DESIGN, FABRICATION, AND STATIC TESTING OF FIRST-STAGE ATTACHED INFLATABLE DECELERATOR (AID) MODELS

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for

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FOREWORD

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CONTENTS

ILLUSTRATIONS

TABLES

DESIGN, FABRICATION, AND STATIC TESTING OF FIRST-STAGE ATTACHED INFLATABLE DECELERATOR (AID) MODELS

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SUMMARY

Goodyear Aerospace Corporation (GAC) designed and fabricated wind-tunnel models of a first-stage Attached Inflatable Decelerator (AID) for the NASA Langley Research Center (LRC).

Six models were furnished by GAC for the current program. The AID canopies were attached directly to a payload in a method which simulated a first-stage AID. All six models had 140-deg conical aeroshells as their forebodies, and each model had four spring-actuated forward inlets mounted on the internal hard structure to provide for initial deployment. Full inflation and final pressurization is accomplished by four aft canopy inlets on each model.

An inflation test was conducted in an environmental chamber to investigate packaging, deployment, and inflation characteristics of the models prior to wind-tunnel testing.

INTRODUCTION

Recent advancements in high-speed flight vehicles have established the need for a deceleration system with good operational characteristics at supersonic speeds. To meet this need, LRC has conducted extensive analytical and experimental investigations in the development of an Attached Inflatable Decelerator (AID), the results of which are summarized in References 1 through 10. An AID consists of a flexible canopy deployed and inflated by ram air, which is attached to the base of the body to be decelerated. AID models investigated to date (References 1 through 10) were representative of a single-stage decelerator in which the deployed drag area was sufficient to decelerate the payload to terminal conditions suitable for descent engine ignition.

A recent trade-off study was conducted by LRC (References 1 and 11) to determine the effects of a two-stage deceleration system on mission performance. This system maximized decelerator efficiency by taking advantage of the high supersonic drag of

the AID as the first-stage and the high subsonic drag of a terminal-stage parachute such as the disk-gap-band parachute (Figure 1). Reference 1 states that for entry into the low-density atmosphere of Mars, the AID will relax the stringent deployment conditions on the parachute and will provide significant increases in landed payload mass without increasing the size of the basic aeroshell (see Figure 2). Complimenting this Reference 1 study was a parametric thermal and stress analysis of an AID operating in the most severe of the postulated Mars atmospheres (Reference 12) which showed the feasibility of deploying an AID at high supersonic speeds.

As part of a continuing effort to develop and to evaluate the AID, the present program investigated the characteristics of a first-stage AID. Since the AID is aerodynamically shaped, its canopy may be tailored to the application for which it is intended and to the attachment locations available. Key factors in this program were the investigation of a new canopy shape and a new attachment scheme. The AID models incorporated smaller volume canopies than those models described in References 3, 9 and 12 and were attached to a simulated payload in a manner which would permit detachment of the AID and deployment of a subsonic parachute rather than being attached directly to the 140-deg aeroshells. Thus, the objectives of the investigation were to design, fabricate, and static test AID models in preparation for wind-tunnel testing which will demonstrate deployment and aerodynamic performance at supersonic speeds.

SYMBOLS

B	ballistic coefficient, slugs/sq ft
C_D	drag coefficient
c_p	pressure coefficient, $p_L - P_\omega/q_\infty$
D	diameter, ft
d_g	depth of lobes, in.
F	circumferential membrane stress coefficient
f	fabric stress, lb/in.
$\bar{f}$	nondimensional fabric stress
f_c	circumferential fabric stress resultant, lb/in.
f_m	meridional fabric stress resultant, lb/in.

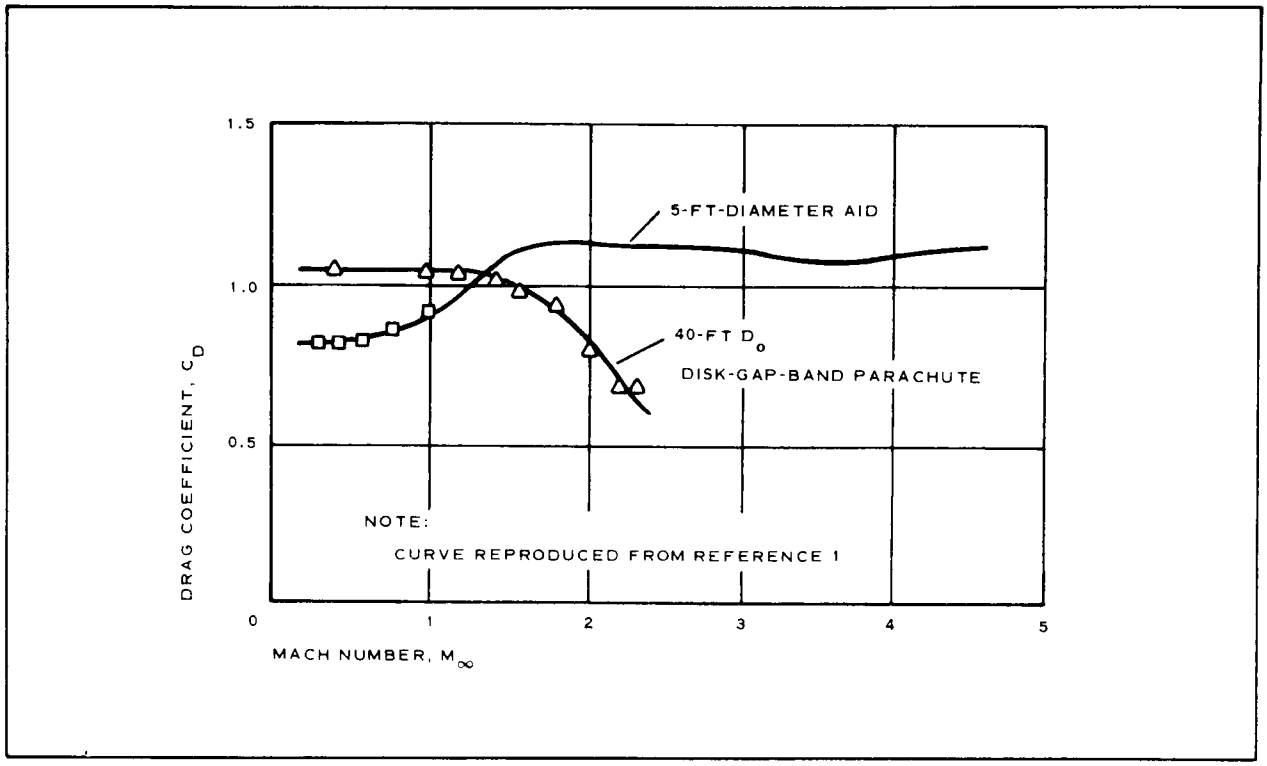


Figure 1. - Drag Performance of AID and Disk-Gap-Band Parachute

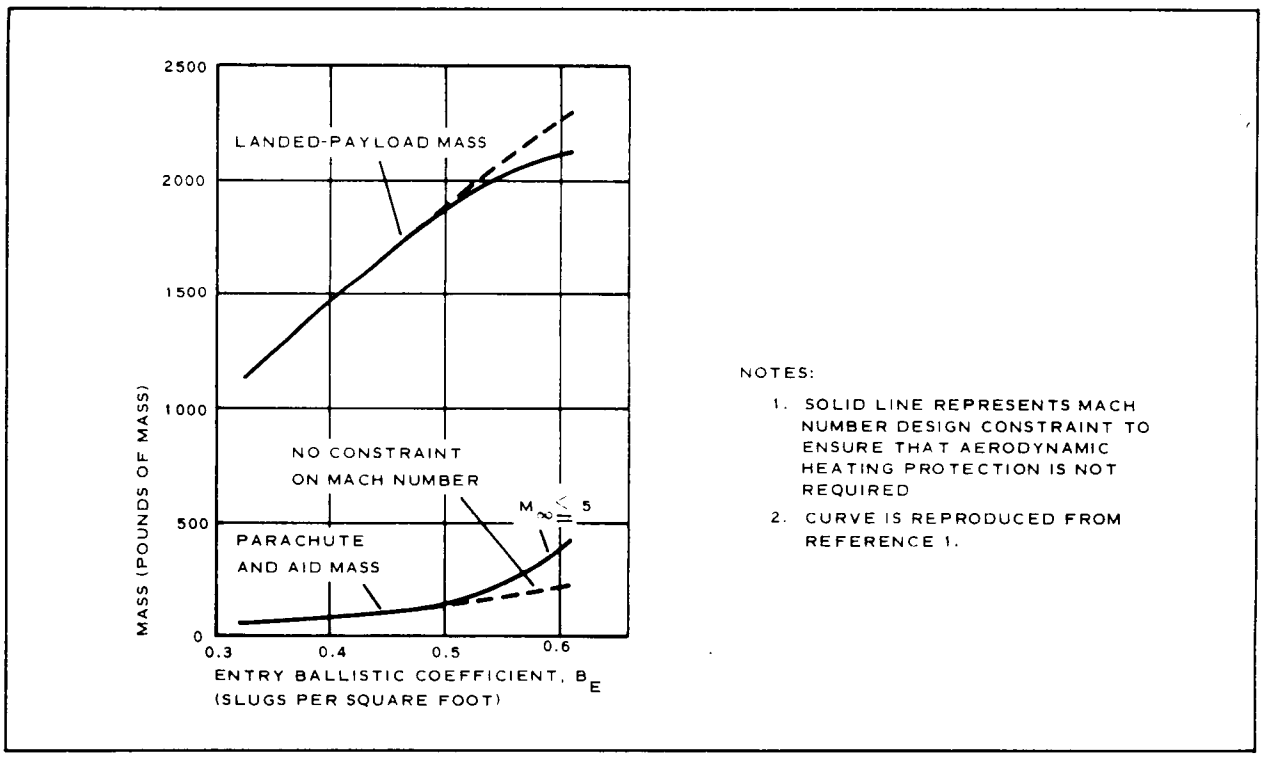


Figure 2. - Variations in Decelerator Mass and Landed-Payload Mass with Ballistic Coefficient

M	Mach number
N	stress, lb/in.
n	number of gores
p	$p_i - p_b$, psf
q	dynamic pressure, psf
R	maximum canopy radius excluding burble fence, in.
r	aeroshell base radius, in.
r_g	lobe radius, in.
S_g	half-arc length of lobe, in.
T	tension, lb
$\overline{T}$	nondimensional meridional tape load
x/R,y/R	decelerator coordinate shaping factors
β	central half-lobe angle, deg
γ	burble fence load carried by front surface fabric, percent; bias thread set angle, deg
ϵ	strain due to thread racking, in./in.

Subscripts

B	burble fence
b	base
E	entry
f	forward
i	internal
L	local
m	meridian
o	nominal
r	rear
∞	free stream

θ circumferential direction of surface element

ϕ meridional direction of surface element

AID MODEL DESCRIPTION

The configuration details of each of the six models discussed in this report are shown in Figures 3 and 4. Additional design details of the models described in these two figures are presented in assembly Drawings 3063000-001-101, -103, -105, -107, -109, and -111. Table I presents a correlation of model numbers with assembly numbers. The model numbers will be used in any future reference made to the specific details of the models. A complete set of drawings for the models is presented in Appendix A.

TABLE I. - AID MODEL DESIGNATION

Model Number	Assembly Number
IA	3063000-001-101
IB	3063000-001-109
IC	3063000-001-105
ID	3063000-001-111
IIA	3063000-001-103
IIB	3063000-001-107

The models shown in Figures 3 and 4 use ram air for deployment and pressurization. Spring-actuated inlets, similar to those used on the model in Reference 6, provide the initial and restraining forces to align the forward inlets with the air flow. All six models' forward inlets are 2.5 in. in diameter. Models 1A, IC, IIA, and IIB have 2.5-in. diameter aft inlets; models IB and ID have 1.8-in. diameter aft inlets.

All model I configurations have a burble fence extension which increases the maximum decelerator diameter by 10 percent. The model II configurations differ from model I by the absence of a burble fence and the resulting change in shape.

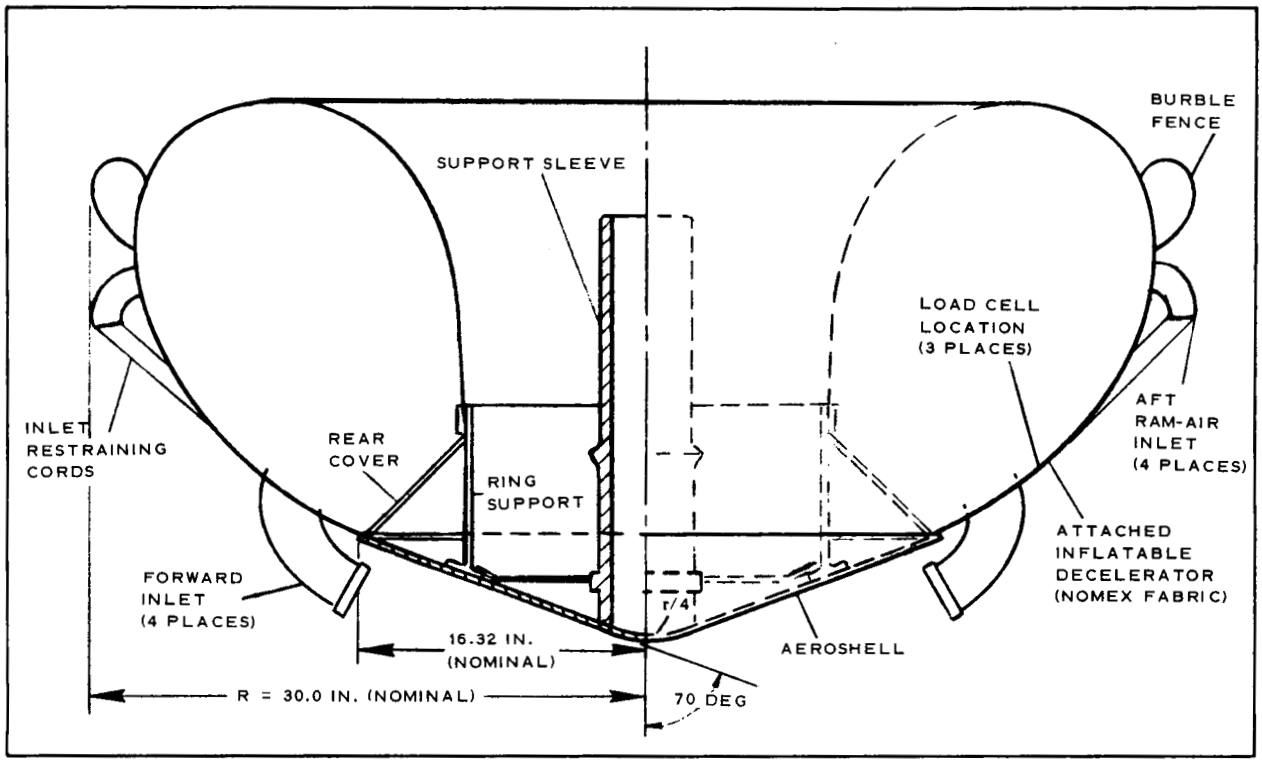


Figure 3. - Details of Model I Configuration

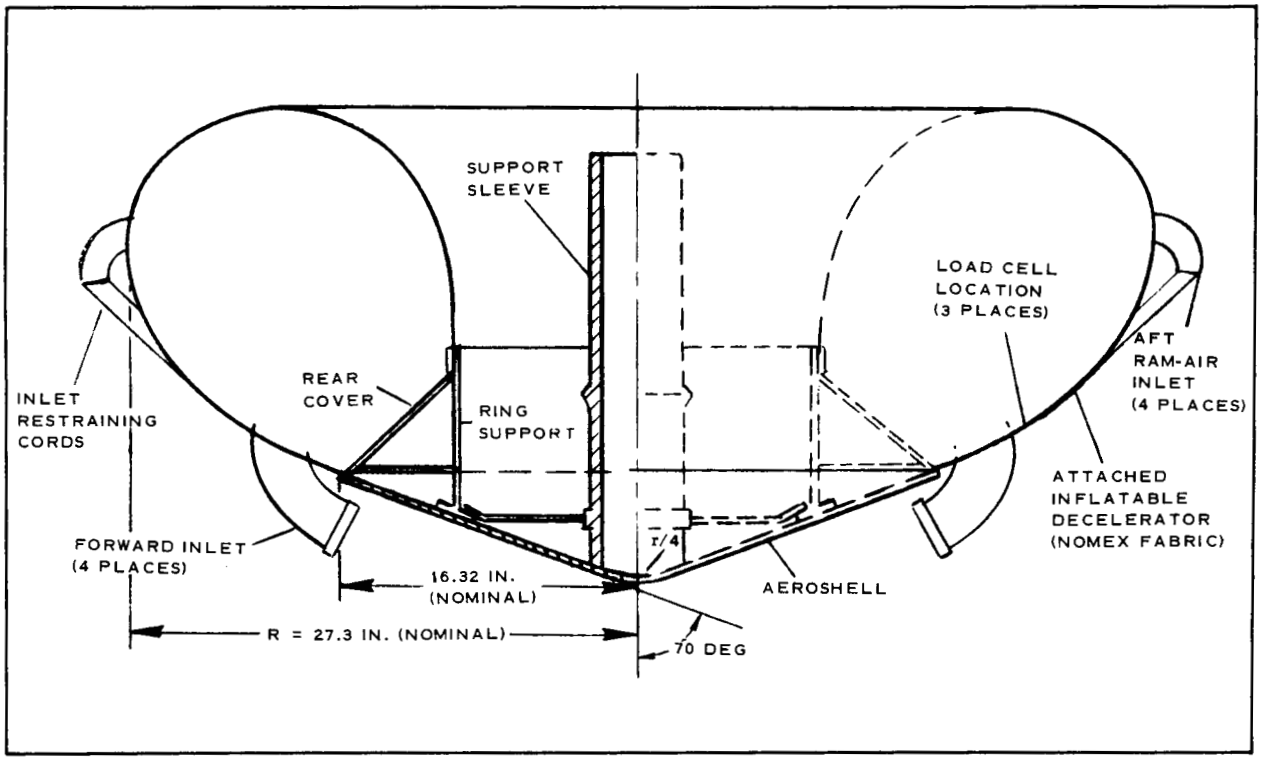


Figure 4. - Details of Model II Configuration

DESIGN CONDITIONS

The aerodynamic design conditions for the AID canopies are presented in Table II. The hard structure was designed to meet the requirements specified by Arnold Engineering Development Center (AEDC) in Reference 13.

TABLE II. - AID DESIGN CONDITIONS

Condition	Magnitude
Deployment Mach number, M	4.4
Deployment dynamic pressure, q (psf)	75.0
Maximum dynamic pressure, q (psf)	200.0

Shape Analysis

The AID canopy is basically a uniform-stress (isotensoid) structure (see Figure 5) whose shape is maintained by a balance of external aerodynamic loads and internal pressurization. The canopy shapes for the present models were derived using the isotensoid analysis described in References 2, 3, and 4. This analysis, computerized during a previous Goodyear Aerospace program (Reference 3) for LRC, uses a theoretical aerodynamic pressure distribution to calculate an initial shape which can then be used to obtain an experimental pressure distribution. This distribution is then inserted in the computerized analysis to obtain an "iterated" shape. This procedure can be repeated until the desired correlation is obtained.

Since numerous canopy shapes result from the isotensoid analysis the shape of the first-stage AID was obtained using an optimization procedure, described in Reference 14, to determine the decelerator shapes which combined the highest drag areas with the lowest canopy weights. The canopy shapes shown in Figures 3 and 4 were the result of this optimization study. Pertinent parameters (described in References 2, 3, and 4) for these shapes are presented in Table III. The pressure distributions used in deriving the shapes of models I and II are presented in Figures 6 and 7.

The internal canopy pressure was obtained from the empirical relation in Reference 3:

$$p/q_\infty = (p_i - p_b)/q_\infty$$

Experimental data taken from Reference 6 yielded a value of $p/q_\infty = 1.9$. This value was used to determine the stresses in the fabric and meridians as described in Appendix B.

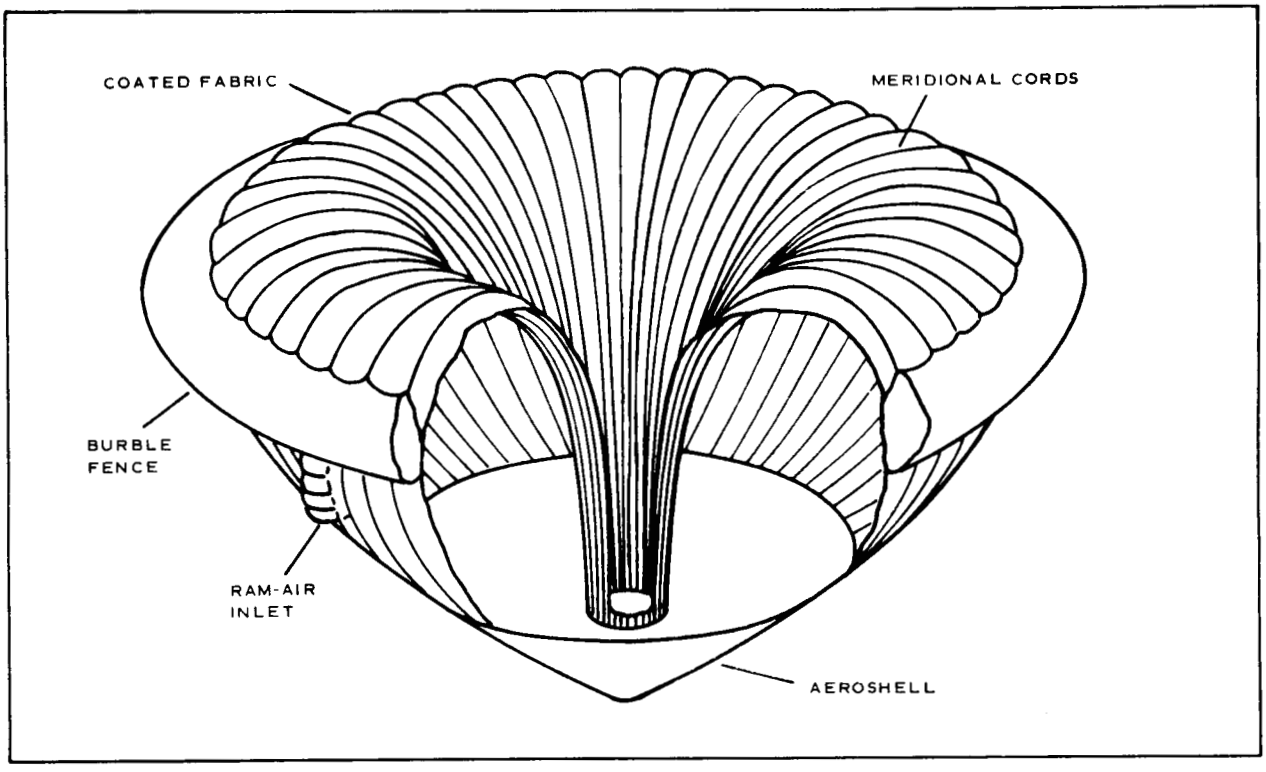


Figure 5 - Cutaway Drawing of an AID

TABLE III. - AID CANOPY PARAMETERS

Condition	Model I	Model II
Nondimensional meridian tape load, $\overline{T}_r$	0.38	0.38
Nondimensional fabric stress, $\overline{f}_r$	0.30	0.175
Ratio of circumferential fabric stress to meridional stresses, f_c/f_m	$0.8 \leq f_c/f_m \leq 1.8$	$0.8 \leq f_c/f_m \leq 1.8$
Nondimensional burble fence load, $\overline{N}_B$	0.0936	0.
Percent of burble fence load carried by front surface fabric, γ	0.1947	0.
Number of gores, n	60	60

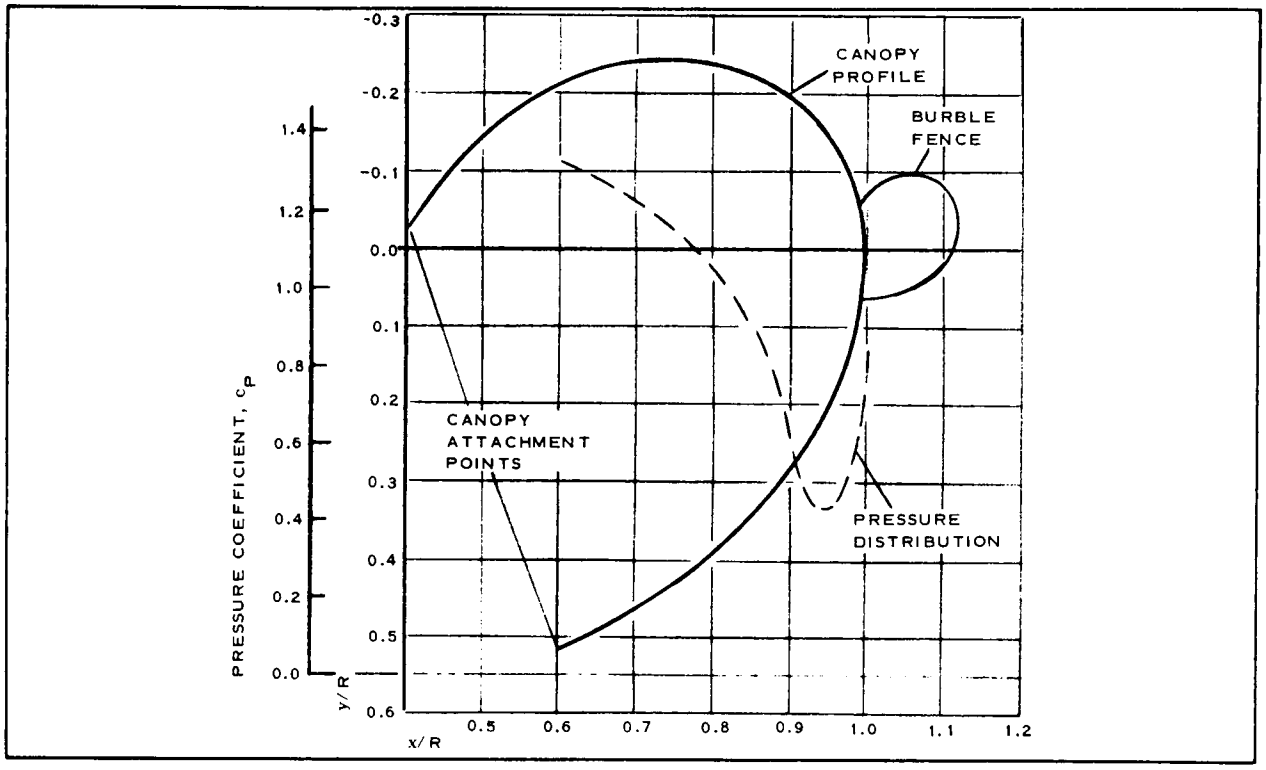


Figure 6. - Analytical Pressure Distribution for Model I

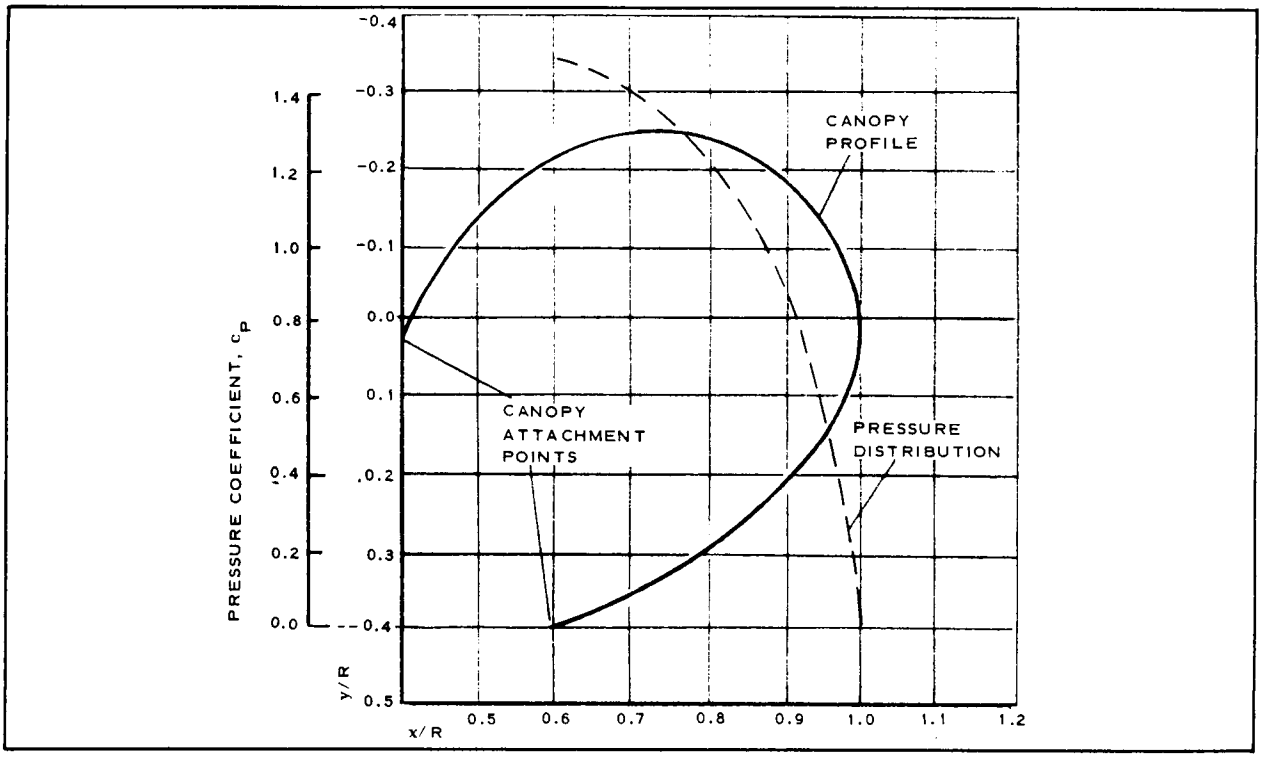


Figure 7. - Analytical Pressure Distribution for Model II

Canopy Gore Patterns

The nondimensional AID coordinates defining the canopy profile are one of the outputs of the isotensoid computer program. These coordinates have been tabulated for models I and II and are presented in Tables IV and V. Utilizing these coordinates in the analytical approach, established by the design analysis in Reference 3, it was determined that 60 gores were needed to maintain f_c/f_m within the limits set forth in Table III. The specific equations, derived in Reference 3, that define gore geometry are presented below. The numerical values of lobe geometry, radial growth due to unrestrained thread racking, and fabric stresses calculated from these equations are presented in Tables VI and VII.

$$\tan \beta = \frac{2\pi\left(\frac{x}{R}\right)}{n\ F} \ ;$$

$$\tan \gamma = \sqrt{\frac{\sin \beta \cos \beta}{\beta}} \ ;$$

$$\frac{r_g}{R} = \frac{\pi}{n \sin \beta}\left(\frac{x}{R}\right) \ ;$$

$$\frac{S_g}{R} = \left(\frac{r_g}{R}\right) \beta \ ;$$

$$\frac{d_g}{R} = \left(\frac{r_g}{R}\right)(1 - \cos \beta) \ ;$$

$$\epsilon_\phi = \sqrt{2} \sin \gamma - 1 \ ;$$

$$\epsilon_\theta = \sqrt{2} \cos \gamma - 1 \ ;$$

$$f_b = F \frac{pR}{4}\left(\frac{\sin \beta}{\beta \sin^2 \gamma}\right) \ ; \text{ and}$$

$$\frac{f_c}{f_m} = \frac{1}{\tan^2 \gamma}$$

The gore patterns shown in Figures 8 and 9 each consist of three gores. Twenty of the patterns were used in constructing each model resulting in a total of 60 gores.

