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PROGRESS REPORT

PERSONNEL OCCUPIED WOVEN ENVELOPE ROBOT

June 1, 1986

Dr. F. C. Wessling

JOHNSON ENVIRONMENTAL AND ENERGY CENTER

Submitted in Response to:
Grant #NAGW-847

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INTRODUCTION

The advent of Space Station provides the opportunity for further advances in the use of non-metallic or woven fabric structures. The use of non-metallic structures in space applications have been considered for many years. Suggestions for possible structures include unpressurized space hangars (1), extensible tunnels for soft docking, (2) manned habitat for Space Station, storage facilities, and work structures. One demonstration of the use of non-metallic structures is the Space Lab Transfer Tunnel flex sections.

Large space structures, such as the Power Tower, could profit from the judicious use of non-metallic or fabric structures. One could envision a flexible tunnel spanning from one end of the Power Tower to the other, or from the habitat to the storage hangar. See Figure 1. Such a tunnel would serve as a passageway for personnel and equipment without their having to suit up for extravehicular activity (EVA). A series of such tunnels could serve as passageways between crew quarters, hangars, equipment storage, and so forth.

A tunnel could also serve as a passageway for access to a control cabin on a space "crane". An astronaut could then maneuver large objects, such as communication satellites or assembled beam sections, and transfer them from cargo bays to hangars or storage areas or assemble other sections of the Power Tower without having to go EVA. An astronaut would then have more maneuverability than standing in a manned maneuvering unit on the end of the remote manipulator arm. The time taken by suiting and unsuiting of the astronaut could be applied to more fruitful tasks. The tunnel itself would act as part of the boom of the crane. It could be attached to a base and moved similar to cranes on earth. See Figure 2. Such a device could service a multitude of microgravity experiments and also a number of production units orbiting near the Space Station. These could then maintain the low gravity conditions necessary for successful experimentation and production (3). This would be a natural extension of the Manufacturing Technology Laboratory (MTL).

An extensible tunnel could be connected to Space Station. This tunnel would serve as a passageway between free flyers and the Space Station. The astronaut would extend the tunnel out to a free flyer and thus, move between the free flyer and Space Station. Servicing of the free flyer could then be completed without EVA if robotic arms were at the end of the tunnel. The astronaut would retract the tunnel upon completion of the servicing of the free flyer.

The POWER (Personnel Occupied Woven Envelope Robot) device is shown in Figure 3. The woven envelope (tunnel) acts as part of the boom of a crane. Its internal pressure and its exoskeleton give it rigidity and strength. Deflection mechanisms placed along the length of the boom, but spaced at equal intervals around the circumference, allow translation of the end of the boom in all directions. (Somewhat like a three degree of freedom finger) The end of the boom contains the operator's pod and controls. The pod has 360 degrees of rotation with respect to the boom. This, along with the flexibility of the boom offers a great deal of freedom of motion.

Potential applications of POWER include:

1. Changing out and servicing payloads on the Power Tower payload platform,

2. Maintaining subsystems such as propulsion and attitude control.

3. Providing satellite and free flyer service.

4. Performing inspections.

5. Supporting the man tended option.

6. Performing remote control operations for hazardous duty.

7. Capturing satellites during final approach.

8. Docking for the orbiter, the orbit maneuvering vehicle and the orbital transfer vehicle.

Wyle has been studying the need for space related services in the commercial sector (4). POWER appears well suited to many of these applications.

On the Space Station or Power Tower side of the base is an air hatch. This serves to isolate the other habitable parts of the Space Station from the base and the woven envelope or boom except during personnel transfer between the Space Station and the control pod.

The woven envelope is constructed from flexible fabrics covered with airtight coatings. The weave of the cloth and possible steel reinforcement strands woven at proper angles allow flexibility. In addition, micrometeroid barriers and vacuum vulcanizing sealants are exterior to the envelope, along with thermal insulation. An exoskeleton provides means to change the shape of the envelope and thus provide translations and rotation. The effect is that of a crane with a deformable boom.

The flexing, expansion and contraction of the boom during translation would cause pressure changes in the boom unless all of the bending of the boom occurs at constant volume. Constant volume translations are also necessary to minimize the amount of force required for deflecting the boom during translations. Thus, as one side of the boom contracts, the other side expands to maintain constant volume. Of course, the linear expansion and contraction of the boom requires volume changes. The amount of force required to contract the boom is proportional to the pressure in the boom. Consequently, trade-offs may be necessary to obtain the proper balance between force required to contract the boom, internal stresses generated, and conservation of breathable gases and energy of the system.

Several possibilities exist for the deflection mechanisms. Numerous possible deflection mechanisms have been considered during the first part of this work. These are explained later in this report. But, design criteria first had to be determined.

DESIGN CRITERIA

Design criteria suitable for operation of POWER on space station were defined during this first reporting period. The following were specified:

1. The extension and retraction of the device must have a length ratio of at least 4 to 1.

2. The boom is to be constructed of identical segments joined together to yield the appropriate length.

3. Each segment is to be capable of tilting between 30° to 45° with respect to its own axis.

4. The design must allow a reasonably easy system of controls.

5. The boom must be structurally stable even if the fabric portion of the boom were ruptured and pressure were lost.

6. The unit must operate in a water environment so that neutral buoyancy tests can be accomplished.

7. The boom must be capable of three dimensional maneuverability.

8. Each segment must be able to provide definite positional feed back.

9. An astronaut in ordinary clothing must be able to traverse from a space station module to the end of the boom.

10. A design length of at least 100 feet is desirable.

11. The complete device must fit in the orbiter payload bay.

Once these criteria were defined, possible mechanisms to allow deflection of the boom or tunnel were considered. The deflection mechanisms could be of several types depending on further mission definition and system complexity. These were tabulated in Table I. Their advantages were tabulated in Table II; their disadvantages in Table III. The mechanism number refers to the number of the entry in Table I.

TABLE I POSSIBLE MECHANISMS FOR POWER

1. Cables originating at the base of the boom, threading through other segments.
2. Cables originating at the base of each segment.

At each segment:

3. Linear actuators.
4. Scissors jack.
5. Hydraulic or pneumatic jacks.
6. Telescoping central jack and support of pivot arm.
7. Scissors jack and hinge segments.
8. Worm screws and motors at each segment.
9. "Camper Jacks".
10. Scissors jack, hinge segments and ball joints.
11. "Tape measure" curved steel tapes (precurved struts) instead of cable.
12. Six degree of freedom table with six legs.

TABLE II ADVANTAGES OF TABLE I MECHANISMS

ADVANTAGES	DESIGN MECHANISMS											
	1	2	3	4	5	6	7	8	9	10	11	12
Modular Construction		X	X	X	X	X	X	X	X	X	X	X
Positional Freedom		X	X	X	X	X	X	X	X	X	X	X
Incremental Positioning	X	X	X	X	X	X	X	X	X	X	X	X
Definite Positioning			X	X	X	X	X	X		X	X	X
Existing Technology		X	X	X	X	X	X	X	X	X	X	X
Structural Rigidity		X	X	X	X		X	X	X	X	X	X
Rotation Measurable			X	X	X	X	X	X	X	X	X	X
Extension Measurable		X	X	X	X	X	X	X	X	X	X	X
Position Independent of tunnel pressure		X	X	X	X	X	X	X		X	X	X
Control Solvable	X	X	X	X	X	X	X	X	X	X	X	X
Number of Activators per segment	3	3	3	2	3	2	6	3	3	12	4	6
Degrees of Freedom per segment	3	3	3	1	3	2	3	3	3	6	3	6

TABLE III DISADVANTAGES OF TABLE I MECHANISMS

DISADVANTAGES	DESIGN MECHANISMS											
	1	2	3	4	5	6	7	8	9	10	11	12
Cable Stretch	X	X										
Position-Force Dependent	X	X										
Limited Maneuverability	X											
Seals Problems					X							
Blocks Tunnel Center						X						
Heavy Construction				X			X			X		
Friction Susceptible	X	X				X			X			
Bending on Members	X		X		X	X		X	X		X	
Tunnel Puncture Danger	X	X	X					X				
Position Indefinite	X	X							X			

Models of segments for design numbers 2, 3, 6, 11 and 12 were built and studied. These models demonstrated some of the advantages and disadvantages of the various designs. Evaluation of the tables and the models narrowed the number of viable options to two: the tape measure based design using four actuators (#11) and the six degree of freedom design using six actuators (#12).

FINAL CONTENDERS

A comparison table of the two final contenders was generated. Assumptions were made for the other structural and tunnel parts to compare the two mechanisms on an equal basis. The results are summarized on Table IV.

TABLE IV POWER CONCEPTS COMPARISION

No.	ITEM	CONCEPT #12	CONCEPT #11
1	Diagram	See Figure 4	See Figure 5
2	Segment Length (L)	80.0" (Limited by Flange Dia. D)	$\geq$ 80.0" (not limited by Flange Dia. D)
3	Total weight per segment:		
	one flange & load carrying members Power drives & accessories omitted.	976.5 lbs	976.5 lbs
4	Type of load carrying members	Screw rods (½" ϕ inside rod & 1" ϕ outside rod) 6 per segment	Spring tubes (7.11" ϕ tube with 1/32" thickness) 4 per segment
5	Weight of load carrying members per segment	64.8 lbs	64.8 lbs
6	Extension to compression ratio per segment	<10:1	$\geq$ 10:1 (limited by buckling & bending capacity of load carrying members)

TABLE IV CONTINUED

No.	Item	Concept #12	Concept #11
7	Type of coupling between the flanges & load carrying members	Universal at both ends	Gimble (hinged) at end A & universal or spherical at end B.
8	Controlled degrees of freedom	6 (3 trans. & 3 rotat.)	3 (1 trans. & 2 rotat.)
9	Fundamental frequency of one segment 80.00" long	13.78 Hz	3.88 Hz
10	Fundamental frequency of 14 segments each 80.0" long	0.142 Hz	0.028 Hz
11	Type of forces produced in load carrying members	Axial	Axial, shear, & bending
12	Max. forces produced for a unit lateral load at end A, with end B constrained. (load carrying members only). See Appendix.	0.57 lbs axial	0.5 lbs shear and 40.0 in lbs bending moment

Comments:

1. Mass of load carrying members (6% of total) was neglected in the calculation of fundamental frequency.

2. The fundamental frequency of 14 segments was calculated using a cantilever beam model (massless) with 14 mass points.

3. The low value of frequency resulted due to the large mass of the flange. More than a 50% increase can be made to this value by the proper design of the flange.

