Fermilab

SDC SOLENOID DESIGN NOTE #139

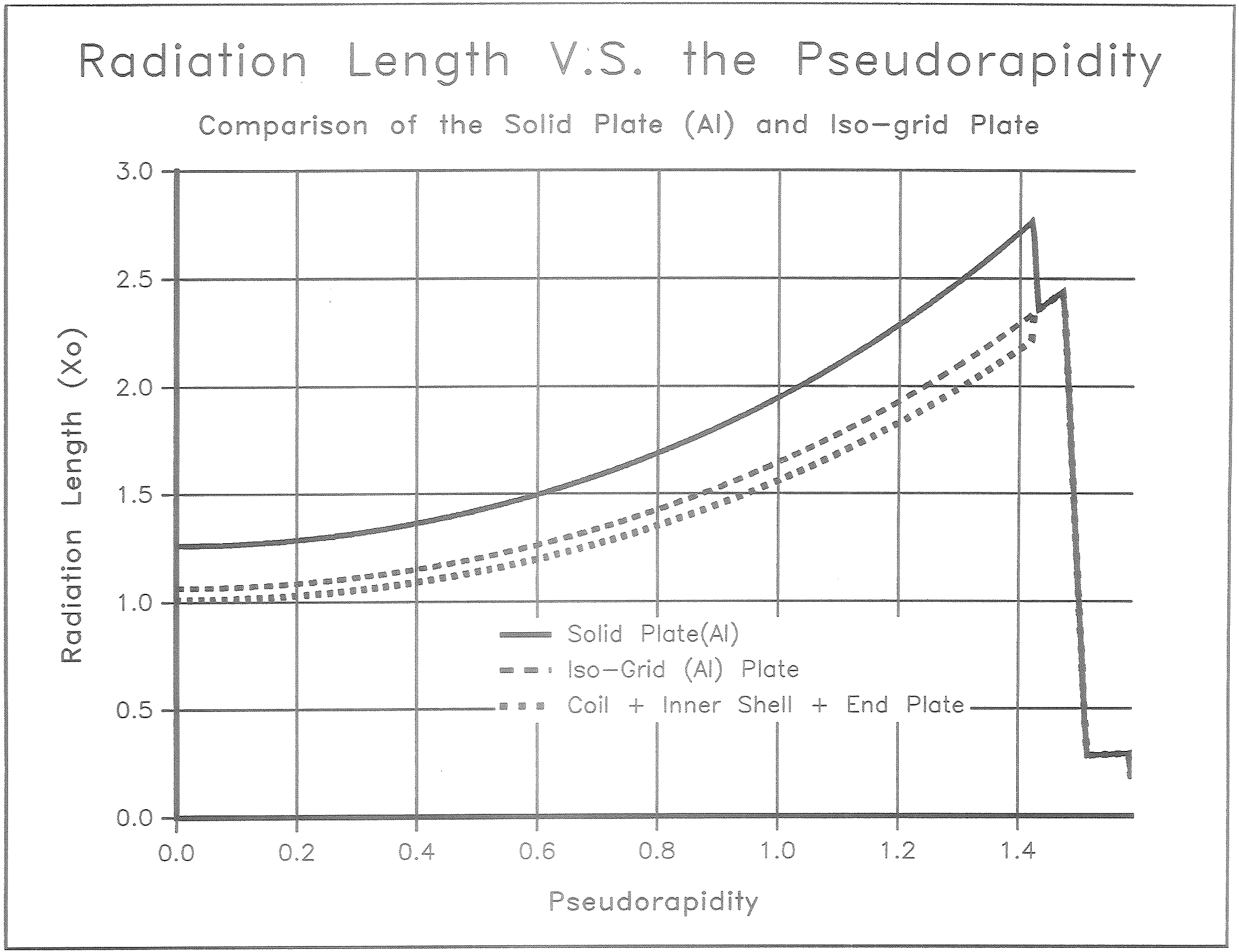
PRESENTATION BEFORE SDC TECHNICAL BOARD

SUPERCONDUCTING SOLENOID

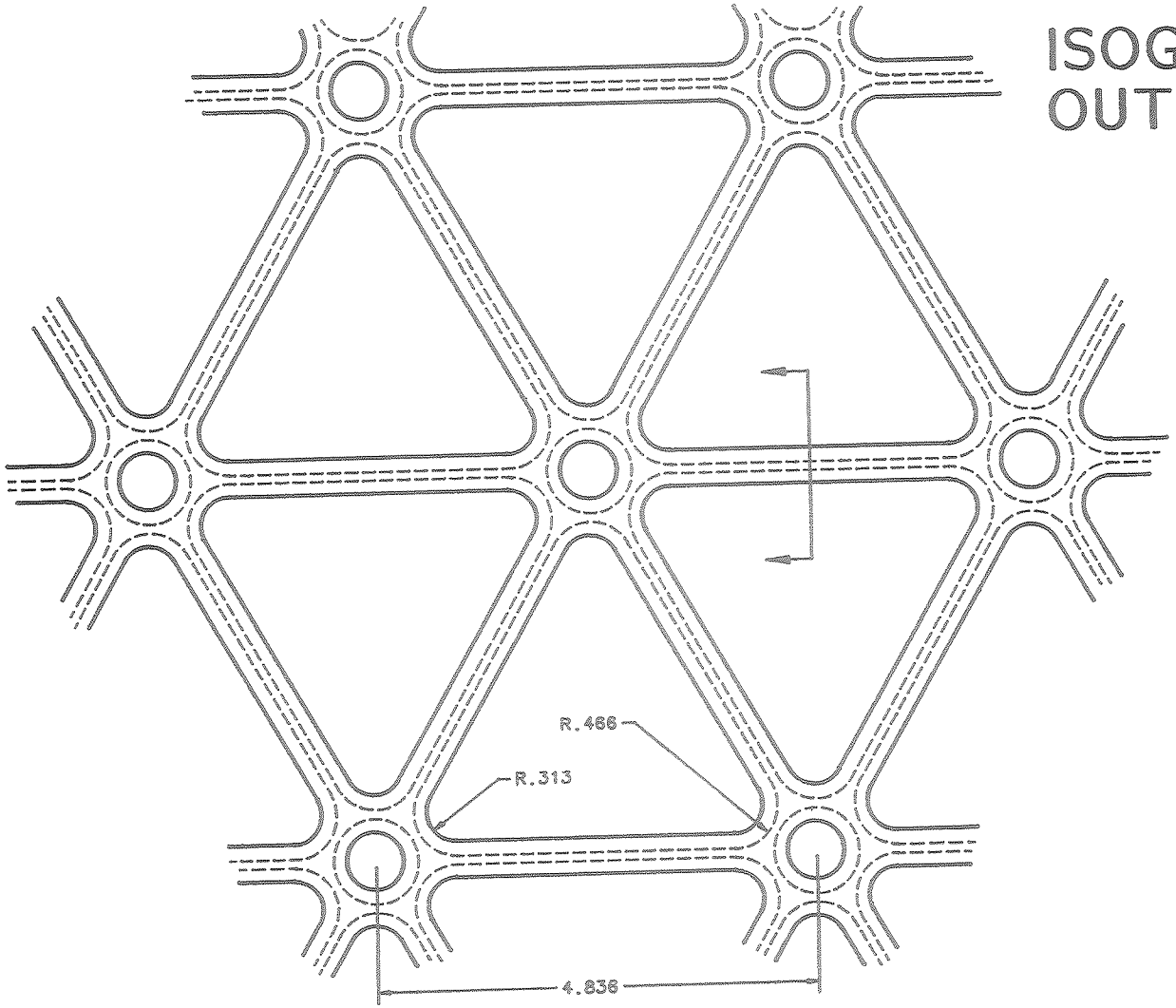
SUMMARY OF FY 91 R & D FY 92 R & D PLAN AND BUDGET

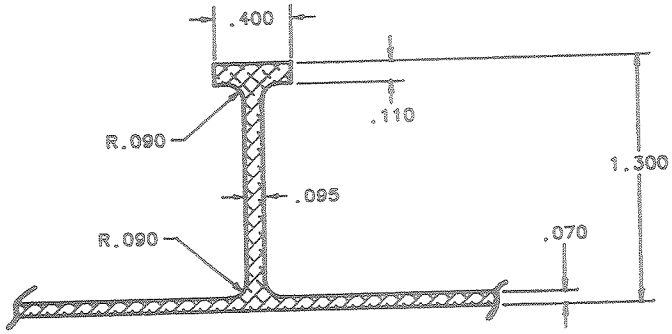
BOB KEPHART

APRIL 12, 1991


Radiation Length V.S. the Pseudorapidity
Comparison of the Solid Plate (Al) and Iso-grid Plate
Radiation Length (Xo)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Pseudorapidity
Solid Plate(Al)
Iso-Grid (Al) Plate
Coil + Inner Shell + End Plate

ISOGRID FOR OUTER VACUUM SHELL





SECTION
SCALE: 2:1

ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.

