-	AD-A0	73 135	AERO	AUTICAL	SYSTE	MS DIV	WRIGHT- R DISSO	PATTERS	ON AFB	OH SH SHOCK	WAVES	F/G 21 ANDE	/5 TC(U)	
	UNCLA	SSIFIED	MAT	ASD-TR	SCHROL	02			_			NL		1. S.
		40 40 4073 35					And it is the second se	Areas P				A second	1	
				A CELE	Fireforty Factor Davids		And	Contraction Contraction Contraction Contraction		भारतित्वस्य स्रोटास्य स्वयत्व स्रोटास्य स्वयत्व स्रोटान्स्य स्वयत्व स्रोटान्स्य स्वयत्व स्रोटान्स्य स्वयत्व	The second section of the second section of the second section of the second se	A MERICAN	1-21-4200 	
			1			The second second	LECTOR CALL	Strange Strang	And	ATAKATAN	LL-TEL Thimpson South and Set of Set of Set of Set of Set of Set of Set	Massing States		And a second sec
				A second	W B		III.							
	****** #*					P (10.5	al sistematica) be added a sis	d Alexandra p consumitive p alexandra p al	b storm Att b storm Att b storm Att b storm Att b store Att store	de adottatititit p. adottatitititi de adottatitititi de adottatititititi the adottatitititititi	l starming k starming k starming k starming k starming k starming k starming k starming k starming k star k s	h sun A. In h sun	i star, m.101 b star, m.101 b star, m.101 b star, m.101 star, m.101 star, m.101	i aler, a bet politiki politiki biologia biologia biologia biologia
	b schung	A part and	d aida Alini Personali and Alini Management Management	era Maria de la constante de Maria de la constante de Maria de la constante de Maria de la constante de Maria de la constante de	END DATE FILMED									
L	. / .											-	-	./





NOTICE

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

W. Schroll

DENNIS W. SCHROLL Aerospace Engineer

C. R. CARROLL Chief, Equipment Engineering

Accession For NTIS GRA&I DDC TAB Unannounced Justification By Distribution/ Availability Codes Availability Codes Dist. Special			And the second s
NTIS GAA&I DDC TAB Unamnounced Justification By Distribution/ Availability Codes Dist Dist Avail and/or special	Access	Lon For	1
DDC TAB Unamiounced Justification By Distribution/ Availability Codes Dist Dist Special	NTLS	GRASI	1
Unamnounced Justification By Distribution/ Availability Codes Natal and/or Special	DDC TA	в . /	1
Justification By Distribution/ Availability Codes Availand/or Special A	Unanno	unced	H .
By Distribution/ Availability Codes Availand/or Special	Justif	ication	
By Distribution/ Availability Codes Availand/or Blat Bpecial	•		
Distribution/ Availability Codes Availand/or Dist. special	Bu	1. 1	
Availability Codes Availability Codes Availand/or Bist. Special	-3		
Availability Codes Availand/or Brecial	Distri	bution/	
Dist. Avail and/or special	Avail	ability Cod	les
A special		Avat and la	71
A	D.d.a.t.	availand/0	•
AII	195.	spectar	
HII	Λ	TTO I LAND	
	V	a series and he	
all W	1		

"If your address has changed, if you wish to be removed from our mailing list, or if the addressee is no longer employed by your organization please notify ASD/YYEE ,N-PAFB, OH 45433 to help us maintain a current mailing list".

Copies of this report should not be returned unless return is required by security considerations, contractual obligations, or notice on a specific document.

REPORT DOCUMENTATION	PAGE	READ INSTRUCTIONS
ASD-TR-79-5002	2. GOVT ACCESSION N	D. 3. RECISIFIT'S CATALOG NUMBER
A. TITLE (and Sublide) SUPERSONIC COMBUSTION, AIR DI THROUGH SHOCK WAVES AND AEROI	SSOCIATION	Final Report PERIOD COVER Period Mar 78 - Oct 7
CHEMICALLY REACTING GASES IN CONVERGING - DIVERGING NO22LE	A PLANAR	6. PERFORMING ORG. REPORT NUMBER
Dennis W. Schroll ASD/YYEE WPAFB OH 45433	ale 1979 - Loonie III Mariere postal e	S. CONTRACT OR GRANT NUMBER(*)
ASD / ENECC WPAFB OH 45433	as atolo ato Storago as 588 Can acons au	10. PROGRAM FLEMENT, PROJECT, TAS
ASD/DPCD Long-Term-Full Time	Training.	May 1979
Contract	Linden avere	41 NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(II dittoren	t from Controlling Office)	15. SECURITY CLASS. (of this report) Unclassified
dosa maare enginy apisoilluba		184. DECLASSIFICATION/DOWNGRADING
7. DISTRIBUTION STATEMENT (of the obstract entered)	in Block 20, 11 different f	ram Report)
7. DISTRIBUTION STATEMENT (of the aboutant enfored 10. SUPPLEMENTARY NOTES Prepared in cooperation with	Prof R. Edse	, Ohio State University
7. DISTRIBUTION STATEMENT (of the abstract entered 7. DISTRIBUTION STATEMENT (of the abstract entered 7. SUPPLEMENTARY NOTES Prepared in cooperation with 9. KEY WORDS (Continue on reverse side if necessary and RAMJET, SCRAMJET, SUPERSONIC DISSOCIATION OF AIR, SHOCK WA 10. ABSTRACT (Continue on reverse side if necessary and Much research and tootix years to develope a supersonic discussed in almost all propu- headway has been made in the of the standard computational combustion do not apply. For	Prof R. Edse d identify by block number COMBUSTION, VES Udentify by block number ag has been a to ramjet enguision texts. oretical desi methods use instance, i	, Ohio State University , Ohio State University CHEMICALLY REACTING GAS ccomplished in the past Ine. The topic is However, very little gn techniques as many d for ramjet subsonic t is possible to use a
7. DISTRIBUTION STATEMENT (of the abstract entered . SUPPLEMENTARY NOTES Prepared in cooperation with . KEY WORDS (Continue on reverse side if necessary and RAMJET, SCRAMJET, SUPERSONIC DISSOCIATION OF AIR, SHOCK WA . ABSTRACT (Continue on reverse side if necessary and Much research and testic years ito develope a supersonid discussed in almost all propu- headway has been made in the of the standard computational combustion do not apply. For constant area nozzle for sube . JAM 75 1473 EDITION OF 1 NOV 65 15 OBSOL	Prof R. Edse d identify by block number COMBUSTION, VES Udentify by block number ag has been a to ramjet eng alsion texts. oretical desi methods use : instance, i bonic combust	ASSIFICATION OF THIS PAGE (The Area A
7. DISTRIBUTION STATEMENT (of the abstract entered . SUPPLEMENTARY NOTES Prepared in cooperation with . KEY WORDS (Continue on reverse side if necessary and RAMJET, SCRAMJET, SUPERSONIC DISSOCIATION OF AIR, SHOCK WA 	Prof R. Edse didentify by block number COMBUSTION, VES Videntify by block number ag has been a to ramjet eng alsion texts. Dretical desi methods use instance, i conic combust	, Ohio State University , Ohio State University CHEMICALLY REACTING GAS Complished in the past ine. The topic is However, very little gn techniques as many d for ramjet subsonic t is possible to use a ion in a ramjet as heat ASSIFICATION OF THIS PAGE (Then Date E

の一日になるのないのである

CURITY CLASSIFICATION OF THIS PAGE (When Date Enter

addition and frictional effects in the combustion chamber will decrease the pressure and accelerate the flow. For supersonic combustion the velocity decreases tending to choke the flow. . To overcome this difficulty area increase in the combustion zone Same used. The analysis assumes a strong normal shock on the diffuser inlet for free stream mach numbers of 5 and 10 and the analysis also considers shock free flow of these mach numbers and assumed Accompanied with the strong normal shock are large stagnation pressure losses in the diffuser inlet, meaning the diffuser inlet will act as a flat plate to oncoming airflow. For this reason, it would be best to provide air spillage and not use too large an inlet. For the shock expelled case, the drag through the engine would be less, but static pressure rises up to 272 atmospheres are calculated.

NAME NOT A THE MUDDED TRUE H

Basic assumptions that apply to the computational schemes in this paper are the quantum mechanical relationships developed by statistical mechanics. This means the assumption of equilib-rium must apply within the zones of the engine calculated. This is a most valid assumption for high speed flow. High energy molecules will have time to reach equilibrium values along each section of the engine, but have little time to dissipate to the walls of the engine. The inviscid assumption is then valid. Of course, chemical reactions within the combustion chamber are not so simple in nature as applied here, but the constant pressure assumption allows chemically reacting computations to be determined and then compared to the perfect gas computational

The final Thrust Specific Fuel Comsumption (TSFC) values are sufficiently high to warrant further investigation into supersonic combustion as a method of propulsion. They are slightly higher than that of a designed ramjet which is in operation with hydrocarbon fuels. At these very high speeds, it is possible to pass a larger amount of air mass per unit time through the supersonic ramjet engine. It's thrust values will therefore be much higher than for the developed ramjets.

pedrest develope a supersonic familet angline. The popic is

then say and the black and the head the solution in the past

when and in theoretical design techniques as many is days compute the main applies applies for ranget succeeds on do not apply. For threade, it is possible to not for spen as felder a distriction of the a chalet as heat

SECURITY CLASSIFICATION OF THIS PAGE

FOREWORD

This report is the compiled results of an in-house research project conducted by the author, Dennis W. Schroll, while attending the Ohio State University, Columbus, Ohio. This final research report was to fulfill the requirements for a Master of Science Degree in Aeronautics and Astronautics under the sponsorship of Aerospace Systems Division (DPCD) Long-Term Full-Time Training Contract F3360-75-A-0549-0002.

The work reported herein was performed during the period March 1978 to October 1978 by the author. This report was released by the author in December 1978.

The author wishes to give special thanks to his immediate supervisor at the time, Mr. W. A. Lucka, for his initial nomination to this program and to Professor R. Edse for being research advisor. This study would not have been possible without Professor Edse's equations and tables which he has developed in his research projects that are closely related to those outlined in this report.

TABLE OF CONTENTS

SECTION	. contraction parts and reason	PAGE
I	INTRODUCTION	1 1
II	COMPRESSION THROUGH VEHICLE BOW SHOCK WAVE	2
III	PERFECT GAS COMPUTATIONS ACROSS DIFFUSER INLET SPIKE	2
IV	AIR DISSOCIATION THROUGH A SHOCK WAVE	4
v	ISENTROPIC DIFFUSER INLET FLOW CALCULATION	8
VI	ISENTROPIC DIFFUSER EXIT FLOW CALCULATIONS	10
VII	SUPERSONIC AIR FLOW AND HYDROGEN FUEL COMBUSTION CALCULATIONS	21
VIII	ISENTROPIC FLOW CALCULATIONS AT NOZZLE	25
IX	CALCULATION OF AREA RATIOS FROM COMPUTED FLOW PROPERTIES	27
x	SPECIFIC NET THRUST AND TSFC	28
XI	CONCLUDING COMMENTS	29
	BIBLIOGRAPHY	61
is	She had I see the the offer a sol and the set of a	
	Shoose Matter B 10, Jos = 0.3. S. 0.00 - 10	
	shood Separated Se " 1." Do " 1. 0.5, 210. Area	
	Shode Endulied. Nort 10. 240 - 925. 2.0 ares	3
	Typical Viight Vendole with duserents hanger Saging	
di la	Emploal al este eith Expersions and hat i est.	5
	Ome Supermente Remjet Sambusticus Medules	4
	V	

- The All and a second

LIST OF ILLUSTRATIONS

FIGURE		PAGE
1 5	Entrance Shock for Starting Ramjet - Supercritical Condition	1
2 s	Shock is Swallowed with Supersonic Flow Throughout - Supercritical Condition	1
3	Inlet Spike or Forward Region of Hypersonic Vehicle	3
4 8	Internal Modes of Energy of Diatomic Oxygen and Nitrogen Showing Regions of Relaxation	4
5 01	Heat Release Values Relative to Air-Fuel Ratios	15
6. 15	Heat Release Values Relative to Air-Fuel Ratios	16
7 35	Supersonic Flow Required at Entrance to the Combustic Chamber as a Function of the Heat Release	on 17
8	Stagnation Pressure Drop Across Variable Area	18
9 ⁸⁸ 29 2	Temperature and Area Increase Across Variable Area Combustion Zone	19
10 10	Total Temperature Change Across Variable Area Combustion Zone	20
11	Shocked Inlet, $M_{\bullet} = 5$, $\vartheta_{02}^{\circ} = 0.5$, 2.0 Area Relationships	21
12	Shocked Inlet, $M_{\bullet} = 10$, $\sqrt[4]{0_2}^{\circ} = 0.5$, 2.0 Area Relationships	31
13	Shock Expelled, $M_{\infty} = 5$, $\vartheta_{0_2}^{\circ} = 0.5$, 2.0 Area Relationships	32
14	Shock Expelled, $M_{e} = 10$, $y_{02}^{\circ} = 0.5$, 2.0 Area Relationships	32
15	Typical Flight Vehicle with Supersonic Ramjet Engine	34
16	Typical Missle with Supersonic Ramjet Engine	34
17	One Supersonic Ramjet Combustion Module	34

vi

LIST OF TABLES

TABLE	Line 08 TATEE: (constitued)	PAGE
PAR	Calculated SNT and TSFC Values	30
2-3	Co-efficients $a^{(j)}(T)$ of Equilibrium Constants $K_{p}^{(j)}(T)$	35-36
4-5	Equilibrium Constants, K ^(j) atm av (j)	37-38
6-7	Reduced Absolute Formation Enthalpies	39-40
8-9	Reduced Sensible Enthalpies, $\left(\frac{H-E}{R}\right)^{T}$ i	41-42
10-11	Reduced Entropies, $\left(\frac{s}{\Re}\right)_{i}^{p=1}$	43-44
12-13	Reduced Specific Heats $\left(\frac{C}{B^{p}}\right)^{T}$	45-46
14-15	Reduced Entropy Divided by $\ln T$, $\begin{bmatrix} \frac{S}{R} \\ \frac{1}{1} \end{bmatrix}$ i	47-48
16	Fluid Properties of Supersonic Combustion Ramjet Shocked Inlet (Critical Condition)	49
17	Fluid Properties of Supersonic Combustion Ramjet Shocked Inlet, $M_{\odot} = 5$, $\gamma_{0_2}^{\circ} = 0.5$	50
- 18	Fluid Properties of Supersonic Combustion Ramjet Shocked Inlet, $M_{co} = 5$, $v_{0_2}^{\circ} = 2$	51
19	Fluid Properties of Supersonic Combustion Ramjet Shocked Inlet (Critical Condition)	52
20	Fluid Properties of Supersonic Combustion Ramjet Shocked Inlet, M = 10, $\mathcal{V}_{0_2}^{\circ} = 0.5$	53
21	Fluid Properties of Supersonic Combustion Ramjet Shocked Inlet, $M_{\odot} = 10$, $V_{0}^{\circ} = 2$	54
22	Fluid Properties of Supersonic Combustion Ramjet Expelled (Supercritical Condition)	55
23	Pluid Properties of Supersonic Combustion Ramjet Shock Expelled, $M_{\infty} = 5$, $V_{0_0}^{\circ} = 0.5$	56
24	Fluid Properties of Supersonic Combustion Ramjet Shock Expelled, $M_{co} = 5$, $y_{0_2}^{\circ} = 2$	57

SILEY OF SALESSE LIST OF TABLES (continued)

TABLE	neutry main the set of the set interest	PAGE
25	Fluid Properties of Supersonic Combustion Ramjet Shock Expelled (Supercritical Condition)	58
26	Fluid Properties of Supersonic Combustion Ramjet Shock Expelled, $M_{o} = 10$, $J_{0_2}^{o} = 0.5$	59
27	Fluid Properties of Supersonic Combustion Ramjet Shock Expelled, $M_{\odot} = 10$, $V_{00}^{\circ} = 2$	60

Aluit Properties of Suparaonic Compusiton Rasjet Shooted Intet. E. 7 . Do. - 2

Picti Coperties of Supersonic Commeries Ramiet's Shooked Friet (Critical Conditien)

Shoadad Files of Supersonic Comparish Ramiet

Plaid Properties of Supersonic Computing Hands t

Flaid Properties of Supersonic Combustion Hamiet Expelled (Supercritical Condition)

Maid Properties of Supersonic Combustion Remjety

Fluid Froperties of Supersinic Combustion Ramiet

Shooing Inlat, Man 10, 100

20

14.14

viii

1	GLOSSARY OF TERMINOLOGY
T	(^O K) temperature
P	(atm) pressure
u	(m/sec) velocity
M	dimensionless frozen flow mach number
ni	partial pressure fractions of molecules and atoms
m	(g/mole) molecular weight
SR2	dimensionless entropy
h _{f abs} T R ₂ T ₂	dimensionless enthalpy
A	(m ²) area
8	ratio of specific heats for frozen flow
n(^g)	global molar value of species i
R	universal gas constant = $8314.33 \text{ J/K-mole}^{\circ}\text{K}$
K _p ⁽ⁱ⁾	equilibrium pressure coefficient
H _r T n T i	absolute enthalpy of each species
	non-dimensionalized specific heat
hf abs	absolute formation enthalpy
T ₀ , P ₀	stagnation fluid properties determined from the isentropic perfect gas relationships
9	density
q	heat addition coefficient
J 02°	fuel-air ratio

correction coefficient

x

ix

GLOSSARY OF TERMINOLOGY (continued) mass fraction of species i specific net thrust

urlairne aaskolaitaitait

cheloltico controerroo

alobal rolar value of species 1

thrust specific fuel consumption mass weighted fuel-air ratio

signifier fluid propertiesedebered ned from the identicatio

x

Xi

TSFC

f

SECTION I

INTRODUCTION

A variable area supersonic combustion ramjet was modeled for free stream mach numbers of 5 and 10. It was desired to use a configuration as that proposed in several articles on a hypersonic research vehicle as a joint NASA-USAF project. The problem is divided into four sections: 1) the starting shock at $M_{\infty} = 5$, 2) the swallowed shock at $M_{\infty} = 5$, 3) the starting shock at $M_{\infty} = 10$, 4) the swallowed shock at $M_{\infty} = 10$.



Figure 1. Entrance Shock for Starting Ramjet-Subcritical Condition

公开在中国大学

Figure 2. Shock is Swallowed with Supersonic Flow Throughout-Supercritical Condition

The flow is considered non-viscous and the geometry of the converging-diverging channels are 2 dimensional and planar. Effects of curvature to compress and expand the flow uniformly across incremental mach lines are ignored. Rather, it is the purpose of this project to determine the fluid properties at various stations through constant properties of entropy and pressure. Dissociation of air and hydrogen/air chemical reactions are computed.

SECTION II

COMPRESSION THROUGH VEHICLE BOW SHOCK WAVE

The bow shock wave off the hypersonic vehicle is considered as the first stage of air compression. From Taylor-Maccoll cone theory (cone at zero angle-of-attack) with a $7\frac{1}{2}$ degree cone half angle, fluid properties are estimated to be:

Mar	enally M1 add (A	T ₁ ^o K	P ₁ atm
5	4.51	236	0.018
10	7.99	306	0.0374
15	10.37	408	0.0687

Because the fluid properties are the average of that from the ray on the shock to the cone surface, the following values are used as initial conditions for the diffuser inlet:

Mœ	M ₁	T ₁ ^o K	P ₁ atm
50 Lingel at a	5	230	0.02
10	8	300	0.04

Thus the bow shock wave off the vehicle acts as a mild first stage compressor.

AIR IS $\longrightarrow 0_2 + 3.76 N_2$ R = 8314.33 Joules/K-mole ^oK

The molar volume of air of 3.76 of nitrogen to 1 of oxygen is assumed and the value of the universal gas constant as used through this report is given.

SECTION III

PERFECT GAS COMPUTATIONS ACROSS DIFFUSER INLET SPIKE

To estimate the fluid properties temperature and pressure across the shock, perfect gas relationships are used with decreasing values of X for higher temperatures.





HEAD OF SHOCK

WAVE

ROTATIONAL EQUILIBRIU VIBRATIONAL

EQUILIBRIUN

TRANSLATIONAL

EQUILIBRIUN

TAIL OF WAVE

EQUILIBRIUM

COMPLETE

5 MEAN FREE PATHS

Figure 4. Internal Modes of Energy of Diatomic Oxygen and Nitrogen Showing Regions of Relaxion

Values of **X** for estimated temperatures can be determined approximately by guessing that the values begin at 1.4 for air $(0_2 + 3.76 N_2)$ and decrease with increasing temperatures where dissociation begins at 1100 ^oK. When M₁=8 for T₁=300 ^oK and **X** =1.3, T₂= 3300 ^oK, however this does not consider molecular dissociation and will need to be adjusted.

SECTION IV

AIR DISSOCIATION THROUGH A SHOCK WAVE

To adjust the temperature and pressure it is necessary to calculate the mole fractions of molecule and atom species of O_2 , N_2 , O, N and NO from the estimated temperature and pressure. The equilibrium pressure

coefficient equations of each individual reaction is written, $(K^{(i)})$ and the fact that the sum of the mole fractions is equal to 1, and the ratio of oxygen to nitrogen atoms is given. The equations are rearranged and values of χ_{0_2} are estimated until the percent error is less than .001.

$$\eta_{o} = K^{(n)} \sqrt{n_{o_{2}}}$$

$$\sqrt{n_{N_{2}}} = \sqrt{a^{2} + 1 - n_{o_{2}} - n_{o}} - a$$
where
$$a = \frac{K^{(n)} + K^{(no)} \sqrt{n_{o_{2}}}}{2}$$

values of \mathcal{N}_{0_2} are assumed until

 $\frac{100}{3.76} \left| \frac{\eta_{N_2} + \frac{1}{2}(\eta_N + \eta_{NO})}{\eta_{O_2} + \frac{1}{2}(\eta_O + \eta_{NO})} - \frac{3.76}{76} \right| = |\Delta| <.001$ and $\eta_{NO} = \sqrt{\eta_{N_2} \eta_{O_2}} K_p^{(NO)}$

5

and

 $\mathcal{N}_{N} = \sqrt{\mathcal{N}_{N_{2}}} K_{P}^{(N)}$

. (0)

$$\frac{P_1}{P_1} = B + \sqrt{B^2 + \frac{T_2}{T_1} \cdot \frac{m_1}{m_2}}$$

where

$$B = \frac{T_{i}}{T_{i}} \cdot \frac{m_{i}}{m_{2}} \sum_{i} n_{i,2} \left(\frac{H_{i}}{RT}\right)_{i}^{T_{i}} - \sum_{i} n_{i,i} \left(\frac{H_{f}}{RT}\right)_{i}^{T_{i}} \cdot \frac{T_{i}}{2} \left(\frac{T_{i}}{T_{i}} \cdot \frac{m_{i}}{m_{2}} - 1\right)$$

It is now necessary to recalculated the molar fractions each time a new pressure is assumed. Now with these series of equations solved for an estimated temperature and corresponding values of pressure, a value of the velocity is calculated.

$$\mathcal{U}_{2} = \frac{T_{2}}{T_{i}} \cdot \frac{\mathcal{M}_{i}}{\mathcal{M}_{2}} \cdot \frac{P_{i}}{P_{2}} \mathcal{U}_{1}$$

$$\left[\mathcal{U}_{i}^{cauc}\right]^{2} = \left[\left(\frac{P_{2}}{P_{i}}-l\right) \div \left(1-\frac{T_{2}}{T_{i}}\cdot\frac{P_{i}}{P_{i}}\right)\right] \left[\frac{T_{i}}{\mathcal{M}_{2}}\frac{\mathcal{H}_{i}}{\mathcal{M}_{i}}\right]$$

until

$$\frac{|\mathcal{U}_{i}^{CALC} - \mathcal{U}_{i}^{HNOWN}|}{100 \times \mathcal{U}_{i}^{HNOWN}} < .01\%$$

By successive linear extrapolation a new value of temperature is determined, the pressure and mole fractions are adjusted until the correct velocity is calculated. This gives values of T_2 , P_2 and u_2 behind the shock.

Now consider frozen flow where a value of **b** is determined for these values of temperature and pressure.

 $\chi^{r_{HOZ}} = \frac{\overline{\xi} \, n_i \frac{c_i}{\overline{n}}}{\overline{\xi} \, n_i \frac{c_i}{\overline{n}}} - 1$

To calculate the mach number (M^{FROZ}) , it is necessary to determine the speed of sound in the mixture at the position behind the shock. For temperatures less than 3000 ^OK, the contributions of the shifting speed of sound are neglible and only the frozen speed of sound is considered. As such the reference mach number is calculated from the definition of the speed of sound.

M FROZ = U CALC W FROZ = U CALC V FROZ # T

at $M_1=8$, the value of the frozen mach number behind the inlet shock is

$$M^{FROZ} = \frac{2785}{\sqrt{1.2891 \left(\frac{8314.33}{28.36149}\right) 3.089}} = 0.3413$$

Now that the fluid properties are determined across the nonisentropic strong normal shock, a question might be posed as to whether the condition of assumed equilibrium is valid. Those modes of energy such as translational, rotational for diatomic oxygen and nitrogen usually reach equilibrium in less than 5 mean free paths of collision of the molecules. Relaxation of the vibrational energy state usually takes a somewhat longer time, but for oxygen and nitrogen relaxation still occurs in a narrow region behind the shock. Therefore the frozen properties are assumed to be determined after relaxation or for equilibrium (see Figure 4).

