Freon 12 system was of little value in determing the accuracy of the computer program. With the exception of the 14.7 psia isobar, a maximum difference of approximately 20% was found in the two methods. However, this discrepency appears to be mostly a result of the use of different sources for physical properties. It would appear that Vaillancourt's 14.7 psia line is in error, although no attempt was made to determine the cause of the error.

The results presented in this report were obtained using a range of data points from 5 psia to 225 psia. The accuracy of the results could be improved by limiting each set of calculations to a smaller pressure range. For example, if the systems presented in this report had been divided into two or three ranges with well chosen data points better coefficients for the polynomials would have resulted. Better results could also be achieved by so selecting the data points that each isobar would fall on or near a data point.

However, the maximum errors recorded here for sonic velocity represent approximately the same reliability obtainable by praphical solutions. The results are also probably much better that the reproducibility of any experimental method for measuring sonic velocity. More important is the fact that the calculations assume equilibrium between two phases at very high velocity, which would certainly be far from accurate for the actual conditions.

From the above considerations it is concluded that the computer program presented in this report provides a method for calculating reliable theoretical data for a curve of sonic velocity versus enthalpy for one component, two phase systems. The reliability ceases in the region below 10% quality, since the change in compressibility is so great as to approach a discontinuity, and results in liquid velocities which are low by several orders of magnitude.

No sonic choke was found in the two phase region for the Freon 12 and Freon 22 systems studied. From the sonic velocity curves, Figs. 3 and 4, it can be seen that for all pressures the lowest velocity calculated occurs for saturated vapor.

However, considering typical approximations in engineering practice, some difficulties can be foreseen in designs based only on the vapor velocity. For example, a mixture of Freon 22 liquid and vapor at 225 psia and 50% quality might be assumed to be 90% vapor by volume. For the maximum vapor velocity being the velocity of sound in pure vapor, the overall maximum mass velocity would be two times 90% of the sonic velocity of the pure vapor, or

$$G_{max} \doteq 2\ (0.9 \times 2078) \doteq 3740\#/ft^2sec.$$

However, from the computer results on page 49 it is seen that $G_{max} \doteq$ 2585#/ft^2sec. for 225 psia and 50% quality. Furthermore, assuming the phases are separate, the liquid velocity would be calculated to be 26.4ft/sec., an entirely reasonable value.

Similarly at 5 psia and 50% quality for Freon 22, an overall maximum mass velocity of 104.2#/ft^2sec. would be calculated assuming 99% of the volume as a vapor. The resulting liquid velocity would be less than

1 ft/sec. However, the maximum mass velocity calculated by the computer is only 72.3#/ft^{2}sec.

In order to reduce the possibility of errors of this type and to check for the existence of limiting sonic velocities within the two phase envelope, it is recommended that the Sonic Velocity program be used to develop sonic velocity curves for common fluids of various type - e.g., steam, inorganics, refrigerants and light hydrocarbons. If this study points to any significant value in these curves, the computer program should be rewritten to make use of a true curve fit routine, in order to make it applicable where the best kind of published physical data is not available.

At the time when this information is found to be of importance, it will also be necessary to find some physical means of verifying the results experimentally.

TABLE 3

COMPARISON OF RESULTS

FOR FREON 12

P(PSIA)	Q(%)	G_{max} (LB./FT^{2}SEC.) COMPUTER	CALCULATED	DEVIATION (%)
224.00	0	3847	3857	-.26
	50	2855	2850	+.18
	100	2331	2311	+.87
60.364	0	1419	1458	-2.68
	50	857.5	862.5	-.58
	100	660.8	658.1	+.20
29.932	0	814.2	804.6	+1.19
	50	447.1	446.4	+.16
	100	338.2	335.4	+.83
14.564	0	451.8	433.2	+4.29
	50	226.7	222.6	+1.84
	100	169.1	167.4	+1.01
5.0516	0	186.9	184.5	+1.30
	50	82.75	83.10	-.42
	100	60.80	60.11	+1.15

TABLE 4

COMPARISON OF RESULTS

FOR FREON 22

P(PSIA)	Q(%)	G_{max} (LB./FT^2SEC.) COMPUTER	CALCULATED	DEVIATION (%)
224.6	0	3643	3580	+1.76
	50	2581	2590	-.35
	100	2074	2050	+1.17
60.23	0	1371	1340	+2.31
	50	759	768	-1.17
	100	575	565	+1.77
29.94	0	796	770	+3.38
	50	396	396	.00
	100	295	287	+2.79
14.54	0	444	417	+6.47
	50	200	201	-.50
	100	147.2	141.8	+3.81
5.100	0	183.0	180	+1.67
	50	73.7	73.0	+.96
	100	53.6	52.2	+2.68

TABLE 5 FREON 12 PROPERTIES

P(PSIA)	H(BTU/LB) CALC.	H(BTU/LB) ACTUAL	DEV. (%)	V(CuFT/LB) CALC.	V(CuFT/LB) ACTUAL	DEV. (%)	S(BTU/LB °F) CALC.	S(BTU/LB °F) ACTUAL	DEV. (%)
				(SATURATED LIQUID)					
224.00	41.464	41.427	+.089	.01379	.013778	+.087	.08068	.080635	+.056
60.364	19.244	19.283	-.204	.01170	.011730	-.256	.04135	.041403	-.128
29.932	10.930	10.901	+.266	.01118	.011173	+.060	.02444	.024413	+.112
14.564	3.8533	3.8100	+1.14	.01077	.010764	+.056	.00891	.008864	+.520
5.0516	-4.7543	-4.6088	+3.16	.01028	.010337	-.552	-.01144	-.011259	+1.61
				(SATURATED VAPOR)					
224.00	89.987	90.028	-.045	.17532	.17561	-.165	.16148	.16154	-.037
60.364	82.364	82.334	+.036	.66703	.66616	+.130	.16540	.16535	+.030
29.932	78.419	78.440	-.027	1.2978	1.2992	-.108	.16786	.16790	-.024
14.564	74.862	74.891	-.039	2.5490	2.5529	-.153	.17120	.17126	-.035
5.0516	70.560	70.471	+.126	6.8746	6.8412	+.488	.17770	.17753	+.096

TABLE 6

FREON 22 PROPERTIES

P(PSIA)	H(BTU/LB) CALC.	H(BTU/LB) ACTUAL	DEV.(%)	V(CuFT/LB) CALC.	V(CuFT/LB) ACTUAL	DEV.(%)	S(BTU/LB °F) CALC.	S(BTU/LB °F) ACTUAL	DEV.(%)
(SATURATED LIQUID)									
224.6	42.26	42.32	-.142	.01415	.01408	+.497	.0850	.0851	-.128
60.23	16.60	16.52	+.484	.01228	.01229	-.081	.0366	.0364	+.55
29.94	7.33	7.43	-1.35	.01174	.01174	.000	.0167	.0170	-1.76
14.54	-.51	-.51	.000	.01131	.01133	-.088	-.0012	-.0012	.000
5.100	-9.74	-9.72	-.206	.01090	.01091	-.092	-.0242	-.0242	.000
(SATURATED VAPOR)									
224.6	113.11	113.16	-.044	.2369	.2370	-.042	.2108	.2107	+.047
60.23	107.32	107.33	-.009	.9036	.9032	+.044	.2249	.2249	.000
29.94	103.62	103.70	-.077	1.753	1.752	+.057	.2319	.2321	-.086
14.54	100.24	100.23	+.010	3.443	3.440	+.087	.2402	.2400	+.083
5.100	95.94	95.92	+.021	9.104	9.086	+.198	.2528	.2526	+.079

CONCLUSIONS

A computer program is presented in this report to calculate sonic velocities in two-phase flow for one component fluids. This program is considered to be a satisfactory tool for two-phase flow studies, if reasonable discretion is used in the choice of data points and pressure ranges. The results from this program are presented for the Freon 12 and Freon 22 systems in both tabulated and graphical form.

For the two systems studied, no sonic choke was found to exist in the two-phase region. However, from common engineering practices it can be seen that systems for handling two-phase fluids might be under-designed if pure vapor sonic velocity is considered the limiting criterion.

The author recommends continued work in this field in the following order:

1. The use of the program to develop velocity curves for other common fluids.
2. Verification of these calculated results with laboratory tests.
3. Revision of the program to incorporate a least squares curve fit routine, for use when less accurate physical properties are available.

Of course the necessity of each of these steps will depend on the previous step confirming the importance of this study.

NOMENCLATURE

A_a - Determinant with dependent variables in first column.

A_b - Determinant with dependent variables in second column.

A_c - Determinant with dependent variables in third column.

A_d - Determinant with dependent variables in fourth column.

A_e - Determinant with dependent variables in fifth column.

B - Determinant with all independent variables.

E - Internal energy.

G - Mass velocity.

G_{max} - Sonic mass velocity - lb/sq.ft. sec.

H - Enthalpy of vapor-liquid mixture above saturated liquid @ -40°F., BTU/lb.

H_L - Enthalpy of saturated liquid above saturated liquid @ -40°F., BTU/lb.

H_V - Enthalpy of saturated vapor above saturated liquid @ -40°F., BTU/lb.

P - Pressure, lb/sq.in. Absolute.

P_1 - .975 P, lb/sq.in. Absolute.

P_2 - 1.025 P, lb/sq.in. Absolute.

Q - Vapor quality, % or Binary point

S - Entropy of vapor-liquid mixture above saturated liquid @ -40°F., BTU/lb. °F.

S_L - Entropy of saturated liquid above saturated liquid @ -40°F., BTU/lb. °F.

S_q - Entropy of vapor-liquid mixture at quality, Q, above saturated liquid @ -40°F., BTU/lb. °F.

S_v - Entropy of saturated vapor above saturated liquid, @ -40°F., BTU/lb. °F.

U - Linear velocity, ft./sec.

V - Volume of vapor-liquid mixture, Cu.Ft./lb.

V_L - Volume of saturated liquid, Cu.Ft./lb.

V_{max} - Fictitious sonic velocity - $G_{max} \times V_v$, Ft./sec.

V_v - Volume of saturated vapor, Cu.Ft./lb.

W - Work done on a system.

a - Zero order coefficient.

a_{mn} - Value of X or Y in row M, column N of determinant.

b - First order coefficient.

c - Second order coefficient.

d - Third order coefficient.

e - Fourth order coefficient.

x - Independent variable.

y - Dependent variable.

α - A particular computer location.

LITERATURE CITED

1. Agocs, W.B., A Method of Determining the Time Break on Deep Sea Seismic Records, Ph.D. Thesis, Lehigh University (1946).

2. Air Conditioning and Refrigeration Institute, Properties of Commonly Used Refrigerants, pp. 25-51, 61-75 (1957).

3. Foust, A.S., College of Engineering, Lehigh University, Personal Communication.

4. Harvey, B.F. and Foust, A.S., Two-Phase One Dimensional Flow Equations and Their Application to Flow in Evaporator Tubes, Heat Transfer Symposium Series No. 5, Vol. 49.

5. Perry, J.H., Chemical Engineer's Handbook, 3rd. edition. McGraw-Hill Book Co., In., New York (1950).

6. Schweppe, J.L. and Foust, A.S., Effect of Forced Circulation Rate on Boiling - Heat Transfer and Pressure Drop in a Short Vertical Tube, Heat Transfer Symposium Series No. 5, Vol. 49.

7. Shapiro, A.H., The Dynamics and Thermodynamics of Compressible Fluid Flow, Vol. 1, pp. 45-49, The Ronald Press Co., New York (1953).

8. Vaillancourt, V.L., Report on Sonic Velocity vs. Enthalpy for Freon 12, M. S. Thesis, Lehigh University (1960).

APPENDIX

CURVE FIT SUBROUTINE

Discussion

The Curve Fit Subroutine was developed to solve for the coefficients of a fourth order log-log or semi-log polynomial and solve for the dependent variable from these coefficients and any value of the independent variable.

The coefficients are calculated by substituting five values of X and the corresponding values of Y into the equation.

$$Y \doteq a + 10^{-1}b(\ln x) + 10^{-2}c(\ln x)^2 + 10^{-3}d(\ln x)^3 + 10^{-4}e(\ln x)^4$$

or the similar log-log equation. The five resulting simultaneous equations are solved for the five coefficients by the use of determinents of the form.

$$\begin{vmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{vmatrix}$$

where each column represents a power of ln x or the five Y values. The subroutine evaluates these determinents by reducing each to twenty minor determinents of third order and substituting values of X and Y.

