N73-25827
CR-132763

20266-6026-RO-00

MONOPROPELLANT HYDRAZINE RESISTOJET

FLIGHT APPLICATION DESIGN TASK SUMMARY REPORT

TRW SYSTEMS GROUP
ONE SPACE PARK
REDONDO BEACH, CALIFORNIA 90278

MARCH 1973

Prepared for
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771

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Prepared by Charles K. Murch
Charles K. Murch

Approved by Dennis Asato
Dennis Asato

TRW
SYSTEMS GROUP

FOREWORD

This is the sixth and final Task Summary Report submitted under Contract NAS5-11477, "Design, Development, and Testing of Engineering Model Nominal 20-Millipound Thrust Monopropellant Hydrazine Resistojet." The program originated in the Auxiliary Propulsion Branch of the NASA/Goddard Space Flight Center. Mr. Dennis Asato is the Technical Officer for NASA/GSFC. Mr. Charles K. Murch is the Project Manager for TRW Systems Group.

TABLE OF CONTENTS

1.0 INTRODUCTION AND SUMMARY

The "Design, Development, and Testing of an Engineering Model Nominal 20-Millipound Thrust Monopropellant Hydrazine Resistojet Program" is directed toward the advanced development of an Electrothermal Hydrazine Thruster (EHT). The EHT decomposes hydrazine thermally and expands the decomposition products through a nozzle to provide the impulse necessary to fulfill spacecraft propulsive requirements. The thruster is capable of operation at pulse widths from 0.050 second to steady state and delivers specific impulse values up to about 230 seconds depending on the duty cycle. The program is comprised of six tasks including analyses, the generation of specifications and other documentation, design, fabrication and test, data correlation, and recommendations for the design of flight units. The first five tasks are summarized in references 1 through 7; this document includes drawings and specific recommendations for flight.

The Engineering Model EHT described in Reference 4 is considered to be flight worthy except for minor design concessions to facilitate testing. This thruster successfully demonstrated 300,000 cycles and 30 hours of steady state operation. The demonstrated lifetime and performance are considered adequate for many flight applications. During the course of the Engineering Model tests, however, areas of potential improvement to the design were noted. These are discussed in Section 2.0 of this report. Section 3.0 includes component and assembly drawings for the EHT.

2.0 RECOMMENDATIONS FOR FLIGHT DESIGN

The overall configuration of the Engineering Model EHT is shown in the cut-away drawing in Figure 1. The thermal, mechanical and electrical interfaces, in general, are compatible with an existing GSFC spacecraft (ATS-F) propulsion subsystem. The Engineering Model tests to which the EHT was subjected are believed to be more severe than the performance portion of the qualification tests required for that spacecraft. On the basis of these tests, the Engineering Model design is believed capable of flight qualification for many applications with a minimum of redesign effort. The next section of this report discusses those minor changes necessary for a flight application. Subsequent sections discuss improvements of a more general nature which are believed to be applicable to all small hydrazine thrusters — both electrothermal and catalytic.

2.1 General Configuration for a Flight Application

As indicated earlier, the overall configuration is compatible with an existing propulsion subsystem. A few minor design concessions were included in the Engineering Model design for ease of test and disassembly.

A chamber pressure tap was included for test purposes. Most flight applications would not require a pressure tap; this is reflected in the nozzle drawings in the next section. As an alternative, flight units could be fabricated and acceptance tested with a chamber pressure tap which could then be crimped, cut off, and welded shut prior to flight.

The outer canister of the EM-EHT (Engineering Model EHT) is a three-piece unit which retains the insulation package. For a flight application, the canister should be more structurally sound. This could be accomplished by spot welding after acceptance test. As an alternative, the outer canister could be manufactured as a one-piece cup which would be welded or bolted to the bracket after the acceptance test.

Finally, the heater lead wires should be provided with a strain-relief device. This could be accomplished with a standard electrical receptacle brazed to the outer canister or with an arrangement similar to that used on the valve as shown in Figure 1.

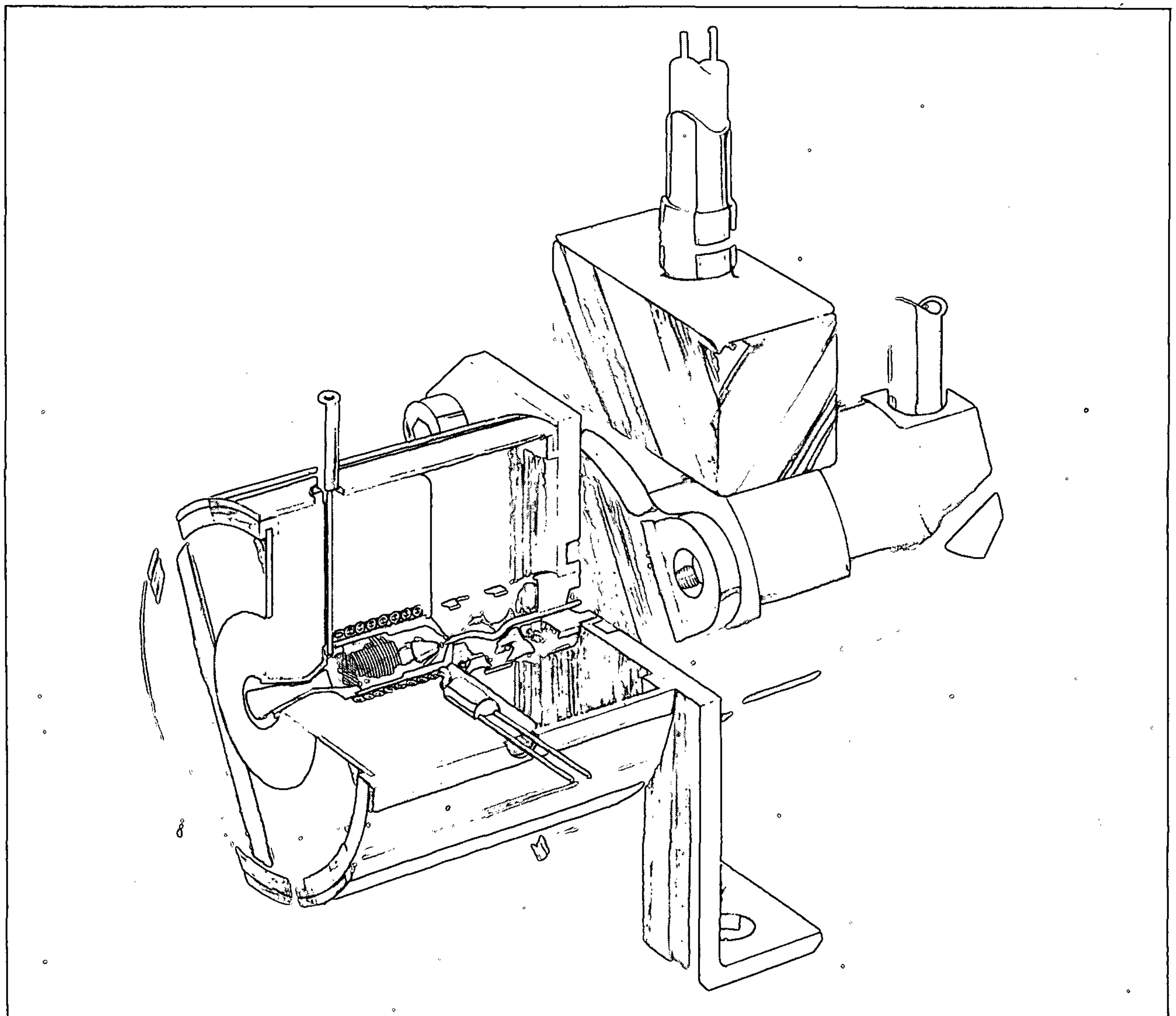


Figure 1. Cutaway Drawing of Engineering Model EHT

2.2 Potential Improvements to the Basic Design

During the course of the Engineering Model tests three areas of potential improvement were noted. These relate to heater manufacturability, thruster materials, and thruster injector design. None of these are unique to the electrothermal hydrazine thruster; all have been encountered previously by TRW and other investigators working with small catalytic thrusters.