A final decision of which design to use will be made shortly after this reporting period. It may be that the two will be combined so that the six degree of freedom geometry is used with the tape measure drive system.

WORK PLANNED

Several items of work will be accomplished during the next reporting period. The final design of a model to be built and tested will be determined. Then, a detailed design of a working model will be completed. Structural analysis of the model will determine whether the model is capable of operating in a one gravity environment or must operate in a neutral buoyancy tank. Final design and construction of the model will then commence.

The design and development of the control algorithms will occur in parallel with the mechanical design. The control algorithm for the six degree of freedom table is available from Wyle Laboratories. Wyle held the original patent, which has now expired, on the six degree of freedom table. Personnel at the University will combine the 6 DOF algorithm with the overall control algorithm of P.O.W.E.R. Control will be carefully considered because no unique solution exists for positioning unless several additional constraints are applied to the system.

Attention will also be given to the possible materials of construction of the tunnel itself. The tunnel must be man rated, yet, flexible and capable of safely undergoing the deflections and strains required to position the control pod at the desired location. It appears, at this time, that the tunnel will be large enough for an astronaut to pass through, but not so large as to cause undesirable levels of stress to be present in the tunnel. The tunnel walls must carry the internal pressure (one atmosphere). The wall stress is proportional to the tunnel diameter. Consequently, the deflection mechanisms will most likely be external to the tunnel in a full scale prototype, thus allowing a smaller tunnel.

ORIGINAL PAGE IS
OF POOR QUALITY

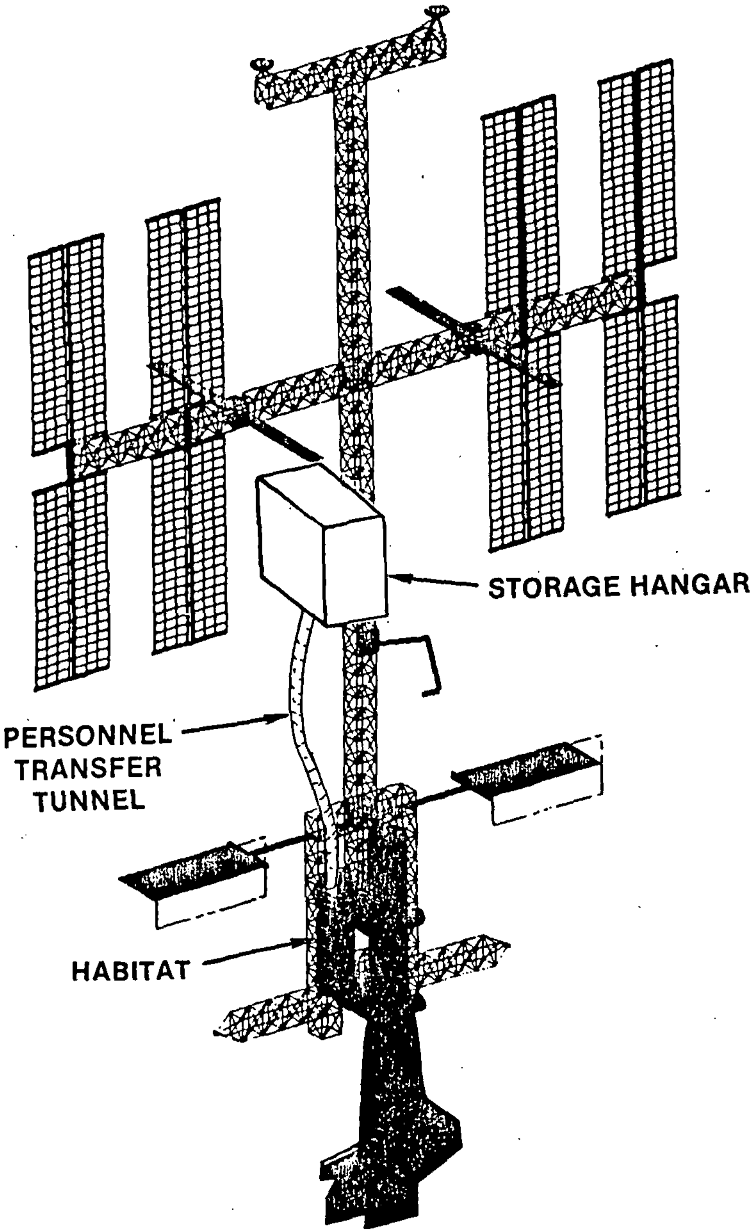

FIGURE 1. SPACE STATION APPLICATION OF PERSONNEL TRANSFER TUNNEL

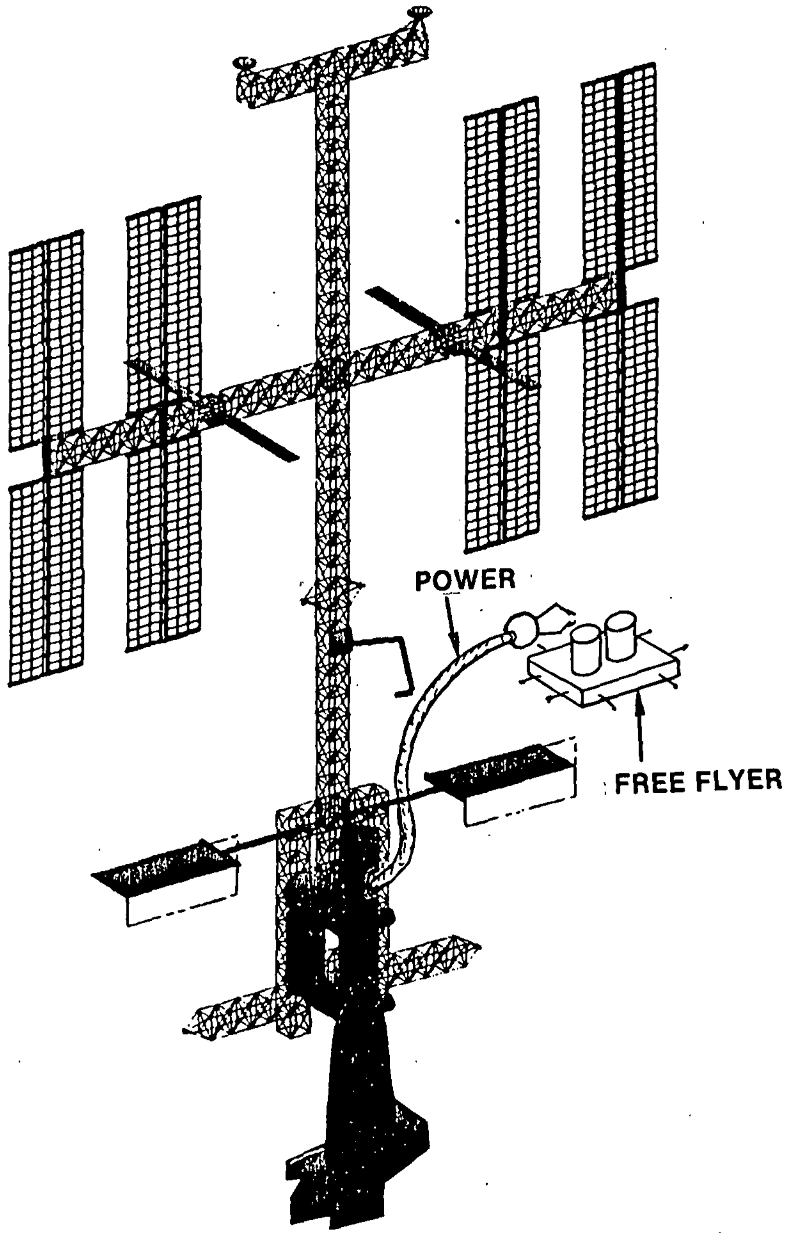

FIGURE 2. POWER SERVICING FREE FLYER

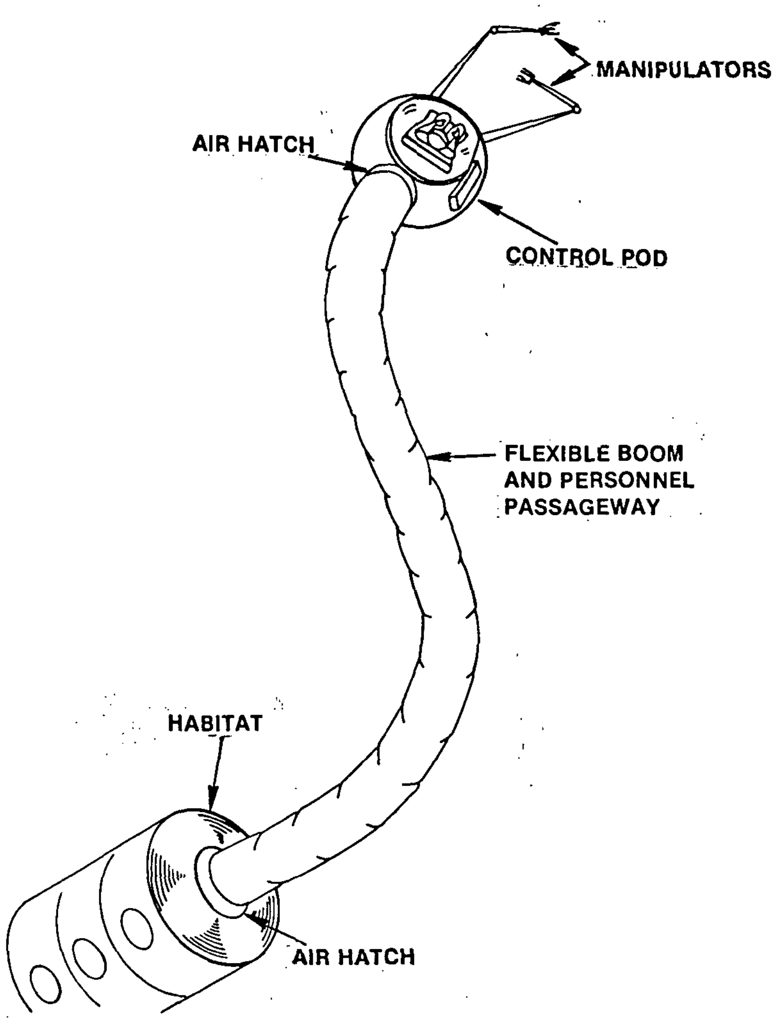

FIGURE 3. PERSONNEL OCCUPIED WOVEN ENVELOPE ROBOT (POWER)