It should be noted that this is not a curve fit in the true sense. i.e. it is not a least squares curves fit. Therefore, it is not the purpose of this subroutine to obtain a smooth curve from scattered data points, but to calculate coefficients by inputing reliable smooth data. The necessity of having smooth data points should be kept in mind when using this routine.

The evaluation of the dependent variable from given coefficients and a value of the independent variable is a straight forward substitution in the polynomial.

DESCRIPTION

Function:

A. To compute the constants for the 4th order eqn:

$Y = a + 10^{-1}b(\ln x) + 10^{-2}c(\ln x)^2 + 10^{-3}d(\ln x)^3 + 10^{-4}e(\ln x)^4$

or $\ln Y = a + 10^{-1}b(\ln x) + 10^{-2}c(\ln x)^2 + 10^{-3}d(\ln x)^3 + 10^{-4}e(\ln x)^4$

B. To calculate the value of Y for any value of X using one of the two above equations and the constants calculated in Function A.

Input:

A. Five values of X and the corresponding values of Y in sequence @ q = 12.

B. Any value of X @ q = 12.

Calling Sequence:

A. Solve for Constants

Location	Order	Address
$\alpha - 2$	Z	$L(X_1)$
$\alpha - 1$	B	L("a")
α	R	2855
$\alpha + 1$	U	2000

B. Solve for Y

Location	Order	Address
α	R	3231
$\alpha + 1$	U	3132

For Function A the address portion of location "α-2" must be the first location in the consecutive storage of 5 values of X and the corresponding values of Y. Instruction "α-1" brings into the accumulator the first address for the desired storage of the constants.

For Function B the value of X for which Y is to be calculated must be stored in location 6262 @ q = 12.

For either function the flag in 3303 must be set at 0 for a semi-log function and at 1 @ 29 for a log-log function.

Output:

Function A: The constants a, b, c, d & e @ q = 12 in sequence beginning at the location established by " -1" of the calling sequence.

Function B: The value of Y in 6262 and in the accummulator @ q = 12.

Storage:

Locations 2000 to 3316

Temporary Storage - 6200 to 6263, 6300, 01, 02, 03, 04, 05, 28, 29, 33, 34, 35, 36, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 55, 56, 57, 58, 60, 61

Program Stops:

4029 - Constant or Y value too large to hold at q = 12.

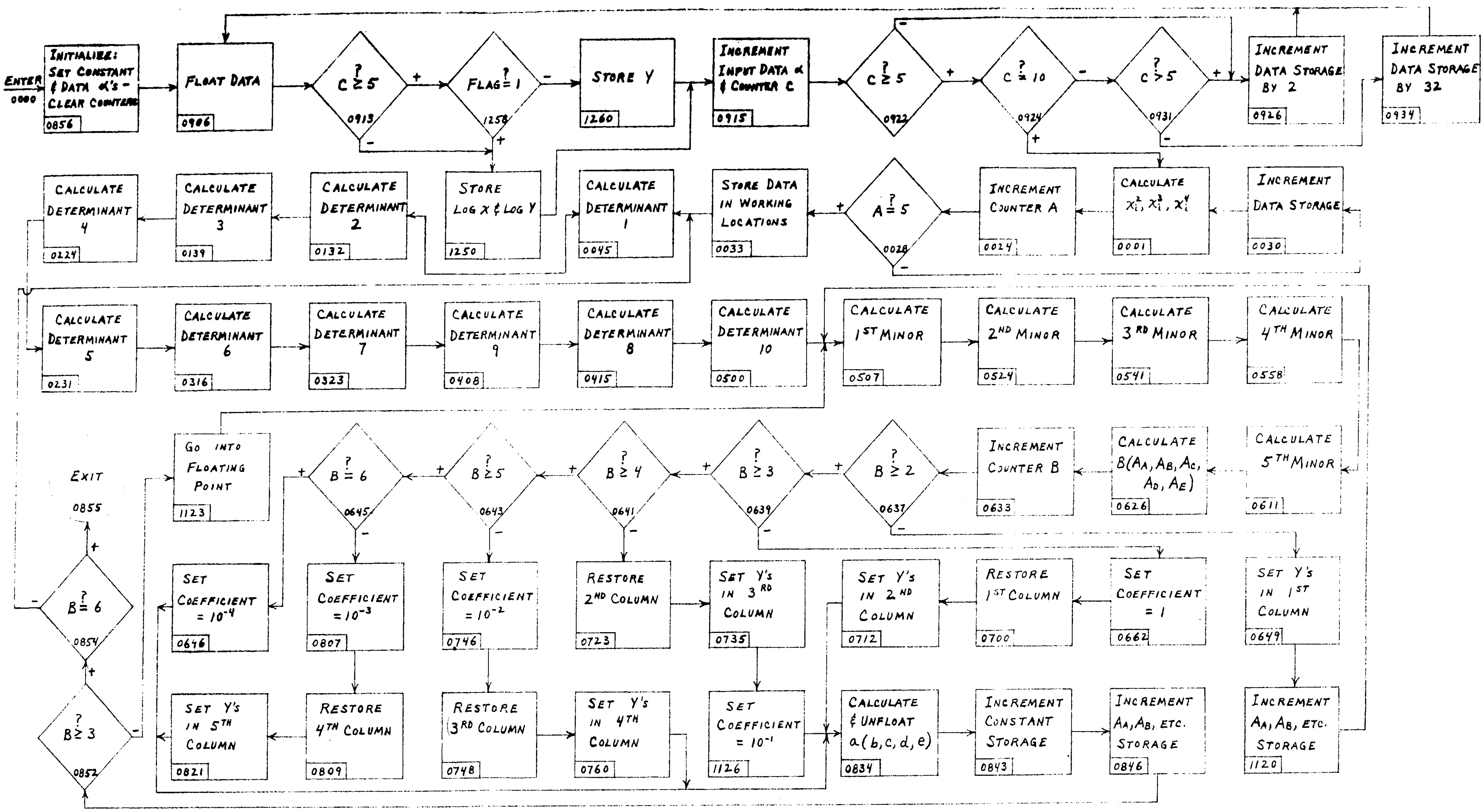
Subroutines:

Data InputRoutine #3	(11.2)	0300 to 0563
Data Output Routine #2	(12.1A)	0600 to 0850
Extended Range Floating Point Interpretive Routine	(24.1)	0900 to 1963
Curve Fit		2000 to 3316
Data Output Driver		3332 to 3363
Logarithm	(18.2)	3419 to 3463
Exponential	(17.2)	3500 to 3663
Alphanumeric	(19.0)	3700 to 3757

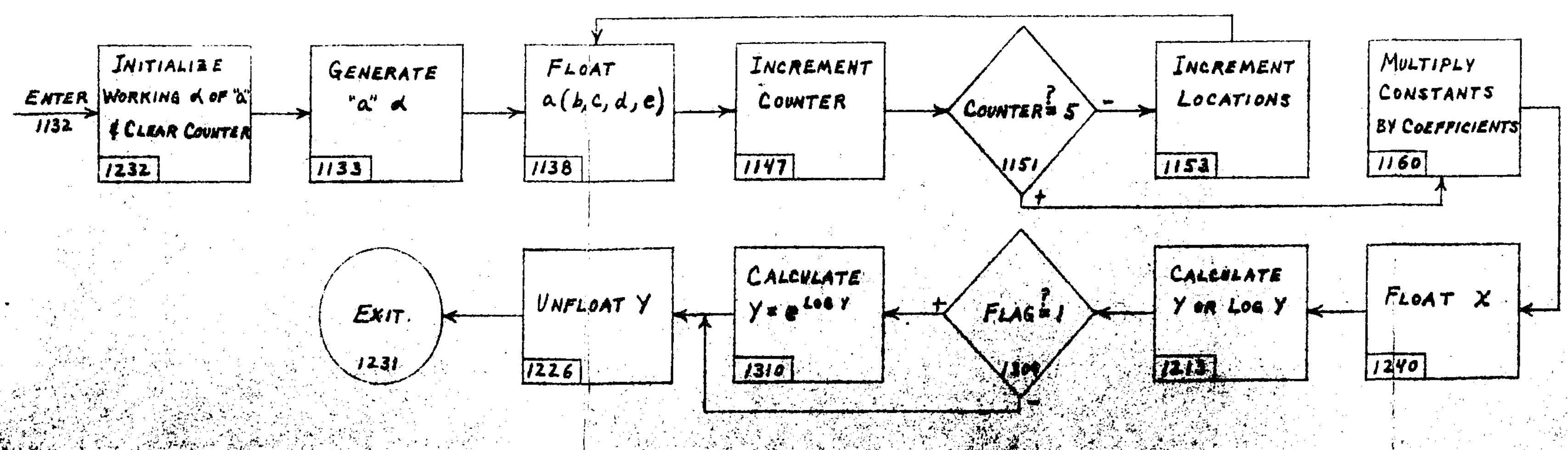
Float & Unfloat	(25.1)	3800 to 4143
Decimal Memory Print Out	(21.0)	5500 to 5863

FIGURE 5 CURVE FIT SUBROUTINE - BLOCK DIAGRAM

(FUNCTION A)



(FUNCTION B)



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JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE: 5/1/63
PROBLEM: CURVE FIT				TRACK 20

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
;00020000	'						
/00020000	'	☒					
		0000		U0856	'	INITIALIZE & FLOAT DATA	
		01		B0725	'	x_1 α	(0925)
		02		Y0014	'		(0032)
		03		Y0015	'	☒	
		04		Y0018	'		
		05		Y0021	'		
		06		A0956	'	10@29	
		07		Y0016	'	☒	
		08		A0956	'	10@29	
		09		Y0019	'		
		10		A0956	'	10@29	
		11		Y0022	'	☒	
		12		XR0900	'	} ERFP	
		13		XU0900	'	}	
		14	800P	[ ]	'	x_i	
		15	800M	[ ]	'	☒ x_i	
		16	800H	[ ]	'	x_i^2	
		17		XU0000	'		
		18	800M	[ ]	'	x_i	
		19	800H	[ ]	'	☒ x_i^3	
		20		XU0000	'		
		21	800M	[ ]	'	x_i	
		22	800H	[ ]	'	x_i^4	
		23		XE0000	'	☒	
		24		B0936	'	COUNTER A	
		25		A0951	'	1@29	
		26		H0936	'	COUNTER A	
		27		S0955	'	☒ 5@29	
		28		T0030	'	[illegible]	
		29		U0033	'	[illegible]	
		30		[illegible]	'	x_i α	(0028)
		31		[illegible]	'	☒ 2@29	

' = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

FORM LGP-11

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Problem: CURVE FIT

Program input codes	Stop	Location	Operation	Address	Stop	Contents of address	Notes
		☒					
		0032	U	0002	·		
		0033	B	1108	·	∠ of 1st "1"	(0029)
		0034	Y	0037	·		(0044)
		0035	A	1063	·	☒ XZ3200	
		0036	Y	0038	·		
		0037	B	[ ]	·	X's (ERFP)	(Storage Location)
		0038	H	[ ]	·		(Working Location)
		0039	B	1109	·	☒ B1048	
		0040	S	0037	·		
		0041	T	0045	·		
		0042	B	0037	·		
		0043	A	0951	·	☒ 1@29	
		0044	U	0034	·		
		0045	XR	0900	·	} ERFP	(0041,0854)
		0046	XU	0900	·	}	
		0047	80XP	6236	·	☒ a_{44}	
		0048	80XM	6248	·	a_{55}	
		0049	XU	0000	·		
		0050	80XM	6224	·	a_{33}	
		0051	80XH	6357	·	☒ Prod. 1	
		0052	80XM	6222	·	a_{32}	
		0053	80XH	6359	·	Prod. 2	
		0054	80XP	6226	·	a_{34}	
		0055	80XM	6238	·	☒ a_{45}	
		0056	XU	0000	·	[illegible]	
		0057	80XM	6244	·	a_{53}	
		0058	800H	1304	·	Prod. 3	
		0059	80XM	6242	·	☒ a_{52}	
		0060	80XH	6323	·	Prod. 4	
		0061	80XP	6228	·	a_{35}	
		0062	80XM	6246	·	a_{54}	
		0063	80XM	6250	·	☒ Determinant	

' = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

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NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE 5/1/63
PROBLEM: CURVE FIT				TRACK 21

