DESIGN AND FABRICATION OF A BRAYTON-CYCLE TURBINE RESEARCH PACKAGE

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONTRACT NAS 3-2778

AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION

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FINAL REPORT

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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SUMMARY

The NASA-Lewis Research Center is presently engaged in an investigation of the turbomachinery components of Brayton-cycle space power systems using solar or nuclear energy as the heat source and an inert gas as the working fluid. Under Contract NAS3-2778, three pieces of hardware are to be designed and developed. The hardware will be used by the NASA for the Brayton-cycle investigation and includes the following:

> <u>Compressor and Turbine Research Packages</u> - The two research packages each include a cold gas model of a high-performance radial wheel and a suitable set of running gear with oil-lubricated bearings. Both research packages are to be used to evaluate component aerodynamic performance.
>
> <u>Gas Generator</u> - This unit combines the turbine and compressor of the two research packages into a single hot unit with the running gear, including gas-lubricated bearings. The gas generator will be used to evaluate the Brayton-cycle turbomachinery in a complete system ground test loop.

This report describes the selection of the system design point and the design, fabrication, inspection, and testing of the compressor research package. The compressor design points for the research package is:

Working fluid	Argon
Mass flow rate, $\overset{o}{m}$ - lbs per sec.	0.621

Compressor inlet temperature, T_1 - ^oR	520
Compressor inlet pressure, P_1 - psia	6.0
Compressor pressure ratio, r_c	2.30
Design operating corrected speed, $N/\sqrt{\theta}$-rpm	37,900

$$\theta = \frac{T_1}{518.7}$$

The research package consists of a 6-inch-diameter compressor wheel and shaft mounted on ball bearings and the associated mounting hardware.

Development testing of the compressor consisted of running the uncut development impeller with three diffusers--a nominal diffuser, a negative 3-degree diffuser, and a positive 3-degree diffuser. After mapping with the three diffusers, the impeller was cut back and run with the nominal and the positive 3-degree diffusers. After the final impeller configuration was determined, acceptance testing of the shipping units was accomplished. The first shipping unit was run for three speed lines and the second shipping unit was operated at design speed for 1.2 hours.

At the conclusion of the compressor research package development two conclusions are evident:

(a) A high-efficiency radial compressor can be designed to operate on inert gas.

(b) At the design point, the efficiency can be accurately predicted (predicted $\eta = 0.798$, test $\eta = 0.80$).

DESIGN AND DEVELOPMENT OF A HIGH-PERFORMANCE BRAYTON-CYCLE COMPRESSOR RESEARCH PACKAGE

1.0 INTRODUCTION

This report describes the design, fabrication, inspection, and testing of a Brayton-cycle compressor research package that will be used to evaluate the aerodynamic performance of Brayton-cycle compressors. The compressor was designed for high-efficiency, low-Reynolds-number operation with an inert gas used as the working fluid. With the recent development of Brayton-cycle space-power systems, high-efficiency, low-Reynolds-number type turbomachinery has only recently been required and, therefore, no prior work on turbomachinery of this type has been accomplished.

The compressor research package consists of a 6-inch-diameter radial compressor wheel and shaft mounted on ball bearings with the associated mounting hardware. Notable features of the compressor research package include the advanced aerodynamic design procedures and the utilization of extremely thin blade sections. The same design goals have been used in a 6-inch-diameter turbine research package developed for NASA under the same contract and a 3.2-inch-diameter compressor developed for the Air Force [Contract AF33(657)-11721].

With the development of the compressor research package, the feasibility to design high-efficiency radial compressors for operation on inert gas has been proven. Test results on the compressor research package when tested on argon indicated efficiencies in excess of 0.81 total-to-total.

2.0 SELECTION OF DESIGN CONDITIONS

Figure 1 shows a schematic of the NASA Brayton-cycle space power system. Contract NAS 3-2778 calls for the development of the gas generator package, a turbine research test package, and a compressor research test package, with the same turbomachinery used in the test packages as in the gas generator. As specified by the contract, the gas generator and research test packages have identical design conditions when corrected mass-flow rates are compared. Table 1 presents a summary of the design conditions as specified by the contract. In addition to the conditions listed in Table 1, the most important remaining system variables include:

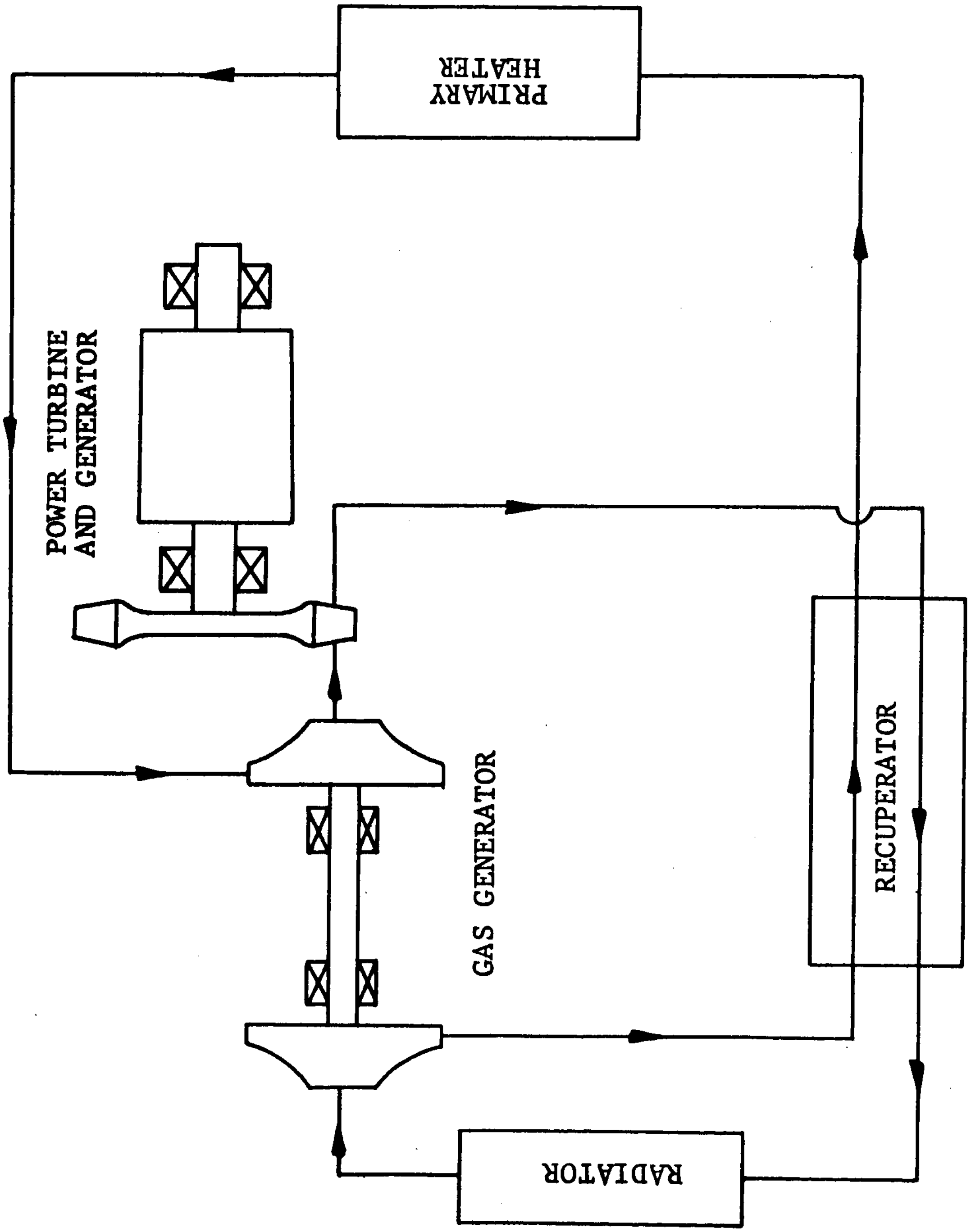
(a) Recuperator effectiveness, E_R

(b) Pressure loss parameter, r_t/r_c

(c) Shaft speed, N

(d) Compressor specific speed, N_{S_c}

As the recuperator effectiveness is increased, the cycle thermal efficiency and mass-flow rate increase and the optimum compressor pressure is reduced. The low compressor pressure ratio, in turn, leads to higher compressor efficiency. Moreover, at low power levels, the increased mass-flow rate is beneficial to the turbomachinery as a result of the higher attendant Reynolds number in the turbine and compressor. Since increased recuperator effectiveness lowers both the radiator inlet temperature and



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NASA BRAYTON-CYCLE-POWER SYSTEM

FIGURE 1

TABLE 1

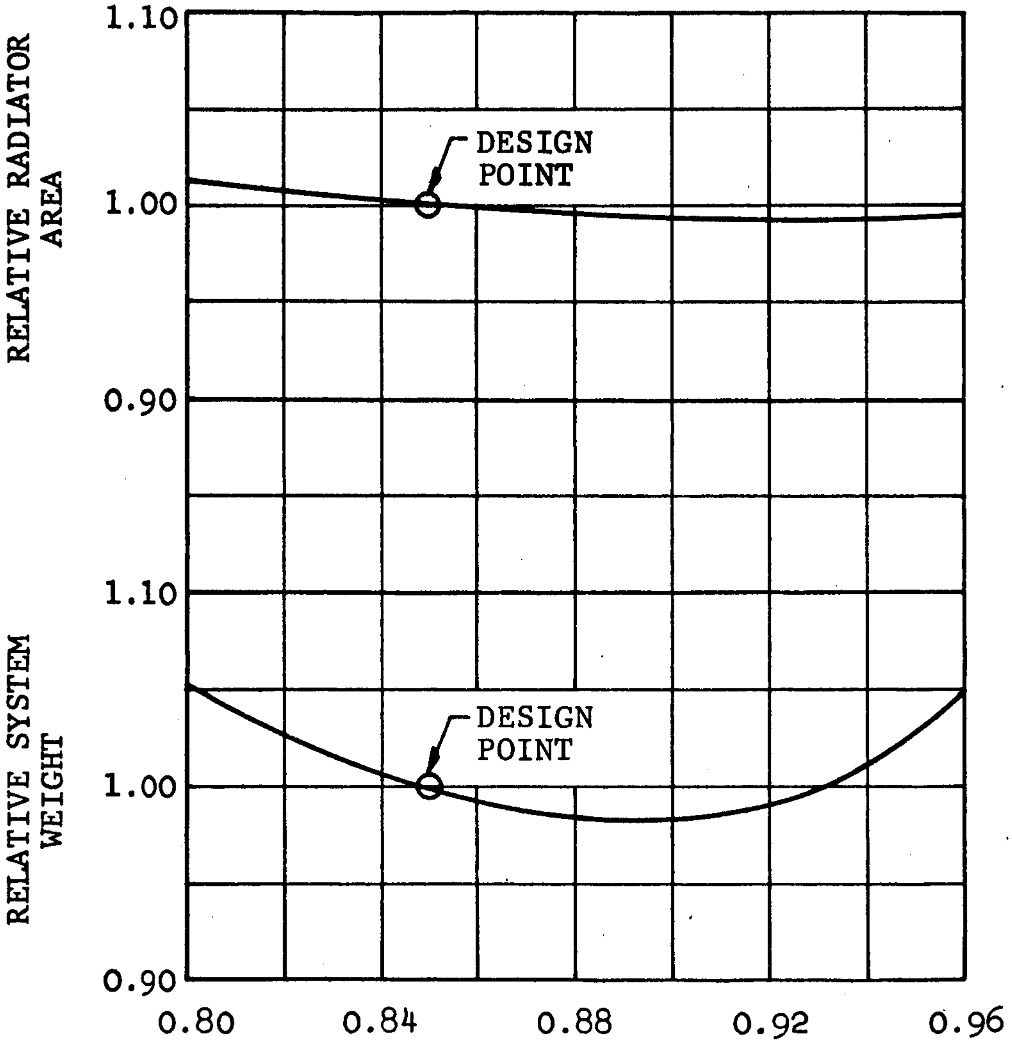
DESIGN PARAMETERS FIXED BY CONTRACT NAS 3-2778

	Turbine Package	Compressor Package	Gas Generator
Working fluid	Argon	Argon	Argon
Mass flow rate, $\overset{o}{m}$ -lbs per sec.	1.184	0.621	0.611
Turbine inlet temperature, T_3, °R	520	-	1950
Turbine inlet pressure, P_3, psia	13.2	-	13.2
Turbine pressure ratio, r_{t1}	1.56	-	1.56
Compressor inlet temperature, T_1, °R	-	520	536
Compressor inlet pressure, P_1, psia	-	6.0	6.0
Compressor pressure ratio, r_c	-	2.30	2.30
Corrected mass flow rate:			
$W\sqrt{\theta}/\delta$ turbine, lbs per sec.	1.3185	-	1.3185
$W\sqrt{\theta}/\delta$ compressor, lbs per sec.	-	1.5214	1.5217

the heat load, the radiator area is not strongly affected. Referring to Figure 2, the optimum recuperator effectiveness is established by a weight tradeoff between the recuperator and other components. Although a recuperator effectiveness of 0.9 appears to be optimum, a value of 0.85 has been chosen in view of the mass flow rate and compressor pressure ratio being specified.

The effect of the cycle pressure-loss parameter on system performance is shown in Figure 3. Although a value of 0.95 would be near optimum for the pressure-loss parameter, the value chosen was 0.90. This value allows increased flexibility, since the heat exchangers and manifolds would have to be designed for extremely low pressure drops if a pressure-loss parameter of 0.95 were utilized.

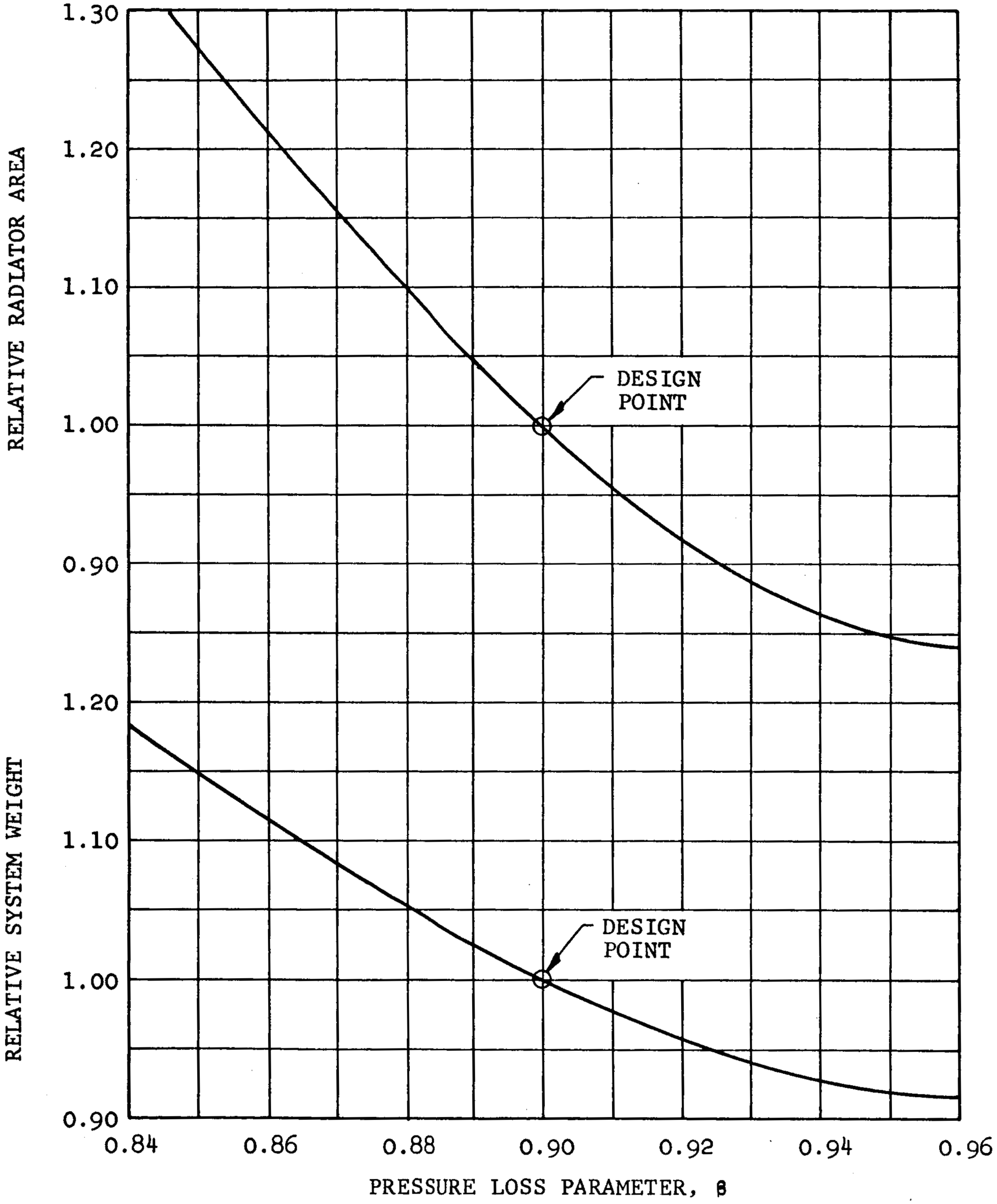
With the design point conditions listed in Table 1, a recuperator effictiveness of 0.85, and a pressure-loss parameter of 0.90, a design-point study was conducted to establish the gas generator thermodynamic and aerodynamic operating conditions. Figures 4 and 5 illustrate the variation of wheel diameters, component and cycle efficiencies, component specific speeds, and turbine pressure ratio over the range of shaft speeds with the turbine and compressor matched. (A list of the symbols used throughout this report can be found on page 10.) Wheel diameters of 6 inches occur for both the turbine and the compressor at a shaft rotational speed of 38,500 rpm with reasonable adiabatic efficiencies for the units. With this size wheels, manufacturing tolerances can be readily maintained to provide aerodynamic passages with surfaces that are hydraulically smooth.



RECUPERATOR EFFECTIVENESS - R_E

VARIATION OF SYSTEM WEIGHT AND RADIATOR AREA
VERSUS RECUPERATOR EFFECTIVENESS

FIGURE 2

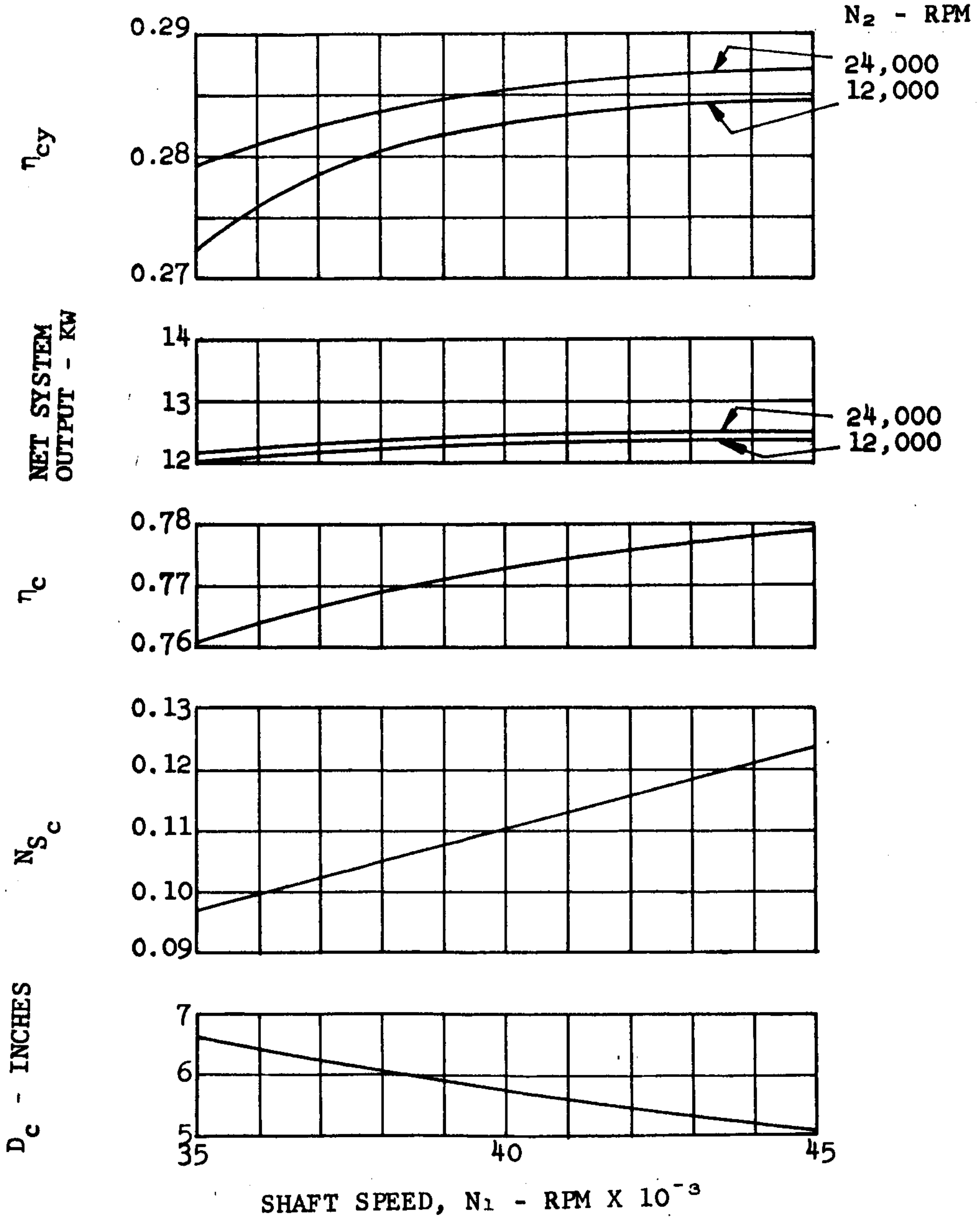


VARIATION OF SYSTEM WEIGHT AND RADIATOR AREA
VERSUS PRESSURE LOSS PARAMETER
FIGURE 3

COMPRESSOR INLET TEMPERATURE, T_1 = 536°R
TURBINE INLET TEMPERATURE, T_3 = 1950°R
RECUPERATOR EFFECTIVENESS, E_R = 0.85
WORKING FLUID = ARGON

$\frac{\text{TURBINE PRESSURE RATIO}}{\text{COMPRESSOR PRESSURE RATIO}}$, β = 0.90

COMPRESSOR PRESSURE RATIO, r_c = 2.30
COMPRESSOR INLET PRESSURE, P_1^c = 6.0 PSIA
MASS FLOW RATE, $\dot{m}$ = 0.611 LBS PER SEC

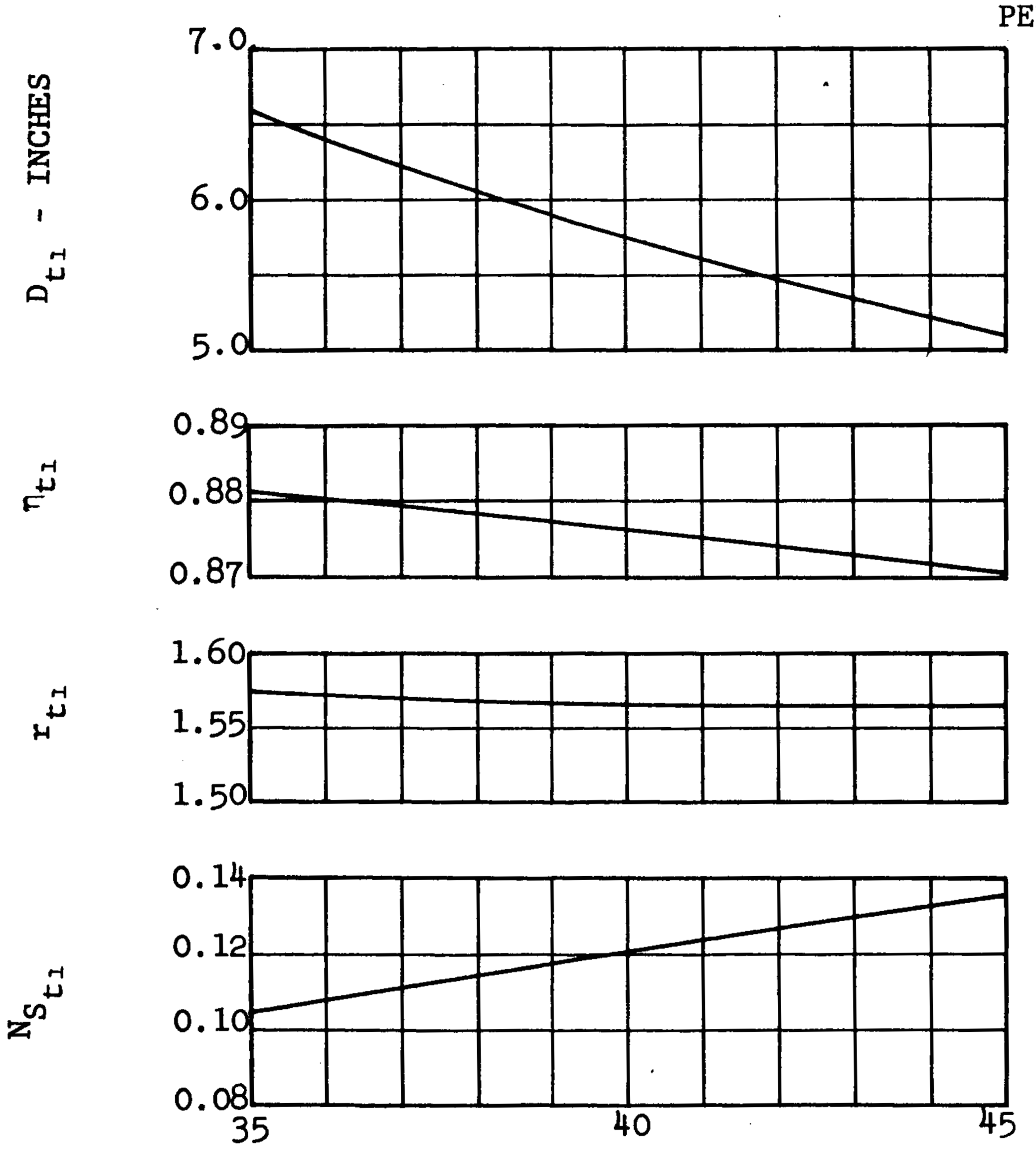


COMPRESSOR DESIGN
NASA DESIGN POINT
FIGURE 4

COMPRESSOR INLET TEMPERATURE, T_1 = 536°R
TURBINE INLET TEMPERATURE, T_3 = 1950°R
RECUPERATOR EFFECTIVENESS, E_R = 0.85
WORKING FLUID = ARGON

$\frac{\text{TURBINE PRESSURE RATIO}}{\text{COMPRESSOR PRESSURE RATIO}}$, β = 0.90

COMPRESSOR PRESSURE RATIO, r_c = 2.30
COMPRESSOR INLET PRESSURE, P_1 = 6.0 PSIA
MASS FLOW RATE, $\dot{m}$ = 0.611 LBS PER SEC



SHAFT SPEED, N_1 - RPM X 10^{-3}

FIRST STAGE TURBINE
NASA DESIGN POINT
FIGURE 5

LIST OF SYMBOLS

g = conversion factor = 32.2 ft lb per lb sec.^{2}
$\overset{o}{m}$ = molal gas flow rate, lbs mol per sec.
r_c = compressor pressure ratio
r_{t_1} = gas-generator turbine pressure ratio
r_{t_2} = power-turbine pressure ratio
D_c = compressor-wheel diameter, inches
D_{t_1} = gas-generator turbine-wheel diameter, inches
E_R = recuperator effectiveness
M = molecular weight, lbs per lb mol
N_1 = gas-generator shaft speed, rpm
N_2 = power-turbine shaft speed, rpm
N_{S_c} = compressor shaft speed
$N_{S_{t_1}}$ = gas-generator turbine specific speed
$N_{S_{t_2}}$ = power-turbine specific speed
P_1 = compressor inlet pressure, lbs per sq ft
P_3 = gas-generator turbine inlet pressure, lbs per sq ft
R = universal gas constant = 1545 ft-lbs per lb-mol ^oR
T_1 = compressure inlet temperature, ^oR
T_3 = gas-generator turbine-inlet temperature, ^oR
$\beta = \dfrac{\text{turbine pressure ratio}}{\text{compressor pressure ratio}} = \dfrac{r_{t_1} \times r_{t_2}}{r_c}$

LIST OF SYMBOLS (Contd.)

γ = ratio of gas specific heats = 1.667 for monatomic gases

θ = $(\gamma - 1)/\gamma = 0.4$ for monatomic gases

$\eta_{cy} = \dfrac{\text{power-turbine shaft power output}}{\text{gas-cycle input rate}}$

η_c = compressor adiabatic efficiency

η_{t_1} = gas-generator turbine adiabatic efficiency

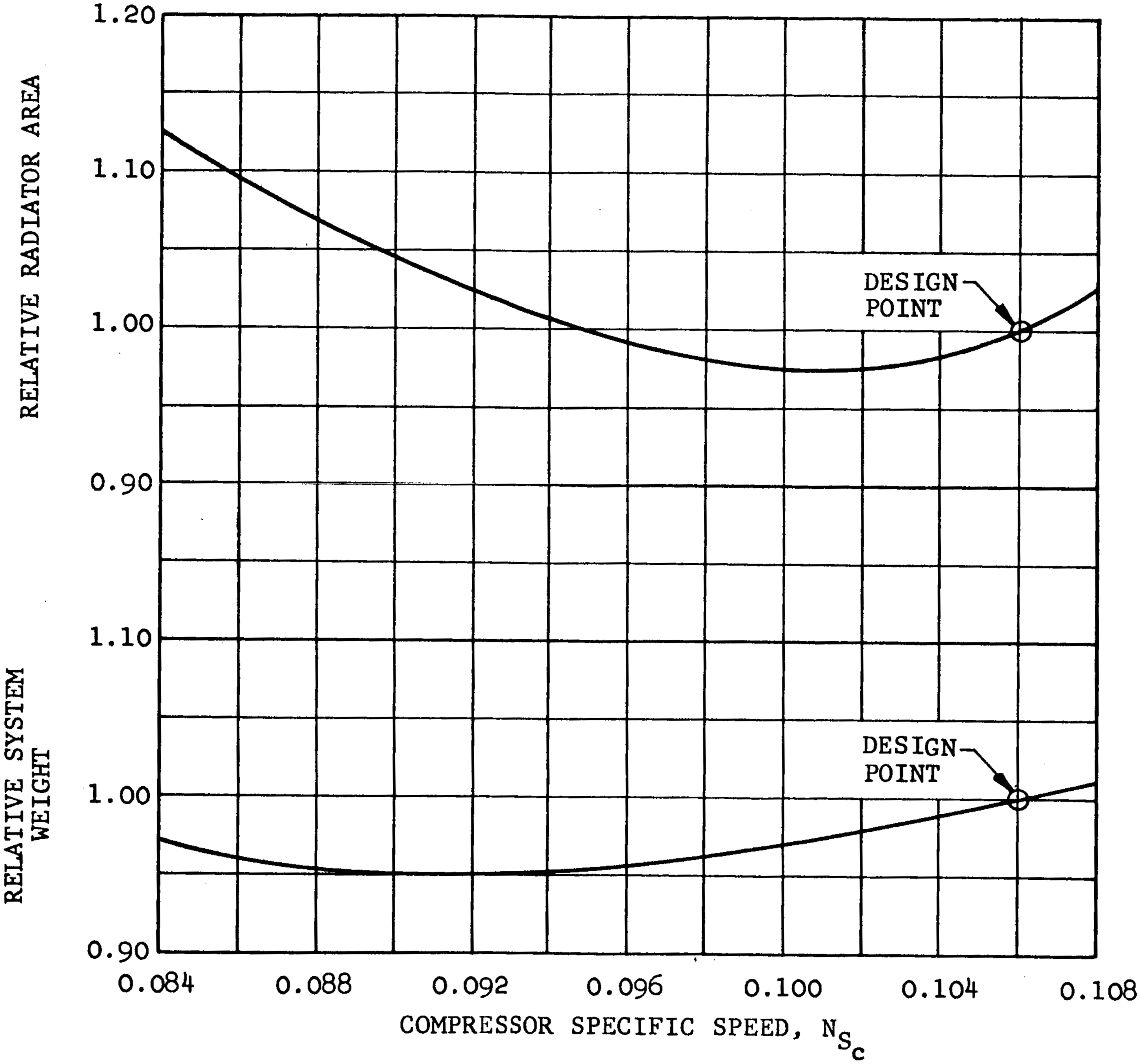
η_{t_2} = power-turbine adiabatic efficiency

A low compressor specific speed results at the shaft speed of 38,500 rpm, and the cycle efficiency is not seriously reduced from that which would be obtained at higher shaft speeds and smaller wheel diameters. The variation of system weight and radiator area versus compressor specific speed is shown in Figure 6. A compressor specific speed of 0.09 is near optimum based on the consideration of system weight; based on the consideration of both system weight and radiator area, the optimum specific speed is approximately 0.096. From the expression for compressor specific speed

$$N_{S_c} = \frac{N}{60} \left(\frac{1}{RT_1}\right)^{1/4} \left(\frac{\dot{m}}{P_1}\right)^{1/2} \left[\frac{(\gamma - 1)M}{\gamma g(r_c^{\theta} - 1)}\right]^{3/4}$$

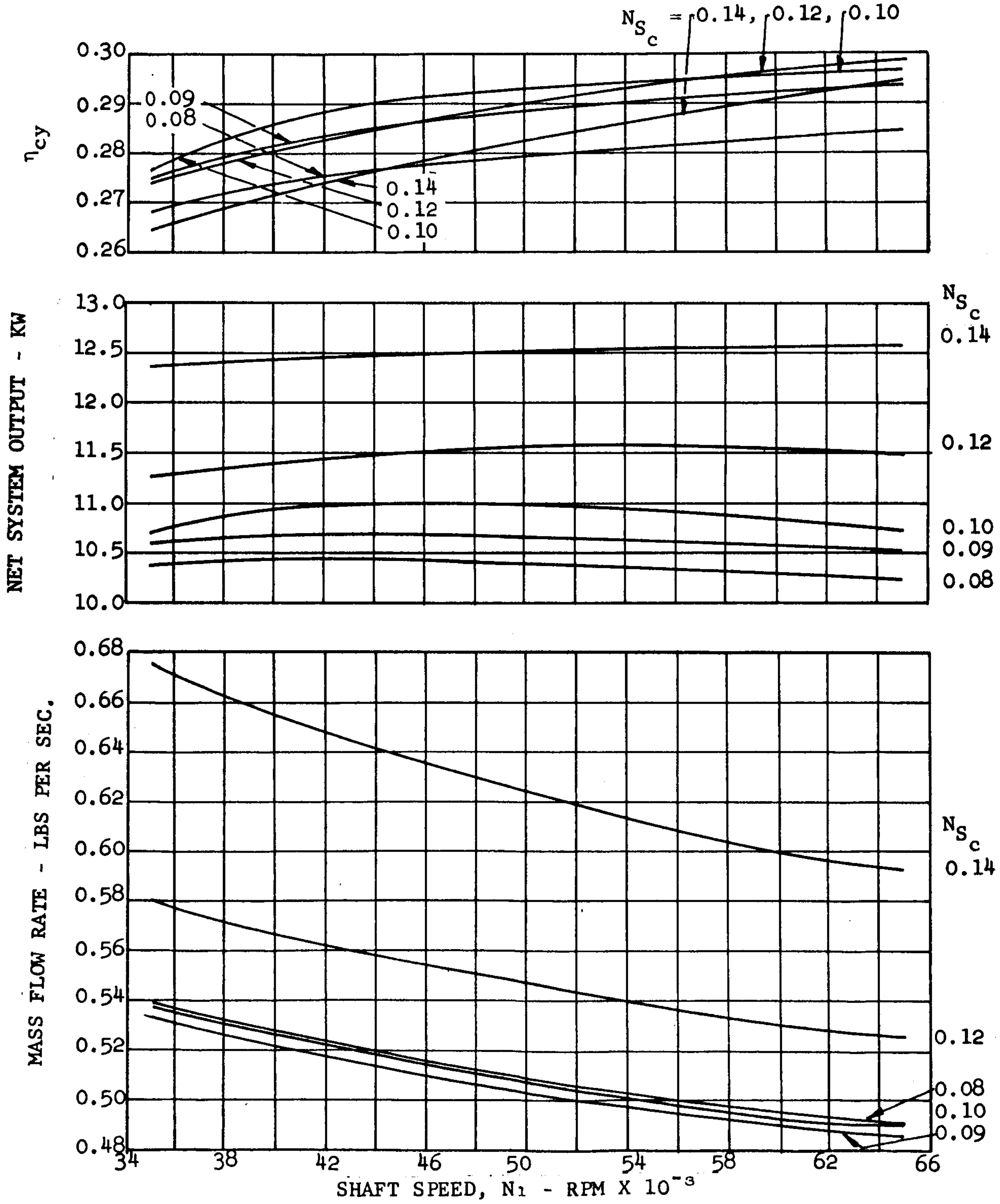
it can be seen that the compressor specific speed is a function only of shaft speed, since the remaining variables are fixed by the contract. Therefore, the shaft speed selected is nearly optimum for the specified conditions. A lower shaft speed would result in a more desirable compressor specific speed, but the wheel sizes would be unnecessarily large and the slow speed could result in bearing problems.

Additional computer runs were made with variable cycle pressure level, mass flow rate, and compressor pressure ratio (variable compressor specific speed) over a gas-generator speed range of 35,000 to 65,000 rpm with a free-turbine shaft speed of 24,000 rpm. These calculations were made to supply added insight into the design-point examination and are summarized in Figures 7 through 11.



VARIATION OF SYSTEM WEIGHT AND RADIATOR AREA
VERSUS COMPRESSOR SPECIFIC SPEED
FIGURE 6

COMPRESSOR INLET TEMPERATURE, T_1 = 536°R
TURBINE INLET TEMPERATURE, T_3 = 1950°R
RECUPREATOR EFFECTIVENESS, E_R = 0.85
WORKING FLUID = ARGON
$\frac{\text{TURBINE PRESSURE RATIO}}{\text{COMPRESSOR PRESSURE RATIO}}$, β = 0.90
FREE TURBINE ROTOR SPEED, N_2 = 24,000 RPM



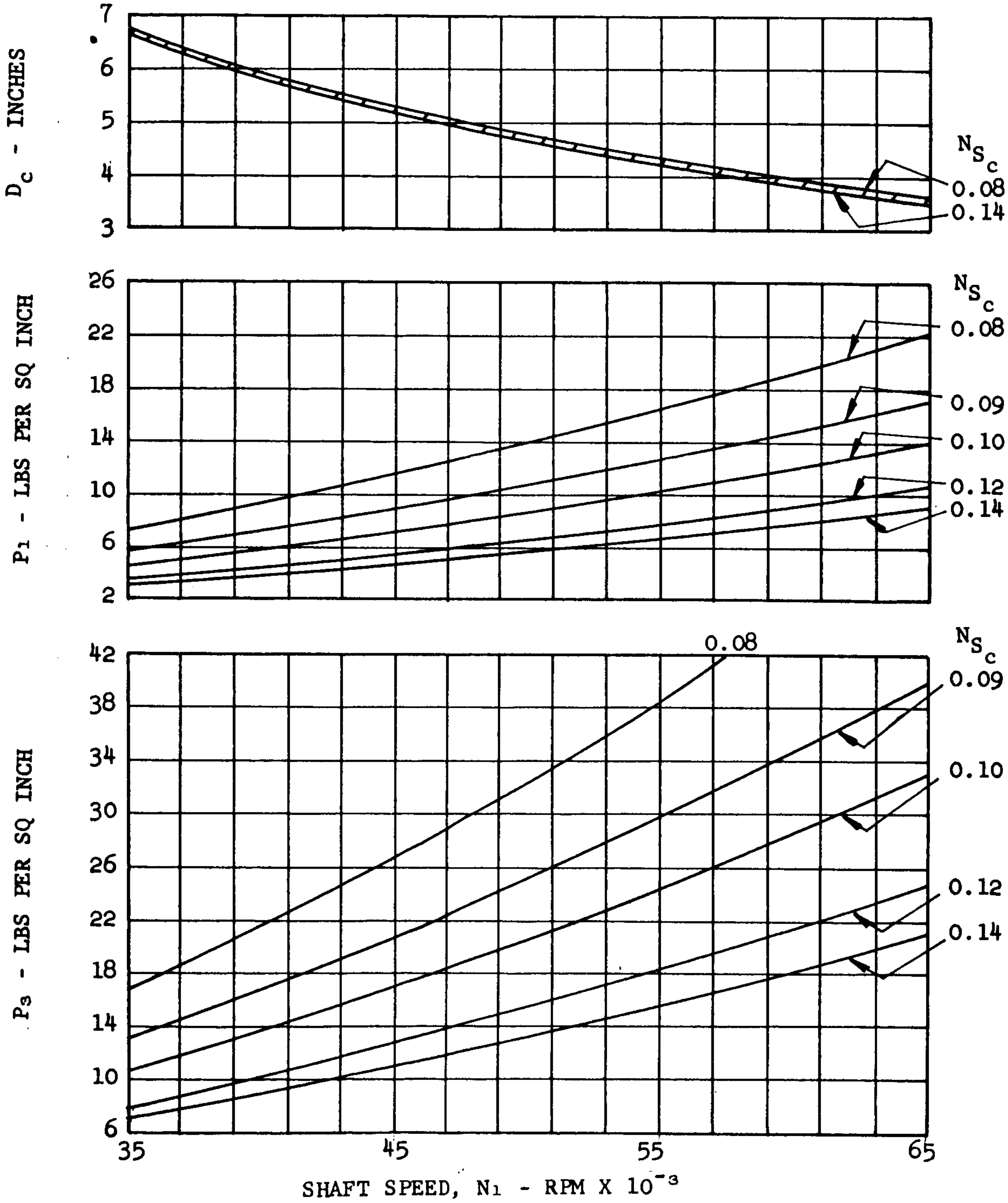
OPTIMIZED NASA SYSTEM

A31494-1

FIGURE 7

COMPRESSOR INLET TEMPERATURE, T_1 = 536°R
TURBINE INLET TEMPERATURE, T_3 = 1950°R
RECUPERATOR EFFECTIVENESS, E_R = 0.85
WORKING FLUID = ARGON

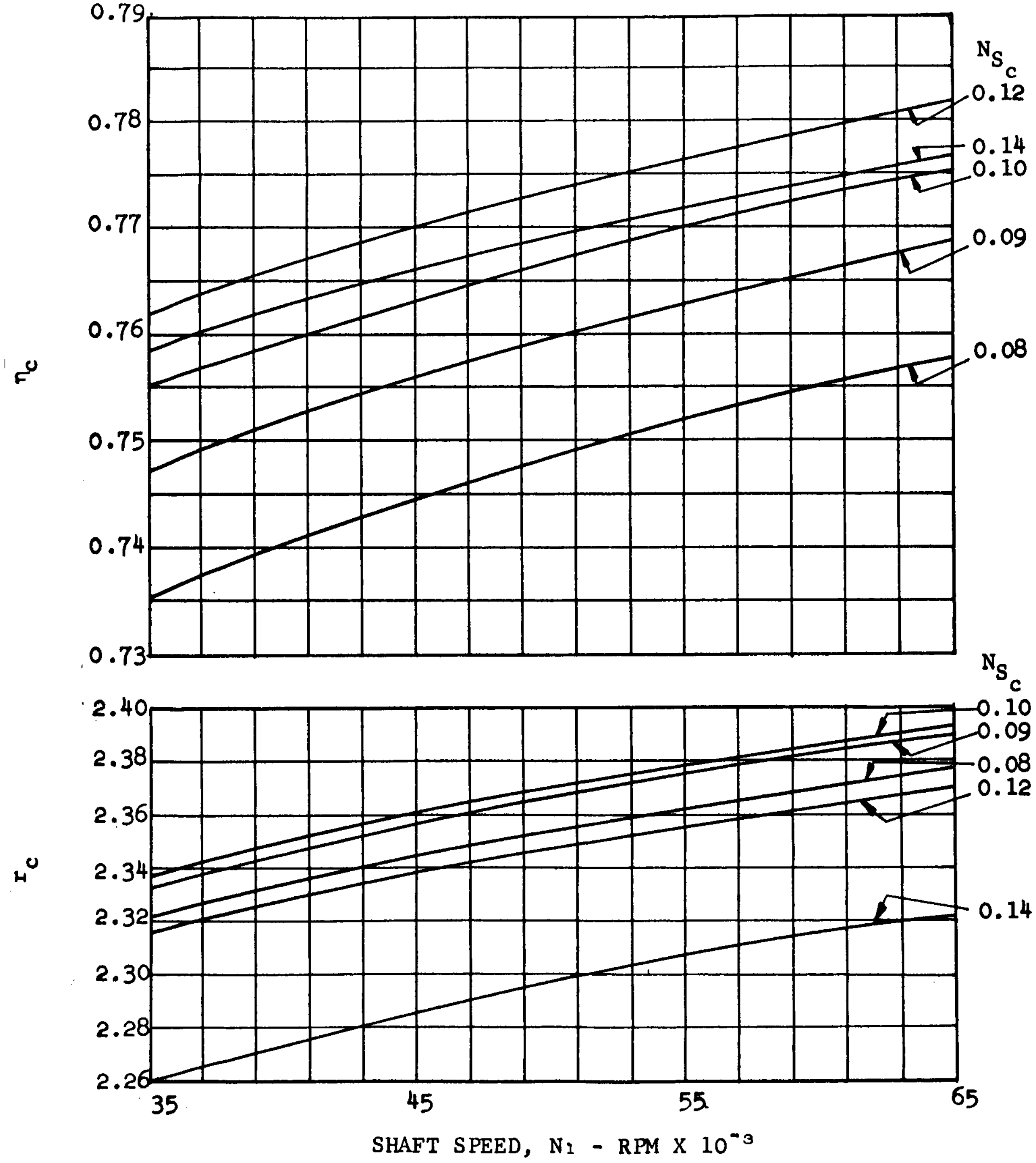
$\frac{\text{TURBINE PRESSURE RATIO}}{\text{COMPRESSOR PRESSURE RATIO}}$, β = 0.90



COMPRESSOR DIAMETER, COMPRESSOR INLET PRESSURE AND TURBINE INLET PRESSURE FOR OPTIMIZED NASA SYSTEM
FIGURE 8

A31495-1

COMPRESSOR INLET TEMPERATURE, T_1 = 536°R
TURBINE INLET TEMPERATURE, T_3 = 1950°R
RECUPERATOR EFFECTIVENESS, E_R = 0.85
WORKING FLUID = ARGON
$\frac{\text{TURBINE PRESSURE RATIO}}{\text{COMPRESSOR PRESSURE RATIO}}$, β = 0.90

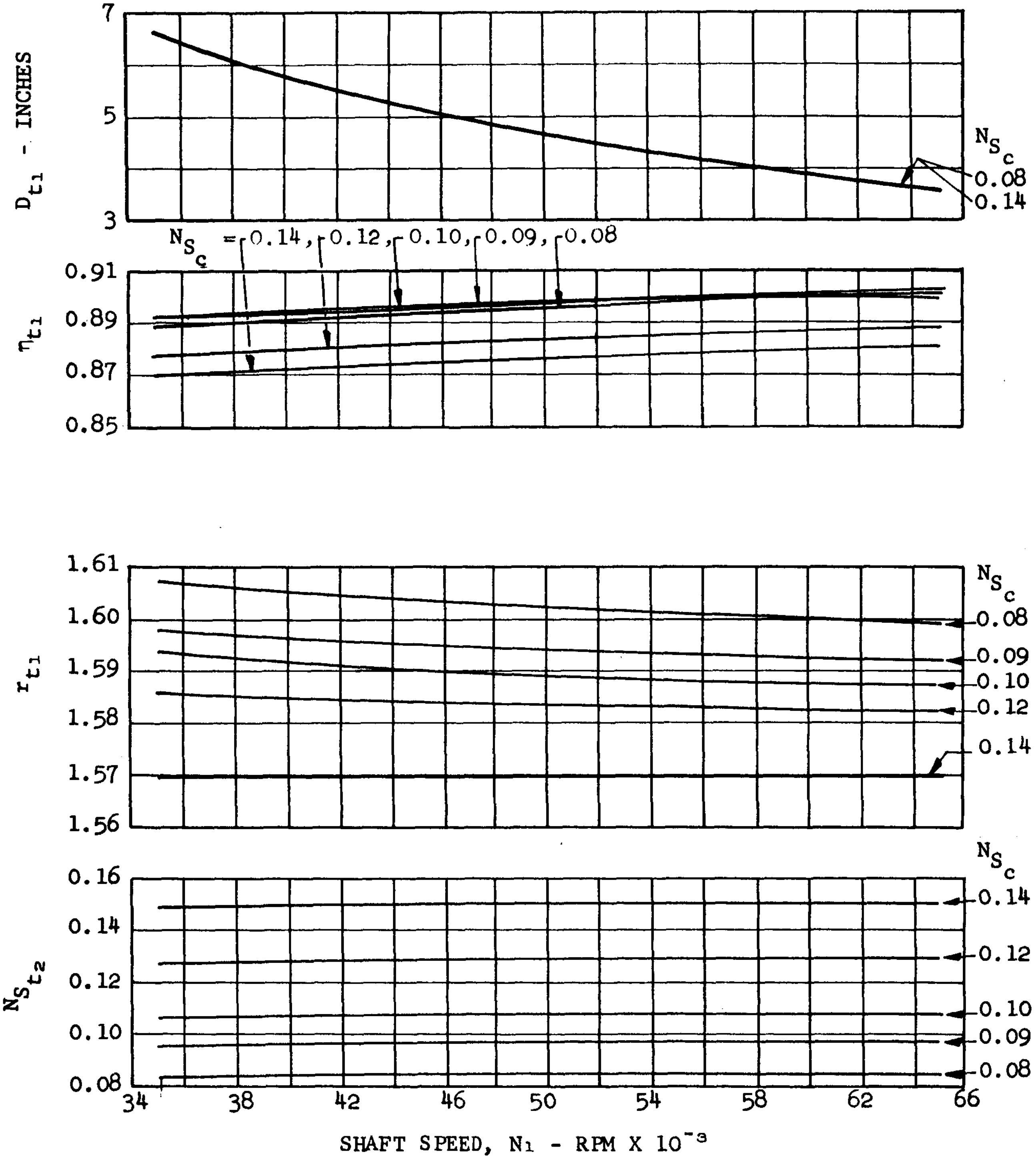


COMPRESSOR EFFICIENCY AND
COMPRESSOR PRESSURE RATIO FOR
OPTIMIZED NASA SYSTEM

FIGURE 9

A31496-1

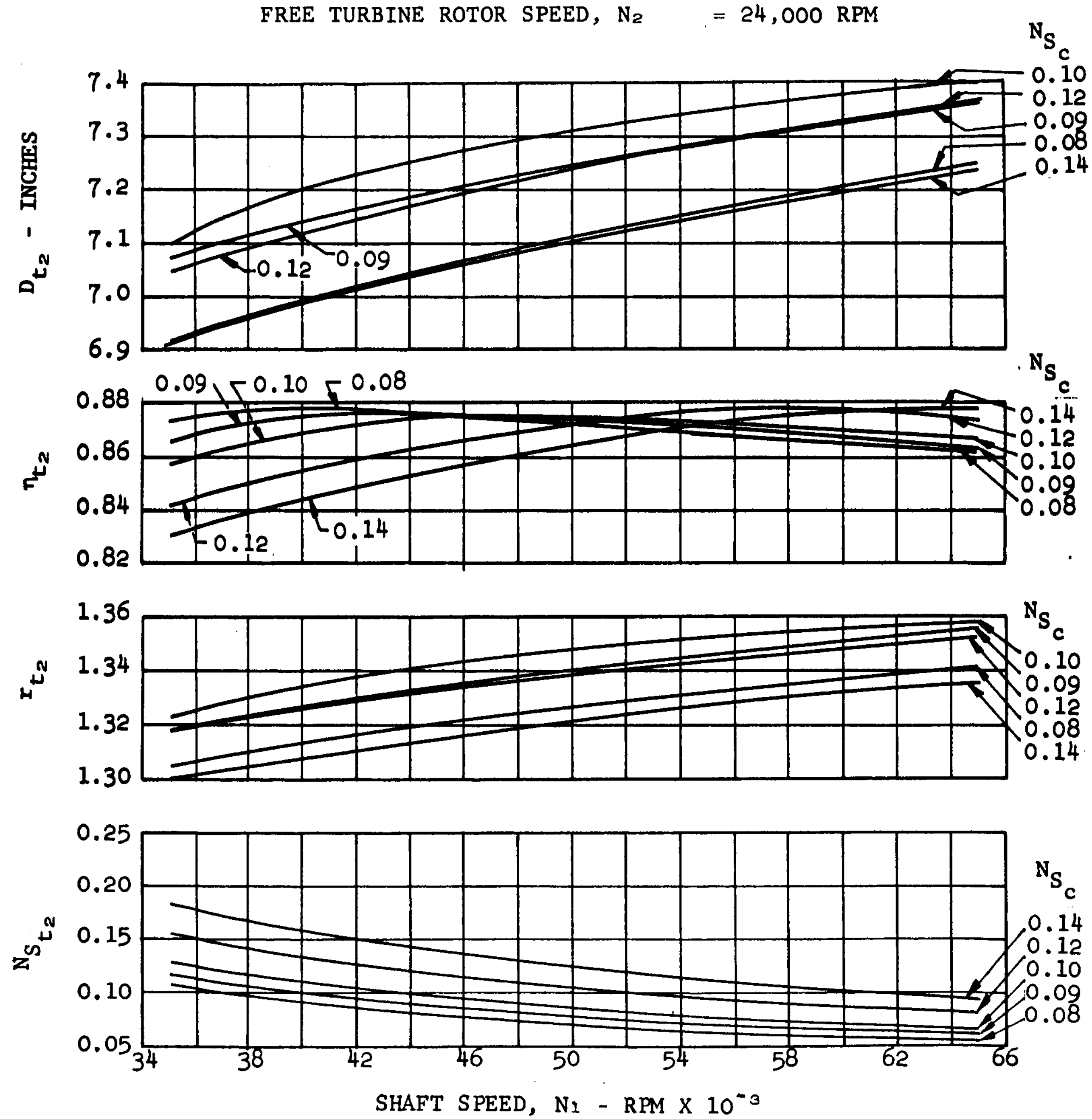
COMPRESSOR INLET TEMPERATURE, T_1 = 536°R
TURBINE INLET TEMPERATURE, T_3 = 1950°R
RECUPERATOR EFFECTIVENESS, E_R = 0.85
WORKING FLUID = ARGON
$\frac{\text{TURBINE PRESSURE RATIO}}{\text{COMPRESSOR PRESSURE RATIO}}$, β = 0.90
FREE TURBINE ROTOR SPEED, N_2 = 24,000 RPM



FIRST STAGE TURBINE
OPTIMIZED NASA SYSTEM
FIGURE 10

A31497-1

COMPRESSOR INLET TEMPERATURE, T_1 = 536°R
TURBINE INLET TEMPERATURE, T_3 = 1950°R
RECUPERATOR EFFECTIVENESS, E_R = 0.85
WORKING FLUID = ARGON
$\frac{\text{TURBINE PRESSURE RATIO}}{\text{COMPRESSOR PRESSURE RATIO}}, \beta$ = 0.90
FREE TURBINE ROTOR SPEED, N_2 = 24,000 RPM



FREE TURBINE
OPTIMIZED NASA SYSTEM
FIGURE 11

A31498-1

A comparison was made between NASA design-point conditions at 38,500 rpm (6.0-inch wheels) and 45,000 rpm (5.1-inch wheels) and the "optimized" design-point conditions at 38,500 rpm (6.0-inch wheels), 45,000 rpm (5.25-inch wheels), and 55,800 rpm (4.3-inch wheels). Selected values of cycle parameters at these conditions appear in Table 2. In addition, the optimized conditions include both a high-cycle pressure cycle ($N_{s_c} = 0.08$) and a case with compressor specific speed comparable to the NASA design conditions.

The above design-point condition studies revealed no major advantage to be gained through a change in design-point conditions from those proposed by NASA. Some advantage in system weight and radiator area would be realized with increased shaft speed and pressure level; however, decreased wheel diameters would result. Therefore, it was recommended that the mass flow rate, compressor pressure ratio, compressor inlet pressure, and working fluid, as recommended by NASA, be established as design values with the gas generator shaft speed of 38,500 rpm.

TABLE 2

BRAYTON-CYCLE DESIGN PARAMETERS

	NASA		AiResearch Optimization					
N_1	38,500	45,000	38,500	38,500	45,000	45,000	55,000	55,000
N_{S_c}	0.106	0.123	0.08	0.10	0.08	0.10	0.08	0.10
η_{cy}	0.281 0.284	0.284 0.287	-- 0.272	-- 0.283	-- 0.277	-- 0.291	-- 0.281	-- 0.294
$\dot{m}$	0.611	0.611	0.531	0.530	0.517	0.517	0.504	0.501
KW_o	12.25 12.40	12.35 12.50	-- 10.45	-- 10.88	-- 10.40	-- 11.00	-- 10.34	-- 10.82
D_c	6.0	5.1	6.0	6.0	5.26	5.24	4.31	4.28
D_{t_1}	6.0	5.1	6.0	6.0	5.24	5.18	4.27	4.25
D_{t_2}	14.3 7.1	14.4 7.2	-- 6.97	-- 7.18	-- 7.05	-- 7.25	-- 7.15	-- 7.32
η_c	0.770	0.779	0.739	0.758	0.745	0.763	0.752	0.770
η_{t_1}	0.878	0.871	0.880	0.883	0.883	0.887	0.887	0.885
η_{t_2}	0.854 0.864	0.853 0.864	-- 0.877	-- 0.865	-- 0.875	-- 0.876	-- 0.868	-- 0.873
P_1	6.0	6.0	8.8	5.4	11.6	7.3	16.6	10.4
P_3	13.2	13.2	20.2	12.7	26.7	17.0	38.6	23.4
r_c	2.30	2.30	2.33	2.35	2.34	2.36	2.36	2.38
r_{t_1}	1.567	1.564	1.606	1.592	1.604	1.588	1.601	1.591
r_{t_2}	1.326	1.328	1.310	1.332	1.320	1.342	1.331	1.349
Vulnerable Area Factor	1.0	1.0	0.826	1.052	0.719	0.908	0.601	0.758

Table 3 presents the final design conditions used for the turbine. These conditions are for cold testing with argon. Design conditions for hot testing are given in Section 3.2.

TABLE 3

DESIGN CONDITIONS
NASA TURBINE RESEARCH PACKAGE

Working fluid	Argon
Flow rate, lbs per sec.	1.184
Inlet temperature, °R	520
Inlet pressure, psia	13.2
Total pressure ratio	1.56
Operating speed, rpm	19,800
Operating life, hr.	100
Speed capability, percent design	120

3.0 TURBINE DESIGN

3.1 Aerodynamic Design Approach

The following discusses the procedure used to design the turbine wheel, nozzle, and scroll.

The rotor diameter was fixed so that there were no incidence losses at the rotor inlet and so that the required power-output was accomplished without exit swirl. The other main turbine dimensions (exducer hub/tip ratio, exducer tip diameter, nozzle area, and tip width) were calculated from a correlation of turbine efficiency versus a parameter involving the various important geometrical ratios. This correlation is based on many AiResearch and other radial turbine data. With these dimensions fixed, a meridional shape was estimated. Using the electric analog field plot method, with approximate corrections for compressibility, blade blockage, and boundary-layer clogging, the meridional velocities along several streamlines were calculated. The meridional shape was adjusted and the calculation repeated until a satisfactory distribution was obtained along the shroud and hub streamlines. Particular care was taken to ensure that the shroud meridional velocity did not have too high a peak and that the hub velocity did not become so low as to cause negative velocities when blade loadings were calculated.

Next, the blade loading diagram was estimated by using a blade-to-blade calculation method. Utilized in these calculations were an assumed number of blades, an assumed blade-angle variation and a calculated slip factor at the blade tip. Since the blade elements were radial, the blade angles along the mean and hub streamlines were calculated from the value of the blade angles at the shroud and, consequently, aerodynamic loading was calculated.

Several combinations of blade-angle distribution and numbers of vanes were checked until the following conditions were avoided:

(a) Excessive deceleration of relative velocity at the shroud.

(b) Very low or negative relative velocities at the shroud.

(c) Excessive decelerations on the suction surface of any streamline.

Due to loading considerations, the desired minimum number of radial blades on the turbine wheel is 17. However, 17 exducer blades result in performance impairment by extra friction losses, and the blade spacing at the exducer hub becomes so small that a fabrication problem results. The most desirable number of exducer blades is 13. If 13 exducer blades and 26 radial blades are used, the friction losses would be large. If 12 exducer and 24 radial blades are used, vibration problems may result. Therefore, the turbine design utilizes 11 exducer blades and 22 radial blades. However, this results in heavily loaded exducer blades.

It is possible to reduce blade loading by increasing the length of the exducer, but the friction losses would increase. Therefore, it is desirable to load the exducer blades heavily so that the friction losses are minimized, provided that the loading does not cause extra diffusion losses or flow separation. If the exducer blades are loaded near the trailing edge, a relatively high deviation of the flow from the blade angle may occur. This deviation is not due to flow separation and is not a cause of pressure losses. A certain length of constant-angle blade section may be added at the trailing edge of the exducer for the purpose of reducing the deviation angle. However, the concomitant friction losses would not justify the convenience of predicting the deviation angle.

The loadings on the radial leading edge portion of the blade were recalculated, based on potential flow analysis with a high-speed digital computer. The results compared favorably with the previously calculated loadings.

The losses in the nozzle and rotor were estimated by use of boundary-layer techniques. The losses considered were: vane and wall friction losses, mixing losses due to boundary-layer and blade wakes, wheel windage losses, clearance losses, incidence loss, and diffusion losses. The pressure ratio was so low that there was no shock loss in the turbine.

The nozzle shape and number of vanes were optimized to yield the lowest overall losses due to friction and mixing losses. The nozzle shape was examined by using the field plotting method to arrive at a shape that yielded a good velocity distribution and reasonable loading.

The scroll areas were calculated by using the well-known scroll equations based on consideration of angular momentum and continuity. Boundary-layer thickness was calculated throughout the scroll, and the areas were adjusted to compensate for blockage. One nozzle vane was elongated and adjusted to become the tongue of the scroll and thus allow control of the flow through the full 360 degrees.

The following is the design procedure for the turbine exducer:

(a) Assume a mean flow direction along the shroud.

(b) The blade loading is calculated with the flow angle and meridional velocity by using the equation as derived below:

$$\Delta\phi\rho\Delta\ (rC_u)\ \bar{w}\cos\beta' = \frac{\rho}{2}\left(w_s^{\,2} - w_p^{\,2}\right)\Delta m$$

where

$$\frac{\bar{w}_u}{Cm} = \tan\beta',\quad \frac{Cm}{\bar{w}} = \cos\beta'$$

$$u - \bar{w}_u = C_u$$

Δm: meridional length along the shroud

β': direction of mean flow measured from the meridional plane

$$\Delta\phi = \frac{2\pi}{\text{No. of Blades}} - \frac{\text{tangential thickness of blade}}{\text{radius}}$$

Assuming $\dfrac{w_s + w_p}{2} = \bar{w}$

$$w_s - w_p = \Delta\phi\,\frac{\Delta(rC_u)}{\Delta m}\cos\beta'$$

$$w_s = \bar{w} + \frac{w_s - w_p}{2}$$

$$w_p = \bar{w} - \frac{w_s - w_p}{2}$$

Notice that the velocity along the blade or blade loading depends only upon the mean flow direction, and it is independent of the deviation angle and real blade angle.

(c) If the velocity distribution in Step (b) is not satisfactory, assume a different mean flow direction along the shroud and repeat Step (b). If the velocity distribution is satisfactory, the real blade geometry is designed as described in Steps (d) through (k).

(d) As a first approximation, draw a pair of imaginary blades that are identical with the flow direction.

(e) Measure the throat width o and blade spacing s. The real flow angle* made by these blades is $\beta' = \cos^{-1} (o/s) + 4(s/\epsilon)$

where ϵ is the mean radius of curvature of the suction surface of the blade section between the blade throat and the blade trailing edge and β' is given by degree.

(f) In order to make the real flow angle identical with the desired flow angle specified in Step (a), the blade angle is increased without increasing the axial length of the exducer.

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*Ainley, D. G., and G. C. R. Mathieson, An Examination of the Flow and Pressure Losses in Blade Rows of Axial-Flow Turbines, ARC, R and M 2891, 1955.

(g) Repeat Steps (e) and (f) until the exit flow angle agrees with the desired angle.

(h) Since the blade element is radial, the variation of the blade angle along the 50-percent streamline and the hub is fixed, and the exit flow direction is calculated with Step (e).

(i) If the flow direction does not agree with the desired flow angle at the 50-percent and hub streamlines, the axial length of the exducer blades may be increased to meet the requirement. If it is necessary to cut back the axial length at the hub and 50 percent streamlines, such geometry is not practical from the stress viewpoint. In such cases the shroud section may be cut back somewhat so that the flow is under-turned while the hub section is extended so that the flow is over-turned, and as a whole the correct amount of work is accomplished. A certain amount of exit swirl does not significantly hurt turbine efficiency.

(j) Distribution of the meridional velocity is influenced by the distribution of blade loading. However, instead of applying the correction of velocity distribution and iterating blade geometry, the blade designed in Step (i) is extended 0.2 inch axially. With a proper cutback of this extended portion of blade, it is possible to adjust the overall work output to fit to the desired value when the meridional velocity distribution is different from the originally assumed distribution.