Heater Element Manufacturability. The heater element design used on the Engineering Model EHT is the same as that used for catalyst bed and line heaters on several flight systems. The reliability of this type of heater has been demonstrated by a cumulative total of tens of thousands of hours of failure-free operation in space and real-time ground testing of about 2000 hours at 1800°F on a number of individual units.

The heater units are differentially swaged by the manufacturers in a number of "standard" diameters, each of which requires special tooling. Should a requirement exist for a specific diameter for which no tooling exists, the manufacturer would embark on a small development program. The initial result is likely to be sub-standard. This was the case with one lot of heaters procured for the EHT program. Until the time of fabrication of the last three EM thrusters, a standard configuration heater was used. No failures were encountered in more than two years of development testing with perhaps 20 different thrusters.

Twelve special-order heaters were procured for the EM thrusters. These units were purchased with a specific resistance, diameter, and maximum length. All were examined by X-ray testing and found to be of questionable quality. One of the units experienced a failure in the lead section.

For a flight program, a new heater element configuration must be treated as any other unqualified component, and not accepted on the basis of similarity to a proven design. This implies vendor surveillance, qualification and screening tests, and a component acceptance test.

Thruster Materials. Small hydrazine thrusters, both catalytic and electrothermal, use small diameter injector tubes. These tubes are typically in the size range of 0.005 to 0.015 inch. Larger hydrazine thrusters have relied on stainless steel and super alloy materials, notably Haynes 25 (also called L-605), for injector materials. For these applications, the relatively slow nitriding rate of Haynes 25 has been adequate. For thrusters smaller than about 0.5 pound thrust, however, even a small amount of nitriding in the injector has proven detrimental for long life missions. While the material strength may not be degraded significantly, a small nitride layer may change the effective injector diameter to a significant degree. This results in an increased pressure drop and decreased thrust. This phenomenon was observed in the EM EHT and is reported in Reference 4.

Noble metals, notably platinum-10 percent iridium, have been found to be much more nitride-resistant to hydrazine than the super alloys. A development model EHT with a Pt-10Ir injector was cycled 10^6 times. Post test inspection showed no evidence of nitriding or materials degradation of the injector. For long-life missions, the use of noble-metal injectors should be investigated further.

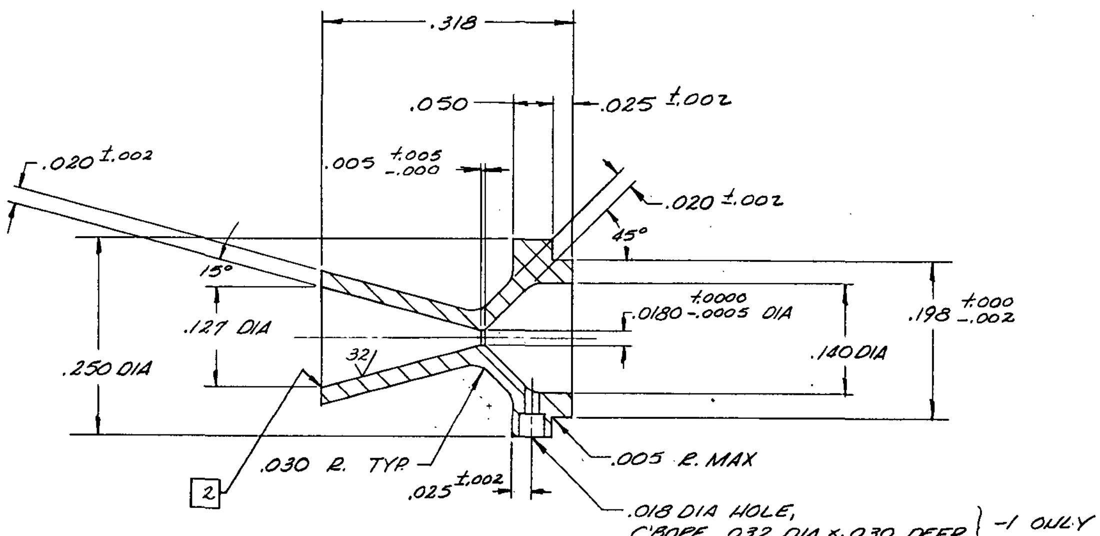
Injector Design. The injectors of most small hydrazine thrusters have a large length-to-diameter ratio to provide a pressure drop sufficient to prevent chamber pressure oscillations from influencing the supply pressure. The injector also supports a very large temperature gradient since it is attached at one end to the control valve at ambient temperature and the thrust chamber at the other end. Under steady state conditions the thrust chamber may reach 1700°F. These two factors combined result in the injector being a very efficient heat exchanger. Heat from the injector is transferred into the incoming propellant immediately upstream of the chamber. If the heat transfer rate is too high, the incoming propellant will be vaporized. This results in a large pressure drop and a reduced flow rate. This phenomenon is most severe for short pulses following a steady state run which heats the chamber to a high temperature.

Performance and pulse shape of the Engineering Model EHT would be improved if the injector tube diameter were larger — the maximum diameter being dictated by factors such as injector exit velocity, "tail off" time due to dribble volume, and decoupling of chamber pressure oscillations from the supply pressure. The increased instantaneous flow rate at the time the valve is opened would result in faster chamber pressure rise times, and a reduced possibility of vaporization in the injector under high chamber temperature conditions. Since the reduced injector pressure drop would result in higher chamber pressures, the thrust would be increased proportionally at any given inlet pressure. This increased thrust could then be decreased by reducing the nozzle throat diameter.

3.0 DRAWINGS

A complete set of Electrothermal Hydrazine Thruster Drawings is included in this section. The Engineering Model is identified as X410572-2. The unit is comprised of the following components.