SECTION V

ISENTROPIC DIFFUSER FLOW CALCULTIONS

Behind the shock wave the flow is subsonic and a converging channel will increase the flow velocity, and decrease the molecule translational energy (temperature) and decrease the pressure. That is, the more random molecular motion will be more ordered and directional. The temperature and pressure are estimated at the throat to be values as determined from the isentropic perfect gas relationships

 $\frac{\frac{r_{0}}{P_{3}}}{P_{3}} = \left(1 + \frac{y-1}{2}M_{3}^{2}\right)^{y-1} \quad \frac{T_{0}}{T} = \left(1 + \frac{y-1}{2}M_{z}^{2}\right)$

It is not necessary to calculate the stagnation properties as ratios can be taken and with sonic velocity assumed at the throat the equations are χ'

quations are $P_{3} = P_{2} \left\{ \frac{(1 + \frac{y-i}{2}M_{2}^{2})}{\frac{y+i}{2}} \right\}^{y-1} \left\{ T_{3} = T_{2} \left\{ \frac{1 + \frac{y-i}{2}M_{2}^{2}}{\frac{y+i}{2}} \right\} \right\}$ equations are

It is now necessary to adjust the pressure and temperature to account for the dissociation of the air. The equation of entropy is

 $\frac{m_2}{2} \left\{ \sum n_i \left(\frac{s}{R} \right)^T \right\}^T - \sum n_i \ln n_i - \ln P$ EST

With the known properties behind the shock the dimensionless entropy is calculated. Next calculate the entropy for the estimated isentropic temperature and pressure. To do this the mole fractions are calculated as previously outlined and then the entropy is adjusted by changing the pressure until it is within .01% that of the entropy behind the shock. Each time a new pressure is assumed new values of

mole fractions must be calculated. However the mole fractions are relatively insensitive to small changes in pressure. To adjust the temperature, the absolute enthalpy is calculated. 11

10

$$\left(\frac{\pi_{f}}{R_{z}}\frac{abs}{T_{z}}\right)^{T} = \frac{T_{EST}}{T_{z}} \frac{\mathcal{M}}{\mathcal{M}} \sum_{i} \mathcal{N}_{i} \left(\frac{\Delta H_{fabs}}{\mathcal{R} T}\right)^{T} \text{ is form the energy equation for no fuel addition to the flow,} h_{fabs}^{0} = h_{fabs}^{T_{z}} + \frac{\mathcal{U}_{z}^{2}}{2} = h_{fabs}^{T_{3}} + \frac{\mathcal{U}_{z}^{2}}{2}$$

$$\mathcal{U}_{s}^{CALC} = \left\{ \left[\left(\frac{h_{fabs}}{R_{z}}\right)^{T_{z}} - \left(\frac{h_{fabs}}{R_{z}}\right)^{T_{s}}\right] \frac{2(8314.33)}{\mathcal{M}_{z}} + \mathcal{U}_{z}^{2} \right]^{T_{z}} \right\}$$

$$\mathcal{V}_{s}^{FROZ} = \frac{\sum_{i} \mathcal{R}_{i} \frac{C_{i}}{\mathcal{R}}}{\sum_{i} \mathcal{R}_{i} \frac{C_{i}}{\mathcal{R}}} \frac{T_{s}}{\mathcal{R}_{s}} - \frac{1}{\mathcal{V}_{s}}$$

$$\mathcal{M}_{s}^{FROZ} = \frac{\mathcal{U}_{s}^{CALC}}{\sqrt{\mathcal{V}_{s}^{FROZ}} \frac{B314.33}{\mathcal{M}_{s}} T_{s}^{T_{s}}}$$

Should the mach number be larger than 1, then choose a value of temperature 100 °K larger and repeat the above procedure until a new mach number is determined. Now by linear extrapolation a third more accurate temperature is determined.

 $T_{3} (est 3) = T_{3}^{est 1} + \left[M_{3} = 1 - M_{3}^{est 1} \right] \\ \times \left[\frac{T_{3} est 2}{M_{3}^{est 2} - \frac{T_{3}^{est 1}}{M_{3}^{est 2}} \right]$

The calculations are now repeated again and usually this value is within 0.1% error as the frozen flow mach number relationship is a fairly linear one with respect to temperature for constant entropy.

mole fractions much be color ater. Havever the mole fractions,

SECTION VI

ISENTROPIC DIFFUSER EXIT FLOW CALCULATIONS

To go to region 3C (exit diffuser and entrance of combustion chamber) is somewhat more involved. Heat addition due to the combustion of hydrogen and air for various values of the heat addition coefficient are calculated.



3 to 3C and for dP=0, du=0 from 3C to 4.

 $M_{4} = \frac{M_{3C}}{\sqrt{1 + \frac{9}{c_{p}T_{3C}}}} \frac{T_{o4}}{T_{o3C}} = 1 + \frac{\frac{9}{c_{p}T_{3C}}}{1 + \frac{8 - 1}{2}M_{3C}^{2}}$ $\frac{1 + \frac{y-1}{2} M_{3c}^{2} \frac{1}{1 + \frac{q}{c_{p}T_{3c}}}}{1 + \frac{y-1}{2} M_{2c}^{2}}$ $\frac{T_{4}}{T} = 1 + \frac{1}{C_{p}T_{c}}$

The heat addition coefficient is then non-dimensionalized with respect to T_3 and plots are made.

 $\frac{\sqrt{1 + \frac{9}{C_0 T_1} \left[\frac{1 + \frac{y - 1}{2} M_{sc}^2}{\frac{1 + y}{2} \right]}}$ $\frac{P_{o4}}{P_{osc}} = \frac{\left[\frac{1+\frac{y-1}{2}M^2}{\frac{1+\frac{y-1}{2}M^2_{x}}{\frac{1+\frac{y-1}{2}M^2_{x}}{\frac{1+\frac{y-1}{2}M^2_{x}}}\right]}{1+\frac{y-1}{2}M^2_{x}}$ $\frac{T_{o4}}{T_{o3c}} = \frac{1 + \frac{2}{C_{o}T_{s}}}{\frac{1 + \frac{y-1}{2}}{1 + \frac{y-1}{2}}} \frac{M_{zc}^{2}}{\frac{1+y}{2}}$ $\frac{A_{4}}{A_{3c}} = \frac{T_{4}}{T_{3c}} = 1 + \frac{9}{C_{p}T_{7}} \left[\frac{1 + \frac{y-1}{2} M_{3c}}{\frac{1+y}{2}} \right]$ $\frac{P_4}{P_{3c}} = 1 \quad \text{where,} \quad q = \chi \frac{\Delta H_{comb}}{m_{fuel-air mix}}$

The non-dimensionalized heat addition coefficient q is given above. See reference 1 for an outline of the procedure to obtain this coefficient. For hydrogen

 $\Delta H_{comB} = 241.52 \times 10^6 \frac{J_{oules}}{K_{amal}}$

The mass of hydrogen-air mixture can be expressed relative to the number of moles of oxygen by ${\mathcal J}_{0_2}^{\circ}$. Before combustion this ratio is given by

 $H_2 + v_{0_2}^{\circ} (0_2 + 3.76 N_2)$

The maximum heat release is obtained for $v_{0_2}^{\circ} = 0.5$ as the oxygenhydrogen chemical reaction is $H_2 + \frac{1}{2}O_2 + H_2O_2$.

However, it is possible to have a leaner fuel-air mixture ratio

 $\frac{1}{2} \leq \sqrt{0_{0}^{\circ}} \leq \infty$.

 $q = \frac{A H_{comb}}{m_{H_a} + v_o^{\circ} (m_{o_2} + 3.76 m_{N_a})}$

The specific heat of the mixture, m is given as

 $C_{P,m} = \frac{\gamma_m}{\gamma_m - 1} R_m$ where $R_m = \frac{\gamma_m}{R_m} R_m$ and =8314.33 is the Universal Gas Constant

Several ideal assumptions are made in the combustion chamber that expedite computations. The hydrogen enters the combustion chamber at the same speed as that of the air, and its absolute enthalopy is determined at 1000°K for temperatures exceeding this and at the air temperature for air temperatures less than this

 $\frac{q}{C_{P_m}T_3} = \chi \frac{\Delta H_{coms}}{\frac{M_m}{N_m}} \frac{\mathcal{R}}{\mathcal{R}} \left[\mathcal{M}_{H_2} + \mathcal{V}_{o_2}^{\circ} (\mathcal{M}_{o_2} + 3.76 \mathcal{M}_{H_2}) \right]$

Now according to the method outlined in reference 1 the value of \mathcal{M}_{m} is,

 $\mathcal{M}_{m} = \frac{4.76 \, v_{o_{2}}^{\circ} \, \frac{m_{H_{2}}}{m_{o_{2}} + 3.76 \, m_{N_{2}}}}{1 + 4.76 \, v_{o_{2}}^{\circ} \, \frac{m_{o_{2}} + 3.76 \, m_{N_{2}}}{m_{o_{2}} + 3.76 \, m_{N_{2}}}} \left(\mathcal{M}_{o_{2}} + 3.76 \, m_{N_{2}} \right)$

For temperatures less than 2000 °K the mass of the decelerated air is almost equal to $\mathcal{M}_{0_2} + 3.76 \mathcal{M}_{N_2}$. Substituting in all the approprite values and cancelling out gives,

 $\frac{q}{C_{e_{m}}T_{i}} = \chi \frac{\chi - 1}{\chi} \frac{29048}{(4.76)_{o_{i}}^{\circ} + 1} T_{i}$

for hydrogen air mixture \checkmark will range from 1.441 (no combustion) to 1.25 (combustion temperatures up to 3000 °K). Since this nondimensionalized heat coefficient is mainly used to get an estimate of M_{3C} , $\checkmark = 1.4$ is used as this is at the position of combustion initiation. A few words should be said about the correction coefficient X, as this pertains to the degree of combustion of gases as they travel across the nozzle. It can range from 0.4 for high temperatures and low pressures up to 1.0 for low temperatures and high pressures. With the possible exception of one case $M_{3C} = 10$, no shock, values of 0.7 would seem satisfactory. For the sake of comparison, 0.7 is used in all computations. Two combustion cases were taken for all computations.

 $\mathbf{y}_{02}^{\circ} = 0.5 \quad (\text{rich mixture - maximum heat release}) \\
 \mathbf{y}_{02}^{\circ} = 2 \quad (\text{lean mixture - minimum heat release})$ The procedure to determine the fluid properties at the diffuser exit

3C was to first of all assume we want $M_{ij} = 1.2$. Too high a mach number in the combustion chamber will mean problems with mixing fuel and air. However, should the flow go subsonic again this would mean flow choking (M = 1) and the flow in the combustion chamber will go to low mach numbers. Therefore, in conclusion, it is desired to keep the flow within the mach number range at $M_3 = 1$ at the throat to $M_{ij} = 1.2$ at the exit of the combustion chamber.

Looking at Figure 3, M_3 can be determined from a calculated heat release coefficient and assumed value of M_{ij} = 1.2. This mach number is then used to calculate the fluid properties isentropically at the diffuser exit.

 $T_{3c} = \frac{T_{3c}}{T_{o3c}} \frac{T_{o3}}{T_{3}} T_{3} = \frac{\left[1 + \frac{y-1}{2} M_{3}^{2}\right] T_{3}}{\left[1 + \frac{y-1}{2} M_{3}^{2}\right] T_{3}}$ $P_{3c} = \frac{P_{sc}}{R_{sc}} \frac{P_{os}}{R_{s}} P_{3} = \frac{1 + \frac{y-1}{2} M_{3}^{2}}{1 + \frac{y-1}{2} M_{2}^{2}} \frac{y_{s-1}}{r_{3}} P_{3}$

Next, calculate the flow properties considering air dissociation by the same method as used to determine the flow properties at the throat until the value of $M_{3C}^{\rm FROZ}$ is within 0.1% error of that of the mach number determined by the perfect gas method. Inspection of Figures 5 through 10 reveals that it is necessary to add fuel and combust the gas downstream of the throat to prevent choking the flow. Even though the molecular velocity will approximately double in magnitude from the diffuser throat to the diffuser exit for supersonic flow, the expanding nozzle will result in a decrease in temperature and pressure













with an appropriate increase in X FROZ . Inspection of Figure 7 shows that for constant values of heat release coefficient at the combustion chamber exit, larger mach numbers are required at the diffuser exit to lower the resultant mach numbers at the combustion chamber exit.

SECTION VII

SUPERSONIC AIR FLOW AND HYDROGEN FUEL COMBUSTION CALCULATIONS

It was determined for the lower speeds of $M_{\infty} = 5$ and $\int_{0_2}^{0} = 0.5$ that the temperature reduced to 739 °K for the shocked inlet and 754.9°K for the shock free inlet. For these calculations from then on out to the nozzle exit it was assumed that ignition of the hydrogen-air mixture was achieved by other means rather than self ignition as the flow would quench below approximately 900 °K. The next procedure is to calculate the fluid properties of the hydrogen-air mixture at the combustion entrance and exit for chemically reacting gases. Consider the energy equation,

 $h_{fabs} + \frac{u_{3c}}{2} = h_{fabs} + \frac{u_{4}}{2}$

The assumption of constant pressure combustion implies that dp=0 and therefore du=0 from the momentum equation.

 $\frac{\mathcal{R} T_{sc}}{\mathcal{M}_{sc}} \sum \mathcal{R}_{i,sc} \left[\frac{\Delta H_{fals}}{\mathcal{R} T'} \right]_{i}^{T_{sc}} = \frac{\mathcal{R} T_{4}}{\mathcal{M}_{4}} \sum \mathcal{N}_{i,4} \left[\frac{\Delta H_{fals}}{\mathcal{R} T'} \right]_{i}^{T_{sc}}$

That is, the enthalpy of the hydrogen-air mixture before combustion is equal to the enthalpy of the combustion of gases at the combustion chamber exit.

Tie = Xair hfair + XH2 hf. H2 TH2

where Xair and XH, are the mass fractions of the air and hydrogen.

$$X_{air} = \frac{\int_{0}^{0} (32 + 3.76(28.016))}{\int_{0}^{0} (32 + 3.76(28.016)) + 2.016} \frac{\kappa_{g}}{\kappa_{mole}}$$

and

$$X_{hyd} = \frac{2.016}{V_{02}} \frac{K_{9}}{(32+3.76(28.016))+2.016} \frac{K_{9}}{K_{8}} + \frac{2.016}{V_{02}} \frac{K_{9}}{(32+3.76(28.016))+2.016} \frac{K_{9}}{K_{8}} + \frac{K_{13c}}{M_{3c}} \sum_{i} \mathcal{N}_{i} \left(\frac{\Delta H_{Fabs}}{\mathcal{R}_{T}}\right)_{i}^{T_{hyd}} \frac{J}{K_{9}} + \frac{K_{13c}}{M_{3c}} \sum_{i} \mathcal{N}_{i} \left(\frac{\Delta H_{Fabs}}{\mathcal{R}_{T}}\right)_{i}^{T_{1000}} + \frac{K_{13}}{K_{9}} + \frac{K_{13}}{M_{hyd}} \sum_{i} \mathcal{N}_{i} \left(\frac{\Delta H_{Fabs}}{\mathcal{R}_{T}}\right)_{H_{2}}^{T_{2}} + \frac{K_{13}}{K_{9}} + \frac{K_{13}}{M_{hyd}} \sum_{i} \mathcal{N}_{i} \left(\frac{\Delta H_{Fabs}}{\mathcal{R}_{T}}\right)_{H_{2}}^{T_{2}} + \frac{K_{13}}{K_{9}} + \frac{K_{13}}{M_{hyd}} + \frac{K_{13}}{K_{1000}} + \frac{K_{13}}{K_{10$$

nFhyd = 8317.33 (1000) (2. Fabs) 2.016 (2. T)H2

Recalling that it is assumed that the temperature of the hydrogen entering the airstream is 1000 $^{\circ}$ K or less (equivalent to the temperature of the airstream.) For example, if the airstream was 3000 $^{\circ}$ K, the hydrogen temperature is 1000 $^{\circ}$ K, and if the temperature of the airstream were 950 $^{\circ}$ K, the hydrogen temperature is given as 950 $^{\circ}$ K also. The reason for this was to avoid the possibility of dissociation

of the H_2 molecules into H atoms before they enter the airstream. This would affect the enthalpy, molecular weight of the mixture. Even though this effect would be slight the enthalpic state of hydrogen is much larger than air because of its much smaller molecular weight of 2.016 versus 28.853 for air. This could mean changes of up to 100 ^OK in the final computations, and it is also unlikely that H_2 would be injected into the airstream at higher temperatures.

Now to determine the temperature at the exit of the combustion chamber, values are actually just guessed at approximately 1500-2000 $^{\circ}$ K above that of the air at the entrance of the combustion chamber. The pressure of course was assumed to be constant.

The first thing to do is to calculate the mole fractions at a given pressure and temperature.

n = K(to2) 1 no.

 $\mathcal{N}_{H_2} = \left\{ \sqrt{\left(\frac{A}{B}\right)^2 + \frac{1 - 0.5 \mathcal{N}_0}{B}} - \frac{A}{B} \right\}^2$

where

 $A = 0.25 \left[H^{\left(\frac{1}{2}H_{2}\right)} + \left(\frac{n_{o_{2}} + n_{N_{2}}^{g}}{n_{3}} + 1\right) H^{\left(\frac{1}{2}H_{2}\right)} + \left(\frac{n_{o_{2}} + n_{N_{2}}}{n_{3}} + 1\right) H^{\left(\frac{1}{2}H_{2}\right)} \right]$

and

 $B = 0.5 + \left(\frac{n_{01}^{3} + n_{N_{2}}^{3}}{n_{\mu}^{3}} + 0.5\right)\left(1 + K^{(H_{2}0)}\sqrt{n_{2}}\right)$
$n_{H} = K^{\left(\frac{1}{2}H_{2}\right)}\sqrt{n_{H_{2}}}$

noH = K (OH) JNO2 JNH2 $\mathcal{N}_{H_{2}0} = K^{(H_{2}0)} \sqrt{\mathcal{N}_{02}} \mathcal{N}_{H_{2}}$

 $\mathcal{N}_{N_{2}} = \left\{ \sqrt{\left[0.25 \, \text{K}^{(NO)} \sqrt{\mathcal{N}_{O_{2}}}\right]^{2} + \left(\mathcal{N}_{H_{2}O} + \mathcal{N}_{H_{2}} + 0.5 \left[\mathcal{N}_{OH} + \mathcal{N}_{H}\right] \frac{n_{N_{2}}}{n_{H}}} \right\} \right\}$ -0.25 K (NO) / No2 }2

and

no = K (NO) Jno Jno

These calculations are repeated with improved values of the estimated mole fractions of oxygen until

 $\left|\frac{n_{o_2}^3}{n_{\mu}^3} - \mathcal{Y}_{o_2}^{\circ}\right| < .001 \quad \frac{n_{o_2}^3}{n_{\mu}^3} = \frac{n_{o_2} + 0.5(n_0 + n_{H_20} + n_{00} + n_{00})}{n_{H_2} + n_{H_2} + 0.5(n_{0H} + n_{H})}$

Successively closer values of the enthalpic state at the exit of the combustion are determined until an accuracy of

 $\frac{h_{\rm Fmix} - h_{\rm Fmix}^{T_{\rm SC}}}{h_{\rm Smix}}$ 0.01 is achieved.

Since again the mach number can be calculated in the same manner as at the nozzle throat. Viewing the results of the calculations, it is evident that water and nitrogen are the final chemical constituients provided the temperatures are not to great and the hydrogen, oxygen and nitrogen atoms are not allowed to reform into molecules.

SECTION VIII

ISENTROPIC FLOW CALCULATIONS AT NOZZLE

The most desirable or ideal state at the exit of the engine would be that no underexpanded flow, $P_{exit} < P_1$ or overexpanded flow where $P_{exit} > P_1$ would exit the end of the nozzle. For the purpose of calculating the ideal nozzle flow the pressure was assumed equal to that entering the engine behind the bow shock wave. $P_5 = 0.02$ for $M_1 = 5$ and $P_5 = 0.04$ for $M_1 = 8$. Also it was assumed that the flow went from the combustion chamber exit to the nozzle exit isentropically. A reasonably valid assumption provided the hydrogen gas combustion reaction is complete. That is, the hydrogen gas has released all its heat content within the combustion chamber and no additional heat is released within the nozzle exit. The decrease in temperature and resulting increase in velocity of the gases is a transformation of molecular random motion into more ordered and directional motion.

The entropy at the exit of the combustion chamber can be determined as the temperature, pressure and mole fractions are known.

 $\left(\frac{s}{R_{2}}\right)^{T_{4}} = \frac{m_{2}}{m_{4}} \left[\sum_{i} n_{i,4} \left(\frac{s}{R_{1}}\right)^{T_{4}}_{i} - \sum_{i} n_{i,4} - \ln P_{4}\right]$

Pressure and temperature will decrease for nozzle expansion and the velocity will increase. The frozen flow mach number and χ are calculated at station 4 and using these values the estimates at station 5 are made with perfect gas isentropic relationships.

$$\frac{P_s}{P_{os}}\Big|_{M_s} = \frac{P_s}{P_4} \frac{P_4}{P_{o4}}\Big|_{M_s}$$

where

 $\frac{P_{04}}{P_4} = \left[1 + \frac{y-1}{2}M_4^2\right]^{y/y-1}$

Also

$$M_{\mathfrak{F}} = \left\{ \left(\left(\frac{P_{os}}{P_{s}} \right)^{s-1/s} - 1 \right) \frac{\varepsilon}{s-1} \right\}^{s/s}$$

After estimating M_5 the temperature corresponding to the pressure is determined.

$$T_{5} = \frac{T_{5}}{T_{o5}} \frac{T_{o4}}{T_{4}} T_{4} = \frac{\left[1 + \frac{y-1}{2}M_{4}^{2}\right]}{\left[1 + \frac{y-1}{2}M_{5}^{2}\right]} T_{4}$$

Keeping in mind that the value of X used is that frozen from the combustion chamber exit. The temperature and pressure are adjusted accounting for chemical reactions and with this estimate of temperature the mole fractions from the previous equations given are calculated. The entropy is,

$$\left(\frac{s}{R_2}\right)^{T_s} = \frac{m_2}{m_4} \left[\sum_i n_{i,4} \left(\frac{s}{R}\right)_i^{T_s} - \sum_i n_{i,s} \ln n_{i,s} - \ln P_s \right]$$

The temperature T_5 is adjusted until the entropy at station 5 is within 0.01% of that at station 4. The corresponding absolute enthalpy is then determined.

 $\frac{h_{fabs}}{R_{c}T_{c}} = \frac{m_{2}}{m_{c}} \frac{T_{s}}{T_{c}} \sum \mathcal{R}_{i,s} \left(\frac{\Delta H_{fabs}}{\mathcal{R}_{c}}\right)^{s}$

 $\mathcal{U}_{5}^{calc} = \left\{ \left[\left(\frac{h_{fabs}}{R_{2} T_{2}} \right)^{T_{4}} - \left(\frac{h_{fabs}}{R_{1} T_{2}} \right)^{T_{5}} \right] \frac{2 (8314.33) T_{4}}{M_{4}} + \mathcal{U}_{4} \right\}^{2}$



$$\mathcal{M}_{5}^{FROZ} = \frac{\mathcal{U}_{5}^{CALC}}{\sqrt{\frac{\gamma}{5}} \frac{\mathcal{P}_{C}}{\mathcal{M}_{5}} \frac{\mathcal{P}_{C}}{\mathcal{M}_{5}} \frac{\mathcal{P}_{C}}{\mathcal{T}_{5}}}$$

SECTION IX

CALCULATION OF AREA RATIOS FROM COMPUTED FLOW PROPERTIES The area ratios can now be determined from the conservation of mass and the equation of state.

 $\rho = \frac{P}{T} \frac{m}{2}$ $(\rho u A)_{1} = (\rho u A)_{2}$ or $\frac{A_1}{A_1} = \frac{T_2}{T_1} \frac{P_1}{P} \frac{\mathcal{M}_1}{\mathcal{M}_2} \frac{\mathcal{U}_2}{\mathcal{U}_2}$

Note that a specific area cannot be found for any one location. A reference area must be established. The sonic throat is chosen at the reference area as it supposedly represents the smallest area. The area ratio at the throat is given and is that location where the flow is sonic (M = 1).

te vioutre ant filter bateuchs of

SECTION X

SPECIFIC NET THRUST AND TSFC

The specific net thrust (SNT) and thrust specific fuel consumption (TSFC) are determined as follows:

 $\frac{1}{m_{e}} = (1+f)\mathcal{U}_{5} - \mathcal{U}_{1}$ $P_a = P_a$ ma - mass flow rate of air through the engine configuration f - fuel air ratio u5 - exit velocity of burned gases u1 - flight velocity of the engine (initially specified) $\frac{\text{mass fuel / per unit time}}{\text{mass air / per unit time}} = \frac{2.016}{V_{\odot}^{\circ}(32 + (3.76)(28.016))} \frac{K_{\odot}}{K-m_{\odot}k-m_{\odot}k}$ $f = \frac{2.016}{0.5(32+3.76(28.016))} = 0.0293578$ for $U_0^* = \frac{1}{2}$ $f = \frac{2.016}{2(32+3.76(28.016))} = 0.0073394 \text{ for } U_{0_2}^\circ = 2$ $TSFC = \frac{m_f}{T} = \frac{f}{T_{line}}$

SECTION XI

CONCLUDING COMMENTS

The resulting specific net thrusts and associated TSFC are rather high. As would be expected the greatest amount of thrust would be provided for the richest mixture of hydrogen to air at $\sqrt{0_2}^\circ = 0.5$. The thrust falls off dramatically for leaner mixtures and for the shocked inlet at $M_{\infty} = 10$ for $\sqrt{0_2}^\circ = 2$ negative thrust or drag is provided.

Rather encouraging results are obtained for the shocked inlet. The thrust values are reasonably high and the associated TSFC's are almost double that of some typical ramjets (designed and in operation.) This type of design would require that the stagnation pressure drop such that P_{3C}/P_{03C} , $P_{4/}/P_{04}$, and P_{5}/P_{05} be below values of 0.528 or it would not be possible to obtain supersonic flow in the aft side of the diffuser. This can be determined from perfect gas tables, shock tables, and the graphs included herein for stagnation pressure drops across the combustion chamber.

For $M_{\infty} = 5$, $\sqrt[9]{0_2}^{\circ} = 0.5$, and the shocked inlet, $P_{3C}/P_{03C} = 0.1113$ $P_{4}/P_{04} = 0.3969$ $P_{5}/P_{05} = 0.10994$ all of which are below $P/P_{0} = 0.528$. This means the flow will indeed go supersonic. Similarly, the other conditions can be checked.