(k) A one-dimensional calculation of velocity distribution along blades is not always very accurate. An example of the discrepancy from two-dimensional analysis for turbine rotor inlet showed the discrepancy to be relatively small and, therefore, the one-dimensional calculation was deemed to be adequate.

3.2 Aerodynamic Design

The following is a list of pertinent information, resulting from the aerodynamic analysis of the turbine research package, which defines the turbine and nozzle geometry. These design conditions are for hot operation of the turbine research package and are also applicable for the gas generator turbine configuration.

A. Efficiencies

Total-to-total efficiency = 88.0%
Total-to-static efficiency = 82.4%

B. Pressure Ratios

Total-to-total pressure ratio = 1.560
Total-to-static pressure ratio = 1.613

C. Speed = 38,500 rpm
D. Specific work = 49.15 hp per lb per sec.
E. Weight flow = 0.611 lb per sec.
F. Specific speed = 0.118

G. Loss Distribution

1. Rotor Losses (All losses in % of isentropic work)

(a)	Main blade friction	2.00	
(b)	Splitter vane friction	0.53	
(c)	Main blade mixing	0.40	
	(1) Blade thickness		
	(2) Boundary layer		
(d)	Splitter vane mixing	0.13	
	(1) Blade thickness		
	(2) Boundary layer		
(e)	Shroud friction	0.76	
(f)	Windage	2.04	
(g)	Clearance loss	1.45	
(h)	Hub diffusion loss	0.10	
(i)	Shock loss	0.00	
	Estimated rotor losses	7.41	
	Contingency	0.37	
	Total rotor losses		7.78

2. Stator Losses

(a)	Scroll	0.90	
(b)	Nozzle friction	2.49	
(c)	Nozzle mixing	0.31	
	(1) Blade thickness	--	
	(2) Boundary layer	--	
(d)	Vaneless space	0.52	
	Total stator losses		4.22
	Overall estimated losses		12.00

Estimated total-to-total efficiency 100 - 12.0 = 88.0%

H. Total and Static Pressures

	Stator inlet total pressure	= 13.15 psia
	Stator inlet static pressure	= 12.82 psia
Outside Blade	Stator exit total pressure	= 13.00 psia
	Stator exit static pressure	= 10.89 psia
Outside Blade	Rotor inlet total pressure	= 12.97 psia
	Rotor mean inlet static pressure	= 10.79 psia
Outside Blade	Rotor exit total pressure	= 8.47 psia
	Rotor exit static pressure	= 8.18 psia

I. Total Temperatures

Inlet total temperature = 1950°R

Outlet total temperature = 1671°R

J. Gas Velocity Distribution

See Figure 12 for shroud velocity distribution.

See Figure 13 for 50 percent streamline velocity distribution.

See Figure 14 for hub velocity distribution.

K. Stator and Rotor Aerodynamic Physical Dimensions

See Drawing 369724 for stator physical dimension.

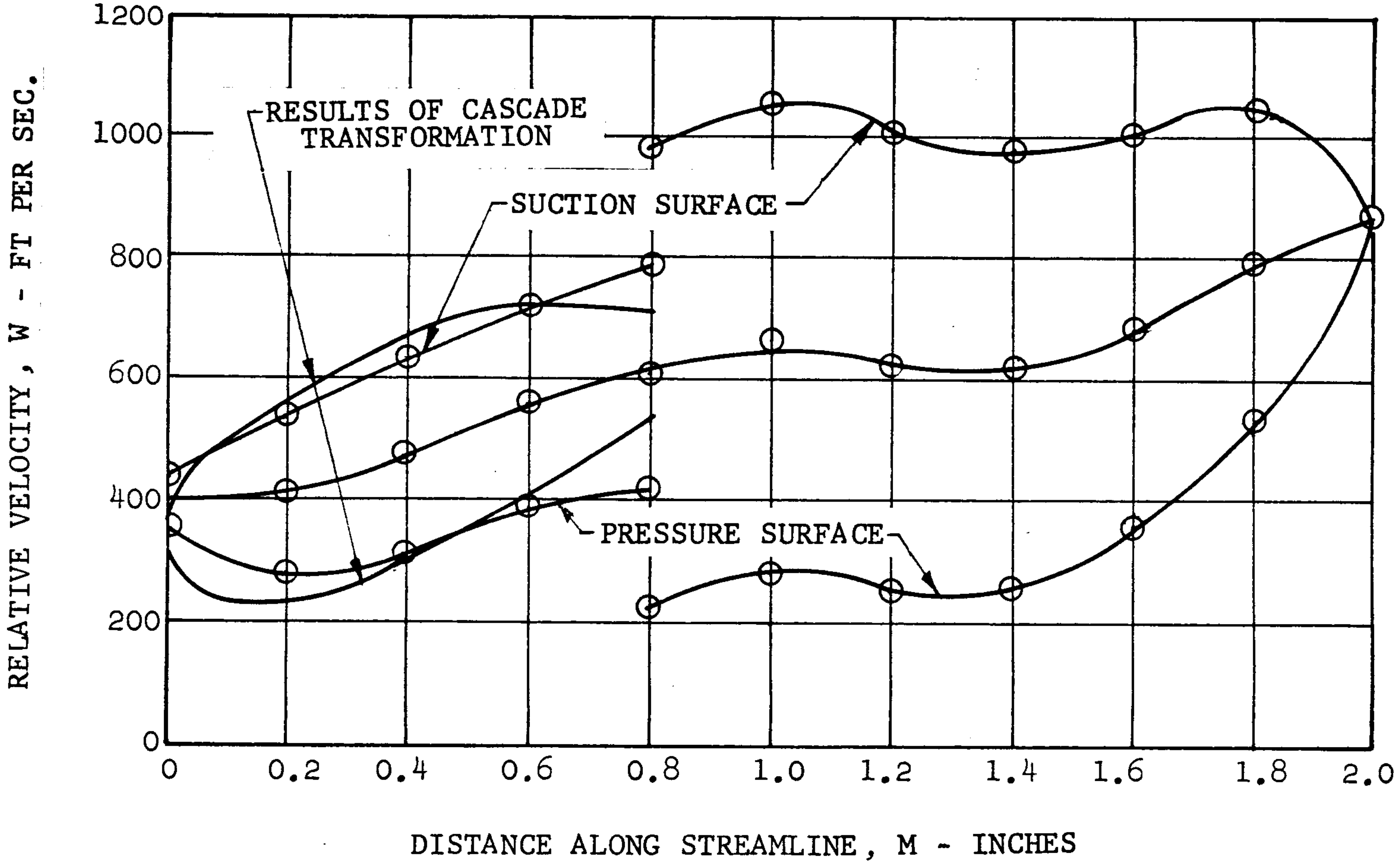
See Drawing 369726 for rotor physical dimensions.

L. Velocity Diagrams

See Figure 15 for stator velocity diagrams.

See Figure 16 for rotor velocity diagrams.

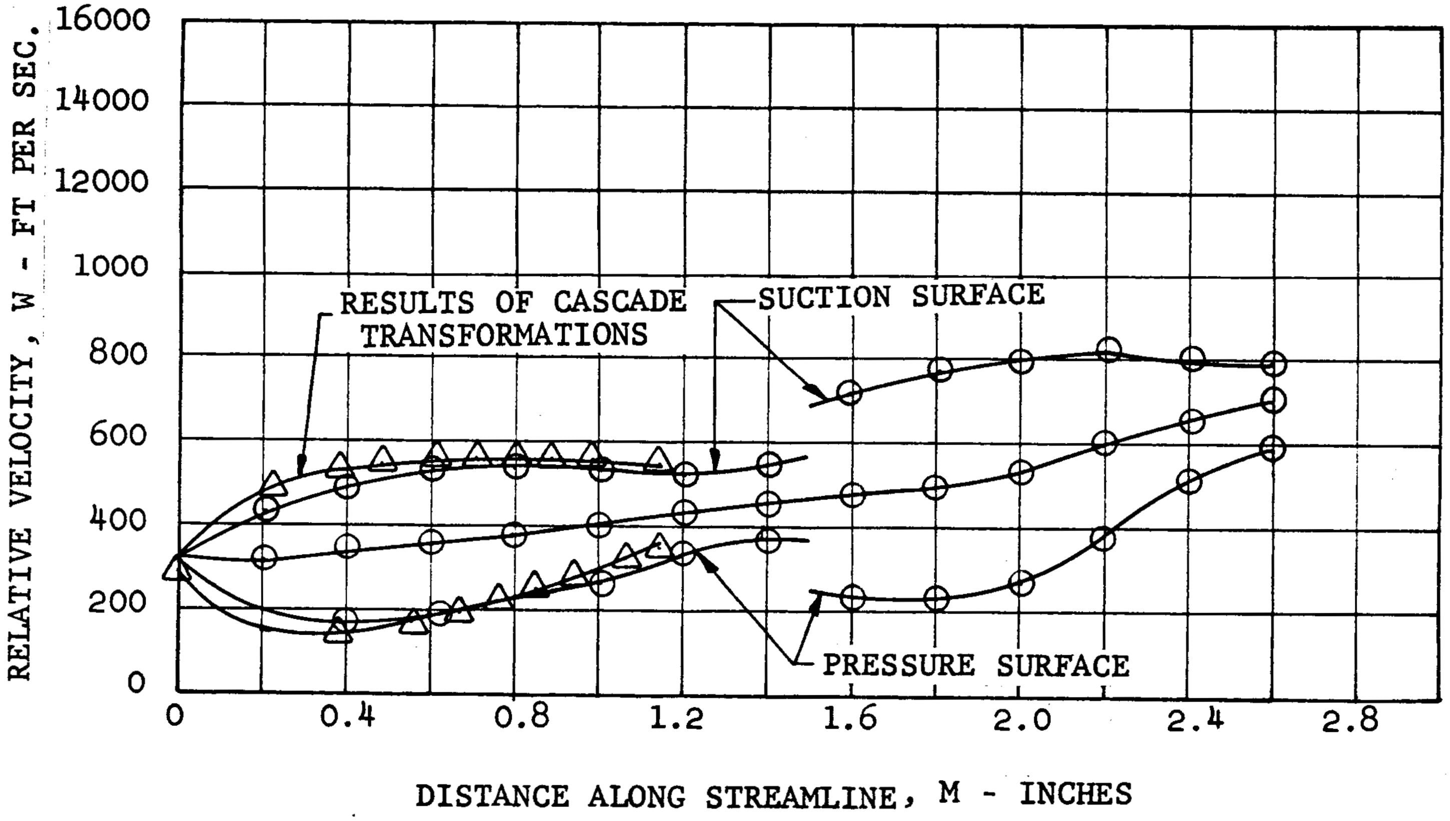
Figure 17 shows the station numbers corresponding to the velocity diagrams. Also shown is the temperature drop based on the velocity triangles, as compared to the total temperature drop based on the total temperatures shown in paragraph I above.



SHROUD LOADING FOR
RESEARCH PACKAGE TURBINE

FIGURE 12

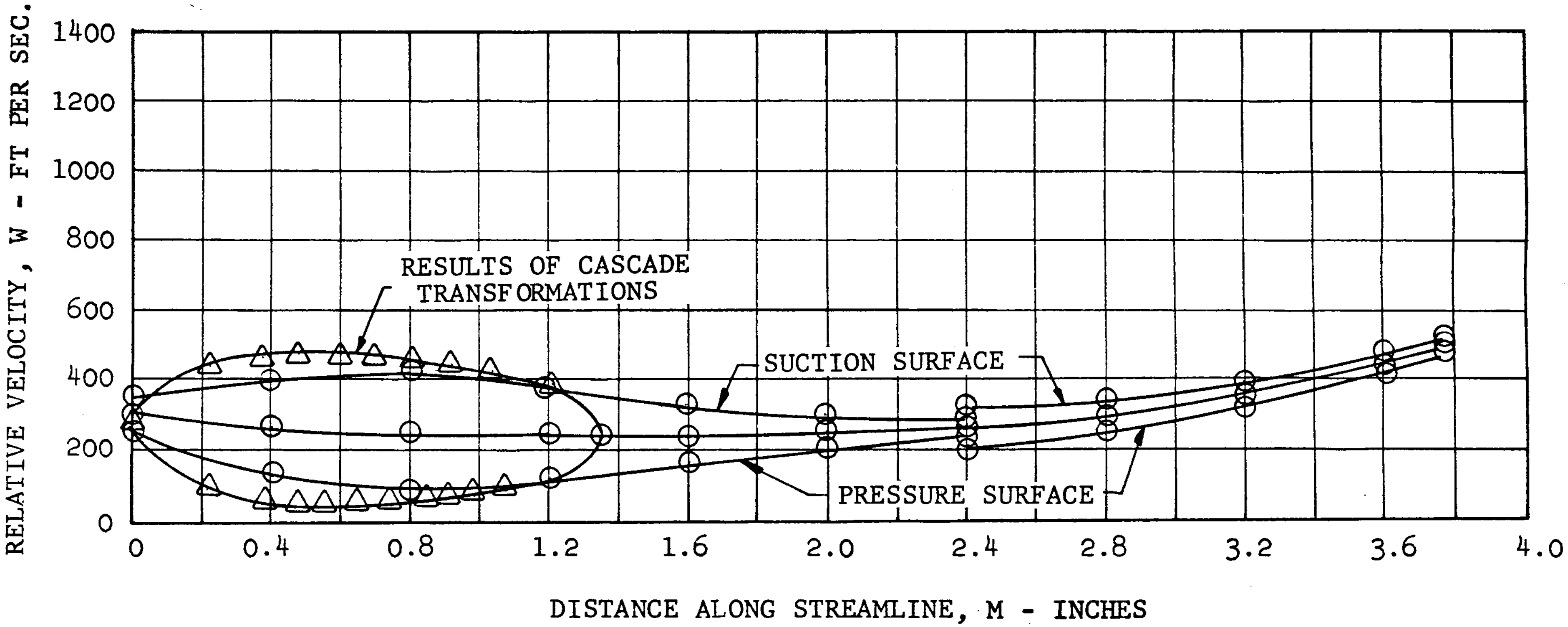
A30686-1



50 PERCENT STREAMLINE LOADING
FOR RESEARCH PACKAGE TURBINE

FIGURE 13

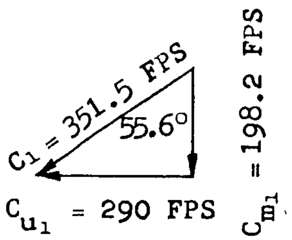
A30688-1



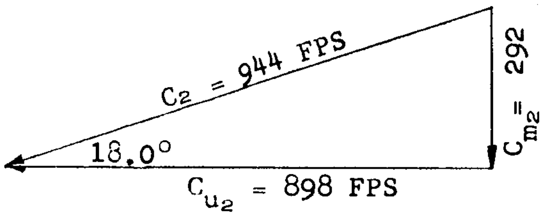
HUB LOADING FOR
RESEARCH PACKAGE TURBINE

FIGURE 14

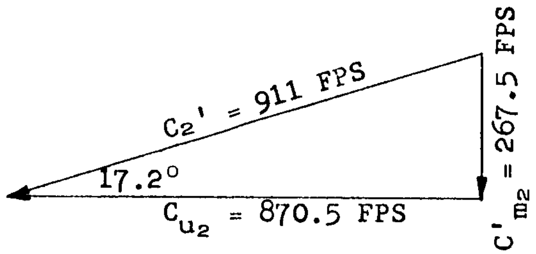
A30687-1



STATOR INLET



STATOR EXIT (INSIDE BLADE, BASED ON CORE VELOCITY)

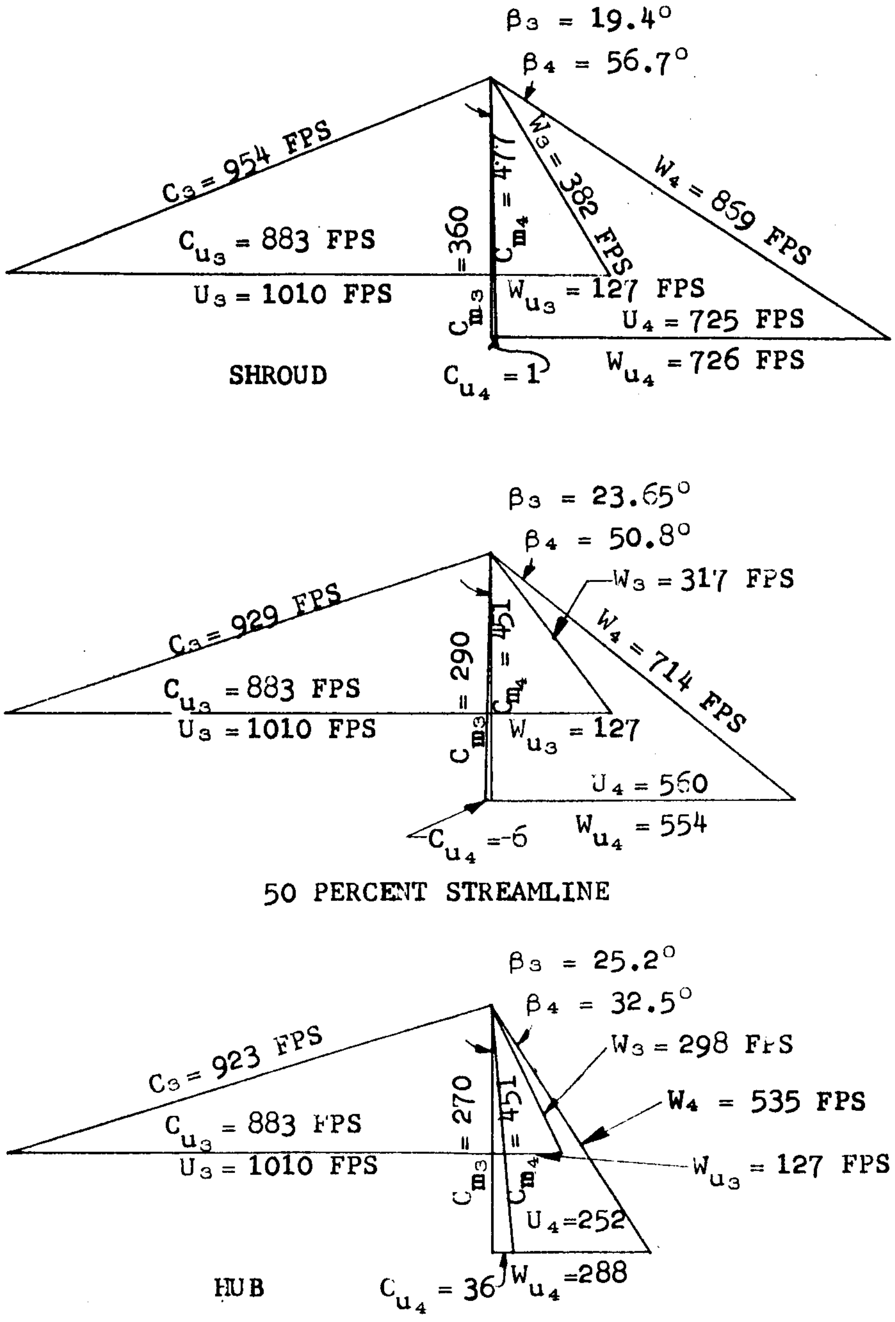


STATOR EXIT (OUTSIDE BLADE)

PREPARED	EAM	10-63	STATOR VELOCITY DIAGRAMS FOR TURBINE RESEARCH PACKAGE	
WRITTEN				
APPROVED			AiResearch Manufacturing Company of Arizona	A30689

FORM P793A-1

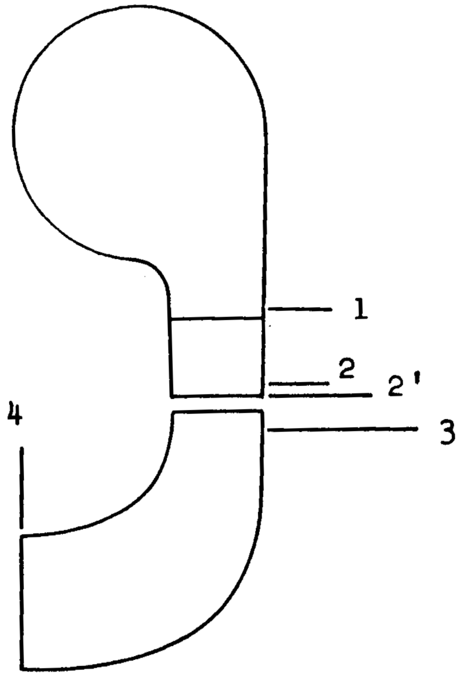
FIGURE 15



PREPARED	EAM	10-63	ROTOR VELOCITY DIAGRAMS FOR TURBINE RESEARCH PACKAGE	
WRITTEN				
APPROVED			AiResearch Manufacturing Company of Arizona	A30590

FORM P793A-1

FIGURE 16



REFER TO FIGURE 16.

U_3 = 1010 FPS C_{u_3} = 883 FPS

$$\Delta T = \frac{U_3 \; C_{u_3}}{gJC_p}$$

WHERE
U = WHEEL TANGENTIAL VELOCITY
C_u = TANGENTIAL COMPONENT OF GAS ABSOLUTE VELOCITY
g = GRAVATIONAL ACCELERATION, 32.2 FPS
J = 778.26 FT-LBS PER BTU
C_p = GAS SPECIFIC HEAT = 0.1243 BTU PER LB-°F

$$\Delta T = \frac{1010 \cdot 883}{32.2 \cdot 778.26 \cdot 0.1243}$$

$$= 286.3^{\circ}F$$

FROM PARAGRAPH G.1, PAGE 29 WINDAGE LOSS = 2.04%
ΔT DUE TO WINDAGE = (286.3)(0.0204) = 5.84°F

TEMPERATURE DROP DUE TO USEFUL WORK EXTRACTION = 286.3 - 5.8 = 280.5°F

TEMPERATURE DROP BASED ON TOTAL TEMPERATURE
DIFFERENCE = 1950 - 1671 = 279° (SEE PARAGRAPH I, PAGE 31)

FIGURE 17

3.3 Mechanical Design Analysis

3.3.1 Dynamic Analysis

The dynamic analysis of the turbine research package was accomplished on a digital computer by use of a program written for turbomachinery critical speed and bearing load analyses. A 4.0-inch bearing spacing and 25-millimeter bearings were chosen for the research package. The rear bearing was rigidly mounted to limit the rotor radial motion within the required shroud clearance. This gave an effective spring rate of 450,000 pounds per inch for the rear mount. The critical speeds for the turbine were analyzed by using front bearing spring rates from 5,000 to 30,000 pounds per inch (see Figure 18). Using a front bearing spring rate of 15,000 pounds per inch, bearing loads for a 0.0005-inch c.g. eccentricity were determined. Figure 19 shows the results of the bearing load analysis.

3.3.2 Turbine Wheel Temperature and Stress Analysis

Figure 20 shows the turbine-wheel configuration used in the turbine research package. In calculating the turbine-wheel temperature distribution for the gas generator configuration, it was assumed (1) that no heat would be transferred to the shaft and (2) that the shaft would conduct heat to the compressor. Turbine inlet temperature was assumed at 1950°R with the operating speed of 38,500 rpm. Gas temperatures relative to the wheel and heat-transfer coefficients were calculated on the Bendix G-20 computer. Figure 21 is the result of the calculation. The turbine blade and disc temperature distributions for Conditions (1) and (2) are shown on Figures 22 and 23.

$M = 0.0101$ LB SEC^2/IN.
$J = -0.004$ IN. LB SEC^2
$D = 6.0$ IN.

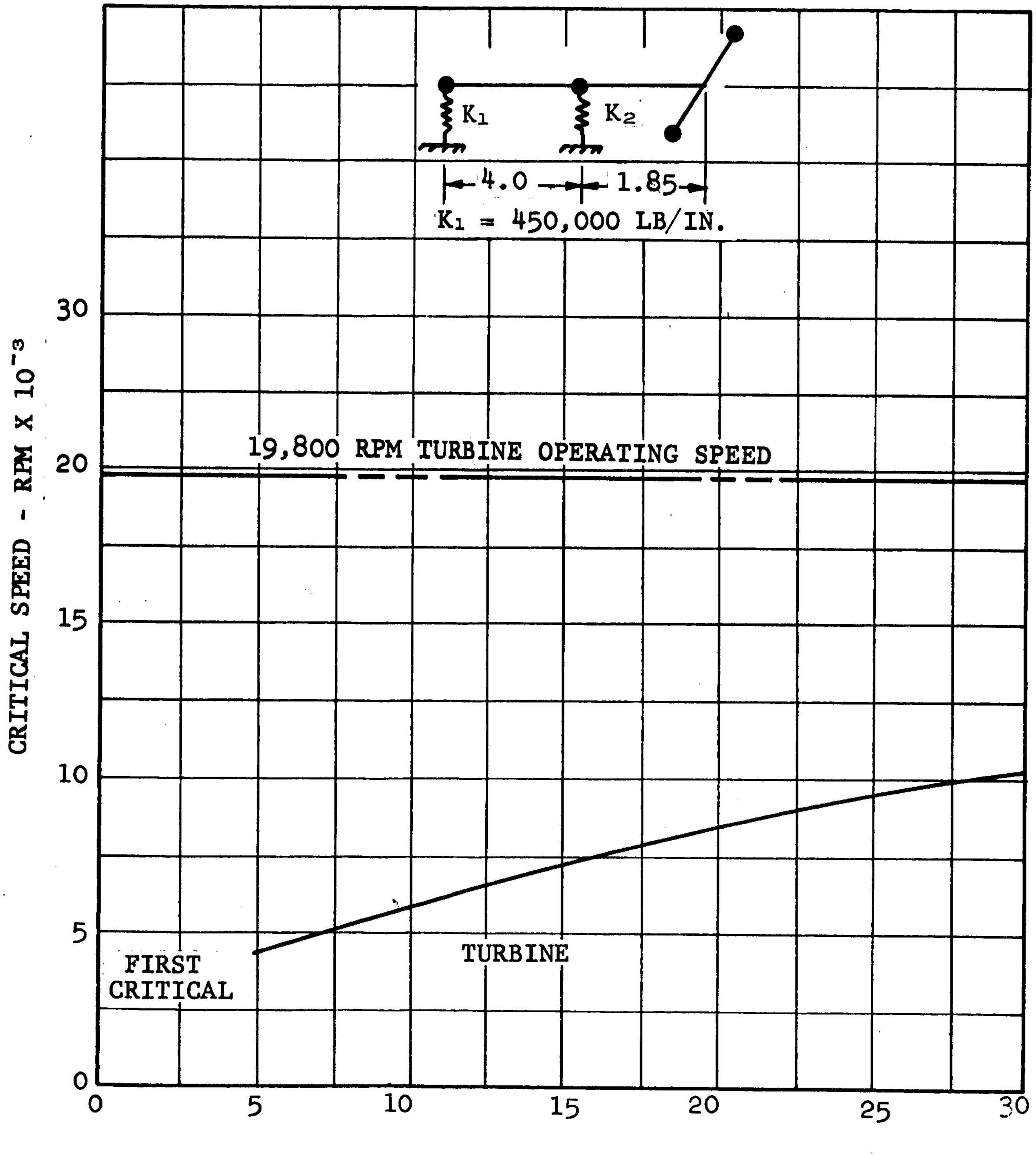


FIGURE 18

A30736-1

PAGE 1 OF 2

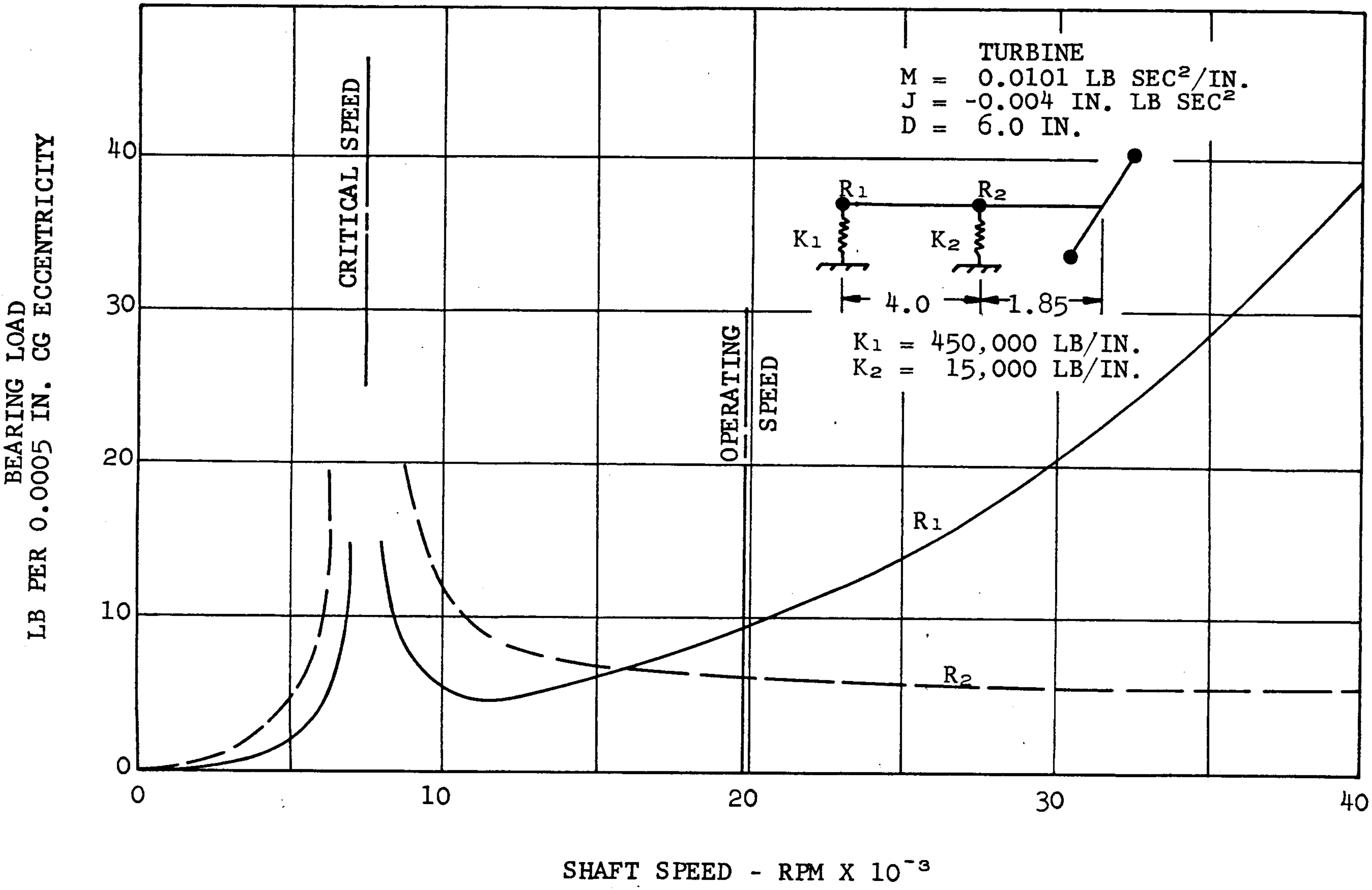
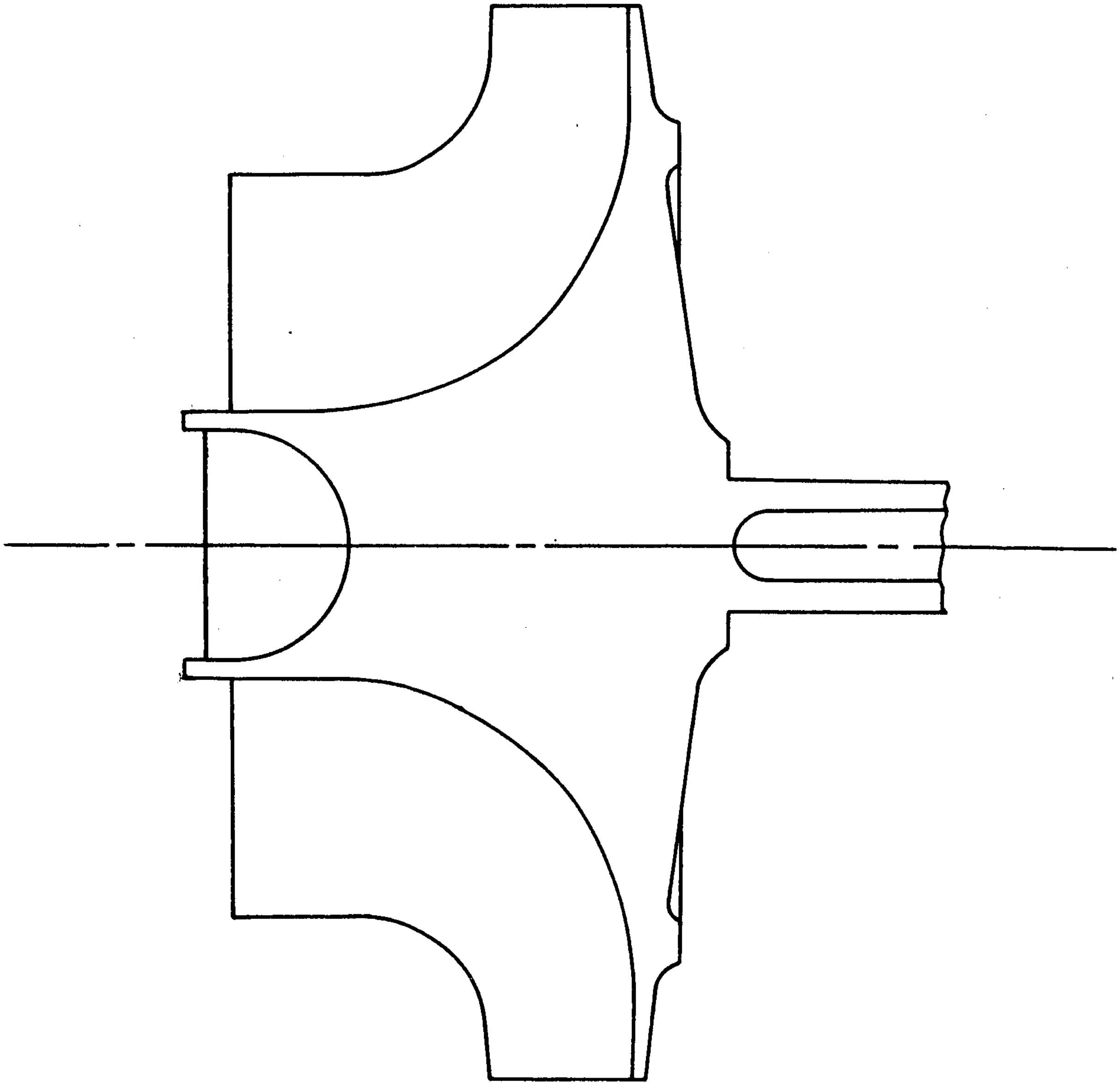


FIGURE 19

BEARING LOADS VS SPEED FOR
NASA TURBINE BALL BEARING
TEST RIG WITH K_2 = 15,000 LB/IN

A30738-1

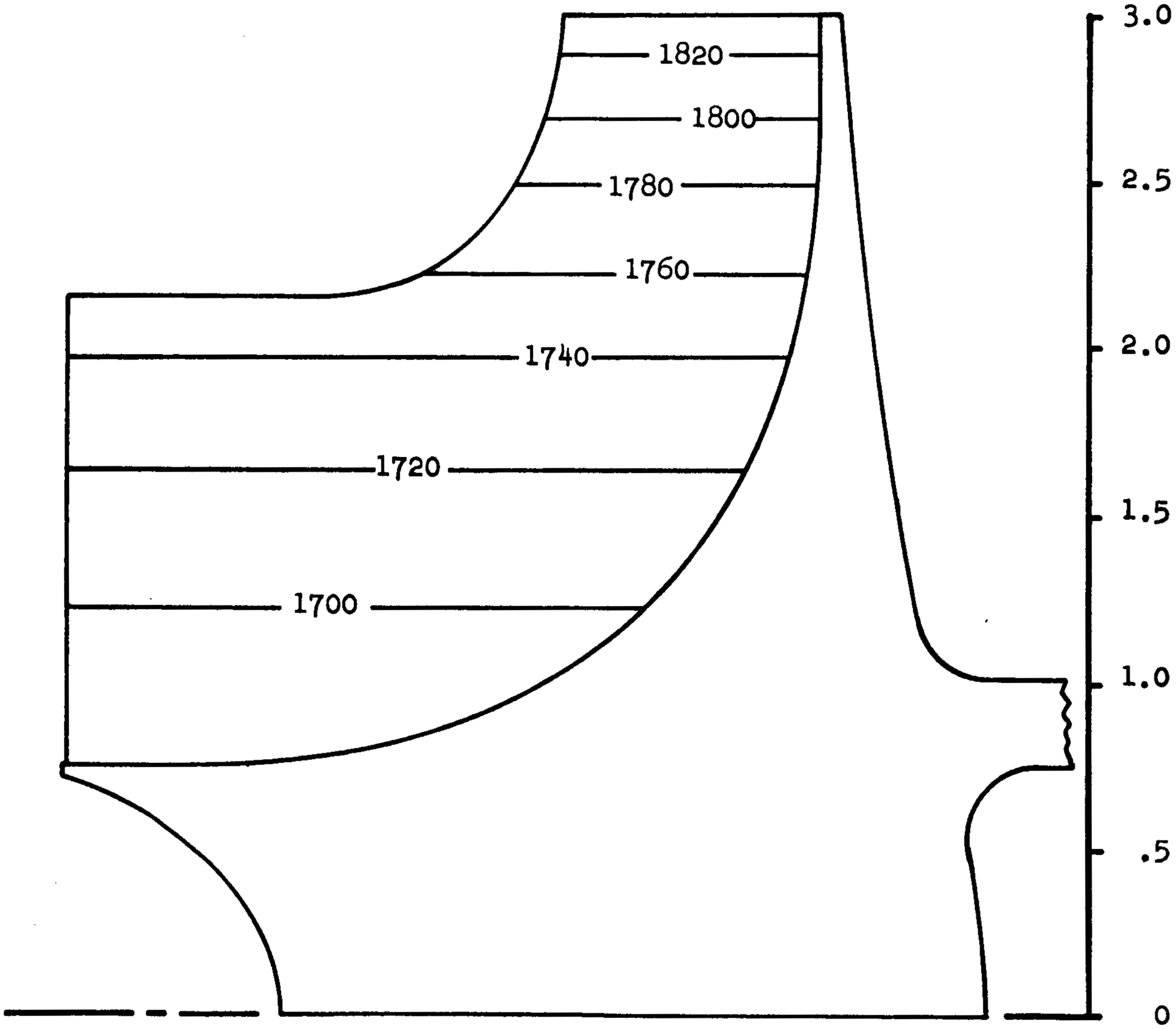


NASA BRAYTON-CYCLE
TURBINE WHEEL CONFIGURATION

FIGURE 20

A31549

NOTE:
(1) TURBINE INLET TEMPERATURE 1950°R
(2) TURBINE WHEEL SPEED 38,500 RPM

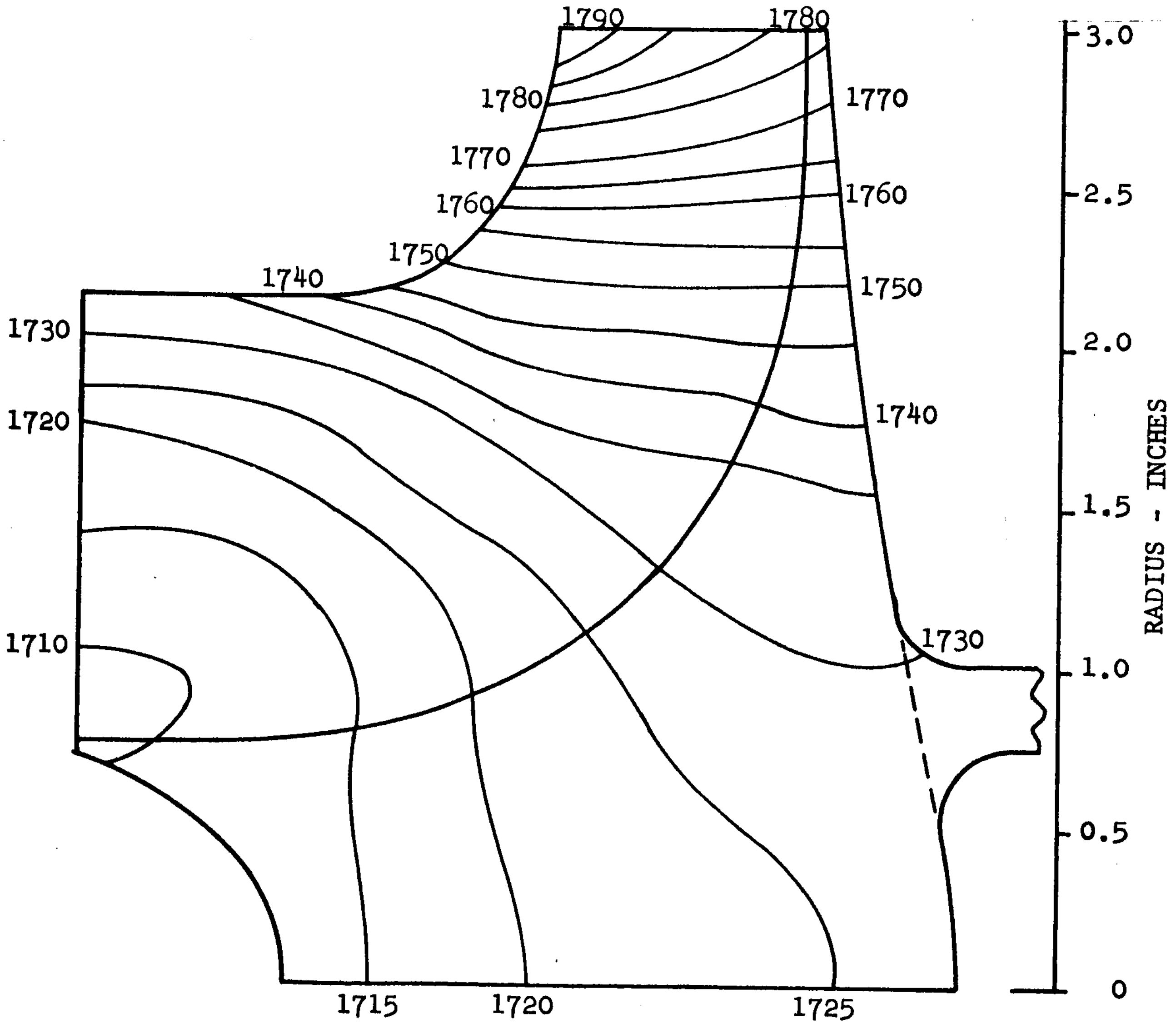


PREPARED	GL	9-63	GAS TEMPERATURES RELATIVE TO THE NASA BRAYTON-CYCLE TURBINE WHEEL, °R	A11781
WRITTEN	GL	9-63		
APPROVED	E.W.	9-63	AiResearch Manufacturing Company of Arizona	

FORM P703A-1

FIGURE 21

NOTES:
(1) TEMPERATURES ARE DEGREES RANKINE
(2) SPEED IS 38,500 RPM



PREPARED	G-20	8-63	STEADY-STATE TEMPERATURES NASA BRAYTON-CYCLE TURBINE WHEEL WITH NO HEAT TRANSFERRED TO SHAFT	A11782
WRITTEN	EW	8-63		
APPROVED	EW	8-63	AiResearch Manufacturing Company of Arizona	

FORM P793A-1

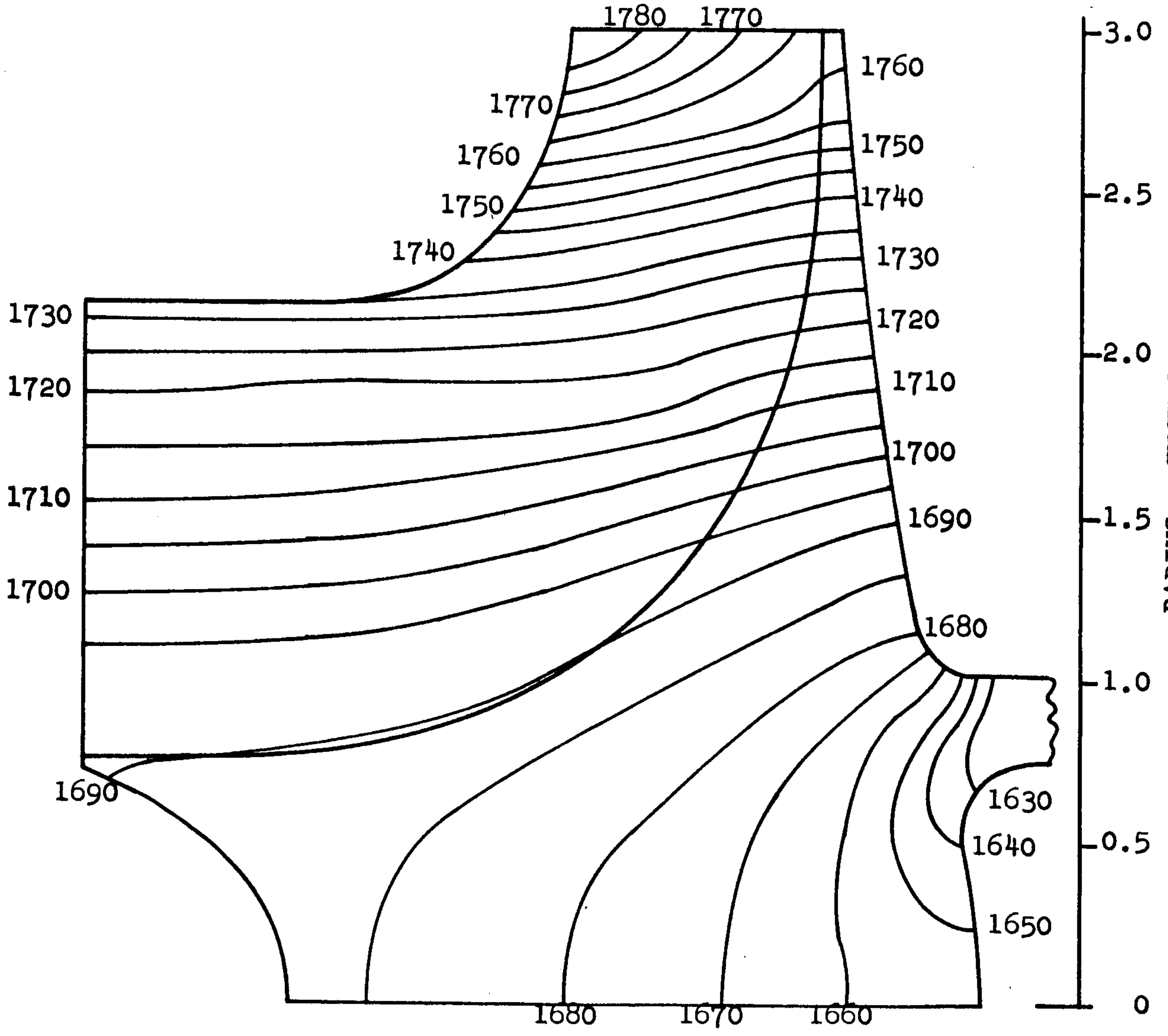
FIGURE 22

NOTES:

(1) TEMPERATURES ARE DEGREES RANKINE

(2) SPEED IS 38,500 RPM

(3) TEMPERATURE OF HEAT SINK AT COMPRESSOR IS 650°R



PREPARED	G-20	8-63	STEADY-STATE TEMPERATURES NASA BRAYTON-CYCLE TURBINE WHEEL WITH SHAFT CONDUCTING HEAT TO COMPRESSOR	A11783
WRITTEN	EW	8-63		
APPROVED	EW	8-63	AiResearch Manufacturing Company of Arizona	

FORM P793A-1

FIGURE 23

The temperature distributions discussed above were used in calculating the combined thermal and centrifugal stresses for the turbine wheel operating at 38,500 rpm. Radial and tangential stresses are shown in Figures 24 and 25.

Yielding of the blades and in the disc will begin at minimum speeds of 67,000 and 66,000 rpm, respectively, based on Von Mise's yield criterion. Originally, the turbine wheels were to be made of Waspaloy. The material was changed to Inconel 713C so that the wheel could be cast instead of machined from a forging. As can be seen in Figure 26, the stress level in the wheel is well below the 10,000-hour stress-rupture curve for Inconel 713C.

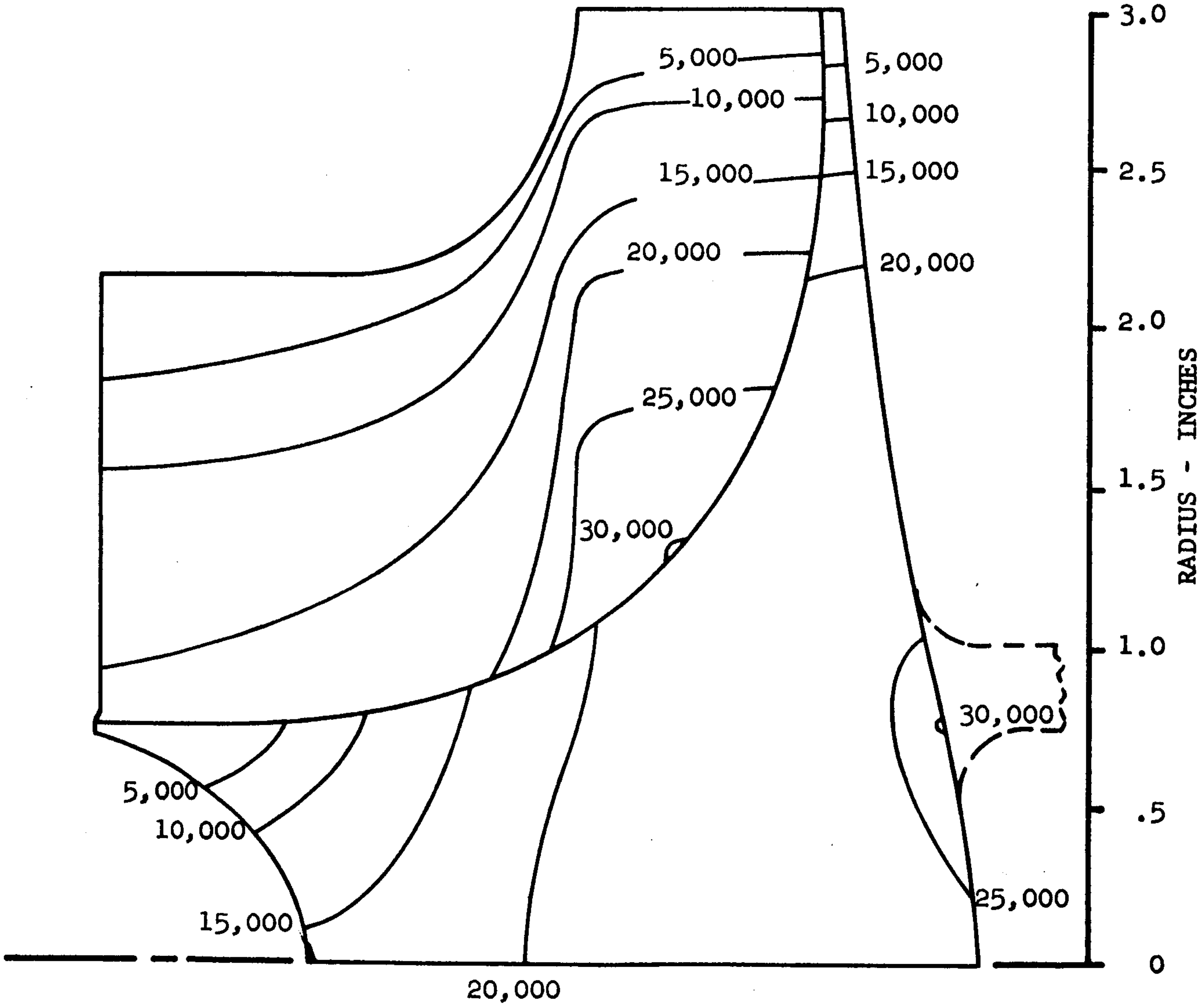
3.3.3 Growth and Burst Tests

The results of the Stresscoat test on the turbine wheel are shown in Figures 27 and 28. These values compare favorably with those calculated in Section 3.3.2. The maximum indicated stress at 38,500 rpm was 34,900 psi compared to a calculated value of slightly over 30,000 psi. This apparent discrepancy may be explained since the Stresscoat results are room-temperature values while the calculated stresses are for operating temperatures. The operating temperatures change the stress distribution due to thermal gradients in the wheel. After the Stresscoat tests, the wheel was etched to determine the grain structure in the cast wheel as shown in Figure 29.

A growth-and-burst test was also conducted on the wheel. Residual growth was measured on the outside diameter at two points 90° apart, and the results are shown in Figure 30. The results of the burst test are shown in Figure 31. Burst occurred at 86,000 rpm--well within the calculated burst range of 77,000 to 109,000 rpm.

NOTE:

(1) SPEED - 38,500 RPM
(2) AVERAGE TANGENTIAL STRESS - 17,700 PSI
(3) MATERIAL - INCONEL 713C
(4) SHAFT CONDUCTING HEAT TO COMPRESSOR



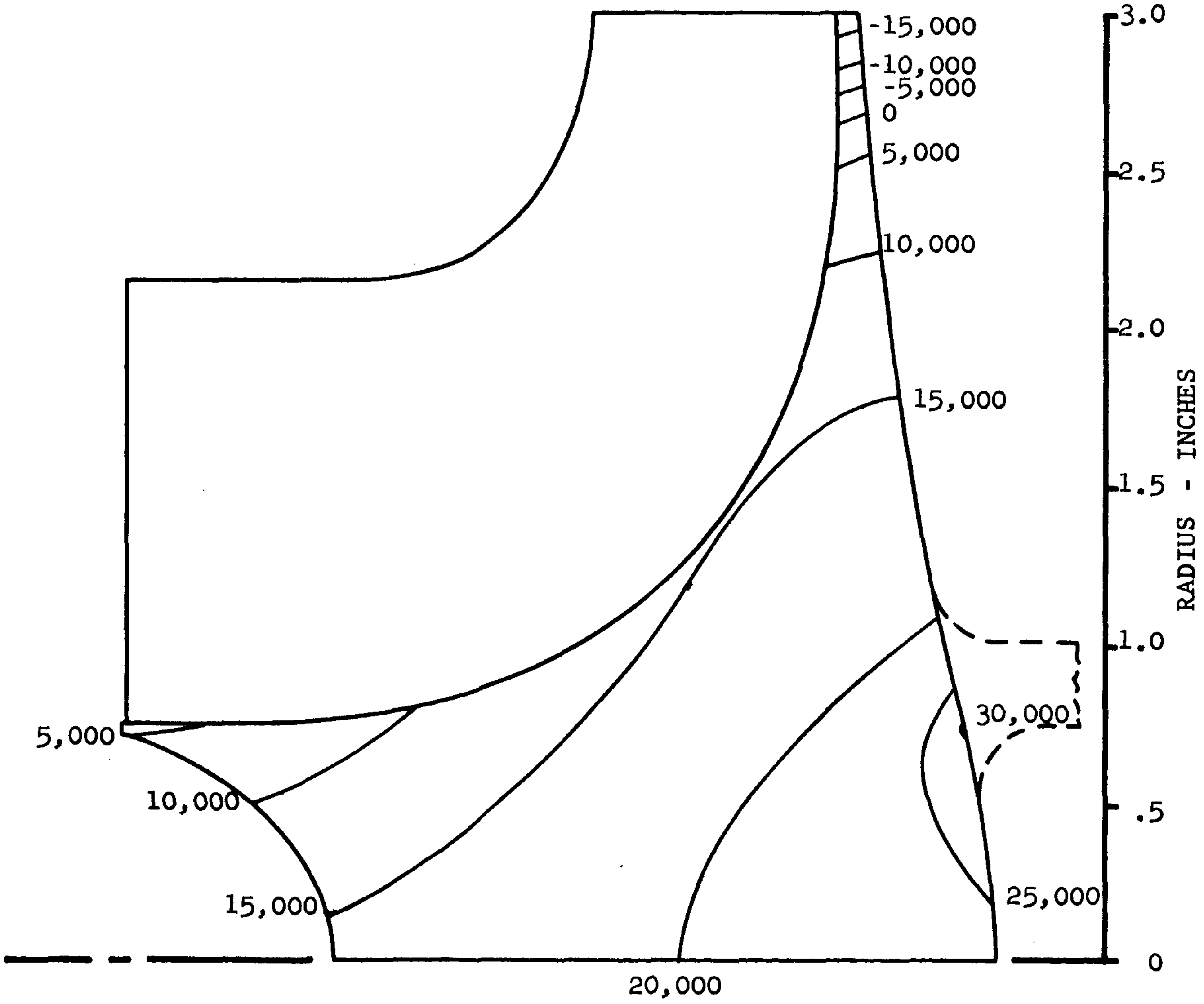
PREPARED	GEL	8-63	RADIAL STRESS DISTRIBUTION FOR NASA BRAYTON-CYCLE TURBINE WHEEL STRESS IN PSI	A11785
WRITTEN	GL	8-63		
APPROVED	E.W.	9-63	AiResearch Manufacturing Company of Arizona	

FORM P798A-1

FIGURE 24

NOTE:

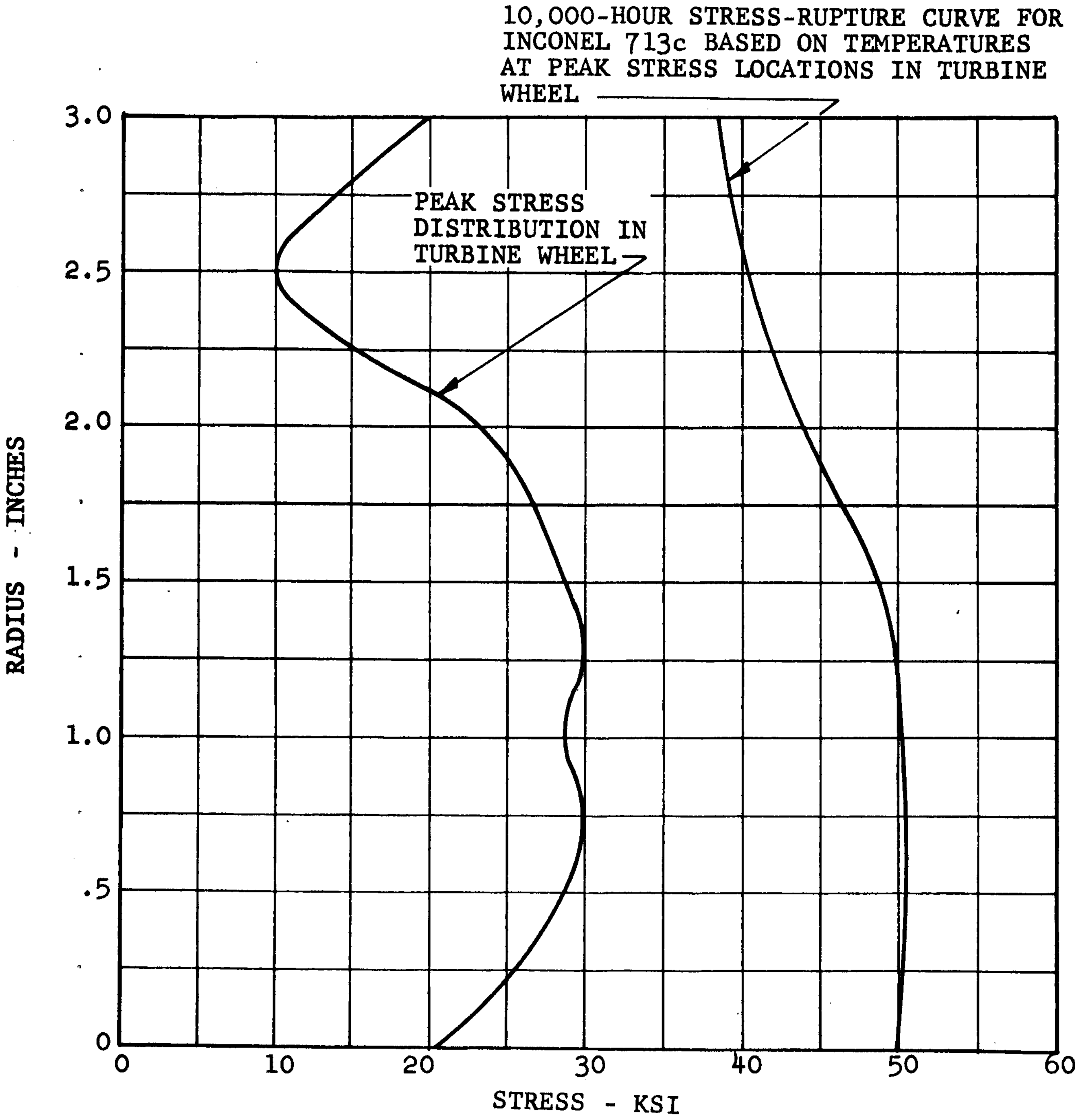
(1) SPEED - 38,500 RPM
(2) AVERAGE TANGENTIAL STRESS - 17,700 PSI
(3) MATERIAL - INCONEL 713C
(4) SHAFT CONDUCTING HEAT TO COMPRESSOR



PREPARED	GEL	8-63	TANGENTIAL STRESS DISTRIBUTION FOR NASA BRAYTON-CYCLE TURBINE STRESS IN PSI	A11784
WRITTEN				
APPROVED	E.W.	9-63	AiResearch Manufacturing Company of Arizona	

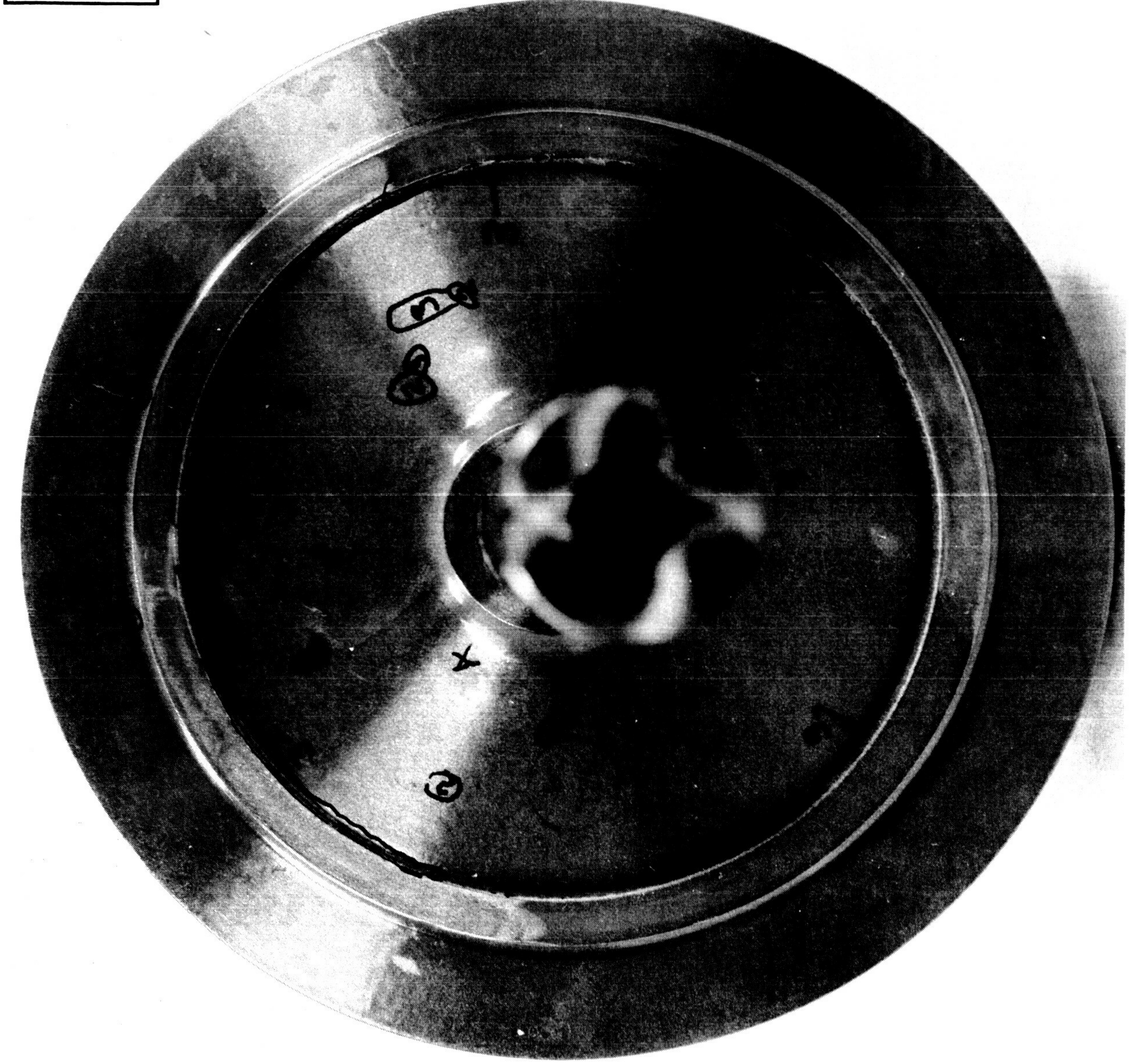
FORM P793A-1

FIGURE 25



NASA BRAYTON-CYCLE WHEEL PEAK STRESS DISTRIBUTION AND ALLOWABLE STRESS DISTRIBUTION FOR 10,000-HOUR LIFE

FIGURE 26

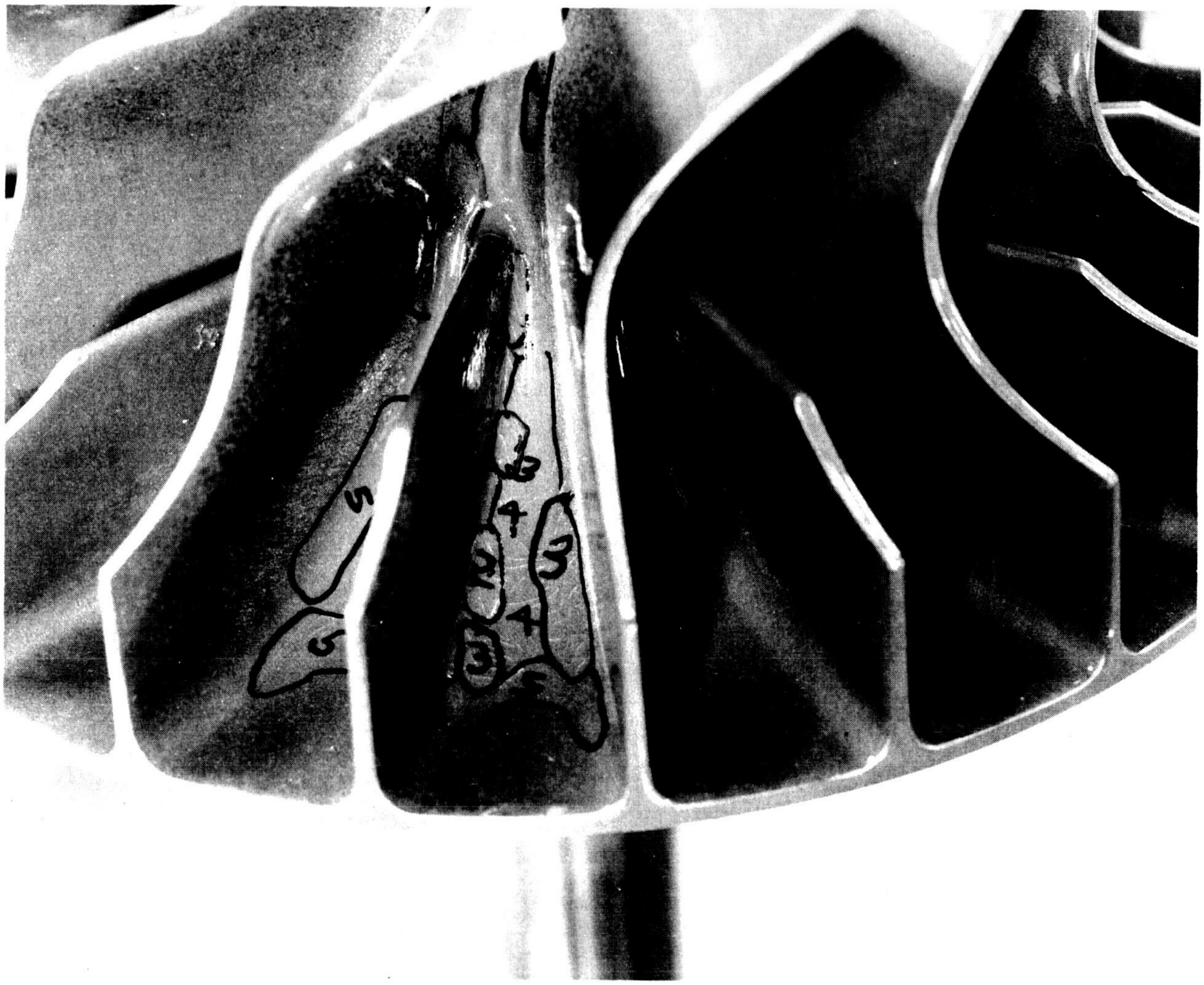


STRESSCOAT TEST OF NASA BRAYTON-CYCLE
CAST TURBINE WHEEL, PART 369726 STRESSES BELOW
ARE FOR UNIAXIAL STRESSES AT 38,500 RPM
ESTIMATED ACCURACY OF STRESSES: ±20%
AVERAGE STRESSCOAT SENSITIVITY 0.00073
MATERIAL: INCONEL 713C $E = 28.6 \times 10^6$ PSI
1-8-64