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	·	☒					
		0100	80XM	6234	·	a_{43}	
		01	80XH	6333	·	PROD. 5	
		02	80XM	6232	·	a_{42}	
		03	80XH	6335	·	☒ PROD. 6	
		04	80XP	6238	·	a_{45}	
		05	80XM	6246	·	a_{54}	
		06	XU	0000	·		
		07	80XM	6224	·	☒ a_{33}	
		08	80XH	6343	·	PROD. 7	
		09	80XM	6222	·	a_{32}	
		10	80XH	6345	·	PROD. 8	
		11	80XP	6226	·	☒ a_{34}	
		12	80XM	6248	·	a_{55}	
		13	XU	0000	·		
		14	80XM	6234	·	a_{43}	
		15	80XH	6347	·	☒ PROD. 9	
		16	80XM	6232	·	a_{42}	
		17	80XH	6349	·	PROD. 10	
		18	80XP	6228	·	a_{35}	
		19	80XM	6236	·	☒ a_{44}	
		20	XU	0000	·		
		21	80XM	6244	·	a_{53}	
		22	80XH	6351	·	PROD. 11	
		23	80XM	6242	·	☒ a_{52}	
		24	80XH	6355	·	PROD. 12	
		25	80XB	6357	·	PROD. 1	
		26	800A	1304	·	PROD. 2	
		27	80XA	6333	·	☒ PROD. 3	
		28	80XS	6343	·	PROD. 7	
		29	80XS	6347	·	PROD. 9	
		30	80XS	6351	·	PROD. 11	
		31	80XM	6250	·	☒ DETERMINANT 1	

· = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

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PROBLEM: CURVE FIT				TRACK 21

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
		☒					
		0132	80XB	6359		PROD. 2	
		33	80XA	6328		PROD. 4	
		34	80XA	6335		PROD. 6	
		35	80XS	6345	☒	PROD. 8	
		36	80XS	6349		PROD. 10	
		37	80XS	6355		PROD. 12	
		38	80XH	6252		DETERMINANT 2	
		39	80XP	6222	☒	a_{32}	
		40	80XM	6234		a_{43}	
		41	XU	0000			
		42	80XM	6248		a_{55}	
		43	80XH	6357	☒	PROD. 1	
		44	80XM	6246		a_{54}	
		45	80XH	6359		PROD. 2	
		46	80XP	6224		a_{33}	
		47	80XM	6242	☒	a_{52}	
		48	XU	0000			
		49	80XM	6238		a_{45}	
		50	800H	1304		PROD. 3	
		51	80XM	6236	☒	a_{44}	
		52	80XH	6328		PROD. 4	
		53	80XP	6232		a_{42}	
		54	80XM	6244		a_{53}	
		55	XU	0000	☒		
		56	80XM	6228		a_{35}	
		57	80XH	6333		PROD. 5	
		58	80XM	6226		a_{34}	
		59	80XH	6335	☒	PROD. 6	
		60	80XP	6222		a_{32}	
		61	80XM	6244		a_{53}	
		62	XU	0000		[illegible]	
		63	80XM	6238	☒	a_{45}	

' = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

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PROGRAM CHECKED BY:	
PROBLEM:	CURVE FIT
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TRACK	22

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	☒						
		0200	80XH	6343	·	PROD. 7	
		01	80XM	6236	·	a_{44}	
		02	80XH	6345	·	PROD. 8	
		03	80XP	6224	·	☒ a_{33}	
		04	80XM	6232	·	a_{42}	
		05	XU	0000	·		
		06	80XM	6248	·	a_{55}	
		07	80XH	6347	·	☒ PROD. 9	
		08	80XM	6246	·	a_{54}	
		09	80XH	6349	·	PROD. 10	
		10	80XP	6234	·	a_{43}	
		11	80XM	6242	·	☒ a_{52}	
		12	XU	0000	·		
		13	80XM	6228	·	a_{35}	
		14	80XH	6351	·	PROD. 11	
		15	80XM	6226	·	☒ a_{34}	
		16	80XH	6355	·	PROD. 12	
		17	80XB	6357	·	PROD. 1	
		18	800A	1304	·	PROD. 3	
		19	80XA	6333	·	☒ PROD. 5	
		20	80XS	6343	·	PROD. 7	
		21	80XS	6347	·	PROD. 9	
		22	80XS	6351	·	PROD. 11	
		23	80XH	6254	·	☒ DETERMINANT 3	
		24	80XB	6359	·	PROD. 2	
		25	80XA	6328	·	PROD. 4	
		26	80XA	6335	·	PROD. 6	
		27	80XS	6345	·	☒ PROD. 8	
		28	80XS	6349	·	PROD. 10	
		29	80XS	6355	·	PROD. 12	
		30	80XH	6256	·	DETERMINANT 4	
		31	80XP	6220	·	☒ a_{31}	

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PROBLEM: CURVE FIT				TRACK 22

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	☒						
		0232	80XM	6248		a_{55}	
		33	XU	0000			
		34	80XM	6236		a_{44}	
		35	80XH	6357	☒	PROD. 1	
		36	80XM	6234		a_{43}	
		37	80XH	6359		PROD. 2	
		38	80XP	6238		a_{45}	
		39	80XM	6240	☒	a_{51}	
		40	XU	0000			
		41	80XM	6226		a_{34}	
		42	800H	1304		PROD. 3	
		43	80XM	6224	☒	a_{33}	
		44	80XH	6328		PROD. 4	
		45	80XP	6228		a_{35}	
		46	80XM	6230		a_{41}	
		47	XU	0000	☒		
		48	80XM	6246		a_{54}	
		49	80XH	6333		PROD. 5	
		50	80XM	6244		a_{53}	
		51	80XH	6335	☒	PROD. 6	
		52	80XP	6220		a_{31}	
		53	80XM	6238		a_{45}	
		54	XU	0000			
		55	80XM	6246	☒	a_{54}	
		56	80XH	6343		PROD. 7	
		57	80XM	6244		a_{53}	
		58	80XH	6345		PROD. 8	
		59	80XP	6230	☒	a_{41}	
		60	80XM	6248		a_{55}	
		61	XU	0000			
		62	80XM	6226		a_{34}	
		63	80XH	6347	☒	PROD. 9	

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PROBLEM: CURVE FIT				TRACK 23

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	☒						
		0300	80XM	6224		a_{33}	
		01	80XH	6349		PROD. 10	
		02	80XP	6228		a_{35}	
		03	80XM	6240	☒	a_{51}	
		04	XU	0000			
		05	80XM	6236		a_{44}	
		06	80XH	6351		PROD. 11	
		07	80XM	6234	☒	a_{43}	
		08	80XH	6355		PROD. 12	
		09	80XB	6357		PROD. 1	
		10	800A	1304		PROD. 3	
		11	80XA	6333	☒	PROD. 5	
		12	80XS	6343		PROD. 7	
		13	80XS	6347		PROD. 9	
		14	80XS	6351		PROD. 11	
		15	80XH	6258	☒	DETERMINANT 5	
		16	80XB	6359		PROD. 2	
		17	80XA	6328		PROD. 4	
		18	80XA	6335		PROD. 6	
		19	80XS	6345	☒	PROD. 8	
		20	80XS	6349		PROD. 10	
		21	80XS	6355		PROD. 12	
		22	80XH	6260		DETERMINANT 6	
		23	80XP	6220	☒	a_{31}	
		24	80XM	6246		a_{54}	
		25	XU	0000			
		26	80XM	6234		a_{43}	
		27	80XH	6357	☒	PROD. 1	
		28	80XM	6232		a_{42}	
		29	80XH	6359		PROD. 2	
		30	80XM	6236		a_{44}	
		31	80XM	6240	☒	a_{51}	

• = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

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PROBLEM: CURVE FIT	TRACK 23

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	☒						
		0332	XU	0000			
		33	80XM	6224		a_{33}	
		34	800H	1304		PROD. 3	
		35	80XM	6222	☒	a_{32}	
		36	80XH	6328		PROD. 4	
		37	80XP	6226		a_{34}	
		38	80XM	6230		a_{41}	
		39	XU	0000	☒		
		40	80XM	6244		a_{53}	
		41	80XH	6333		PROD. 5	
		42	80XM	6242		a_{52}	
		43	80XH	6335	☒	PROD. 6	
		44	80XP	6220		a_{31}	
		45	80XM	6236		a_{44}	
		46	XU	0000			
		47	80XM	6244	☒	a_{53}	
		48	80XH	6343		PROD. 7	
		49	80XM	6242		a_{52}	
		50	80XH	6345		PROD. 8	
		51	80XP	6230	☒	a_{41}	
		52	80XM	6246		a_{54}	
		53	XU	0000			
		54	80XM	6224		a_{33}	
		55	80XH	6347	☒	PROD. 9	
		56	80XM	6222		a_{32}	
		57	80XH	6349		PROD. 10	
		58	80XP	6226		a_{34}	
		59	80XM	6240	☒	a_{51}	
		60	XU	0000			
		61	80XM	6234		a_{43}	
		62	80XH	6351		PROD. 11	
		63	80XM	6232	☒	a_{42}	

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TRACK 24

JOB NO. | PROGRAM NO. | PROGRAM PREPARED BY: | PROGRAM CHECKED BY:

PROBLEM: CURVE FIT

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION (OPERATION / ADDRESS)	STOP	CONTENTS OF ADDRESS	NOTES
	·					
	· ☒					
		0400	80XH6355	·	PROD. 12	
		01	80XB6357	·	PROD. 1	
		02	800A1304	·	PROD. 3	
		03	80XA6333	· ☒	PROD. 5	
		04	80XS6343	·	PROD. 7	
		05	80XS6347	·	PROD. 9	
		06	80XS6351	·	PROD. 11	
		07	80XH6262	· ☒	DETERMINANT 7	
		08	80XB6359	·	PROD. 2	
		09	80XA6328	·	PROD. 4	
		10	80XA6335	·	PROD. 6	
		11	80XS6345	· ☒	PROD. 8	
		12	80XS6349	·	PROD. 10	
		13	80XS6355	·	PROD. 12	
		14	80XH6302	·	DETERMINANT 9	
		15	80XP6220	· ☒	a_{31}	
		16	80XM6232	·	a_{42}	
		17	XU0000	·		
		18	80XM6248	·	a_{55}	
		19	80XH6357	· ☒	PROD. 1	
		20	80XM6244	·	a_{53}	
		21	80XH6359	·	PROD. 2	
		22	80XP6222	·	a_{32}	
		23	80XM6240	· ☒	a_{51}	
		24	XU0000	·		
		25	80XM6238	·	a_{45}	
		26	800H1304	·	PROD. 3	
		27	80XM6234	· ☒	a_{43}	
		28	80XH6328	·	PROD. 4	
		29	80XP6230	·	a_{41}	
		30	80XM6242	·	a_{52}	
		31	XU0000	· ☒		

FORM LP-14 · = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

LGP-30 CODING SHEET

PREPARED FOR:				PAGE 10 OF 30
JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE 5/1/63
PROBLEM: CURVE FIT				TRACK 24

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
		☒					
		0432	80XM	6228		a_{35}	
		33	80XH	6333		PROD. 5	
		34	80XM	6224		a_{33}	
		35	80XH	6335	☒	PROD. 6	
		36	80XP	6220		a_{31}	
		37	80XM	6242		a_{52}	
		38	XU	0000			
		39	80XM	6238	☒	a_{45}	
		40	80XH	6343		PROD. 7	
		41	80XM	6234		a_{43}	
		42	80XH	6345		PROD. 8	
		43	80XP	6222	☒	a_{32}	
		44	80XM	6230		a_{41}	
		45	XU	0000			
		46	80XM	6248		a_{55}	
		47	80XH	6347	☒	PROD. 9	
		48	80XM	6244		a_{53}	
		49	80XH	6349		PROD. 10	
		50	80XP	6232		a_{42}	
		51	80XM	6240	☒	a_{51}	
		52	XU	0000			
		53	80XM	6228		a_{35}	
		54	80XH	6351		PROD. 11	
		55	80XM	6224	☒	a_{33}	
		56	80XH	6355		PROD. 12	
		57	80XB	6357		PROD. 1	
		58	800A	1304		PROD. 3	
		59	80XA	6333	☒	PROD. 5	
		60	80XS	6343		PROD. 7	
		61	80XS	6347		PROD. 9	
		62	80XS	6351		PROD. 11	
		63	80XH	6300	☒	DETERMINANT 8	

LGP-30 CODING SHEET

PREPARED FOR:				PAGE 11 OF 30
JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE 5/1/63
PROBLEM: CURVE FIT				TRACK 25

