Angle Committee Committee

# NOTICE

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. Report No.	2. Government A	Accession No.	3. Recipient's Catalog N	NO.
ASA CR-120942			5. Report Date	
. Title and Subtitle	TOTALL ST.	ticen ann cunoun	March 1973	
ACKSWEPT IMPELLER AND OR NASA ADVANCED-CONCI	VANE-ISLAND DIFF EPTS COMPRESSOR T	EST RIG	6. Performing Organizat	tion Code
/. Author(s)			8. Performing Organizat	ion Report No.
G.L. Perrone, M.R. Holl	brook and T.M. M	lcVaugh	AT-6131-R	
.L. Perrone, M.R. non	prook, and b.m. m		10. Work Unit No.	
9. Performing Organization Name and	Address			
AiResearch Manufacturi Phoenix, Arizona 8501	ng Company of Ari O	zona	11. Contract or Grant N NAS 3-15328	lo.
			13. Type of Report and	Period Covered
2. Sponsoring Agency Name and Add	dress		Contractor Rep	ort
National Aeronautics a Nashington, D.C. 205	ration	14. Sponsoring Agency	Code	
5. Supplementary Notes				
Program Monitor, Rober	t Y. Wong, NASA I	Lewis Research Ce	nter, Cleveland, O	hio
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### FOREWORD

This is the final report covering work performed under Contract No. NAS3-15328 during the period May 1, 1970 through November 30, 1972.

This contract with AiResearch Manufacturing Company, Phoenix, Arizona, was under the technical direction of Mr. R. Wong, Lewis Research Center, of the National Aeronautics and Space Administration.

Mr. G. L. Perrone is the principal investigator and Mr. K. W. Benn, the program director. The efforts of Mr. D. Edmonds, designer, Mr. M. R. Holbrook, aerodynamicist, Mr. J. M. McVaugh, stress engineer, and Mr. G. R. Metty and Mr. G. L. Reese, development engineers, are greatly appreciated in the conduct of the program.

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### SUMMARY

This report presents a detailed description of the work performed under Contract NAS3-15328 for NASA-Lewis Research Center, Cleveland, Ohio.

The purpose of the program was to design, fabricate, and deliver a backswept impeller, a vaned island diffuser, and the components necessary to operate this compressor configuration in the NASA advanced-concepts compressor test rig developed by AiResearch under Contract NAS3-14306.

The utilization of this impeller in the NASA advanced-concepts compressor test rig will provide evaluation of two compressor-design approaches.

### INTRODUCTION

The NASA-Lewis Research Center is currently engaged in a program to study small, advanced-concept, high-pressure-ratio centrifugal compressors. As part of this program, a backswept impeller, vane island diffuser and shroud were supplied under Contract NAS3-15328 with AiResearch Manufacturing Company of Arizona. These components are for use in the NASA advanced-concept compressor test rig developed by AiResearch under Contract NAS3-14306.

The impeller supplied was aerodynamically identical to an impeller being supplied to the Air Force as Part Number 976511, but without a notch at the exit. The diffuser used in the program is a conventional vane-island design.

This report discusses the requirements and design objectives in the development of the compressor. Results from preliminary and detailed analyses as well as concluding remarks are included.

#### TECHNICAL DISCUSSION

### Task I, Aerodynamic Design

### Impeller Design

The aerodynamic design of the impeller used for this program is the same as that for Part Number 976511 used in the U.S. Air Force advanced APU, which has an AiResearch designation GTCP305-1, being developed under AFSC Contract F33615-69-C-1100. Thus no additional aerodynamic design effort was required to define it. This impeller is a scaled version of the Model TSE36-10 Impeller.

In compliance with Article XII B of Schedule Attachment of Contract NAS3-15328, the following impeller data is submitted:

- (a) Coordinates for shroud contour (R versus Z) are given in Table I.
- (b) Coordinates for hub contour (R versus Z) are given in Table II.
- (c) The polar coordinate angle theta versus meridional length is given for the shroud and hub in Tables I and II.
- (d) The average exit flow angle is 45.19 degrees.
- (e) The blade thickness distribution is given in Tables I and II.

Detail, instrumentation and assembly drawings were forwarded to NASA for approval. Hardware was ordered for all detail parts.

### Diffuser Aerodynamic Design

Since neither the Air Force diffuser or a scaled version of the 36-10 diffuser could be used, it was necessary to design a new diffuser. Two diffuser concepts were investigated. One concept was a conventional design utilizing a vane with a blunt trailing edge of sufficient thickness to allow a bolt to pass through the airfoil shape to clamp two halves together. The second concept consisted of a thin airfoil section machined on one wall and brazed to the other wall. The second design has the advantage of better vane support to prevent vane flutter in the leading edge region.

TABLE I. IMPELLER CHARACTERISTICS ALONG SHROUD

R in.	Z in.	Theta Deg	M <sub>s</sub> in.	t <sub>n</sub> in.
1.922	0.000	-12.0	0.000	0.0137
1.922	0.124	- 5.48	0.124	0.0146
1.922	0.260	1.02	0.260	0.0160
1.922	0.395	6.74	0.395	0.0173
1.924	0.530	11.59	0.530	0.0185
1.936	0.664	15.59	0.665	0.0191
1.961	0.797	18.88	0.800	0.0193
1.999	0.927	21.57	0.935	0.0193
2.049	1.052	23.78	1.070	0.0193
2.112	1.172	25.61	1.205	0.0193
2.186	1.284	27.17	1.340	0.0193
2.272	1.388	28.56	1.475	0.0193
2.369	1.481	29.84	1.609	0.0193
2.476	1.562	31.09	1.744	0.0193
2.592	1.631	32.35	1.879	0.0193
2.717	1.684	33.68	2.015	0.0193
2.850	1.722	35.15	2.153	0.0193
2.989	1.741	36.80	2.293	0.0193
3.129	1.744	38.62	2.433	0.0193
3.264	1.744	40.51	3.316	0.0193

t<sub>n</sub> = normal thickness of blade

θ=0

M<sub>1</sub>

M<sub>N</sub>

M<sub>N</sub>

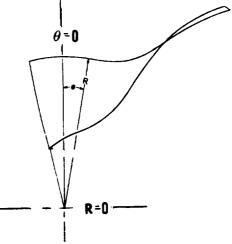


TABLE II. IMPELLER CHARACTERISTICS ALONG HUB

R in.	Z in.	Theta Deg	M <sub>n</sub> in.	$t_{ m N}$ in.
0.878	0.074	- 8.08	0.070	0.0448
0.944	0.196	0.53	0.224	0.0450
1.029	0.364	9.18	0.413	0.0469
1.115	0.526	15.61	0.596	0.0463
1.204	0.680	20.04	0.774	0.0440
1.294	0.827	22.99	0.947	0.0416
1.388	0.968	24.92	1.116	0.0397
1.486	1.103	26.15	1.282	0.0385
1.588	1.230	26.95	1.445	0.0376
1.695	1.351	27.50	1.607	0.0370
1.808	1.464	27.92	1.767	0.0370
1.929	1.568	28.31	1.926	0.0377
2.058	1.663	28.74	2.086	0.0393
2.196	1.746	29.27	2.248	0.0462
2.346	1.816	29.99	2.413	0.0462
2.506	1.871	30.95	2.582	0.0408
2.674	1.909	32.23	2.755	0.0367
2.845	1.929	33.83	2.927	0.0322
3.011	1.936	35.68	3.093	0.0277
3.169	1.937	37.71	3.251	0.0239

Note: Definition of coordinates is given in Table I.