PARTS LIST

UNLESS OTHERWISE SPECIFIED	ORIGINATOR	R. FAST/ C. GROZIS	4/91
FRACTIONS / DECIMALS / ANGLES	DRAWN	D. FRIEND	4/4/91
± / ± / ±	CHECKED		
1. BREAK ALL SHARP EDGES 1/64 MAX. 2. DO NOT SCALE DRWG. 3. DIMENSIONING IN ACCORD WITH ANSI Y14.5 STD's.	APPROVED		
	USED ON		
√ MAX. ALL MACHINED SURFACES	MATERIAL		C

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

SOLENOIDAL DETECTOR COLLABORATION
SUPERCONDUCTING SOLENOID
PSA'S ISOGRID DETAIL

SCALE	DRAWING NUMBER	SHEET NO.	REV.
1:1		1	

PARTICIPATION IN SOLENOID R & D

KEK A. Yamamoto

Industrial partner:
Toshiba Corp.

Fermilab

R. Kephart	W. Foster
R. Fast	R. Stanek
B. Wands	L. Bartoszek
A. Stefanik	J. Grimson
J. Krebs	C. Drennan
A. Lee	
C. Grozis	
D. Friend	

Industrial partner:
PS Associates P. Slysh

DIVISION OF 91-92 R & D EFFORT

KEK	Both	Fermilab
Conductor	Magnetics	Vacuum vessel
Coil design	EM forces	Chimney
Coil winding	Quench analysis	Supports
Prototype coil, outer support cylinder		Cryogenics
		High-current electrical equipment
		Prototype cryostat

Assembly of prototype

Testing of prototype

Write procurement design report

SUMMARY OF FERMILAB R & D

Outer vacuum shell--investigated honeycombs, carbon -epoxy composites and isogrid. Placed contract with PS Associates, Inc. for feasibility and preliminary design study of aluminum isogrid.

Chimney--calculated that the chimney must be one square foot. Preferred route is straight up through calorimeter and muon system.