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	·	⊠					
		0500	80XB	6359	·	PROD. 2	
		01	80XA	6328	·	PROD. 4	
		02	80XA	6335	·	PROD. 6	
		03	80XS	6345	·	⊠ PROD. 8	
		04	80XS	6349	·	PROD. 10	
		05	80XS	6355	·	PROD. 12	
		06	80XH	6304	·	DETERMINANT 10	
		07	80XP	6256	·	⊠ DETERMINANT 4	(0661, 1122, 1125)
		08	80XM	6218	·	a_{25}	
		09	800H	1110	·		
		10	80XP	6254	·	DETERMINANT 3	
		11	80XM	6216	·	⊠ a_{24}	
		12	800H	1112	·		
		13	80XP	6252	·	DETERMINANT 2	
		14	80XM	6214	·	a_{23}	
		15	800H	1114	·	⊠	
		16	80XP	6250	·	DETERMINANT 1	
		17	80XM	6212	·	a_{22}	
		18	800S	1110	·		
		19	800A	1112	·	⊠	
		20	800S	1114	·		
		21	XU	0000	·		
		22	80XM	6200	·	a_{11}	
		23	800H	1100	·	⊠ 1ST MINOR	
		24	80XP	6262	·	DETERMINANT 7	
		25	80XM	6218	·	a_{25}	
		26	800H	1110	·		
		27	80XP	6260	·	⊠ DETERMINANT 6	
		28	80XM	6216	·	a_{24}	
		29	800H	1112	·		
		30	80XP	6258	·	DETERMINANT 5	
		31	80XM	6214	·	⊠ a_{23}	

FORM LP-102 · = CONDITIONAL STOP CODE ⊠ CARRIAGE RETURN

LGP-30 CODING SHEET

PREPARED FOR:

JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	PAGE 12 OF 30
				DATE 5/1/63
PROBLEM: CURVE FIT				TRACK 25

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	·	☒					
		0532	800H	1114	·		
		0533	80XP	6250	·	DETERMINANT 1	
		0534	80XM	6210	·	a_{21}	
		0535	800S	1110	·	☒	
		0536	800A	1112	·		
		0537	800S	1114	·		
		0538	XU	0000	·		
		0539	80XM	6202	·	☒ a_{12}	
		0540	800H	1102	·	2ND MINOR	
		0541	80XP	6302	·	DETERMINANT 9	
		0542	80XM	6218	·	a_{25}	
		0543	800H	1110	·	☒	
		0544	80XP	6300	·	DETERMINANT 8	
		0545	80XM	6216	·	a_{24}	
		0546	800H	1112	·		
		0547	80XP	6258	·	☒ DETERMINANT 5	
		0548	80XM	6212	·	a	
		0549	800H	1114	·		
		0550	80XP	6252	·	DETERMINANT 2	
		0551	80XM	6210	·	☒ a_{21}	
		0552	800S	1110	·		
		0553	800A	1112	·		
		0554	800S	1114	·		
		0555	XU	0000	·	☒	
		0556	80XM	6204	·	a_{13}	
		0557	80XH	1104	·	3RD MINOR	
		0558	80XP	6304	·	DETERMINANT 10	
		0559	80XM	6218	·	☒ a_{25}	
		0560	800H	1110	·		
		0561	80XP	6300	·	DETERMINANT 8	
		0562	80XM	6214	·	a_{23}	
		0563	800H	1112	·	☒ B(A.., A.., [illegible])	

FORM LGP-12 · CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

LGP-30 CODING SHEET

PREPARED FOR: | PAGE 13 OF 30 | DATE 5/1/63 | TRACK 26

JOB NO. | PROGRAM NO. | PROGRAM PREPARED BY: | PROGRAM CHECKED BY:

PROBLEM: CURVE FIT

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	⊠						
		0600	80XP	6260		DETERMINANT 6	
		01	80XM	6212		a_{22}	
		02	800H	1112			
		03	80XP	6254		⊠ DETERMINANT 3	
		04	80XM	6210		a_{21}	
		05	800S	1110			
		06	800A	1112			
		07	800S	1114		⊠	
		08	XU	0000			
		09	80XM	6206		a_{14}	
		10	800H	1106		4TH MINOR	
		11	80XP	6304		⊠ DETERMINANT 10	
		12	80XM	6216		a_{24}	
		13	800H	1110			
		14	80XP	6302		DETERMINANT 9	
		15	80XM	6214		⊠ a_{23}	
		16	800H	1112			
		17	80XP	6262		DETERMINANT 7	
		18	80XM	6212		a_{22}	
		19	800H	1114		⊠	
		20	80XP	6256		DETERMINANT 4	
		21	80XM	6210		a_{21}	
		22	800S	1110			
		23	800A	1112		⊠	
		24	800S	1114			
		25	XU	0000			
		26	80XM	6208		a_{15}	
		27	800S	1106		⊠	
		28	800A	1104			
		29	800S	1102			
		30	800A	1100			
		31	800H	[ ]		⊠ B(A_A, A_B, A_C, A_D, A_E)	

' = CONDITIONAL STOP CODE ⊠ CARRIAGE RETURN

LGP-30 CODING SHEET

PREPARED FOR:				PAGE 14 OF 30
JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE 5/1/63
PROBLEM: CURVE FIT				TRACK 26

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	'						
	'	☒					
		0632	XE	0000	'		
		33	B	0937	'	COUNTER B	
		34	A	0951	'	1@29	
		35	H	0937	'	☒ COUNTER B	
		36	S	0952	'	2@29	
		37	T	0649	'		
		38	S	0951	'	1@29	
		39	T	0662	'	☒	
		40	S	0951	'	1@29	
		41	T	0723	'		
		42	S	0951	'	1@29	
		43	T	0746	'	☒	
		44	S	0951	'	1@29	
		45	T	0807	'		
		46	B	1208	'	α of 10^{-4}	
		47	Y	0836	'	☒ $\frac{A_E}{B \times 10^{-4}}$	
		48	U	0832	'		
		49	XR	0900	'	} ERFP	(0637)
		50	XU	0900	'	}	
		51	800B	1050	'	☒ y_1	
		52	80XH	6200	'	a_{11}	
		53	800B	1052	'	y_2	
		54	80XH	6202	'	a_{21}	
		55	800B	1054	'	☒ y_3	
		56	80XH	6204	'	a_{31}	
		57	800B	1056	'	y_4	
		58	80XH	6206	'	a_{41}	
		59	800B	1058	'	☒ y_5	
		60	80XH	6208	'	a_{51}	
		61	U	1120	'		
		62	B	0702	'	α of 1	(0639)
		63	Y	0836	'	☒ $\frac{A_A}{B \times 1}$	

' CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

FORM LP-18

LGP-30 CODING SHEET

PREPARED FOR:

PAGE OF	DATE	TRACK
15 / 30	5/1/63	27

JOB NO. | PROGRAM NO. | PROGRAM PREPARED BY: | PROGRAM CHECKED BY:

PROBLEM: CURVE FIT

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
		☒					
		0700	XR	0900		} ERFP	
		01	XU	0900			
		02	800B	1000		1	
		03	80XH	6200	☒	a_{11}	
		04	800B	1002		1	
		05	80XH	6202		a_{21}	
		06	800B	1004		1	
		07	80XH	6204	☒	a_{31}	
		08	800B	1006		1	
		09	80XH	6206		a_{41}	
		10	800B	1008		1	
		11	80XH	6208	☒	a_{51}	
		12	800B	1050		y_1	
		13	80XH	6210		a_{12}	
		14	800B	1052		y_2	
		15	80XH	6212	☒	a_{22}	
		16	800B	1054		y_3	
		17	80XH	6214		a_{32}	
		18	800B	1056		y_4	
		19	80XH	6216	☒	a_{42}	
		20	800B	1058		y_5	
		21	80XH	6218		a_{52}	
		22	U	0834			
		23	XR	0900	☒	} ERFP	(0641)
		24	XU	0900			
		25	800B	1010		x_1	
		26	80XH	6210		a_{12}	
		27	800B	1012	☒	x_2	
		28	80XH	6212		a_{22}	
		29	800B	1014		x_3	
		30	80XH	6214		a_{32}	
		31	800B	[illegible]	☒	x_4	

· = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

LGP-30 CODING SHEET

PREPARED FOR:				PAGE 16 OF 30
JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE 5/1/63
PROBLEM: CURVE FIT				TRACK 27

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
		0732	80XH	6216		a_{42}	
		0733	800B	1018		x_5	
		0734	80XH	6218		a_{52}	
		0735	800B	1050	☒	y_1	
		0736	80XH	6220		a_{13}	
		0737	800B	1052		y_2	
		0738	80XH	6222		a_{23}	
		0739	800B	1054	☒	y_3	
		0740	80XH	6224		a_{33}	
		0741	800B	1056		y_4	
		0742	80XH	6226		a_{43}	
		0743	800B	1058	☒	y_5	
		0744	80XH	6228		a_{53}	
		0745		U1126			
		0746		B1061		α OF 10^{-2}	(0643)
		0747		Y0836	☒	$\frac{A_c}{B \times 10^{-2}}$	
		0748		XR0900		} ERFP	
		0749		XU0900		}	
		0750	800B	1020		x_1^2	
		0751	80XH	6220	☒	a_{13}	
		0752	800B	1022		x_2^2	
		0753	80XH	6222		a_{23}	
		0754	800B	1024		x_3^2	
		0755	80XH	6224	☒	a_{33}	
		0756	800B	1026		x_4^2	
		0757	80XH	6226		a_{43}	
		0758	800B	1028		x_5^2	
		0759	80XH	6228	☒	a_{53}	
		0760	800B	1050		y_1	
		0761	80XH	6230		a_{14}	
		0762	800B	1052		y_2	
		0763	80XH	6232	☒	a_{24}	

☒ CARRIAGE RETURN

LGP-30 CODING SHEET

PREPARED FOR:				PAGE 17 OF 30
JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE 5/1/63
PROBLEM: CURVE FIT				TRACK 28

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
		☒					
		0800	800B	1054		y_3	
		01	80XH	6234		a_{34}	
		02	800B	1056		y_4	
		03	80XH	6236	☒	a_{44}	
		04	800B	1058		y_5	
		05	80XH	6238		a_{54}	
		06	U	0834			
		07	B	1062	☒	α of 10^{-3}	(0645)
		08	Y	0836		$\frac{A_D}{B \times 10^{-3}}$	
		09	XR	0900		} ERFP	
		10	XU	0900		}	
		11	800B	1030	☒	x_1^3	
		12	80XH	6230		a_{14}	
		13	800B	1032		x_2^3	
		14	80XH	6232		a_{24}	
		15	800B	1034	☒	x_3^3	
		16	80XH	6234		a_{34}	
		17	800B	1036		x_4^3	
		18	80XH	6236		a_{44}	
		19	800B	1038	☒	x_5^3	
		20	80XH	6238		a_{54}	
		21	800B	1050		y_1	
		22	80XH	6240		a_{15}	
		23	800B	1052	☒	y_2	
		24	80XH	6242		a_{25}	
		25	800B	1054		y_3	
		26	80XH	6244		a_{35}	
		27	800B	1056	☒	y_4	
		28	80XH	6246		a_{45}	
		29	800B	1058		y_5	
		30	80XH	6248		a_{55}	
		31	U	0834	☒		

FORM LP-12 · = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

LGP-30 CODING SHEET

PREPARED FOR:				PAGE 18 OF 30
JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE 5/1/63
PROBLEM: CURVE FIT				TRACK 28

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	☒						
		0832	XR	0900		} ERFP	(0648,1129)
		33	XU	0900		}	
		34	800B	[ ]		A_A, A_B, A_C, A_D, A_E	(0722,0806,083[illegible]
		35	800D	0939		☒ B	
		36	800D	[ ]		$1, 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}$	
		37	XE	0000			
		38	XR	3851			UNFLOAT a, b, c, d, e
		39	XU	4008		☒	
		40	XZ	0900			
		41	XZ	0012			
		42	C	[ ]			
		43	B	0842		☒	
		44	A	0951		1@29	
		45	Y	0842			
		46	B	0834			
		47	A	0952		☒ 2@29	
		48	Y	0834			
		49	Y	0631			
		50	B	0937		COUNTER B	
		51	S	0953		☒ 3@29	
		52	T	1123			
		53	S	0953		3@29	
		54	T	0045			
		55	U	[ ]		☒ EXIT	
		56	Y	0842		"a" α	(0000)
		57	B	0855		EXIT α	
		58	S	0954		4@29	
		59	Y	0860		☒	
		60	B	[ ]		1^{ST} DATA α	
		61	Y	0906			
		62	B	0835		B α	
		63	Y	0631		☒	

FORM LP-12 · CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

LGP-30 CODING SHEET

PREPARED FOR:				PAGE 19 OF 30
JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE 5/1/63
PROBLEM: CURVE FIT				TRACK 29