TABLE IV.- AID COORDINATES FOR MODEL I

x/R	y/R Front Surface	y/R Rear Surface
1.00000000E+00	0.	0.
9.99000000E-01	3.32819083E-02	-2.18055561E-02
9.75000000E-01	1.57445013E-01	-1.06822237E-01
9.50000000E-01	2.15344557E-01	-1.46923795E-01
9.25000000E-01	2.57259133E-01	-1.74868922E-01
9.00000000E-01	2.91124148E-01	-1.95961495E-01
8.75000000E-01	3.19948723E-01	-2.12278774E-01
8.50000000E-01	3.45388508E-01	-2.24885511E-01
8.25000000E-01	3.55328597E-01	-2.34409186E-01
8.00000000E-01	3.69548927E-01	-2.41240012E-01
7.75000000E-01	4.09314684E-01	-2.45535116E-01
7.50000000E-01	4.27876412E-01	-2.47760148E-01
7.25000000E-01	4.45423735E-01	-2.47712996E-01
7.00000000E-01	4.62103963E-01	-2.45550488E-01
6.75000000E-01	4.78934542E-01	-2.41275627E-01
6.50000000E-01	4.93311462E-01	-2.34552759E-01
6.25000000E-01	5.08013585E-01	-2.26202029E-01
6.00000000E-01	5.22207965E-01	-2.15192459E-01
5.75000000E-01	0.	-2.01628729E-01
5.50000000E-01	0.	-1.85228031E-01
5.25000000E-01	0.	-1.55579370E-01
5.00000000E-01	0.	-1.42065396E-01
4.75000000E-01	0.	-1.13725751E-01
4.50000000E-01	0.	-7.88773238E-02
4.25000000E-01	0.	-3.41413527E-02
4.00000000E-01	0.	-2.99577046E-02

TABLE V. - AID COORDINATES FOR MODEL II

x/R	y/R Front Surface	y/R Rear Surface
1.00000000E+00	0.	0.
9.99000000E-01	2.18208275E-02	-2.18055561E-02
9.75000000E-01	1.08690517E-01	-1.08322257E-01
9.50000000E-01	1.52395361E-01	-1.46923759E-01
9.25000000E-01	1.86225965E-01	-1.74868922E-01
9.00000000E-01	2.12351377E-01	-1.95961495E-01
8.75000000E-01	2.35798587E-01	-2.12278774E-01
8.50000000E-01	2.56617725E-01	-2.24885511E-01
8.25000000E-01	2.75437917E-01	-2.34409188E-01
8.00000000E-01	2.92672967E-01	-2.41240072E-01
7.75000000E-01	3.88612555E-01	-2.45535116E-01
7.50000000E-01	3.23459744E-01	-2.47750148E-01
7.25000000E-01	3.37406088E-01	-2.47712998E-01
7.00000000E-01	3.50548378E-01	-2.45550498E-01
6.75000000E-01	3.62998515E-01	-2.41275627E-01
6.50000000E-01	3.74839562E-01	-2.34852759E-01
6.25000000E-01	3.88101055E-01	-2.26202029E-01
6.00000000E-01	3.96961188E-01	-2.15192459E-01
5.75000000E-01	0.	-2.01528729E-01
5.50000000E-01	0.	-1.85228031E-01
5.25000000E-01	0.	-1.55579374E-01
5.00000000E-01	0.	-1.42068396E-01
4.75000000E-01	0.	-1.13725751E-01
4.50000000E-01	0.	-7.88773238E-01
4.25000000E-01	0.	-3.41413527E-01
4.00000000E-01	0.	2.99577046E-02

Table VI. - Model I Lobe Geometry, Radial Growth Due to Unrestrained Thread Racking, and Fabric Stresses

x/R	β		d_g/R	r_g/R	S_g/R	f_b	γ		ϵ_ϕ	ϵ_θ	f_c/f_m
	deg	min				lb/in.	deg	min			
.60*	30	27	.02900	.06199	.0329	4.46	42	10	-.0507	.0482	1.219
.65	32	29	.02744	.06337	.0359	4.46	41	58	-.0543	.0515	1.232
.70	34	26	.02586	.06482	.0389	4.54	41	21	-.0670	.0627	1.294
.75	36	18	.02430	.06633	.0420	4.58	40	57	-.0733	.0681	1.326
.80	38	5	.02280	.06791	.0451	4.62	40	31	-.0712	.0751	1.370
.85	39	47	.02126	.06955	.0483	4.68	40	3	-.0900	.0825	1.415
.90	41	24	.01977	.07126	.0515	4.73	39	37	-.0982	.0894	1.457
.95	42	55	.01830	.07303	.0547	4.79	39	13	-.1060	.0956	1.504
1.00	44	25	.01680	.07481	.0579	4.84	38	46	-.1145	.1026	1.551
1.00	49	44	.02426	.06860	.0595	4.24	37	1	-.1486	.1291	1.762
.95	48	17	.02228	.06660	.0561	4.17	37	32	-.1386	.1213	1.695
.90	46	44	.02035	.06470	.0527	4.11	38	2	-.1289	.1130	1.632
.85	45	6	.01847	.06280	.0494	4.03	38	35	-.1182	.1053	1.571
.80	43	21	.01664	.06100	.0461	3.99	39	5	-.1086	.0975	1.519
.75	41	26	.01484	.05930	.0429	3.93	39	38	-.0980	.0890	1.457
.70	39	34	.01318	.05750	.0397	3.87	40	9	-.0883	.0810	1.404
.65	37	49	.01160	.05540	.0366	3.84	40	31	-.0827	.0734	1.369
.60	35	37	.01010	.05390	.0335	3.77	41	5	-.0721	.0643	1.315
.55	33	18	.00860	.05240	.0305	3.74	41	38	-.0620	.0553	1.267
.50	30	15	.00722	.05110	.0275	3.68	42	10	-.0521	.0466	1.217
.45	28	15	.00593	.04980	.0245	3.66	42	31	-.0458	.0407	1.188
.40	25	32	.00474	.04860	.0216	3.36	43	1	-.0367	.0324	1.150
.38	24	24	.00430	.04810	.0205	3.62	43	11	-.0337	.0296	1.137

* Indicates x/R value of forward attachment points for Models IA, IB, IC, and ID

Table VII. - Model II Lobe Geometry, Radial Growth Due to Unrestrained Thread Racking, and Fabric Stresses

x/R	β		d_g/R	r_g/R	S_g/R	f_b	γ		ϵ_ϕ	ϵ_θ	f_c/f_m
	deg	min				lb/in.	deg	min			
.60*	35	37	.01010	.0539	.0335	3.77	41	5	-.0721	.0643	1.315
.65	37	49	.01160	.0554	.0366	3.84	40	31	-.0827	.0734	1.369
.70	39	34	.01318	.0575	.0397	3.87	40	9	-.0883	.0810	1.404
.75	41	26	.01484	.0593	.0429	3.93	39	38	-.0980	.0890	1.457
.80	43	21	.01664	.0610	.0461	3.99	39	5	-.1086	.0975	1.519
.85	45	6	.01847	.0628	.0494	4.03	38	35	-.1182	.1053	1.571
.90	46	44	.02035	.0647	.0527	4.11	38	2	-.1289	.1130	1.632
.95	48	17	.02228	.0666	.0561	4.17	37	32	-.1386	.1213	1.695
1.00	49	44	.02426	.0686	.0595	4.24	37	1	-.1486	.1291	1.762
.95	48	17	.02228	.0666	.0561	4.17	37	32	-.1386	.1213	1.695
.90	46	44	.02035	.0647	.0527	4.11	38	2	-.1289	.1130	1.632
.85	45	6	.01847	.0628	.0494	4.03	38	35	-.1182	.1053	1.571
.80	43	21	.01664	.0610	.0461	3.99	39	5	-.1086	.0975	1.519
.75	41	26	.01484	.0593	.0429	3.93	39	38	-.0980	.0890	1.457
.70	39	34	.01318	.0575	.0397	3.87	40	9	-.0883	.0810	1.404
.65	37	49	.01160	.0554	.0366	3.84	40	31	-.0827	.0734	1.369
.60	35	37	.01010	.0539	.0335	3.77	41	5	-.0721	.0643	1.315
.55	33	18	.00860	.0524	.0305	3.74	41	38	-.0620	.0553	1.267
.50	30	15	.00722	.0511	.0275	3.68	42	10	-.0521	.0466	1.217
.45	28	15	.00593	.0498	.0245	3.66	42	31	-.0458	.0407	1.188
.40	25	32	.00474	.0486	.0216	3.63	43	1	-.0367	.0324	1.150
.38	24	24	.00430	.0481	.0205	3.62	43	11	-.0337	.0296	1.137

* Indicates x/R value of forward attachment point for models IIA and IIB

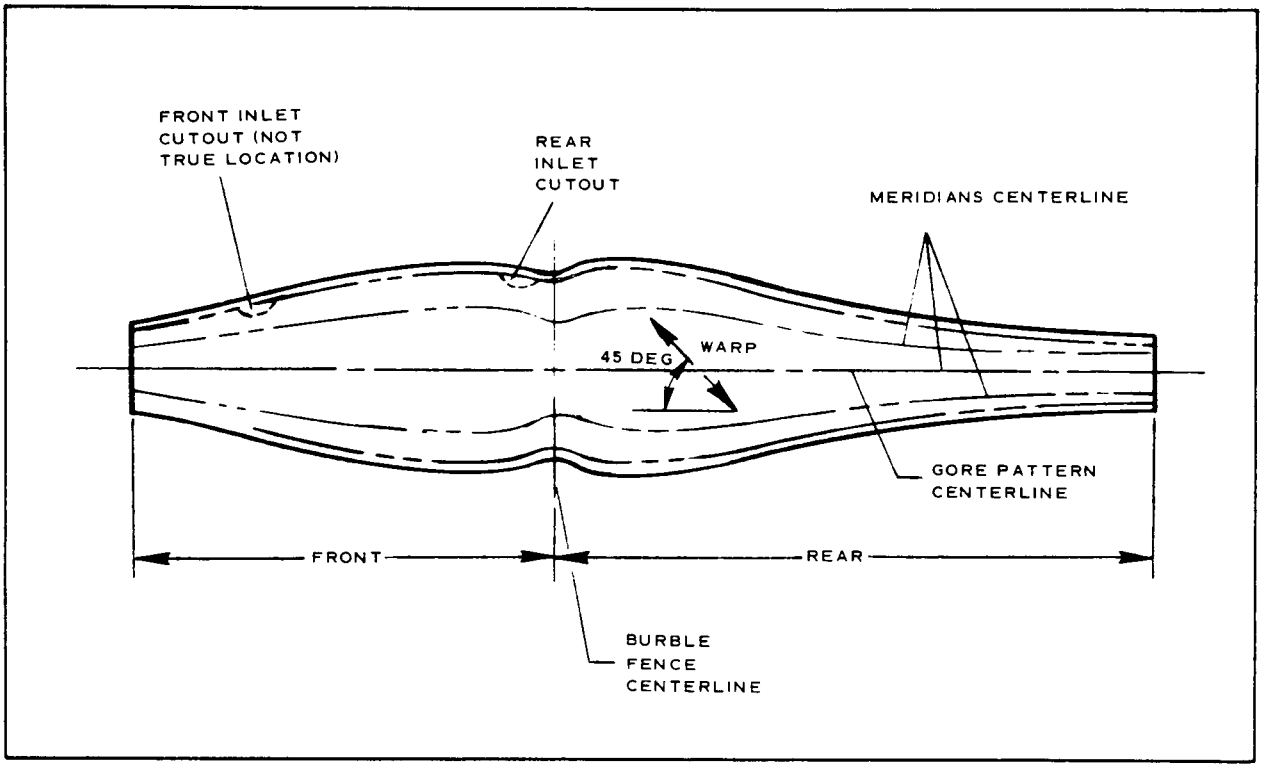


Figure 8. - Model I Gore Pattern

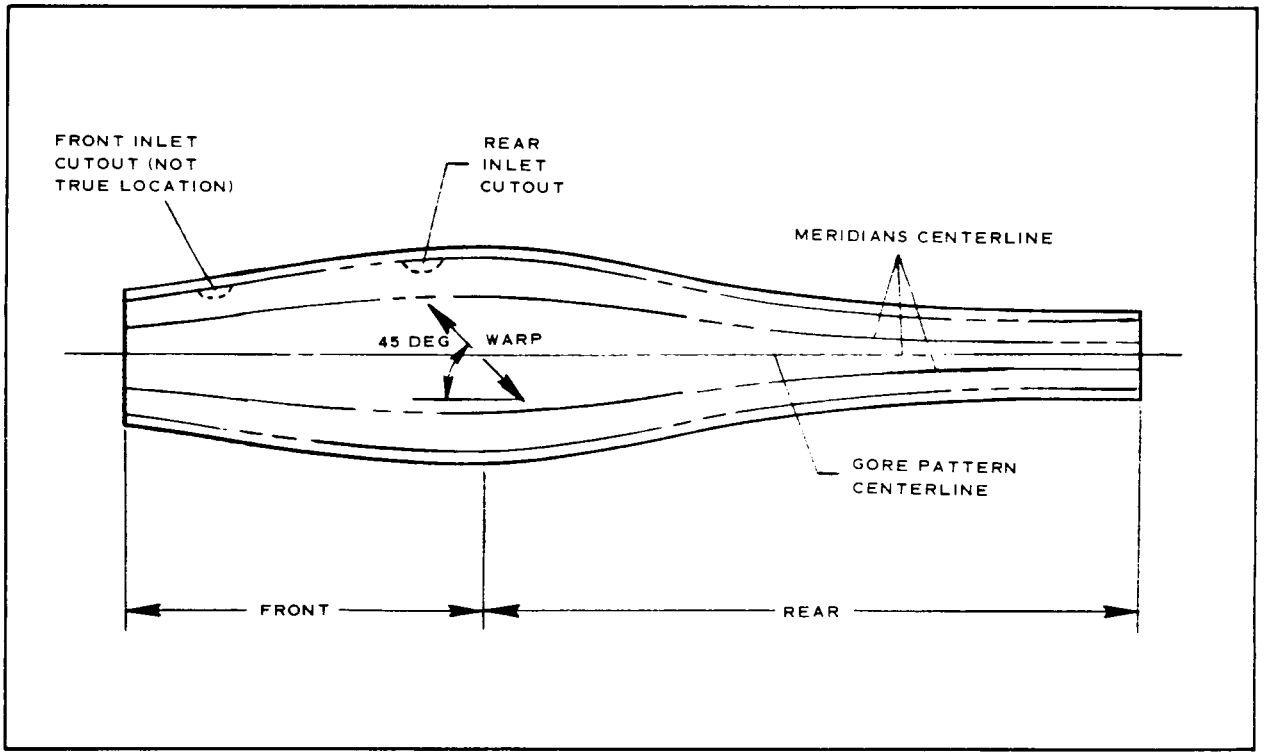


Figure 9. - Model II Gore Pattern

Inlet Sizing

One of the present program's objectives was to investigate the effects of inlet size on canopy deployment and inflation. Wind-tunnel tests (Reference 6) conducted previously used AIDs with aft inlets larger in area than the forward inlets. In this investigation, it was of interest to determine the effects of aft inlets equal to and smaller than the area of the forward inlets.

The four forward inlets were selected as 2.5 in. in diameter based upon the satisfactory performance of the same size inlets in the wind-tunnel tests described in Reference 6. Accordingly, the four aft inlets were 2.5 in. in diameter and 1.8 in. in diameter, the latter being the same size as the inlets on the models described in Reference 9. The combination of the inlets on the models is presented in Table VIII.

TABLE VIII. - AID INLET SIZES

Model	Forward Inlet Diameter (in.)	Aft Inlet Diameter (in.)
IA	2.5	2.5
IB	2.5	1.8
IC	2.5	2.5
ID	2.5	1.8
IIA	2.5	2.5
IIB	2.5	2.5

An inflation analysis computer program was developed by Goodyear Aerospace under this investigation which predicts AID model inflation times. This program, described in Reference 9, verified that both inlet size combinations would inflate the current models within the 1.0-sec design goal.

SYSTEM DESIGN

Forward Inlets

The forward canopy inlets incorporate torsion springs to deploy and to hold the inlets in the air flow. The springs, similar to those used on the models of Reference 6, were selected on a basis of their mechanical simplicity and demonstrated reliability.

The spring design is basically that of a torsion spring. The spring rotates about an aluminum shaft which is attached to the outer ring by two clamps. The free ends of the spring are fastened to the outer ring by an aluminum clamping block (see Figure 10). The spring has a preload torque of 20.6 ± .05 in.-lb at an angle of 70 deg (Figure 11) and a maximum torque of 40.7 ± 1 in.-lb at an angle of 275 deg when in the packed condition.

The construction of the fabric inlets was identical to the techniques used on the inlets described in References 3 and 9. The mouth of the inlet incorporates a wire loop which serves to prevent the inlet from collapsing during inflation and to which the ring section of the torsion spring is attached (see Figure 12).

Aft Inlets

The aft inlets are identical in construction to those on the models of Reference 9. Two different size inlets were fabricated as presented in Table VIII.

The forward and aft inlets were placed at 45 deg relative to each other in order to prevent flow interference and to provide symmetry (see Figure 13). No canopy meridians were cut as a result of this placement.

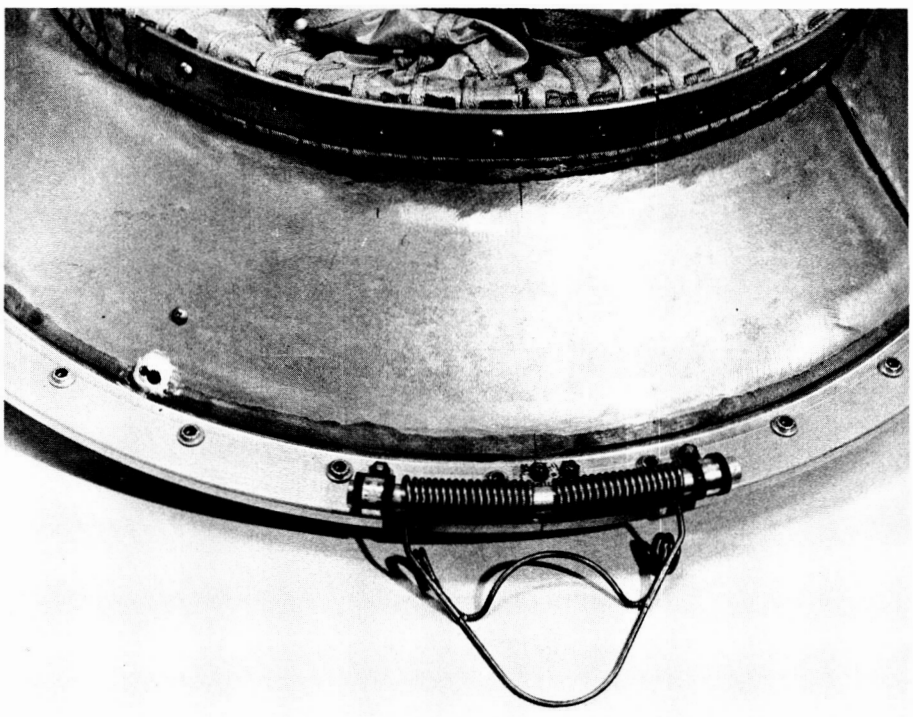


Figure 10. - Forward Inlet Spring Attached to Hard Structure

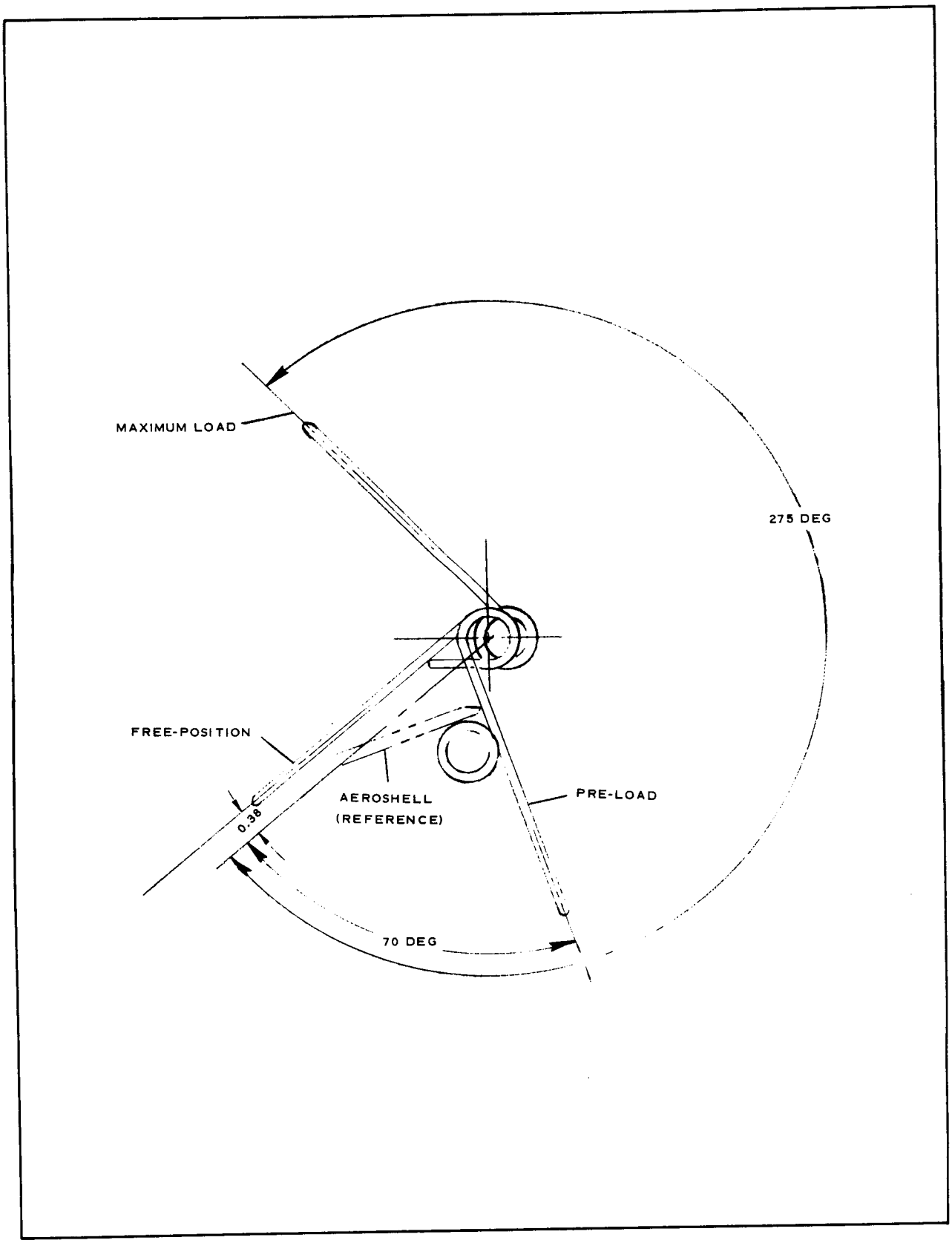


Figure 11. - Forward Inlet Spring Positions

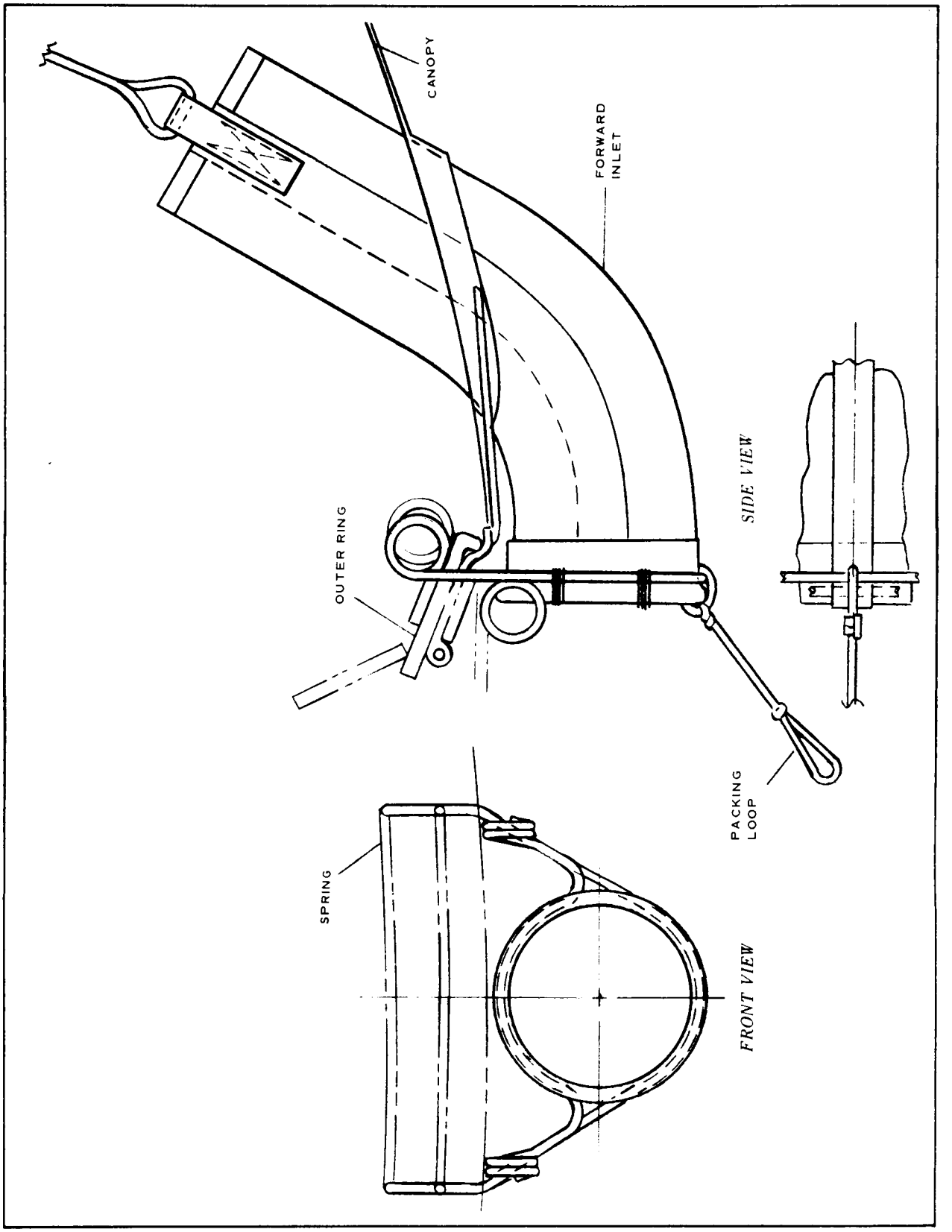


Figure 12. - Forward Inlet Sketch

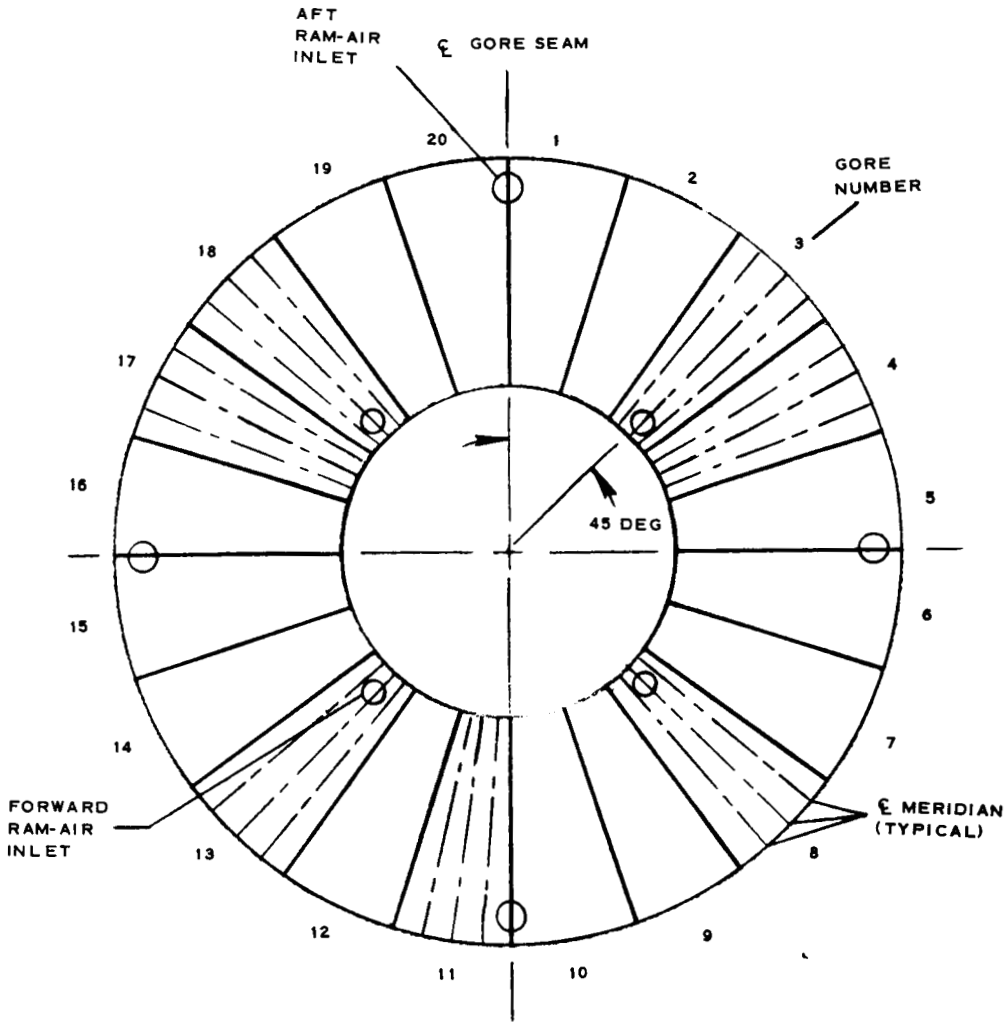


Figure 13. - Relative Angular Deplacement of Inlets (Looking Downstream)

Canopy Attachment Scheme

Figure 14 shows the method of attaching the canopy to the hard structure. The aft canopy clamping band is held to the ring support by six clamping sectors (see Figure 10). The forward canopy clamping band is attached to the outer ring by a large clamping ring. Fabric spacers made of webbing similar in thickness to the meridional tapes were sewn in between each meridian at the attachment to provide a better clamping surface. A layer of epoxy was used in the interface between the fabric and metal structure under the clamping rings and in all the fabric-metal joints to prevent air leakage.