(1)	Nozzle-EHT	X409237-1
(1)	Body, Thruster-EHT	X409235-1
(1)	Standoff-EHT	X410562-2
(1)	Tube, Barrier-EHT	X409236-1
(1)	Bracket, Thruster MTG, EHT	X410560-1
(1)	Seal, Tube-EHT	X410563-1
(2)	End Plate-EHT	X410561-1
(1)	Shield-EHT	X410559-2
(1)	Tube, Injector	X409240-14
(1)	Sleeve, Injector	X409240-13
(60)	Screen	X409240-7
(1)	Screen	X409240-8
(1)	Tube, Pressure Tap	S409240-4
(1)	Sleeve	X409240-5
(1)	Valve	Parker, 5701060-104
(1)	O-Ring	Parker, 2-12
(1)	Heater	Am.Std. BXA04-FB-AM
(1)	Insulation Package	X410572, WRP-X
(3)	Bolt	#10-32UNF 3BTHRD



DET -1

-2 SAME EXCEPT ELIMINATE .018 DIA HOLE & .032 DIA x .030 DEEP CBORE

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

PARTS LIST

CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPEC	REF DES	ITEM NO.
	-2	NOZZLE	L605 (HAYNES 25) BAR	AMS 5759		
	-1	NOZZLE	L605 (HAYNES 25) BAR	AMS 5759		

QTY REQD PER ASSY CONFIGURATION

FINISH

HEAT TREAT

UNLESS OTHERWISE SPECIFIED
1. INTERPRET PER MIL-STD-100.
2. DIMENSIONS ARE IN INCHES
3. SURFACE TEXTURE SHALL BE 63
4. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING.
5. REMOVE BURRS & SHARP EDGES

TOLERANCES ON DECIMAL DIMENSIONS: .XXX ± .010, .XX ± .03, .X ± .1

TOLERANCES ON ANGULAR DIMENSIONS: MACHINED & LOCATING ± 0°30', FORMED ± 2°, CHAMFERS ± 5°

TOLERANCES - ALL HOLE DIA		
FROM	THRU	TOL.
UNDER	.0140	+.0020 -.0005
.0145	.125	+.004 -.001
.126	.250	+.005 -.001
.251	.500	+.006 -.001
.501	.750	+.008 -.001
.751	1.000	+.010 -.001
1.001	2.000	+.012 -.001
OVER	2.000	+.015 -.005

DO NOT SCALE DRAWING

CONTRACT NO.

DRAWN J. WINGERSON 16 DEC 1971

CHECKED

STRUCTURES

MAT'L & PROCESS

ENGR [signature] 3/22/72

SUPERVISOR [signature] 3/22/72

OTHER APPROVALS

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

NOZZLE - EHT

SIZE C | CODE IDENT NO. 11982 | X409237

SCALE 10/1 | SHEET

2 REMOVE BURR BUT DO NOT BREAK SHARP CORNER.

1. IDENTIFICATION MARKNG PER PR 12-6-0900
TYPE____ CLASS____
PART NUMBER____

NOTES: UNLESS OTHERWISE SPECIFIED

USED ON	NEXT ASSY	NEXT ASSY QTY REQD
EHT	X409240	1(-1)

APPLICATION

PR 12-6

APPLICABLE SPECIFICATIONS

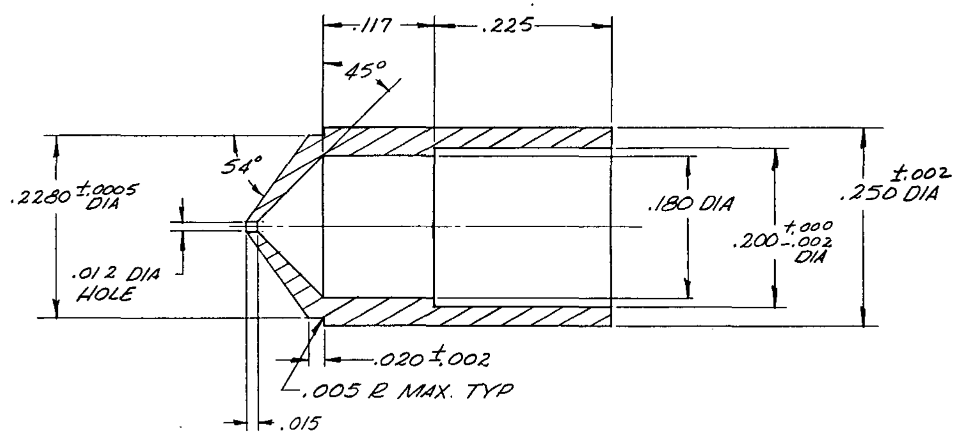
THE ABOVE TRW SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

X409237

6/68 DIETZGEN-POST CLEARPRINT 1000

SYSTEMS 14510 REV. 5-68

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



X409235

CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPEC.	REF DES	ITEM NO.
	-1	THRUSTER BODY	L-605(HAYNES 25) BAR	AMS5759		

PARTS LIST

QTY REQD PER ASSY CONFIGURATION

FINISH

HEAT TREAT

UNLESS OTHERWISE SPECIFIED
1. INTERPRET PER MIL-STD-100.
2. DIMENSIONS ARE IN INCHES
3. SURFACE TEXTURE SHALL BE 125
4. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING.
5. REMOVE BURRS & SHARP EDGES

TOLERANCES ON DECIMAL DIMENSIONS: .XXX ± .010, .XX ± .03, .X ± .1

TOLERANCES ON ANGULAR DIMENSIONS: MACHINED & LOCATING ± 0°30', FORMED ± 2°, CHAMFERS ± 5°

TOLERANCES - ALL HOLE DIA		
FROM	THRU	TOL.
UNDER	.0140	+.0020 −.0005
.0145	.125	+.004 −.001
.126	.250	+.005 −.001
.251	.500	+.006 −.001
.502	.750	+.008 −.001
.751	1.000	+.010 −.001
1.001	2.000	+.012 −.001
OVER	2.000	+.015 −.005

DO NOT SCALE DRAWING

CONTRACT NO.

DRAWN	J. WINGERSON	16 DEC 1971
CHECKED		
STRUCTURES		
MAT'L & PROCESS		
ENGR	[signature]	3/22/73
SUPERVISOR	[signature]	3/22/73
OTHER APPROVALS		

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

BODY, THRUSTER-EHT

SIZE	CODE IDENT NO.	
C	11982	X409235

SCALE 10/1 SHEET

PR 12-6
APPLICABLE SPECIFICATIONS

THE ABOVE TRW SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

USED ON	NEXT ASSY	NEXT ASSY QTY REQD
EHT	X409240	1(-1)
APPLICATION		

1. IDENTIFICATION MARKING PER PR 12-6-0900
TYPE ______ CLASS ______
PART NUMBER ______

NOTES: UNLESS OTHERWISE SPECIFIED

TABULATION			
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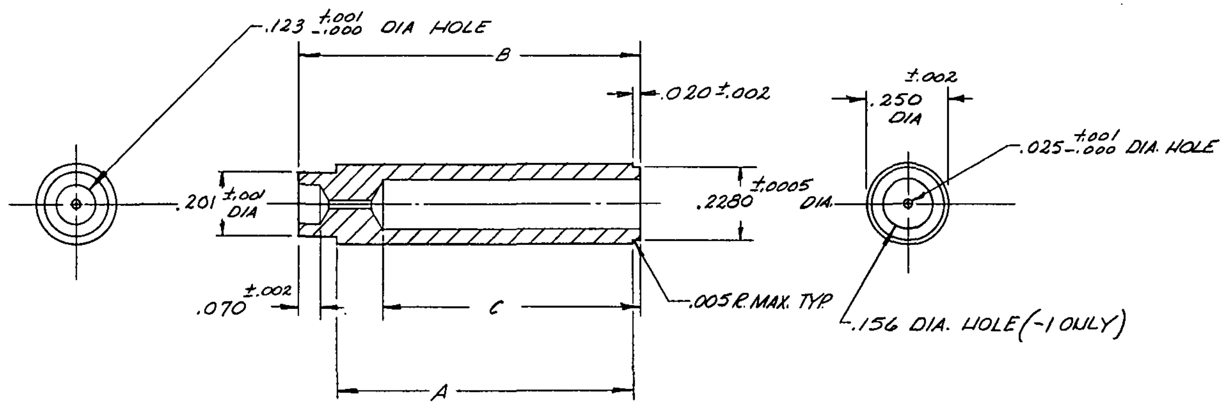
-2	.140 ±.005	.270 ±.005	—