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION: OPERATION	INSTRUCTION: ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	·	☒					
		0900	U	1116	·		
		01	Y	1253	·		(1119)
		02	XC	6300	·		(1302)
		03	C	0936	·	☒ COUNTER A	
		04	C	0937	·	COUNTER B	
		05	C	0938	·	COUNTER C	
		06	B	[ ]	·		(1302) FLOAT DATA (06–10)
		07	XR	3816	·	☒	
		08	XU	3800	·		
		09	XZ	0900	·		
		10	XZ	0012	·		
		11	B	0938	·	☒ COUNTER C	
		12	S	0955	·	5@29	
		13	T	1250	·		
		14	U	1256	·		
		15	B	0906	·	☒	(1255,1300)
		16	A	0951	·	1@29	
		17	Y	0906	·		
		18	B	0938	·	COUNTER C	
		19	A	0951	·	☒ 1@29	
		20	H	0938	·	COUNTER C	
		21	S	0955	·	5@29	
		22	T	0926	·		
		23	S	0955	·	☒ 5@29	
		24	T	0930	·		
		25	U	0001	·	(DATA COMPLETE)	
		26	B	0952	·	2@29	(0922,0932)
		27	A	1253	·	☒	(0935)
		28	Y	1253	·		
		29	U	1301	·		
		30	A	0954	·	4@29	(0924)
		31	T	0934	·	☒	

· = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

FORM LP-10

LGP-30 CODING SHEET

PREPARED FOR:				PAGE 20 OF 30
JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE 5/1/63
PROBLEM: CURVE FIT				TRACK 29

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION (OPERATION / ADDRESS)	STOP	CONTENTS OF ADDRESS	NOTES
	·					
	·	☒				
		0932	U0926	·		
		33	XZ0032	·		
		34	B0933	·	32@29	(0931)
		35	U0927	·	☒	
		36	[ ]	·	COUNTER A	
		37	[ ]	·	COUNTER B	
		38	[ ]	·	COUNTER C	
		39	[	·	☒ B	
		40	]	·		
		41	[	·	A_A	
		42	]	·		
		43	[	·	☒ A_B	
		44	]	·		
		45	[	·	A_C	
		46	]	·		
		47	[	·	☒ A_D	
		48	]	·		
		49	[	·	A_E	
		50	]	·		
		51	XZ0001	·	☒ 1@29	
		52	XZ0002	·	2@29	
		53	XZ0003	·	3@29	
		54	XZ0004	·	4@29	
		55	XZ0005	·	☒ 5@29	
		56	XZ0010	·	10@29	
		57	XZ0008	·	8@29	
90000006'		58	66666666	·	} 10^{-1}	
		59	WWWWWWW4	·	☒ }	
		60	51QG851Q	·	} 10^{-2}	
		61	WWWWWWQ8	·	}	
		62	4189374J	·	} 10^{-3}	
		63	WWWWWWKJ	·	☒ }	

FORM LP-12 · CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

PREPARED FOR:				PAGE 21 OF 30
JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE 5/1/63
PROBLEM: CURVE FIT				TRACK 30

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
		[X]					
10000010		1000	4000	0000		1	
		01		4			
		02	4000	0000		1	
		03		4	[X]		
		04	4000	0000		1	
		05		4			
		06	4000	0000		1	
		07		4	[X]		
		08	4000	0000		1	
		09		4			
		10	[	]		x_1	
		11	[	]	[X]		
		12	[	]		x_2	
		13	[	]			
		14	[	]		x_3	
		15	[	]	[X]		
		16	[	]		x_4	
		17	[	]			
		18	[	]		x_5	
		19	[	]	[X]		
		20	[	]		x_1^2	
		21	[	]			
		22	[	]		x_2^2	
		23	[	]	[X]		
		24	[	]		x_3^2	
		25	[	]			
		26	[	]		x_4^2	
		27	[	]	[X]		
		28	[	]		x_5^2	
		29	[	]			
		30	[	]		x_1^3	
		31	[	]	[X]		

FORM LP-19 · = CONDITIONAL STOP CODE [X] CARRIAGE RETURN

LGP-30 CODING SHEET

PREPARED FOR:
JOB NO.: | PROGRAM NO.: | PROGRAM PREPARED BY: | PROGRAM CHECKED BY:

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DATE 5/1/63
TRACK 30

PROBLEM: CURVE FIT

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
		☒					
		1032	[			x_2^3	
		33		]			
		34	[			x_3^3	
		35		]		☒	
		36	[			x_4^3	
		37		]			
		38	[			x_5^3	
		39		]		☒	
		40	[			x_1^4	
		41		]			
		42	[			x_2^4	
		43		]		☒	
		44	[			x_3^4	
		45		]			
		46	[			x_4^4	
		47		]		☒	
		48	[			x_5^4	
		49		]			
		50	[			y_1	
		51		]		☒	
		52	[			y_2	
		53		]			
		54	[			y_3	
		55		]		☒	
		56	[			y_4	
		57		]			
		58	[			y_5	
		59		]		☒	
		60	Z	0958			
		61	Z	0960			
		62	Z	0962			
		63	X	2200		☒	

CONDITIONAL STOP CODE · ☒ CARRIAGE RETURN

FORM LP-112

LGP-30 CODING SHEET

PREPARED FOR:

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JOB NO.: | PROGRAM NO.: | PROGRAM PREPARED BY: | PROGRAM CHECKED BY: | DATE 5/1/63

PROBLEM: CURVE FIT | TRACK 31

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	'						
	'	☒					
		1100	[	]	'	1ST MINOR	
		01	[	]	'		
		02	[	]	'	2ND MINOR	
		03	[	]	'	☒	
		04	[	]	'	3RD MINOR	
		05	[	]	'		
		06	[	]	'	4TH MINOR	
		07	[	]	'	☒	
		08	Z	1000	'		
		09	B	1048	'		
		10	[	]	'		
		11	[	]	'	☒	
		12	[	]	'		
		13	[	]	'		
		14	[	]	'		
		15	[	]	'	☒	
		16	A	0952	'	2 @ 29	(0900)
		17	Y	0834	'		
		18	B	0725	'	x_1 α	
		19	U	0901	'	☒	
		20	E	0834	'		(0661)
		21	Y	0631	'		
		22	U	0507	'		
		23	XR	0900	'	☒ } ERFP	(0852)
		24	XU	0900	'	}	
		25	U	0507	'		
		26	XE	0000	'		(0745)
		27	B	1060	'	☒ α or 10^{-1}	
		28	Y	0836	'	$\frac{A_B}{B \times 10^{-1}}$	
		29	U	0832	'		
1000000002	'	30	68KG8GFJ			} 10^{-7}	
		31	WWWWWWJJ			☒	

' = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

FORM LP-12

LGP-30 CODING SHEET

PREPARED FOR:

JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	PAGE 24 OF 30
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PROBLEM: CURVE FIT

TRACK 31

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
		☒					
		1132	U	1232			INITIALIZE
		33	B	1231		EXIT α	(1236)
		34	S	0953		3@29	
		35	Y	1136		☒	
		36	B	[ ]		α of "a"	
		37	Y	1138			
		38	B	[ ]		CONSTANTS }	(1159)
		39	XR	3816		☒	
		40	XU	3800			FLOAT
		41	XZ	0900			a, b, c, d, e
		42	XZ	0012			
		43	XR	0900		☒ } ERFP	
		44	XU	0900			
		45	800C	[ ]			
		46	XE	0000			
		47	B	1237		☒ COUNTER	
		48	A	0951		1@29	
		49	H	1237		COUNTER	
		50	S	0955		5@29	
		51	T	1153		☒	
		52	U	1160			
		53	B	1138			(1151)
		54	A	0951		1@29	
		55	Y	1138		☒	
		56	B	1145			
		57	A	0952		2@29	
		58	Y	1145			
		59	U	1138		☒	
		60	XR	0900		} ERFP	(1152)
		61	XU	0900			
		62	800P	[illegible]		10^{-4}	
		63	80X[illegible]	626[illegible]		☒ EXIT	

CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

LGP-30 CODING SHEET

PAGE	25 OF 30
DATE	5/1/63
TRACK	32
PREPARED FOR:	
JOB NO. / PROGRAM NO. / PROGRAM PREPARED BY: / PROGRAM CHECKED BY:	
PROBLEM:	CURVE FIT

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION: OPERATION	INSTRUCTION: ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	·						
	·	☒					
		1200	80XC	6260	·	$10^{-4}e$	
		01	80OP	0962	·	10^{-3}	
		02	80XM	6258	·	d	
		03	80XC	6258	·	☒ $10^{-3}d$	
		04	80OP	0960	·	10^{-2}	
		05	80XM	6256	·	c	
		06	80XC	6256	·	$10^{-2}c$	
		07	U	1246	·	☒	
		08	Z	1130	·		
		09	XR	0900	·	} ERFP	(1245)
		10	XU	0900	·	}	
		11	XN	0000	·	☒ LOG	(1316)
		12	80XC	6262	·	x	
		13	80XP	6262	·	x → M REGISTER	}
		14	80XM	6260	·	$10^{-4}e$	}
		15	80XA	6258	·	☒ $10^{-3}d$	}
		16	XU	0000	·		}
		17	80XM	6262	·	x	} CALCULATE
		18	80XA	6256	·	$10^{-2}c$	} y
		19	XU	0000	·	☒	}
		20	80XM	6262	·	x	}
		21	80XA	6254	·	$10^{-1}b$	}
		22	XU	0000	·		}
		23	80XM	6262	·	☒ x	}
		24	80XA	6252	·	a	}
		25	U	1306	·		}
		26	XR	3851	·		} (1309, 1314)
		27	XU	4008	·	☒	} UNFLOAT y
		28	XZ	0900	·		}
		29	XZ	0012	·		}
		30	XM	6262	·	y @12	
		31	XU	[000]	·	☒ EXIT	

· = CONDITIONAL STOP CODE ☒ CARRIAGE RETURN

LGP-30 CODING SHEET

PREPARED FOR:				PAGE 26 OF 30
JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE 5/1/63
PROBLEM: CURVE FIT				TRACK 32

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
		☒					
		1232		B1238			(1132)
		1233		Y1145			
		1234		XC6300			
		1235		C1237		☒ COUNTER	
		1236		U1133			
		1237	[	]		COUNTER	
		1238		XZ6252		α of "a"	
		1239		XE0000		☒	(1249)
		1240		XB6262		x@12	FLOAT X
		1241		XR3816			
		1242		XU3800			
		1243		XZ0900		☒	
		1244		XZ0012			
		1245		U1209			
		1246	800	P0958		10^{-1}	(1207)
		1247	80X	M6254		☒ b	
		1248	80X	C6254		10^{-1}b	
		1249		U1239			
		1250		XR0900			(0913,1259)
		1251		XU0900		☒	
		1252		XN0000		LOG	
		1253	800	C[ ]		LOG x & LOG y	
		1254		XE0000			
		1255		U0915		☒	
		1256		B1303		FLAG	(0914)
		1257		S0951		1@29	
		1258		T1260			
		1259		U1250		☒	
		1260		XR0900		ERFP	(1258)
		1261		XU0900			
		1262	800	C[ ]		y	
		1263		XE0000		☒	

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PROBLEM: CURVE FIT	TRACK 33

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	⊠						
		1300	U	0915			
		01	Y	1262			(0929)
		02	U	0906			
		03	[	]	⊠	FLAG @29	
		04	[			PRODUCT 3	
		05	[	]			
		06	XE	0000			
		07	B	1303	⊠	FLAG	
		08	S	0951		1@29	
		09	T	1226			
		10	XR	0900		} ERFP	
		11	XU	0900	⊠	}	
		12	XH	0000		EXPONENTIAL	
		13	XE	0000			
		14	U	1226			
		15	80XB	6262	⊠		
		16	U	1211			
		17					
		18					
		19			⊠		
		20					
		21					
		22					
		23			⊠		
		24					
		25					
		26					
		27			⊠		
		28					
		29					
		30					
		31			⊠		

FORM LP-10 · = CONDITIONAL STOP CODE ⊠ CARRIAGE RETURN

Problem: CURVE FIT (FUNCTION A)