Canopy Storage and Release

It is very important that the canopy be packaged in a manner which: (1) eliminates frictional heating due to excess rubbing of the fabric and (2) provides for the erection of the inlets in the airstream for immediate inflation and ram-air pressurization. Several methods of folding and restraining the AIDs were investigated to ensure that the best packaging method would be selected.

Details of canopy folding pattern are shown in Figure 15. The outer fold of the AID was brought straight back to the top edge of the inner ring. A canopy stowage loop was placed on each meridian through which a restraining cord was passed to hold the canopy tightly against the rear surface. The cord was also passed through six pyrotechnic cutters spaced equidistantly around the top inner surface of the ring support (see Figure 16). Activation of the cutters will sever the cord in six places allowing it to be pulled through the loops as the AID inflates. The cord was terminated in a tuck-splice to allow the end to pass through the loops without interference.

The forward inlets were secured in a similar manner. A cord was passed through the loop attached to each inlet, through two pyrotechnic cutters, and terminated in a tuck splice (see Figure 16). In their stowed position, the inlets are held out of the air flow against the canopy. Release of the spring-mechanisms will occur when the cutters are fired.

MODEL INSTRUMENTATION

Each model was instrumented with one pressure transducer for measuring internal canopy pressure-time history; and three load cells for measuring meridional tape load-time history.

One pressure transducer, having a ± 5.0 psid range, was mounted on the back surface of each model's rear cover so as not to interfere with the packing of the canopy against the rear cover. Two rubber

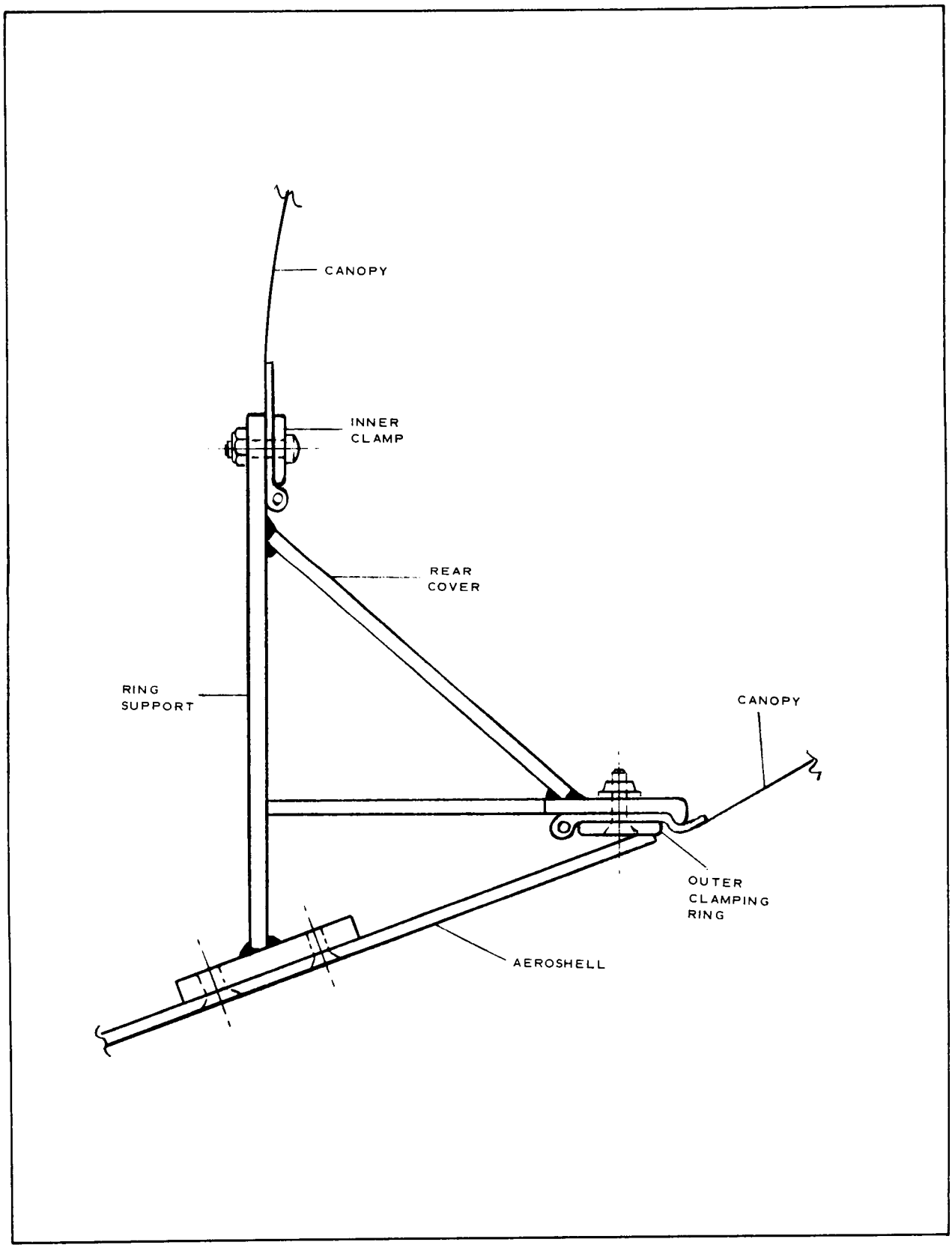


Figure 14. - Canopy Attachment Scheme

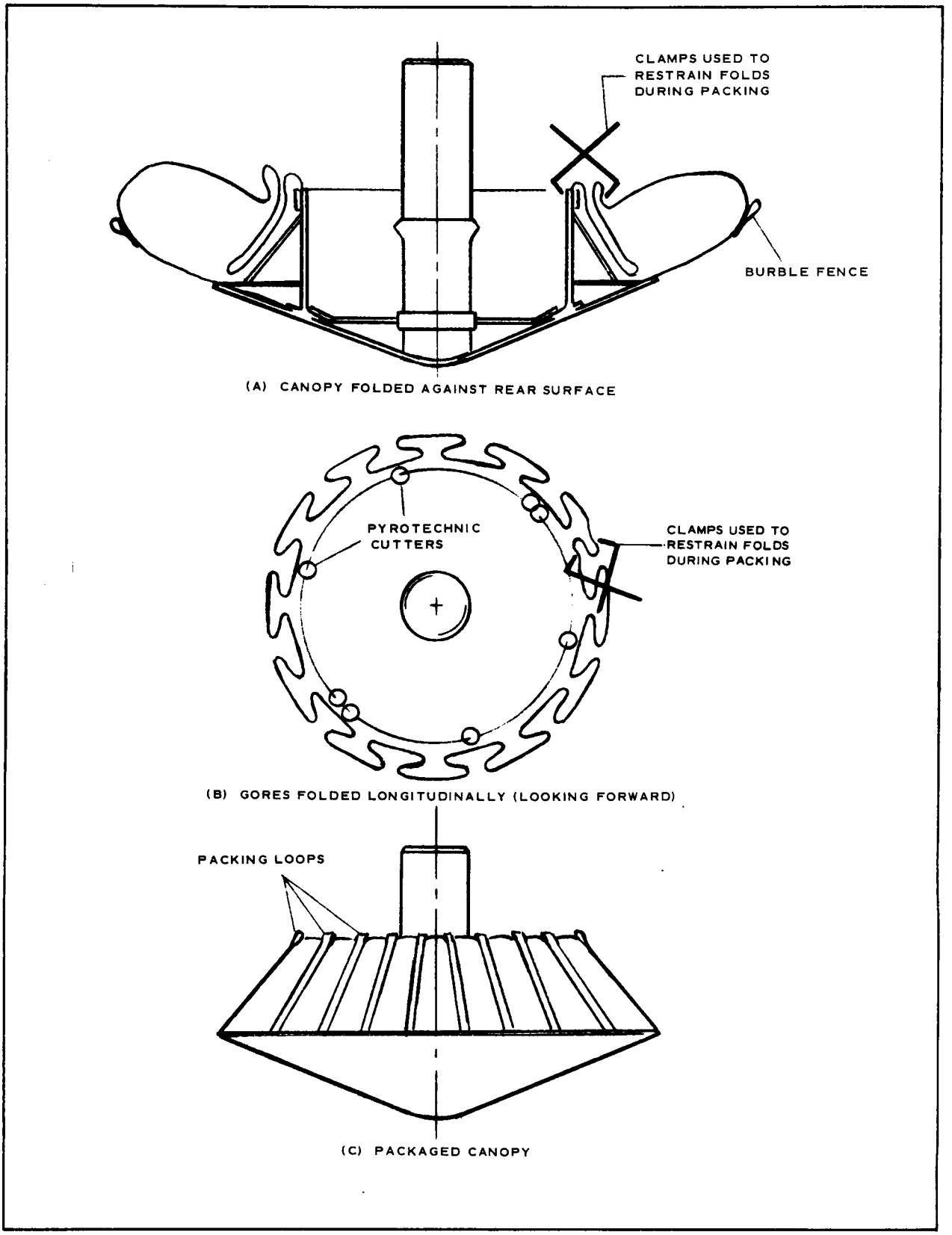


Figure 15. - Canopy Stowage and Release Scheme

Figure 16. - AID Model in Packaged Configuration

tubes extended through an opening in the rear cover into the internal canopy for sensing pressure (see Figure 10). One tube was attached to the pressure transducer; the other tube is for use in measuring final canopy pressure.

The load cells, each capable of measuring up to 180 pounds, were installed on each of three meridional tapes symmetrically on the front surface at x/R = 0.70 as shown in Figure 17. Exact load cell locations and load cell numbers for each model are shown in Figure 18.

PIVOTAL BALANCE ADAPTER

A pivotal balance adapter support sleeve (see Figure 19) was designed and fabricated by GAC for use in wind-tunnel testing the current models. This adapter, which permits the models' freedom in pitch and yaw, was designed to mate with the AEDC sting system designated S-5.53M-123-9.12M (Reference 15).

The adapter consists of four major components: an aeroshell attachment arm, a spherical bearing, a locking pin and a hydraulic cylinder. In operation, the locking pin is seated in the bearing preventing the model from moving during tunnel start and shutdown. During the test, the pin will be withdrawn by the hydraulic cylinder allowing the model freedom to pivot. Rotational motion is limited by two radial pins.

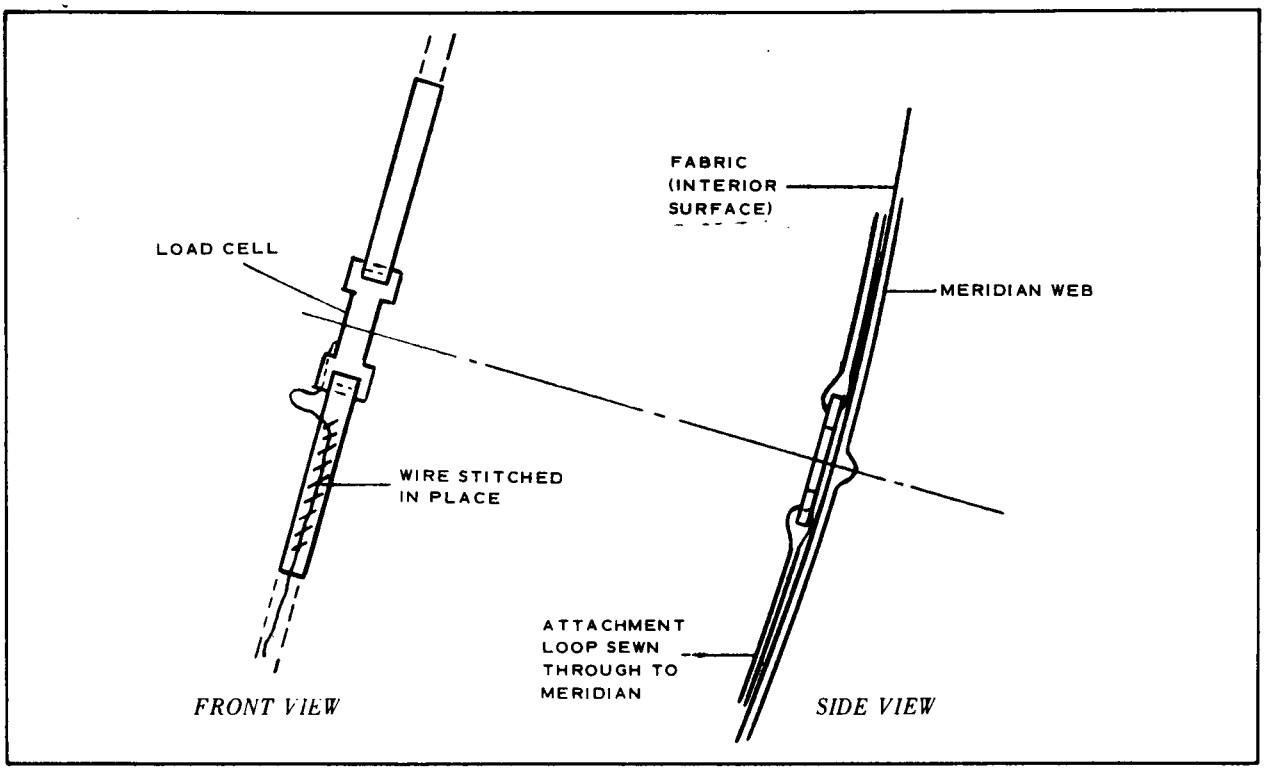


Figure 17. - Load Cell Attachment to Meridian

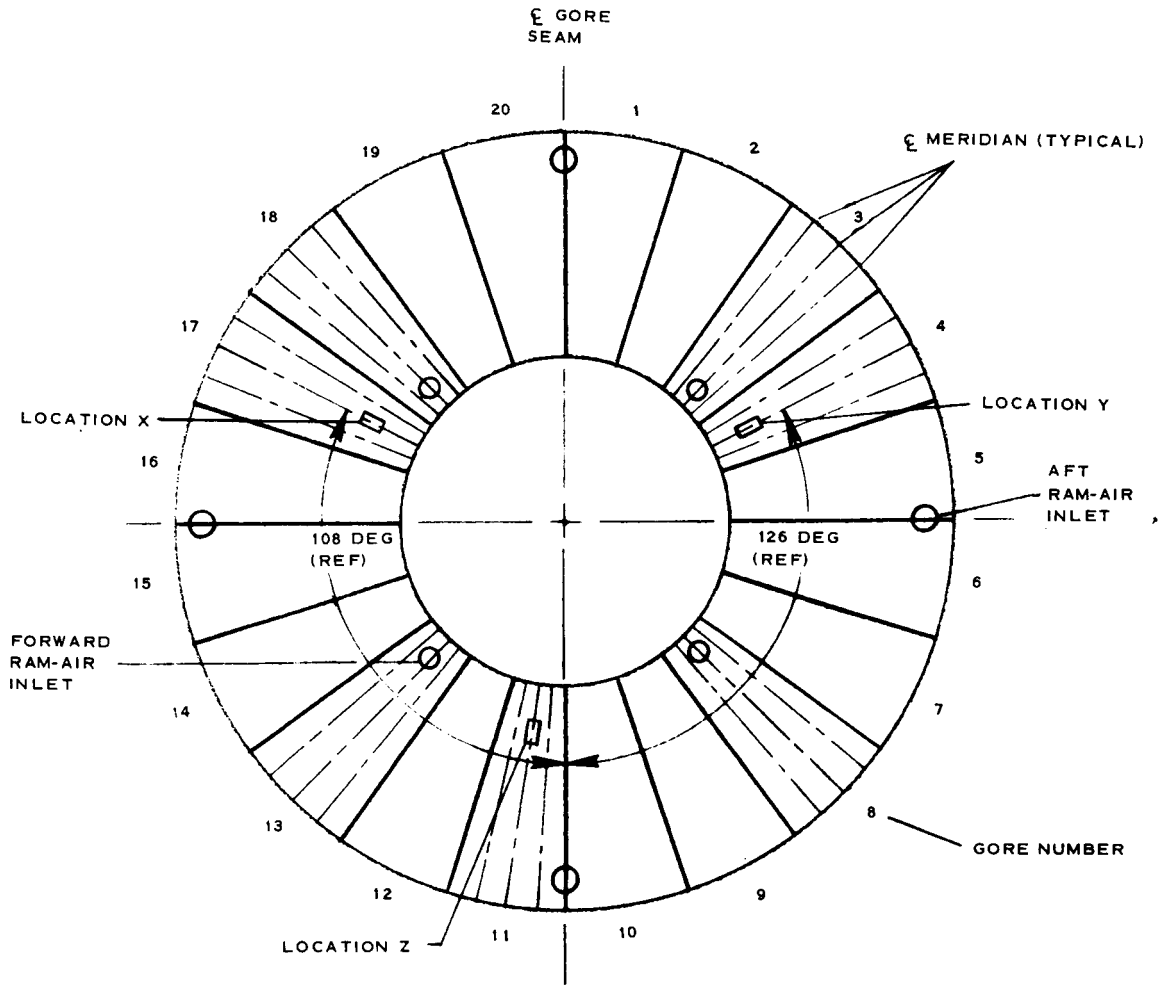
The adapter will permit angular movement in pitch and yaw up to ± 20 deg and in rotation up to ± 15 deg. The pivot bearing has a rated radial load of 123,000 lb and a rated thrust load of 30,875 lb. The hydraulic cylinder is rated at 1500 psi. The time required for the locking pin to release the model is approximately 1 sec at a pressure of 500 psi.

The pivotal adapter was tested after fabrication to demonstrate its ability to withstand aerodynamic loads expected in the wind tunnel. The setup for this test is shown in Figure 20. The tests showed that displacement caused by induced moments were within acceptable limits. A weight analysis summary which presents the center of gravity locations for Model I and II configurations and component weights is found in Appendix C.

MATERIAL SELECTION

Hard Structure

The aeroshells were spun-form from aluminum alloy sheets into final shape. A rigid, close-fitting, low-carbon steel tube serves as the transitional support sleeve between the sting-mounted internal balance and the aeroshells on models IA, IB, and IIA. Models IC,



MODEL NO.	POSITION	SERIAL NUMBER
1A	X	1
	Y	2
	Z	3
1B	X	7
	Y	8
	Z	9
1C	X	4
	Y	5
	Z	6

MODEL NO.	POSITION	SERIAL NUMBER
1D	X	10
	Y	12
	Z	13
IIA	X	15
	Y	16
	Z	14
IIB	X	17
	Y	18
	Z	19

Figure 18. - Serial Numbers and Locations of Load Cells for Each Model

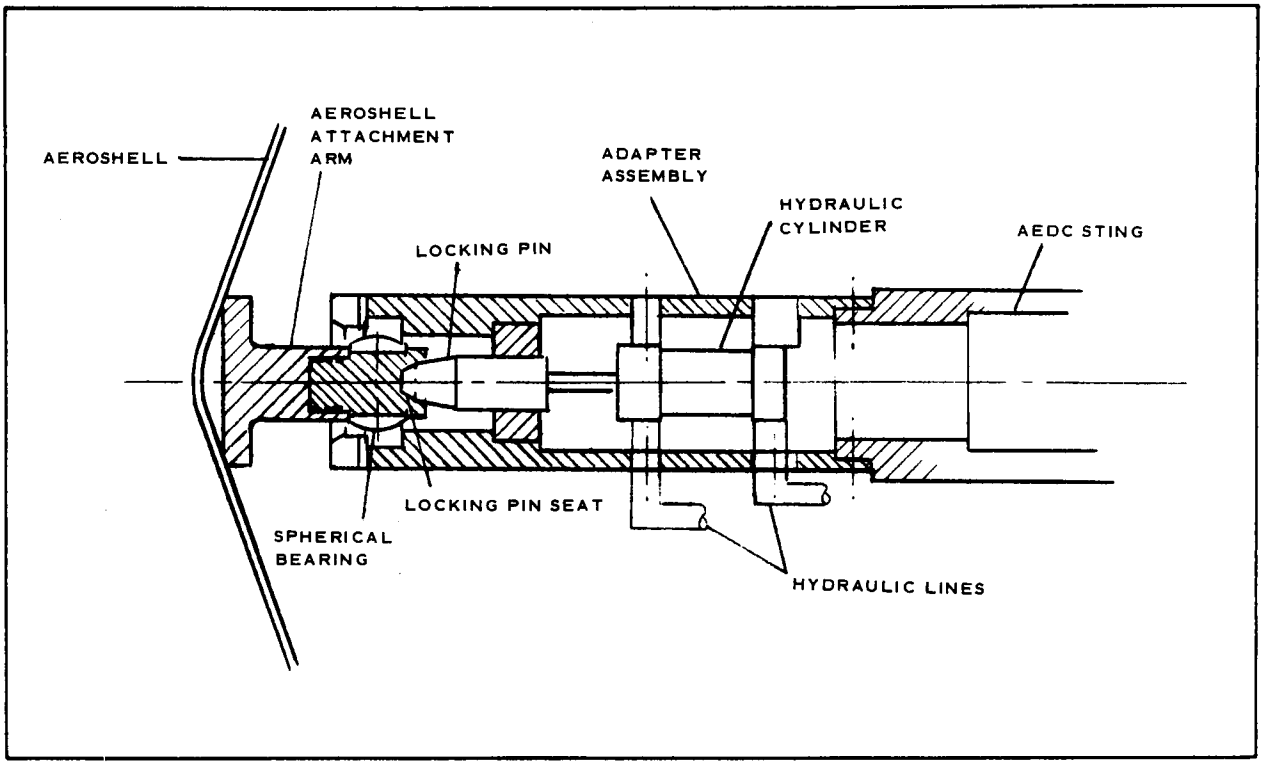


Figure 19. - Sketch of Pivotal Adapter

ID, and IIB utilize the pivotal adapter, described above, as the transitional support. A hardened steel mounting pin is the load-carrying member between each support sleeve and the AEDC balance.

The AID was secured to the hard structure by clamping the canopy end bands (see Figure 14). Attachment to the outer ring was achieved by a 6061-T6 aluminum alloy clamping ring; inner attachment to the ring support was accomplished by six 6061-T6 aluminum alloy clamping sectors. The remainder of the hard structure was fabricated from 6061 aluminum alloy and welded in accordance with Reference 13 requirements (see Drawing 3063000-003, Appendix A).

Fabric

All six models were fabricated from Nomex cloth. The cloth was calendered* and coated to reduce its permeability to a level such that the ram-air pressurization through the inlets would maintain the design shape and internal pressure.

*Calendering of the cloth is a mechanical process for reducing the fabric permeability by passing a heated mandrel under pressure over the cloth. The cloth is restrained at its perimeter to reduce shrinkage.

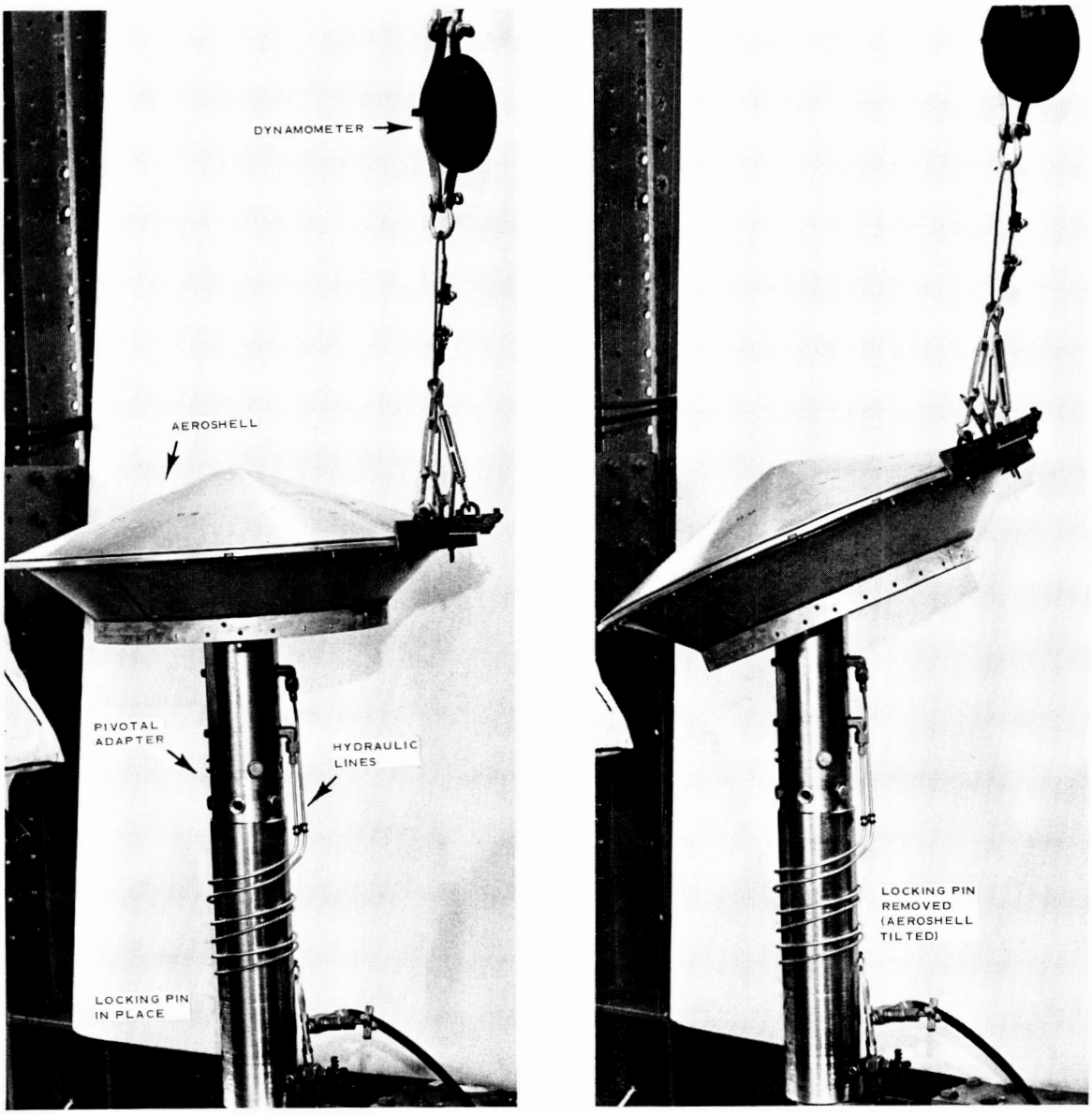


Figure 20. - Test Setup of Static Test of Pivotal Adapter

The Nomex fabric was coated with 0.4 oz/sq yd of the same Viton fluorelastomer which had been successfully employed in the model designs of References 3, 6, and 9. The coating was applied by machine, predried at 150 deg, and final cured at 325 deg F.