Additional diffusion of the flow through the vaneless space was used to achieve a Mach Number of approximately 0.2 at the radius of 6.29 inches. The achievement of this Mach Number level at this radius permits direct comparison of performance maps for this compressor and the compressor designed under NASA Contract NAS3-14306, because the instrumentation can be common to both programs.

The initial diffuser design shown in figure 1 used vanes with a trailing edge thickness of 0.300-inch to allow for through-bolt clamping of the two diffuser halves. Analysis showed that this design would have high exit dump losses due to large vane-exitwake vortices. A second design, shown in figure 2, was undertaken with a vane trailing edge thickness of 0.080 inch. The area distribution for these two designs is shown in figure 3. Comparative analysis shows an 8.4-percent higher static pressure recovery for the second design (figure 4).

The Mach Number at a radius of 6.29 is 0.17, compared with 0.22 for the initial design as shown in Table III. The design at the vane trailing edge thickness of 0.080 inch was employed for this program because of better predicted vaned-diffuser performance and resistance to mechanical failure.

Table IV lists the aerodynamic geometry parameters for the selected vaned section shown in figure 5. Figure 6 lists pertinent flow parameters along with vector diagrams for the vane leading and trailing edge locations and the gauging station location. Figure 7 shows the predicted flow meanline velocity profile for each vaned passage. Figure 8 shows a detailed drawing of the selected diffuser design.

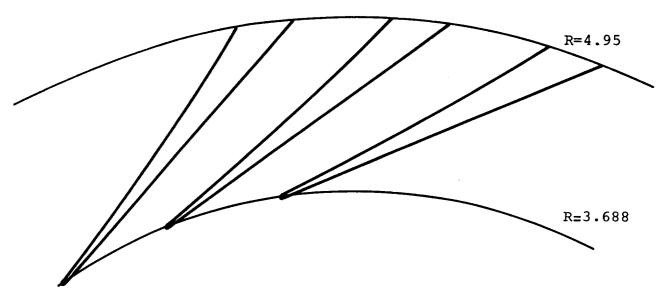


Figure 1. Initial design, 27 vanes, 0.300-inch trailing edge thickness.

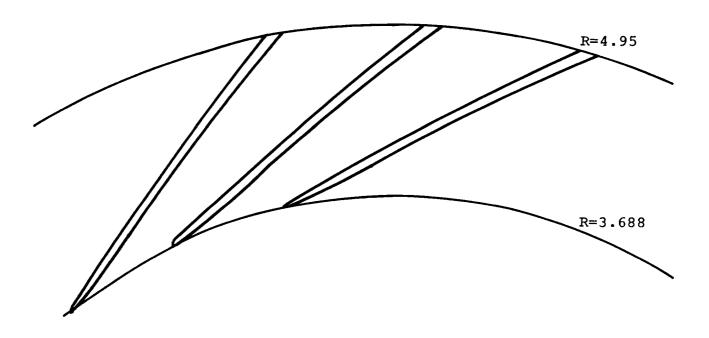
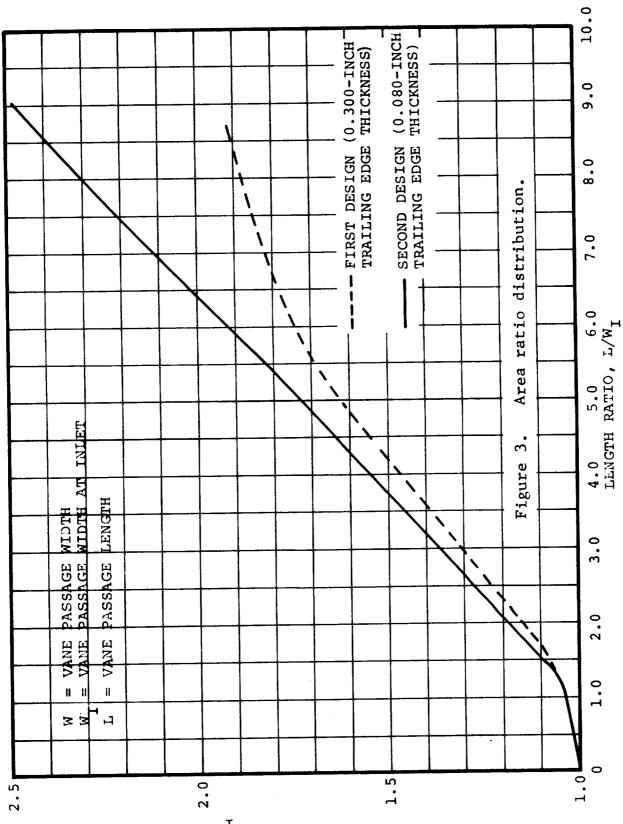


Figure 2. Second design, 27 vanes, 0.080-inch trailing edge thickness



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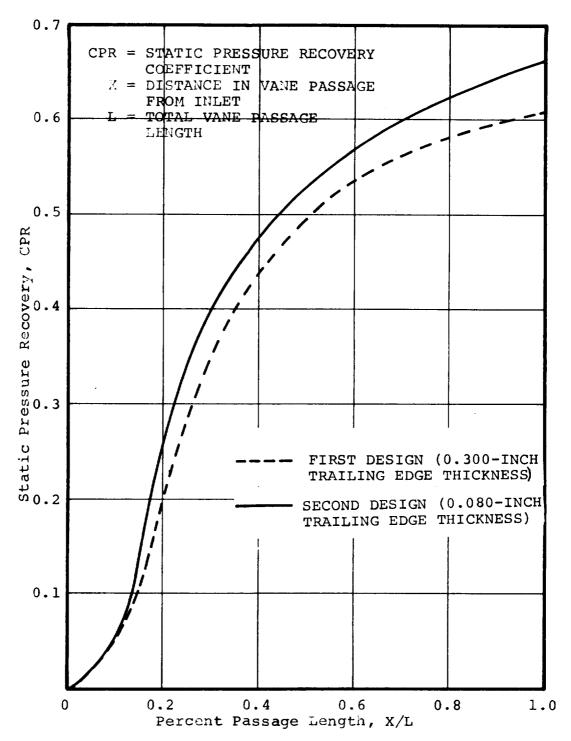


Figure 4. Pressure recovery in vaned diffuser.