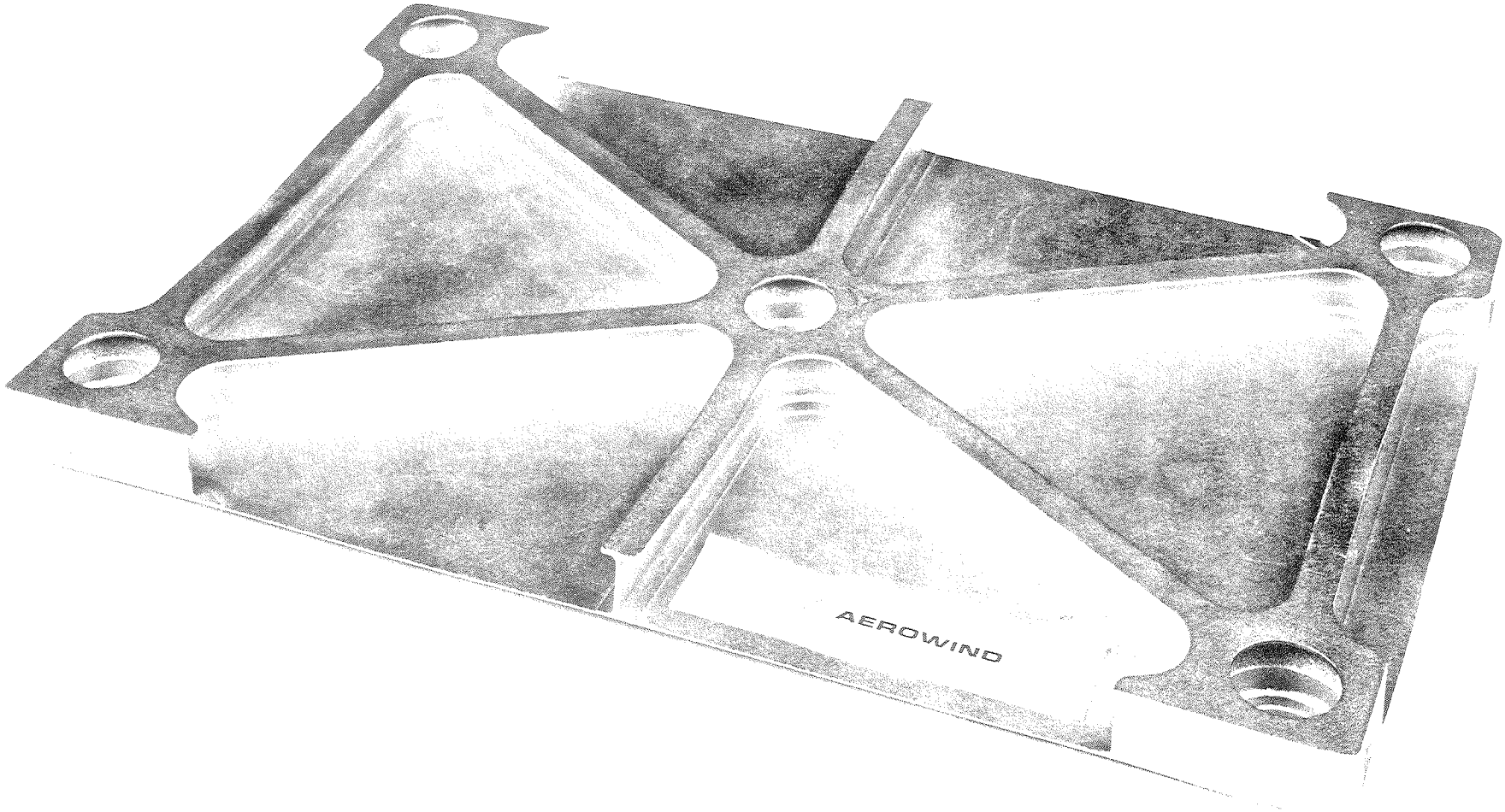
Supports--studied many possibilities, are concentrating now on a Warren truss at one end and a system of radial supports on the other.

Cryogenics--performed heat load analysis and sized refrigerator. Studied several 4.5-K cooling schemes.

High-current electrical equipment--located vendors for 10-kA power supply, dump switch and dump resistor; sized bus to surface.

Magnetostatics--using ANSYS studied the effect of iron calorimeter geometry on coil forces. Studied effects of axial preload.

Quench analysis--developed a method to use ANSYS to follow quench propagation and calculate coil temperature following a quench.


AEROWIND

SUMMARY OF KEK R & D

Conductor development--leading to a high-strength, low-resistivity Al/Cu/Nb-Ti composite conductor

Development of winding technique and equipment for winding on the inside of the outer suppport cylinder--with Toshiba as partner