Track 62

Sector	Quantity	Q	Sector	Quantity	Q
00	[a_{11}		32	[a_{42}	
01	]		33	]	
02	[a_{12}		34	[a_{43}	
03	]		35	]	
04	[a_{13}		36	[a_{44}	
05	]		37	]	
06	[a_{14}		38	[a_{45}	
07	]		39	]	
08	[a_{15}		40	[a_{51}	
09	]		41	]	
10	[a_{21}		42	[a_{52}	
11	]		43	]	
12	[a_{22}		44	[a_{53}	
13	]		45	]	
14	[a_{23}		46	[a_{54}	
15	]		47	]	
16	[a_{24}		48	[a_{55}	
17	]		49	]	
18	[a_{25}		50	[DETERMINANT 1	
19	]		51	]	
20	[a_{31}		52	[DETERMINANT 2	
21	]		53	]	
22	[a_{32}		54	[DETERMINANT 3	
23	]		55	]	
24	[a_{33}		56	[DETERMINANT 4	
25	]		57	]	
26	[a_{34}		58	[DETERMINANT 5	
27	]		59	]	
28	[a_{35}		60	[DETERMINANT 6	
29	]		61	]	
30	[a_{41}		62	[DETERMINANT 7	
31	]		63	]	

Problem CURVE FIT

Track 63

Sector	Quantity	Q	Sector	Quantity	Q
00	[DETERMINANT 8]		32		
01			33	[PRODUCT 5]	
02	[DETERMINANT 9]		34		
03			35	[PRODUCT 6]	
04	[DETERMINANT 10]		36		
05			37		
06			38		
07			39		
08			40		
09			41		
10			42		
11			43	[PRODUCT 7]	
12			44		
13			45	[PRODUCT 8]	
14			46		
15			47	[PRODUCT 9]	
16			48		
17			49	[PRODUCT 10]	
18			50		
19			51	[PRODUCT 11]	
20			52		
21			53		
22			54		
23			55	[PRODUCT 12]	
24			56		
25			57	[PRODUCT 1]	
26			58		
27			59		
28	[PRODUCT 4]		60	[PRODUCT 2]	
29			61		
30			62		
31			63		

Problem CURVE FIT (FUNCTION B)

Track 62

Sector	Quantity	Q	Sector	Quantity	Q
00			32		
01			33		
02			34		
03			35		
04			36		
05			37		
06			38		
07			39		
08			40		
09			41		
10			42		
11			43		
12			44		
13			45		
14			46		
15			47		
16			48		
17			49		
18			50		
19			51		
20			52	[a	
21			53	]	
22			54	[b or $10^{-1}b$	
23			55	]	
24			56	[c or $10^{-2}c$	
25			57	]	
26			58	[d or $10^{-3}d$	
27			59	]	
28			60	[e or $10^{-4}e$	
29			61	]	
30			62	[x	
31			63	]	

Sectors 52–63: FIXED POINT OR FLOATING POINT

CHECK CURVE FIT

Description

Function:

A. To compute the constants for the 4th order equation

$Y = a + 10^{-1}b\ (\ln x) + 10^{-2}c\ (\ln x)^2 + 10^{-3}d\ (\ln x)^3 + 10^{-4}e\ (\ln x)^4$

or $\ln Y = a + 10^{-1}b\ (\ln x) + 10^{-2}c\ (\ln x)^2 + 10^{-3}d\ (\ln x)^3 + 10^{-4}e\ (\ln x)^4$

B. To compare the values of Y from the equation at the original values of X used.

C. To evaluate Y for any other value of X.

Input:

A. & B. Five values of X and the corresponding values of Y.

C. Any 5 values of X.

Operation:

A. & B. Halt and transfer to 5200. When the computer stops for data input set the Flag in 3303 at 0 for semi-log function or at 1 @ 29 for log-log function. Fill in 5 values of X and the 5 corresponding values of Y starting at 5405 at a q of 12. Exit from data input.

C. When the computer stops for data input fill in 5 values of X starting in 5405 at a q of 12. Exit from data input.

Output:

A. & B. The 5 input values of X on the first line, the 5 corresponding input values of Y on the second line, the calculated constants on the third line followed by the word "constants", the input values of X on the fourth line and the calculated values of Y on the fifth line. At this point the computer stops at data input for function C. The constants are held in 5425 to 5429 at a q of 12. They are also held in 5415 through 5424 in Extended Range Floating Point Format #2.

C. The 5 input values of X on the first line and the 5 calculated values of Y on the next line. At this point the computer stops at data input to repeat function C for 5 more values of X. The values of Y are held in 5410 to 5414 at a q of 12.

Storage:

Locations 5200 through 5441

No temporary storage.

Program Stops:

4029 - Constant or Y value too large to hold at q = 12.

Subroutines:

Data Input Routine #3	(11.2)	0300 to 0563
Data Output Routine #2	(12.1A)	0600 to 0850
Extended Range Floating Point Interpretive Routine	(24.1)	0900 to 1963
Curve Fit		2000 to 3316
Data Output Driver		3332 to 3363
Logarithm	(18.2)	3419 to 3463
Exponential	(17.2)	3500 to 3663
Alphanumeric	(19.0)	3700 to 3757

Float and Unfloat	(25.1)	3800 to 4143
Decimal Memory Print Out	(21.0)	5500 to 5863

Note:

This program is part of the major Sonic Velocity Program.