AREA	STRESS (PSI)
1	34,900
2	30,500
3	27,100
4	24,000
5	20,400

PHOTO NO. P-22334-1

FIGURE 27

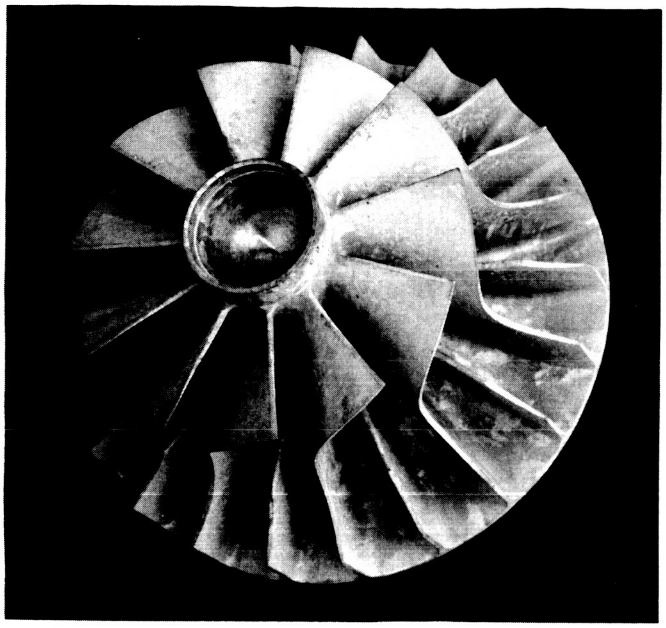


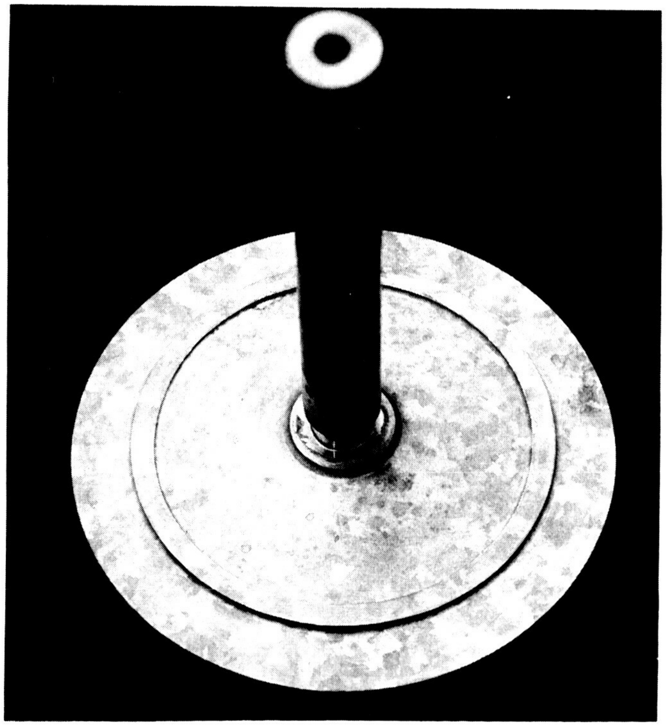
STRESSCOAT TEST OF NASA BRAYTON-CYCLE
CAST TURBINE WHEEL, PART 369726 STRESSES BELOW
ARE FOR UNIAXIAL STRESSES AT 38,500 RPM
ESTIMATED ACCURACY OF STRESSES: ±20%
AVERAGE STRESSCOAT SENSITIVITY 0.00073
MATERIAL: INCONEL 713C E = 28.6 x 10^6 PSI
1-8-64

AREA	STRESS (PSI)
1	34,900
2	30,500
3	27,100
4	24,000
5	20,400

PHOTO NO. P-22334-4

FIGURE 28

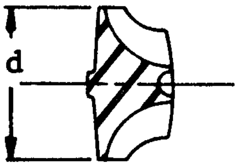




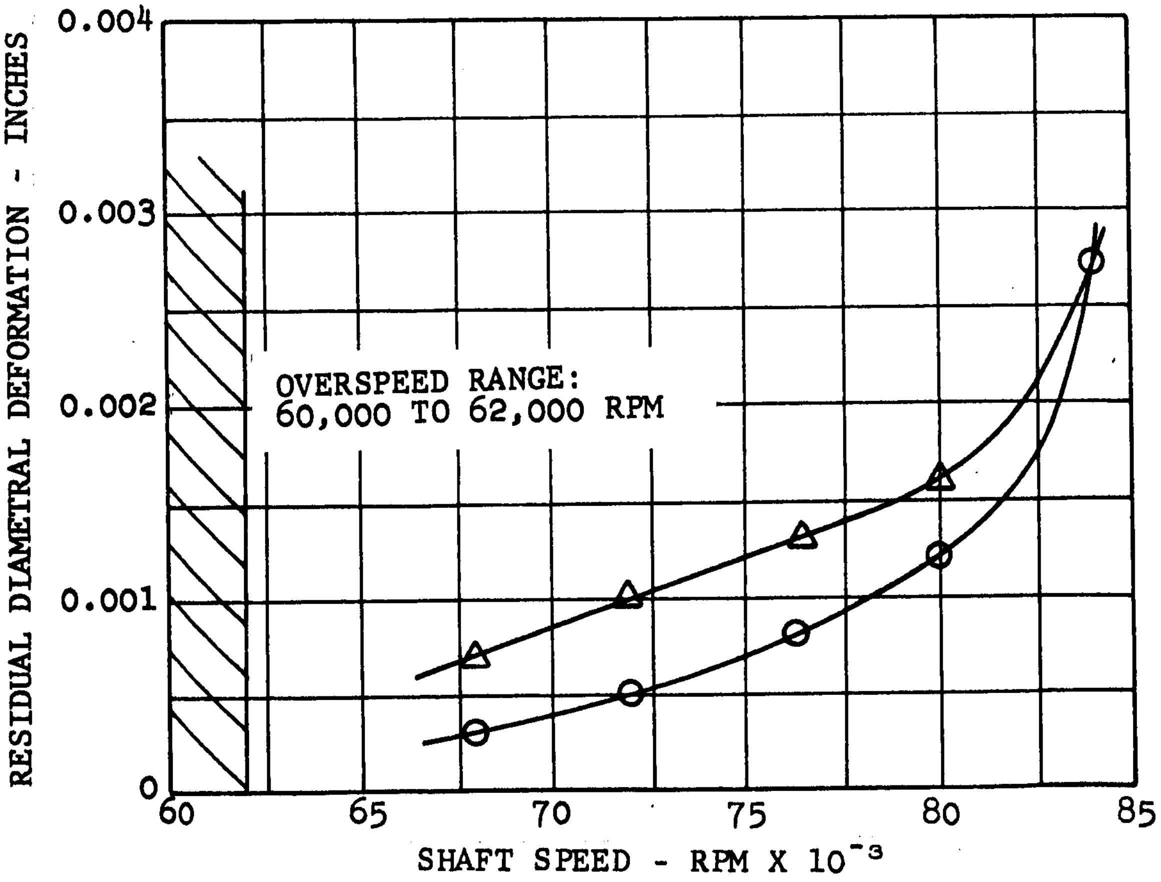
GRAIN STRUCTURE OF NASA TURBINE WHEEL
FIGURE 29

MP-5192

MATERIAL: INCONEL 713C
BURST OCCURRED AT 86,000 RPM
GROWTH MEASURED ON DIAMETER d



DIAMETER NO. 1 (PRERUN DIA. = 6.0213 INCH)
DIAMETER NO. 2 (90° FROM DIA. NO. 1;
PRERUN DIA. = 6.0210 INCH)



GROWTH OF NASA BRAYTON
CYCLE TURBINE WHEEL

FIGURE 30

A60246-1

PART 369726, SERIAL NO. 3Q 391 TURBINE WHEEL
FOR THE NASA BRAYTON-CYCLE GAS GENERATOR
AFTER BURST AT 86,000 RPM
CAST INCONEL 713C

PHOTO NO. P-22411

MP-5197

FIGURE 31

3.4 Mechanical Design

3.4.1 General Unit Description

A cross-sectional view of the turbine research package is shown in Assembly Drawing 369721. The units consists of the turbine wheel and shaft assembly (369726) mounted in the main housing (369722) on two antifriction bearings (358313). The front bearing (turbine end) is resiliently mounted with a spring rate of 15,000 pounds per inch. The rear bearing is rigidly mounted, and a coil spring provides 30 pounds of axial preload on the bearings. An oil jet (369728) supplies pressurized oil to each bearing and a carbon-face-type oil seal (369738 and 358319) is provided at each end of the housing. The turbine end seal has an argon purge chamber located between the face seal and an annular shaft seal to prevent any minute amount of oil leakage past the face seal from contaminating the system argon. A spline-connected stub shaft (369746) located at the output end of the turbine wheel and shaft assembly permits adaptation to an external power-absorbing device.

The turbine nozzle and scroll assembly (369725) attaches to the main housing by a bolted flange. Shimming to obtain the desired turbine-wheel-to-shroud-face clearance is accomplished at this flange by providing a shim of predetermined thickness between the housing and the scroll flanges (369745). A compromise value of the clearance was established at 0.010- to 0.012-inch. From an aerodynamic consideration, a zero clearance would be optimum, however, a clearance of 0.002 inches per inch of wheel diameter can be utilized without serious performance penalty. From a mechanical consideration, it is advantageous to maintain large clearances so that, with rotor radial and axial displacement due to tolerance stackup and flexible bearing displacements, the rotor does not rub on the shroud. Sealing at the shim is accomplished with two O-rings (369813). Bolt flanges at the turbine scroll inlet and exhaust permit adaptation of appropriate ducting (369810 and 369811). A rigid mounting base (369752) provides for mounting the turbine research package to the test stand bed plate.

Figures 32, 33, and 34 are photographs of the turbine research package, Serial No. P-B, prior to shipment. Outline Drawing 369720 shows three views of the unit, along with pertinent package dimensions for installation purposes. Table 4 is a summary of the parts for the turbine research package.

3.4.2 Instrumentation

Provisions were made for incorporating certain instrumentation on the turbine research package as follows:

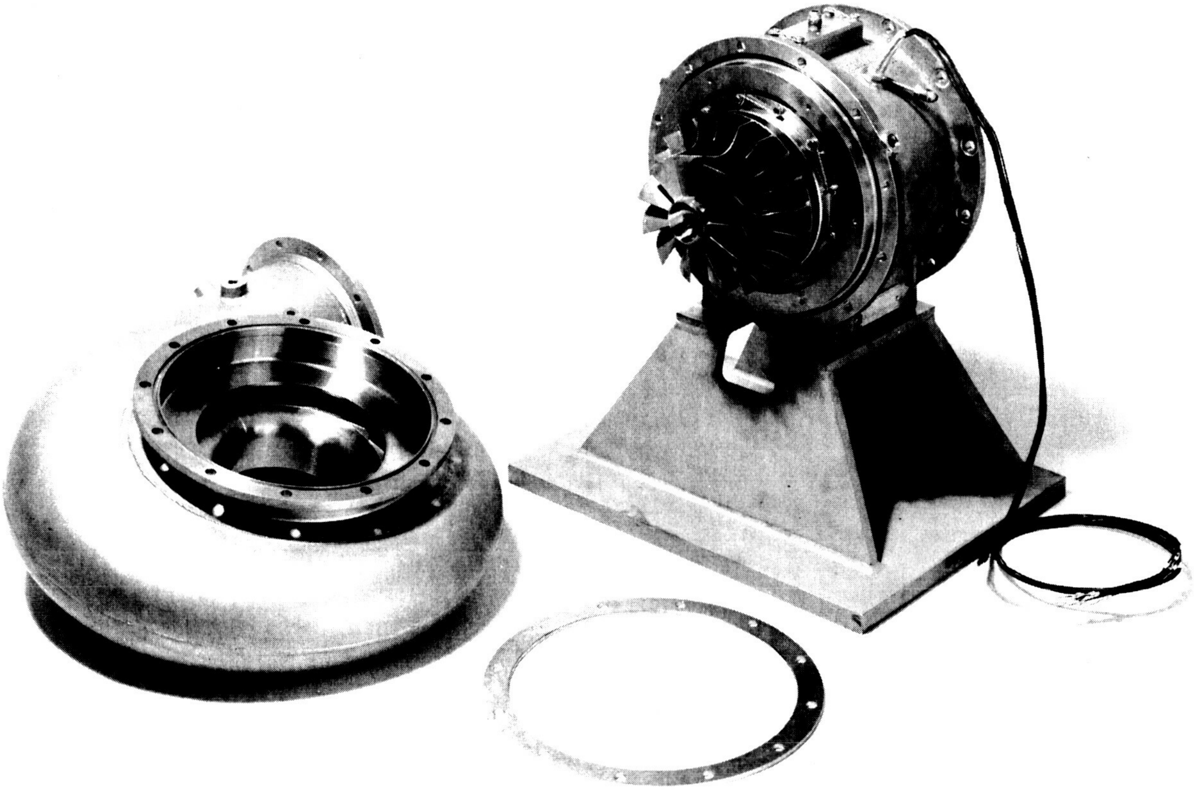
(a) Four static pressure taps, 90° apart, one-half duct diameter downstream of the scroll inlet flange.

(b) Two total pressure-total temperature taps, 90° apart, one-half inch downstream of the static pressure taps.

(c) Five static pressure taps at four cross-channel positions across the nozzle exit.

(d) Three I.C. thermocouples located on the outer race of each ball bearing.

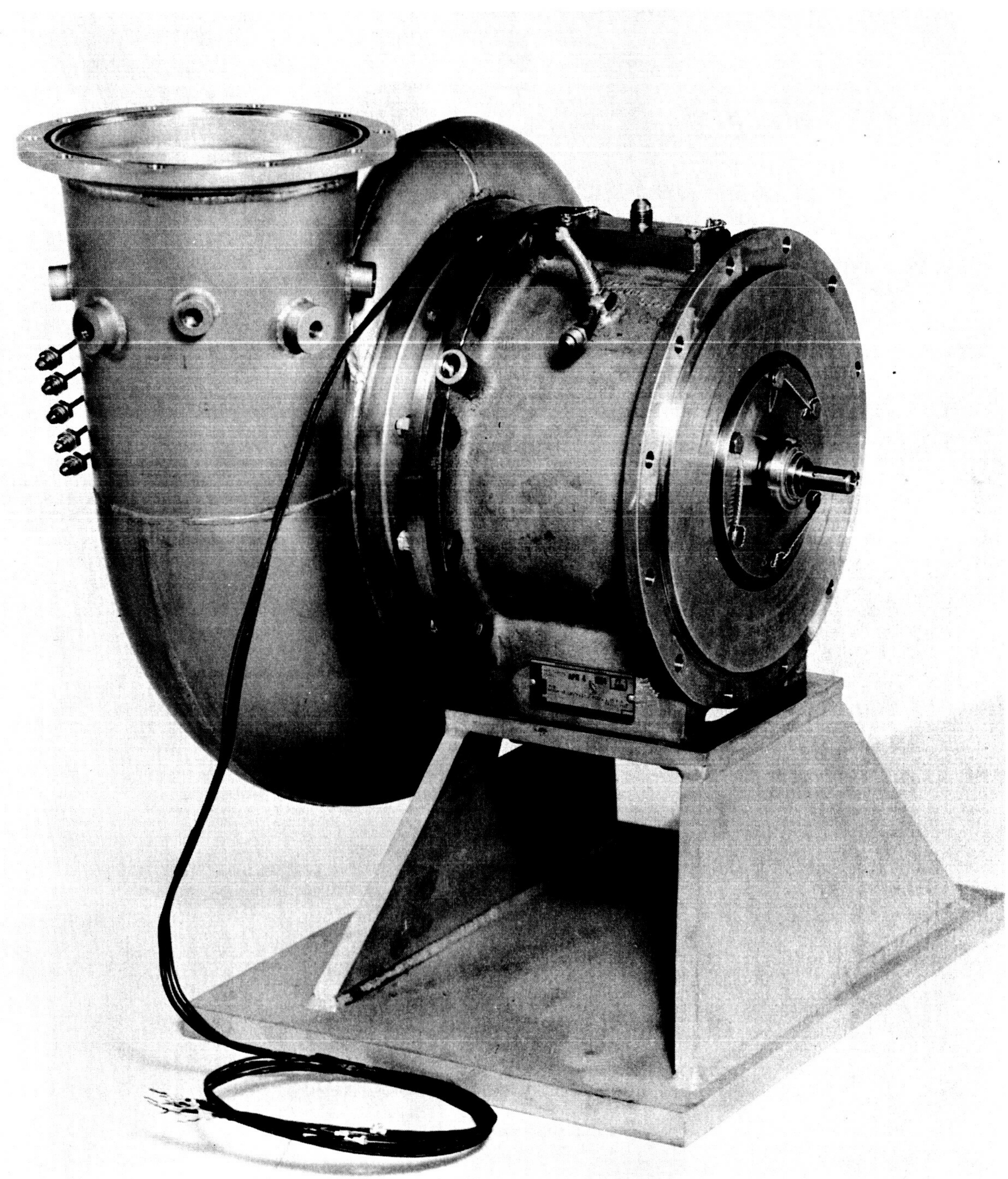
On the first unit, Serial No. P-A, undrilled bosses were provided for Items (a), (b), and (c). The second shipping unit, Serial No. P-B, was provided with instrumentation as shown in Figures 33 and 34.



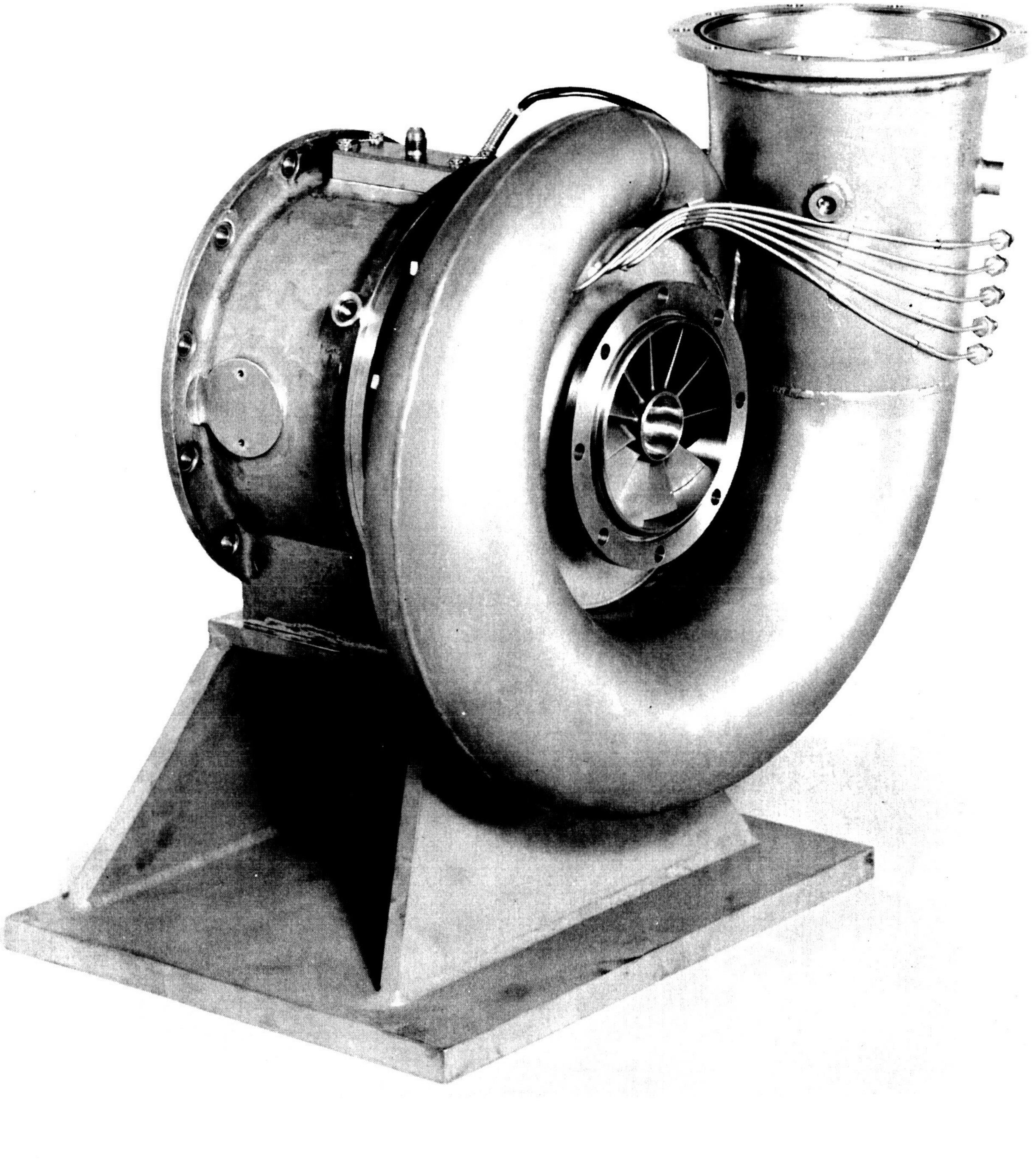
NASA TURBINE RESEARCH PACKAGE

FIGURE 32

MP-6243



INSTRUMENTED NASA TURBINE RESEARCH PACKAGE
FIGURE 33



INSTRUMENTED NASA TURBINE RESEARCH PACKAGE

FIGURE 34

MP-6245

TABLE 4

NASA TURBINE RESEARCH PACKAGE DRAWING AND PARTS LIST

DRAWING OR PART NUMBER	TITLE	USED ON	NUMBER REQUIRED
369720	Turbine Outline, Test, Brayton Cycle		
369721	Turbine Assembly, Main		
369722	Housing Assembly, Main	369721	1
369723	Spacer	369721	1
369724	Nozzle, Turbine	369725	1
369725-2	Turbine Nozzle and Scroll Assembly	369721	1
369726	Wheel Assembly	369721	1
369727	Carrier, Seal	369721	1
369728	Nozzle Assembly, Oil	369721	1
369729	Spacer, Labyrinth (Optional)*	369721	1
369732	Spacer, Bearing	369721	1
369733	Mount, Bearing, Resilient	369721	1
369734	Carrier, Bearing	369721	1
369735	Carrier, Bearing	369721	1
369737	Carrier Assembly, Labyrinth Seal (Optional)	369721	1
369738	Carrier Assembly, Carbon Seal	369753	1
369743	Shim, Bearing Carrier	369721	As required
369744	Shim, Seal	369721	As required
369745	Shim, Sealing Spacer	369721	1
369746	Shaft, Quill**	369721	1
369752	Shaft Assembly, Mounting	369721	1
369753	Seal Assembly, Carbon	369721	1
369810	Flange, Turbine Inlet**		1
369811	Flange, Turbine Outlet**		1
369813	Seal, O-Ring	369721	1
111917	Spring, Compression	369721	1
358313	Ball, Single Row, Angular Contact	369721	2
358319	Seal, Air-Oil	369721	1
358320	Seal, Argon, Oil-Metal Bellows (Optional)	369721	1
358321	Seal Set, Gas-Oil, Matched	369753	1
	COMMERCIAL PARTS		
MS16555-617	Pin	369722	2
MS16555-625	Pin	369722	3
MS16555-644	Pin	369726	3
MS16555-646	Pin	369752	2
MS21045-C5	Nut	369721	12
MS24673-2	Screw	369721	12
MS24673-5	Screw	369721	4
MS24630-2	Type "F" Screw	369721	2
MS29561-015	O-Ring	369721	2
MS29561-235	O-Ring	369721	1

*Parts marked (optional) may be used as an alternate.

**These parts are shipped loose to the customer. The flanges are to be welded into the customer's inlet and exhaust ducting.

TABLE 4 (Cont'd)

DRAWING OR PART NUMBER	TITLE	USED ON	NUMBER REQUIRED
AN3CH5A	Screw	369721	6
AN5C-12	Screw	369721	12
AN6CH10A	Screw	369721	4
AN816-5-4S	Connector	369728	1
AN960C616	Washer	369721	4
S8152AT101-0-120	Pin Diam = 0.0469 Both end chamfered Length = 0.120 45° x 0.008 Material: SAE 4340 Hardness - R_c 40	369734	1
S8152AT101-0-220	Pin Diam = 0.0469 Both ends chamfered Length = 0.220 45° x 0.008 Material: SAE 4340 Hardness - R_c 40	369733	1
S8152BG17-0-590	Pin	369738	2
S8152BG17-0-590	Pin Diam = 0.2032 Both ends chamfered Length = 0.590 45° x 0.015 Material: 321 Cres Steel Condition: A annealed	369737	2
S8152BG40-0-310	Pin Diam = 0.2500 Both ends chamfered Length = 0.310 45° x 0.025 Material: 321 Cres Steel Condition: A annealed	369728	1
S8860C1P1	Plate Identification Thickness: 0.016 Condition: 1/2 hard Material: 301 Cres Steel	369721	1
362-522-9002	Gasket - Metal O-Ring 1/16-inch tube, 0.010-inch wall Ring OD = 0.502 inch Vendor: The D.S.D. Manufacturing Company Hamden, Connecticut Fed Sup Code 97968 Vendor Part No. A0500C-AG	369721	2
362-506-9012	Gasket - Metal O-Ring 3/32-inch tube, 0.010-inch wall Ring OD = 5.252 inch Vendor: The D.S.D. Manufacturing Company Hamden, Connecticut Fed Sup Code 97968 Vendor Part No. C5250C-AG	369721	1
525-577-9006	Nut, Self-Locking, Round, Bearing Retaining Nominal OD = 1 9/16 inch Vendor: Shur-Lok Corporation Anaheim, California Fed Sup Code 97393 Vendor Part No. S658N05C	369721	1

3.4.3 Inspection

Inspection of the turbine research package parts and final assembly were in accordance with the quality-assurance program as outlined in AiResearch Report RC-5130-R. Figure 35 shows the Critical Part Inspection and Serialization Record for both turbine wheels. Figures 36 and 37 show both sides of the Assembly Inspection and Laboratory Traveler for the two turbine research packages. As can be seen from these figures, the first shipping unit was started three times and ran a total of 5 hours for the acceptance test. The second unit was started and ran for a total of 5 hours and 17 minutes for its acceptance test. Following completion of the acceptance test, the acceptance tag was completed as shown in Figure 38.

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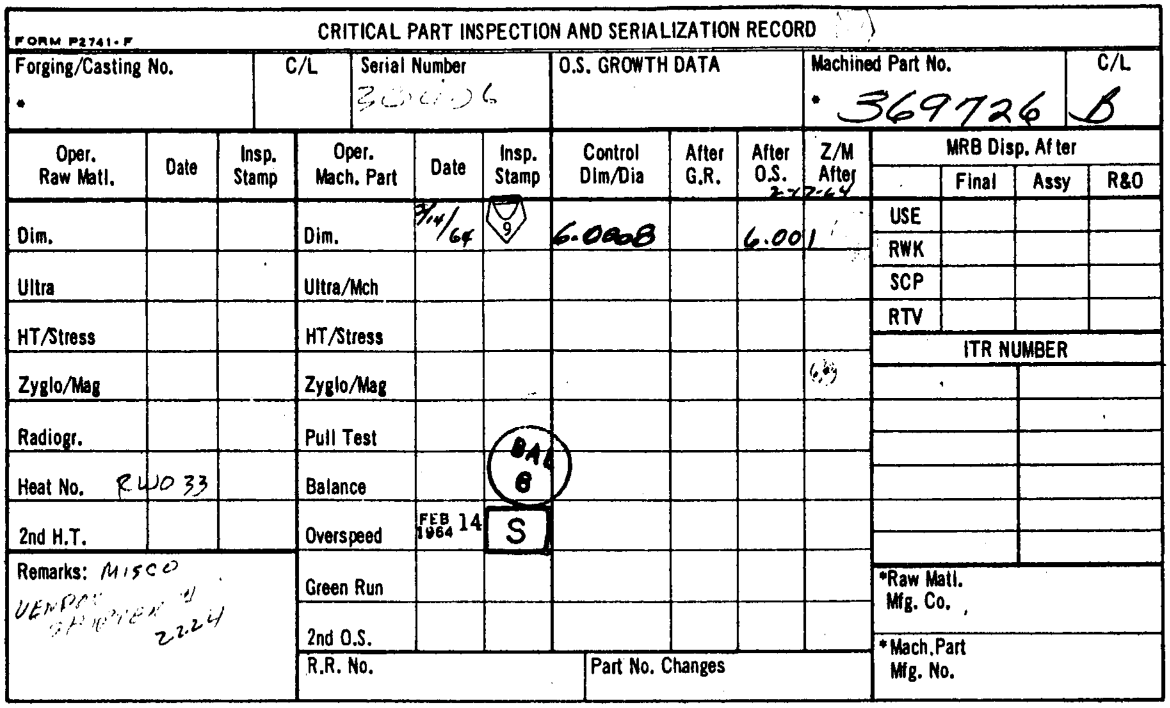
PHOENIX, ARIZONA



FORM P2741-F

CRITICAL PART INSPECTION AND SERIALIZATION RECORD

Forging/Casting No.	C/L	Serial Number	O.S. GROWTH DATA	Machined Part No.	C/L
*		[illegible]		* 369726	B

Oper. Raw Matl.	Date	Insp. Stamp	Oper. Mach. Part	Date	Insp. Stamp	Control Dim/Dia	After G.R.	After O.S. 2-17-64	Z/M After
Dim.			Dim.	2/14/64	9	6.0008		6.001	
Ultra			Ultra/Mch						
HT/Stress			HT/Stress						
Zyglo/Mag			Zyglo/Mag						
Radiogr.			Pull Test						
Heat No. RW033			Balance		BAL 6				
2nd H.T.			Overspeed	FEB 14 1964	S				
Remarks: MISCO [illegible] 2224			Green Run						
			2nd O.S.						

R.R. No.

Part No. Changes

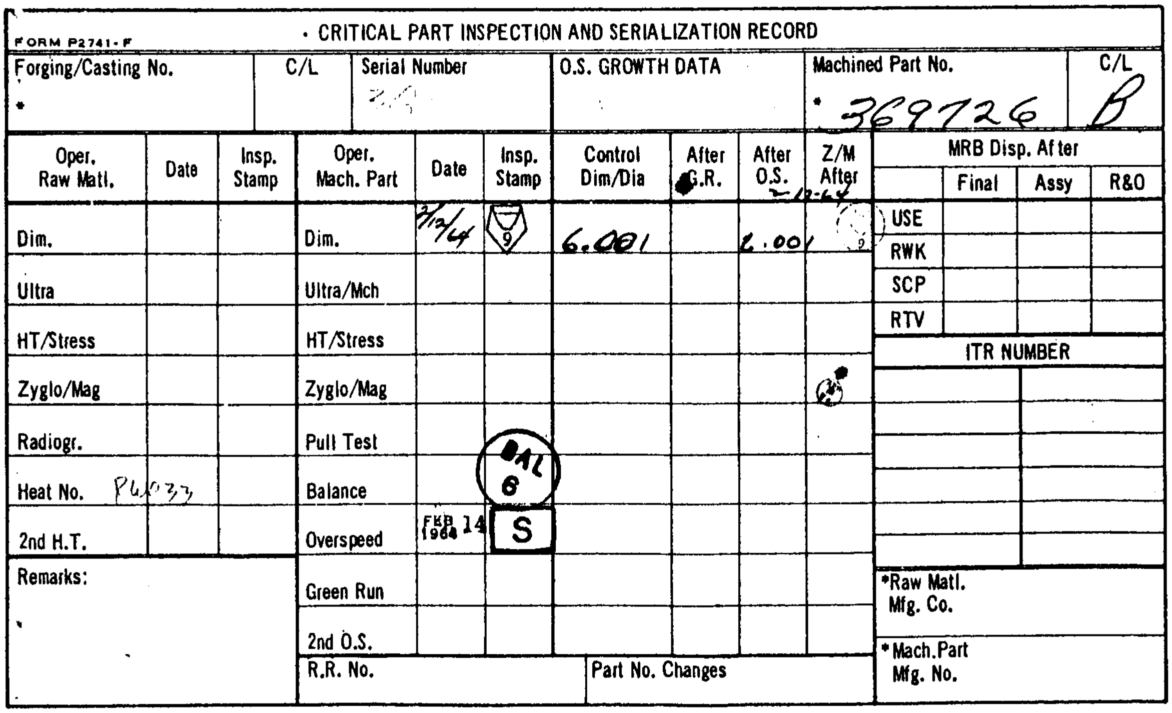
MRB Disp. After	Final	Assy	R&O
USE			
RWK			
SCP			
RTV			

ITR NUMBER

*Raw Matl. Mfg. Co.

*Mach. Part Mfg. No.

TURBINE RESEARCH PACKAGE
SERIAL NO. P-A



FORM P2741-F

CRITICAL PART INSPECTION AND SERIALIZATION RECORD

Forging/Casting No.	C/L	Serial Number	O.S. GROWTH DATA	Machined Part No.	C/L
*		[illegible]		* 369726	B

Oper. Raw Matl.	Date	Insp. Stamp	Oper. Mach. Part	Date	Insp. Stamp	Control Dim/Dia	After G.R.	After O.S. 2-12-64	Z/M After
Dim.			Dim.	2/12/64	9	6.001		6.001	
Ultra			Ultra/Mch						
HT/Stress			HT/Stress						
Zyglo/Mag			Zyglo/Mag						
Radiogr.			Pull Test						
Heat No. RW033			Balance		BAL 6				
2nd H.T.			Overspeed	FEB 14 1964	S				
Remarks:			Green Run						
			2nd O.S.						

R.R. No.

Part No. Changes

MRB Disp. After	Final	Assy	R&O
USE			
RWK			
SCP			
RTV			

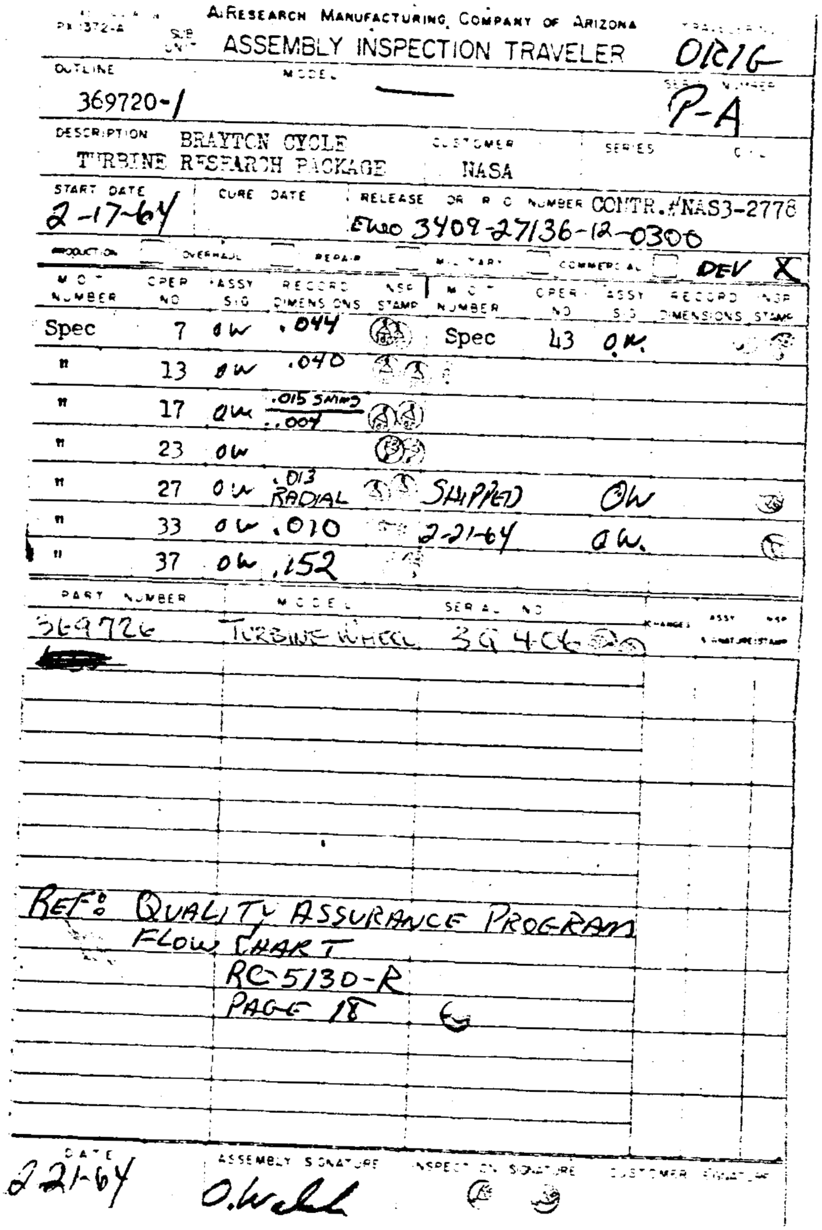
ITR NUMBER

*Raw Matl. Mfg. Co.

*Mach. Part Mfg. No.

TURBINE RESEARCH PACKAGE
SERIAL NO. P-B

FIGURE 35



PX 1572-A
SUB UNIT
AiResearch Manufacturing Company of Arizona
ASSEMBLY INSPECTION TRAVELER
TRAVELER NO. ORIG

OUTLINE 369720-/
MODEL —
SERIAL NUMBER P-A
DESCRIPTION BRAYTON CYCLE TURBINE RESEARCH PACKAGE
CUSTOMER NASA
SERIES
C/L
START DATE 2-17-64
CURE DATE
RELEASE OR R.O. NUMBER CONTR.#NAS3-2778 EWO 3409-27136-12-0300

PRODUCTION ☐ OVERHAUL ☐ REPAIR ☐ MILITARY ☐ COMMERCIAL ☐ DEV X

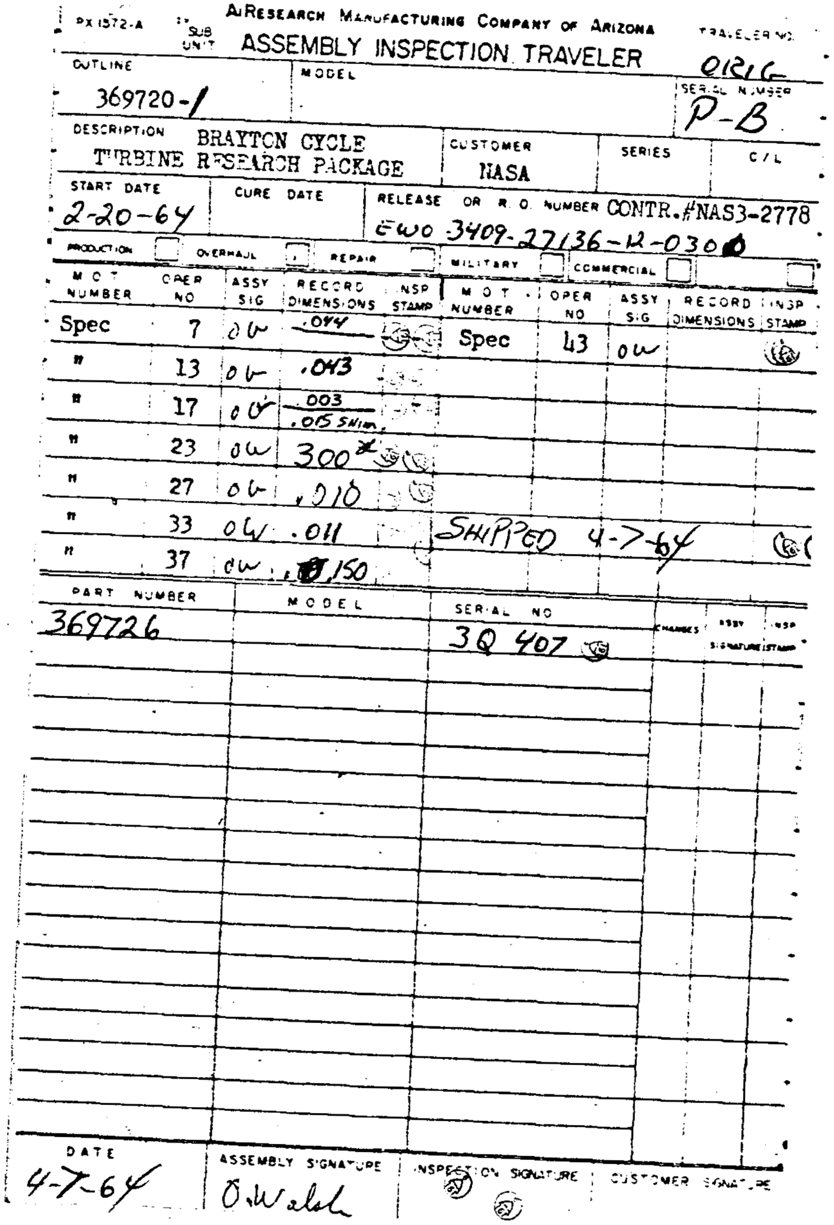
M.O.T. NUMBER	OPER NO	ASSY SIG	RECORD DIMENSIONS	INSP STAMP	M.O.T. NUMBER	OPER NO	ASSY SIG	RECORD DIMENSIONS	INSP STAMP
Spec	7	OW	.044		Spec	43	OW		
"	13	OW	.040						
"	17	OW	.015 SHIMS .004						
"	23	OW							
"	27	OW	.013 RADIAL		SHIPPED		OW		
"	33	OW	.010		2-21-64		OW		
"	37	OW	.152						

PART NUMBER 369726
MODEL TURBINE WHEEL
SERIAL NO 3Q 406
CHANGES
ASSY SIGNATURE
INSP STAMP

REF: QUALITY ASSURANCE PROGRAM
FLOW CHART
RC-5130-R
PAGE 18

DATE 2-21-64
ASSEMBLY SIGNATURE O.Walsh
INSPECTION SIGNATURE
CUSTOMER SIGNATURE

SERIAL NO. P-A



PX 1572-A
SUB UNIT
AiResearch Manufacturing Company of Arizona
ASSEMBLY INSPECTION TRAVELER
TRAVELER NO. ORIG

OUTLINE 369720-/
MODEL
SERIAL NUMBER P-B
DESCRIPTION BRAYTON CYCLE TURBINE RESEARCH PACKAGE
CUSTOMER NASA
SERIES
C/L
START DATE 2-20-64
CURE DATE
RELEASE OR R.O. NUMBER CONTR.#NAS3-2778 EWO 3409-27136-12-0300

PRODUCTION ☐ OVERHAUL ☐ REPAIR ☐ MILITARY ☐ COMMERCIAL ☐ ☐

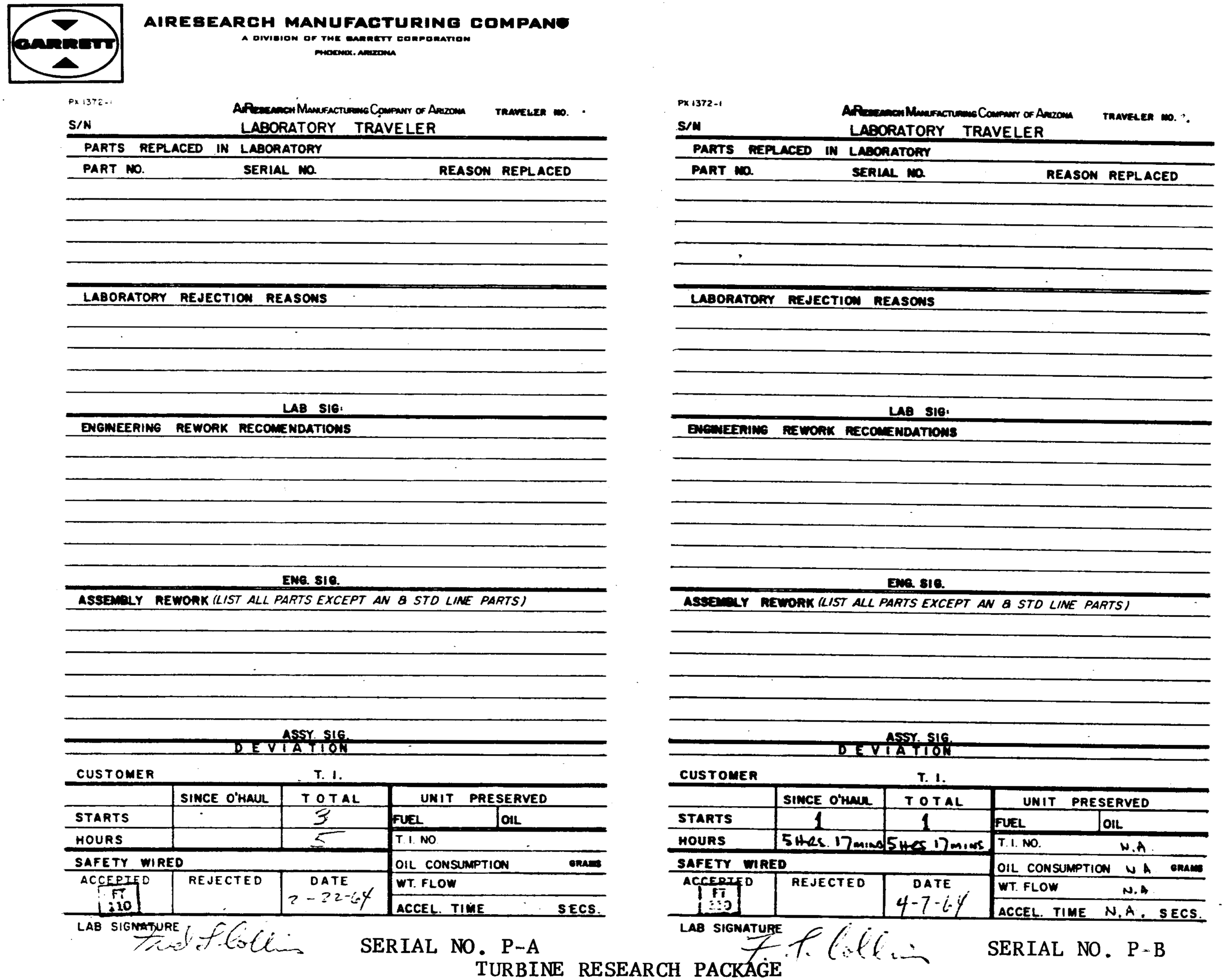
M.O.T. NUMBER	OPER NO	ASSY SIG	RECORD DIMENSIONS	INSP STAMP	M.O.T. NUMBER	OPER NO	ASSY SIG	RECORD DIMENSIONS	INSP STAMP
Spec	7	OW	.044		Spec	43	OW		
"	13	OW	.043						
"	17	OW	.003 .015 SHIM						
"	23	OW	300						
"	27	OW	.010						
"	33	OW	.011		SHIPPED 4-7-64				
"	37	OW	~~.0~~.150						

PART NUMBER 369726
MODEL
SERIAL NO 3Q 407
CHANGES
ASSY SIGNATURE
INSP STAMP

DATE 4-7-64
ASSEMBLY SIGNATURE O.Walsh
INSPECTION SIGNATURE
CUSTOMER SIGNATURE

SERIAL NO. P-B

TURBINE RESEARCH PACKAGE
FIGURE 36



AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
PHOENIX, ARIZONA

PX 1372-1

AiResearch Manufacturing Company of Arizona TRAVELER NO.

S/N

LABORATORY TRAVELER

PARTS REPLACED IN LABORATORY

PART NO.	SERIAL NO.	REASON REPLACED

LABORATORY REJECTION REASONS

LAB SIG:

ENGINEERING REWORK RECOMENDATIONS

ENG. SIG.

ASSEMBLY REWORK *(LIST ALL PARTS EXCEPT AN & STD LINE PARTS)*

ASSY. SIG.

DEVIATION

CUSTOMER T. I.

	SINCE O'HAUL	TOTAL
STARTS		3
HOURS		5

SAFETY WIRED

ACCEPTED	REJECTED	DATE
FT 110		2-22-64

UNIT PRESERVED

FUEL OIL

T. I. NO.

OIL CONSUMPTION GRAMS

WT. FLOW

ACCEL. TIME SECS.

LAB SIGNATURE Fred F. Collins

SERIAL NO. P-A

PX 1372-1

AiResearch Manufacturing Company of Arizona TRAVELER NO.

S/N

LABORATORY TRAVELER

PARTS REPLACED IN LABORATORY

PART NO.	SERIAL NO.	REASON REPLACED

LABORATORY REJECTION REASONS

LAB SIG:

ENGINEERING REWORK RECOMENDATIONS

ENG. SIG.

ASSEMBLY REWORK *(LIST ALL PARTS EXCEPT AN & STD LINE PARTS)*

ASSY. SIG.

DEVIATION

CUSTOMER T. I.

	SINCE O'HAUL	TOTAL
STARTS	1	1
HOURS	5 HRS. 17 MINS	5 HRS 17 MINS

SAFETY WIRED

ACCEPTED	REJECTED	DATE
FT [illegible]		4-7-64

UNIT PRESERVED

FUEL OIL

T. I. NO. N.A.

OIL CONSUMPTION N.A. GRAMS

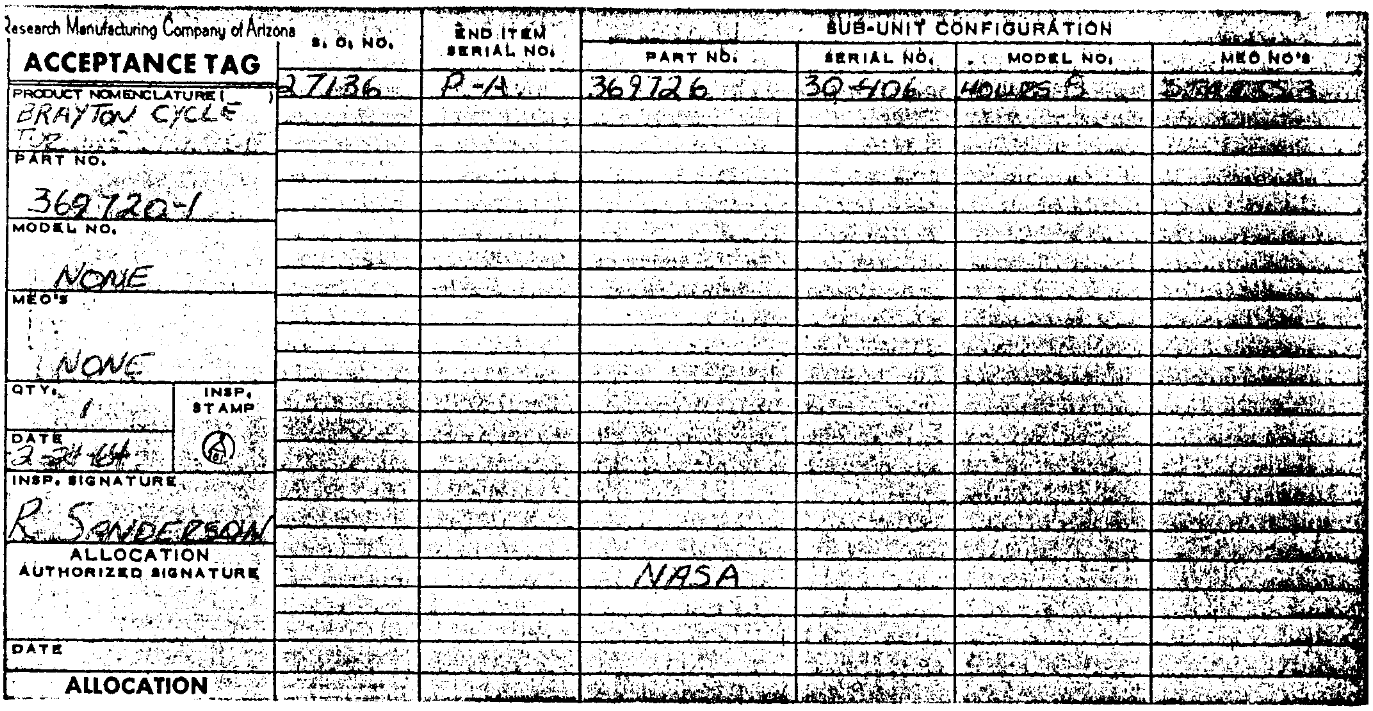
WT. FLOW N.A.

ACCEL. TIME N.A. SECS.

LAB SIGNATURE F. F. Collins

SERIAL NO. P-B

TURBINE RESEARCH PACKAGE
FIGURE 37



Research Manufacturing Company of Arizona

ACCEPTANCE TAG

PRODUCT NOMENCLATURE ( )
BRAYTON CYCLE
TJ[illegible]

PART NO.
369720-1

MODEL NO.
NONE

MEO'S
NONE

QTY.
1

INSP. STAMP

DATE
2-24-64

INSP. SIGNATURE
R. SANDERSON

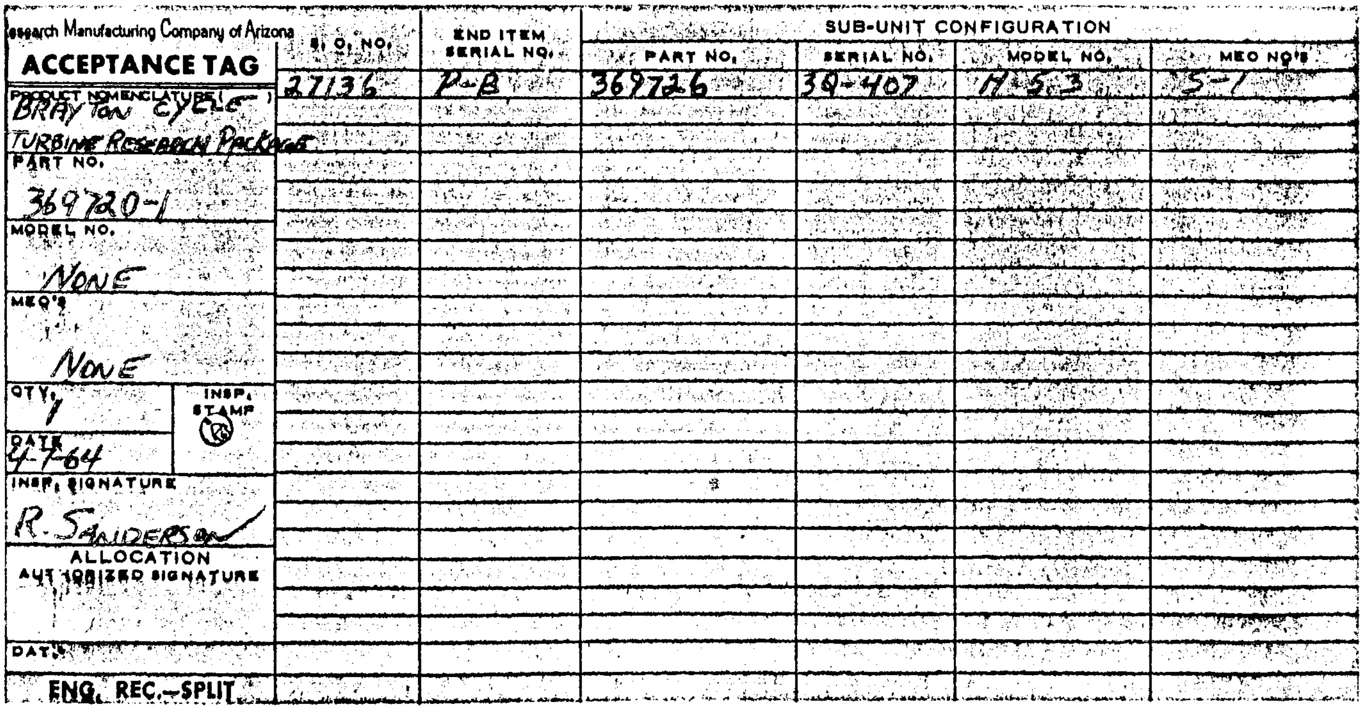
ALLOCATION
AUTHORIZED SIGNATURE

DATE

ALLOCATION

S. O. NO.	END ITEM SERIAL NO.	SUB-UNIT CONFIGURATION			
		PART NO.	SERIAL NO.	MODEL NO.	MEO NO'S
27136	P-A	369726	3Q-406	HOURS 8	[illegible]
		NASA			

SERIAL NO P-A



Research Manufacturing Company of Arizona

ACCEPTANCE TAG

PRODUCT NOMENCLATURE ( )
BRAYTON CYCLE
TURBINE RESEARCH PACKAGE

PART NO.
369720-1

MODEL NO.
NONE

MEO'S
NONE

QTY.
1

INSP. STAMP

DATE
4-7-64

INSP. SIGNATURE
R. SANDERSON

ALLOCATION
AUTHORIZED SIGNATURE

DATE

ENG. REC.—SPLIT

S. O. NO.	END ITEM SERIAL NO.	SUB-UNIT CONFIGURATION			
		PART NO.	SERIAL NO.	MODEL NO.	MEO NO'S
27136	P-B	369726	3Q-407	H-5-3	S-1

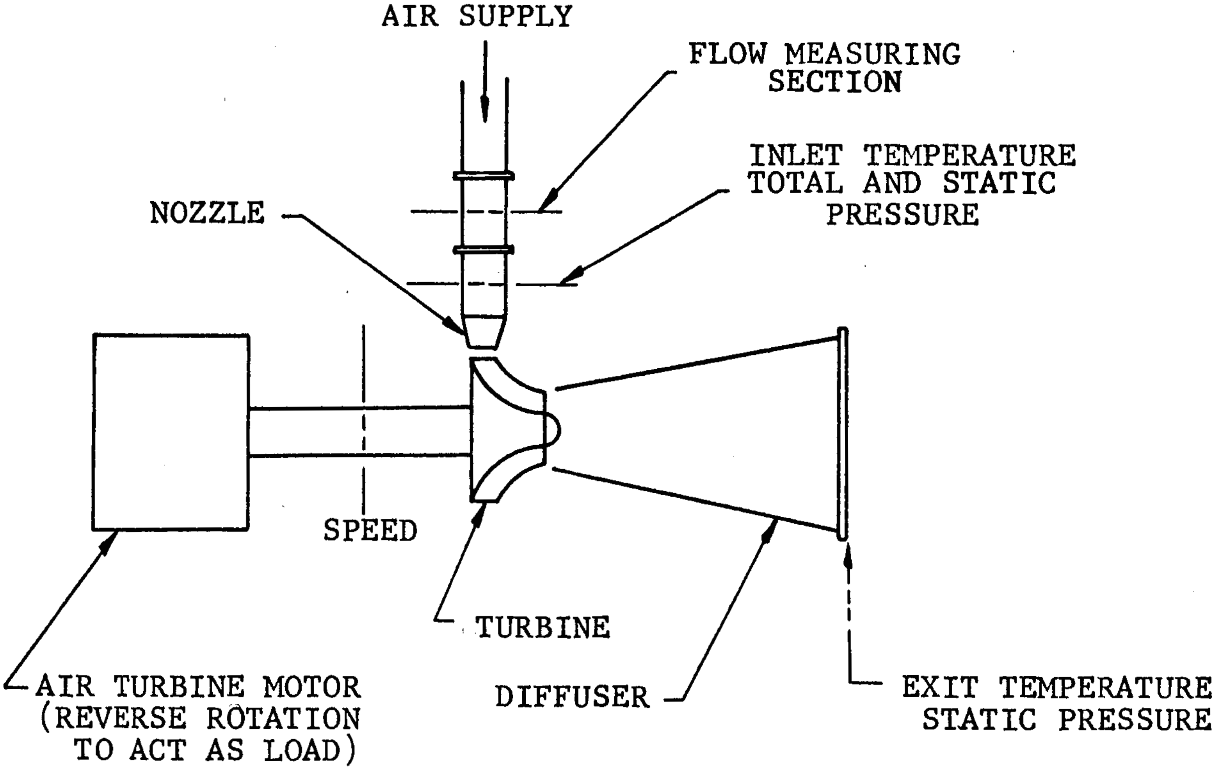
SERIAL NO. P B

TURBINE RESEARCH PACKAGE
FIGURE 38

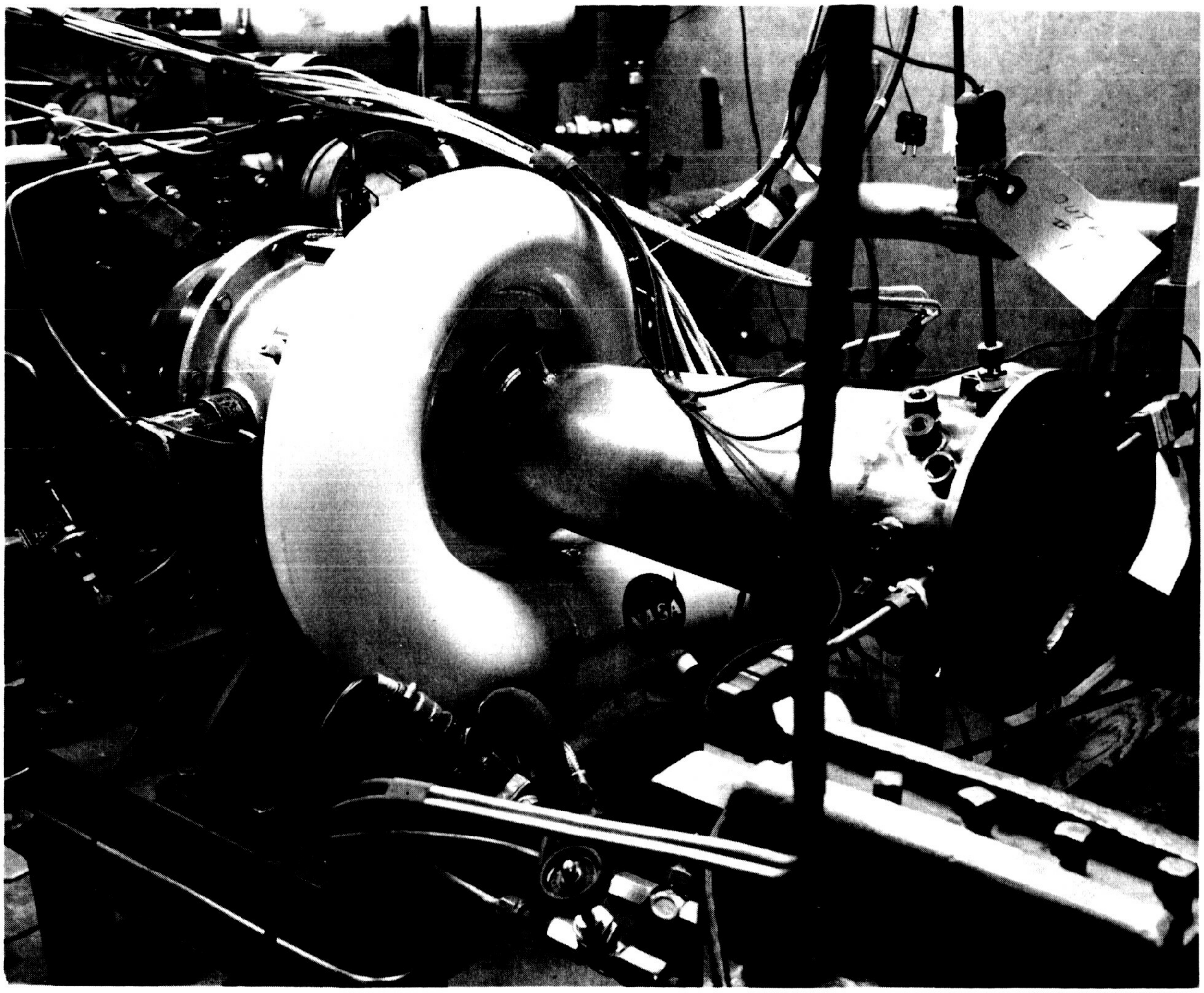
4.0 TURBINE TESTING

4.1 Test Setup

The turbine research packages were tested in the AiResearch turbomachinery testing facility in Phoenix, Arizona. The test setup is shown schematically below:



Compressed air was supplied to the test turbine from the plant air system lines. An air turbine motor, driven in reverse, was used to load the test turbine. Figure 39 shows the turbine research package, Serial No. P-A, mounted in the test setup.



