(NASA-CR-160992) AUGMENTED ORBITER HEAT REJECTION STUDY Final Report (Vought Corp., Dallas, Tex.) 132 p HC A07/MF A01 CSCL 22B

N81-25135

Unclas
G3/16 26551

Augmented Orbiter Heat Rejection Study

NASA CR-160992

FINAL REPORT
CONTRACT NAS9-14907 (Mod. 18)
REPORT NO. 2-53020/1R-52679

PREPARED FOR

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JOHNSON SPACE CENTER

18 FEBRUARY 1981

by

VOUGHT CORPORATION

Augmented Orbiter Heat Rejection Study

FINAL REPORT
CONTRACT NAS9-14907 (Mod. 18)
REPORT NO. 2-53020/1R-52679

PREPARED FOR

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JOHNSON SPACE CENTER

18 FEBRUARY 1981

by

VOUGHT CORPORATION

PREPARED BY: C. W. Hixon
C. W. HIXON

REVIEWED BY: J. A. Oren
J. A. OREN

APPROVED BY: R. L. Cox
R. L. COX

PREFACE

This document is submitted by the Vought Corporation, an LTV Company, Dallas, Texas 75265 to the National Aeronautics and Space Administration, Johnson Spacecraft Center (JSC), Houston, Texas, in accordance with Contract No. NAS9-14907 Modifications No. 18, dated 1 August 1980. It is the Final Report, and fulfills the requirements of DRL No. T-7777, Line Item 2, DRD MA-183T.

PRESENTATION OUTLINE

PRECEDING PAGE BLANK NOT FILMED

OVERVIEW

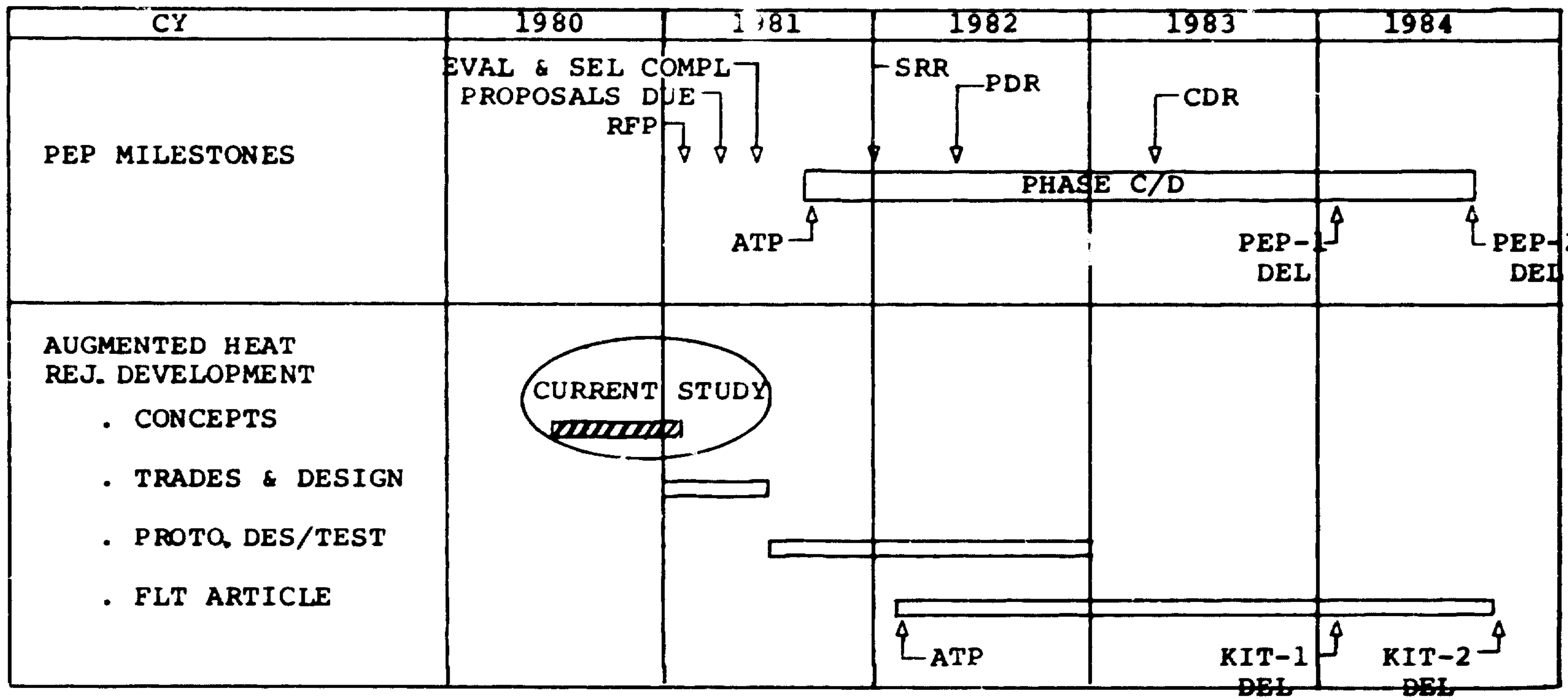
STUDY PURPOSE AND SCOPE

- DERIVE HEAT REJECTION KIT CONCEPTS TO RELIEVE ATTITUDE RESTRICTIONS REQUIRED BY THE SHUTTLE ORBITER SPACE RADIATOR FOR BASELINE AND EXTENDED CAPABILITY STS MISSIONS.

- CONSIDER COST-EFFECTIVE HEAT REJECTION KITS WHICH:
  - ADD ADDITIONAL CAPABILITY IN THE FORM OF ATTACHED SPACELAB RADIATORS OR A DEPLOYABLE RADIATOR MODULE

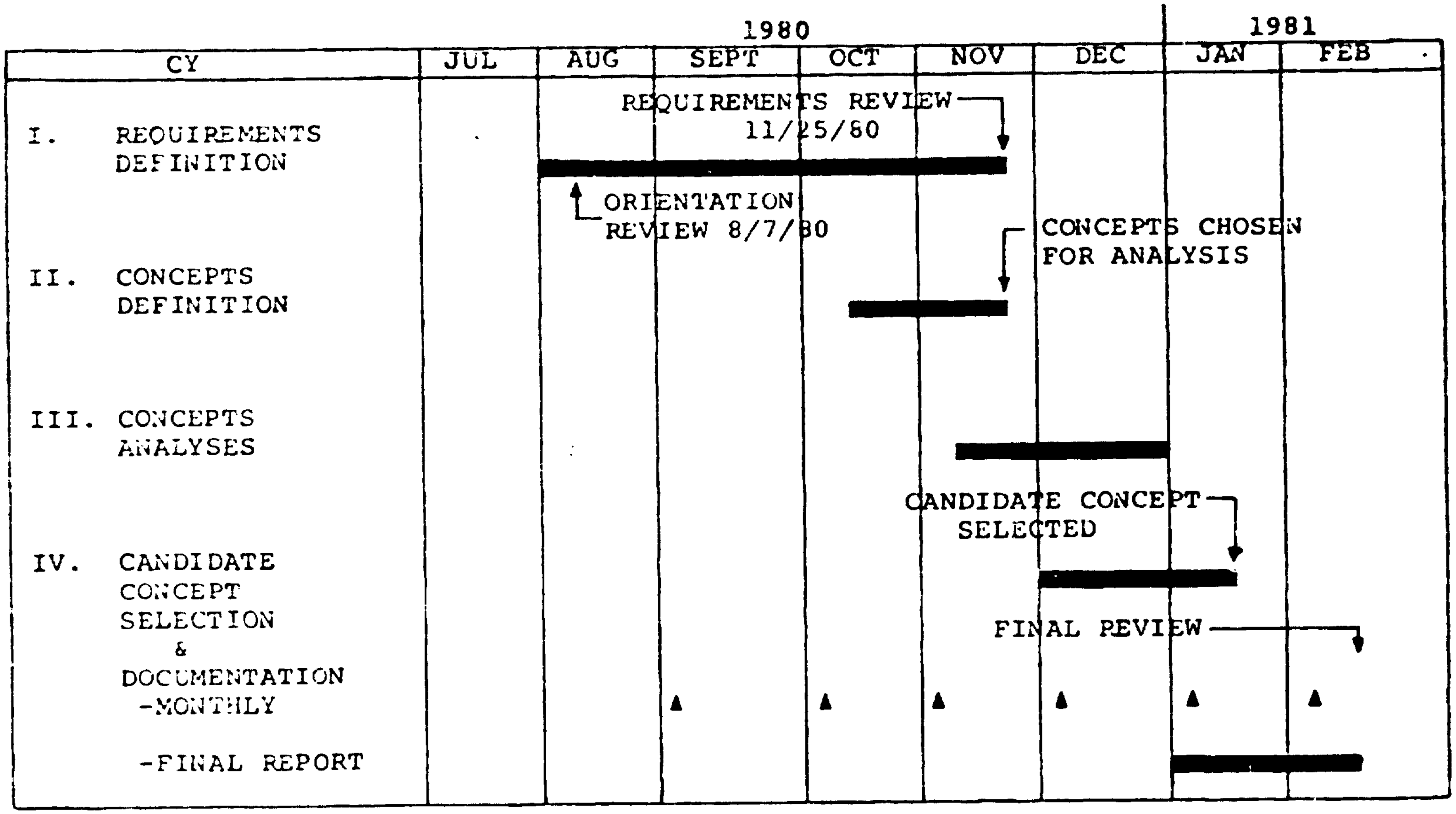
- SCOPE OF THIS STUDY:
  - DEFINE REQUIREMENTS
  - DERIVE, SIZE, AND SELECT CONCEPTS FOR SUBSEQUENT DETAILED TRADE STUDIES

PEP PROJECT SCHEDULE



Rev. 11/12/80

CURRENT STUDY SCHEDULE



Revised 11/12/80

REQUIREMENTS AND GUIDELINES

REQUIREMENTS AND GUIDELINES

VEHICLE OPERATIONAL MODES (SAME AS PEP)

- 100 NM TO 600 NM ALTITUDE
- 28.5° TO 104° INCLINATION
- ALL ATTITUDE POINTING
- UP TO 48 DAY DURATION
- ADDENDUM A TO PRELIMINARY PEP SYSTEM SPECIFICATION

NATURAL AND INDUCED ENVIRONMENTS

- APPENDIX I OF PEP ADDENDUM A

STRUCTURAL

- CONSISTENT WITH PEP (ADDENDUM A)
- VERNIER RCS AND CREW PUSH-OFF LOADS ON-ORBIT
- RETRACTION PERMITTED DURING PRIMARY RCS OPERATION

LIFE

- SERVICE LIFE OF 80 MISSIONS OVER 10 YEARS
- 8 MISSIONS PER YEAR
- 14 DAY AVERAGE MISSION, 48 DAY MAXIMUM
- 3 YEAR ON-ORBIT LIFE, 7 YEAR STORAGE
- 2 OR MORE DEPLOYMENT/RETRACTIONS PER MISSION
- 50 DEPLOYMENT/RETRACTIONS WITHOUT MAINTENANCE
- 240 DEPLOYMENT/RETRACTION LIFE WITH MAINTENANCE BETWEEN MISSIONS

RELIABILITY GOALS

- NO SINGLE FAILURE CAUSE LOSS OF MISSION
- NO DUAL FAILURE AFFECT CREW SAFETY OR VEHICLE INTEGRITY
- MICROMETEROID PROTECTION SHOULD NOT DRIVE DESIGN
- 0.99 PROBABILITY OF RELIABILITY AND LIFE GOALS

REQUIREMENTS AND GUIDELINES (CONT'D)

SAFETY

- JETTISON CAPABILITY (NO PYROTECHNICS)
- NO HAZARDS TO EVA

INTERFACES

- JSC-07700 FOR ORBITER STANDARD INTERFACES
- ADDENDUM B TO PRELIMINARY PEP SYSTEM SPECIFICATION FOR PEP INTERFACE DEFINITION DOCUMENT
- DIRECT FLUID LOOP FLUID INTERFACES ALLOWED (PAYLOADS ONLY)
- NOT PRECLUDE PEP PERFORMANCE/OPERATIONS PER ADDENDUM A
- MINIMIZE SCAR OR OPERATIONAL IMPACTS TO ORBITER/PEP

HEAT REJECTION AND TEMPERATURES

- HEAT LOAD DEFINED BY DEFICIT AT 29 KW_e PEP OPERATION WITH SUSTAINED FE OPERATION - CONSIDER PEP DESIGN MISSIONS DATA
- PROVIDE 40°F KIT RADIATOR OUTLET AT NOMINAL 110°F INLET
- CONSIDER OPTIONAL 250°F KIT RADIATOR INLET
- DESIRABLE TO REDUCE SPACELAB COOLANT TEMPERATURE BELOW 45°F
- INTERFACE TYPE AND LOCATION SHOULD CONSIDER ORBITER AND SPACELAB EQUIPMENT TEMPERATURE LIMITS
- ENVIRONMENTAL SINK TEMPERATURES CONSISTENT WITH PEP OPERATIONAL ENVELOPE

TRADE PARAMETERS

- COST TO ORBIT: $700/LB
- POWER: 2100/29 = 85 LB/KW
- COST AND WEIGHT ARE CRITICAL
- LENGTH IN CARGO BAY SHOULD BE MINIMIZED

REQUIREMENTS AND GUIDELINES (CONT'D)

DEPLOYMENT/RETRACTION

- RMS ASSIST AVAILABLE FOR DEPLOYMENT OR RETRACTION
- DEPLOYMENT TIME IS NOT CRITICAL (UNDER 1 HOUR)
- EVA AS BACKUP MODE ONLY

MODULARITY

- BOLT-ON VARIOUS LEVELS OF HEAT REJECTION DESIRED
- INTEGRATION FLEXIBILITY OPTIONS DESIRED
  - DEDICATED HEAT REJECTION MODULE
  - INTERFACE INDIVIDUAL PAYLOADS
- CONSIDER HEAT REJECTION DIRECTLY TO PAYLOAD OR ORBITER

STOWAGE

- LENGTH IN CARGO BAY: 1 M TO 3 M RANGE
- COMPATIBLE WITH 88 INCH RADIUS PAYLOAD ENVELOPE

MAINTENANCE AND GROUND OPERATIONS

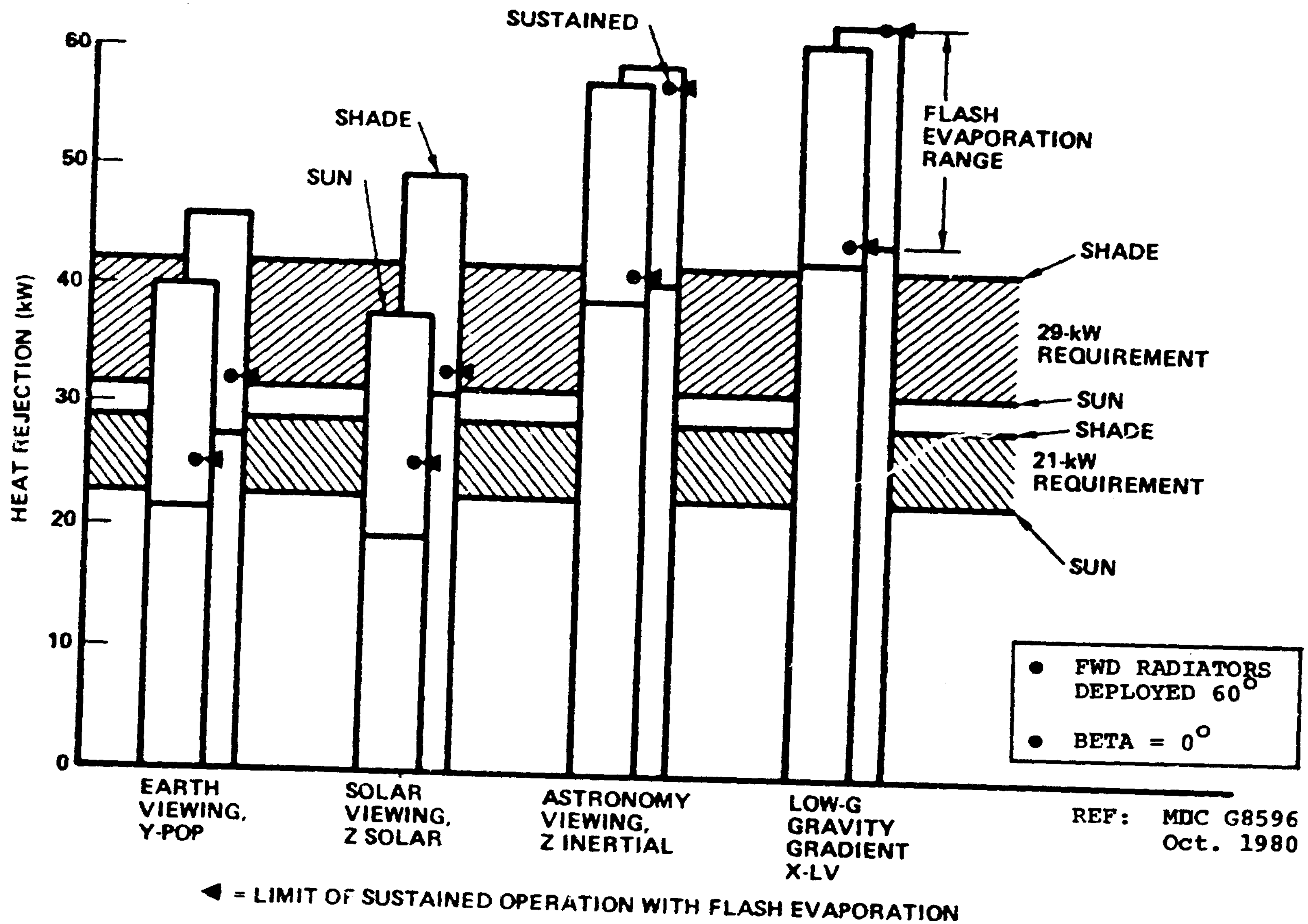
- BETWEEN MISSION MAINTENANCE ONLY (NONE PLANNED ON-ORBIT)
- KIT OPERATIONS SHOULD NOT IMPACT GROUND TURN AROUND TIME
- DESIGN KIT FOR "EASY IN/EASY OUT"

GENERAL

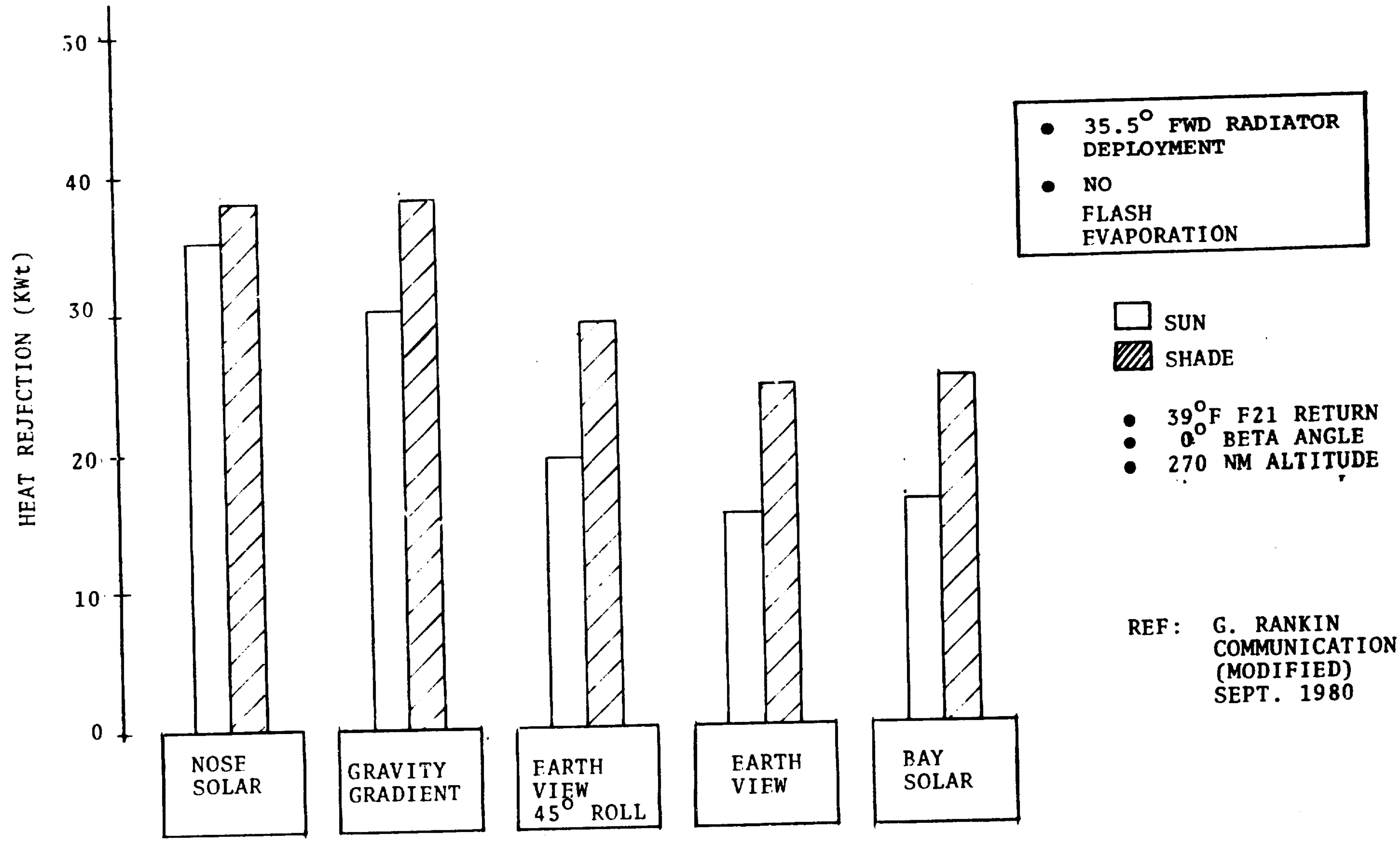
- MINIMIZE PAYLOAD VIEWING OBSTRUCTION
- MINIMIZE AERODYNAMIC DRAG
- MINIMIZE MOMENTS OF INERTIA
- MINIMIZE CONTAMINATION POTENTIAL TO PAYLOADS
- MINIMIZE INTERACTION WITH VRCS PLUME
- NO CREW MONITORING OR CONTROL AFTER DEPLOYMENT
- C&W INSTRUMENTATION
- EMPHASIZE "OFF-THE-SHELF" OR "MODIFIED OFF-THE-SHELF" HARDWARE
- TECHNOLOGY READINESS COMPATIBLE WITH PEP DEVELOPMENT SCHEDULE

DETERMINATION OF HEAT REJECTION REQUIREMENTS

ORBITER HEAT REJECTION WITH PEP



AVAILABLE ORBITER HEAT REJECTION



NET WATER GENERATION

NET WATER GENERATION/ORBIT*

(POUNDS)

CAVITY ANGLE	EARTH VIEW	SOLAR VIEW	ASTRO. VIEW	GRAV. GRAD.
36^{0}	-13.5	-20.5	+14.1	+4.9
45^{0}	-10.8	-19.3	+14.1	-1.2
60^{0}	-6.6	-15.0	+14.1	+1.5

* FUEL CELL GENERATION - FES USE-CREW USE

NOTE: 5 LB WATER PER 90 MINUTE ORBIT PROVIDES 1 KWt FES HEAT REJECTION AT 95% EVAPORATION EFFICIENCY.

VOUGHT

RESULTING SUPPLEMENTAL HEAT REJECTION REQUIREMENTS

BETA = 0°
270 NM
29 KWe

MISSION	TOTAL Q REQ'D (KWt)	QAVAIL. (KWt)		QDEFICIT=QSUPPL. REQ'D (KWt)	
		NO FE	SUSTAINED FE	NO FE	SUSTAINED FE
EARTH VIEW					
35.5° CAVITY					
SUN	31.5	15.3	NOT AVAILABLE	16.2	NOT AVAILABLE
SHADE	42.0	24.3		17.7	
60° CAVITY					
SUN	31.5	21.5	25.0	10.0	6.5
SHADE	42.0	27.5	32.0	14.5	10.0
SOLAR VIEW					
35.5° CAVITY					
SUN	31.5	16.0	NOT AVAILABLE	15.5	NOT AVAILABLE
SHADE	42.0	24.6		16.4	
60° CAVITY					
SUN	31.5	19.2	25.5	12.3	6.5
SHADE	42.0	31.0	33.0	11.0	9.0

REVISED: 2/16/81

SUPPLEMENTAL HEAT REJECTION REQUIREMENTS CONCLUSIONS

VOUGHT

- 60° RADIATOR DEPLOYMENT ANGLE DATA (MDAC) INIDCATES MAXIMUM LOADS ARE:

  NIGHTTIME: 14.5 KWt WITHOUT FE

  10.0 KWt WITH SUSTAINED FE

  DAYTIME : 12.3 KWt WITHOUT FE

  6.5 KWt WITH SUSTAINED FE

- 35.5° RADIATOR DEPLOYMENT ANGLE DATA (NASA) INDICATES MAXIMUM LOADS ARE:

  NIGHTTIME: 17.7 KWt WITHOUT FE

  DAYTIME : 16.2 KWt WITHOUT FE

  NO CORRESPONDING DATA WITH SUSTAINED FE OPERATION ARE AVAILABLE.

- RECENT ROCKWELL DATA INDICATES LOWER MAXIMUM LOADS OF 3-4 KWt ORBITAL AVERAGE WITH SUSTAINED FE OPERATION.

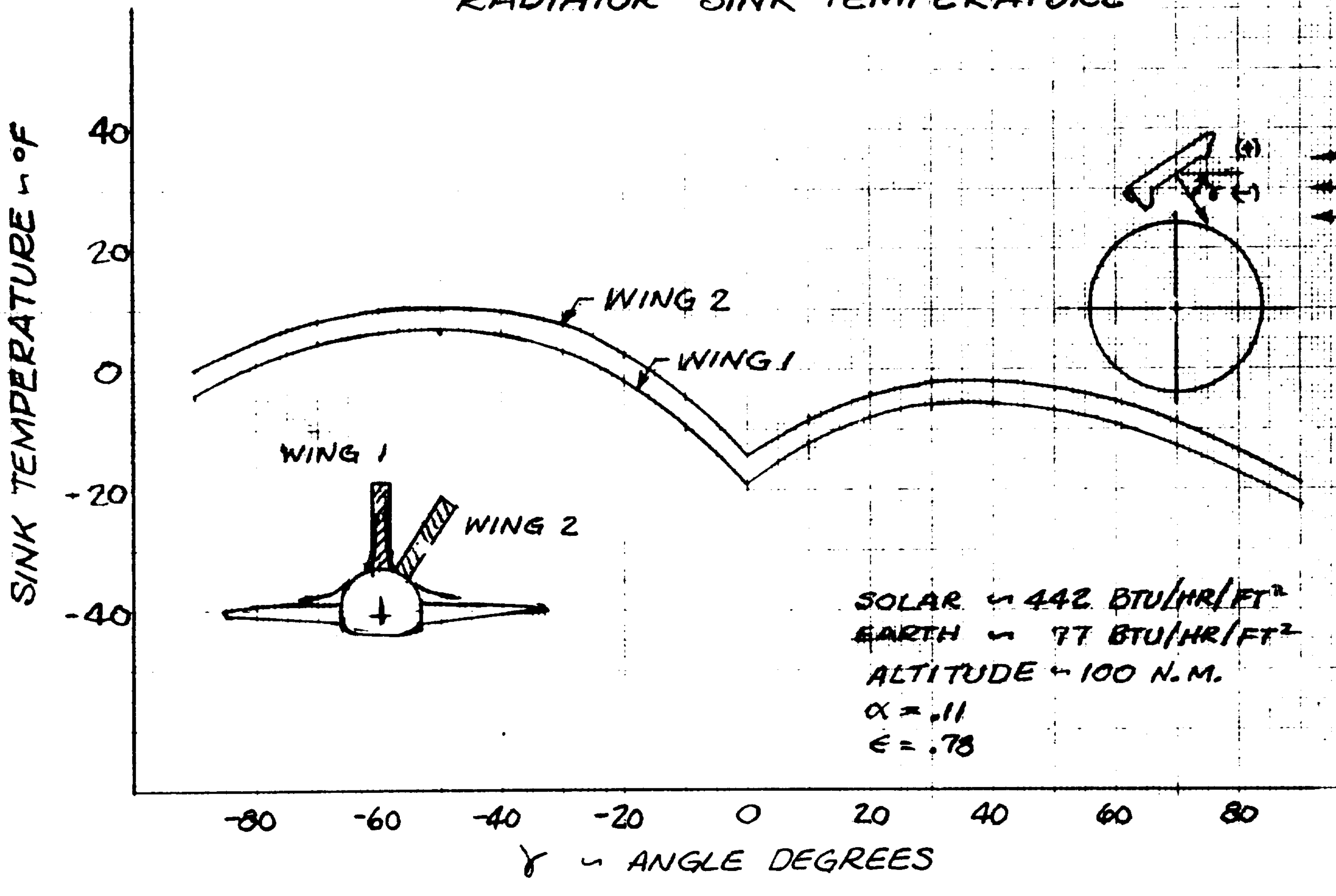
  - 36° RADIATOR DEPLOYMENT ANGLE REQUIREMENTS ARE ABOUT 1 KWt GREATER THAN 60°.

- CONCLUDE FOR CURRENT DESIGN STUDIES:

  - 8 KWt SUPPLEMENTAL HEAT REJECTION REQUIRED DAYTIME
  - 11 KWt SUPPLEMENTAL HEAT REJECTION REQUIRED NIGHTTIME

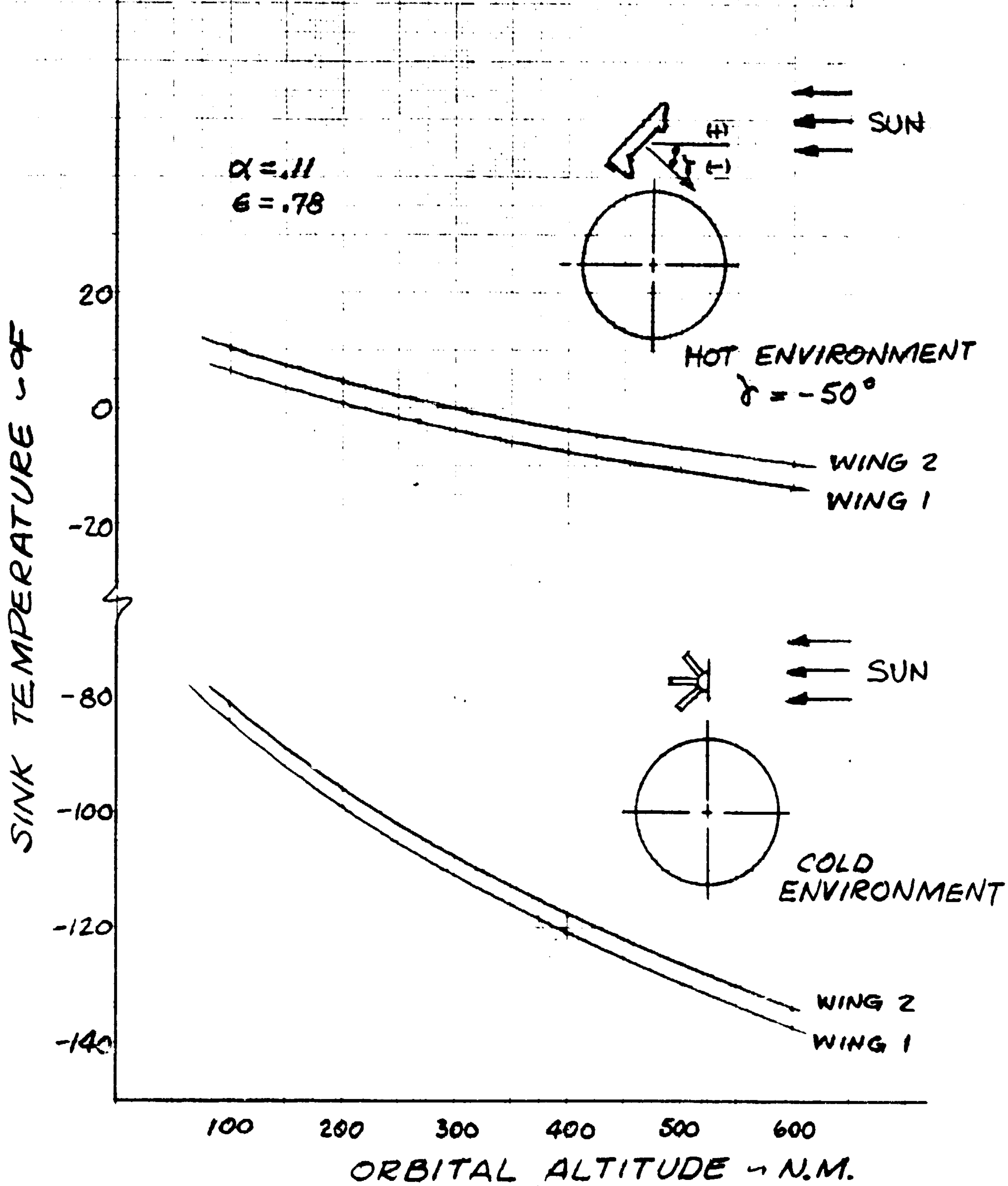
DETERMINATION OF ENVIRONMENTAL SINK TEMPERATURES

RADIATOR SINK TEMPERATURE



VOUGHT

EFFECT OF ORBIT ALTITUDE ON SINK TEMPERATURE



CONCLUSIONS FROM ENVIRONMENT STUDIES

- WORST ENVIRONMENTS ARE AT BETA = 90° AND VEHICLE ORIENTED WITH CARGO BAY VIEWING BOTH EARTH AND SUN:

  $T_{SINK} = 10^{\circ}F$ @ 100 NM

  $T_{SINK} = -10^{\circ}F$ @ 600 NM

- WORST CASE MISSIONS AVAILABLE FROM PEP STUDIES ARE AT 0° BETA AND 270 NM

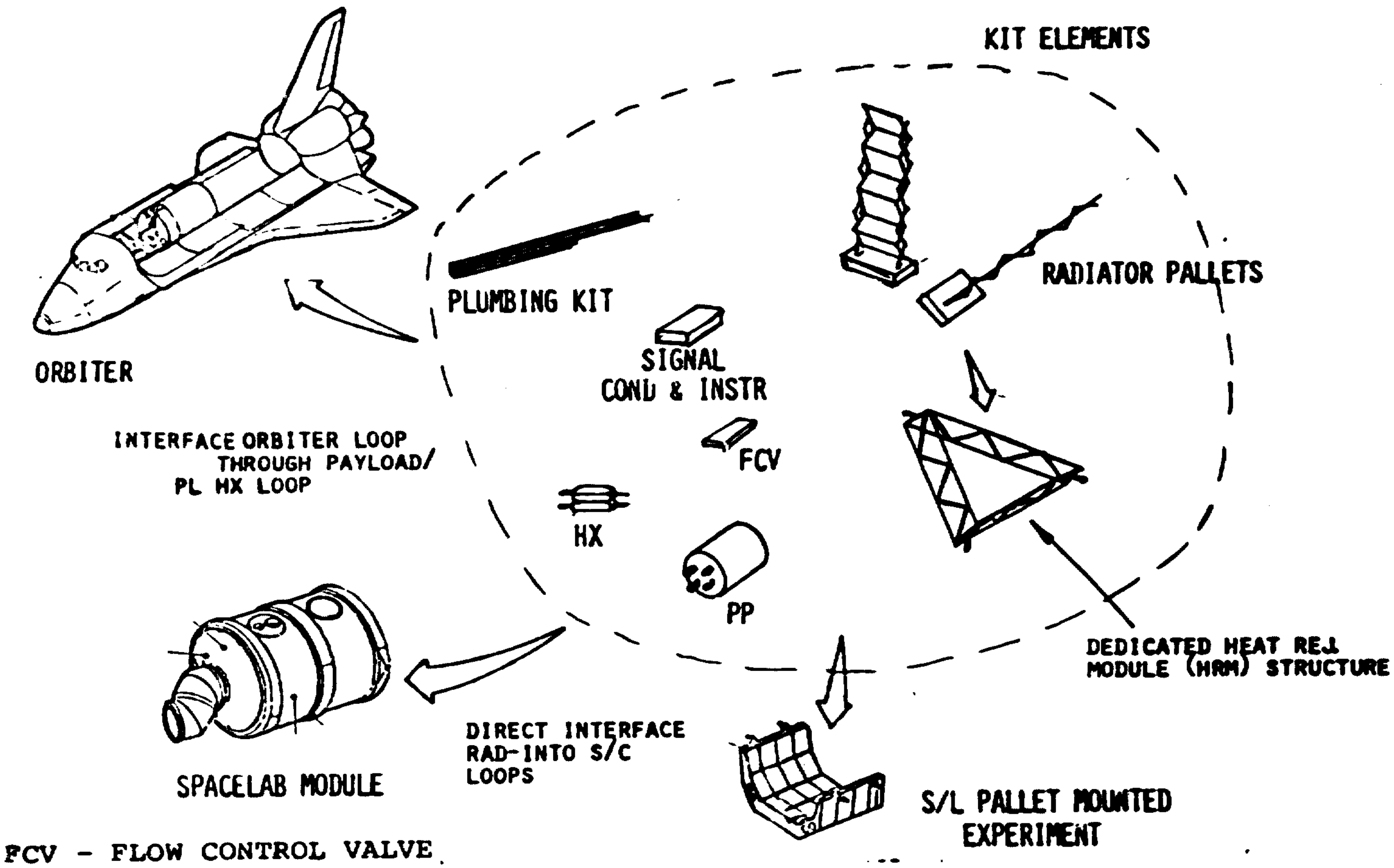
  - EXPFCT T_{SINK} BELOW $0^{\circ}F$

- SELECT $T_{SINK} = 0^{\circ}F$ FOR PARAMETRIC HFAT REJECTION STUDIES

CONCEPT STUDIES AND TRADES

VOUGHT

RADIATOR KIT CONCEPT AND INTEGRATION OPTIONS

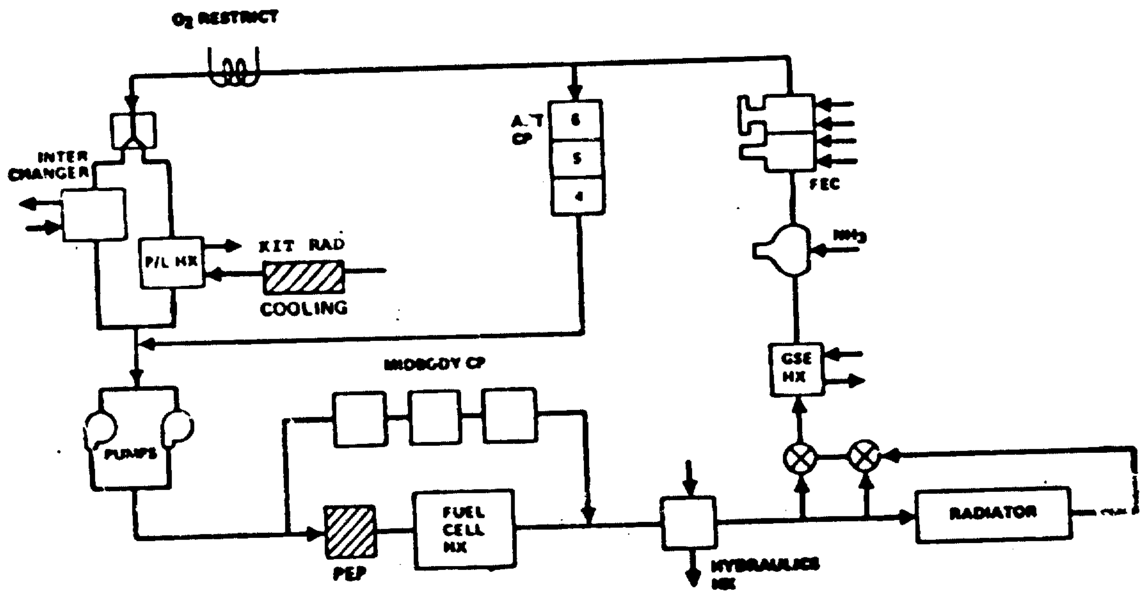


FCV - FLOW CONTROL VALVE
PP - PUMP PACKAGE

FLUID LOOP INTEGRATION CONCEPTS

FLUID LOOP INTEGRATION OPTIONS

CONCEPT A - INTEGRATION INTO ORBITER PAYLOAD HEAT EXCHANGER, THROUGH PAYLOAD SIDE OF LOOP



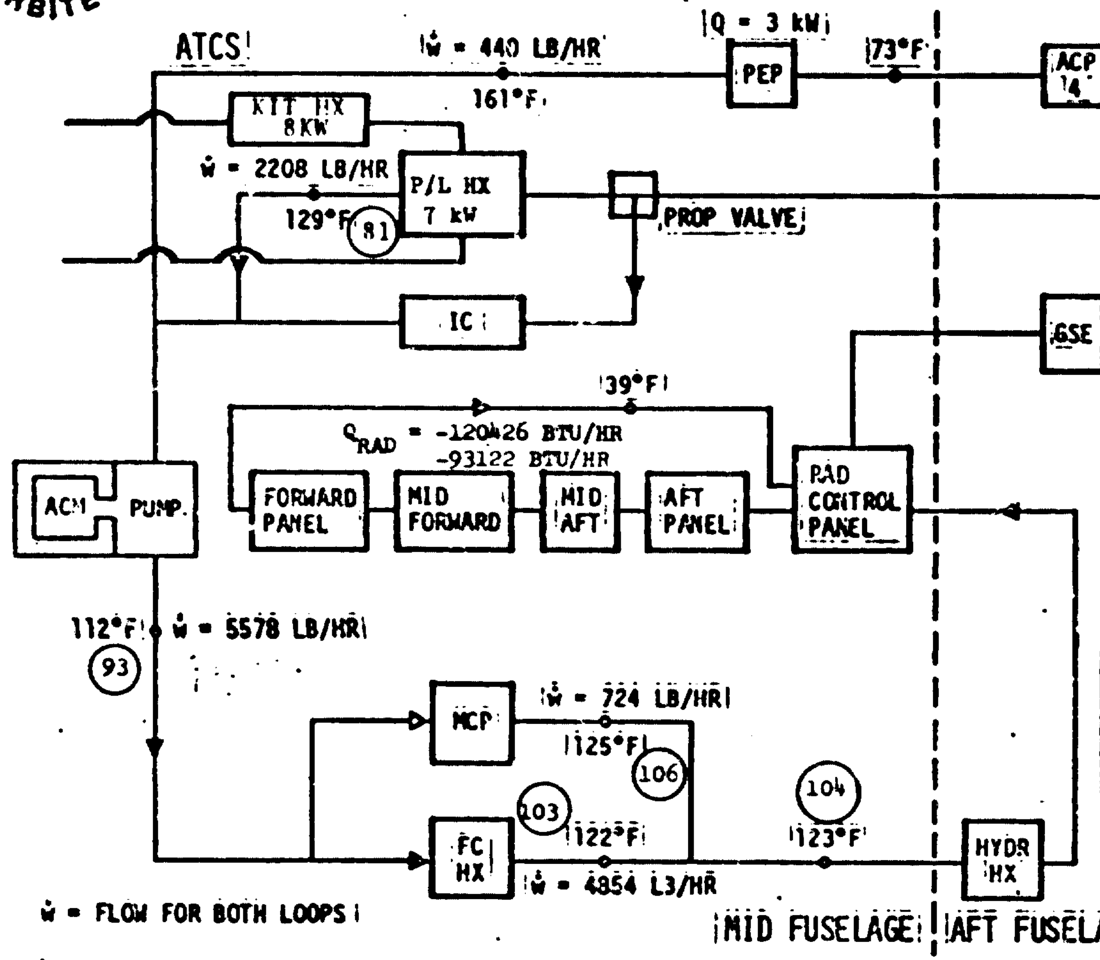
ISSUES:

1. DOES THIS ADEQUATELY REDUCE ORBITER ATCS LOADS TO PREVENT OVERTEMPERATURE OF ORBITER EQUIPMENT?
2. DOES IT PROVIDE ADEQUATE COOLING OF PAYLOAD EQUIPMENT (I.E., ESPECIALLY SPACELAB)?