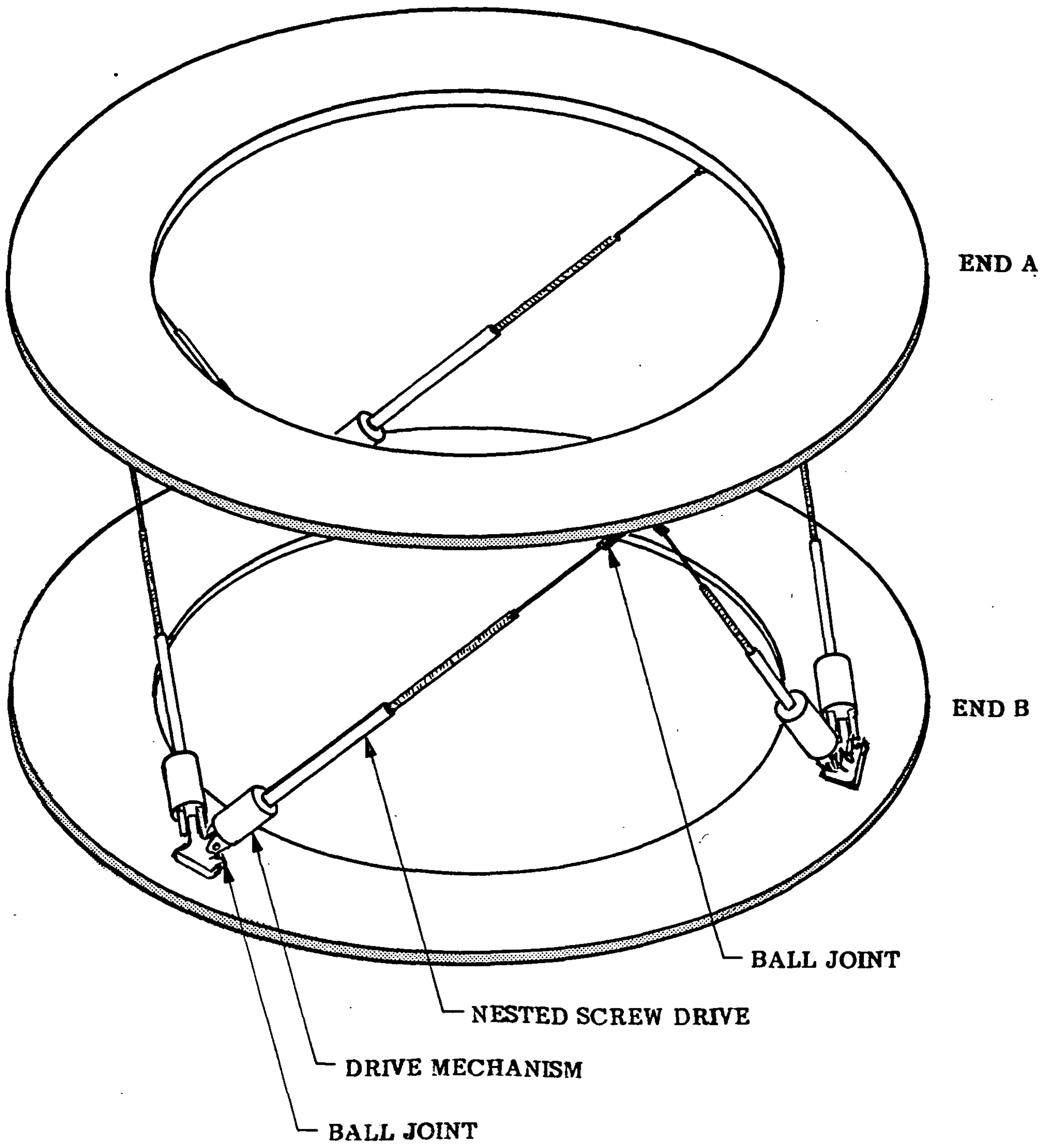

FIGURE 4 MECHANISM #12

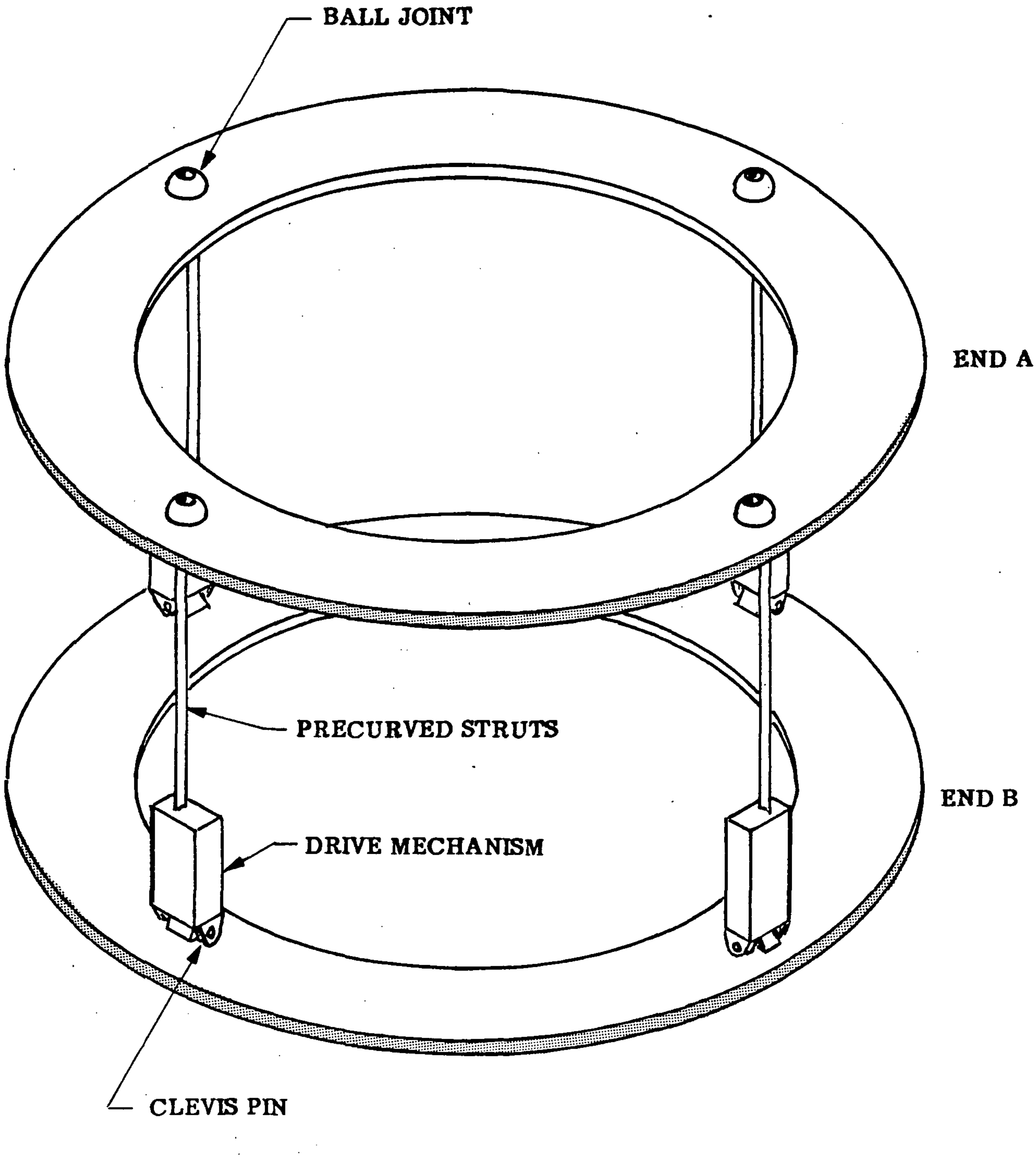

FIGURE 5 MECHANISM # 11

REFERENCES

1. "Preliminary Study to Adapt Inflatable Structures to a Space Station Manned Habitat and an Orbit Transer Vehicle (OTV) Hangar". Study for Rockwell International, Downey CA. Contract No. NAS8-34677.

2. F. D. Stimler "System Definition Study of Non-Metallic Space Structures" for NASA, Marshall Space Flight Center, Huntsville, AL. 35812 Goodyear Aerospace Corporation Contract No. NAS8-35498, June 1984.

3. "Top Level Requirements for Microgravity Science and Applications Research on Space Station" Final Report Contract No. NAS8-36117, Wyle Laboratories Report No. WR 85-03, March 1985.

4. D. L. Christensen and J. W. Monroe, "Sciences for Commercialization of Space Related Services", Wyle Laboratories Research Report #WR84-07.