TURBINE RESEARCH PACKAGE
IN TEST SETUP

FIGURE 39

4.2 Development Test

The development test consisted of determining the amount of exducer cutback required to obtain a minimum axial swirl of the turbine discharge gas. After installation of the research package into the test setup, initial performance checks were accomplished and the amount of discharge swirl measured. Figure 40 shows the performance measured during the test. The average swirl was zero and, therefore, no exducer cutback was required.

4.3 Acceptance Tests

4.3.1 Test Requirements

The turbine acceptance tests were performed in accordance with Contract NAS 3-2778 Specification, Article V, paragraph A. Acceptability was demonstrated by meeting a three-part requirement:

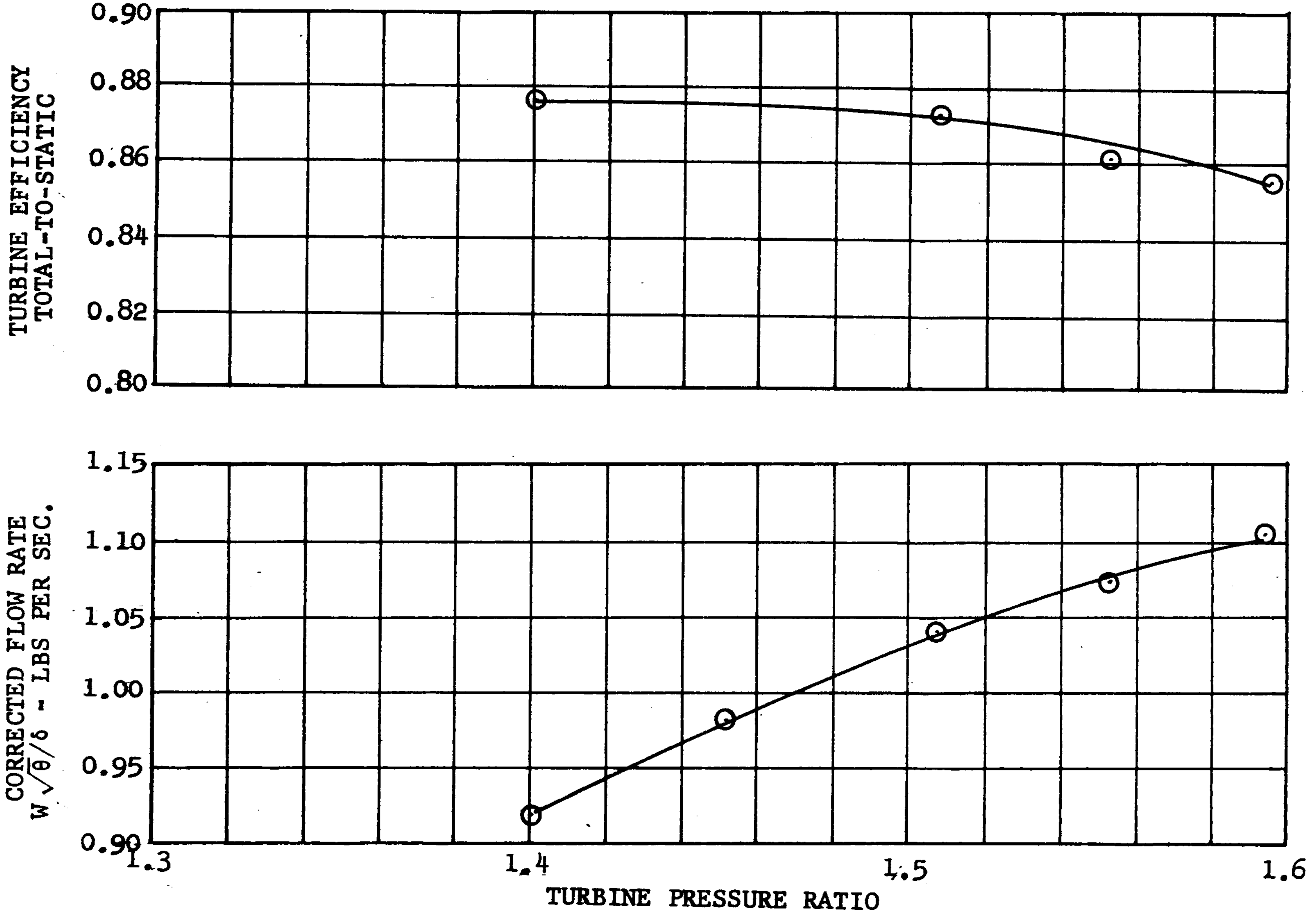
(a) The research package must conform to drawing definition.

(b) The research package must be run at design speed for 5 hours.

(c) At the conclusion of 5 hours of operation, the parts must not show any indication of damage or have demonstrated excessive vibration during operation.

The acceptance tests were performed on each of the two turbine research packages. The tests were witnessed and approved by representatives from NASA Lewis Laboratories.

INLET TEMPERATURE, T_3 = 500°R
SHAFT SPEED, N_1 = 22,400 RPM
WORKING FLUID = AIR

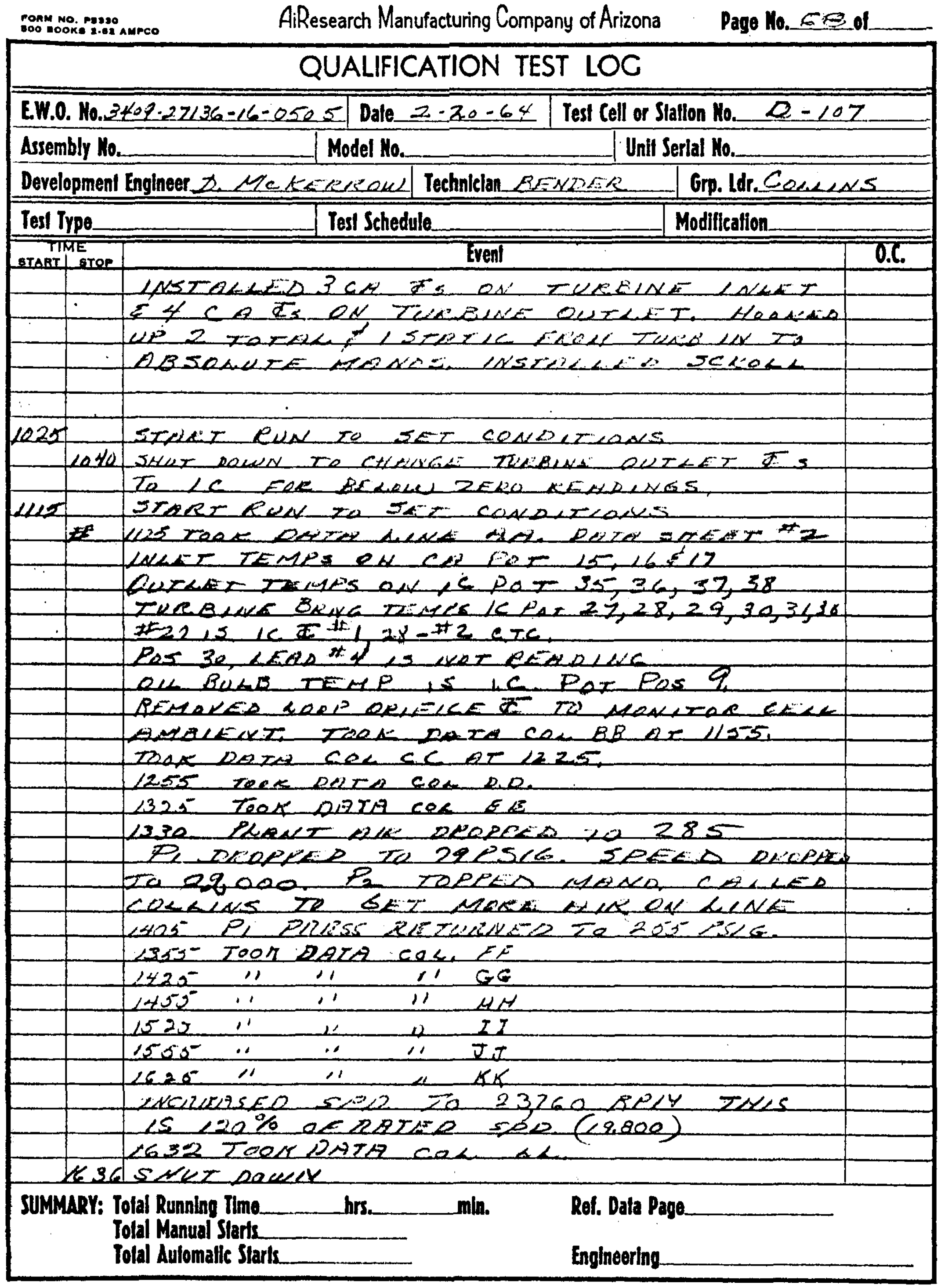


TURBINE RESEARCH PACKAGE ACCEPTANCE TEST WITH AIR
FIGURE 40

A31897

4.3.2 Test Results

The turbine acceptance tests were completed without incident. Although performance demonstration was not required, measurements were required to establish steady-state operation and control during tests. From these measurements, turbine performance calculations are possible. Figures 41, 42, and 43 show the test cell log sheets for the acceptance tests on the research packages, Serial No. P-A and P-B, respectively. Figure 44 shows the data log sheets for both acceptance tests.



FORM NO. P8330
500 BOOKS 2-62 AMPCO

AiResearch Manufacturing Company of Arizona

Page No. 68 of

QUALIFICATION TEST LOG

E.W.O. No. 3409-27136-16-0505 Date 2-20-64 Test Cell or Station No. Q-107

Assembly No. Model No. Unit Serial No.

Development Engineer D. McKERROW Technician BENDER Grp. Ldr. COLLINS

Test Type Test Schedule Modification

TIME START	TIME STOP	Event	O.C.
		INSTALLED 3 CA Ŧs ON TURBINE INLET	
		& 4 CA Ŧs ON TURBINE OUTLET. HOOKED	
		UP 2 TOTAL & 1 STATIC FROM TURB IN TO	
		ABSOLUTE MANOS. INSTALLED SCROLL	
1025		START RUN TO SET CONDITIONS	
	1040	SHUT DOWN TO CHANGE TURBINE OUTLET Ŧs	
		TO IC FOR BELOW ZERO READINGS.	
1115		START RUN TO SET CONDITIONS	
	#	1125 TOOK DATA LINE AA. DATA SHEET #2	
		INLET TEMPS ON CA POT 15, 16 & 17	
		OUTLET TEMPS ON IC POT 35, 36, 37, 38	
		TURBINE BRNG TEMPS IC POT 27, 28, 29, 30, 31, 16	
		#27 IS IC Ŧ #1, 28 - #2 ETC.	
		POS 30, LEAD #4 IS NOT READING	
		OIL BULB TEMP IS IC POT POS 9.	
		REMOVED LOOP ORIFICE Ŧ TO MONITOR CELL	
		AMBIENT. TOOK DATA COL BB AT 1155.	
		TOOK DATA COL CC AT 1225.	
		1255 TOOK DATA COL D.D.	
		1325 TOOK DATA COL EE	
		1330 PLANT AIR DROPPED TO 285	
		P1 DROPPED TO 79 PSIG. SPEED DROPPED	
		TO 22,000. P2 TOPPED MANO. CALLED	
		COLLINS TO GET MORE AIR ON LINE	
		1405 P1 PRESS RETURNED TO 205 PSIG.	
		1355 TOOK DATA COL. FF	
		1425 " " " GG	
		1455 " " " HH	
		1525 " " " II	
		1555 " " " JJ	
		1626 " " " KK	
		INCREASED SPD TO 23760 RPM THIS	
		IS 120% OF RATED SPD. (19,800)	
		1632 TOOK DATA COL LL	
	1636	SHUT DOWN	

SUMMARY: Total Running Time hrs. min. Ref. Data Page

Total Manual Starts

Total Automatic Starts Engineering

ORIGINAL

NOTES

START ACCEPTANCE TEST, ON UNIT SERIAL NO. P-A

FIGURE 41

FORM NO. P5330
500 BOOKS 2-62 AMPCO

AiResearch Manufacturing Company of Arizona

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QUALIFICATION TEST LOG

E.W.O. No. 3409-27136-16-050 Date 2-20-64 Test Cell or Station No. D-107

Assembly No.

Model No.

Unit Serial No.

Development Engineer D. McKELROY

Technician BENDER

Grp. Ldr. COLLINS

Test Type

Test Schedule

Modification

TIME START	TIME STOP	Event	O.C.
		TO DO	
		1. REMOVE TURB ASSY & DELIVER TO DEV. ASSY.	
		2-20-64 SWING.	
		REMOVED TURBINE ASSY & DELIVERED TO DEV. ASSY.	

SUMMARY: Total Running Time ______ hrs. ______ min.

Total Manual Starts

Total Automatic Starts

Ref. Data Page

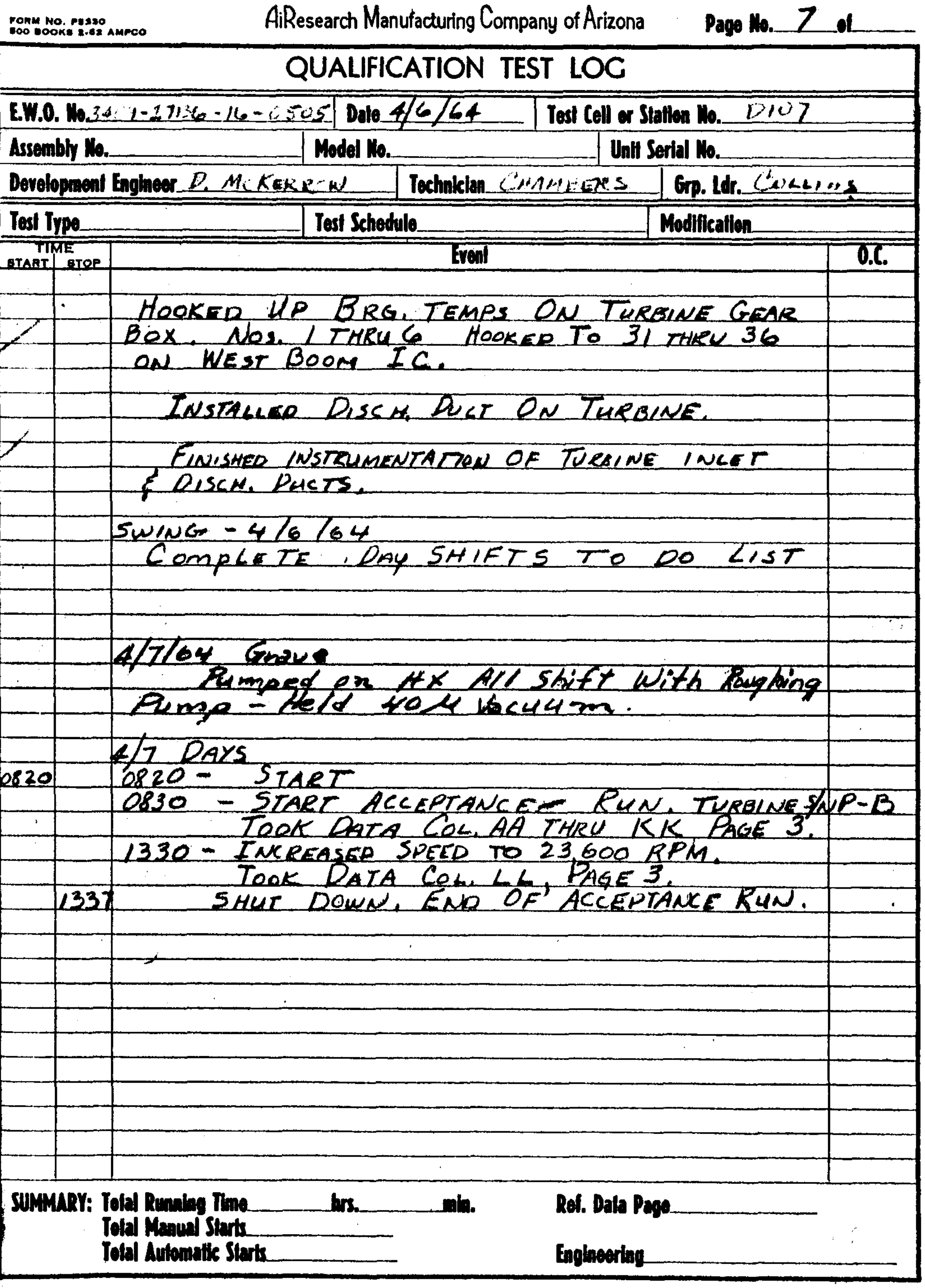
Engineering

ORIGINAL

NOTES

END OF ACCEPTANCE TEST ON UNIT SERIAL NO. P-A TOTAL TIME RUN=5 hr. 36 min.

FIGURE 42



FORM NO. F5330
500 BOOKS 2-62 AMPCO

AiResearch Manufacturing Company of Arizona

Page No. 7 of

QUALIFICATION TEST LOG

E.W.O. No. 34[illegible]1-27136-16-6505
Date 4/6/64
Test Cell or Station No. D107
Assembly No.
Model No.
Unit Serial No.
Development Engineer D. McKERROW
Technician CHAMBERS
Grp. Ldr. COLLINS
Test Type
Test Schedule
Modification

TIME START	TIME STOP	Event	O.C.
		HOOKED UP BRG. TEMPS ON TURBINE GEAR	
		BOX. NOS. 1 THRU 6 HOOKED TO 31 THRU 36	
		ON WEST BOOM I.C.	
		INSTALLED DISCH. DUCT ON TURBINE.	
		FINISHED INSTRUMENTATION OF TURBINE INLET	
		& DISCH. DUCTS.	
		SWING - 4/6/64	
		Complete Day SHIFTS TO DO LIST	
		4/7/64 Grave	
		Pumped on HX All Shift With Roughing	
		Pump - Held 40μ Vacuum.	
		4/7 DAYS	
0820		0820 - START	
		0830 - START ACCEPTANCE RUN. TURBINE S/N P-B	
		TOOK DATA COL. AA THRU KK PAGE 3.	
		1330 - INCREASED SPEED TO 23,600 RPM.	
		TOOK DATA COL. LL, PAGE 3.	
	1337	SHUT DOWN. END OF ACCEPTANCE RUN.	

SUMMARY: Total Running Time hrs. min.
Total Manual Starts
Total Automatic Starts
Ref. Data Page
Engineering

NOTES

START ACCEPTANCE TEST ON UNIT SERIAL NO. P-B

TOTAL TIME RUN=5 hr. 17 min.

FIGURE 43

	AA	BB	CC	DD	EE	FF	GG	HH	II	JJ	KK	LL
COLD BLEED ORIFICE P_1	220	237	223	236	230	-	253	256	257	260	256	259
COLD BLEED ORIFICE ΔP	31.5	30.2	31.8	28.3	29.3	-	29.9	29.6	29.3	29.6	29.0	28.1
COLD BLEED ORIFICE T_1	47	47	48	50	51	-	49	49	50	49	50	50
COLD BLEED FLOW #/MIN	93	95	94.5	92	92	-	97	97	97	97	97	95
INLET PRESS STATIC "HG	43.65	43.70	43.70	43.30	43.30	43.75	43.30	43.20	43.15	43.20	43.20	43.25
INLET PRESS TOTAL #1 "HG	44.2	44.2	44.2	43.75	43.75	44.30	43.80	43.65	43.70	43.70	43.70	43.75
INLET PRESS TOTAL #2 "HG	43.7	43.7	43.7	43.30	43.35	43.75	43.30	43.25	43.20	43.25	43.25	43.30
INLET TEMP #1 CA	42	40	41	44	44	43	42	41	40	39	40	40
INLET TEMP #2 CA	42	40	40	44	44	42.5	42	41	40	39	40	40
INLET TEMP #3 CA	43	40	40	44	44	43.0	42	41	41	39	40	40
OUTLET TEMP #1 IC	-6.0	-8	-6	-4	-4	-7	-6	-5	-5	-6	-5	-4
OUTLET TEMP #2 IC	-6.0	-8	-7	-4	-4	-7	-6	-5	-5	-6	-5	-4
OUTLET TEMP #3 IC	-6.5	-8	-7	-4	-4	-7	-6	-5	-5	-6	-5	-4
OUTLET TEMP #4 IC	-6.0	-8	-6.5	-4	-4	-7	-6	-5	-5	-6	-5	-4
SPEED EPUT x 2 CPS	11285	11299	11306	11308	11310	11290	11308	11305	11310	11288	11280	11281
VIBRATION SIDE	.03	.03	.031	.030	.032	.028	.030	.030	.030	.030	.031	.030
VIBRATION BOTTOM	.027	.031	.029	.031	.029	.030	.029	.030	.030	.030	.030	.031
DESIRED PRESS RATIO	1.51:1	1.51:1	1.51:1	1.51:1	1.51:1	1.51:1	1.51:1	1.51:1	1.51:1	1.51:1	1.51:1	1.51:1
BEARING TEMP #1 °F	106	105	104	103	104	104	105	104	104	104	103	104.5
#2	106	106	105	104	104	104	105	104	104	104	104	105
#3	105	106	104	103	104	103	104	104	103	104	103	104
#4	~~104~~	—	—	—	—	—	—	—	—	—	—	—
#5	104	104	103	102	104	104	104	104	104	103	102	103
#6	104	104	103	101	103	103	104	103	103	102	102	103
OIL PUMP TEMP INLET BULB	84	84	82	81	81	82	82	82	81	81	81	81
CELL AMBIENT °F				53	53	53	52	52	52	52	52.5	50.5
TIME	1125	1155	1225	1255	1325	1355	1425	1455	1525	1555	1625	1632
BAROMETER	28.83	28.83	28.81	28.80	28.80	28.80	28.77	28.77	28.75	28.75	28.76	28.76
COLD ORIFICE SIZE 4DX2.00												

TECHNICIANS - BENDER - SMITH
DATE 2-20-64
CELL D-107

ALTITUDE EQUIPMENT DIVISION
CALCULATED
RECORDED
DRAWN
CHECKED
APPROVED

ACCEPTANCE TEST
NASA TURBINE ~~RESEARCH PACKAGE~~
SERIAL NO. P-A

AiResearch Manufacturing Company of Arizona

2

	AA	BB	CC	DD	EE	FF	GG	HH	II	JJ	KK	LL		
COLD BLEED ORIFICE P_1 PSIG	280	297	294	295	295	291	295	296	295	297	294	297		
COLD BLEED ORIFICE ΔP "H_2O	27.1	25.0	25.1	25.0	25.1	25.5	25.0	25.1	25.0	24.8	24.8	24.0		
COLD BLEED ORIFICE T_1 °F	51	50	50	47	50	51	50	51	53	52	53	54		
COLD BLEED FLOW #/MIN														
INLET PRESS. STATIC "Hg G ~~Hg A~~	15.3	15.25	15.15	15.2	15.15	15.15	15.1	15.1	15.1	15.2	15.15	15.15		
INLET PRESS. TOTAL #1 "Hg G	15.9	15.75	15.75	15.75	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.75		
" " TOTAL #2 "Hg G	15.3	15.25	15.2	15.2	15.2	15.15	15.1	15.15	15.15	15.15	15.15	15.20		
INLET TEMP. #1 (IC) °F	45	44	44	42	44	45	44	44	47	46	47	47		
" " #2 °F	44	43	43	40	44	44	44	43	46	45	46	46		
" " #3 °F	44	43	43	41	44	44	44	43	46	45	46	46		
OUTLET TEMP #1 (IC) °F	-4	-5	-5	-7	-5	-3	-4	-5	-2	-3	-2	~~0~~-2		
" " #2 °F	-5	-5	-5	-7	-5	-4	-4	-5	-2	-3	-2	-2		
" " #3 °F	-5	-5	-5	-7	-5	-4	-4	-5	-2	-3	-2	-2		
" " #4 °F	-5	-5	-5	-7	-5	-4	-5	-5	-2	-3	-2	-2		
SPEED (EPUT X 2 = RPM) EPUT	11284	11290	11296	11288	11340	11288	11278	11301	11296	11302	11299	11801	8470	6378
VIBRATION - SIDE MILS	.02	.02	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.03	.02
DESIRED PRESS. RATIO														
BEARING TEMP #1 °F	124	110	106	102	100	99	100	100	99	99	100	102		
#2 °F	125	111	107	103	101	100	100	101	100	100	101	102		
#3 °F	126	112	108	104	102	101	102	102	101	102	102	103		
#4 °F	122	110	105	100	99	98	98	99	98	98	98	101		
#5 °F	122	111	106	100	99	99	99	99	98	98	98	100		
#6 °F	120	108	104	99	98	97	97	98	96	97	97	98		
OIL PUMP TEMP. INLET BULB °F	105	88	83	79	77	75	76	76	75	76	76	77		
CELL AMBIENT °F	58	58	57	51	52	52	51	52	53	53	52	51		
TIME	0830	0900	0930	1000	1030	1100	1130	1200	1232	1302	1330	1337	1339	
BAROMETER	28.86	28.86	28.86	28.87	28.87	28.87	28.87	28.86	28.86	28.84	28.84	28.84		
COLD ORIFICE 4DX 2.00														

DATE 1/7/64
CELL D-107

ALTITUDE EQUIPMENT DIVISION
CALCULATED
RECORDED
DRAWN
CHECKED
APPROVED

ACCEPTANCE TEST
NASA TURBINE
SERIAL NO. P-B

AiResearch Manufacturing Company of Arizona

3

CHAMBERS
ROWE

ACCEPTANCE TEST DATA SHEETS
FIGURE 44

AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
PHOENIX, ARIZONA

NASA CONTRACTOR REPORT

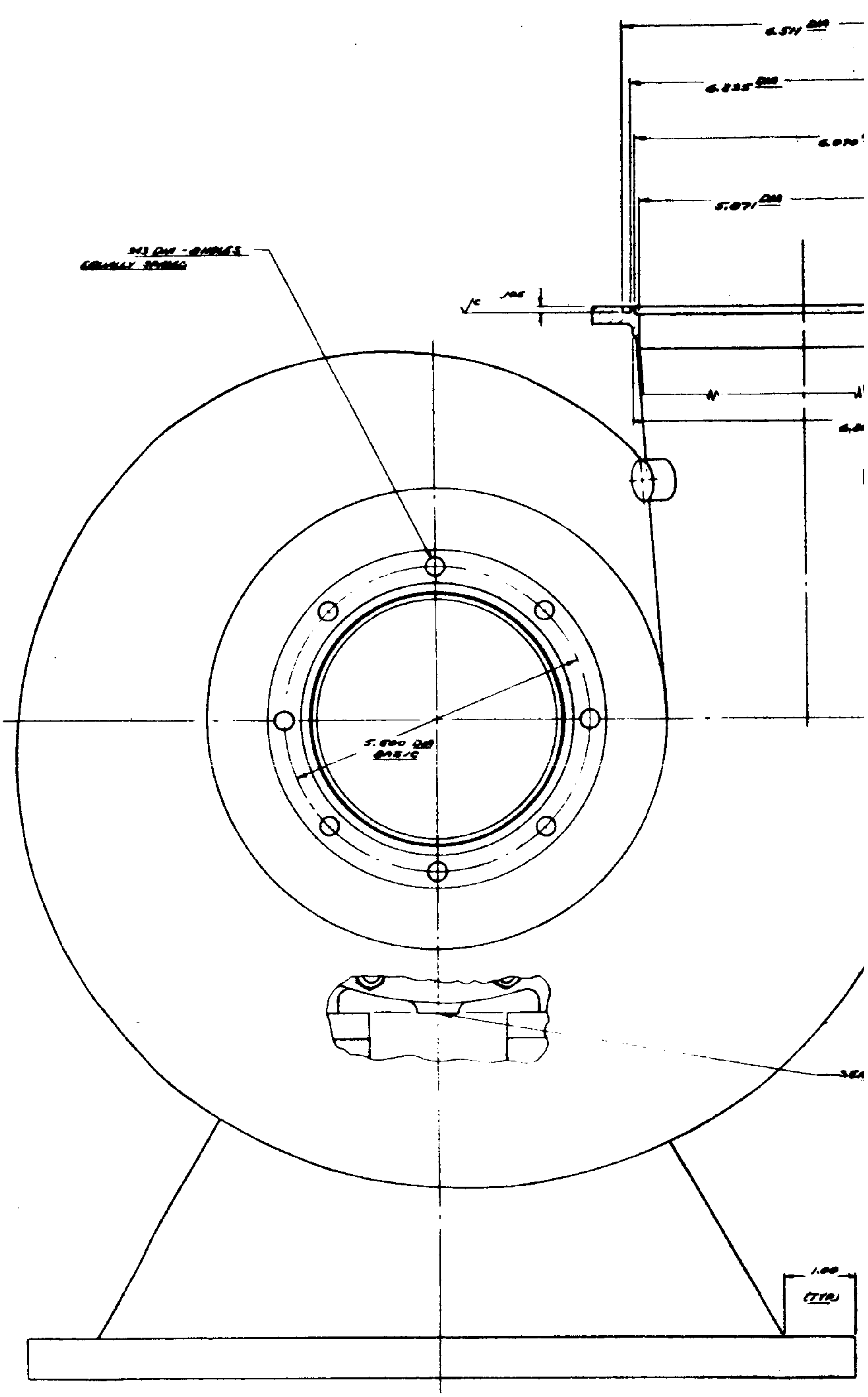
DESIGN AND DEVELOPMENT OF A HIGH-PERFORMANCE BRAYTON-CYCLE COMPRESSOR RESEARCH PACKAGE

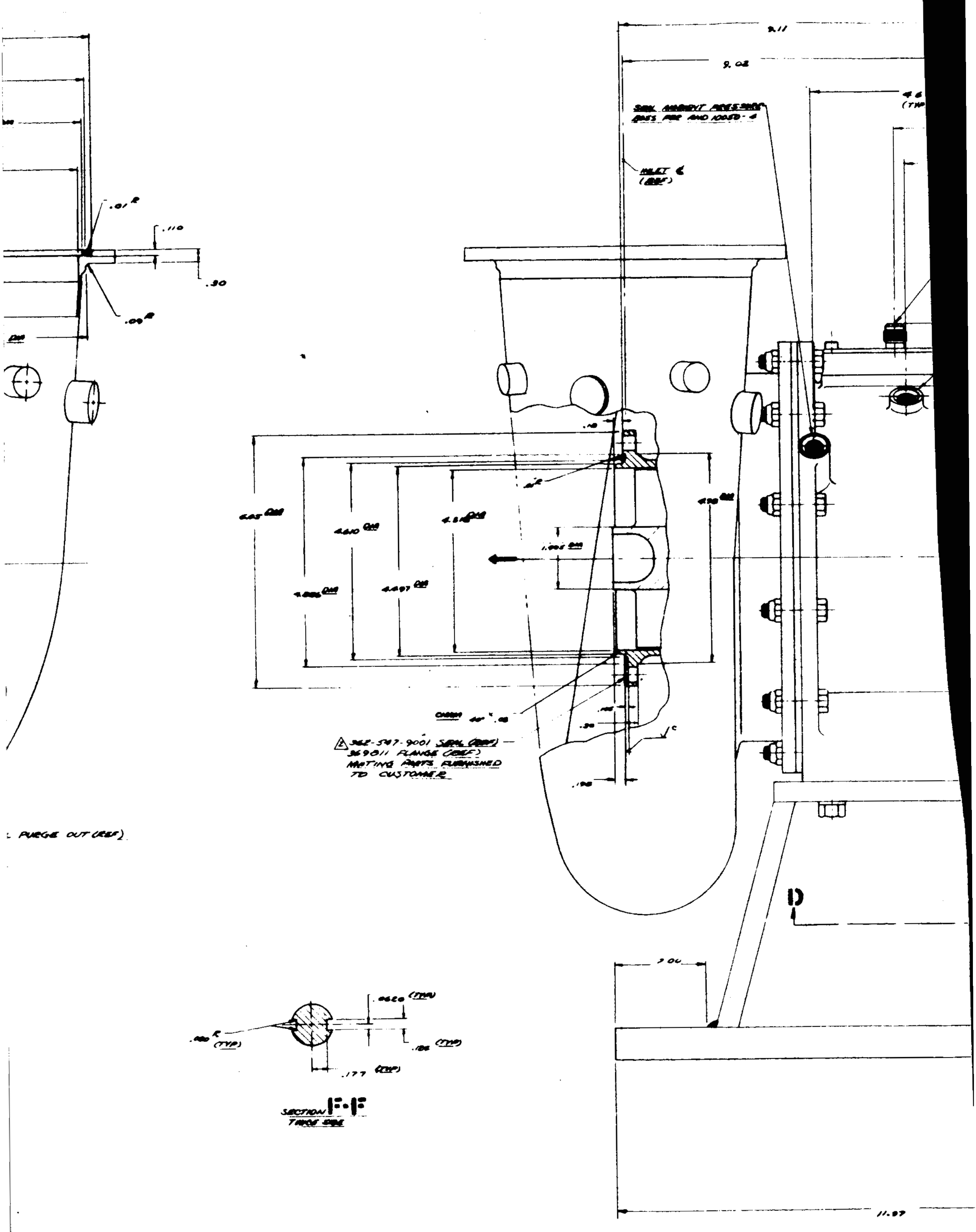
AiResearch Manufacturing Company of Arizona

ABSTRACT

In this development program, advanced aerodynamic design procedures were used to design a high-efficiency radial compressor for operation on monatomic gases. The compressor research package consists of a 6-inch-diameter compressor wheel and shaft mounted on ball bearings and the associated mounting hardware. Following development testing, the final configuration was defined, and when the unit was tested on argon, efficiencies in excess of 0.80 total-to- total were obtained. Additional testing is to be accomplished by the NASA.

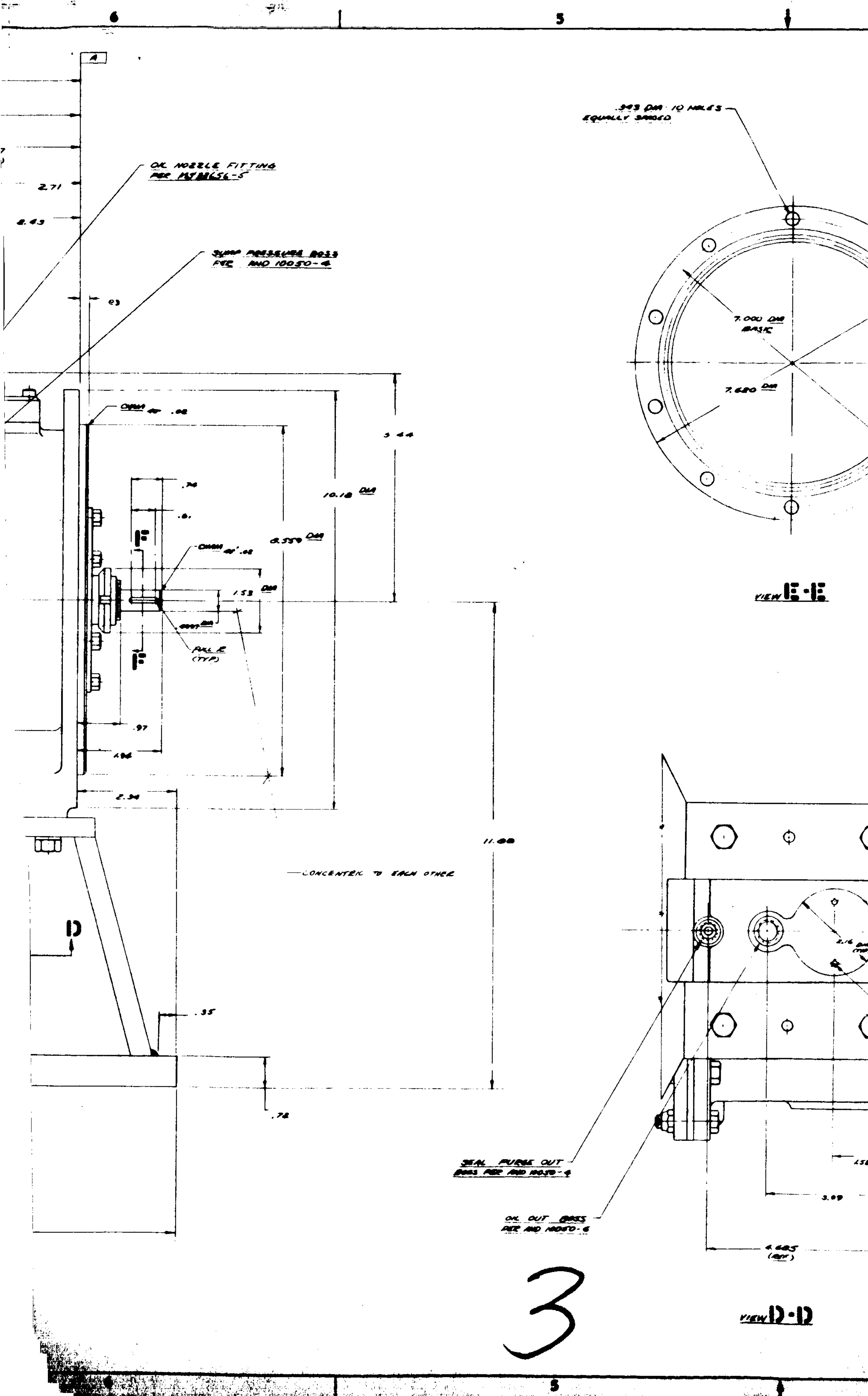
APS 5108-R


6.511 DIA
6.235 DIA
6.070
5.871 DIA
.343 DIA - 8 HOLES
EQUALLY SPACED
.105
5.600 DIA
BASIC
1.00
(TYP)
10
9
D
C
B
A

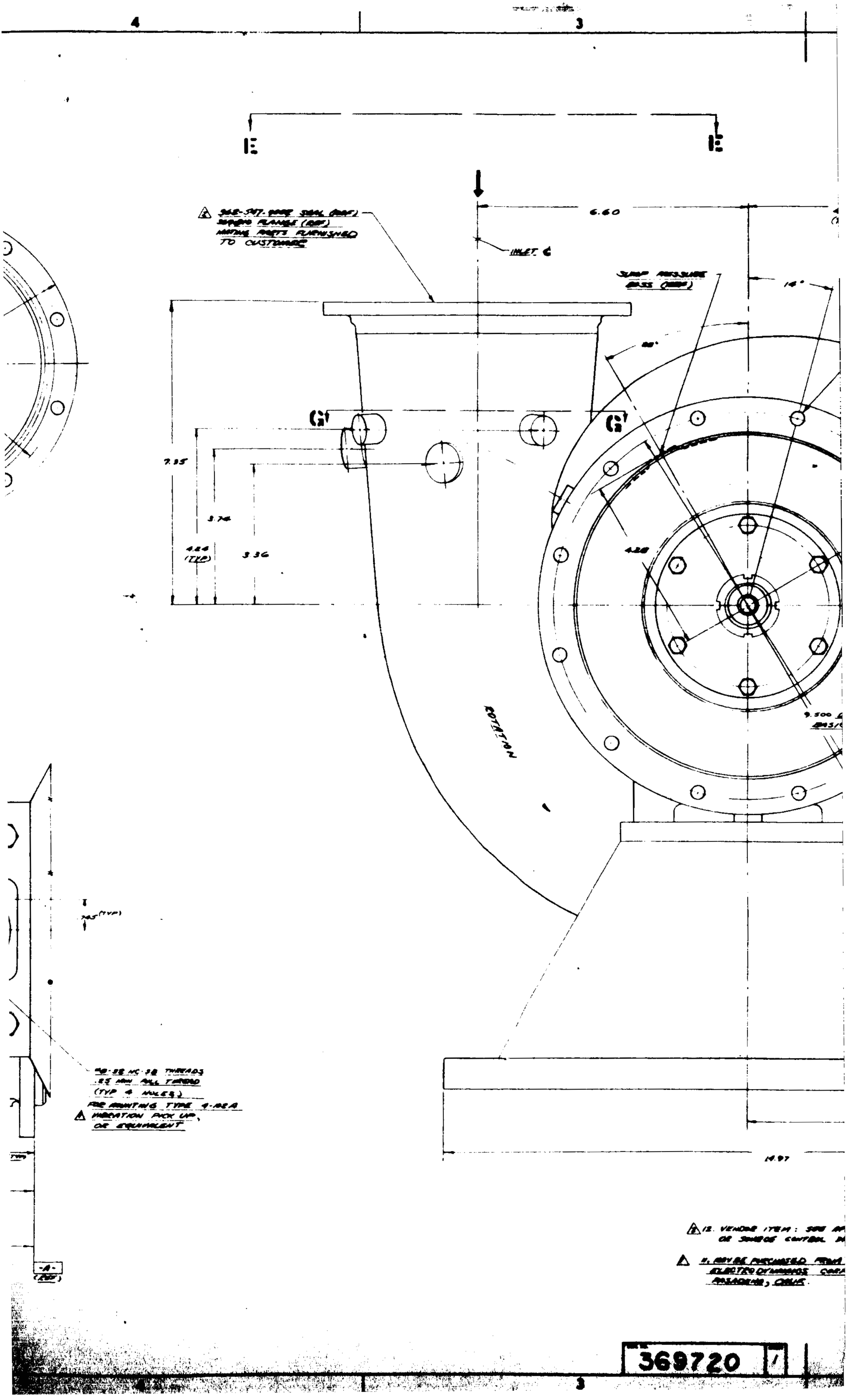

9.11
9.02
4.6
(TYP
SEAL AMBIENT PRESSURE
PASS PER AND 10050-4
INLET ℄
(REF)
.01 R
.110
.30
.09 R
DIA
.10
R
6.65 DIA
4.610 DIA
4.518 DIA
4.90 DIA
1.905 DIA
4.886 DIA
4.497 DIA
CHAM 45° X .05
362-547-9001 SEAL (REF)
369811 FLANGE (REF)
MATING PARTS FURNISHED
TO CUSTOMER
.30
.198
PURGE OUT (REF)
D
7.00
.0620 (TYP)
.020 R
(TYP)
.186 (TYP)
.177 (TYP)
SECTION F-F
TWICE SIZE
11.87

2

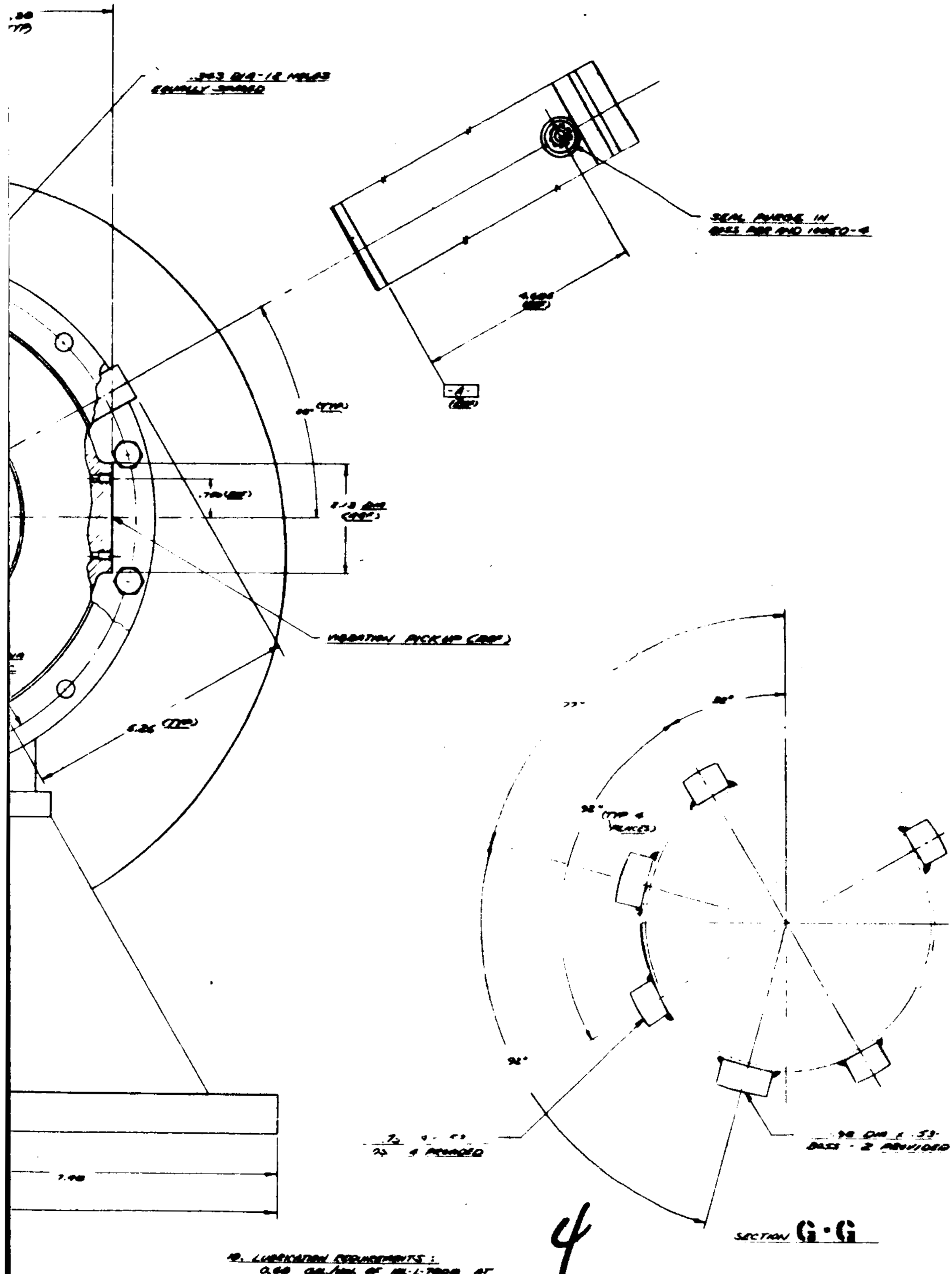
369720 1


6
5
A
OIL NOZZLE FITTING
PER MS33656-5
2.71
8.43
SUMP PRESSURE BOSS
PER AND 10050-4
.03
CHAM 45° × .02
5.44
.76
.61
10.18 DIA
8.559 DIA
F
CHAM 45° × .02
1.53 DIA
.6997 DIA
FULL R
(TYP)
F
.97
1.96
2.34
11.88
CONCENTRIC TO EACH OTHER
D
.35
.78
.343 DIA 10 HOLES
EQUALLY SPACED
7.000 DIA
BASIC
7.680 DIA
VIEW E-E
2.16 DIA
(TYP)
SEAL PURGE OUT
BOSS PER AND 10050-4
OIL OUT BOSS
PER AND 10050-6
1.58
3.09
4.685
(REF)
VIEW D-D

3

4
3
E
E
362-547-0000 SEAL (REF)
SEMCO FLANGE (REF)
MATING PARTS FURNISHED
TO CUSTOMER
6.60
INLET ℄
SUMP PRESSURE
BOSS (REF)
14°
G
G
7.35
3.74
4.24
(TYP)
3.36
4.28
ROTATION
9.500
BASIC
.765 (TYP)
#10-32 NC-3B THREADS
.25 MIN FULL THREAD
(TYP 4 HOLES)
FOR MOUNTING TYPE 4-102A
VIBRATION PICK UP,
OR EQUIVALENT
TYP
-A-
(REF)
14.97
12. VENDOR ITEM: SEE
OR SOURCE CONTROL
11. MAY BE PURCHASED FROM
ELECTRO DYNAMICS CORP
PASADENA, CALIF.
3

369720 | 1



SECTION G-G

4

10. LUBRICATION REQUIREMENTS :
0.60 GAL/MIN OF MIL-L-7808 AT
60-80 PSIG & 150°F (MAX).

9. POSITIONAL & GEOMETRICAL TOLERANCE
SYMBOLS PER MIL-STD-8.

[illegible]

FOR FINAL ASSY - SEE 369721

LIST OF MATERIAL

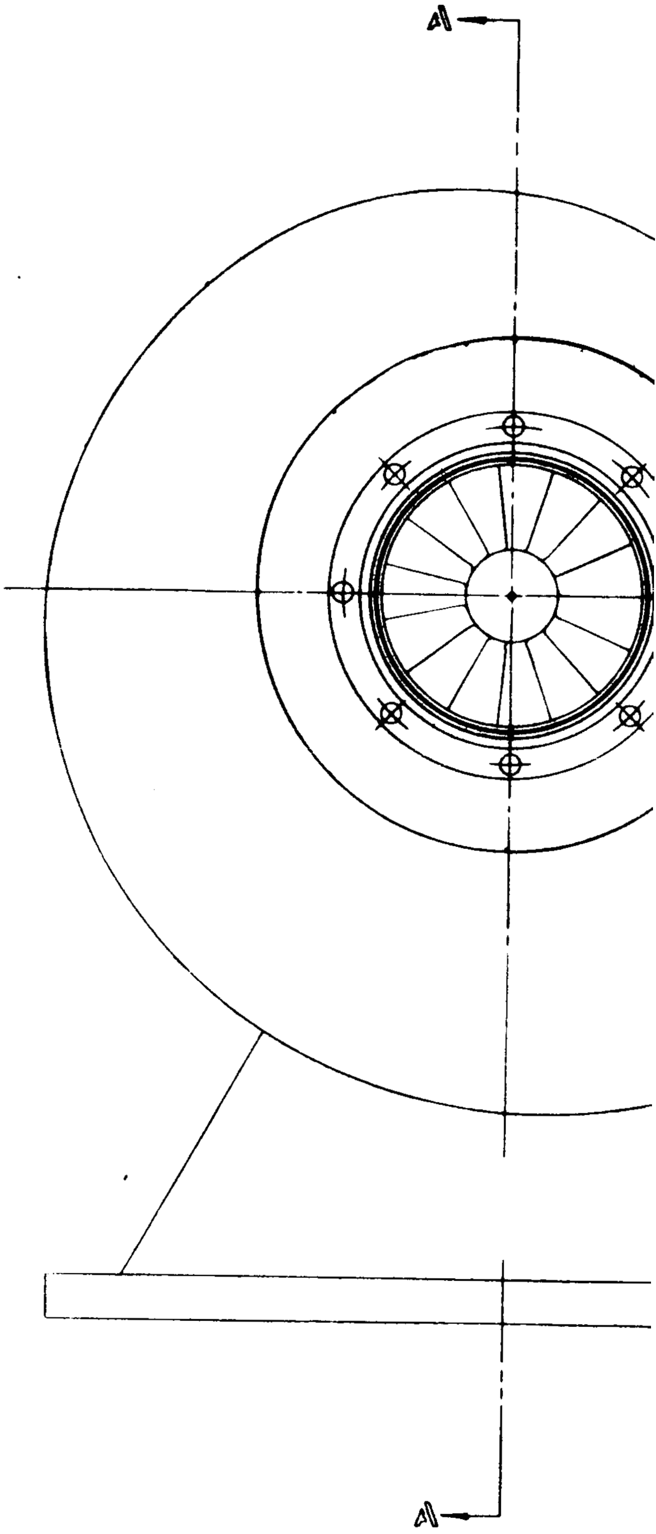
TURBINE OUTLINE,
TEST, BRAYTON CYCLE

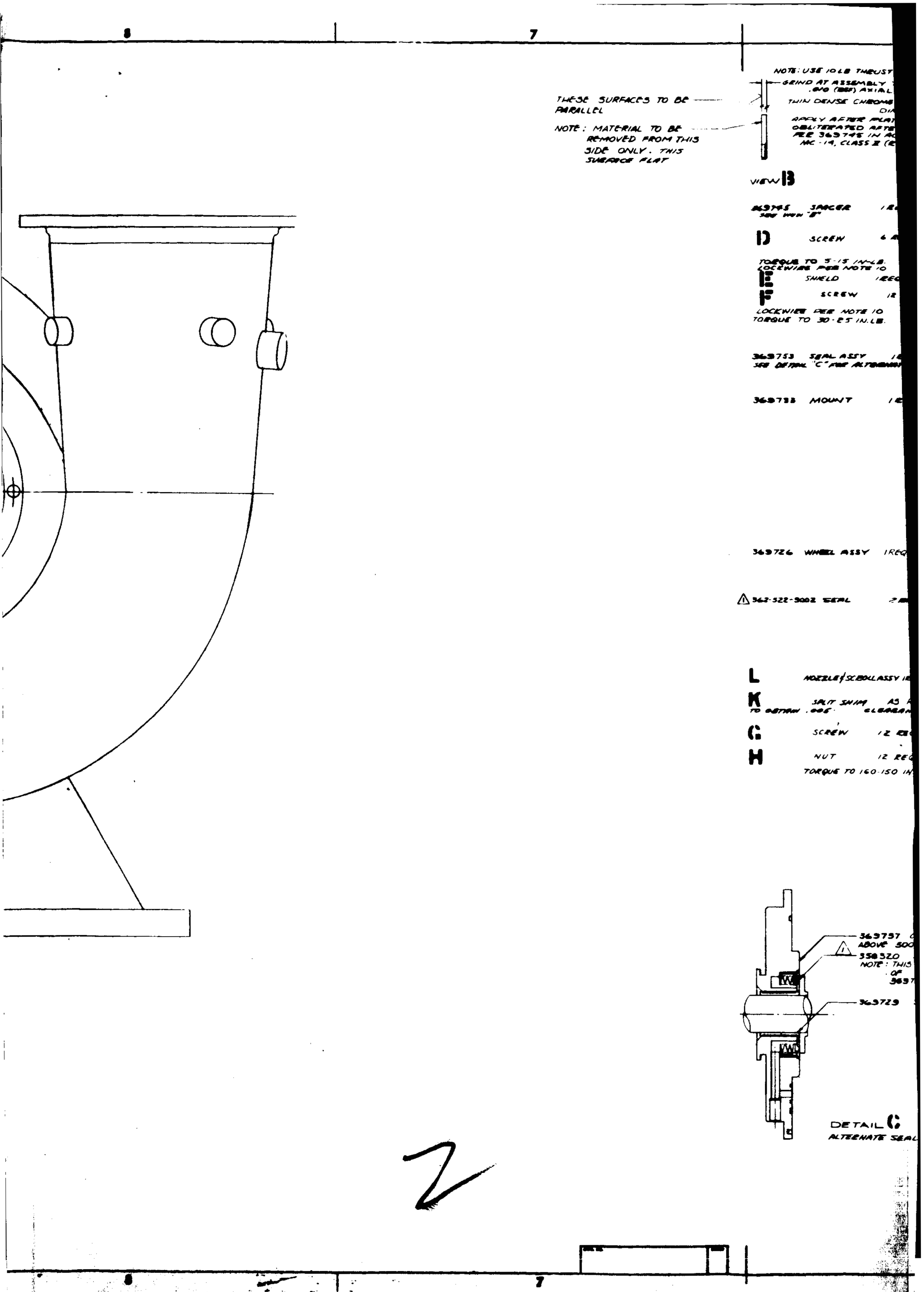
99193	J	369720

SHEET 1 OF 1

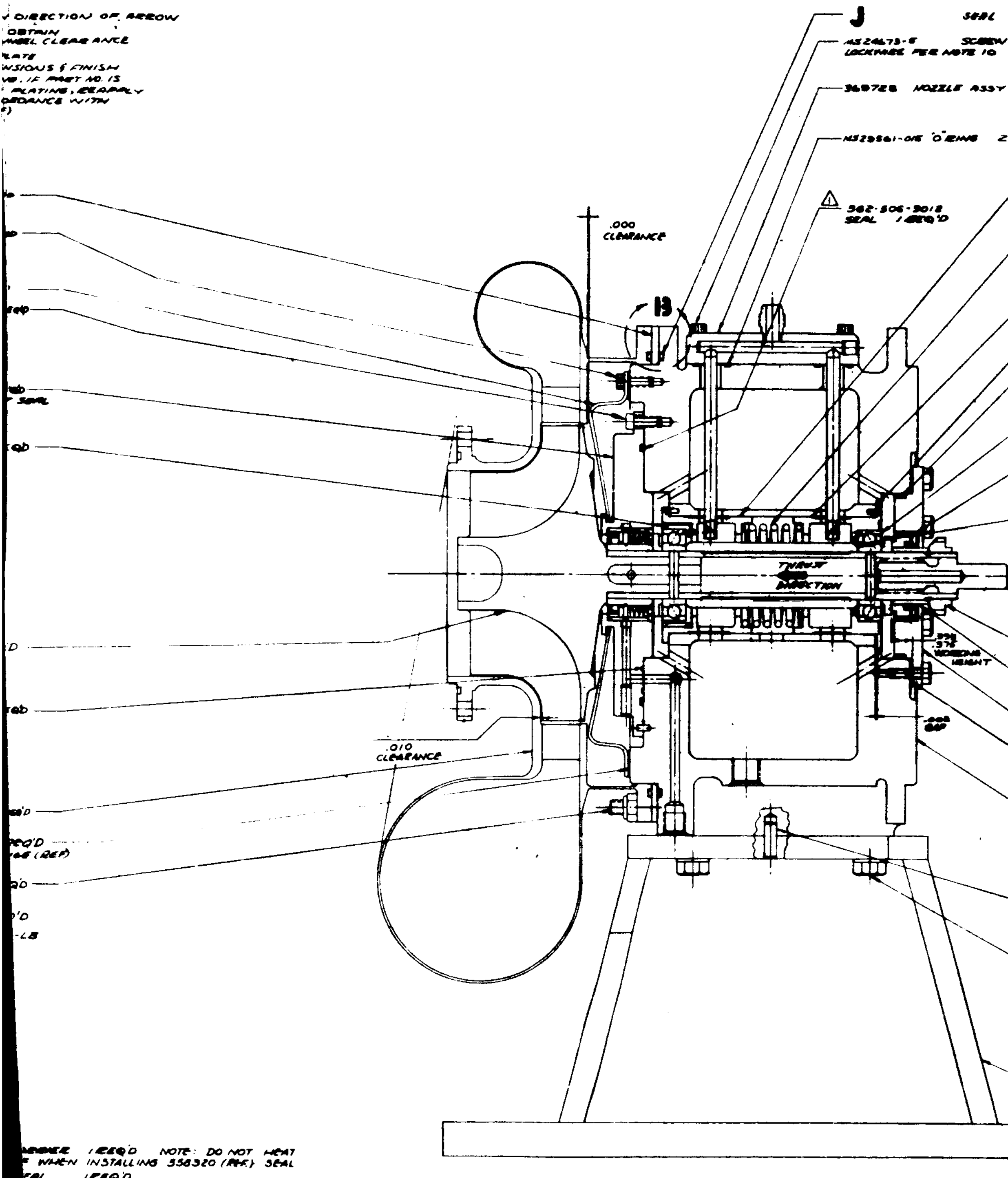
NUMBER	D	E	F	G	H	J	K	L
369721-1	NOT REQ'D	NOT REQ'D	MS24678-8	AN 6C12	MS21042C5	369813	NOT REQ'D	369785-6

A [illegible]




8
7
THESE SURFACES TO BE PARALLEL
NOTE: MATERIAL TO BE REMOVED FROM THIS SIDE ONLY. THIS SURFACE FLAT
NOTE: USE 10 LB THRUST
GRIND AT ASSEMBLY
.010 (REF) AXIAL
THIN DENSE CHROME
DIA
APPLY AFTER PLAT
OBLITERATED AFTE
PER 363745 IN AC
MC-14, CLASS II (E
VIEW B
363745 SPACER 1 RE
SEE VIEW "B"
D SCREW 6 R
TORQUE TO 5-15 IN-LB.
LOCKWIRE PER NOTE 10
E SHIELD 1 REQ
F SCREW 12
LOCKWIRE PER NOTE 10
TORQUE TO 30-25 IN.LB.
363753 SEAL ASSY 1
SEE DETAIL "C" FOR ALTERNAT
363733 MOUNT 1
363726 WHEEL ASSY 1 REQ
⚠ 362-522-9002 SEAL 2
L NOZZLE/SCROLL ASSY 1
K SPLIT SHIM AS
TO OBTAIN .005 CLEARAN
G SCREW 12 RE
H NUT 12 REQ
TORQUE TO 160-150 IN
363757
ABOVE 500
⚠ 358320
NOTE: THIS
OF
3637
363729
DETAIL C
ALTERNATE SEAL
2

DIRECTION OF ARROW
OBTAIN
WHEEL CLEARANCE
RATE
NSIONS & FINISH
WG. IF PART NO. IS
PLATING, REAPPLY
ORDANCE WITH
E)

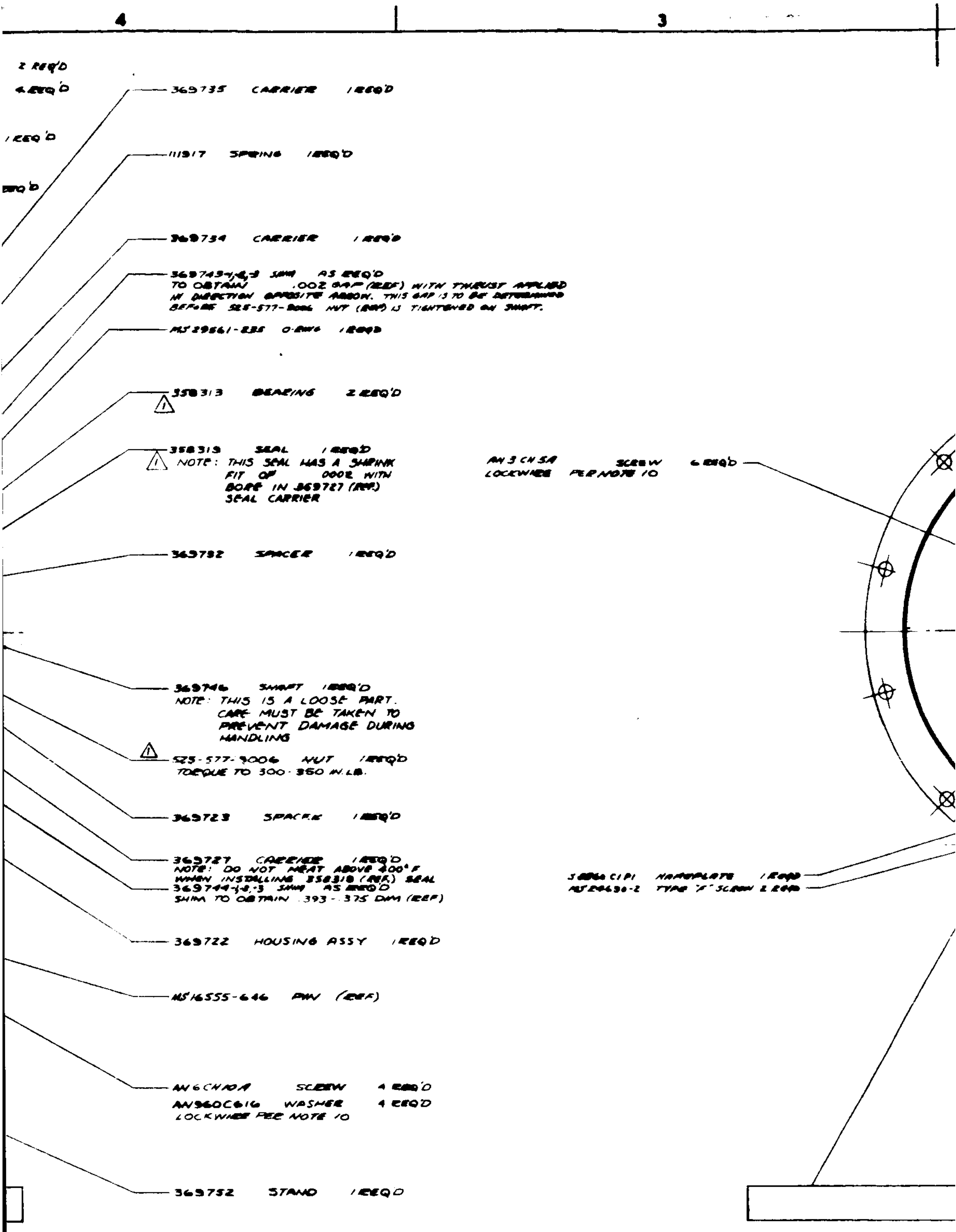


BEARING 1 REQ'D NOTE: DO NOT HEAT
WHEN INSTALLING 558320 (REF.) SEAL
SEAL 1 REQ'D
SEAL HAS A SHRINK FIT
.0005 WITH BORE IN
(REF.) SEAL CARRIER