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



NOTES: UNLESS OTHERWISE SPECIFIED

1. IDENT. MARKING PER PR 12-6-0900

QTY REQD PER ASSY	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPEC	REF DES	ITEM NO.
		-2	STANDOFF	TYPE 304 CRES	QQ-S-763		
		-1	STANDOFF	TYPE 304 CRES	QQ-S-763		

PARTS LIST

UNLESS OTHERWISE SPECIFIED

1. DO NOT SCALE DRAWING.
2. INTERPRET PER MIL-STD-100.
3. DIMENSIONS ARE IN INCHES.
4. SURFACE TEXTURE SHALL BE 125
5. REMOVE BURRS AND SHARP EDGES.
6. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING.
7. PARENTHETICAL DATA IS FOR REFERENCE ONLY.

TOLERANCES

ON ALL HOLE DIAMETERS

UNDER .0140	+.0020 -.0005	.501 THRU .750	+.008 -.001
.014 THRU .125	+.004 -.001	.751 THRU 1.000	+.010 -.001
.126 THRU .250	+.005 -.001	1.000 THRU 2.000	+.012 -.001
.251 THRU .500	+.006 -.001	OVER 2.000	+.015 -.005

ON DECIMAL DIMENSIONS:
.XXX ± .010
.XX ± .03
.X ± .1

ON ANGULAR DIMENSIONS:
MACHINED ± 0°30'
LOCATING ± 0°30'
FORMED ± 2°
CHAMFERS ± 5°

FINISH

HEAT TREAT

USED ON	NEXT ASSY	NEXT ASSY QTY REQD
EHT		1(-2)
EHT		1(-1)

APPLICATION

PR12-6

APPLICABLE SPECIFICATIONS

THE ABOVE TRW SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

CONTRACT NO.

DRAWN	WINGERSON	3-21-72
CHECKED		
STRUCTURES		
MATERIAL/PROCESS		
ENGINEER	C.A. Hunter	3/22/72
SUPERVISOR	C.K. Hund	3/22/72
PROJECT		
OTHER APPROVALS		

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

STANDOFF - EHT

SIZE	CODE IDENT NO.	
C	11982	X410562

SCALE 4/1 SHEET

X410562

5/71 DIETERICH-POST CLEARPRINT 1020

SYSTEMS 3400 REV. 8-71

REVISIONS			
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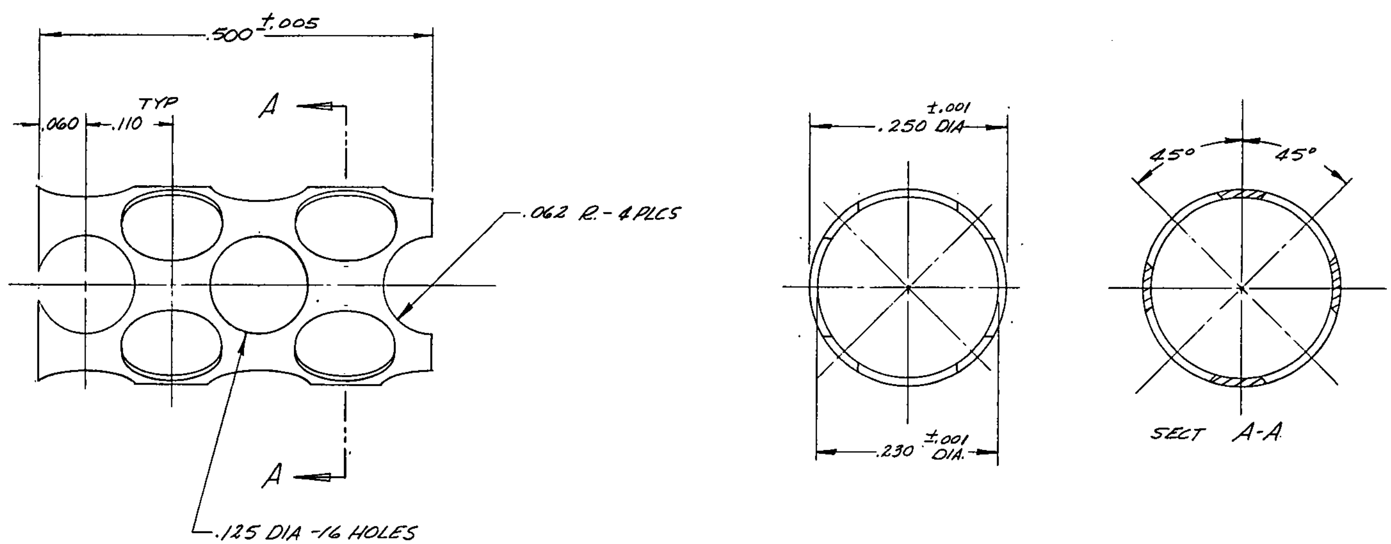

X409236

CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPEC.	REF DES	ITEM NO.
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PARTS LIST

QTY REQD PER ASSY CONFIGURATION

FINISH

HEAT TREAT

PR 12- 6

APPLICABLE SPECIFICATIONS

THE ABOVE TRW SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

UNLESS OTHERWISE SPECIFIED

1. INTERPRET PER MIL-STD-100.
2. DIMENSIONS ARE IN INCHES
3. SURFACE TEXTURE SHALL BE 125/
4. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING.
5. REMOVE BURRS & SHARP EDGES

TOLERANCES ON DECIMAL DIMENSIONS: .XXX ± .010, .XX ± .03, .X ± .1

TOLERANCES ON ANGULAR DIMENSIONS: MACHINED & LOCATING ± 0°30', FORMED ± 2°, CHAMFERS ± 5°

TOLERANCES - ALL HOLE DIA		
FROM	THRU	TOL.
UNDER	.0140	+.0020 −.0005
.0145	.125	+.004 −.001
.126	.250	+.005 −.001
.251	.500	+.006 −.001
.501	.750	+.008 −.001
.751	1.000	+.010 −.001
1.001	2.000	+.012 −.001
OVER	2.000	+.015 −.005

DO NOT SCALE DRAWING

CONTRACT NO.		
DRAWN	J. WINGERSON	16 DEC 1971
CHECKED		
STRUCTURES		
MAT'L & PROCESS ENGR	C.R. Hunter	3/22/73
SUPERVISOR	C.K. Murch	3/22/73
OTHER APPROVALS		