APPENDIX

Structur - Analysis - System S A R A

TCAE - Version 3.00, AUGUST 1985

POWER, CONCEPT #11 1986/05/12

C O N T R O L - I N F O R M A T I O N

```
Number of Nodal Points               =   34
Number of Element-Types              =    1
Number of Load Cases                 =    1
Number of Frequencies                =    0

Analysis Code (NDYN)............... =    0
    EQ.0, Static Analysis
    EQ.1, Modal Analysis
    EQ.2, Forced Response
    EQ.3, Response  Spectrum
    EQ.4, Direct Integration
    EQ.5, Frequenzy Response
    EQ.6, Buckling Analysis

Solution Mode    (MODEX)............ =    0
    EQ.0, Execution
    EQ.1, Data Check

Number of Supspace
Iteration Vektoren (NAD)             =    0
Equations per Block                  =    0
Tape10 Save Flag (N10SV)             =    0

Gravitational-Constant               = 9.8066


Bandwidth Minimization is required

Structur-Plot is required
```

O U T P U T   O F   T H E   N O D A L - P O I N T   D A T A

NODAL POINT INPUT DATA

NODE- NUMBER	BOUNDARY CONDITION CODE X	Y	Z	XX	YY	ZZ	NODAL POINT COORDINATES X	Y	Z		T
1C	0	0	0	0	0	0	61.250	.000	-80.000	0	.000
2	0	0	0	0	0	0	61.217	2.000	-80.000	0	.000
3	0	0	0	0	0	0	32.340	52.016	-80.000	0.	.000
4	0	0	0	0	0	0	28.877	54.016	-80.000	0	.000
5	0	0	0	0	0	0	.000	61.250	-80.000	0	.000
6	0	0	0	0	0	0	-28.877	54.016	-80.000	0	.000
7	0	0	0	0	0	0	-32.340	52.016	-80.000	0	.000
8	0	0	0	0	0	0	-61.217	2.000	-80.000	0	.000
9	0	0	0	0	0	0	-61.250	.000	-80.000	0	.000
10	0	0	0	0	0	0	-61.217	-2.000	-80.000	0	.000
11	0	0	0	0	0	0	-32.340	-52.016	-80.000	0	.000
12	0	0	0	0	0	0	-28.877	-54.016	-80.000	0	.000
13	0	0	0	0	0	0	.000	-61.250	-80.000	0	.000
14	0	0	0	0	0	0	28.877	-54.016	-80.000	0	.000
15	0	0	0	0	0	0	32.340	-52.016	-80.000	0	.000
16	0	0	0	0	0	0	61.217	-2.000	-80.000	0	.000
17	1	1	1	1	0	0	61.250	.000	.000	0	.000
18	1	1	1	1	1	1	61.217	2.000	.000	0	.000
19	1	1	1	1	1	1	32.340	52.016	.000	0	.000
20	1	1	1	1	1	1	28.877	54.016	.000	0	.000
21	1	1	1	0	1	0	.000	61.250	.000	0	.000
22	1	1	1	1	1	1	-28.877	54.016	.000	0	.000
23	1	1	1	1	1	1	-32.340	52.016	.000	0	.000
24	1	1	1	1	1	1	-61.217	2.000	.000	0	.000
25	1	1	1	1	0	0	-61.250	.000	.000	0	.000
26	1	1	1	1	1	1	-61.217	-2.000	.000	0	.000
27	1	1	1	1	1	1	-32.340	-52.016	.000	0	.000
28	1	1	1	1	1	1	-28.877	-54.016	.000	0	.000
29	1	1	1	0	1	0	.000	-61.250	.000	0	.000
30	1	1	1	1	1	1	28.877	-54.016	.000	0	.000
31	1	1	1	1	1	1	32.340	-52.016	.000	0	.000
32	1	1	1	1	1	1	61.217	-2.000	.000	0	.000
33	0	0	0	0	0	0	.000	.000	-80.000	0	.000
34	1	1	1	1	1	1	.000	.000	.000	0	.000

B E A M - E L E M E N T (three-dim.)

Number of Beams	=	22
Number of Geometric Property Sets	=	3
Number of Fixed End Force Sets	=	0
Number of Material Properties	=	2
Number of Intermediate Loads Input	=	0

Material - Data

Material Property	E-Modul	Poisson Number	Density	Weight	Coefficient of therm. Expansion X	Y	Z	Referenz-Temp.
1	.2900E+08	.3300	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
2	.2900E+08	.3300	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00

Geometric Property

Geometric Number	Axial Area A(1)	Shear Area A(2)	A(3)	Torsional Inertia J(1)	Flexural Inertia I(2)	I(3)	Section Modulus S(2)	S(3)
1	.8750E+01	.8750E+01	.8750E+01	.1000E+01	.1823E+00	.2233E+03	.0000E+00	.0000E+00
2	.6980E+00	.6980E+00	.6980E+00	.1000E+01	.4411E+01	.4411E+01	.0000E+00	.0000E+00
3	.1000E+03	.1000E+03	.1000E+03	.8330E+03	.8330E+03	.8330E+03	.0000E+00	.0000E+00

Gravity Element Load Factor

	A	B	C	D
X - Dir.	.000000E+00	.000000E+00	.000000E+00	.000000E+00
Y - Dir.	.000000E+00	.000000E+00	.000000E+00	.000000E+00
Z - Dir.	.000000E+00	.000000E+00	.000000E+00	.000000E+00

Beam Element-Data

Beam Number	Node -I	Node -J	Node -K	Material Number	Geometric Number	Element Laod A	B	C	D	End-Code -I	-J	Band
1	1	2	33	1	1	0	0	0	0	0 0	0 0	12
2	2	3	33	1	1	0	0	0	0	0 0	0 0	12
3	3	4	33	1	1	0	0	0	0	0 0	0 0	12
4	4	5	33	1	1	0	0	0	0	0 0	0 0	12
5	5	6	33	1	1	0	0	0	0	0 0	0 0	12
6	6	7	33	1	1	0	0	0	0	0 0	0 0	12
7	7	8	33	1	1	0	0	0	0	0 0	0 0	12
8	8	9	33	1	1	0	0	0	0	0 0	0 0	12
9	9	10	33	1	1	0	0	0	0	0 0	0 0	12
10	10	11	33	1	1	0	0	0	0	0 0	0 0	12
11	11	12	33	1	1	0	0	0	0	0 0	0 0	12
12	12	13	33	1	1	0	0	0	0	0 0	0 0	12
13	13	14	33	1	1	0	0	0	0	0 0	0 0	12
14	14	15	33	1	1	0	0	0	0	0 0	0 0	12
15	15	16	33	1	1	0	0	0	0	0 0	0 0	12
16	16	1	33	1	1	0	0	0	0	0 0	0 0	96
17	1	17	33	2	2	0	0	0	0	0111	0 0	98
18	5	21	33	2	2	0	0	0	0	0111	0 0	76
19	9	25	33	2	2	0	0	0	0	0111	0 0	54
20	13	29	33	2	2	0	0	0	0	0111	0 0	32
21	5	33	1	2	3	0	0	0	0	0 0	0 0	86
22	13	33	1	2	3	0	0	0	0	0 0	0 0	38

B A N D W I D T H - M I N I M I Z A T I O N

MINBND (Control Paramameter) = 1

Equation Numbers after the Minimization

Nodal Numbers old	new	X	Y	Z	XX	YY	ZZ
1	20	103	104	105	106	107	108
2	19	97	98	99	100	101	102
3	17	85	86	87	88	89	90
4	15	73	74	75	76	77	78
5	13	61	62	63	64	65	66
6	10	47	48	49	50	51	52
7	6	27	28	29	30	31	32
8	4	15	16	17	18	19	20
9	2	3	4	5	6	7	8
10	3	9	10	11	12	13	14
11	5	21	22	23	24	25	26
12	7	33	34	35	36	37	38
13	12	55	56	57	58	59	60
14	14	67	68	69	70	71	72
15	16	79	80	81	82	83	84
16	18	91	92	93	94	95	96
17	21	0	0	0	0	109	110
18	22	0	0	0	0	0	0
19	23	0	0	0	0	0	0
20	24	0	0	0	0	0	0
21	11	0	0	0	53	0	54
22	25	0	0	0	0	0	0
23	26	0	0	0	0	0	0
24	27	0	0	0	0	0	0
25	1	0	0	0	0	1	2
26	28	0	0	0	0	0	0
27	29	0	0	0	0	0	0
28	30	0	0	0	0	0	0
29	8	0	0	0	39	0	40
30	31	0	0	0	0	0	0
31	32	0	0	0	0	0	0
32	33	0	0	0	0	0	0
33	9	41	42	43	44	45	46
34	34	0	0	0	0	0	0

Equation Banowidth after Minimization = 28

Bandwidth before Minimization	=	28
Bandwidth after Minimization	=	5

E Q U A T I O N - P A R A M E T E R S :

Number of Equations	=	110
Bandwidth	=	28
Number of Equations per Block	=	110
Number of Blocks	=	1

Nodal Loads (static) or Masses (dynamic)

Node Number	Load Case	X -Axis Force	Y -Axis Force	Z -Axis Force	X -Axis Moment	Y -Axis Moment	Z -Axis Moment
33	1	-1.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00

All Equations are built right !!

Structure Load Case	Element Load Multipliers A	B	C	D
1	.000	.000	.000	.000

Parameter of the Stiffness-Matrix :

minimal Diagonal-Element not equal cero	=	9.527E+05
maximal Diagonal-Element	=	6.570E+09
Maximum/Minimum	=	6.896E+03
Average of the Diagonal-Element	=	5.922E+08
Data-Density of the Stiffness-Matrix	=	16.6 PCT.