TABLE III
PREDICTED DIFFUSER PERFORMANCE COMPARISON

# FIRST DESIGN, 0.300-INCH TRAILING EDGE THICKNESS VANES

Location	Radius	Mach No.	P <sub>t</sub> , Psi	P <sub>s</sub> , Psi
Vane L.E.  Vane T.E.  Measuring Station	3.688	0.855	96.406	60.049
	<b>4.</b> 95	0.298	87.4681	82.2375
	6.29	0.2193	86.8558	83.9645

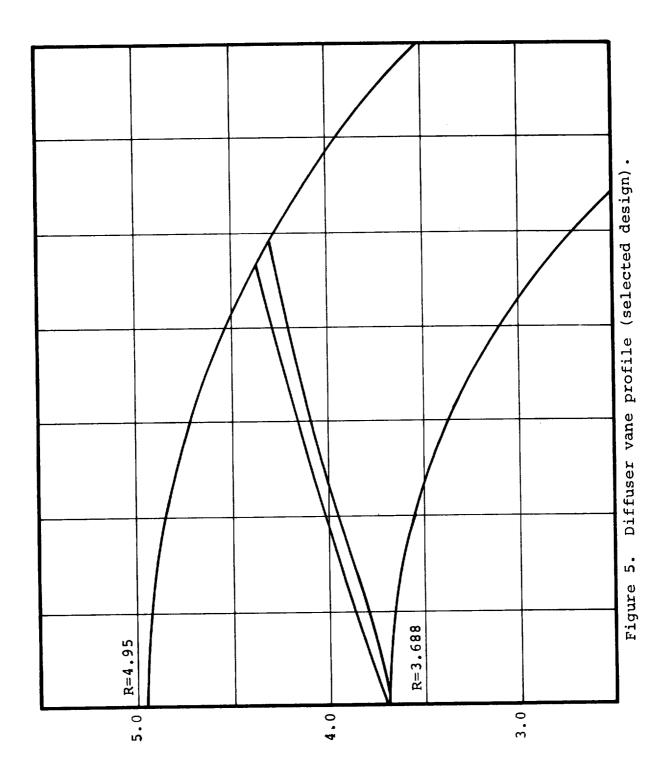
# SECOND DESIGN, 0.080-INCH TRAILING EDGE THICKNESS VANES

Location	Radius	Mach No.	P <sub>t</sub> , Psi	P <sub>s</sub> , Psi
Vane L.E.  Vane T.E.  Measuring Station	3.688	0.855	96.406	60.049
	4.95	0.226	87.1385	84.0974
	6.29	0.1704	86.8684	85.1150

TABLE IV

VANED DIFFUSER GEOMETRY (SELECTED DESIGN)

Number of vanes -	27
Radius at leading edge -	3.688 in.
Leading edge β angle -	7 <b>4.</b> 4 deg
Leading edge thickness -	0.020 in.
Throat width -	0.295 in.
Radius at trailing edge -	4.95 in.
Trailing edge β angle -	46.2 deg
Trailing edge thickness -	0.080 in.
Diffuser meridional b width -	0.211
Area ratio -	2.48



Vane Leading Edge (Outside Vane Row)

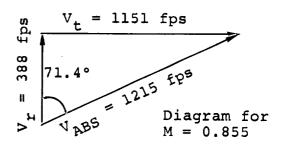
R = 3.688 in.

 $P_0 = 96.406 \text{ psia}$ 

 $T_o = 959.6$ °R

 $P_s = 60.049 \text{ psia}$ 

 $T_{g} = 837.193^{\circ}R$ 



Vane Trailing Edge (Inside Vane Row)

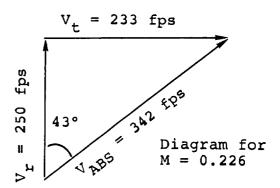
R = 4.95 in.

 $P_0 = 87.1385 \text{ psia}$ 

 $T_{O} = 959.6^{\circ}R$ 

 $P_{g} = 84.0974 \text{ psia}$ 

 $T_s = 949.898$ °R



Vaneless Space Exit

R = 6.29 in.

 $P_{o} = 86.9032 \text{ psia}$ 

 $T_{O} = 959.6^{\circ}R$ 

 $P_s = 85.1066 \text{ psia}$ 

 $T_{g} = 953.842^{\circ}R$ 

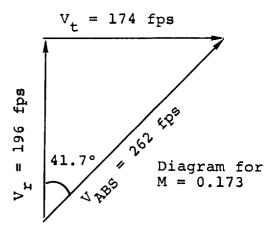
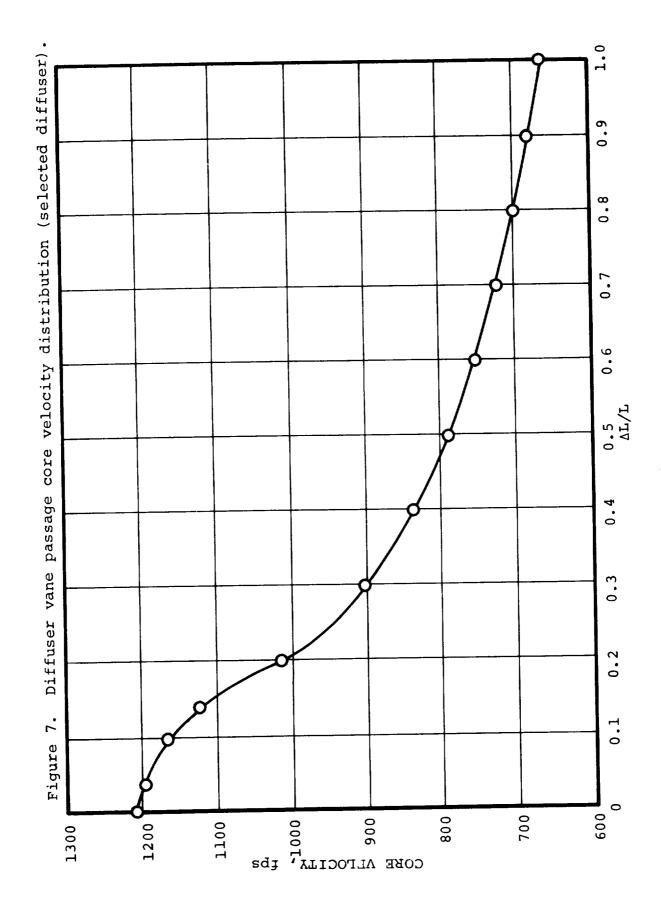


Figure 6. Vector diagrams and state conditions for selected diffuse:



# Task II. Mechanical Design

# Impeller

A stress analysis was conducted to determine thermal and centrifugal stresses of the compressor and shroud at the design operating speed, 68,384 rpm. The calculated values are shown in figure 9. A stress analysis of the impeller backface design was performed. The analysis showed stress levels to be highest at the backface near the root as shown in figures 10, 11, and 12. These stress levels, however, were well within the design stress tolerances of the impeller. The axial deflection at 80,000 rpm was 0.019 inch and the radial deflection was 0.012 inch.