TABLE 1	CALCULATED SNT	AND TSFC VALUES	The test
CUOCKET	ana DNGT Abrildos		ALLANDER ATT
SHUCKEL	INLET ENGINE	The instant of a	ad burn is nature
Mœ	Jo2	//m _a (N/Kg/sec)	TSFC (Kg/hr/N)
5	0.5	341.334	0.3096
5	2	110.312	0.2395
10	0.5	441.404	0.2394
10	s Olal bataloosaa	-359.567	NA
SHOCK F	REE ENGINE		
Mœ	Jo2°	\mathcal{T}/m_{a} (N/Kg/sec	TSFC (Kg/hr/N)
5	0.5	901.037	0.1173
5	2	230.790	0.1145
10	0.5	739.172	0.1430
10	2	-12.412	NA

SOME TYPICAL	VALUES OF TSFC FOR	R OTHER TYPES O	F ENGINES ARE
RAMJET	0.173 - 0.265	(N/Kg/sec)	M = 2
TURBOJETS	0.0763 - 0.1078	(N/Kg/sec)	STATIC
TURBOFANS	0.0509 - 0.0611	(N/Kg/sec)	STATIC

and the second

enstration in the distance





While the values of thrust and TSFC for the shock free engine look to be promising, it must also be considered that the static pressures of up to 272 atmospheres would be prohibitive. In fact, it would be necessary to open up the diffuser rather than closing it to provide permissible operating pressures. Also, to prevent choking in the combustion chamber the engine would have to be opened even more. This would require a tremendously large engine with a large associated wave drag. As such, only the shocked inlet configuration appears to be promising.

A method of injecting and combusting the gases across oblique shock waves in the combustion chamber for the shocked inlet configuration should be investigated as to its feasibility. Also, the same methods outlined in this paper could be used to investigate the feasibility of an external ramp over which combustion would take place on the aft side.



TABLE 2 COEFFICIENTS $a^{(j)}(T)$ OF EQUILIBRIUM CONSTANTS $K_p^{(j)}(T)$

(x)	.(4.)	('u'.)	*(m) 813+ 40 14 01	N 2+ 10 4 10
1100	16.038	39.145	6.4.16	0.314;6
IGAN	14.342	39.709	6.3673	0.10951
130	14.019	40.7/0	6.3.5%	0.10".1/
1500	15.049	40.041	6.2436	0.0:043
1600	15.252	41.0.3	6.193	0.09/11
1700	15.428	41.244	6.1493	0.09359
1000	15.002	41.3.4	6.1027	0.05:35
2000	15.653	41.400	6.0105	0.00%
2100	16.002	41.692	s.ern	o.nanı)
2200	16.119	41.475	5.9440	0.05718
2400	16.275	41 3Ch	5.9110	0.00.14
2500	16.351	41.269	5.8457	0.00531
2600	16.405 .	41.207	5.8133	0.00483
2800	10.451	41.112	5.7610	0.08450
2900	16.543	40.852	5.7490	0.00403
3000	15.585	40.719	5.6854	0.00352
3100	16.602	40.553	5.6594	0.06326
1300	16.635	40.391	5.0334	0.05307
3400	16.642	40.001	5.5820	0.0000
3500	16.645	39.901	5.5564	0.00004
3600	16.045	39.736	5.5310	0.08282
3000	16.625	39.413	5.2000	0.00203
3900	16.612	39.2%	5.4553	0.00292
4000	10.608	39.067	5.4303	0.08300
4100	16.588	38.904	5.4001	0.06303
4300	16.557	38.544	5.3639	0.05313
4400	16.539	38.363	5.3420	0.06382
1400	16 1.70		7. 340k	0.00331
4700	16.453	17.868	5.2767	0.08152
1800	16.423	37.690	5.2551	0.00359
4900 5000	16.392	37.517	5.2336	0.0836
5100	16.325	17.159	5,1909	0.08383
5200	16.209	36.905	5.1690	0.03302
5300	15.240	36.011	5.1485	0.0003
5500	16.163	36.463	5.10CA	0.08426
9600	16.122	36.8%	5.0055	0.0%
5700	16.079	36.138	5.0CA7	0.0547
\$200	15.601	35.919	5.0440	0.0%58
6000	15.943	35.63	5.cort	0.09490
(3)	arola		194 - 194 194 - 194	
4	C)/2	27012	4675	-2073.
(3).	0.5	0.5	0.0	-0.5

with the state

 $(T) = e^{(1)}(T_{L}) \left[\frac{e^{(1)}(T_{L} - 100)}{e^{(1)}(T_{L})} \right]^{(1)} \cdot T^{L}(3) \cdot ent \left[-(\Lambda X_{L}^{(1)}/4) \cdot (1/T) \right] \left[e^{LA'_{A}} {}^{(1)} \right]$

TABLE 3 COEFFICIENTS $a^{(j)}(T_1)$ OF EQUILIBRIUM CONSTANTS $K_p^{(j)}(T_1)$

(X)	(.u.)	(IID)	(00)
1100	35.800	4.2716	1.7175 -5
1300	37.909	4. 214	1.0580 -5
1400	38.20	4.3432	1.5717 -5
1500	38.555	4.3623	1.5537 -5
1600	38.873	4.3793	1.5341 -5
1800	39.322	4.6079	1.512/ -5
1900	39.444	4.4196	1.9048 -5
0000	39.523	4.4250	1.4985 -5
5500 5700	39.674	4.4373	1.49/7 -5
300	39.813	4.4531	1.4987 -5
500	39.865	4.45%	1.5092 -5
600	39.865	4.4651	1.53 37 -5
1700	39.80	h. 4009	1.5199 .5
2900	39.804	4.4007	1.5730 -5
9000	39.73	4.4705	1.5366 -5
3100	39.701	4.4709	1.5441 -5
3300	39.630	4.400	1.5520 -5
3400	39.566	4.4057	1.5703 -5
900	39.539	4.4669	1.5786 -5
600	39.408	4.4G47	1.5870 -5
800	39.369	4.4564	1.5950 -5
900	39.302	4.4549	1.6128 -5
	39.220	4.4513	1.6214 -5
100	39.157	4.4509	1.6297 -5
300	39.013	4.4382	1.6470 -5
100	36.9%	4.4250	1.6570 -5
-	30.000		1.0079 -7
700	38.775	4.40%	1.6745 -5
008	38.721	4.4009	1.6922 -5
000	30.675	4.36/7	1.7014 -5
100	38.502	4.3015	1.7191 -5
5200	30.536	4.3750	1.7280 -5
5400	30.501	4.3514	1.7371 -5
500	30.426	4.3540	1.7552 -5
5600	38.401	4.3475	1.7040 -5
5800	36.351	4.33%	1.7720 -5
900	38.33	4.3267	1.7900 -5
000	38.317	4.3198	1.7985 -5
(1)			
,)	56613	10799	-33970
3)	0.5	0.0	0.125
	and the second	COMPANY STREET	

for the particular and a solar

36

Sitist and a sit

TABLE 4 EQUILIBRIUM CONSTANTS, K(j) atm

1100 2.5704 -6 2.4774 -9 9.1033 -2 7.6350 f 1200 1.1015 -6 2.7797 -7 1.3778 -1 1.1507 f 1400 4.017 -6 9.3772 -7 2.2200 -1 2.2733 f 1500 1.7498 -5 4.0272 -6 2.7606 -1 2.3008 f 1500 1.7498 -5 4.0371 -5 3.3963 -1 1.513 f 1700 1.4655 -4 4.0371 -5 3.3964 -1 5.0003 f 1800 3.545 -4 1.2075 -4 4.5394 -1 1.0221 f 1900 7.606 A 2.5760 -4 5.1761 -1 7.6913 3 2000 3.046 -3 1.904 -3 6.45374 -4 5.6076 -1 3.4674 3 2100 3.046 -3 1.904 -3 6.45373 -1 2.7733 1 2.7733 1 2200 9.6233 -3 4.9371 -3 7.77446 -1 4.064 2 2 2900 9.6233 -1 1.6044 2 1.9373 -1 2.7733 2 2 2900 3.6394 -2 9.321 -2 9.6461 -1 1.0495 2 2700	T (K)		502 = 0	K (UN) 100 - ON	Kp ala" Na+ De = NgO	
1200 1.959 -7 2.4009 -8 1.0272 -1 7.9290 7 1500 1.1015 -6 1.7579 7 1.7376 1.1356 7 1600 1.0105 -6 1.7579 7 1.7376 1 2.1554 7 1600 1.4057 -5 1.3964 1 2.0005 1 2.0005 1 1700 1.4057 -5 1.3964 -5 3.3963 1 1.515 5 1800 7.9068 4 2.2076 4 4.5394 -1 1.6021 1 1900 7.9068 4 2.6537 -6.5374 4 5.1761 1 1.6045 2 2000 5.6105 -3 1.904 -3 6.4565 -1 1.6045 2 2000 5.6105 -3 1.904 -3 6.4565 -1 1.6045 2 2000 5.6144 2 5.3103 -3 7.0796 1 1.6045 2 2000 5.6144 -3 <th>1100</th> <th>2.5704 -8</th> <th>2.47/4 -9</th> <th>9.1033 -2</th> <th>7.6384 8</th> <th></th>	1100	2.5704 -8	2.47/4 -9	9.1033 -2	7.6384 8	
1800 1.1032 -6 9.377 -7 1.1376 -1 1.1569 7 1800 1.2426 -5 4.0272 -6 2.2606 -1 9.3066 5 1600 5.4075 -5 1.4968 -5 3.3953 -1 1.5135 5 1700 1.4655 -4 1.2976 -4 5.1966 -1 5.0003 4 1800 1.4655 -4 1.2976 -4 5.1966 -1 5.0003 4 1900 1.6604 -3 1.9964 -5 3.3953 -1 1.021 4 1900 1.6604 -3 1.9964 -3 5.4976 -1 3.4674 3 2000 1.6604 -3 1.9964 -3 7.0758 -1 1.6574 3 2100 3.1046 -3 1.9904 -3 6.4565 -1 1.6575 3 2200 9.6303 -3 2.6693 -3 7.0758 -1 8.7052 3 2100 3.3045 -2 1.6977 3 7.4446 -1 4.0045 2 2100 9.6303 -3 2.6693 -3 7.0758 -1 1.6769 2 2100 1.2599 -2 8.6077 -3 7.4446 -1 4.0045 2 2100 1.2595 -1 1.4389 -2 9.2773 3 6.4565 -1 1.6769 2 2100 1.1256 -1 1.2593 0	1200	1.9634 -7	2.4869 -8	1.27/2 -1	7.9250 7	
1300 1.7495 5.9772 - 7 2.2200 - 1 5.9065 5 1600 5.4075 - 5 1.4966 - 5 3.3943 - 1 1.513 5 1700 1.4655 - 4 1.2078 - 4 5.1964 - 1 5.0003 4 1800 3.565 - 4 1.2078 - 4 5.1964 - 1 7.6013 4 1900 7.9006 - 4 2.950 - 4 5.1761 - 1 7.6013 4 1900 7.9006 - 3 2.66374 - 4 5.4076 - 1 3.4674 3 2000 5.6105 - 3 2.6637 - 3 7.7958 - 1 8.795 - 1 8.7968 - 2 2000 5.6105 - 3 2.6693 - 3 7.0758 - 1 8.7958 - 1 8.7958 - 2 2000 5.6105 - 3 2.6693 - 3 7.7958 - 1 8.7958 - 2 8.7938 - 1 2000 5.6105 - 2 1.4394 - 2 9.5121 - 2 9.6161 - 1 1.6057 2 2000 5.6264 - 2 3.5200 - 2 1.6233 0 6.8077 1 2000 8.1470 - 2 3.5300 - 2 1.0233 0 6.8077 1 2000 1.2135 - 1 7.6066 - 1 1.2531 0 1.9665 1 3000 1.3770 - 1 1.1246 - 1 1.3573 0	1300	1.1015 -6	1.7579 -7	1.7378 -1.	1.1584 7	
1600 5.4075 -5 1.4988 -5 3.3943 -1 1.513 5 1700 1.4675 -4 1.2078 -4 5.2078 -4 1.2021 4 1800 3.7966 -4 2.2960 -4 5.2176 -1 1.2021 4 1900 7.9068 -4 2.9960 -4 5.2176 -1 3.4674 3 2000 1.6101 -3 6.6374 -4 5.4076 -1 3.4674 3 2100 3.0466 -3 1.9904 -3 6.4965 -1 1.6076 3 2200 5.6105 -3 2.6079 -3 8.7733 -1 2.7733 2 2200 9.6303 -3 4.9917 -3 7.7446 -1 4.0056 2 2200 9.6303 -2 1.4914 -2 9.6161 -1 1.0497 2 2500 2.9061 -2 1.4914 -2 9.6161 -1 1.0497 2 2700 5.6674 -2 3.9500 -2 1.0233 0 6.8077 1 2800 1.1455 -1 7.8076 -1 1.1327 0 2.2029 1 2900 1.1455 -1 7.8076 -1 1.3267 0 2.2029 1 2000 5.1470 -2 3.9500 -1 1.9571 0 1.9666 1 3000 1.3770 -1 1.1225 0 6.7681 0	1500	1.7498 -5	4.02/2 -6	2.7606 -1	5.3088 5	
1700 1.4655 -4 1.278 -4 5.296 -1 5.0003 4 1900 7.9968 -4 2.978 -4 5.1761 -1 7.6913 3 2000 1.6411 -3 6.6374 -4 5.1076 -1 1.4674 3 2100 3.1046 -3 1.9704 -1 5.1076 -1 1.6454 3 2200 5.6405 -3 2.6793 -3 7.0796 -1 1.6454 3 2200 5.6405 -3 2.6793 -3 7.0796 -1 1.6454 2 2200 5.6405 -3 2.6793 -3 7.0796 -1 1.6454 2 2200 5.635 -3 4.9317 -3 7.7446 -1 4.1054 2 2200 5.6354 -2 2.6693 -3 8.9790 -1 1.6745 2 2500 2.5061 -2 1.4346 -2 9.6461 -1 1.0495 2 2700 5.6624 -2 5.3500 -2 1.0233 0 6.8977 1 2800 1.1457 -1 7.5668 -1 1.2531 0 1.9495 1 3000 2.5760 -1 1.1246 -1 1.1967 0 2.8029 1 3100 2.1184 -1 1.5668 -1 1.2531 0 1.9495 1 3000 3.6392 -1 2.642 -1 1.3642 0 <t< td=""><td>1600</td><td>5.4075 -5</td><td>1.4308 -5</td><td>3.3343 -1</td><td>1.513: 5</td><td></td></t<>	1600	5.4075 -5	1.4308 -5	3.3343 -1	1.513: 5	
1900 3.9249 -4 1.2075 -4 4.2394 -1 1.2091 3 1900 1.6101 -3 6.6374 4 5.16076 -1 3.4674 3 2100 3.1046 -3 6.6374 4 5.16076 -1 3.4674 3 2100 3.605 -3 2.6493 -3 7.0758 -1 8.7052 3 2000 9.6383 -4 2.6793 -3 7.74764 -1 1.6952 2 2000 9.6383 -4 2.9373 -1 1.6745 2 2 7 2 3 3 3 2 3<	1700	1.4655 -4	4.4361 -5	3.9864 -1	5.0003 4	
2000 1.2000 2.2000	1000	3.7/47 -4	1.20/8 -4	4.5394 -1	1.8621 4	
2100 3.1046 -3 1.904 -3 6.4565 -1 1.655 3 2300 9.6303 -3 4.9317 -3 7.0798 -1 8.7096 2 2400 1.589 -2 6.6099 -3 6.3753 -1 2.7733 2 2500 2.5001 -2 1.4368 -2 8.9750 -1 1.6745 2 2500 3.6194 -2 9.3121 -2 9.6161 -1 1.0495 2 2700 5.6644 -2 3.5500 -2 1.0233 0 6.0777 1 2800 1.455 -1 7.8866 -2 1.1402 0 3.1261 1 2800 1.455 -1 7.6866 -2 1.1402 0 3.1261 1 3000 1.5740 -1 1.1266 -1 1.1967 0 2.8099 1 3100 2.1184 -1 1.5668 -1 1.2531 0 1.5661 0 3200 3.6392 -1 2.8678 -1 1.3563 0 8.7498 0 3400 3.6392 -1 2.8676 -1 1.3563 0 8.7498 0 3500 5.8749 -1 3.777 -1 1.4125 0 6.661 0 3500 1.3978 0 1.7686 -1 1.5560 0 3.2137 0 3600 1.3979 0 1.7886 -1 1.5560 0 3.2137	2000	1.6101 -3	6.63/4 -4	5.80% -1	3.4674 3	
2200 5.6105 -3 2.6403 -3 7.0768 -1 8.7056 -1 8.7056 -1 2300 9.6383 -3 h.9317 -3 7.7446 -1 4.0055 2 2500 2.5061 -2 1.4368 -2 8.3753 -1 2.7733 2 2500 3.6194 -2 9.3121 -2 9.6161 -1 1.0495 2 2700 5.6624 -2 3.5600 -2 1.0233 0 6.8077 1 2800 8.1470 -2 5.3751 -2 1.0014 0 4.5499 1 2800 1.1455 -1 7.8886 -2 1.1402 0 3.1261 1 3000 1.5740 -1 1.1246 -1 1.1507 0 2.8029 1 3100 2.1184 -1 1.5668 -1 1.2531 0 1.5465 1 3200 2.7990 -1 2.1360 -1 1.3574 0 1.566 1 3300 3.6322 -1 2.6027 -1 1.4525 0 6.7681 0 3400 8.6599 -1 3.7757 -1 1.4622 0 5.1323 0 3600 9.0365 -1 7.6886 -1 1.5560 0 3.2137 0 3600 1.6990 0 9.8401 -1 1.6032 0 2.5682 0 3700 9.2364 0 1.7728 0 1	2100	3.1046 -3	1.3/10/ -3	6.4565 -1	1.68% 3	
2300 9.6303 - 3 4.9317 - 3 7.7446 - 1 4.004. 2 2400 1.5849 - 2 8.6099 - 3 8.3733 - 1 2.7733 2 2500 2.5001 - 2 1.4346 - 2 8.3753 - 1 2.7733 2 2500 3.6194 - 2 9.3121 - 2 9.6461 - 1 1.0695 2 2700 5.6624 - 2 3.5810 - 2 1.0233 0 6.8077 1 2800 1.1470 - 2 5.3751 - 2 1.0144 0 4.5499 1 2900 1.5740 - 1 1.1246 - 1 1.1602 0 3.1261 1 3000 1.5740 - 1 1.1246 - 1 1.3072 0 3.28029 1 3100 2.1184 - 1 1.5668 - 1 1.2531 0 1.3666 1 3300 3.6392 - 1 2.8642 - 1 1.3973 0 8.7493 0 3400 4.6599 - 1 3.7757 - 1 1.4125 0 6.7493 0 3500 5.8749 - 1 4.8976 - 1 1.4622 0 5.1323 0 3600 1.3274 0 1.234 0 1.6444 0 2.1038 0 3700 9.0365 - 1 7.7886 - 1 1.5660 0 3.2137 0 3900 1.0990 0 9.8401 - 1	2200	5.6105 -3	2.6853 -3	7.058 -1	8.7496 2	
2500 2.5061 -2 1.4348 -2 8.5753 -1 2.7733 2 2600 3.6134 -2 1.4348 -2 9.6161 -1 1.6745 2 2600 3.6134 -2 2.321 -2 9.6161 -1 1.0495 2 2700 5.6624 -2 5.3751 -2 1.0214 0 4.5499 1 2800 8.1470 -2 5.3751 -2 1.0214 0 4.5499 1 2800 1.1455 -1 7.8646 -1 1.1957 0 2.8691 1 3000 2.1184 -1 1.2668 -1 1.3573 0 8.7493 1 3100 2.1184 -1 1.2668 -1 1.3573 0 8.7493 0 1.6661 3300 3.6392 -1 2.8697 1 1.4682 0 5.7493 0 1.6666 0 1.7268 0 5.7493 0 2.6664 0 5.7595 2.66974 0 1.6025 <t< td=""><td>2300</td><td>9.6383 -3</td><td>4.9317 -3</td><td>7.7446 -1</td><td>4.605. 2</td><td></td></t<>	2300	9.6383 -3	4.9317 -3	7.7446 -1	4.605. 2	
2600 3.8194 -2 P.3121 -2 9.6161 -1 1.0495 2 2700 5.6624 -2 3.5610 -2 1.0233 0 6.8077 1 2800 8.1470 -2 5.3551 -2 1.0214 0 4.5499 1 2900 1.1555 -1 7.8686 -2 1.1402 0 3.1261 1 3000 1.3767 -1 1.2466 -1 1.1957 0 2.899 1 3100 2.1184 -1 1.5668 -1 1.2531 0 1.5485 1 3200 3.6322 -1 2.8642 -1 1.3543 0 8.7493 0 3100 2.1184 -1 1.5668 -1 1.5560 0 8.7493 0 3100 3.6322 -1 2.8642 -1 1.3543 0 8.7493 0 3500 3.6322 -1 2.8642 -1 1.5161 0 4.0458 0 3500 5.8749 -1 4.8978 -1 1.4125 0 6.6681 0 3500 5.8749 -1 1.2344 0 1.6125 0 3.2137 0 3600 1.0990 0 9.8401 -1 1.6032 0 2.5682 0 3700 9.0950 1 1.2134 0 1.6466 0 1.7756 0 3900 1.3274 0 1.2134 0 1.6466 0 1.7756 0<	2500	2.5061 -2	1.43AB -2	8.3753 -1 8.9990 -1	2.7733 2 1.6749 2	
2700 5.6(2%) -2 3.5610 -2 1.0233 0 6.80%7 1 2800 8.1%70 -2 5.3051 -2 1.021% 0 4.5499 1 3900 1.1%75 -1 7.80%6 -2 1.1%02 0 3.1261 1 3000 1.57%0 -1 1.12%6 -1 1.1967 0 2.2029 1 3100 2.118% -1 1.5668 -1 1.2531 0 1.5685 1 3200 2.7990 -1 2.1360 -1 1.30% 0 1.1666 1 3300 3.6332 -1 2.80%2 -1 1.3573 0 8.7%61 0 3400 4.6599 -1 3.7757 -1 1.4125 0 6.7661 0 3500 5.67%9 -1 3.7057 -1 1.5500 0 3.2137 0 3500 5.67%9 -1 4.8978 -1 1.5560 0 3.2137 0 3500 1.0990 0 9.8001 -1 1.6032 0 2.5882 0 3500 1.273% 0 1.6444 0 2.1036 0 1.7705 0 3600 1.5899 0 1.4791 0 1.6466 0 1.7298 0 1.4355 0 3600 1.273% 0 1.6455 0 1.7796 0 1.21955 0 3900 2.5823 0 2.9531 0 1.8056 0 <td>2600</td> <td>3.81.94 -2</td> <td>2.3121 -2</td> <td>9.6161 -1</td> <td>1.0495 2</td> <td></td>	2600	3.81.94 -2	2.3121 -2	9.6161 -1	1.0495 2	
2800 8.1470 -2 5.3551 -2 1.0314 0 4.5499 1 2900 1.1455 -1 7.8646 -2 1.1402 0 3.1261 1 3000 1.5760 -1 1.1246 -1 1.1567 0 2.2029 1 3100 2.1184 -1 1.5668 -1 1.2531 0 1.5485 1 3200 3.6322 -1 2.360 -1 1.3563 0 8.7496 0 3100 2.1184 -1 1.5668 -1 1.2531 0 1.5485 1 3200 3.6322 -1 2.8042 -1 1.3563 0 8.7496 0 3100 4.6559 -1 3.7757 -1 1.4125 0 6.7681 0 3500 5.8749 -1 4.8978 -1 1.4622 0 5.1523 0 3600 1.0990 0 9.8401 -1 1.5060 0 3.2137 0 3900 1.3274 0 1.2134 0 1.6466 0 1.7726 0 4000 1.5849 0 1.4791 0 1.6666 0 1.7726 0 4100 1.8793 0 1.7805 0 1.7298 0 1.4355 0 4200 2.9282 0 2.351 0 1.0077 0 1.0116 0 4400 2.9282 0 2.9554 0 1.8450 0 7.3621 -1	2700	5.0024 -2	3.5810 -2	1.0233 0	6.8077 1	
2500 1.1425 -1 7.6666 -2 1.1462 0 3.1261 1 3000 1.5740 -1 1.1246 -1 1.1957 0 2.8069 1 3100 2.1184 -1 1.5668 1 1.5531 0 1.5485 1 3200 2.7590 -1 2.1380 -1 1.5531 0 1.7466 1 3300 3.6322 -1 2.3602 -1 1.5533 0 6.7493 0 3400 4.6559 -1 2.8642 -1 1.5543 0 6.7681 0 3500 5.8749 -1 4.8978 -1 1.4622 5.1523 0 3600 7.3282 -1 6.2517 -1 1.5101 0 4.04956 0 3700 9.0355 -1 7.6886 -1 1.5760 3.2137 0 3900 1.3274 0 1.6072 0 1.4355 0 4000 1.8793 0 1.7691 0 1.4355	2800	8.1470 -2	5.3951 -2	1.0314 0	4.5499 1	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	3000	1.1455 -1 1.5740 -1	7.886 -2	1.1967 0	3.1261 1 2.2029 1	
3200 2.7990 -1 2.1360 -1 1.3072 0 1.1666 1 3300 3.6392 -1 2.8042 -1 1.3543 0 8.7496 0 3500 5.6392 -1 2.8042 -1 1.4125 0 6.7661 0 3500 5.8749 -1 4.8978 -1 1.4125 0 5.1323 0 3600 7.3282 -1 6.2517 -1 1.5101 0 4.0496 0 3700 9.0365 -1 7.8886 -1 1.5950 0 3.2137 0 3600 1.0990 0 9.8401 -1 1.6032 0 2.588 0 3900 1.5849 0 1.2134 0 1.6446 0 2.1036 0 4000 1.6793 0 1.7805 0 1.7298 0 1.4355 0 4100 1.6793 0 1.7805 0 1.7298 0 1.4355 0 4200 2.5823 0 2.9531 0 1.6072 0 1.0116 0 4400 2.9923 0 2.9654 0 1.8435 0 5.609 -1 4500 3.4914 0 1.6156 0 7.3521 -1 1 4600 3.9355 0 4.0551 0 1.9456 0 5.5081 -1 4500 3.4924 0 1.6156 0 5.5081 -1 1	3100	2.1184 -1	1.5668 -1	1.2531 0	1.5885 1	
3300 3.6392 -1 2.80/2 -1 1.3583 0 8.7681 0 3400 4.6579 -1 3.7757 -1 1.4125 0 6.7681 0 3500 5.8749 -1 4.8978 -1 1.4622 0 5.1323 0 3600 7.3282 -1 6.2517 -1 1.5101 0 4.04988 0 3700 9.0365 -1 7.8886 -1 1.5560 0 3.2137 0 3800 1.0990 0 9.8401 -1 1.6022 0 2.5889 0 3900 1.3274 0 1.2134 0 1.6466 0 1.7298 0 4000 1.5899 0 1.4791 0 1.6666 0 1.7298 0 4100 1.8793 0 1.7055 0 1.7298 0 1.4355 0 4200 2.2080 0 2.1380 0 1.7701 0 1.1995 0 4300 2.5823 0 2.9531 0 1.6072 0 1.0116 0 4400 2.9223 0 2.9534 0 1.84350 0 7.3621 -1 4500 3.4435 0 3.4914 0 1.8636 0 7.3621 -1 4600 3.9355 0 4.0551 0 1.9495 0 5.5081 -1 4500 5.4639 0 5.3703 0 1.9495 0 5.5081 -1	3200	2.7990 -1	2.1380 -1	1.30 2 0	1.1666 1	
3900 4.6359 -1 1.4125 0 6.7681 0 3500 5.8749 -1 4.8978 -1 1.4622 0 5.1323 0 3600 7.3282 -1 6.2517 -1 1.5101 0 4.0498 0 3600 1.0990 9.98401 -1 1.5260 3.2137 0 3.2137 0 3600 1.3274 0 1.2134 0 1.6444 0 2.1036 0 3900 1.3274 0 1.2134 0 1.6444 0 2.1036 0 4000 1.8793 0 1.7896 0 1.4355 0 1.4791 0 1.68666 1.7296 0 4100 1.8793 0 1.7896 0 1.4355 0 1.4355 0 4200 2.9823 0 2.9654 0 1.8070 0 1.3955 0 4400 2.9923 0 2.9654 0 1.9450 7.3621 -1 1 4500 3.9355 0<	3300	3.6392 -1	2.8012 -1	1.3583 0	8.7498 0	
3C00 7.3282 -1 6.2517 -1 1.5101 0 4.0458 0 3700 9.0365 -1 7.8886 -1 1.5560 3.2137 0 3900 1.0990 9.9401 -1 1.6032 0 2.588 0 3900 1.3274 0 1.2134 0 1.6446 2.1036 0 4000 1.5899 0 1.4791 0 1.66266 1.7298 0 4100 1.8793 0 1.7865 0 1.7298 0 1.4355 0 4200 2.2080 2.1380 0 1.6072 0 1.0116 0 4300 2.9233 2.9694 0 1.8050 0 3.6099 1 4500 3.4435 0 3.6914 0 1.8056 7.3521 1 4500 3.4435 0 4.0551 0 1.9143 0 6.3533 -1 4500 <t< td=""><td>3500</td><td>4.6559 -1 5.8749 -1</td><td>3.7/57 -1 4.8978 -1</td><td>1.4125 0</td><td>6.681 0 5.1523 0</td><td></td></t<>	3500	4.6559 -1 5.8749 -1	3.7/57 -1 4.8978 -1	1.4125 0	6.681 0 5.1523 0	
3700 9.0365 -1 7.8886 -1 1.5760 3.2137 0 3800 1.0990 9.8401 -1 1.6032 2.5882 0 3900 1.3274 0 1.2134 0 1.6444 2.1036 0 4000 1.5849 0 1.4791 0 1.6866 1.7296 0 4100 1.6793 0 1.7850 1.7701 1.1995 0 4200 2.2080 2.1380 1.7701 1.1995 0 4300 2.5823 2.9531 0 1.6979 0 1.0110 0 4500 3.4923 2.9531 0 1.6979 0 1.0110 0 4500 3.4923 2.9531 0 1.6979 0 1.6100 0 4500 3.4935 0 1.69150 0 6.3933 -1 1 4500 3.4935 0 1.9143 0 6.3533 -1 1 4500 3.4935 0 3.703 1.9496 5.5081 -1 4700	3600	7.3282 -1	6.2517 -1	1,5101 0	4.0458 0	
3800 1.0990 9.8401 -1 1.032 0 2.588 0 3900 1.3274 0 1.2134 0 1.0144 0 2.1036 0 4000 1.5849 0 1.4791 0 1.6626 0 1.7296 0 4100 1.8793 0 1.7865 0 1.7298 0 1.4355 0 4200 2.2080 0 2.1380 0 1.7701 0 1.0116 0 4300 2.5623 0 2.9531 0 1.8150 0 3.6099 -1 4300 2.5623 0 2.9531 0 1.8150 0 3.6099 -1 4400 2.9923 0 2.9531 0 1.8150 0 7.3621 -1 4500 3.4435 0 4.6531 0 1.9143 0 6.3533 -3 4700 4.4681 0 1.9143 0 5.5081 -1 -1 4600 5.0599 5.3703 0 1.9415	3700	9.0365 -1	7.8886 -1	1.5560 0	3.2137 0	
3500 1.3274 0 1.6444 0 2.1035 0 4000 1.5649 0 1.4791 0 1.6666 0 1.7296 0 4100 1.5793 0 1.7695 0 1.7296 0 1.4355 0 4200 2.2050 2.1380 0 1.7701 0 1.1995 0 4300 2.5923 0 2.5351 0 1.8072 0 1.0110 0 4400 2.9923 0 2.9554 0 1.8150 0 8.6099 -1 4500 3.9355 0 4.0551 0 1.9195 0 5.5031 -1 4600 3.9355 0 4.0551 0 1.9195 0 5.5031 -1 4600 3.9355 0 4.0551 0 1.9195 0 5.5031 -1 4600 3.9355 0 4.0581 0 1.9195 0 5.7061 -1 4600 3.9357 0 4.05931 0 2.0137	3800	1.0990 0	9.8401 -1	1.6032 0	2.5882 0	
k100 1.6793 0 1.7805 0 1.7298 0 1.4355 0 k200 2.2080 0 2.1380 0 1.7701 0 1.1995 0 k300 2.5823 0 2.9531 0 1.6072 0 1.0116 0 k400 2.9923 0 2.9531 0 1.8050 0 1.6072 0 1.0116 0 k500 3.4435 0 2.9531 0 1.8156 0 7.3621 1.71701 0 1.6136 0 7.3521 1.71701 0 1.6136 0 7.3521 1.71701 0 1.6136 0 7.3521 1.71701 0 1.6135 0 5.7333 1.7170 0 1.61376 0 2.0137 0 4.2073 1 M500 5.0599 0 7.3728 0 2.0137 0 4.2073 1 M500 7.1480 6.13776 2.0137 0	4000	1.5849 0	1.4791 0	1.6866 O	2.1035 0 1.7296 0	
4200 2.2080 0 2.1380 0 1.7701 0 1.1995 0 4300 2.5823 0 2.5351 0 1.8072 0 1.0112 0 4500 2.9823 0 2.9854 0 1.8072 0 1.0112 0 4500 3.4435 0 2.9854 0 1.8050 8.6091-1 1 4500 3.4435 0 3.4914 0 1.8150 0 6.3533-2 4500 3.4935 0 3.4914 0 1.9143 0 6.3533-2 4700 4.4771 0 4.6481 6 1.9495 0 5.9581-1 4800 5.0699 0 5.3703 0 1.9815 0 4.7773-1 4900 5.7148 0 6.1376 0 2.0146 0 3.7154-1 5100 7.1450 0 7.8524 0 2.0749 0 3.2885-1 5200 5.7148 0 7.0790 3.2885-1 3.9952 2.942-1 5	4100	1.8793 0	1.7865 0	1.7298 0	1.4355 0	
4300 2.5823 0 2.5351 0 1.6072 0 1.6115 0 4400 2.9923 0 2.9654 0 1.8450 0 8.6099 1 4500 3.4355 0 3.4914 0 1.6856 0 7.3521 1 4600 3.9355 0 4.0551 0 1.9143 0 6.3533 -1 4600 3.9355 0 4.0551 0 1.9495 0 5.5081 -1 4600 5.0699 0 5.3703 0 1.9615 0 4.2073 -1 4900 5.7148 0 6.9663 0 2.0137 0 4.2073 -1 4900 5.7148 0 6.9663 0 2.01464 0 3.7154 -1 5100 7.1450 0 7.8524 0 2.0749 0 3.2885 -1 5300 6.3973 0 8.8396 2.1036 2.9482 -1 -1 5300 7.9433 0 8.8396	4200	2.2080 0	2.1380 0	1.7701 0	1.1995 0	
4400 2.9923 0 2.9654 0 1.0150 0 0.0099 -1 4500 3.4435 0 3.4914 0 1.6136 0 7.3621 -1 4600 3.9355 0 4.0551 0 1.9136 0 6.3533 -1 4600 3.9355 0 4.0551 0 1.9196 0 5.3533 -1 4600 5.0599 0 5.3703 0 1.9615 0 4.7773 -1 4500 5.7148 0 6.1376 0 2.0137 0 4.8073 -1 5000 6.3973 0 6.9663 0 2.0137 0 4.8073 -1 5100 7.1450 0 7.9524 0 2.0749 0 3.8805 -1 5100 7.1450 0 7.8524 0 2.0749 0 3.8805 -1 5100 7.1450 0 7.8524 0 2.0749 0 3.8805 -1 5100 8.7922 0	4300	2.5823 0	8.5351 0	1.8072 0	1.0116 0	
\$\$600 3.9355 0 \$\$4.0551 0 1.91\$ 0 6.3533 -> \$\$700 \$\$4.771 0 \$\$4.6881 0 1.91\$ 0 5.35081 -> \$\$400 \$\$5.0699 \$\$5.3703 0 1.9615 0 \$\$4.777.1 0 \$\$4.6881 0 1.9615 0 \$\$4.777.3 -> \$\$400 \$\$5.0699 \$\$5.3703 0 1.9615 0 \$\$4.777.3 -> \$\$900 \$\$5.3773 0 \$\$6.9663 0 \$2.0137 0 \$\$4.2073.1 \$\$900 \$\$6.3973 0 \$\$6.9663 0 \$2.0137 0 \$\$4.2073.1 \$\$100 7.1\$450 0 7.8724 0 \$2.0146 0 3.7154 -1 \$\$100 7.1\$433 0 8.8055 0 \$2.1036 2.9842 -1 \$200 7.9022 9.96875 0 \$2.1281 0 \$2.6122 -1 \$300 8.6826	4400	2.9923 0	2.9654 0	1.8450 0	8.6099 -1 7.3621 -1	
\$4700 \$4.4771 \$6 \$4.6831 \$6 \$1.9495 \$5.5051 \$1.1 \$4800 \$5.0699 \$5.3703 \$1.9615 \$5.7031 \$1.9615 \$4.7973 \$1.9005 \$5.7733 \$1.9615 \$4.7973 \$1.9005 \$5.3703 \$1.9615 \$4.7973 \$1.9005 \$5.7148 \$6.1376 \$2.0137 \$4.8073 \$1.3733 \$1.9615 \$2.0137 \$4.8073 \$1.7154 \$1.9005 \$5.7148 \$6.9563 \$2.0137 \$6.8073 \$1.7154 \$1.71556 \$1.711556 \$1.7256 \$1.7256	4600	3.9355 0	4.0551 0	1.9143 0	6. 1513 -)	
4800 5.0699 0 5.3703 0 1.9815 0 4.7973 -1 4900 5.7148 0 6.1376 0 2.0137 0 4.2073 -1 9000 6.3973 0 6.9663 0 2.0137 0 4.2073 -1 9000 6.3973 0 6.9663 0 2.0464 0 3.7154 -1 9100 7.1450 0 7.8524 0 2.0749 0 3.2855 -1 9200 7.902 0 9.6875 0 2.1036 0 2.6122 -1 9300 6.7902 0 9.6875 0 2.1281 0 2.6122 -1 9400 9.6828 0 1.1015 1 2.1286 0 2.1135 -1 9500 1.0641 1 1.8246 1 2.1287 0 2.1135 -1 9500 1.1641 1 0.1552 1	4700	4.47/2 0	4.6881 0	1.9498 0	5.5081 -1	
4900 5.7148 0 6.1376 0 2.0137 0 4.2073 -1 9000 6.3973 0 6.9663 0 2.0464 0 3.7154 -1 \$100 7.1490 0 7.6524 0 2.0464 0 3.2805 -1 \$2000 7.9433 0 8.8308 2.1038 0 2.942 -1 \$2000 7.9433 0 8.8308 2.1038 0 2.942 -1 \$2000 7.9433 0 8.8308 2.1038 0 2.942 -1 \$2000 7.9433 0 8.8308 2.1038 0 2.942 -1 \$2000 8.7902 0 9.6875 0 2.1281 0 2.9442 -1 \$5000 1.0641 1 1.2246 1 2.1526 0 2.1135 -1 \$5000 1.1641 1 1.3552 1 2.22844 0 1.7256 1 .9077 -1 \$5000 1.36351 1 1.6406 <t< td=""><td>4800</td><td>5.0699 0</td><td>5.3703 0</td><td>1.9815 0</td><td>4.7973 -1</td><td></td></t<>	4800	5.0699 0	5.3703 0	1.9815 0	4.7973 -1	
\$100 7.1450 0 7.8724 0 2.0749 0 3.2885 -1 \$200 7.9433 0 8.8308 0 2.1038 0 2.942 -1 \$300 8.7902 0 9.6875 0 2.1281 0 2.6122 -1 \$400 9.6828 0 1.1015 1 2.1528 0 2.3442 -1 \$500 1.0641 1 1.8246 2.1827 0 2.1135 -1 \$600 1.1641 1 1.9552 2.8289 0 1.9076 -1 \$700 1.2706 1 1.4928 2.2284 0 1.7576 -1 \$700 1.3706 1 1.4928 2.2284 0 1.7576 -1 \$700 1.3036 1 1.6406 2.28410 1.7576 -1 \$900 1.5031 1 1.7947 2.24751 0 1.4368 -1	4900 9000	5.7148 0 6.3973 0	6.1376 0 6.9663 0	2.0137 0 2.0464 0	4.2073 -1 3.7154 -1	
2800 7.9433 0 8.8308 0 2.1035 0 2.942 -1 5900 8.7902 0 9.6855 0 2.1281 0 2.6122 -1 5400 9.6828 0 1.1015 1 2.1588 0 2.942 -1 5500 1.0641 1 1.2246 1 2.1588 0 2.9442 -1 5500 1.0641 1 1.2246 1 2.1827 0 2.1135 -1 5600 1.1641 1 1.3552 1 2.2029 0 1.9796 -1 5700 1.2706 1 1.4928 1 2.2284 0 1.7296 -1 5800 1.3836 1 1.6406 1 2.2841 0 1.7296 -1 5900 1.5031 1 1.7947 1 2.9751 0 1.4386 -1	5100	7.1450 0	7.8524 0	2.0749 0	1.2005 -1	
5300 8.7902 0 9.6855 0 2.1281 0 2.6182 -1 5400 9.6828 0 1.1015 1 2.1588 0 2.3442 -1 5500 1.0641 1 1.8246 2.1827 0 2.1135 -1 5600 1.1641 1 1.5522 2.8029 0 1.5070 1.7256 -1 5600 1.3336 1 1.6406 2.2284 0 1.7256 -1 5600 1.3336 1 1.6406 2.2394 0 1.7556 -1 5600 1.3336 1 1.6406 2.2914 0 1.7556 -1 5900 1.5031 1 1.7547 2.8751 0 1.4366 -1	5200	7.9433 0	8.8308 0	2.1038 0	2.9842 -1	
5400 9.6828 0 1.1015 1 2.1528 0 2.3442 -1 5500 1.0641 1 1.8246 1 2.1528 0 2.1135 -1 5600 1.1641 1 1.8552 2.8029 0 1.9070 -1 5700 1.3706 1 1.4928 2.2284 0 1.7256 -1 5800 1.3036 1 1.6406 2.2284 0 1.7256 -1 5800 1.3036 1 1.6406 1 2.2810 0 1.7556 -1 5900 1.5031 1 1.7547 1 2.7751 0 1.4368<-1	5300	8.7902 0	9.8855 0	2.1261 0	2.6122 -1	
\$600 1.1641 1.3552 2.2029 0 1.9077 -1 \$700 1.2706 1 1.9281 2.2284 0 1.7296 -1 \$800 1.3836 1 1.4026 1 2.2284 0 1.7296 -1 \$800 1.3836 1 1.6406 1 2.2841 0 1.7296 -1 \$900 1.5031 1 1.6406 1 2.2411 0 1.5760 -1 \$900 1.5031 1 1.7967 1 2.7751 0 1.4388 -1	5500	9.6626 0 1.0641 1	1.1015 1 1.2246 1	2.1528 0 2.1827 0	2.3442 -1 2.1135 -1	
5700 1.2706 1 1.4928 1 2.2284 0 1.7256 -1 5800 1.3836 1 1.6406 1 2.2891 0 1.7256 -1 5800 1.3836 1 1.6406 1 2.2891 0 1.5740 -1 5900 1.5031 1 1.7967 1 2.9751 0 1.4388 -1	5000	1.1641 1	1.3552 1	2.2029 0	1.9922 -1	
5800 1.3836 1 1.0406 1 2.2891 0 1.5740 -1 5900 1.5031 1 1.7947 1 2.5751 0 1.4388 -1	5700	1.2706 1	1.4928 1	2.2284 0	1.72% -1	
200 1.201 1 1.7947 1 2.2751 0 1.4368 -1	5800	1.3836 1	1.6406 1	2.2491 0	1.5%0 -1	
	2900	1.5031 1	1.7947 1	2.2751 0	1.4300 -1	