B E A M - E L E M E N T (FORCE AND MOMENT)

B E A M - E L E M E N T (FORCE AND MOMENT)

0 No.	Load No.	Axial R1	Shear R2	Shear R3	Torsion M1	Bending M2	Bending M3	P/A+M2/S2	P/A-M2/S2	P/A+M3/S3	P/A-M3/S3
1	1	1.053E-01	-3.529E-04	-2.136E-08	-6.425E-07	6.898E-07	-1.654E+00				
		-1.053E-01	3.529E-04	2.136E-08	6.425E-07	-6.471E-07	1.652E+00				
2	1	9.109E-02	-5.316E-02	-2.136E-08	-2.474E-07	8.777E-07	-1.650E+00				
		-9.109E-02	5.316E-02	2.136E-08	2.474E-07	3.561E-07	-1.420E+00				
3	1	5.434E-02	-9.027E-02	-2.136E-08	-3.923E-07	-1.847E-07	1.421E+00				
		-5.434E-02	9.027E-02	2.136E-08	3.923E-07	2.702E-07	-1.781E+00				
4	1	2.752E-02	-1.011E-01	-2.136E-08	-4.514E-07	-1.520E-07	1.779E+00				
		-2.752E-02	1.011E-01	2.136E-08	4.514E-07	7.879E-07	-4.788E+00				
5	1	-2.848E-02	-1.006E-01	-2.131E-08	-4.517E-07	7.860E-07	-4.781E+00				
		2.848E-02	1.006E-01	2.131E-08	4.517E-07	-1.516E-07	1.787E+00				
6	1	-5.634E-02	-9.028E-02	-2.131E-08	-3.927E-07	2.699E-07	-1.787E+00				
		5.634E-02	9.028E-02	2.131E-08	3.927E-07	-1.846E-07	1.426E+00				
7	1	-9.239E-02	-5.340E-02	-2.131E-08	-2.478E-07	3.562E-07	-1.426E+00				
		9.239E-02	5.340E-02	2.131E-08	2.478E-07	8.747E-07	-1.657E+00				
8	1	-1.065E-01	6.676E-04	-2.131E-08	-6.414E-07	-6.443E-07	1.657E+00				
		1.065E-01	-6.676E-04	2.131E-08	6.414E-07	6.869E-07	-1.659E+00				
9	1	-1.061E-01	2.614E-03	2.133E-08	6.418E-07	-6.879E-07	1.657E+00				
		1.061E-01	-2.614E-03	-2.133E-08	-6.418E-07	6.452E-07	-1.651E+00				
10	1	-9.191E-02	5.318E-02	2.133E-08	2.477E-07	-8.757E-07	1.648E+00				
		9.191E-02	-5.318E-02	-2.133E-08	-2.477E-07	-3.562E-07	1.423E+00				
11	1	-5.240E-02	8.969E-02	2.134E-08	3.926E-07	1.847E-07	-1.423E+00				
		5.240E-02	-8.969E-02	-2.134E-08	-3.926E-07	-2.700E-07	1.781E+00				
12	1	-2.700E-02	1.009E-01	2.133E-08	4.516E-07	1.517E-07	-1.780E+00				
		2.700E-02	-1.009E-01	-2.133E-08	-4.516E-07	-7.867E-07	4.783E+00				
13	1	2.691E-02	1.010E-01	2.128E-08	4.520E-07	-7.848E-07	4.789E+00				
		-2.691E-02	-1.010E-01	-2.128E-08	-4.520E-07	1.513E-07	-1.782E+00				
14	1	5.676E-02	9.095E-02	2.128E-08	3.930E-07	-2.697E-07	1.780E+00				
		-5.676E-02	-9.095E-02	-2.128E-08	-3.930E-07	1.846E-07	-1.415E+00				
15	1	9.301E-02	5.297E-02	2.128E-08	2.481E-07	-3.563E-07	1.415E+00				
		-9.301E-02	-5.297E-02	-2.128E-08	-2.481E-07	-8.728E-07	1.643E+00				

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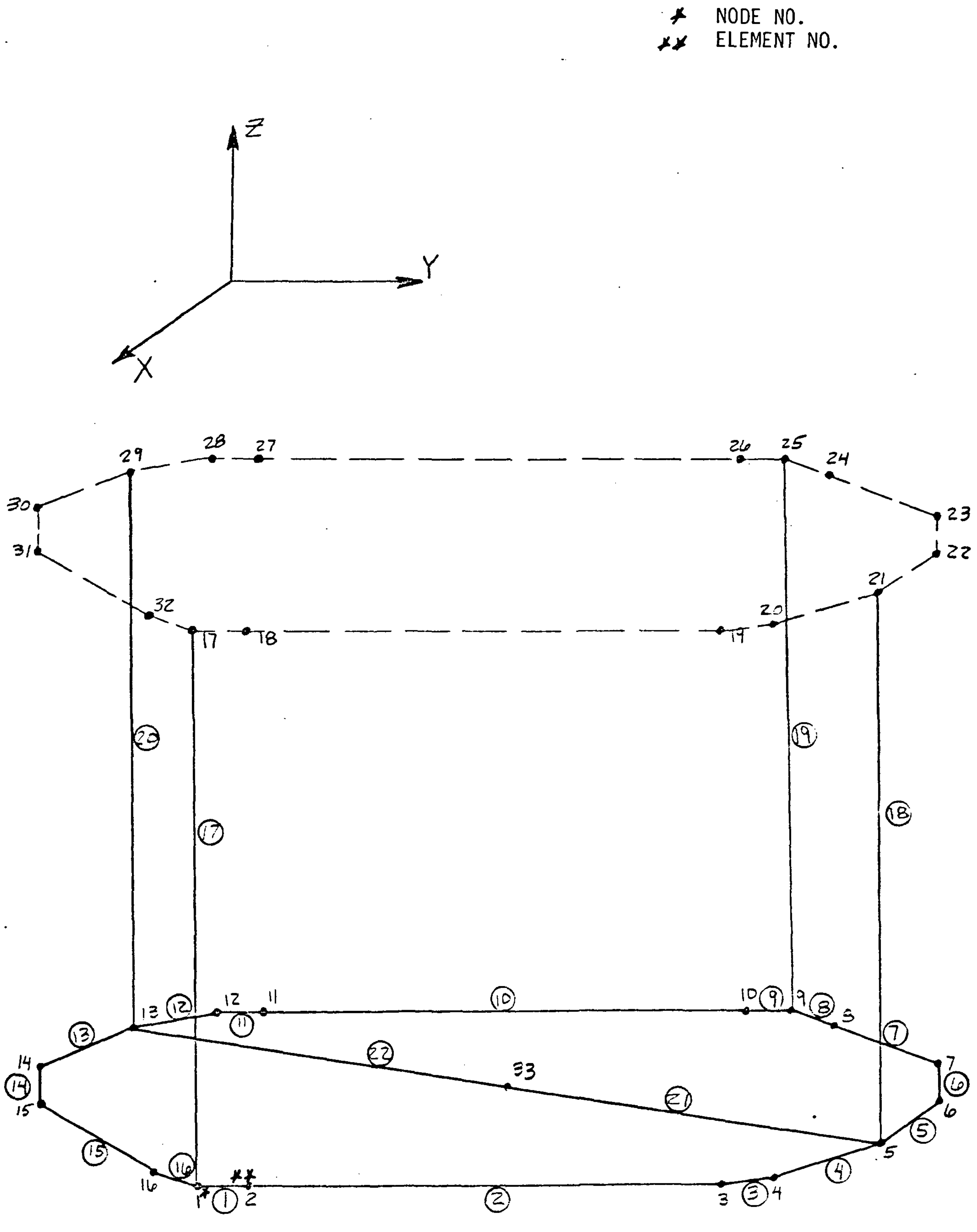
16	1	1.071E-01	1.544E-03	2.128E-08	6.407E-07	6.424E-07	-1.647E+00
		-1.071E-01	-1.544E-03	-2.128E-08	-6.407E-07	-6.850E-07	1.651E+00

B E A M - E L E M E N T (FORCE AND MOMENT)

0 No.	Load No.	Axial R1	Shear R2	Shear R3	Torsion M1	Bending M2	Bending M3	P/A+M2/S2	P/A-M2/S2	P/A+M3/S3	P/A-M3/S3
17	1	4.264E-08	1.663E-08	-1.834E-03	.000E+00	.000E+00	.000E+00				
		-4.264E-08	-1.663E-08	1.834E-03	.000E+00	1.467E-01	2.706E-07				
18	1	-9.435E-11	-4.122E-11	-5.052E-01	.000E+00	.000E+00	.000E+00				
		9.435E-11	4.122E-11	5.052E-01	.000E+00	4.042E+01	-9.628E-10				
19	1	-4.264E-08	-4.876E-08	3.875E-04	.000E+00	.000E+00	.000E+00				
		4.264E-08	4.876E-08	-3.875E-04	.000E+00	-3.100E-02	9.740E-07				
20	1	9.601E-11	4.365E-11	5.038E-01	.000E+00	.000E+00	.000E+00				
		-9.601E-11	-4.365E-11	-5.038E-01	.000E+00	-4.030E+01	3.020E-09				
21	1	-1.851E-04	5.000E-01	4.458E-11	6.250E-10	-2.732E-09	9.569E+00				
		1.851E-04	-5.000E-01	-4.458E-11	-6.250E-10	9.729E-13	2.105E+01				
22	1	-1.811E-04	5.000E-01	4.458E-11	5.974E-10	-2.730E-09	9.572E+00				
		1.811E-04	-5.000E-01	-4.458E-11	-5.974E-10	-9.740E-13	2.105E+01				



FINITE ELEMENT MODEL OF CONCEPT NO. 11

Structur - Analysis - System   S A R A

TCAE - Version 3.00, AUGUST 1985

POWER, CONCEPT #12   1986/05/12

C O N T R O L - I N F O R M A T I O N

```
Number of Nodal Points                  =   40
Number of Element-Types                 =    1
Number of Load Cases                    =    1
Number of Frequencies                   =    0

Analysis Code (NDYN)............... =    0
    EQ.0, Static Analysis
    EQ.1, Modal Analysis
    EQ.2, Forced Response
    EQ.3, Response  Spectrum
    EQ.4, Direct Integration
    EQ.5, Frequenzy Response
    EQ.6, Buckling Analysis

Solution Mode    (MODEX)............ =    0
    EQ.0, Execution
    EQ.1, Data Check

Number of Supspace
Iteration Vektoren (NAD)               =    0
Equations per Block                    =   28
Tape10 Save Flag (N10SV)               =    0

Gravitational-Constant                 =  9.8066


Bandwidth Minimization is required

Structur-Plot is required
```