# Diffuser

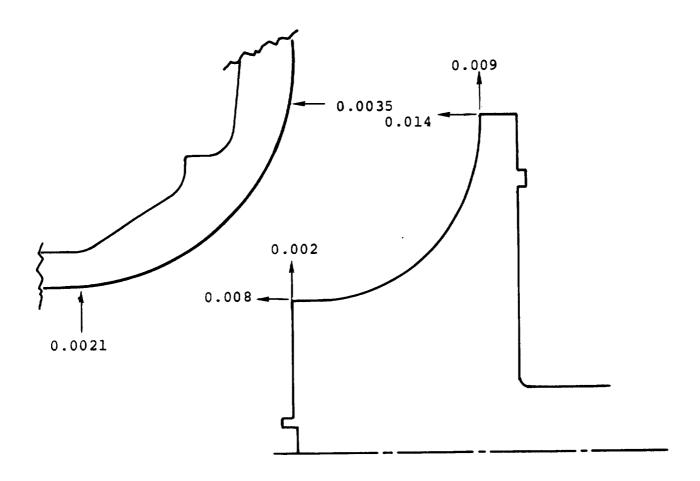
The diffuser vanes were machined as shown in figure 13. Figure 8 shows the location of the pressure taps. The two diffuser halves were brazed together and final machining was completed. Figure 14 shows the diffuser halves prior to brazing.

### <u>Instrumentation</u>

The instrumentation probe requirements for the performance mapping of this configuration are identical to the requirements of Contract NAS3-14306. Figure 8 defines the locations of the static pressure taps on the two diffuser walls. The static pressure locations on the shroud are shown in figure 15 (SKP26261).

### Thrust

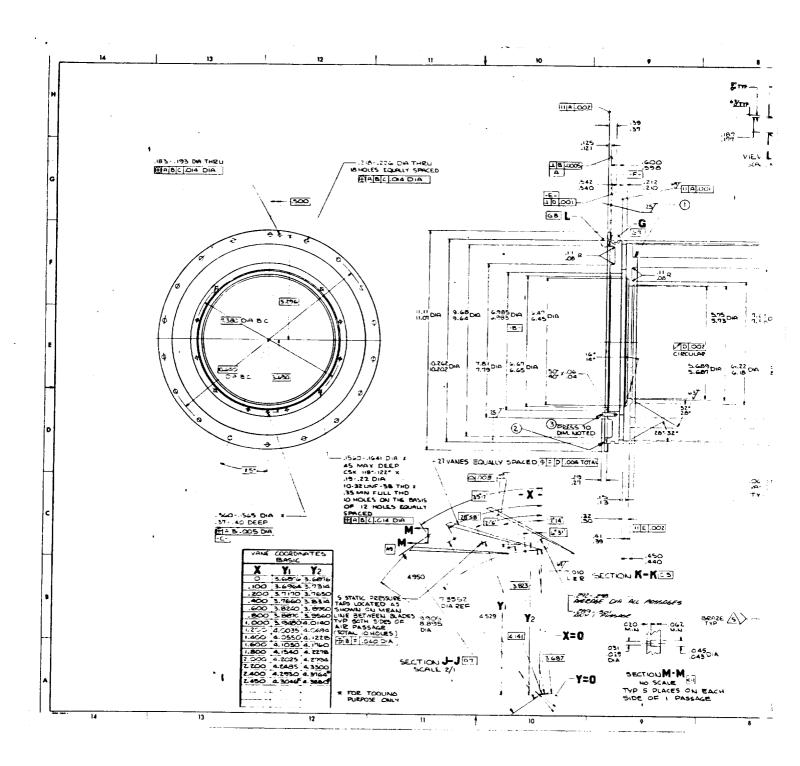
The estimated forward thrust for the compressor is 551.3 pounds. This takes into account momentum forces on the inlet, pressure forces over the inlet and shroud, and the pressure force on the back-face down to a hub diameter of 1.32 inches.

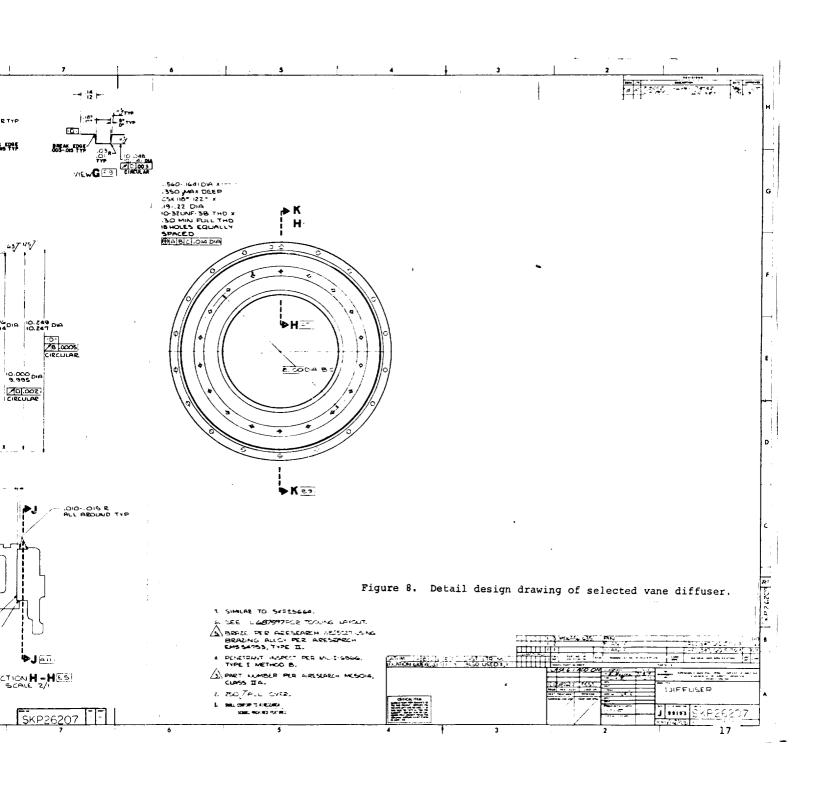


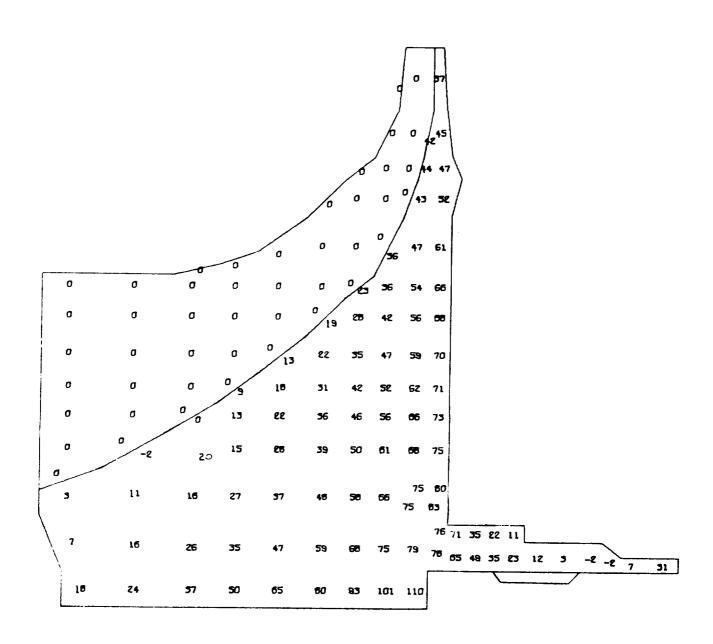
### NOTES

- 1) Deflection in inches
- 2) Radial deflections with respect to centerline
- 3) Axial deflection with respect to compressor bearings
- 4) 68,384 rpm

Figure 9. Centrifugal and thermal deflections.