TABLE 5 EQUILIBRIUM CONSTANTS, Kp (j) (j)

,	Kg atan	K(IIO) atan	Kp
(x)	ju _a e u	1Na+ 100 " ND	CO + Da + CO.
1100	5.4325 -20	2,3281 -h	7.5858 8
1200	4.1976 -18	5,3080 -k	5.8076 7
1300	1.6672 -16	1,0666 -3	6.6222 6
1400	3.9264 -15	1,9409 -3	1.0328 6
1500	6.0674 -14	3,2584 -3	2.0701 5
1600	6.6834 -13	5.1286 -3	5.0816 h
1700	5.5463 -12	7.6560 -3	1.4791 4
1800	3.6559 -11	1.0914 -2	4.9317 3
1900	1.9724 -10	1.5031 -2	1.8493 3
8000	8.9950 -10	1.9999 -2	7.640 2
2100	3.5563 -9	2.5942 -2	3.4594 2
2200	1.2445 -8	3.2810 -2	1.6827 2
2300	3.8994 -8	4.0644 -2	8.7056 1
2400	1.1117 -7	4.9745 -2	4.7753 1
2500	2.9174 -7	5.9243 -2	2.7542 1
2600	7.0958 -7	7.0246 -2	1.6558 1
2700	1.6218 -6	8.1846 -2	1.0351 1
2800	3.4914 -6	9.4406 -2	6.6834 0
2900	7.1285 -6	1.0789 -1	4.4566 0
3000	1.3868 -5	1.2218 -1	3.0549 0
3100	2.5882 -5	1.3/09 -1	2.1478 0
3200	4.6559 -5	1.5311 -1	1.5453 0
3300	8.0724 -5	1.6943 -1	1.1324 0
3400	1.3552 -4	1.8664 -1	8.4918 -1
3500	2.2080 -4	2.0417 -1	6.4565 -1
3600 3700 3900 3900	3.5075 -4 5.4325 -4 8.2035 -4 1.2162 -3 1.7701 -3	2.2233 -1 2.4099 -1 2.6002 -1 2.7925 -1 2.9923 -1	4.9888 -1 5.9064 -1 3.1046 -1 2.4946 -1 2.0324 -1
4100	2.5235 -3	3.1915 -1	1.6672 -1
4200	3.5461 -3	3.3884 -1	1.3068 -1
4300	4.8976 -3	3.5975 -1	1.1588 -1
4300	6.6661 -3	3.8019 -1	9.7949 -2
4500	8.9743 -3	4.0087	8.3368 -2
4600	1.1912 -2	4.2170 -1	7.1285 -2
4700	1.5595 -2	4.8259 -1	6.1518 -2
4800	2.0830 -2	4.6452 -1	5.3456 -2
4900	2.6002 -2	4.8529 -1	4.6774 -2
5000	3.3037 -2	5.0582 -1	4.1115 -2
5100	4.1990 -2	5.2723 -1	3.6308 -2
5200	5.2000 -2	5.4826 -1	3.2211 -2
5300	6.4417 -2	5.6885 -1	2.8774 -2
5400	7.9068 -2	5.9020 -1	2.5763 -2
5500	9.6363 -2	6.1094 -1	2.3174 -2
5600	1.1695 -1	6.3241 -1	2.0941 -2
5700	1.4060 -1	6.5313 -1	1.8967 -2
5800	1.6887 -1	6.7296 -1	1.7258 -2
5900	2.0045 -1	6.9343 -1	1.5776 -2
6000	2.3714 -1	7.1205 -1	1.54421 -2