O U T P U T O F T H E N O D A L - P O I N T D A T A

NODAL POINT INPUT DATA

NODE-	BOUNDARY CONDITION CODE						NODAL POINT COORDINATES				
NUMBER	X	Y	Z	XX	YY	ZZ	X	Y	Z		T
1C	0	0	0	0	0	0	61.250	.000	-80.000	0	.000
2	0	0	0	0	0	0	61.217	2.000	-80.000	0	.000
3	0	0	0	0	0	0	32.340	52.016	-80.000	a	.000
4	0	0	0	0	0	0	28.877	54.016	-80.000	0	.000
5	0	0	0	0	0	0	.000	61.250	-80.000	0	.000
6	0	0	0	0	0	0	-28.877	54.016	-80.000	0	.000
7	0	0	0	0	0	0	-32.340	52.016	-80.000	0	.000
8	0	0	0	0	0	0	-61.217	2.000	-80.000	0	.000
9	0	0	0	0	0	0	-61.250	.000	-80.000	0	.000
10	0	0	0	0	0	0	-61.217	-2.000	-80.000	0	.000
11	0	0	0	0	0	0	-32.340	-52.016	-80.000	0	.000
12	0	0	0	0	0	0	-28.877	-54.016	-80.000	0	.000
13	0	0	0	0	0	0	.000	-61.250	-80.000	0	.000
14	0	0	0	0	0	0	28.877	-54.016	-80.000	0	.000
15	0	0	0	0	0	0	32.340	-52.016	-80.000	0	.000
16	0	0	0	0	0	0	61.217	-2.000	-80.000	0	.000
17	1	1	1	1	1	1	61.250	.000	.000	0	.000
18	1	1	1	1	1	1	61.217	2.000	.000	0	.000
19	1	1	1	0	0	0	32.340	52.016	.000	0	.000
20	1	1	1	0	0	0	28.877	54.016	.000	0	.000
21	1	1	1	1	1	1	.000	61.250	.000	0	.000
22	1	1	1	1	1	1	-28.877	54.016	.000	0	.000
23	1	1	1	1	1	1	-32.340	52.016	.000	0	.000
24	1	1	1	0	0	0	-61.217	2.000	.000	0	.000
25	1	1	1	1	1	1	-61.250	.000	.000	0	.000
26	1	1	1	0	0	0	-61.217	-2.000	.000	0	.000
27	1	1	1	1	1	1	-32.340	-52.016	.000	0	.000
28	1	1	1	1	1	1	-28.877	-54.016	.000	0	.000
29	1	1	1	1	1	1	.000	-61.250	.000	0	.000
30	1	1	1	0	0	0	28.877	-54.016	.000	0	.000
31	1	1	1	0	0	0	32.340	-52.016	.000	0	.000
32	1	1	1	1	1	1	61.217	-2.000	.000	0	.000
33	0	0	0	0	0	0	.000	.000	-80.000	0	.000
34	0	0	0	0	0	0	46.779	27.008	-40.000	0	.000
35	0	0	0	0	0	0	.000	54.016	-40.000	0	.000
36	0	0	0	0	0	0	-46.779	27.008	-40.000	0	.000
37	0	0	0	0	0	0	-46.779	-27.008	-40.000	0	.000

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NODAL POINT INPUT DATA

NODE-NUMBER	BOUNDARY CONDITION CODE X	Y	Z	XX	YY	ZZ	NODAL POINT COORDINATES X	Y	Z		T
38	0	0	0	0	0	0	.000	-54.016	-40.000	0	.000
39	0	0	0	0	0	0	46.779	-27.008	-40.000	0	.000
40	1	1	1	1	1	1	.000	.000	.000	0	.000

B E A M - E L E M E N T (three-dim.)

Number of Beams	=	46
Number of Geometric Property Sets	=	4
Number of Fixed End Force Sets	=	0
Number of Material Properties	=	2
Number of Intermediate Loads Input	=	0

Material - Data

Material Property	E-Modul	Poisson Number	Density	Weight	Coefficient of therm. Expansion X	Y	Z	Referenz-Temp.
1	.2900E+08	.3300	.7513E-03	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
2	.2900E+08	.3300	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00

Geometric Property

Geometric Number	Axial Area A(1)	Shear Area A(2)	A(3)	Torsional Inertia J(1)	Flexural Inertia I(2)	I(3)	Section Modulus S(2)	S(3)
1	.8750E+01	.8750E+01	.8750E+01	.1000E+01	.1824E+00	.2233E+03	.0000E+00	.0000E+00
2	.1963E+00	.1963E+00	.1963E+00	.1000E+01	.3068E-02	.3068E-02	.0000E+00	.0000E+00
3	.5890E+00	.5890E+00	.5890E+00	.1000E+01	.4600E-01	.4600E-01	.0000E+00	.0000E+00
4	.1000E+03	.1000E+03	.1000E+03	.8330E+03	.8330E+03	.8330E+03	.0000E+00	.0000E+00

Gravity Element Load Factor

	A	B	C	D
X - Dir.	.000000E+00	.000000E+00	.000000E+00	.000000E+00
Y - Dir.	.000000E+00	.000000E+00	.000000E+00	.000000E+00
Z - Dir.	.000000E+00	.000000E+00	.000000E+00	.000000E+00

Beam Element-Data

Beam Number	Node -I	Node -J	Node -K	Material Number	Geometric Number	Element Laod A	B	C	D	End-Code -I	-J	Band
1	1	2	33	1	1	0	0	0	0	0 0	0 0	12
2	2	3	33	1	1	0	0	0	0	0 0	0 0	12
3	3	4	33	1	1	0	0	0	0	0 0	0 0	12
4	4	5	33	1	1	0	0	0	0	0 0	0 0	12
5	5	6	33	1	1	0	0	0	0	0 0	0 0	12
6	6	7	33	1	1	0	0	0	0	0 0	0 0	12
7	7	8	33	1	1	0	0	0	0	0 0	0 0	12
8	8	9	33	1	1	0	0	0	0	0 0	0 0	12
9	9	10	33	1	1	0	0	0	0	0 0	0 0	12
10	10	11	33	1	1	0	0	0	0	0 0	0 0	12
11	11	12	33	1	1	0	0	0	0	0 0	0 0	12
12	12	13	33	1	1	0	0	0	0	0 0	0 0	12
13	13	14	33	1	1	0	0	0	0	0 0	0 0	12
14	14	15	33	1	1	0	0	0	0	0 0	0 0	12
15	15	16	33	1	1	0	0	0	0	0 0	0 0	12
16	16	1	33	1	1	0	0	0	0	0 0	0 0	96
17	17	18	40	1	1	0	0	0	0	0 0	0 0	0
18	18	19	40	1	1	0	0	0	0	0 0	0 0	3
19	19	20	40	1	1	0	0	0	0	0 0	0 0	6
20	20	21	40	1	1	0	0	0	0	0 0	0 0	3
21	21	22	40	1	1	0	0	0	0	0 0	0 0	0
22	22	23	40	1	1	0	0	0	0	0 0	0 0	0
23	23	24	40	1	1	0	0	0	0	0 0	0 0	3
24	24	25	40	1	1	0	0	0	0	0 0	0 0	3
25	25	26	40	1	1	0	0	0	0	0 0	0 0	3
26	26	27	40	1	1	0	0	0	0	0 0	0 0	3
27	27	28	40	1	1	0	0	0	0	0 0	0 0	0
28	28	29	40	1	1	0	0	0	0	0 0	0 0	0
29	29	30	40	1	1	0	0	0	0	0 0	0 0	3
30	30	31	40	1	1	0	0	0	0	0 0	0 0	6
31	31	32	40	1	1	0	0	0	0	0 0	0 0	3
32	32	17	40	1	1	0	0	0	0	0 0	0 0	0
33	2	34	33	2	3	0	0	0	0	0111	0 0	120
34	19	34	40	2	2	0	0	0	0	0 0	0 0	30
35	6	35	33	2	3	0	0	0	0	0111	0 0	102
36	20	35	40	2	2	0	0	0	0	0 0	0 0	33
37	7	36	33	2	3	0	0	0	0	0111	0 0	102
38	24	36	40	2	2	0	0	0	0	0 0	0 0	36
39	11	37	33	2	3	0	0	0	0	0111	0 0	84
40	26	37	40	2	2	0	0	0	0	0 0	0 0	39

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42	30	38	40	2	2	0	0	0	0	0 0	0	0	42
43	16	39	33	2	3	0	0	0	0	0111	0	0	66

Beam Number	Node -I	Node -J	Node -K	Material Number	Geometric Number	Element Laod A	B	C	D	End-Code -I		-J		Band
44	31	39	40	2	2	0	0	0	0	0	0	0	0	45
45	5	33	1	2	4	0	0	0	0	0	0	0	0	96
46	13	33	1	2	4	0	0	0	0	0	0	0	0	48

B A N D W I D T H   -   M I N I M I Z A T I O N

MINBND (Control Paramameter) = 1

Equation Numbers after the Minimization

Nodal Numbers old	new	X	Y	Z	XX	YY	ZZ
1	6	25	26	27	28	29	30
2	10	46	47	48	49	50	51
3	15	76	77	78	79	80	81
4	19	97	98	99	100	101	102
5	22	112	113	114	115	116	117
6	25	130	131	132	133	134	135
7	27	142	143	144	145	146	147
8	26	136	137	138	139	140	141
9	24	124	125	126	127	128	129
10	21	106	107	108	109	110	111
11	17	85	86	87	88	89	90
12	12	58	59	60	61	62	63
13	14	70	71	72	73	74	75
14	9	40	41	42	43	44	45
15	5	19	20	21	22	23	24
16	3	10	11	12	13	14	15
17	30	0	0	0	0	0	0
18	31	0	0	0	0	0	0
19	16	0	0	0	82	83	84
20	20	0	0	0	103	104	105
21	32	0	0	0	0	0	0
22	33	0	0	0	0	0	0
23	34	0	0	0	0	0	0
24	29	0	0	0	154	155	156
25	35	0	0	0	0	0	0
26	8	0	0	0	37	38	39
27	36	0	0	0	0	0	0
28	37	0	0	0	0	0	0
29	38	0	0	0	0	0	0
30	4	0	0	0	16	17	18
31	2	0	0	0	7	8	9
32	39	0	0	0	0	0	0
33	18	91	92	93	94	95	96
34	11	52	53	54	55	56	57
35	23	118	119	120	121	122	123
36	28	148	149	150	151	152	153
[illegible]	[illegible]	64	65	66	67	68	69

39	1	1	2	3	4	5	6
40	40	0	0	0	0	0	0

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Equation Bandwidth before Minimization	=	120
Equation Bandwidth after Minimization	=	36
Bandwidth before Minimization	=	32
Bandwidth after Minimization	=	5

EQUATION - PARAMETERS:

Number of Equations	=	156
Bandwidth	=	36
Number of Equations per Block	=	28
Number of Blocks	=	6

Nodal Loads (static) or Masses (dynamic)

Node Number	Load Case	X -Axis Force	Y -Axis Force	Z -Axis Force	X -Axis Moment	Y -Axis Moment	Z -Axis Moment
33	1	-1.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00

All Equations are built right !!