CONCEPT A - IMPACT ON ORBITER EQUIPMENT COOLING

ATCS PERFORMANCE - SUN SIDE OF ORBIT
15 kW PAYLOAD PLUS 3 kW PEP

VOUGHT

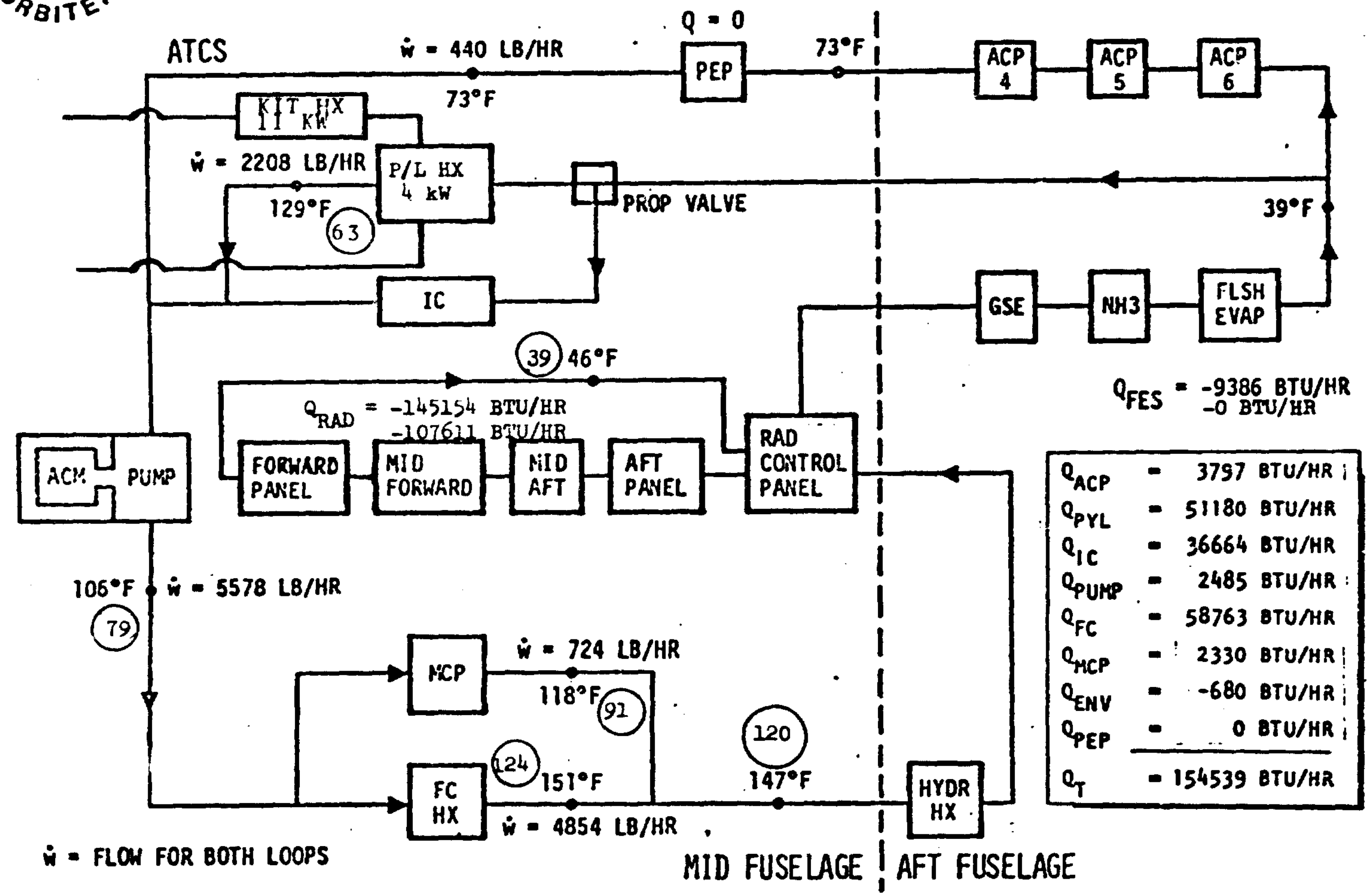


Q_{ACP}	=	13797 BTU/HR
Q_{PYL}	=	51180 BTU/HR
Q_{IC}	=	36664 BTU/HR
Q_{PUMP}	=	2485 BTU/HR
Q_{FC}	=	14420 BTU/HR
Q_{MCP}	=	2330 BTU/HR
Q_{ENV}	=	-680 BTU/HR
Q_{PEP}	=	10230 BTU/HR
Q_T	=	120426 BTU/HR

CONCEPT A - IMPACT ON ORBITER EQUIPMENT COOLING

ATCS PERFORMANCE - SHADOW SIDE OF ORBIT
15 kW PAYLOAD PLUS 0 kW PEP

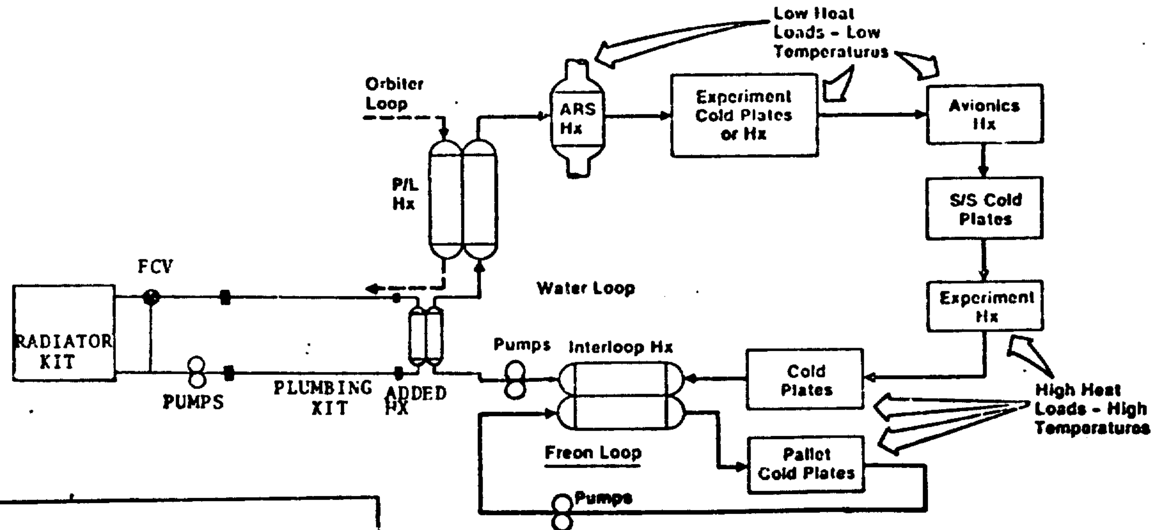
VOUGHT

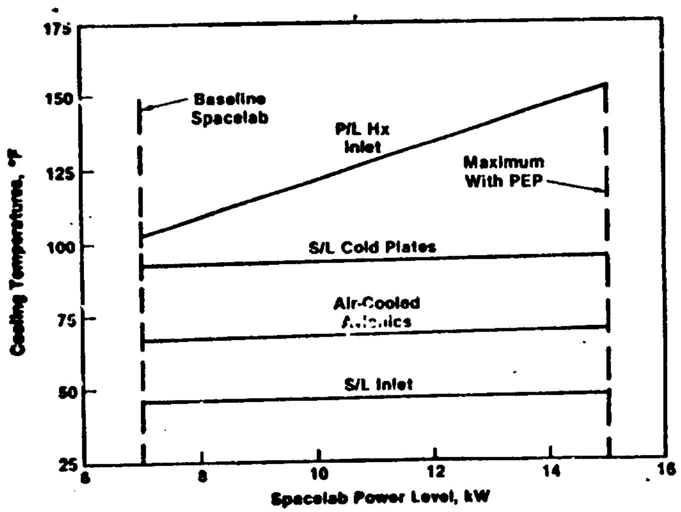


Q_{ACP}	=	3797 BTU/HR
Q_{PYL}	=	51180 BTU/HR
Q_{IC}	=	36664 BTU/HR
Q_{PUMP}	=	2485 BTU/HR
Q_{FC}	=	58763 BTU/HR
Q_{MCP}	=	2330 BTU/HR
Q_{ENV}	=	-680 BTU/HR
Q_{PEP}	=	0 BTU/HR
Q_T	=	154539 BTU/HR

CONCEPT A EVALUATION
EFFECT ON SPACELAB COOLING

VOUGHT





EFFECT ON SPACELAB TEMPERATURES:

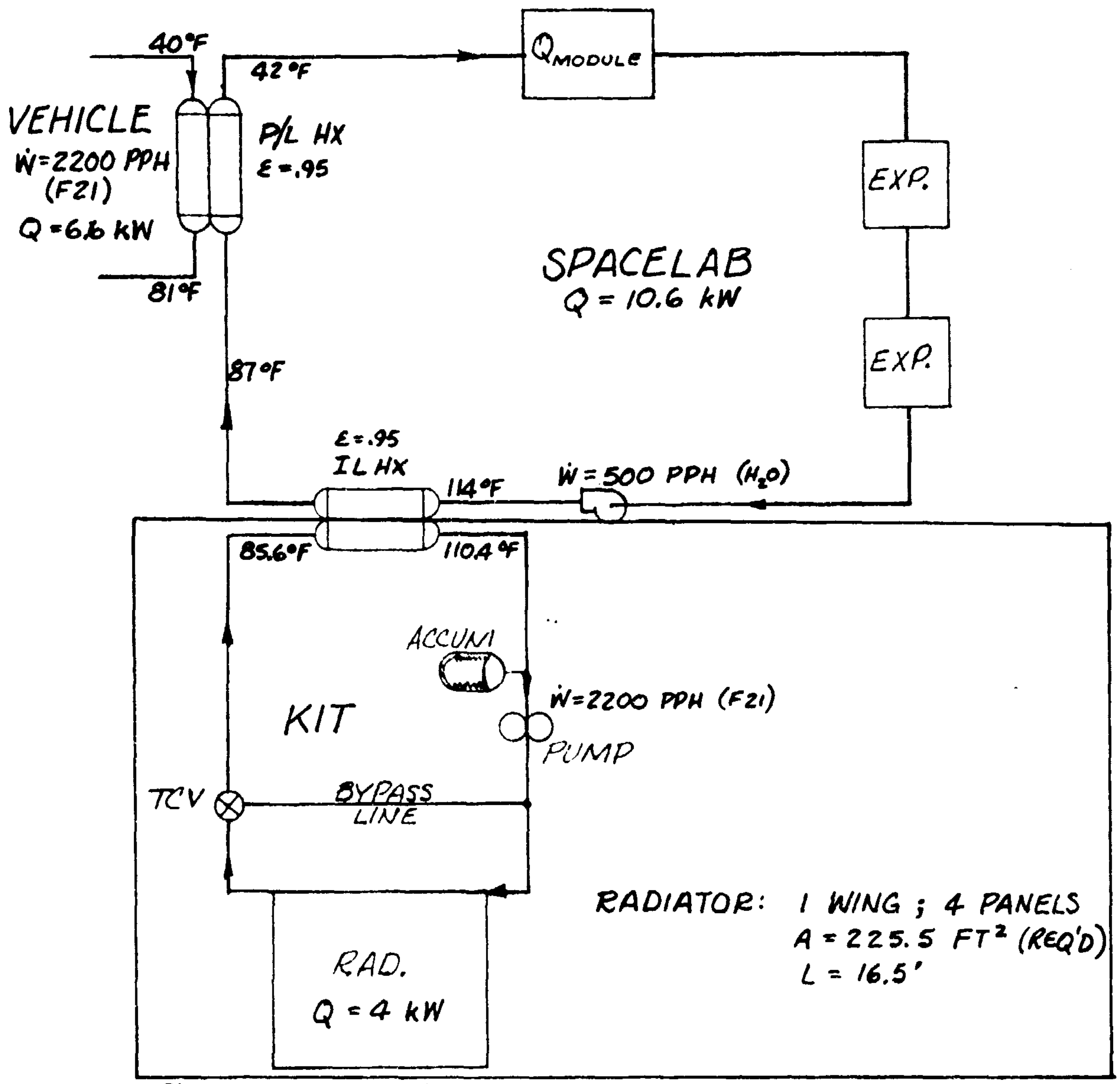
- CURVE INDICATES APPROX. 150°F MAXIMUM TEMPERATURE IN PAYLOAD LOOP (PROBABLY OK)
- ORBITER EQUIPMENT COOLING OK PER PRIOR CHART
- MORE DETAILED EVALUATION OF S/L INLET TEMP NEEDED

CONCEPT A

EVALUATION OF EFFECT ON SPACELAB COOLING
(CASE FOR MINIMAL ELECTRICAL POWER CHANGES TO SPACELAB

INTERLOOP HX INTERFACE
(ILHX SAME AS PLHX)

VOUGHT



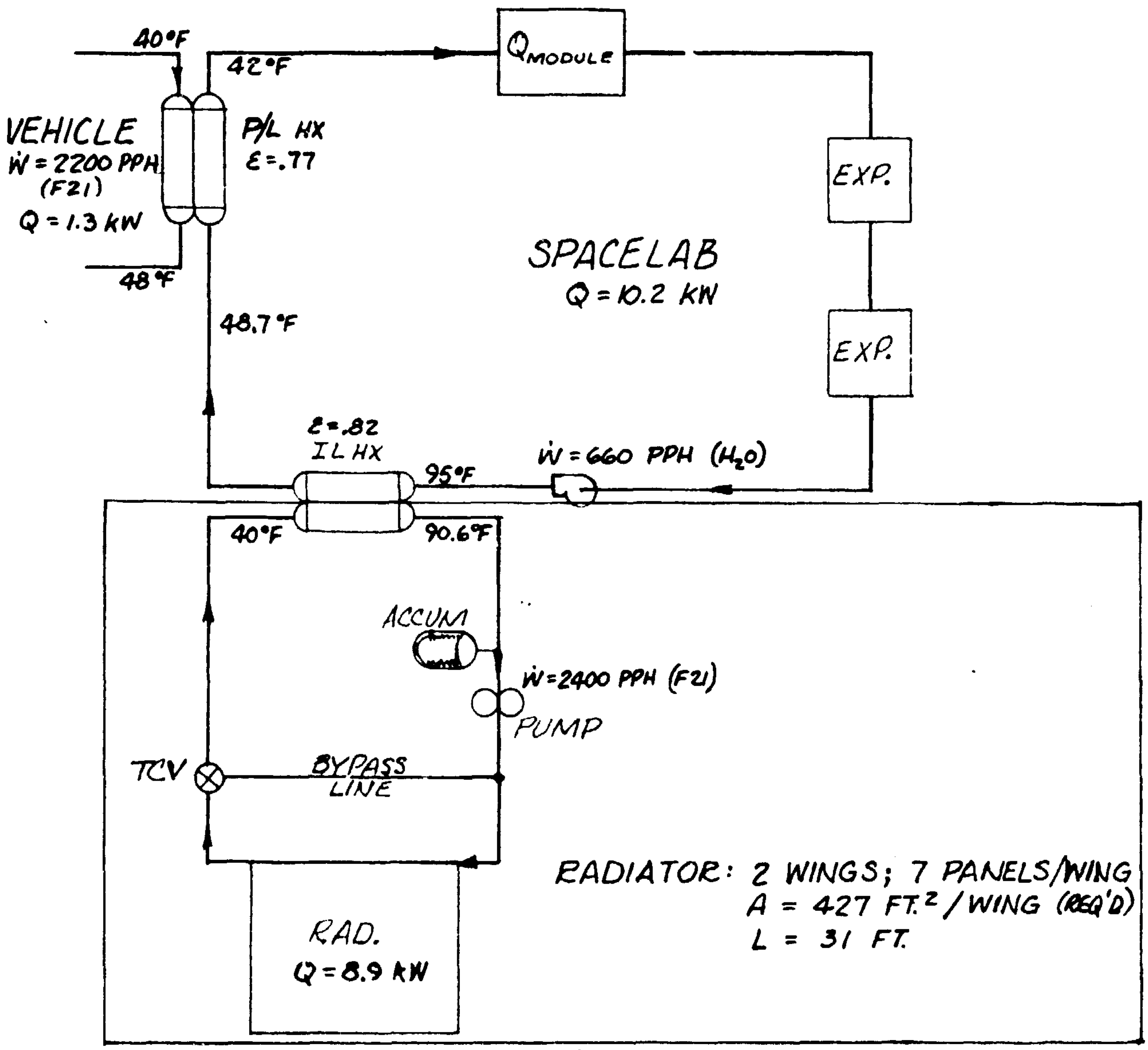
EXAMPLE SHOWN WITH HARD TUBE RADIATOR

RESULTS:

1. ILHX ADDS ABOUT 1.5 PSI WATER ΔP
2. 4 KW SUPPLEMENTARY HEAT REJECTION MAINTAINS SPACELAB WATER INLET AT 42°F AND ORBITER LOAD BELOW 8.5 kW

CONCEPT A
EVALUATION OF EFFECT ON SPACELAB COOLING
(CASE FOR MINIMAL ELECTRICAL POWER CHANGES)
INTERLOOP HX INTERFACE
(ILHX SAME AS PLHX)
INCREASED SPACELAB WATER FLOW

VOUGHT

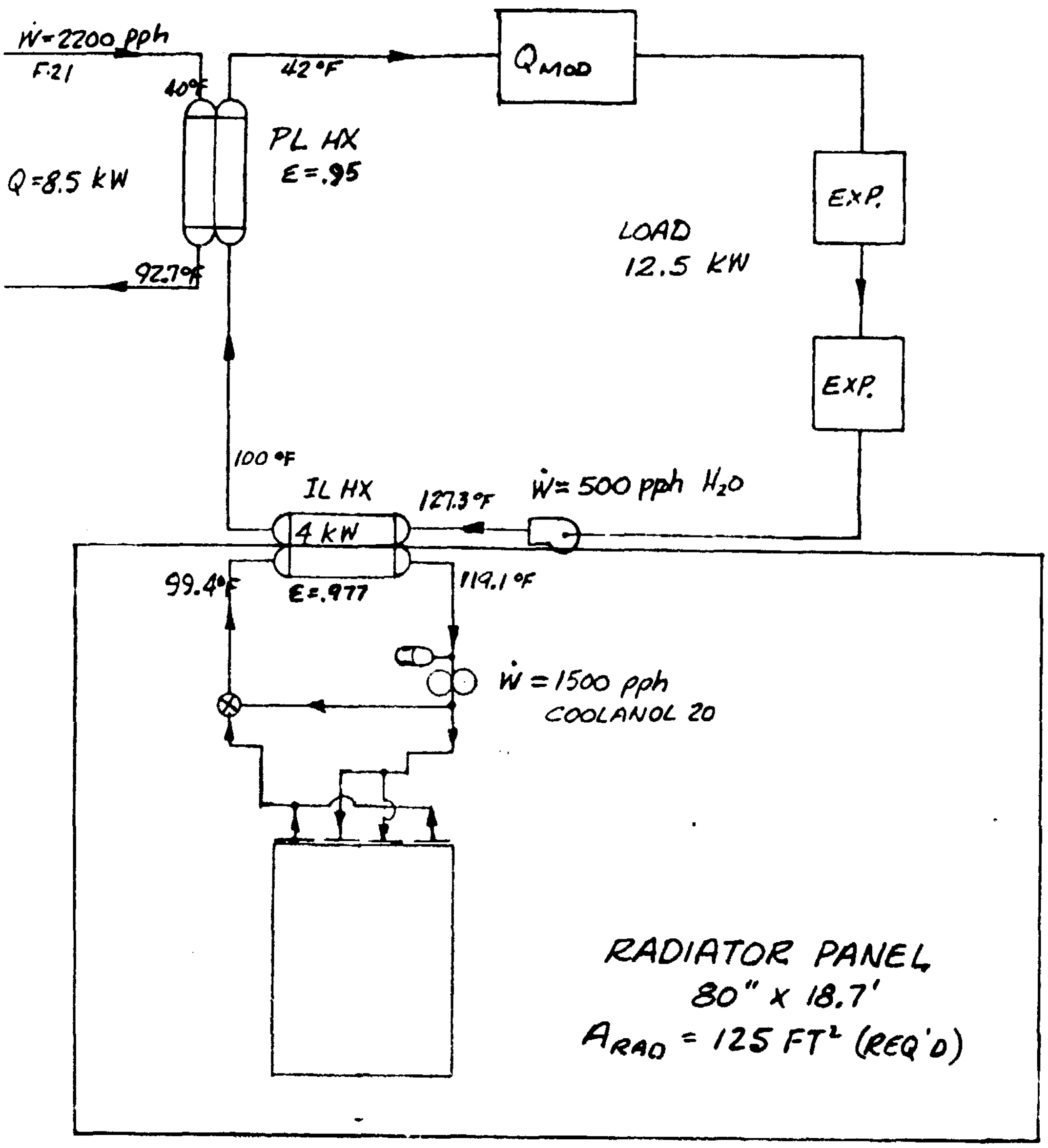


EXAMPLE SHOWN WITH HARD TUBE RADIATOR

RESULTS:

1. ILHX ADDS ABOUT 2.5 PSI WATER ΔP
2. 8.9 kW SUPPLEMENTARY HEAT REJECTION MAINTAINS SPACELAB INLET TEMPERATURE AT 42°F
3. NO ADVANTAGE TO RAISING WATER FLOWRATE

CONCEPT A
EVALUATION OF EFFECT ON SPACELAB COOLING
(CASE FOR MORE EXTENSIVE ELECTRICAL POWER CHANGES TO SPACELAB)
INTERLOOP HX INTERFACE
(ILHX SAME AS PLHX)



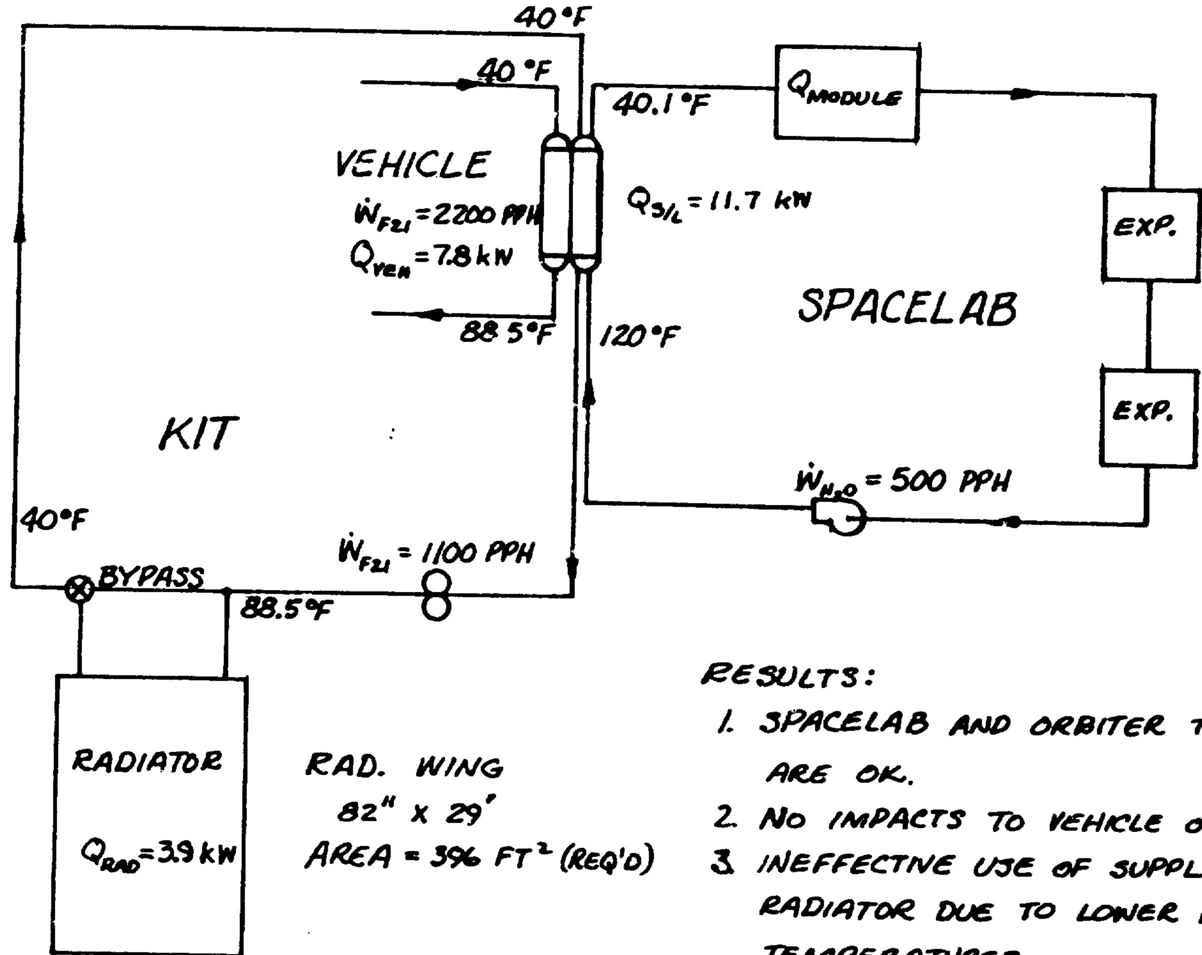
EXAMPLE SHOWN WITH SOFT TUBE RADIATOR

RESULTS:

1. ILHX ADDS ABOUT 1-1.5 PSI WATER ΔP
2. 4 KW SUPPLEMENTARY HEAT REJECTION MAINTAINS SPACELAB WATER INLET AT 42°F AND ORBITER LOAD AT 8.5 KW_t

VOUGHT

CONCEPT A
EVALUATION OF EFFECT ON SPACELAB COOLING KIT COOLING THROUGH PAYLOAD HX
(CASE FOR MINIMAL ELECTRICAL POWER CHANGES TO SPACELAB FOR PEP



RAD. WING
82" x 29'
AREA = 396 FT² (REQ'D)

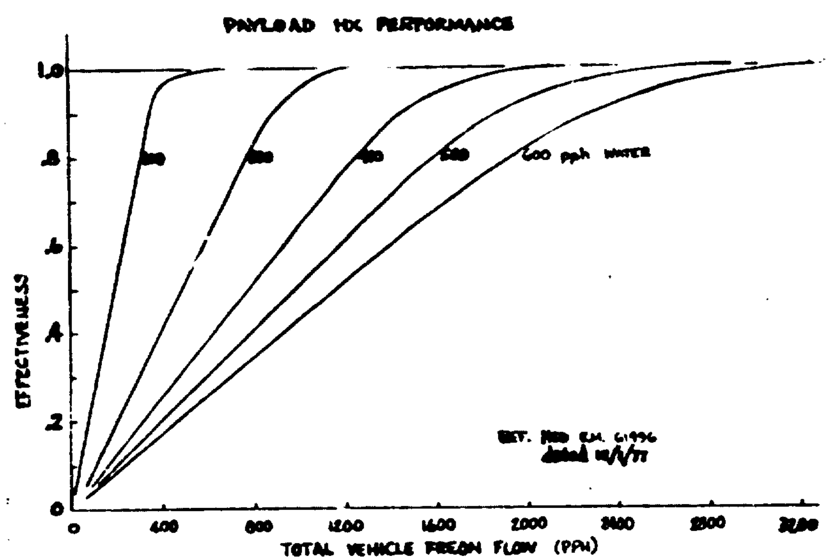
RESULTS:

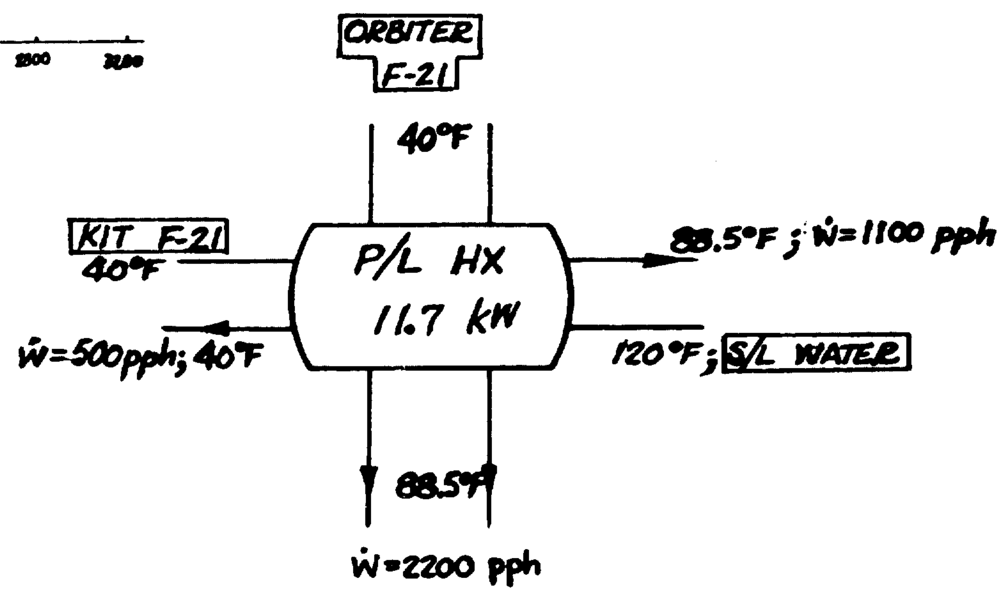
1. SPACELAB AND ORBITER TEMPERATURES ARE OK.
2. NO IMPACTS TO VEHICLE OR SPACELAB
3. INEFFECTIVE USE OF SUPPLEMENTARY RADIATOR DUE TO LOWER KIT FLUID TEMPERATURES.

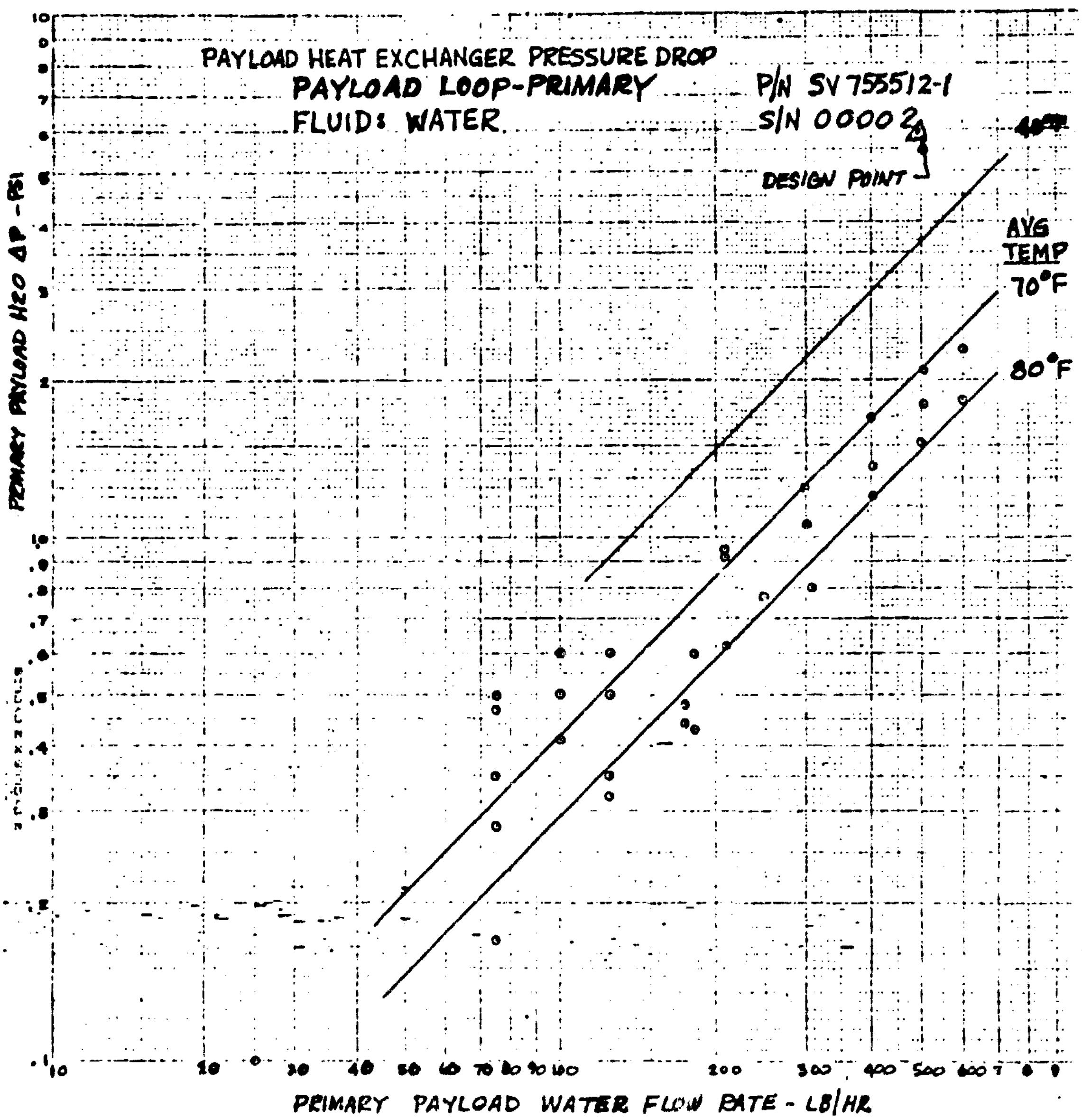
VOUGHT

VOUGHT

HEAT EXCHANGER ANALYSIS







REF. HSO E.M. 61996
DATED 12/1/77

J.V. CARMODY

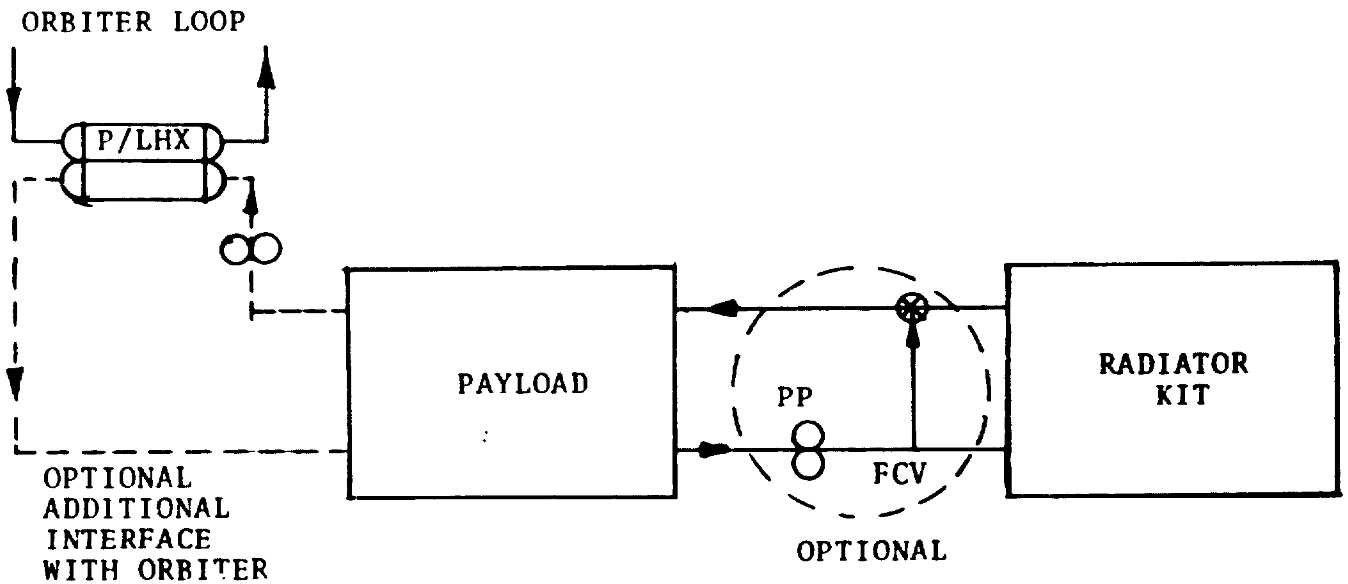
ASSESSMENT OF CONCEPT A

- ORBITER EQUIPMENT COOLING IS SATISFACTORY
- SPACELAB THERMAL INTERFACE CONCEPT APPEARS SATISFACTORY
  - SMALL INCREASE IN WATER LOOP DELTA-P
  - NO NEED TO INCREASE WATER FLOWRATE
- USE OF SECOND PASSAGE IN ORBITER PAYLOAD HX IS FEASIBLE WITH SPACELAB AND PROVIDES MINIMUM IMPACT (BUT MAXIMUM SUPPLEMENTARY RADIATOR AREA)
- PALLET PAYLOAD INTERFACES APPEAR WORKABLE
  - INTEGRATION CONCEPT IS PAYLOAD DEPENDENT

FLUID LOOP INTEGRATION OPTIONS

VOUGHT

CONCEPT B - INTEGRATION OF HEAT REJECTION DIRECTLY INTO PAYLOAD



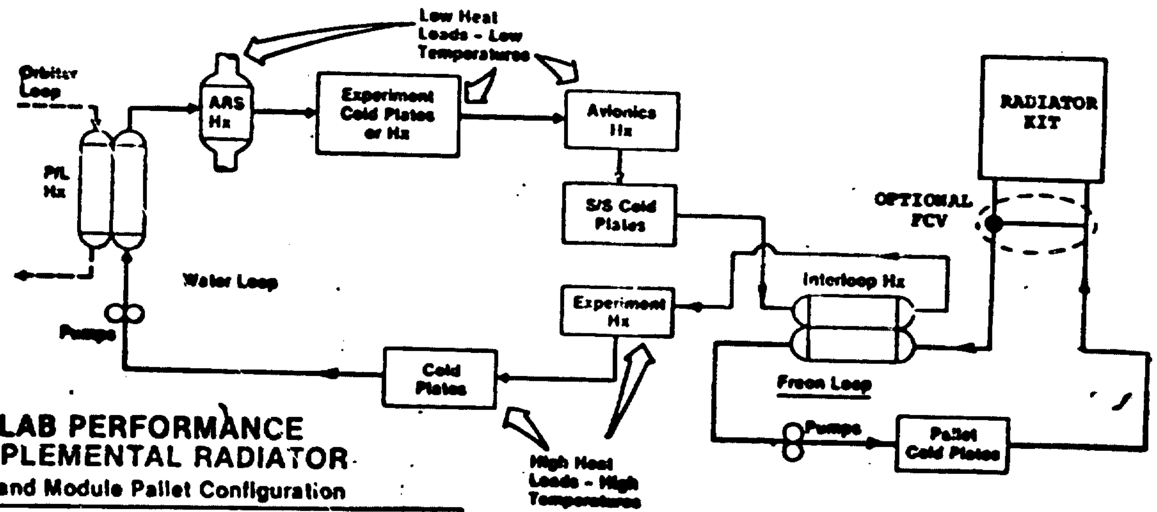
ISSUES:

1. DOES CONCEPT B ADEQUATELY REDUCE ORBITER ATCS LOADS TO PREVENT OVER TEMPERATURES OF ORBITER EQUIPMENT (ESPECIALLY WITH HIGH TEMPERATURE PAYLOADS REJECTING THEIR LOADS THROUGH KIT RADIATOR)?
2. DOES IT PROVIDE ADEQUATE COOLING TO PAYLOAD EQUIPMENT?

CONCEPT B EVALUATION - SPACELAB

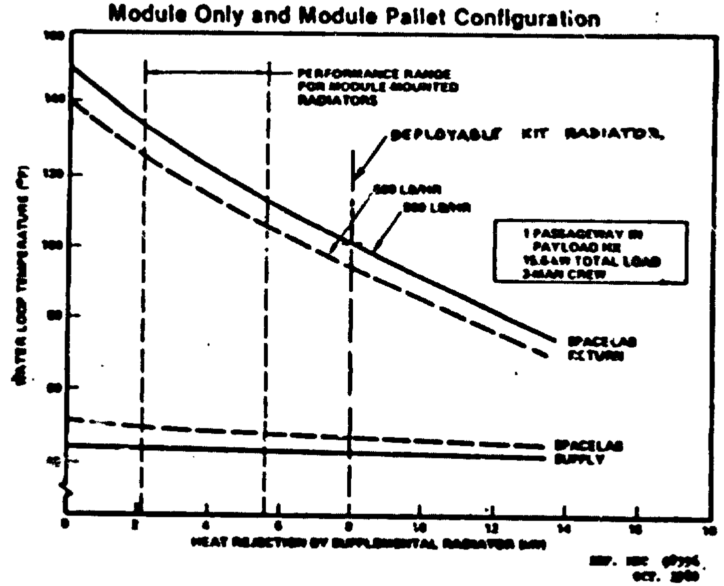
VOUGHT

(ESA CONCEPT)



SPACELAB PERFORMANCE WITH SUPPLEMENTAL RADIATOR

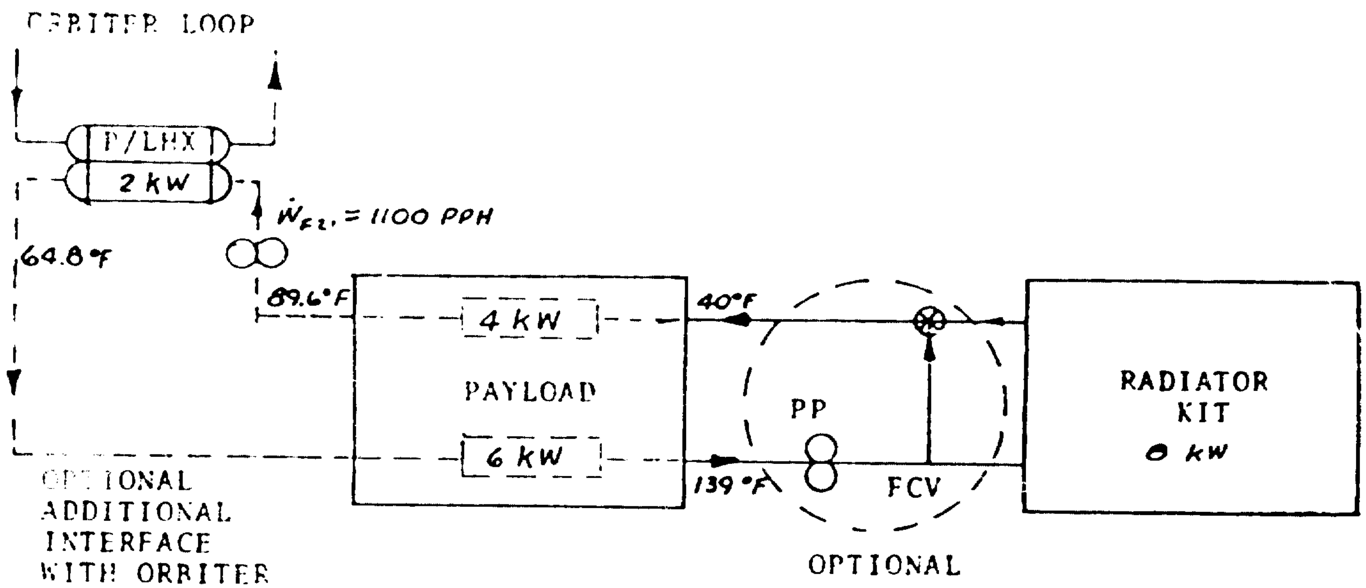
Module Only and Module Pallet Configuration



Conclusions:

1. Maximum water loop temperatures are reduced to about 100 F at 15 kW total load
2. No impact to Orbiter equipment cooling

CONCEPT B EVALUATION - EXAMPLE WITH 10 kW PAYLOAD

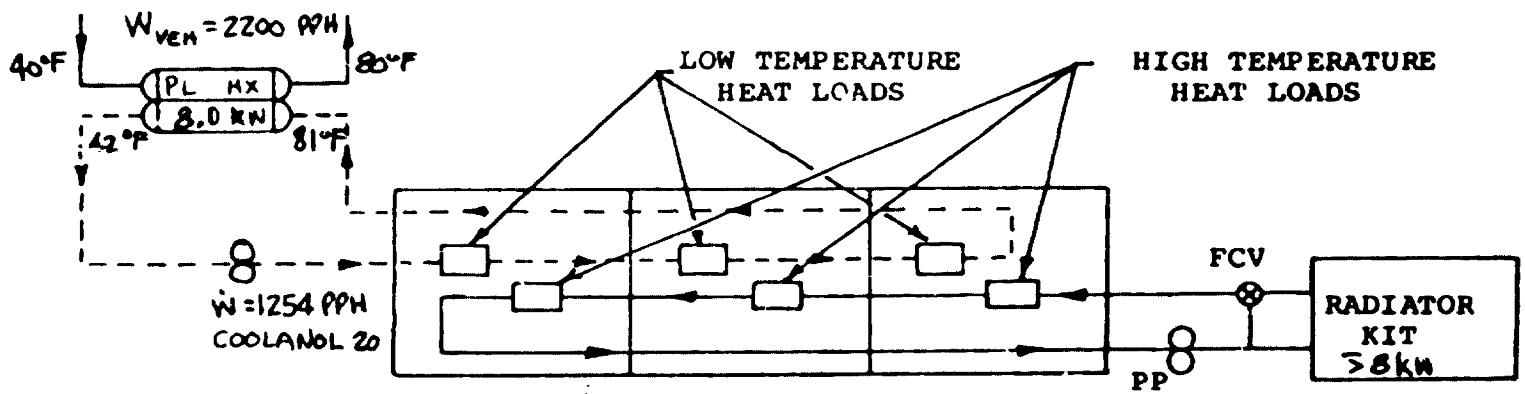


CONCLUSION:

1. UP TO 16.5 kW_t PAYLOAD HEAT CAN BE REMOVED USING FULL 8.5 kW_t ORBITER PAYLOAD HX CAPABILITY
2. NO IMPACT TO ORBITER EQUIPMENT COOLING UP TO THIS LEVEL

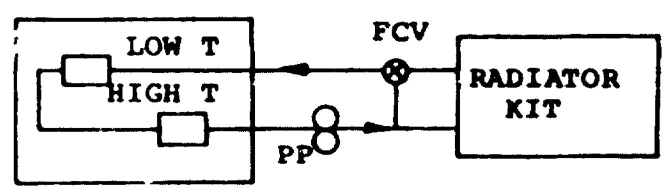
CONCEPT B EVALUATION - PALLET PAYLOADS

VOUGHT



OPTION 1 - SPLIT LOOP: COOL LOW T. LOADS WITH ORBITER, HIGH WITH KIT

OR ⟹



OPTION 2 - COOL ALL LOADS WITH KIT

CONCLUSION:

1. SPLIT LOOP PERMITS 8.5 kW_t LOW TEMP PAYLOAD COOLING PLUS > 8 kW_t HIGH TEMP PAYLOAD COOLING
2. NO IMPACT TO ORBITER COOLING AT THIS LEVEL

ASSESSMENT OF CONCEPT B

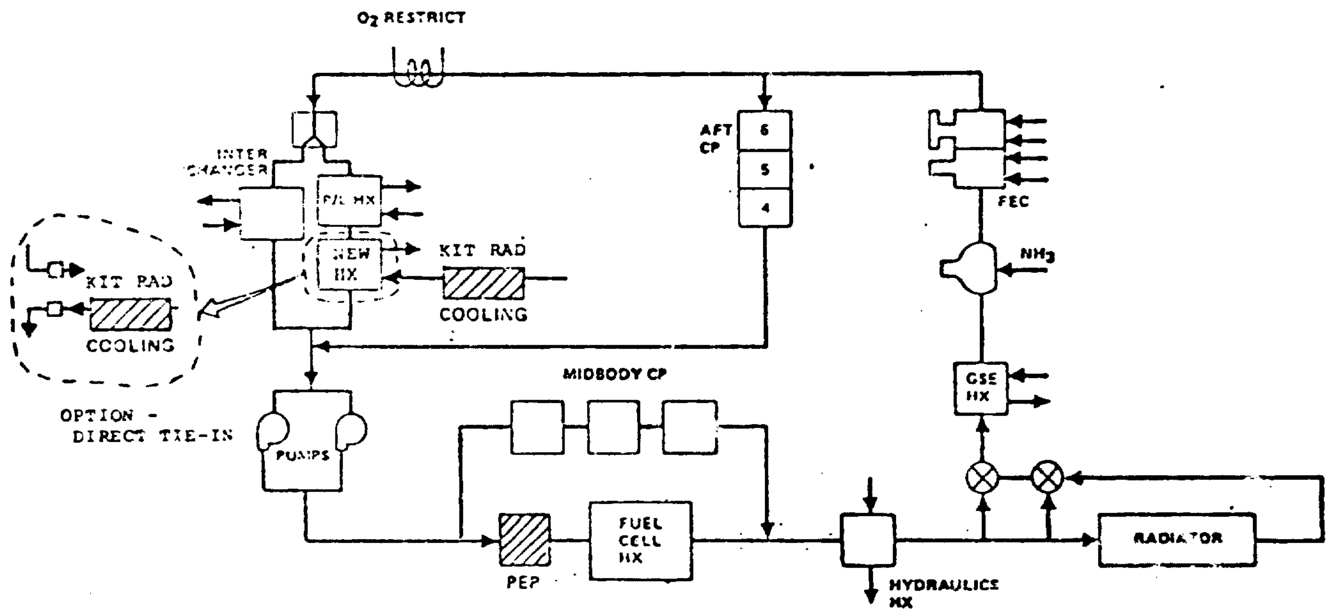
- ORBITER EQUIPMENT COOLING WOULD BE SATISFACTORY WITH SPACELAB AND WITH PALLET MODES
- SPACELAB THERMAL INTERFACE APPEARS SATISFACTORY, NEED EVALUATION OF FLOWRATE/ΔP IMPACT AND PHYSICAL INTERFACES
- PALLET PAYLOAD INTERFACES APPEAR WORKABLE, NEED EVALUATE RANGES OF APPLICABILITY AND APPLICABLE FLUIDS
- DEFINITE ADVANTAGE IN RADIATOR AREA AVAILABLE FOR PREDOMINATLY HIGH TEMPERATURE PALLET PAYLOADS

- CONCLUDE THAT INTEGRATION INTO PAYLOADS IS SATISFACTORY AND PROVIDES FLEXIBILITY OF OPTIONS

FLUID LOOP INTEGRATION OPTIONS

VOUGHT

CONCEPT C - INTEGRATION INTO ORBITER ATCS, THROUGH HEAT EXCHANGER OR THROUGH DIRECT TIE-IN



THIS CONCEPT ELIMINATED DUE TO ORBITER IMPACTS

RADIATOR CONCEPTS

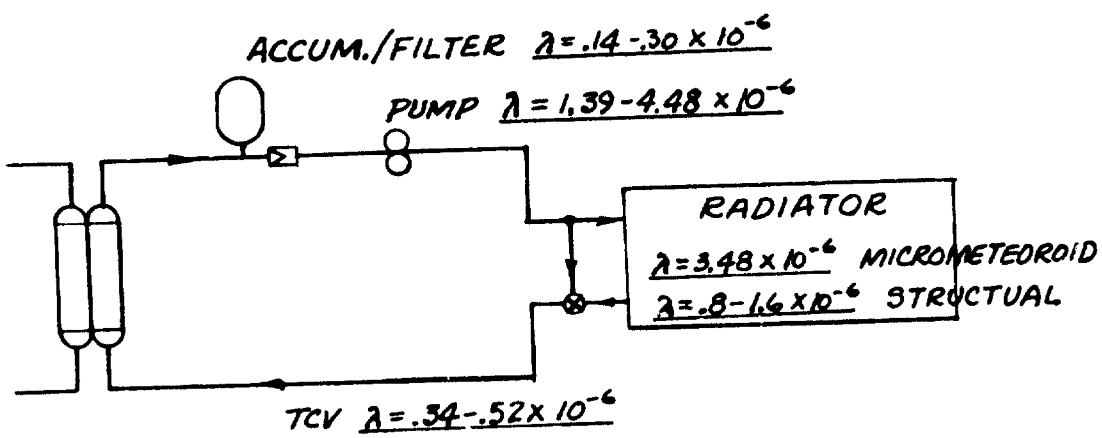
- RELIABILITY CONSIDERATIONS
- SOFT TUBE PANEL CONTROL SYSTEM
- PARAMETRIC ANALYSIS OF HEAT REJECTION CAPABILITY
- PANEL AND DEPLOYMENT CONCEPTS FOR CONSIDERATION
- DESIGN PACKAGING STUDIES ON RIGID PANEL CONCEPT
- HEAT PIPE VS PUMPED FLUID CONSIDERATION

VOUGHT

RADIATOR CONCEPTS -

- RELIABILITY CONSIDERATIONS

ORBITER KIT SYSTEM RELIABILITY



SINGLE COMPONENTS - SINGLE LOOP

FILL/DRAIN VALVES	$\lambda = .05 \times 10^{-6}$
TEMP. SENSOR	$\lambda = 1.5 \times 10^{-6}$
LINES/FITTINGS	$\lambda = .05 \times 10^{-6}$

PROBABILITY OF SUCCESS

MISSION LENGTH	PROBABILITY
30 DAYS	.994 - .991
48 DAYS	.991 - .986

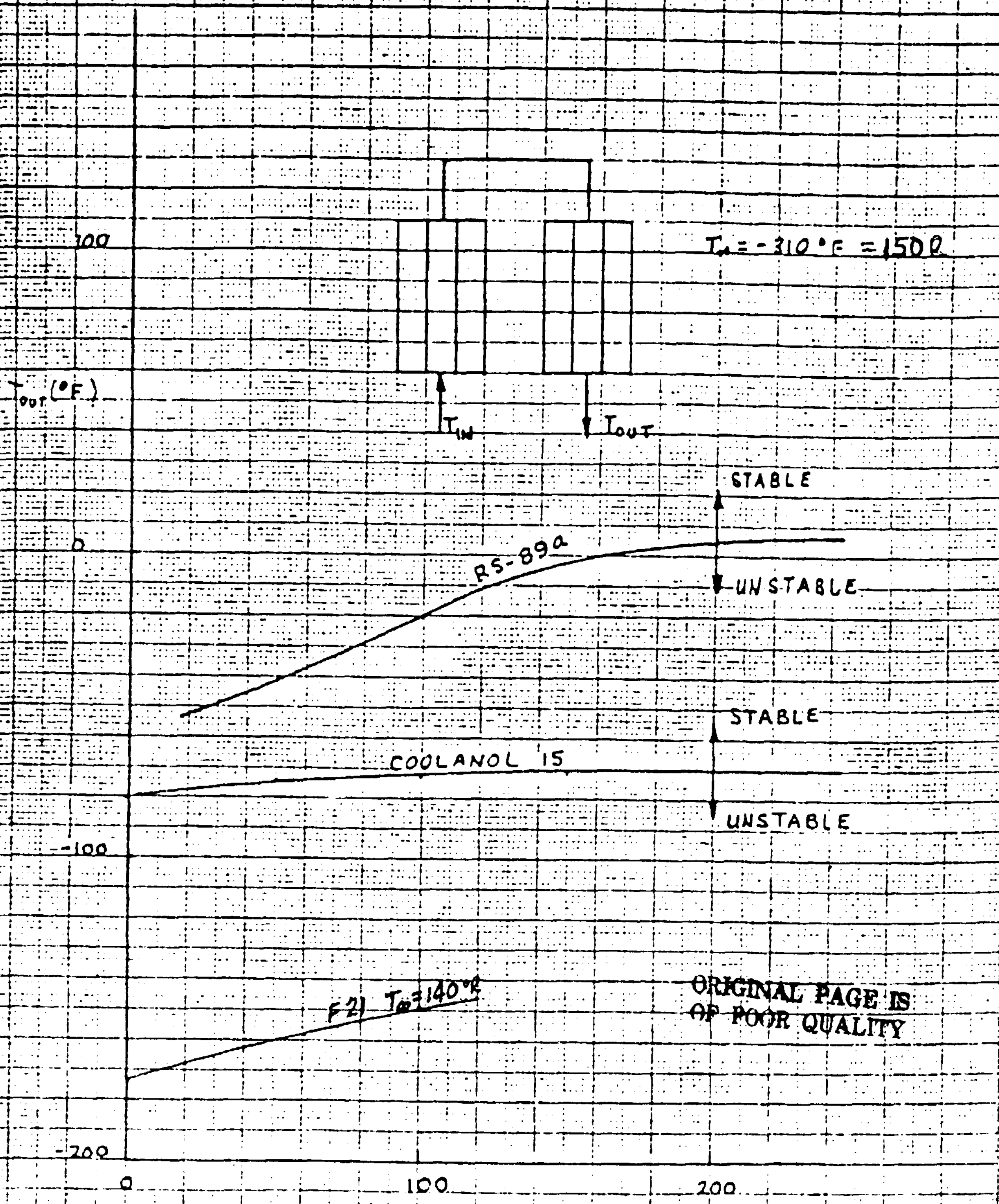
VOUGHT

VOUGHT

RADIATOR CONCEPTS -

- SOFT TUBE PANEL CONTROL SYSTEM

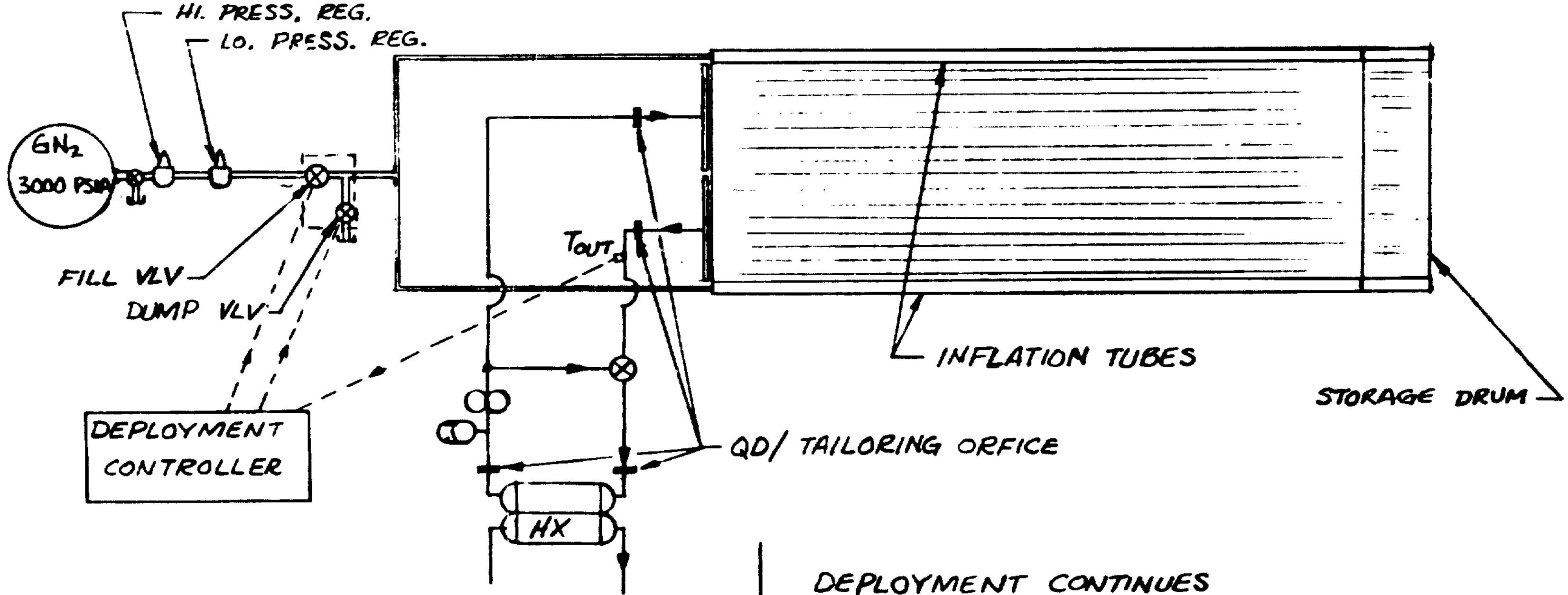
VOUGHT

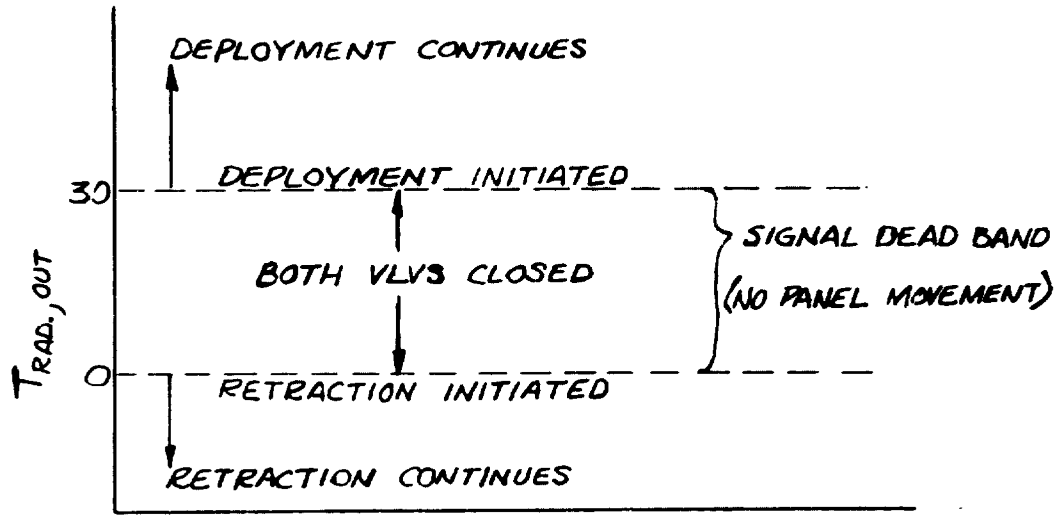


ORIGINAL PAGE IS OF POOR QUALITY

FIG. 1 APPROXIMATE STABILITY CURVES FOR CANDIDATE FLEXIBLE RADIATOR FLUIDS

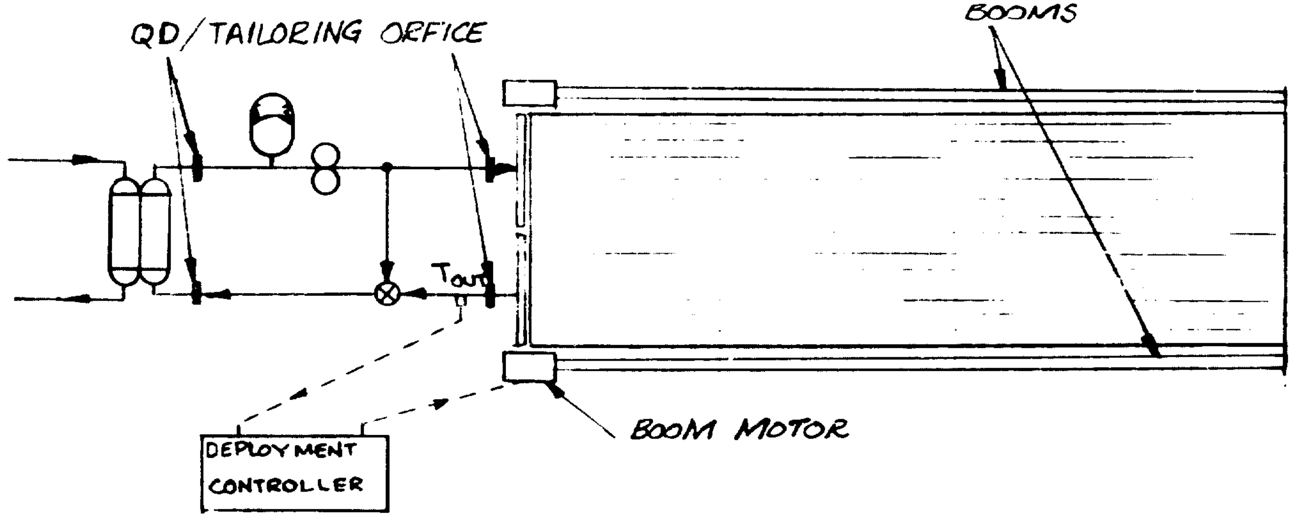
SOFT TUBE RADIATOR
DEPLOYMENT/RETRACTION CONTROL

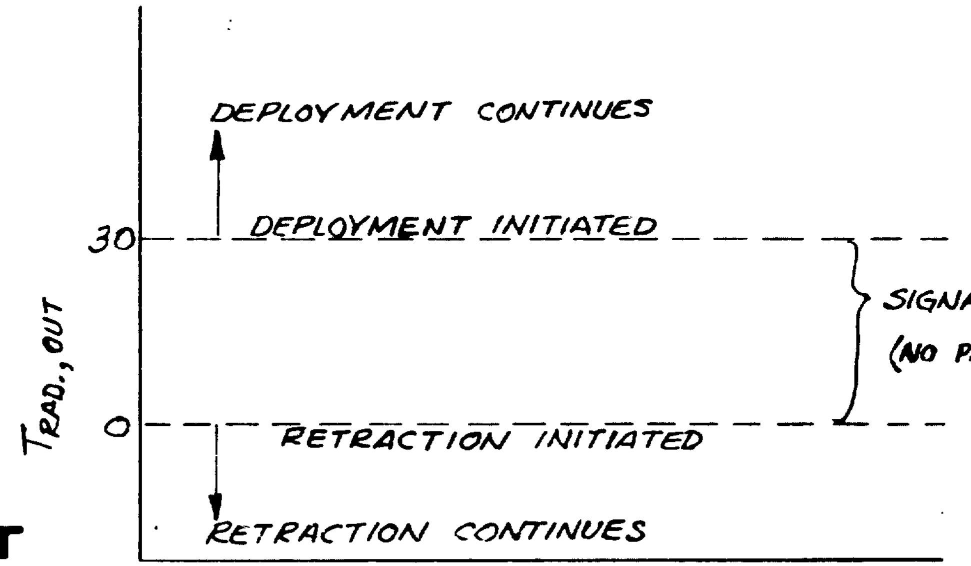




VOUGHT

SOFT TUBE RADIATOR
DEPLOYMENT/RETRACTION CONTROL



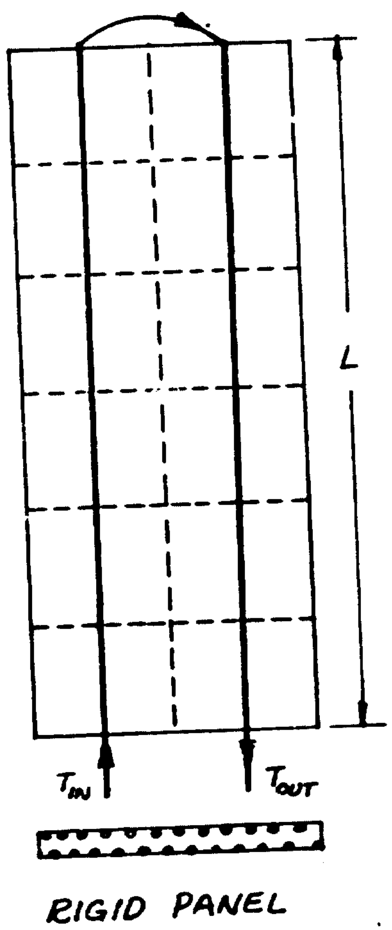


VOUGHT

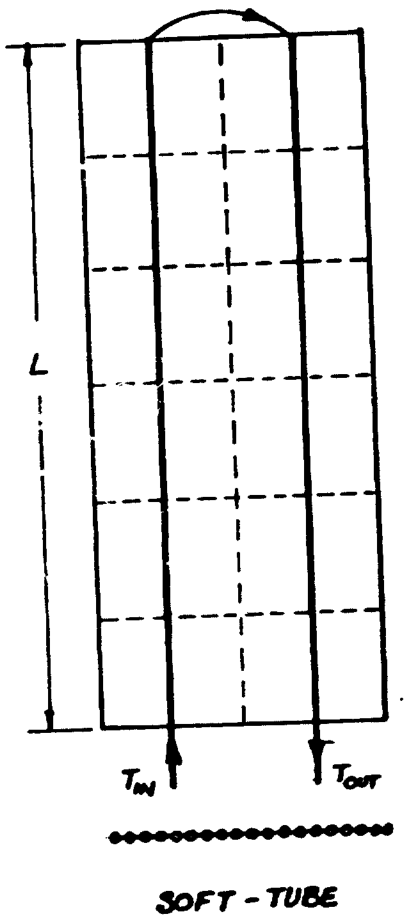
RADIATOR PANEL CONCEPTS -

- PARAMETRIC ANALYSIS OF HEAT REJECTION CAPABILITY

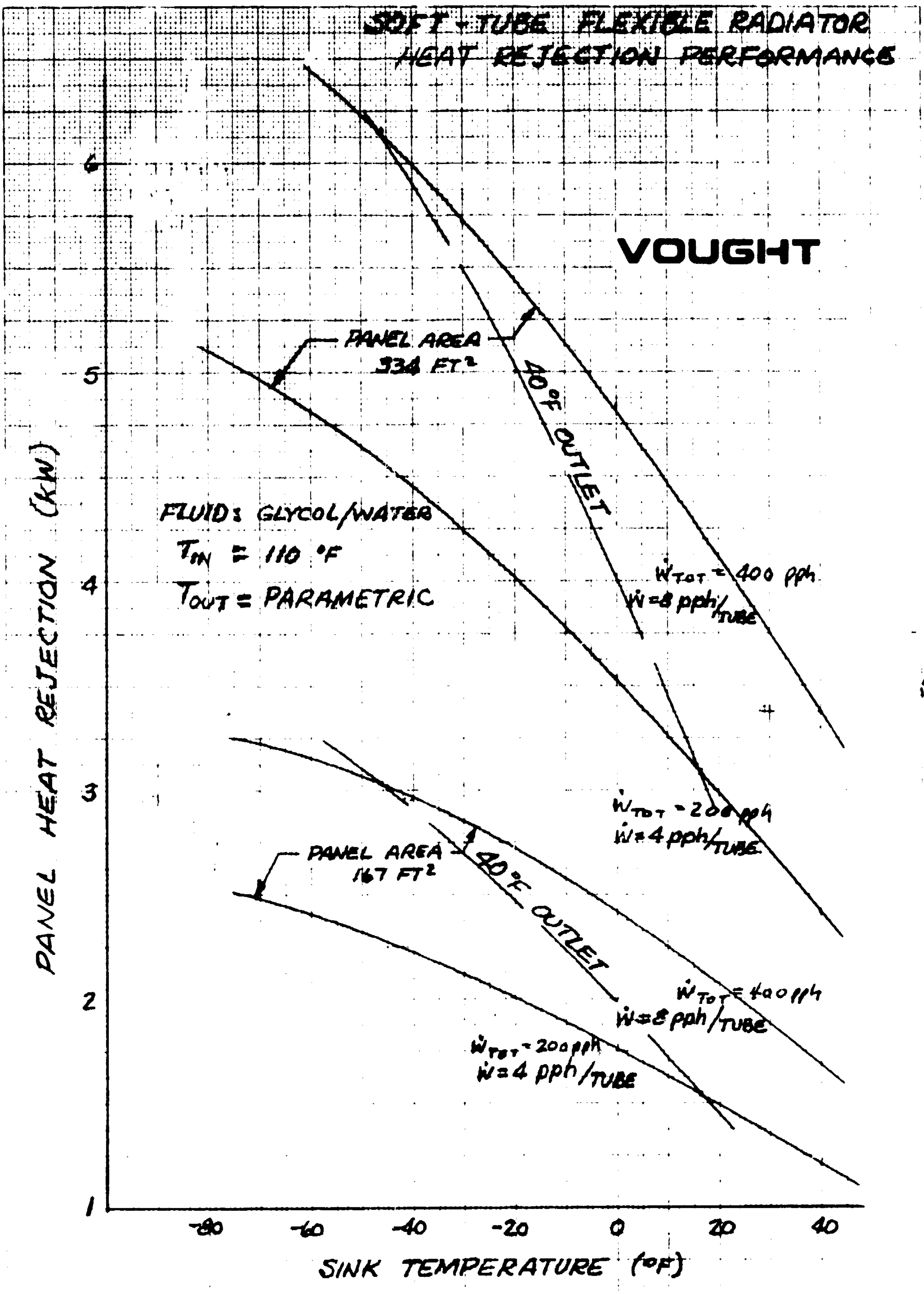
RADIATOR ANALYSIS MODEL



ITERATIVE,
STEADY STATE
PERFORMANCE

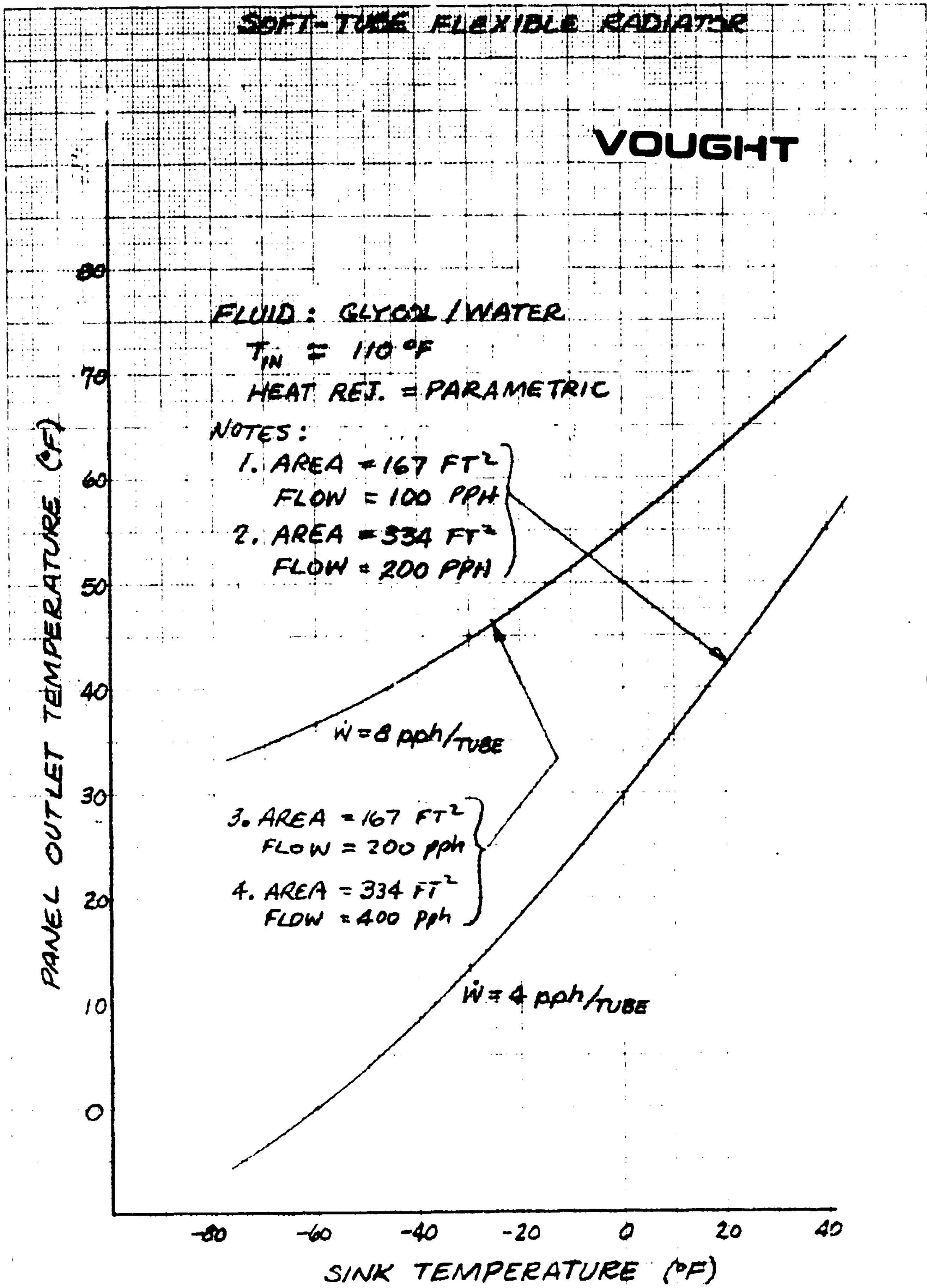


VOUGHT



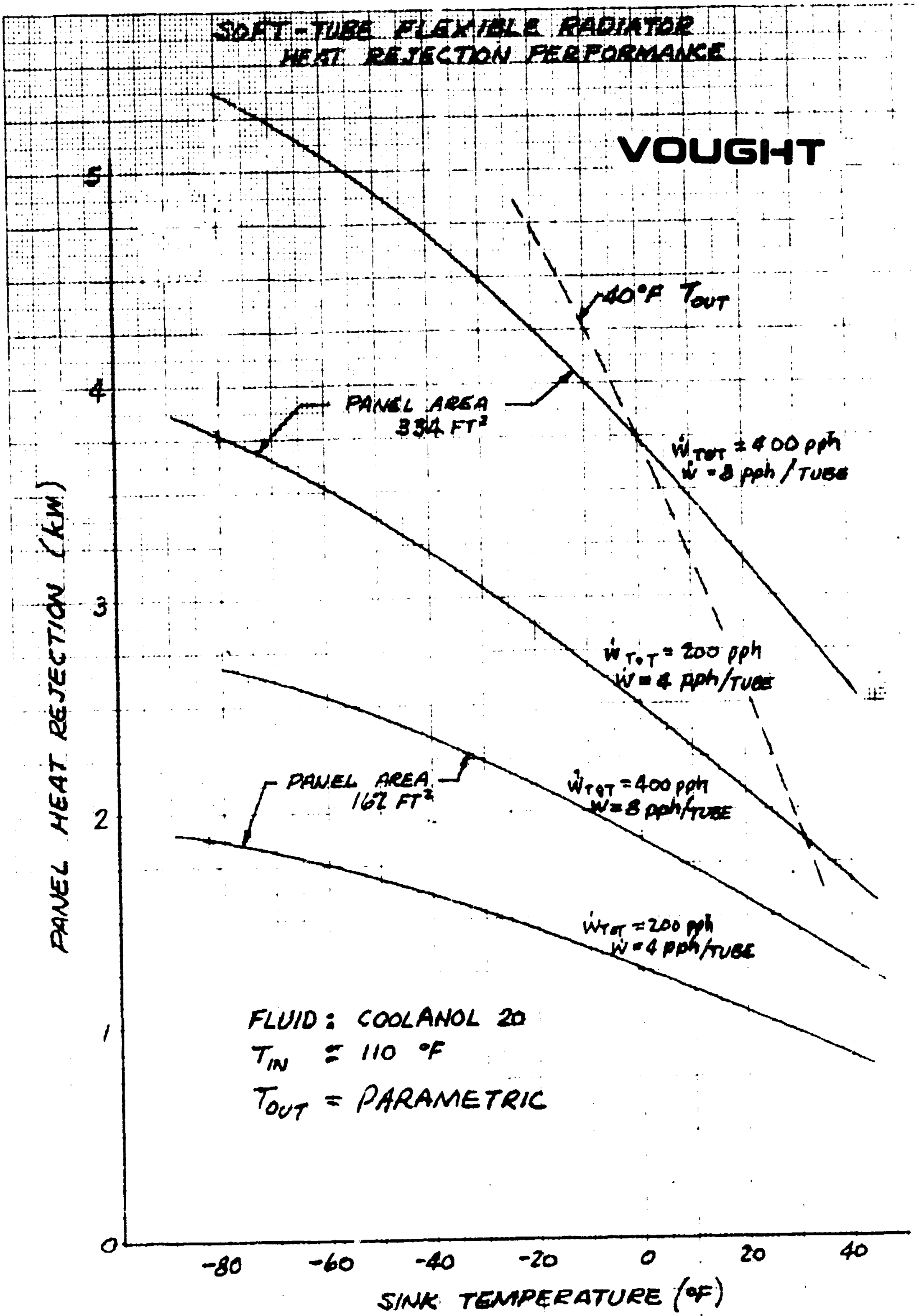
SOFT-TUBE FLEXIBLE RADIATOR
HEAT REJECTION PERFORMANCE
VOUGHT
PANEL AREA 334 FT²
40°F OUTLET
FLUID: GLYCOL/WATER
T_IN = 110 °F
T_OUT = PARAMETRIC
Ẇ_TOT = 400 pph
Ẇ = 8 pph/TUBE
Ẇ_TOT = 200 pph
Ẇ = 4 pph/TUBE
PANEL AREA 167 FT²
40°F OUTLET
Ẇ_TOT = 400 pph
Ẇ = 8 pph/TUBE
Ẇ_TOT = 200 pph
Ẇ = 4 pph/TUBE
PANEL HEAT REJECTION (kW)
1
2
3
4
5
6
-80
-60
-40
-20
0
20
40
SINK TEMPERATURE (°F)

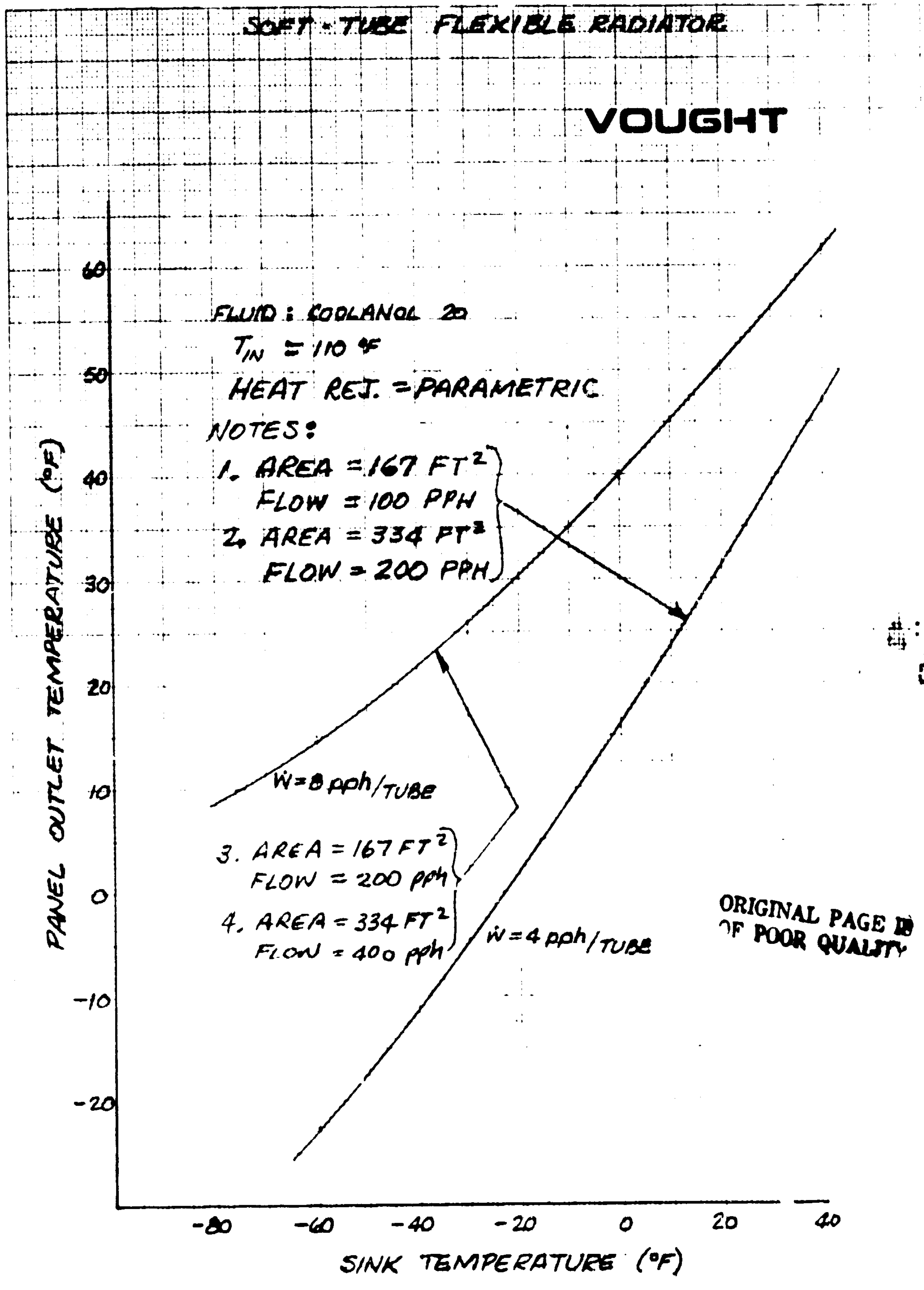
46 1513

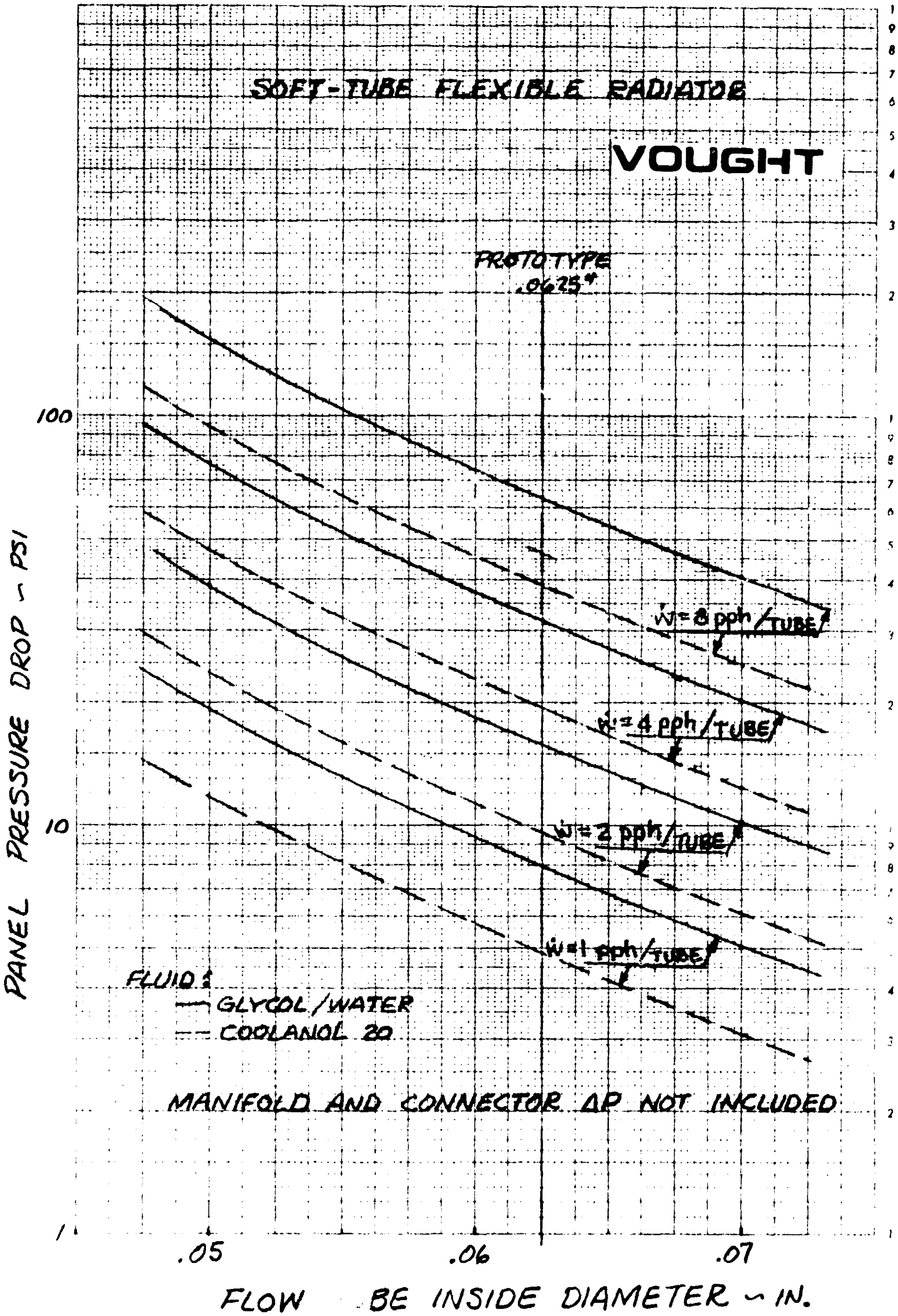


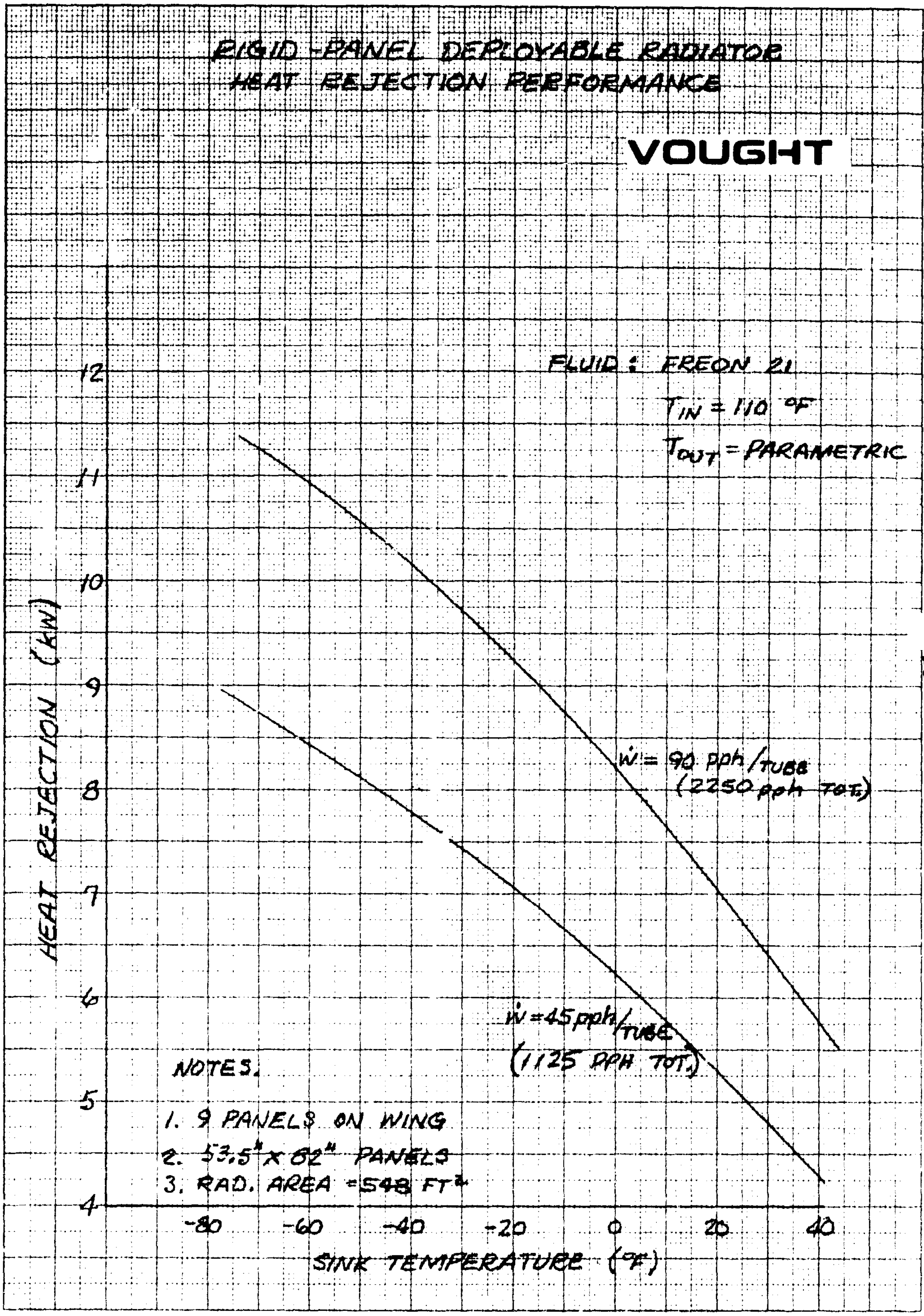
SOFT-TUBE FLEXIBLE RADIATOR
VOUGHT
FLUID: GLYCOL/WATER
T_{IN} = 110 °F
HEAT REJ. = PARAMETRIC
NOTES:
1. AREA = 167 FT²
FLOW = 100 PPH
2. AREA = 334 FT²
FLOW = 200 PPH
Ẇ = 8 pph/TUBE
3. AREA = 167 FT²
FLOW = 200 pph
4. AREA = 334 FT²
FLOW = 400 pph
Ẇ = 4 pph/TUBE
PANEL OUTLET TEMPERATURE (°F)
80
70
60
50
40
30
20
10
0
-80
-60
-40
-20
0
20
40
SINK TEMPERATURE (°F)