SPACER 1 REQ'D

SECTION A-A

3



4

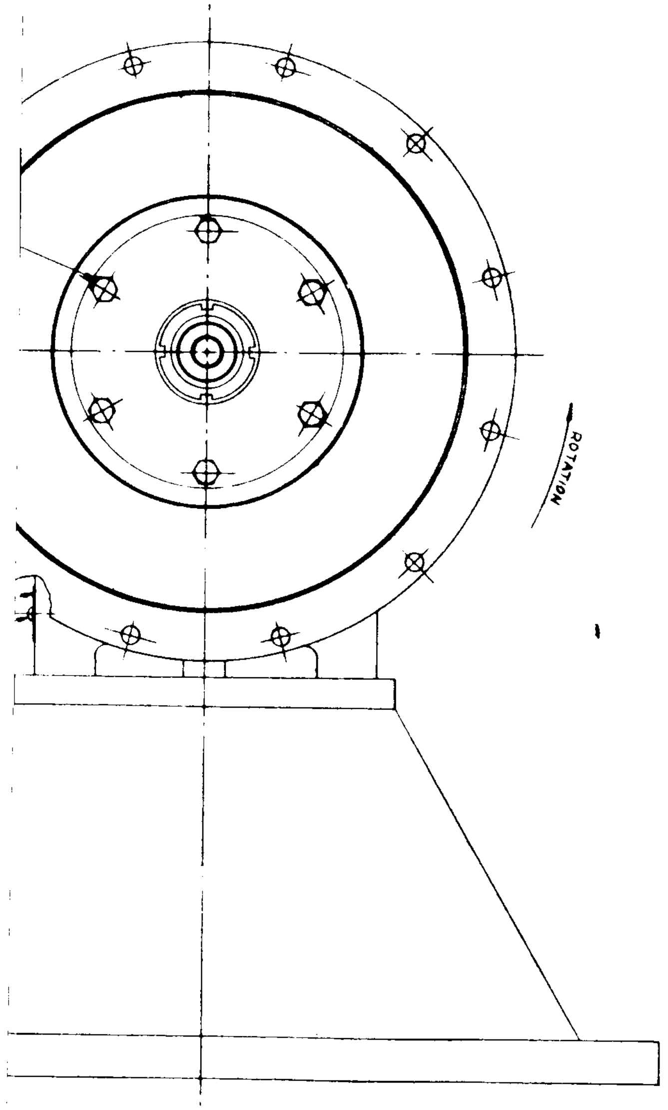
12. TORQUE VALUES GIVEN ARE
FRICTION TORQUE DEVELOP
DEVICES IS TO BE ADDED
MUST BE DETERMINED FO

11. LUBRICATE ALL THREADS WITH
BEFORE ASSEMBLY.

10. LOCKWIRE PER MS 33540 US

1 9. VENDOR ITEM: SEE APPLICABLE S

SEE ENGINEERING ORDER



5

FOR FASTENER LOADING.
ED FROM SELF-LOCKING
TO FASTENER LOADING TORQUE &
EACH FASTENER.
1 219-025-9001 COMPOUND
VS MS20995C32 LOCKWIRE
PECIFICATION OR SOURCE CONTROL DWG

[redacted]

LIST OF MATERIAL

1	369720	369720

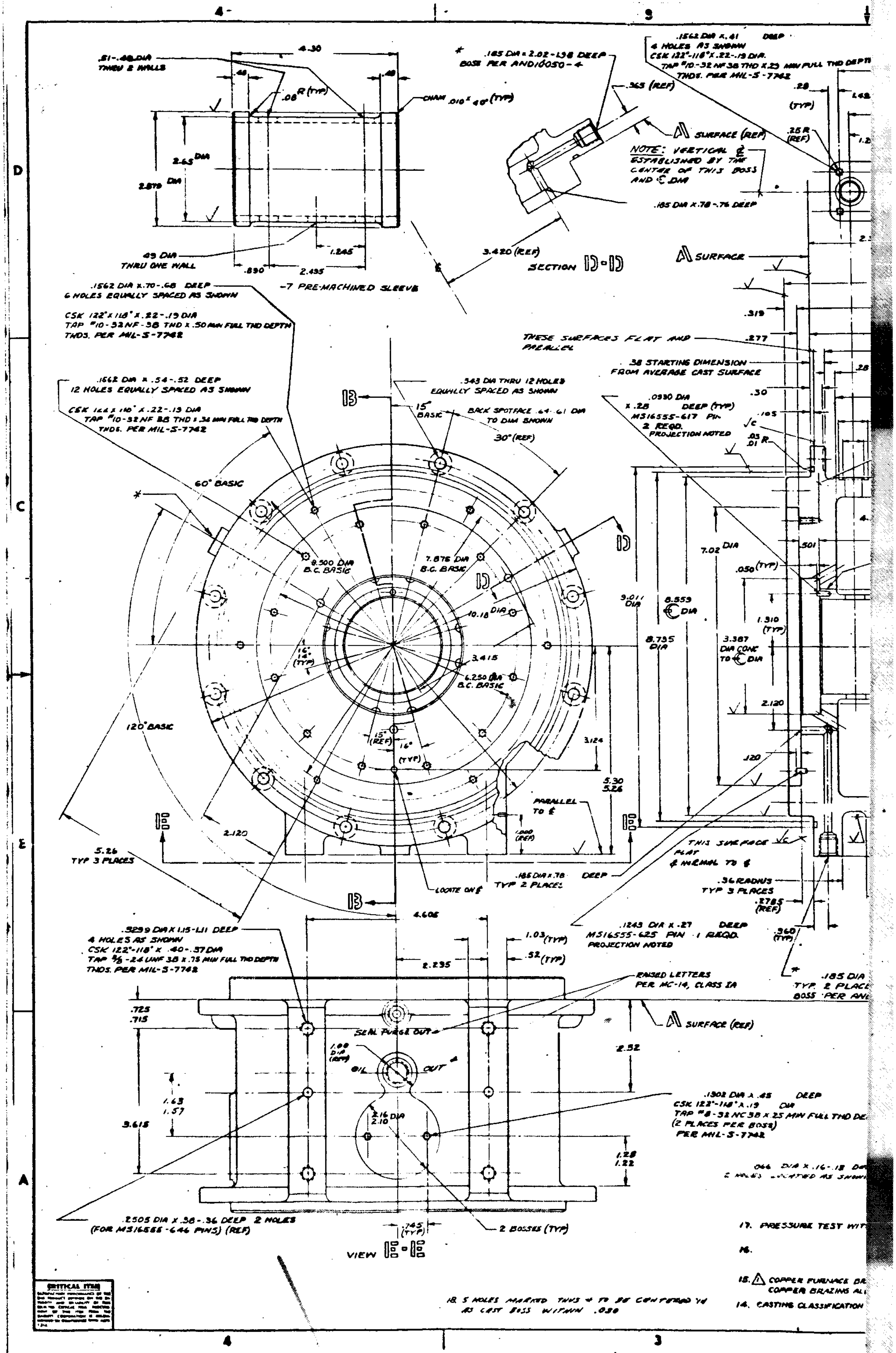
TURBINE ASSEMBLY,
NASA

99193 J 369721

SCALE FULL

SHEET 1 OF 1

369721



18. 5 HOLES MARKED THUS * TO BE CENTERED IN AS CAST BOSS WITHIN .030

17. PRESSURE TEST WIT

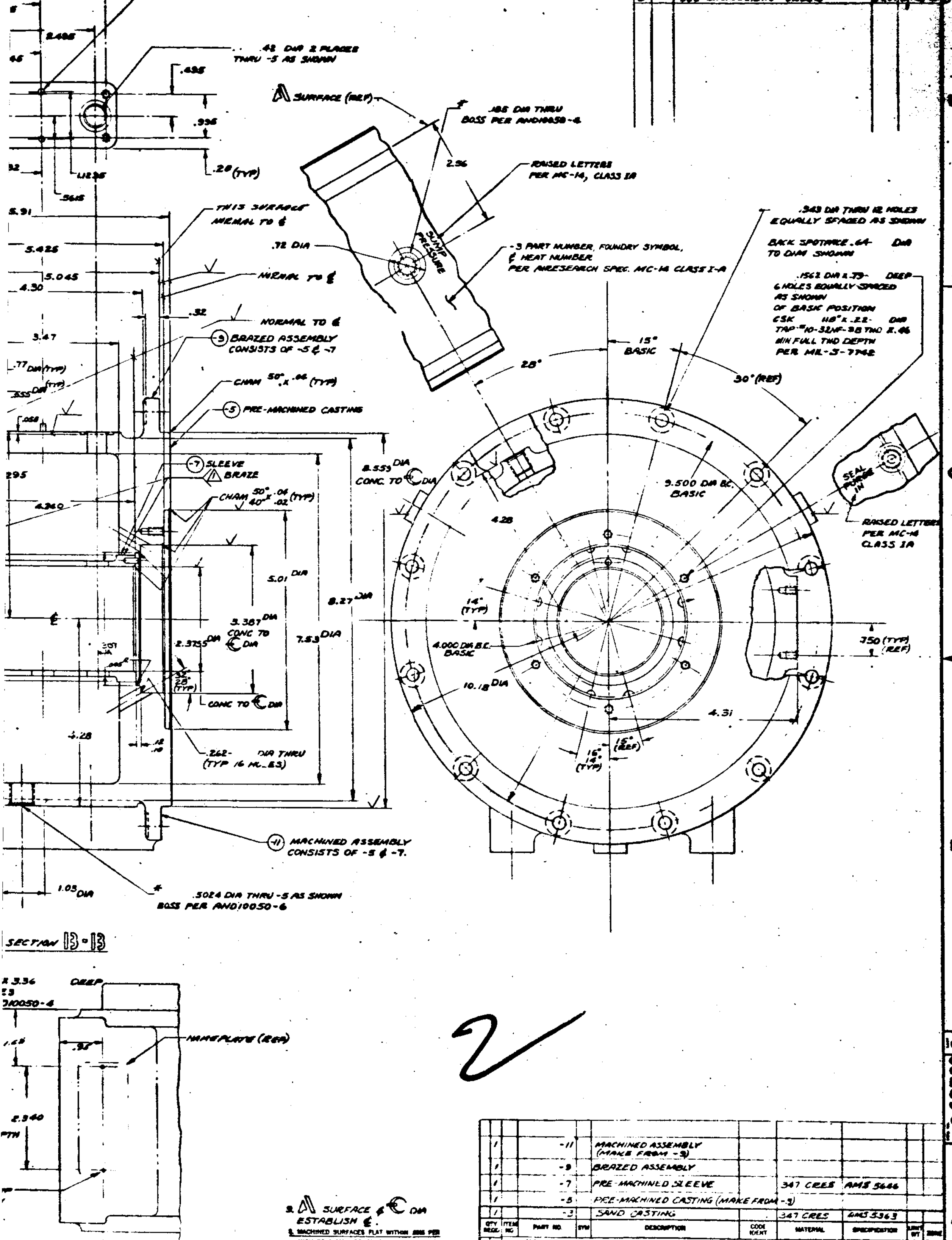
16.

15. △ COPPER FURNACE BR
COPPER BRAZING AL

14. CASTING CLASSIFICATION

APS-5108-R
APS-5109-R

		REVISIONS		
A		SEE ENGINEERING ORDER		
B		SEE ENGINEERING ORDER		
C		SEE ENGINEERING ORDER		
D		SEE ENGINEERING ORDER		



AIR AT 15 P.SIG FOR ONE MINUTE.

ARE PER SPEC. AMS 2671 USING
OY PER AMS 4701 OR AMS 4500.

9. SURFACE & ℄ DIA ESTABLISH ℄.
8. MACHINED SURFACES FLAT WITHIN .005 PER INCH TO A MAX OF .005 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX OF .012 FOR ANY SURFACE.
6. MACHINED DIAS ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .010 - .015.
3. BREAK ALL CORNERS AND SHARP EDGES .010 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED.

QTY REQD	ITEM NO	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT	ZONE
1		-11		MACHINED ASSEMBLY (MAKE FROM -9)					
1		-9		BRAZED ASSEMBLY					
1		-7		PRE-MACHINED SLEEVE		347 CRES	AMS 5646		
1		-5		PRE-MACHINED CASTING (MAKE FROM -3)					
1		-3		SAND CASTING		347 CRES	AMS 5363		

← ASSYS — LIST OF MATERIAL

	NEXT ASSY	USED ON
	369741	369740
	369721	369180
1	369721	369720
REQD		

HEAT TREATMENT: NOTED
PROCESS

SIGNATURES	DATES
Pat Bell	9-16-63
	9-26-63
	9-27-63
	9-27-63

AiResearch Manufacturing Company of Arizona

HOUSING ASSEMBLY, MAIN

99193 | E | 369722

SCALE FULL | WT | SHEET 1 OF 1

369722 D

APS-5105-R
APS-5109-R

THESE SURF.
€ DIA
PARALLEL

20 DIA
CONE TO .5 DIA

PART NO. HERE PER
MC 14, CLASS II

11. MAGNETIC INSPECTION PER MIL-I-6868
10.

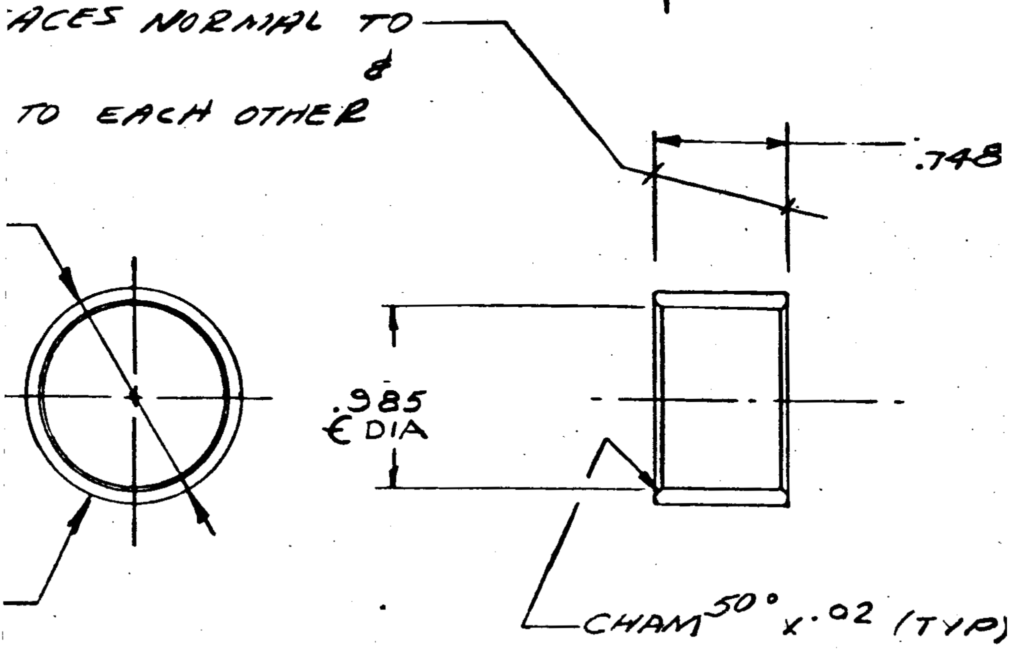
8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015.
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

QTY.
/
/
/
REQD
HEAT
HARD
Rc
SPEC.

PS544 — SIMS - CRONAFLEX

SYM	



REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION
	← ASSYS			LIST C

369741	369740
369731	369730
369721	369720
NEXT ASSY.	USED ON

T TREATMENT	PROCESS
NESS 40-46	NAME
	SPEC.

SIGNATURES	DATES
DFT. Montgomery	8-24-63
CHK.	8-24-63
MFG. ENG.	
MAT. & PROCESS	9-25-63
STRESS D.K. Wesley	9-25-63
AERO	
APP.	9-26-63
APP.	
DESIGN ACTIVITY APP.	9-26-63
OTHER ACTIVITY APP.	

AiRes

DWG. T

CODE

99

SCAL

2

D

REVISIONS		
DESCRIPTION	DATE	APPROVED

LAST LTR. —

DWG. NO. 369723

CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR. 1.313.

		4340	AMS 6415	
	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.

F MATERIAL

arch Manufacturing Company of Arizona

PHOENIX, ARIZONA

A division of THE GARRETT CORPORATION

TLE

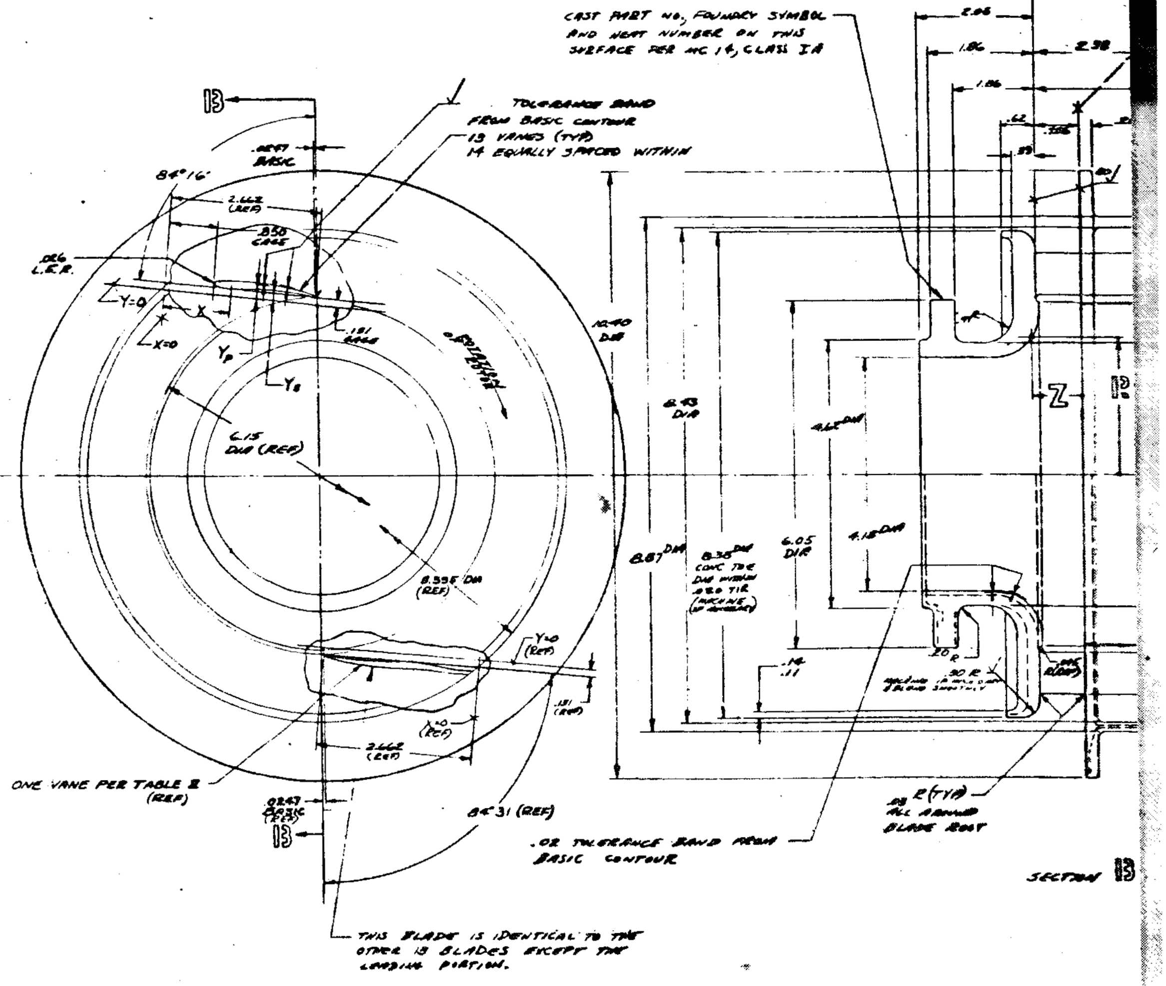
SPACER

IDENT NO.	SIZE	DWG. NO.
193	B	369723

FULL | WT. | SHEET 1 OF 1

3

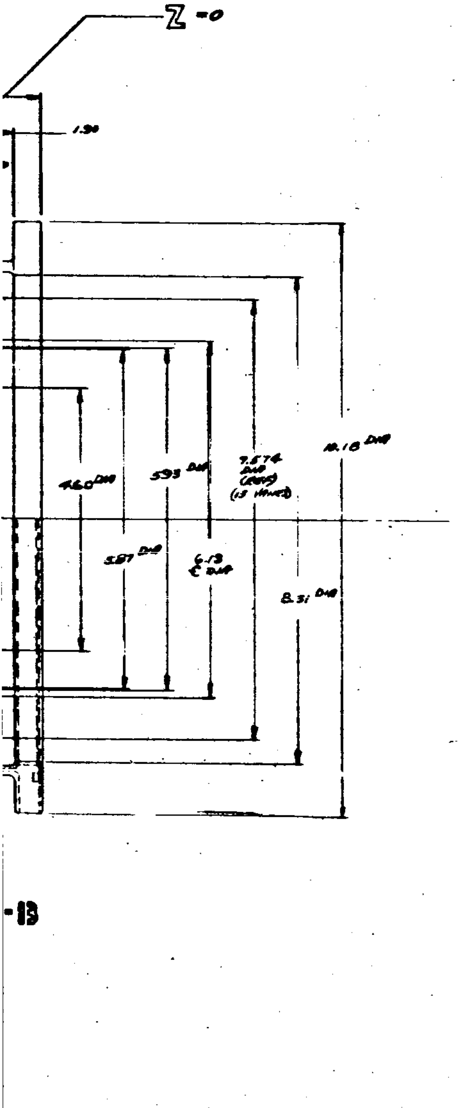
APS-5108-R



CRITICAL ITEMS

[illegible]

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED
A		SEE ENGINEERING ORDER	10-17-63	
B		ADDED GEN. NOTE 14. SEE E.O.		
C		SEE ENGINEERING ORDER		



8. MACHINED SURFACES FLAT WITHIN .000 PER INCH TO A MAX OF .00[illegible] FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .00[illegible] PER INCH TO A MAX OF .00[illegible] FOR ANY SURFACE.
6. MACHINED DIAS ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS CONCENTRIC WITHIN .010 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .010 .015.
3. BREAK ALL CORNERS AND SHARP EDGES .005 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED.

QTY REQD	ITEM NO	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.	ZONE
				INVESTMENT CASTING		W1-52			

← ASSYS LIST OF MATERIAL

REQD	NEXT ASSY	USED ON
1	369725	369720

HEAT TREATMENT: NOTED

SIGNATURES	DATES
	8-30-63
	9-11-63
	9-16-63
	9-12-63
	9-12-63
	9-11-63
	9-16-63

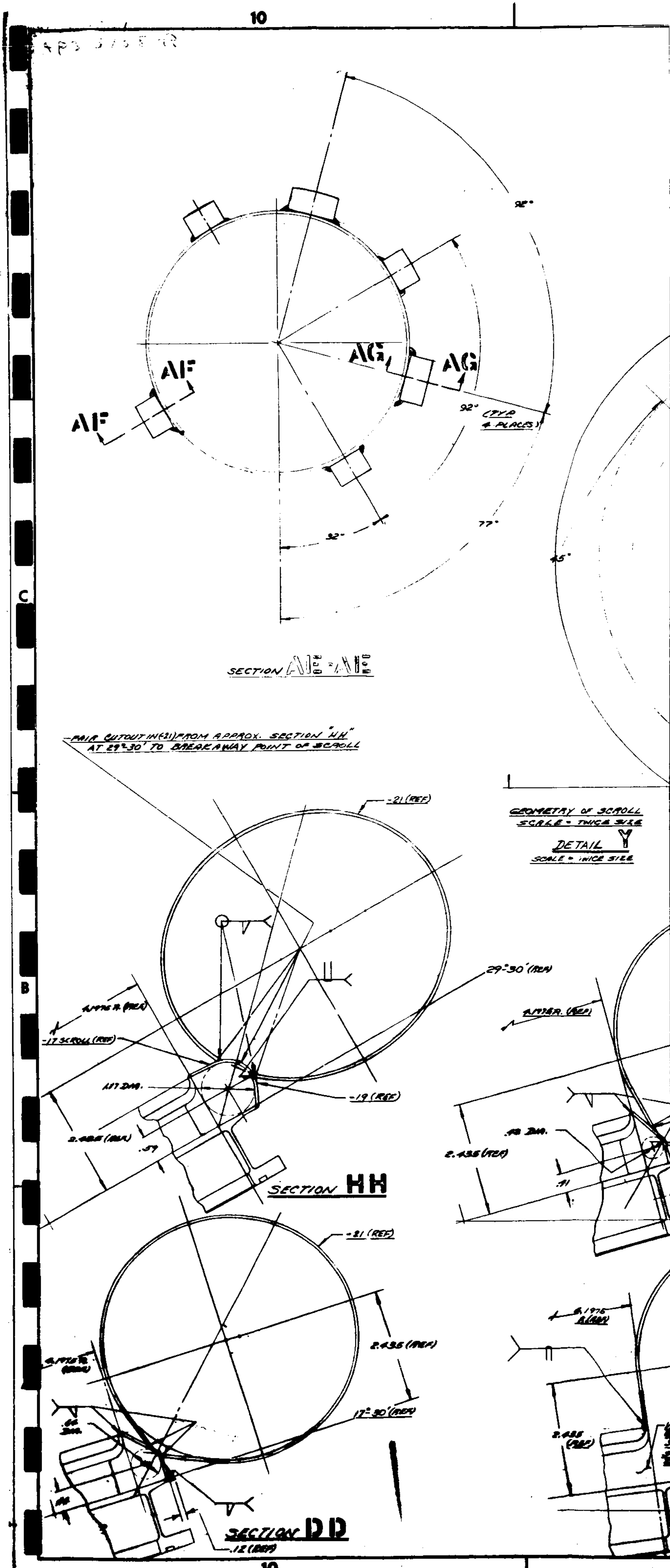
NOZZLE, TURBINE

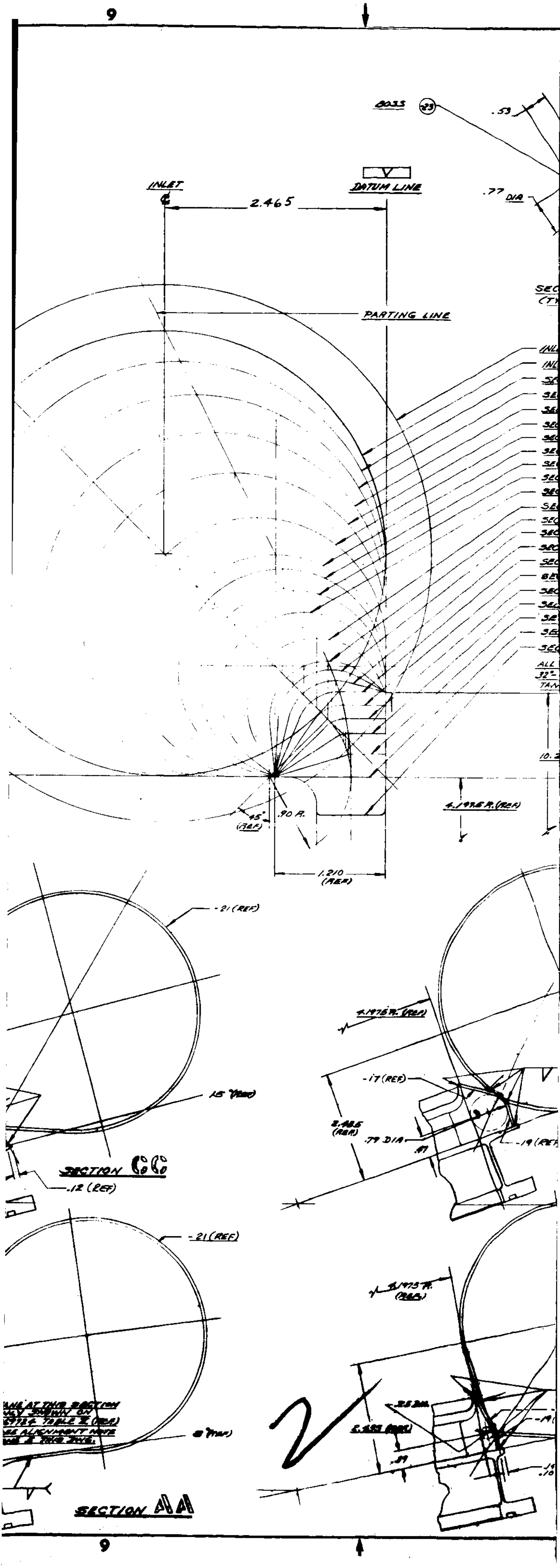
CODE IDENT NO.	SIZE	DWG NO.
99193	E	369724

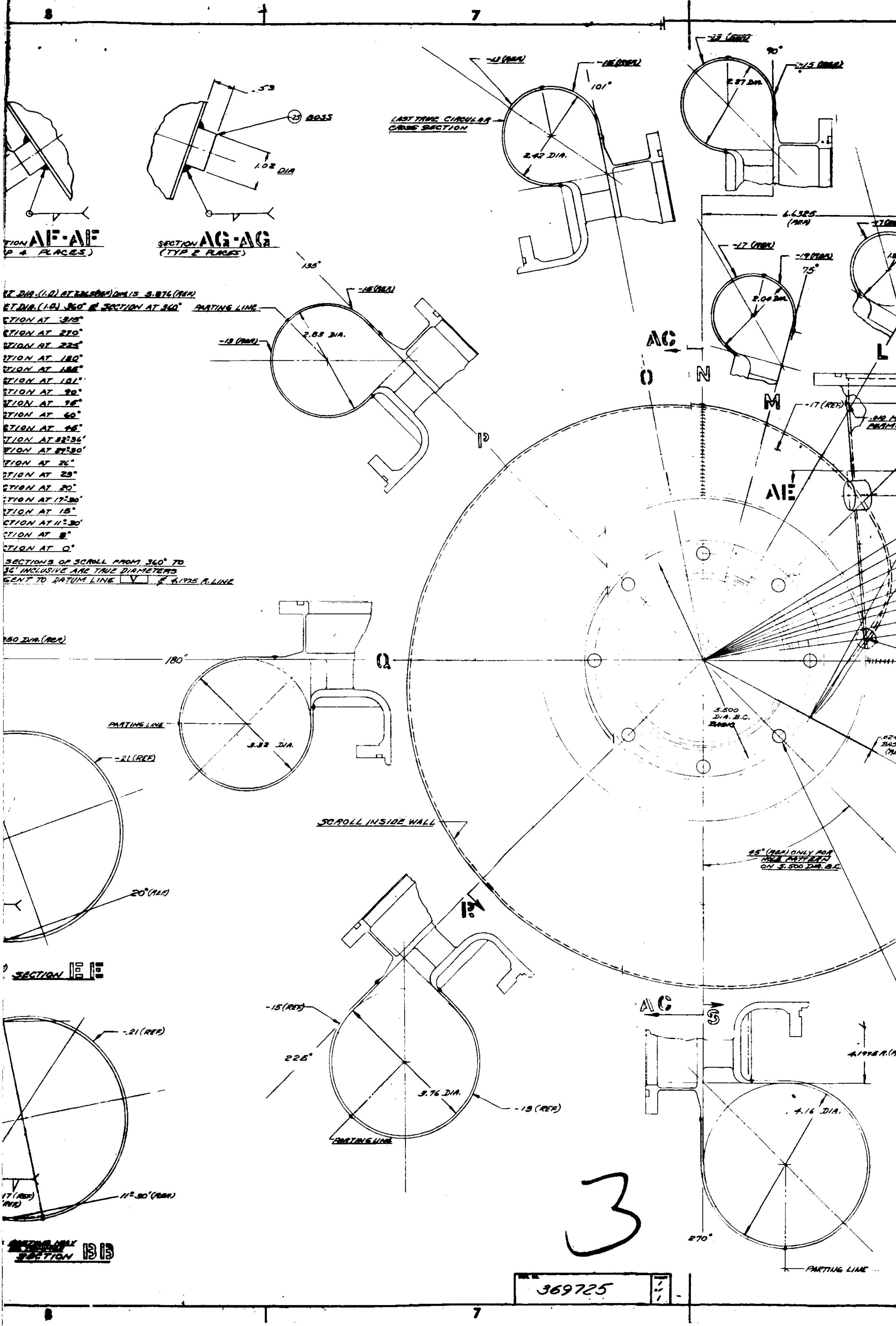
SCALE FULL

SHEET 1 OF 1

369724 C

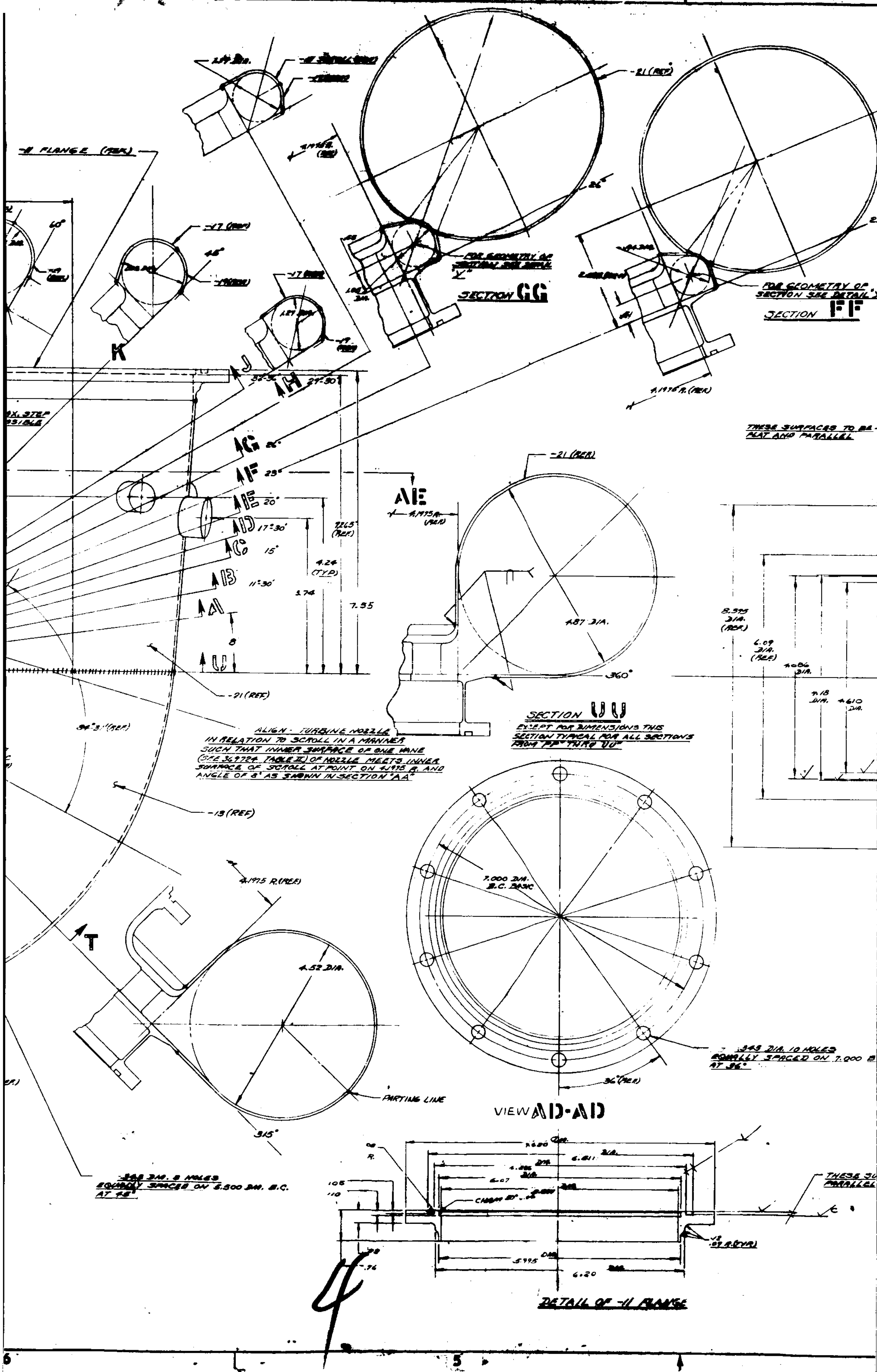

10
AF
AF
AG
AG
92°
92° (TYP 4 PLACES)
92°
77°
45°
SECTION AE-AE
FAIR CUTOUT IN (-21) FROM APPROX. SECTION "HH" AT 29°30' TO BREAKAWAY POINT OF SCROLL
GEOMETRY OF SCROLL
SCALE = TWICE SIZE
DETAIL Y
SCALE = TWICE SIZE
-21 (REF)
29°30' (REF)
1.1976 R. (REF)
-17 SCROLL (REF)
.117 DIA.
-19 (REF)
2.485 (REF)
.57
SECTION HH
1.1976 R. (REF)
.48 DIA.
2.435 (REF)
.41
-21 (REF)
2.435 (REF)
1.1976 R. (REF)
17°30' (REF)
.66 DIA.
.12 (REF)
SECTION DD
1.1976 R (REF)
2.485 (REF)
C
B
10


9
BOSS
23
.53
.77 DIA
V
DATUM LINE
INLET
℄
2.465
SEC
(TY
PARTING LINE
INL
INL
SE
SE
SE
SE
SE
SE
SE
SE
SE
SE
SE
SE
SE
SE
SE
SE
SE
SE
SE
ALL
32°
TAN
10.2
45°
(REF)
.90 R.
4.1975 R. (REF)
1.210
(REF)
-.21 (REF)
.15 (REF)
SECTION CC
.12 (REF)
4.1975 R. (REF)
-.17 (REF)
2.486
(REF)
.79 DIA
.97
-.19 (REF
-.21 (REF)
4.1975 R.
(REF)
.28 DIA
2.499 (REF)
.39
-.19
.19
.10
ANE AT THIS SECTION
LY SHOWN ON
6978 TABLE II (REF)
SE ALIGNMENT NOTE
NE 2 THIS DWG.
.8 (REF)
SECTION AA
9

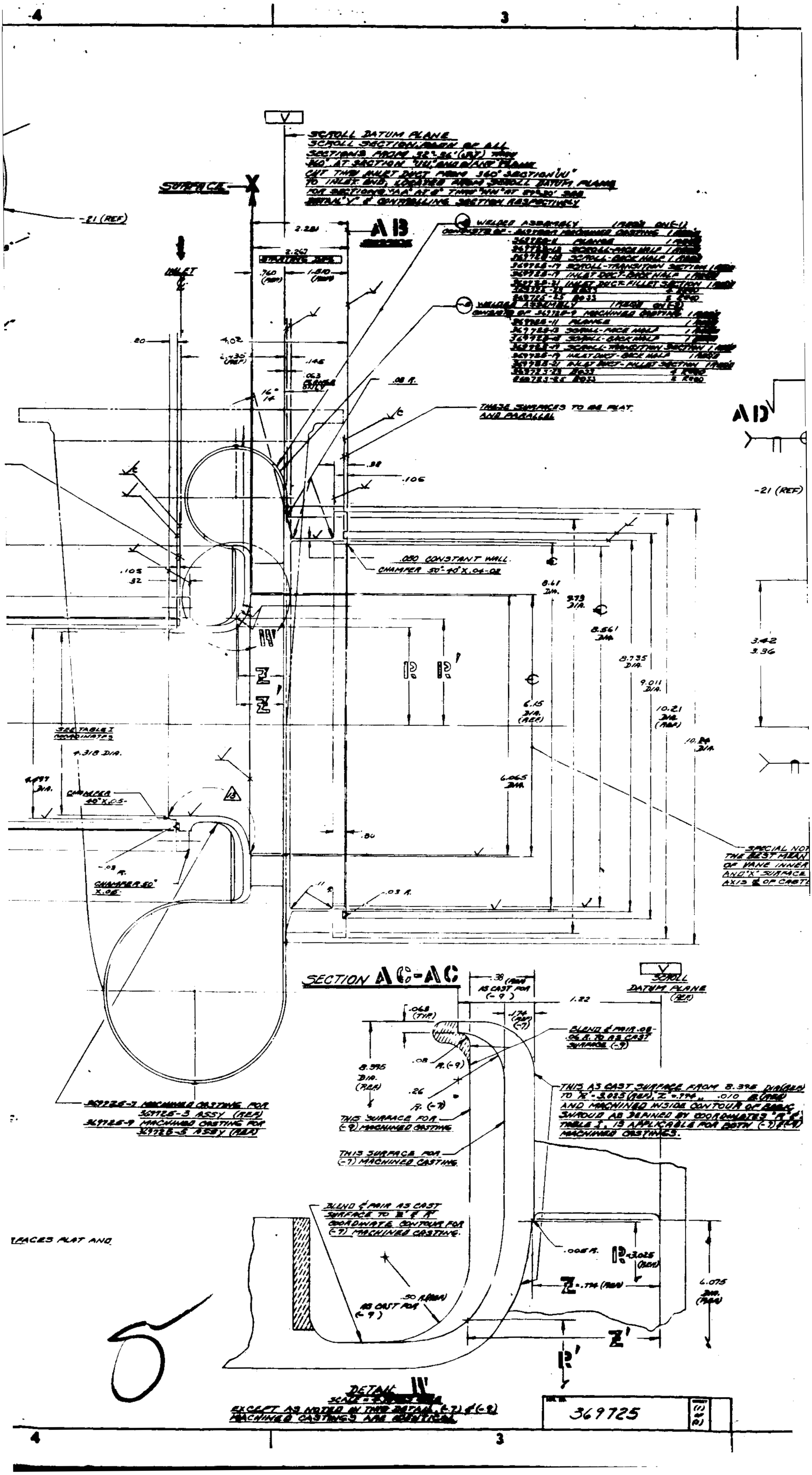

8
7
.53
25 BOSS
1.02 DIA
TION AF-AF
P 4 PLACES)
SECTION AG-AG
(TYP 2 PLACES)
T DIA.(I.D.) AT 226.5°(REF) DIA IS 5.876 (REF)
ET DIA.(I.D.) 360° ℄ SECTION AT 360°
CTION AT 315°
CTION AT 270°
CTION AT 225°
CTION AT 180°
CTION AT 135°
CTION AT 101°
CTION AT 90°
TION AT 75°
CTION AT 60°
CTION AT 45°
CTION AT 32°36'
TION AT 27°30'
TION AT 26°
CTION AT 23°
CTION AT 20°
CTION AT 17°30'
CTION AT 15°
CTION AT 11°30'
CTION AT 8°
CTION AT 0°
SECTIONS OF SCROLL FROM 360° TO
36' INCLUSIVE ARE TRUE DIAMETERS
GENT TO DATUM LINE V ℄ 4.1975 R. LINE
250 DIA. (REF)
-13 (REF)
-15 (REF)
101°
LAST TRUE CIRCULAR CROSS SECTION
2.42 DIA.
-13 (REF)
90°
-15 (REF)
2.37 DIA.
6.6325 (REF)
-17 (REF)
-19 (REF)
75°
2.04 DIA.
135°
-15 (REF)
PARTING LINE
-13 (REF)
2.83 DIA.
P
AC
O
N
M
L
-17 (REF)
.010 M
PERM
AE
180°
Q
PARTING LINE
3.32 DIA.
-21 (REF)
5.500 DIA. B.C. BASIC
.62
BOS
SCROLL INSIDE WALL
45° (REF) ONLY FOR HOLE PATTERN ON 5.500 DIA. B.C.
20° (REF)
SECTION EE
P
-15 (REF)
225°
3.76 DIA.
-13 (REF)
PARTING LINE
AC
S
4.1975 R.
4.16 DIA.
-.21 (REF)
17 (REF)
11°30' (REF)
PARTING LINE
SECTION BB
270°
PARTING LINE
7
8

3

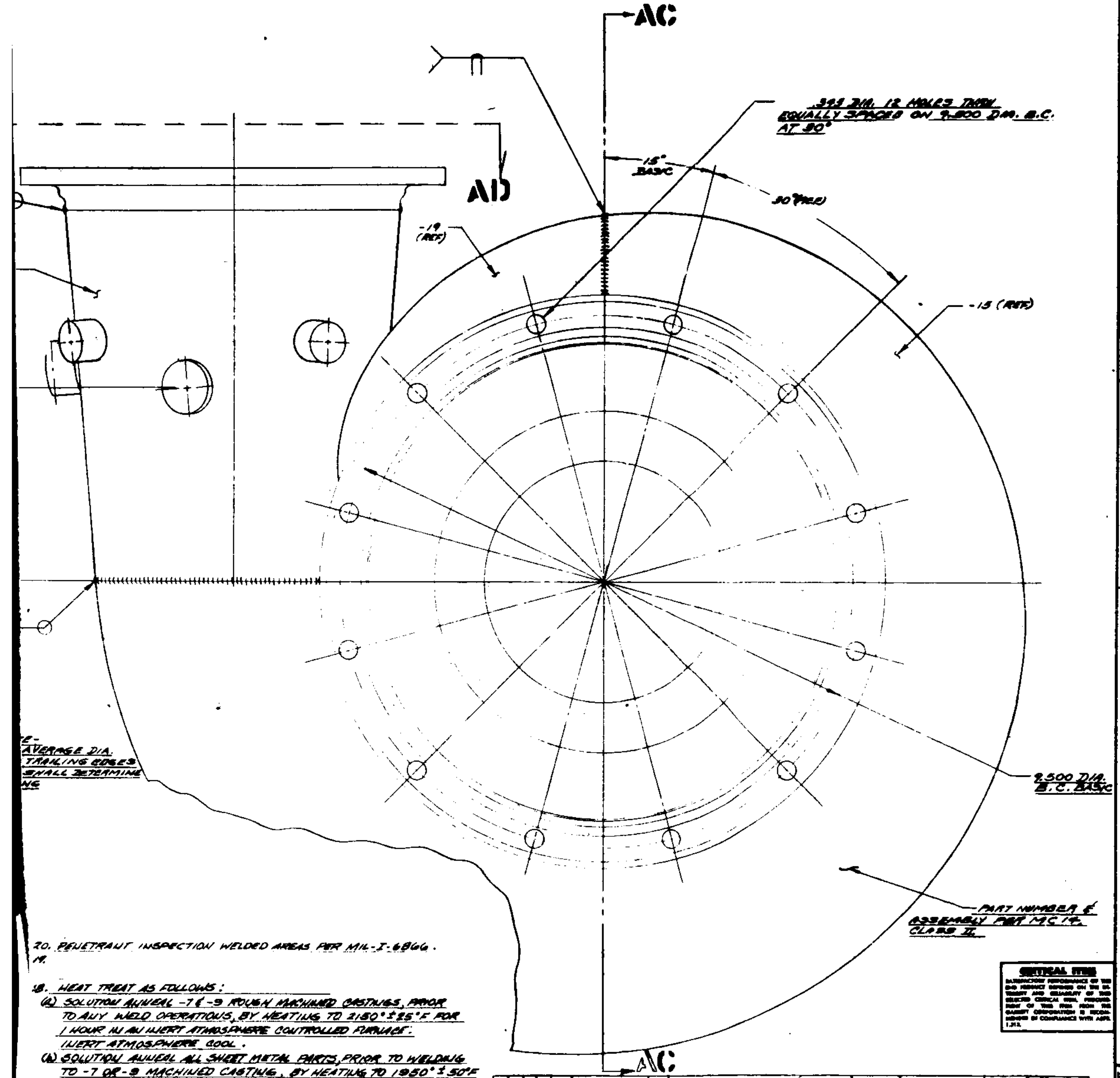
369725


6
5
-11 FLANGE (REF)
-17 (REF)
45°
60°
K
J
H
G
F
AE
AD
AC
AB
AA
U
T
32°30'
27°30'
26°
23°
20°
17°30'
15°
11°30'
8
7.265 (REF)
4.24 (TYP)
3.74
7.55
4.1975 R. (REF)
-21 (REF)
26°
FOR GEOMETRY OF SECTION SEE DETAIL "V"
SECTION GG
FOR GEOMETRY OF SECTION SEE DETAIL "V"
SECTION FF
4.1975 R. (REF)
THESE SURFACES TO BE FLAT AND PARALLEL
4.87 DIA.
360°
SECTION UU
EXCEPT FOR DIMENSIONS THIS SECTION TYPICAL FOR ALL SECTIONS FROM "FF" THRU "UU"
ALIGN - TURBINE NOZZLE IN RELATION TO SCROLL IN A MANNER SUCH THAT INNER SURFACE OF ONE VANE (SEE 369724 TABLE II) OF NOZZLE MEETS INNER SURFACE OF SCROLL AT POINT ON 4.1975 R. AND ANGLE OF 8° AS SHOWN IN SECTION "AA"
-21 (REF)
-13 (REF)
34°3' (REF)
8.395 DIA. (REF)
6.09 DIA. (REF)
4.086 DIA.
4.18 DIA.
4.610 DIA.
7.000 DIA. B.C. BASIC
.343 DIA. 10 HOLES EQUALLY SPACED ON 7.000 B.C. AT 36°
36° (REF)
4.1975 R. (REF)
4.52 DIA.
PARTING LINE
315°
VIEW AD-AD
.343 DIA. 8 HOLES EQUALLY SPACED ON 5.500 DIA. B.C. AT 45°
6.811 DIA.
6.07
6.20 DIA.
5.995 DIA.
CHAM 30°
.105
.110
.76
.09 R (TYP)
THESE SURFACES PARALLEL
DETAIL OF -11 FLANGE
6
5

4


4
3
V
SCROLL DATUM PLANE
SCROLL SECTION, [illegible] OF ALL
SECTIONS FROM 32°-36' (REF) THRU
360° AT SECTION "UU" AND [illegible] PLANE
CUT THRU INLET DUCT FROM 360° SECTION "UU"
TO INLET END, LOCATED FROM SCROLL DATUM PLANE
FOR SECTIONS "AA" AT 6° THRU "UU" AT 89°-30' SEE
DETAIL "Y" & CONTROLLING SECTION RESPECTIVELY
SURFACE X
-21 (REF)
INLET ℄
2.281
2.262
STARTING [illegible]
.760 (REF)
1.510 (REF)
AB SURFACE
WELDED ASSEMBLY (REF) ONE (-1)
CONSISTS OF - 369725-7 MACHINED CASTING 1 REQD
369725-11 FLANGE 1 REQD
369725-13 SCROLL-FACE HALF 1 REQD
369725-15 SCROLL-BACK HALF 1 REQD
369725-17 SCROLL-TRANSITION SECTION 1 REQD
369725-19 INLET DUCT-BACK HALF 1 REQD
369725-21 INLET DUCT-FILLET SECTION 1 REQD
369725-23 BOSS 2 REQD
369725-25 BOSS 2 REQD
WELDED ASSEMBLY (REF) ON (-3)
CONSISTS OF 369725-9 MACHINED CASTING 1 REQD
369725-11 FLANGE 1 REQD
369725-13 SCROLL-FACE HALF 1 REQD
369725-15 SCROLL-BACK HALF 1 REQD
369725-17 SCROLL-TRANSITION SECTION 1 REQD
369725-19 INLET DUCT-BACK HALF 1 REQD
369725-21 INLET DUCT-FILLET SECTION 1 REQD
369725-23 BOSS 2 REQD
369725-25 BOSS 2 REQD
.20
4.02
2.430 (REF)
.145
.063 FLANGE ONLY
.08 R.
16° 14
THESE SURFACES TO BE FLAT AND PARALLEL
AD
-21 (REF)
.38
.106
.080 CONSTANT WALL.
CHAMFER 50°-40' X .04-.02
.105 .32
W
8.61 DIA.
9.73 DIA.
8.561 DIA.
8.735 DIA.
9.011 DIA.
10.21 DIA. (REF)
10.84 DIA.
R R'
Z Z'
6.15 DIA. (REF)
6.065 DIA.
3.42 3.36
SEE TABLE I COORDINATES
4.318 DIA.
4.497 DIA.
CHAMFER 40° X .05
.80
-.03 R.
CHAMFER 50° X .05
.11
.03 R.
SPECIAL NOT
THE BEST MEAN
OF VANE INNER
AND "X" SURFACE
AXIS ℄ OF CASTI
369725-7 MACHINED CASTING FOR
369725-3 ASSY (REF)
369725-9 MACHINED CASTING FOR
369725-5 ASSY (REF)
SECTION AC-AC
.38 (REF) AS CAST FOR (-9)
V SCROLL DATUM PLANE (REF)
1.22
.068 (TYP)
.174 (REF) (-7)
BLEND & FAIR .08-.06 R. TO AS CAST SURFACE (-9)
8.395 DIA. (REF)
.08 R. (-9)
.26 R. (-7)
THIS SURFACE FOR (-9) MACHINED CASTING
THIS AS CAST SURFACE FROM 8.395 DIA (REF)
TO R = 3.025 (REF), Z = .774 " .010 [illegible] (REF)
AND MACHINED INSIDE CONTOUR OF BASIC
SHROUD AS DEFINED BY COORDINATES "R" &
TABLE I, IS APPLICABLE FOR BOTH (-7) & (-9)
MACHINED CASTINGS.
THIS SURFACE FOR (-7) MACHINED CASTING
BLEND & FAIR AS CAST SURFACE TO R' & R' COORDINATE CONTOUR FOR (-7) MACHINED CASTING
.005 R.
R = 3.025 (REF)
Z = .774 (REF)
6.075 DIA. (REF)
.50 R (REF)
AS CAST FOR (-9)
Z'
R'
FACES FLAT AND
5
DETAIL W
SCALE = [illegible]
EXCEPT AS NOTED IN THIS DETAIL (-7) & (-9)
MACHINED CASTINGS ARE IDENTICAL
369725
(1) OF (1)
4
3

SYM	ZONE	DESCRIPTION	DATE	APPROVED
A		SEE ENGINEERING ORDER	[illegible]	[illegible]
B		SEE ENGR ORDER	[illegible]	[illegible]
C		SEE ENGR ORDER	1-9-[illegible]	[illegible]
D		SEE ENGR ORDER	[illegible]	[illegible]
E		SEE ENGR ORDER	[illegible]	[illegible]



CRITICAL ITEM
SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.

20. PENETRANT INSPECTION WELDED AREAS PER MIL-I-6866.

19.

18. HEAT TREAT AS FOLLOWS:

(a) SOLUTION ANNEAL -7 & -9 ROUGH MACHINED CASTINGS, PRIOR TO ANY WELD OPERATIONS, BY HEATING TO 2150° ± 25°F FOR 1 HOUR IN AN INERT ATMOSPHERE CONTROLLED FURNACE. INERT ATMOSPHERE COOL.

(b) SOLUTION ANNEAL ALL SHEET METAL PARTS, PRIOR TO WELDING TO -7 OR -9 MACHINED CASTING, BY HEATING TO 1950° ± 50°F FOR 30 MINUTES IN AN INERT ATMOSPHERE CONTROLLED FURNACE. INERT ATMOSPHERE COOL.

(c) STRESS RELIEVE -3 & -5 WELDED ASSEMBLIES, PRIOR TO FINAL MACHINING, BY HEATING TO 1675° ± 25°F FOR 1 HOUR IN AN INERT ATMOSPHERE CONTROLLED FURNACE, INERT ATMOSPHERE COOL.

17. ALL MACHINED SURFACES MARKED ✓ TO BE ✓

16. DIAMETER MARKED THUS Ⓒ TO BE CONCENTRIC WITH THE Ⓒ DIAMETER (SEE NOTE 15)

15. "AB" SURFACE AND ℄ ESTABLISH ℄ OF FINISHED PART

14. "AB" SURFACE PARALLEL TO "AVERAGE" "X" SURFACE

13. INSIDE CONTOUR SHOWN TABLE I. ANY DIA. OR PLANE OF ANY DIA. WITHIN THIS AREA TO BE NORMAL OR CONCENTRIC TO ℄

12. ALL BUTT JOINTS TO HAVE FULL WELD PENETRATION. ALL [illegible] GREATER THAN 10° TO [illegible] AS [illegible]

11. LOCATIONS OF SHEET METAL MATING LINES & ADEQUACY OF FORCED [illegible] SCROLL PORTION OF ASSY. ARE OPTIONAL & SUBJECT TO PRIOR ENGINEERING APPROVAL

10.

9. DIMENSIONAL TOLERANCES [illegible] & ANGLES ARE BASIC.

8. MACHINED SURFACES FLAT WITHIN [illegible] PER INCH TO A MAX. OF [illegible] FOR ANY SURFACE.
7. MACHINED SURFACES SQUARE OR PARALLEL WITHIN [illegible] PER INCH TO A MAX. OF [illegible] FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN [illegible] TIR. UNMACHINED DIAS. CONCENTRIC WITHIN [illegible] TIR.
5. DIMENSION LIMITS HOLD AFTER PLATING.
4. MACHINED FILLET RADII [illegible].
3. BREAK ALL CORNERS AND SHARP EDGES [illegible] MAX. NO TRIMMING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED.

6

-5	-3	-2	-1	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.	ZONE
		2	2		369725-25		BOSS 1.000 DIA BAR		CRES	AMS-5645 TYPE 321		
		4	4		369725-23		BOSS .750 DIA BAR		CRES	AMS-5646 TYPE 347		
		1	1		369725-21		INLET TRANSITION .063 SHEET		NICKEL BASE	AMS-5540 INCONEL		
		1	1		369725-19		TANG BACK HALF .063 SHEET		NICKEL BASE	AMS-5540 INCONEL		
		1	1		369725-17		TANG FACE HALF .063 SHEET		NICKEL BASE	AMS-5540 INCONEL		
		1	1		369725-15		SCROLL-BACK HALF .063 SHEET		NICKEL BASE	AMS-5540 INCONEL		
		1	1		369725-13		SCROLL-FACE HALF .063 SHEET		NICKEL BASE	AMS-5540 INCONEL		
		1	1		369725-11		FLANGE 1.00 PLATE		NICKEL BASE	MIL-N-6840 INCONEL		
1					369725-9		MACHINED CASTING (MADE FROM 369730)					
	1				369725-7		MACHINED CASTING (MADE FROM 369724)					
		1			369725-5		WELDED ASSEMBLY		NOTED	NOTED		
			1		369725-3		WELDED ASSEMBLY		NOTED	NOTED		
			/		369725-2		ALTERNATE ASSEMBLY (MACHINED)		NOTED	NOTED		
			/		369725-1		BASIC ASSEMBLY (MACHINED)		NOTED	NOTED		
-5	-3	-2	-1	← ABOVE BASIC ASSEMBLY			LIST OF MATERIAL					

REQD	NEXT ASSY	USED ON
(-3)	369728H	369720
(-1)	369728H	369720

HEAT TREATMENT: NOTED
PROCESS

SIGNATURES / DATES
9/12/63
9-24-63
1-8-64
1-8-64
1-9-64
1-8-64
10-1-63

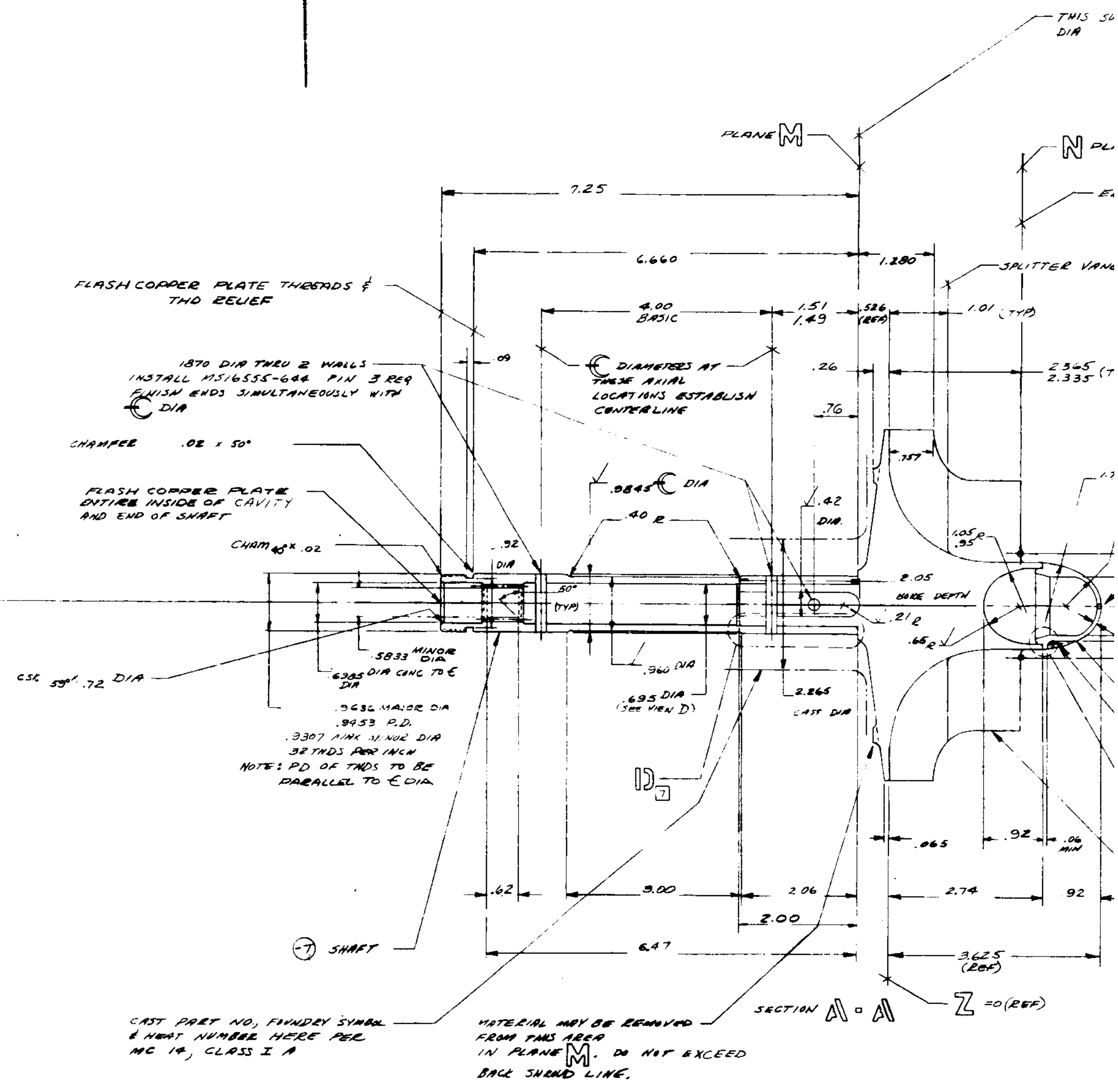
AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

TITLE: TURBINE NOZZLE & SCROLL ASSEMBLY

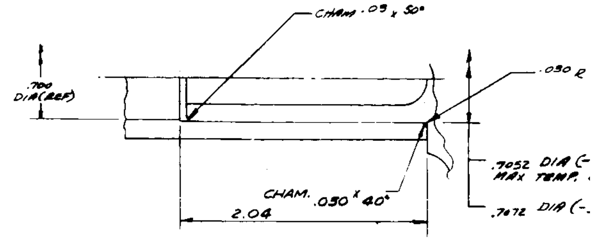
CODE IDENT NO. 99193
SIZE J
DWG NO. 369725
SCALE
SHEET 1 of 1

369725
E

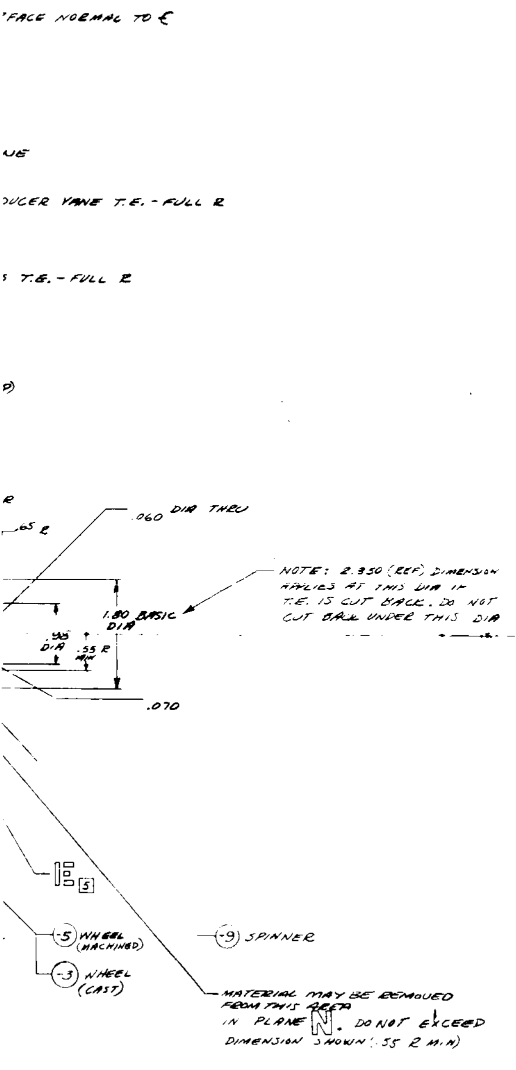
INTERNAL SPLINE DATA	E.C. W... 9-17-63
ASA B5.15-1960 STANDARD INVOLUTE	15 TEETH
DIAMETRAL PITCH	24 / 48
PRESSURE ANGLE	30°
FLAT ROOT - SIDE FIT	
MAJOR DIAMETER	.6881-.6790
MEASUREMENT BETWEEN .0600 DIAMETER PINS	.5594 MAX
CIRCULAR SPACE WIDTH WITH GAGE	.0637 MIN EFFECTIVE
TOOTH PARALLELISM ERROR ACROSS FACE WIDTH	.0003 MAX EP
ECCENTRICITY OF PITCH DIAMETER WITH AXIS OF ℄ DIAMETERS	.0010 FIR MAX

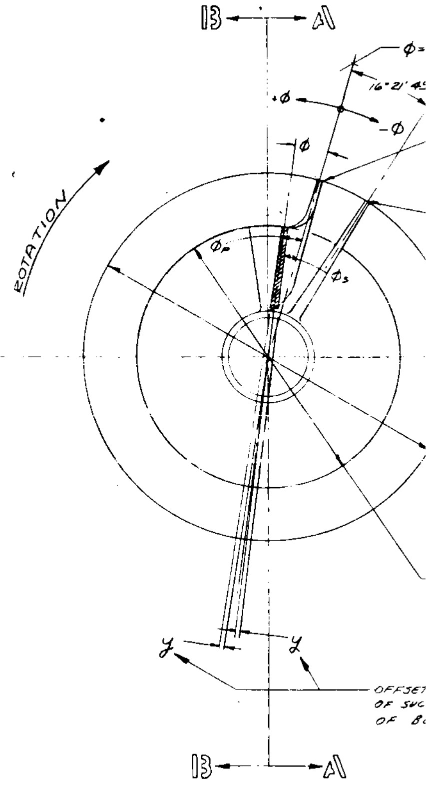


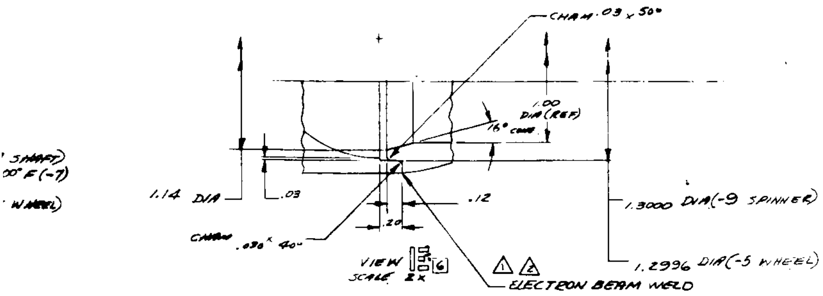
SECTION A - A



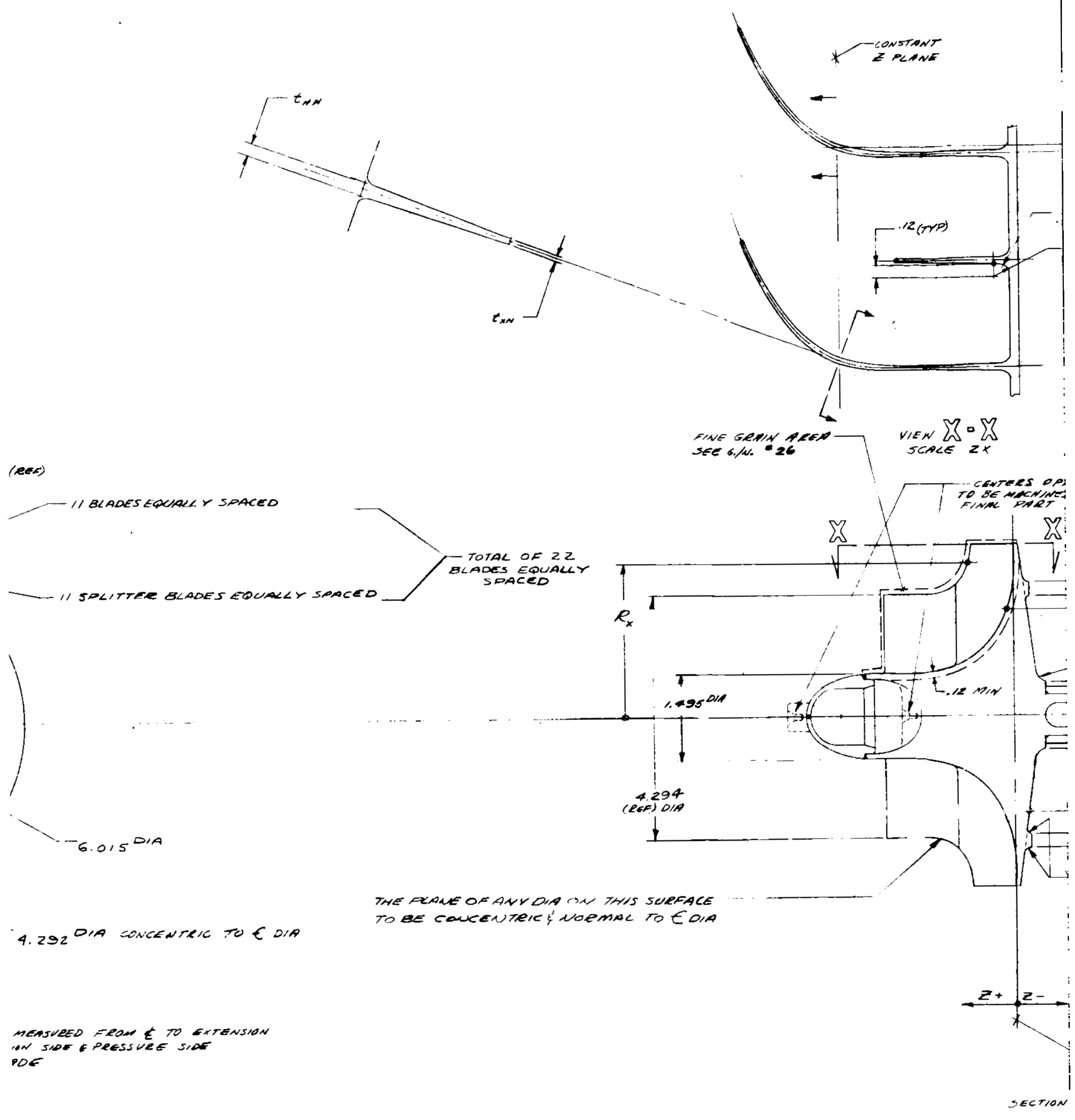
VIEW D 7
SCALE 2X







1 28.
2 27. ELECTR
EXCEPT
MUST
26. BLADES
USING
.06 - .12
25. TEST S
& CONFI
OPTIO
24.
23. FINISH
22. ALL MA
21.
20.
3 19.