Structure Load Case	Element A	Load B	Multipliers C	D
1	.000	.000	.000	.000

Parameter of the Stiffness-Matrix :

minimal Diagonal-Element not equal cero	=	4.221E+01
maximal Diagonal-Element	=	6.570E+09
Maximum/Minimum	=	1.556E+08
Average of the Diagonal-Element	=	5.057E+08
Data-Density of the Stiffness-Matrix	=	15.4 PCT.

S T A T I C - A N A L Y S I S

Load - Case : 1

N O D E D I S P L A C E M E N T S / R O T A T I O N S

Node Number	X- Translation	Y- Translation	Z- Translation	X- Rotation	Y- Rotation	Z- Rotation
1	-5.16513E-05	3.06313E-09	-1.87127E-05	-7.64304E-10	3.87656E-06	-6.04099E-11
2	-5.16518E-05	2.12443E-09	-1.83449E-05	2.40670E-07	3.87862E-06	5.02813E-10
3	-5.18506E-05	-1.36325E-07	1.76354E-04	1.64983E-06	2.73952E-06	1.55628E-09
4	-5.18540E-05	-1.43746E-07	1.88298E-04	1.45345E-06	2.35576E-06	4.58793E-10
5	-5.18129E-05	1.06761E-08	2.02636E-04	1.86007E-09	-2.21992E-06	-1.58136E-08
6	-5.18077E-05	2.31082E-07	2.92838E-05	2.49304E-06	-9.65411E-06	-2.24285E-10
7	-5.18038E-05	2.29974E-07	-1.07384E-05	2.70227E-06	-1.01900E-05	1.48934E-09
8	-5.15032E-05	1.18180E-08	-3.65486E-04	1.04091E-07	-9.52362E-06	8.36848E-10
9	-5.15023E-05	1.02599E-08	-3.65905E-04	9.85629E-10	-9.52276E-06	-6.08421E-11
10	-5.15034E-05	8.69794E-09	-3.65490E-04	-1.02166E-07	-9.52365E-06	-9.58546E-10
11	-5.18100E-05	-2.12920E-07	-1.07476E-05	-2.70328E-06	-1.01922E-05	-1.60509E-09
12	-5.18142E-05	-2.14419E-07	2.92848E-05	-2.49412E-06	-9.65640E-06	1.09064E-10
13	-5.18202E-05	2.66453E-09	2.02677E-04	-2.53387E-09	-2.21992E-06	1.56964E-08
14	-5.18605E-05	1.53734E-07	1.88348E-04	-1.45409E-06	2.35518E-06	-5.76052E-10
15	-5.18568E-05	1.45903E-07	1.76405E-04	-1.65051E-06	2.73901E-06	-1.67393E-09
16	-5.16520E-05	4.00588E-09	-1.83418E-05	-2.42184E-07	3.87861E-06	-6.23586E-10
19	.00000	.00000	.00000	-1.80597E-09	1.30229E-09	-7.57259E-13
20	.00000	.00000	.00000	-1.85446E-09	1.23696E-09	-5.11938E-13
24	.00000	.00000	.00000	-1.29825E-11	2.69158E-10	2.44884E-13
26	.00000	.00000	.00000	1.27890E-11	2.68873E-10	-2.44794E-13
30	.00000	.00000	.00000	1.85805E-09	1.23876E-09	5.12512E-13
31	.00000	.00000	.00000	1.81003E-09	1.30456E-09	7.58308E-13
33	-5.27234E-05	6.67029E-09	2.02589E-04	-3.37430E-10	-2.21992E-06	-5.99153E-11
34	-1.82947E-05	4.02425E-08	-6.40362E-06	1.19953E-07	6.10556E-07	-3.36954E-07
35	-1.98864E-05	6.00656E-08	8.26851E-06	2.11614E-09	7.62747E-07	-2.86699E-09
36	-1.95974E-05	-1.11259E-06	-1.90650E-06	-6.76725E-08	5.75086E-07	3.34954E-07
37	-1.95939E-05	1.11219E-06	-1.90221E-06	6.80567E-08	5.75296E-07	-3.34946E-07
38	-1.98855E-05	-5.41287E-08	8.26513E-06	-1.94117E-09	7.62899E-07	2.74327E-09
39	-1.82980E-05	-2.80115E-08	-6.39770E-06	-1.20040E-07	6.10529E-07	3.36903E-07

B E A M - E L E M E N T (FORCE AND MOMENT)

0 No.	Load No.	Axial R1	Shear R2	Shear R3	Torsion M1	Bending M2	Bending M3	P/A+M2/S2	P/A-M2/S2	P/A+M3/S3	P/A-M3/S3

B E A M - E L E M E N T (FORCE AND MOMENT)

0 No.	Load No.	Axial R1	Shear R2	Shear R3	Torsion M1	Bending M2	Bending M3	P/A+M2/S2	P/A-M2/S2	P/A+M3/S3	P/A-M3/S3
1	1	1.181E-01	-1.862E-03	2.211E-05	1.051E-02	6.384E-01	-1.825E+00				
		-1.181E-01	1.862E-03	-2.211E-05	-1.051E-02	-6.384E-01	1.821E+00				
2	1	8.999E-02	-5.900E-02	-1.708E-02	3.192E-01	5.530E-01	-1.822E+00				
		-8.999E-02	5.900E-02	1.708E-02	-3.192E-01	4.338E-01	-1.586E+00				
3	1	4.850E-02	-9.588E-02	-1.708E-02	5.964E-02	-5.352E-01	1.585E+00				
		-4.850E-02	9.588E-02	1.708E-02	-5.964E-02	6.036E-01	-1.969E+00				
4	1	2.026E-02	-1.055E-01	-1.710E-02	-1.085E-01	-5.967E-01	1.969E+00				
		-2.026E-02	1.055E-01	1.710E-02	1.085E-01	1.106E+00	-5.111E+00				
5	1	4.993E-01	-4.017E-02	-1.710E-02	2.234E-01	-1.134E+00	-3.989E+00				
		-4.993E-01	4.017E-02	1.710E-02	-2.234E-01	1.643E+00	2.793E+00				
6	1	1.801E-01	-9.173E-03	4.448E-01	-2.366E-01	-1.642E+00	-2.793E+00				
		-1.801E-01	9.173E-03	-4.448E-01	2.366E-01	-1.373E-01	2.757E+00				
7	1	-1.697E-01	-9.800E-02	-2.261E-05	-1.363E-01	2.372E-01	-2.757E+00				
		1.697E-01	9.800E-02	2.261E-05	1.363E-01	-2.359E-01	-2.903E+00				
8	1	-1.959E-01	-3.528E-03	-4.713E-05	-4.595E-03	2.726E-01	2.903E+00				
		1.959E-01	3.528E-03	4.713E-05	4.595E-03	-2.727E-01	-2.910E+00				
9	1	-1.959E-01	3.343E-03	-8.763E-05	4.408E-03	2.729E-01	2.910E+00				
		1.959E-01	-3.343E-03	8.763E-05	-4.408E-03	-2.725E-01	-2.903E+00				
10	1	-1.697E-01	9.802E-02	2.783E-05	1.362E-01	2.361E-01	2.903E+00				
		1.697E-01	-9.802E-02	-2.783E-05	-1.362E-01	-2.377E-01	2.758E+00				
11	1	1.804E-01	9.004E-03	-4.450E-01	2.368E-01	1.378E-01	-2.758E+00				
		-1.804E-01	-9.004E-03	4.450E-01	-2.368E-01	1.642E+00	2.794E+00				
12	1	4.992E-01	4.012E-02	1.710E-02	-2.233E-01	-1.644E+00	-2.794E+00				
		-4.992E-01	-4.012E-02	-1.710E-02	2.233E-01	1.135E+00	3.988E+00				
13	1	2.032E-02	1.055E-01	1.709E-02	1.085E-01	-1.105E+00	5.110E+00				
		-2.032E-02	-1.055E-01	-1.709E-02	-1.085E-01	5.968E-01	-1.970E+00				
14	1	4.860E-02	9.597E-02	1.710E-02	-5.962E-02	-6.037E-01	1.970E+00				
		-4.860E-02	-9.597E-02	-1.710E-02	5.962E-02	5.353E-01	-1.586E+00				
15	1	9.001E-02	5.900E-02	1.708E-02	-3.192E-01	-4.338E-01	1.586E+00				
		-9.001E-02	-5.900E-02	-1.708E-02	3.192E-01	-5.529E-01	1.821E+00				

16	1	1.181E-01	2.135E-03	1.324E-05	-1.056E-02	6.383E-01	-1.821E+00
		-1.181E-01	-2.135E-03	-1.324E-05	1.056E-02	-6.384E-01	1.825E+00