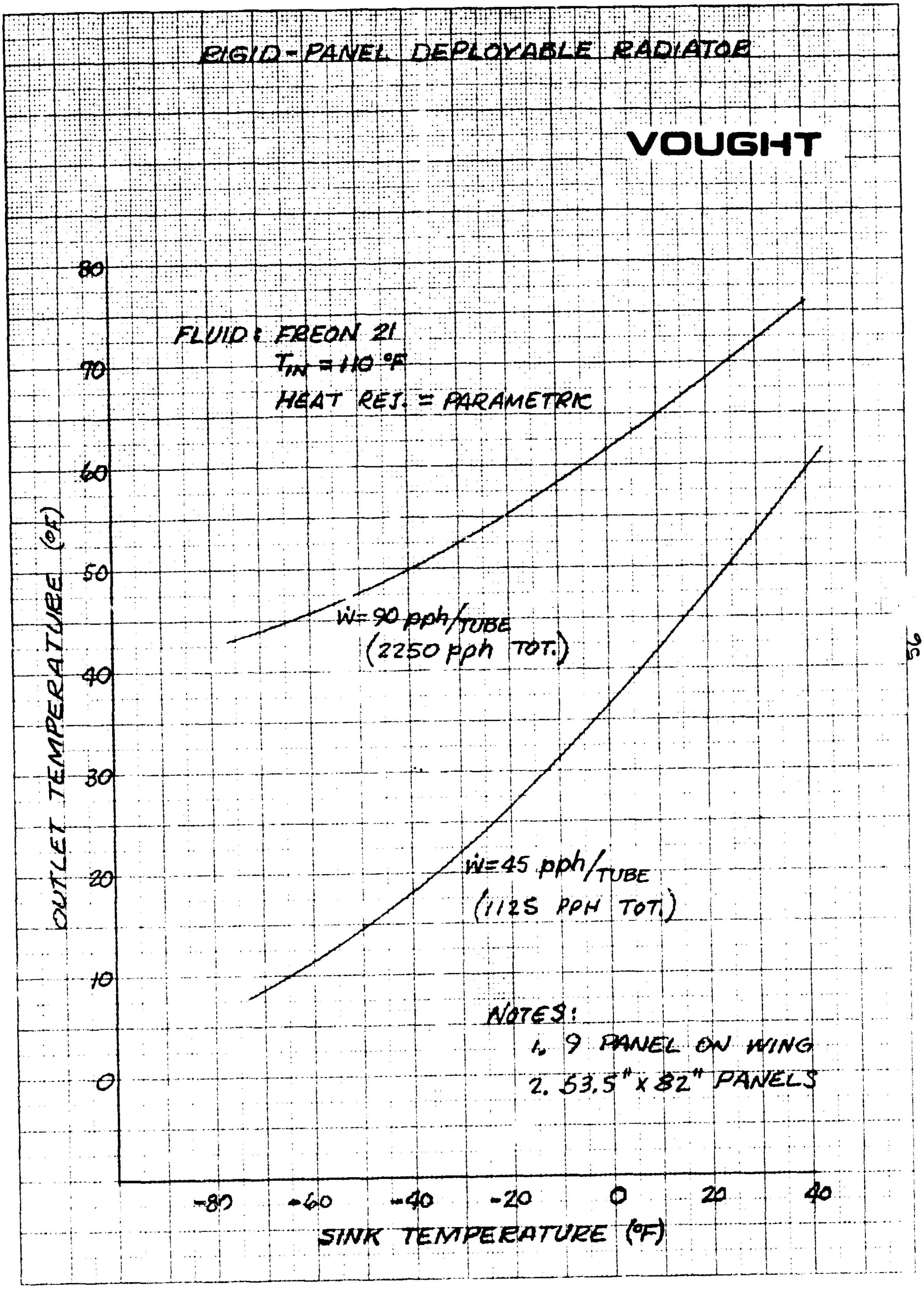
46 1513


SOFT-TUBE FLEXIBLE RADIATOR
HEAT REJECTION PERFORMANCE
VOUGHT
40°F T_{OUT}
PANEL AREA
334 FT²
$\dot{W}_{TOT}$ = 400 pph
$\dot{W}$ = 8 pph / TUBE
$\dot{W}_{TOT}$ = 200 pph
$\dot{W}$ = 4 pph/TUBE
PANEL AREA
167 FT²
$\dot{W}_{TOT}$ = 400 pph
$\dot{W}$ = 8 pph/TUBE
$\dot{W}_{TOT}$ = 200 pph
$\dot{W}$ = 4 pph/TUBE
FLUID: COOLANOL 20
T_{IN} = 110 °F
T_{OUT} = PARAMETRIC
PANEL HEAT REJECTION (kW)
0
1
2
3
4
5
-80
-60
-40
-20
0
20
40
SINK TEMPERATURE (°F)


SOFT - TUBE FLEXIBLE RADIATOR
VOUGHT
FLUID : COOLANOL 20
T_{IN} = 110 °F
HEAT REJ. = PARAMETRIC
NOTES:
1. AREA = 167 FT²
FLOW = 100 PPH
2. AREA = 334 FT²
FLOW = 200 PPH
Ẇ = 8 pph/TUBE
3. AREA = 167 FT²
FLOW = 200 pph
4. AREA = 334 FT²
FLOW = 400 pph
Ẇ = 4 pph/TUBE
PANEL OUTLET TEMPERATURE (°F)
60
50
40
30
20
10
0
-10
-20
-80
-60
-40
-20
0
20
40
SINK TEMPERATURE (°F)


SOFT-TUBE FLEXIBLE RADIATOR
VOUGHT
PROTOTYPE
.0625"
ẇ = 8 pph/TUBE
ẇ = 4 pph/TUBE
ẇ = 2 pph/TUBE
ẇ = 1 pph/TUBE
FLUID:
GLYCOL/WATER
COOLANOL 20
MANIFOLD AND CONNECTOR ΔP NOT INCLUDED
PANEL PRESSURE DROP ~ PSI
100
10
1
.05
.06
.07
FLOW BE INSIDE DIAMETER ~ IN.


RIGID-PANEL DEPLOYABLE RADIATOR
HEAT REJECTION PERFORMANCE
VOUGHT
FLUID: FREON 21
T_{IN} = 110 °F
T_{OUT} = PARAMETRIC
$\dot{w}$ = 90 pph/TUBE
(2250 pph TOT.)
$\dot{w}$ = 45 pph/TUBE
(1125 PPH TOT.)
NOTES:
1. 9 PANELS ON WING
2. 53.5" x 82" PANELS
3. RAD. AREA = 548 FT²
HEAT REJECTION (KW)
12
11
10
9
8
7
6
5
4
-80
-60
-40
-20
0
20
40
SINK TEMPERATURE (°F)


RIGID-PANEL DEPLOYABLE RADIATOR
VOUGHT
FLUID: FREON 21
T_{IN} = 110 °F
HEAT REJ. = PARAMETRIC
ẇ = 90 pph/TUBE
(2250 pph TOT.)
ẇ = 45 pph/TUBE
(1125 PPH TOT.)
NOTES:
1. 9 PANEL ON WING
2. 53.5" x 82" PANELS
OUTLET TEMPERATURE (°F)
80
70
60
50
40
30
20
10
0
-80
-60
-40
-20
0
20
40
SINK TEMPERATURE (°F)

VOUGHT

FLEXIBLE RADIATOR TRANSPORT FLUID SELECTION CONSIDERATIONS

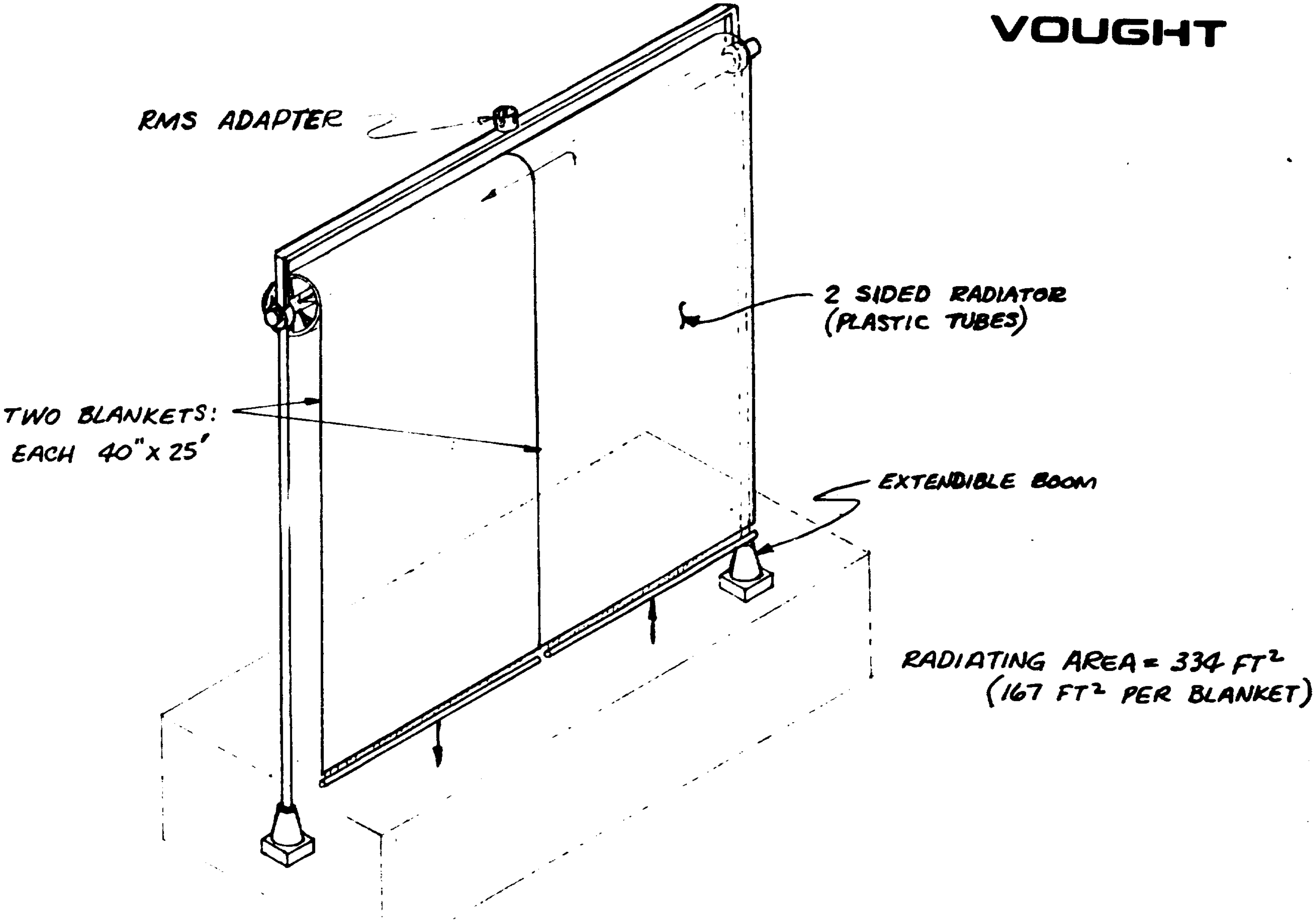
	COOLANOL	GLYCOL/WATER
PRIOR TEST ARTICLE USAGE	ENGINEERING MODEL (COOLANOL 15)	FULL SCALE PROTOTYPE (RS89a)
FLUID STABILITY	COOLANOL 15 PREDICTED BETTER THAN RS89a, NO PREDICTIONS AVAILABLE ON COOLANOL 20	—
AVAILABILITY	COOLANOL 15 NOT AVAILABLE, COOLANOL 20 AVAILABLE	YES
COST	—	LOWEST
THERMAL PERFORMANCE	—	6% BETTER
FLOWRATE REQUIRED PER 4 kW WING	430 pph	275 pph
PRESSURE DROP (.08" ID TUBES)	APPROX. 20 PSI @ 430 pph	APPROX. 10 PSI @ 275 pph
MATERIALS COMPATIBILITY	EXCELLENT	POTENTIAL CORROSION FOR LONG TERM
FLIGHT HARDWARE EXPERIENCE	SKYLAB	APOLLO
CONTAMINATION THREAT	YES - SKYLAB LEAKS	PROBABLY LESS, NEEDS EVALUATION

VOUGHT

RADIATOR PANEL CONCEPT -

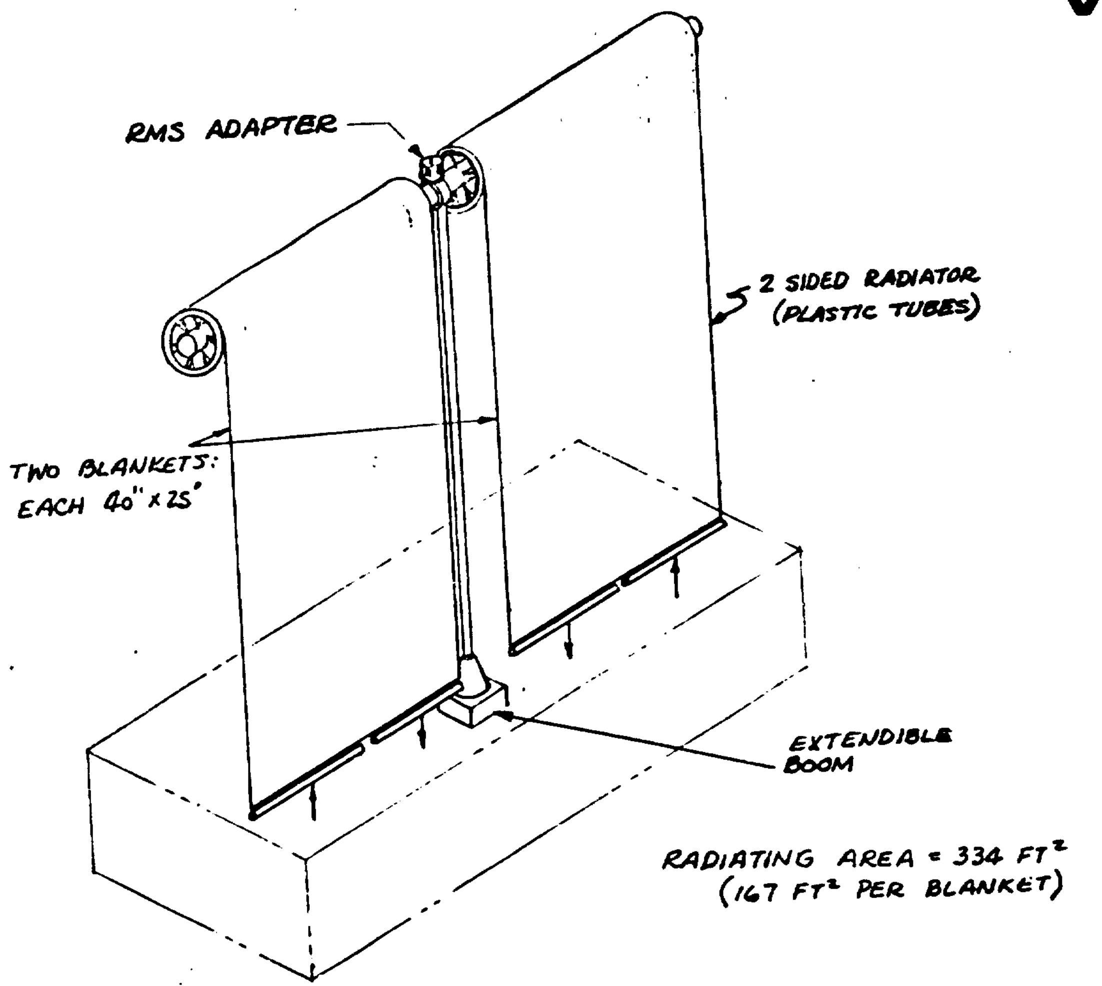
- PANEL AND DEPLOYMENT CONCEPTS FOR CONSIDERATION

CONCEPT 1 - FLEXIBLE RADIATOR, DUAL STEM DEPLOY, RMS ASSIST



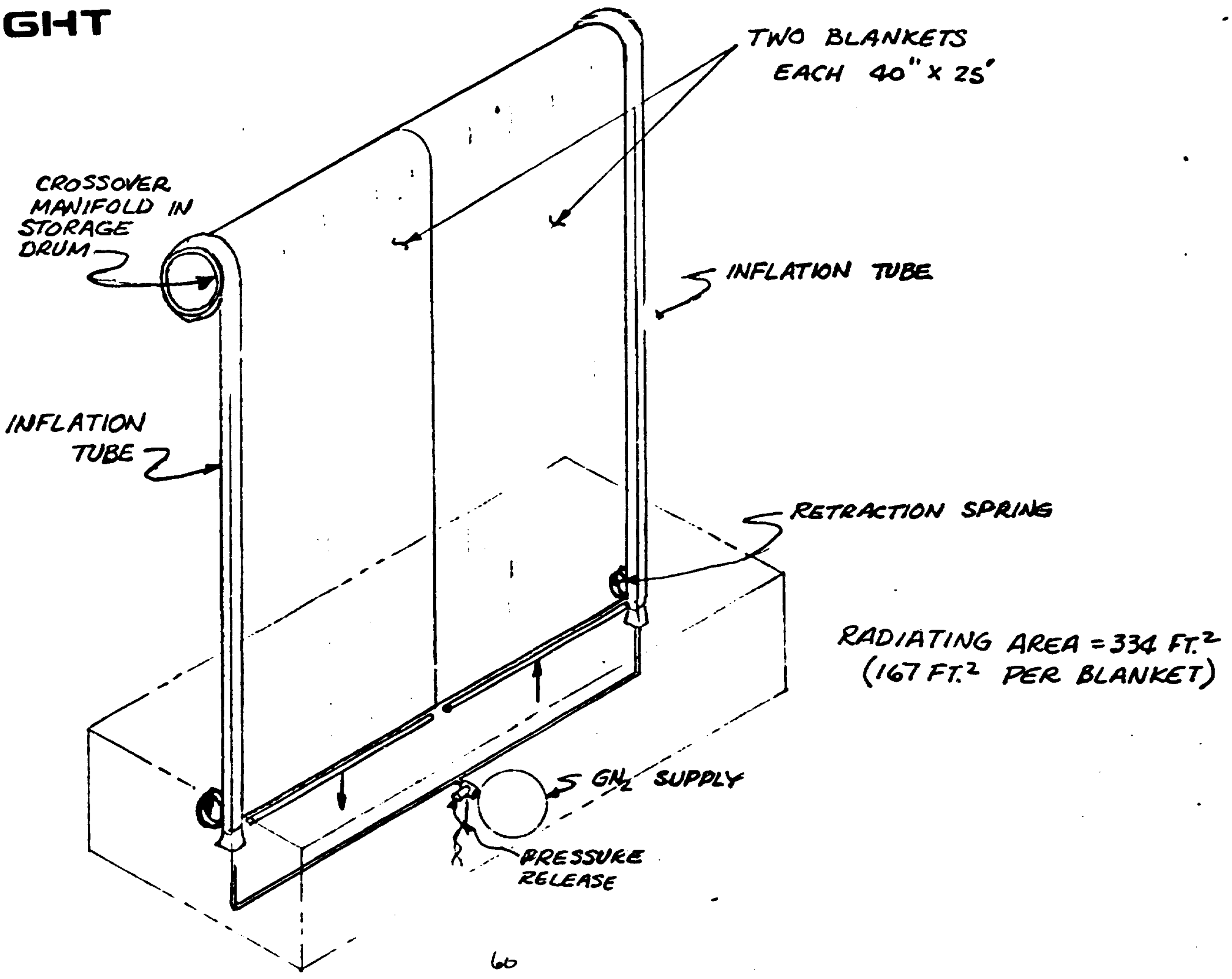
CONCEPT 2 - FLEXIBLE RADIATOR, SINGLE STEM DEPLOY, RMS ASSIST

VOUGHT



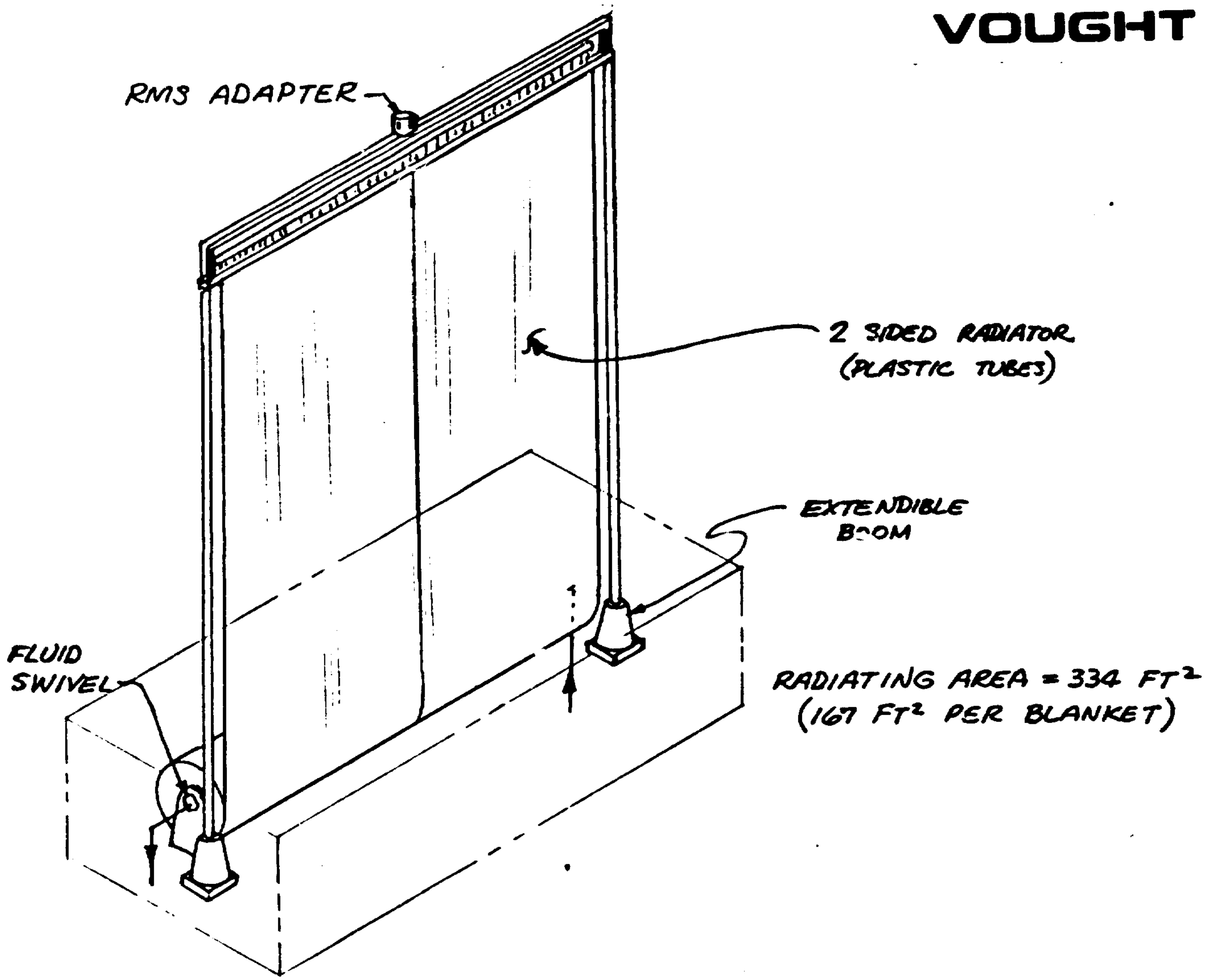
CONCEPT 3 - FLEXIBLE RADIATOR, INFLATION TUBE DEPLOYMENT

VOUGHT



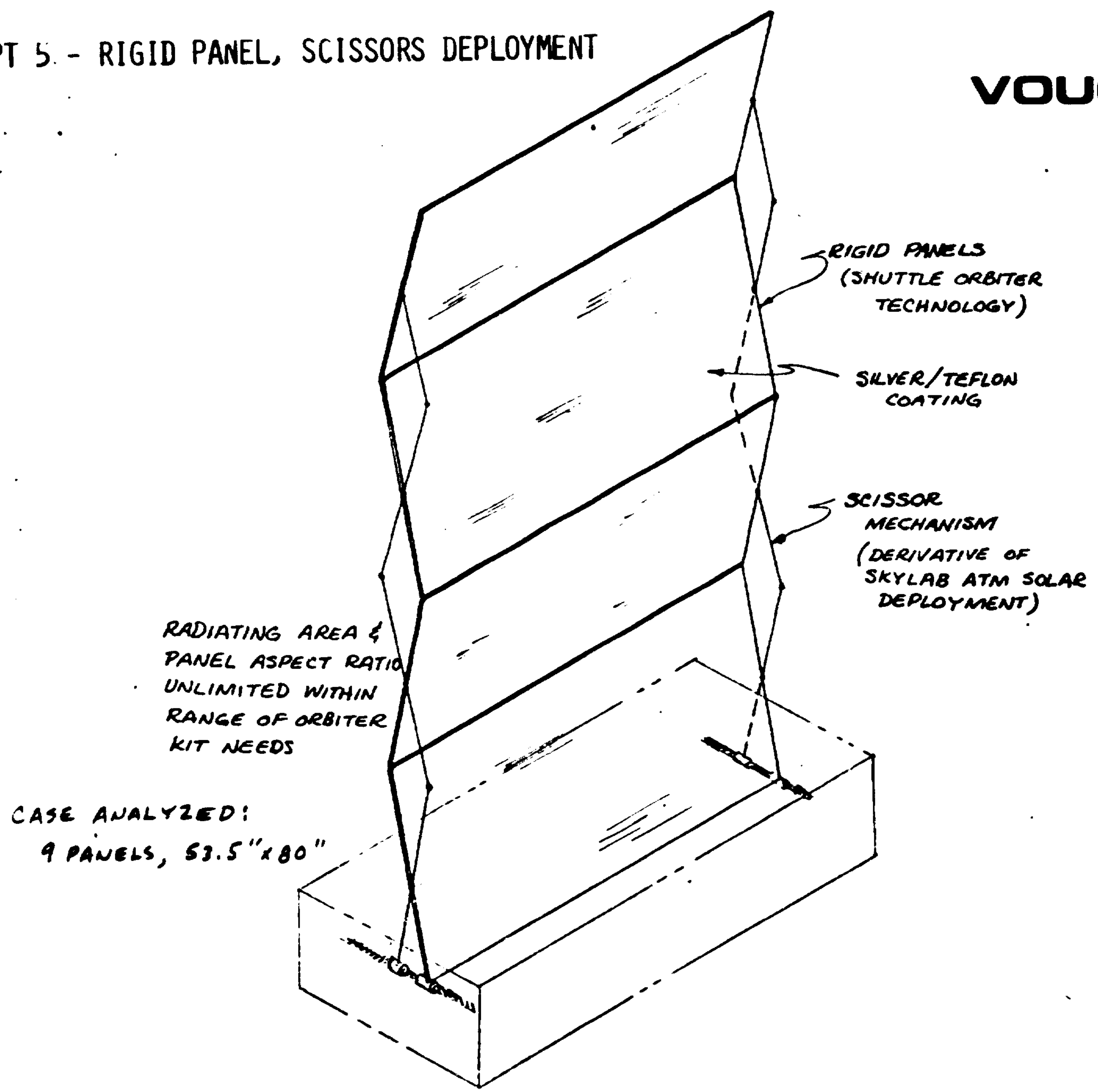
CONCEPT 4 - FLEXIBLE RADIATOR, DUAL STEM DEPLOY, SPOOL AT BASE, RMS ASSIST

VOUGHT



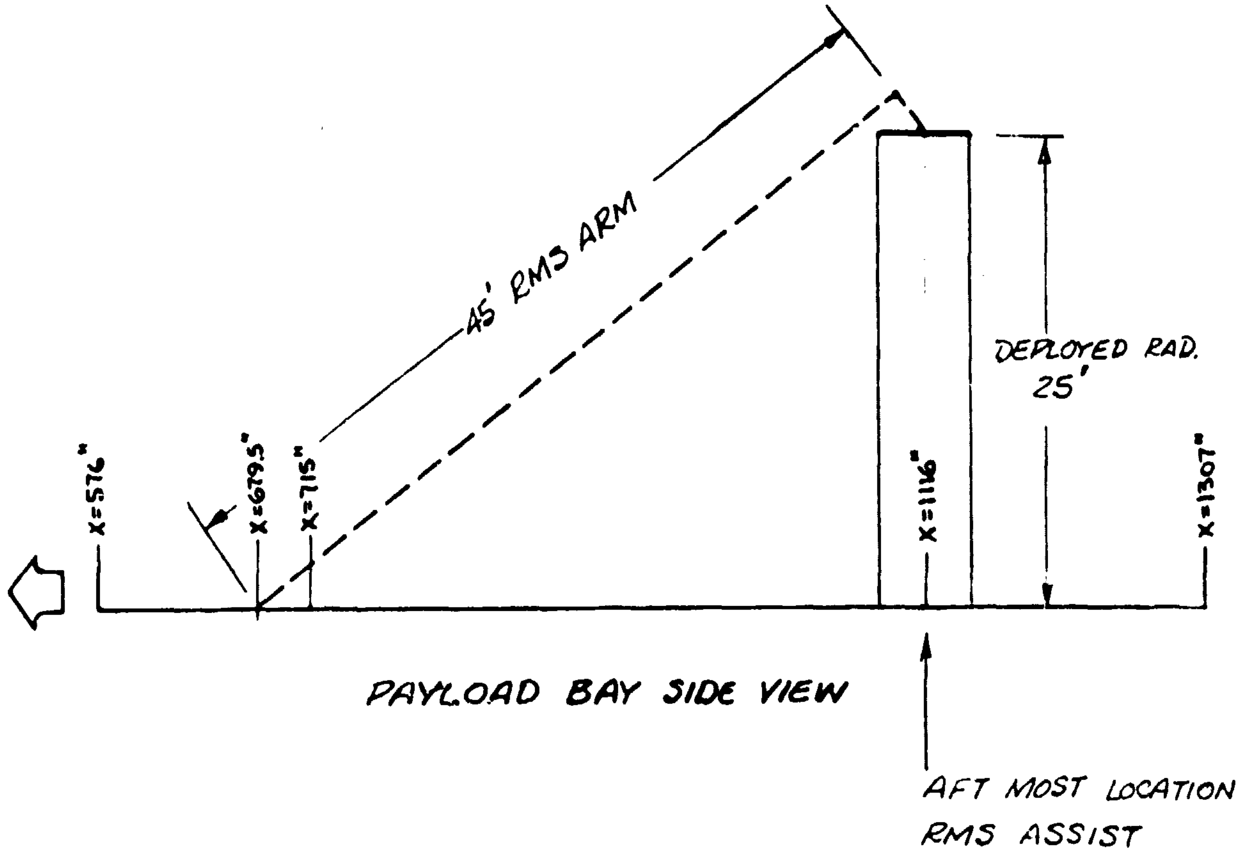
CONCEPT 5 - RIGID PANEL, SCISSORS DEPLOYMENT

VOUGHT

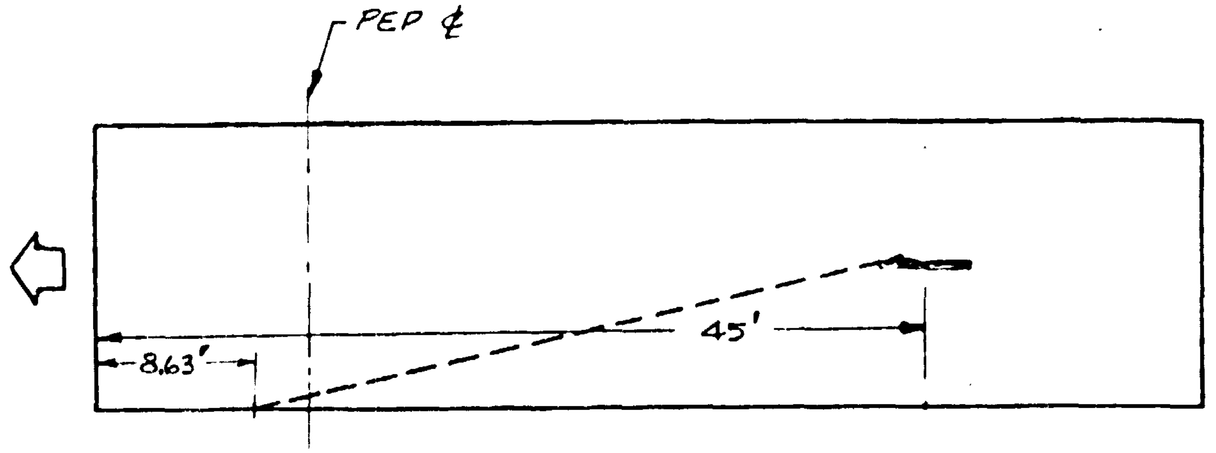


ORBITER RMS REACH ENVELOPE

VOUGHT



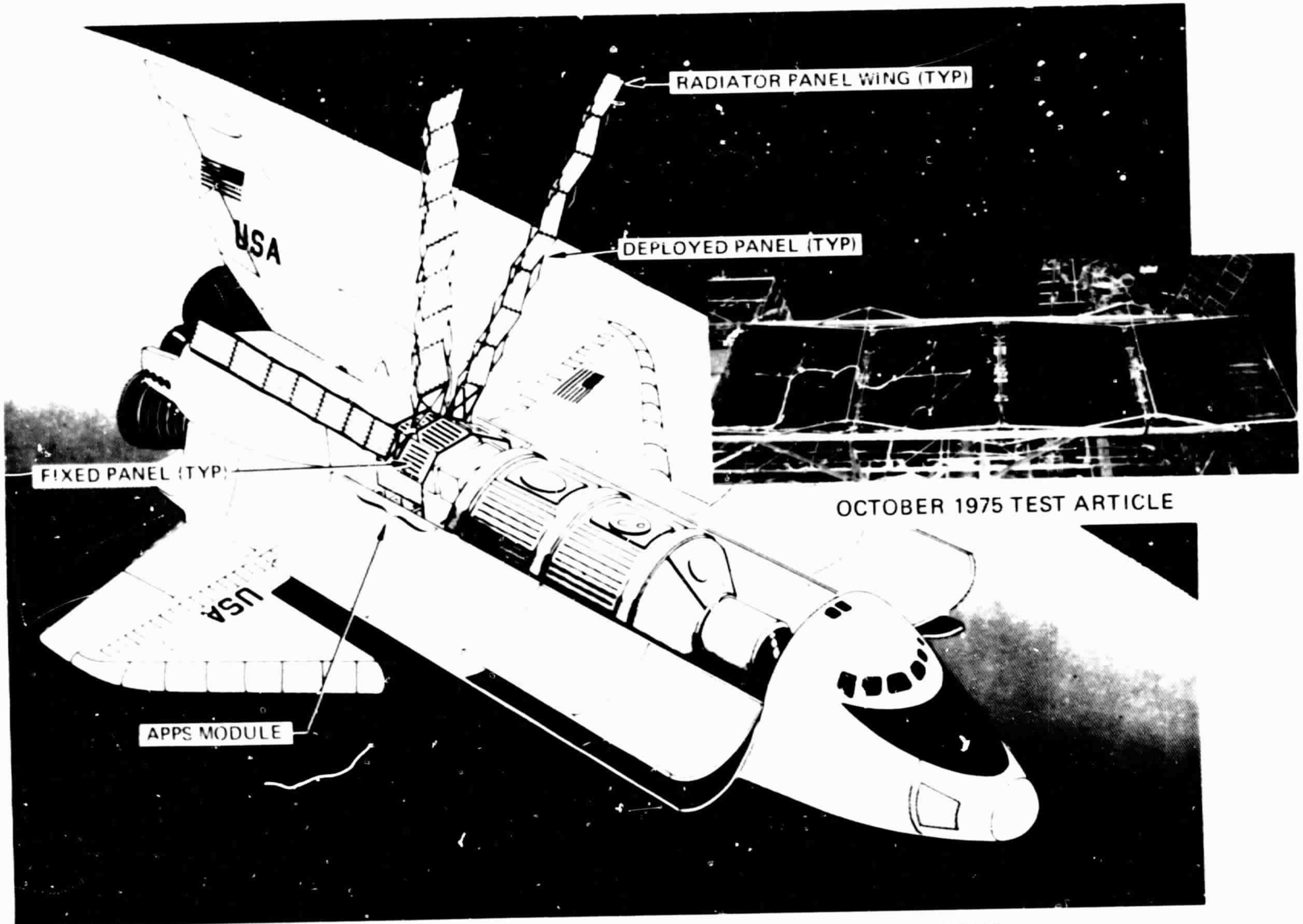
PAYLOAD BAY SIDE VIEW



PAYLOAD BAY TOP VIEW

RADIATOR PANEL CONCEPTS -

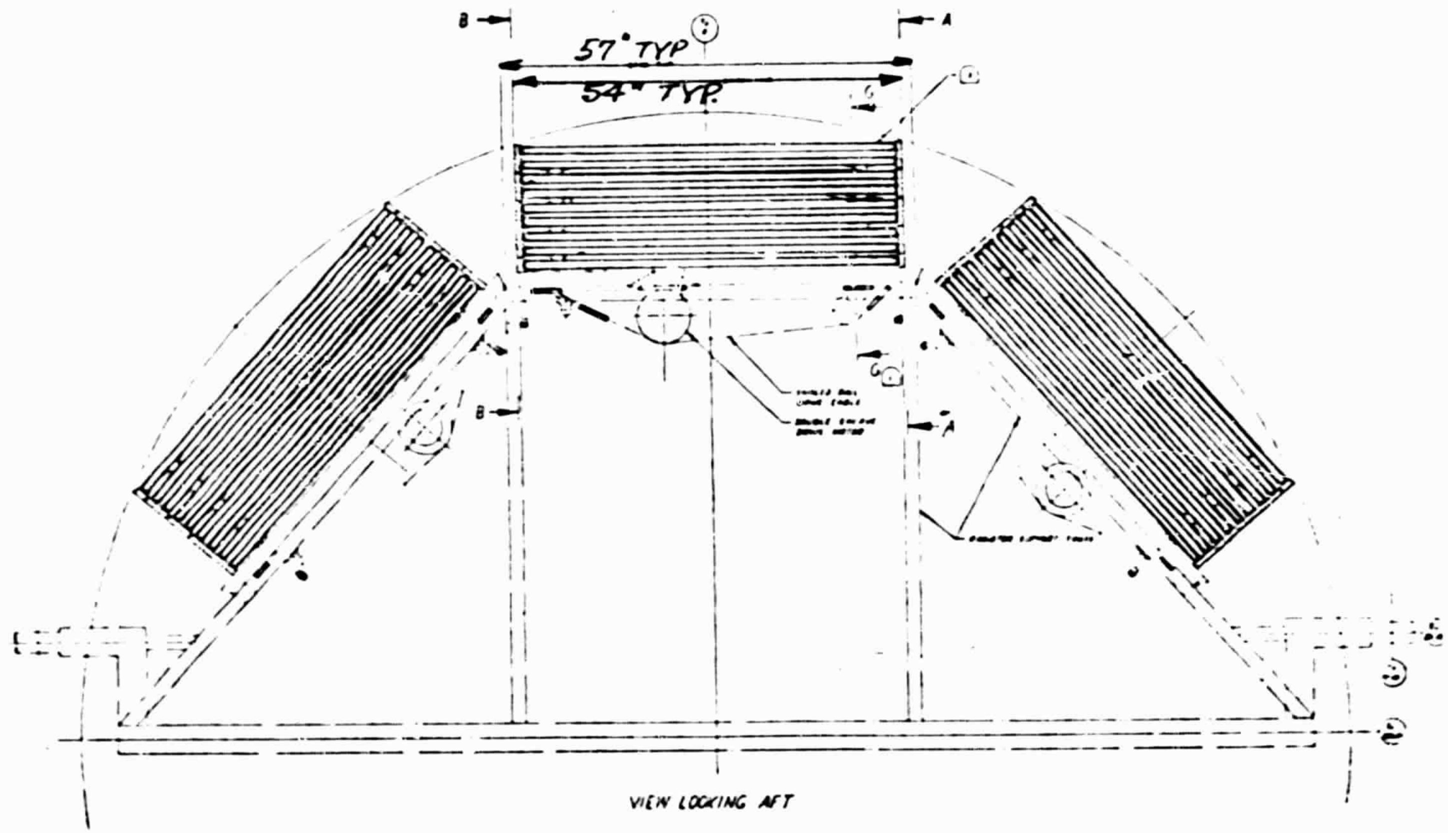
- DESIGN PACKAGING STUDIES ON RIGID PANEL CONCEPT