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

TUBE, BARRIER - EHT

SIZE	CODE IDENT NO.	
C	11982	X409236

SCALE 10/1 | SHEET

1. IDENTIFICATION MARKING PER PR 12-6-0900

TYPE______ CLASS______

PART NUMBER______

NOTES: UNLESS OTHERWISE SPECIFIED

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APPLICATION

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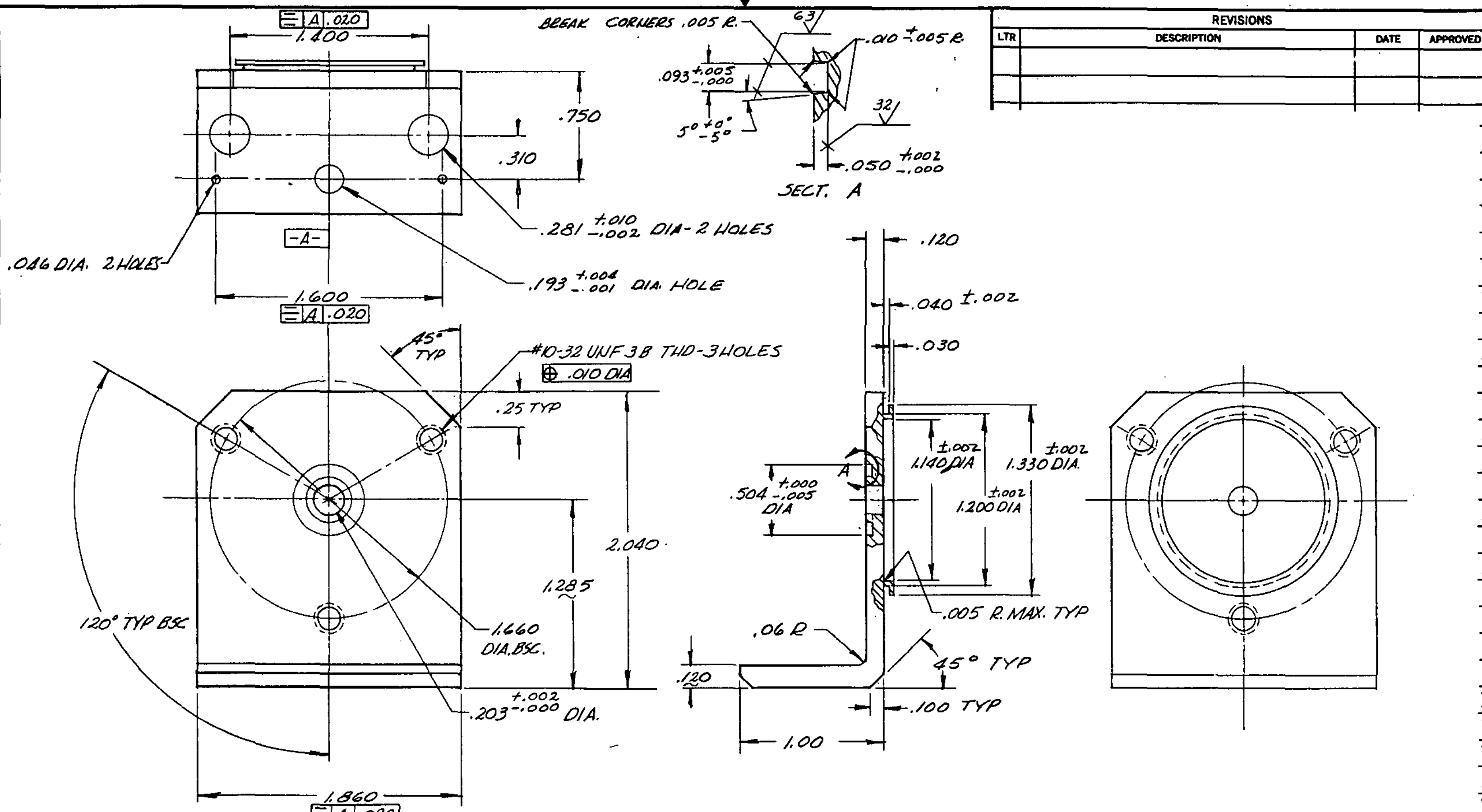

X410560

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REVISIONS			
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PARTS LIST

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		-1	BRACKET	TYPE 303 se CRES BAR	QQ-S-764		

UNLESS OTHERWISE SPECIFIED

1. DO NOT SCALE DRAWING.
2. INTERPRET PER MIL-STD-100.
3. DIMENSIONS ARE IN INCHES.
4. SURFACE TEXTURE SHALL BE 125
5. REMOVE BURRS AND SHARP EDGES.
6. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING.
7. PARENTHETICAL DATA IS FOR REFERENCE ONLY.

TOLERANCES

ON ALL HOLE DIAMETERS

UNDER .0140	+.0020 -.0005	.501 THRU .750	+.008 -.001
.014 THRU .125	+.004 -.001	.751 THRU 1.000	+.010 -.001
.126 THRU .250	+.005 -.001	1.000 THRU 2.000	+.012 -.001
.251 THRU .500	+.006 -.001	OVER 2.000	+.015 -.005

ON DECIMAL DIMENSIONS:
.XXX ± .010
.XX ± .03
.X ± .1

ON ANGULAR DIMENSIONS:
MACHINED ± 0°30'
LOCATING ± 0°30'
FORMED ± 2°
CHAMFERS ± 5°

FINISH

HEAT TREAT

CONTRACT NO.		
DRAWN	J. WINGERSON	17 MAR 1972
CHECKED		
STRUCTURES		
MATERIAL/PROCESS		
ENGINEER	C.R. Hunter	3/22/73
SUPERVISOR	[signature]	3/22/73
PROJECT		
OTHER APPROVALS		

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

BRACKET-THRUSTER MTG, EHT

SIZE	CODE IDENT NO.	
C	11982	X410560
SCALE 2/1		SHEET

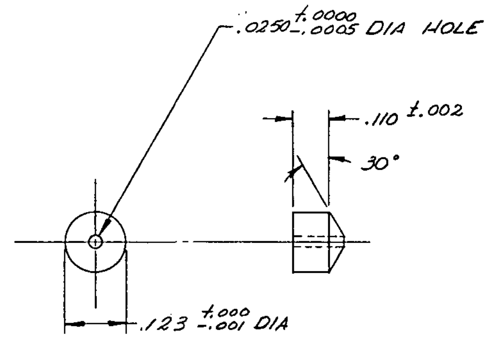
APPLICATION		
USED ON	NEXT ASSY	NEXT ASSY QTY REQD
EHT		1(-1)

APPLICABLE SPECIFICATIONS
THE ABOVE TRW SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

8/71 DIETZGEN-POST CLEARPRINT 1020

SYSTEMS 3405 REV. 8-71

LTR	REVISIONS DESCRIPTION	DATE	APPROVED



NOTES: UNLESS OTHERWISE SPECIFIED

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PARTS LIST

UNLESS OTHERWISE SPECIFIED

1. DO NOT SCALE DRAWING.
2. INTERPRET PER MIL-STD-100.
3. DIMENSIONS ARE IN INCHES.
4. SURFACE TEXTURE SHALL BE 125
5. REMOVE BURRS AND SHARP EDGES.
6. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING.
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TOLERANCES — ON ALL HOLE DIAMETERS

UNDER .0140	+.0020 -.0005	.501 THRU .750	+.008 -.001
.014 THRU .125	+.004 -.001	.751 THRU 1.000	+.010 -.001
.126 THRU .250	+.005 -.001	1.000 THRU 2.000	+.012 -.001
.251 THRU .500	+.006 -.001	OVER 2.000	+.015 -.005

ON DECIMAL DIMENSIONS: .XXX ±.010; .XX ±.03; .X ±.1

ON ANGULAR DIMENSIONS: MACHINED ± 0°30'; LOCATING ± 0°30'; FORMED ± 2°; CHAMFERS ± 5°

FINISH

HEAT TREAT

USED ON	NEXT ASSY	QTY REQD	APPLICABLE SPECIFICATIONS
EHT		1(-1)	PR 12-6

APPLICATION

THE ABOVE TRW SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

CONTRACT NO.