2100 14.8724 16.6857 6.0302 -8.55 2500 13.1200 15.4525 5.6736 -7.56 2500 13.2556 14.9126 5.6736 -7.56 2500 13.5256 14.9126 5.6736 -7.56 2500 13.5256 14.9126 5.6786 -6.75 2500 12.4931 13.5934 5.6685 -5.11 2600 12.4931 13.5334 5.6685 -5.11 2600 11.7795 13.11418 5.5976 -4.86 2500 11.4593 12.1285 5.4685 -5.11 2600 11.4593 12.1285 5.4681 -3.76 2500 11.4593 12.1285 5.4681 -3.76 2500 10.6134 11.8135 5.4681 -3.76 2500 10.5150 12.8255 5.4197 -3.125 3100 10.6134 11.8135 5.4499 -3.49 3100 10.5250 5.2375 -4.83 <th>1600 16.7386 21.1171 6.6299 -13.24 1700 17.7635 20.0497 6.3222 -11.11 1200 16.1747 18.1707 6.3225 -10.21 1200 15.4910 17.3954 6.0225 -00.21 2000 15.4910 17.3955 6.1225 -9.60 2100 14.6724 16.6697 6.0302 -7.96 2000 13.7565 15.4925 5.4736 -7.96 2000 13.7957 15.4925 5.6425 -7.96 2000 12.4931 13.9993 5.66425 -7.76 2100 12.4931 13.9993 5.66425 -7.76 2100 12.4931 13.9993 5.66425 -7.76 2100 12.4931 13.9993 5.66425 -7.76 2100 12.4931 13.9355 5.4997 -3.49 3100 10.6394 11.6335 -4.48 3000 10.6494 11.6335 -4.49</th> <th>1100 55.1200 29.5734 7.8800 -29.49 1200 81.1317 27.5705 7.3565 -39.49 1400 81.0317 27.5705 7.0335 -39.49 1400 81.0317 27.5705 7.0335 -39.49 1400 81.0326 83.7756 7.0333 -31.49 1700 17.7855 80.6726 6.4770 -31.24 1300 15.5904 13.0497 6.3222 -31.24 1300 15.5904 13.0497 6.3225 -40.21 1300 15.5904 17.3945 6.1225 -7.96 2100 31.6764 16.6977 6.0226 -7.96 2100 31.5764 14.5697 6.0226 -7.96 2100 31.5764 14.928 5.0769 -7.96 2100 31.5794 14.928 5.0769 -7.96 2100 13.3997 13.3999 5.6489 -7.92 2100 13.5997 14.92 5.9769</th> <th>600 13.4031 11.4071 11</th> <th>100 840 190 131 1550 17100 </th> <th></th> <th></th> <th></th> <th></th> <th></th>	1600 16.7386 21.1171 6.6299 -13.24 1700 17.7635 20.0497 6.3222 -11.11 1200 16.1747 18.1707 6.3225 -10.21 1200 15.4910 17.3954 6.0225 -00.21 2000 15.4910 17.3955 6.1225 -9.60 2100 14.6724 16.6697 6.0302 -7.96 2000 13.7565 15.4925 5.4736 -7.96 2000 13.7957 15.4925 5.6425 -7.96 2000 12.4931 13.9993 5.66425 -7.76 2100 12.4931 13.9993 5.66425 -7.76 2100 12.4931 13.9993 5.66425 -7.76 2100 12.4931 13.9993 5.66425 -7.76 2100 12.4931 13.9355 5.4997 -3.49 3100 10.6394 11.6335 -4.48 3000 10.6494 11.6335 -4.49	1100 55.1200 29.5734 7.8800 -29.49 1200 81.1317 27.5705 7.3565 -39.49 1400 81.0317 27.5705 7.0335 -39.49 1400 81.0317 27.5705 7.0335 -39.49 1400 81.0326 83.7756 7.0333 -31.49 1700 17.7855 80.6726 6.4770 -31.24 1300 15.5904 13.0497 6.3222 -31.24 1300 15.5904 13.0497 6.3225 -40.21 1300 15.5904 17.3945 6.1225 -7.96 2100 31.6764 16.6977 6.0226 -7.96 2100 31.5764 14.5697 6.0226 -7.96 2100 31.5764 14.928 5.0769 -7.96 2100 31.5794 14.928 5.0769 -7.96 2100 13.3997 13.3999 5.6489 -7.92 2100 13.5997 14.92 5.9769	600 13.4031 11.4071 11	100 840 190 131 1550 17100					
2100 14.8724 16.6857 6.0302 8.55 2800 13.7955 15.4525 5.9736 -7.96 2800 13.7955 15.4525 5.8736 -6.75 2800 13.7955 15.4525 5.8736 -6.75 2800 12.823 14.8170 5.7770 -6.85 2800 12.4931 13.9593 5.6680 -5.76 2700 12.4230 13.5354 5.6680 -5.76 2800 11.4593 12.7732 5.59761 -4.86 2900 11.4593 12.7732 5.3373 -4.11 3100 10.6134 11.818 5.9976 -4.86 3000 10.4135 14.9335 5.4999 -3.43 3100 10.6134 11.8266 5.4991 -3.46 3000 10.1418 11.8266 5.4197 -3.43 3100 10.5134 11.8105 5.4499 -3.43 3100 10.51418 11.8266 5.3937	1600 18.7388 \$1.1171 6.6299 -13.24 1700 17.7895 \$0.0276 6.4770 -12.12 1900 16.3747 18.1767 6.2225 -10.21 1900 15.4920 17.3945 6.0226 -10.21 2000 15.4920 17.3945 6.1225 -9.00 2100 14.6784 16.6977 6.0302 -8.69 2100 14.5784 16.6977 6.0302 -7.96 2100 14.5784 16.697 6.0302 -7.96 2100 14.5784 16.697 6.0302 -7.96 2100 13.7575 15.4925 5.6795 -7.96 2100 13.7575 13.1925 5.6900 -7.96 2100 12.4931 13.9593 5.6920 -5.76 2100 11.4793 13.1418 5.9767 -4.80 2100 11.4793 13.1418 5.9776 -4.80 2100 10.6194 11.8135 5.4999	1100 86.1200 89.5754 7.8800 -81.78 1200 82.4327 87.3205 7.3568 -33.49 1400 82.0986 83.7756 7.0113 -13.49 1500 19.6213 28.3565 6.8057 -14.50 1500 17.765 81.1171 6.6299 -13.24 1700 17.7657 80.0276 6.4770 -12.22 1700 17.7657 80.0277 6.3622 -11.11 1700 14.5744 19.0497 6.3622 -11.11 1700 14.5744 16.6977 6.3622 -11.11 1700 13.7955 15.4925 5.4795 -7.948 8000 14.5744 16.6977 6.3629 -3.5 8000 13.5755 15.4925 5.4795 -7.948 8000 12.1830 13.5953 5.6689 -5.76 8000 12.1830 13.5354 5.4957 -5.91 8000 12.1830 13.5354 5.4999 <td>600 b5.8033 92.1170 11.4277 -13.80 700 39.6171 45.0351 30.9935 -85.95 900 31.5599 35.593 8.106 -7.47 1000 86.1800 89.5754 7.6800 -81.949 1000 86.1200 89.5754 7.6800 -81.949 1000 86.1200 89.5754 7.6800 -81.73 1200 84.12317 87.3605 7.3568 -19.49 1300 84.6512 85.1117 6.6899 -11.31 1500 19.6813 28.3560 6.6977 -13.80 1500 17.7655 20.0278 6.14770 -13.21 1000 16.7346 81.1171 6.6299 -11.31 1000 16.7346 81.1171 6.1977 -13.80 1100 16.9344 19.0497 6.3282 -11.31 1000 16.7346 81.177 6.3282 -11.31 1000 14.5794 16.6977 6.3285</td> <td>100 8/2 3/00 299.50/0 90.970 -48.40 200.16 132.1120 133.1520 27.1000 -139.4 200 99.106/ 102.4/00 19.2/17 19.305 -2.499 200 97.400 10.4/00 19.2/17 -7.499 -7.499 200 97.400 10.4/00 19.2/17 -7.349 200 97.401 45.003 10.2/27 -9.5/93 -9.4/93 200 97.401 45.003 10.2/27 -9.4/93 -9.4/93 200 97.4/11 45.000 95.57/4 7.6800 -4.7 1000 84.1307 87.790 7.5368 -13.4 -14.4 1000 84.1307 87.790 7.5368 -14.4 -14.4 1000 84.1307 87.790 7.5368 -14.4 -14.4 1000 11.7957 80.0776 6.5297 -14.4 -14.4 1000 11.7957 80.0776 6.5292 -10.1 -14.4</td> <td>5/00 5/100 5/000</td> <td>7.1396 7.05% 6.9191 6.9191 6.8303</td> <td>7.8999 7.7779 7.0101 7.9994 7.9139</td> <td>5.0741 5.0741 5.0780 5.0724 5.0952</td> <td>1.04 1.14 1.27 1.30 1.45</td>	600 b5.8033 92.1170 11.4277 -13.80 700 39.6171 45.0351 30.9935 -85.95 900 31.5599 35.593 8.106 -7.47 1000 86.1800 89.5754 7.6800 -81.949 1000 86.1200 89.5754 7.6800 -81.949 1000 86.1200 89.5754 7.6800 -81.73 1200 84.12317 87.3605 7.3568 -19.49 1300 84.6512 85.1117 6.6899 -11.31 1500 19.6813 28.3560 6.6977 -13.80 1500 17.7655 20.0278 6.14770 -13.21 1000 16.7346 81.1171 6.6299 -11.31 1000 16.7346 81.1171 6.1977 -13.80 1100 16.9344 19.0497 6.3282 -11.31 1000 16.7346 81.177 6.3282 -11.31 1000 14.5794 16.6977 6.3285	100 8/2 3/00 299.50/0 90.970 -48.40 200.16 132.1120 133.1520 27.1000 -139.4 200 99.106/ 102.4/00 19.2/17 19.305 -2.499 200 97.400 10.4/00 19.2/17 -7.499 -7.499 200 97.400 10.4/00 19.2/17 -7.349 200 97.401 45.003 10.2/27 -9.5/93 -9.4/93 200 97.401 45.003 10.2/27 -9.4/93 -9.4/93 200 97.4/11 45.000 95.57/4 7.6800 -4.7 1000 84.1307 87.790 7.5368 -13.4 -14.4 1000 84.1307 87.790 7.5368 -14.4 -14.4 1000 84.1307 87.790 7.5368 -14.4 -14.4 1000 11.7957 80.0776 6.5297 -14.4 -14.4 1000 11.7957 80.0776 6.5292 -10.1 -14.4	5/00 5/100 5/000	7.1396 7.05% 6.9191 6.9191 6.8303	7.8999 7.7779 7.0101 7.9994 7.9139	5.0741 5.0741 5.0780 5.0724 5.0952	1.04 1.14 1.27 1.30 1.45
2100 14.8724 16.6857 6.0302 -8.55 2200 13.7955 15.4525 5.9680 -7.96 2400 13.7955 15.4525 5.8736 -7.96 2400 13.7955 15.4525 5.8736 -6.77 2500 12.8528 14.8170 5.8659 -6.77 2500 12.4931 13.9593 5.6690 -5.76 2600 12.4230 13.5354 5.6690 -5.76 2700 12.4230 13.5354 5.6690 -5.76 2700 12.4230 13.5354 5.6690 -5.76 2800 11.4593 12.7732 5.5373 -4.11 3100 10.6134 11.818 5.9961 -4.68 3000 10.1435 14.933 5.3173 -4.11 3100 10.6134 11.818 5.9976 -4.83 3300 10.3733 11.535 5.4999 -3.12 3400 10.41818 11.8659 5.3980 <t< td=""><td>1600 18.7368 £1.1171 6.6299 -13.24 1700 17.7635 \$0.0226 6.4770 -12.12 1000 16.9344 19.0497 6.3622 -11.13 1000 15.4930 17.3945 6.1225 -10.21 2000 15.4930 17.3945 6.1225 -9.46 2100 14.6724 16.6957 6.0302 -8.57 2100 14.7100 15.0412 5.9480 -7.94 2100 14.7100 15.0412 5.9480 -7.94 2100 14.7100 15.0412 5.9480 -7.94 2100 13.7905 15.0425 5.6736 -7.94 2100 13.7905 15.997 6.0302 -6.77 2100 13.5954 14.9128 5.6069 -5.76 2100 12.1291 13.9593 5.6425 -5.16 2100 11.7793 13.118 5.9975 -4.98 2100 11.1677 12.128 5.9481</td><td>1100 #6.1200 #9.5754 7.6800 -81.78 1200 28.1517 27.5205 7.5365 -19.48 1400 21.0986 23.7756 7.0113 -13.69 1400 21.0986 23.7756 7.0113 -13.69 1500 18.7868 21.1171 6.6299 -13.24 1600 18.7868 21.1171 6.6299 -13.24 1000 16.7968 20.0226 6.4770 -13.24 1000 16.7964 19.0497 6.5925 -10.21 1000 15.7871 17.3995 6.1225 -9.46 2000 13.7975 15.4925 5.6736 -7.98 2000 13.7975 15.4925 5.6736 -7.98 2000 13.7975 15.4925 5.6736 -7.98 2000 13.7975 13.5935 5.6990 -5.76 2000 12.4931 13.5935 5.6990 -5.76 2000 13.7935 13.5935 5.6990</td><td>600 45.8033 52.1100 11.4227 -45.80 700 39.6171 45.0351 10.2995 -55.91 900 31.5599 35.793 8.8104 -77.87 900 31.5599 35.793 8.8104 -77.87 1000 28.1200 29.5794 7.6800 -81.73 1100 28.1200 29.5794 7.6800 -81.73 1200 28.1317 27.305 7.5365 -3.94 (3) 1300 28.4562 25.4115 7.2525 -17.85 1400 21.0966 21.1171 6.6299 -13.24 1500 16.7968 21.1171 6.6299 -13.24 1700 17.7875 20.0276 6.4770 -13.24 1000 16.7944 16.6977 6.3922 -11.11 1000 14.5744 16.6977 6.0302 -5.76 2100 14.5744 15.6975 -7.98 -7.96 2900 13.5956 14.9128 5.6485<td>100 8.2.500 299.5070 20.3700 .480.80 200 12.4100 131.550 27.100 .430.80 300 89.611 102.575 19.505 .92.575 300 89.601 102.575 19.505 .92.59 300 91.650 101.560 101.560 .92.5775 300 91.650 11.427 .91.80 .92.5775 300 91.650 92.5775 10.2995 .91.80 300 91.5070 93.7273 9.5995 .91.80 300 91.5070 93.7273 9.5995 .91.80 3000 91.5070 93.7273 9.5995 .91.80 3000 91.5070 93.7273 9.5995 .91.80 3000 91.5070 93.7273 7.5860 .91.74 3000 91.690 91.73 92.995 .91.74 3000 91.690 91.775 92.990 .13.24 3000 10.697 6.4977 6.4977</td><td>5100 5900 5900 5900</td><td>7.5945 7.49% 7.4023 7.3115 7.5240</td><td>8.3705 8.8707 8.1539 8.0522 7.9543</td><td>5.1207 5.1320 5.1031 5.07.7 5.00H0</td><td>0.44 0.57 0.44 0.84</td></td></t<>	1600 18.7368 £1.1171 6.6299 -13.24 1700 17.7635 \$0.0226 6.4770 -12.12 1000 16.9344 19.0497 6.3622 -11.13 1000 15.4930 17.3945 6.1225 -10.21 2000 15.4930 17.3945 6.1225 -9.46 2100 14.6724 16.6957 6.0302 -8.57 2100 14.7100 15.0412 5.9480 -7.94 2100 14.7100 15.0412 5.9480 -7.94 2100 14.7100 15.0412 5.9480 -7.94 2100 13.7905 15.0425 5.6736 -7.94 2100 13.7905 15.997 6.0302 -6.77 2100 13.5954 14.9128 5.6069 -5.76 2100 12.1291 13.9593 5.6425 -5.16 2100 11.7793 13.118 5.9975 -4.98 2100 11.1677 12.128 5.9481	1100 #6.1200 #9.5754 7.6800 -81.78 1200 28.1517 27.5205 7.5365 -19.48 1400 21.0986 23.7756 7.0113 -13.69 1400 21.0986 23.7756 7.0113 -13.69 1500 18.7868 21.1171 6.6299 -13.24 1600 18.7868 21.1171 6.6299 -13.24 1000 16.7968 20.0226 6.4770 -13.24 1000 16.7964 19.0497 6.5925 -10.21 1000 15.7871 17.3995 6.1225 -9.46 2000 13.7975 15.4925 5.6736 -7.98 2000 13.7975 15.4925 5.6736 -7.98 2000 13.7975 15.4925 5.6736 -7.98 2000 13.7975 13.5935 5.6990 -5.76 2000 12.4931 13.5935 5.6990 -5.76 2000 13.7935 13.5935 5.6990	600 45.8033 52.1100 11.4227 -45.80 700 39.6171 45.0351 10.2995 -55.91 900 31.5599 35.793 8.8104 -77.87 900 31.5599 35.793 8.8104 -77.87 1000 28.1200 29.5794 7.6800 -81.73 1100 28.1200 29.5794 7.6800 -81.73 1200 28.1317 27.305 7.5365 -3.94 (3) 1300 28.4562 25.4115 7.2525 -17.85 1400 21.0966 21.1171 6.6299 -13.24 1500 16.7968 21.1171 6.6299 -13.24 1700 17.7875 20.0276 6.4770 -13.24 1000 16.7944 16.6977 6.3922 -11.11 1000 14.5744 16.6977 6.0302 -5.76 2100 14.5744 15.6975 -7.98 -7.96 2900 13.5956 14.9128 5.6485 <td>100 8.2.500 299.5070 20.3700 .480.80 200 12.4100 131.550 27.100 .430.80 300 89.611 102.575 19.505 .92.575 300 89.601 102.575 19.505 .92.59 300 91.650 101.560 101.560 .92.5775 300 91.650 11.427 .91.80 .92.5775 300 91.650 92.5775 10.2995 .91.80 300 91.5070 93.7273 9.5995 .91.80 300 91.5070 93.7273 9.5995 .91.80 3000 91.5070 93.7273 9.5995 .91.80 3000 91.5070 93.7273 9.5995 .91.80 3000 91.5070 93.7273 7.5860 .91.74 3000 91.690 91.73 92.995 .91.74 3000 91.690 91.775 92.990 .13.24 3000 10.697 6.4977 6.4977</td> <td>5100 5900 5900 5900</td> <td>7.5945 7.49% 7.4023 7.3115 7.5240</td> <td>8.3705 8.8707 8.1539 8.0522 7.9543</td> <td>5.1207 5.1320 5.1031 5.07.7 5.00H0</td> <td>0.44 0.57 0.44 0.84</td>	100 8.2.500 299.5070 20.3700 .480.80 200 12.4100 131.550 27.100 .430.80 300 89.611 102.575 19.505 .92.575 300 89.601 102.575 19.505 .92.59 300 91.650 101.560 101.560 .92.5775 300 91.650 11.427 .91.80 .92.5775 300 91.650 92.5775 10.2995 .91.80 300 91.5070 93.7273 9.5995 .91.80 300 91.5070 93.7273 9.5995 .91.80 3000 91.5070 93.7273 9.5995 .91.80 3000 91.5070 93.7273 9.5995 .91.80 3000 91.5070 93.7273 7.5860 .91.74 3000 91.690 91.73 92.995 .91.74 3000 91.690 91.775 92.990 .13.24 3000 10.697 6.4977 6.4977	5100 5900 5900 5900	7.5945 7.49% 7.4023 7.3115 7.5240	8.3705 8.8707 8.1539 8.0522 7.9543	5.1207 5.1320 5.1031 5.07.7 5.00H0	0.44 0.57 0.44 0.84
2100 14.8724 16.6857 6.0302 -8.55 2800 14.3100 16.0412 5.9480 -7.96 2800 13.7955 15.4525 5.6736 -7.96 2800 13.7955 15.4525 5.6736 -7.96 2800 13.7955 15.4525 5.6736 -7.96 2800 12.8528 14.0126 5.8059 -6.75 2500 12.4931 13.9593 5.6980 -5.76 2600 12.4931 13.9593 5.6980 -5.76 2700 12.4931 13.9593 5.6980 -5.76 2700 12.4931 13.9593 5.6980 -5.76 2700 11.7793 13.1418 5.9976 -4.88 3000 11.1607 12.4330 5.3173 -4.11 3100 10.6813 12.1128 5.4621 -3.76 3100 10.6194 11.6035 5.4999 -3.43 3100 10.6194 11.5355 5.4999	1600 18.7368 £1.1171 6.6299 -13.24 1700 17.7635 \$0.0226 6.4770 -12.12 1000 16.9344 19.0497 6.3622 -11.13 1000 16.1747 18.1767 6.2255 -10.21 2000 15.490.0 17.3945 6.1225 -9.40 2000 15.490.0 17.3945 6.0302 -8.57 2000 15.7505 15.4825 -9.40 -7.94 2000 15.7505 15.4825 -9.40 -7.94 2000 13.7505 15.4825 -5.715 -7.94 2000 13.7505 15.4825 -5.715 -7.94 2000 13.2956 14.9128 5.6029 -5.76 2000 12.4920 13.5954 5.6425 -5.16 2000 11.7793 13.1418 5.5975 -4.48 3000 11.45933 12.7128 5.9561 -4.48 3000 10.8133 12.1286 5.4021	1100 86.1200 89.57/54 7.6800 41.74 1200 84.1517 27.3205 7.3368 -19.49 1300 82.4852 25.4116 7.2582 -17.65 1400 81.0562 23.7756 7.0113 -13.64 1500 19.6213 22.5580 6.8057 -14.50 1600 16.7368 81.1171 6.6299 -13.24 1700 17.7355 80.0276 6.4770 -12.12 1000 16.3744 19.0497 6.8255 -10.21 1000 16.3747 18.1707 6.82255 -10.21 1000 16.3747 18.1707 6.82255 -10.21 1000 16.3744 19.6497 6.0928 -6.55 2000 13.7955 15.4925 5.8756 -7.94 2000 13.7955 15.4925 5.8756 -7.94 2000 13.7953 5.6697 -5.76 -7.94 2000 13.7955 15.4925 5.8775 <td>600 45.8033 52.1100 11.4227 -43.80 700 39.6171 45.0351 10.2956 -35.91 900 39.775 39.723 9.4593 -37.92 900 31.3599 35.7293 8.4104 -37.47 1000 26.1200 29.2100 8.2950 -4.4 1100 26.1200 29.5754 7.6800 -9.7 1200 24.452 27.4115 7.2528 -17.45 1200 24.452 27.4115 7.2528 -17.45 1200 21.0926 23.7756 7.0113 -13.46 1300 19.6213 23.5756 6.6977 -14.50 1400 17.7855 20.0226 6.4770 -12.12 1000 16.7747 18.177 6.3225 -10.21 1000 16.7747 18.177 6.3225 -10.21 1000 16.7747 18.1707 6.3225 -10.21 1000 16.7747 18.1707 6.3225</td> <td>100 842.3740 299.5070 50.3750 20.3750 295.16 392.4110 132.1550 27.1010 -133.45 300 89.1057 101.640 19.2123 -9.45 300 89.1057 101.640 19.2123 -9.45 400 67.4550 76.1495 13.2575 -97.45 500 94.5640 62.033 52.1775 59.775 59.5775 600 45.6033 52.1170 11.4227 -43.80 -9.459 500 31.559 35.5293 8.4104 -9.474 1000 86.1200 59.5754 7.6800 -9.474 1000 86.1200 59.5754 7.6800 -9.474 1200 84.1217 27.3905 7.5368 -13.94 1200 84.1217 27.3905 7.5368 -13.94 1200 84.1217 27.3905 7.5368 -13.94 1200 14.7365 80.0276 7.5368 -13.94 1200 14</td> <td>4000 4700 4800 4900 5000</td> <td>8.1483 8.0281 7.5029 7.8024 7.6054</td> <td>8.9963 8.8610 8.7304 8.6052 8.4860</td> <td>5.1733 5.1617 5.1500 5.1401 5.1300</td> <td>-0.20 -0.19 0.09 0.17 0.31</td>	600 45.8033 52.1100 11.4227 -43.80 700 39.6171 45.0351 10.2956 -35.91 900 39.775 39.723 9.4593 -37.92 900 31.3599 35.7293 8.4104 -37.47 1000 26.1200 29.2100 8.2950 -4.4 1100 26.1200 29.5754 7.6800 -9.7 1200 24.452 27.4115 7.2528 -17.45 1200 24.452 27.4115 7.2528 -17.45 1200 21.0926 23.7756 7.0113 -13.46 1300 19.6213 23.5756 6.6977 -14.50 1400 17.7855 20.0226 6.4770 -12.12 1000 16.7747 18.177 6.3225 -10.21 1000 16.7747 18.177 6.3225 -10.21 1000 16.7747 18.1707 6.3225 -10.21 1000 16.7747 18.1707 6.3225	100 842.3740 299.5070 50.3750 20.3750 295.16 392.4110 132.1550 27.1010 -133.45 300 89.1057 101.640 19.2123 -9.45 300 89.1057 101.640 19.2123 -9.45 400 67.4550 76.1495 13.2575 -97.45 500 94.5640 62.033 52.1775 59.775 59.5775 600 45.6033 52.1170 11.4227 -43.80 -9.459 500 31.559 35.5293 8.4104 -9.474 1000 86.1200 59.5754 7.6800 -9.474 1000 86.1200 59.5754 7.6800 -9.474 1200 84.1217 27.3905 7.5368 -13.94 1200 84.1217 27.3905 7.5368 -13.94 1200 84.1217 27.3905 7.5368 -13.94 1200 14.7365 80.0276 7.5368 -13.94 1200 14	4000 4700 4800 4900 5000	8.1483 8.0281 7.5029 7.8024 7.6054	8.9963 8.8610 8.7304 8.6052 8.4860	5.1733 5.1617 5.1500 5.1401 5.1300	-0.20 -0.19 0.09 0.17 0.31
2100 14.8724 16.6857 6.0302 .8.55 2200 14.3100 16.0412 5.9480 .7.96 2300 13.7905 15.4525 5.8765 .7.96 2400 13.7905 15.4525 5.8766 .7.96 2500 12.8528 14.9128 5.8669 .6.78 2500 12.8528 14.4170 5.7470 .6.29 2600 12.4931 13.9593 5.6580 .5.76 2700 12.1230 13.1354 5.6425 .5.11 2600 11.7793 13.1418 5.9976 .4.88 2600 11.7793 12.1718 5.9561 .4.48 3000 11.1607 12.4330 5.5173 .4.11 3100 10.6813 12.1128 5.4821 .3.76 3900 10.6194 11.0135 5.4899 .3.49 3100 10.6394 11.0135 5.4899 .3.49 3100 10.64394 11.8035 5.4899	1600 18.7388 21.1171 6.6299 -13.24 1700 17.7635 20.0226 6.4770 -12.12 1000 16.5344 19.0497 6.3522 -11.11 1000 16.5344 19.0497 6.3522 -11.11 1000 16.1747 18.1767 6.8225 -9.40 2000 13.4920 17.3945 6.1225 -9.40 2100 14.6724 16.6857 6.0302 -8.55 2200 13.7505 15.4525 5.6736 -7.94 2500 13.7505 15.4525 5.6736 -7.94 2500 13.5254 14.9128 5.6059 -6.78 2500 12.4593 13.9593 5.6976 -4.68 2500 12.4593 13.9593 5.6425 -5.11 2600 11.7753 13.1418 5.9976 -4.68 2500 11.4593 12.7128 5.9561 -4.12 2600 11.14593 12.1218 5.4821	1100 86.1200 89.5754 7.6800 81.79 1200 84.1517 27.3205 7.3365 -19.49 1300 82.4852 25.4116 7.2582 -17.65 1400 81.0546 23.7756 7.0113 -15.69 1500 19.6213 22.3580 6.6057 -14.50 1500 16.7366 81.1171 6.6299 -13.24 1700 17.7355 80.0276 6.4770 -12.12 1000 16.3744 19.0497 6.2255 -10.21 1000 16.3747 18.1707 6.2255 -10.21 1000 16.3747 18.1707 6.2255 -10.21 1000 16.3747 18.1707 6.3922 -11.11 1000 16.3747 18.1707 6.3922 -10.21 2000 13.7924 16.6057 6.0322 -7.960 2100 13.7925 15.4525 5.8736 -7.94 2100 14.3100 16.0412 5.9480<	600 45.8033 52.1190 11.4227 -43.80 700 39.6171 45.0351 10.2996 -36.91 800 39.5775 39.7273 9.4993 -36.91 900 31.5599 35.5693 8.104 -47.47 1000 26.1200 29.5754 7.6800 -41.74 1200 26.1200 29.5754 7.6800 -41.74 1200 26.1200 29.5754 7.6800 -41.74 1200 26.1200 29.5754 7.6800 -41.74 1200 26.1200 29.5754 7.6800 -41.74 1200 26.1200 29.5756 7.0113 -13.49 1300 26.1205 21.7756 7.0113 -13.49 1400 21.0566 23.7756 7.0113 -13.24 1500 16.7368 21.1171 6.6299 -13.24 1700 17.7835 20.0276 6.3625 -10.21 1000 16.1747 18.1767 6.3225 </td <td>100 8:2:,3:00 299,5:0/0 50,3:50 27,1000 -135,-9 296,16 89,6:01 132,4:100 131,15:50 27,1000 -135,-9 300 99,106/7 101,5:40 19,2!123 -7,29 400 67,4:5:50 76,495 15,2:7/5 -7,29 500 54,4:640 (2,033) 12,2:7/0 -7,29 500 54,4:640 (2,033) 11,4:27 -11,3:80 700 39,6171 45,0351 10,2:295 -35,91 600 45,8033 52,1150 11,4:27 -11,3:80 700 39,6171 45,0351 10,2:295 -35,91 8000 34,375 35,253 8,7104 -47,47 1000 86,1200 82,2520 8,2950 -94,93 1200 86,1200 82,37736 7,0113 -13,84 1200 12,028 23,47756 7,0113 -13,84 1200 16,7368 81,1171 6,6299 -11,84 1200</td> <td>4100 4200 4300 4400 4500</td> <td>8.8371 8.6852 8.5423 8.4050 8.2738</td> <td>9.7782 9.6059 9.4434 9.2876 9.1387</td> <td>5.2442 5.2281 5.2132 5.1975 5.1079</td> <td>-1.17 -0.97 -0.51</td>	100 8:2:,3:00 299,5:0/0 50,3:50 27,1000 -135,-9 296,16 89,6:01 132,4:100 131,15:50 27,1000 -135,-9 300 99,106/7 101,5:40 19,2!123 -7,29 400 67,4:5:50 76,495 15,2:7/5 -7,29 500 54,4:640 (2,033) 12,2:7/0 -7,29 500 54,4:640 (2,033) 11,4:27 -11,3:80 700 39,6171 45,0351 10,2:295 -35,91 600 45,8033 52,1150 11,4:27 -11,3:80 700 39,6171 45,0351 10,2:295 -35,91 8000 34,375 35,253 8,7104 -47,47 1000 86,1200 82,2520 8,2950 -94,93 1200 86,1200 82,37736 7,0113 -13,84 1200 12,028 23,47756 7,0113 -13,84 1200 16,7368 81,1171 6,6299 -11,84 1200	4100 4200 4300 4400 4500	8.8371 8.6852 8.5423 8.4050 8.2738	9.7782 9.6059 9.4434 9.2876 9.1387	5.2442 5.2281 5.2132 5.1975 5.1079	-1.17 -0.97 -0.51
2100 14.8724 16.6857 6.0302 -8.55 2200 14.3100 16.0412 5.9480 -7.96 2300 13.7955 15.4525 5.8736 -7.96 2400 13.7955 15.4525 5.8736 -7.96 2500 13.7955 15.4525 5.8736 -7.96 2500 12.8528 14.4170 5.7470 -6.85 2600 12.4931 13.9593 5.6980 -5.76 2700 12.4931 13.9593 5.6980 -5.76 2700 11.793 13.1418 5.9765 -4.88 2900 11.4593 12.7722 5.5561 -4.48 3000 11.4593 12.7722 5.5561 -4.48 3000 10.8813 12.1128 5.4821 -3.76 3100 10.6813 12.1128 5.4821 -3.76 3100 10.6394 11.6335 5.4899 -3.49 3100 10.6394 11.8335 5.4899	1600 18.7388 21.1171 6.6299 -13.24 1700 17.7635 20.0226 6.4770 -12.12 1000 16.9344 19.0497 6.3522 -11.11 1000 16.1747 18.1767 6.8255 -10.21 1000 16.1747 18.1767 6.8255 -10.21 1000 15.4900 17.3945 6.1225 -9.40 2100 14.8724 16.6957 6.0302 -8.55 2200 13.3100 15.0412 5.9480 -7.96 2100 14.8724 16.6957 6.0302 -8.55 2200 13.7955 15.4525 5.6736 -7.96 2900 13.7955 15.4525 5.6736 -7.96 2900 13.5954 14.9128 5.6629 -6.76 2900 12.2230 13.3554 5.6425 -5.11 2000 11.7793 13.118 5.9766 -4.86 2900 11.4593 12.7752 5.9561	1100 26.1200 29.5754 7.6800 .21.76 1200 24.1517 27.3205 7.3365 .19.49 1300 22.4852 23.4116 7.2522 .17.46 1400 21.0546 23.7756 7.0113 .15.69 1500 19.6213 22.3580 6.8097 .14.50 1600 16.7348 21.1171 6.6299 .13.24 1700 17.7835 20.0228 6.4770 .22.12 1200 16.7348 21.1171 6.6299 .13.24 1200 17.7835 20.0228 6.4770 .22.12 1300 16.37447 18.1767 6.3225 .10.21 1300 16.1747 18.1767 6.3225 .9.40 2100 14.8724 16.68577 6.1225 .9.40 2100 13.7905 13.4925 5.6736 .7.94 2100 13.7905 15.4920 .7.956 .2.940 .7.95 2100 13.7905 15.4925<	600 45.8033 52.1190 11.4227 -43.80 700 39.6171 45.0351 10.2996 -36.91 800 39.5775 39.7273 9.4993 -12.82 900 31.559 35.7293 8.4104 -47.47 1000 26.1200 29.5754 7.8600 -41.78 1200 28.4150 32.2503 6.7054 -49.49 1200 28.41517 27.3205 7.3568 -19.49 1200 28.41527 27.3205 7.3568 -19.49 1200 28.41527 27.3205 7.0113 -13.49 1200 28.4552 25.4116 7.8282 -17.48 1400 21.0986 23.7756 7.0113 -13.49 1500 19.6213 28.3550 6.60577 -14.50 1600 16.7986 21.1171 6.3622 -11.11 1000 16.7986 21.0177 6.3622 -11.11 1000 16.7986 21.0797 6.36	100 842.500 299.5070 50.3760 460.60 800 132.4100 131.1550 27.1010 -135.47 298.16 99.1057 102.5755 19.315 -22.35 500 99.1057 102.5400 13.2775 -27.89 500 94.4640 62.0330 12.2770 -53.375 600 45.8033 92.1170 11.4227 -43.80 700 39.6171 45.0351 10.2995 -45.91 800 34.5603 35.5693 8.7164 -74.79 900 31.3509 35.5693 8.7164 -74.7 900 31.3509 35.5693 8.7164 -74.7 1000 86.1200 89.5794 7.8800 -91.78 1200 24.852 25.4116 7.3322 -17.82 1200 24.852 25.4116 7.3322 -17.82 1200 24.852 25.4116 7.3322 -17.82 1200 16.7388 21.1171 6.62	3600 3700 3800 3900	9.7372 9.5222 9.3374 9.1621 8.9955	10.7818 10.5550 10.3468 10.1485 9.9593	5.3486 5.3195 5.2993 5.2797 5.2618	-2.29 -2.34 -1.31 -1.59 -1.37
2100 14.8724 16.6857 6.0302 -8.55 2200 14.3100 16.0412 5.9480 -7.96 2300 13.7955 15.4525 5.8736 -7.36 2400 13.7955 15.4525 5.8736 -7.36 2400 13.7955 15.4526 5.8059 -6.79 2500 12.8528 14.4170 5.7470 -6.25 2600 12.4931 13.9593 5.6980 -5.76 2700 22.1230 13.3354 5.6980 -5.76 2700 12.4931 13.9593 5.6980 -5.76 2700 12.4930 13.3354 5.6980 -5.76 2700 12.4931 13.9593 5.6980 -5.76 2700 12.4930 13.1818 5.5976 -4.88 2900 11.4593 12.7724 5.5561 -4.48 3000 11.1607 12.4330 5.5173 -4.113	1600 18.7388 21.1171 6.6299 -13.24 1700 17.7635 20.0226 6.4770 -12.12 1000 16.9344 19.0497 6.3225 -10.21 1000 16.1747 18.1747 6.2255 -10.21 1000 16.1747 18.1747 6.2255 -10.21 1000 15.4900 17.3945 6.1225 -9.40 2100 14.8724 16.6957 6.0302 -8.55 2200 14.3100 16.0412 5.9480 -7.96 2100 14.8724 16.6957 6.0302 -8.55 2200 13.3254 14.9128 5.9480 -7.96 2900 13.7955 15.4925 5.765 -7.349 2900 13.5954 14.9128 5.8059 -6.76 2900 12.8928 14.4170 5.7470 -6.25 2600 12.4931 13.9593 5.6980 -5.76 2700 12.1230 13.3354 5.6485	1100 26.1200 29.5754 7.6800 .21.76 1200 24.1517 27.3205 7.5368 -19.49 1300 22.4852 25.4116 7.2522 -17.68 1400 21.0366 23.7756 7.0113 -15.68 1400 21.0366 23.7756 7.0113 -15.68 1500 19.8213 22.3580 6.6057 -14.50 1500 19.8213 22.3580 6.6057 -14.50 1600 16.7368 21.1171 6.6299 -13.244 1700 17.7635 80.0226 6.4770 -12.12 1900 16.1747 18.1747 6.2255 -10.21 1900 15.1747 18.1767 6.3225 -9.40 2100 14.8724 16.6957 6.0302 -8.55 2200 13.7955 13.4925 5.6736 -7.96 2900 13.7955 13.4925 5.6736 -7.96 2900 13.7955 15.4925 5.6736 </td <td>600 45.8033 52.1190 11.4227 -43.80 700 39.6171 45.0351 10.2996 -35.91 800 39.6171 45.0351 10.2996 -35.91 800 39.5775 39.7273 9.4996 -35.91 900 31.5599 35.7693 8.7104 -47.47 1000 28.44280 32.2820 8.2960 -41.47 1200 28.4512 27.3205 7.3368 -19.49 1200 28.4512 25.4116 7.3328 -17.48 1400 28.4512 25.4116 7.3328 -17.48 1400 28.4552 25.4116 7.3328 -13.49 1500 19.6213 28.3580 6.8057 -14.50 1500 18.7368 21.1171 6.6299 -13.24 1700 16.57368 21.1171 6.5295 -10.21 1000 16.7368 21.1171 6.5299 -13.24 1700 16.5734 19.077 6.3225</td> <td>100 842.300 299.5070 50.3700 -30.600 800 132.4100 131.1550 27.1010 -135.79 298.16 99.6411 102.2755 19.315 -92.38 300 69.1067 102.2755 19.315 -92.38 400 67.4550 76.4955 15.3575 -57.62 500 54.4640 62.0330 12.9770 -53.62 500 54.4640 62.0330 12.9770 -53.62 600 45.8033 52.1170 11.4227 -43.60 700 39.6171 45.0351 10.2995 -55.91 600 94.9775 39.7223 9.4995 -43.90 900 28.489 32.2600 8.2960 -41.40 1000 28.1207 27.925 7.3566 -19.49 1000 28.1207 27.925 7.3566 -19.49 1000 28.1207 27.925 7.3566 -19.49 1000 28.1207 27.925 7.35</td> <td>3100 3800 3300 3500</td> <td>10.8813 10.6194 10.3733 10.1418 9.9234</td> <td>12.1128 11.8135 11.5325 11.8669 11.0174</td> <td>5.4021 5.4499 5.4197 5.3980 5.3667</td> <td>-3.76 -3.43 -3.12 -2.83 -2.55</td>	600 45.8033 52.1190 11.4227 -43.80 700 39.6171 45.0351 10.2996 -35.91 800 39.6171 45.0351 10.2996 -35.91 800 39.5775 39.7273 9.4996 -35.91 900 31.5599 35.7693 8.7104 -47.47 1000 28.44280 32.2820 8.2960 -41.47 1200 28.4512 27.3205 7.3368 -19.49 1200 28.4512 25.4116 7.3328 -17.48 1400 28.4512 25.4116 7.3328 -17.48 1400 28.4552 25.4116 7.3328 -13.49 1500 19.6213 28.3580 6.8057 -14.50 1500 18.7368 21.1171 6.6299 -13.24 1700 16.57368 21.1171 6.5295 -10.21 1000 16.7368 21.1171 6.5299 -13.24 1700 16.5734 19.077 6.3225	100 842.300 299.5070 50.3700 -30.600 800 132.4100 131.1550 27.1010 -135.79 298.16 99.6411 102.2755 19.315 -92.38 300 69.1067 102.2755 19.315 -92.38 400 67.4550 76.4955 15.3575 -57.62 500 54.4640 62.0330 12.9770 -53.62 500 54.4640 62.0330 12.9770 -53.62 600 45.8033 52.1170 11.4227 -43.60 700 39.6171 45.0351 10.2995 -55.91 600 94.9775 39.7223 9.4995 -43.90 900 28.489 32.2600 8.2960 -41.40 1000 28.1207 27.925 7.3566 -19.49 1000 28.1207 27.925 7.3566 -19.49 1000 28.1207 27.925 7.3566 -19.49 1000 28.1207 27.925 7.35	3100 3800 3300 3500	10.8813 10.6194 10.3733 10.1418 9.9234	12.1128 11.8135 11.5325 11.8669 11.0174	5.4021 5.4499 5.4197 5.3980 5.3667	-3.76 -3.43 -3.12 -2.83 -2.55
2100 14.8724 16.6857 6.0302 -8.55 2200 14.3100 16.0412 5.9460 -7.56 2300 13.7355 15.4525 5.8736 -7.34 2400 13.3258 14.9128 5.8059 -6.74 2500 12.8523 14.4170 5.7470 -6.254	1600 18.7348 21.1171 6.6299 -13.244 1700 17.7635 20.0226 6.4770 -12.12 1800 16.9344 19.0497 6.3629 -11.11 1900 16.1747 18.1767 6.3629 -11.11 1900 16.1747 18.1767 6.3629 -10.21 2000 15.1747 18.1767 6.2255 -9.403 2000 15.4910 17.3945 6.1225 -9.403 2100 14.8724 16.6857 6.0302 -8.553 2200 14.3100 16.0412 5.9460 -7.964 2300 13.7355 15.4525 5.8736 -7.364 2400 13.3258 14.9128 5.8059 -6.76 2500 12.8523 14.4170 5.7470 -6.854	1100 96.1200 29.5/754 7.6800 -91.74 1200 28.1517 27.3205 7.5368 -19.49 1300 22.4852 25.4116 7.2522 -17.48 1400 21.0586 23.7756 7.0113 -15.66 1500 19.6213 22.3580 6.8057 -14.50 1500 19.6213 22.3580 6.8057 -14.50 1600 18.7368 21.1171 6.6299 -13.244 1700 17.7635 20.0226 6.4770 -12.12 1800 16.3744 19.0497 6.3622 -9.402 1900 16.1747 18.1707 6.3622 -9.402 1900 15.784 16.6857 6.1225 -9.402 2100 14.8724 16.6857 6.0302 -8.552 2100 14.8724 16.6857 6.0302 -8.552 2200 13.7305 15.4525 5.8736 -7.368 2800 13.7305 15.4525 5.87	600 45.8033 52.1170 11.4227 -43.807 700 39.6171 45.0351 10.2995 -35.81 800 34.9775 39.7273 9.4993 -35.61 900 31.5699 35.7293 9.4993 -49.4 1000 28.4500 32.2620 8.2950 -49.4 1100 26.1200 29.5754 7.6800 -91.74 1200 28.4552 25.4116 7.2528 -19.499 1200 28.4552 25.4116 7.2528 -17.68 1400 28.0986 23.7756 7.0113 -15.68 1500 19.6213 28.3580 6.8097 -14.50 1500 19.6213 28.3580 6.8097 -14.50 1600 16.7388 21.1171 6.6299 -13.24 1700 15.7944 19.0497 6.3022 -11.11 1900 15.744 19.0497 6.3022 -11.11 1900 15.744 19.0497 6.3022 <td>100 8:2:, 5'00 299, 50'70 50, 37'00 -36, 60' 8:00 132, 41:00 131, 15:50 27, 1010 -135, 7'7 9:96, 16 9:0, 64:11 102, 27'51 19, 38:15 -92, 38 300 9:1067 101, 64:00 19, 21:23 -92, 38 400 67, 45:50 76, 4995 15, 37'5 -97, 38 500 54, 46:40 62, 0330 12, 597'0 -53, 48 500 54, 46:40 62, 0330 12, 597'0 -53, 48 600 45, 8033 52, 11'70 11, 4227 -43, 80 700 39, 61.71 45, 0351 10, 2995 -56, 91 800 34, 977'5 39, 722'3 9, 4596 -11, 42 900 31, 3509 32, 2820 8, 2950 -44, 47 1000 86, 1200 32, 2820 8, 2950 -44, 47 1200 84, 1310 27, 3205 7, 5368 -19, 49 1300 82, 1307 27, 5350 7, 5368 -19, 49</td> <td>2600 2700 2800 2900 3000</td> <td>12.4931 12.1230 11.7793 11.4593 11.1607</td> <td>13.9593 13.5354 13.1418 12.7752 12.4330</td> <td>5.6920 5.6425 5.5976 5.5961 5.5173</td> <td>-5.76 -5.30 -4.39 -4.13</td>	100 8:2:, 5'00 299, 50'70 50, 37'00 -36, 60' 8:00 132, 41:00 131, 15:50 27, 1010 -135, 7'7 9:96, 16 9:0, 64:11 102, 27'51 19, 38:15 -92, 38 300 9:1067 101, 64:00 19, 21:23 -92, 38 400 67, 45:50 76, 4995 15, 37'5 -97, 38 500 54, 46:40 62, 0330 12, 597'0 -53, 48 500 54, 46:40 62, 0330 12, 597'0 -53, 48 600 45, 8033 52, 11'70 11, 4227 -43, 80 700 39, 61.71 45, 0351 10, 2995 -56, 91 800 34, 977'5 39, 722'3 9, 4596 -11, 42 900 31, 3509 32, 2820 8, 2950 -44, 47 1000 86, 1200 32, 2820 8, 2950 -44, 47 1200 84, 1310 27, 3205 7, 5368 -19, 49 1300 82, 1307 27, 5350 7, 5368 -19, 49	2600 2700 2800 2900 3000	12.4931 12.1230 11.7793 11.4593 11.1607	13.9593 13.5354 13.1418 12.7752 12.4330	5.6920 5.6425 5.5976 5.5961 5.5173	-5.76 -5.30 -4.39 -4.13
	1600 18.7348 21.1171 6.6299 -13.24 1700 17.7635 20.0226 6.4770 -12.12 1800 16.9344 19.0497 6.3222 -11.11 1900 16.1747 18.1767 6.3225 -10.21 1900 16.1747 18.1767 6.3225 -9.40 2000 15.4910 17.3945 6.1225 -9.40	1100 26.1200 29.5/54 7.6800 -21.74 1200 28.1517 27.3205 7.5368 -19.49 1300 22.4852 25.4116 7.2522 -17.68 1400 21.0586 23.7756 7.0113 -15.68 1500 19.6213 22.3580 6.8057 -14.50 1500 19.6213 22.3580 6.8057 -14.50 1600 18.7368 21.1171 6.6299 -13.244 1700 17.7635 20.0226 6.4770 -12.12 1800 16.3944 19.0497 6.3225 -10.21 1900 16.1747 18.1767 6.2255 -10.21 1900 15.4910 17.3945 6.1225 -9.402	600 45.8033 52.1170 11.4227 -43.807 700 39.6171 45.0351 10.2995 -35.81 800 34.9775 39.7273 9.4993 -31.92 900 31.5699 35.7593 8.7104 -87.47 1000 28.4500 32.2820 8.2950 -49.4 1100 26.1200 29.5754 7.6800 -91.74 1200 28.4130 32.28120 8.2950 -49.4 1200 28.4512 25.4116 7.2528 -17.96 1300 22.4852 25.4116 7.2528 -17.96 1400 21.0986 23.7756 7.0113 -13.96 1500 19.6213 28.3580 6.8057 -14.50 1500 19.6213 28.3580 6.8057 -14.50 1600 18.7368 21.1171 6.6299 -13.24 1700 17.7635 20.0226 6.4770 -12.12 1900 16.5944 19.0497 6.3225<	100 8.2. 5°00 299. 5070 50. 3700 -36. 80 800 132. 41.00 131. 1550 27. 101.0 -135. 47 998.16 89. 1067 102. 2755 19. 3815 -92. 38 300 89. 1067 101. 6440 19.2123 -91. 48 400 67. 4550 76. 4935 15. 3775 -97. 48 400 67. 4550 76. 4935 15. 3775 -97. 48 500 54. 4640 62. 0330 12. 9970 -53. 48 600 45. 8033 52. 1170 11. 4227 -43. 80 700 39. 6171 45. 0351 10. 2996 -85. 90 800 34. 9775 39. 7223 9. 4593 -11. 42 900 31. 5509 32. 2820 8. 2950 -41. 42 1000 86. 1200 32. 2820 8. 2950 -41. 42 1100 86. 1200 29. 5754 7. 8800 -21. 78 1100 86. 1200 29. 5754 7. 8800 -21. 78 1200	2100 2200 2300 2400 2500	14.8724 14.3100 13.7965 13.3258 12.8528	16.6857 16.0412 15.4525 14.9128 14.4170	6.0302 5.9480 5.8736 5.8069 5.7470	-8.55 -7.98 -7.34 -6.79 -6.25