ON BEAM WELD TO BE RADIOGRAPHIC INSPECTED PER MIL-I-6865
THAT TWO PICTURES ARE REQUIRED AT 90° APART. X-RAY
HOW A MINIMUM OF 80% SOUND WELD.
AND HUB SURFACE AREAS SHOWN ARE TO BE CAST
INE GRAIN CONTROL WITH A GRAIN SIZE OF
AVERAGE GRAIN DIAMETER. SEE SECTION B-B.
ECIMENS SHALL BE CAST INTEGRAL WITH WHEEL, LOCATION
URATION TO BE APPROVED BY ENGINEERING
AL: A SCRAP WHEEL MAY BE SECTIONED TO OBTAIN
METALURGICAL SPECIMENS AS TYPICAL OF GIVEN
LOT OR POUR IN LIEU OF INTEGRAL CAST SPECIMENS

SPLINE TOOTH PROFILES ✓
HINED SURFACES $^{125}\surd$

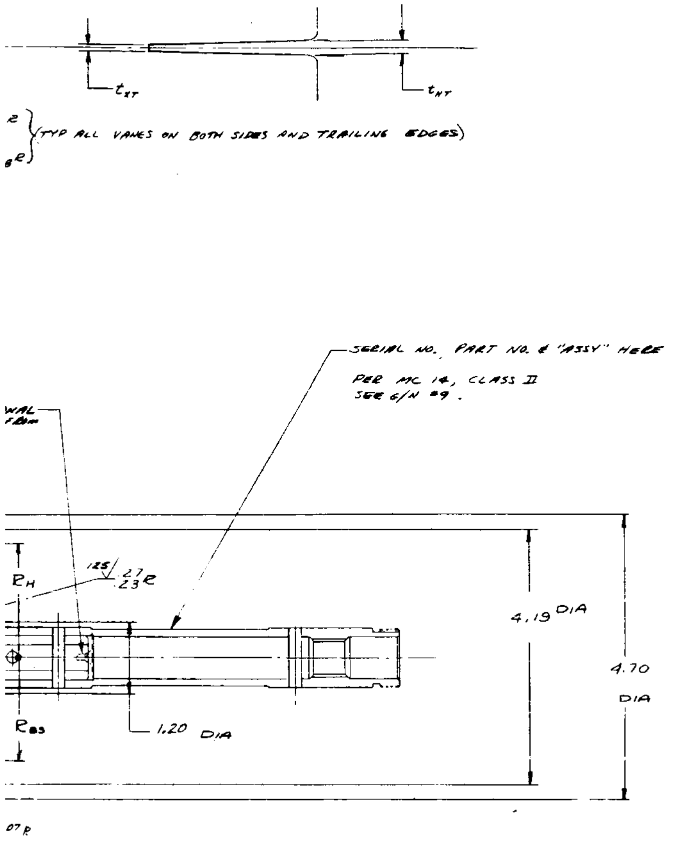
18.
17. SIMILAR TO 379900
16. BLADE SHAPE TO FAIR SMOOTHLY BETWEE
15. BLADE & HUB AREAS TO BE $^{80}\surd$ FINISH AS CAST
14.

13.
12.

11.
10. AFTER FINAL MACHINING PENETRANT INS
9. CASTING TO BE SERIALIZED BY VENDOR A
AND IDENTIFIED IN SEQUENCE AS FOLLO
a. ELECTRO ETCH THE LETTERS S/N
b. ELECTRO ETCH WITH AN IDENTIFYING PE
THIS PREFIX TO BE ASSIGNED BY AIRE
c. ELECTRO ETCH SERIAL NUMBERS IN CON
THERE SHALL BE NO DUPLICATION OF T
BY ANY ONE VENDOR
THE SERIAL NUMBER SO CONSTITUTED W
ALL MANUFACTURING OPERATIONS AND
FINISHED PART BE MAINTAINED THROU

3

SYM	ZONE	DESCRIPTION	DATE	APPROVED
A		SEE ENGINEERING ORDER	10-17-63	
B		SEE ENGINEERING ORDER	11-14-63	



Z=0

3-13

POINTS DIMENSIONED IN TABLES
OTHER 250√

CT PER MIL-I-6866 TYPE I
NOTED
S:

FIX DENOTING SOURCE
TACH
CUTIVE ORDER
SE SERIAL NUMBERS

L BE CALIBRATED
E APPLIED IN THE
OF THE PART

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .005 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR. UNMACHINED DIAS. CONCENTRIC WITHIN .012 TIR.
5. DIMENSION LIMITS HELD [illegible] BEFORE PLATING
4. MACHINED FILLET RADII [illegible]
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED.

QTY REQD	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.	ZONE
		-11		WELDED ASSY					
		-9		SPINNER		NICKEL BASE	AMS 5665 (INCONEL)		
		-7		SHAFT		STEEL	(4340)		
		-5		ROTOR WHEEL -MACHINED					
		-3		INVESTMENT CASTING		NICKEL BASE	(INCO 713C)		

←ASSYS

LIST OF MATERIAL

1	369721	369720
REQD	NEXT ASSY	USED ON

HEAT TREATMENT | PROCESS
FINISH: NOTED
MATERIAL: NOTED

SIGNATURES	DATES
	9-4-63
	9-14-63
	9-16-63
DA Dudley	9-16-63
	9-16-63
	9-17-63
	9-16-63

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA
THE GARRETT CORPORATION

WHEEL ASSEMBLY, TURBINE

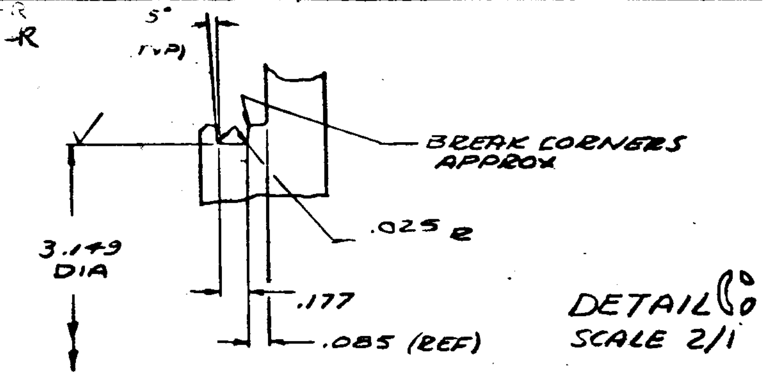
AD39(4)

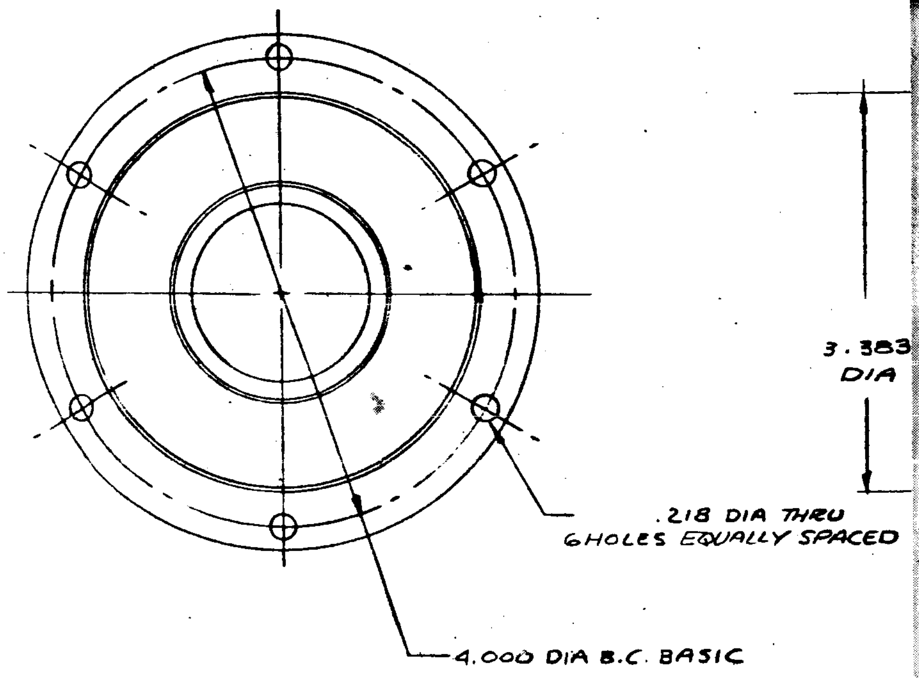
CODE IDENT NO.	SIZE	DWG. NO.
99193	J	369726

SCALE | WT 5.25 LB CALC | SHEET 1 OF 1

369726

APS-5108-R
APS-5109-R





CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPL 1.312.

11.

10. POSITIONAL & GEOMETRICAL TOLERANCE SYMBOLS PER MIL-STD-8

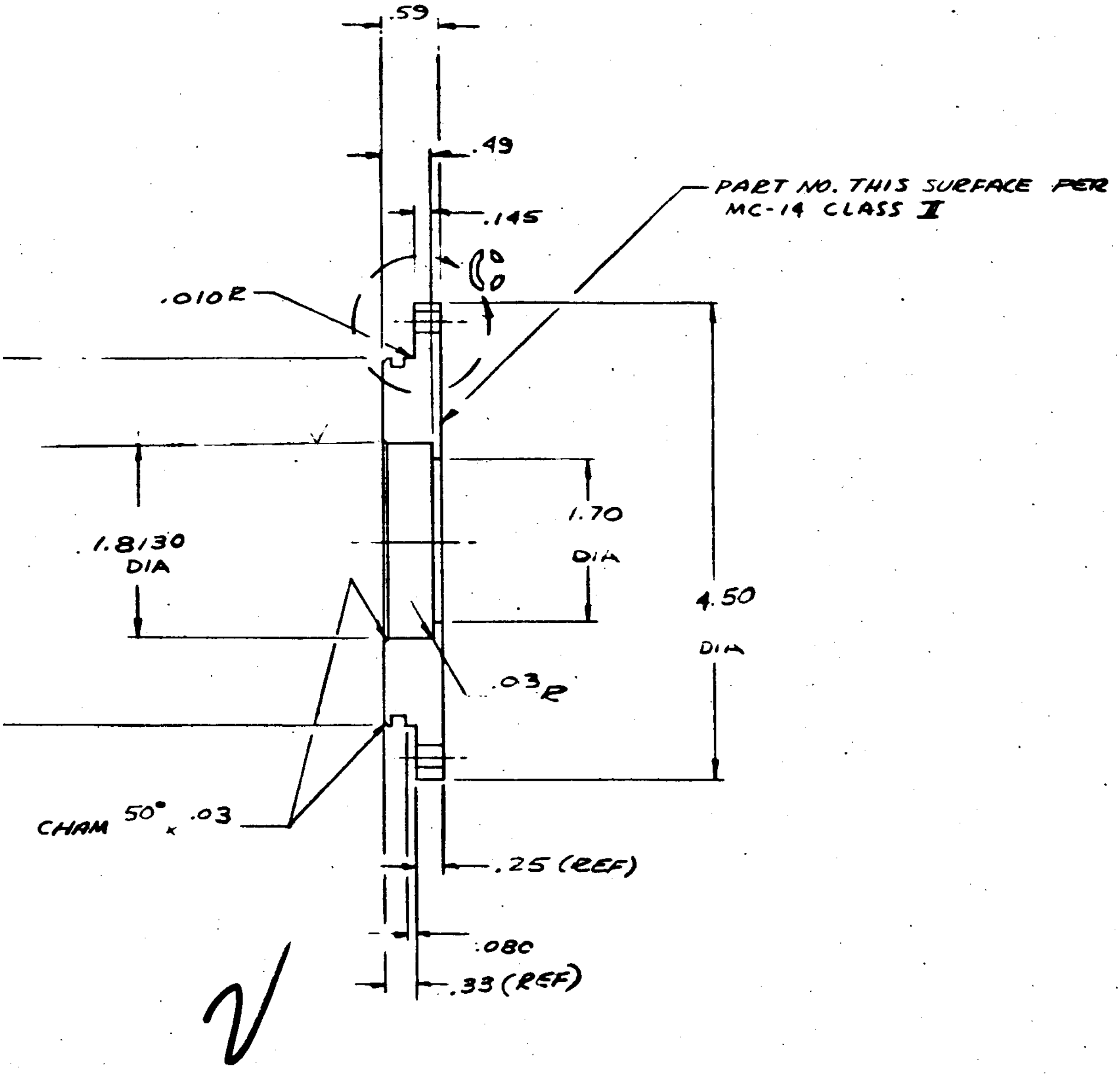
9.

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII 030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

P9549 SIMS - K & E 193 HERCULENE

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	SEE ENGR ORDER	11-12-63	
B	SEE ENGR ORDER	1-14-64	



LAST LTR B

DWG NO. 369727

				PLATE		CRES 347	MIL-S-6721	
TY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
	←ASSYS			LIST OF MATERIAL				

	369741	369740
	369731	369730
1	369721	369720
EQD.	NEXT ASSY.	USED ON

SIGNATURES		DATES
DFT		9-19-63
CHK		10-1-63
MFG ENG		
MAT & PROCESS		10 8 63
STRESS		10-8-63
AERO		
APP		10-9-63
APP		
DESIGN ACTIVITY		10-9-63
OTHER ACTIVITY APP.		

EAT TREATMENT	PROCESS
ARDNESS NOTED	NAME
PEC. HT-38	SPEC.

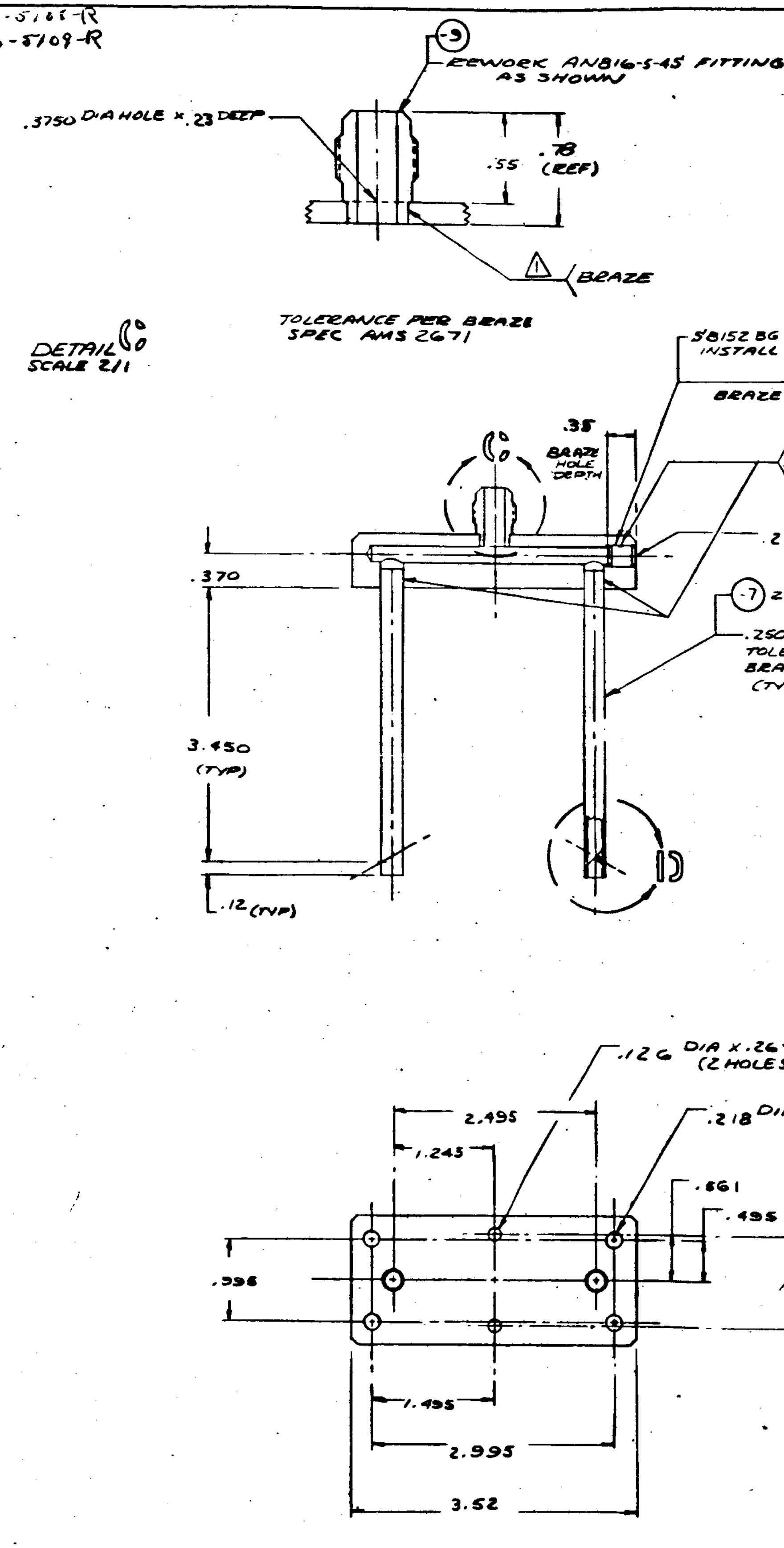
AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

DWG TITLE
CARRIER, SEAL

CODE IDENT NO.	SIZE	DWG NO.
99193	C	369727

SCALE FULL | WT. | SHEET 1 OF 1

APS-5108-R
APS-5109-R



11. PRESSU
ONE
△10. COPP

CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE [illegible] PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS [illegible] CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1-3

P9840 - DWG K&E 100 HERCULENE

10-0-310 PIN 1REQ
FULL DEPTH

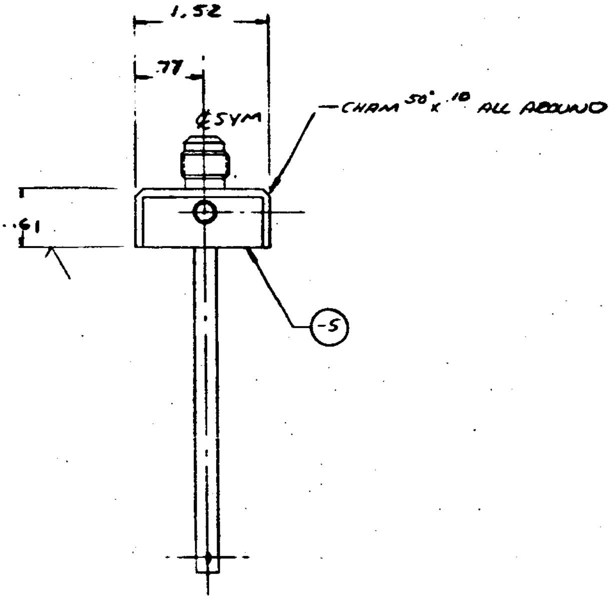
- TOLERANCE PER
SPEC AMS 2671

BRAZE ⚠1

18 DIA x 3.26-3.22 DEEP

REQ

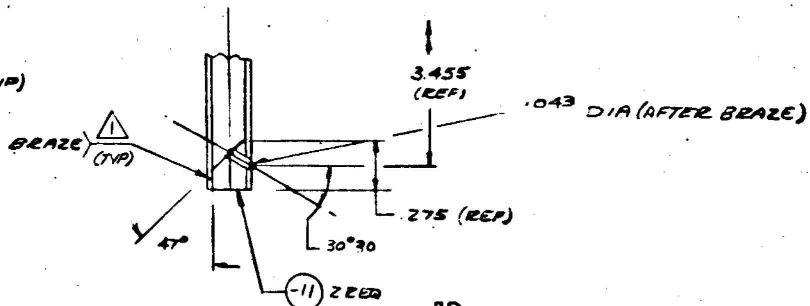
O.D. TUBING -.035 WALL
RANCE HOLE PER
ZE SPEC AMS 2671
P)



-.22DEEP
5)

9 THRU(TYP)

.123



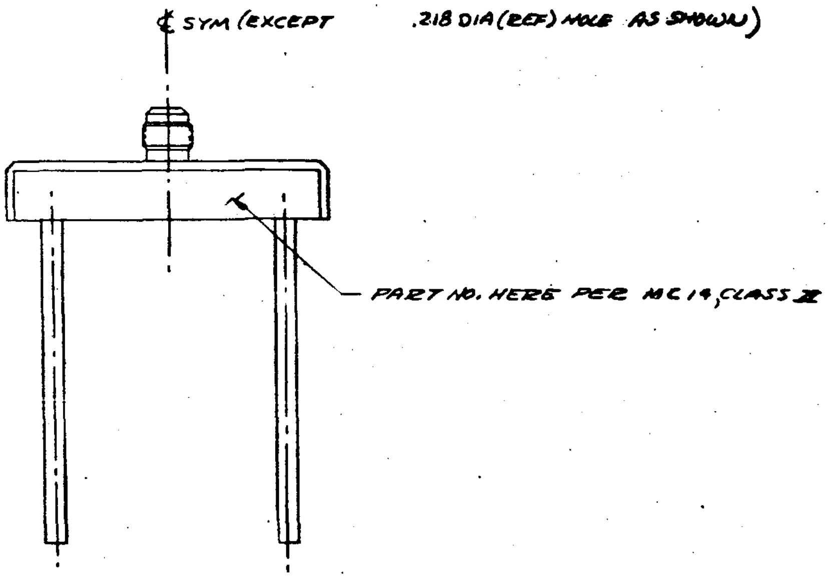
DETAIL D
SCALE 2/1

8 MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7 MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX OF .012 FOR ANY SURFACE
6 MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5 DIMENSION LIMITS HELD AFTER PLATING.
4 MACHINED FILLET RADII .030 - .015
3 BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2 SURFACE ROUGHNESS PER MIL-STD-10.
1 DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED.

URE TEST WITH OIL AT 150 PSIG FOR
MINUTE.
PER BRAZE PER AMS 2671

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED



3

QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
2		-11		ORFICE PLUG		CRES 347	QQ-S-763	
1		-9		CONNECTOR				
2		-7		TUBE		CRES 347		
1		-5		BODY		CRES 347	MIL-S-6721	
		-3		BRAZED ASSY				

← ASSYS

LIST OF MATERIAL

REQD	NEXT ASSY.	USED ON
	369741	369740
	369731	369730
1	369721	369720

HEAT TREATMENT	PROCESS
HARDNESS	NAME
SPEC.	SPEC.

SIGNATURES	DATES
DR.	9-19-63
CHK.	9-20-63
MFG. ENG.	
	9-25-63
STRESS	9-27-63
AERO.	
APP.	9-26-63
APP.	
DESIGN ACTIVITY APP. Willson	9-16-63
OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona

DWG. TITLE

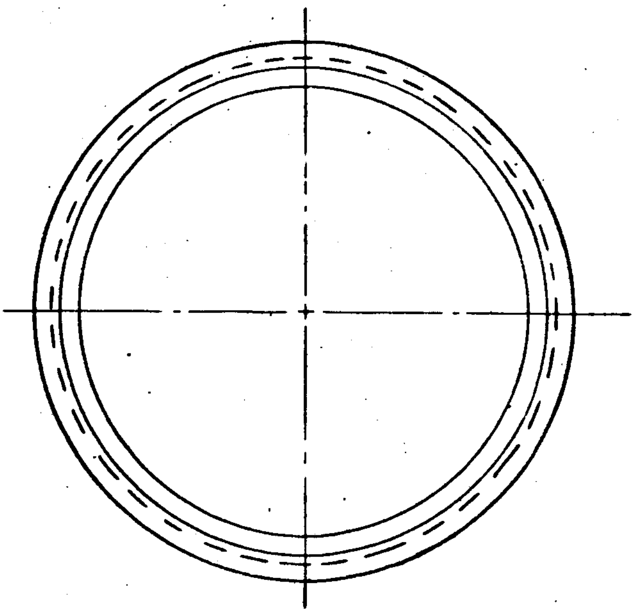
NOZZLE ASSEMBLY, OIL

CODE IDENT NO.	SIZE	DWG. NO.
99193	D	369728

SCALE FULL | WT | SHEET 1 OF 1

369728

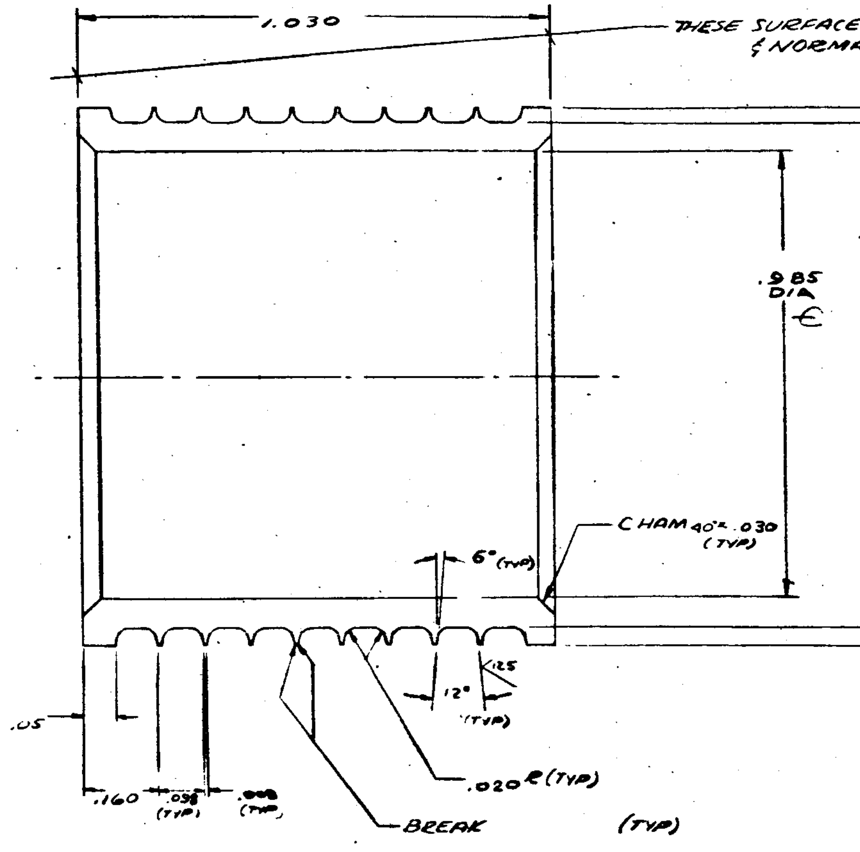
APS-5108-R
APS-5109-R



CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SPECIFIED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1-313.

11. PENETRANT INSPEC
10. PART NUMBERING

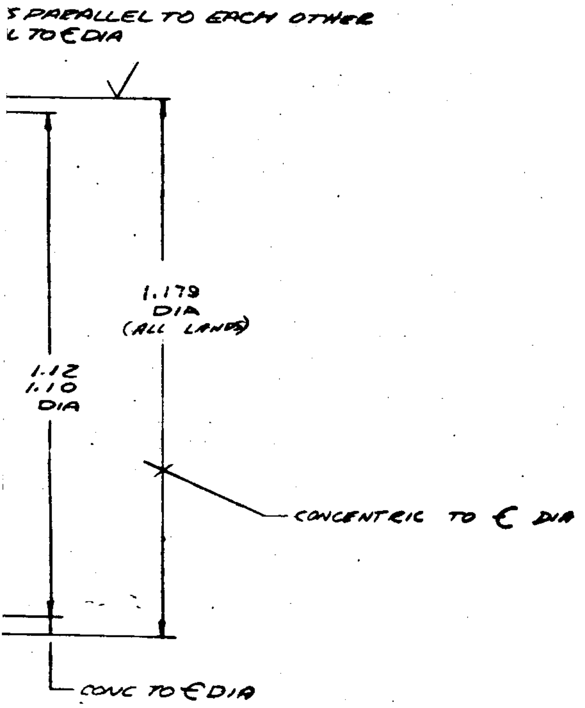


PER MIL-I-6866
: NONE

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX OF .012 FOR ANY SURFACE
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



3

REQD	ITEM NO	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
						N5-25		

←ASSYS

LIST OF MATERIAL

NEXT ASSY	USED ON
369741	369740
369731	369730
369721	369720

TREATMENT	PROCESS
15-55	NAME
	SPEC

SIGNATURES	DATES
DR	9-18-63
CHK	9-25-63
MFG ENG	
MAT & PROCESS	9-25-63
STRESS	9-25-63
ATRO.	
APP	9-26-63
APP	
DESIGN ACTIVITY APP. Willson	9-26-63
OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

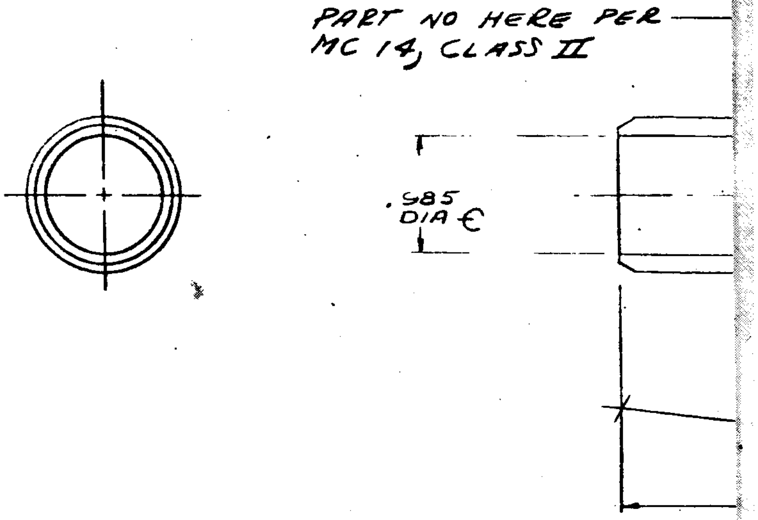
DWG TITLE
SPACER, LABYRYNTH

CODE IDENT NO	SIZE	DWG NO.
99193	D	369729

SCALE 5/1 | WT | SHEET 1 OF 1

DWG NO. 369729

APS-51[illegible]-R
APS-5109-R



CRITICAL ITEM

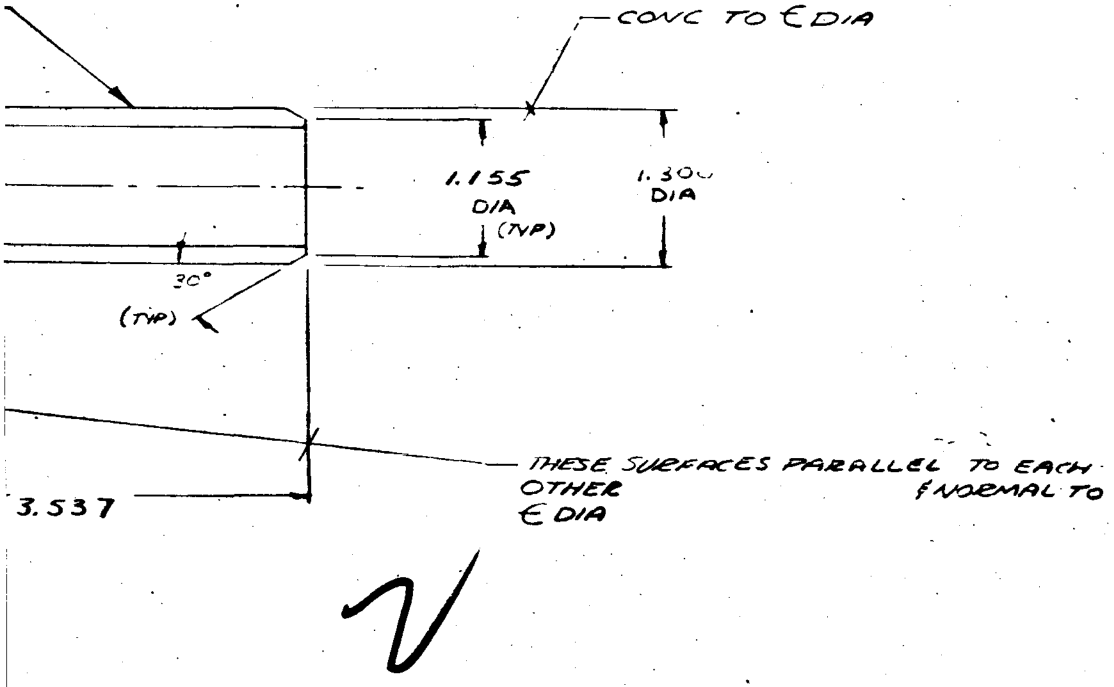
SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ~~ALL~~ CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

18.
17. MAGNETIC INSPECTION PER MIL-I-6868
16. SIMILAR TO 369539
9

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



THESE SURFACES PARALLEL TO EACH OTHER & NORMAL TO ℄ DIA

				BAR OR TUBING		STEEL 4340	AMS 6415	
QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.

←ASSYS LIST OF MATERIAL

REQD.	NEXT ASSY.	USED ON
	369741	369740
	369731	369730
1	369721	369720

HEAT TREATMENT	PROCESS
HARDNESS Rc 46-40	NAME
SPEC. MIL-H-6875	SPEC.

SIGNATURES	DATES
DFT.	9-16-63
CHK.	9-25-63
MFG ENG	
MAT. & PROCESS	9-25-63
STRESS	9-25-63
AERO	
APP	9-26-63
APP	
DESIGN ACTIVITY APP.	9-26-63
OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

DWG. TITLE
SPACER, BEARING

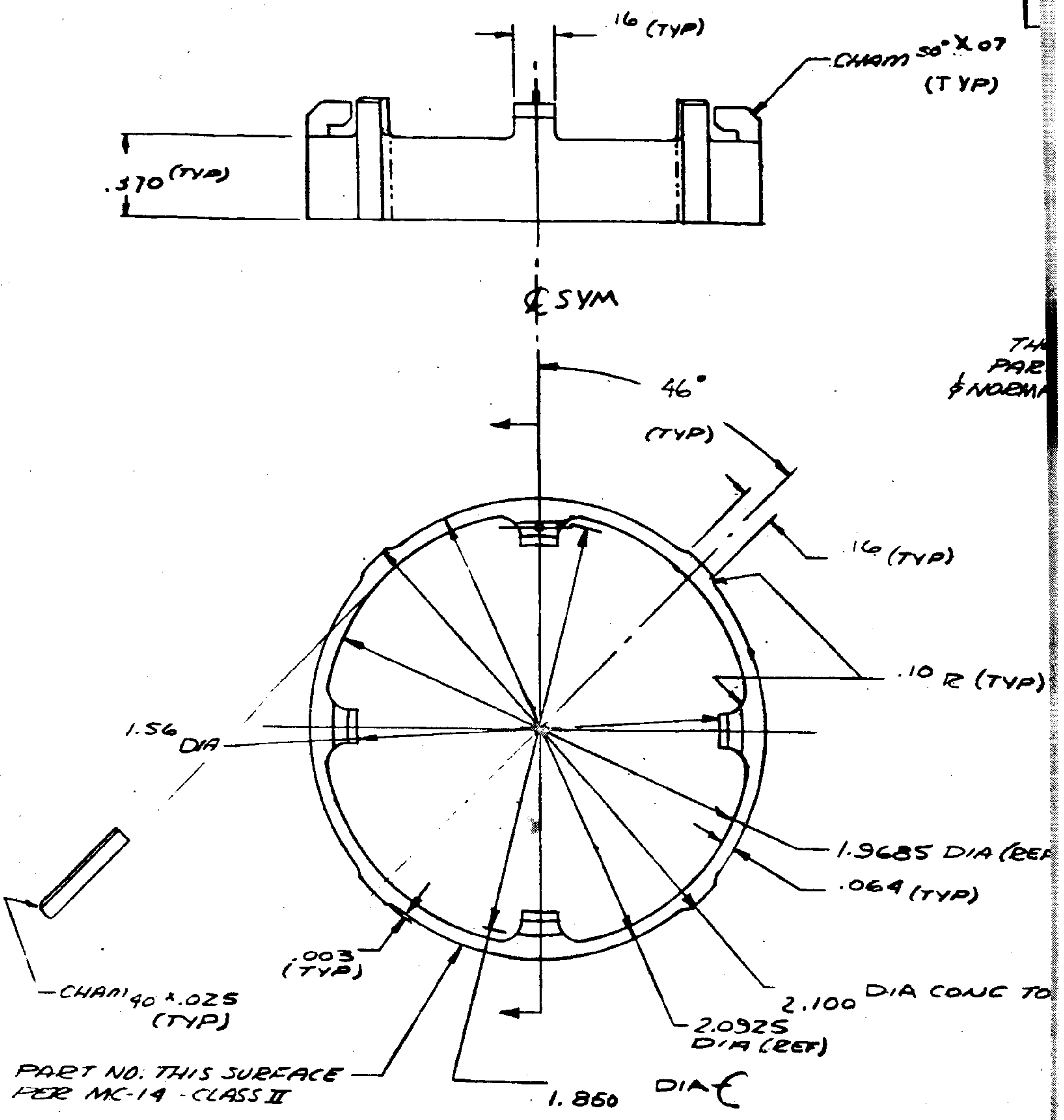
CODE IDENT NO.	SIZE	DWG. NO.
99193	C	369732

SCALE FULL WT. SHEET 1 OF 1

LAST LTR
DWG NO 369732

APS-5108

APS-5169-R



CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPL 1.313.

12. CONCENTRICITY SHOWN NEED NOT
BE CHECKED IN FREE STATE.

11. MAGNETIC INSPECTION PER MIL-I-6868

10. SIMILAR TO PA 369572

9.

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO
MAX. OF .006 FOR ANY SURFACE.

7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .0
PER INCH TO A MAX. OF .012 FOR ANY SURFACE.

6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTR
WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WIT
IN .032 TIR.

5. DIMENSION LIMITS HELD AFTER PLATING.

4. MACHINED FILLET RADII .030 - .015

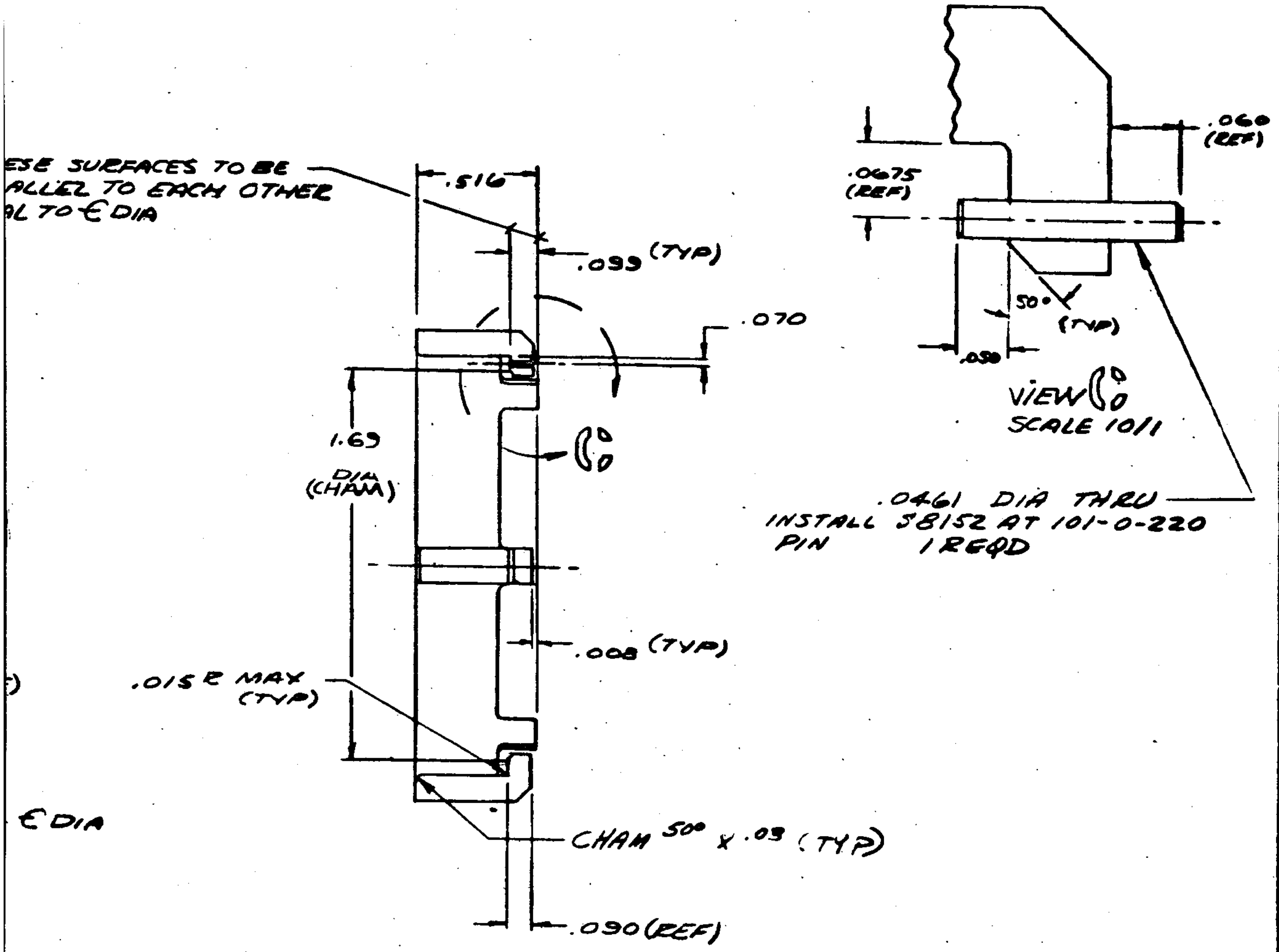
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX.
NO HANGING BURRS ALLOWED

2. SURFACE ROUGHNESS PER MIL-STD-10.

1. DIMENSIONS ARE IN INCHES

UNLESS OTHERWISE SPECIFIED

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



LAST LTR. —

DWG. NO. 369733

				BAR		STEEL 4340	AMS 6415	
QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.

←ASSYS

LIST OF MATERIAL

369741	369740
369731	369730
369721	369720
REQD. NEXT ASSY.	USED ON

HEAT TREATMENT	PROCESS
HARDNESS	NAME
SPEC.	SPEC.

SIGNATURES	DATES
DFT.	9-17-63
CHK.	9-25-63
MFG. ENG.	
MAT. & PROCESS	9-25-63
STRESS	9-25-63
AERO	
APP.	9-26-63
APP.	
DESIGN ACTIVITY APP.	9 26-63
OTHER ACTIVITY APP.	

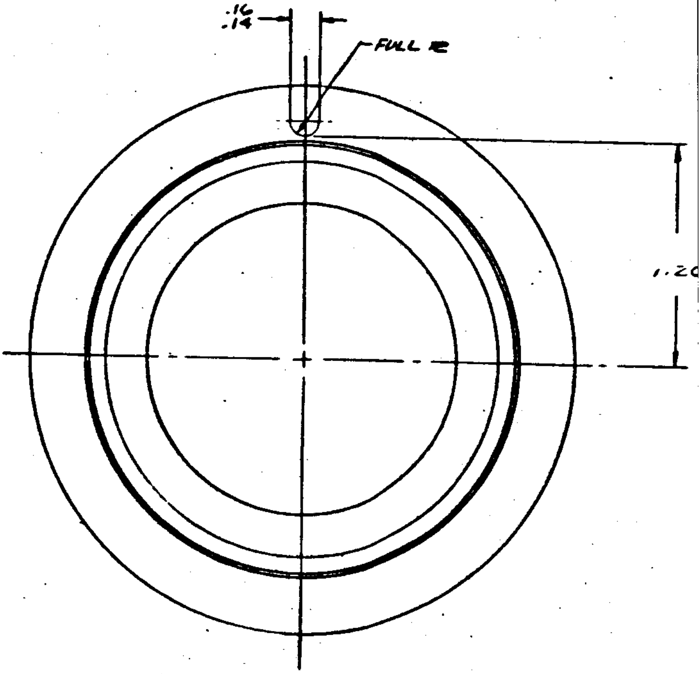
AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

DWG. TITLE
MOUNT, BEARING - RESILIENT

CODE IDENT NO.	SIZE	DWG. NO.
99193	C	369733

SCALE 2/1 WT. SHEET 1 OF 1

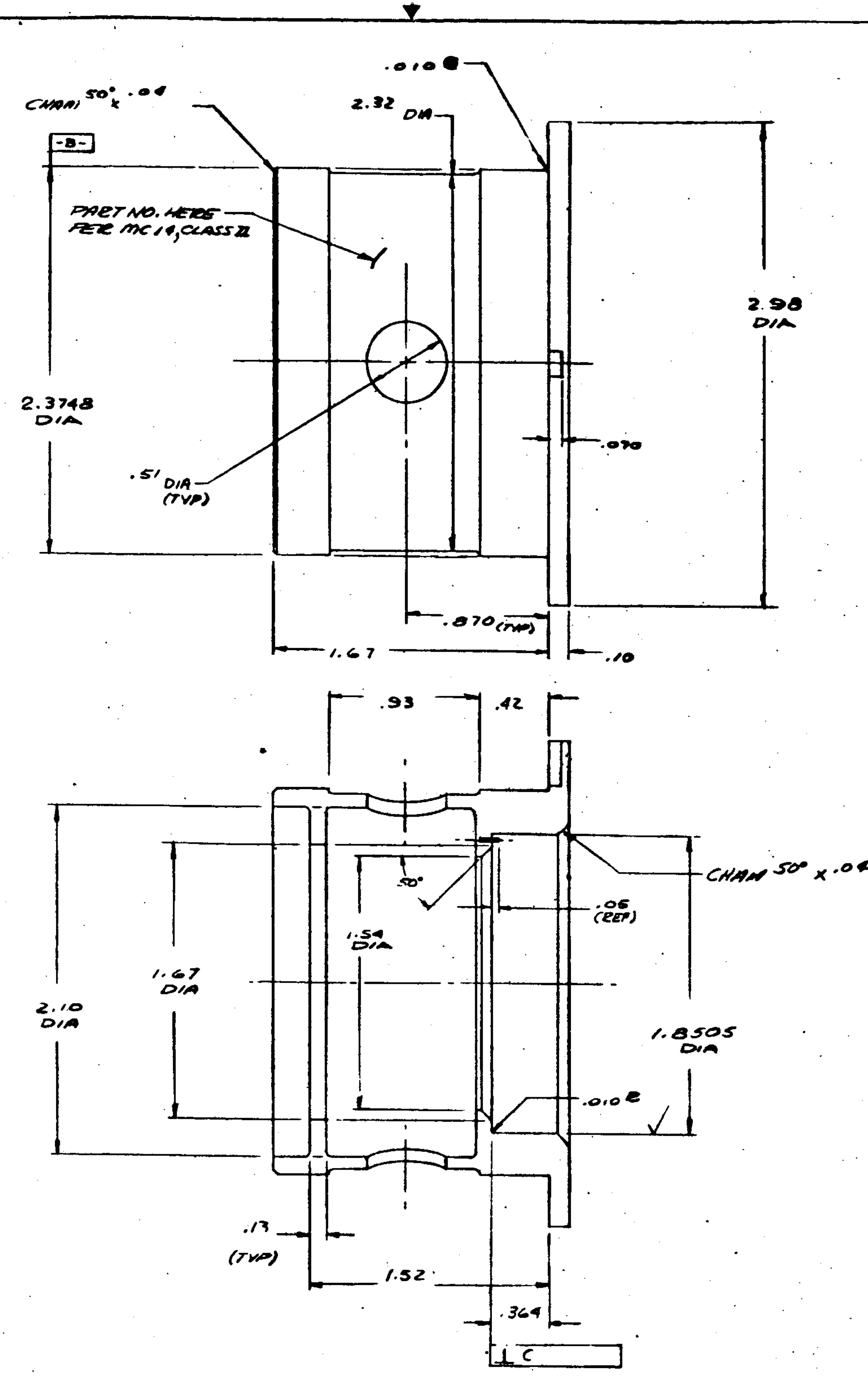
APS-5108-R
APS-5109-R



CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.

12. POSITIONAL & GE
11. SIMILAR TO PA
10. MAGNETIC INSP



9. FINISH ALL OVER 125

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX OF .006 FOR ANY SURFACE

7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE

6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS CONCENTRIC WITHIN .032 TIR.

5. DIMENSION LIMITS HELD AFTER PLATING.

4. MACHINED FILLET RADII .030 - .015

3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.

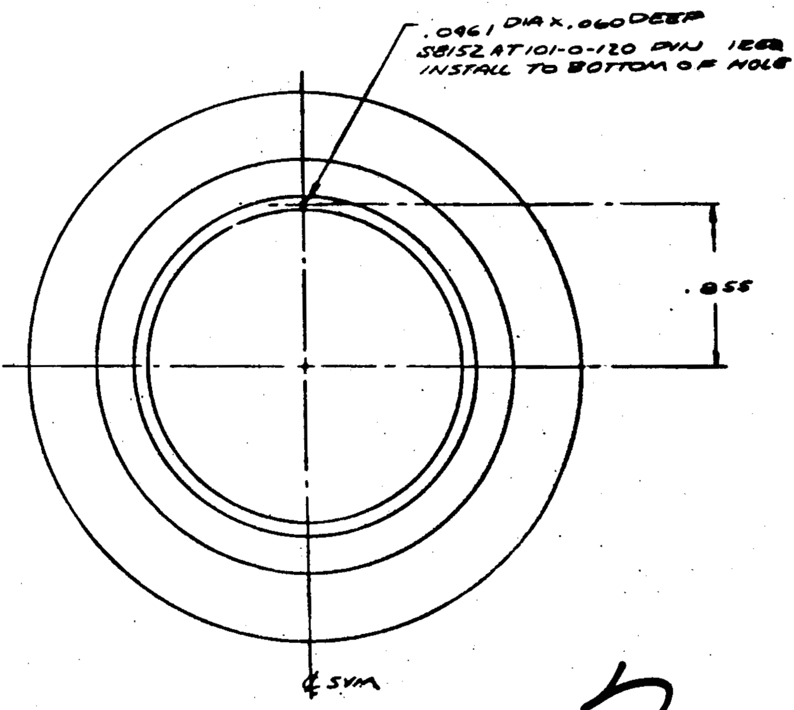
2. SURFACE ROUGHNESS PER MIL-STD-10.

1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

METRIC SYMBOLS PER MIL-STD-8
369573
CTION PER MIL-I-6868

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	SEE ENGINEERING ORDER		



3

				BAR		STEEL 4340	AMS 6415	
QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.

← ASSYS

LIST OF MATERIAL

	369741	369740
	369731	369730
1	369721	369720
REQD.	NEXT ASSY.	USED ON

HEAT TREATMENT	PROCESS
HARDNESS Rc 36-42	NAME
SPEC. MIL-H-6875	SPEC.

SIGNATURES		DATES
DR.		9-19-63
CHK.		9-25-63
MFG. ENG.		
MAT. & PROCESS		9-25-63
STRESS		9-25-63
AERO.		
APP.		9-26-63
APP.		
DESIGN ACTIVITY APP.		9-26-63
OTHER ACTIVITY APP.		

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

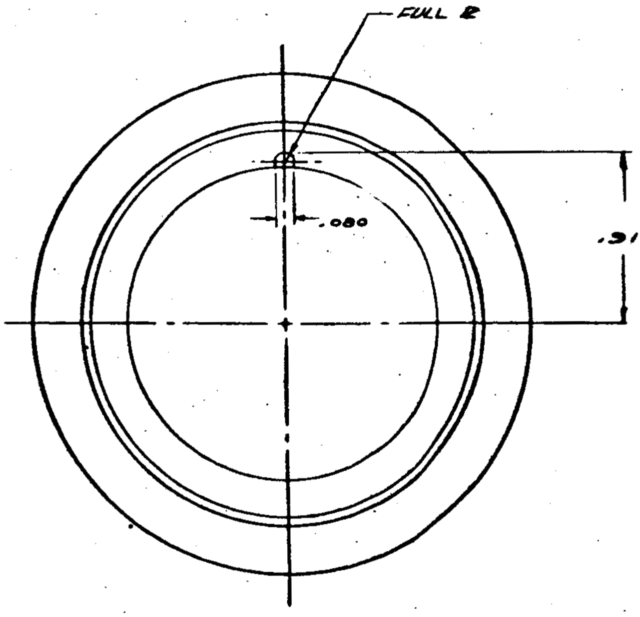
DWG. TITLE
CARRIER, BEARING

CODE IDENT NO.	SIZE	DWG. NO.
99193	D	369734

SCALE 2/1 WT. SHEET 1 OF 1

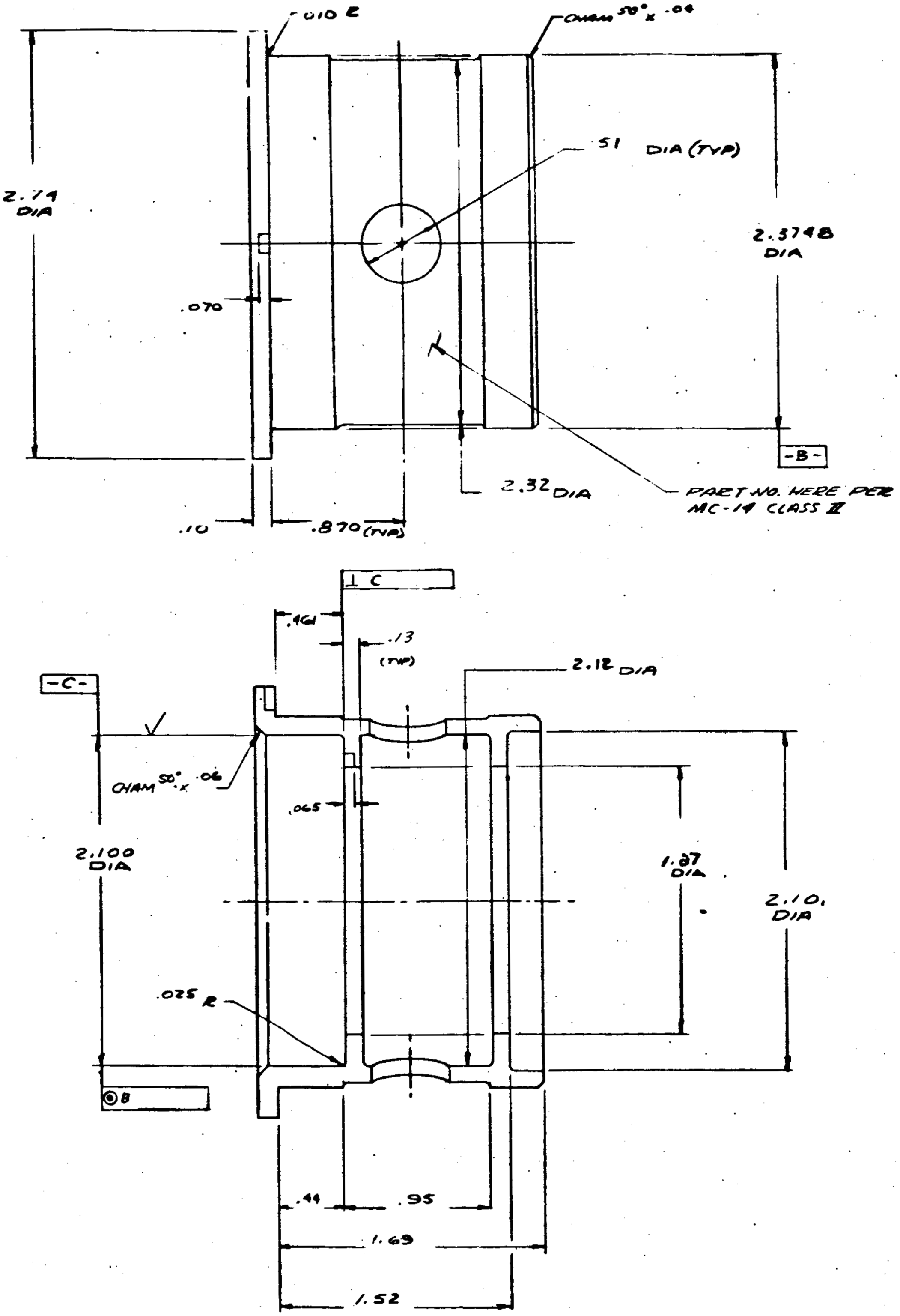
369734 A

APS-5108-R
APS-5109-R



[illegible]

12.
11.
10.



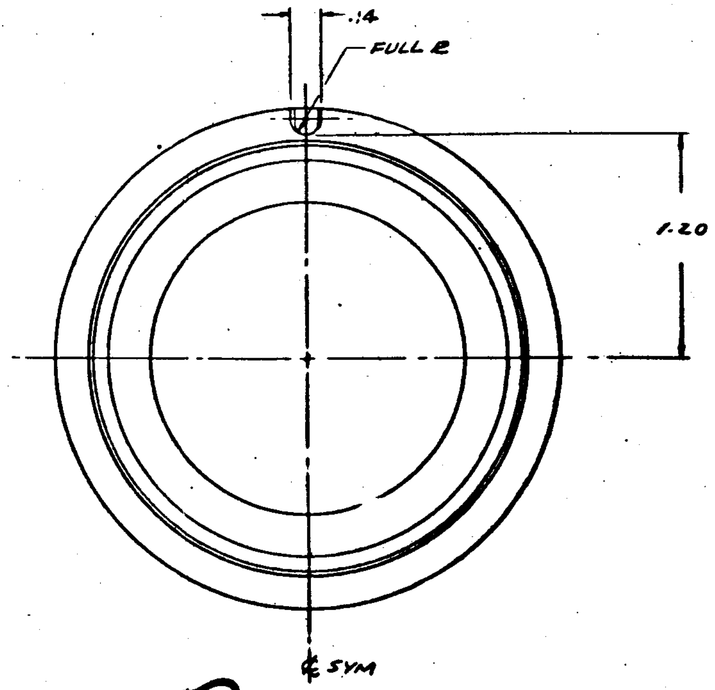
8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

POSITIONAL & GEOMETRIC SYMBOLS PER MIL-STD-8
SIMILAR TO PA 363572
MAGNETIC INSPECTION PER MIL-I-6868

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED
A	SEE ENGINEERING ORDER	1-5-64	



3

QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
				BAR		STEEL 4340	AMS 6415	

←ASSYS

LIST OF MATERIAL

REQD.	NEXT ASSY.	USED ON
	365741	365740
	365731	365730
1	365721	365720

HEAT TREATMENT

HARDNESS Rc 36-42

SPEC. MIL-H-6875

PROCESS

NAME

SPEC.