DRAWN	J. Wingerson	3/21/72
CHECKED		
STRUCTURES		
MATERIAL/PROCESS		
ENGINEER	[illegible]	3/21/72
SUPERVISOR	[illegible]	3/22/72
PROJECT		
OTHER APPROVALS		

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SEAL, TUBE-EHT

SIZE C | CODE IDENT NO. 11982 | X410563

SCALE NONE | SHEET

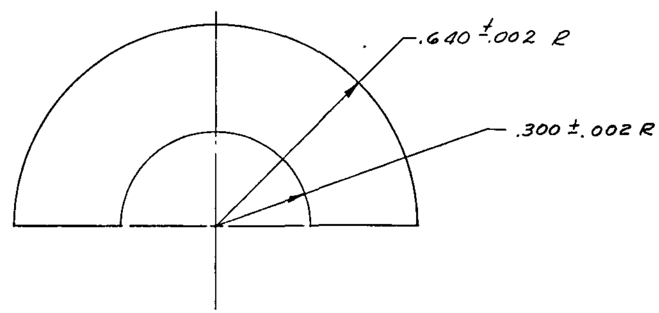
X410563

8/71 DIETZGEN-POST CLEARPRINT 1020 — SYSTEMS 3405 REV. 8-71

X410561

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



NOTES: UNLESS OTHERWISE SPECIFIED

1. IDENT MARKING PER PR 12-6-0900

PARTS LIST

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UNLESS OTHERWISE SPECIFIED

1. DO NOT SCALE DRAWING.
2. INTERPRET PER MIL-STD-100.
3. DIMENSIONS ARE IN INCHES.
4. SURFACE TEXTURE SHALL BE 125
5. REMOVE BURRS AND SHARP EDGES.
6. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING.
7. PARENTHETICAL DATA IS FOR REFERENCE ONLY.

TOLERANCES

ON ALL HOLE DIAMETERS

UNDER .0140	+.0020 −.0005	.501 THRU .750	+.008 −.001
.014 THRU .125	+.004 −.001	.751 THRU 1.000	+.010 −.001
.126 THRU .250	+.005 −.001	1.000 THRU 2.000	+.012 −.001
.251 THRU .500	+.006 −.001	OVER 2.000	+.015 −.005

ON DECIMAL DIMENSIONS: .XXX ± .010, .XX ± .03, .X ± .1

ON ANGULAR DIMENSIONS: MACHINED ± 0°30′, LOCATING ± 0°30′, FORMED ± 2°, CHAMFERS ± 5°

FINISH

HEAT TREAT

CONTRACT NO.	
DRAWN J. WINGERSON	3/21/72
CHECKED	
STRUCTURES	
MATERIAL/PROCESS	
ENGINEER [signature]	3/22/72
SUPERVISOR [signature]	3/22/72
PROJECT	
OTHER APPROVALS	

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

END PLATE - EHT

SIZE	CODE IDENT NO.	
C	11982	X410561

SCALE 4/1 SHEET

USED ON	NEXT ASSY	NEXT ASSY QTY REQD	APPLICABLE SPECIFICATIONS
EHT		2(-1)	PR12-6

APPLICATION

THE ABOVE TRW SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

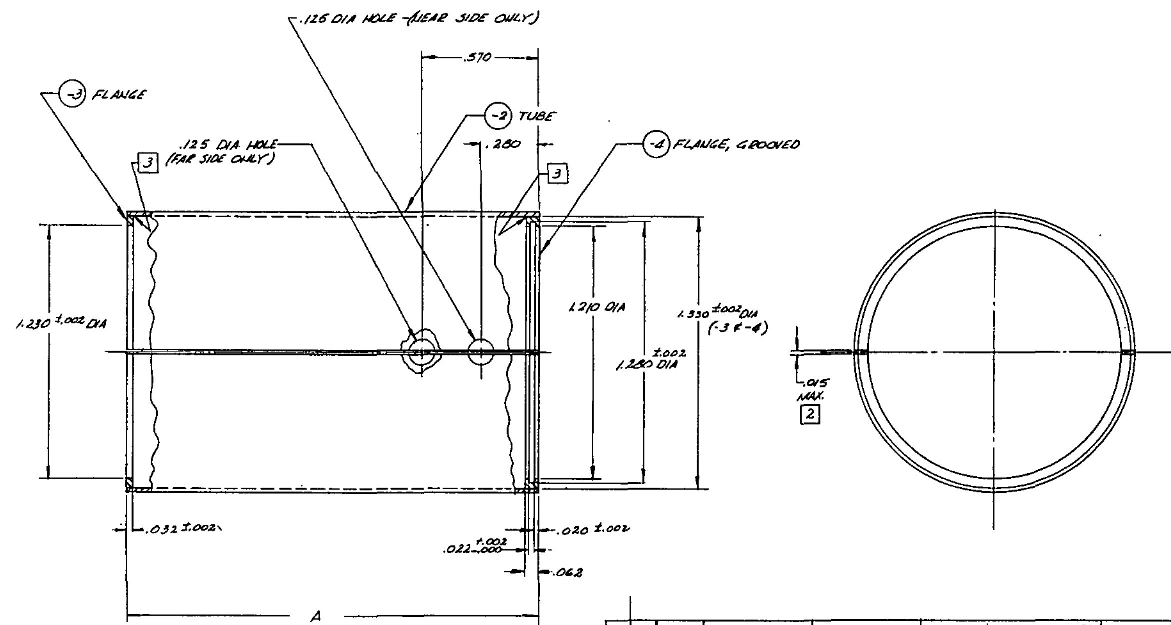
8/71 DIETERICH-POST CLEARPRINT 1020

SYSTEMS 3693 REV. 8-71

TABULATION	
PART NO.	DIM A
-1	2.020
-2	1.270

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
A	.032 ±.002 WAS .062	2 MAY 1972	



QTY REQD PER ASSY -2	QTY REQD PER ASSY -1	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPEC	REF DES	ITEM NO.
1	1			TUBE	1.375 OD x .020 WALL - 321 CRES	MIL-T-8808		
1	1		-4	FLANGE, GROOVED	TYPE 321 CRES	MIL-S-6721		
1	1		-3	FLANGE	TYPE 321 CRES	MIL-S-6721		
	1		-2	TUBE	1.375 O.D. x .020 WALL - 321 CRES	MIL-T-8808		

PARTS LIST

QTY REQD PER ASSY CONFIGURATION

4. MACHINED CORNER RADII TO BE .005 MAX.

3. BRAZE PER 3-16 · USE NICROBRAZE 210 BRAZING ALLOY

2. AFTER MACHINING, CUT LENGTHWISE TO FORM 2 HALVES AS SHOWN.

1. IDENTIFICATION MARKING PER PR 12-6-0900 TYPE____CLASS____PART NUMBER____

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT ASSY	USED ON
EHT	

APPLICATION

APPLICABLE SPECIFICATIONS: (4) PR 3-16, PR 12-6

THE ABOVE TRW SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

UNLESS OTHERWISE SPECIFIED: 1. INTERPRET PER MIL-STD-100. 2. DIMENSIONS ARE IN INCHES. 3. SURFACE TEXTURE SHALL BE 125. 4. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING. 5. REMOVE BURRS & SHARP EDGES.