SONIC VELOCITY - HEX PUNCH

```
.0005800
03000763
v1400300'104fj'k03g0'80098'40000'j05gj'g0354'
w05f8'f0320'g0300'q0598'60074'90484'
j3w08'903f8'70590'f0340'q3w08'j3w0j'
903f0'703f4'f0360'303g0'f0328'80'
q3w0j'2045j'w04kj'905j4'g0380'k3w04'
w3w04'f0384'q05w4'704w8'j0478'f0394'
78'1055j'905gj'f03fj'wwwww00'f0000000'
3j3j3j0'70520'q0578'j3w0j'70480'f03j0'
q056j'203w0'10390'w0478'w3w0j'g0464'
q044j'203q8'10570'20448'104w8'k0450'
10538'k3w00'80050'40000'60574'70594'
g0428'f0410'w04gj'g0494'q047j'305fj'
f05g0'f0448'904g8'w04gj'g0300'q047j'
305fj'f05g0'k3w0j'w3w0j'f0488'4j0'
20000'53w00'703g0'k3kq0'f05q0'k3w10'
105j0'20448'1044j'f049j'44f0'2'
20000000'5wkwkwj'50450'53w00'f045j'k3w08'
f045j'w3w10'204f4'10300'f04g0'q0578'
k03g0'f03w0'1wwwwwwq'2'7wwwwwwq'40000000'
20000000'10000000'8000000'4000000'2000000'1000000'
800000'400000'200000'100000'80000'40000'
20000'10000'8000'4000'2000'1000'
800'400'200'100'80'40'
20'10'8'7wwwwwwq'50000000'32000000'
1w400000'13880000'j350000'7f12000'4j4g400'2wfw080'
1kjk650'70000000'1q1q1q0'1q01wq00'g2000000'534'
f0488'8''q3w0j'j3w10'905w8'
705wj'f059j'k0000000'20000000'4'q3w10'
f05fj'300'4'f0424'j0478'90560'
f05j8'12126146'f0454'wwww0000'70590'q0478'
j3w0j'90564'70568'f057j'105f8'q045j'
k045j'800g0300'f03w8'1000000'1wwq0000'93880000'
10614'w075j'2060j'130w8'207gj'1310j'
907j4'w07fj'g0640'f0870'q07k4'907f0'
706w8'q07q0'j0800'f07g0'q087j'j07k4'
906w4'q07kj'206kj'106q4'f0628'107qj'
f0680'81710'106j0'j0764'1081j'w0834'
g081j'f0840'206k8'w0830'j0834'f06k0'
q07qj'207qj'106w0'7072j'f07q8'80650'
j0700'10774'60840'f06j4'3j00'80250'
g0778'90770'j0774'f0740'j0700'1072j'
50714'70738'f0858'j'q'4'
8000000'j'20000000'4''7wwwwwwq'
50000000'32000000'1w400000'13880000'j350000'7f12000'
4j4g400'2wfw080'1kjk650'3q76j148'7wwwwwwq'10000000'
20000000'40000000'70808'906g8'q06gj'k06f4'
w06wj'q0700'f0760'j'j'g0778'
f06f4'4'7wwwwwwq'1360k400'81808'1080j'
q07gj'207gj'107k4'4'w0804'g07f4'
j07k4'f0838'w0'10614'f0824'10000'
207qj'10860'k0764'13kwj'f07j8'w3w7j'
j0774'g0848'f0864'38'807j0'730'
704'10774'j072j'w0714'q06q8'g065j'
1076j'f0690'
082kq504'.
```

```
08001263
v1400800'714'100'2800'4'803j0'803j0'
f06j8'1j'f0778'q06qj'20614'f0614'
w0704'10'10800'f07g0'f'f06f4'
107k8'k0814'w0774'f07q8'g06q8'f0880'
g0664'10810'k0814'f07q4'10614'20878'
f310j'ww00'j072j'w08j0'g08j4'f08g8'
600'w06qj'g08g8'80310'j0700'1072j'
60840'j072j'40'f0884'1072j'f0814'
jjjjjj'10700'f0894'k3w00'108qj'q08w8'
208w4'13w00'g08w4'w08wj'g2k78'q08wj'
f2k7j'4'2'10900'130kj'20fjj'
j3w44'710k4'q09gj'209j0'10kj4'f0920'
90fjj'w0jk0'f09j0'k3wf0'f0w70'j0f1j'
g1174'30f94'f0998'73w9j'j3wf0'f0f50'
k3wwj'f0974'10fjj'912k0'w0jk4'g0950'
f0970'f0w78'10g00'q0fjj'20fk0'90w0j'
q112j'20fkj'f0f24'70q1j'w0jjj'f0ff8'
13w44'g0j20'f0958'3jwww850'3jwww850'3jwww850'
3jwww850'3jwww850'3jwww850'9j4'f09q8'f1000'
f0938'f115j'f0q60'f126j'f0w14'f0fgj'
f0j9j'f1334'f1234'f1360'f0f70'f0wg4'
f10g8'f0g1j'g1w48'30f94'f0998'k3wk4'
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123j0'w12f8'g23g4'f24w0'823wkwq'40000000'
40000000'900'k3w18'w0f1j'w24q8'g23qj'
q240j'f2468'k23j0'f2370'613k8''
f0q8j'j3w44'j3w48'j3w4j'j3w50'j3w54'
j3w58'72340'q2344'73w48'q234j'73w50'
q2338'73w58'q2440'73w44'q2348'73w4j'
q2334'73w54'w233j'g2324'q2444'72448'
j3wf0'12388'q0f1j'f0f54'j'900'
12380'j3wf0'12388'f0f54'12j48'925g0'
f250j'w259j'g2550'f2544'7q000000'87q0000'
4000'3w00'80068'j'4'j'
12500'q25jj'f25f8'125jj'q2500'f25q0'
q2518'j251j'72520'92524'q2528'k25gj'
f2538'q2518'j251j'72520'92524'q2528'
k25gj'w2530'q2534''g2500'f25gj'
100'7q000000'12500'f25q0'22500'f25g8'
7q7q7q7q''1252j'80468'j2534'1251j'
f25k0'4'62598'w259j'g256j'f259j'
225q4'f2j48'30g60'f0g00''4'
73w04'73w00'
14ffg504'

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38004263
v1402600'j27j8'12640'q287j'227kj'w2884'k2688'
k27f8'f263j'q295j'f2968'j9287200'40000000'
q27f4'q27f8'f2684'127q8'q20fj'f2714'
j'w40k7800'k27f8'f265j'10'127qj'
f2768'7262j'j09f4'j09f8'j09fj'j09g0'
j09g4'j09g8'f27kj'k0f1j'f20g4'2600'
11j'k27qj'w27j8'f2768'2'8000000'
q281j'62658'k27qj'w28w0'q27f8'f2650'
8'4'12690'q30q8'22844'f2998'
4'7wwwwwwq'k27f8'f26qj'62840'k28g4'
f26wj'109f4'f278j'127f8'w28fj'k27f8'
128g4'f2968'4'2266j'q28q0'22674'
q2878'2267j'w2880'22668'q26j0'22670'
q26j0'22678'f2744'q28k4'22684'f2754'
2600'127j8'g2694'w2898'g2684'q26f0'
w26f4'g26f8'w27fj'g27g0'w28k0'g27w0'
w28k8'g26q8'f2620'628q4'j283j'f2844'
'80''100'wwwwwwkj'8000000'
628qj'k2628'w2648'q27f8'k27f8'f27k0'
280000'40'12628'f2968'80'120g0'
w29f8'f2980'f8'28000000'62710'k264j'
f27wj'127f8'w2874'k27f8'1264j'f2968'
28q4''80'8000000'126jj'q287j'
22864'q26k8'2285j'f26j8'295j'79www0f0'
2'10f1j'w27k8'g2860'w2818'f2864'
72948'f30w0'q279j'w30qj'g288j'w26j4'
g2990'8'8'4'14'3wwwj'
'q2838'22858'f289j'2'w2810'
g28j8'1283j'f2858'4'2600'k0000000'
k2964'w28j4'f2664'50000000'k2888'f285j'
10000000'68'20000000''8'2'
4'8'10'20'40'80'
100'200'400'800'1000'2000'
4000'8000'10000'20000'40000'80000'
100000'200000'400000'800000'1000000'2000000'
4000000'8000000'10000000'20000000'40000000'40000000'
78'ww6kfw1j'926kj'j28j4'127j8'g28g8'
128j4'f2664'g2630'k28kj'w28kj'f2634'
1283j'f285j'w2960'226w4'f26w4''
100'50wq8'70w08'30q3j'f0k00'72gqj'
50w14'f29kj'q2gw0'50w08'30q3j'f0k00'
50w08'k3qgj'f29w0'13q24'50w24'f2990'
109g0'70w2j'30q3j'f0k00'f3178'13338'
j32j8'30320'f0300'400'132j4'22f30'
13334'22f34'q3314'22f38'10000'j0000'
j0000'13264'q3300'j3264'w3310'g2f88'
w3310'g2fg0'w3300'g2fgj'w330j'g2f88'
k3w00'k3264'13268'q3300'j3268'w3304'
g2fjj'f2g34'12f30'q3300'22f30'12f34'
q3300'22f34'12f38'q3300'22f38'f2f30'
12f34'22f38'f2f88'12f34'q3310'22f34'
f2fg0'k3w00'k210j'13274'132j8'31jkj'
f1400'132j8'q3310'j32j8'13300'j210j'
1329j'132j8'
0w2q6f68'
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43004763
v1402g00'31jkj'f1400'13268'w3308'g2g18'f2gg4'
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f2f0j'1333j'j1j94'k3w00'k210j'13274'
132j8'31jkj'f1400'f2g88'90000'11jf8'
w332j'73378'5337j'q3330'22g7j'30900'
f0900'800j0000'90000'f1j98'132j8'q3310'
j32j8'13300'j210j'1329j'132j8'31jkj'
f1400'12g80'f3390'800'32500'f2500'
20104206'4j427f22'72043074'64j2j06'3q087242'461f1004'
3062064j'f5f5208'26100j08'f100430'3q064j6f'8520610'
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2f4f5j10'6540430'5j06083f'724q0610'4j0j080f'26107f08'
74061054'85f0q10'7f084f6f'1004303q'6083f72'4q06104j'
54085f26'107f084f'6f100420'87q0000'13kkj'w3380'
g2j74'f36jj'13314'w326j'j3g78'13kg8'
k3kq0'k326j'f2jf0'1326j'q3300'j326j'
w3314'g2j8j''13328'w326j'22j98'
13kj8'f2j4j'13kq0'32640'f2600'900'
30'30900'f0900'800j3g80'80083g80'80073368'
800j3j30'80073360'800j3j38'800k3qw8'93120'2210j'
80013jg0'33260'f31jj'800j3j48'80013j30'800k3qw8'
80013jg0'33260'f31jj'800j3j40'80013j38'800k3qw8'
93300'2210j'80013jk8'33260'f31jj'800j3j58'
80013j30'800k3qw8'80013jk8'33260'f31jj'800j3j50'
80013g80'800k3qw8'93120'2210j'80013jg0'33260'
f31jj'800j3gg8'80013g80'800k3qw8'93300'2210j'
80013jk8'33260'f31jj'800j3gj0'80013j38'800k3qw8'
93120'2210j'80013j60'33260'f31jj'800j3gk0'
80013j30'800k3qw8'80013j60'33260'f31jj'800j3gj8'
80013j38'800k3qw8'93300'2210j'80013j88'33260'
f31jj'800j3gq0'80013j30'800k3qw8'80013j88'33260'
f31jj'800j3gk8'80013g80'800k3qw8'93120'2210j'
80013j60'33260'f31jj'800j3gq8'80013g80'800k3qw8'
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80013350'800j3gw8'f33k8'80073gw0'800j32jj'80013358'
800w3gw8'f0000'80073gq8'800q32jj'800j3j00'800w3gj8'
800j32k4'80013gk8'800w3gj8'800j32kj'800132k4'800532kj'
800j3j08'f0000'80073gf8'800j32jj'80013358'800w3j08'
f0000'80073g98'800q32jj'800j3j18'80013j00'800w3gk0'
800j32k4'80013gq0'800w3gk0'800j32kj'800132k4'800532kj'
800j3j10'g2qk0'800w3358'g2qw0'80013gw8'800j3j10'
80013g80'800j3g90'80013gg8'800j3gf0'80013gj0'800j3gg0'
80083j10'80073gg0'800j32jj'80013358'800w3j10'f0000'
80073gf0'800q32jj'800j3j20'800w3j18'800j32k4'80013g90'
800w3g88'800532k4'20000'30000'f0000'80073370'
800j3j28'90000'326jj'f2820'900'38'
k3kw4'w3gw8'g2wg0'81000''30900'
f0900'80013g80'90000'326jj'f2820'900'
30'j3kq0'800'13kq0'30614'f0600'
30'f2wg0'81000''81800''
30900'f0900'80013gw8'90000'326jj'f2820'
900'4'73384'j3kq4'30900'f0900'
80013j00'90000'326jj'f2820'900'30'
j3kw0'13kq0'
1k3742jq'
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48005263
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j32qj'13kq0'k3qw8'13300'k210j'13g14'
3207j'f1w80'j32w0'13kq4'53384'j32w4'
732w0'53378'j32jj'13378'w32w4'732qj'
53378'q32jj'j3kq8'13kq0'k3qw8'k210j'
13g50'3207j'f1w80'j32q4'13kq0'k3qw8'
13300'k210j'13g64'3207j'f1w80'j32q8'
732w4'53378'j32jj'13378'w32w4'732q4'
53378'q32jj'j3kqj'30900'f0900'80083j28'
8073gj0'90000'326jj'f2820'900'38'
j3kw8'800'13kq4'30614'f0600'430'
238'f33j0'53384'w3378'g312j'81000'
'13g78'f314j'q338j'32640'f2600'
900'4'30900'f0900'f2q34'w3300'
j3g78'f36gj'q3324'22j64'f2j64'1000'
30320'f0300'13kg8'f2j68'k3w00'k3264'
k3268'k326j'k3270'k3kg4'k3kg8'k3kgj'
k3kj0'k3kj4'k3kj8'k3kjj'k3kk0'k3kk4'
k3kk8'k3kkj'1331j'j32j4'12g80'j1j94'
f2f04'90000'13320'231w8'13260'w3308'
231q4'12q20'231w4'30900'f0900'80013jf8'
800k3qw0'90000'13270'q3300'j3270'w3310'
g3228'13340'j20j4'13344'j2068'f33f4'
131w4'q3304'231w4'131w8'q3304'231w8'
f31qj'13348'j20j4'1334j'k2068'k3270'
30900'f0900'f2q2j''''
''''''
''''''
''''''
'''''4f2j10'
10'94w36300'wwwwwww8'46q08388'wwwwwwwj'1654'
4f2j12'wwg0kk6f'2wqq334'40000000'''
4'8'j'10'14'28'
3j'3k00'3qk0'3kg4'3kkj'3g28'
3j60'3274'3g00'f2g58'f2034'f3244'
f209j'326jj'''40000000'4'
4199999f'4'7jjjj000''4411qg80'1j'
40000000'20000000'2'6400000'100000'46666668'
j1j94'f2g08'12j98'22j64'f2j58'30900'
f0900'80013qw8'60000'800k3qw8'90000'f1ww0'
81000''81800''13kq4'f3110'
80013j30'800j3g88'80013j38'800j3g90'80013j40'800j3g98'
80013j48'800j3gf0'80013j50'f36f8'13680'j1j94'
13684'j20j4'f3418''30320'f0300'
13614'1347j'31jkj'f1400'f3464'90000'
11jf8'w3494'73378'5337j'q349j'23458'
30900'f0900'800j0000'90000'f1j98'800'
13614'30614'f0600'530'81000'3664'
13628'30614'f0600'530'81000'3664'
81000'363j'13664'30614'f0600'530'
32500'f2500'30106f08'46327f5f'72325f7f'20207q00'
1349j'234wj'13550'23500'13568'23524'
k3w00'k3678'k367j'136f0'f369j'30900'
f0900'80010000'
1kgqj9q8'

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53005463
v0803500'800k0000'90000'13678'q3300'j3678'w3310'
g35k8'3207j'flww0'j0000'1367j'q3300'
j367j'w3310'g35f0'13614'30614'f0600'
530'81000'3qk0'13628'30614'f0600'
530'81000'3628'81000''13688'
j1j94'1368j'j20j4'f358j''30320'
f0300'13684'j20j4'f34j8'13524'f3690'
135g4'q3300'235g4'10000'32640'f2600'
900'30'f2024''''
134wj'q3304'234wj'13500'q3304'23500'
f34w4'32640'f2600'900'30'30900'
f0900'800j3qw8'f34wj''''
''''''
''''''
''''''
''''''
f3434'f213j'90000'f209j'q3300'23524'
f35f8'235g4'13614'f35w4'800j3gf8'80013j58'
800j3gg0'80083gw8'f2q3j'w3300'g3164'q3300'
f3158'13328'w326j'22j64'f2j58'w3q34'
f3g7j'f377j'f3770'376j8g44'1000'999999f'
7wkw3g64'50w08'
03918448'
```

LGP-30 DATA LOAD SHEET

PAGE 1 OF 2

PREPARED FOR:

JOB NO. | PROGRAM NO. | PROGRAM PREPARED BY: | PROGRAM CHECKED BY:

DATE 5/20/63

DATA INPUT NO 3

PROBLEM: SONIC VELOCITY OF FREON-12

NOTES	p	± q	LOCATION	STOP	± NUMBER	STOP	CGE RET
P_1	3	+12	6100	'	2051	'	
P_2					10320	'	X
P_3					39310	'	
P_4					121220	'	X
P_5					246400	'	
H_{L1}					-0010409	'	X
H_{L2}					843	'	
H_{L3}					13958	'	X
H_{L4}					29663	'	
H_{L5}					43578	'	X
H_{V1}					67355	'	
H_{V2}					73354	'	X
H_{V3}					79904	'	
H_{V4}					86521	'	X
H_{V5}					90482	'	
					-0000000	"	X
P_1	3	+12	6115	'	2051	'	
P_2					10320	'	X
P_3					39310	'	
P_4					121220	'	X
P_5					246400	'	
					-0000000	'	X
S_{L1}	6	+12	6120	'	-0026367	'	
S_{L2}					001995	'	X
S_{L3}					030772	'	
S_{L4}					060690	'	X
S_{L5}					084096	'	
S_{V1}					183980	'	X
S_{V2}					173130	'	
S_{V3}					166830	'	X
S_{V4}					163380	'	
S_{V5}					161150	'	X

PUNCH A STOP CODE AFTER THE LAST NUMBER?