APPS RADIATOR SYSTEM INSTALLED ON THE SPACE SHUTTLE

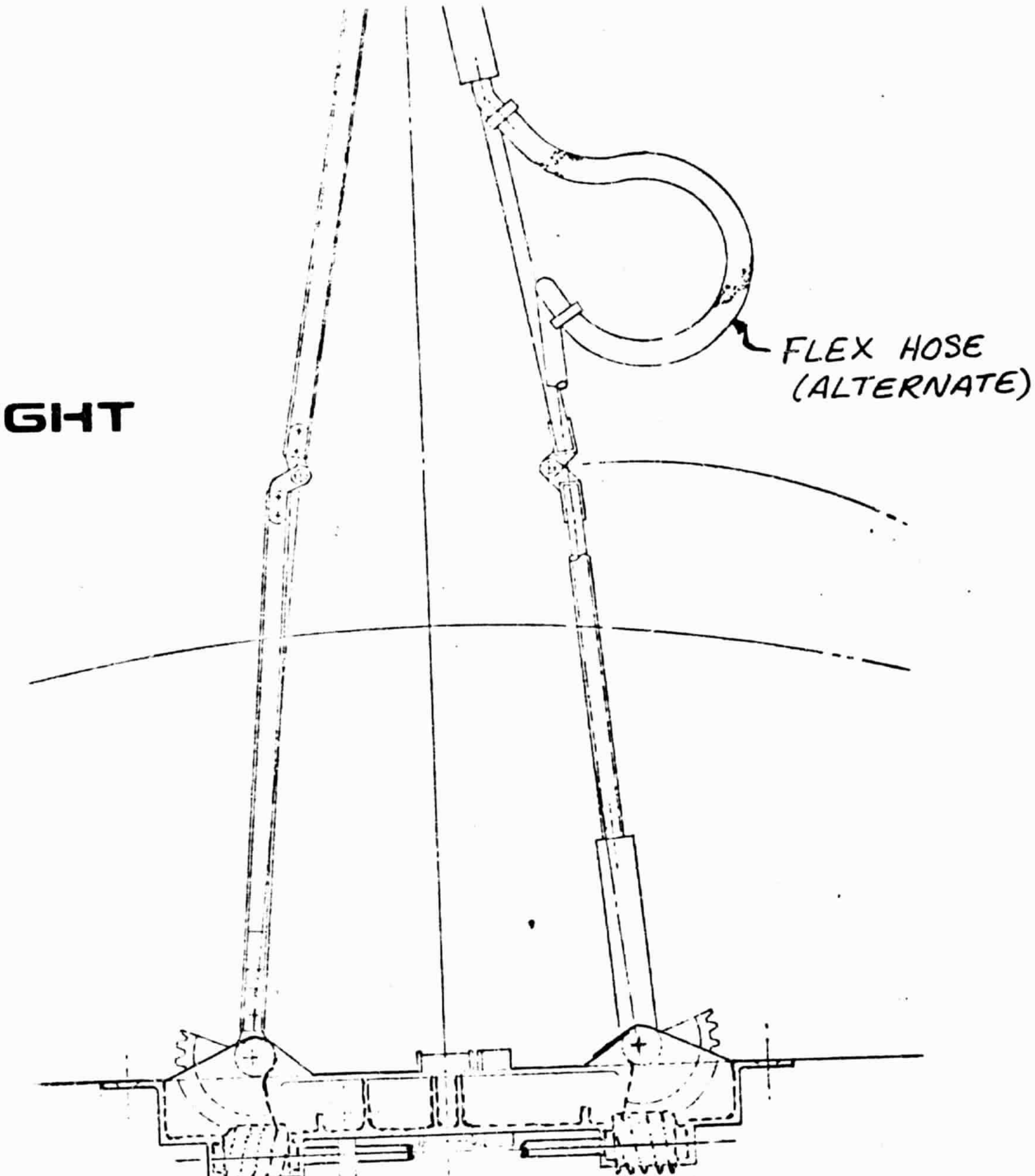
TYPICAL 3 WING 9 PANEL CONFIGURATION

VOUGHT

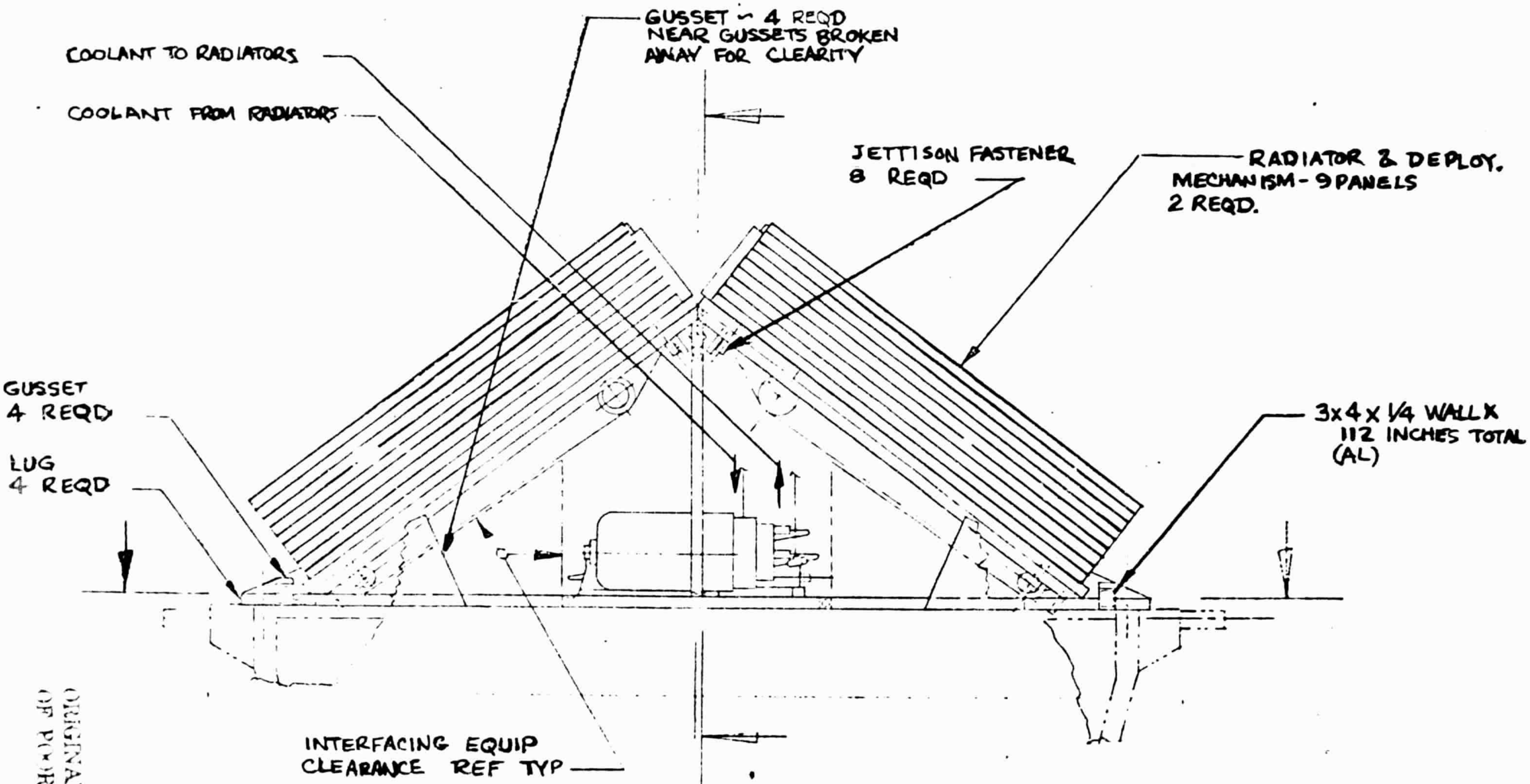


WING DEPLOYMENT MECHANISM

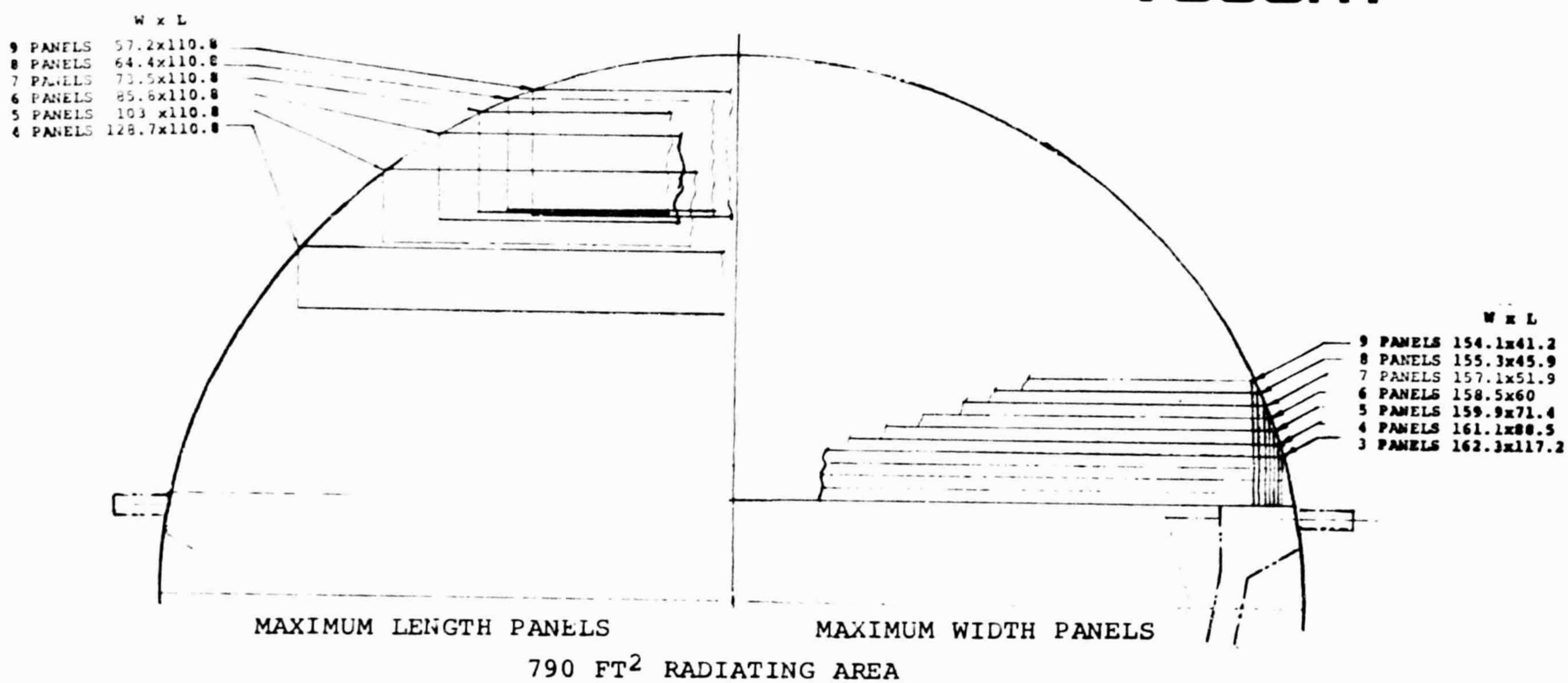
VOUGHT



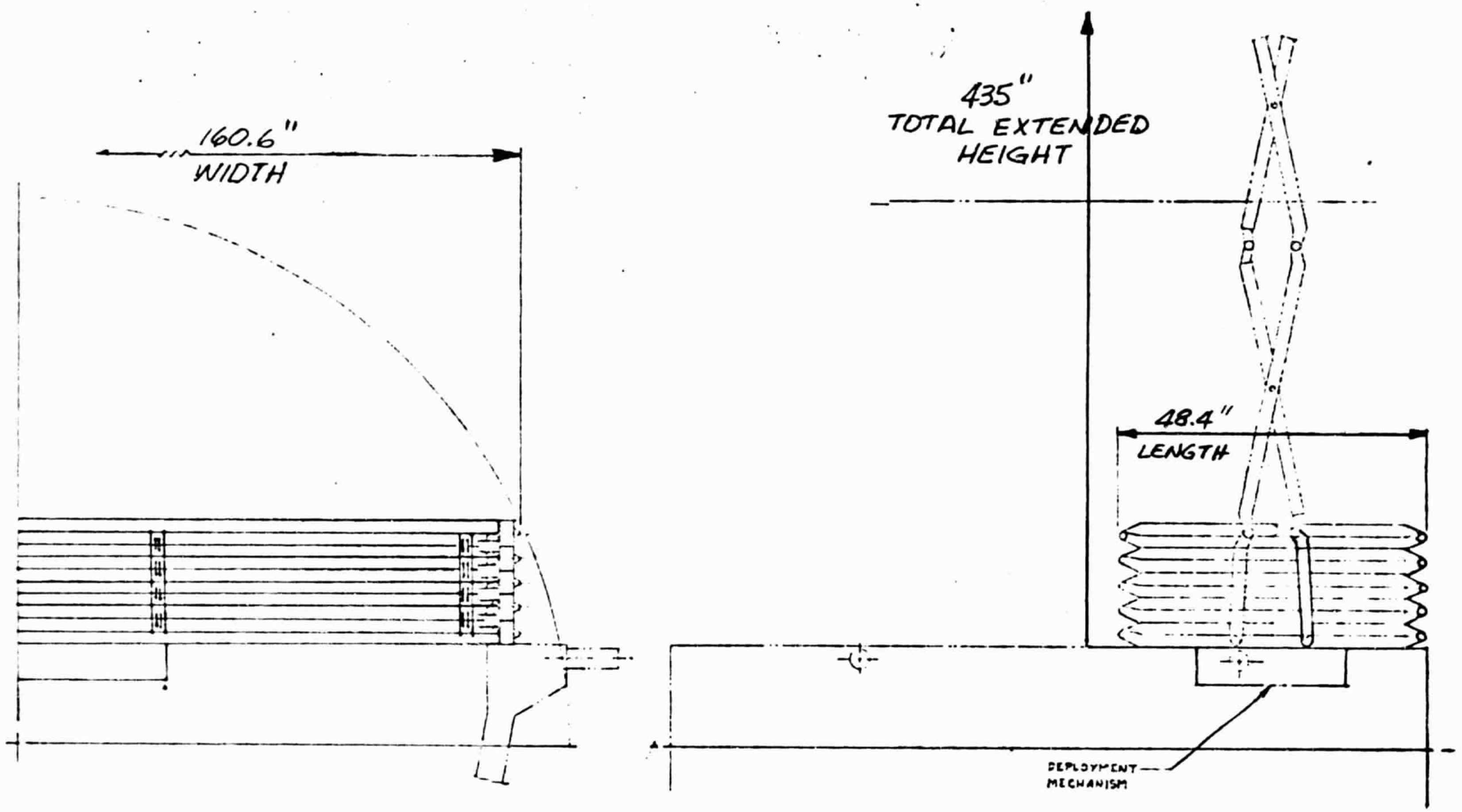
TYPICAL 2 WING 9 PANEL CONFIGURATION



VOUGHT



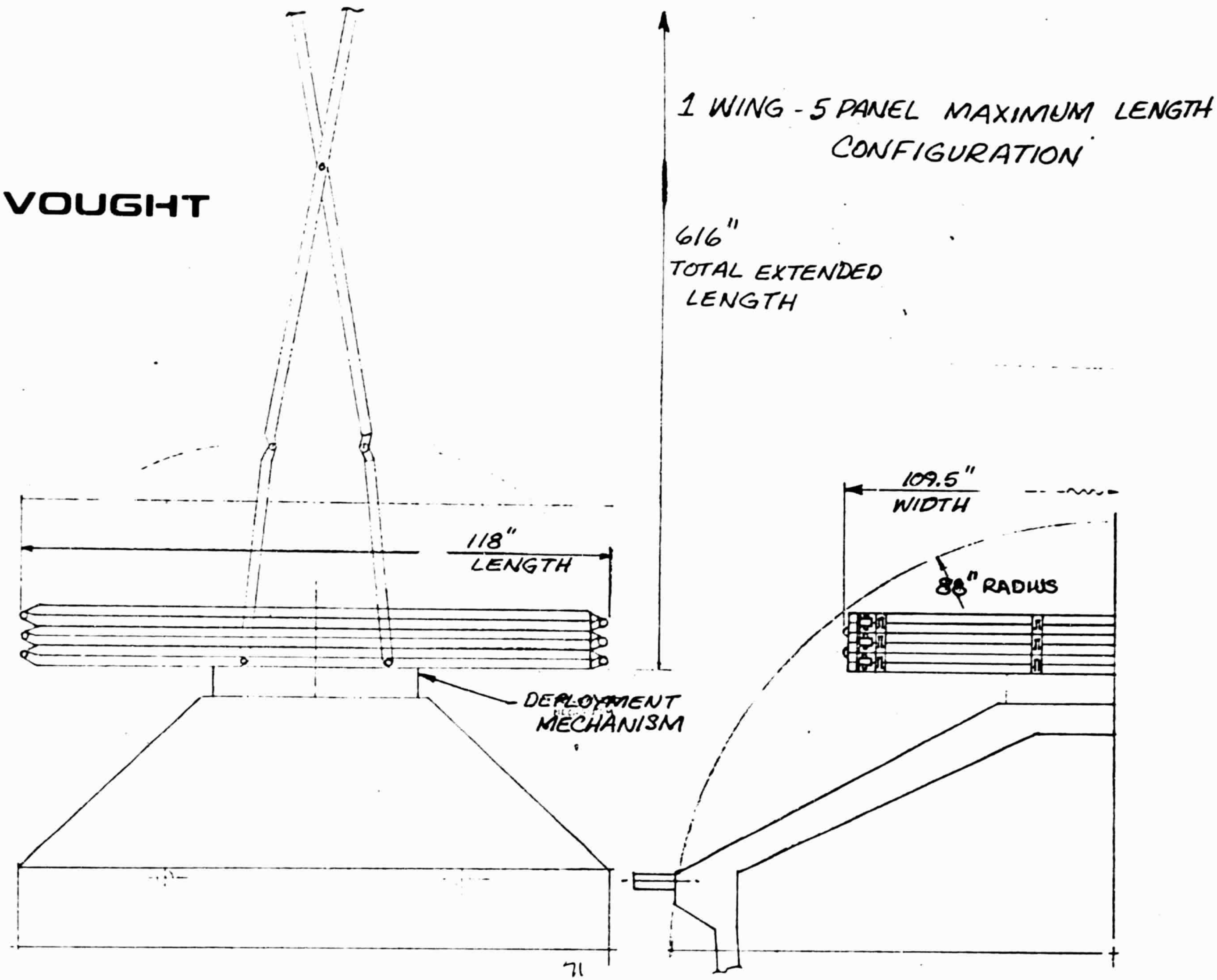
PARAMETRIC PACKAGING STUDY OF STOWAGE ENVELOPE FOR SINGLE RADIATOR



1 WING - 9 PANEL MAXIMUM WIDTH CONFIGURATION

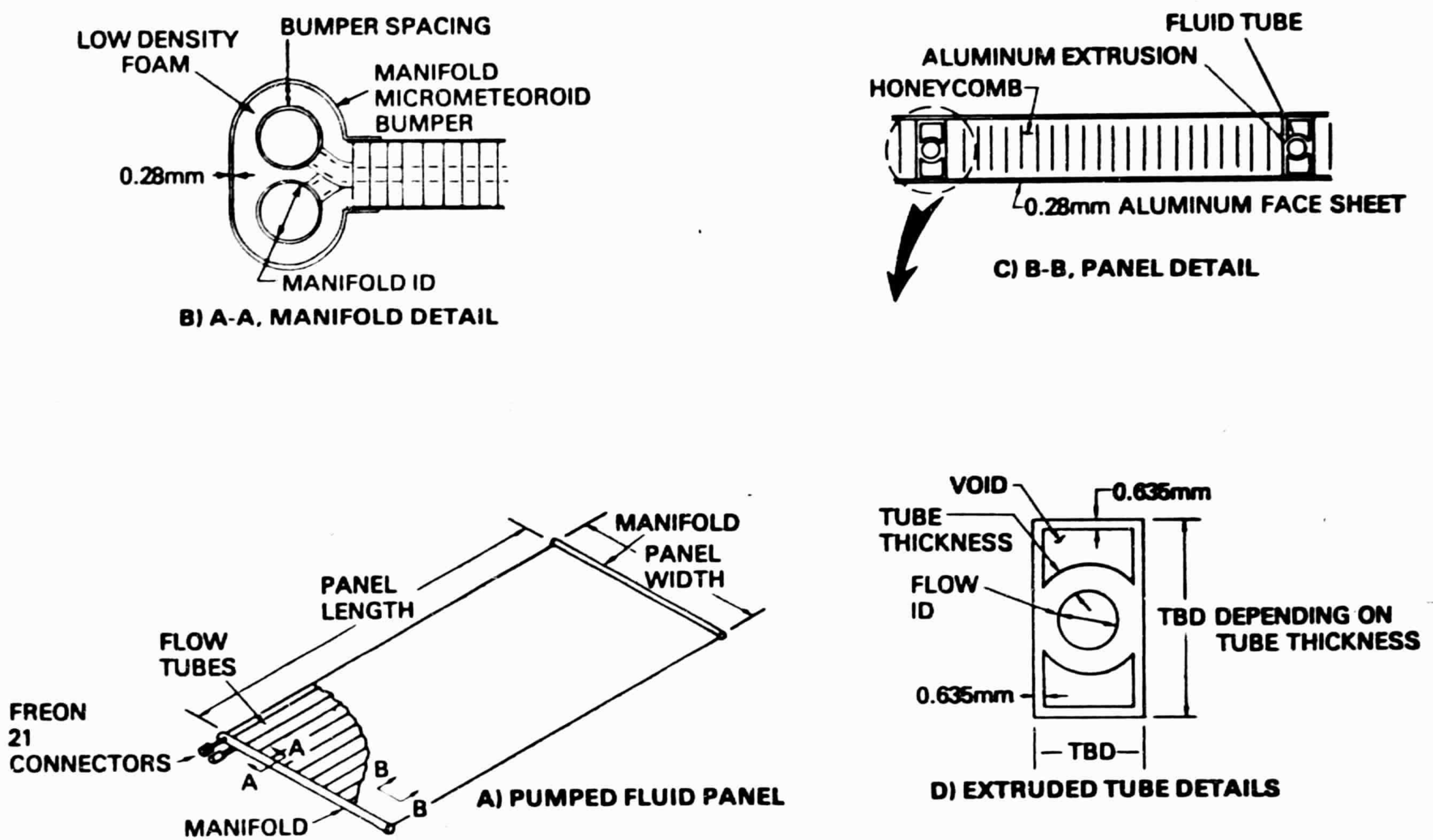
VOUGHT

VOUGHT

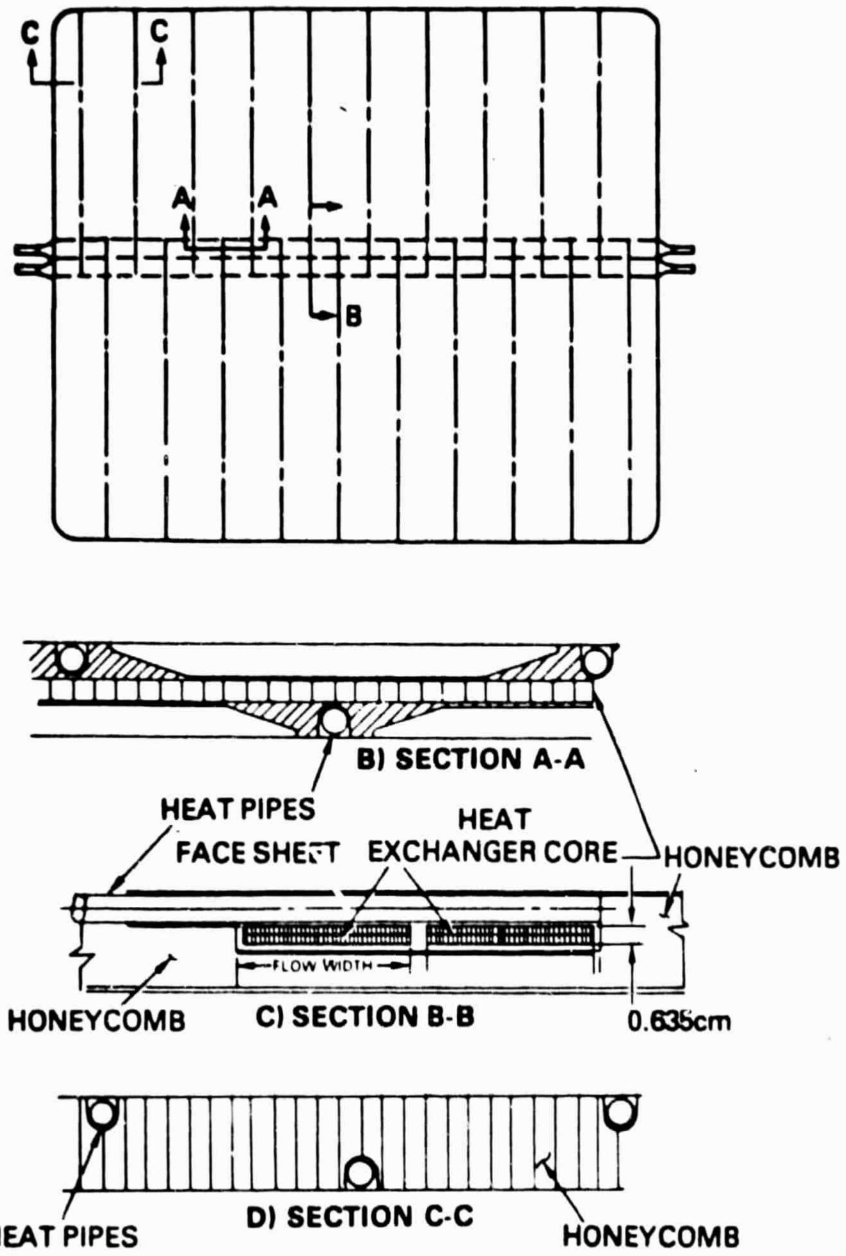

1 WING - 5 PANEL MAXIMUM LENGTH CONFIGURATION
616" TOTAL EXTENDED LENGTH
118" LENGTH
DEPLOYMENT MECHANISM
109.5" WIDTH
88" RADIUS

RADIATOR PANEL CONCEPTS -

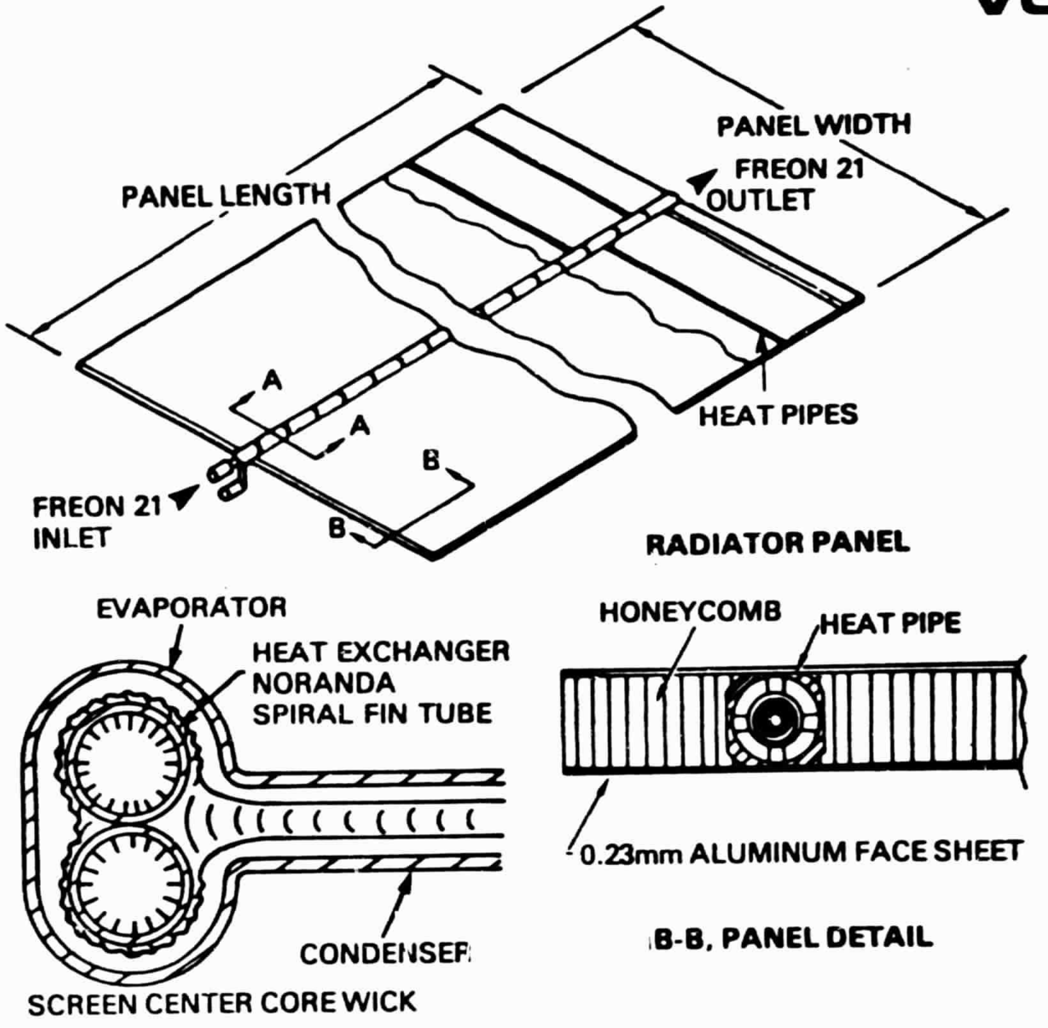
- HEAT PIPE VS PUMPED FLUID CONSIDERATIONS



PUMPED FLUID RADIATOR CONCEPT



LOW COST HYBRID HEAT PIPE CONCEPT

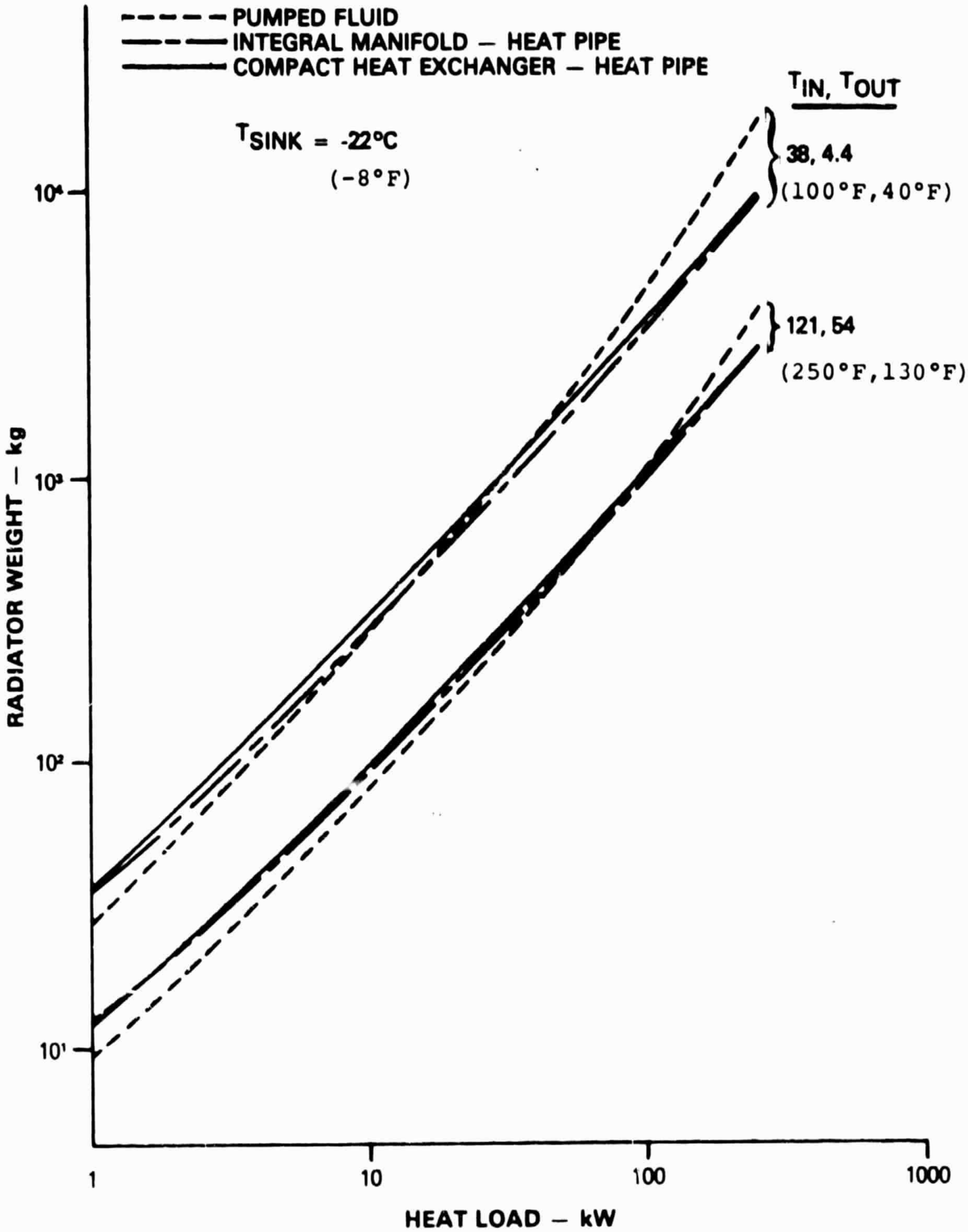


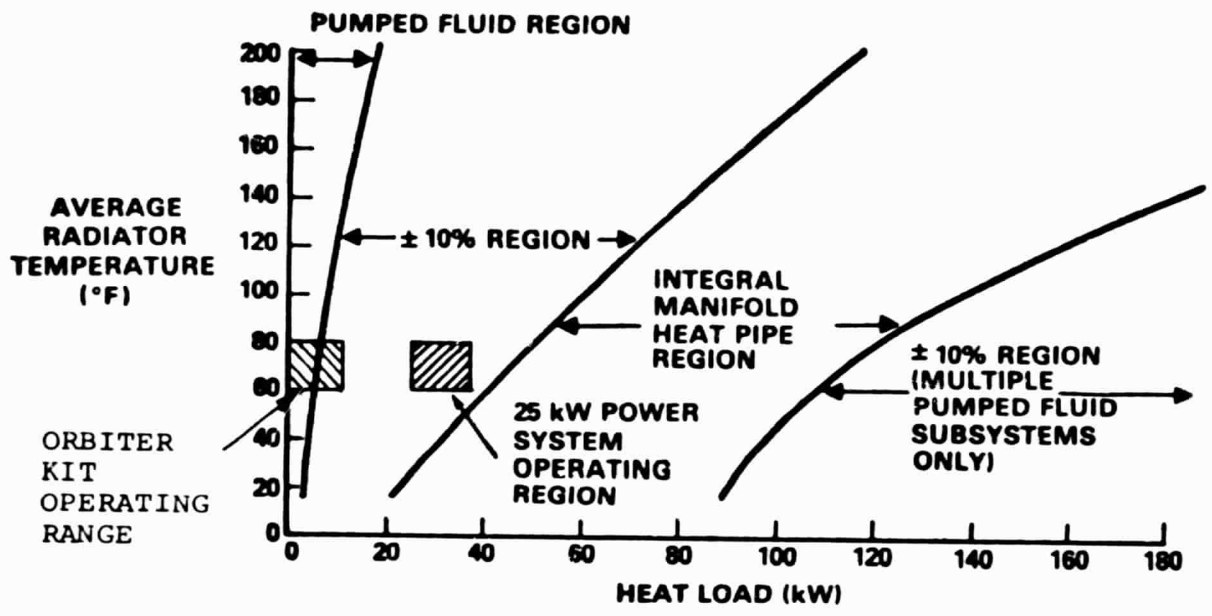
RADIATOR PANEL

A-A, HEAT PIPE DETAIL
(REDUNDANT FLOW PASSAGE SHOWN)

B-B, PANEL DETAIL

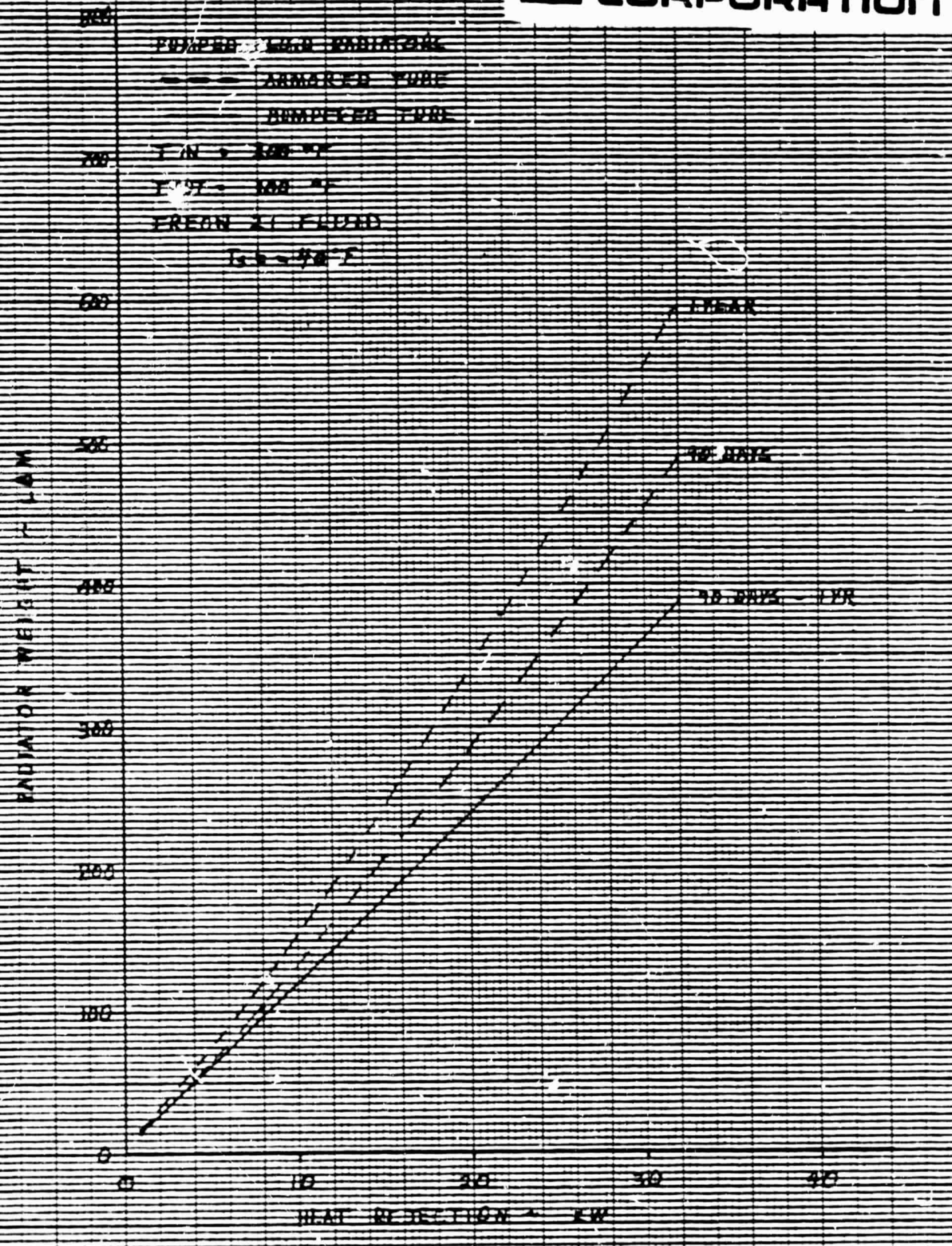
INTEGRAL MANIFOLD HEAT PIPE RADIATOR CONCEPT


PUMPED FLUID
INTEGRAL MANIFOLD — HEAT PIPE
COMPACT HEAT EXCHANGER — HEAT PIPE
T_{SINK} = -22°C
(-8°F)
T_{IN}, T_{OUT}
38, 4.4
(100°F, 40°F)
121, 54
(250°F, 130°F)
RADIATOR WEIGHT — kg
10^4
10^3
10^2
10^1
1
10
100
1000
HEAT LOAD — kW



HEAT PIPE/PUMPED FLUID RADIATOR WEIGHT OPTIMUM OPERATING REGIONS

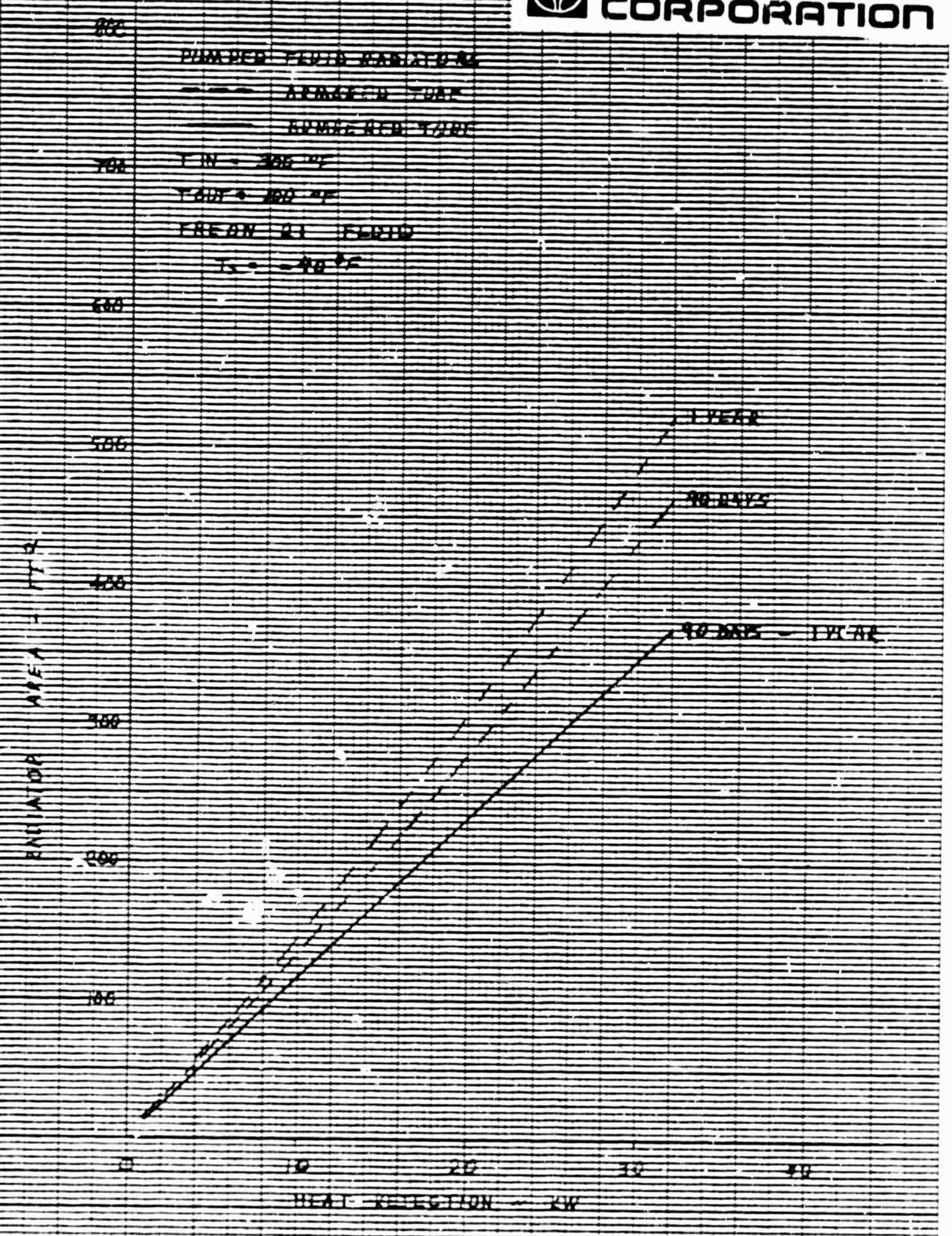
VOUGHT CORPORATION



PUMPED FLUID MINIMUM WEIGHT RADIATOR

46 1320

K·E 10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO.



PUMPED FLUID OPTIMUM WEIGHT RADIATOR AREA

VOUGHT

HE[illegible] vs PUMPED FLUID
CONCLUSIONS

1. FOR THE HEAT LOAD RANGE AND MISSION DURATION OF THE KIT RADIATOR, PUMPED FLUID PANELS ARE LIGHTEST WEIGHT.

2. FOR THE MISSION DURATION AND AREA REQUIREMENTS OF THE KIT RADIATOR, BUMPERED METEOROID PROTECTION PROVIDES ONLY **A** 2-3% REDUCTION IN RADIATOR WEIGHT, AND IS NOT JUSTIFIED.