The meridional tapes are similar to MIL-T-5038 Type V tape but were specially woven of Nomex instead of nylon. To simulate the relative meridian size better, the 500-lb tape was folded to 1/4 in. wide for attachment to the fabric. The gore and the burble fence seams used a simple lap seam, 5/8 in. wide, and two rows of Federal Specification 751 Type 301 lockstitching and one row of single-throw Type 304 zig-zag stitching. The zig-zag stitch was used to secure the edge of the fabric that is exposed to the airstream. To reinforce the gore around the inlet, a Goodyear Aerospace-developed, 300-lb braided Nomex cord was sewn in place. Actual loads for both the fabric and meridional tapes are calculated in Appendix B.

DEVELOPMENT TESTS

General

Development tests conducted include: (1) tensile tests of both the uncoated and uncalenered Nomex and the calendered and coated Nomex fabric, (2) permeability tests of the calendered and coated Nomex fabric, and (3) a rapid deployment and inflation test of one of the completed AID models.

Tensile Tests of Nomex Fabric

Variations in the tensile strength characteristics of textile materials woven to the same specification can occur among different lots. To account for these variations, it was necessary to conduct tensile strength tests to determine the exact strength characteristics of the lot used. Tensile tests were conducted on 1-in. ravelled strips of both the uncoated and uncalendered Nomex fabric (HT-189) and the coated and calendered Nomex fabric (GX601V0262) in accordance with Federal Specification CCC-T-191b on a tensile testing machine. A summary of these tests is presented in Table IX. Strength tests were not conducted on the Nomex meridional tapes or the various thread types used in the fabrication of the canopies. These materials were taken from the same lot as the materials used in the fabrication of earlier models, the strength of which is documented in References 3 and 10. The gore seams, burble fence seams, and inlets seams were identical to those used on the models in References 3 and 6; and as a result, strength tests were not repeated during this program. The structural integrity of the load cell attachment to the meridians, the forward inlet, and the forward attachment was established by the tensile tests of Reference 9.

TABLE IX. - TENSILE STRENGTH TEST RESULTS OF CANOPY FABRIC

Specimen	HT-189 Fabric Ultimate Load (lb/in.)	GX601V0262 Fabric Ultimate Load (lb/in.)
Warp Direction		
1	101.0	93.0
2	99.0	95.0
3	105.0	101.0
4	102.0	97.0
5	101.0	99.0
Average	101.6	97.0
Fill Direction		
1	120.0	115.0
2	115.0	106.0
3	118.0	110.0
4	117.0	111.0
5	119.0	113.0
Average	117.8	111.0

Fabric Permeability Tests

To obtain the high pressure recovery needed to produce the design shape and design drag coefficient, the Nomex was calendered and coated to reduce its permeability level. The results of this operation provided a permeability of approximately 0.5 cu ft/sq ft-min at 1/2 in. of water. Experience has shown that sewing operations and normal handling will tend to increase the permeability level slightly up to that required of 1.0 cu ft/sq ft-min at 1/2 in. of water.

Deployment and Inflation Test

To demonstrate the adequacy of the packaging, deployment, and inflation characteristics of the models, a deployment and inflation test was conducted in an environmental chamber. Model IC successfully deployed and inflated at the following conditions: 20 psfa and approximately 170 deg F. These conditions were established by deployment and inflation tests in Reference 3.

Inflation was initiated by rapid vaporization of a water-alcohol solution contained in a reservoir within the packaged canopy. A pressure transducer mounted internally and load cells attached to the canopy provided measurements of the differential pressure and the loads imposed on the meridians during deployment.

The inflation test setup, Figure 21, describes the sequence of events. A shape controlling spoked guide shown in Figure 21 serves to cradle the AID when inflated preventing the canopy from inflating in a distored shape due to the absence of aerodynamic loads (Reference 3).

The differential pressure-time history of the AID during its deployment and inflation is shown in Figure 22. Full inflation of the canopy occurred in 0.36 sec. Load cell force-history for the three load cells are shown in Figure 23. The peak loads occurred just prior to inflation. Figure 24 is a picture of the AID model at full inflation. A review of the film coverage of the test indicated that the packaging and deployment scheme was suitable for use in the wind tunnel.

CONCLUSIONS

Six first stage attached inflatable decelerator models have been designed and fabricated for supersonic wind-tunnel evaluation. The models incorporate spring-actuated forward inlets for initial deployment and aft inlets for full inflation and final pressurization The model I configurations differ from the model II configurations by the presence of a 10-percent burble fence and the resultant geometry change. The following conclusions can be drawn: (1) a canopy which simulated a first-stage AID both in shape and attachment locations was designed and fabricated; (2) the workability of the models' packaging and restraining system, and successful AID deployment were demonstrated during a rapid inflation test.

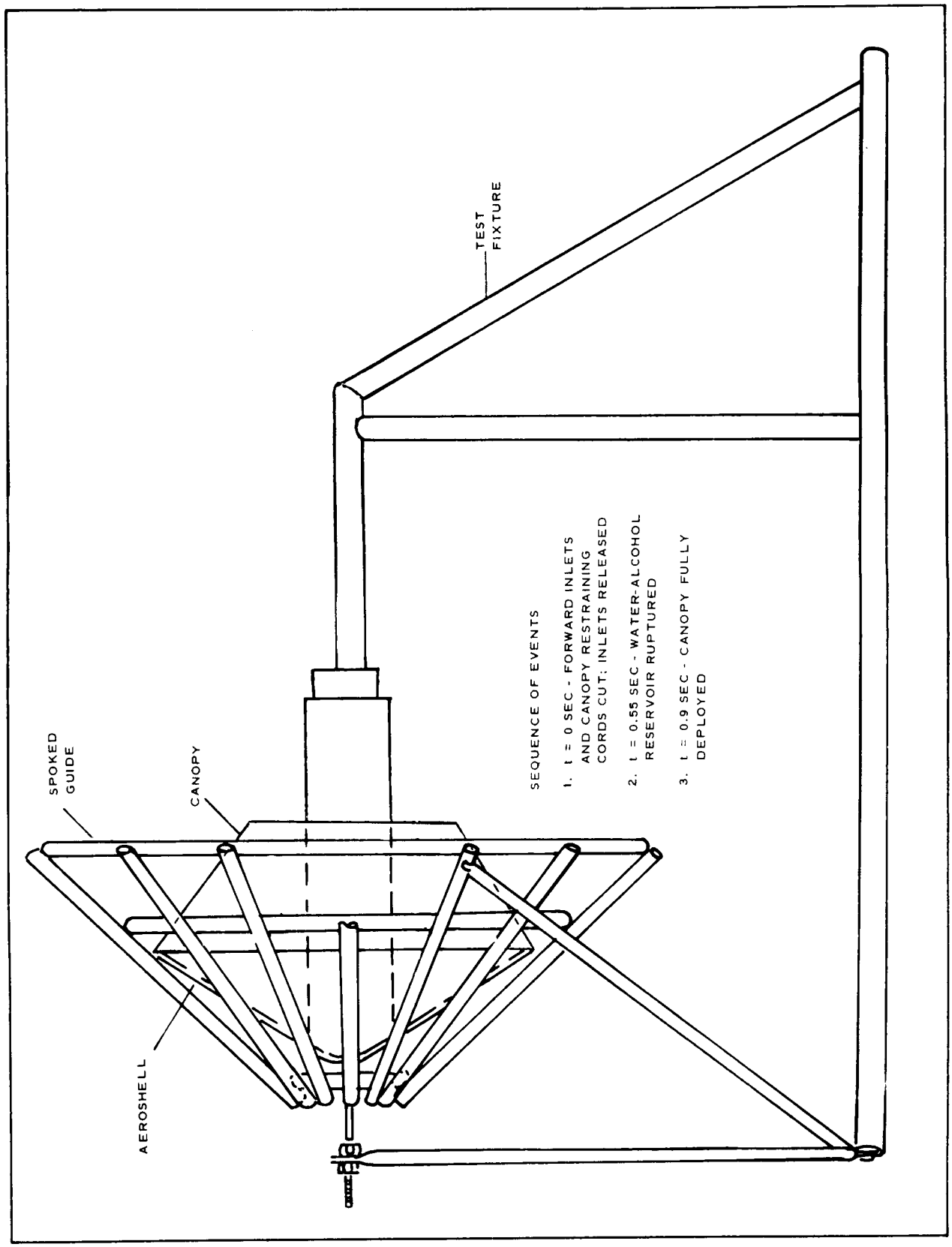


Figure 21. - Water-Alcohol Inflation Test Setup

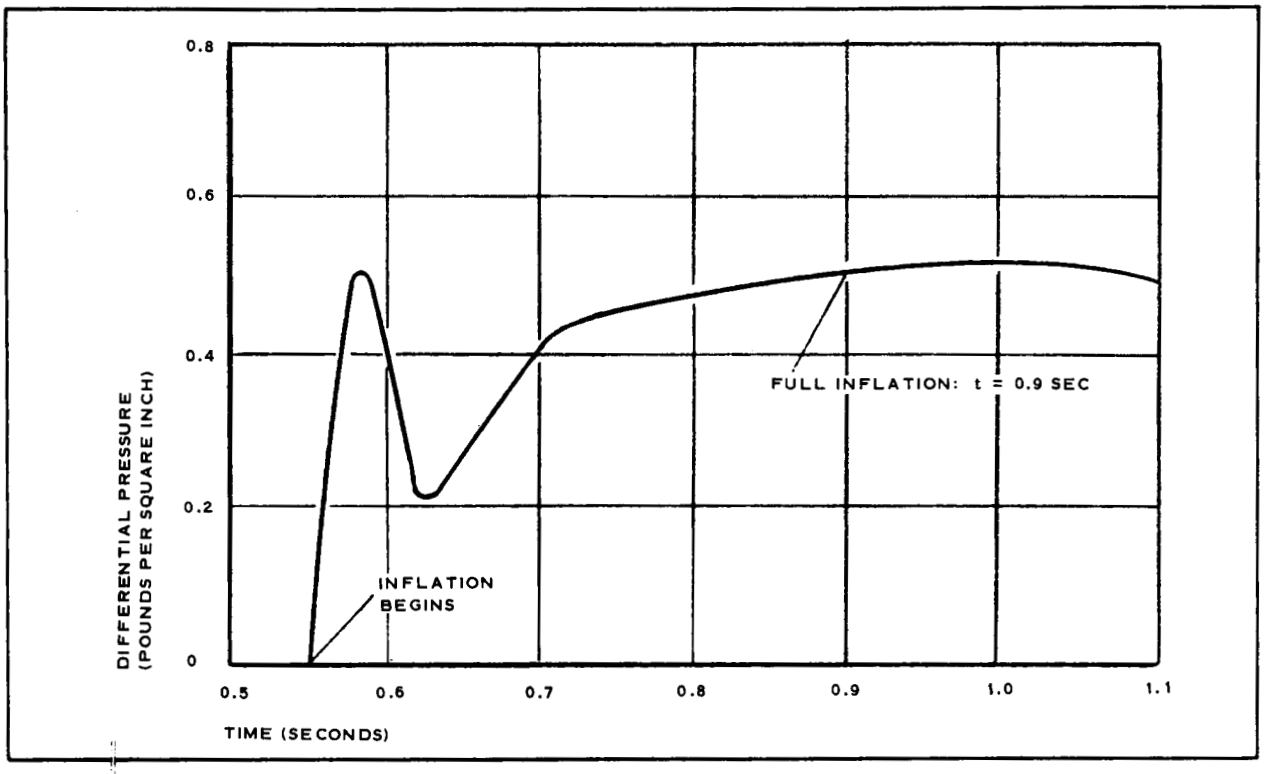


Figure 22. - AID Differential Pressure-Time History

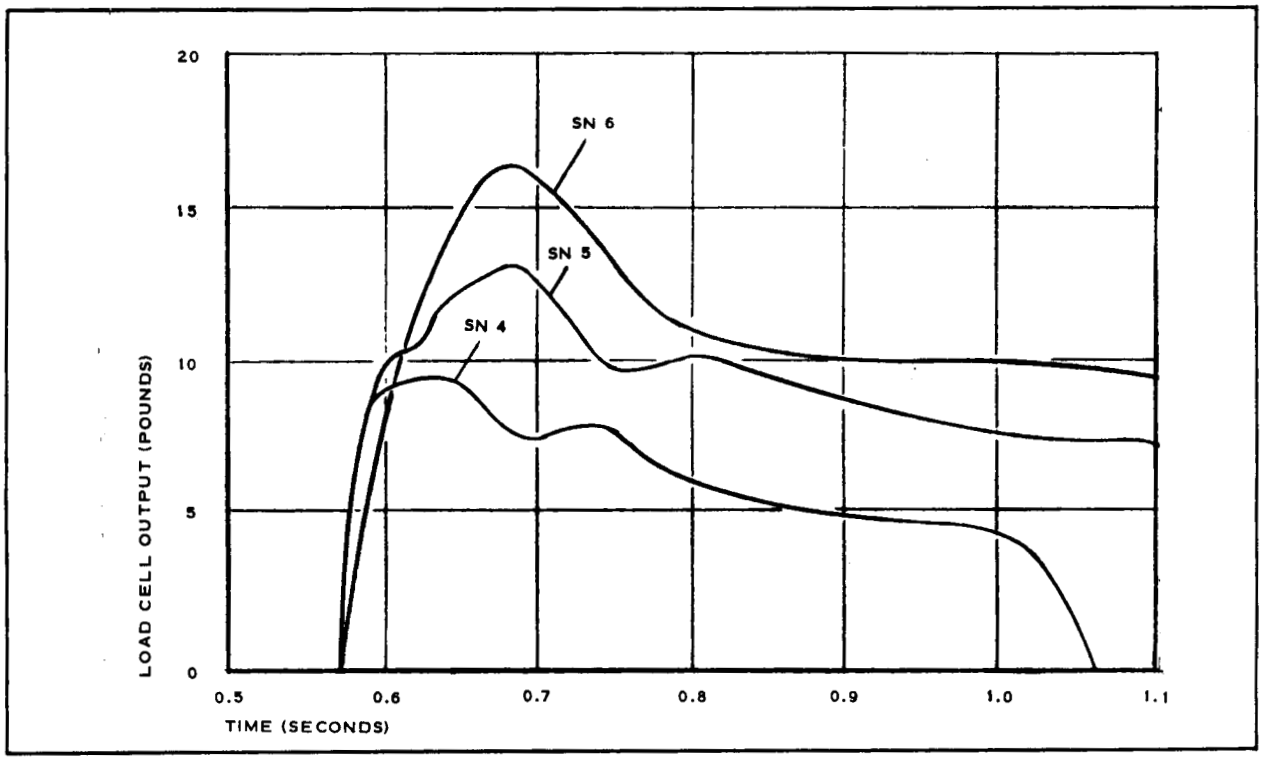


Figure 23. - Load Cell Force-Time History

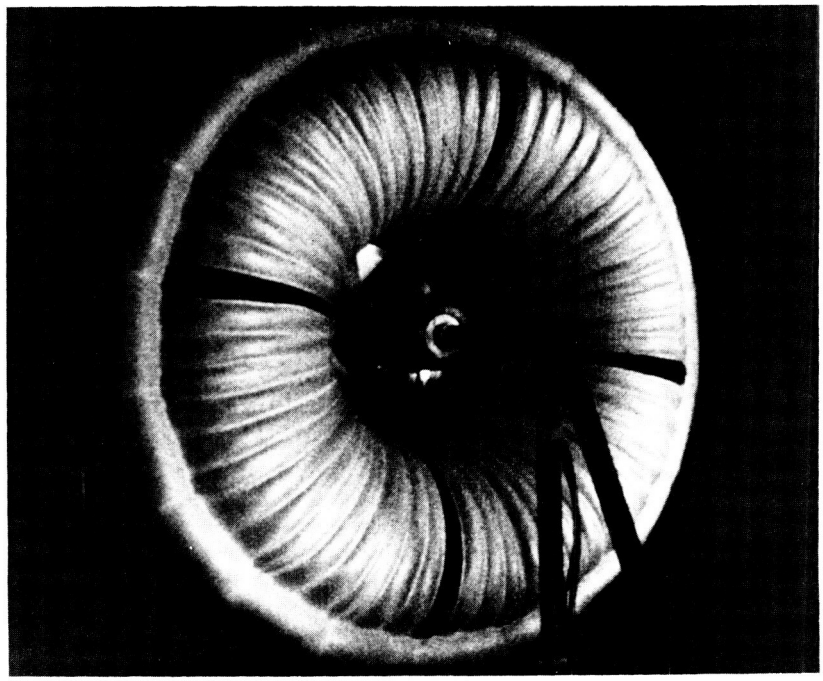


Figure 24. - Fully Inflated AID

APPENDIX A. - DRAWINGS

The working drawings for the attached inflatable decelerator system were generated by Goodyear Aerospace and are given below (see Figures A-1 through A-27).

1. Drawing 3063000-001: Attached Inflatable Decelerator System (5 sheets), 20 August 1970.

2. Drawing 3063000-002: Decelerator Assembly, Attached Inflatable (10 sheets), 20 August 1970.

3. Drawing 3063000-003: Support Ring Assembly and Aeroshell, Attached Inflatable Decelerator System (6 sheets), 20 July 1970.

4. Drawing 3063000-004: Support Assembly, Attached Inflatable Decelerator (4 sheets), 7 August 1970.

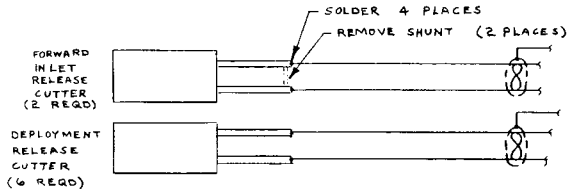
5. Drawing 3063000-110: Spring and Ring Assembly, Decelerator Assembly, Attached Inflatable (1 sheet), 9 October 1970.

6. Drawing 3063000-112: Tube Assembly, Decelerator Assembly (1 sheet), 23 February 1971.

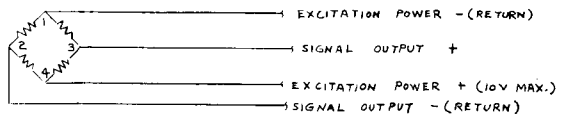
REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
2A	A	REVISED REVISION STATUS BLOCK REVISED SH 4	12-9-70	BY R.SPIERS
				ENGR
				CUST

NOTES:

1. IDENTIFY PER MIL-STD-130 (GAC PROCESS SPEC J2)
2. DRESS AEROSHELL SCREWS HEADS WITH DOW CORNING RTV-731 MIXED WITH 1 PART IN 10 OF ALUMINUM POWDER. PRIME SURFACE WITH DOW CORNING A-4094 PRIMER
3. BEAD CANOPY END BANDS & POT HOLES FOR AIR SEAL WITH DOW CORNING RTV-731 ADHESIVE. WHEN USING ON METAL, PRIME WITH DOW CORNING A-4094 PRIMER
4. INSTALL INSERT PER MIL-SPEC MS33646 (GAC PROCESS SPEC M69)
5. MAKE NOMEX TUBULAR BRAIDED CORD FROM 1200 DENIER 3 1/4 Z TWIST NOMEX YARN AS FOLLOWS: 16 CARRIERS, 2 ENDS PER CARRIER, 9 TO 11 PICKS PER INCH
6. TORQUE WITH MS33750 DRIVER, RECESS NO 4, TO 40 IN. LBS.



210918 LINE CUTTER SCHEMATIC



CEC 4-316 PRESSURE TRANSDUCER & 4-019 ADAPTER SCHEMATIC

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1	1	1	1	1	1			TYPE 4-316 TYPE 4-019	PRESSURE TRANSDUCER ADAPTER			2E2
8	8	8	8	8	8			MS21919WG9	CLAMP			2C2
8	8	8	8	8	8			MS21919WDG-5	CLAMP			8G2
1	1	1	1	1	1			MS21919WDG-16	CLAMP			1D2
	8			8	8			MS21209F4-20	INSERT			6A3
1	1	1	1	1	1			AN520-10R	SCREW			
20	20	20	20	20	20			MS24694S152	SCREW			
8	8	8	8	8	8			MS24693S274	SCREW			

PARTS LIST

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18	18	18	18	18	18			NAS1219-4-11	SCREW	6		
30	30	30	30	30	30			NAS1216-4-14	SCREW	6		
23	23	23	23	23	23			NAS679A3	NUT-LOCK			
30	30	30	30	30	30			NAS679A4	NUT-LOCK			
20	20	20	20	20	20			NAS679A5	NUT-LOCK			
6	6	6	6	6	6			NAS561C4-12	PIN-SLOTTED			6F2
AS REQD	AS REQD	AS REQD	AS REQD	AS REQD	AS REQD			-9	CABLE, SHIELDED (FOR Z 210918 LINE CUTTERS)	MIL-W-16878/6A, TYPE E, 2 CONDUCTOR 20 GAGE, BLK & WHITE	12 FT LG.	5D2
1	1	1	1	1	1			-7	FORWARD INLET RELEASE CORD	NOMEX CORD 5		
1	1	1	1	1	1			-5	DECELERATOR RELEASE CORD	EXERCISER CORD-No 216 MIL-C-5650 - 1/8 DIA.		8B2
1	1	1	1	1	1			-3	VITON TUBING (FOR REF PRESSURE)	.19 I.D. x .31 O.D. 6 FT. LG.		2F2
1	1	1	1	1	1			-1	VITON TUBING (FOR REMOTE PRESSURE)	.06 I.D. x .19 O.D. 6 FT. LG.		4E2
4	4	4	4	4	4			3063000-110-13	BLOCK			2B2
4	4	4	4	4	4			3063000-110-11	SHAFT			2B2
	1			1	1			3063000-003-105	RING SUPPORT WELDMENT			6B3
	1			1	1			3063000-003-17	SUPPORT			7A3
1	1	1	1	1	1			3063000-003-11	OUTER CLAMP			4B3 4B4
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6	6	6	6	6	6			3063000-003-7	CLAMP			FE3 FE4
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			1		1			3063000-002-101	DECELERATOR ASSY (MODEL I)			3N3 3N4
1		1	1					3063000-004-101	SUPPORT ASSY			6C4
	1			1	1			610A000-102-101	SUPPORT ASSY			7D3
								-111	MODEL I DECELERATOR ASSY	(WITH BURBLE FENCE)		SH4
								-109	MODEL I DECELERATOR ASSY	(WITH BURBLE FENCE)		SH3
								-107	MODEL II DECELERATOR ASSY	(WITHOUT BURBLE FENCE)		SH4
								-105	MODEL I DECELERATOR ASSY	(WITH BURBLE FENCE)		SH4
								-103	MODEL II DECELERATOR ASSY	(WITHOUT BURBLE FENCE)		SH3
								-101	MODEL I DECELERATOR ASSY	(WITH BURBLE FENCE)		SH3

PARTS LIST

3063000-001-000

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOLERANCES ON: DECIMALS .X ± .1, .XX ± .04, .XXX ± .010; ANGLES ± 1°
MATERIAL:
SEE GR60-9-60 FOR DRAWING INTERPRETATION STANDARDS.

CONTR
WTS
STRESS Barrow 9-1-70
ENGR Johnson 9/2/70
CHECK
DRAWN R. SPIERS 8-20-70
GAC APPROVAL
CUSTOMER APPROVAL

GOODYEAR AEROSPACE CORP
AKRON, OHIO

ATTACHED INFLATABLE DECELERATOR SYSTEM

SIZE E | CODE IDENT NO. 25500 | DRAWING NO. 3063000-001
SCALE | SHEET 1 OF 5

REV STATUS OF SHEETS: SHEET 1 2 3 4 5; REV - - - A

E-IN-60 (2-66)

Figure A-1. - Attached Inflatable Decelerator System
Drawing 3063000-001, Sheet 1

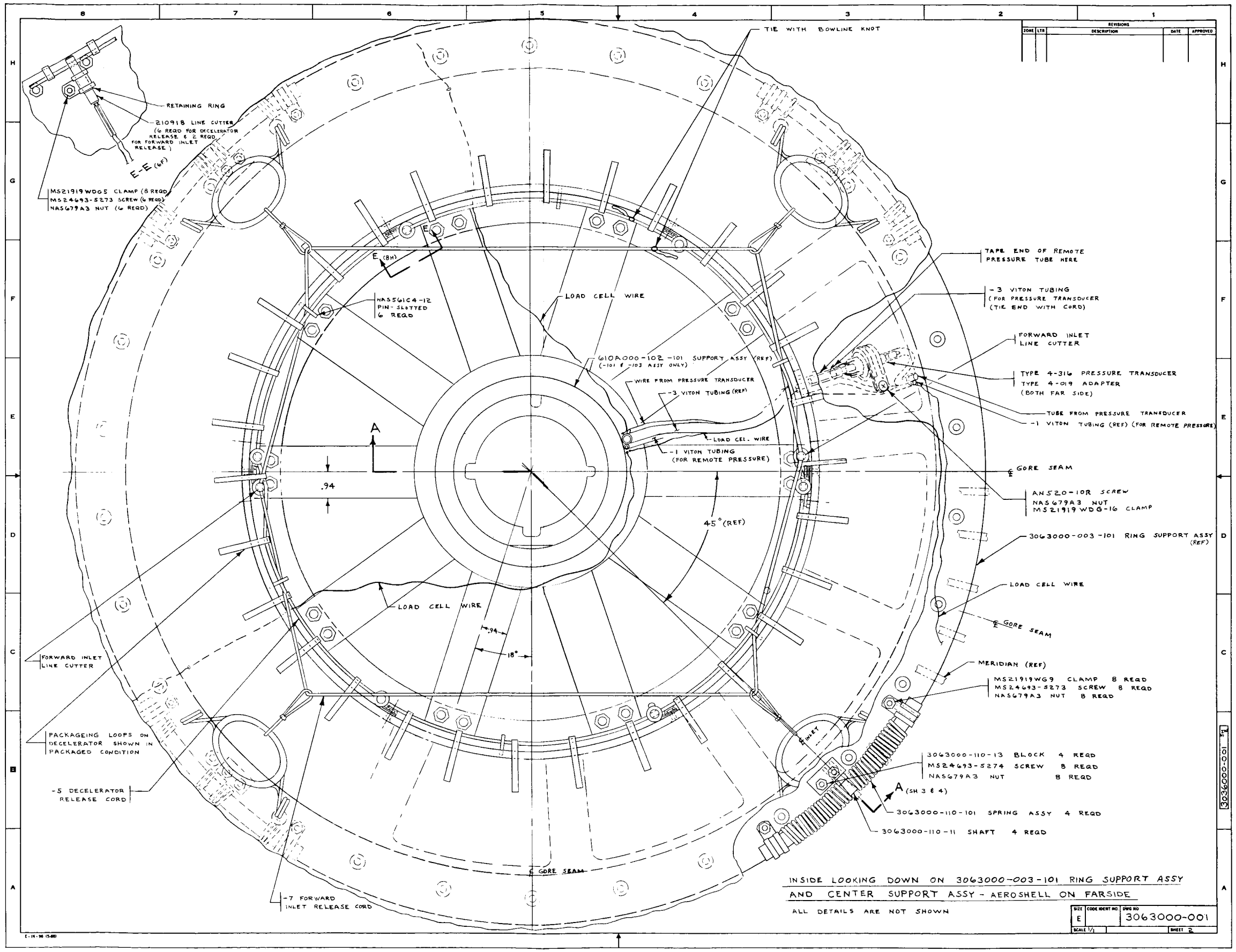


Figure A-2. - Attached Inflatable Decelerator System
Drawing 3063000-001, Sheet 2