DO NOT SCALE DRAWING

DRAWN J. WILKERSON 3-21-72

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

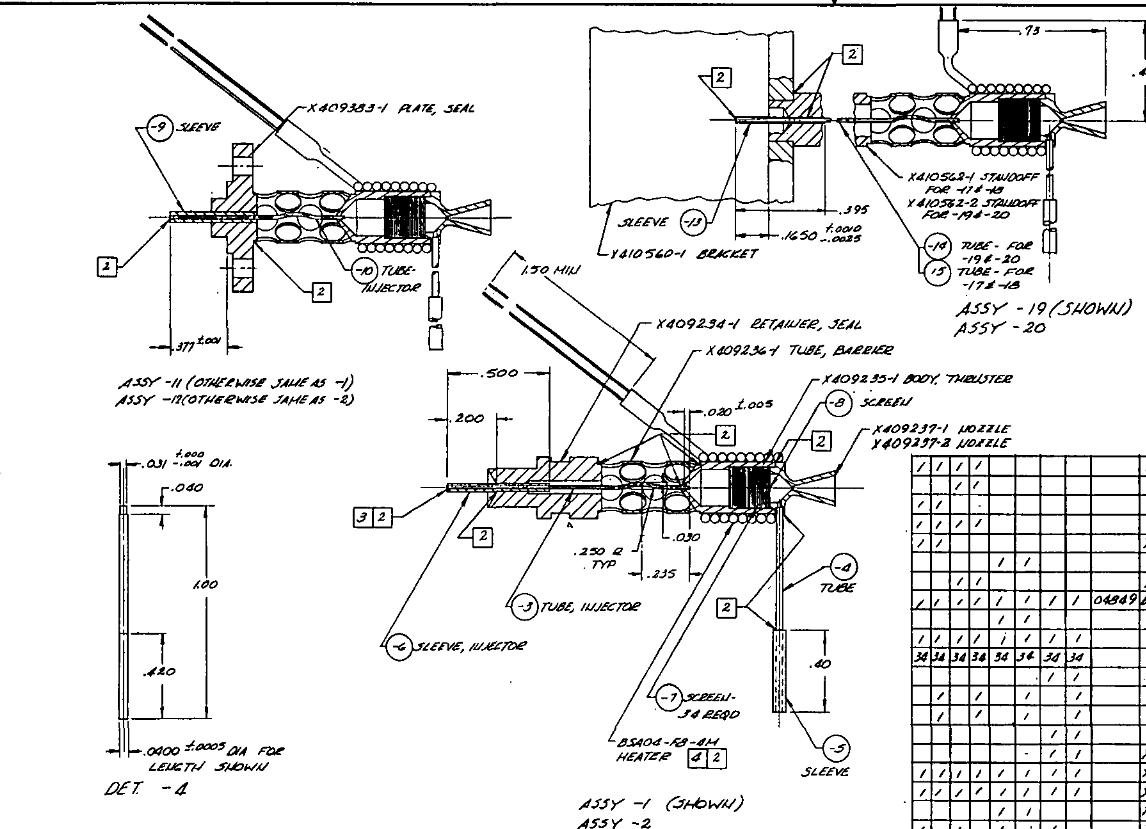
TRW SYSTEMS GROUP — ONE SPACE PARK · REDONDO BEACH, CALIFORNIA

SHIELD - EHT

SIZE D — CODE IDENT NO. 11982 — X410559

SCALE 4/1

X410559 A



20	19	18	17	-12	-11	-2	-1	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPEC	REF DES	ITEM NO.
/	/	/	/						X410560-1	BRACKET				
		/	/						-15	TUBE, INJECTOR	.014 O.D. x .005 I.D. TUBE L-605(HAYNES 25)			
/	/		.						-14	TUBE, INJECTOR	.014 O.D. x .005 I.D. TUBE L-605(HAYNES 25)			
/	/	/	/						-13	SLEEVE, INJECTOR	.0240 O.D. x .016 I.D. TUBE TYPE 304 CRES			
/	/								X410562-2	STANDOFF				
				/	/				-10	TUBE, INJECTOR	.014 O.D. x .005 I.D. TUBE L-605(HAYNES 25)			
		/	/						X410562-1	STANDOFF				
/	/	/	/	/	/	/	/	04849	BXA04-F8-4M	HEATER				
				/	/				-9	SLEEVE, INJECTOR	.030 O.D. x .015 I.D. TUBE TYPE 304 CRES			
/	/	/	/	/	/	/	/		-8	SCREEN,	40 MESH, .011 L-605(HAYNES 25) WIRE - .196 ±.001 DIA			
34	34	34	34	34	34	34	34		-7	SCREEN, PLATINUM	52 MESH, .004 PLATINUM WIRE - .201 ±.001 DIA			
						/	/		-6	SLEEVE, INJECTOR	.038 O.D. x .018 I.D. TUBE TYPE 304 CRES			
	/		/		/		/		-5	SLEEVE	.062 O.D. x .042 I.D. TUBE TYPE 304 CRES			
	/		/		/		/		-4	TUBE, PRESSURE TAP	.042 O.D. x .016 I.D. TUBE L-605(HAYNES 25)			
						/	/		-3	TUBE, INJECTOR	.014 O.D. x .005 I.D. TUBE - L-605(HAYNES 25)			
					-	/	/		X409234-1	RETAINER, SEAL				
/	/	/	/	/	/	/	/		X409235-1	BODY, THRUSTER				
/	/	/	/	/	/	/	/		X409236-1	TUBE, BARRIER				
				/	/				X409383-1	PLATE, SEAL				
/		/		/	.	/			X409237-2	NOZZLE				
	/		/		/		/		X409237-1	NOZZLE				

QTY REQD PER ASSY

PARTS LIST

NOTES: UNLESS OTHERWISE SPECIFIED

1. IDENTIFY PER PR 12-6-0900
2. BRAZE PER PR 3-16. USE NICROBRAZE 210 BRAZING ALLOY.
3. SWAGE -6 TO -3 BEFORE BRAZING
4. WRAP HEATER AROUND THRUSTER BODY & BRAZE IN PLACE
5. I.D. OF -3,-4,5-10 TUBES TO BE CLEAN & FREE FROM BRAZING MAT'L.

USED ON	NEXT ASSY	ASSY QTY REQD	
EHT	X409290	(K2)	
EHT	X409290	(-1)	
EHT	X409289	(-2)	
EHT	X409289	(-1)	PR 12-6
APPLICATION			APPLICABLE SPECIFICATIONS

THE ABOVE TRW SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

UNLESS OTHERWISE SPECIFIED
1. DO NOT SCALE DRAWING.
2. INTERPRET PER MIL-STD-100.
3. DIMENSIONS ARE IN INCHES.
4. SURFACE TEXTURE SHALL BE 125
5. REMOVE BURRS AND SHARP EDGES.
6. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING.
7. PARENTHETICAL DATA IS FOR REFERENCE ONLY.