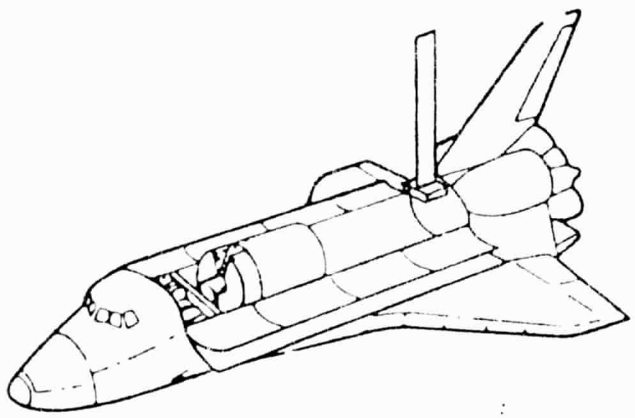
CONCEPT DEFINITION

VOUGHT

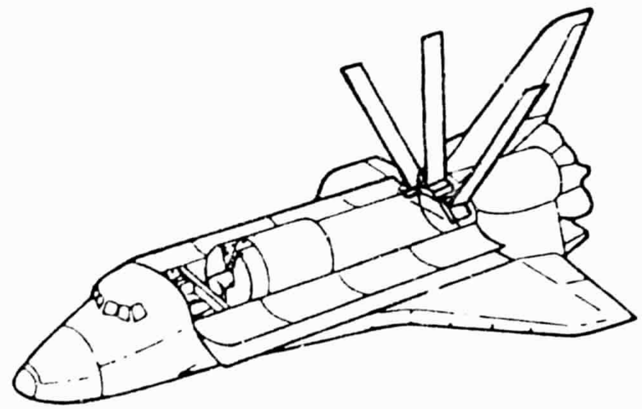
SELECTION OF RADIATOR KIT SIZE AND CONCEPT

- BASIC RADIATOR PALLET IS A NOMINAL 4 kw WING
- TWO OR MORE PALLETS PROVIDE ADDED HEAT REJECTION
- PALLETS ARE RELOCATABLE
- ONE FLUID LOOP PACKAGE SERVICES ONE OR MORE 4 kw PALLETS
- FLUID LOOP PACKAGE CONTAINS THERMAL VALVE, PUMP PACKAGE, AND OPTIONAL HX

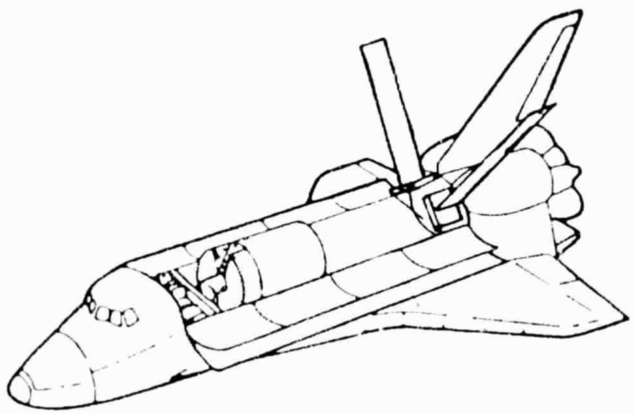
HEAT REJECTION KIT ACCOMMODATION



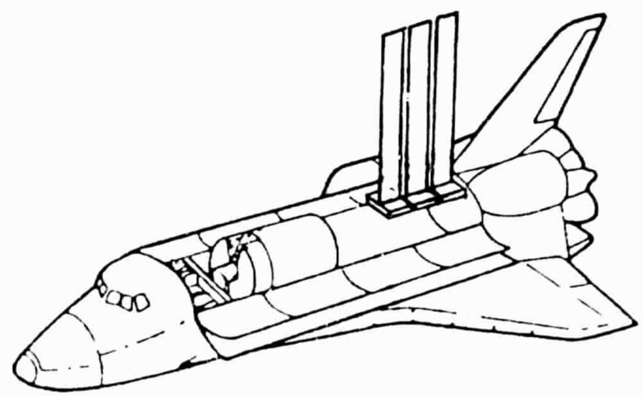
ONE WING 4 kW



THREE WINGS 12 kW



TWO WINGS 8 kW



THREE WINGS 12 kW

CONCEPTS SELECTED FOR PRELIMINARY DESIGN

1. SOFT TUBE FLEXIBLE RADIATOR WITH GAS DEPLOYMENT

2. SOFT TUBE FLEXIBLE RADIATOR WITH EXTENDABLE BOOM DEPLOYMENT

3. RIGID PANEL FOLDOUT RADIATOR WITH SCISSORS DEPLOYMENT

DESCRIPTION OF SOFT TUBE FLEXIBLE RADIATOR WITH GAS DEPLOYMENT

- EACH RADIATOR PANEL/PALLET IS 80" WIDE BY 27' LONG DEPLOYED
- TRANSPORT FLUID FLOW IS PARALLEL TO LONG DIMENSION
- COOLANT 20 TRANSPORT FLUID
- AREA CONTROL PROVIDED TO AVOID FLUID INSTABILITIES AT LOW LOAD
- GASEOUS NITROGEN STORED AT 3000 psia PROVIDES DEPLOYMENT/RETRACTION - SIZED FOR 1/2 CYCLE PER ORBIT (768 HALF-CYCLES)

DESIGN SUMMARY - SOFT TUBE RADIATOR

PERFORMANCE - 1 WING

FLUID	=	COOLANOL 20
T_{IN}	=	110°F
T_{OUT}	=	40°F
FLOWRATE	=	430 PPH
T_{SINK}	=	0°F
Q_{REJ}	=	4 kW
ΔP	=	10 PSI (0.08" I.D. TUBE)

PHYSICAL DESCRIPTION - 1 WING

2 BLANKETS, TOTAL WIDTH 80" (360 FT^2 RADIATING AREA)

DEPLOYED LENGTH = 27 FT

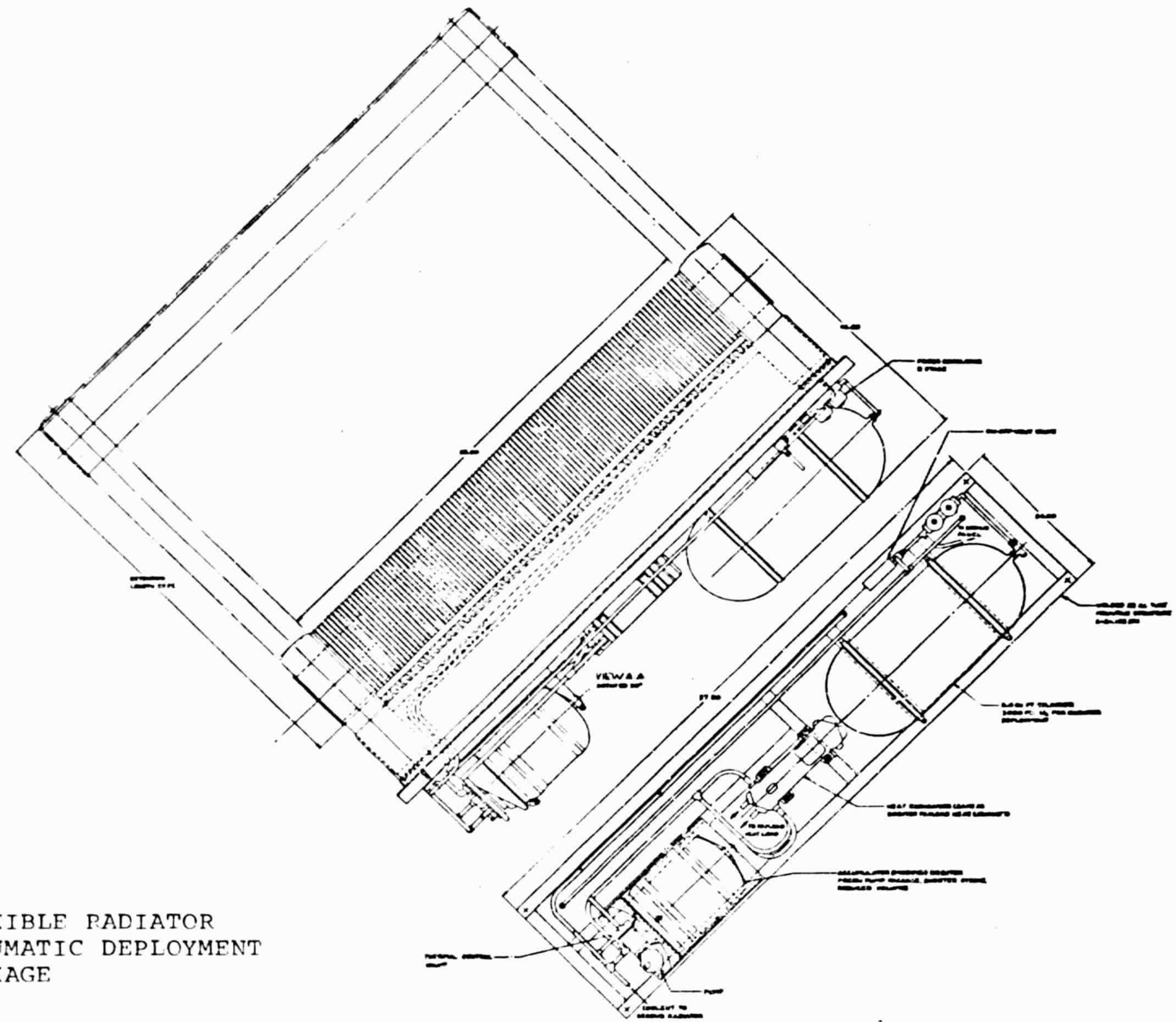
RADIATOR PALLET STOWAGE ENVELOPE (INCL. FLUID PACKAGE)

46.6" x 24" x 97.8" (GAS)
44.0" x 25" x 108.9" (BOOM)

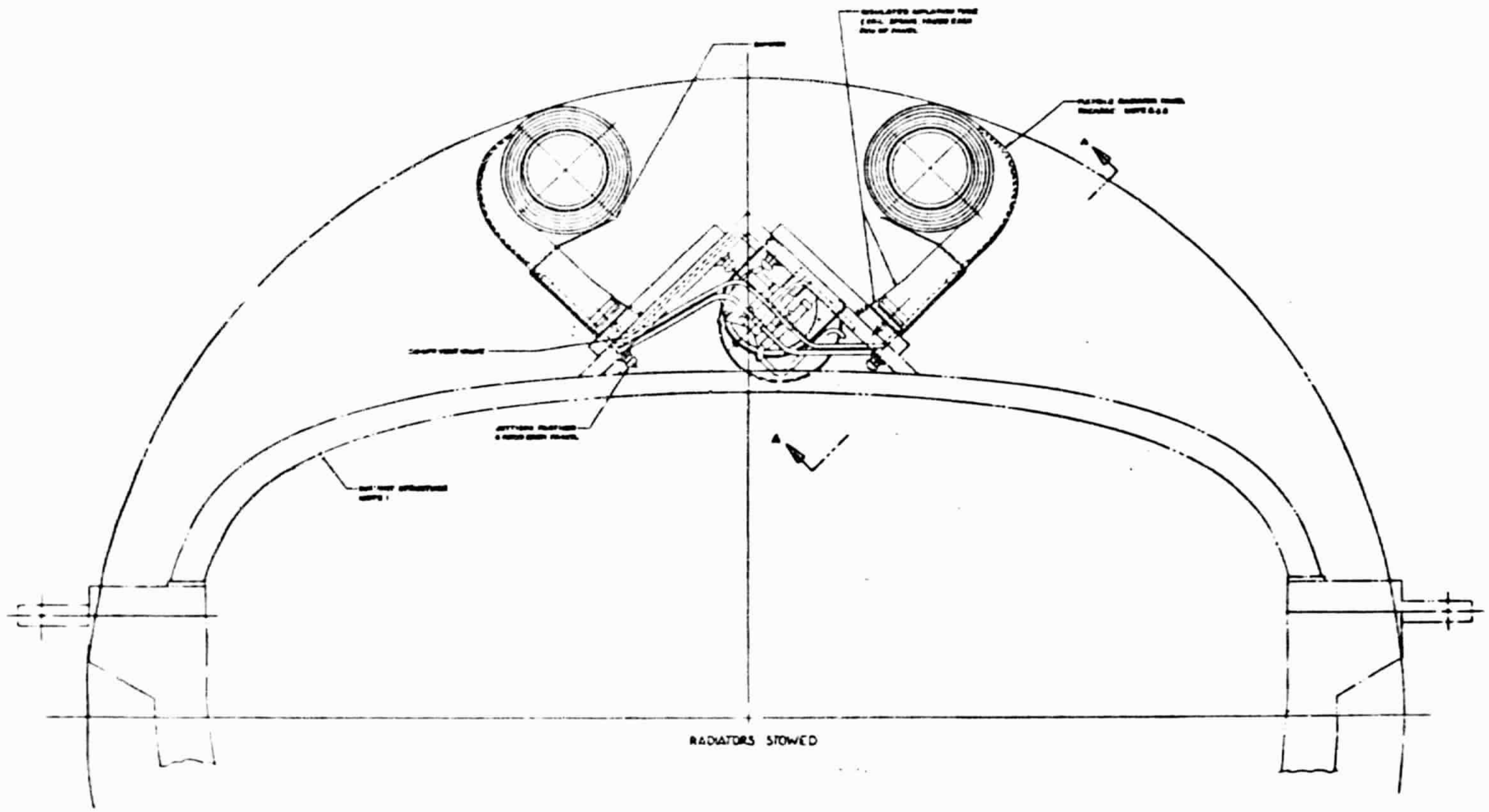
TOTAL WEIGHT - 2 WINGS PLUS FLUID PACKAGE

738 LBS WET (GAS DEPLOYED)

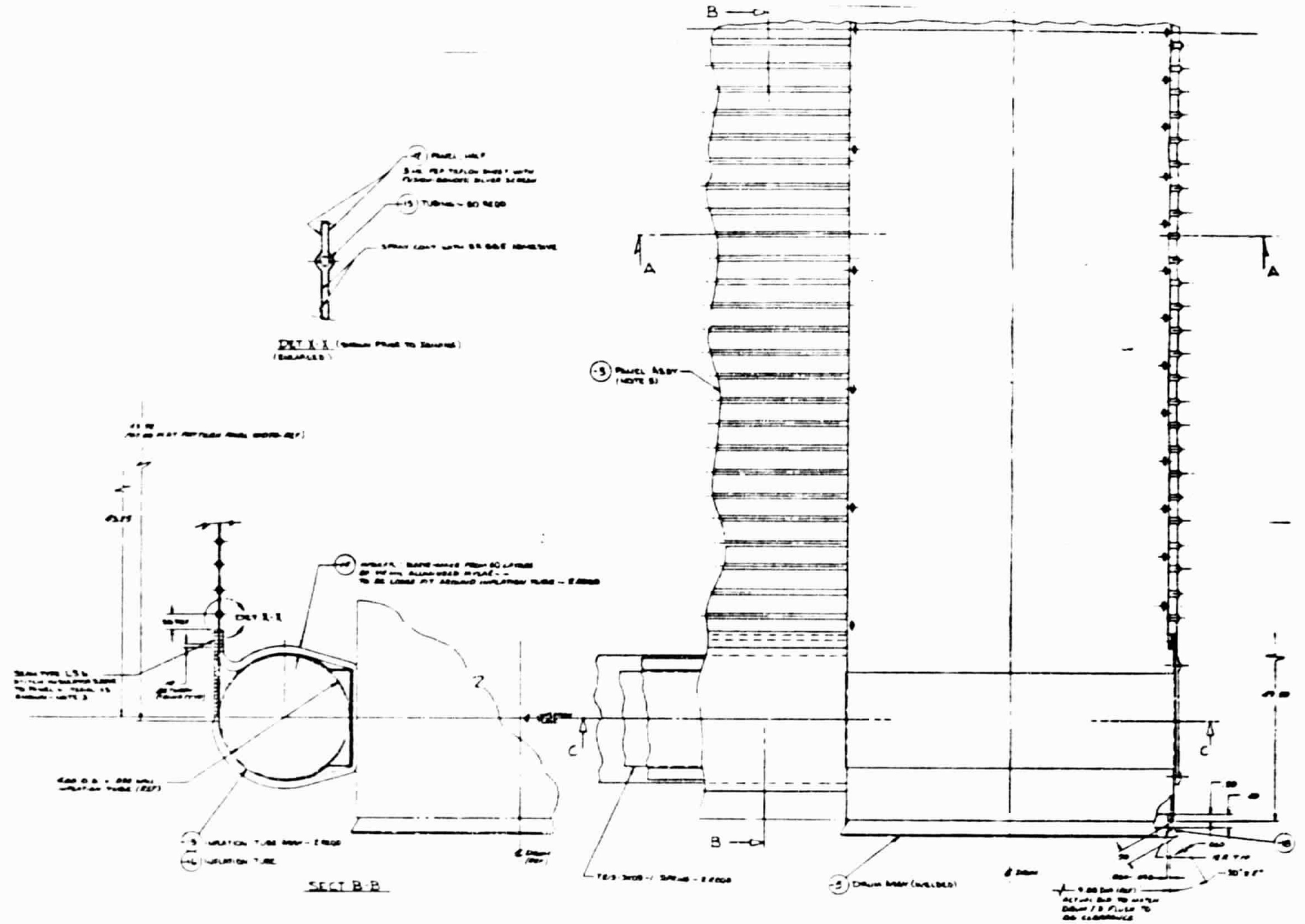
460 LBS WET (BOOM DEPLOYED)



FLEXIBLE RADIATOR
PNEUMATIC DEPLOYMENT
PACKAGE



FLEXIBLE RADIATOR PNEUMATIC DEPLOYMENT



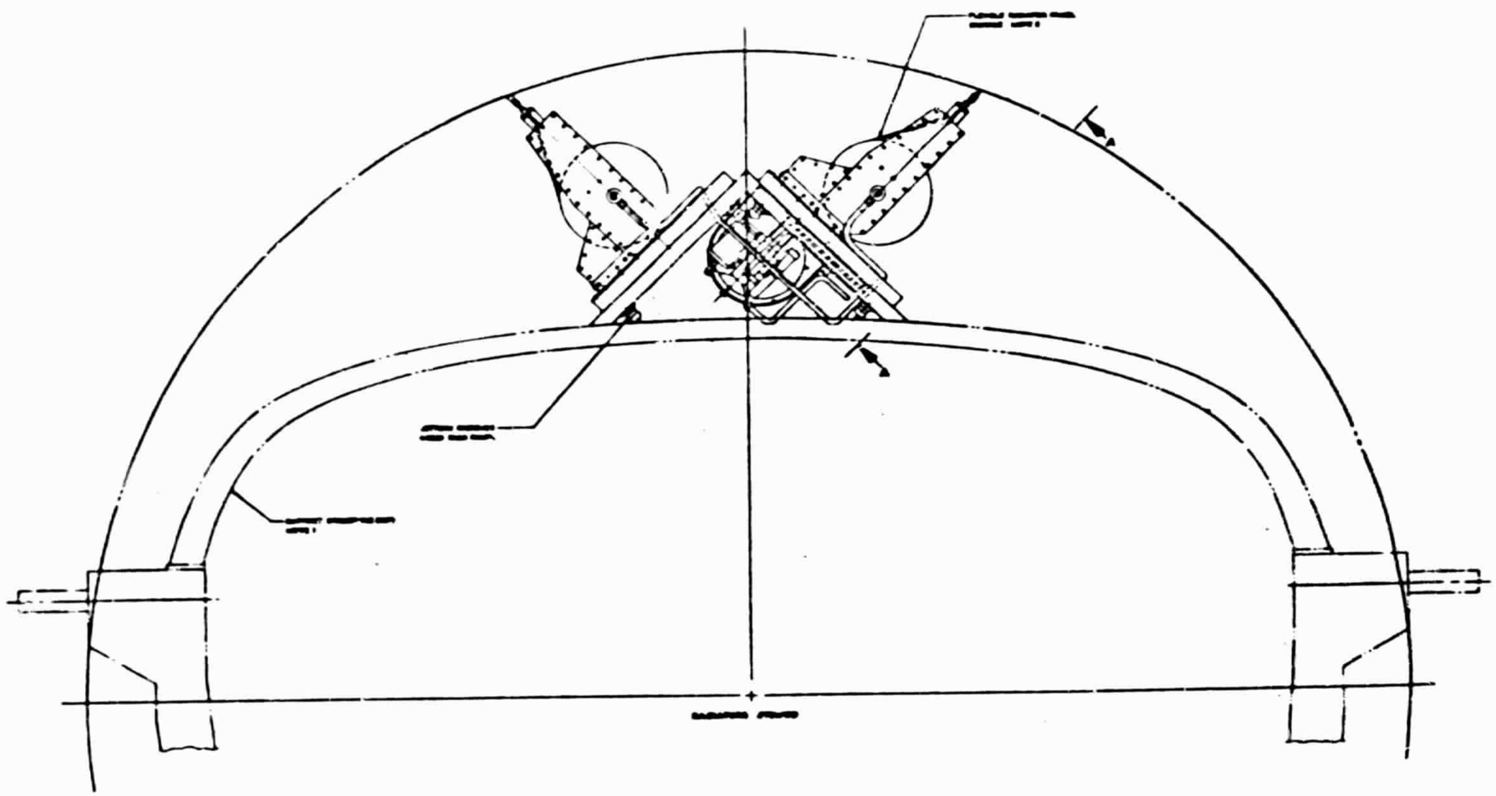
FLEXIBLE RADIATOR CONSTRUCTION WITH PNEUMATIC DEPLOYMENT

FLEXIBLE PANEL RADIATOR
PNEUMATIC DEPLOYMENT
(2 WINGS)

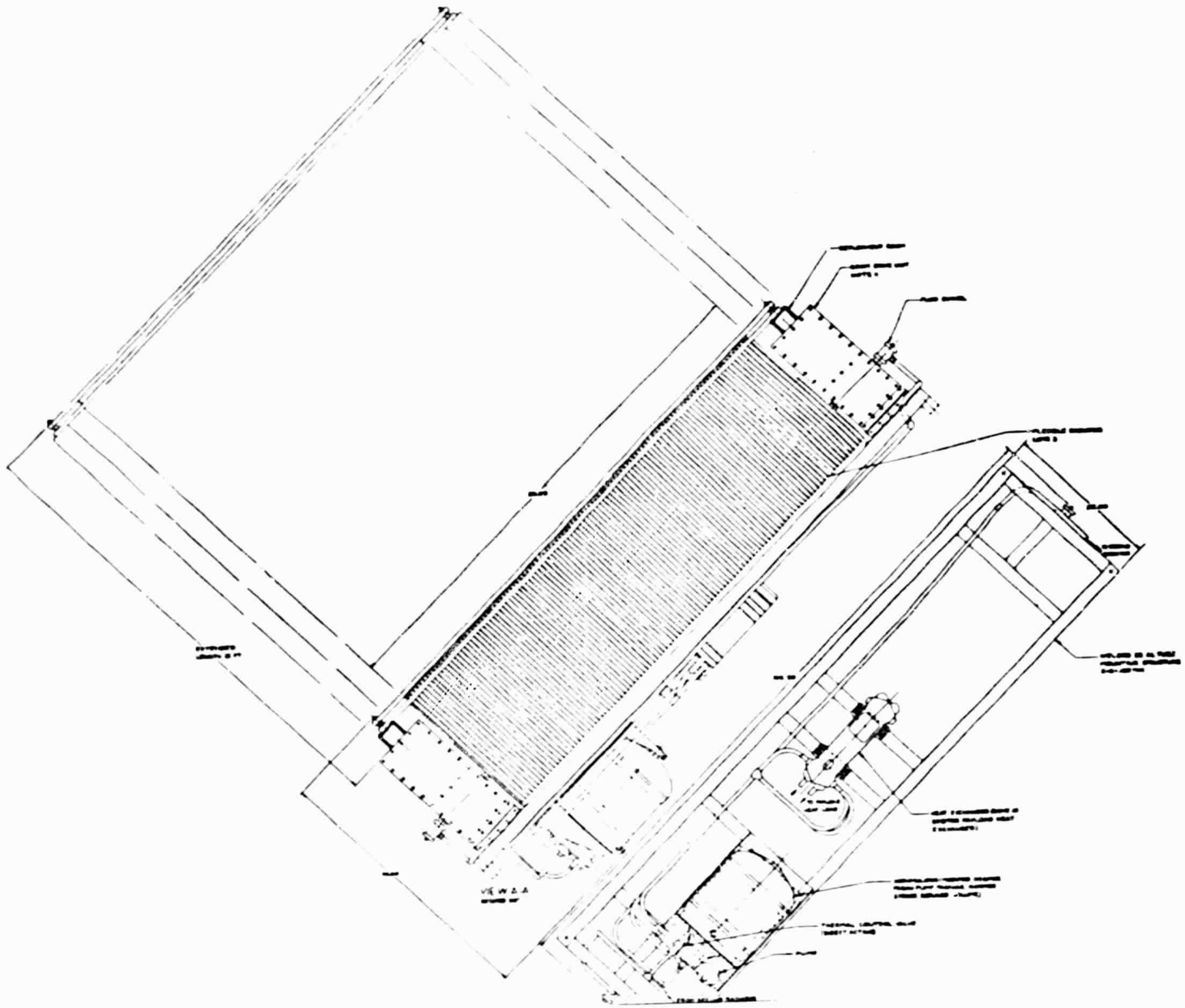
PANEL		74.7
PANEL CLAMP		8.0
PANEL MANIFOLD & FITTINGS		12.0
DRUM & PLUMBING		26.0
INFLATION TUBE & SPRING SUPPORT, CLAMPS, & HARDWARE		108.9
ACCUMULATOR PKG		41.0
HEAT EXCHANGER		32.8
COOLANT PLUMBING, CLAMPS & HARDWARE		10.4
N_2 CYLINDER		177.0
CYLINDER MTG. CLAMPS		5.6
N_2 ON-OFF-VENT VALVE (2)		6.0
N_2 PLUMBING, CLAMPS & HARDWARE		4.9
N_2 REGULATOR		2.0
N_2 ELECT. CONTROL BOX		4.0
MOUNTING FRAME		65.0
JETTISON FASTNERS		4.0
	DRY WEIGHT	582.3
COOLANOL 20		54.0
N_2 GAS		46.9
	WET WEIGHT	683.2
PRODUCTION GROWTH (8%)		54.7
	PRODUCTION WEIGHT	737.9

DESCRIPTION OF SOFT TUBE FLEXIBLE RADIATOR WITH EXTENDIBLE BOOM DEPLOYMENT

- EACH RADIATOR PANEL/PALLET IS 80" WIDE BY 27' LONG DEPLOYED
- TRANSPORT FLUID FLOW IS PARALLEL TO LONG DIMENSION
- COOLANOL 20 TRANSPORT FLUID
- AREA CONTROL PROVIDED TO AVOID FLUID INSTABILITIES AT LOW LOAD
- EXTENDIBLE BOOMS (ON EACH SIDE OF PANEL) DRIVE FROM SINGLE SHAFT TO ALLEVIATE SYNCHRONIZATION PROBLEMS



FLEXIBLE RADIATOR BOOM DEPLOYMENT



FLEXIBLE RADIATOR - BOOM DEPLOYMENT PACKAGE

FLEXIBLE PANEL RADIATOR
BOOM DEPLOYMENT

(2 WINGS)

PANEL	74.7
BOOM DRIVE UNIT	51.8
MANIFOLD & FITTINGS	12.0
CLAMP	8.0
SWIVEL	5.0
DRUM WITH PLUMBING & SHAFT TO SWIVEL	62.0
ACCUMULATOR PKG.	41.0
HEAT EXCHANGER	32.8
COOLANT PLUMBING, CLAMPS & HARDWARE	10.8
MOUNTING FRAME	72.8
JETTISON FASTNERS	4.0
DRY WEIGHT	374.9
COOLANOL 20	54.0
WET WEIGHT	428.9
PRODUCTION GROWTH (8%)	
PRODUCTION WEIGHT	463.2

VOUGHT

COOLANOL 20 KIT ACCUMULATOR

COMPONENT DESCRIPTION	VOLUME, FT^3
RADIATORS (3 WINGS, 1000 FT^2)	0.550
COLDPLATES (20)	0.586
PAYLOAD HX (2 LOOPS)	0.071
FLEX HOSES (CONNECTING C/P)	0.219
HARDLINES	0.127
INTERFACE HOSE ASSY	0.253
ULLAGE	0.014
MISC.	0.028
	1.848

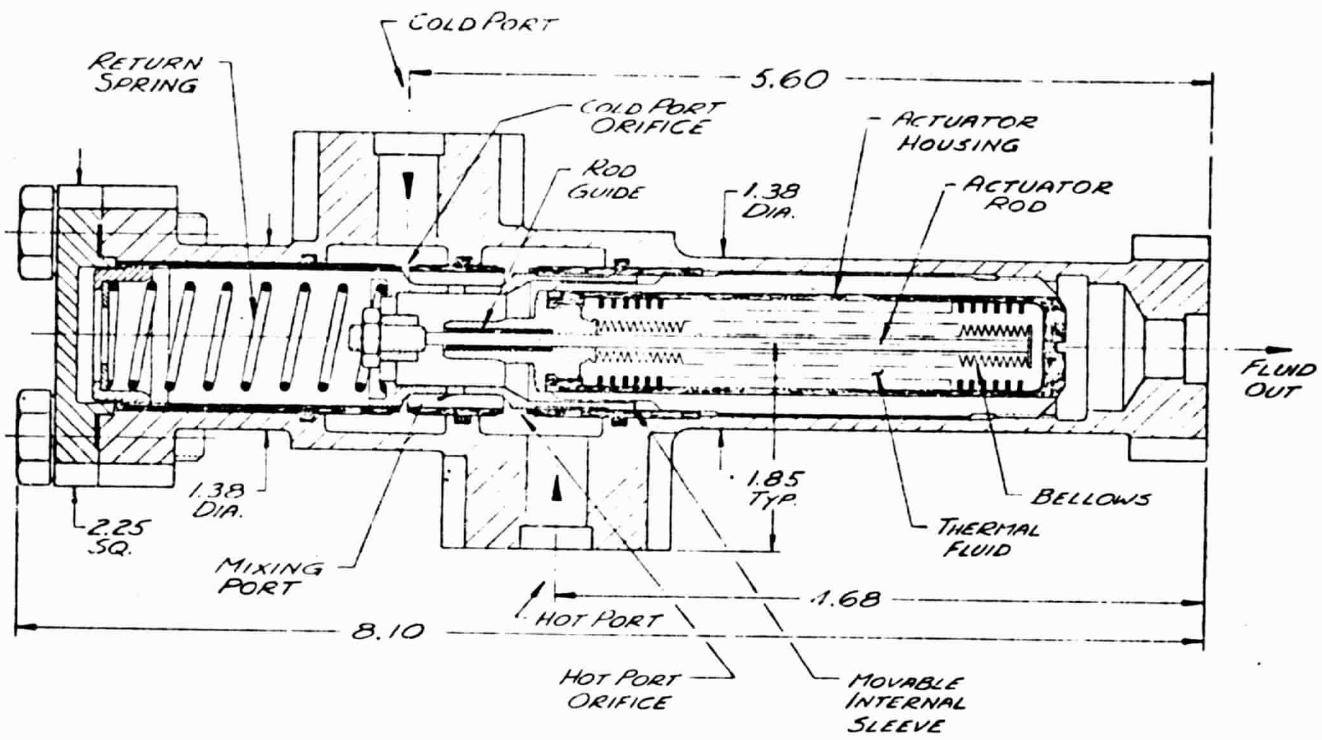
FLUID VOLUME TEMPERATURE RANGE + 200 OF TO - 50^0F

PRESENT VOLUME CHANGE = 16.6%

ACCUMULATOR VOLUME = .31 FT^3

C-2

REPRESENTATIVE THERMAL CONTROL VALVE
(WILLIAM WAHL CORP)



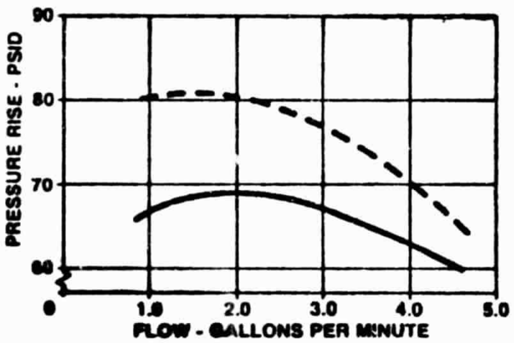
VALVE SCHEMATIC

- Prior use on Skylab
- Control mixed temperature to $\pm$ 2°F
- 2.5-5 psid delta-P @ 450 pph Coolanol
- Weight 3 lbs

VOUGHT

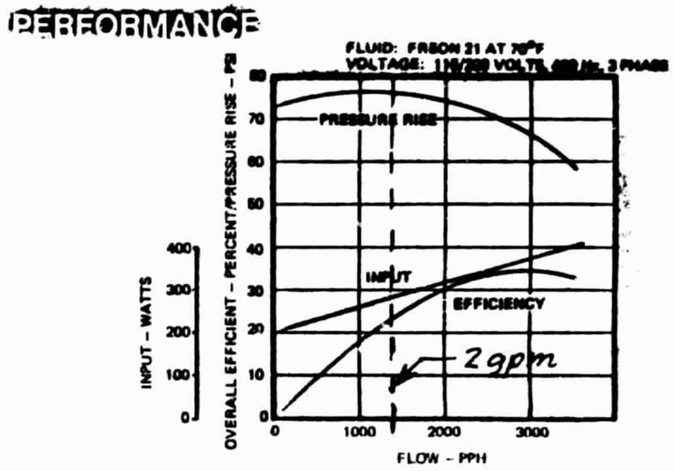
REPRESENTATIVE COOLANOL 20 PUMP FOR FLEXIBLE RADIATOR

PRESSURE RISE vs. FLOW

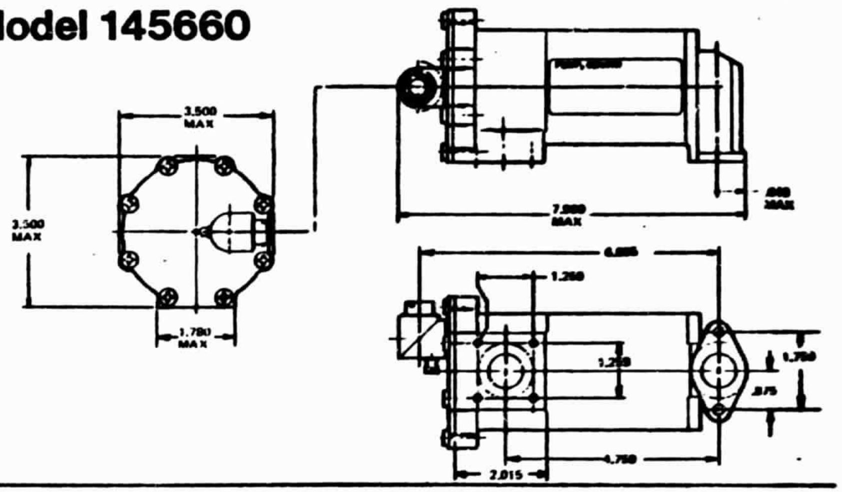


- - - - SHUTTLE MOTOR/PUMP AT 400 HZ, 115 VAC WITH FREON 21 FLUID

——— SIMILAR MOTOR/PUMP AT 450 HZ, 46.4 VAC WITH COOLANOL 20 FLUID



Model 145660



- ESTIMATED 1-3 GPM COOLANOL 20 REQUIRED FOR KIT RADIATOR CONFIGURATIONS
- ESTIMATED 35-50 PSI PRESSURE RISE REQD
- MODIFIED ORBITER FREON 21 PUMP MEETS THESE REQUIREMENTS - USE TAILORING ORIFICE TO ADJUST TO SPECIFIC KIT RADIATOR MISSION NEEDS
- SIMILAR ORBITER PUMP MODIFICATION FOR SIRE PROGRAM

Sundstrand Aviation Mechanical

VOUGHT

DESCRIPTION OF RIGID PANEL FOLDOUT RADIATOR WITH SCISSORS DEPLOYMENT

- o EACH RADIATOR PANEL IS 71.3" LONG BY 80"
- o TRANSPORT FLUID FLOW IS PARALLEL TO PANEL SHORT DIMENSION
- o FREON 21 TRANSPORT FLUID
- o SCISSORS MECHANISM DEPLOYS/RETRACTS THE RADIATOR WING

VOUGHT

DESIGN SUMMARY - RIGID PANEL RADIATOR

PERFORMANCE - 1 WING

FLUID	=	FREON 21
T_{IN}	=	110°F
T_{OUT}	=	40°F
FLOWRATE	=	800 PPH
T_{SINK}	=	0°F
Q_{REJ}	=	4 kW
ΔP	=	3.6 PSI

PHYSICAL DESCRIPTION - 1 WING

5 PANELS, 7.13" x 80" EACH (396 FT^2 RADIATING AREA)

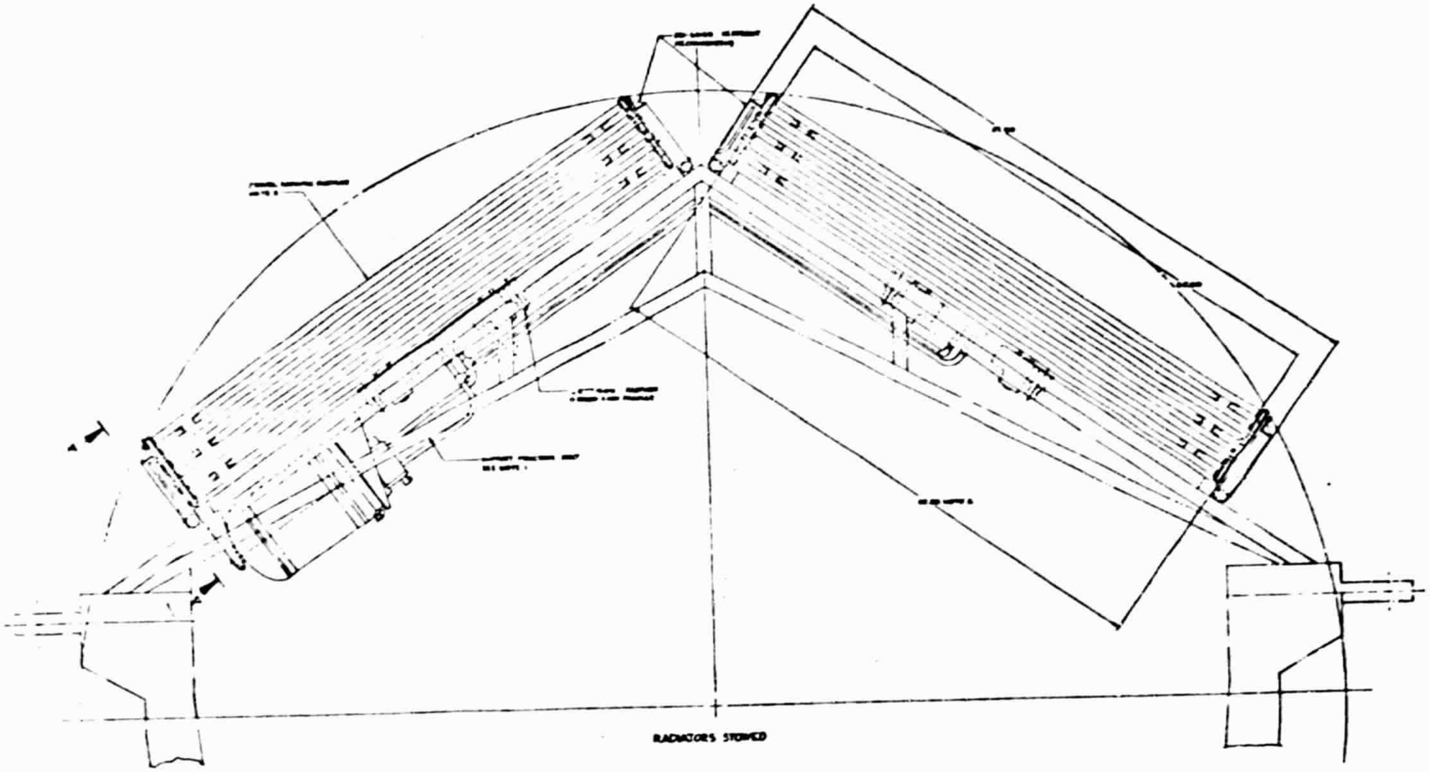
DEPLOYED LENGTH - 32 FT

RADIATOR PALLET STOWAGE ENVELOPE (INCL. FLUID PACKAGE)

82.2" x 82.2" x 28.8"

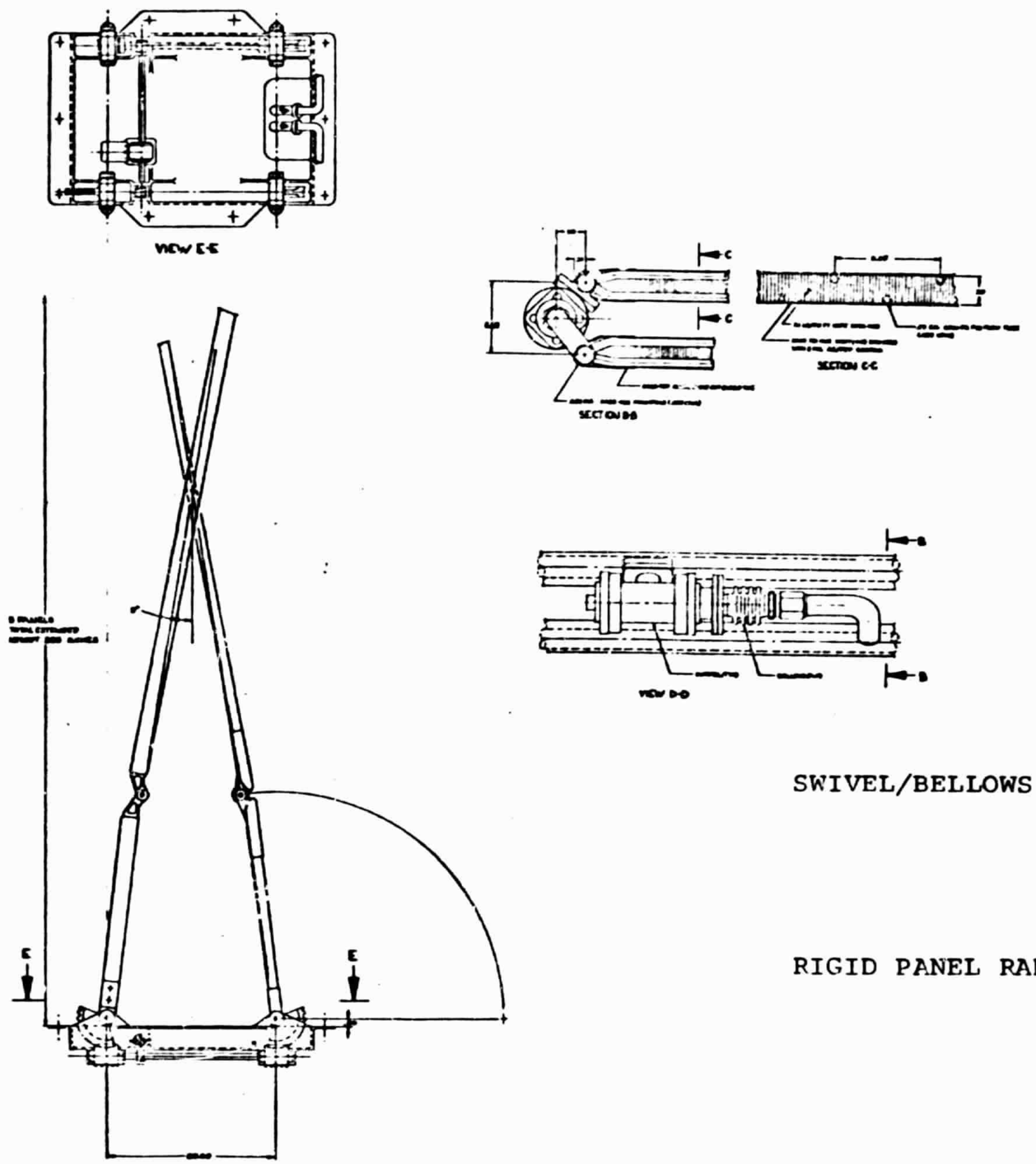
TOTAL WEIGHT - 2 WINGS PLUS FLUID PACKAGE

1220 LBS (WET)



RIGID PANEL RADIATOR

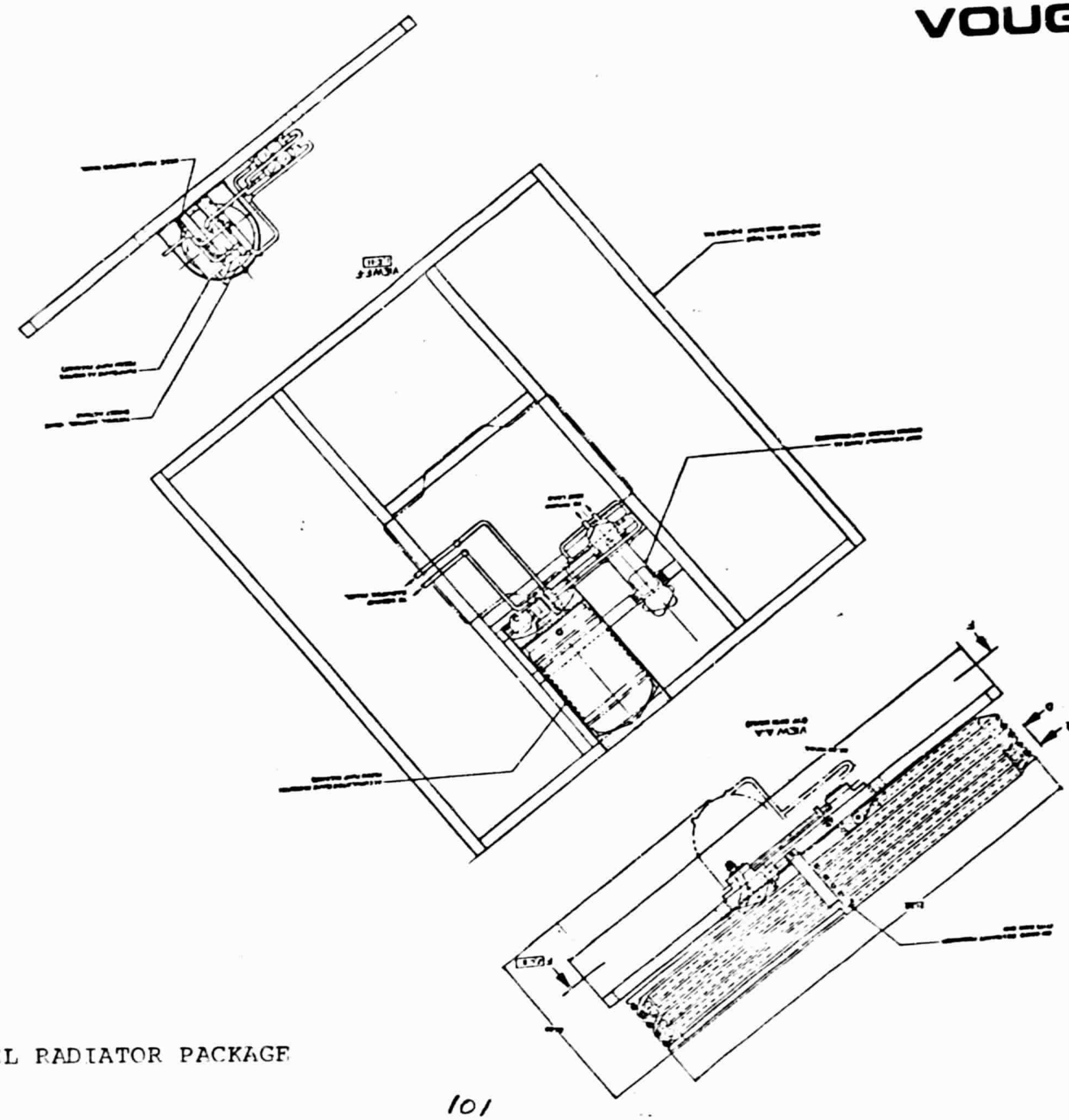
VOUGHT



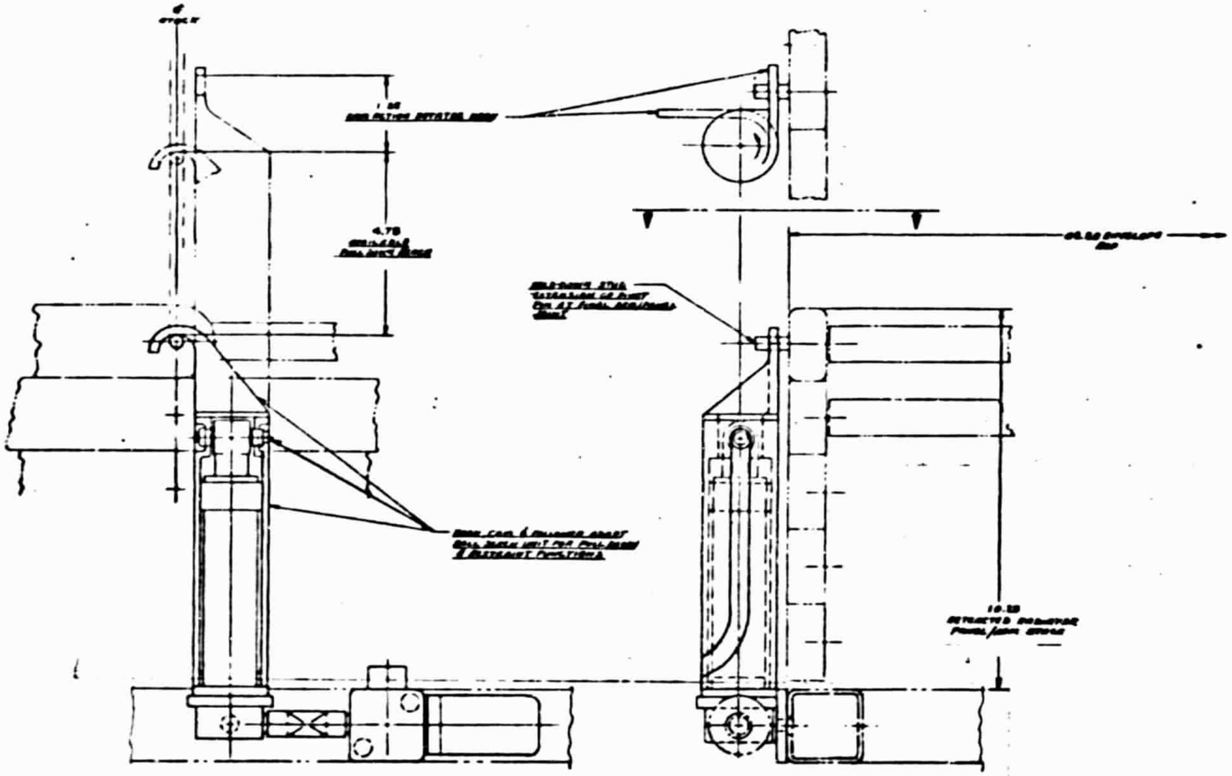
SWIVEL/BELLOWS DETAIL

RIGID PANEL RADIATOR

RADIATOR DEPLOYED



RIGID PANEL RADIATOR PACKAGE



RIGID PANEL RESTRAINT MECHANISM

FREON 21 KIT ACCUMULATOR

COMPONENT DESCRIPTION	VOLUME, FT^3
RADIATOR (10 PANELS, 791 FT^2)	0.997
CONNECTING LINES (3/4"x.035"x70 FT)	0.177
PAYLOAD HX (2 LOOPS)	0.071
COLDPLATES (20)	0.586
FLEX HOSES (CONNECTING C/P)	0.219
ULLAGE	0.014
MISC.	0.028
	2.092

FLUID VOLUME TEMPERATURE RANGE + 200^0F TO -135^0F

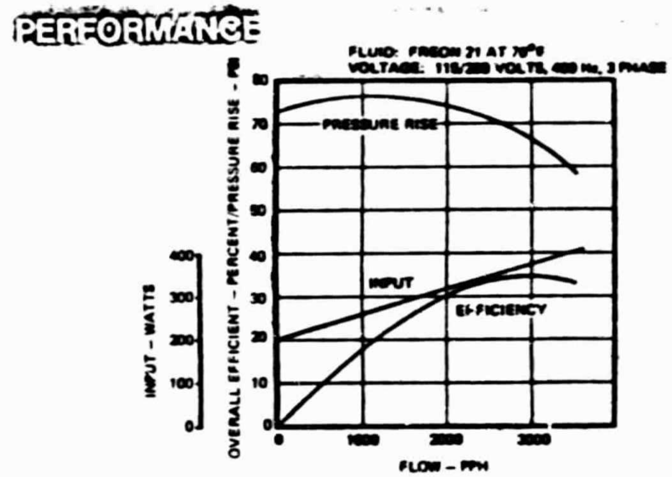
PERCENT VOLUME CHANGE 38.6%

ACCUMULATOR VOLUME = .81 FT^3

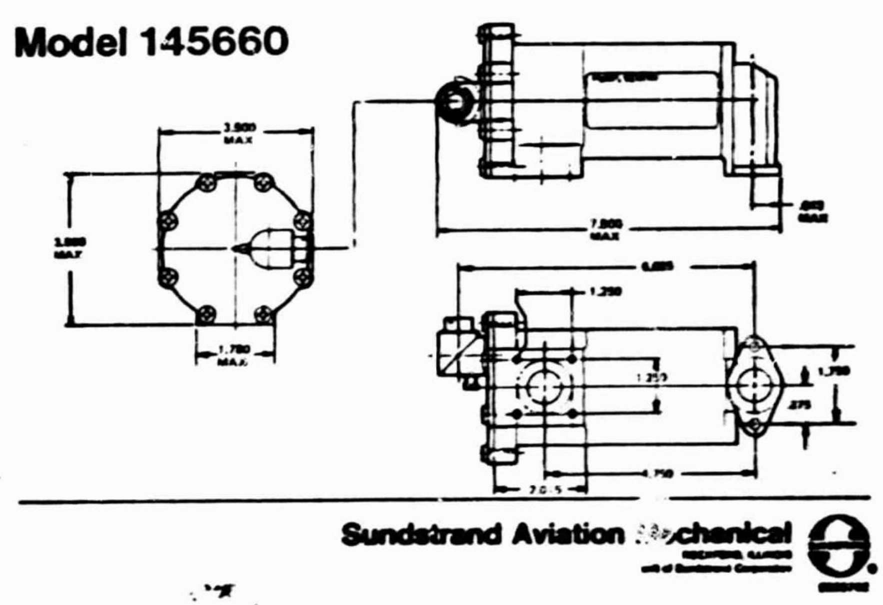
REPRESENTATIVE FREON 21 PUMP FOR RIGID PANEL KIT

SPECIFICATIONS

- . FLOW: 2540 PPH (3.72 GPM)
- . PRESSURE RISE: 69 PSI MIN
- . INPUT POWER: 115/200 VOLTS, 400 Hz, 3 PHASE
- . CURRENT: 1.70 AMPS PER PHASE
- . FLUID: FREON 21 ($CHCL_2F$)
- . WEIGHT: 3.9 LBS.