Practice winding at Toshiba

KEK DATA ON CONDUCTOR

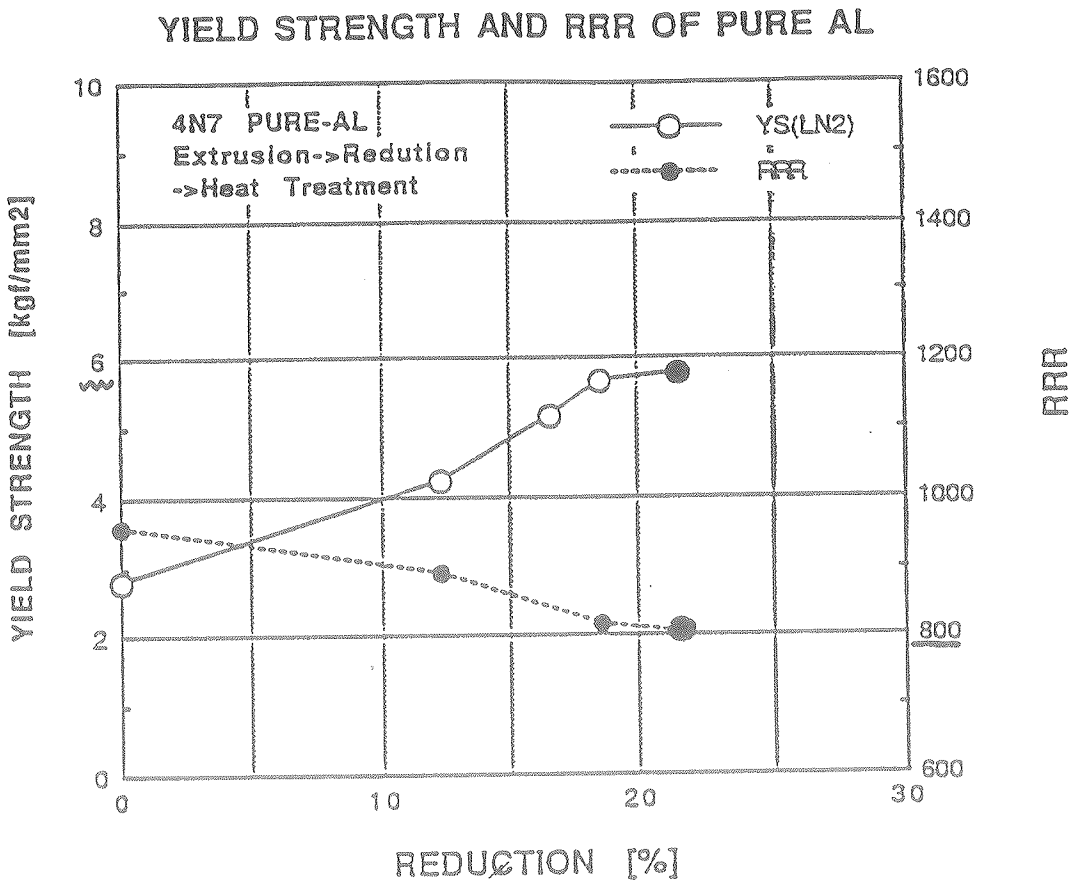