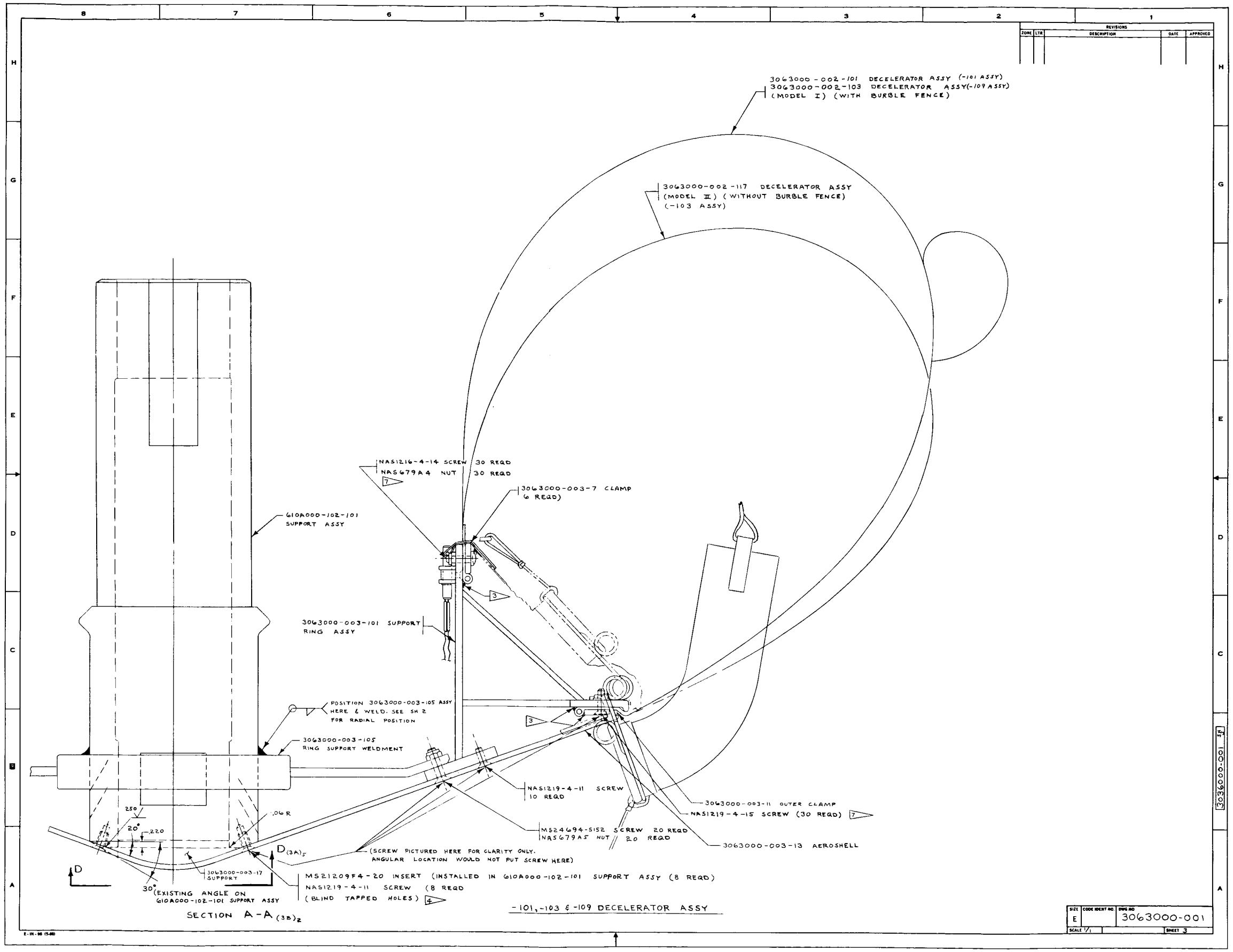


Figure A-3. - Attached Inflatable Decelerator System
Drawing 3063000-001, Sheet 3

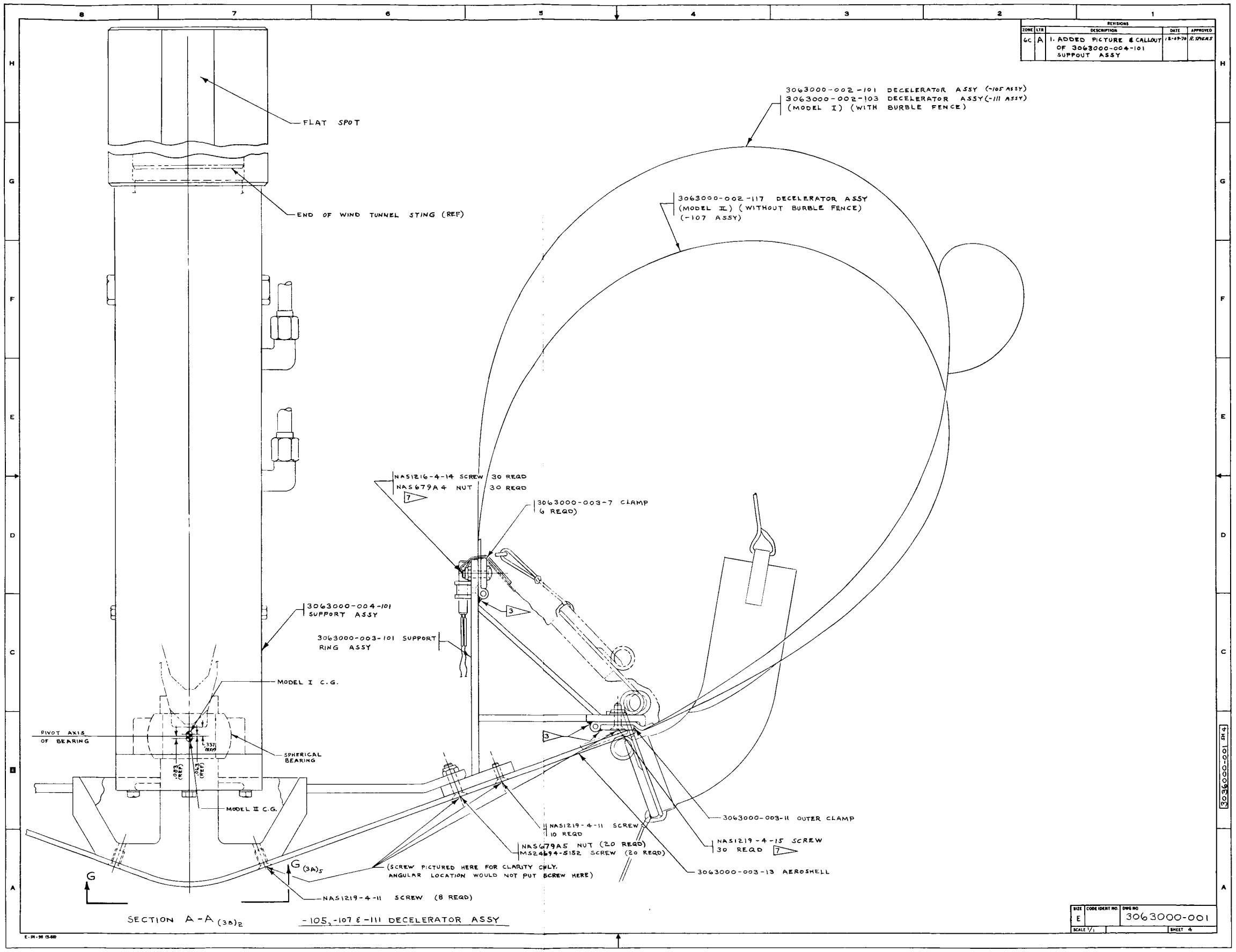
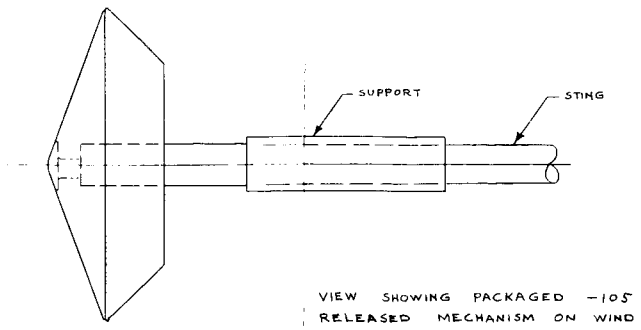


Figure A-4. - Attached Inflatable Decelerator System
Drawing 3063000-001, Sheet 4

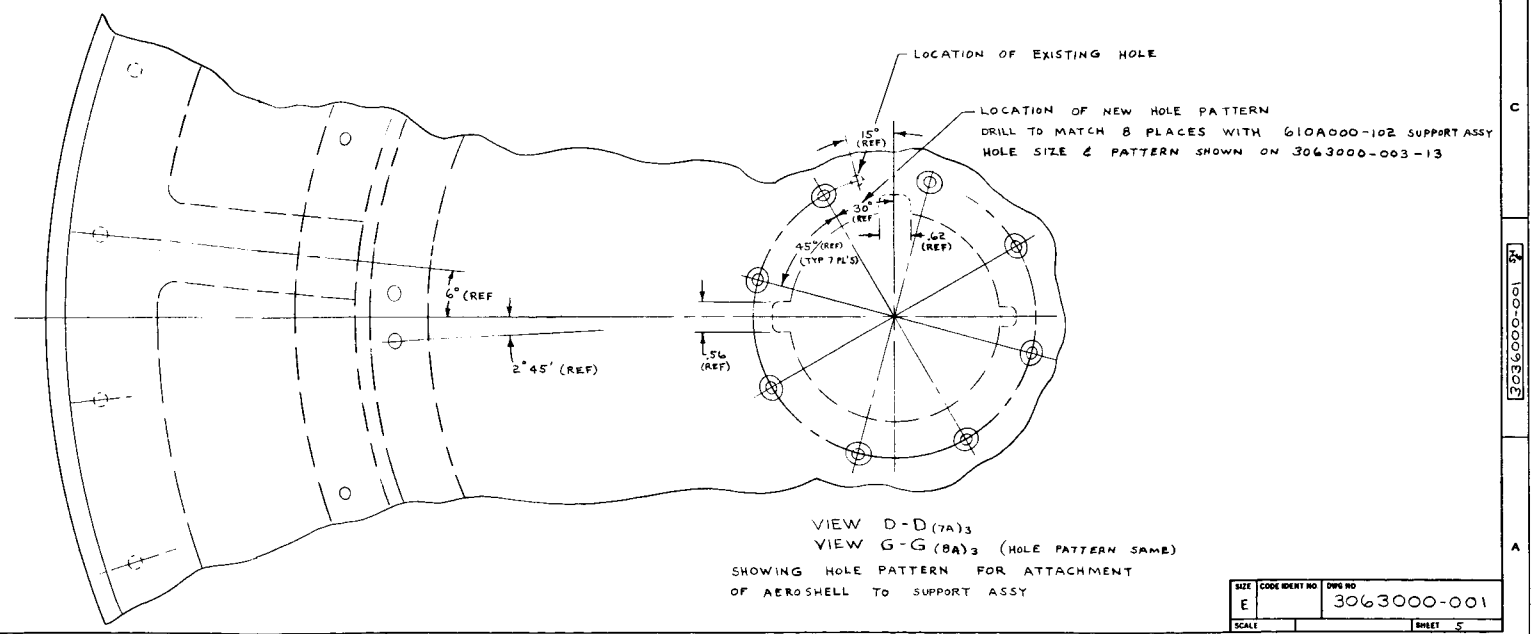
REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



VIEW SHOWING PACKAGED -105 & -107 DECELERATOR ASSY & RELEASED MECHANISM ON WIND TUNNEL STING

-101 & -103 ASSY'S SIMILAR

SCALE 3/16 = 1"



VIEW D-D (7A)3
VIEW G-G (8A)3 (HOLE PATTERN SAME)
SHOWING HOLE PATTERN FOR ATTACHMENT OF AEROSHELL TO SUPPORT ASSY

SIZE	CODE IDENT NO	DWG NO
E		3063000-001
SCALE		SHEET 5

3063000-001 5

Figure A-5. - Attached Inflatable Decelerator System
Drawing 3063000-001, Sheet 5

NOTES:

1. IDENTIFY PER MIL-STD-130 (GAC PROCESS SPEC J2.)
2. SEW PER STD 751 (SEE GR60-4-51 FOR SEWING SYMBOL EXPLANATION)
3. GOODYEAR AEROSPACE CORP. CODE GX60IV027 NOMEX/VITON FABRIC (WHITE) 2.6 OZ/YD², 95 X 85 LBS/IN. TENSILE STRENGTH
4. NOMEX TAPE - SIMILAR TO MIL-T-5038, TYPE V, 9/16 WIDE, 500 LBS TEN.
5. MAKE NOMEX TUBULAR BRAIDED CORD FROM 1200 DENIER 3 1/4 OZ TWIST NOMEX YARN AS FOLLOWS: 16 CARRIERS, 2 ENDS PER CARRIER, 9 TO 11 PICKS PER INCH
6. PUT -39 MERIDIAN WEB UNDER 5 ± 1/2 LBS FOR ONE MINUTE MAX TO MARK TO ENVELOPE MATCH MARKS
7. PRIOR TO CLOSING ASSY, COAT ALL STITCHING INSIDE ENVELOPE (INCLUDING BURBLE FENCE) WITH ONE BRUSH COAT OF VITON (12.0% SOLIDS) IN ACCORD WITH GER 13317
8. ALTERNATE DIRECTION OF WARP FROM GORE TO GORE WHEN ASSEMBLING GORES
9. CANOPY SHAPE PARAMETERS:

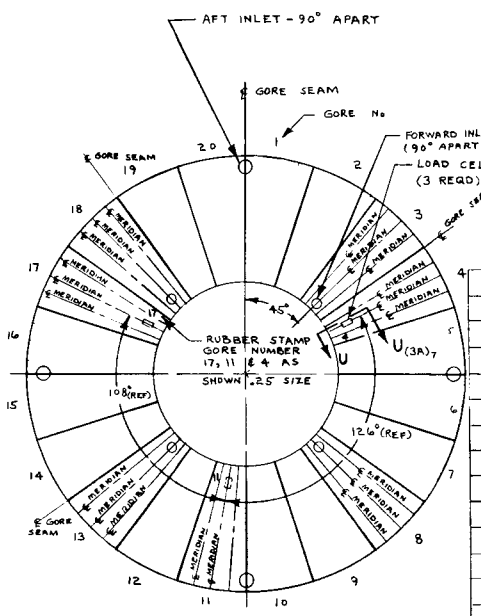
   MODEL I & II - $\overline{r}_r = .3666$, $\overline{r}_t = .0887$

   MODEL I ONLY - $\overline{r}_f = .4422$, $\overline{r}_c = .1069$

   MODEL I ONLY - $\overline{N}_B = .0936$, $\gamma = .1947$

		MODEL I	MODEL II
FORWARD RING	X/R	0.60	0.60
	Y/R	0.522	0.397
REAR RING	X/R	0.38	0.38
	Y/R	0.30	0.175

10. TOLERANCE FOR DIMENSION: 0 TO 2.0 INCH ±.04; 2.0 TO 10.0 INCH ±.06; 10.0 TO 30.0 INCH ±.19; 30.0 TO 60.0 ±.25; 60.0 INCH & UP ±1%
11. ALL 'X' DIMENSIONS ARE REFERENCED FROM X=0.00 ON GORES
12. NOMEX TUBULAR WEB, SIMULAR TO MIL-W-5625, 1/2 WIDE (1000 LBS TENSILE)
13. MATERIAL SAME AS [3] EXCEPT IN GREIGE GOODS



SCHEMATIC OF INLETS & LOAD CELL LOCATION
LOOKING INTO FORWARD END
NO SCALE

QTY REQD	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SIZE	ZONE	ITEM OR FIND NO.
1		3063000-110-103	RING ASSY			3B2
1		3063000-110-101	SPRING ASSY			2B2
3	3		LOAD CELL	GOVT FURN EQUIP CONTR INSTALLED		
1		-97	AFT INSIDE HALF INLET	[13]		3C2
4		-95	AFT OUTSIDE HALF INLET	[13]		2D2
1		-93	AFT INLET TIE CORD	[5]		7A7
1		-91	FORWARD INLET RELEASE CORD	[5]		5A2
1		-89	FORWARD OUTSIDE HALF INLET	[13]		3C2
1		-87	FORWARD INSIDE HALF INLET	[13]		5C2
4	4	-113 (DETAIL SH 2)	AFT INLET ASSY			2E2
1		-85	WEB	NOMEX WEB - NUMN1748 2.00 BEADED EDGE-2000LB		4A2
AS REQD		-83	CORD	DACRON CORD - NAT. SIMILAR TO MIL-C-17151 TYPE III - 8 FT. LG.		7C2
1		-79	WEB	[4]		4A2
60	60	-77	WEB SPACER AFT END	[4]		4G5
8		-75 (DETAIL SH 5)	PATCH	[3]		5B5
8		-73	OUTSIDE AFT INLET TIE CORD	[5] 15 IN. LG		5B5
4	4	-71	FORWARD TIE CORD	[5] 42.0 IN. LG		6E3
4		-69	AFT TIE CORD	[5] 30.0 IN. LG		3G3
	4	-67	AFT TIE CORD	[5] 30.0 IN LG		3G2
52	52	-65	WEB SPACER FORWARD END	NYLON WEB - NATURAL MIL-W-5038 TYPE III 1.0 WIDE		7E7
1	1	-63	ROPE - AFT END	3/16 DIA DACRON (SAMSON CORDAGE STABLE BRAID)		7E4
1		6454000-108-109	RING ASSY			

PARTS LIST

QTY REQD	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SIZE	ZONE	ITEM OR FIND NO.
4		-117	DECELERATOR ASSY	MODEL II (WITHOUT BURBLE FENCE)		SH 10
4		-115 (DETAIL SH 9)	AFT INLET REINF ASSY			5A7
AS REQD		SIZE B	THREAD	NYLON-NAT. V-T-295 TYPE I		
AS REQD		SIZE F	THREAD	NOMEX-NAT. SIMILAR TO V-T-295 TYPE I		
AS REQD		SIZE E	THREAD	NOMEX-NAT. SIMILAR TO V-T-295 TYPE I		
30		-61	PACKAGEING LOOPS	[4]		
4		-111 (DETAIL SH 9)	FORWARD INLET REINF ASSY			1E7
4		-109 (DETAIL SH 2)	FORWARD INLET ASSY			5A2
1	1	-59	BAND	[3]		6A8
1	1	-57	COLLAR	[3]		6A8
1		-55	FORWARD REINF	[3]		2A8
1		-53	AFT INSIDE HALF INLET	[13]		4D3
1		-51	AFT OUTSIDE HALF INLET	[13]		2D3
4		-49	FORWARD TIE DOWN CORD	[5] 3 FT LG		
4		-47	AFT TIE DOWN CORD	[5] 2 FT LG		
8		-45	LOOP	[4]		5H3 4H2
6		-43	LOAD CELL TIE DOWN WEB	[4]		2D7
1		-41	CLOTH TAPE	[3]		2D8
60	60	-39	MERIDIAN WEB	[4] [6]		3B5
1	1	-37	AFT CORD REINF	[5] 2 FT. LG.		5D8
1		-35	REINF	[3]		7B8
1		-33	COLLAR	[3]		4D8
16		-31	TAPE	[3]		4F7
1		-29	TAPE	[12]		3C2
1		-27	LOOP	[12]		2D2
2	2	-25	LOOP	[4]		3F2
8		-23	WEB	NYLON WEB - NAT MIL-W-5038 TYPE III 1.0 WIDE		2H7
1		-21	AFT STRIP-BIAS	[3]		7F4
1		-19	ROPE - FORWARD END	3/16 DIA DACRON (SAMSON CORDAGE STABLE BRAID)		8A4
1		-17 (DETAIL SH 4)	FORWARD REINF	[3]		6B4
2	2	-15	B/F STRIP-BIAS	[3]		3F4
1	1	-13	B/F STRIP-BIAS	[3]		3B4
1	1	-11	B/F STRIP-BIAS	[3]		4C4
10	10	-10 (DETAIL SH 7)	BURBLE FENCE PANEL (OPP)	[3]		2E4
10	10	-9 (DETAIL SH 7)	BURBLE FENCE PANEL (SHOWN)	[3]		2E4
40	40	-7 (DETAIL SH 6)	REINF	[3]		6D6
10	10	-6 (DETAIL SH 6)	GORE REINF (OPP)	[3]		5F6
10	10	-5 (DETAIL SH 6)	GORE REINF (SHOWN)	[3]		5F6
10		-4 (DETAIL SH 6)	GORE (OPP)	[3]		2F10
10		-3 (DETAIL SH 6)	GORE (SHOWN)	[3]		2F10
10	10	-2 (DETAIL SH 6)	GORE (OPP)	[3]		3C3
10	10	-1 (DETAIL SH 6)	GORE (SHOWN)	[3]		3C3
4		-107 (DETAIL SH 8)	AFT INLET REINF ASSY			4B5
4		-105 (DETAIL SH 3)	AFT INLET ASSY			3E3
		-103 [7]	DECELERATOR ASSY	MODEL I (WITH BURBLE FENCE)		SH 2
		-101 [7]	DECELERATOR ASSY	MODEL I (WITH BURBLE FENCE)		SH 3

-117 -115 -113 -111 -109 -107 -105 -103 -101

QTY REQD	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SIZE	ZONE	ITEM OR FIND NO.

PARTS LIST

DASH NO.	NEXT ASSY	USED ON
	3063000-001	3063

APPLICATION

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
			BY	
			ENGR	
			CUST	

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOLERANCES ON: DECIMALS X ±.1, XX ±.04, XXX ±.010 [10]; ANGLES ±1°
MATERIAL:
SEE GR60-9-60 FOR DRAWING INTERPRETATION STANDARDS.

CONTR
WTS
STRESS
ENGR JOHNSON 9/5/70
CHECK
DRAWN 9-21-70
GAC APPROVAL
CUSTOMER APPROVAL

GOODYEAR AEROSPACE CORP
AKRON, OHIO

DECELERATOR ASSY ATTACHED INFLATABLE

SIZE E | CODE IDENT NO. 25500 | DRAWING NO. 3063000-002
SCALE | SHEET 1 OF 10

3063000-002 SH 1

E-IN-80 12-68

Figure A-6. - Decelerator Assembly, Attached Inflatable Drawing 3063000-002, Sheet 1

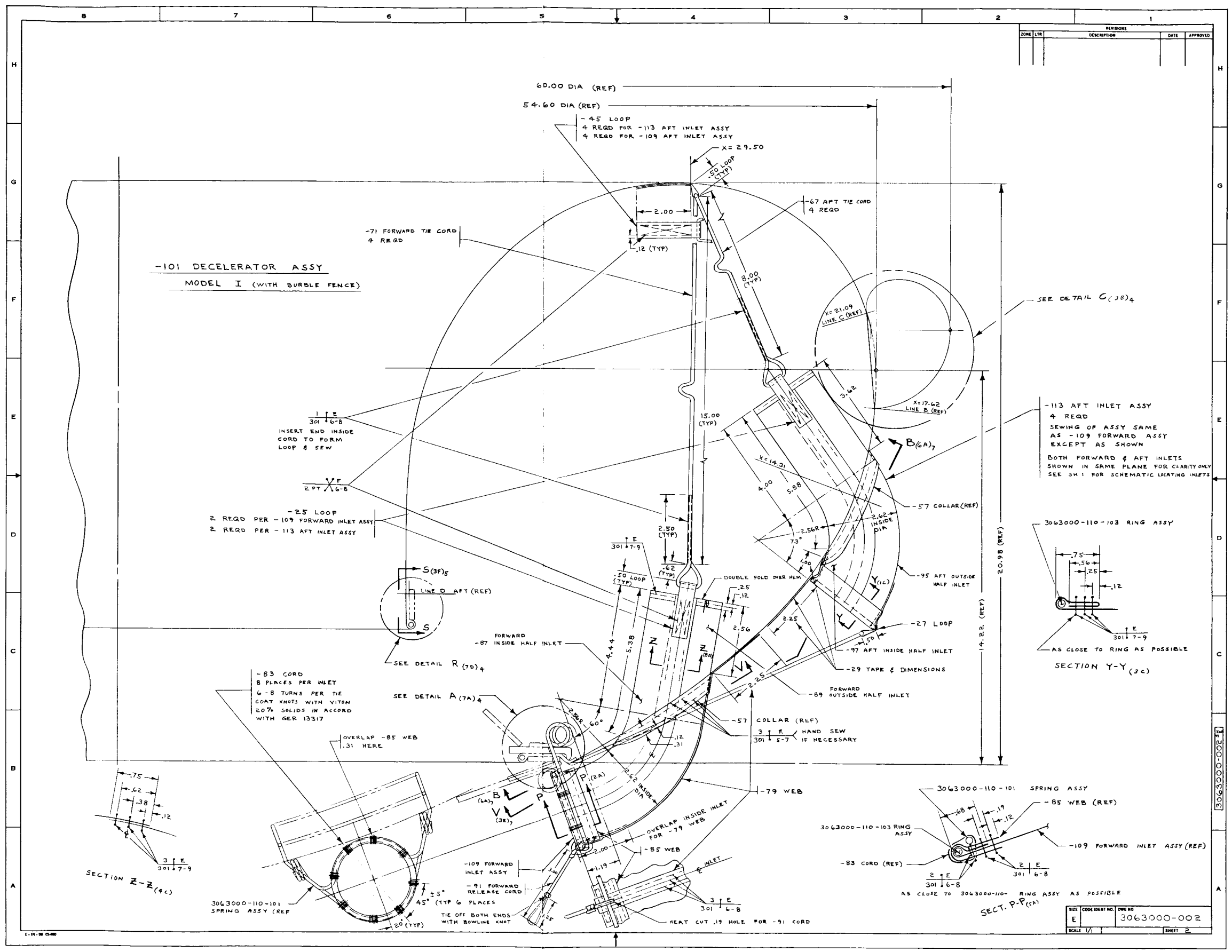


Figure A-7. - Decelerator Assembly, Attached Inflatable
Drawing 3063000-002, Sheet 2

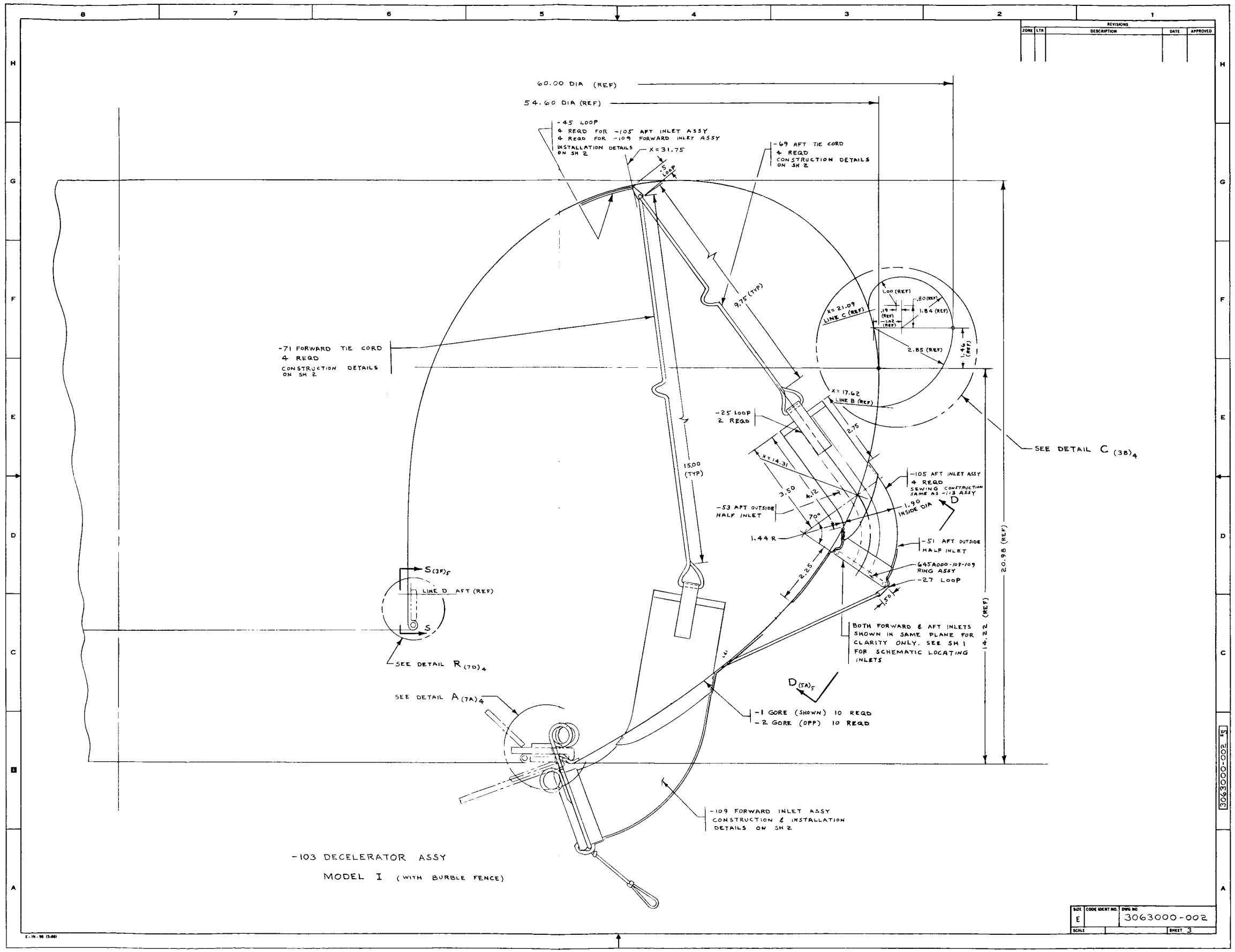


Figure A-8. - Decelerator Assembly, Attached Inflatable
Drawing 3063000-002, Sheet 3