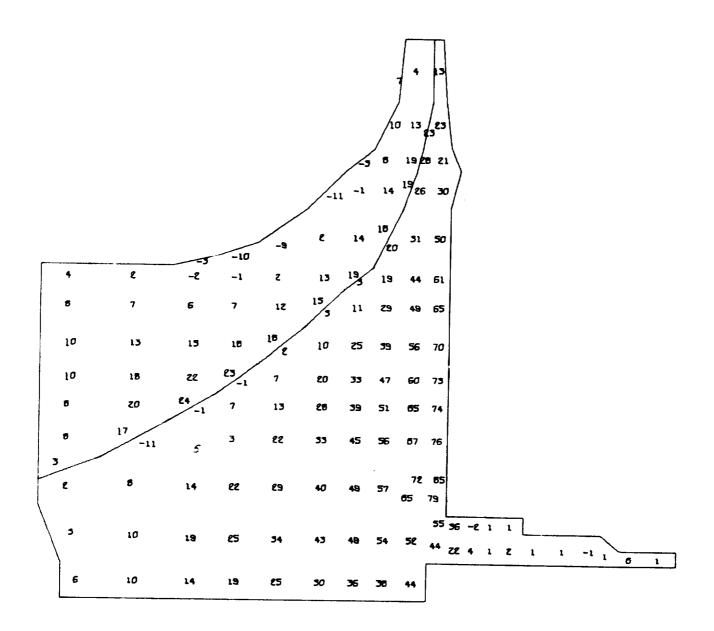






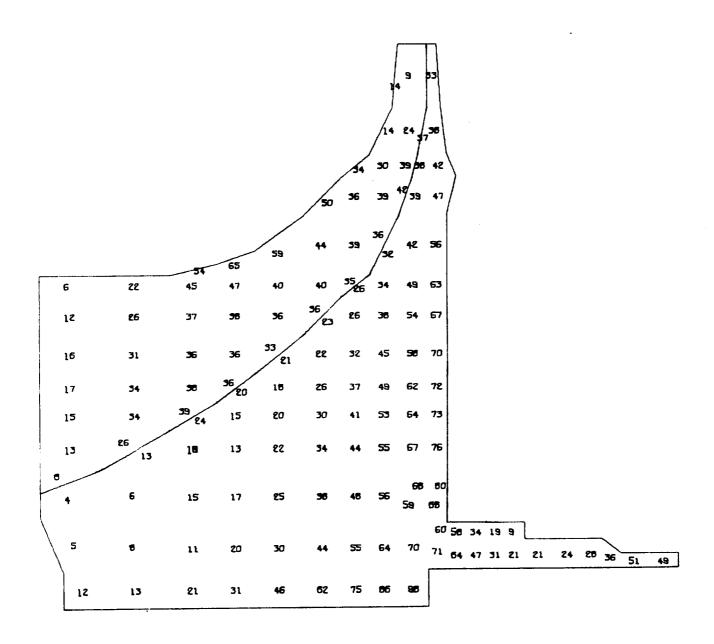
TANG. STRESS. KSI

Figure 10. Impeller stress, tangential.



RADIAL STRESS. KSI

Figure 11. Impeller stress, radial.



EQUIV. STRESS. KSI

Figure 12. Impeller stress, equivalent.



Figure 13. Diffuser machined vanes.

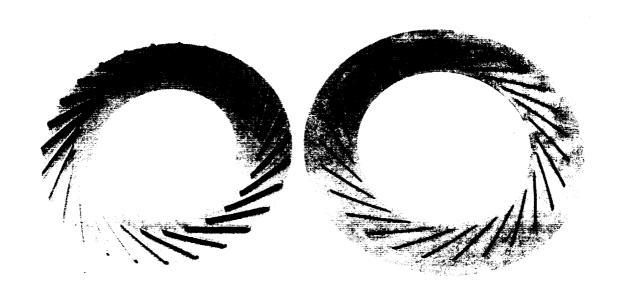
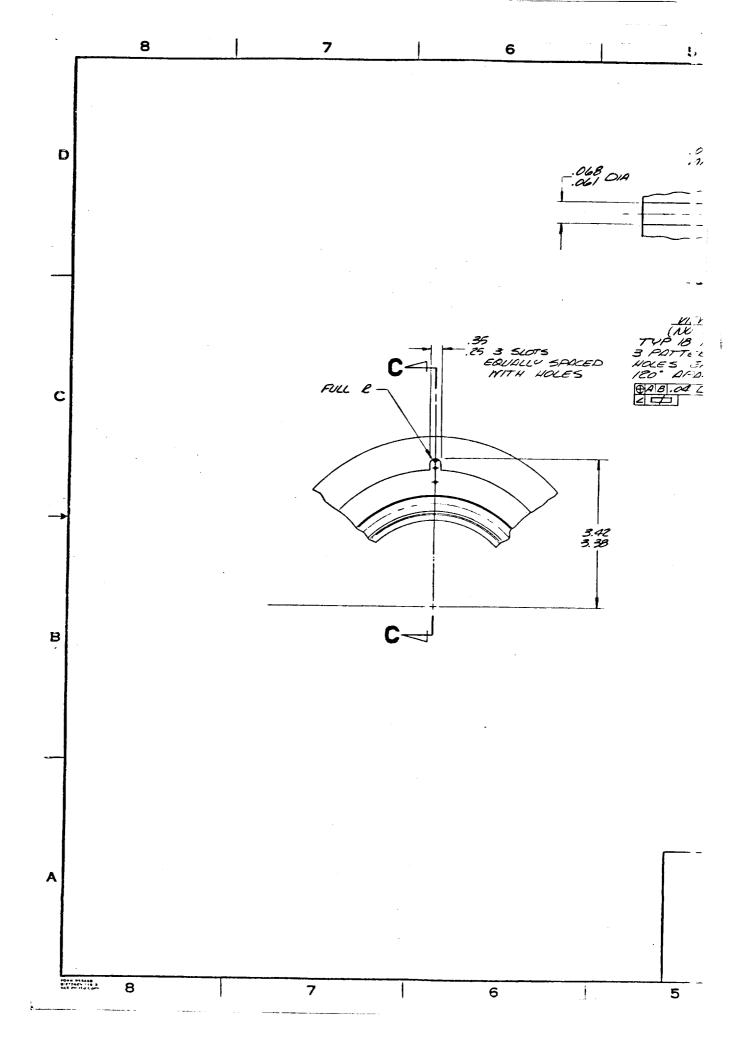