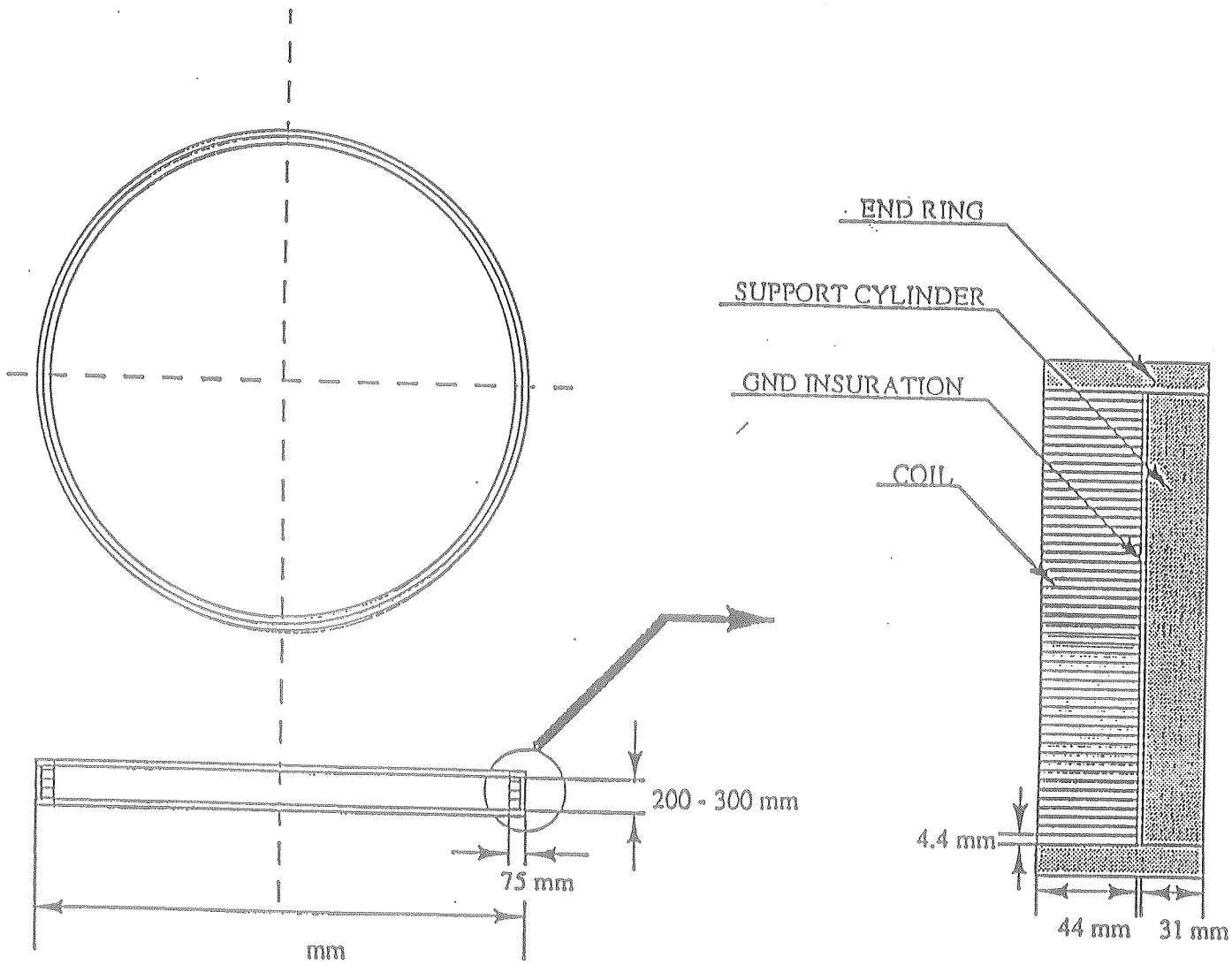