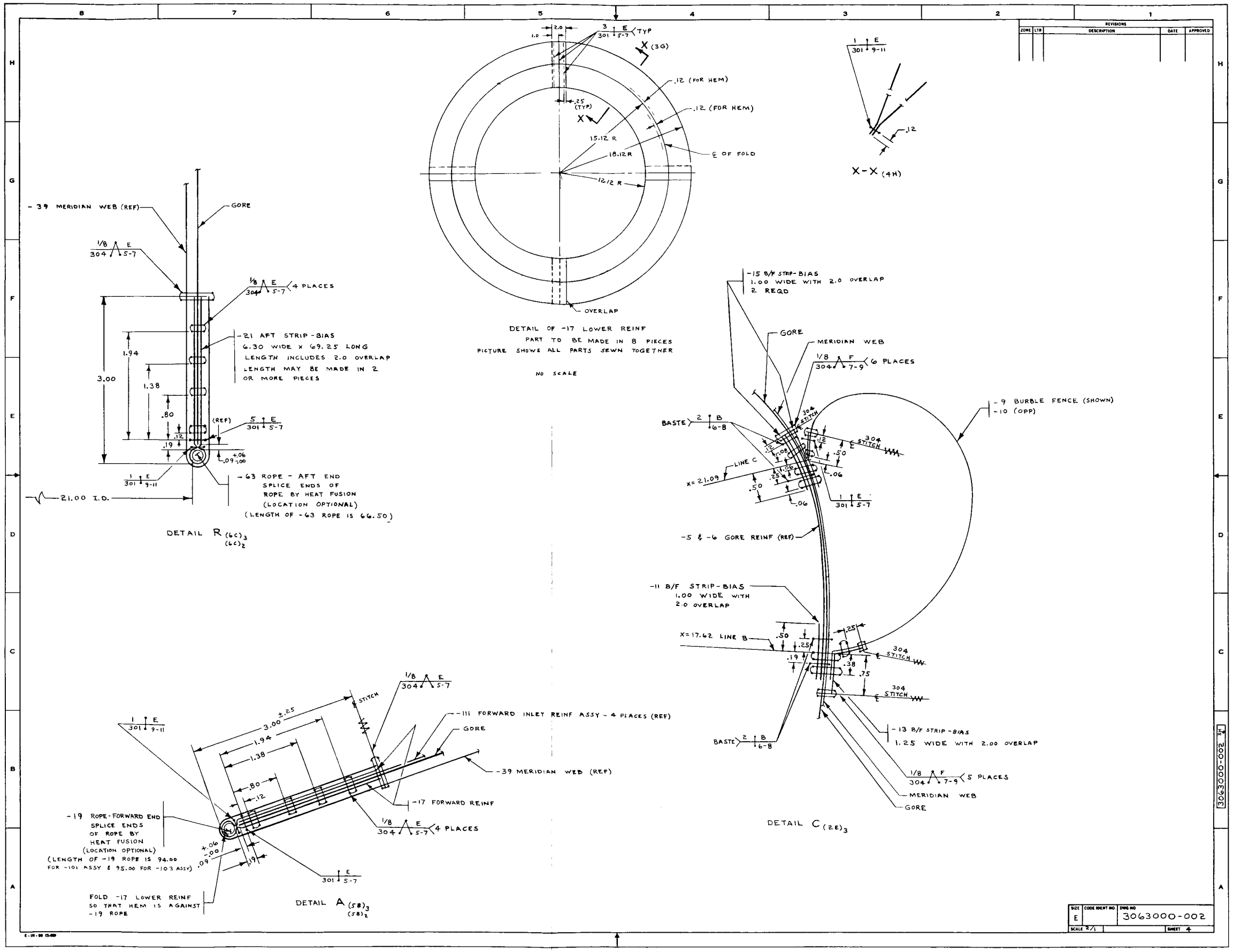


Figure A-9. - Decelerator Assembly, Attached Inflatable
Drawing 3063000-002, Sheet 4

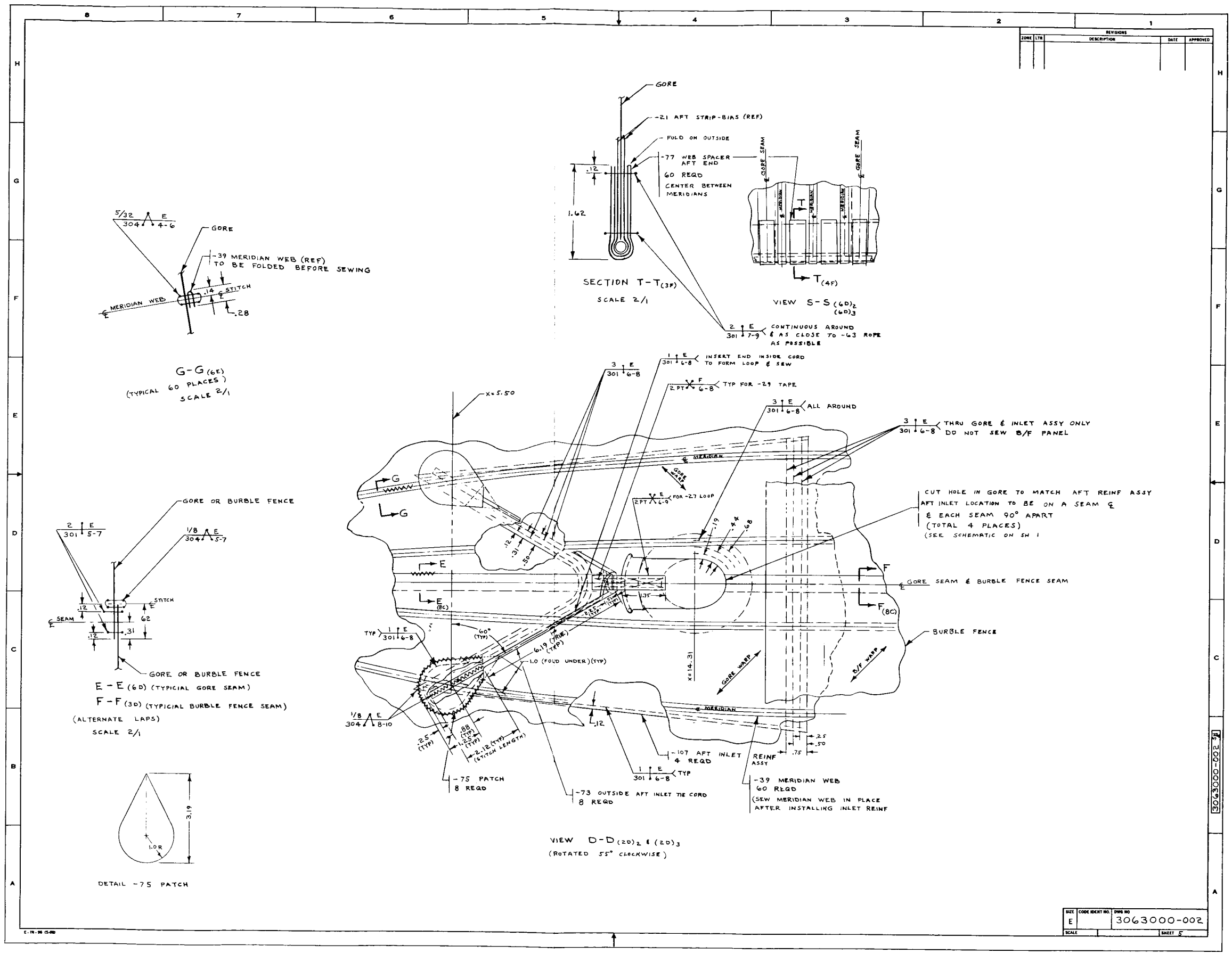


Figure A-10. - Decelerator Assembly, Attached Inflatable Drawing 3063000-002, Sheet 5

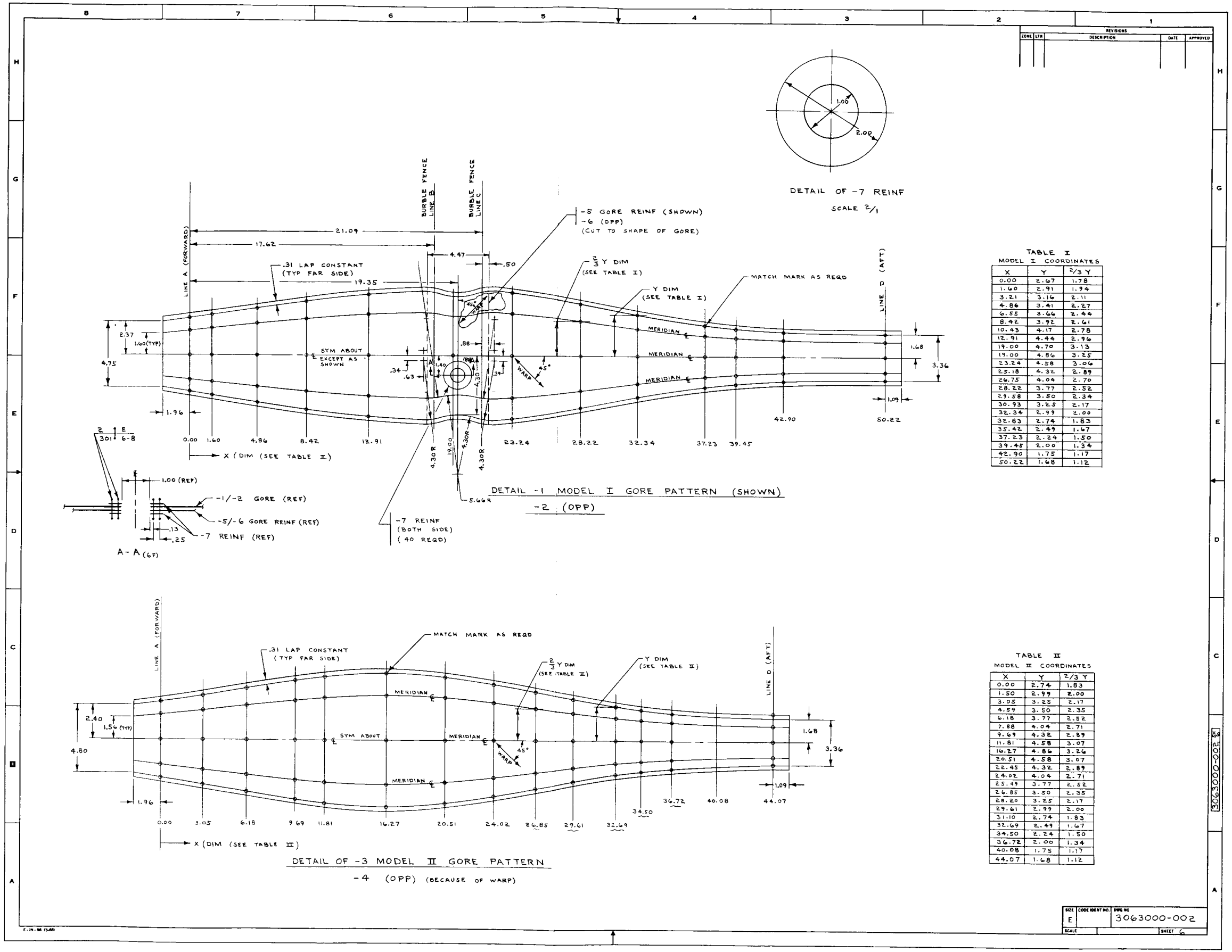


Figure A-11. - Decelerator Assembly, Attached Inflatable
Drawing 3063000-002, Sheet 6

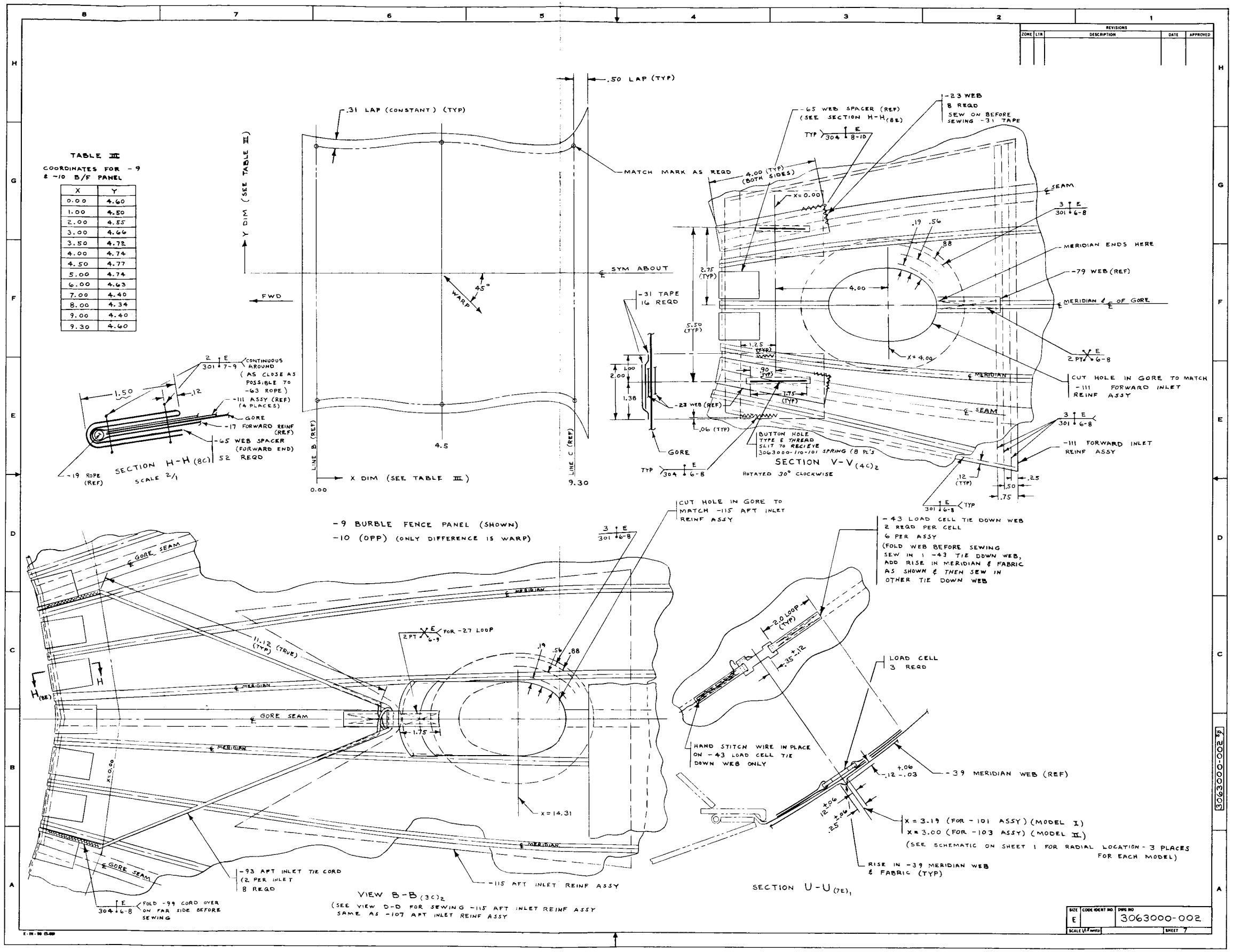


Figure A-12. - Decelerator Assembly, Attached Inflatable
Drawing 3063000-002, Sheet 7

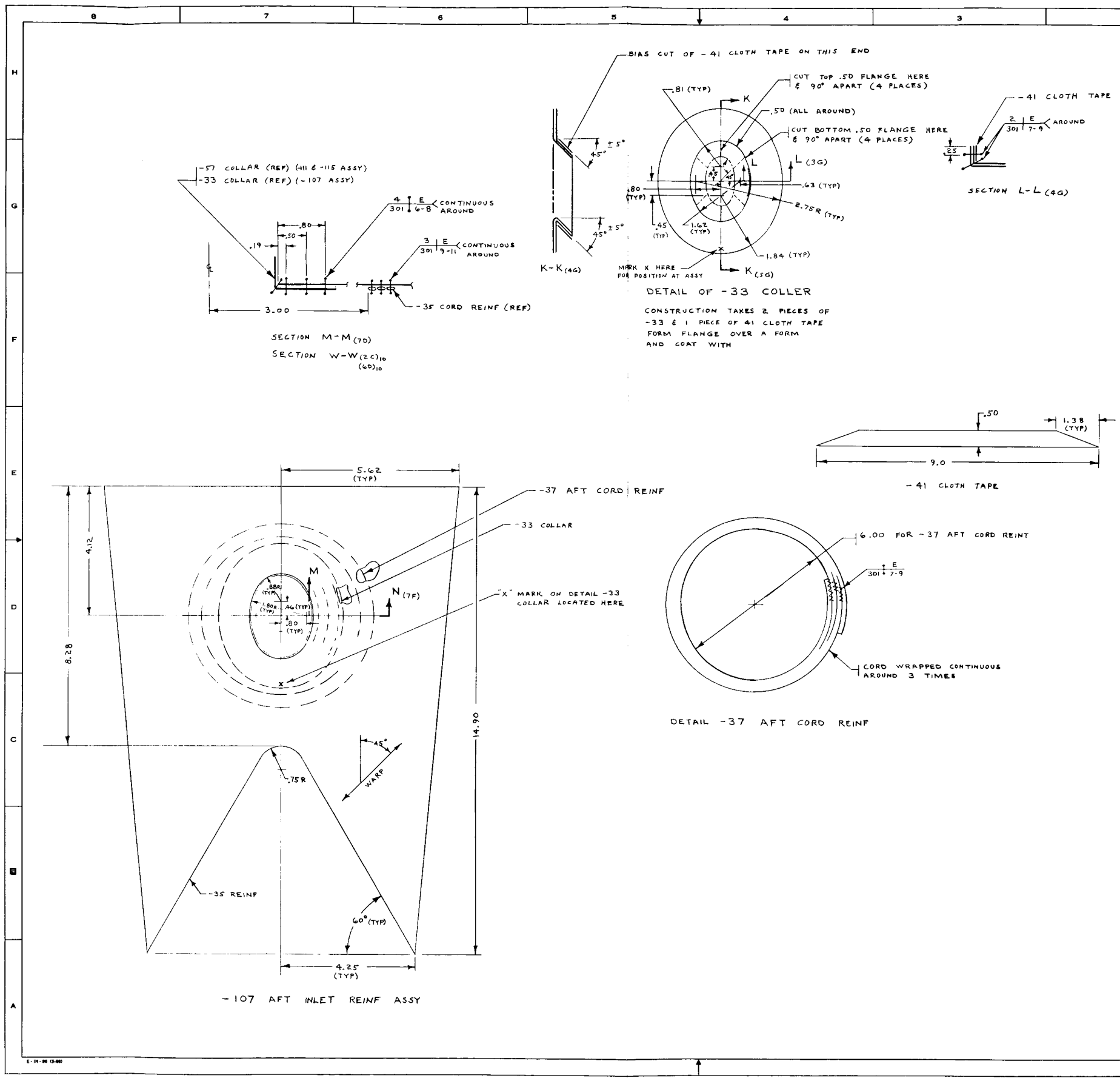


Figure A-13. - Decelerator Assembly, Attached Inflatable
Drawing 3063000-002, Sheet 8

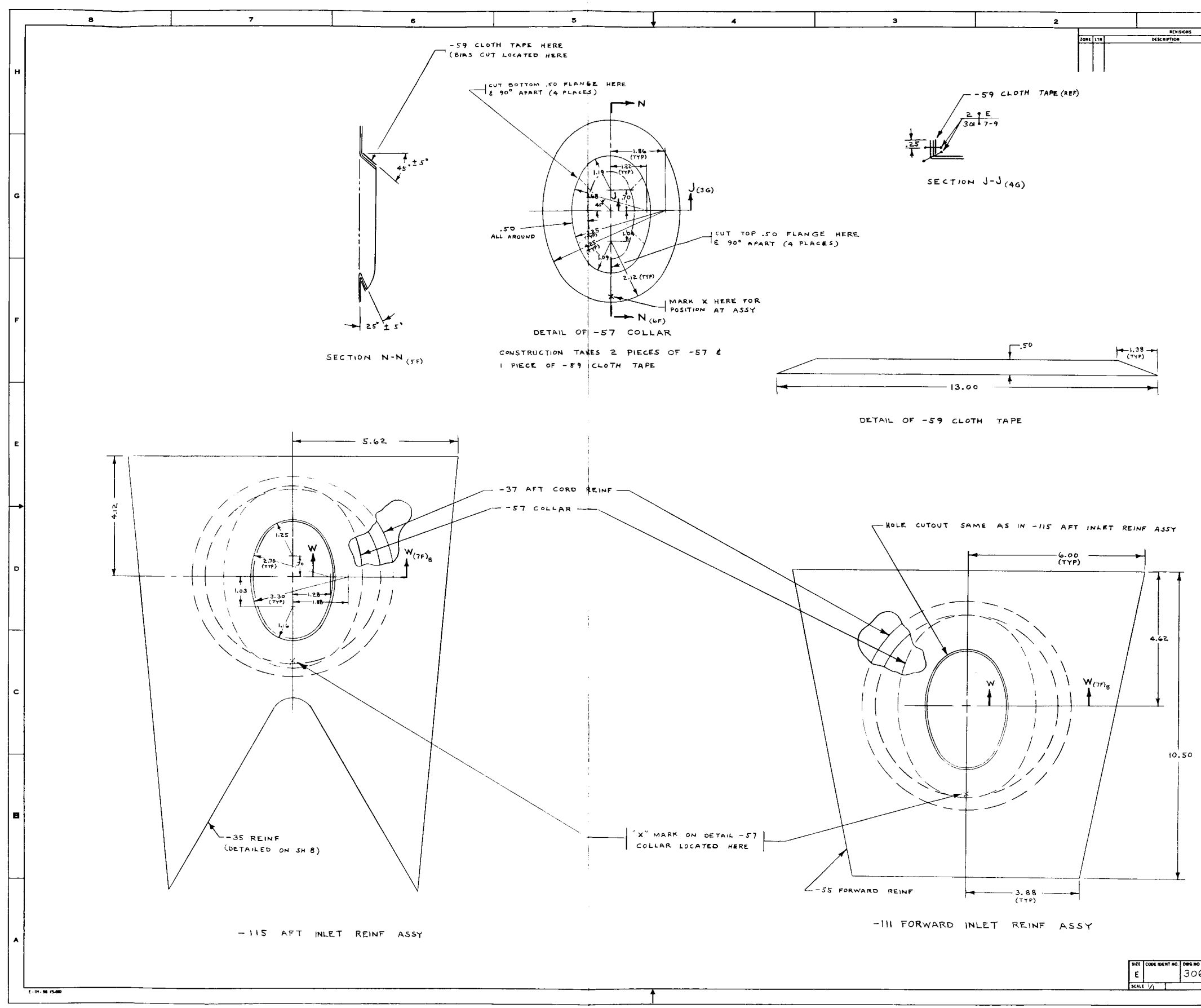


Figure A-14. - Decelerator Assembly, Attached Inflatable
Drawing 3063000-002, Sheet 9

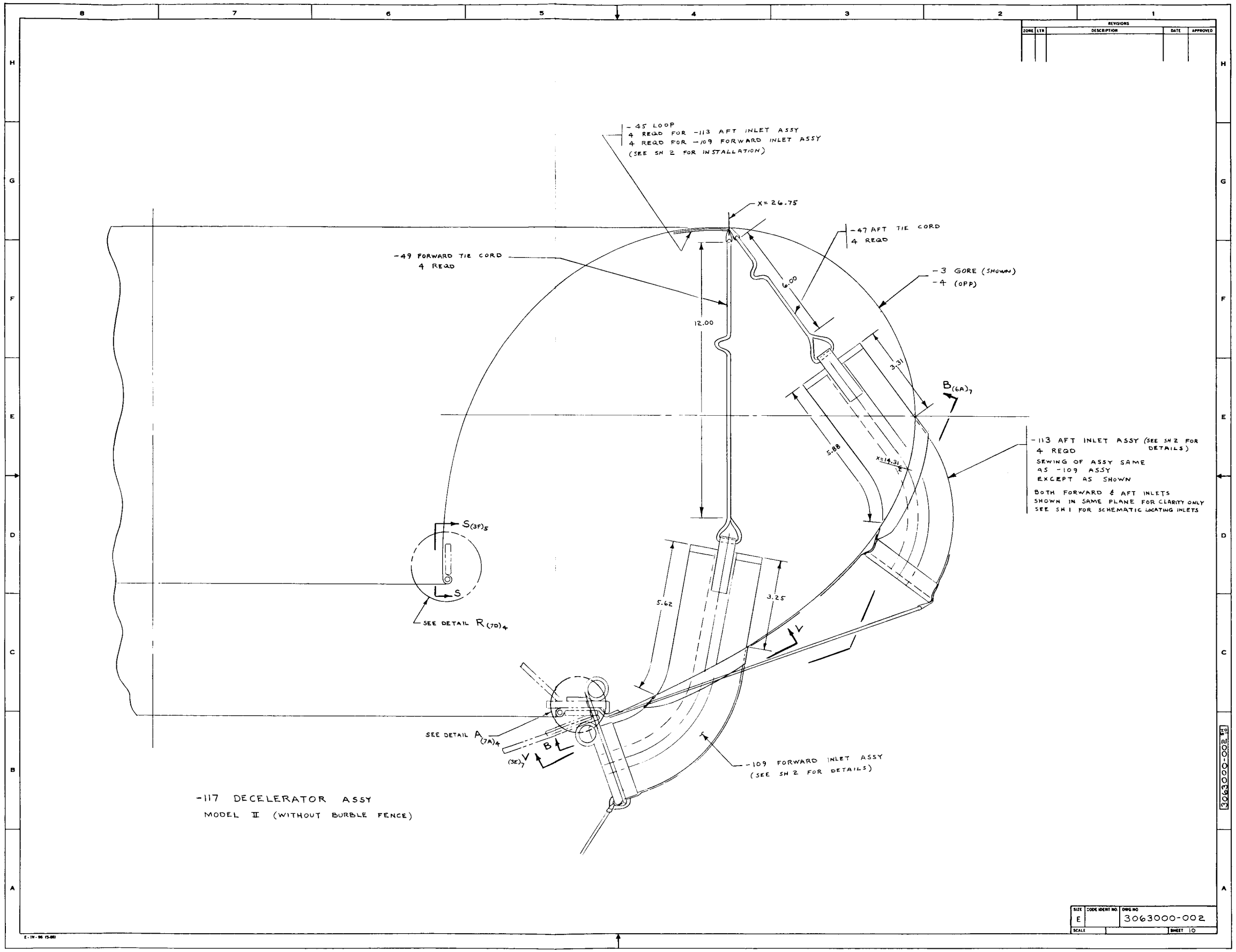


Figure A-15. - Decelerator Assembly, Attached Inflatable
Drawing 3063000-002, Sheet 10

Figure A-16. - Support Ring Assembly and Aeroshell, Attached Inflatable Decelerator System Drawing 3063000-003, Sheet 1

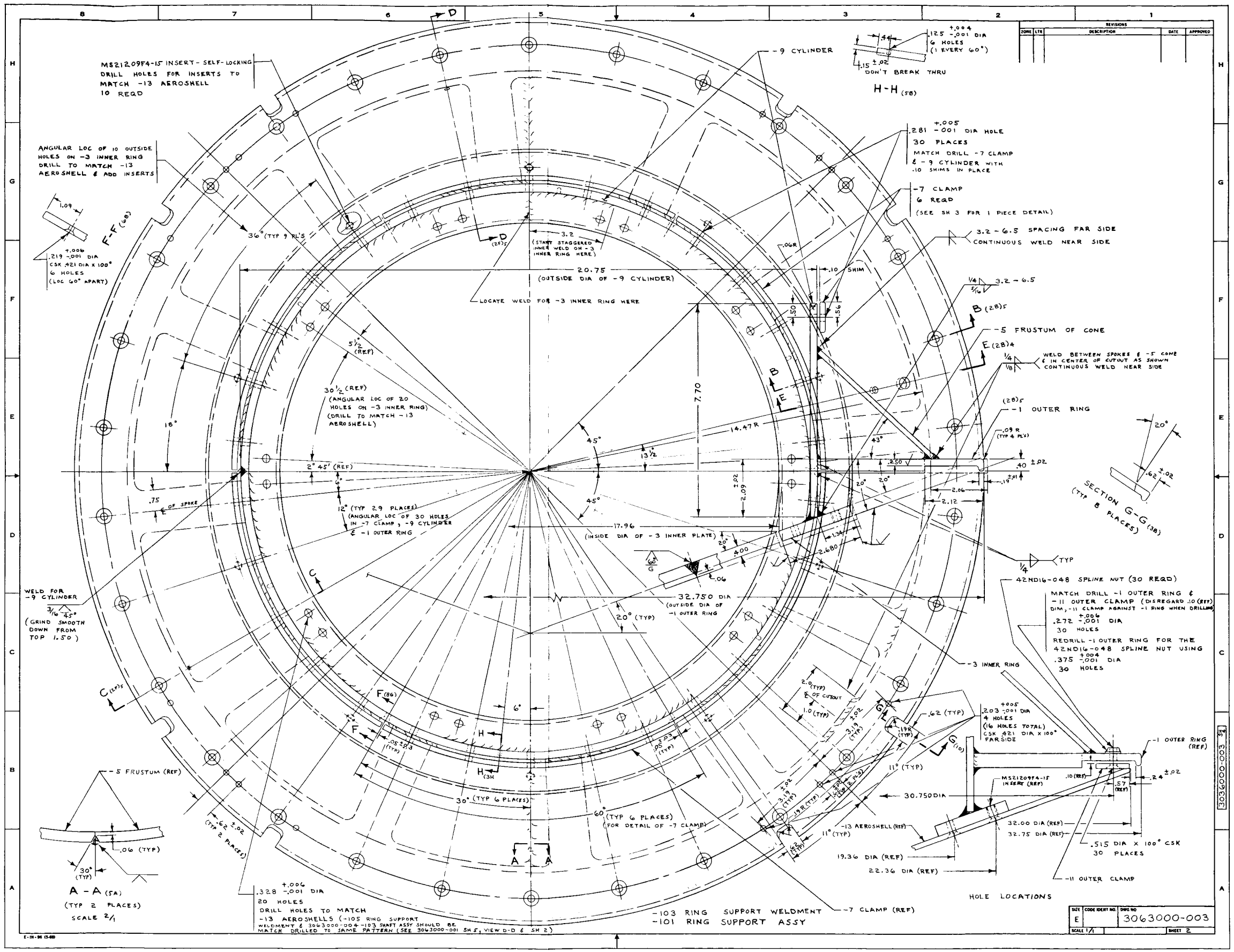


Figure A-17. - Support Ring Assembly and Aeroshell, Attached Inflatable Decelerator System Drawing 3063000-003, Sheet 2