SIGNATURES	DATES
DFT.	9-18-63
CHK.	9-20-63
MFG. ENG.	
MAT. & PROCESS	9-25-63
STRESS	9-25-63
AERO.	
APP.	9-26-63
APP.	
DESIGN ACTIVITY APP.	9-26-63
OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

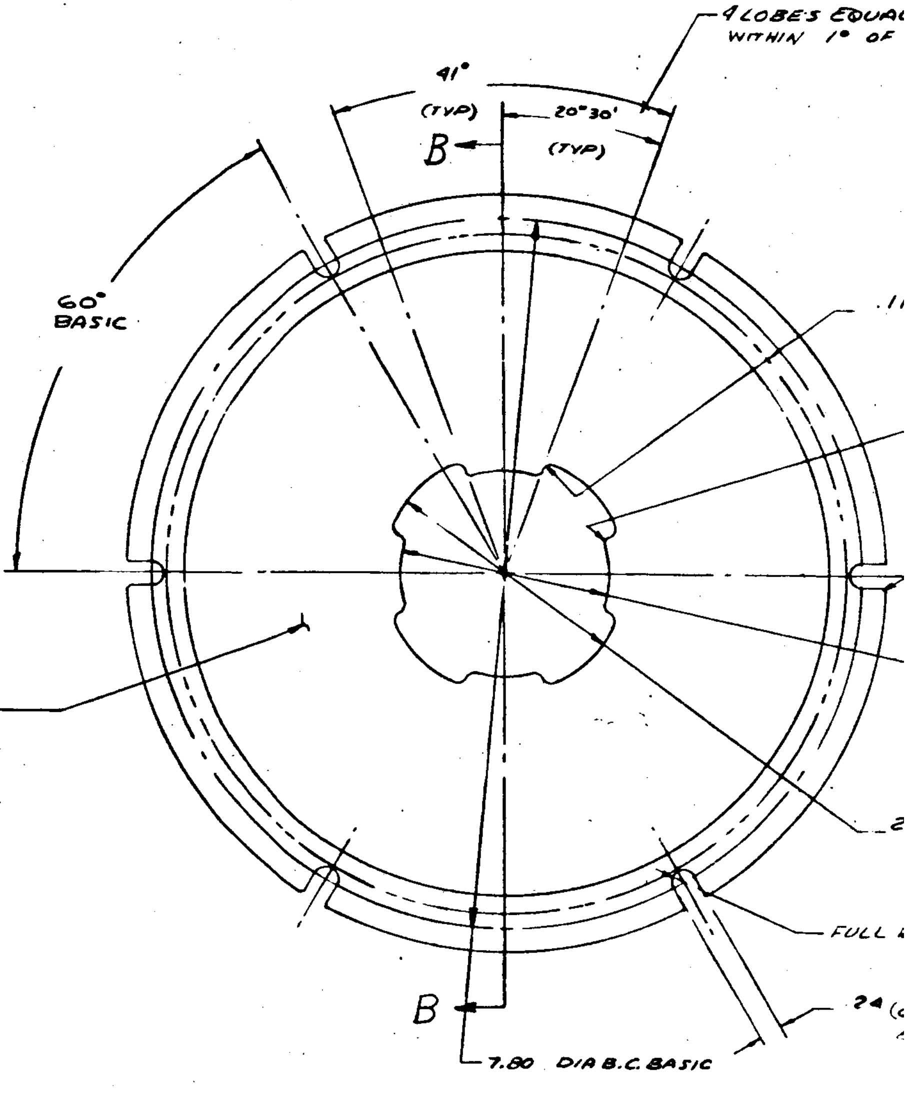
DWG. TITLE
CARRIER, BEARING

CODE IDENT NO.	SIZE	DWG. NO.
99193	D	369735

SCALE 2/1 WT. SHEET

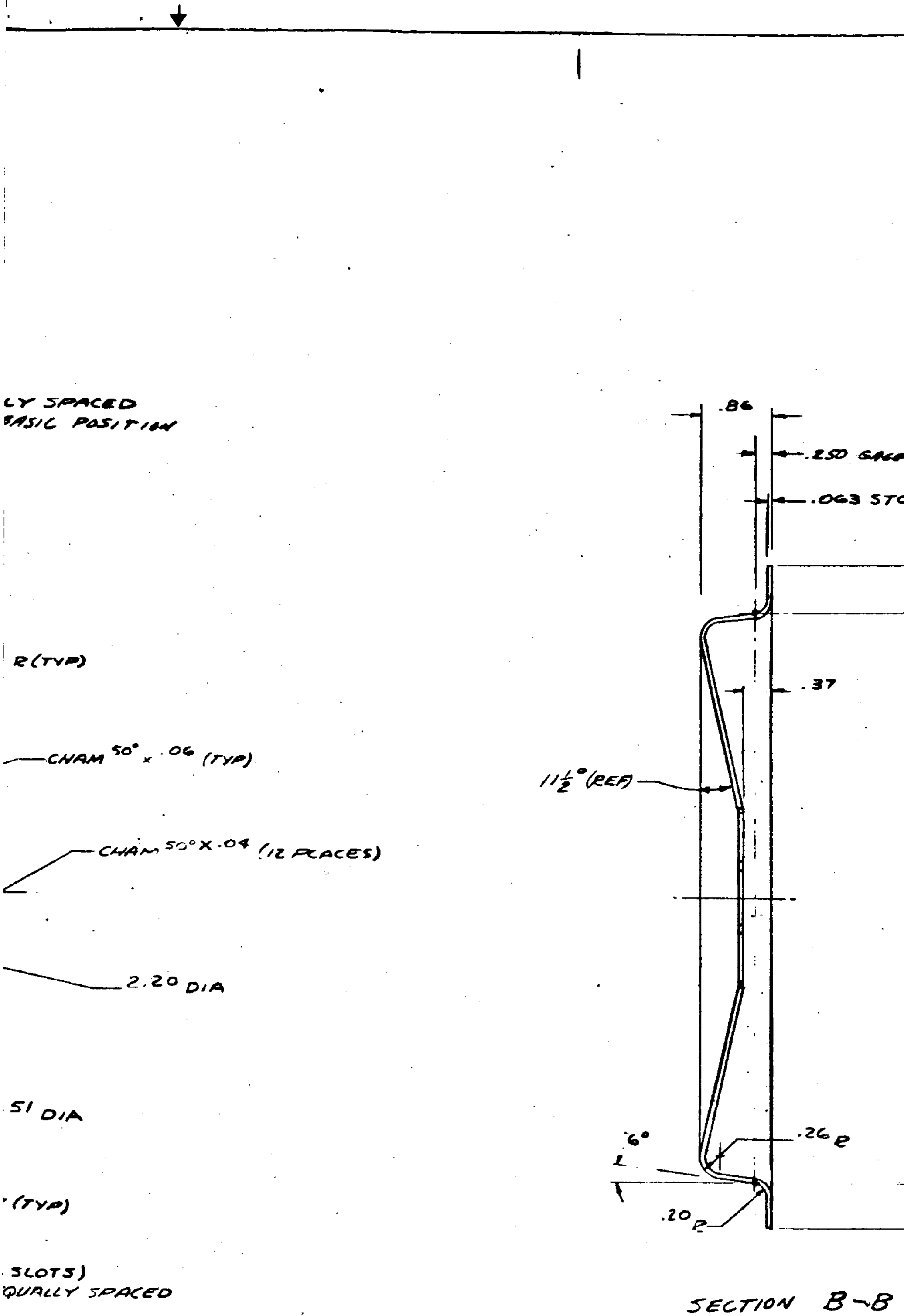
369735 A

APS-5108-R



13. AGE BY HEATING AT 1300°F FOR TWENTY
AIR COOL
12. ANNEAL AS NECESSARY DURING FORMING OF
HEAT AT 2100°F FOR 4 HOURS RAPID AIR CO
11. MAXIMIUM METAL THINING AFTER FORM

10. POSITIONAL & GEOMETRICAL TOLERANCE SYMB
9.



SECTION B-B

HOLES.

ERATIONS

L

NG 30%

XLS PER MIL-STD-8

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

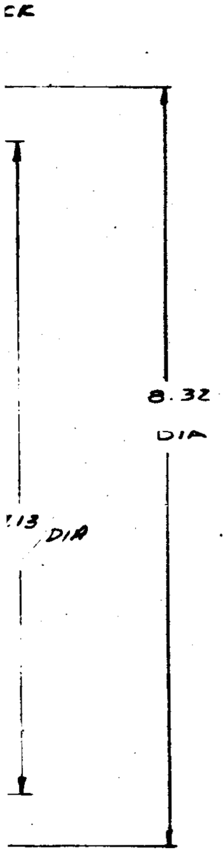
QTY. REQD.	ITEM NO.	PART NO.	SYM
	← ASSYS		

1	369721	369720
REQD.	NEXT ASSY.	USED ON

HEAT TREATMENT	PROCESS
HARDNESS NOTED	NAME
SPEC. NOTED	SPEC.

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

D



3

369736

		INCONEL X750	AMS 5542	
DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.

LIST OF MATERIAL

ATURES	DATES
	9-16-63
	9-26-63
	9-26-63
	9-25-63
	9-26-63
	9-26-63
ITY APP.	

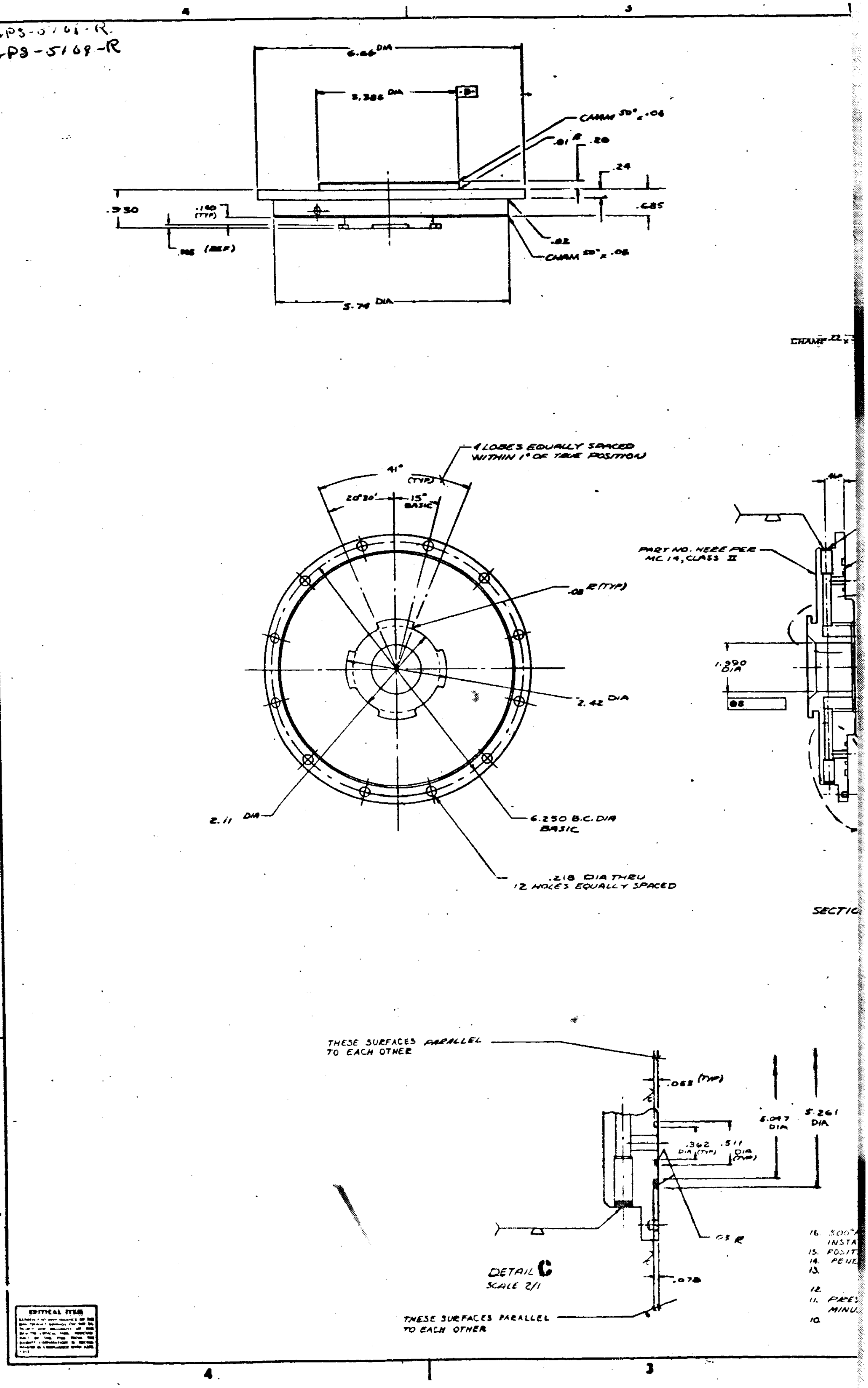
AiResearch Manufacturing Company of Arizona

DWG. TITLE
SHIELD-HEAT

CODE IDENT NO.	SIZE	DWG. NO.
99193	D	369736

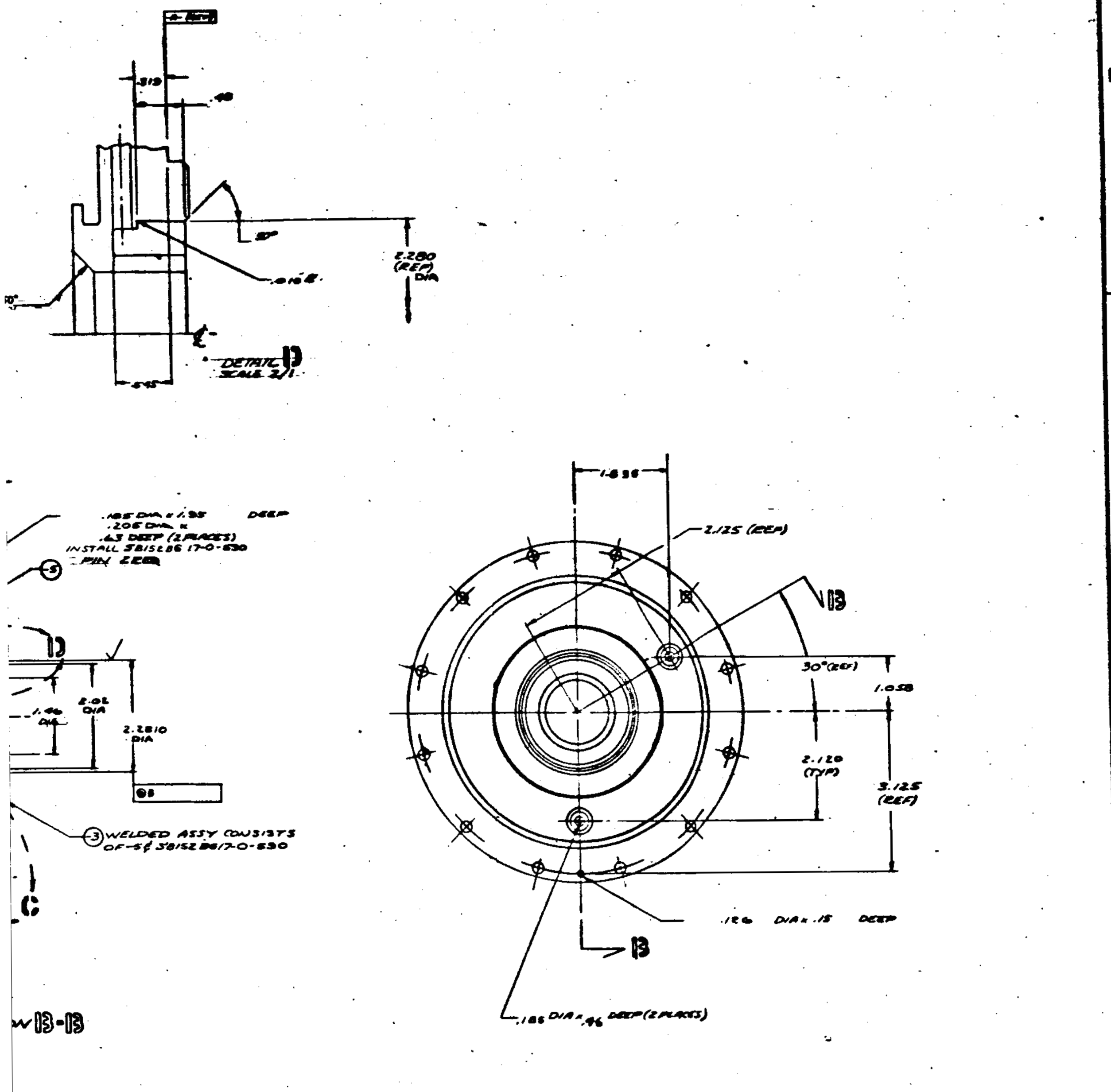
SCALE FULL | WT. | SHEET 1 OF 1

APS-5761-R
APS-5169-R



16. 500°
INSTA
15. POSIT
14. PENE
13.
12.
11. PRES
MINU
10.

		REVISIONS		
A		SEE ENGINEERING ORDER	[illegible]	[illegible]
B		SEE ENGINEERING ORDER	[illegible]	[illegible]



2

MAX TEMP OF THIS PART WHEN
LLING SEAL (
ONAL & GEOMETRIC SYMBOLS PER MIL-STD-8
TRANT INSPECTION PER MIL-I-6866

SSURE TEST WITH AIR AT 150 PSIG FOR ONE
TE.

8. MACHINED SURFACES FLAT WITHIN [illegible] PER INCH TO A MAX OF [illegible] FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN [illegible] PER INCH TO A MAX OF .012 FOR ANY SURFACE.
6. MACHINED DIAS ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS CONCENTRIC WITHIN [illegible] TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII [illegible]
3. BREAK ALL CORNERS AND SHARP EDGES [illegible] NO MARKING [illegible] ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10
1. DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED

2		[illegible]		PIN					
1		-5		PLATE		CRES 347	MIL-S-6721		
		-3		WELDED ASSY					
QTY REQD	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.	ZONE

LIST OF MATERIAL

369741	369740
369381	369770
369721	369770

CARRIER ASSEMBLY, LABYRINTH SEAL

NOTED
NOTED
9-26-68

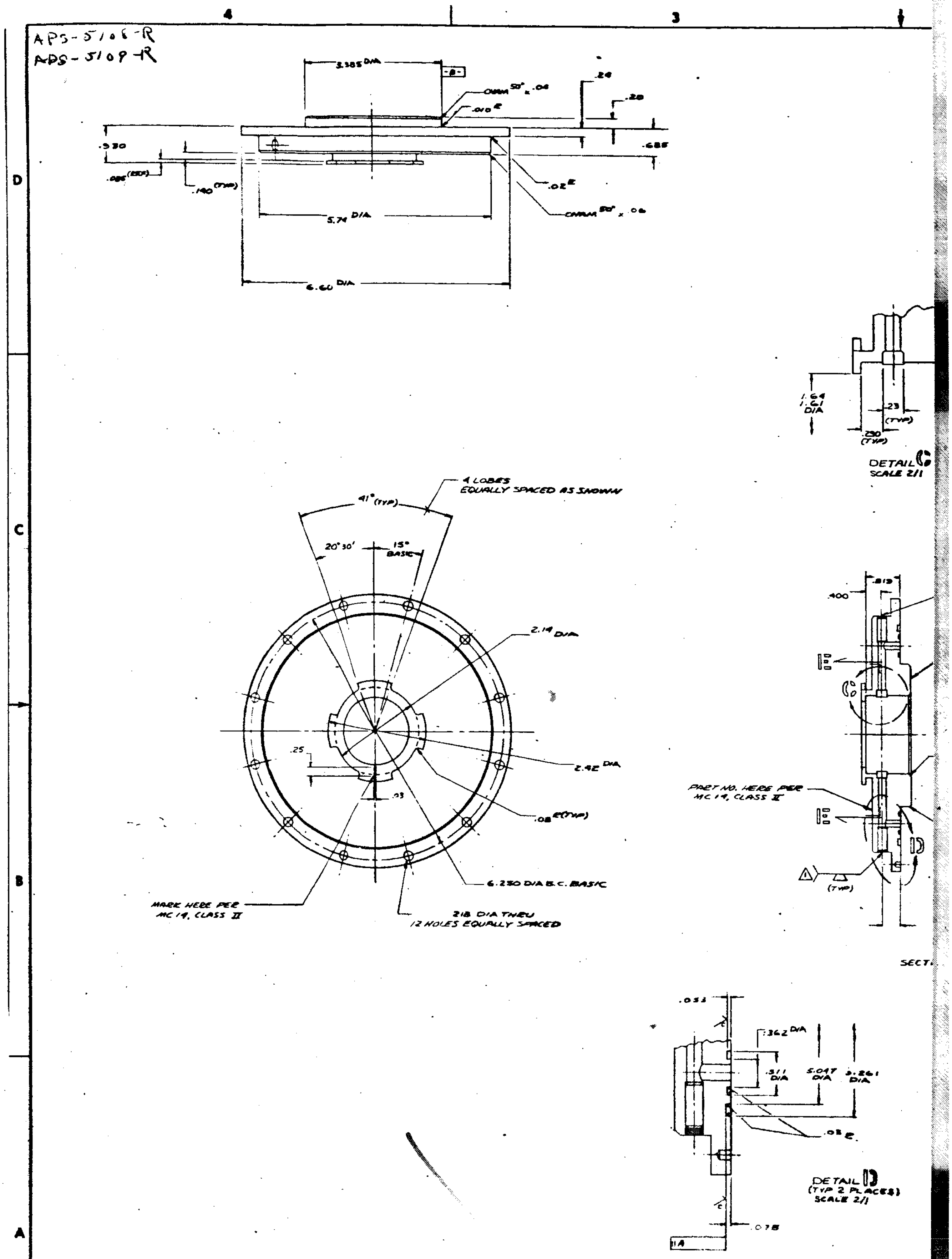
99193 E 369737

SHEET 1 OF 1

1

369737

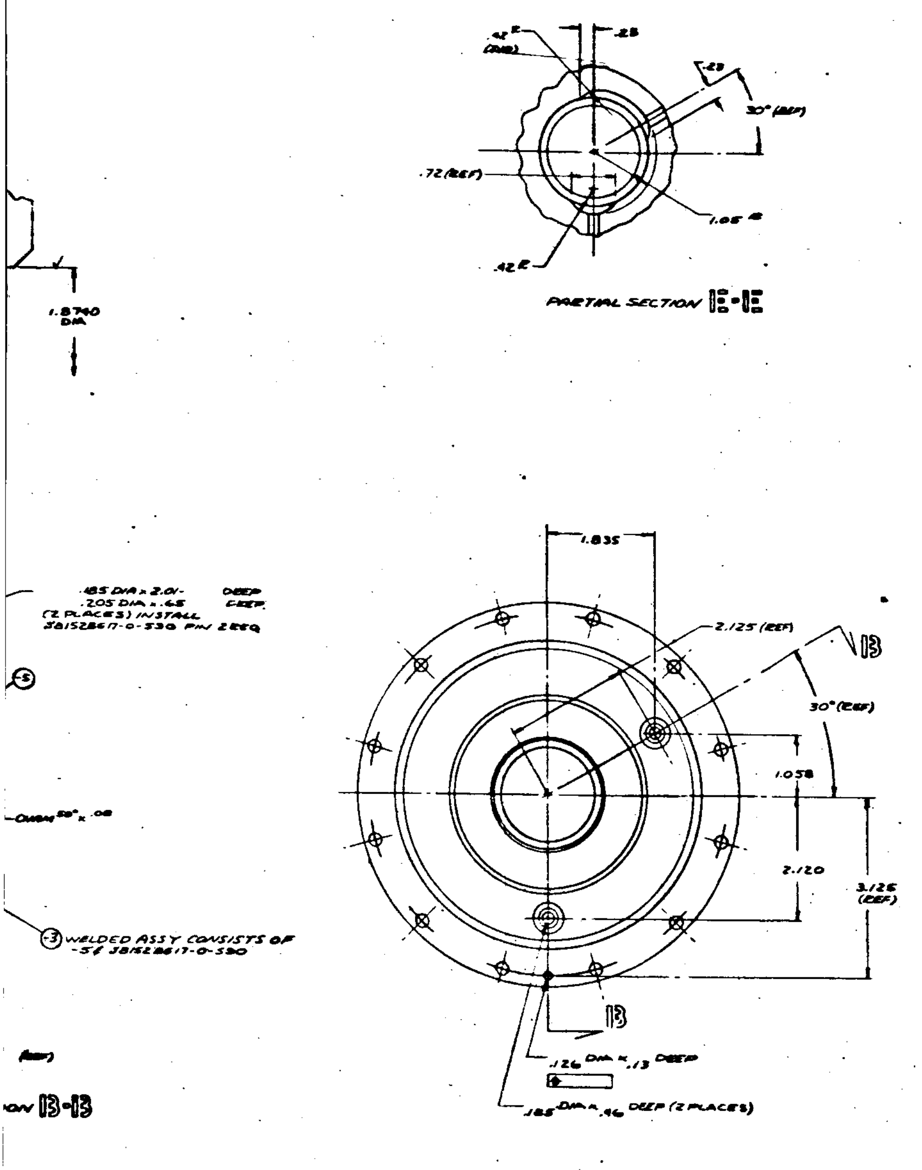
APS-5108-R
APS-5109-R



16. POSITIONAL & GEOMET
15.

12.
11. PRESSURE TEST
ONE MINUTE
10.
9.

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED
A		SEE ENGINEERING ORDER		
B		SEE ENGINEERING ORDER		



2

...TRIC TOLERANCE SYMBOLS PER MIL-STD-8

...WITH AIR AT 150 PSIG FOR

8. MACHINED SURFACES FLAT WITHIN [illegible] PER INCH TO A MAX OF [illegible] FOR ANY SURFACE
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN [illegible] PER INCH TO A MAX OF [illegible] FOR ANY SURFACE.
6. MACHINED DIAS ON A COMMON CENTERLINE CONCENTRIC WITHIN [illegible] TIR UNMACHINED DIAS CONCENTRIC WITHIN [illegible] TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII [illegible]
3. BREAK ALL CORNERS AND SHARP EDGES [illegible] NO HANGING BURRS ALLOWED
2. SURFACE ROUGHNESS PER MIL-STD-10
1. DIMENSIONS ARE IN INCHES
UNLESS OTHERWISE SPECIFIED.

QTY REQD	ITEM NO	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT	ZONE
2		38152B617-0-590		PIN					
1		-5		PLATE		CRES 347	MIL-S-6721		
1		-3		WELDED ASSY					
← ASSYS				LIST OF MATERIAL					

QTY REQD	NEXT ASSY	USED ON
		369740
		369739
1	369759	369729

SIGNATURES	DATES
	9-23-63
	9-23-63
	9-27-63
	9-27-63
	9-23-63
	9-31-63

HEAT TREATMENT | PROCESS: NOTED

FINISH: NOTED

CARRIER ASSEMBLY,
CARBON SEAL

CODE IDENT NO.	SIZE	DWG NO.
99193	E	369738

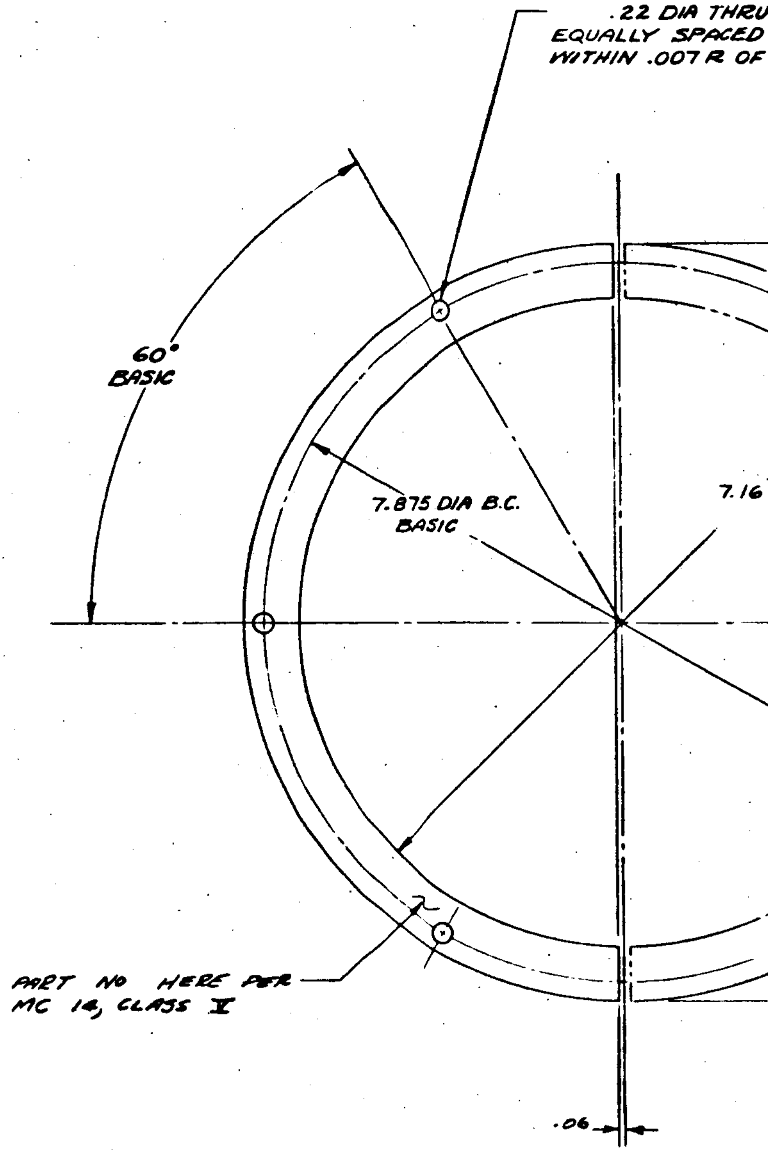
SCALE FULL

SHEET 1 OF 7

369738

PART NUMBER	T
369739-1	.013-.011
369739-2	.026-.024

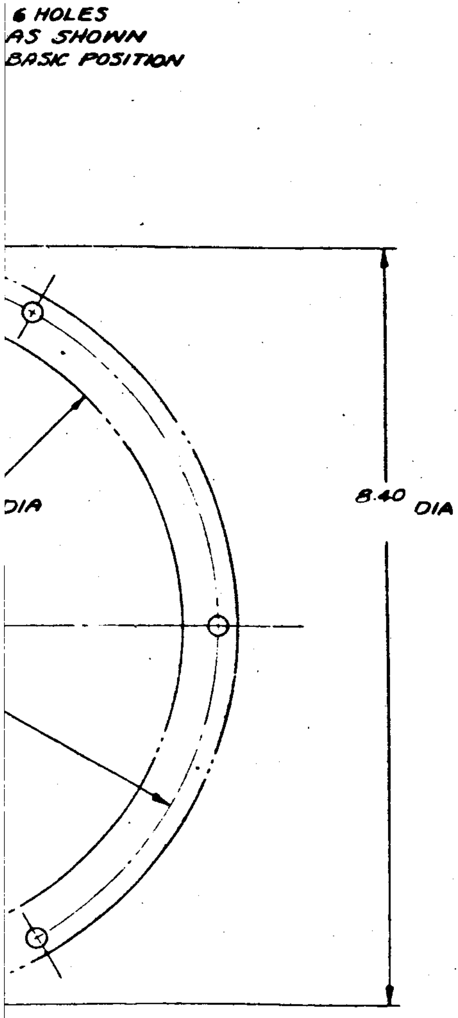
MPS-5106-R

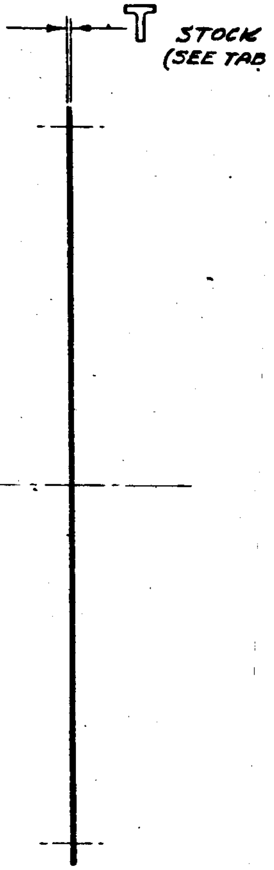


11. RE

10. MU

9. SH





MOVE BURRS.

ST BE FREE FROM WRINKLES.

ARP EDGES PERMISSIBLE.

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX OF 006 FOR ANY SURFACE
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX OF 012 FOR ANY SURFACE
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN 005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII 030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

BLOCK)

3

369739

		SEE TAB.		SHEET		CRES	MIL-S-6721	
QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.

←ASSYS LIST OF MATERIAL

REQD	NEXT ASSY.	USED ON
	369731	369730
6(-2)	369721	369720
2(-1)	369721	369720

HEAT TREATMENT: HARDNESS, SPEC.
PROCESS: NAME, SPEC.

SIGNATURES		DATES
DFT	Ed L. Bell	9-26-63
CHK	ford	9-28-63
MFG. ENG.		
MAT & PROCESS		
STRESS		
AERO.		
APP		9-30-63
APP		
DESIGN ACTIVITY APP.	Wilhon	9-30-63
OTHER ACTIVITY APP.		

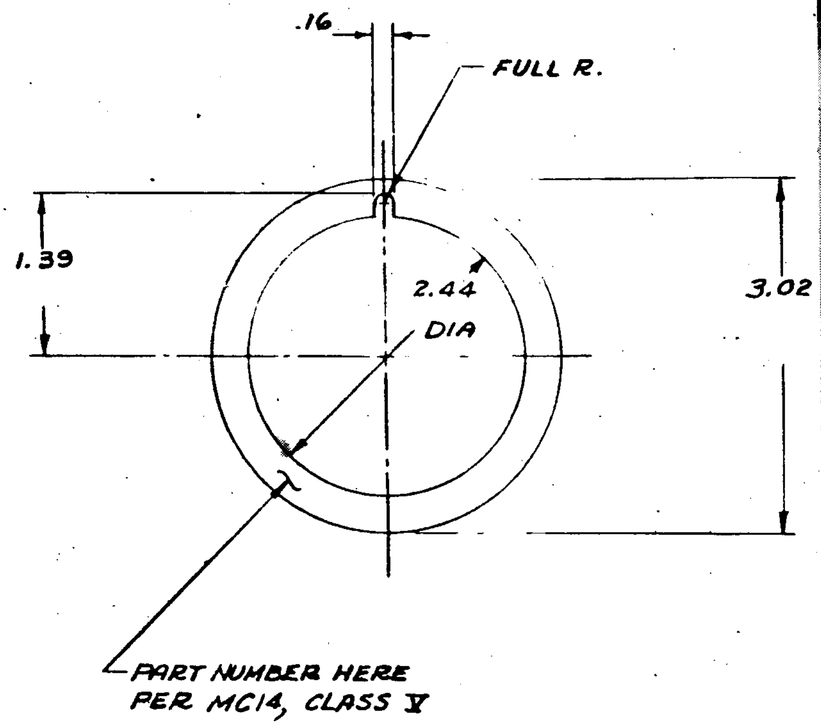
AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

DWG. TITLE
SHIM, SPLIT,
HEAT SHIELD

CODE IDENT NO. 99193
SIZE D
DWG. NO. 369739
SCALE FULL
WT.
SHEET 1 OF 1

PART NUMBER	T
369743-1	.013 - .011
369743-2	.004-.002
369743-3	007-.005

APS-5108-R
APS-5109-R

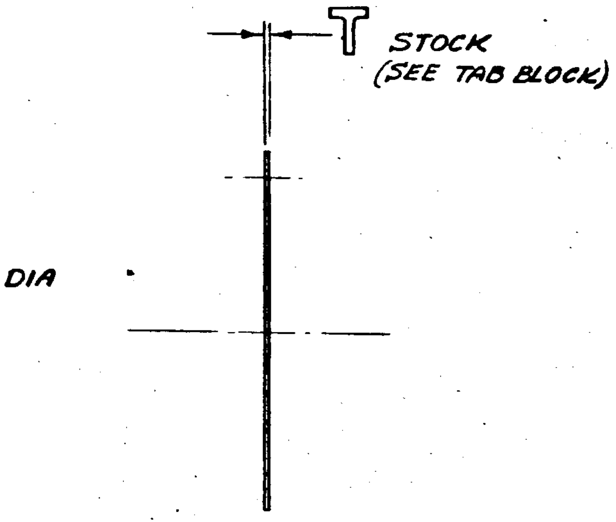


11. REMOVE BURRS.
10. MUST BE FREE FROM WRINKLES.
9. SHARP EDGES PERMISSIBLE.

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED.

P5548 - SIMS - K & E 103 HERCULENE

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



LAST LTR

DWG. NO. 369743

		SEE TAB.		SHEET		CRES	MIL-S-6721	
TY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.

←ASSYS LIST OF MATERIAL

	369741	369740
-3	369731	369730
(-2)	369721	369720
(-1)	369721	369720
EQD.	NEXT ASSY.	USED ON

EAT TREATMENT	PROCESS
ARDNESS	NAME
EC.	SPEC.

SIGNATURES		DATES
DFT	Ed. L. Bell	9-26-63
CHK.	Crawford	9-28-63
MFG. ENG.		
MAT. & PROCESS		
STRESS		
AERO		
APP.		9-30-63
APP.		
DESIGN ACTIVITY APP.		9-30-63
OTHER ACTIVITY APP.		

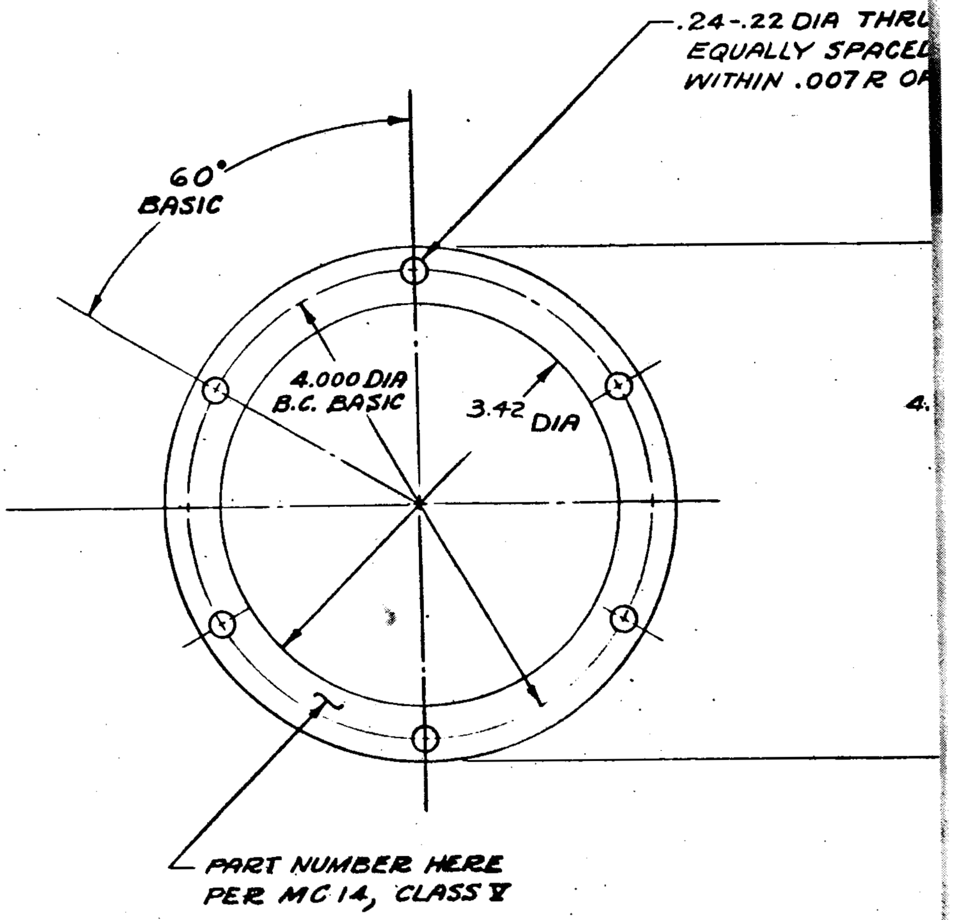
AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

DWG. TITLE
SHIM,
BEARING CARRIER

CODE IDENT NO.	SIZE	DWG. NO.
99193	C	369743
SCALE FULL	WT.	SHEET 1 OF 1

PART NUMBER	T
369744-1	.013-.011
369744-2	.026-.024
369744-3	.007-.005

APS-5108-R
APS-5109-R



11. REMOVE BURRS,
10. MUST BE FREE FROM WRINKLES.
9. SHARP EDGES PERMISSIBLE.

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

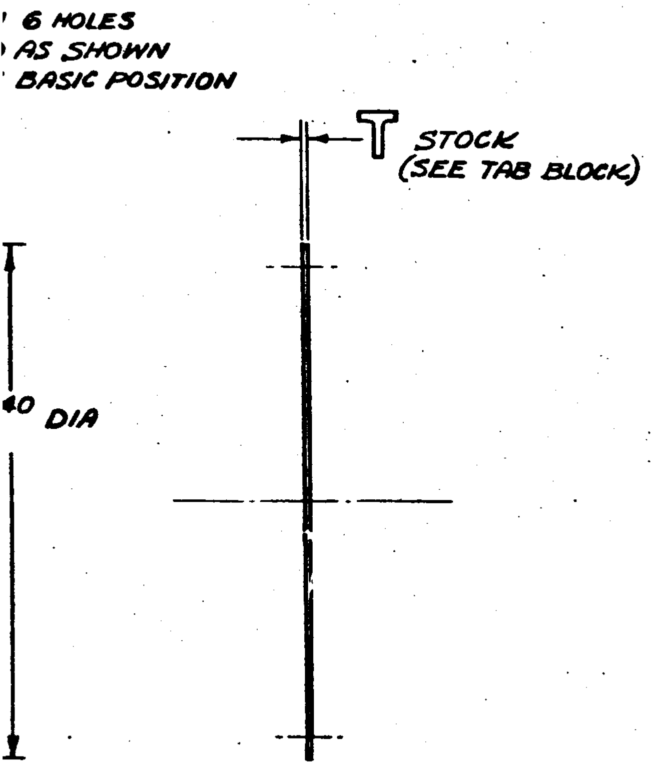
UNLESS OTHERWISE SPECIFIED.

QTY. REQ

HEAT TR

REVISIONS

YM	DESCRIPTION	DATE	APPROVED
A	SEE ENGINEERING ORDER	1-14-64	



LAST LTR. A

DWG. NO. 369744

	SEE TAB.		SHEET		CRES	MIL-S-6721	
ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
←ASSYS			LIST OF MATERIAL				

SIGNATURES	DATES
DFT.	9-26-63
CHK.	9-28-63
MFG. ENG.	
MAT. & PROCESS	
STRESS	
AERO.	
APP.	9-30-63
APP.	
	9-28-63

NEXT ASSY. | USED ON

TREATMENT | FINISH

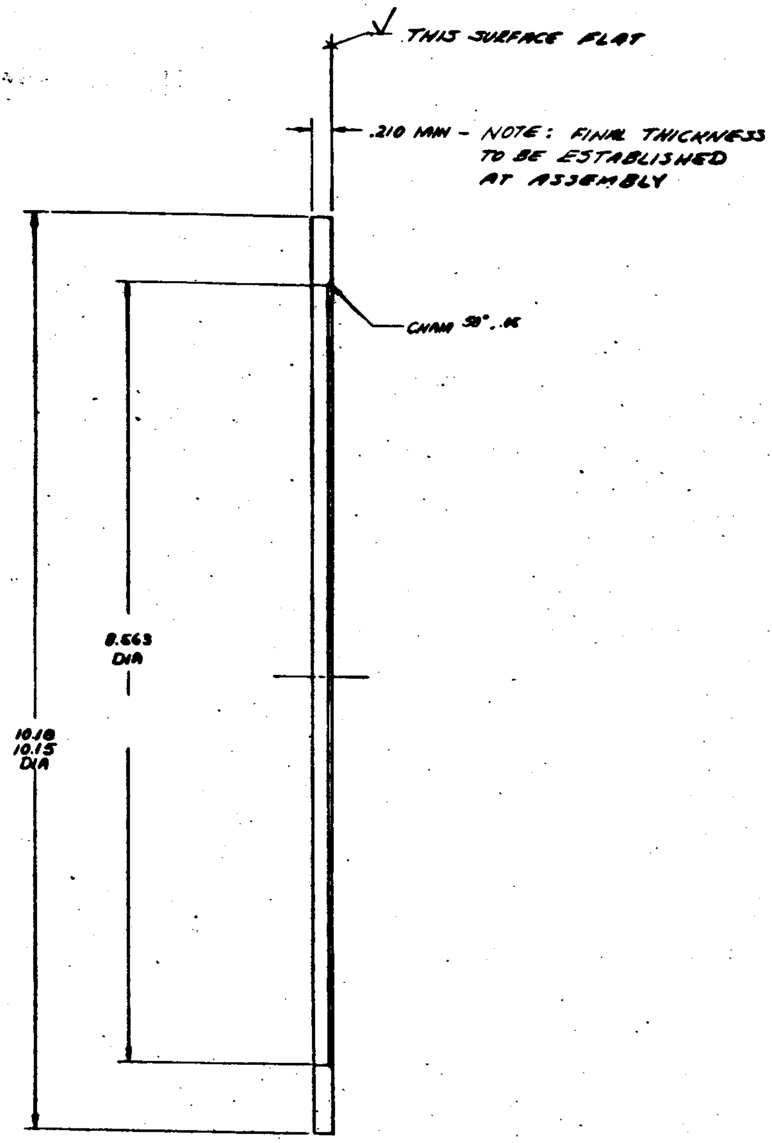
AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

DWG. TITLE
SHIM,
SEAL

CODE IDENT NO.	SIZE	DWG. NO.
99193	C	369744

SCALE FULL | WT. | SHEET 1 OF 1

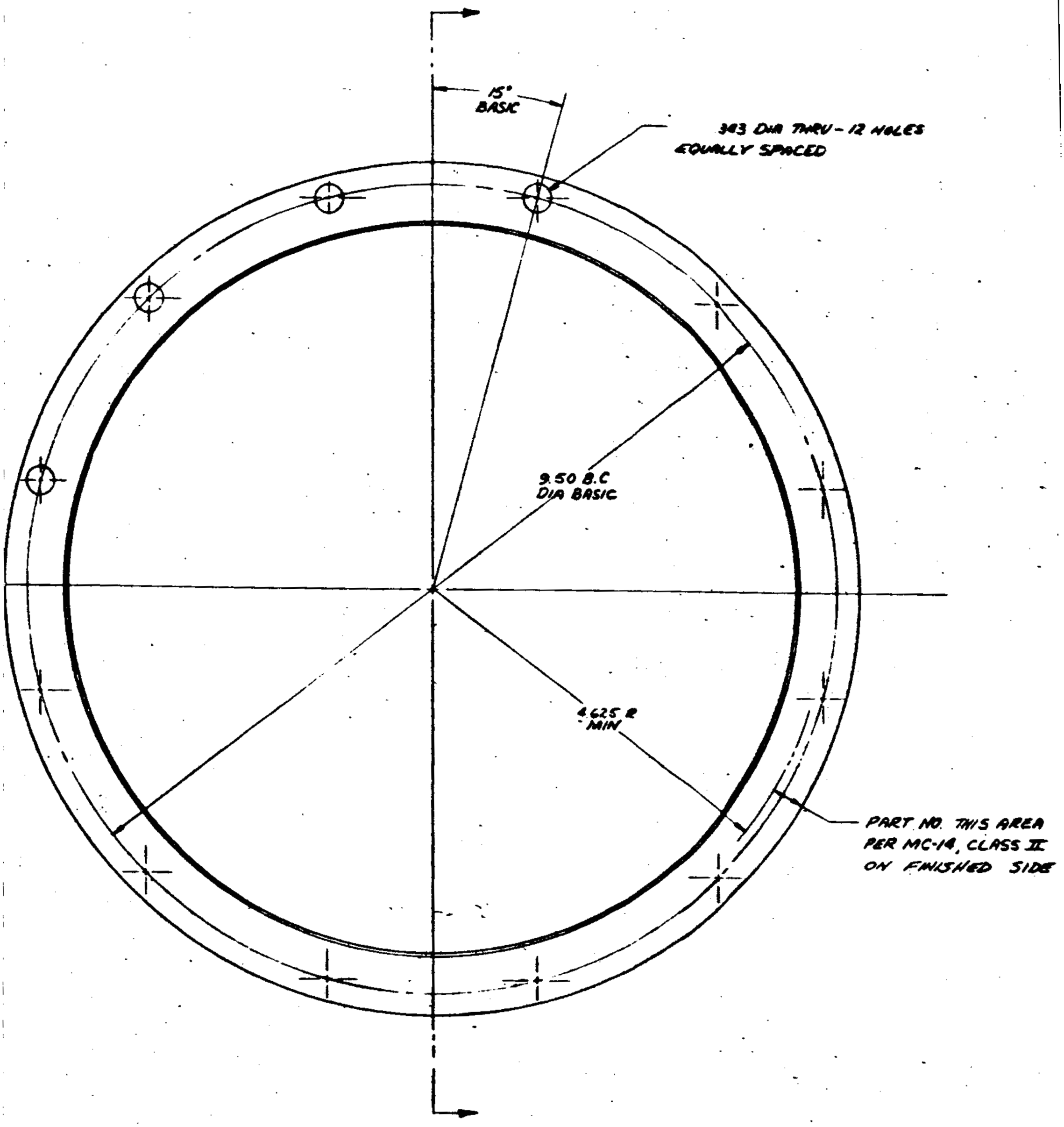
APS-5108-R
APS-5109-R



CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR [illegible]

9. MAGNETIC PARTICLE



N

INSPECT PER MIL-I-6868

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

QTY. REQD.	ITEM NO.	PART
	←ASSYS	

REQD.	NEXT ASSY.	USED
	369741	369
	369731	369
1	369721	369

HEAT TREATMENT	PROC
HARDNESS ROCK "C" 40-34	NAME
SPEC. MIL-H-6875	SPEC.

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED
1	SEE ENGINEERING ORDER	10-11-63	

3

369745

NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
				STEEL	2525	

LIST OF MATERIAL

740
730
720
ON
SS

SIGNATURES	DATES
DFT.	9-30-63
CHK. Crawford	10-3-63
MFG. ENG.	
MAT. & PROCESS	10-8-63
STRESS	10-5-63
AERO	
APP.	10-4-63
APP.	
DESIGN ACTIVITY APP.	10-9-63
OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

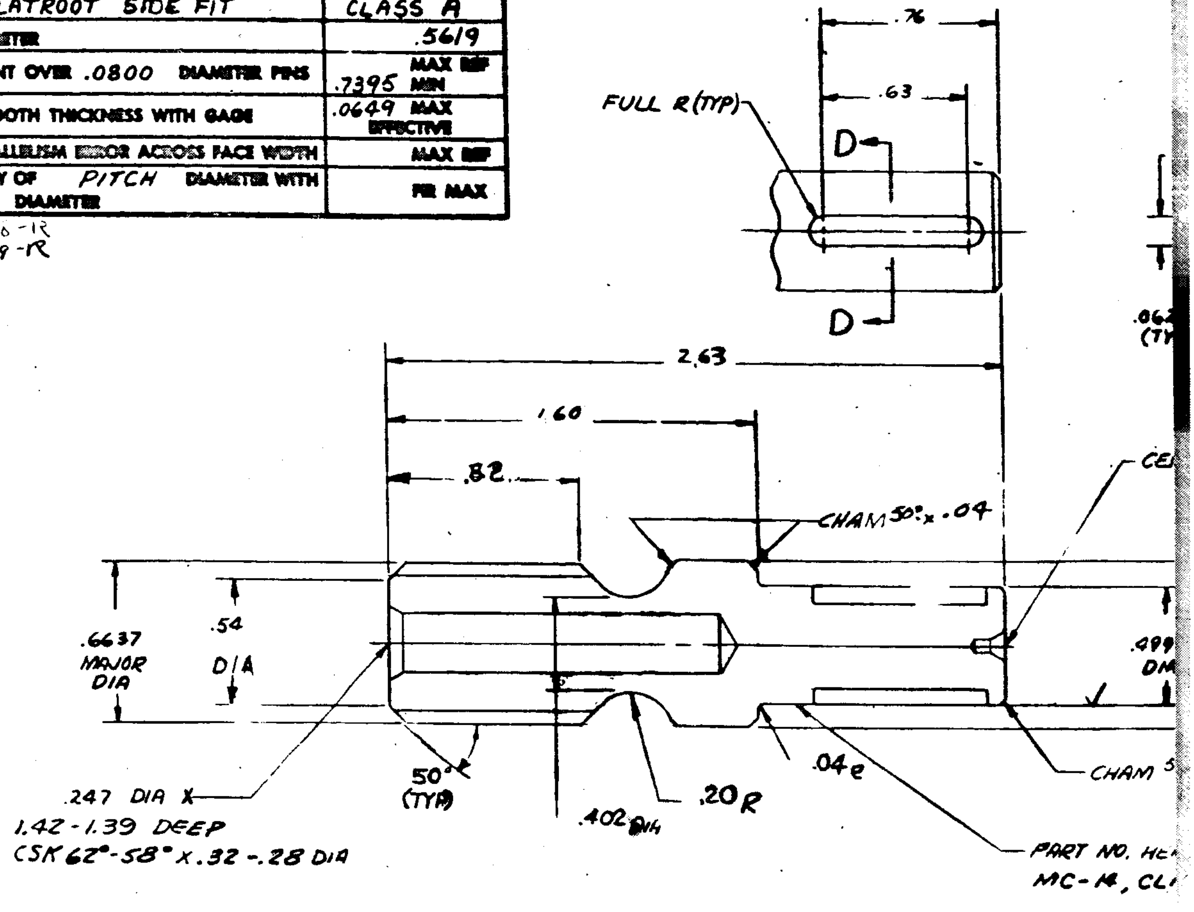
DWG. TITLE
SHIM-
SEALING SPACER

CODE IDENT NO.	SIZE	DWG. NO.
99193	D	369745

SCALE FULL
WT.
SHEET 1 OF 1

EXTERNAL SPLINE DATA	R.C.Wright 10-2-63
ASA B5.15 -1960 STANDARD INVOLUTE	15 TEETH
DIAMETRAL PITCH	24 / 48
PRESSURE ANGLE	30°
TYPE - FLATROOT SIDE FIT	CLASS A
MINOR DIAMETER	.5619
MEASUREMENT OVER .0800 DIAMETER PINS	MAX REF .7395 MIN
CIRCULAR TOOTH THICKNESS WITH GAGE	.0649 MAX EFFECTIVE
TOOTH PARALLELISM ERROR ACROSS FACE WIDTH	MAX REF
ECCENTRICITY OF PITCH DIAMETER WITH AXIS OF ℄ DIAMETER	TIR MAX

APS-5708-R
APS-5709-R



SECTION B-B

CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.

16. ALTERNATE MATERIAL PER MIL-S-5000. HEAT TREAT PER MIL-H-6875 TO ROCK "C" 34-36

15.

14.

13. FLUORESCENT PENETRANT INSPECT PER MIL-I-6866.

12.

11. POSITIONAL & GEOMETRIC TOLERANCE SYMBOLS PER MIL-STD-8.

10. FINISH SPLINE TOOTH PROFILES ✓

9.

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.

7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.

6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.

5. DIMENSION LIMITS HELD BEFORE PLATING.

4. MACHINED FILLET RADII .030 - .015

3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.

2. SURFACE ROUGHNESS PER MIL-STD-10.

1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

QTY. REQD

1 36

1 36

REQD NE

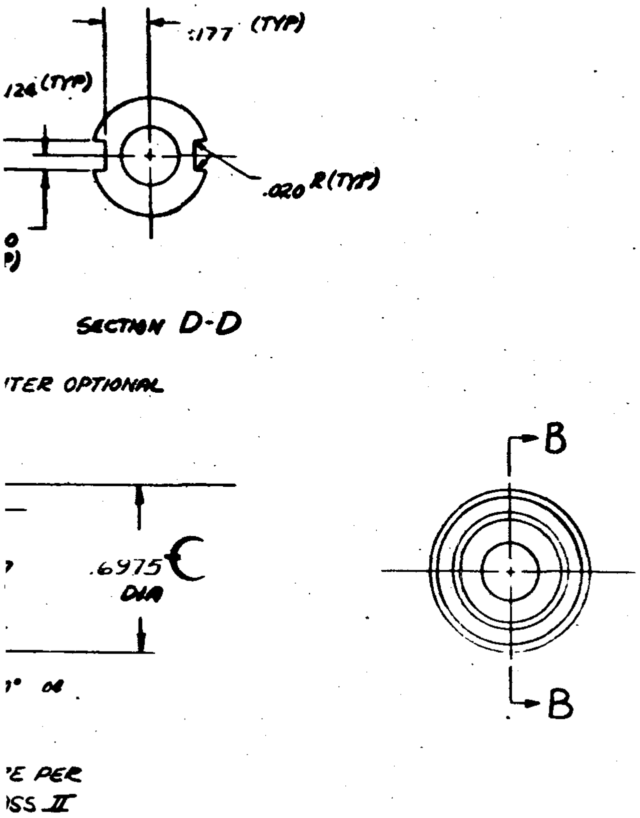
HEAT TREA

HARDNESS

SPEC.

F3548 · SIMS · K & E 163 HERCULENE

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A2	SEE ENGINEERING ORDER	11/3/63	



					STEEL		
ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.

←ASSYS

LIST OF MATERIAL

731	369730
721	369720
T ASSY.	USED ON
MENT	PROCESS
	NAME
	SPEC.

SIGNATURES	DATES
DFT.	10-1-63
CHK.	10-3-63
MFG. ENG.	
MAT. & PROCESS	10-9-63
STRESS	10-6-63
AERO	
APP.	10-9-63
APP.	
DESIGN ACTIVITY APP.	10-9-63
OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

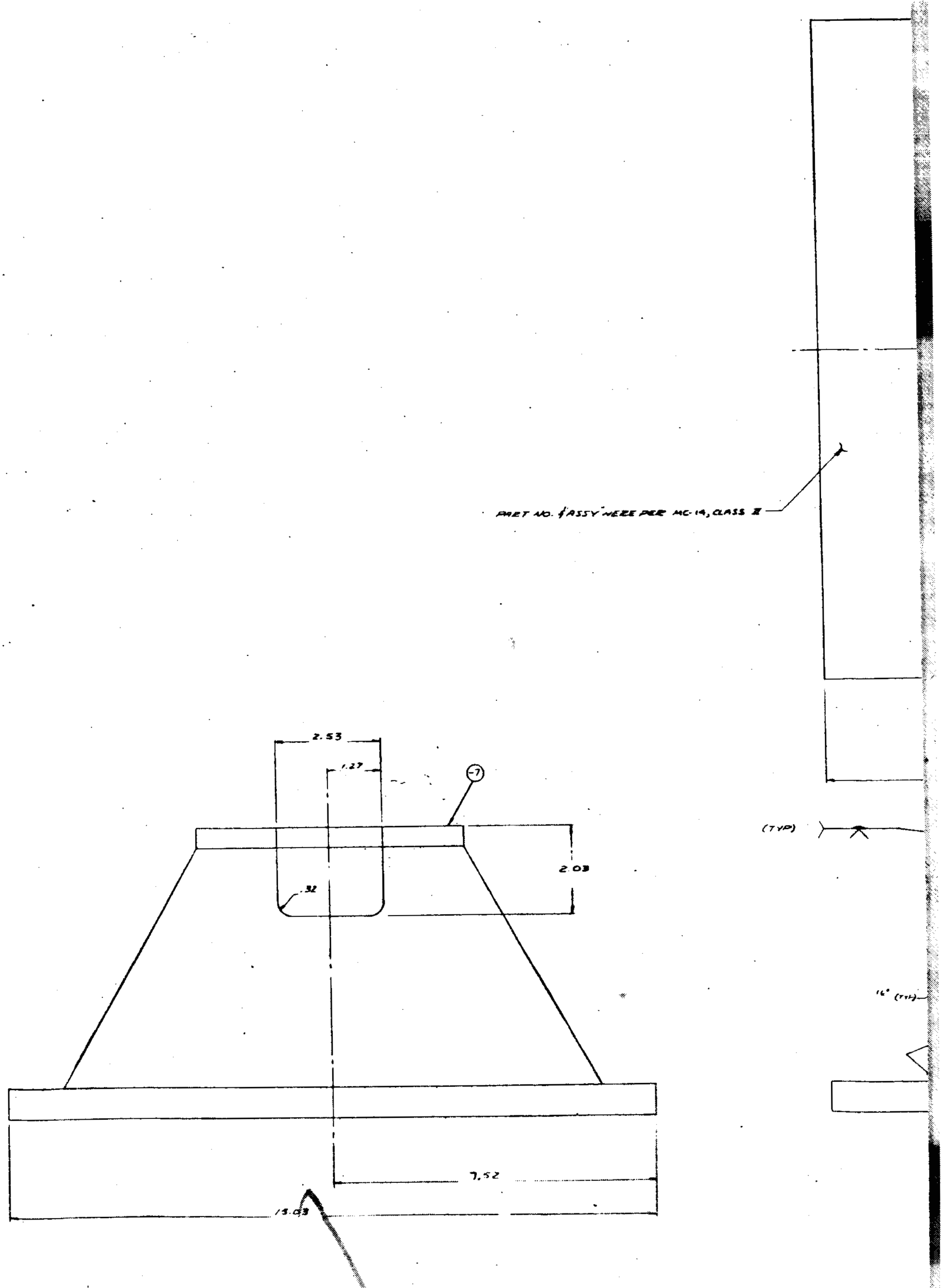
DWG. TITLE
SHAFT, QUILL

CODE IDENT NO 99193
SIZE C
DWG. NO 369746

SCALE TWICE
WT.
SHEET 1 OF 1

DWG. NO. 369746
LAST A

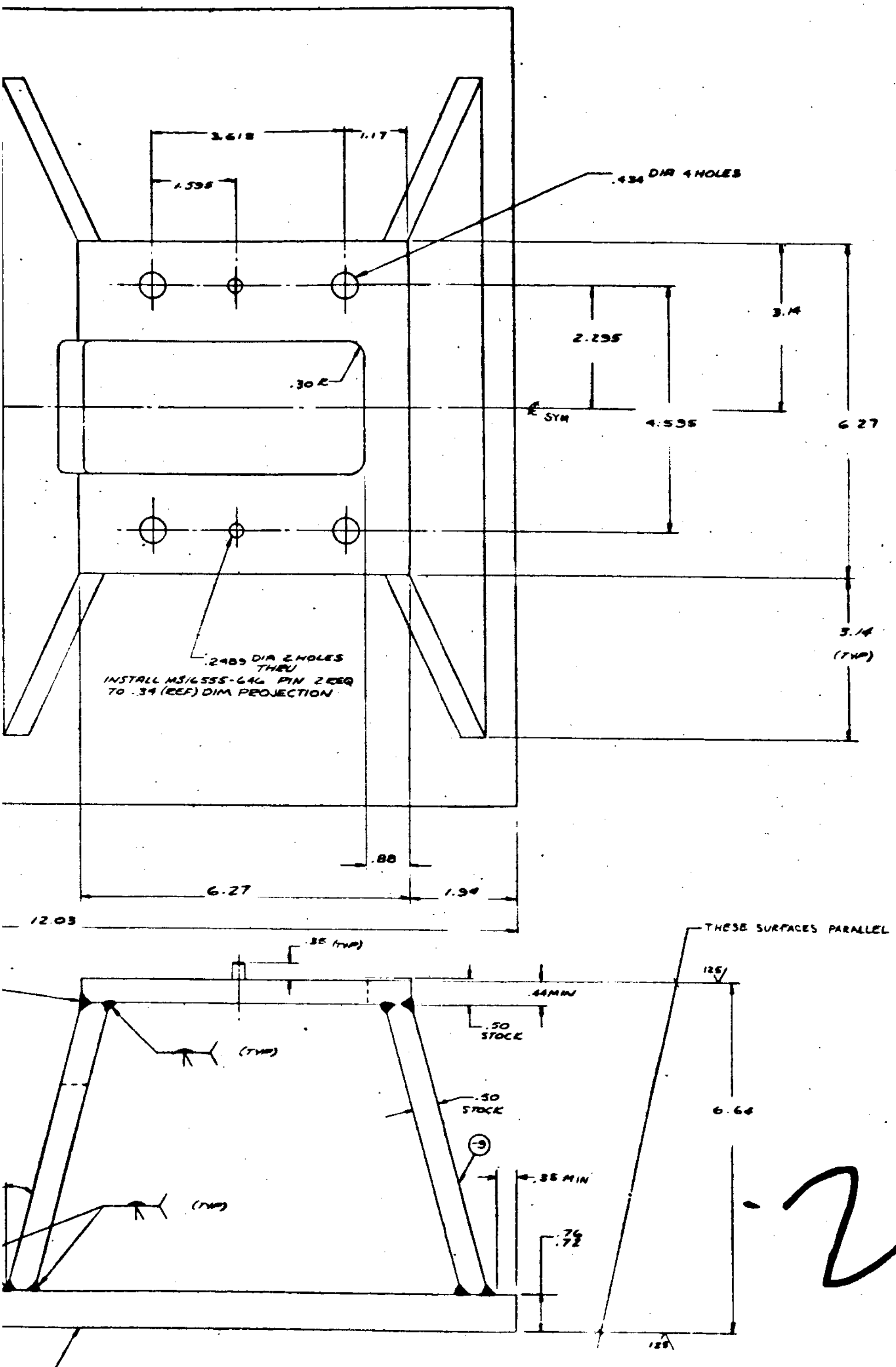
APS-5108-R
APS-5109-R



CRITICAL ITEM

13.
12. PENETRAN
11.
10
9 ASSY TO BE

REVISIONS



-2

8. MACHINED SURFACES FLAT WITHIN .003 PER INCH TO A MAX OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX OF .012 FLR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .002 TIR, UNMACHINED DIAS CONCENTRIC WITHIN .010 TIR
5. DIMENSION LIMITS HELD AFTER PLATING
4. MACHINED FILLET RADII .015 .030
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED
2. SURFACE ROUGHNESS PER MIL-STD-10
1. DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

T INSPECT WELD PER MIL-I-6866

FREE OF WELD SPATTER

QTY REQD	ITEM NO	PART NO	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT	ZONE
2				MS16555-646 PIN					
2		-9		LEG		CRES 347	MIL-S-6721		
1		-7		TOP		CRES 347	MIL-S-6721		
1		-5		BASE		CRES 347	MIL-S-6721		
		-3		[illegible]					

←ASSYS

LIST OF MATERIAL

365741	369740

HEAT TREATMENT

DATES 10-9-63

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA
THE GARRETT CORPORATION

STAND ASSEMBLY
MOUNTING

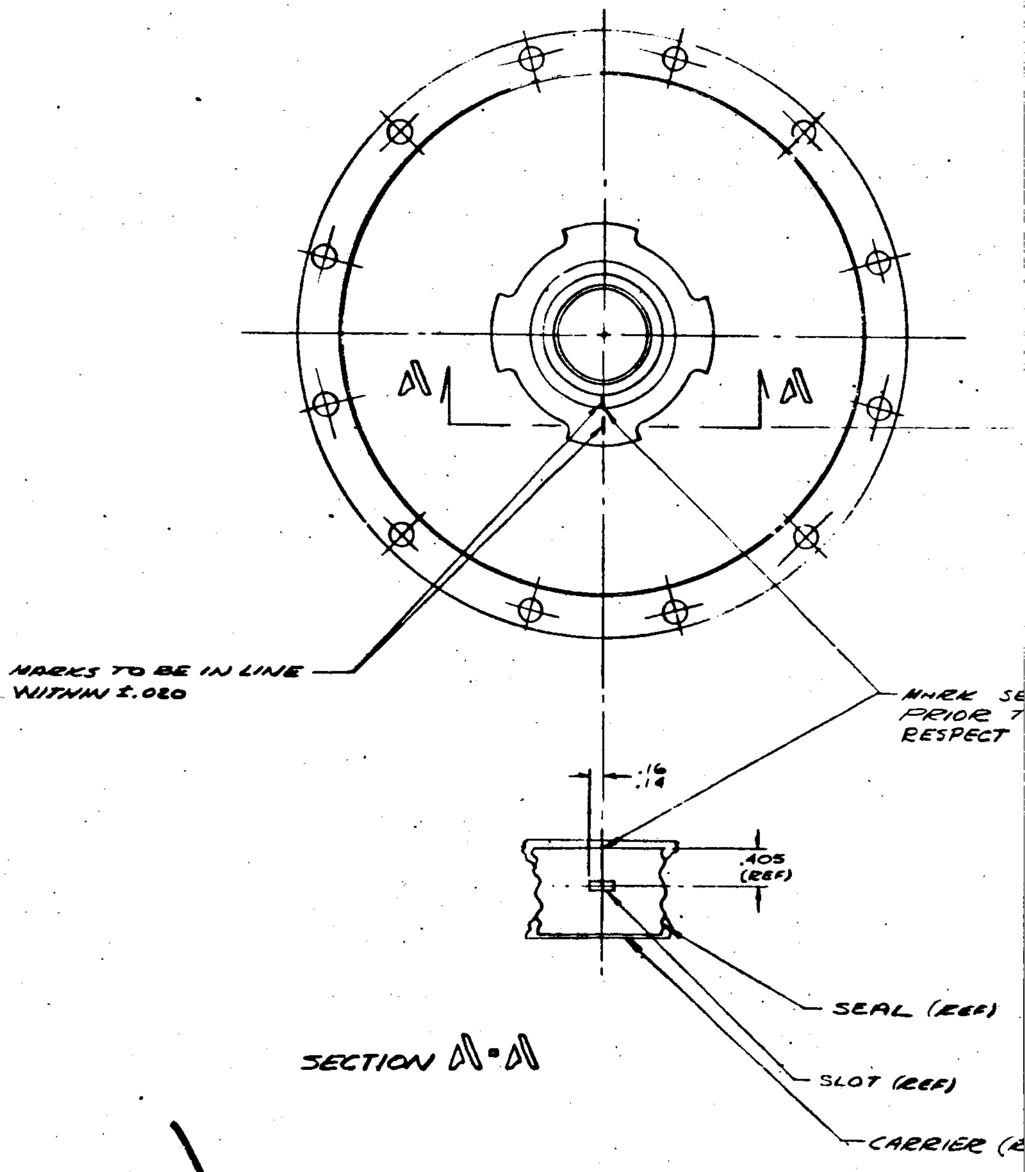
99193 | E | 369752

SCALE

SHEET 1 OF 1

369752

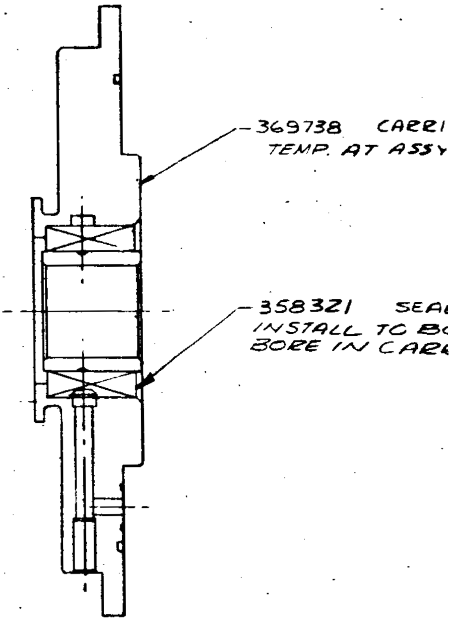
APS-5108-R
APS-5109-R



CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR. 1.313

P0046 — DWG K&E 102 HERCULENE



AL HERE PER MC14, CLASS II
D ASSY . LOCATE AS SHOWN WITH
TO SLOT IN SEAL.