TOLERANCES

FINISH

HEAT TREAT

CONTRACT NO.

DRAWN J. WILKERSON 21 OCT 1971

CHECKED

STRUCTURES

MATERIALS/PROCESS ENGINEER

SUPERVISOR

PROJECT

OTHER APPROVALS

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

THRUSTER ASSY, EHT

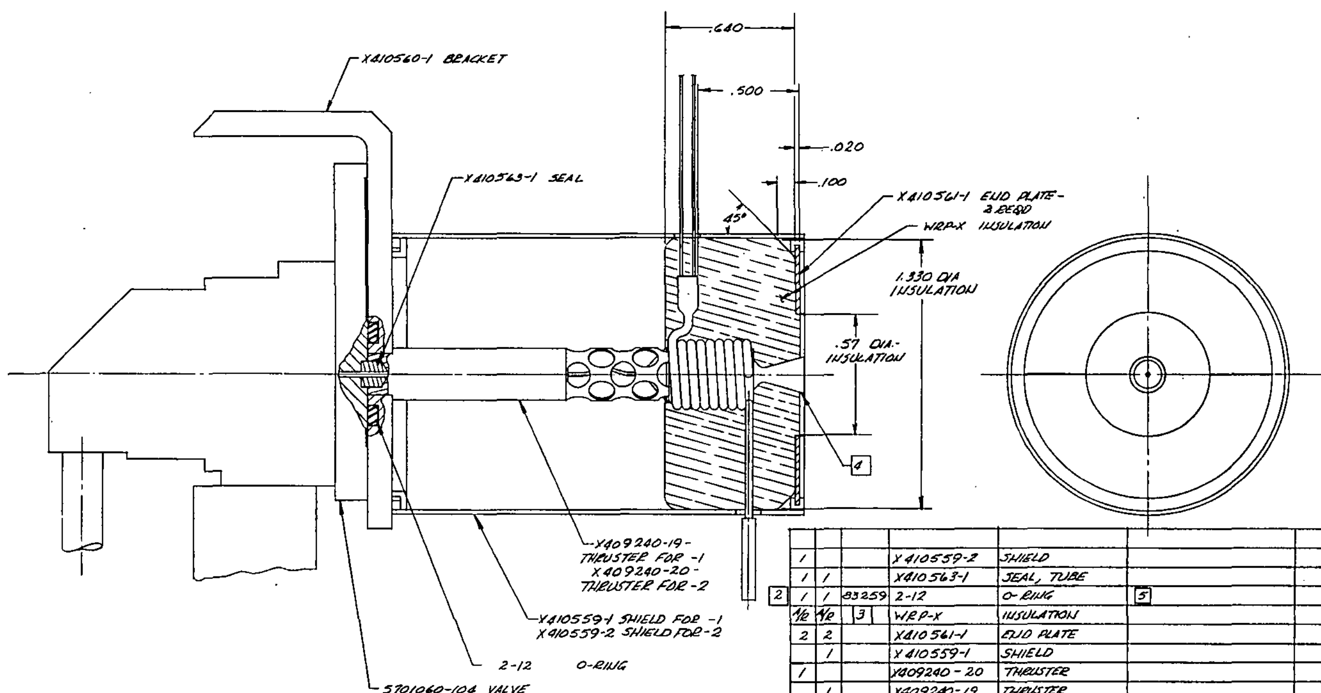
SIZE D | CODE IDENT NO. 11982 | X409240

SCALE 4/1 | SHEET

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

X409240



NOTES: UNLESS OTHERWISE SPECIFIED

1. IDENT MARKING PER PR 12-6-0900
2 SUGGESTED VENDOR
3 REFRACTORY PRODUCTS CO., 220 S. LINCOLN CARPENTERSVILLE, ILL.
4 INSULATION MUST BE .020 BACK FROM END OF NOZZLE
5 MATL. TO BE ETHYLENE PROPYLENE RESIN (PARKER # E515-8 COMPOUND)

	-2	-1	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPEC	EFF DES	ITEM NO.
	1			X410559-2	SHIELD				
	1	1		X410563-1	SEAL, TUBE				
2	1	1	83259	2-12	O-RING	5			
	1/2	1/2	3	WRP-X	INSULATION				
	2	2		X410561-1	END PLATE				
		1		X410559-1	SHIELD				
	1			X409240-20	THRUSTER				
		1		X409240-19	THRUSTER				
	1	1		X410560-1	BRACKET				
2	1	1	92003	5701060-104	VALVE				

QTY REQD PER ASSY — PARTS LIST

UNLESS OTHERWISE SPECIFIED
1. DO NOT SCALE DRAWING.
2. INTERPRET PER MIL-STD-100.
3. DIMENSIONS ARE IN INCHES.
4. SURFACE TEXTURE SHALL BE 125
5. REMOVE BURRS AND SHARP EDGES.
6. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING.
7. PARENTHETICAL DATA IS FOR REFERENCE ONLY.

TOLERANCES

APPLICATION			
USED ON	NEXT ASSY	NEXT ASSY QTY REQD	
EHT		K-1	PR12-6
EHT		(-2)	

APPLICABLE SPECIFICATIONS: THE ABOVE TRW SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

FINISH

HEAT TREAT

CONTRACT NO.

DRAWN J. WINKERON 4/26/72

CHECKED

STRUCTURES

MATERIAL/PROCESS

ENGINEER

SUPERVISOR

PROJECT

OTHER APPROVALS

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

ELECTRO THERMAL HYDRAZINE VALVE AND THRUSTER ASSY

SIZE	CODE IDENT NO.	
D	11982	X410572

SCALE 4/1

SHEET

X410572

4.0 CONCLUSIONS

On the basis of the results of the Engineering Model tests, the thruster is capable of rapid flight qualification to performance and lifetime requirements applicable to a large class of spacecraft. Only minor modifications are required to the configuration of the Engineering Model EHT.

5.0 REFERENCES

1. Monopropellant Hydrazine Resistojet, Analysis Task Summary Report, TRW Document 20266-6006-R0-00, November 1971.
2. Monopropellant Hydrazine Resistojet, Preliminary Design Task Summary Report, TRW Document 20266-6009-R0-00, February 1972.
3. Monopropellant Hydrazine Resistojet, Model Specification Task Summary Report, TRW Document 20266-6010-R0-00, February 1972.
4. Monopropellant Hydrazine Resistojet, Engineering Model Fabrication and Test Task Summary Report, TRW Document 20266-6024-R0-00, March 1973.
5. Monopropellant Hydrazine Resistojet, Data Correlation Task Summary Report, TRW Document 20266-6025-R0-00, March 1973.
6. Murch, Charles K. and Charles R. Hunter, Electrothermal Hydrazine Thruster Development, AIAA Paper No. 72-451, April 1972.
7. Callens, R. A. and Charles K. Murch, Electrothermal Hydrazine Thruster Analyses and Performance Evaluation, AIAA Paper No. 72-1152, November 1972.