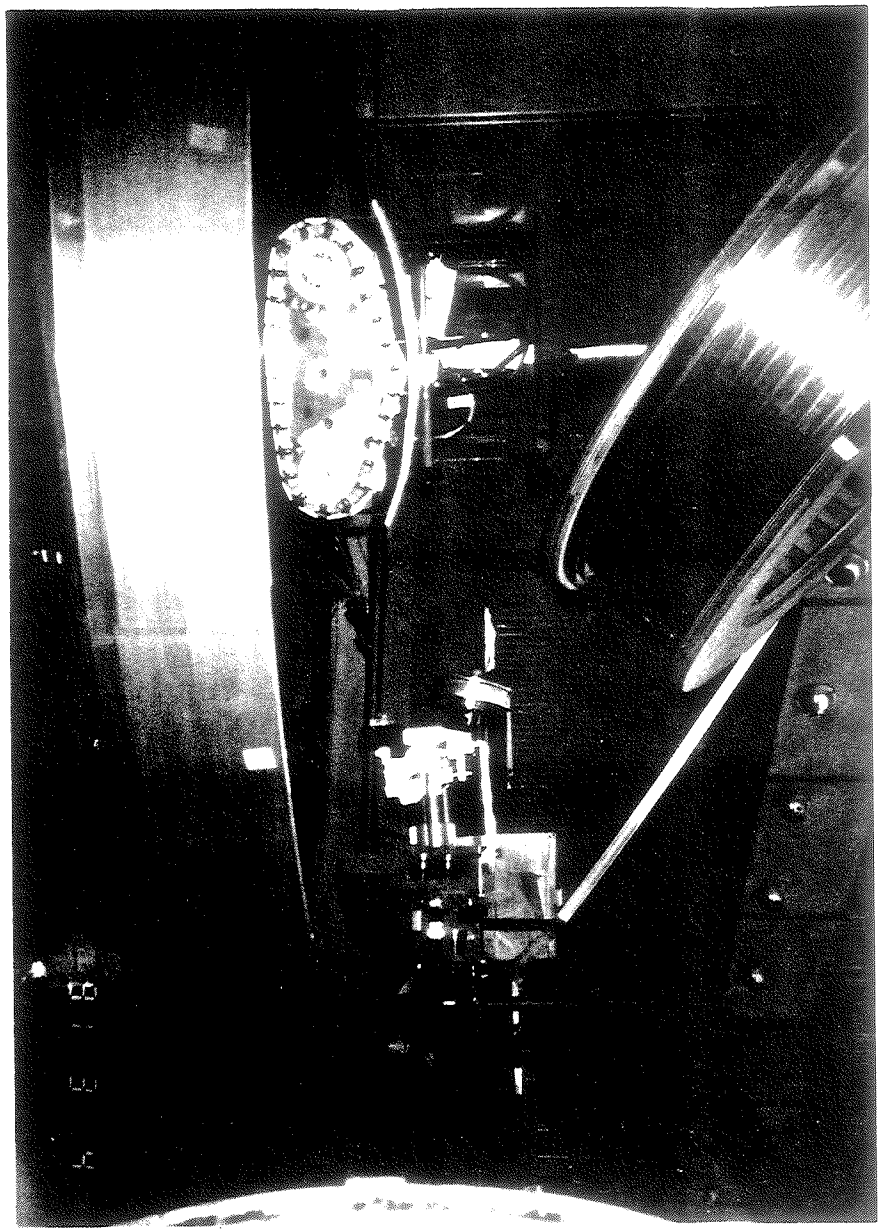
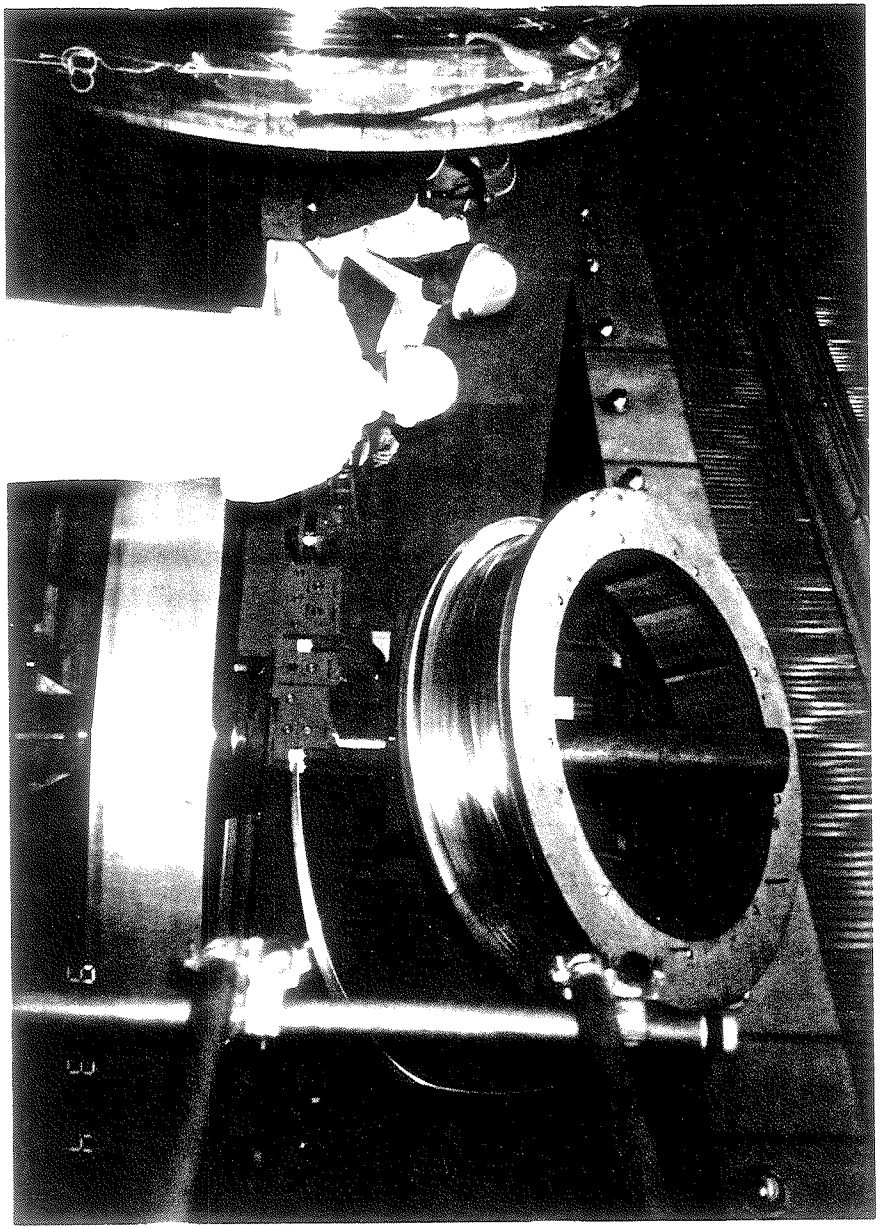