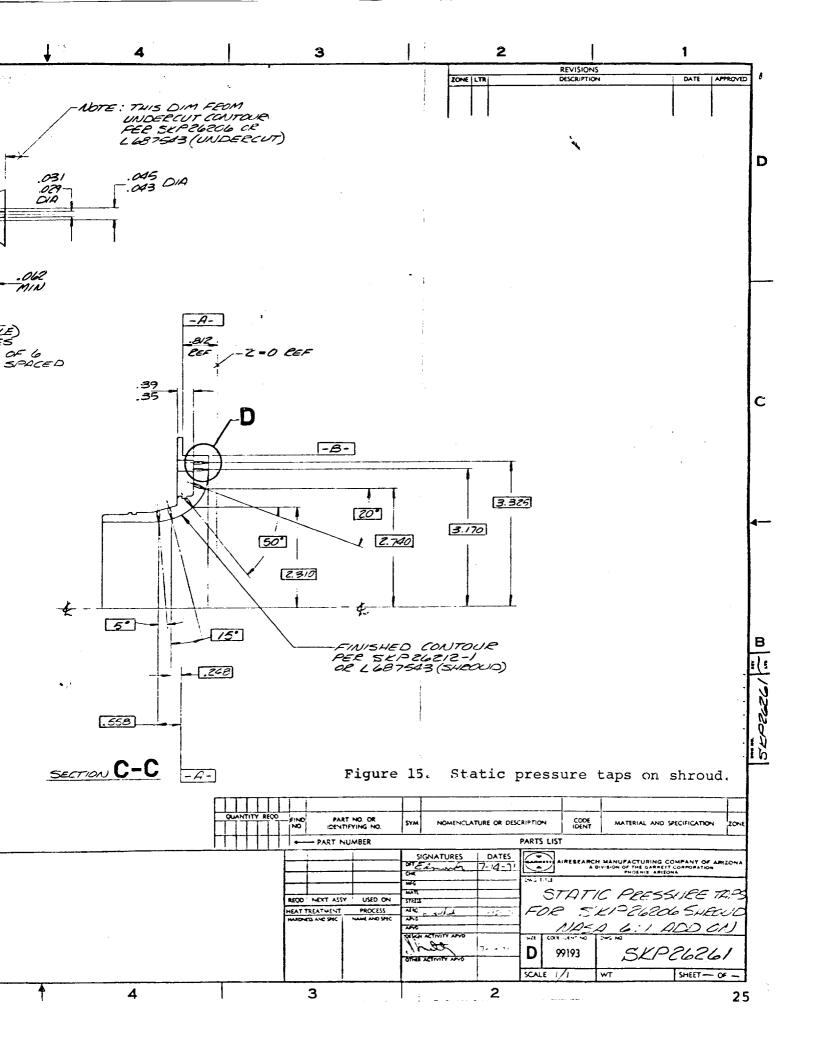
Figure 14. Test diffuser before brazing.

MP-31427

# Task III. Fabrication

A group of specialists in the Development Fabrication department participated in the finalization of detail drawings and decisions relative to manufacturing, materials, and tolerances. A Development Fabrication specialist was assigned to the program to follow the manufacturing processes and assure the hardware received the required inspection. The drawings were reviewed and primary dimensions essential to assembly were established. Critical cards reflecting these dimensions were created and used by inspection to record the observed physical dimensions. The critical cards are given in figures 16 through 30.





## Task IV. Spin Test

The impeller defined in SKP26205-1 was successfully operated to an overspeed of 112,000 rpm on 14 October 1971. Mr. Robert Wong, NASA Representative, witnessed the test. As shown on the critical card (figure 16), the dimensions before and after overspeed were:

	Before		Aft	er
Bore:	0.4117	inch	0.4145	inch
OD:	6.3388	inches	6.3418	inches

7 A	UALITY CONTROL REINSPECTION RE	-	PART NUMBER SKP 26205 C/L A PART NAME IMPELLER COMP.						
Nex	t AssemblyC/L	Final Asse	mbly JK	P2621	2-/	S/N			
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2	SEAL 0.0.	3-6	2.00			acceptable for less			
3	SEAL O.D. / L	3-6	CIRCUAR	NA					
4	BLADE LENGTH	4-F	1942	1.937					
5	FLATNESS OF NO	SE 4-6	1 C	0002 3					
6	BORE	5-6	4043	4046					
7	1 A-B	5-6	.0003	(É/000.					
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9	AC-B	5-0	.001	.0002(3)					
10	BALANCE				·T-2	4730 NOTE 5			
<b>Ins</b> p	ection Before le dering	Date <u>3</u>				Date Date			

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	Next	AssemblyC/LFin	al Asse	mbiy			_S/N			
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Figure 16. Inspection cards.

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Figure 17. Inspection report.

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	Next	AssemblyC/LFind	l Asser	mbly 5KPZGZ1Z-1 S/N _2_							
	NO.	Dimension and Location		BP FIRE	Before	After	Remark				
	ı	SHAFT 10 IMP. TIP	3-0	1.526	1.525						
	2	SEAL OD	3.4				,	1			
	3	SEAL O.D. A L	3.G	CIRCULAR	/			4			
	4	BLADE LENGTH		1.942				-			
•	5	FLATNESS OF NOSE	4-6	1 C				-			
	6	BORE	5-0	.4043	<u>:</u>	<u> </u>		4			
	7	1 AB	5-6	.0003	,0002			4			
	8	PILOT	5-0	1.4030	T			┦			
	9	AC-B	5.0	-00/	0003	ļ		4			
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Figure 18. Inspection cards.

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Figure 19. Inspection report.

	REINSPECTION RECORD	PART NUMBER XP 26205 C/L C PART NAME IMPELLER COMP						
	t AssemblyC/LFind			2-/_	_s/n ac/-2			
NO.	Dimension and Location	8 P ##	Before	After	Remark			
	SHAFT TO IMP TIP	3-0	1.576	1.5 8 1.5 8		TWO ISEN - WELDOWS.		
2	5ENC 0.0.	3.64	2.005	1-0045				
3	5011 00 1 L	3.6	CIRCULAL	0005				
4	BLADE LONGTH	1/- 1		1.94/		CONCAUS		
5	FLATIVESS OF NOSE	4.0		<del></del>				
6	ESTO	5.6		4040				
7	N 113 .	5.0	,,n <u>,n</u> ,n,g	l				
8	A Comment	370	7.700	1.4015				
9	1000	.= =.0	.00/	2003				
10	1 2776 777266				l	11.000 cm "		
Insp	Date After		と Quality _ Engine			Date		

40	ALITY CONTROL REINSPECTION RECO	ORD	PART	NAME -	- : <sub>+</sub> : ,*	
	AssemblyC/L	Final Asse	mbly			S/N ACI-2_
NO.	Dimension and Location	`	BP max.	Before	After	Remark
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Figure 20. Inspection cards.