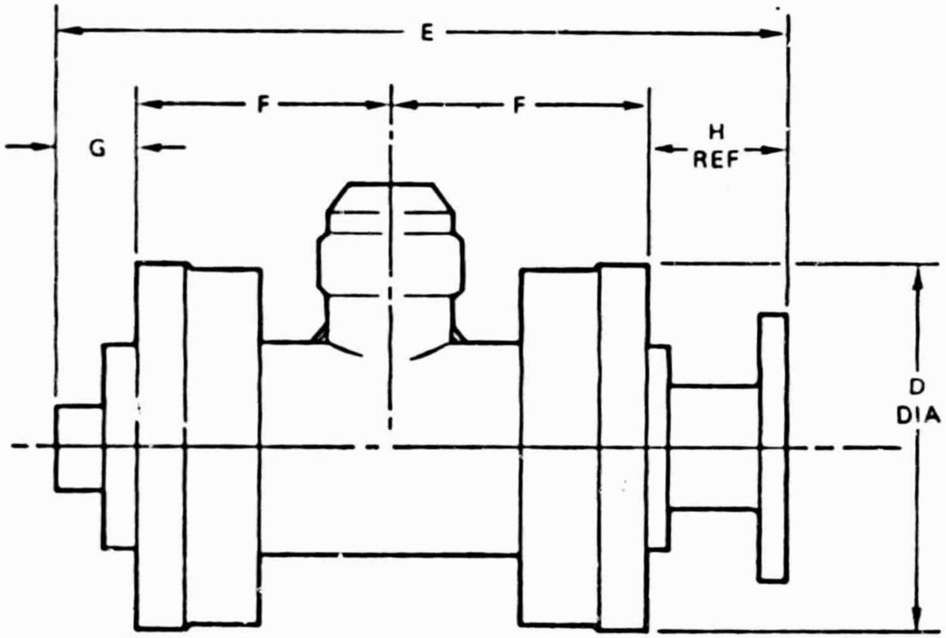


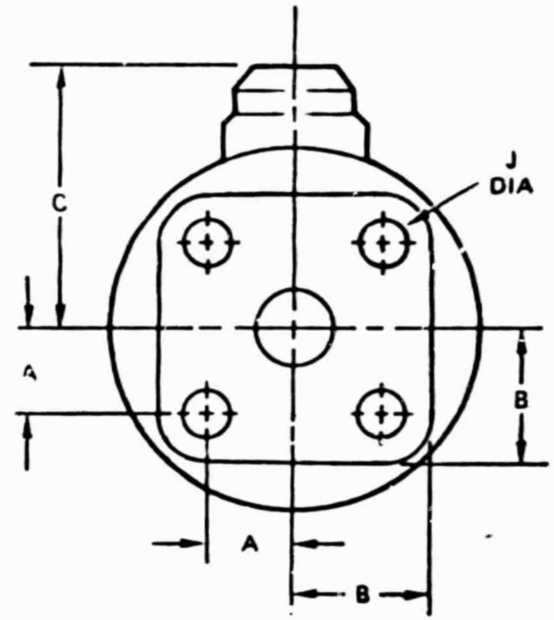
- ESTIMATE 1100-3300 PPH FREON 21 REQUIREMENTS FOR POTENTIAL RIGID PANEL KIT RADIATOR CONFIGURATIONS
- ESTIMATE 25-40 PSI PRESSURE RISE REQT
- ORBITER FREON 21 PUMP MEETS THESE REQUIREMENTS WITHOUT MODIFICATIONS
- USE TAILORING ORIFICE TO ADJUST TO SPECIFIC KIT RADIATOR MISSIONS



VOUGHT

VOUGHT FREON SWIVEL
RIGHT ANGLE DESIGN





SWIVEL SIZE	WEIGHT *STEEL	WEIGHT AL	A	B	C	D DIA	E	F	G	H	J DIA
1/2	1.34	.80	.44	.72	1.40	1.96	3.81	1.34	.38	.75	.25
5/8	1.42	.85	.48	.74	1.44	1.96	3.94	1.44	.40	.66	.25
3/4	2.04	1.22	.56	.80	1.78	2.22	4.35	1.61	.40	.73	.25
1.0	2.59	1.61	.62	.87	2.00	2.46	4.50	1.68	.40	.74	.25

SWIVEL SHOWN → 5/8

VOUGHT CORPORATION

RIGID PANEL RADIATOR

(2 WINGS)

		LBS
PANEL		500.5
SCISSORS ARMS		105.7
DEPLOYMENT MECHANISM		10.9
ACCUMULATOR ASSEMBLY		42.5
LATCHING MECHANISM		24.0
SWIVELS		29.2
BELLOWS		33.6
HEAT EXCHANGER		32.8
MOUNTING FRAME		113.4
JETTISON FASTNERS		4.0
BOTTOM DUMMY PANEL STRUCTURE		28.0
	DRY WEIGHT	932.0
FREON 21		200.0
	WET WEIGHT	1132.0
PRODUCTION GROWTH (8%)		90.6
	PRODUCTION WEIGHT	1222.6

VOUGHT

CONCLUSIONS

1. MODULAR PALLET CONCEPT WITH NOMINAL 4 kw_t WINGS WILL ACCOMMODATE PEP REQUIREMENTS WITH ONE-TO-TWO WINGS.

2. KIT CONCEPT WILL ALLOW VARIOUS INTERFACES THROUGH ORBITER PAYLOAD HEAT EXCHANGER AND/OR DIRECT PAYLOAD INTERFACE. THERE ARE NO ORBITER IMPACTS.

3. KIT FLUID LOOP COMPONENTS USING CURRENTLY SPACE QUALIFIED OR DERIVATIVE HARDWARE IS PRACTICAL.

4. RIGID PANEL OR ROLL-OUT RADIATORS ARE VIABLE KIT APPROACHES; RIGID PANEL CONCEPTS REQUIRE LESS DEVELOPMENT RISK.

FUTURE WORK

REQUIREMENTS

- NEED REFINEMENT OF PEP HEAT LOADS AND RADIATOR ENVIRONMENTS
- NEED CONSIDERATION OF OTHER THAN BETA = 0^{o} PEP MISSIONS

KIT DESIGN

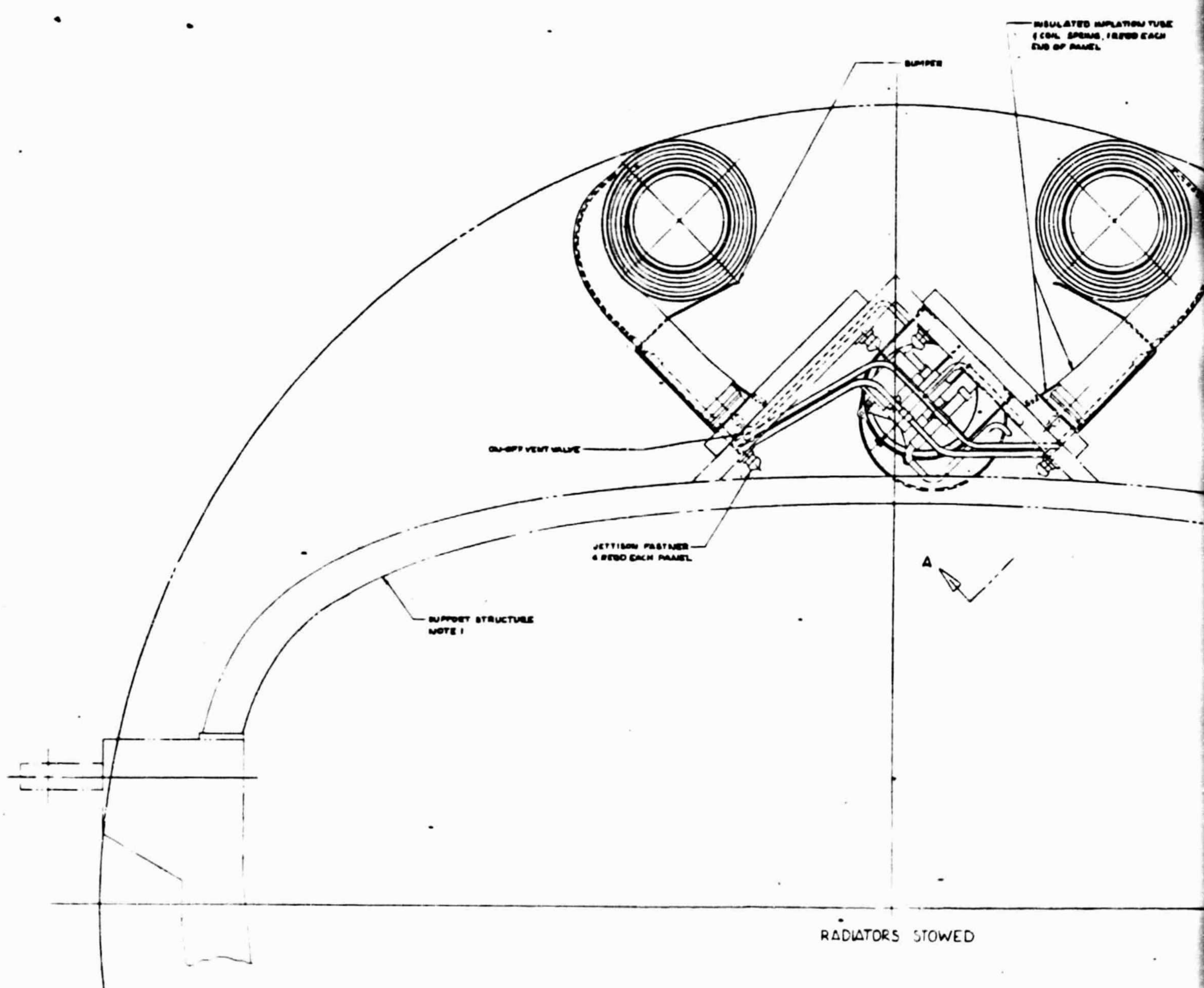
- DETAILED DESIGN TRADES ON SOFT TUBE DEPLOYMENT SYSTEMS AND CONTROL
- DETAILED DESIGN DEFINITION & COST/TECHNICAL TRADES OF THE 3 RADIATOR CONCEPTS - SELECT ONE

ACCOMMODATION STUDIES

- EVALUATE SPECIFIC PAYLOADS AND MISSIONS TO DEMONSTRATE AND VERIFY INTEGRATION

APPENDIX A

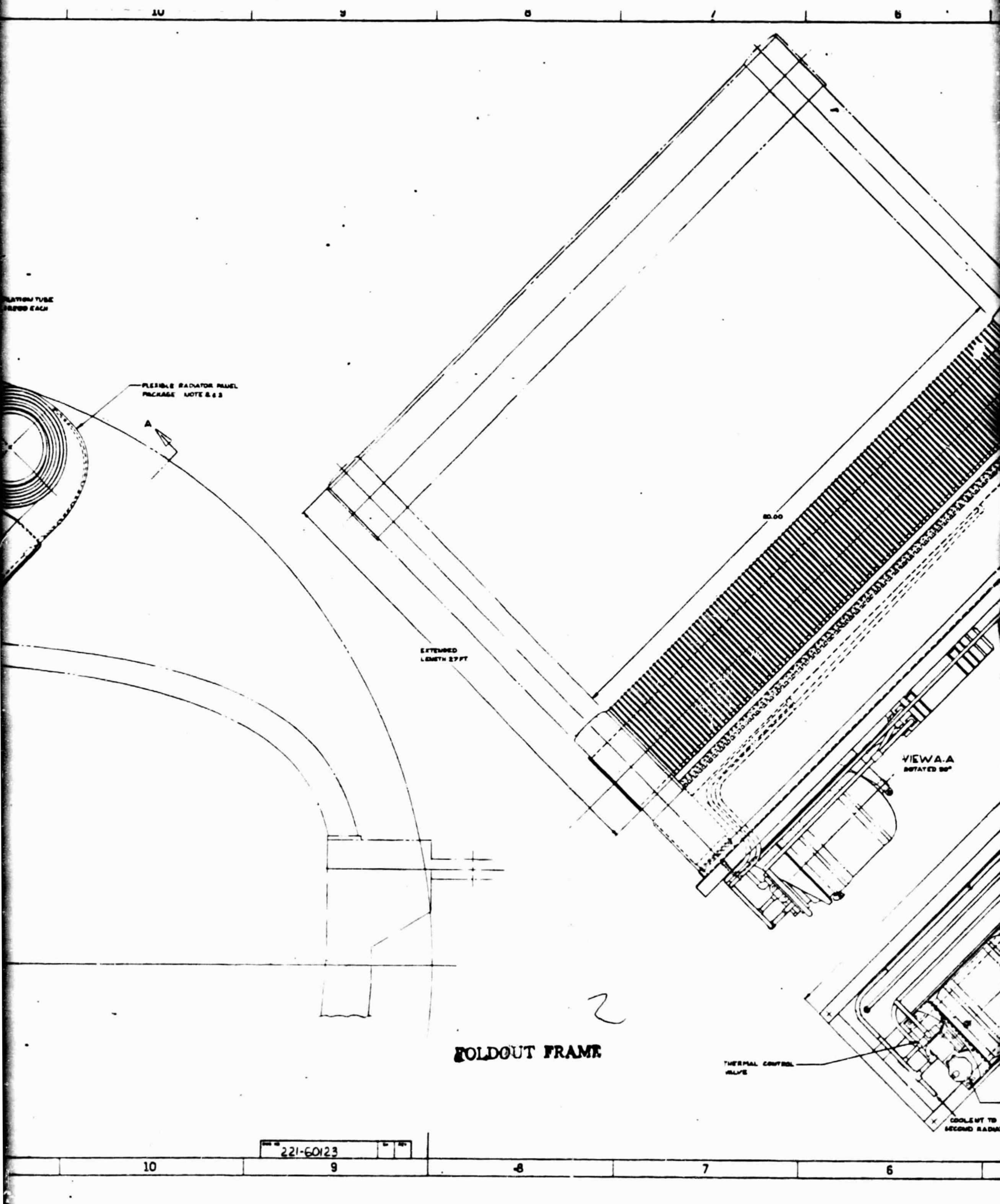
PRELIMINARY DESIGN DRAWINGS



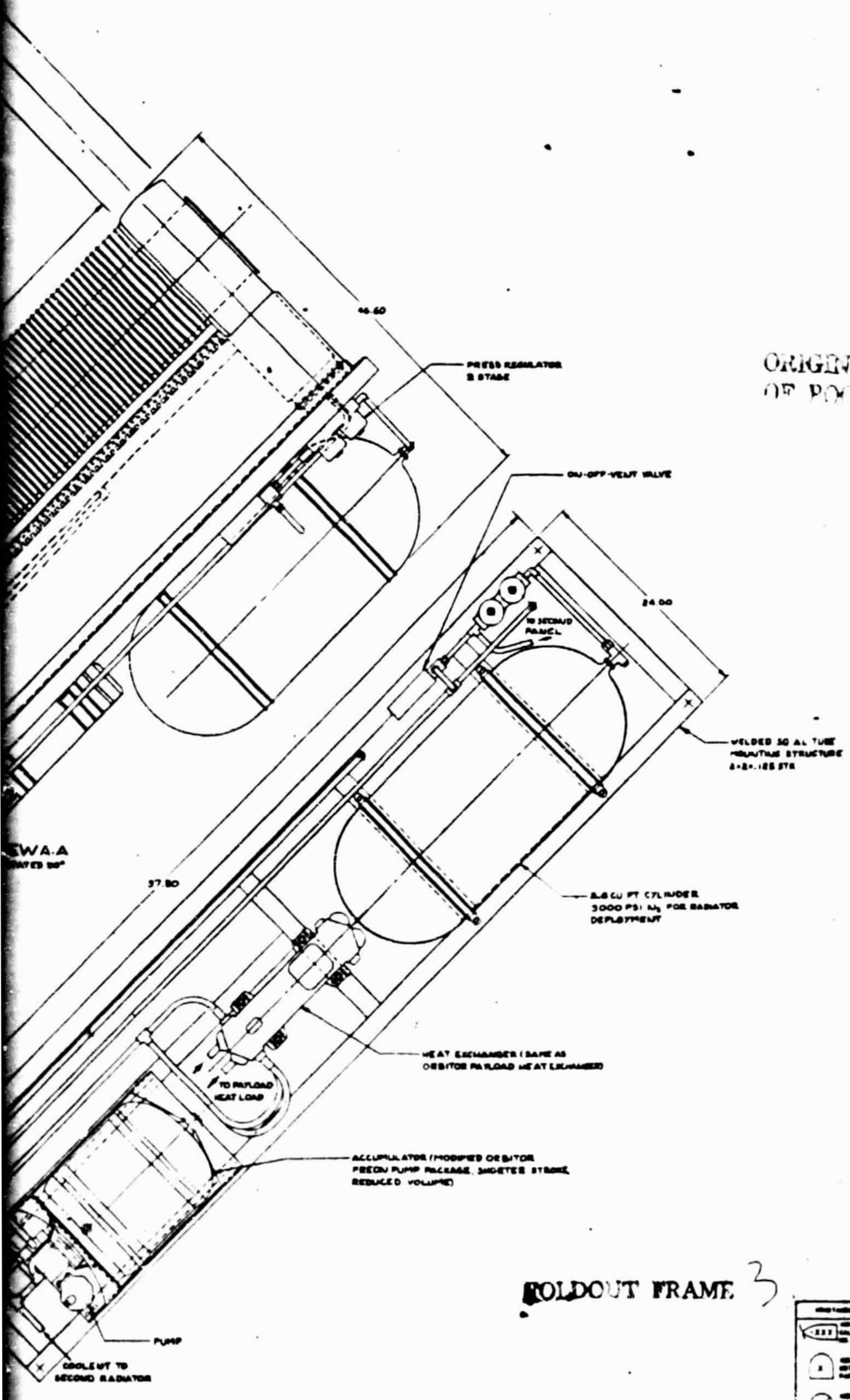
RADIATORS STOWED

FOLDOUT FRAME

15 14 13 12 11


FLEXIBLE RADIATOR PANEL PACKAGE NOTE 2 & 3
A
80.00
EXTENDED LENGTH 27 FT
VIEW A-A
ROTATED 90°
THERMAL CONTROL VALVE
FOLDOUT FRAME
221-60123
10
9
8
7
6

NOTES:
1. TYPICAL SUPPORT STRUCTURE CONCEPT SHOWN. ACTUAL SUPPORT STRUCTURE CONFIGURATION SHALL BE CUSTOMIZED TO MEET APPLICABLE PAYLOAD & MISSION REQUIREMENTS.
2. EACH FLEXIBLE RADIATOR PANEL PACKAGE WILL PROVIDE 4 KW HEAT REJECTION. 2 PACKAGES (PANELS) AS SHOWN REQD FOR 8KW HEAT REJECTION.
3. FOR DETAIL CONFIGURATION OF FLEXIBLE PANEL SEE TS13-3K00



ORIGINAL PAGE IS OF POOR QUALITY

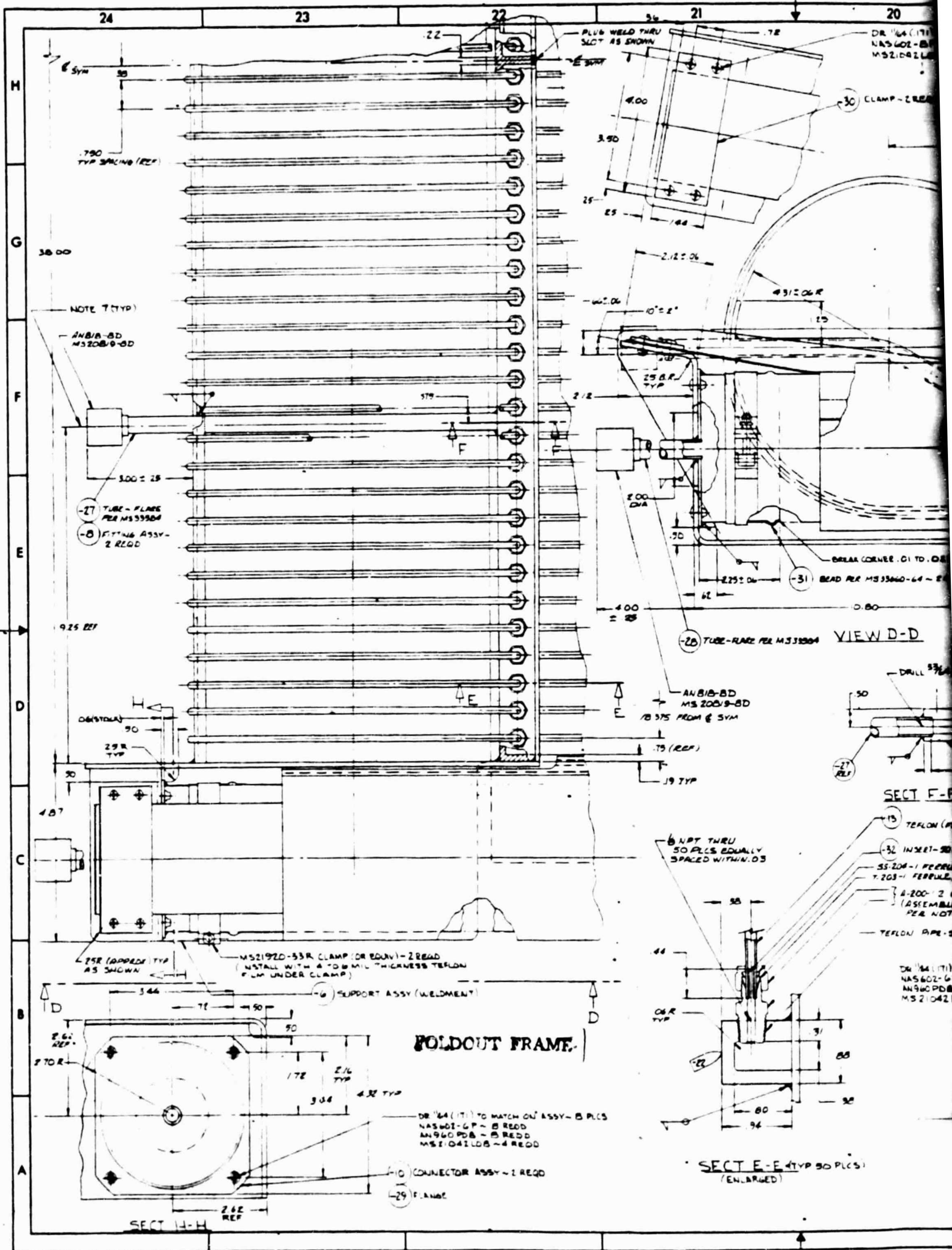
A-1

FOLDOUT FRAME 3

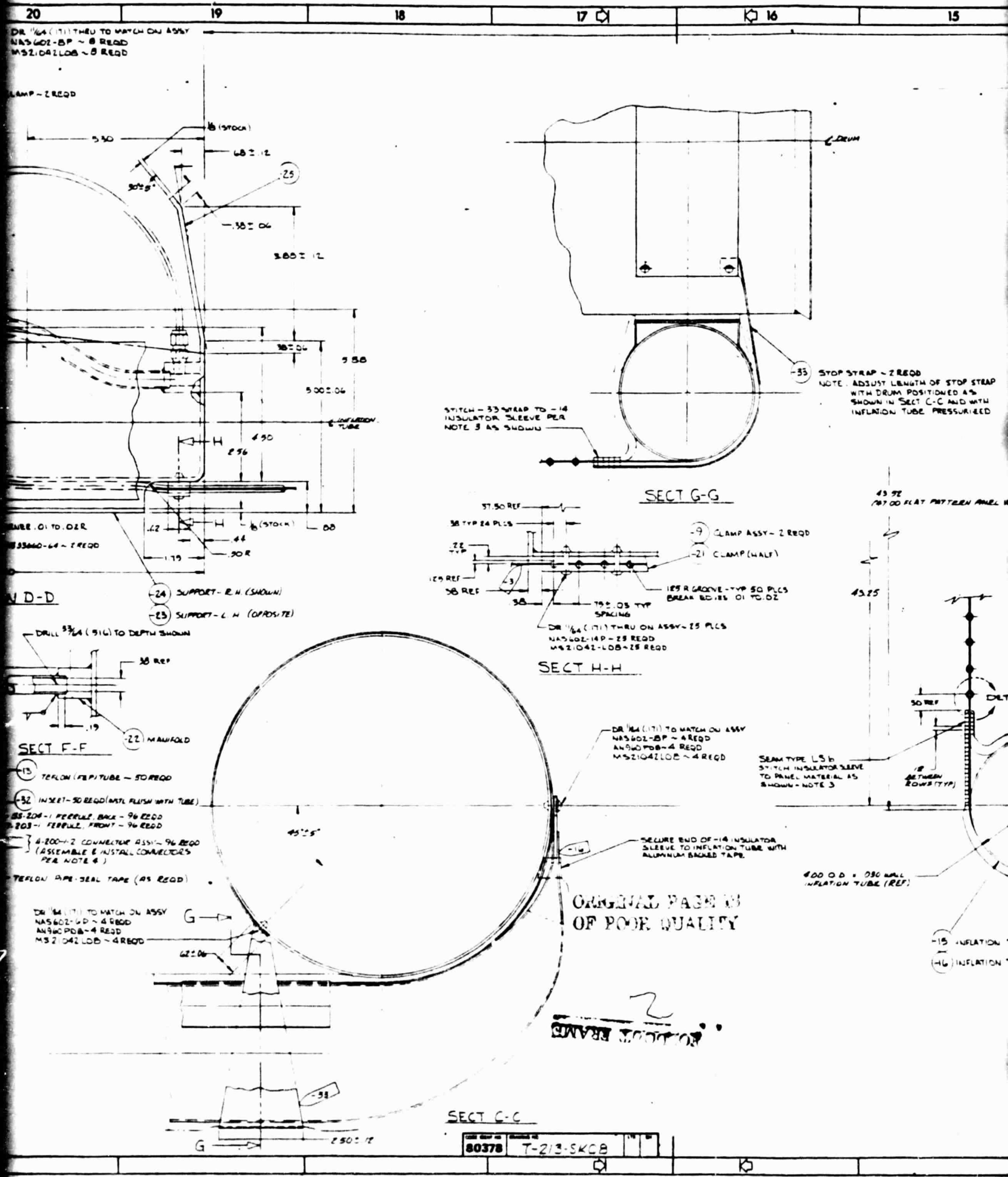
VOUGHT CORPORATION

PEP FLEXIBLE RADIATOR PNEUMATIC DEPLOYMENT GENERAL ARRANGEMENT

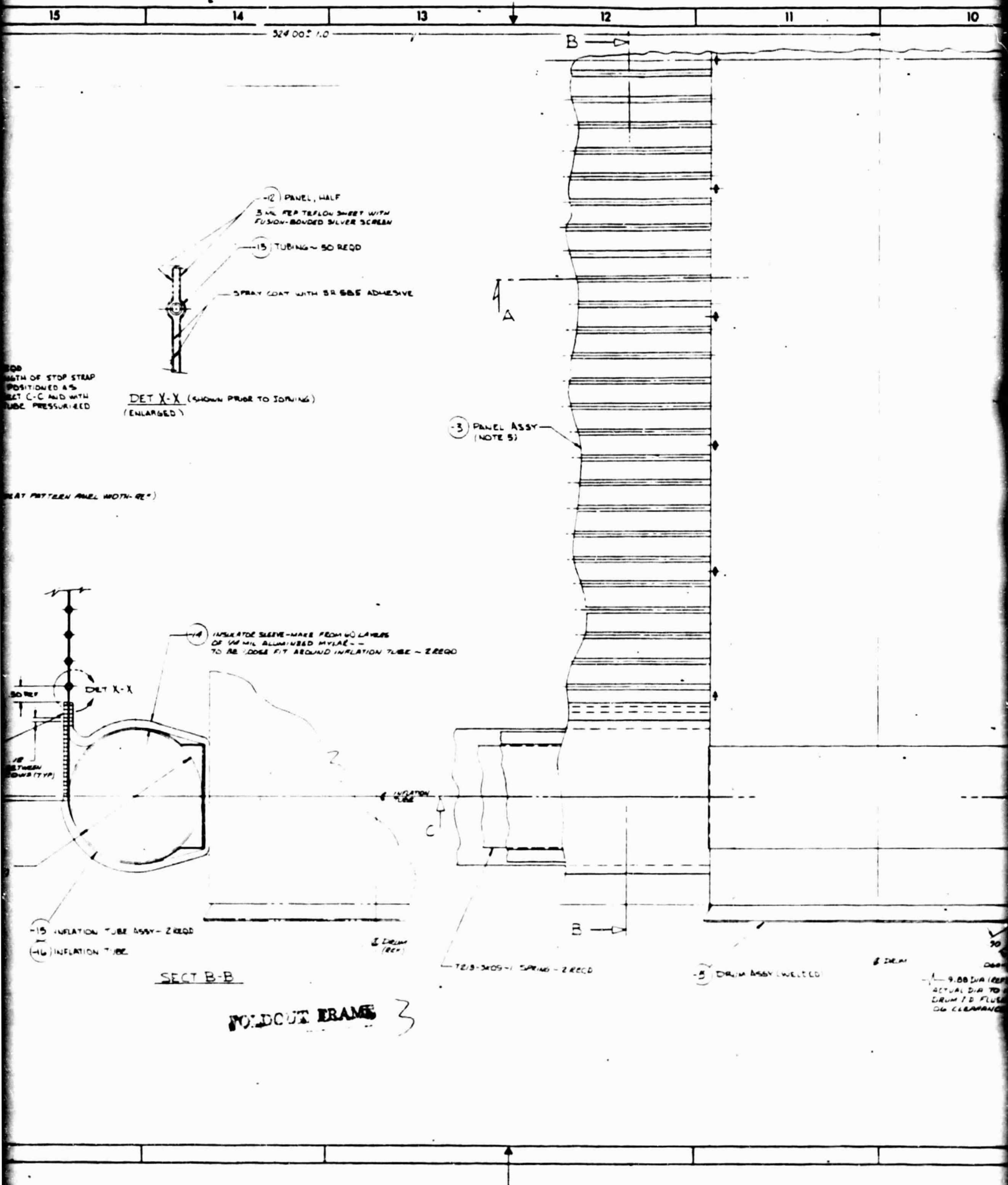
J 80378 221-60123



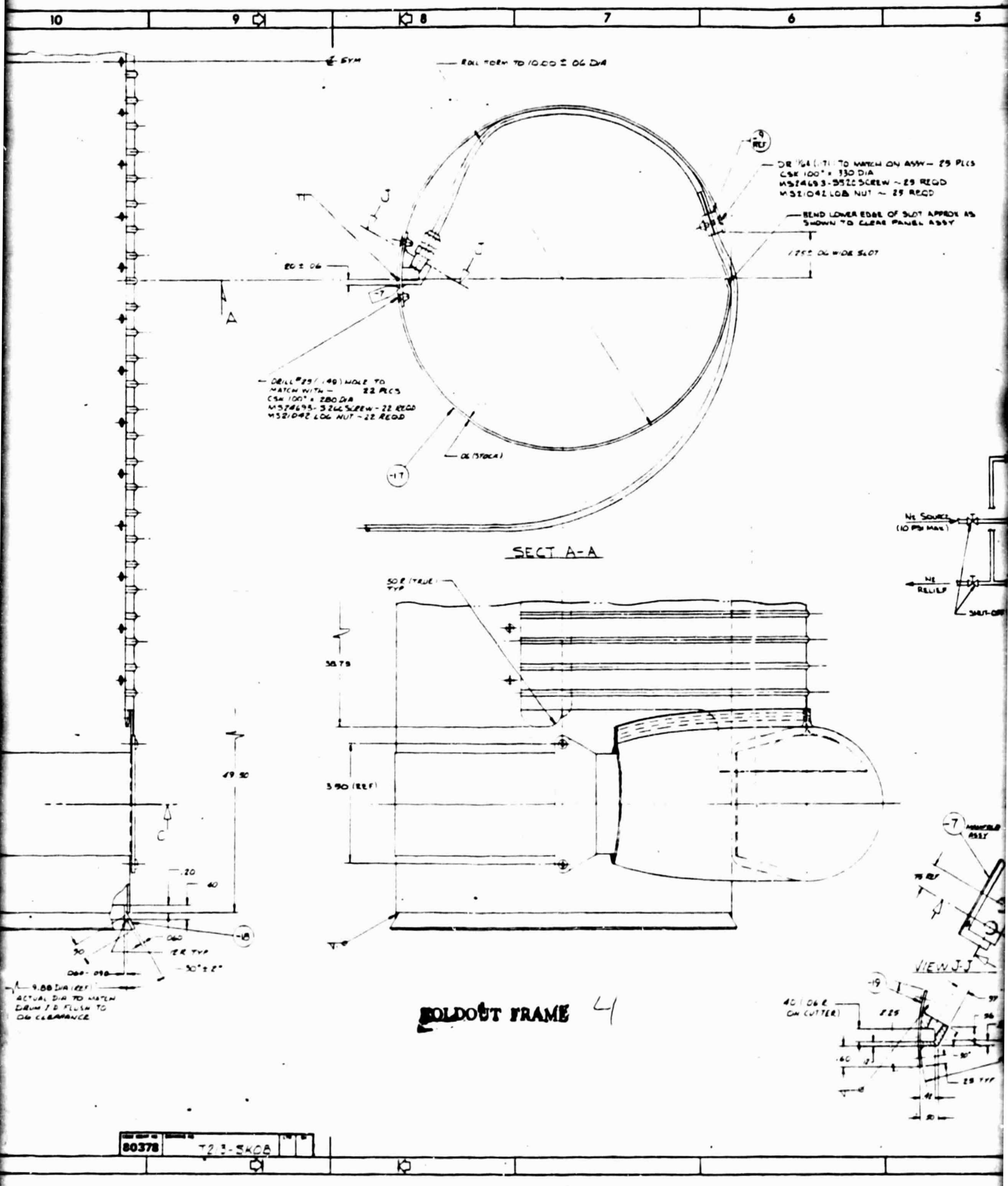
FOLDOUT FRAME



20
19
18
17
16
15
DR 11/64 (.171) THRU TO MATCH ON ASSY
NAS602-8P ~ 8 REQD
MS21042L08 ~ 8 REQD
CLAMP ~ 2 REQD
1/8 (STOCK)
5.30
.68 ± .12
30°± 5°
25
.38 ± .06
3.88 ± .12
.38 ± .06
5.58
5.00 ± .06
℄ INFLATION TUBE
4.50
2.56
.42
.44
.50 R
1.19
1/8 (STOCK)
.88
.01 TO .02 R
33660-64 ~ 2 REQD
D-D
24 SUPPORT - R.H. (SHOWN)
23 SUPPORT - L.H. (OPPOSITE)
DRILL 33/64 (.516) TO DEPTH SHOWN
.38 REF
.19
22 MANIFOLD
SECT F-F
13 TEFLON (FEP) TUBE ~ 50 REQD
32 INSERT - 50 REQD (INSTL FLUSH WITH TUBE)
SS-204-1 FERRULE, BACK - 96 REQD
203-1 FERRULE, FRONT - 96 REQD
4-200-1-2 CONNECTOR ASSY ~ 96 REQD
(ASSEMBLE & INSTALL CONNECTORS PER NOTE 4)
TEFLON PIPE-SEAL TAPE (AS REQD)
℄ DRUM
33 STOP STRAP ~ 2 REQD
NOTE: ADJUST LENGTH OF STOP STRAP WITH DRUM POSITIONED AS SHOWN IN SECT C-C AND WITH INFLATION TUBE PRESSURIZED
STITCH - 33 STRAP TO - 14 INSULATOR SLEEVE PER NOTE 3 AS SHOWN
SECT G-G
37.50 REF
.38 TYP 24 PLCS
.22 TYP
9 CLAMP ASSY ~ 2 REQD
21 CLAMP (HALF)
.125 REF
.58 REF
.125 R GROOVE - TYP 50 PLCS
BREAK EDGES .01 TO .02
.38
.75 ± .03 TYP SPACING
DR 11/64 (.171) THRU ON ASSY ~ 25 PLCS
NAS602-14P ~ 25 REQD
MS21042-L08 ~ 25 REQD
SECT H-H
43.92
787.00 FLAT PATTERN PANEL
43.25
.50 REF
DETAIL
SEAM TYPE LSb
STITCH INSULATOR SLEEVE TO PANEL MATERIAL AS SHOWN - NOTE 3
.12 BETWEEN ROWS (TYP)
DR 11/64 (.171) TO MATCH ON ASSY
NAS602-8P ~ 4 REQD
AN960PD8 ~ 4 REQD
MS21042L08 ~ 4 REQD
45° ± 5°
16
SECURE END OF -14 INSULATOR SLEEVE TO INFLATION TUBE WITH ALUMINUM BACKED TAPE
4.00 O.D. × .030 WALL INFLATION TUBE (REF)
ORIGINAL PAGE IS OF POOR QUALITY
15 INFLATION
16 INFLATION
DR 11/64 (.171) TO MATCH ON ASSY
NAS602-6P ~ 4 REQD
AN960PD8 ~ 4 REQD
MS21042L08 ~ 4 REQD
.62 ± .06
G
33
2.50 ± .12
SECT C-C
80378
T-213-SKCB



FOLDOUT FRAME 3



10
9
8
7
6
5
SYM
ROLL FORM TO 10.00 ± .06 DIA
DR 1/64 (.171) TO MATCH ON ASSY — 25 PLCS
CSK 100° × .330 DIA
MS24693-S52C SCREW ~ 25 REQD
MS21042L08 NUT ~ 25 REQD
BEND LOWER EDGE OF SLOT APPROX AS SHOWN TO CLEAR PANEL ASSY
.25 ± .06 WIDE SLOT
.80 ± .06
A
DRILL #29 (.149) HOLE TO MATCH WITH — 22 PLCS
CSK 100° × .280 DIA
MS24693-S26 SCREW - 22 REQD
MS21042 L06 NUT - 22 REQD
.06 (STOCK)
-17
-9 REF
-7
SECT A-A
N2 SOURCE (10 PSI MAX)
N2 RELIEF
SHUT-OFF
.50 R (TRUE) TYP
38.75
49.50
3.50 (REF)
C
.20
.40
-18
.060
.12 R TYP
30° ± 2°
30
.060-.090
9.88 DIA (REF) ACTUAL DIA TO MATCH DRUM I.D. FLUSH TO .06 CLEARANCE
-7 MANIFOLD ASSY
.75 REF
VIEW J-J
-19
.40 (.06 R ON CUTTER)
.225
.60
.25 TYP
FOLDOUT FRAME 4
80378
T213-SK08

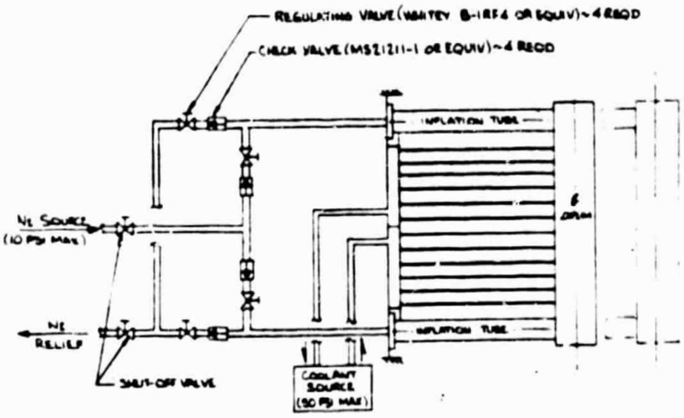
NOTES:

1. BREAK ALL SHARP EDGES
2. FUSION WELD PER SPEC CVA17-12
3. STITCHING TO BE PER FED STD 781
4. ATTACH NOTED TUBE CONNECTIONS AS FOLLOWS:
   A. INSTALL UNIONS IN MANIFOLDS WITH TEFLON SEAL TAPE ON THREADS
   B. AFTER TUBES ARE CUT TO FINAL LENGTH ETCH TUBE ENDS APPROX 1/2" WITH ETCHING SOLUTION (TETRA-ETCH OR EQUIV).
   C. PLACE CONNECTOR NUT & BACK FERRULE OVER TUBE ENDS.
   D. LIGHTLY COAT ETCHED TUBE ENDS AND THE FRONT FERRULE I.D. WITH EC 2216 ADHESIVE AND SLIDE FERRULE ONTO TUBES
   E. THREAD NUT TO CONNECTOR UNION AND TORQUE 3/4 TO 1 TURN AFTER FINGER TIGHT
5. THE -3 PANEL ASSY SHALL BE FABRICATED USING VACUUM TOOLING PLATE T213-SK07
6. ANODIZE NOTED ITEMS PER SPEC CVA9-4 TYPE A
7. ATTACH TEMPERATURE INSTRUMENTATION AS SHOWN ON DRAWING T213-SK08 SHEET 2

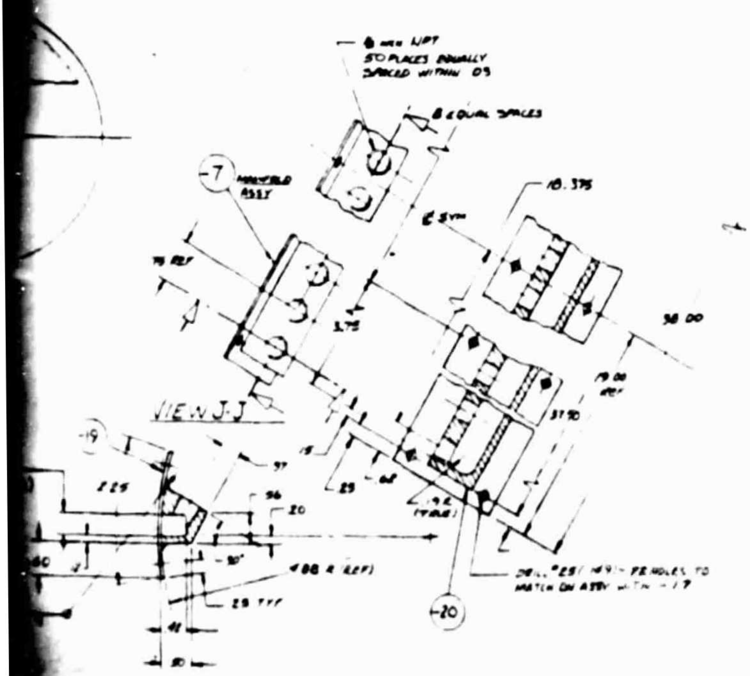
...I TO MATCH ON ASSY ~ 25 PLCS
... .130 DIA
...-3520 SCREW ~ 25 REQD
...LOB NUT ~ 25 REQD

... LOWER EDGE OF SLOT APPROX AS ...N TO CLEAR PANEL ASSY

...S WIDE SLOT



SCHEMATIC



FOLDOUT FRAME

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

A-2

ENVIRON CONT SYS

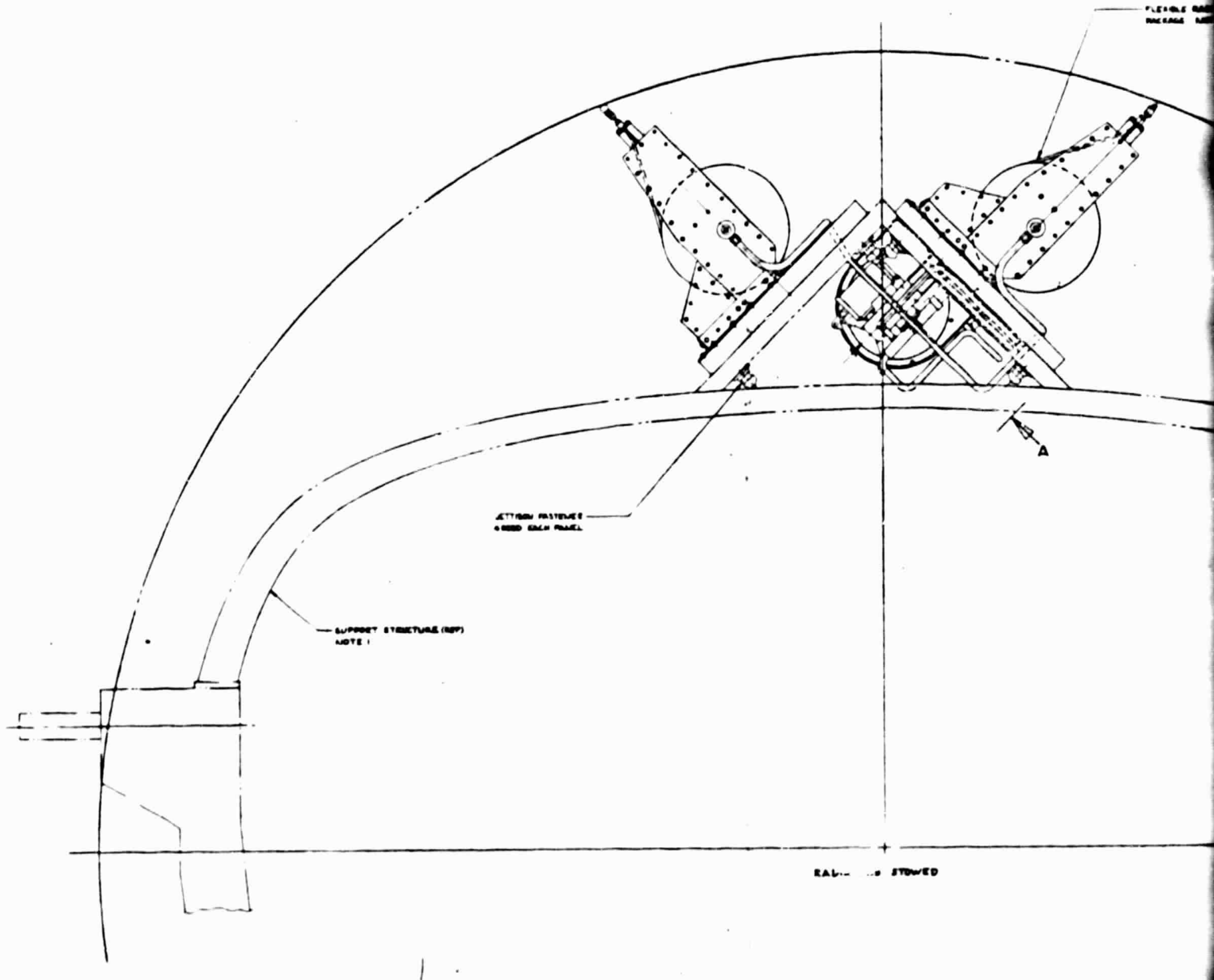
VOUGHT CORPORATION

RADIATOR - FLEXIBLE PNEUMATIC DEPLOYED

J 80378 T213-SK08

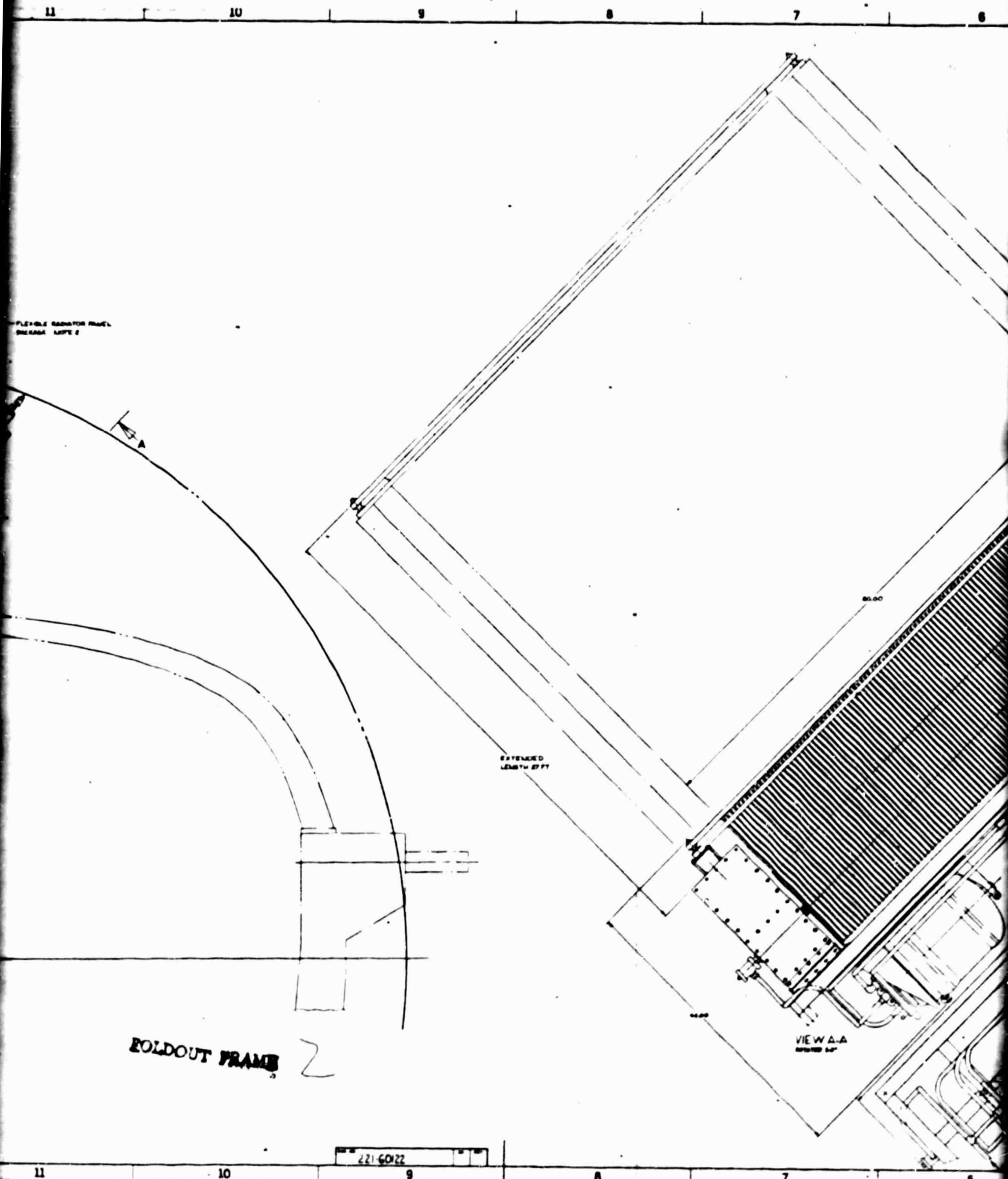
SHEET 2 OF 2

16	15	14	13	12	11



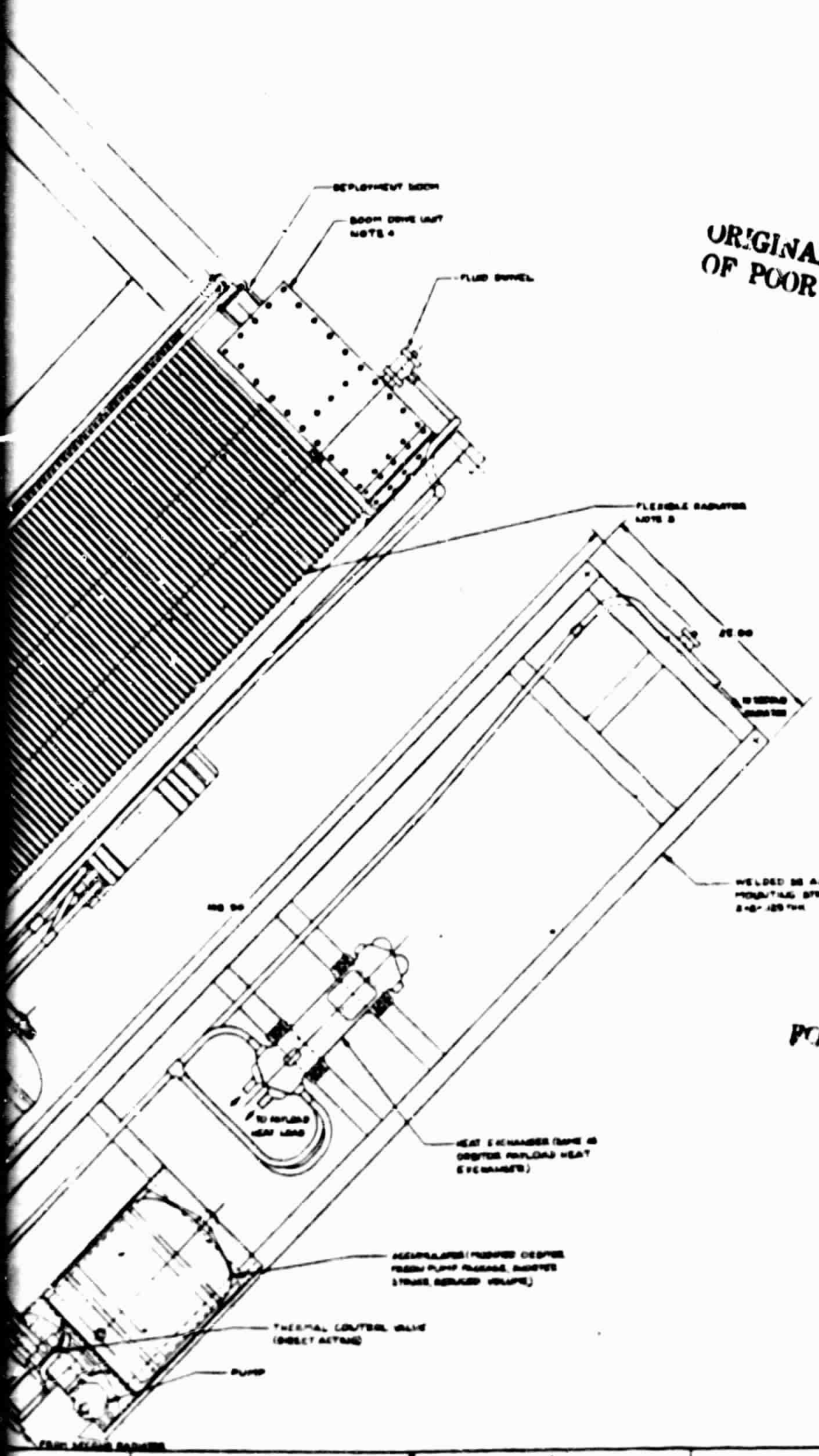
FOLDOUT FRAME

16	15	14	13	12	11



FOLDOUT FRAME 2

NOTES:
1. TYPICAL SUPPORT STRUCTURE CONCEPT SHOWN. ACTUAL SUPPORT STRUCTURE CONFIGURATION SHALL BE CUSTOMIZED TO MEET APPLICABLE PAYLOAD & MISSION REQUIREMENTS
2. EACH FLEXIBLE RADIATOR PANEL PACKAGE WILL PROVIDE 6 KW HEAT REJECTION. 2 PACKAGES (PANELS) AS SHOWN REQD FOR 12 KW HEAT REJECTION.
3. FOR DETAIL CONFIGURATION OF FLEXIBLE PANEL SEE T313-5800
4. TWO BOOM DRIVE UNITS ARE REQUIRED, ONE AT EACH END OF PANEL. THE MASTER UNIT HOUSES THE DRIVE MOTOR. THE SECOND IS A SLAVE UNIT DRIVEN THROUGH A CONNECTING TORQUE TUBE.



ORIGINAL PAGE IS OF POOR QUALITY

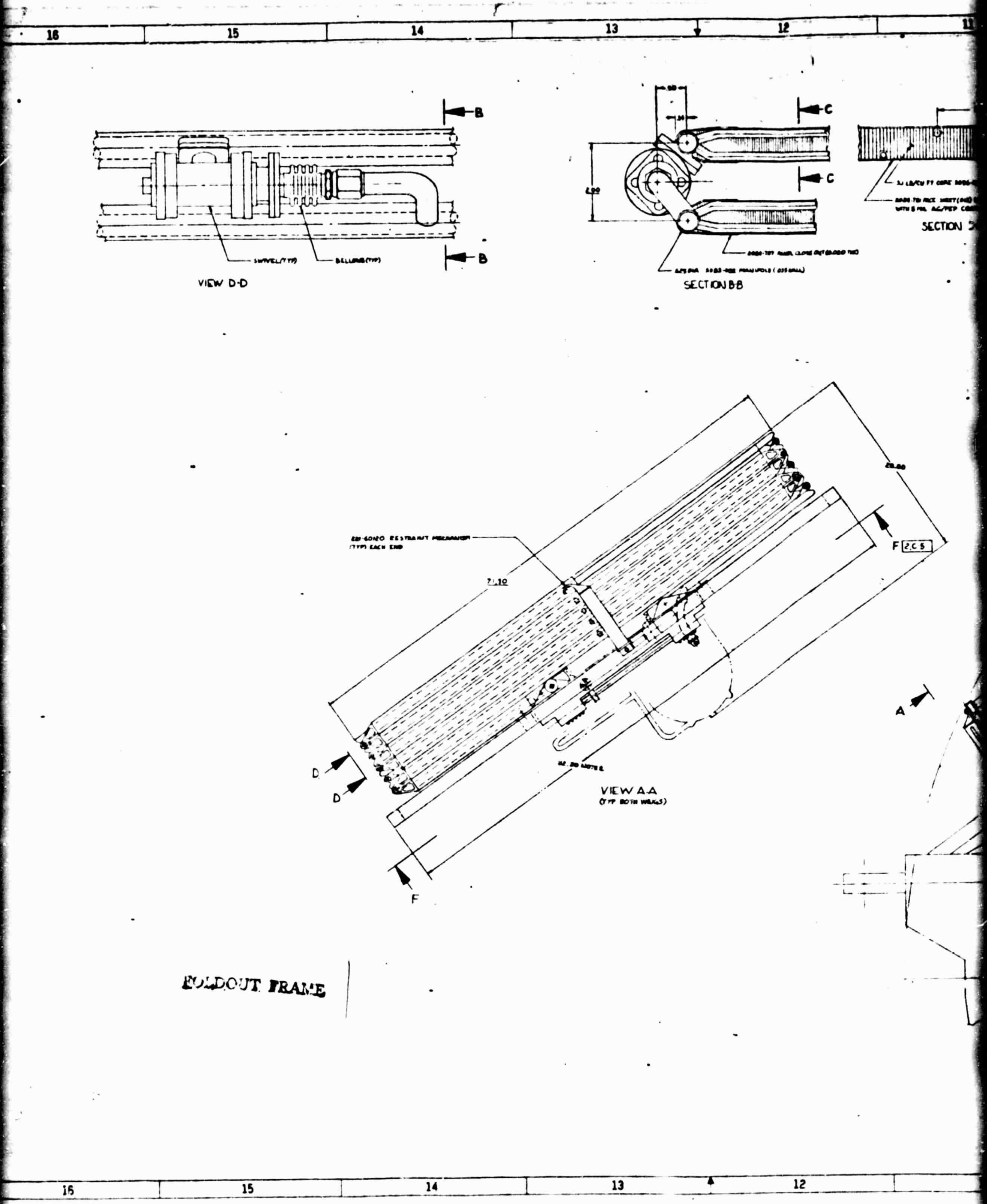
FOLDOUT FRAME 3

A-3

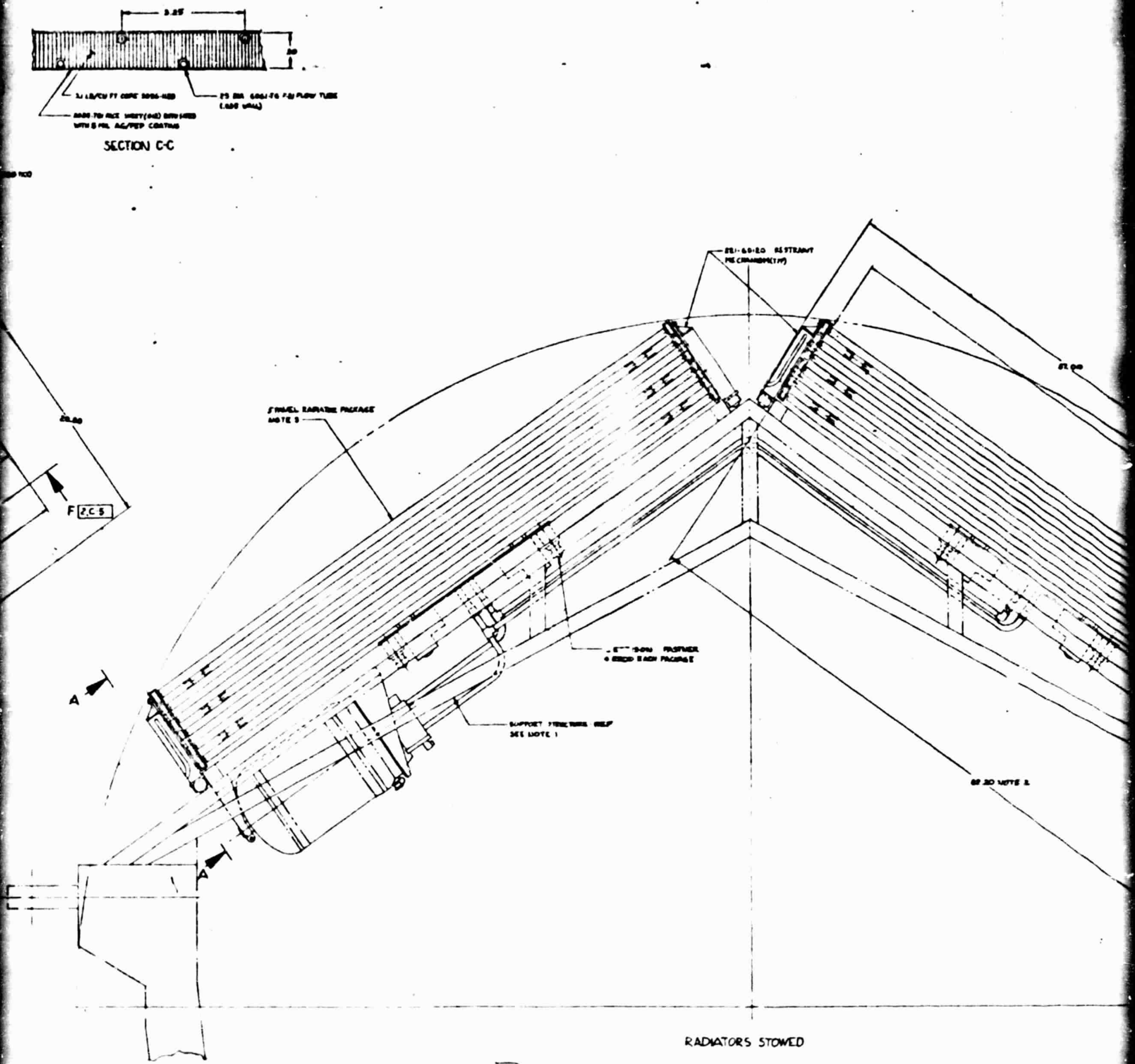
VOUGHT CORPORATION

PEP FLEXIBLE RADIATOR BOOM DEPLOYMENT GENERAL ARRANGEMENT

80378 | 221-60122

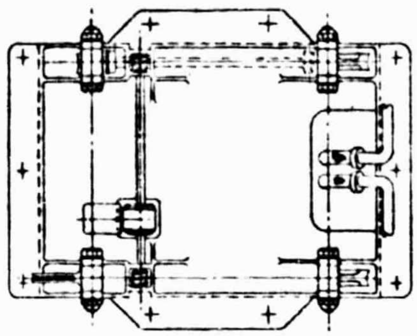


FOLDOUT FRAME

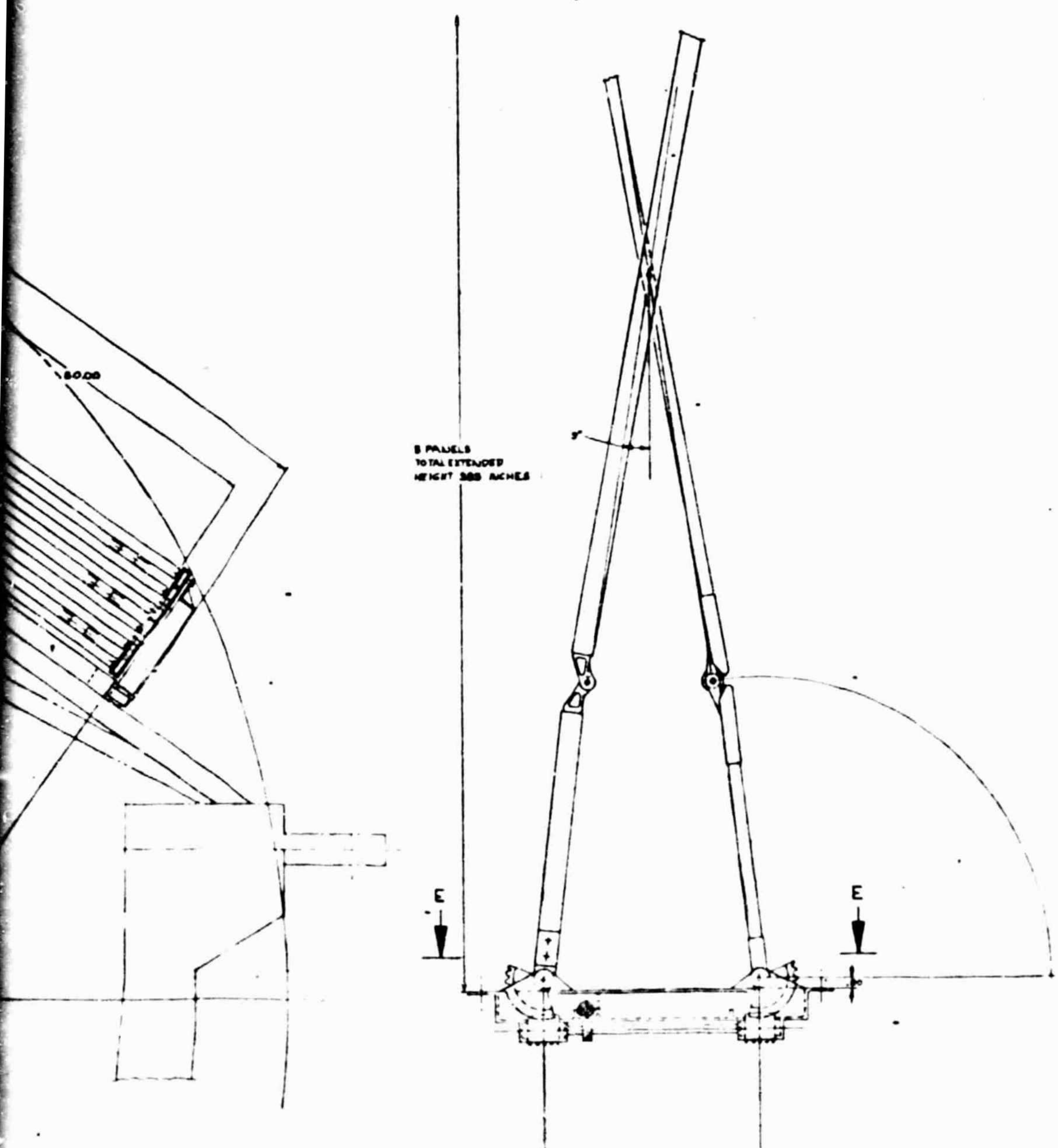


FOLDOUT FRAME 2

NOTES:
1. TYPICAL SUPPORT STRUCTURE CONCEPT SHOWN. ACTUAL SUPPORT STRUCTURE CONFIGURATION SHALL BE CUSTOMIZED TO MEET APPLICABLE PAYLOAD AND MISSION REQUIREMENTS.
2. RADIATOR MOUNTING BASE IS 82.80 SQUARE SYMMETRICAL CONFIGURATION FOR VERSATILE MOUNTING TO ACCOMODATE VARIOUS PAYLOADS CONFIGURATIONS.
3. EACH 8 PANEL RADIATOR PACKAGE WILL PROVIDE 4 KW HEAT REJECTION. 2 PACKAGES (WINGS) AS SHOWN REQUIRED FOR 8 KW HEAT REJECTION.
4. FREON R-21 PUMP PACKAGE MOUNTS TO BOTTOM SIDE OF RADIATOR PACKAGE MOUNTING STRUCTURE. ONLY ONE PUMP PACKAGE REQUIRED FOR 1 OR 2 RADIATOR PACKAGES.



VIEW E-E



RADIATOR DEPLOYED

FOLDOUT FRAME 3

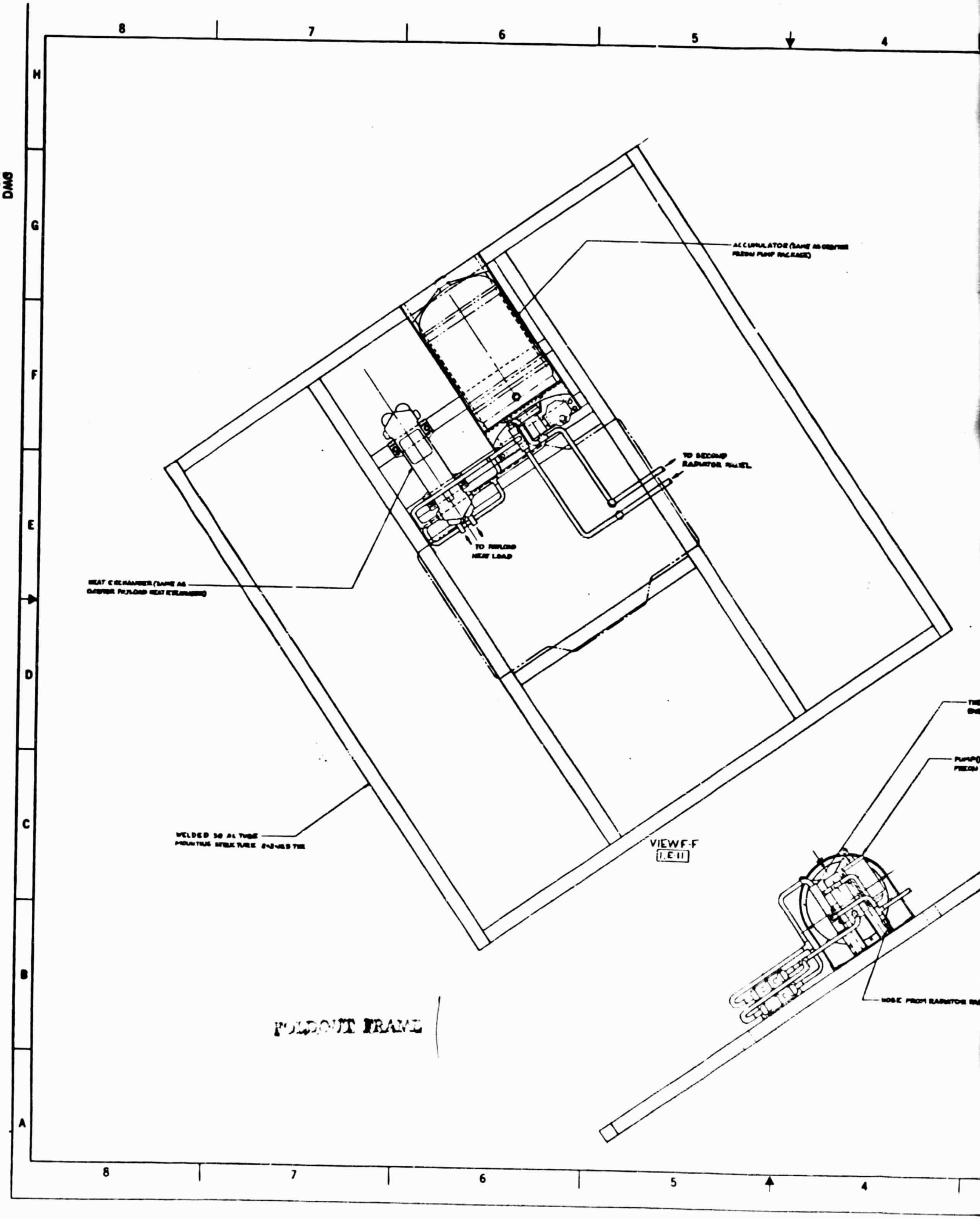
A-4

SEE SEPARATE PARTS LIST

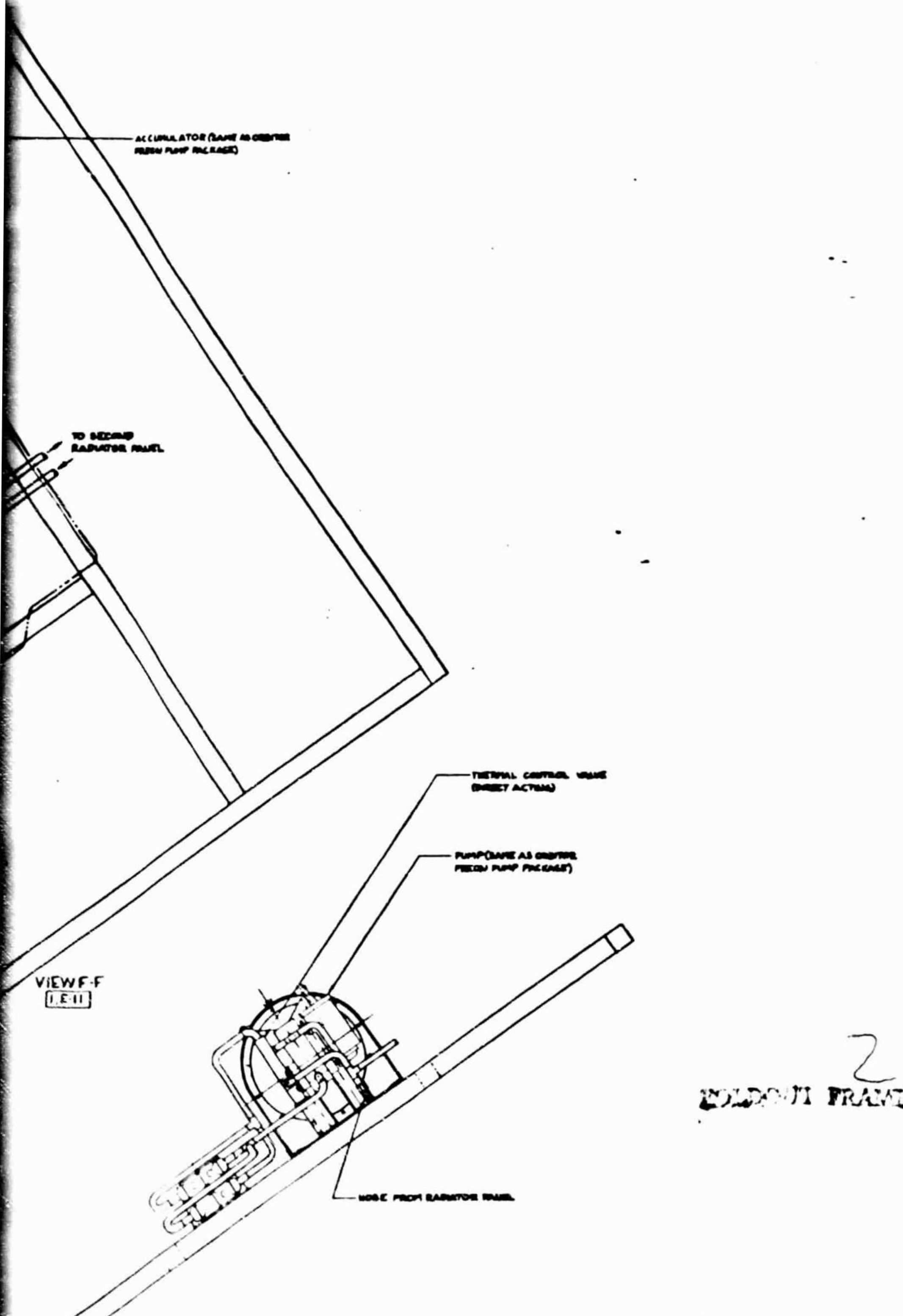
VOUGHT CORPORATION

PEP. RIGID PANEL RADIATOR GENERAL ARRANGEM

J 80378 221-60119



ACCUMULATOR
TO SECOND RADIATOR PANEL
TO PAYLOAD HEAT LOAD
WELDED
VIEW F-F
FOLDOUT FRAME



FOLDOUT FRAME 2

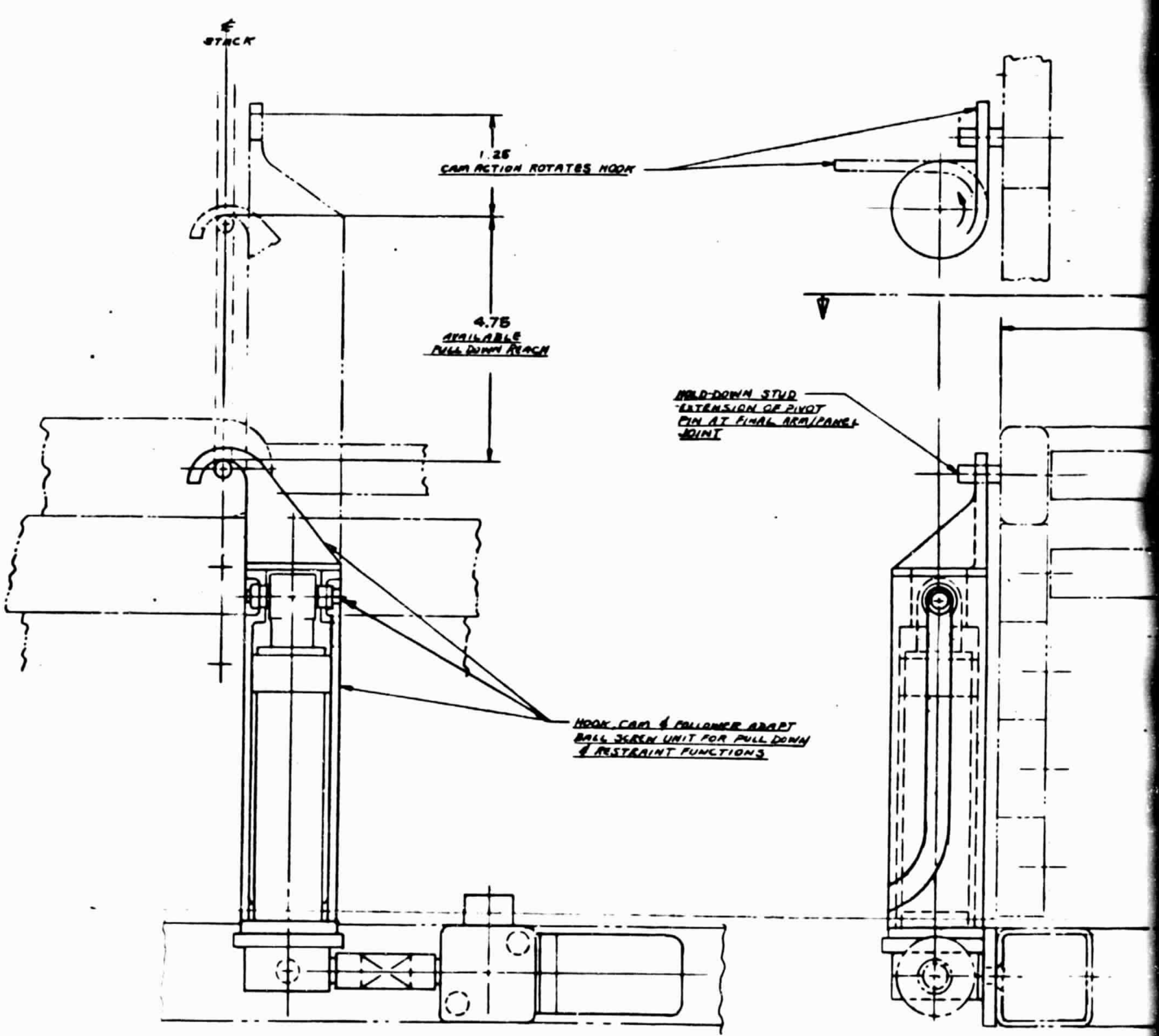
A-5

VOUGHT CORPORATION

RIGID PANEL RADIATOR GENERAL ARRANGEMENT

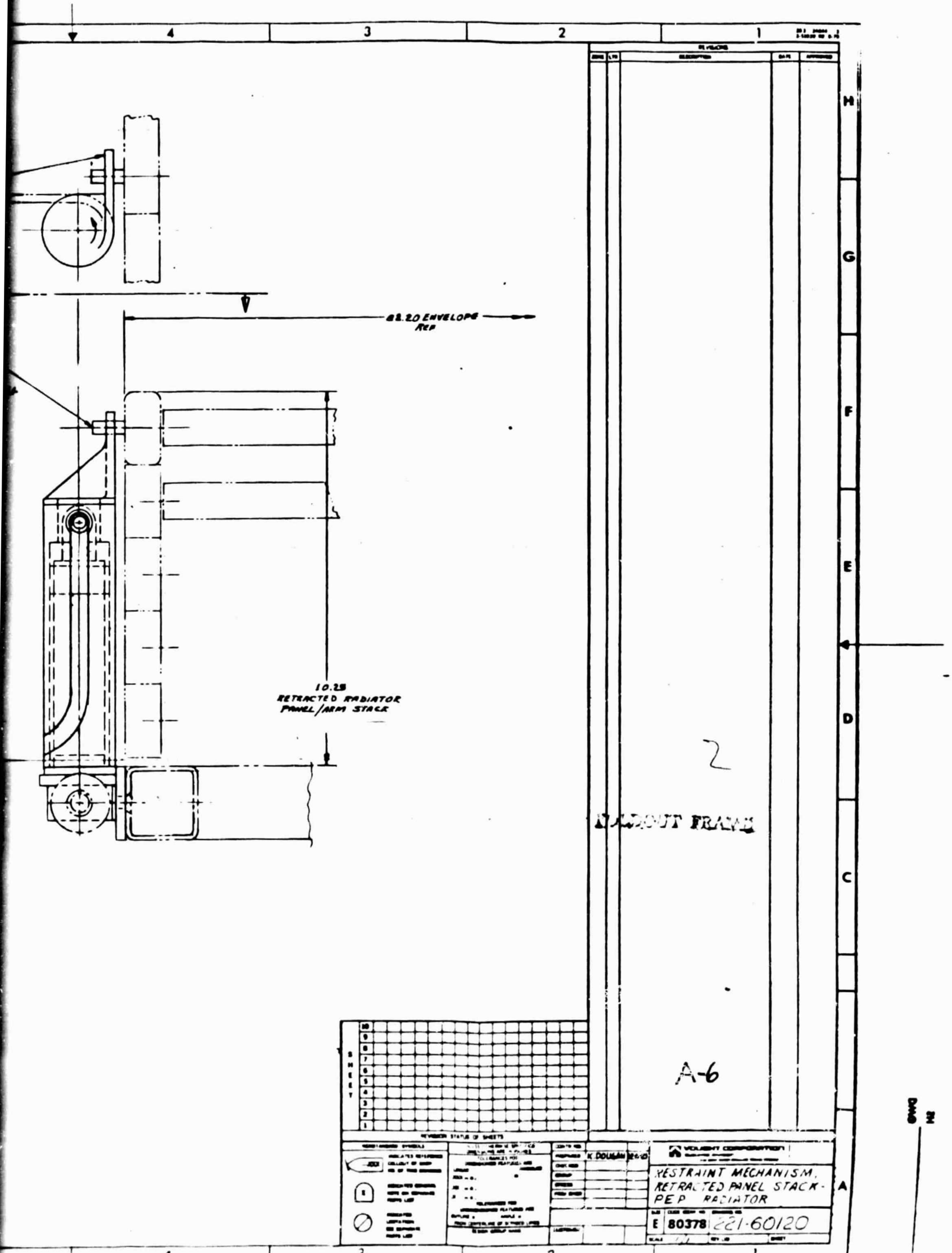
E 80378 221-60119

221-60119



FOLDOUT FRAME

ORIGINAL PAGE IS
OF POOR QUALITY


4
3
2
1
H
G
F
E
D
C
A
22.20 ENVELOPE REF
10.25
RETRACTED RADIATOR
PANEL/ARM STACK
2
FOLDOUT FRAME
A-6
REVISION STATUS OF SHEETS
K. DOUGAN
VOUGHT CORPORATION
RESTRAINT MECHANISM,
RETRACTED PANEL STACK -
PEP RADIATOR
E
80378
221-60120