TABLE 7 REPUGED ABSOLUTE FORMATION ENTHALPIES $\begin{bmatrix} \Delta H_{f.abs} \\ \hline H_T \end{bmatrix}_{i}^{T} = \begin{bmatrix} \Delta E_{o.f} \\ \hline H_{c} \end{bmatrix}_{i}^{T} \cdot \frac{1}{T} + \begin{bmatrix} H - E_{o} \end{bmatrix}_{i}^{T}$

(N)	-		60	ro:-
100	111.7640	564.6300	-1117. 1030	-h(0. 36%
003	57.7490	285.6150	0. 40. Hu-	-27. 60
298.16	39.9289	195.3746	-42.400	-15.813
300	38.7037	191.2100	-42.129/	-153.859
400	30.6765	144.0325	-30.7190	-114.154
			- Justo	
600	21.6743	96.8550	-19.2833	-12 820
800	17.2178	73.2663	-13.5250	-54 260
900	15.7469	65.4033	-11.5919	-47.941
1000	14.5780	59.1130	-10.0370	-42.1-2
1100	13.6273	53.9064	-8.7586	-31.120
1200	12.6392	49.6715	-7.6861	-34.06
1300	12.1759	46.0485	-6.7/92	- 30.840
1400	11.6100	42.9379	-5.9901	-20.103
1,000	11.1223	40.2420	-9-3193	-27.027
1600	10.6974	37.8831	-4.7170	-23.769
1800	0.0004	37.0010	-3.7164	-20 25
1900	9.6967	32.2963	-3.2022	-18.8
2000	9.4315	30.0065	-2.9110	-17.50
2100	9.1934	29.4586	-2.5641	-16.357
2200	8.9767	28.2332	-2.2478	-15.319
2300	8.7792	27.1143	-1.9593	-14.3:4
2400 2500	8.4336	25.1452	-1.6933	-13.430
-	8	-	1 2226	11 858
2700	8.1406	23.4689	-1.0126	-11.115
2800	8.0098	22.7199	-0.8176	-10.4:2
2900	7.6688	22.0237	-0.6350	-9.8:5
3000	1.11.51	21.3130	-0.4041	-7.673
31.00	7.6705	20.7653	-0.3055	-8.717
3200	7. 576	10 ((05	-0.1775	-0.215
3400	7. 1922	19.2109	0.1161	-7.20
3500	7.3114	18.6831	0.2431	-6.841
3600	7.2337	18.2348	0.3618	-6.401
3700	7.1616	17.8118	0.4745	-6.0.2
3800	7.0928	17.4112	0.5809	-5.72.
4000	6.9658	17.0312	0.6823	-5.300
h100	6 0060	16		1.00
4200	6.8512	16.0023	0.9550	-4.452
4300	6.7984	15.6928	1.0407	-4.17:
4400	6.7473	15.3966	1.1211	-3.902
	0.0900			-3.043
4600	0.0520	14.8452	1.2703	-3.400
1000	6.468	14. 2414	2.4083	-3.070
4900	6.5269	14.1057	1.4725	-2.722
5000	6.4876	13.8796	1.5344	-2.523
5100	6.4505	13.6636	1.5941	-2.312
5200	6.4197	13.4551	1.6517	-2.12
5300	0.3725	13.2557	1.7074	-1.93
5500	6.3165	12.0003	1.8123	-1.5%
5600	6.2064	18.0035	1.0:17	-1.415
\$700	6.2%	12.551	1.90%	-1.25
5000	6.2789	12. 9:19	1.9.70	-1.09
5900	6.2013	12.000	2.0457	-0.947
inter ()		-	1044	S. Cardina