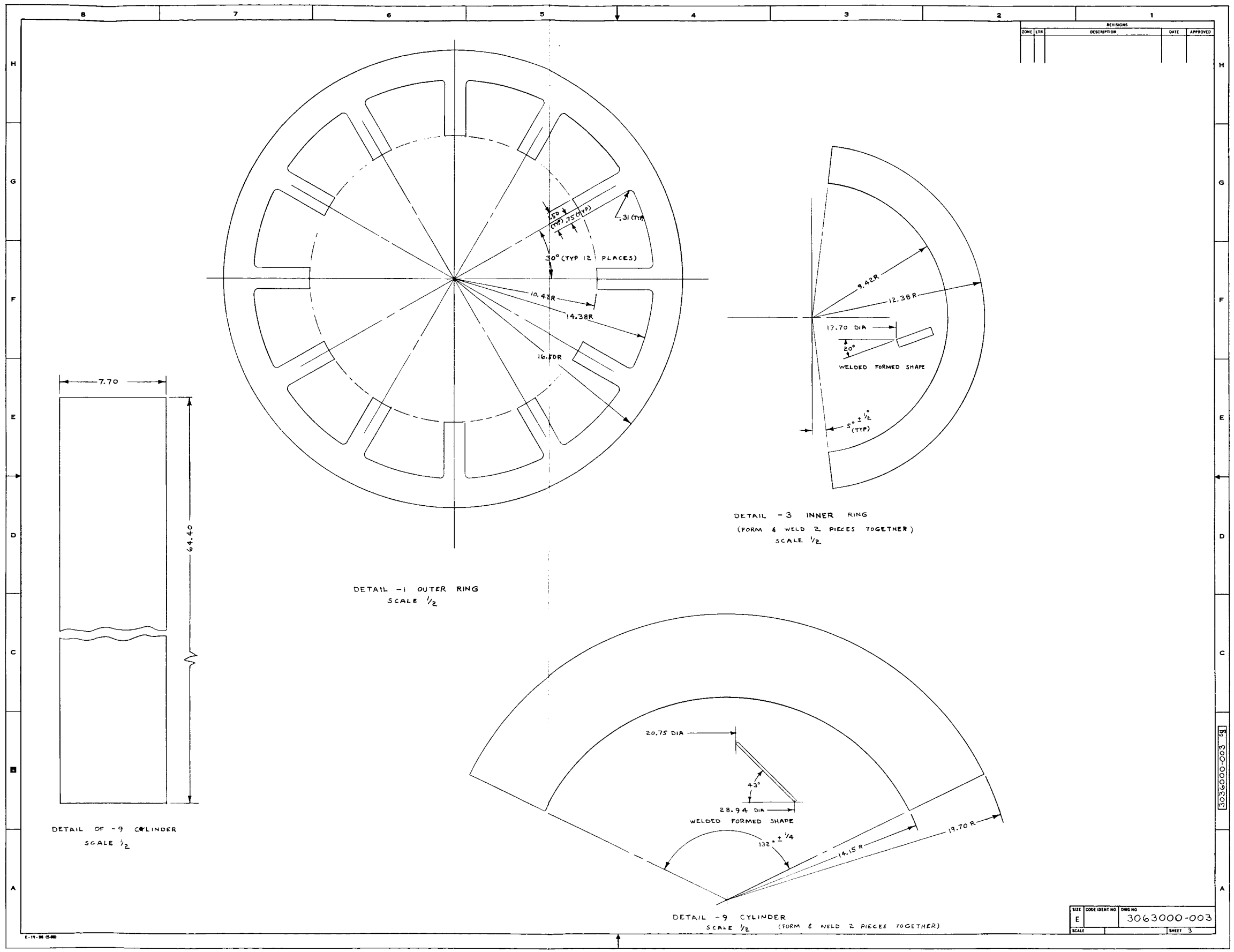
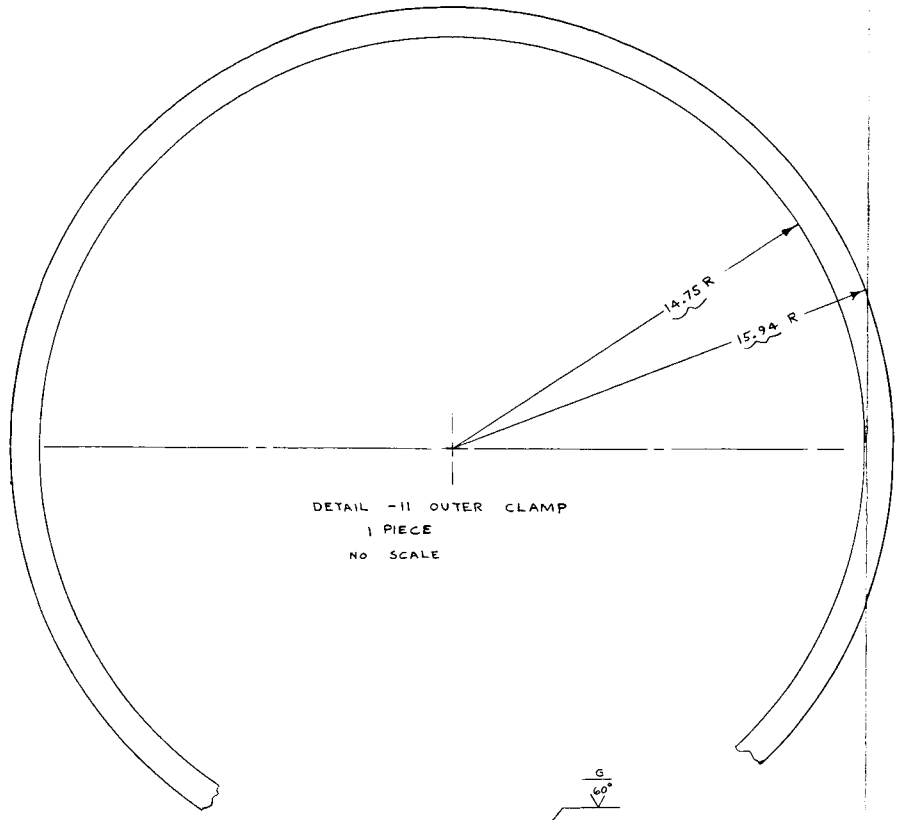
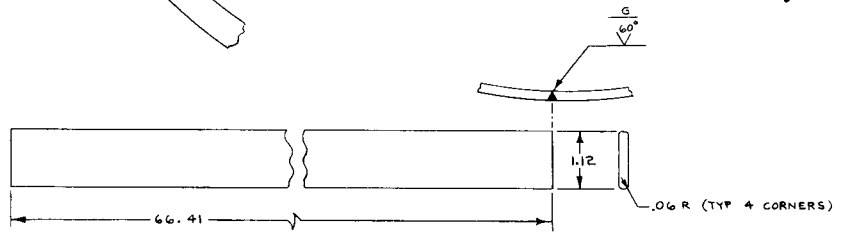


Figure A-18. - Support Ring Assembly and Aeroshell, Attached Inflatable Decelerator System Drawing 3063000-003, Sheet 3



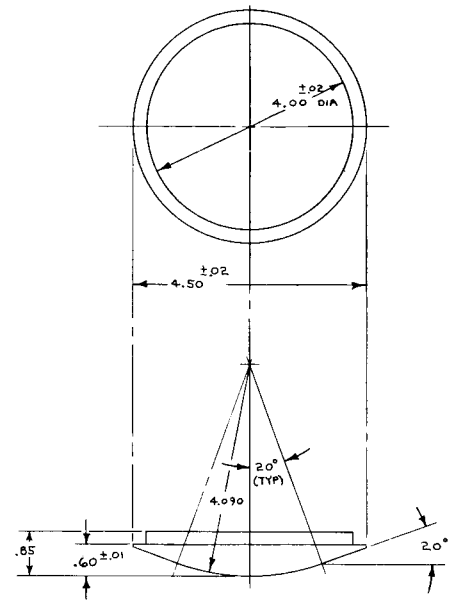
DETAIL -11 OUTER CLAMP
1 PIECE
NO SCALE



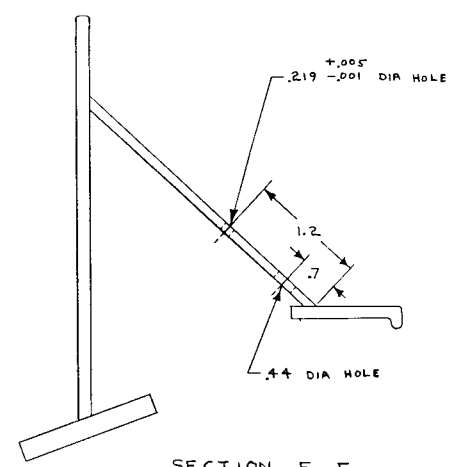
DETAIL -7 CLAMP

FORM INTO A DIAMETER & WELD AS SHOWN
AFTER ADDING HOLES AT ASSEMBLY, CUT
INTO 6 PIECES AS SHOWN AT ASSEMBLY
POSITION WELD AT A PARTING LINE BEFORE
ADDING HOLES

SCALE 1/1



DETAIL OF -17 SUPPORT



SECTION E-E (2F)2
ROTATED 13½° CLOCKWISE
SCALE 1/1

REVISIONS			
ZONE	LTR	DESCRIPTION	DATE	APPROVED

SIZE	CODE IDENT NO.	DWG NO
E		3063000-003
SCALE		SHEET 4

3036000-003-4

Figure A-19. - Support Ring Assembly and Aeroshell, Attached Inflatable Decelerator System Drawing 3063000-003, Sheet 4

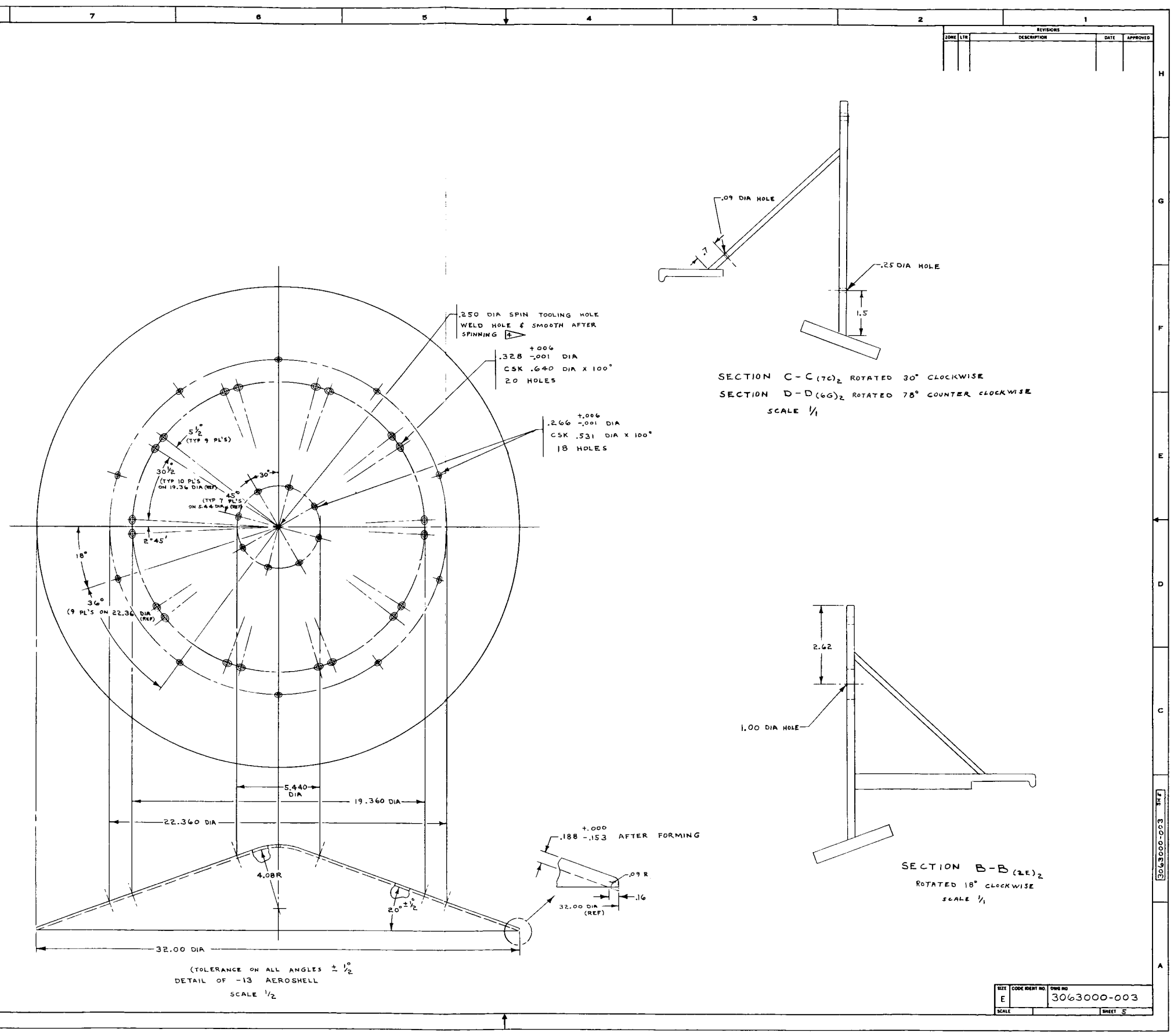


Figure A-20. - Support Ring Assembly and Aeroshell, Attached Inflatable Decelerator System Drawing 3063000-003, Sheet 5

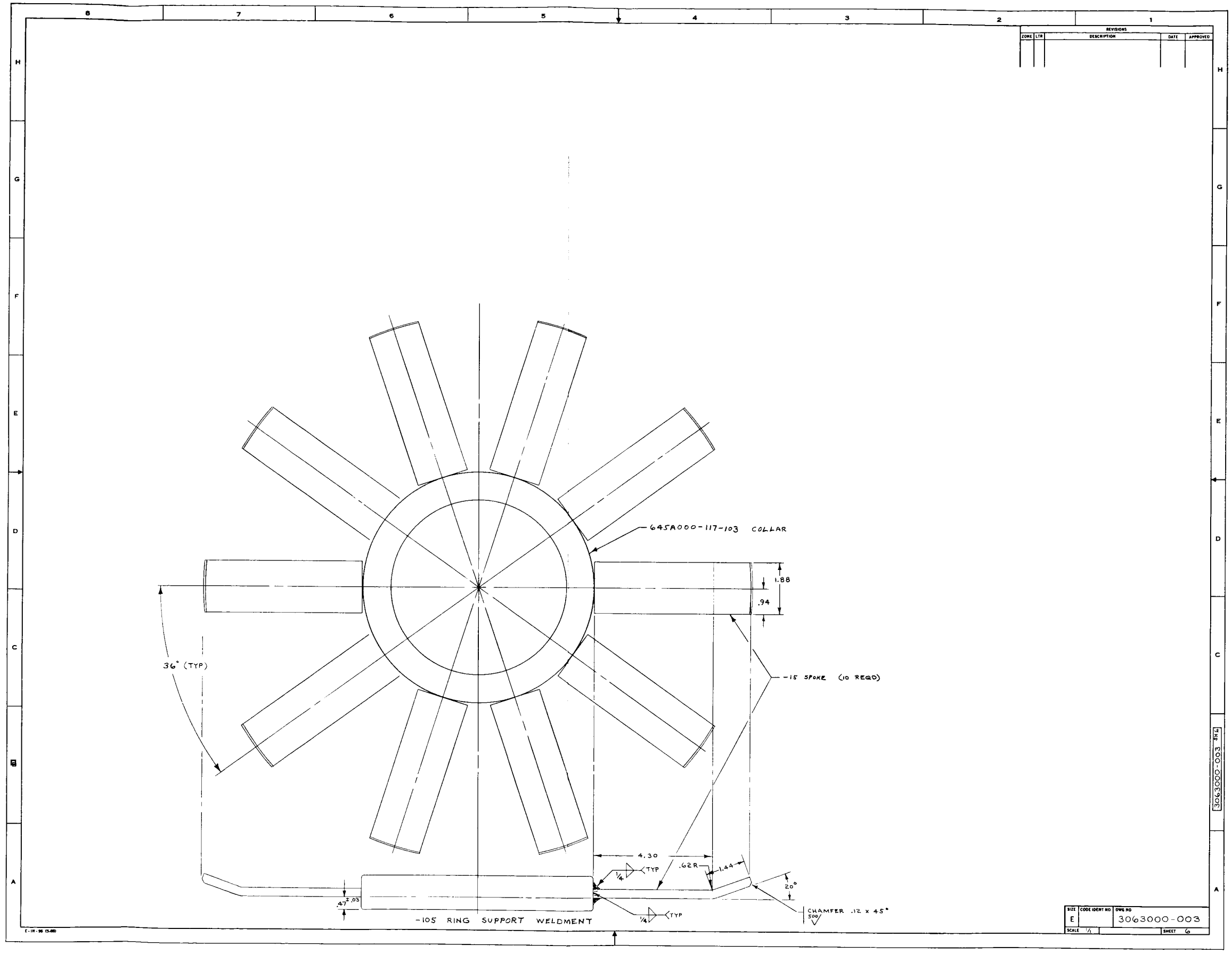
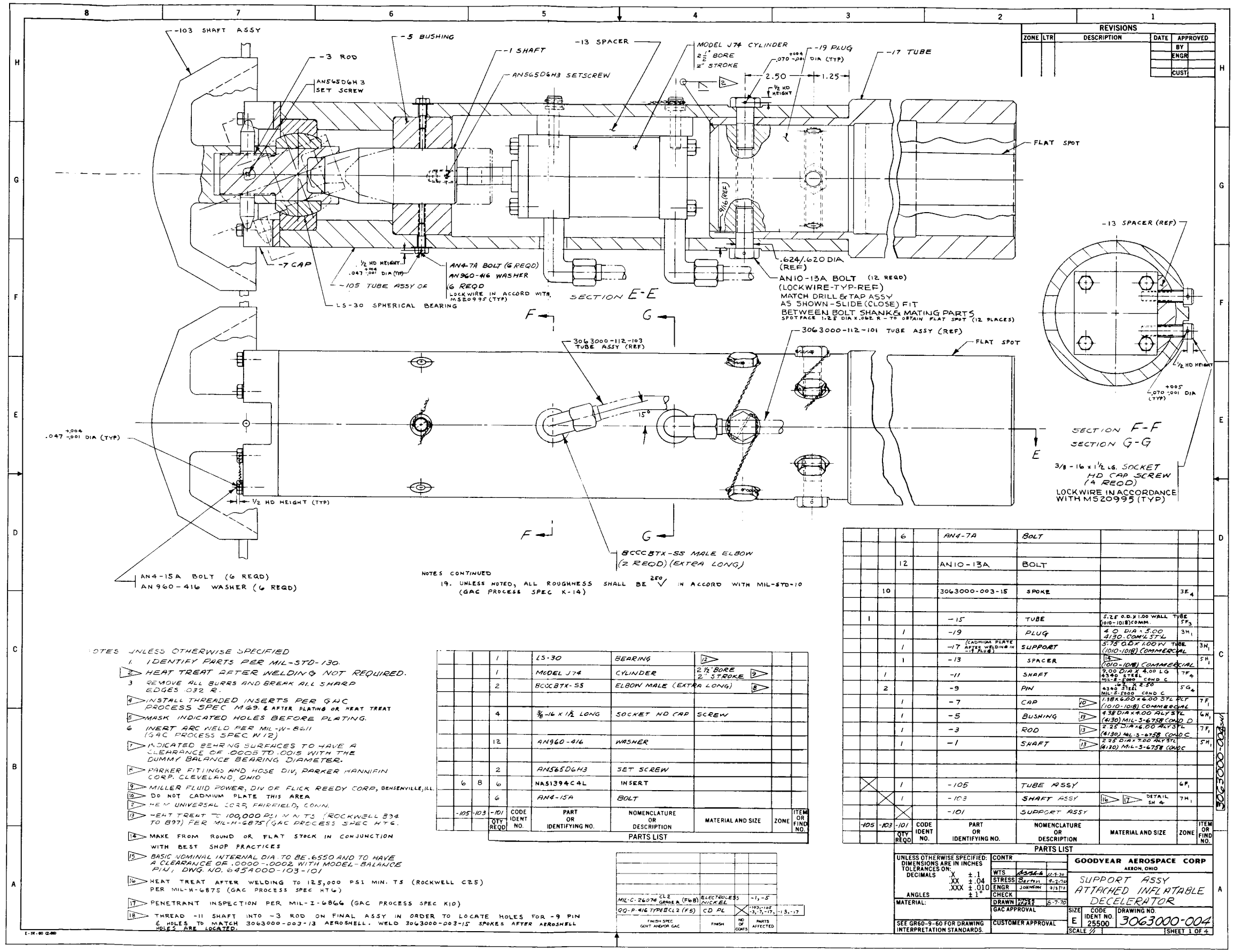


Figure A-21. - Support Ring Assembly and Aeroshell, Attached Inflatable Decelerator System Drawing 3063000-003, Sheet 6



NOTES CONTINUED

19. UNLESS NOTED, ALL ROUGHNESS SHALL BE 250 √ IN ACCORD WITH MIL-STD-10 (GAC PROCESS SPEC K-14)

NOTES UNLESS OTHERWISE SPECIFIED

1. IDENTIFY PARTS PER MIL-STD-130.
2. HEAT TREAT AFTER WELDING NOT REQUIRED.
3. REMOVE ALL BURRS AND BREAK ALL SHARP EDGES .032 R.
4. INSTALL THREADED INSERTS PER GAC PROCESS SPEC M69. & AFTER PLATING OR HEAT TREAT
5. MASK INDICATED HOLES BEFORE PLATING.
6. INERT ARC WELD PER MIL-W-8611 (GAC PROCESS SPEC N12)
7. INDICATED BEARING SURFACES TO HAVE A CLEARANCE OF .0005 TO .0015 WITH THE DUMMY BALANCE BEARING DIAMETER.
8. PARKER FITTINGS AND HOSE DIV, PARKER HANNIFIN CORP. CLEVELAND, OHIO
9. MILLER FLUID POWER, DIV OF FLICK REEDY CORP, BENSENVILLE, ILL.
10. DO NOT CADMIUM PLATE THIS AREA
11. H.M. UNIVERSAL CORP, FAIRFIELD, CONN.
12. HEAT TREAT TO 100,000 PSI MIN. T.S. (ROCKWELL 33½ TO 39½) PER MIL-H-6875 (GAC PROCESS SPEC HT6.
14. MAKE FROM ROUND OR FLAT STOCK IN CONJUNCTION WITH BEST SHOP PRACTICES
15. BASIC NOMINAL INTERNAL DIA TO BE .6550 AND TO HAVE A CLEARANCE OF .0000 - .0002 WITH MODEL-BALANCE PIN, DWG. NO. 6454000-103-101
16. HEAT TREAT AFTER WELDING TO 125,000 PSI MIN. TS (ROCKWELL C25) PER MIL-H-6875 (GAC PROCESS SPEC HT6)
17. PENETRANT INSPECTION PER MIL-I-6866 (GAC PROCESS SPEC K10)
18. THREAD -11 SHAFT INTO -3 ROD ON FINAL ASSY IN ORDER TO LOCATE HOLES FOR -9 PIN & HOLES TO MATCH 3063000-003-13 AEROSHELL. WELD 3063000-003-15 SPOKES AFTER AEROSHELL HOLES ARE LOCATED.

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
			BY	
			ENGR	
			CUST	

			6	AN4-7A	BOLT			D
			12	AN10-13A	BOLT			
		10		3063000-003-15	SPOKE		3E4	
	1			-15	TUBE	5.25 O.D. x 1.00 WALL TUBE (1010-1018) COMM.	5F3	
		1		-19	PLUG	4.0 DIA x 2.00 4130 .10 CRES. STL	3H1	
		1		-17 (CADMIUM PLATE AFTER WELDING IN -1, -3 SUB.)	SUPPORT	5.75 OD x 1.00 W TUBE (1010-1018) COMMERCIAL	3H1	C
		1		-13	SPACER	16 (1010-1018) COMMERCIAL	5H1	
	1			-11	SHAFT	9.00 O.D. x 4.00 LG 4340 STEEL MIL-S-5000 COND C	7F4	
		2		-9	PIN	4340 STEEL MIL-S-5000 COND C	5G4	
		1		-7	CAP	20 1.38 x 6.00 x 6.00 STL HCT (1010-1018) COMMERCIAL	7F1	
		1		-5	BUSHING	18 (4130) MIL-S-6758 COND D	6H1	
		1		-3	ROD	13 2.25 DIA x 6.00 ALY STL (4130) MIL-S-6758 COND C	7F1	
		1		-1	SHAFT	13 2.25 DIA x 7.20 ALY STL (4130) MIL-S-6758 COND C	5H1	
	X	1		-105	TUBE ASSY		6F1	
	X	1		-103	SHAFT ASSY	16 17 DETAIL SH 4	7H1	
	X			-101	SUPPORT ASSY			
-105	-103	-101	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SIZE	ZONE	ITEM OR FIND NO.
		QTY REQD						

PARTS LIST

			1	LS-30	BEARING	12		
			1	MODEL J74	CYLINDER	2½" BORE 2" STROKE 9		
			2	BCCCBTX-SS	ELBOW MALE (EXTRA LONG)	8		
			4	⅜-16 x 1½ LONG	SOCKET HD CAP	SCREW		
			12	AN960-416	WASHER			
			2	AN565D6H3	SET SCREW			
	6	8	6	NAS1394C4L	INSERT			
			6	AN4-15A	BOLT			
-105	-103	-101	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SIZE	ZONE	ITEM OR FIND NO.
		QTY REQD						

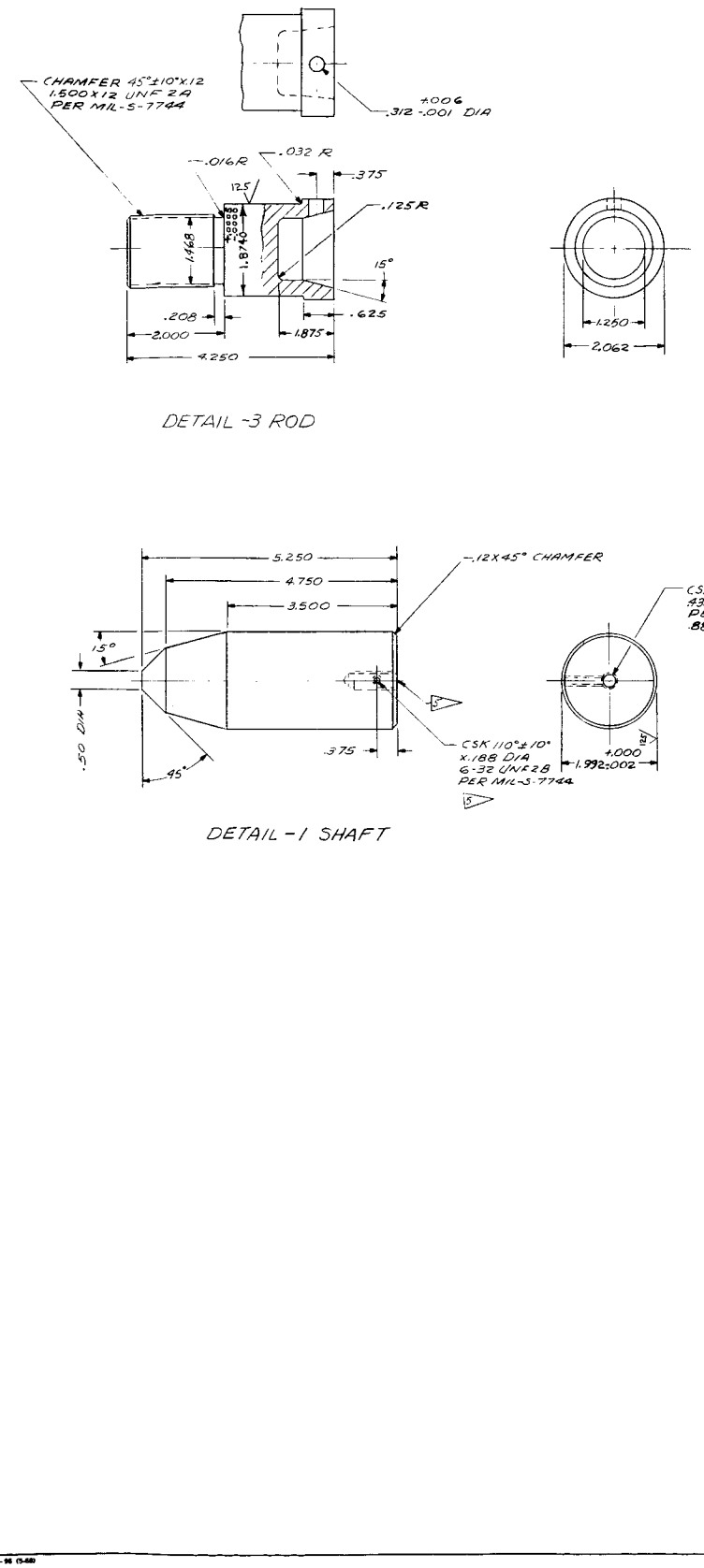
PARTS LIST

MIL-C-26074 CL2 GRADE A (FLB)	ELECTROLESS NICKEL	-1, -5	
QQ-P-416 TYPE II CL 2 (FS)	CD PL	-103 USE -3, -7, -13, -17	
FINISH SPEC GOVT AND/OR GAC	FINISH	NO OF COATS	PARTS AFFECTED