YES ☐ NO ☐

LGP-30 DATA LOAD SHEET

PREPARED FOR:	PAGE 2 OF 2
JOB NO. / PROGRAM NO. / PROGRAM PREPARED BY: / PROGRAM CHECKED BY:	DATE 5/20/63
PROBLEM: SONIC VELOCITY OF FREON - 12	DATA INPUT NO. 3

NOTES	p	± q	LOCATION	STOP	± NUMBER	STOP	CODE RET.
				.	-0000000	"	
P_1	3	+12	6130	'	2051	'	X
P_2				.	10^320	'	
P_3				.	39^310	'	X
P_4				.	121^220	'	
P_5				.	246^400	'	X
				.	-0000000	'	
V_{L1}	6	+12	6135	'	^010073	'	X
V_{L2}				.	^010607	'	
V_{L3}				.	^011366	'	X
V_{L4}				.	^012562	'	
V_{L5}				.	^014043	'	X
				.	-0000000	'	
V_{V1}	5	+12	6140	'	15^82100	'	X
V_{V2}				.	3^51980	'	
V_{V3}				.	1^00390	'	X
V_{V4}				.	^33540	'	
V_{V5}				.	^15774	'	X
				.	-0000000	'	
ISOBAR #1	1	+12	6146	'	225^0	'	X
2				.	150^0	'	
3				.	100^0	'	X
4				.	60^0	'	
5				.	45^0	'	X
6				.	30^0	'	
7				.	20^0	'	X
8				.	14^7	'	
9				.	10^0	'	X
10				.	5^0	'	
				.	-0000000	"	X
				.		.	
				.		.	X

$0 \le p \le 9$
$-28 \le q \le 47$
$0000 \le Loc \le 6363$

PUNCH A STOP CODE AFTER THE LAST NUMBER?
YES ☐ NO ☐

LGP-30 DATA LOAD SHEET

PREPARED FOR:				PAGE 1 OF 2
JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE 5/20/63
PROBLEM: SONIC VELOCITY OF FREON-22				DATA INPUT NO. 3

NOTES	p	± q	LOCATION	STOP	± NUMBER	STOP	CGE RET
P_1	3	+12	6100	'	4^787	'	
P_2					16^970	'	X
P_3					51^590	'	
P_4					121^000	'	X
P_5					243^400	'	
H_{L1}					-0010^220	'	X
H_{L2}					1^050	'	
H_{L3}					14^360	'	X
H_{L4}					28^460	'	
H_{L5}					44^350	'	X
H_{V1}					95^680	'	
H_{V2}					100^930	'	X
H_{V3}					106^500	'	
H_{V4}					110^930	'	X
H_{V5}					113^290	'	
					-0000^000	"	X
P_1	4	+12	6115	'	4^7870	'	
P_2					16^9700	'	X
P_3					51^5900	'	
P_4					121^0000	'	X
P_5					243^4000	'	
S_{L1}					-000^0255	'	X
S_{L2}					^0025	'	
S_{L3}					^0319	'	X
S_{L4}					^0600	'	
S_{L5}					^0886	'	X
S_{V1}					^2535	'	
S_{V2}					^2383	'	X
S_{V3}					^2264	'	
S_{V4}					^2181	'	X
S_{V5}					^2096	'	
					-000^0000	"	X

$0 \leq p \leq 9$
$-28 \leq q \leq 47$
$0000 \leq Loc \leq 6363$

PUNCH A STOP CODE AFTER THE LAST NUMBER? YES ☐ NO ☐

LGP-30 DATA LOAD SHEET
PAGE 2 OF 2 DATE 5/20/63 DATA INPUT NO. 3
SONIC VELOCITY OF FREON-12
-119-

LGP-30 DATA LOAD SHEET

PREPARED FOR:				PAGE 2 OF 2
JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE 5/20/63
PROBLEM	SONIC VELOCITY OF FREON - 22			DATA INPUT NO 3

NOTES	p	± q	LOCATION	STOP	±	NUMBER	STOP	CODE RET
P_1	3	+12	6130	'		4787	'	
P_2				.		16970	'	
P_3				.		51590	'	
P_4				.		121000	'	
P_5				.		243400	'	
				.	-	00000000	'	
V_{L1}	5	+12	6135	'		01090	'	
V_{L2}				.		01140	'	
V_{L3}				.		01215	'	
V_{L4}				.		01307	'	
V_{L5}				.		01433	'	
V_{V1}				.		965000	'	
V_{V2}				.		298100	'	
V_{V3}				.		104800	'	
V_{V4}				.		45460	'	
V_{V5}				.		21670	'	
				.	-	00000000	'	
ISOBAR # 1	1	+12	6146	'		2250	'	
2				.		1500	'	
3				.		1000	'	
4				.		600	'	
5				.		450	'	
6				.		300	'	
7				.		200	'	
8				.		147	'	
9				.		100	'	
10				.		50	'	
				.	-	00000000	"	

$0 \leq p \leq 9$
$-28 \leq q \leq 47$
$0000 \leq Loc \leq 6363$

PUNCH A STOP CODE AFTER THE LAST NUMBER? YES ☐ NO ☐

PRINTED IN U.S.A.

LGP-30 DATA LOAD SHEET

SONIC VELOCITY OF FREON - 12

TABLE 7 SONIC VELOCITY IN TWO PHASE FREON-12 SYSTEM

P (PSIA)	Q (% Vapor)	H (BTU/Lb)	V (Cu Ft/Lb)	S (BTU/Lb-deg F)	G max (Lb/Sq Ft-Sec)	V max (Ft/Sec)
224.00000	.00000	41.46429	.01379	.08068	3847.267	674.5468
	10.00000	46.31654	.02994	.08876	3601.293	631.4199
	20.00000	51.16879	.04609	.09684	3361.489	589.3747
	30.00000	56.02105	.06224	.10492	3163.983	554.7458
	40.00000	60.87331	.07840	.11300	2997.645	525.5814
	50.00000	65.72556	.09455	.12108	2855.054	500.5807
	60.00000	70.57782	.11070	.12916	2731.049	478.8388
	70.00000	75.43008	.12686	.13724	2621.915	459.7041
	80.00000	80.28233	.14301	.14532	2524.899	442.6941
	90.00000	85.13459	.15917	.15340	2437.9113	427.4425
	100.00000	89.98685	.17532	.16148	2331.1713	408.7277
60.36400	.00000	19.24402	.01170	.04135	1419.4367	946.8200
	10.00000	25.55597	.07723	.05376	1232.8684	822.3717
	20.00000	31.8693	.14276	.06616	1095.3813	730.6624
	30.00000	38.17989	.20830	.07856	995.5544	664.0739
	40.00000	44.49185	.27383	.09097	918.8354	612.8993
	50.00000	50.80381	.33936	.10338	857.4956	571.9832
	60.00000	57.11576	.40489	.11578	806.9997	538.3005
	70.00000	63.42772	.47043	.12819	764.4884	509.9438
	80.00000	69.73969	.53596	.14059	728.0572	485.6428
	90.00000	76.05164	.60149	.15299	696.3827	464.5146
	100.00000	82.36360	.66703	.16540	660.7722	440.7610

29.93200	.00000	10.92988	.01118	.02444	814.1785	1056.6747
	10.00000	17.67878	.13983	.03878	678.4410	880.5089
	20.00000	24.42769	.26850	.05313	589.2465	764.7486
	30.00000	31.17661	.39717	.06747	527.9564	685.2038
	40.00000	37.92552	.52583	.08181	482.5174	626.2312
	50.00000	44.67443	.65450	.09615	447.0966	580.2606
	60.00000	51.42334	.78317	.11049	418.4823	543.1238
	70.00000	58.17226	.91183	.12484	394.7412	512.3116
	80.00000	64.92117	1.04050	.13918	374.6305	486.2111
	90.00000	71.67008	1.16917	.15352	357.3103	463.7322
	100.00000	78.41900	1.29784	.16786	338.2113	438.9448
14.56400	.00000	3.85333	.01077	.00891	451.7714	1151.5883
	10.00000	10.95419	.26459	.02514	360.4799	918.8817
	20.00000	18.05505	.51842	.04137	306.6230	781.5977
	30.00000	25.15592	.77225	.05760	271.3919	691.7918
	40.00000	32.25679	1.02608	.07383	246.0499	627.1937
	50.00000	39.35766	1.27991	.09005	226.6960	577.8596
	60.00000	46.45853	1.53372	.10629	211.2913	538.5924
	70.00000	53.55940	1.78755	.12251	198.6530	506.3766
	80.00000	60.66026	2.04138	.13874	188.0411	479.3264
	90.00000	67.76113	2.29521	.15497	178.9664	456.1944
	100.00000	74.86201	2.54904	.17120	169.0901	431.0192

5.05160	.00000	-4.75425	.01028	-.01144	186.9461	1285.1790
	10.00000	2.77716	.69670	.00748	139.4678	958.7846
	20.00000	10.30858	1.38313	.02639	115.4211	793.4733
	30.00000	17.84000	2.06957	.04530	100.6479	691.9133
	40.00000	25.37141	2.75599	.06422	90.3988	621.4553
	50.00000	32.90283	3.44241	.08313	82.7541	568.9008
	60.00000	40.43424	4.12885	.10204	76.7697	527.7604
	70.00000	47.96565	4.81528	.12096	71.9203	494.4227
	80.00000	55.49707	5.50170	.13987	67.8872	466.6970
	90.00000	63.02849	6.18813	.15878	64.4644	443.1670
	100.00000	70.55991	6.87457	.17770	60.7979	417.9607

TABLE 8

SONIC VELOCITY IN TWO PHASE FREON-22 SYSTEM

P (PSIA)	Q (% Vapor)	H (BTU/Lb)	V (Cu Ft/Lb)	S (BTU/Lb-deg F)	G max (Lb/Sq Ft-Sec)	V max (Ft/Sec)
224.60000	.00000	42.26272	.01415	.08499	3643.469	863.0804
	10.00000	49.34725	.03641	.09757	3357.857	795.4234
	20.00000	56.43179	.05869	.11014	3100.163	734.3798
	30.00000	63.51634	.08096	.12272	2893.941	685.5291
	40.00000	70.60087	.10323	.13530	2724.062	645.2873
	50.00000	77.68541	.12551	.14787	2580.968	611.3906
	60.00000	84.76995	.14778	.16045	2458.2875	582.3296
	70.00000	91.85449	.17005	.17302	2351.5877	557.0541
	80.00000	98.93903	.19232	.18560	2257.6750	534.8076
	90.00000	106.02357	.21460	.19817	2174.1840	515.0299
	100.00000	113.10812	.23688	.21075	2074.1702	491.3382
60.23000	.00000	16.59846	.01228	.03656	1370.9253	1238.7776
	10.00000	25.67046	.10140	.05540	1146.5451	1036.0261
	20.00000	34.74248	.19054	.07423	997.9241	901.7311
	30.00000	43.81449	.27967	.09307	895.2792	808.9805
	40.00000	52.88650	.36880	.11191	818.9353	739.9956
	50.00000	61.95851	.45793	.13075	759.2910	686.1006
	60.00000	71.03053	.54707	.14958	711.0293	642.4910
	70.00000	80.10253	.63619	.16842	670.9367	606.2631
	80.00000	89.17455	.72533	.18726	636.9415	575.5448
	90.00000	98.24656	.81446	.20609	607.6399	549.0677
	100.00000	107.31857	.90360	.22493	575.3513	519.8914

29.94000	.00000	7.32710	.01174	.01672	795.9578	1395.1769
	10.00000	16.95658	.18585	.03824	631.8858	1107.5870
	20.00000	26.58607	.35996	.05976	536.3767	940.1760
	30.00000	36.21556	.53406	.08128	474.1960	831.1839
	40.00000	45.84506	.70817	.10280	429.5959	753.0076
	50.00000	55.47454	.88228	.12432	395.5988	693.4165
	60.00000	65.10402	1.05638	.14584	368.5755	646.0493
	70.00000	74.73351	1.23049	.16736	346.4273	607.2274
	80.00000	84.36300	1.40460	.18887	327.8452	574.6562
	90.00000	93.99249	1.57871	.21039	311.9647	546.8203
	100.00000	103.62198	1.75282	.23191	294.7557	516.6560
14.54000	.00000	-.51392	.01131	-.00116	443.5573	1527.2388
	10.00000	9.56145	.35449	.02298	334.2642	1150.9250
	20.00000	19.63683	.69768	.04711	277.6971	956.1555
	30.00000	29.71220	1.04086	.07124	242.6418	835.4546
	40.00000	39.78758	1.38404	.09538	218.2038	751.3106
	50.00000	49.86296	1.72723	.11951	199.9189	688.3526
	60.00000	59.93834	2.07041	.14364	185.5742	638.9615
	70.00000	70.01372	2.41359	.16777	173.9315	598.8741
	80.00000	80.08910	2.75678	.19191	164.2369	565.4940
	90.00000	90.16447	3.09996	.21604	156.0014	537.1377
	100.00000	100.23986	3.44315	.24017	147.1697	506.7289

5.10000	.00000	-9.74102	.01090	-.02419	183.0091	1666.1541
	10.00000	.82748	.92023	.00351	129.0938	1175.2972
	20.00000	11.39600	1.82955	.03122	104.7902	954.0321
	30.00000	21.96452	2.73888	.05892	90.4884	823.8253
	40.00000	32.53304	3.64822	.08662	80.7953	735.5777
	50.00000	43.10154	4.55754	.11432	73.6709	670.7154
	60.00000	53.67005	5.46687	.14202	68.1501	620.4528
	70.00000	64.23857	6.37620	.16972	63.7094	580.0240
	80.00000	74.80709	7.28553	.19743	60.0371	546.5910
	90.00000	85.37560	8.19486	.22513	56.9345	518.3440
	100.00000	95.94412	9.10420	.25283	53.6415	488.3632