TABLE 8 REDUCED SENSIBLE ENTHALPIES,

 $\begin{bmatrix} H - E_0 \\ \hline R T \end{bmatrix}^T$ i

(K)	Ny		¢	n	NO	N,O
100	3.420	8.500	3.600	2.657	3.641	3.955
200	3.427	2.500	3.491	2.730	3.72	3.903
300	3.417	2.500	3.502	2.714	3.699	3.996
400	3.436	2.500	3.921	2.(87	3.670	4.016
500	3.4%2	2.500	3.553	2.653	3.647	4.047
600	3.4.4	2.500	3.594	2.644	3.631	4.090
800	3.484	2.500	3.687	2.610	3.616	4.199
900	3.495	2.500	3.732	2.606	3.646	4.253
	3.901	2.900	3.115	8.791	3.041	4.300
1100	3.520	2.500	3.810	2.589	3.630	1.448
1,300	3.550	2.500	3.884	2.571	3.656	4.510
1400	3.968	2.500	3.92	2.508	3.602	4.503
1600	1.608		1 041	2 61	2 219	L 712
1700	3.628	2.500	4.008	2.501	3.771	4.782
1800	3.6%	2.500	4.034	2.558	3.740	4.645
2000	3.692	2.500	4.050	2.555	3.705	4.907
2100	3.714	2.500	4.105	2.550	s. Ack	5.085
2200	3.736	2.500	4.121	2.548	3.823	5.001
2300	3.757	2.500	4.148	2.546	3.841	5.135
2500	3.799	2.500	4.100	2.543	3.871	5.238
2600	3.819	2.500	4.208	2.542	3.894	5.886
2700	3.839	2.500	4.227	8.541	3.911	5.333
0005	3.859	2.500	4.245	2.540	3.928	5.378
3000	3.897	2.500	4.281	2.530	3.959	5.463
3100	3.916	2.500	4.258	2.537	3.974	5.503
3200	3.934	2.500	4.315	2.537	3.989	5.542
3500	3.969	2.500	4.348	2.531	4.003	5.616
3500	3.907	2.500	4.364	2.536	4.031	5.651
3600	4.003	2.500	4.379	2.536	4.044	5.685
3700	4.020	2.500	4.395	2.537	4.056	5.717
3900	4.053	2.500	4.424	2.537	4.081	5.779
6000	4.009	2.500	4.438	2.538	4.093	5.809
4100	4.004	2.500	4.452	2.539	4.104	5.837
4100	4.100	2.500	4.405	2.539	4.115	5.055
NOO	4.130	2.500	4.491	2.541	4.137	5.918
4900	4.145	2.500	4.504	2.542	4.147	5.943
N600	4.160	2.500	4.516	2.543	4.157	5.967
4800	4.100	2.500	4.540	2.545	4.107	5.991
4900	4.202	2.500	4.551	8.547	4.10%	6.037
9000	4.216	8.500	4.568	2.549	4.195	6.058
5100	4.230	2.500	4.573	2.5%	h.204	6.00
5300	4.257	2.500	4.504	8.553	4.221	6.120
shoo	4.270	2.500	4.004	2.555	4.230	6.140
5500	4,263	8.500	4.614	2.557	4.836	6.159
5700	4.996	2.500	4.624	2.270	h. 946	8.172
			h. Che	2.78	4.142	6.914
5900	4.341			and the second second		
5900 5%00	1.3.0	2.500	4.451	2.5%	4.270	6.831
	T T 100 200 293.14 300 300 200 200 200 1000 200 1000 200 1000 200 1000 1000 1000 1000 1000 1000 1000 1000 1000 1000 1000 1000 2000 2100 2100 2100 2100 2100 2100 2100 2100 2100 2100 2100 2100 2100 2100 2100 2100 2100 2100 2100 2100 2100 2100 3000 3100 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 <td< td=""><td>T Hg 100 3.420 200 3.427 295.14 3.417 300 3.436 200 3.427 295.14 3.417 300 3.436 200 3.436 200 3.436 200 3.474 900 3.474 900 3.474 900 3.474 900 3.474 900 3.475 1000 3.597 1000 3.597 1000 3.597 1000 3.597 1000 3.597 1000 3.668 1700 3.668 1700 3.668 1700 3.692 2100 3.714 2200 3.671 2000 3.672 2000 3.692 2000 3.693 2000 3.697 3000 3.992</td><td>T H2 H 100 3.480 #.500 200 3.487 2.500 295.14 3.417 2.500 200 3.427 2.500 200 3.427 2.500 200 3.422 2.500 200 3.422 2.500 200 3.428 2.500 200 3.428 2.500 200 3.448 2.500 200 3.455 2.500 200 3.459 2.500 1000 3.597 2.500 1000 3.597 2.500 1000 3.597 2.500 1000 3.698 2.500 1000 3.692 2.500 1000 3.692 2.500 1000 3.692 2.500 1000 3.692 2.500 1000 3.692 2.500 2000 3.776 2.500 2000 3.776</td><td>T H2 H C. 100 3.487 2.500 3.497 200 3.427 2.500 3.497 200 3.417 2.500 3.507 200 3.417 2.500 3.507 200 3.417 2.500 3.521 200 3.418 2.500 3.521 200 3.418 2.500 3.521 200 3.418 2.500 3.521 200 3.418 2.500 3.647 900 3.458 2.500 3.647 900 3.458 2.500 3.647 900 3.597 2.500 3.647 900 3.597 2.500 3.647 900 3.597 2.500 3.647 900 3.597 2.500 3.672 1000 3.668 2.500 3.672 1000 3.668 2.500 4.038 1000 3.668 2.500 4.0</td><td>T Hg H Ci C 100 3.487 2.500 3.497 2.500 3.497 2.730 200 3.427 2.500 3.497 2.730 2.730 200 3.427 2.500 3.502 2.714 400 3.435 2.500 3.502 2.714 400 3.435 2.500 3.523 2.643 700 3.474 2.500 3.777 2.597 1000 3.495 2.500 3.777 2.597 1000 3.590 2.500 3.777 2.597 1000 3.590 2.500 3.644 2.507 1000 3.597 2.500 3.649 2.577 1000 3.597 2.500 3.640 2.531 1000 3.560 2.500 3.691 2.541 1000 3.668 2.500 4.034 2.541 1000 3.646 2.500 4.034 2.543</td><td>T H5 H C: 6 OH 100 3.480 6.500 3.497 2.607 3.641 200 3.487 2.500 3.547 2.705 3.764 201 3.487 2.500 3.547 2.705 3.764 200 3.437 2.500 3.521 2.643 3.679 200 3.437 2.500 3.574 2.643 3.647 200 3.437 2.500 3.775 2.643 3.647 200 3.447 2.500 3.775 2.643 3.641 200 3.447 2.500 3.775 2.597 3.641 2000 3.548 2.500 3.775 2.577 3.641 1000 3.594 2.500 3.792 2.577 3.641 1000 3.597 2.500 3.592 2.577 3.642 1000 3.692 2.500 3.592 2.577 3.646 1000 3</td></td<>	T Hg 100 3.420 200 3.427 295.14 3.417 300 3.436 200 3.427 295.14 3.417 300 3.436 200 3.436 200 3.436 200 3.474 900 3.474 900 3.474 900 3.474 900 3.474 900 3.475 1000 3.597 1000 3.597 1000 3.597 1000 3.597 1000 3.597 1000 3.668 1700 3.668 1700 3.668 1700 3.692 2100 3.714 2200 3.671 2000 3.672 2000 3.692 2000 3.693 2000 3.697 3000 3.992	T H2 H 100 3.480 #.500 200 3.487 2.500 295.14 3.417 2.500 200 3.427 2.500 200 3.427 2.500 200 3.422 2.500 200 3.422 2.500 200 3.428 2.500 200 3.428 2.500 200 3.448 2.500 200 3.455 2.500 200 3.459 2.500 1000 3.597 2.500 1000 3.597 2.500 1000 3.597 2.500 1000 3.698 2.500 1000 3.692 2.500 1000 3.692 2.500 1000 3.692 2.500 1000 3.692 2.500 1000 3.692 2.500 2000 3.776 2.500 2000 3.776	T H2 H C. 100 3.487 2.500 3.497 200 3.427 2.500 3.497 200 3.417 2.500 3.507 200 3.417 2.500 3.507 200 3.417 2.500 3.521 200 3.418 2.500 3.521 200 3.418 2.500 3.521 200 3.418 2.500 3.521 200 3.418 2.500 3.647 900 3.458 2.500 3.647 900 3.458 2.500 3.647 900 3.597 2.500 3.647 900 3.597 2.500 3.647 900 3.597 2.500 3.647 900 3.597 2.500 3.672 1000 3.668 2.500 3.672 1000 3.668 2.500 4.038 1000 3.668 2.500 4.0	T Hg H Ci C 100 3.487 2.500 3.497 2.500 3.497 2.730 200 3.427 2.500 3.497 2.730 2.730 200 3.427 2.500 3.502 2.714 400 3.435 2.500 3.502 2.714 400 3.435 2.500 3.523 2.643 700 3.474 2.500 3.777 2.597 1000 3.495 2.500 3.777 2.597 1000 3.590 2.500 3.777 2.597 1000 3.590 2.500 3.644 2.507 1000 3.597 2.500 3.649 2.577 1000 3.597 2.500 3.640 2.531 1000 3.560 2.500 3.691 2.541 1000 3.668 2.500 4.034 2.541 1000 3.646 2.500 4.034 2.543	T H5 H C: 6 OH 100 3.480 6.500 3.497 2.607 3.641 200 3.487 2.500 3.547 2.705 3.764 201 3.487 2.500 3.547 2.705 3.764 200 3.437 2.500 3.521 2.643 3.679 200 3.437 2.500 3.574 2.643 3.647 200 3.437 2.500 3.775 2.643 3.647 200 3.447 2.500 3.775 2.643 3.641 200 3.447 2.500 3.775 2.597 3.641 2000 3.548 2.500 3.775 2.577 3.641 1000 3.594 2.500 3.792 2.577 3.641 1000 3.597 2.500 3.592 2.577 3.642 1000 3.692 2.500 3.592 2.577 3.646 1000 3

 $\begin{pmatrix} \underline{\mathbf{u}} & \underline{\mathbf{u}} \\ \underline{\mathbf{u}} \end{pmatrix}_{1}^{\mathbf{v}} \cdot \begin{pmatrix} \underline{\mathbf{u}} & \underline{\mathbf{u}} \\ \underline{\mathbf{u}} \end{pmatrix}_{1}^{\mathbf{v}_{1}} + \frac{\mathbf{v}}{\mathbf{x}} \frac{\mathbf{u}}{\mathbf{x}} \end{pmatrix}_{1}^{\mathbf{v}_{1}} + \frac{\mathbf{v}}{\mathbf{x}} \frac{\mathbf{u}}{\mathbf{x}} \begin{pmatrix} \underline{\mathbf{u}} & \underline{\mathbf{u}} \\ \underline{\mathbf{u}} \end{pmatrix}_{1}^{\mathbf{v}_{1}} - \begin{pmatrix} \underline{\mathbf{u}} & \underline{\mathbf{u}} \\ \underline{\mathbf{u}} \end{pmatrix}_{1}^{\mathbf{v}_{1}} \end{pmatrix}_{1}^{\mathbf{v}_{1}}$ $\mathbf{v}_{1} < \mathbf{v} < \mathbf{v}_{1} + \mathbf{\lambda} \mathbf{x}, \quad \mathbf{v}_{2}$

Ti < T < Ti + 100 - Ta

$$\left(\frac{H-H_0}{4T}\right)_1^{T} - \left(\frac{H-H_0}{4T}\right)_1^{T_1} + \frac{T-T_1}{100} \left[\left(\frac{H-H_0}{4T}\right)_1^{T_2} - \left(\frac{H-H_0}{4T}\right)_1^{T_1} \right]$$

(x)	Ny	10		00	en.
100	3.407	3.7%	2.501	3.487	3.49
200 298.16	3.495	3.754	8.301	3.495	3.5%
300	3.491	3.701	2.199	3.497	3.781
400	3.500	3.679 3.669	2.500	3.901 3.512	4.257
600	3.520	3.076	2.500	3.530	4.4GE
700	3.541	3.6A	2.500	3.555	4.64
900	3.594	3.748	2,500	3.617	4.999
1000	3.624	3.779	2.500	3.651	5.144
1100	3.655	3.810	2.500	3.685	5.277
1300	3.717	3.809	2.500	3.750	5.50
1400	3.746	3.097	2.500	3.781 3.810	5.607
1600	3.802	3.948	2.500	3.830	5.784
1700	3.828	3.9/1	2.500	3.864	5.862
1800	3.052	3.993	2.500	3.866	5.934
2000	3.898	4.032	2.500	3.933	6.063
2100	3.918	4.051	2.500	3.954	6.120
2300	3.957	4.084	2.500	3.998	6.225
2400	3.975	4.099	2.500	4.010	6.272
2600	k.008	4.128	2.501	4.0h2	5. 358
2700	4.024	4.141	2.501	4.057	6.39
2000	4.038	4.153	2.501	4.071	6.435
3000	4.066	4.176	2.502	4.098	6.504
3100	4.078	4.187	2.503	4.110	6.536
3300	4.102	4.207	2.505	4.133	6.595
3400	4.113	4.216	2.506	4.144	6.623
3500	4.124	4.220	2.900	4.174	0.049
3700	1.114	4.243	2.509	4.164	6.69
3000	4.154	4.251	2.513	4.183	6.722
3900	4.103	4.250	2.515	4.192	6.744
4100	4.180	4.273	2.520	4.209	6.78
4200	4.189	4.280	2.523	4.217	6.800
N400 .	4.204	4.293	2.530	4.232	6.844
4900	4.812	4.299	2.534	4.239	6.862
4600	4.219	4.305	2.538	4.246	6.879
4800	4.233	4.317	2.547	4.260	6.912
4900 5000	4.240	4.323	2.552 2.557	4.266	6.926
5100	4.853	4.333	8.563	4.278	6.959
5200	4.259	4.339	2.568	4.204	6.913
5400	4.271	4.348	2.581	4,295	7.00%
5500	4.276	4.353	2.587	4.301	7.015
5600	4.282	4.358	2.594	4.306	7.008
SACO	4.293	4.31	2.607	4.317	7.054
5907	4.298	4.371	2.622	4.327	7.0.7
		18	- Ten		

TABLE 9 REDUCED SENSIBLE ENTHALPIES,

 $\begin{bmatrix} H - E_{o} \\ \overline{\mathcal{R} T} \end{bmatrix}^{T}_{i}$

 $\begin{bmatrix} \underline{\mathbf{S}^{\mathbf{p}=1}} \\ \overline{\mathcal{H}} \end{bmatrix}_{\mathbf{i}}^{\mathbf{T}}$

TABLE 10 REDUCED ENTROPTES ,

(K.)	Ho		e.	v	CH	11.41
100	12.272	11.053	10.894	16.3.57	18.041	18.31%
200	14.351	12.7.8	23.205	18.7th	20.142	\$1.041
2.41.16	15.704	13.78%	24.159	19.357	22.100	22. Grit
300	15.720	13.799	24.641	19.374	25.155	22.7:"
400	16.730	14.518	25.709	20.124	23.1.0	23.8-14
500	17.515	15.077	20.530	20.097	23.44	24.625
600	18.157	15.55	27.222	21.1.2	24.590	25.609
700	10.702	15.917	27.826	21.553	25.14	50.505
000	19.170	10.22	20. 41	21.80	-5.010	20.973
1000	19.978	16.609	29.283	22.453	21.420	27.9/4
1100	20. 126	17.048	20			SA Lab
1200	20.648	17.265	20 056	22 010	27 110	24 404
1300	20.947	17. 1.5	20 401	24 111	27 416	20 221
1400	21.229	17.00	20 704	93 307	27 704	20 726
1500	21.495	17.103	31.000	23.471	27.915	30,121
1600	21.747	17.094	21 210			30 400
1700	21.938	18.136	31. 10	23.7/4	215 4.16	30,843
1800	22.217	18.279	31.635	23.971	28.709	31.184
1900	22.436	18.414	32.079	24.063	28.932	31.501
2000	22.646	18.:42	32.311	24.191	29.145	31.620
2100	22.849	18.664	\$2.533	24.313	29.349	12.172
2200	23.043	18.781	32.747	24.430	29.545	32,412
2300	23.231	18.891	32.951	24.541	29.734	32.694
2400	23.413	18.998	33.149	24.648	29.916	32.9.5
2500	23.568	19.100	33.339	24.760	30.092	33.229
2600	23.758	19.198	33.524	24.849	30.201	33.484
2700	23.922	19.292	33.702	24.913	30.425	33.731
2800	24.082	19.383	33.874	25.035	30.584	33.9/0
2900	24.237	19.471	34.042	25.123	30.738	34.203
3000	24.300	19.555	34.204	25.209	30.888	34.430
3100	24.534	19.638	. 34. 362	25.291	31.033	34.650
3200	24.677	19.717	34.516	25.371	31.174	34.864
3300	24.017	19.794	34.665	25.449	31.311	35.072
3400	24.952	19.869	34.811	25.525	31.444	35.276
5,000		19.911	34.373	23.390	34.913	33.4/4
3600	25.214	20.011	35.092	25.670	31.701	35.668
3800	87.341 96 bis	20.000	37.227	25.739	31.625	35.0%
3000	25.586	20.212	35. 500	25.007	31.947	30.011
4000	25.705	20.275	35.615	25.938	32.178	36.397
100	25 801	90 117	35 730	-	33 901	16 160
4200	25.935	20.397	35.859	26.004	32.001	¥6.7%
4300	26.047	20.456	35.978	26.124	32.500	16.001
4400	26.157	20.513	36.024	26.183	12.614	37.065
4500	26.264	20.570	36.208	26.242	32.727	37.224
4600	26.170	20.624	36, 110	26.900	32.810	17. 170
4700	26.475	20.678	35.429	26.354	12.918	37.51
4800	26.577	20.731	36.536	26.409	33.015	37.681
4900	25.677	20.752	36.640	26.453	33.111	37.827
5000	26.776	20.833	36.744	20.516	33.805	37.971
5100	25.874	20.883	36.845	26.568	33.291	30.113
5200	26.969	20.931	36.944	26.619	33.357	30.852
5300	27.0CA	20.919	37.042	86.669	33.476	38. yW
5400	87.1%	21.025	37.138	26.719	33.563	34.522
5500	27.245	\$1.0/1	37.233	26.708	33.649	38.64
5600	27.334	21.116	37.325	M.815	33.733	38.714
5700	27.427	21.100	37.416	26.863	33.616	38.911
5800	27.515	21.904	37.506	\$6.919	33.1154	39.037
5900	\$7.601	P1 . Phy	37.5%	21. 934	33.5/M	39.361
6000	27.006	21.209	31.082	26.97)	N.057	32.813

REDUCED ENTROPIES. TABLE 11

T (K)

State of the second sec

20

ないないのであるので

and and states

s^{p=1} R T NO c0.2 11-. co 21.279 23.091 25.335 25.355 26.355 26.350 27.200 19.885 22.355 23.758 23.780 24.790 25.402 21.777 24.057 25.700 25.727 27.088 28.241 19.179 21.631 23.032 23.053 24.062 24.851 15.693 17.427 18.424 18.440 19.159 19.717 20.173 20.558 20.892 21.186 21.450 27.876 28.662 28.993 29.452 29.452 29.879 29.249 30.147 30.958 31.698 32.378 25.505 26.069 26.568 27.018 27.428 26.243 26.814 27.321 27.777 28.194 27.806 28.157 28.483 28.789 29.077 30.271 30.634 30.971 31.287 31.583 21.608 21.906 22.106 22.291 22.464 28.577 28.932 29.263 29.573 29.864 33.007 33.599 34.136 34.650 35.132 29.349 29.606 29.850 30.083 30.304 22.625 22.777 22.919 23.054 23.183 35.588 36.018 36.428 36.817 37.188 31.861 32.125 32.374 32.611 32.837 30.138 30.398 30.644 30.878 31.102 30.515 30.718 30.912 31.099 31.279 32.851 33.258 33.455 33.645 33.645 23.305 23.421 23.532 23.639 23.741 31.314 31.518 31.714 31.902 32.062 31.452 31.619 31.780 31.936 32.087 34.002 34.172 34.335 34.492 34.645 23.839 23.934 24.026 24.114 24.199 32.256 32.424 32.586 32.743 32.895 32.233 32.375 32.513 32.646 32.776 24.282 24.362 24.440 24.516 24.516 24.590 33.041 33.184 33.322 33.457 33.587 34.793 34.936 35.075 35.211 35.342 32.903 33.026 33.147 33.264 33.378 35.470 35.594 35.716 35.834 35.949 24.663 24.733 24.802 24.869 24.936 33.714 33.838 33.959 34.076 34.191

1600 1700 1800 1900 2000 37.543 37.883 38.209 38.522 38.824 2100 2200 2300 2400 2500 39.114 39.394 39.393 39.996 40.180 2600 2700 2800 2900 3000 40.426 40.664 40.896 41.120 41.339 31.00 3200 3300 3400 3500 3600 3700 3800 3900 41.552 41.759 41.961 42.159 42.351 4100 4200 4300 4400 33.490 33.599 33.706 33.810 33.810 33.912 36.062 36.171 36.279 36.384 36.487 25.001 25.065 25.127 25.189 25.250 34.303 34.413 34.519 34.624 34.727 42.539 42.723 42.902 43.078 43.250 4600 4700 4800 4900 5000 34.012 34.110 34.206 34.299 34.392 34.827 34.925 35.021 35.116 35.208 48.451 43.583 43.745 43.904 44.059 36.588 36.655 36.783 36.877 36.971 25.310 25.369 25.427 25.484 25.484 25.541 5100 5200 5300 5400 5500 34.482 34.572 3 658 34.744 34.828 37.151 37.151 37.238 37.324 37.509 25.597 25.658 25.707 25.762 25.815 35.299 35.388 35.475 35.961 35.645 44.212 44.302 44.509 44.693 44.796 9(00 5700 5800 5900 34.911 34.992 35.072 35.151 35.228 25.922 25.922 25.974 26.026 26.077 35.728 35.810 35.890 35.749 35.749 44.935 45.073 45.369 45.369 45.369 37.492 37.5% 37.6% 37.6% 37.733 37.811

44

.

.

TABLE 12 REDUCED SPECIFIC HEATS,

and the second sec

7 (K)	14	н	0,-	n	ON
100 200 298.16 300 400 500	2.714 3.200 3.468 3.469 3.510 3.519	2.500 2.500 2.500 2.500 2.500 2.500	3.501 3.503 3.533 3.534 3.621 3.739	2.691 2.735 2.435 2.434 2.434 2.434 2.557	3.904 3.700 3.00 3.00 3.900 3.900
600 700 800 900	3.527 3.541 3.546 3.597 3.633	2.500 2.500 2.500 2.500 2.500	3.860 3.907 4.058 4.133 4.195	2.54) 2.531 2.524 2.519 2.516	3.55 3.50 3.59 3.64 3.69
1100 1200 1300 1400 1500	3.674 3.719 3.769 3.885 3.885	2.500 2.500 2.500 2.500 2.500	4.247 4.291 4.330 4.365 4.397	2.513 2.511 2.510 2.508 2.508 2.507	3.74 3.79 3.85 3.90 3.90
1600 1700 1800 1900 2000	3.937 3.986 4.034 4.080 4.124	2.500 2.500 2.500 2.500 2.500	4.428 4.458 4.467 4.515 4.515	2.507 2.506 2.505 2.505	4.05 4.05 4.09 4.13 4.17
2100 2200 2300 2400 2500	4.166 4.206 4.244 4.260 4.315	2.500 2.500 2.500 2.500 2.500	4.571 4.599 4.627 4.654 4.681	2.505 2.506 2.506 2.507 2.508	4.23 4.23 4.26 4.29 4.33
2600 2700 2800 2900 3000	4.347 4.378 4.407 4.435 4.458	2.500 2.500 2.500 2.500 2.500	4.707 4.733 4.758 4.782 4.806	2.509 2.511 2.513 2.516 2.518	4.39 4.96 4.96 4.40
3100 3800 3300 3900 3500	4.484 4.530 4.535 4.560 4.584	2.500 2.500 2.500 2.500 2.500	4.829 4.851 4.872 4.893 4.913	2.521 2.525 2.529 2.533 2.533	4.45 4.45 4.46 4.48
3600 3700 3900 3900	4.609 4.632 4.656 4.679 4.701	2.500 2.500 2.500 2.500 2.500	4.931 4.949 4.966 4.902 4.902	2.541 2.546 2.551 2.557 2.562	4.50 4.52 4.53 4.54
4100 4200 4300 4400 4500	4.723 4.745 4.767 4.768 4.808	2.500 2.500 2.500 2.500 2.500	5.013 5.026 5.040 5.052 5.063	2.568 2.574 2.580 2.586 2.592	4.56 4.57 4.50 4.59
4600 4700 4800 4900 9000	4.888 4.848 4.868 4.867 4.905	2.500 2.500 2.500 2.500 2.500	5.075 5.085 5.094 5.103 5.111	2.598 2.604 2.610 2.616 2.622	1.0.0
5100 5300 5400 5500	1.931 1.931 1.975	2.500 2.500 2.500 2.500 2.500 2.500	5.119 5.126 5.133 5.139 5.139 5.146	2.628 2.634 2.640 2.646 2.646	1.65 1.67 1.60
5000 5000 5900	5.015 5.038 5.069 5.066	2.500 2.500 2.500 2.500 2.500	5.158 5.157 5.168 5.167	9.697 9.663 9.668 9.668	1.60 1.70

 $\begin{pmatrix} c_{2} \\ c_{3} \end{pmatrix}_{1}^{2} \cdot \begin{pmatrix} c_{2} \\ c_{3} \end{pmatrix}_{1}^{r_{1}} \cdot \frac{1}{1200} \left[\begin{pmatrix} c_{2} \\ c_{3} \end{pmatrix}_{1}^{r_{2}} \cdot \begin{pmatrix} c_{3} \\ c_{3} \end{pmatrix}_{1}^{r_{1}} \right]$

TABLE 13 REDUCED SPECIFIC HEATS,

 $\begin{bmatrix} C_{\rm p} \\ \hline \partial C \end{bmatrix}^{\rm T}_{\rm i}$

(x)				C02	00	H-0
100 200 298.16	3.500 3.501 3.503 3.503	2.500 2.500 2.500 2.500	3.805	3.513 3.692 4.466	3.500	4.000 4.010 4.035
400 500	3.518 3.557	2.500	3.607	4.970	3.529	4.119
600 700	3.621	2.500	3.757 3.852	5.692	3.601 3.749	4.36
900 900	3.700 3.860 3.933	2.500	3.941 4.020 4.088	6.186 6.374 6.532	3.63/ 3.918 3.991	4.653
1100	3.998	2.500	4.146	6.664	4.055	5.109
1300 1400 1500	4.107 4.153 4.192	2.500 2.500 2.500	4.237 4.273 4.304	6.872 6.952 7.022	4.155 4.200 4.230	5.411 5.529 5.653
1600	4.226 4.256	2.500	4.330	7.052	4.257	5.768
1800 1900 2000	4.283 4.307 4.328	2.500 2.501 2.501	4.374 4.392 4.408	7.181 7.222 7.259	4.319 4.341 4.360	5.973 6.063 6.145
2100	4.347	2.501	4.422	7.291	4.377	6.220
2300 2400 2500	4.380 4.394 4.406	2.502 2.504 2.505	4.447 4.458 4.467	7.347 7.371 7.393	4.406 4.419 4.430	6.359 6.418 6.473
2600	4.418	2.507	4.476	7.415	4.441	6.524
2000 3000	4.438 4.448 4.456	2.513 2.517 2.522	4.492 4.499 4.506	7.451 7.468 7.485	4.468 4.468 4.476	6.615 6.657 6.695
3100	4.464 4.472	2.527	4.513	7.499	4.484	6.730 6.764
3300 3400 3570	4.479 4.486 4.492	2.541 2.550 2.559	4.525	7.526 7.539 7.551	4.407 4.503 4.509	6.795 6.825 6.852
3600	4.498	2.570	4.540	7.564	4.515	6.903
3800 3900	4.510 4.515 4.521	2.595 2.608 2.623	4.550 4.554 4.558	7.586 7.597 7.608	4.526 4.531 4.536	6.926 6.949 6.970
4100	4.526	2.639	4.562	7.618	4.541	6.990
4300 4400 4500	4.535 4.540 4.544	2.674 2.693 2.712	4.570 4.574 4.578	7 639 7.648 7.657	4.550	7.027 7.044 7.060
4600 4700	4.549	2.733	4.582	7.666	4.563 4.567	7.076
4800 4900 5000	4.558 4.562 4.566	2.776 2.799 2.822	4.589	7.685 7.694 7.702	4.571 4.575 4.579	7.105 7.120 7.133
5100 5200	4.571	2.846	4.599	7.713	4.583	7.146
5300 5400 5500	4.579 4.584 4.588	2.894 2.919 2.944	4.602	7.735 7.746 7.757	4.591	7.173 7.18%
5600	4.593	2.969	4.615	7.768	4.00	7.210
5000	4.COP 4.COT	3.019	4.621	7.790	4.610	7.2%

 $\begin{pmatrix} C_{\mu} \\ \overline{q} \end{pmatrix}_{1}^{T} \cdot \begin{pmatrix} C_{\mu} \\ \overline{q} \end{pmatrix}_{1}^{T_{1}} + \frac{T - T_{1}}{T^{TH}} \begin{bmatrix} \begin{pmatrix} C_{\mu} \\ \overline{q} \end{pmatrix}_{1}^{T_{2}} - \begin{pmatrix} C_{\mu} \\ \overline{q} \end{pmatrix}_{1}^{T_{1}} \end{bmatrix}$ $F_{1} < T < F_{1} + 100 = T_{2}$

TABLE 14 REDUCED ENTROPY DIVIDED BY In T,

and a set of the Index of the set of the set

 $\begin{bmatrix} \underline{S^{p=1}} \\ \hline \\ \hline \\ \hline \\ 1n T \end{bmatrix}^{T}_{i}$