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i&T REQU				CORR	ECTIVE AC	, ,	TO MATERIA	L REVIEW	∞be	gry.		ECTED BY	101 AL		REC. NE	P./PW0	'
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				C/A H	YES DAY	W:	RELEASED T	ED	6	,	Lille	-	отнажи	SE U.K.	<u></u>	<i>5.2 -</i>	
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LOT NO.					D	—— L	PROD.		,	·	5054500	-	RECT.	EQ. HO	III	Des.	en
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				KE	-A3UNS F	OR REJEC	TION	-	pr. Z	2 <b>C P</b>	/_	h 0	<u>.</u>	NVR	ACC	.RWK	SCP
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	-		J #/4	u:	HAVE	200	V DAD	MEED	£ A	16 Z	HIC	WAT	0.0	L			
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sk ]			7/1/	HAN				6	1/5	2000		-	·		4		
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RWK. ES		<u> </u>		4	٠,					SIG	M			DATE			
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Figure 21. Inspection report.

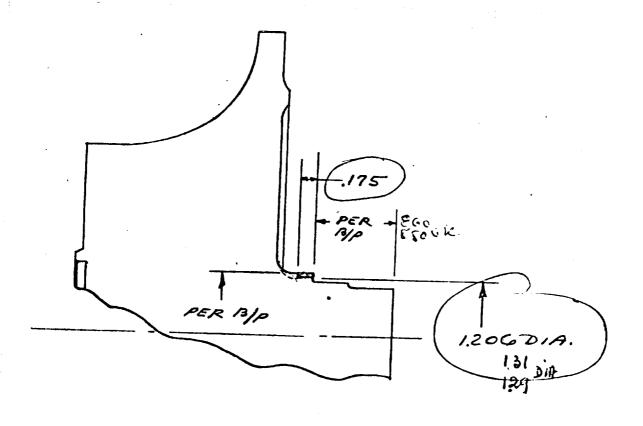
MINTOGORDON	 a a company	••	

T M	aterial	Revie	w		DATE											
				n is requested on1	7/31/72											
•		part v	vith the	discrepancies listed below.												
м.о.т.	Date No.			<del>C/L</del>	2620	)- <u>1</u>										
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ENDOR	SIGNAT	URE	Enr	2. Haguewood	DEVELOPMENT		PR	ODUC	TION [	<u></u>						
ROUP NO.	QTY.	ZONE	VIEW	DISCREPANCIES (Descri	be Fully)		NVR	ACP	RWK	SRP						
	1	4E	Sec.	D-D 1.29 - 1.31 dia. is U/S to 1	206 for a longth	- f			1							
	-	76	Jec.		ZUO für a length	OI .				<del>                                     </del>						
				.175 See attached sketch.	-											
										<u>L</u> .						
				Suggested repair: blend mis-	Suggested repair: blend miscut dia to 1.244 - 1											
				Surface with a .1820 rad		'	<u> </u>									
				Surface with a .1020 fad	ius. See skettii.											
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JUALIT	Y CONT	ROL RE	P. ,	ENGINERATING REPO 3/4/ MILITARY	REP.	DATE										
				17/72 J		<u> </u>										
	CTIVE	ACT	ON TA	KEN TO PREVENT RECURRENCE	CH SHOULD TAKE TO ASSIST IN (	RESOLVING	THE PRO	BLEM.I								
JOKKI	ORMATION	UML T.	HIS SPAC	MA, ALDO SE SEED IN DECEMBER AND ADDRESS OF THE COLUMN												
	PMATION			ncy \$3 due to human error. Operato				,								

Figure 22. Request for material review action.

Note to Vendors MR. Case No. must be shown on Packing List accompanying these parts, and no other parts are to be included on the same Packing List.

SIGNATURE:



XXX ± 005	FINISH 63	CONCENTATION TARE
Pamocy	CHECKED BY	7-24-72
ACE	INDUSTR	ES BANTA PE ETTING
SKP	26205	-"८"
ARS-PHOEL	NIX	
SCALE	MATERIAL	DRAWING NO.
FULL		5K0724-72

Figure 23. Detail sketch of SKP 26205 Impeller.

	UALITY CONTROL REINSPECTION RECOR		PART	NAME _	DIFFL	
Nex	AssemblyC/LF	inal Asse	mbly	11-12	12-1	_S/N
NO.	Dimension and Location		BP mox.	Before	After	Remark
1		7.6	10.240	10.249		
2		7.6	10000	7.998		
3	AD (REF 2 ACOVE)	7.6	1000	0005		
4		9€	5.657	5.6882		
5	AD(REFAREOUE)	9.€	100 Z			
6	DICEUSER INSTAGE CA	- 1	1001	N/A		
7	L D	10.F	1001	8005		· · · · · · · · · · · · · · · · · · ·
8	IIA	10·H	1002	NA		
9						•
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nspe	oction Before & Willacle Do	0/4/2	- Quality	Control		Date
	AfterDat	e	. Enginee	ring		

Q	NRESECTION RECORD  NECTOR OF THE PROPERTY OF T		PART	NAME _	NUET	HOUSING
	I AssemblyC/LFi	inal Asse	کت mbly	1276.71	2-1	S/N/
NO.	Dimension and Location		BP mox.		After	Remark
		1:-5	51.129	5.1266		
2	AB (Ref 1 Above)	يي يت	1001			
3		5-6	1.360	4.378		
4	AB (Rof. 3 Alova)	5-0	2001			·
5	B DIA	5-0	1.2210	4.280		
6		3.6	सुरुक्ट सुरुक्ट	3.9395		
7	A B (Ket GAbove)	شق سند	1001 CIPCULAR			
8	A SURFACE ET	5.61	1001	.00/	,	
9	A SURFACE LB	5-6	,001	.0005		
10		6.0	1.785	1.77	-	
Insp	ection Before N. Hutter Date	e <i>I-/I-7/</i>	Quality C	Control		Date

Figure 24. Inspection cards.

Qï	Research Manufo JALITY CONT REINSPE	ROL CTION REC		PART	NUMBE NAME _	RJKF BOLL	MOUTH CILA
Next	Assembly	C/L	_ Final Asse	mbly -	CP76.2	57.	S/N
NO.	Dimension and	Location		BP max.	Before	After	Remark
1	RADIU	5	60	3.96 3.92	3.94		
2	0.0.		70	12.26	12.190		
3	DIA.		SC	3.94z 3.938	3.939		
4	LENGTI	7	60	6.52	6.484	·	
5	B033 6	OCATION	50	1.24	1.254		LABEL I
6	. ·			1.24	249		CABEL Z
7	4	٠.	٠,	1.24	1.240		LABEL 3
8			<u> </u>		112.50		Mc# 08661 4
9							116 3066/ 5
10							
Inspec	ction Before	Victoria Co	Date	2/Quality	Control		Date

67.	Ai Q l	Research Manufacturing Cornp JALITY CONTROL REINSPECTION RE					MOUTH CILMS
		AssemblyC/L	Finol Ass			//-/	S/N
L	NO.	Dimension and Location		BP mox.	Before	After	Remark
	1	LADIUS OF BEL	<b>c</b> .	3,750	3.750		COX INST. PRWG.
	2	OVERALL LENGTH		7.500	7 296		"
	3	BORE DIA		3.250	3.753		.,
	4	BOSS LOCATION		1.270	1.273		CABEL 1
	5			1.270	1.271		LABEE Z
	6	· ·		1.270	1266		LABEL 3
	7	OUTSIDE DIA		11.25	11.240		DOWN TO
	8						
٠, ]	9						
	10		/ D.				
1	Inspe	ction Before Ac Sturfing					
		After	Date	Enginee	ring		Date

Figure 25. Inspection cards.