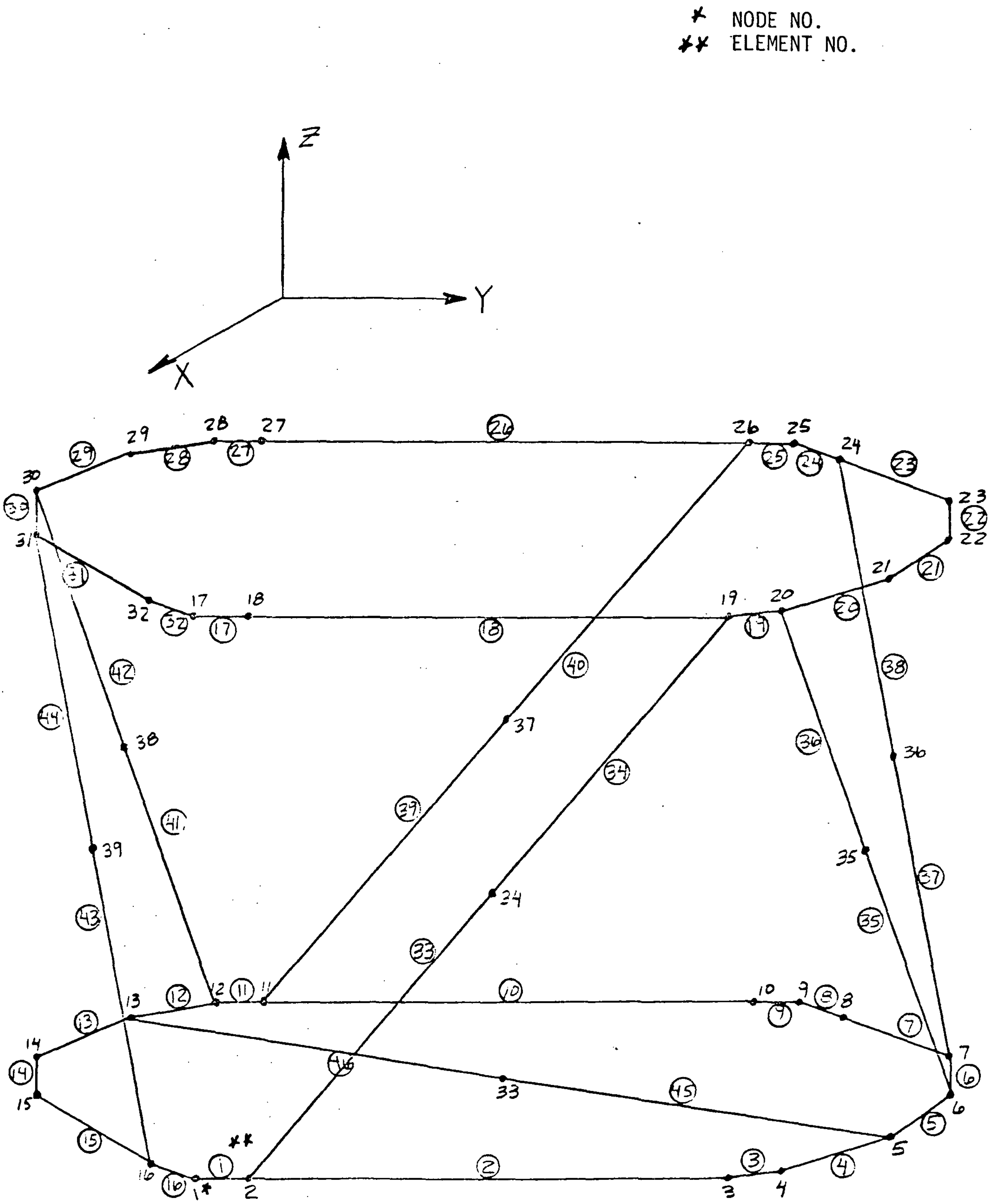
B E A M - E L E M E N T (FORCE AND MOMENT)

O No.	Load No.	Axial R1	Shear R2	Snear R3	Torsion M1	Bending M2	Bending M3	P/A+M2/S2	P/A-M2/S2	P/A+M3/S3	P/A-M3/S3
17	1	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00				
		.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00				
18	1	.000E+00	-7.090E-06	-8.683E-06	-3.834E-04	1.671E-04	-1.198E-04				
		.000E+00	7.090E-06	8.683E-06	3.834E-04	3.343E-04	-2.896E-04				
19	1	.000E+00	-5.937E-05	7.015E-04	-2.540E-05	-1.510E-03	-5.160E-04				
		.000E+00	5.937E-05	-7.015E-04	2.540E-05	-1.296E-03	2.785E-04				
20	1	.000E+00	-1.170E-05	2.681E-05	7.689E-04	-5.322E-04	-2.854E-04				
		.000E+00	1.170E-05	-2.681E-05	-7.689E-04	-2.659E-04	-6.271E-05				
21	1	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00				
		.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00				
22	1	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00				
		.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00				
23	1	.000E+00	2.293E-06	1.387E-06	4.278E-05	-2.670E-05	3.875E-05				
		.000E+00	-2.293E-06	-1.387E-06	-4.278E-05	-5.341E-05	9.367E-05				
24	1	.000E+00	1.162E-05	1.185E-04	-1.466E-03	-1.646E-04	6.044E-04				
		.000E+00	-1.162E-05	-1.185E-04	1.466E-03	-7.243E-05	-7.812E-04				
25	1	.000E+00	-1.162E-05	-1.171E-04	1.464E-03	7.160E-05	7.809E-04				
		.000E+00	1.162E-05	1.171E-04	-1.464E-03	1.627E-04	-8.041E-04				
26	1	.000E+00	-2.292E-06	-1.384E-06	-4.275E-05	5.330E-05	-9.363E-05				
		.000E+00	2.292E-06	1.384E-06	4.275E-05	2.664E-05	-3.873E-05				
27	1	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00				
		.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00				
28	1	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00				
		.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00				
29	1	.000E+00	1.171E-05	-2.684E-05	-7.703E-04	2.662E-04	6.278E-05				
		.000E+00	-1.171E-05	2.684E-05	7.703E-04	5.328E-04	2.858E-04				
30	1	.000E+00	5.945E-05	-7.009E-04	2.363E-05	1.294E-03	-2.792E-04				
		.000E+00	-5.945E-05	7.009E-04	-2.363E-05	1.509E-03	5.169E-04				
31	1	.000E+00	7.100E-06	8.706E-06	3.841E-04	-3.352E-04	2.900E-04				
		.000E+00	-7.100E-06	-8.706E-06	-3.841E-04	-1.676E-04	1.200E-04				
32	1	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00				
		.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00				

33	1	2.110E-02	1.700E-05	-3.532E-06	.000E+00	.000E+00	.000E+00
		-2.110E-02	-1.700E-05	3.532E-06	.000E+00	1.743E-04	8.365E-04

B E A M - E L E M E N T (FORCE AND MOMENT)

O No.	Load No.	Axial R1	Shear R2	Shear R3	Torsion M1	Bending M2	Bending M3	P/A+M2/S2	P/A-M2/S2	P/A+M3/S3	P/A-M3/S3
34	1	2.110E-02	-8.609E-06	-1.461E-05	9.242E-10	1.452E-03	-8.708E-04				
		-2.110E-02	8.609E-06	1.461E-05	-9.242E-10	-7.310E-04	4.461E-04				
35	1	-5.697E-01	-7.436E-06	-1.686E-05	.000E+00	.000E+00	.000E+00				
		5.697E-01	7.436E-06	1.686E-05	.000E+00	8.315E-04	-3.668E-04				
36	1	-5.697E-01	-7.380E-06	-1.733E-05	-1.639E-09	1.691E-03	-7.201E-04				
		5.697E-01	7.380E-06	1.733E-05	1.639E-09	-8.362E-04	3.560E-04				
37	1	5.487E-01	-7.118E-06	-1.057E-05	.000E+00	.000E+00	.000E+00				
		-5.487E-01	7.118E-06	1.057E-05	.000E+00	5.216E-04	-3.512E-04				
38	1	5.487E-01	2.328E-05	-2.503E-06	-8.357E-09	2.238E-04	1.769E-03				
		-5.487E-01	-2.328E-05	2.503E-06	8.357E-09	-1.004E-04	-6.208E-04				
39	1	5.489E-01	-7.095E-06	1.065E-05	.000E+00	.000E+00	.000E+00				
		-5.489E-01	7.095E-06	-1.065E-05	.000E+00	-5.256E-04	-3.500E-04				
40	1	5.489E-01	2.321E-05	2.390E-06	6.343E-09	-2.218E-04	1.768E-03				
		-5.489E-01	-2.321E-05	-2.390E-06	-6.343E-09	1.039E-04	-6.229E-04				
41	1	-5.700E-01	-7.445E-06	1.689E-05	.000E+00	.000E+00	.000E+00				
		5.700E-01	7.445E-06	-1.689E-05	.000E+00	-8.332E-04	-3.673E-04				
42	1	-5.700E-01	-7.361E-06	1.727E-05	1.649E-09	-1.690E-03	-7.201E-04				
		5.700E-01	7.361E-06	-1.727E-05	-1.649E-09	8.377E-04	3.570E-04				
43	1	2.105E-02	1.697E-05	3.605E-06	.000E+00	.000E+00	.000E+00				
		-2.105E-02	-1.697E-05	-3.605E-06	.000E+00	-1.778E-04	8.372E-04				
44	1	2.105E-02	-8.742E-06	1.455E-05	7.684E-09	-1.450E-03	-8.739E-04				
		-2.105E-02	8.742E-06	-1.455E-05	-7.684E-09	7.326E-04	4.426E-04				
45	1	-1.897E-01	5.000E-01	9.198E-06	-3.010E-04	8.660E-01	9.100E+00				
		1.897E-01	-5.000E-01	-9.198E-06	3.010E-04	-8.670E-01	2.153E+01				
46	1	-1.897E-01	5.000E-01	-2.984E-05	-3.704E-04	-8.655E-01	9.098E+00				
		1.897E-01	-5.000E-01	2.984E-05	3.704E-04	8.669E-01	2.153E+01				



FINITE ELEMENT MODEL OF CONCEPT NO. 12