	The Article Manager	1	1		1.000 1.000
Ha	H	o.,	•	ON	N.P
2.0048	2.4003	4.5371	3.5475	3.9170	3.977
2.742	2.4193	4.3779	3.39/4	3.8783	3.983
2.7923 2.81M	2.4231 2.4201	4.2909	3.3548	3.8.39	3.98
2.8304	2.4200	4.8555	3.3041	3.8440	4.003
2.1687	8.4313	4.2427	3.8747	3.8321	4.024
8.8981	2.4334	4.2391	3.8904	3.82:8	4.030
2.9024	2.4344	4.2389	3.8403	3.8%3	4.063
2.9214	2.4358	4.2400	3.2232	3.14.50	4.090
2.939R	2.4371	4.8425	3.8094	3.1753	4.116
2.9476	2.4376 2.4382	4.2438	3.2031 3.1975	3.8266	4.132
2.9540	2.4386	4.2472	3.1992	3.6301	4.159
2.9794	2.4394	4.2509	3.1006	3.0344	4.18
2.9870 2.9941	2.4398	4.2529	3.1783 3.1743	3.8366 3.8389	4.195
3.0012	2.4405	4.2569	3.1704	3.6413	4.22
3.0148	2.4412	4.2611	3.1633	3.8461	4.847
3.0214	2.4415	4.2634	3.1601 3.1569	3.8484	4.25
3.0340	2.4423	4.2677	3.1541	3.8532	4.275
3.0461	2.4426	4.2721	3.1486	3.0579	4.300
3.0518	2.4430	4.2743	3.1460	3.8625	4.319
3.0632	2.4432 2.4435	4.2787	3.1412	3.8648	4.329
3.0739	2.4436	4.2632	3.1368	3.8698	4.347
3.0043	2.4437	4.2054	3.1348	3.8713 3.8735	4.355
3.0943	2.4442	4.2996	3.1309	3.8755	4.378
3.0992	2.4445	4.2940	3.1273	3.8796	4.300
3.1007	2.4449	4.2962	3.1257	3.8817	4.403
3.1179	8.4451	4.3024	3.1210	3.80/5	4.410
3.1867	2.44%	4.3044	3.1197	3.00%	4,427
3.1312	2.4456	4.3084	3.1169	3.8932	1.15
3.1396	2.4458	4.3121	3.1144	3.6758	4.451
3.1400	2.4462	4.3150	3.1191	1.9003	4.66
3.1519	2.4462	4.3177	3.1110	3.9000	4.470
3.1590	2.44GA	4.313	3.1070	3.7053	h.hCz
3.16%	8.4467	4.3940	3.3070	3.90%	4.60
3.1714	2.4407	4.3944	3.102	3.5118	4.4%
3.1764	2.4470	4.345	3.1043	3.91 13	6.510
	-				2
- 41	"[[:]	/	(INI)]Th	[(=)]	**
·	I.	1-31		·	I
	H: 2.1648 2.70% 2.7742 2.7923 2.8189 2.8334 2.8334 2.8334 2.8334 2.8334 2.8334 2.8334 2.8334 2.9305 2.9392 2.9214 2.9305 2.9392 2.9214 2.9305 2.9392 2.9394 2.9395 2.93960 2.93960 2.9394 2.93960 2.9394 2.93960 2.9394 3.0012 3.0012 3.0012 3.0012 3.0014 3.0217 3.0340 3.0461 3.0518 3.0575 3.0655 3.0575 3.0565 3.0575 3.0565 3.0575 3.0565 3.0575 3.0565 3.0575 3.0565 3.0575 3.0565 3.0575 3.0565 3.05757 3.05757 3.05757 3.05757 3.05757 3.05757 3	H- H 2.0648 2.4001 2.7522 2.4030 2.7522 2.4193 2.7522 2.4193 2.7521 2.4231 2.7521 2.4231 2.7521 2.4393 2.7521 2.4231 2.7521 2.4331 2.7521 2.4331 2.7521 2.4334 2.8324 2.4200 2.8324 2.4334 2.9222 2.4334 2.9222 2.4335 2.9222 2.4335 2.9222 2.4356 2.9222 2.4356 2.9222 2.4356 2.9237 2.4356 2.9256 2.4366 2.9275 2.4366 2.9778 2.4366 2.9779 2.4376 2.9779 2.4396 2.9779 2.4403 3.0012 2.4403 3.0021 2.4403 3.0021 2.4403 3.0277 <t< td=""><td>H- H 0. 2.0040 2.4000 4.9371 2.7040 2.4190 4.9371 2.7040 2.4190 4.9371 2.7742 2.4193 4.3779 2.7921 2.4193 4.3719 2.7922 2.4193 4.3719 2.7923 2.4293 4.3203 2.7924 2.4297 4.803 2.7925 2.4313 4.8203 2.9926 2.4313 4.8203 2.9927 2.4334 4.8203 2.9928 2.4334 4.8203 2.9927 2.4351 4.8493 2.9928 2.4374 4.8493 2.9929 2.4374 4.8493 2.9927 2.4376 4.8495 2.9928 2.4376 4.8495 2.9929 2.4376 4.8495 2.9927 2.4376 4.8495 2.9927 2.4376 4.8495 2.9927 2.4376 4.8495 2.9927 2.4376</td><td>H: H C. C 2.00640 2.40001 4.9371 3.5473 2.7542 2.4130 4.9371 3.5976 2.7742 2.4130 4.3779 3.3976 2.7742 2.4193 4.3779 3.3976 2.7742 2.4193 4.3779 3.3976 2.7742 2.4193 4.3779 3.3976 2.7742 2.4193 4.4273 3.5646 2.9374 2.4200 4.3592 3.3976 2.9374 2.4200 4.3592 3.2900 2.6212 2.4334 4.2403 3.2646 2.9025 2.4371 4.2403 3.2076 2.9026 2.4366 4.4300 3.2170 2.9027 2.4374 4.2403 3.2076 2.9027 2.4374 4.2403 3.2076 2.9027 2.4374 4.2403 3.2076 2.9026 2.4376 4.2403 3.2076 2.9027 2.4374 4.2509 3.1673</td><td>H- H O. C OH 2.000. 2.4010 4.3370 3.4773 3.9776 3.6775 2.700. 2.4130 4.3279 3.3976 3.6775 2.700. 2.4130 4.3270 3.3976 3.6775 2.770.3 2.4231 4.8009 3.3580 3.6413 2.6304 2.4231 4.8009 3.3590 3.6413 2.6304 2.4231 4.8009 3.8001 3.6212 2.6304 2.4231 4.2003 3.601 3.6212 2.6004 2.4324 4.2003 3.6233 3.6232 2.0024 2.4324 4.2939 3.6003 3.6233 2.0024 2.4326 4.8400 3.2031 3.6263 2.0025 2.4326 4.8403 3.0031 3.6266 2.9705 2.4326 4.8403 3.0031 3.6263 2.9705 2.4326 4.8503 3.1077 3.6263 2.9705 2.4326 4.8753 3.1</td></t<>	H- H 0. 2.0040 2.4000 4.9371 2.7040 2.4190 4.9371 2.7040 2.4190 4.9371 2.7742 2.4193 4.3779 2.7921 2.4193 4.3719 2.7922 2.4193 4.3719 2.7923 2.4293 4.3203 2.7924 2.4297 4.803 2.7925 2.4313 4.8203 2.9926 2.4313 4.8203 2.9927 2.4334 4.8203 2.9928 2.4334 4.8203 2.9927 2.4351 4.8493 2.9928 2.4374 4.8493 2.9929 2.4374 4.8493 2.9927 2.4376 4.8495 2.9928 2.4376 4.8495 2.9929 2.4376 4.8495 2.9927 2.4376 4.8495 2.9927 2.4376 4.8495 2.9927 2.4376 4.8495 2.9927 2.4376	H: H C. C 2.00640 2.40001 4.9371 3.5473 2.7542 2.4130 4.9371 3.5976 2.7742 2.4130 4.3779 3.3976 2.7742 2.4193 4.3779 3.3976 2.7742 2.4193 4.3779 3.3976 2.7742 2.4193 4.3779 3.3976 2.7742 2.4193 4.4273 3.5646 2.9374 2.4200 4.3592 3.3976 2.9374 2.4200 4.3592 3.2900 2.6212 2.4334 4.2403 3.2646 2.9025 2.4371 4.2403 3.2076 2.9026 2.4366 4.4300 3.2170 2.9027 2.4374 4.2403 3.2076 2.9027 2.4374 4.2403 3.2076 2.9027 2.4374 4.2403 3.2076 2.9026 2.4376 4.2403 3.2076 2.9027 2.4374 4.2509 3.1673	H- H O. C OH 2.000. 2.4010 4.3370 3.4773 3.9776 3.6775 2.700. 2.4130 4.3279 3.3976 3.6775 2.700. 2.4130 4.3270 3.3976 3.6775 2.770.3 2.4231 4.8009 3.3580 3.6413 2.6304 2.4231 4.8009 3.3590 3.6413 2.6304 2.4231 4.8009 3.8001 3.6212 2.6304 2.4231 4.2003 3.601 3.6212 2.6004 2.4324 4.2003 3.6233 3.6232 2.0024 2.4324 4.2939 3.6003 3.6233 2.0024 2.4326 4.8400 3.2031 3.6263 2.0025 2.4326 4.8403 3.0031 3.6266 2.9705 2.4326 4.8403 3.0031 3.6263 2.9705 2.4326 4.8503 3.1077 3.6263 2.9705 2.4326 4.8753 3.1

TABLE	15	REDUCED	EN
		THEOLER	

REDUCED	ENTROPY	DIVIDED	BY	ln	T,

т (к)	Ha	NU	н	. 00	.00
100	4.1647	4.0207	3.4077	4.3180	6.72R3
298.16	4.0424	4.4466	3.2330	4.2690	4.510
300	4.0417	4.4498	3.2329	4.169?	4.5211
500	3.9968	4.3768	3.1727	4.1100	4.5443
600	3.9071	4.3577	3.1535	4.1024	4.5723
800	3.9745	4.3358	3.1254	4.00/1	3.6312
000	3.9706	4.3254	3.1052	4.0015	4.6072
100	3.9705	4.3225	3.0959	4.0805	4.7132
300	3.9725	4.3195	3.0831	4.0800	4.7611
400 500	3.9741 3.9760	4.3189	3.0/71 3.0717	4.0023	4.7831 4.8039
600	3.9780	4.32.05	3.0666	4.0850	4.8231
.700 800	3.9802	4.3168	3.0621	4.0866	4.8422
1900	3.9847	4.3196	3.0537	4.0900	4.8767
100	3,9890	4.3207	3.0465	4.0935	4.9078
200	3.9913	4.3213	3.0432	4.0953	4.9223
400	3.9956	4.3228	3.0372	4.0988	4.9494
.900	3.9910	4.3435	3.0344	4.1004	4.9021
700	4.0019	4.3250	3.0317	4.1021	4.9859
2800	4.0038	4.3257	3.0269	4.1054	4.9971 5.0080
000	4.0077	4.3272	3.0225	4.1086	5.0185
100	4.0095	4.3279	3.0205	4.1100 4.1116	5.0286
300	4.0131	4.3294	3.0167	4.1130	5.0478
1900	4.0164	4.3309	3.0149	4.1158	5.0657
600	4.0181	4.3316	3.0118	4.1171	5.0743
800	4.0213	4.3330	3.0089	4.1199	5.0907
900	4.0229	4.3337	3.00%	4,1211	5.0986
100	4.0258	4.3350	3.0054	4.1236	5.1136
300	4.0873	4.3356	3.0044	4.1249	5.1209
400	4.0301	4.33/9	3.0025	4.1271	5.1348
600	4.0328	4.3383	3.0010	4.1294	5.1484
700	4.0341	4.3308	3.0004	4.1305	5.1545
900	4.0366	4.3400	2.9992	4.1328	5.1670
	4.03/9	4.3407	e.9900	4.1330	7.1729
200	4.0404	4.3419	2.9900	4.1350	5.1846
100	4.0415	4.3424	2.99/1	4.1368	5.1903
500	4.0439	4.3436	2.9974	4.1308	5.2013
600	4.0451	4.3441 4.3447	2.9974	4.3397 4.1407	5.2016
500	4.0473	4. 74.2	2.9774	4.3h17	5.2169
6000	4.0494	4.3463	8.997/5	4.1434	5.27/1

and the second strain and the second strain and the first second second second second second second second second

.

FLUID PROPERTIES OF SUPERSONIC COMBUSTION RAMJET SHOCKED INLET (CRITICAL CONDITION)

	FREE	FUSELAGE	DIFFUSER	DIFFUSER
	STREAM .	AIRSTREAM 1	2	THROAT 3
т (К)	200	230	1256.6	1110.5
P (atm)	.01	. 02	. 592 36	.3565
u (m/s)	1420.3	1525	281.315	652.274
M (frozen)	5	5	0.407	1.000
n	.210084	.210084	.209922	.210032
n No	.789916	.789916	.789752	.789864
n 0 ²	0	0	0	0
n N	0	0	0	0
nNO	0	0	.000326	.000104
? _{H2}	0	0	0	0
n H_0	0	0	0	0
ROH	0	0	0	0
n _H	0	0	0	0
m(g/mole)	28.853	28.853	28.853	28.853
8 (frozen)	1.4	1.4	1.319167	1.32772
S R ₂	NC	NC	29.7868	29.7862
hf abs RoTo	NC	• 556455	3.742178	3.263834
Å.,	NA	NA	1.5782	1

NC-means Not Calculated NA-means Not Applicable

and a subscription of the subscription of the

FLUID PROPERTIES OF SUPERSONIC COMBUSTION RAMJET SHOCKED INLET, $M_{1}=5$, $D_{0_{2}}^{\circ}=0.5$

	DIFFUSER EXIT 30	COMBUSTION INLET 3c	CHAMBER EXIT 4	EXHAUST NOZZLE EXIT 5
2.0				
T (K)	739	739	2428	2123
P (atm)	.0722	.0722	.0722	. 02
u (m/s)	1125.78	1125.78	1125.78	1813.105
M (frozen)	2.093	NC	1.088	1.896
N 02	.210084	.147929	.0129	.0071
1 N2	.789916	.556213	.627008	.642571
20	0	0	.004220	.000964
A NO	0	0	.004694	.001853
2H2	0	.295858	.038280	.018524
n _{H₂0}	0	0	.280390	. 318257
n OH	0	0	.019017	.0075696
N _H	0	0	.013169	.003441
M(g/mole)	28.853	NC	23.652848	24.203772
Y (frozen)	1.358717	NC	1.254343	1.253704
SR2	29.7868	NC	42.50791	42.5074
$\frac{h_{f abs}}{R_2 T_2}$	2.101288	NC	2.876558	.087128
A A ₃	1.9028	1.9028	7.6261	14.6064

100

FLUID PROPERTIES OF SUPERSONIC COMBUSTION RAMJET SHOCKED INLET, M =5, $D_{0_2}^\circ$ =2

PLASIES!

	DIFFUSER	COMBUSTION	CHAMBER	EXHAUST
	EXIT	INLET	EXIT	NOZZLE EXIT
	30	3c	4 643	5
T (K)	967	967	1656.7	931
P(atm)	.205	.205	.205	. 02
u (m/s)	870.529	870.529	870.529	1623.397
M (frozen)	1.426	NC	1.085	2.717
n	.210084	.190114	.1486	.1497
n No	.789916	.714829	•749335	.750492
no	0	0	.000024	0
n _N	0	NC	NC	NC
nNO	0	0	.002161	.000018
2 H.	0	.095057	.000007	0
n H_0	0	0	.099592	.099800
noH	0	0	.000379	0
N _H	0	0	.0000006	0
M(g/mole)	28.853	NC	27.614528	27.614592
X (frozen)	1.3373	NC	1.291421	1.330458
SR2	29.7840	NC	33.5544	33.5550
$\frac{h_{f abs}}{R_{2}T_{2}}$	2.804904	NC	3.065934	.473109
Ă Ā	1.1340	1.1340	2.0300	6.2703
3				

FLUID PROPERTIES OF SUPERSONIC COMBUSTION RAMJET SHOCKED INLET (CRITICAL CONDITION)

TAXE 2418	FREE	FUSELAGE	DIFFUSER	DIFFUSER
	STREAM	AIRSTREAM	INLET	THROAT
	8		. 2	3
т (К)	200	300	3084	2835
P (atm)	.01	. 04	3.162	1.046
u (m/s)	2840.5	2785	368.434	1014.94
M (frozen)	10	8	0.341	0.986
n 02	.210084	.210084	.16568	.17679
n N2	.789916	.789916	•752654	.761866
no	0	0	.034057	.024984
? N 8:00	0	soo 0	.000011	.000004
n NO	0	000.0	.047598	.036356
A		0 099	0	0
A H_0	0 000	0 0	0	0
N OH	0 3000	000 0	0	0
A _H		0	0	0
M(g/mole)	28.853	28.853	28.36149	28.490545
X (frozen)	1.4	1.4	1.289101	1.249
SR2	NC	NC	32.6595	32.6564
$\frac{h_{f abs}}{R_2 T_2}$	NC	. 340277	4.55986	4.065243
Å Å3	NA	NA	• 9958	1

A REAL PROPERTY AND A REAL PROPERTY AND A REAL PROPERTY A REAL PRO

FLUID PROPERTIES OF SUPERSONIC COMBUSTION RAMJET SHOCKED INLET, M =10, $\mathbf{y}_{0_2}^\circ = 0.5$

	DIFFUSER	COMBUSTION	CHAMBER	EXHAUST
	EXIT	INLET	EXIT	NOZZLE EXIT
	30	30	4	5
т (к)	2490	2490	3026.5	2223
P (atm)	.46	.46	.46	.04
u (m/s)	1514.986	1514.986	1514.986	31 34. 385
M (frozen)	1.571	NC	1.247	3.198
n 0,	.193418	.147929	.0222	.0082
n	.775113	.556213	.570000	.639646
no	.008879	0	.027032	.001414
n N	.0000004	0	NC	NC
n NO	.022589	0	.014186	.002508
1 H2	0	.295858	.075977	.022755
RH_0	0	0	.171442	.310772
ROH	0	0	.049762	.009909
N _H	0	0	.069330	.004846
m(g/mole)	28.72488	NC	21.695834	24.09626
Y (frozen)	1.290383	NC	1.273074	1.252743
SR2	32.6600	NC	41.36155	41.38221
hf abs R ₂ T ₂	3.365602	NC	4.500086	0.336135
Ă	1.3901	1.3901	2.1356	7.8505

• ;

FLUID PROPERTIES OF SUPERSONIC COMBUSTION RAMJET SHOCKED INLET, M =10, $\mathcal{Y}_{0_2}^\circ = 2$

	DIFFUSER	COMBUSTION	CHAMBER	EXHAUST
	EXIT	INLET	EXIT	NOZZLE EXIT
	3c	3c	4	5
		. 3502		
т (К)	2661	2661	2836.5	1839
P (atm)	.7			.04
u (m/s)	1300.023	1300.023	1300.023	2407.716
M (frozen)	1.302	NC	1.225	2.852
n 0,	.186028	.190114	.1162	.14697
n N2	.769139	.714829	•713782	•747921
20	.015643	0	,025328	.000332
n	.000001	0	NC	NC
n NO	.029191	0	.028587	.004120
nH2	0	.095057	.006309	.000099
1 H_0	0	0	.071173	.098709
N _{OH}	0	0	.029890	.001824
N _H	0	0	.008782	.000024
M (g/mole)	28.627296	NC	26.790837	27.59534
Y (frozen)	1.289737	NC	1.280166	1.286426
SR2	32.64504	NC	35.3137	35.31434
$\frac{h_{f abs}}{R_2 T_2}$	3.700259	NC	3.79076	1.5194
A A 3	1.0898	1.0898	1.2413	7.3824

.

FLUID PROPERTIES OF SUPERSONIC COMBUSTION RAMJET SHOCK EXPELLED (SUPERCRITICAL CONDITION)

10 2 1

CONTENT OF

BP. LEA

	FREE	FUSELAGE	DIFFUSER	DIFFUSER
	STREAM	AIRSTREAM	INLET	THROAT
		Field Hunties	2	3
т (К)	200	230	230	1107.5
P (atm)	.01	. 02	. 02	6.28
u (m/s)	1420.3	1525	1525	657.56
M (frozen)	5	5	5	1.0103
n 02	.210085	.210084	.210084	.210033
n _{N2}	.789916	.789916	.789916	.789866
20	0	0	0	0
n	0	0	0	0
nNO	0	0	0	.000101
n _{H2}	0	0	0	0
n _{H20}	0	0	0	0
n _{OH}	0	0	0	0
1 H	0	0	0	0
$\mathcal{M}(g/mole)$	28.853	28.853	28.853	28.85297
Y (frozen)	1.4	1.4	1.4	1.327386
SR2	NC	26.907	26.907	26.9061
hf abs R2T2	NC	3.496209	3.496209	17.77895
A A	NA BERBER	NA	28.1177	1

FLUID PROPERTIES OF SUPERSONIC COMBUSTION RAMJET SHOCK EXPELLED, M =5, $\mathcal{V}_{0_2}^\circ = 0.5$

	DIFFUSER	COMBUSTION	CHAMBER	EXHAUST
	EXIT	INLET	EXIT	NOZZLE EXIT
-	30	30	4	5
т (К)	754.9	754.9	2604	1234.5
P (atm)	1.395	1.395	1.395	.02
u (m/s)	1110.205	1110.205	1110.205	2356.845
M (frozen)	2.064	NC	1.046	3.215
n 02	.210084	.147929	.008	.00001
n _{N2}	.78916	.556213	.635607	.652770
20	0	0	.001783	0
n _N	0	0	NC	NC
n _{NO}	0	0	.005034	.000002
n _{H2}	0	.295858	.027711	.000021
n _{H20}	0	0	, 301 792	• 3471 96
n _{OH}	0	0	.014371	.000002
R _H	0	0	.005478	0
n(g/mole)	28.853	NC	23.98566	24.543573
¥ (frozen)	1.329684	NC	1.247582	1.285460
SR2	26.90625	NC	38.92074	38.92110
$\frac{h_{f abs}}{R_2 T_2}$	11.74239	NC	15.928338	-25.9767
A A	1.8175	1.8175	7.5414	114.7979

FLUID PROPERTIES OF SUPERSONIC COMBUSTION RAMJET SHOCK EXPELLED, M =5, $V_{0_2}^{\circ}$ =2

	DIFFUSER	COMBUSTION CHAMBER		EXHAUST
	EXIT	INLET	EXIT	NOZZLE EXIT
	Зс	3с	4	5
т (к)	936	936	1705	484
P (atm)	3.2	3.2	3.2	.02
u (m/s)	910.123	910.123	910.123	1742.997
M (frozen)	1.515	NC	1.119	3.889
n 02	.210084	.190114	.14825	.1497
7 N2	.789916	.714829	.749144	.750499
no	0	0	.000010	0
R _N	0	0	NC	NC
A NO	0	0	.002600	0
n _{Ho}	0	.095057	.000003	0
1 H20	0	0	.099657	.099800
h _{OH}	0	0	.000266	0
R _H	0	0	.0000002	0
n(g/mole)	28.853	NC	27.610155	27.613586
X (frozen)	1.33755	NC	1.289948	1.378425
SR2	26.9074	NC	30.9574	30.9551
$\frac{h_{fabs}}{R_2 T_2}$	14.79195	NC	17.73222	-5.186886
A A3	1.1983	1.1983	2.2811	54.0926

FLUID PROPERTIES OF SUPERSONIC COMBUSTION RAMJET SHOCK EXPELLED (SUPERCRITICAL CONDITION)

	FREE STREAM	FUSELAGE AIRSTREAM	diffuser Inlet	DIFFUSER THROAT
	00	1	2	3
т (К)	200	300	300	2940
P(atm)	.01	. 04	.04	272
u (m/s)	2840.5	2785	2785	1042.96
M (frozen)	10	8	8	0.999
n	.210084	.210084	.210084	.187123
nNo	.789916	.789916	.789916	.767460
no	0	0	0	.002396
nN	0	0	0	.0000005
2 _{NO}	0	0	0	.043021
n _H	0	0	0	0
n _{H_0}	0	0	0	0
noH	0	0	0	0
R _H	0	0	0	0
M(g/mole)	28.853	28.853	28.853	28.818412
8 (frozen)	1.4	1.4	1.4 27.5823	1.284703 27.5793 42.0671
SR2	NC	27.5823		
$\frac{h_{fabs}}{R_2T_2}$	NC	3.49805	3.49805	
Å ₃	NA	NA	259.3541	1

PRI

ġ

6

15

and the constant of a language

FLUID	PROPERTIES	OF	SUI	PERSO	NIC	COMBUSTION	RAMJET
SHOCK	EXPELLED,	M =1	10,	J°o2	=0.	5	

	DIFFUSER	COMBUSTION	CHAMBER	EXHAUST
	EXIT	INLET	EXIT	NOZZLE EXIT
	3c	3c	4	5
т (К)	2570	2570	3579.4	729
P (atm)	136	1 36	136	.04
u (m/s)	1480.836	1480.836	1480.836	3423.661
M (froze	en) 1.516	NC	1.176	5.969
200	.19657	.147929	.099	.0000001
n	.776561	.556213	.613449	.652778
n	.000765	0	.005079	0
2 _N	0	0	NC	NC
A NO	.026104	0	.017033	0
n _{Ho}	0	.295858	.051814	0
n _{H_0}	0	.255195	.347222	. 347222
ROH	0	0	.033965	0
R _H	0	0	.013684	0
Mig/mo:	le) 28.841937	NC	23.389112	24.543781
¥ (froz	en) 1.288146	· NC	1.245256	1.332298
SR2	27.58286	NC	33.8596	33.85376
$\frac{h_{f abs}}{R_2 T_2}$	35.67526	NC	39.433868	-28,35987
A.3	1.2303	1.2303	2.1131	603.1073
TABLE 27 DECKAR ROLDBURGO DINOBULIS TO CONTRA

FLUID PROPERTIES OF SUPERSONIC COMBUSTION RAMJET SHOCK EXPELLED, M =10, $v_0^{\circ} = 2$

	DIFFUSER	COMBUSTION C	HAMBER	EXHAUST
	EXIT	INLET	EXIT	NOZZLE EXIT
	3c	3c	4	5
т (К)	2734	2734	3110	448 (mts)
P (atm)	186	186	186	.04
u (m/s)	1309.282	1309.282	1309.282	2752.387
M (frozen)	1.300	NC	1.197	6.368
n 02	.19268	.190114	.1128	.1497
nN	.772792	.714829	.724572	.750499
n°	.001331	0	.004156	0
A N	.0000001	0	NC	NC
nNO	.033197	0 688305	.041401	0
n _{H2}	0	.095057	.001223	0
A H.0	0	0	.089893	.099800
ROH	00 4886.50	0	.015420	0
N _H	0	0	.000559	0
M(g/mole)	28.83377	NC	27.42287	27.614384
Y(frozen)	1.286661	NC	1.269813	1.385055
SR2	27.58312	NC	29.94482	29.94014
$\frac{h_{f abs}}{R_2 T_2}$	38.4437	NC	39.38418	-4.431565
A A	1.0827	1.0827	1.2950	409.7627

60

BIBLIOGRAPHY

Edse R., Ignition, Combustion, Detonation, and Quenching of Reactive Mixtures, AFOSR-TR-RF Project 3641, November, 1975

Preyss and Hearth, The Case for a Hypersonic Research Vechile, Astronautics and Aeronautics, December 1976

の一日の時代の一日の

Sims, Joseph L. Sims, Tables for Supersonic Flow Around Right Circular Cones at Zero Angle of Attack, NASA SP 3004, 1964