	IALITY CONTROL REINSPECTION RECOR					(2) JEVIL
	AssemblyC/LF	<u>inal Asse</u>			121	S/N
NO.	Dimension and Locution		BP max.	Before	After	Remark
1		3-0	14.341 16.341	16.343		
2	A SUPERICE LB	4.0	·CO:2-	0005	_	
3	il A	5-0	-2005	10.5		MR# 24340
4		5.0	15053 15050	15,950		
5	A A (REF Q. NEOVE)	5.0	INCLYNAL	.0005		
6						
7		,			<del></del>	
В						
9						
10						
Inspec	ction Before de Mucesau Dal	e <u>6-2-7</u>	≥ Quality	Control		Date

Next	REINSPECT Assembly		 I Asse	mbly	172865	17.1	SIN SIN
	Dimension and Loca			8 P max.	Before	After	Remark
1			 5-C	12.603 12.603	13.602		
2							
3							
4							<del></del>
5							
6		· · · · · · · · · · · · · · · · · · ·				,	
7							· · ·
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Figure 26. Inspection cards.

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_0	AIR C								BUYER					LINE		DAT	re 6	. 5	-72
		PROG	RAM		P. O. NO.		ITEM	REC. REPURT N P. W. G. BEAL 1	0660	8		9-00- 9-00-		•	PART OR	ASSEM -26	2/	0-1	N
A	/A)S	SA	6-	,	PURCHASE RE	G. NO.		P. W. C. BERL 1	40,		TRANSFI	ER TO RELE	EASE		TOTAL OF	100	CETÉ	_	
18.T	REQU	IRED	TYPE.		CORRECT	TIVE ACTI	ON	TO MATERIAL	REVIEW	COOK 1	QTY.	INS	PECTED	BY .		1	REC. RE	P./PW0	
	CMR_				C/A REQU	JESTED:	١	RELECTED PO	R REWORK	4					NOT DAT	_			
•					WRITEN	REPLY RE	Q'D:	MELECTED - 1	BCRAP	5					STOK		7	6/-	
					C/A NOTE		<b>':</b>	A RELEASED TO	,	6			NI	lc	OTHERWY			i, O. W. I	
					SIGN	NC	_	EA'G	DISP		1	HUF			INSP AP	PROVA		,	
LOT	NO.				PROD.		PR	RE PROD	00	/	R	ESEARCH			REPL'Y	EQ. NO	•		
GP.	T	ZONE	CODE			ONS FO				6	77	/		0		NVR	ACC	RWK	SCP
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MATERIAL REVIEW

Figure 27. Inspection report.

67	Q I	Research Manufacturing Company of A UALITY CONTROL REINSPECTION RECORD		PART PART	NUMBE NAME 2	R <i>JKP</i> :	262/2_C/L_
	Next	AssemblyC/LFine	ol Asse	مرتشر mbly	ے لئدرہ		S/N
	NO.	Dimension and Location		BP mox.	Before	After	Remark
	-		14D	4.7477	4-146		
	2	AB	14 D	,000 Y			
	3	CONTOUR CHARTS			-003		174 350/
	4			<u> </u>	, –		
l	5						
	6						
	7						
ı	8				•		
1	9						
	10						
	Inspe	ction Beforeateateateate	7.20-	Quality Engineer	Control		Date

Vex:	AssemblyC/LFin-	al Asse	mbly Fr	VAL		S/N
NO.	Dimension and Location		BP MOX.	Before	After	Remark
ı		140	4,7475	4.7463		
2	AB	14 D	1	n/A		
3	Coistour CHARTS					ITR331
4						, , , ,
5						
6						
7	• .	_				
8						
9						
0						

Figure 28. Inspection cards.

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VENDOR		1611.				1	ים	RAVEL F	ARTS		ſ	_ 6TOP	PARTS			
NAME AND			6320		ALES INC	ĺ 🚤	7		•					2	C // 1	Ω
ADDRESS	Pha	MALT	ARIZ	er c	105.		AIR	EREARCH M	AMUTASTU	RING G	THPAN	Y DF 48120	3NA	3	541	. U
DISPO. C						เมเล	CT	ION 1	IR AP	SF	:R [	REPO	ΩТ		•	
AIR OPE				PAR	T LOCATION								PA		0	
PR	OGRA'A		P. O. NO.	ITEM	REC. REPORT NO	BUYER	4.	K1257	ER		LINE		DA	TE	7-21	.72
			374/12 Pundika 10.	01/	1.542	<u> </u>		RELATED S	8 c/ 8 to 801			5K	ASSEM	27	2 4	12/2
NASI	131		14. P. 05842	- 3549	<u> </u>			<u> </u>			·	50	904/	2 /	9559	
I&T REQUIRE	D TYPE		CORRECTIVE AC		TO MATERIAL	REVIEW	ως ε 1	qtv.	INS	PEGTEC	BY.	TOTAL	ITV. ON	'r.C <sub>a</sub> h	EF./FW	,
RR/CMR			C/A REQUESTED:	2:0	PREUESTED PO	REWORK	4					AS TOLA	re			
			WRITTEN REPLY	REQ'D:	S REJECTED - 8	CRAP	5		<del> </del>			DUTE			EXT CPI	ध्य्
			C/A NOTED BELO	NO W-	O RELEASED TO		<del>-</del> 6	<del>  ,                                   </del>	/ /	/		•ार्ट री	120 0.R		6/-	
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SP GTY, ZO	VE CODE		REASONS P	OR REJE	CTION		or. C	25 6	/		0		NVR	AGG	RWK	SCP
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Figure 29. Inspection report.

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Figure 30. Inspection report.

## DISCUSSION OF RESULTS AND CONCLUDING REMARKS

A four-task program culminating in the delivery of a high pressure ratio compressor stage has been completed by the AiResearch Manufacturing Company of Arizona.

In Task I, a centrifugal impeller based on an existing AiResearch design was defined. In addition a vaned diffuser was designed to match this impeller and also be compatible with an existing test rig previously delivered to NASA.

Task II consisted of the mechanical analysis of the design provided in Phase I to insure its mechanical integrity.

In Task III, all hardware was procured and inspected to insure conformity with design tolerances.

In accordance with contractual requirements, Task IV was an overspeed test of one of the impellers fabricated under this program. This successful test was witnessed by a NASA representative.

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