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES ON: DECIMALS .X ±.1, .XX ±.04, .XXX ±.010; ANGLES ±1°	CONTR		GOODYEAR AEROSPACE CORP AKRON, OHIO
	WTS	APPD 9-5-70	SUPPORT ASSY ATTACHED INFLATABLE DECELERATOR
	STRESS	Barton 9-2-70	
	ENGR	JOHNSON 9/3/70	
	CHECK		
MATERIAL:	DRAWN	WEBB 8-7-70	
	GAC APPROVAL		SIZE E; CODE IDENT NO. 25500; DRAWING NO. 3063000-004
SEE GR60-9-60 FOR DRAWING INTERPRETATION STANDARDS.	CUSTOMER APPROVAL		SCALE ½; SHEET 1 OF 4

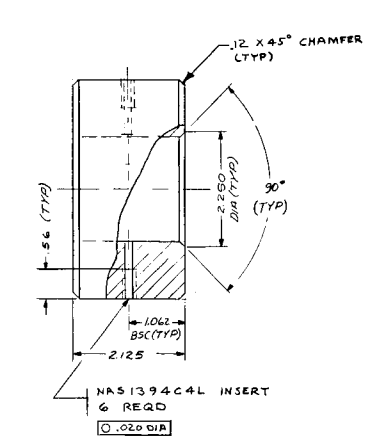
3063000-003-NC

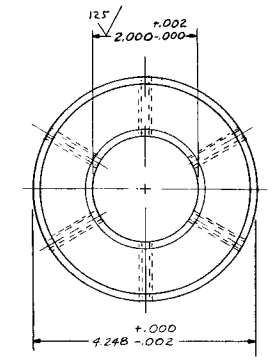
Figure 22. - Support Assembly, Attached Inflatable Decelerator Drawing 3063000-004, Sheet 1



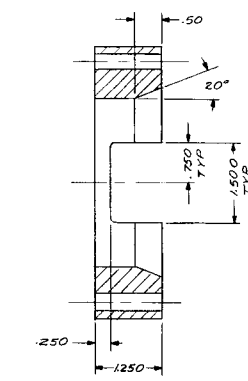
DETAIL -3 ROD

DETAIL -1 SHAFT

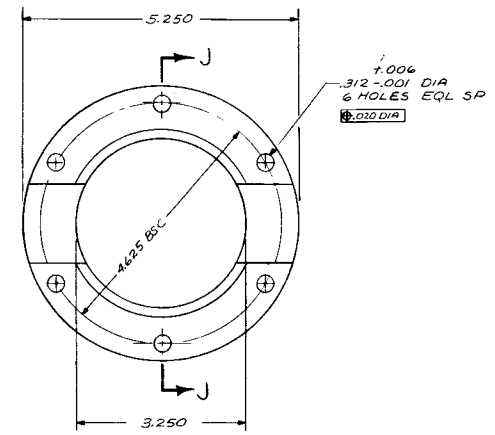




DETAIL OF -5 BUSHING



J-J



DETAIL OF -7 CAP

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

SIZE	CODE IDENT NO.	DWG NO
E	25500	3063000-004
SCALE 1/2		SHEET 2

3063000-004

Figure 23. - Support Assembly, Attached Inflatable Decelerator Drawing 3063000-004, Sheet 2

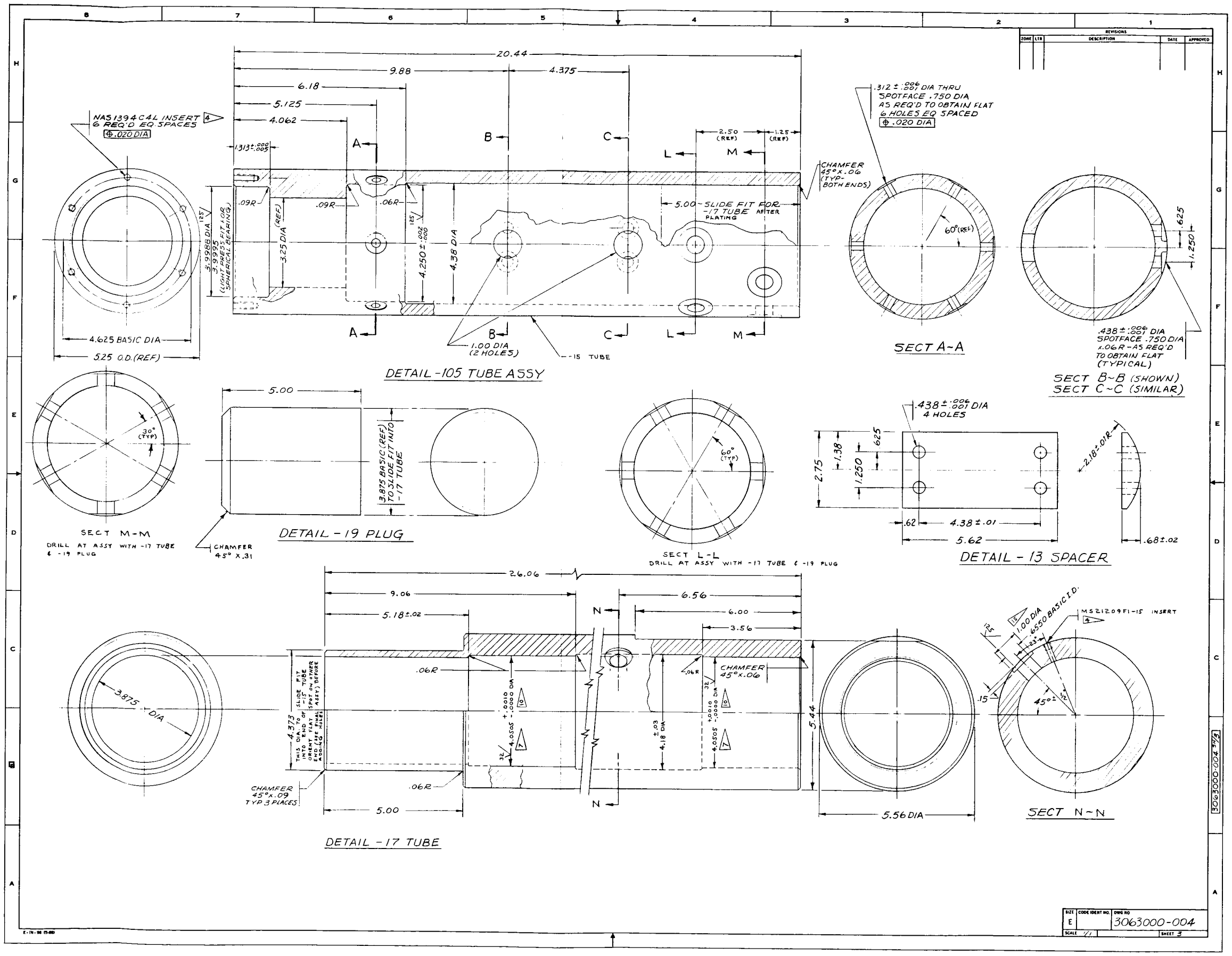


Figure 24. - Support Assembly, Attached Inflatable Decelerator Drawing 3063000-004, Sheet 3

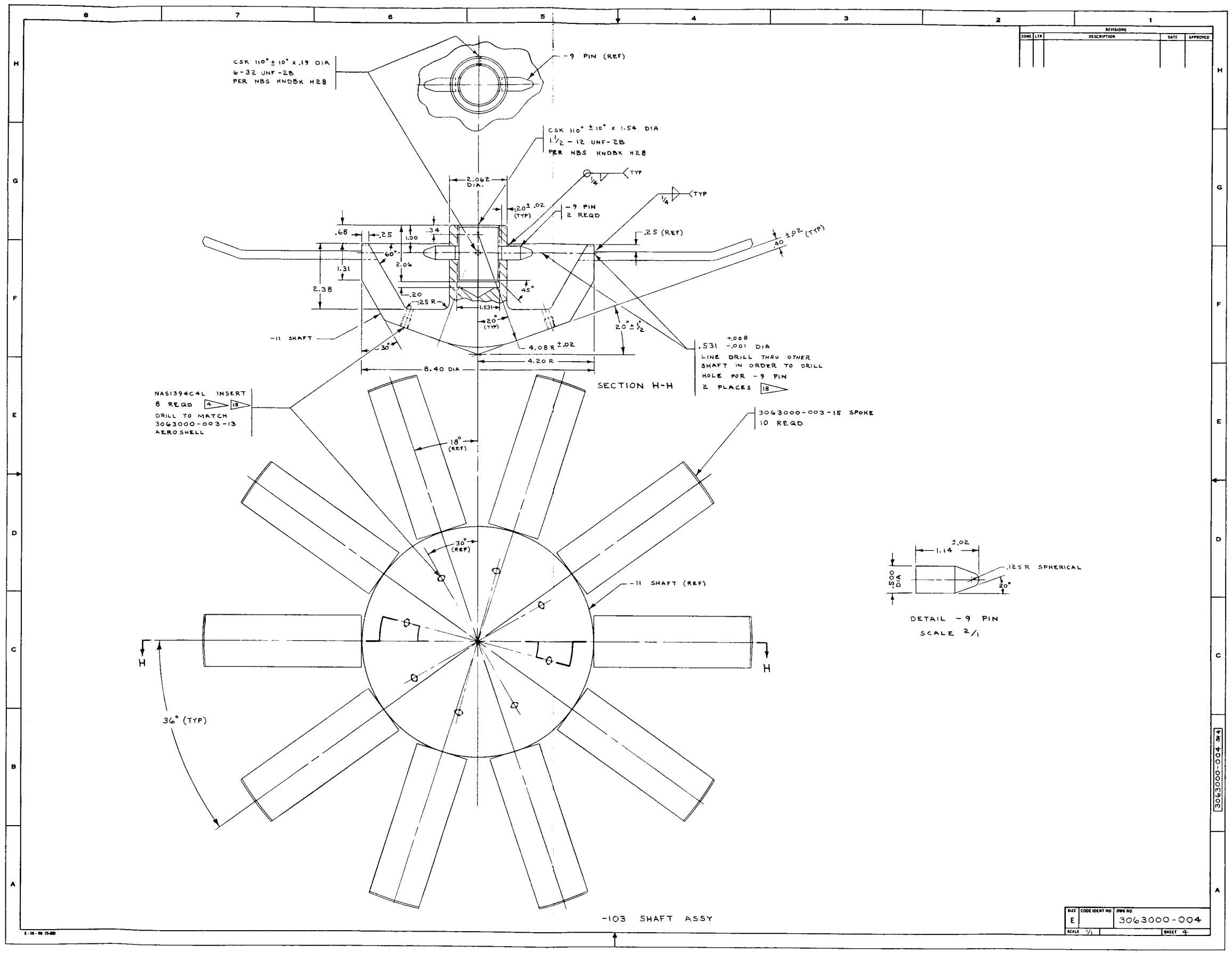


Figure A-25. - Support Assembly, Attached Inflatable Decelerator Drawing 3063000-004, Sheet 4

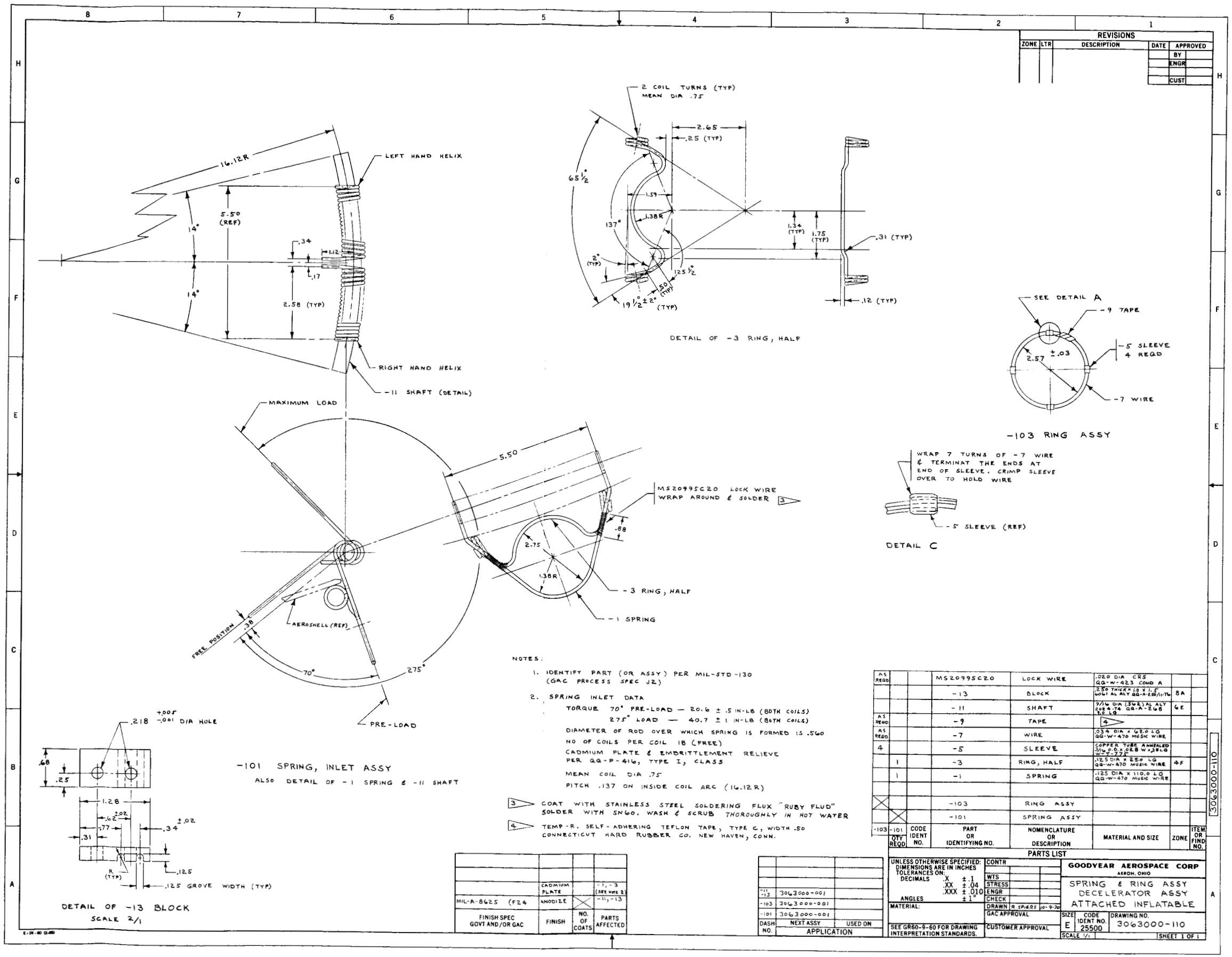
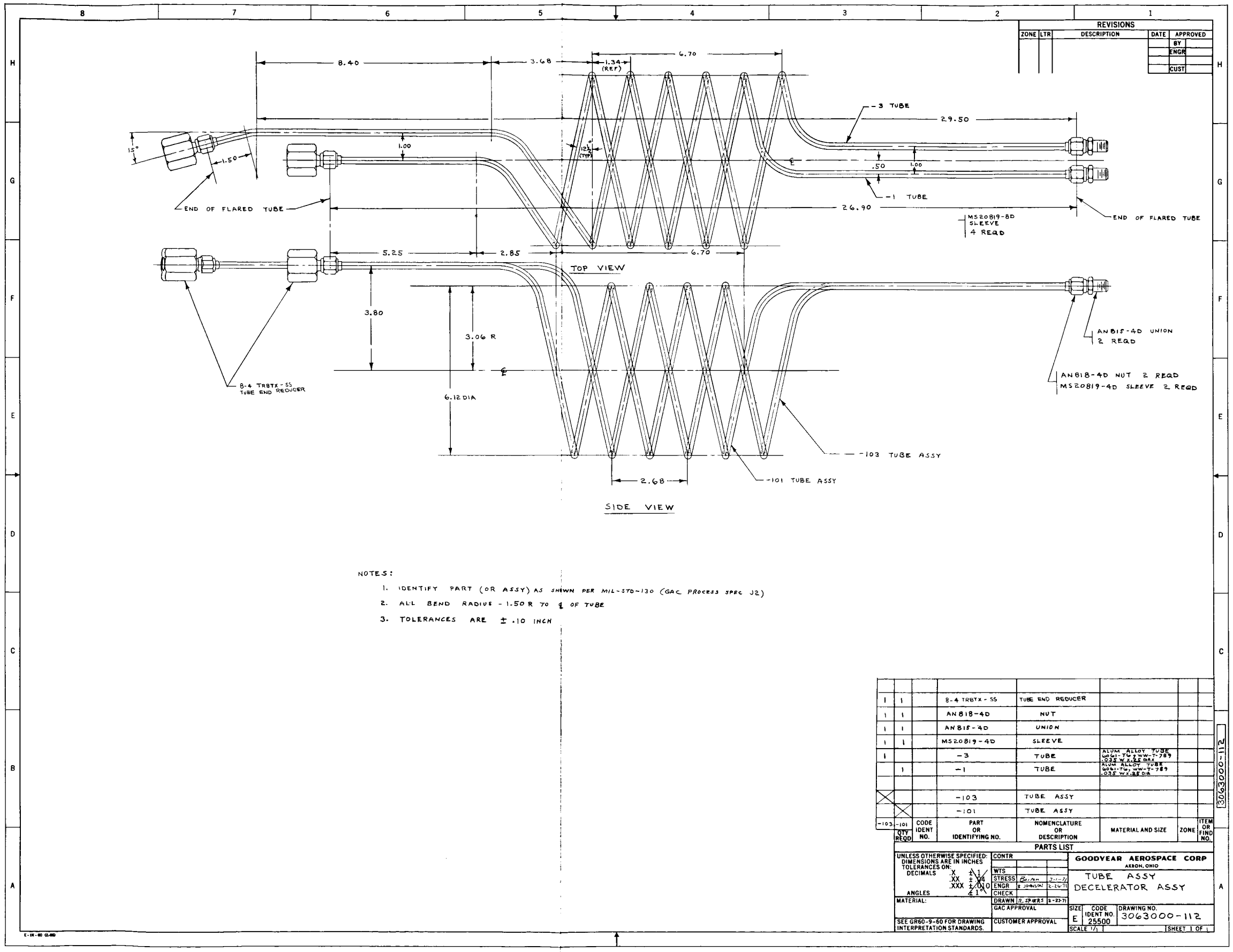


Figure 26. - Spring and Ring Assembly, Decelerator Assembly, Attached Inflatable Drawing 3063000-110, Sheet 1



NOTES:

1. IDENTIFY PART (OR ASSY) AS SHOWN PER MIL-STD-130 (GAC PROCESS SPEC J2)
2. ALL BEND RADIUS - 1.50 R TO ℄ OF TUBE
3. TOLERANCES ARE ± .10 INCH

-103	-101	QTY REQD	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SIZE	ZONE	ITEM OR FIND NO.
1	1			8-4 TRBTX-SS	TUBE END REDUCER			
1	1			AN818-4D	NUT			
1	1			AN815-4D	UNION			
1	1			MS20819-4D	SLEEVE			
1				-3	TUBE	ALUM ALLOY TUBE 6061-T6 per WW-T-789 .035 W x .25 DIA		1
	1			-1	TUBE	ALUM ALLOY TUBE 6061-T6, per WW-T-789 .035 W x .25 DIA		
X				-103	TUBE ASSY			
	X			-101	TUBE ASSY			

PARTS LIST

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOLERANCES ON: DECIMALS .X ±1/16, .XX ±.04, .XXX ±.010
ANGLES ±1°
MATERIAL:
SEE GR60-9-60 FOR DRAWING INTERPRETATION STANDARDS.

CONTR
WTS
STRESS Brown 2-1-71
ENGR E Johnson 2-24-71
CHECK
DRAWN R. Spiers 2-23-71
GAC APPROVAL
CUSTOMER APPROVAL

GOODYEAR AEROSPACE CORP
AKRON, OHIO

TUBE ASSY
DECELERATOR ASSY

SIZE E | CODE IDENT NO. 25500 | DRAWING NO. 3063000-112
SCALE 1/1 | SHEET 1 OF 1

3063000-112

Figure A-27. - Tube Assembly, Decelerator Assembly
Drawing 3063000-112, Sheet 1

APPENDIX B. - STRESS ANALYSIS

Fabric Stresses

A stress analysis was performed on model I only since the same materials were used in both configurations and model I had higher stress levels.

The decelerator stress analysis in Reference 1 presents the following relationships, based on the isotensoid method of analysis, for determining the limit loads for both the meridians and fabric. These relationships are:

$$N_B = \bar{N}_B \frac{pR}{2} \tag{B-1}$$

$$f_r = \bar{f}_r \frac{pR}{2} \tag{B-2}$$

$$f_f = \bar{f}_f \frac{pR}{2} \tag{B-3}$$

$$T_r = \bar{T}_r \frac{\pi pR^2}{n} \tag{B-4}$$

$$T_f = \bar{T}_f \frac{\pi pR^2}{n} \tag{B-5}$$

$$\bar{f}_f = \bar{f}_r + \gamma \bar{N}_B \tag{B-6}$$

$$\bar{T}_f = \bar{T}_r + (1 - \gamma)\bar{N}_B \tag{B-7}$$

From the data in Reference 6:

$$\frac{p}{q_\infty} = 1.9$$

For the maximum dynamic pressure of 200 psf given in Table II,

$$p = 1.9\ (200)$$

$$= 380 \text{ psf}$$

$$= 2.64 \text{ psi}$$

Using the model parameters presented in Table III, the following limit loads were calculated:

APPENDIX C. - WEIGHT ANALYSIS

A weight analysis was performed to determine the weight of the AID models and their corresponding centers of gravity (cg). For the purpose of this analysis, the weight difference between the model I AIDS due to aft inlet size, which was 0.047 lb, was considered negligible and only the heavier model with larger aft inlets was used for cg computations.

The cg was calculated for both models I and II, packaged and deployed, and mounted and unmounted on the pivotal adapter. The last group of computations was performed to determine the cg of the models relative to the pivot axis of the pivotal adapter. A design goal of the program was to have the cg as near the pivot axis as possible in order to reduce model unbalance effects when the locking pin is released during wind tunnel tests.

The reference datum used in these calculations was the base plane of the aeroshell as shown in Figures C-1 and C-2. Figure C-1 also shows the relative position of the pivot axis to the base plane of the aeroshell. Positive moments are aft of the base plane and negative moments are forward of the base plane.

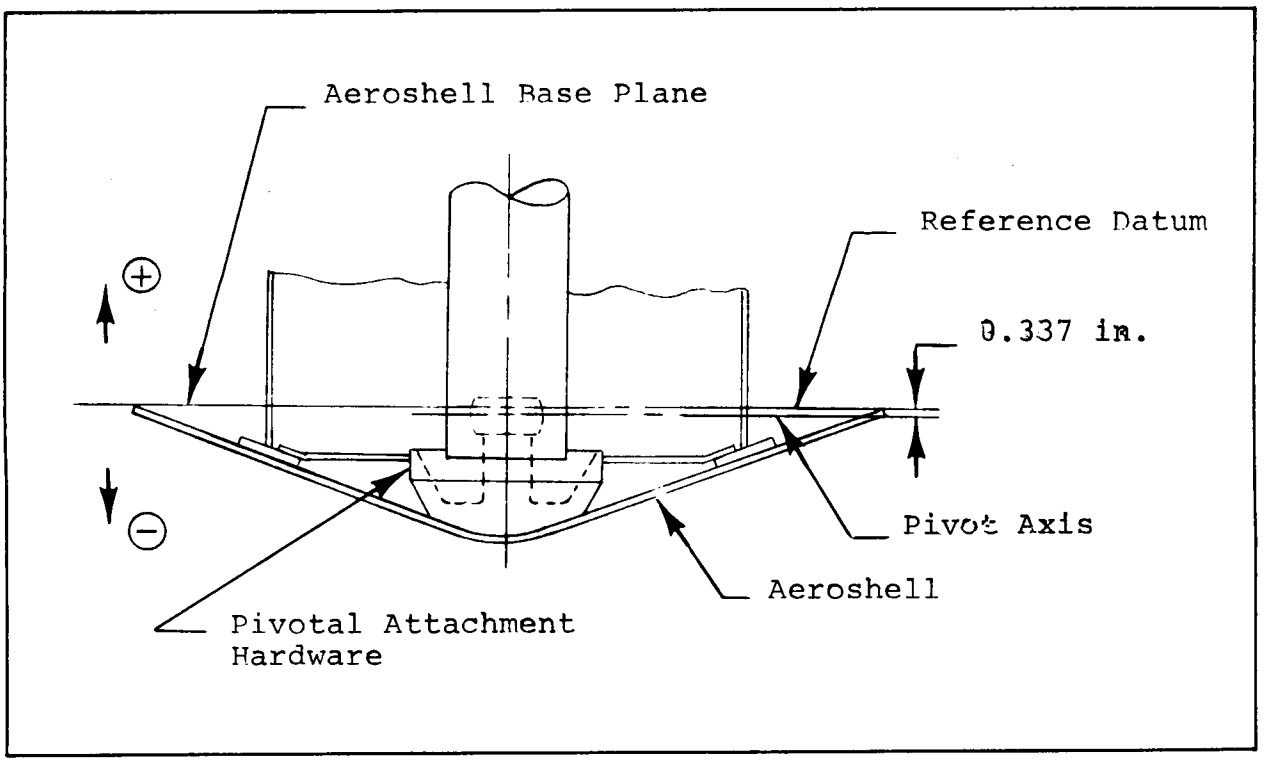


Figure C-1. - Reference Datum for AID Models Mounted on Pivotal Adapter

The canopy weight includes all the fabric, inlets and inlet rings, inlet restraining lines, and load cells. The spring weight includes only the weight of the four forward inlet springs. The aeroshell weight is only that of the aeroshell. The hard structure weight includes all internal supports and structure, clamps, cutters, attachment fittings and screws, nuts, and bolts. The total weight of the model is the weight of the whole AID before attachment to the support sleeve but including the weight of the attachment nuts, bolts and screws. The pivotal attachment hardware weight includes that of the rod and threaded shaft and solid shaft. The total model weight on the pivotal adapter is the weight which must be supported by the pivotal adapter bearing.

The cg locations calculated for models I and II are presented in Table C-II.

TABLE C-II. AID MODELS CENTER OF GRAVITY LOCATIONS

Model	Center of Gravity Location (in.)			
	Model Without Support		Model with Pivotal Attachments	
	Packaged	Deployed	Packaged	Deployed
I	0.391	0.651	-0.533	-0.274
II	0.370	0.477	-0.588	-0.420

REFERENCES

1. Bohon, H. L.; and Miserentino, R.: Attached Inflatable Decelerator Performance Evaluation and Mission-Application Study. AIAA Paper No. 70-1163, AIAA Aerodynamic Deceleration Systems Conference (Dayton, Ohio), September 1970.

2. Mikulas, M. M., Jr.; and Bohon, H. L.: Summary of the Development Status of Attached Inflatable Decelerators. AIAA Paper No. 68-929, AIAA Second Aerodynamic Decelerator Systems Conference (El Centro, California), September 1968.

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4. Houtz, N.: Optimization of Inflatable Drag Devices by Isotensoid Design. AIAA Paper No. 64-437, First Annual AIAA Meeting (Washington, D. C.). 29 June through 2 July 1964.

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6. Baker, D. C.: Investigation of an Attached Inflatable Decelerator with Mechanically Deployed Inlets at Mach Numbers from 2.25 to 4.75. AEDC-TR-69-132, U. S. Air Force, June 1969.

7. Reichenau, David E. A.: Investigation of an Attached Inflatable Decelerator System for Drag Augmentation of the Voyager Entry Capsule at Supersonic Speeds. AEDC-TR-68-71, U. S. Air Force, April 1968.

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