E,)

2

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH
MAX OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN
PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCEN
WITHIN .005 TIR, UNMACHINED DIAS CONCENTRIC W
IN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX.
NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED.

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

ER ASSY 1REQ
: 500°F

(MATCHED SET) 1 REQD
TTON. OF
IER

3

O A

.002

TRIC
TH-

QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
←ASSYS								

LIST OF MATERIAL

	369741	365740
	369731	369730
1	369721	369720
REQD.	NEXT ASSY.	USED ON

HEAT TREATMENT	PROCESS
HARDNESS	NAME
SPEC.	SPEC.

SIGNATURES	DATES
DFTN	10-11-63
CHK	10-24-63
MFG. ENG.	
MAT & PROCESS	
STRESS	
AERO	
APP	5-15-68
APP	
DESIGN ACTIVITY APP	5-15-63
OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

DWG. TITLE
SEAL ASSEMBLY,
CARBON

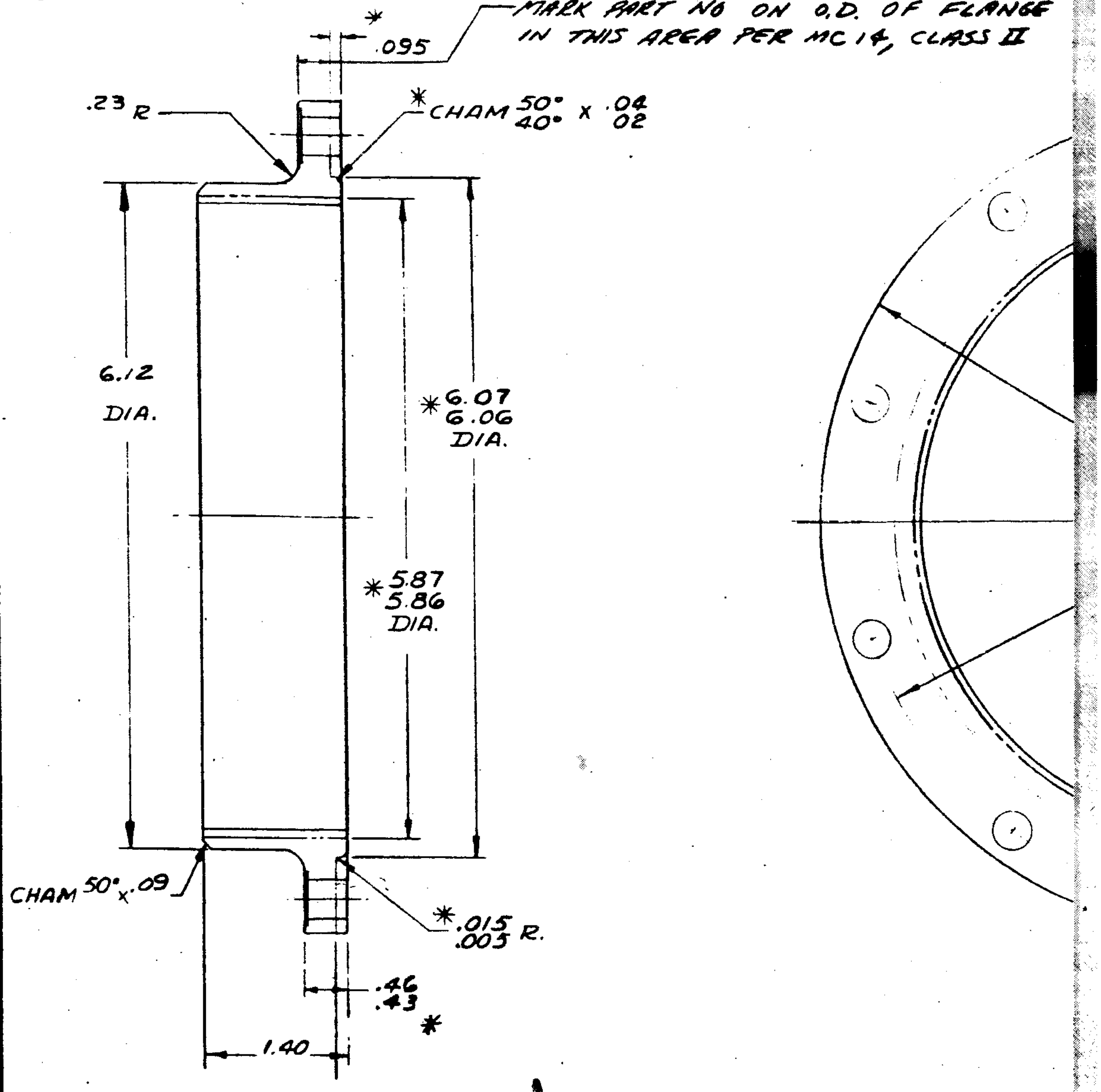
CODE IDENT NO.	SIZE	DWG. NO.
99193	D	369753

SCALE FULL | WT. | SHEET 1 OF 1

DWG. NO. 369753

PART NO.	MATERIAL	OPTIONAL MATERIAL
369810-1	AMS 5667 INCO "X"	AMS 5582 INCO "X"
369810-2	QQ-S-763 347	MIL-S-6721 347 OR [illegible]

APS-5108-R



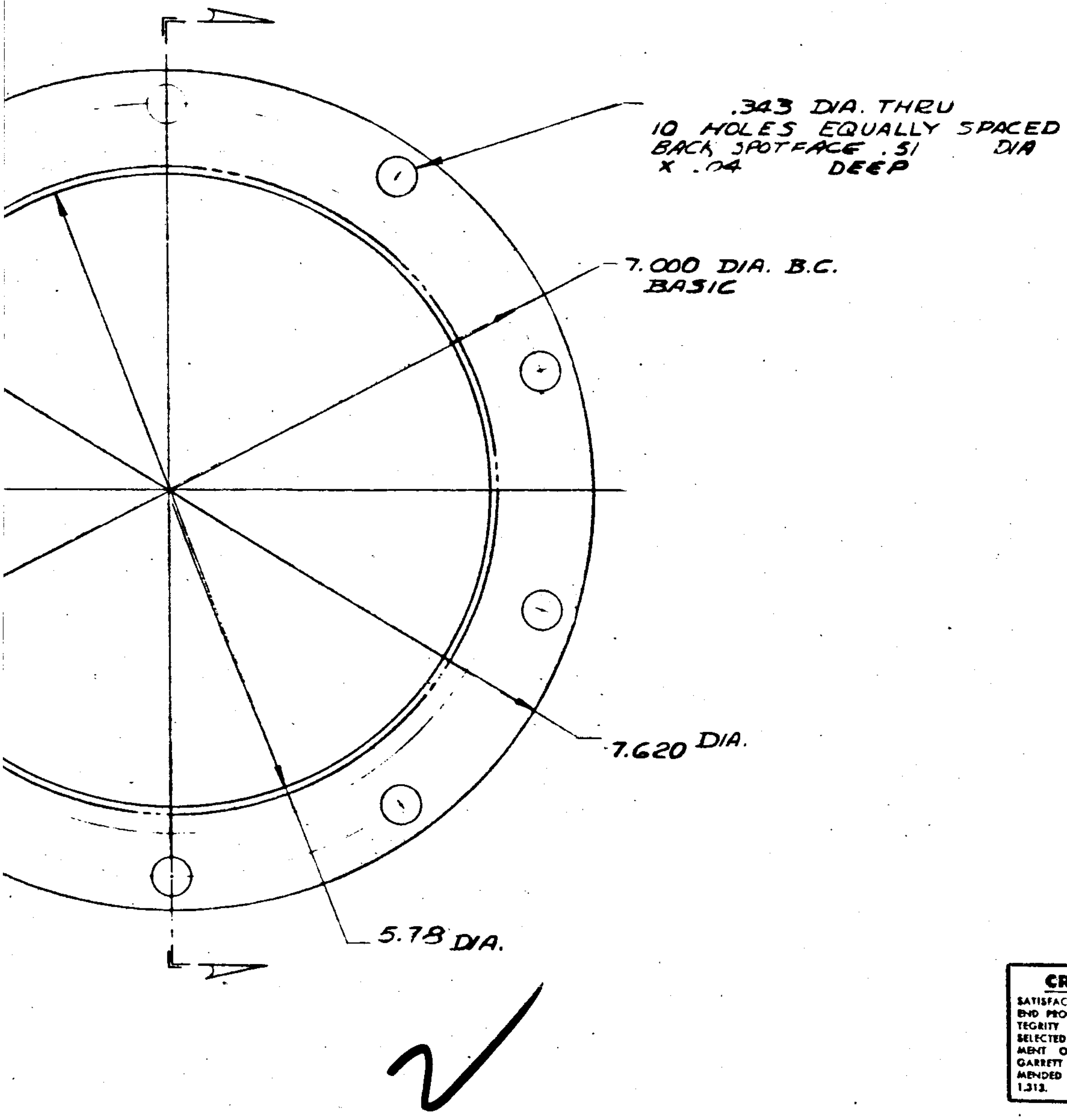
14. AFTER WELDING -1 IN PLACE, CUSTOMER TO AGE PART PRIOR TO FINAL MACHINING BY HEATING TO [illegible]° F FOR 20 HOURS. AIR COOL.
13. AFTER WELDING -2 IN PLACE, CUSTOMER TO STRESS RELIEVE PRIOR TO FINAL MACHINING BY HEATING TO [illegible]°F. FOR 1 HOUR FOLLOWED BY AIR COOL.
12. OPTIONAL MATERIAL (SEE TAB)
11. DIMENSIONS MARKED WITH ASTERISK (*) TO BE MACHINED BY CUSTOMER.
10. POSITIONAL & GEOMETRIC TOLERANCE SYMBOLS PER MIL-STD-8
9. FINISH ALL OVER 125√

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

F6549 - 2198 - K & E 183 HERCULENE

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



LAST LTR

DWG NO 369810

CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.

QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
						CRES	SEE TAB	

←ASSYS

LIST OF MATERIAL

REQD.	NEXT ASSY.	USED ON
	369720	

HEAT TREATMENT

HARDNESS NOTED

SPEC. NOTED

PROCESS

NAME

SPEC.

SIGNATURES		DATES
DFT	W Walker	11-9-63
CHK	Crawford	11-12-63
MFG ENG		
MAT. & PROCESS		12-2-63
STRESS		
AERO		
APP		11-12-63
APP		
DESIGN ACTIVITY APP.	Walker	12-3-63
OTHER ACTIVITY APP.		

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA
A division of THE GARRETT CORPORATION

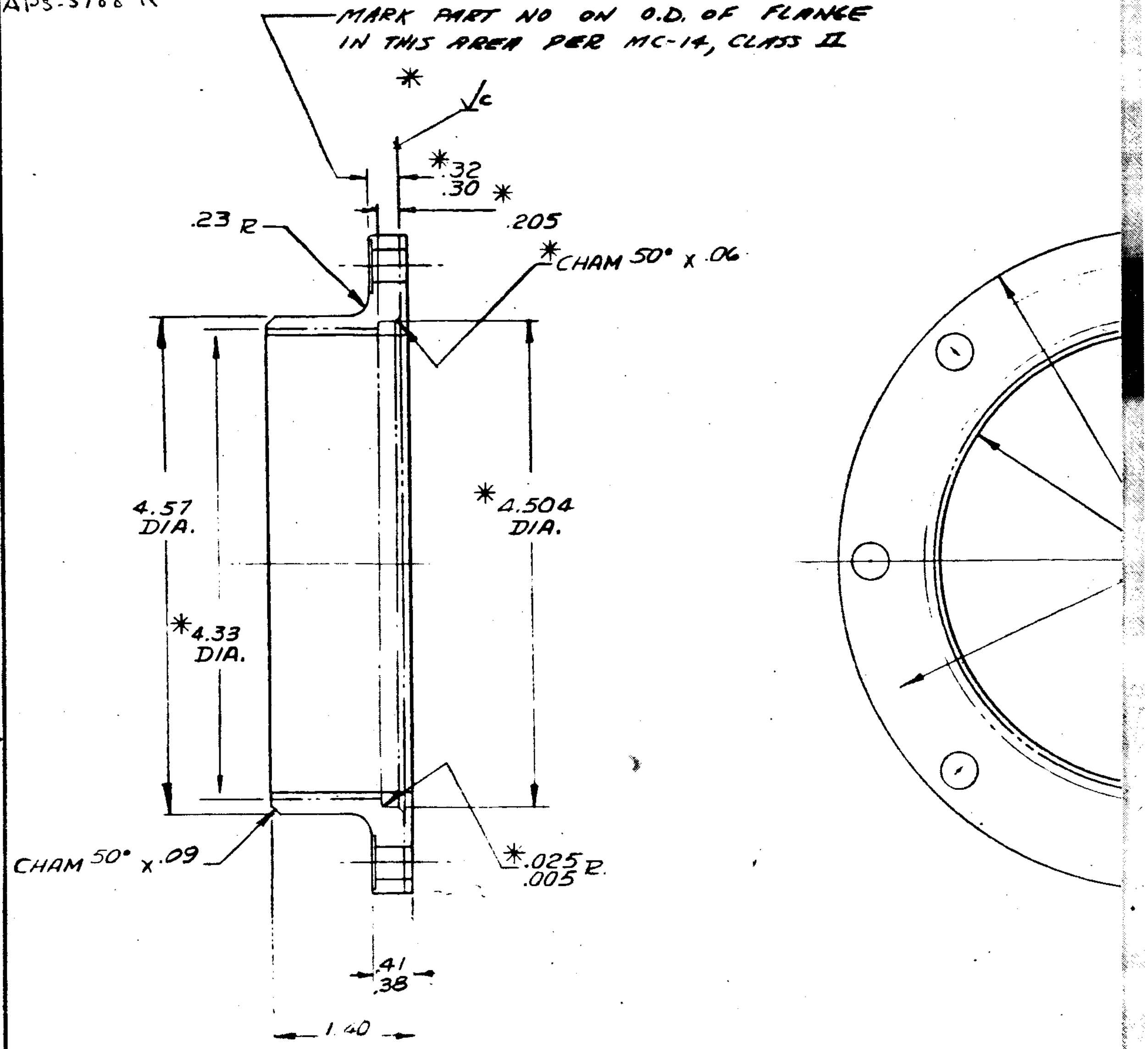
DWG. TITLE
FLANGE, TURBINE
INLET

CODE IDENT NO.	SIZE	DWG. NO.
99193	C	369810

SCALE FULL WT. SHEET 1 OF 1

PART NO.	MATERIAL	ALTERNATE MATERIAL
369811 -1	AMS 5667 INCO "X"	AMS 5542 INCO "X"
-2	QQ-S-763 347	MIL-S-6721 347 OR 321

APS-5106-R



14. AFTER WELDING -1 IN PLACE, CUSTOMER TO AGE PART PRIOR TO FINAL MACHINING BY HEATING TO 1300°F FOR 20 HOURS. AIR COOL.

13. AFTER WELDING -2 IN PLACE, CUSTOMER TO STRESS RELIEVE PRIOR TO FINAL MACHINING HEATING TO 750°-700°F FOR 1 HOUR FOLLOWED BY AIR COOL

12. DIMENSIONS MARKED WITH ASTERISK (*) TO BE MACHINED BY CUSTOMER

11. OPTIONAL MATERIAL: SEE TAB

10. POSITIONAL & GEOMETRIC TOLERANCE SYMBOLS PER MIL-STD-8

9 FINISH ALL OVER 125√

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.

7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.

6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.

5. DIMENSION LIMITS HELD AFTER PLATING

4. MACHINED FILLET RADII .030 - .015

3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.

2. SURFACE ROUGHNESS PER MIL-STD-10.

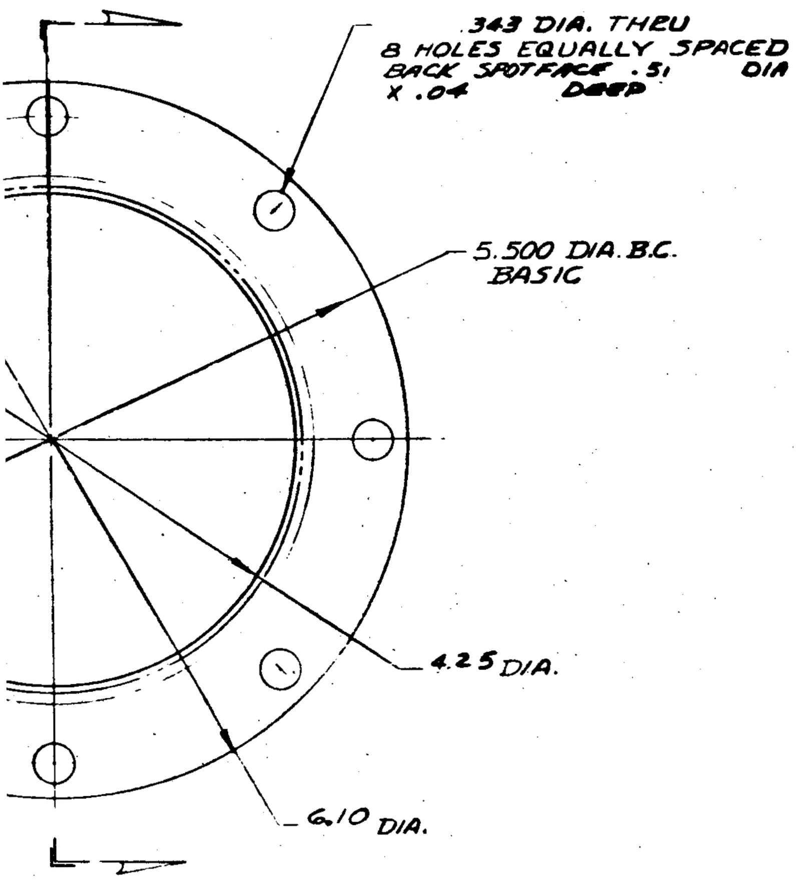
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

P9549 - SIMS K & E 163 HEP

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED



CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.

DWG. NO. 369811

2

Y. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
						CRES	SEE TAB	

←ASSYS LIST OF MATERIAL

369720	
D NEXT ASSY.	USED ON

T TREATMENT	PROCESS
NOTED	NAME
NOTED	SPEC.

SIGNATURES	DATES
DFT. Walker	1-9-63
CHK Munford	11-12-63
MFG ENG	
MAT. & PROCESS	12-2-63
STRESS	
AERO	
APP.	11-12-63
APP.	
DESIGN ACTIVITY APP.	12-3-63
OTHER ACTIVITY APP.	

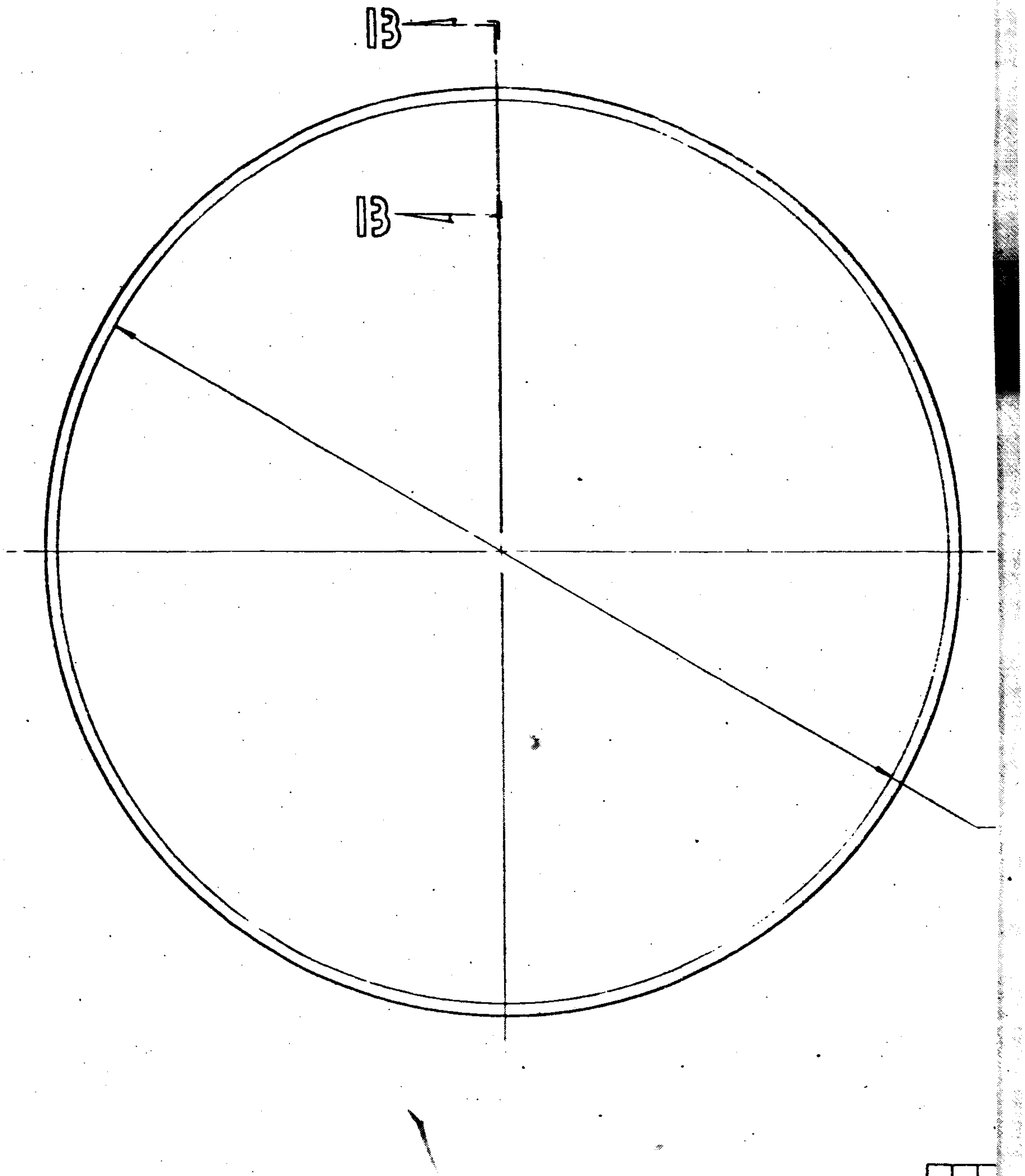
AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

DWG. TITLE
FLANGE, TURBINE
OUTLET

CODE IDENT NO.	SIZE	DWG. NO.
99193	C	369811

SCALE FULL WT. SHEET 1 OF 1

APS-5108-R
APS-5109-R



13. PARTS PROCURED BY VENDOR PART NO SHALL BE PROCURED IN ACCORDANCE WITH THIS AIRESEARCH SOURCE CONTROL DRAWING.

12. PROCUREMENT SOURCE(S) PER ASL 369813

11. ALL DESIGN & PART NO CHANGES MUST RECEIVE PRIOR AIRESEARCH APPROVAL.

10. IDENTIFY ALL PACKAGING WITH AIRESEARCH PART NO.

9. DATE OF MANUFACTURE MUST BE MARKED ON ALL SPARE PARTS PACKAGES.

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.

7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.

6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.

5. DIMENSION LIMITS HELD AFTER PLATING.

4. MACHINED FILLET RADII .030 - .015

3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.

2. SURFACE ROUGHNESS PER MIL-STD-10.

1. DIMENSIONS ARE IN INCHES.

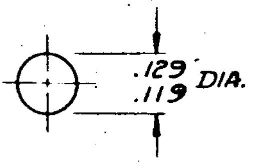
UNLESS OTHERWISE SPECIFIED.

QTY. RE
2 3
2 3
REQD.
HEAT TR
HARDNESS

P5345 · SIMS · K & E 163 HERCULENE

REVISIONS		
DESCRIPTION	DATE	APPROVED

D



SECTION B - B
SCALE: 4/1

ALL DIAMETERS OF CROSS SECTION MUST EQUAL .129 - .119 DIA.

8.78
8.72 DIA.

LAST LTR. —

DWG. NO. 369813

						VITON "A"	MIL-R-25897 TYPE I, CLASS I	
QD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
	← ASSYS			LIST OF MATERIAL				

69741	369740
69731-20	369730
NEXT ASSY.	USED ON

EATMENT | PROCESS
NAME
SPEC.

SIGNATURES	DATES
DFT. Walker	11-13-63
CHK.	11-13-63
MFG. ENG	
MAT. & PROC.	11-14-63
STRESS	
AERO	
APP	11-14-63
APP	
DESIGN ACTIVITY APP.	11-14-63
OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

DWG. TITLE
SEAL, "O" RING

CODE IDENT NO.	SIZE	DWG. NO.
99193	C	369813

SCALE FULL & NOTED | WT. | SHEET 1 OF 1

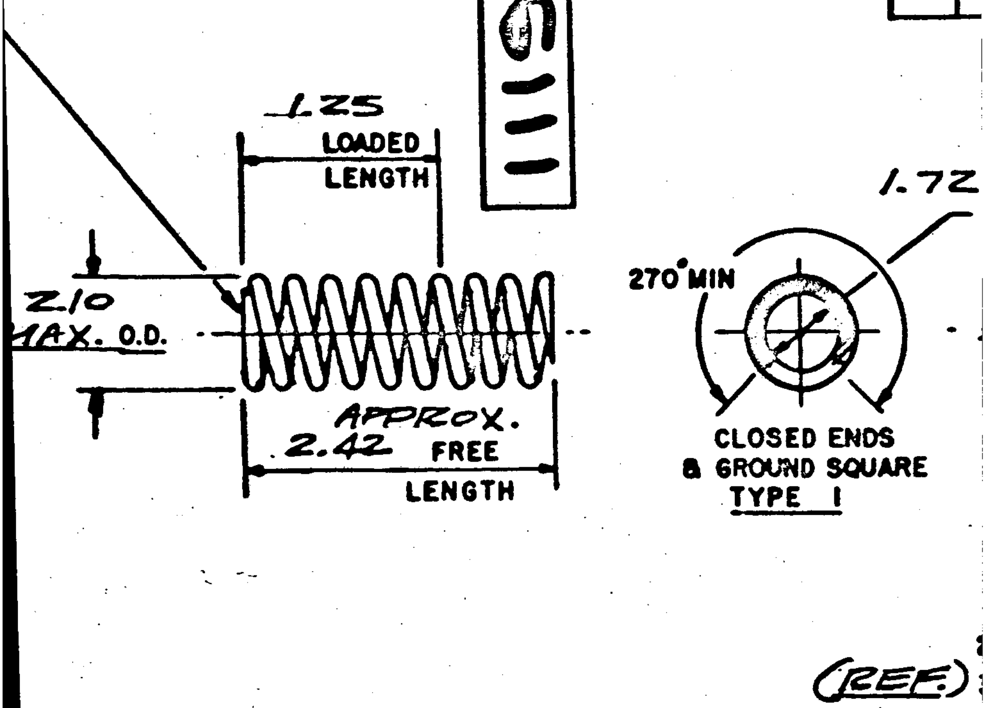
APS-5108-R
APS-5109-R

1. SPRING SHALL NOT TAKE A PERMANENT SET WHEN COMPRESSED TO SOLID HEIGHT.

NOTES: UNLESS OTHERWISE SPECIFIED

111517

E SPRING SPECIFICATIONS FOR
YPE OF ENDS REQUIRED



			NOTED	CRES. ST. WIRE "SPRING TEMPER"	TYPE "B"
R.H.	L.H.	NO. REQ.	SIZE	DESCRIPTION	COND.
DASH NO.			MATERIAL (CONT.)		
CAL. WT.					
___WT.			7-24-56 DRAFTSMAN	7-25-56 CHECKER	7-27-56 APP.

FINISH

HEAT TREAT
—NOTED—

UNLESS OTHERWISE SPECIFIED:
1. DIMENSION TOLERANCES ARE:
DECIMAL = ± .010 ANGLES = ±0°
2. REMOVE BURRS AND BREAK SHARP EDGES.

AIRESEARCH MANUFA

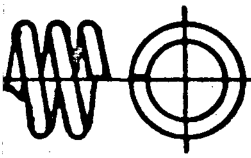
SPRING — COMPR

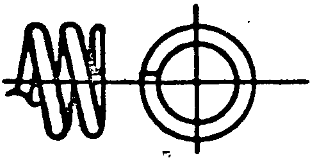
ISSUE

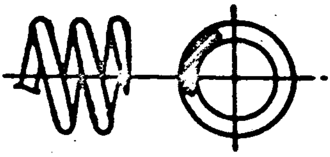
DATE

M.	REVISION	DATE	DRFTM.	APP.

MIN.
I.D.


PLAIN ENDS
TYPE 2


CLOSED ENDS
SQUARED NOT GROUND
TYPE 3


PLAIN ENDS
GROUND SQUARE
TYPE 4

SPRING SPECIFICATIONS

1. .162 DIAMETER OF WIRE
2. 35.0 LB LB. AT LOADED LENGTH
3. 30.0LB. LB. PER INCH (SPRING RATE) BETWEEN LENGTHS OF INCHES AND INCHES
4. 6 TOTAL NUMBER OF COILS
5. 4 ACTIVE COILS
6. — MAXIMUM SOLID HEIGHT
7. LEFT HAND COILED RIGHT HAND COILED
8. I TYPE OF ENDS
9. SHAFT DIAMETER OVER WHICH SPRING WILL FUNCTION
0. HOLE DIAMETER IN WHICH SPRING WILL FUNCTION

THE ABOVE REQUIREMENTS AS CHECKED OR NOTED WILL PROVIDE DATA TO PRODUCE THIS SPRING. BLANK SPACES WILL INDICATE NO REQUIREMENTS.

5

QQ-W-423 MP. FS, (302)		
SPECIFICATION	COND.	ZONE
MATERIAL SPECIFICATION		

-25-56	7-25-56	— —
APP.	APP.	APP.

1	108031-5	108030-5	
NO. REQ.	NEXT ASSY.	OUTLINE	MODEL

ơ.
3. DIMENSION LIMITS HELD AFTER PLATING.
4. R.M.S. √ SURFACE ROUGHNESS PER NAS NO. 30

CTURING COMPANY PHOENIX, ARIZONA

SCALE NONE

ESSION

AREA SQ. FT.	DWG. SIZE	
1.30	B	111917
		DWG. NO.

BEARING DESCRIPTION BALL, ANGULAR CONTACT

GRADE AIRESEARCH 5

INNER RING

MATERIAL: SAE 52100 STEEL

BORE: .9841 TAPER/FT:

WIDTH: .4624

RACE DEPTH REF. 20 MIN %BALL DIA.

RACE CURVATURE REF. 52-53 %BALL DIA.

SEPARATOR PILOT LAND TO GROOVE RUNOUT: TIR

SEPARATOR

MATERIALS: FORGED SILICON IRON BRONZE PER AMS 4616

CONSTRUCTION: MACHINED

ASSEMBLY: ONE PIECE

PILOTING SURFACE: OUTER RING

PILOT CLEARANCE: .008

OPERATIONAL LUBRICANT

NAME: OIL, SYNTHETIC AIRCRAFT GAS TURBINE LUBRICATING

MILITARY SPEC NO. MIL-L-7808

BEARING PRELUBRICATION: DIPS DRAIN

OUTER RING

MATERIAL: SAE 52100 STEEL

OD: 1.8504 TAPER/FT:

FLANGE OD:

WIDTH: .4624

FLANGE WIDTH:

RACE DEPTH REF: 16 MIN %BALL DIA.

RACE CURVATURE REF: 54-55 %BALL DIA.

SEPARATOR PILOT LAND TO GROOVE RUNOUT: TIR

ROLLING ELEMENTS

MATERIAL: SAE 52100/51100 STEEL

COMPLEMENT PER ROW: 13-1/4

CLOSURES

NUMBER: NONE

TYPE: ______ (SHIELDS, SEALS)

MATERIAL:

CONSTRUCTION:

ASSEMBLED BEARING CHARACTERISTICS

TOTAL DIAMETRAL (DIAMETRAL, AXIAL) CLEARANCE OF .0019 ______ UNDER 2 LBS GAGE LOAD

CONTACT ANGLE REF: 20°

MAXIMUM TORQUE: ______ (OZ IN., IN. LBS) AT ______ RPM

UNDER: ______ (GRAMS, LBS) ______ (THRUST, RADIAL) LOAD

STABILIZED FOR OPERATION AT: SEE NOTE I

______ (INNER, OUTER) RING FACE OFFSET: ______

UNDER: ______ LBS THRUST LOAD.

SPECIAL FEATURES

1. PARTS MUST NOT CHANGE IN DIMENSION IN

2. FACE "A" TO BE FLUSH WITH 30 LB THRUST LOAD APPLIED IN DIRECTION SHOWN

3. SEPARATOR POCKET SURFACE CIRCUMFERENTIALLY FORE & AFT TO BE AT BEARING P.D.

4. SEPARATOR TO BE SILVER PLATED .0006-.0020 THICK PER AMS 2412

Form #1552B

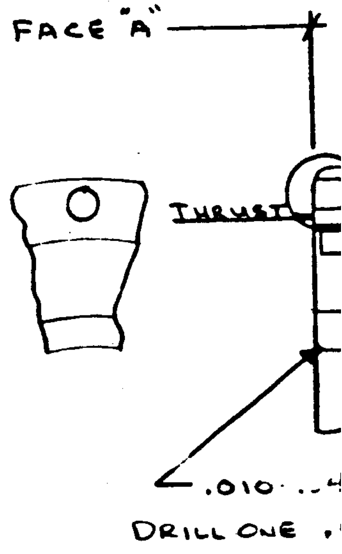
SYM

DWG. NO. 358313

LAST

LET

PACKAGING PER AIR SPEC CP-14	PRODUCTION BULK PACK	COMMERCIAL SPARES PACK	MILITARY SPARES PACK
PRESERVATIVE:	MIL-L-6085	MIL-L-6085	MIL-P-197
AIRESEARCH PART NUMBER:	BASIC	BASIC	BASIC-4
VENDOR NAME & LOCATION	VENDOR PART AND SPECIFICATION NUMBER		
FED. SUPPLY CODE NO.	PROCUREMENT		
FED. SUPPLY CODE NO.	PER ASL		
FED. SUPPLY CODE NO.			



7. PARTS PROCURED BY VENDOR PART NUMBER SHALL BE
ACCORDANCE WITH THIS AIRESEARCH SOURCE CONTRO
6. IDENTIFY PACKAGING WITH AIRESEARCH PART NUMBE
5. ALL DESIGN AND PART NUMBER CHANGES MUST RECEI
AIRESEARCH APPROVAL.
4. ONLY THE ITEMS LISTED ON THIS DRAWING AND
ADDRESSES AND PART NUMBERS HAVE BEEN TES
END UNIT. A SUBSTITUTE ITEM SHALL NOT BE U
APPROVAL BY AIRESEARCH.

3. MILITARY SPARES PACK BEARINGS ARE INTENDE
BEFORE INSTALLATION WASH OUT THE PRESERV
LUBRICANT. AFTER THIS OPERATION THE —4 I
BEARINGS BECOME INTERCHANGEABLE WITH TH
CIAL SPARES PACK BEARINGS. THEY SHOULD N
ATIONS BECAUSE OF THEIR RELATIVELY HIGH

2. FOR ECONOMY, PRODUCTION BULK PACK BEARIN
INSTALLATIONS. COMMERCIAL SPARES PACK BE
MERCIAL SPARES ORDERS.

1. PRODUCTION BULK AND COMMERCIAL SPARES PA

SOURCE CONTROL DRAWING

SIGNATURES	DATES
DRF JOHNSON	8-15-63
CHK J.W. Carlson	8-15-63
APP	8-16-63
APP	8-17-62
APP	
APP	

NW 8-21-63

NAME

BEARING

A

SCALE N

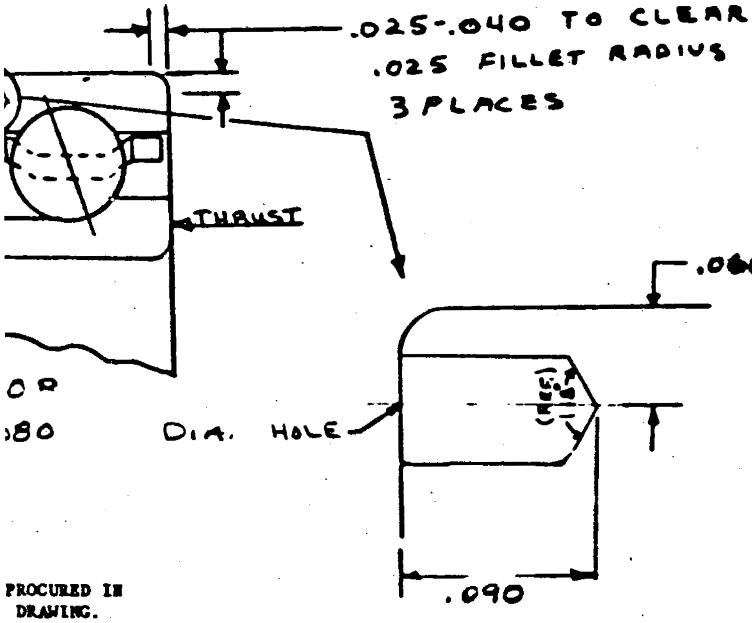
2

D

REVISIONS

DESCRIPTION	DATE	APPROVAL

APS-5108-R
APS-5109-R



PROCURED IN
DRAWING.

E PRIOR

DENTIFIED BY VENDORS' NAMES,
ED AND APPROVED FOR USE IN THE
ED WITHOUT PRIOR TESTING AND

TO FILL MILITARY SPARES ORDERS.
ATIVE AND REPLACE WITH OPERATING
ENTIFICATION IS DROPPED AND THE
PRODUCTION BULK AND COMMER-
IT BE USED IN FACTORY INSTALL-
OST.

ARE PREFERRED FOR ALL FACTORY
RINGS ARE INTENDED TO FILL COM-

CK BEARINGS ARE INTERCHANGEABLE.

CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR. 1.313.

NEXT ASSY	USED ON

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA
division of
THE GARRETT CORPORATION

BALL, SINGLE ROW
NGULAR CONTACT

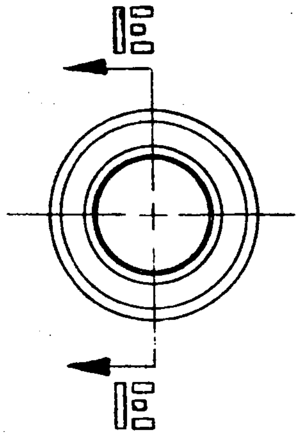
NE | WGT —

DWG. SIZE B | DWG NO. 358313

Code: 99193

3

APS-5709-R
APS-5709-R



21. OPERATING CONDITIONS -

PRESSURE, AIR SIDE, 0 PSIG.
OIL SIDE. - 2 PSIG.
TEMPERATURE, AIR SIDE, 100°F.
OIL SIDE 225°F.
LEAKAGE, AIR TO OIL, .01 LB/MIN
OIL TO AIR, 1 CC/HR.
OIL MIL-L-7808
LIFE REQUIRED 500 HOURS.

20. SEAL CASE TO BE CRES.
19. POSITIONAL & GEOMETRIC TOLERANCE SYMBOLS PER MIL-STD-8.

15. PROCUREMENT SOURCE(S) PER ASL
14. PART TO BE MARKED PER MC-14 CLASS II WITH AIRESEARCH NUMBER 358319.
13. ALL DESIGN AND PART NUMBER CHANGES REQUIRE PRIOR AIRESEARCH APPROVAL.
12. ONLY ITEMS LISTED ON THE APPLICABLE ASL AND IDENTIFIED BY VENDOR'S NAMES, ADDRESSES, AND PART NUMBERS HAVE BEEN TESTED AND APPROVED FOR USE IN THE END UNIT. A SUBSTITUTE ITEM SHALL NOT BE USED WITHOUT PRIOR TESTING AND APPROVAL BY AIRESEARCH.
11. IDENTIFY PACKAGING WITH AIRESEARCH NUMBER.
10. PARTS PROCURED BY VENDOR PART NUMBER SHALL BE PROCURED IN ACCORDANCE WITH THIS AIRESEARCH SOURCE CONTROL DRAWING.
9. DETAILS OF DESIGN AND CONSTRUCTION OTHER THAN SHOWN SHALL BE AT OPTION OF VENDOR.
8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

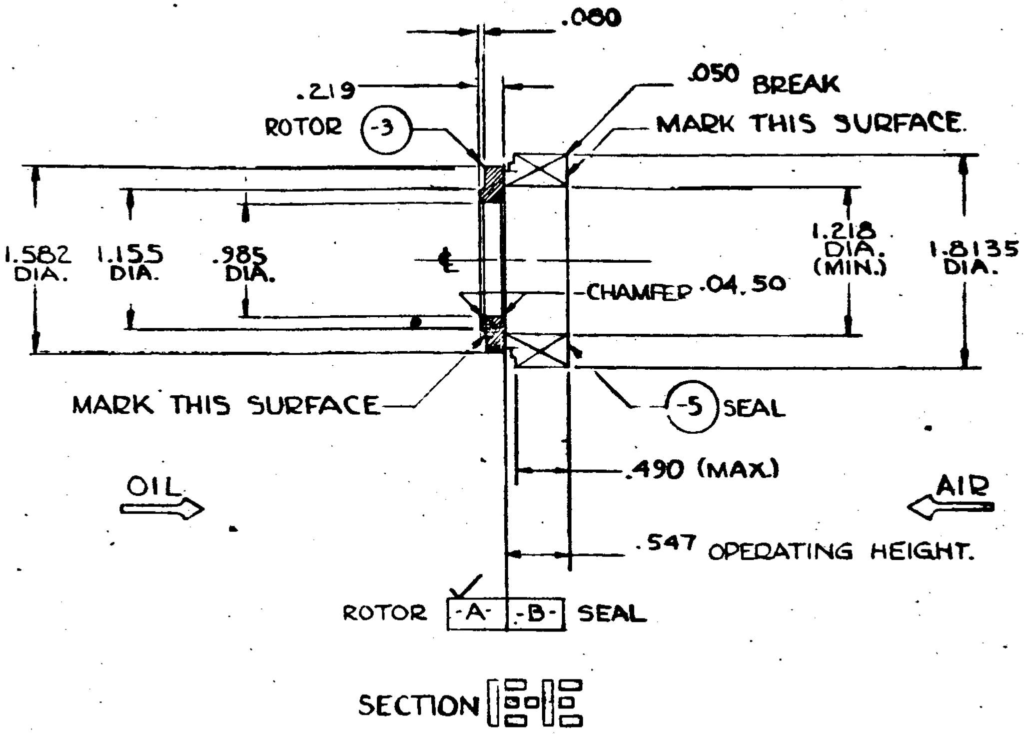
CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.

P-5302

PB545 · STNS · R & E 103 HERCULENE

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



358319

		-3				CRES	QQ-S-763 440F	
Y. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
←ASSYS		LIST OF MATERIAL						

/	369741	369740
/	369731	369730
	369721	369720
QD.	NEXT ASSY.	USED ON

AT TREATMENT | PROCESS
RDNESS | NAME
SPEC.

SIGNATURES	DATES
DFT. J.C. Jones	8/29/63
CHK. J.V. MATTHEWS.	9/3/63.
MFG. ENG. RK	11-14-63
MAT. & PROCESS	
STRESS	
AERO.	
APP.	9-3-63
APP.	11-5-63
DESIGN ACTIVITY APP.	11-13-63
OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

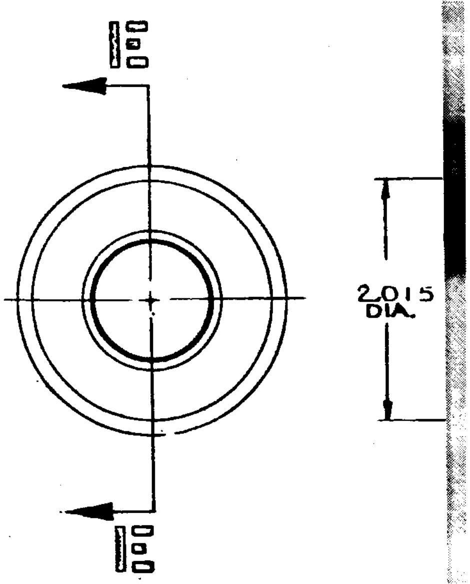
DWG. TITLE
SEAL, AIR-OIL

11/22/63

CODE IDENT NO. 99193
SIZE C
DWG. NO. 358319
SCALE FULL
WT.
SHEET 1 OF 1

PART Nº	SEAL	ROTOR
358320	-5	-3

APS-5708-R
APS-5709-R



OPERATING CONDITIONS	SCHEDULE V
SPEED, RPM	38,500
PRESSURE, PSIG	
GAS SIDE	-1.5
OIL SIDE	-2
TEMPERATURE, °F	
GAS SIDE	800
OIL SIDE	225
LEAKAGE (MAX)	
GAS TO OIL, LBS/MIN	.01
OIL TO GAS CC/HR.	ZERO
LIFE REQ'D, HRS.	500

21. CHROME PLATE SURFACE -A- PER QQ-C-320 CLASS 2, .002-.004 THICK.
20. SURFACE -B- LAPPED FLAT
19.
18. POSITIONAL & GEOMETRIC TOLERANCE SYMBOLS PER MIL-STD-8.
17.
16. (C) **Designate Critical Characteristics**
    (M) **Designate Major Characteristics**

CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.312.

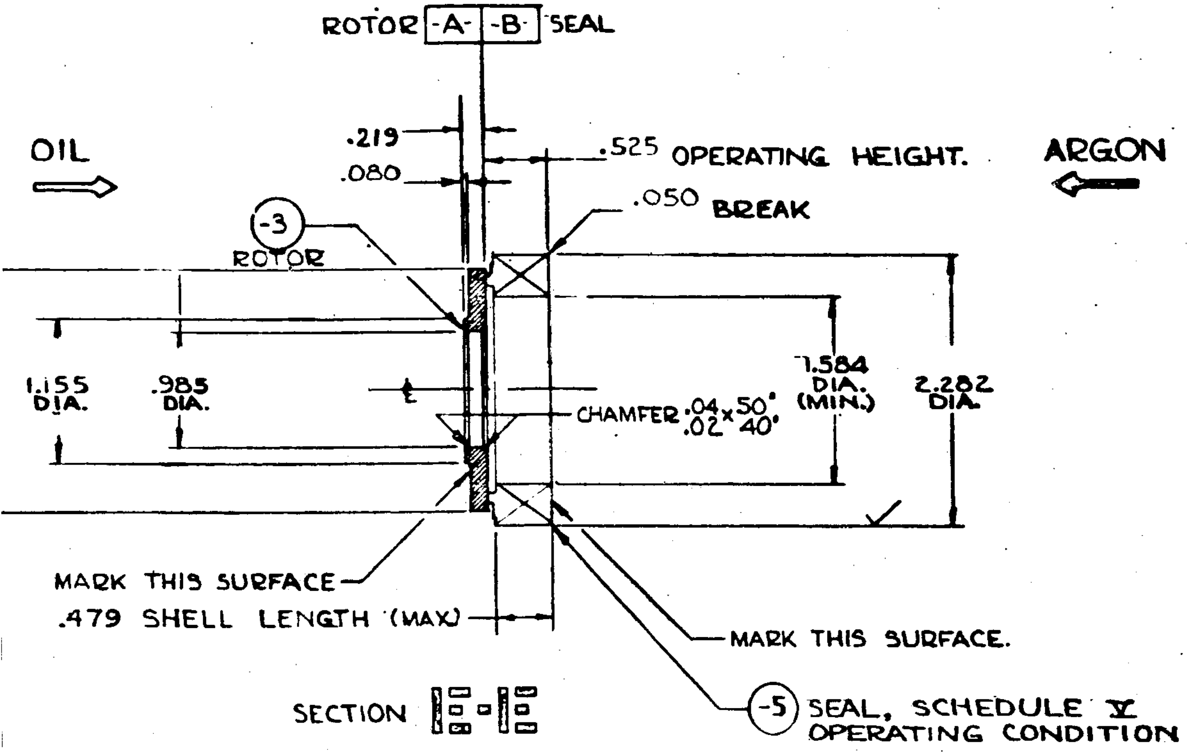
P-2007

15. PROCUREMENT SOURCE(S) PER ASL
14. PART TO BE MARKED PER MC-14 CLASS II WITH AIRESEARCH NUMBER 358320-3, 5, OR 7
13. ALL DESIGN AND PART NUMBER CHANGES REQUIRE PRIOR AIRESEARCH APPROVAL.
12. ONLY ITEMS LISTED ON THE APPLICABLE ASL AND IDENTIFIED BY VENDOR'S NAMES, ADDRESSES, AND PART NUMBERS HAVE BEEN TESTED AND APPROVED FOR USE IN THE END UNIT. A SUBSTITUTE ITEM SHALL NOT BE USED WITHOUT PRIOR TESTING AND APPROVAL BY AIRESEARCH.
11. IDENTIFY PACKAGING WITH AIRESEARCH NUMBER.
10. PARTS PROCURED BY VENDOR PART NUMBER SHALL BE PROCURED IN ACCORDANCE WITH THIS AIRESEARCH SOURCE CONTROL DRAWING.
9. DETAILS OF DESIGN AND CONSTRUCTION OTHER THAN SHOWN SHALL BE AT OPTION OF VENDOR.
8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

QT
RE
HE

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



358320

		-3				TOOL STEEL	AISI M-2	
TY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
←ASSYS				LIST OF MATERIAL				

-1)	369741	369740
1	369731	369730
1	369721	369720
QD.	NEXT ASSY.	USED ON

AT TREATMENT	PROCESS
RDNESS -3 Rc 64/62	NAME
C.	SPEC.

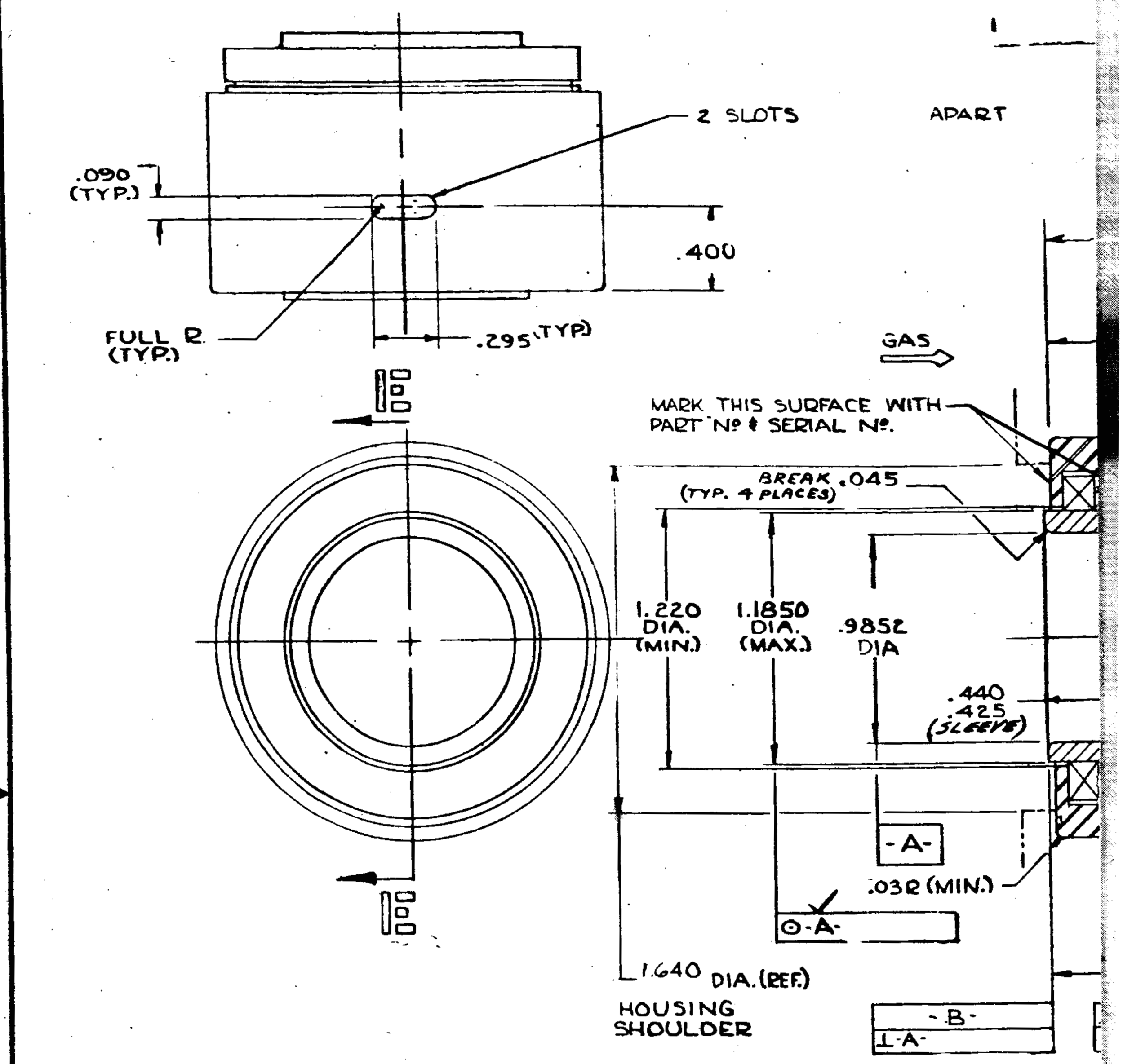
SIGNATURES	DATES
DFT. F C Jones	8/29/63
CHK. J. V. Matthews	9/3/63
MFG. ENG.	11-14-63
MAT. & PROCESS	
STRESS	
AERO.	
APP.	9-3-63
APP.	11-5-63
DESIGN ACTIVITY APP.	
OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA
Division of THE GARRETT CORPORATION

DWG. TITLE
SEAL, ARGON, OIL-
METAL BELLOWS

CODE IDENT NO.	SIZE	DWG. NO.
99193	C	358320
SCALE FULL	WT.	SHEET 1 OF 1

~~APS-5106-R~~
APS-5109-R



16. PARTS TO BE MADE, INSPECTED, STOCKED, & ISSUED AS MATCHED SETS ONLY.

15. SERIAL NUMBER CONTROL MUST BE MAINTAINED ON THIS PART THROUGHOUT MANUFACTURING AND ASSEMBLY CYCLES AND AFTER FINISH MACHINING. SERIAL NUMBERS SHALL BE APPLIED BY THE METHOD AND AT THE LOCATION SPECIFIED.

14. PROCUREMENT SOURCE(S) PER ASL
MARKED PER

13. PART TO BE MC-14 CLASS II WITH AIRESEARCH NUMBER 358321 & SERIAL No.

12. ALL DESIGN AND PART NUMBER CHANGES REQUIRE PRIOR AIRESEARCH APPROVAL.

11. ONLY ITEMS LISTED ON THE APPLICABLE ASL AND IDENTIFIED BY VENDOR'S NAMES, ADDRESSES, AND PART NUMBERS HAVE BEEN TESTED AND APPROVED FOR USE IN THE END UNIT. A SUBSTITUTE ITEM SHALL NOT BE USED WITHOUT PRIOR TESTING AND APPROVAL BY AIRESEARCH.

10. IDENTIFY PACKAGING WITH AIRESEARCH NUMBER.

9. PARTS PROCURED BY VENDOR PART NUMBER SHALL BE PROCURED IN ACCORDANCE WITH THIS AIRESEARCH SOURCE CONTROL DRAWING.

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.

7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.

6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.

5. DIMENSION LIMITS HELD AFTER PLATING.

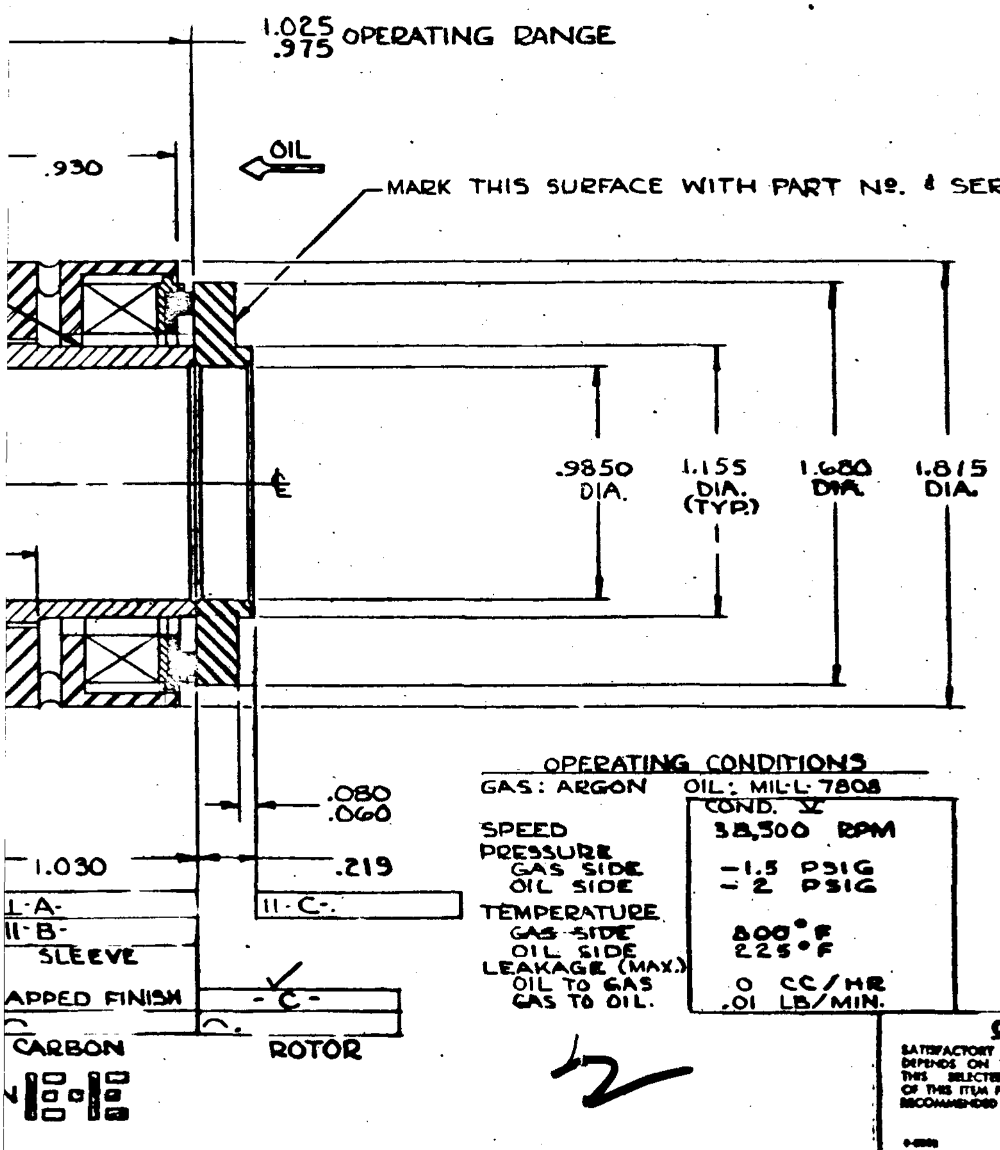
4. MACHINED FILLET RADII .030 - .015

3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.

2. SURFACE ROUGHNESS PER MIL-STD-10.

DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED.

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



OPERATING CONDITIONS

GAS: ARGON OIL: MIL-L-7808

	COND. V
SPEED	38,500 RPM
PRESSURE	
GAS SIDE	−1.5 PSIG
OIL SIDE	−2 PSIG
TEMPERATURE	
GAS SIDE	800°F
OIL SIDE	225°F
LEAKAGE (MAX.)	
OIL TO GAS	0 CC/HR
GAS TO OIL	.01 LB/MIN.

2

CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.

QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.

←ASSYS LIST OF MATERIAL

REQD.	NEXT ASSY.	USED ON
1	369753	369740
1	369753	369730
1	369753	369720

HEAT TREATMENT: HARDNESS / SPEC.

PROCESS: NAME / SPEC.

SIGNATURES	DATES
DFT. B. C. Jones	11/4/63
CHK. J. V. MATTHEWS.	11.5.63
MFG. ENG. R.R.	11-14-63
MAT. & PROCESS	
STRESS	
AERO.	
APP.	11-12-63
APP.	11-8-63
DESIGN ACTIVITY APP. Williams	11-13-63
OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

DWG. TITLE
SEAL SET, GAS-OIL, MATCHED

CODE IDENT NO.	SIZE	DWG. NO.
99193	C	358321

SCALE X 2 WT. SHEET 1 OF 1

DWG. NO. 358321