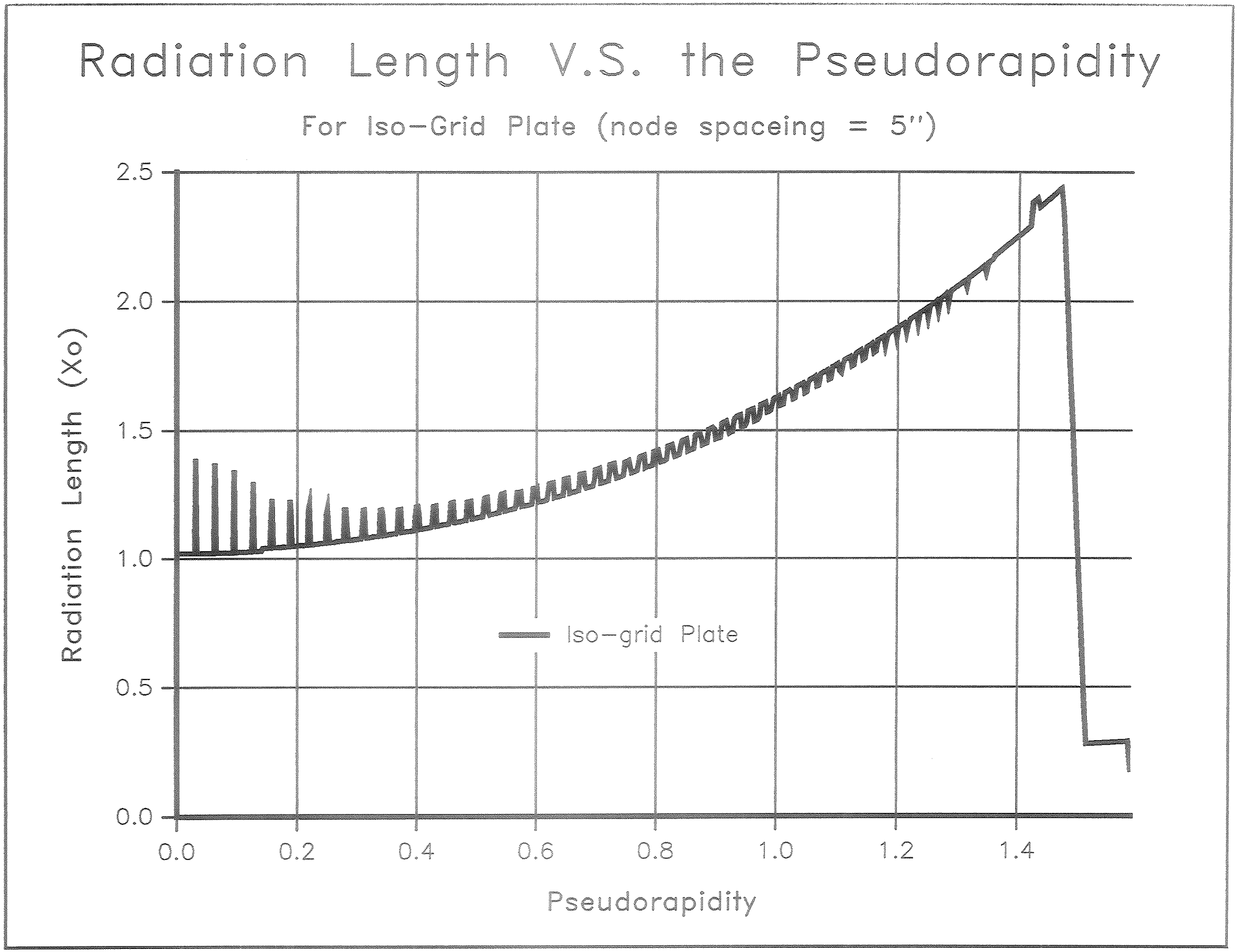
Fig. 8. RRR and yield strength of pure aluminum stabilizer as a function of size reduction ratio during cold work.

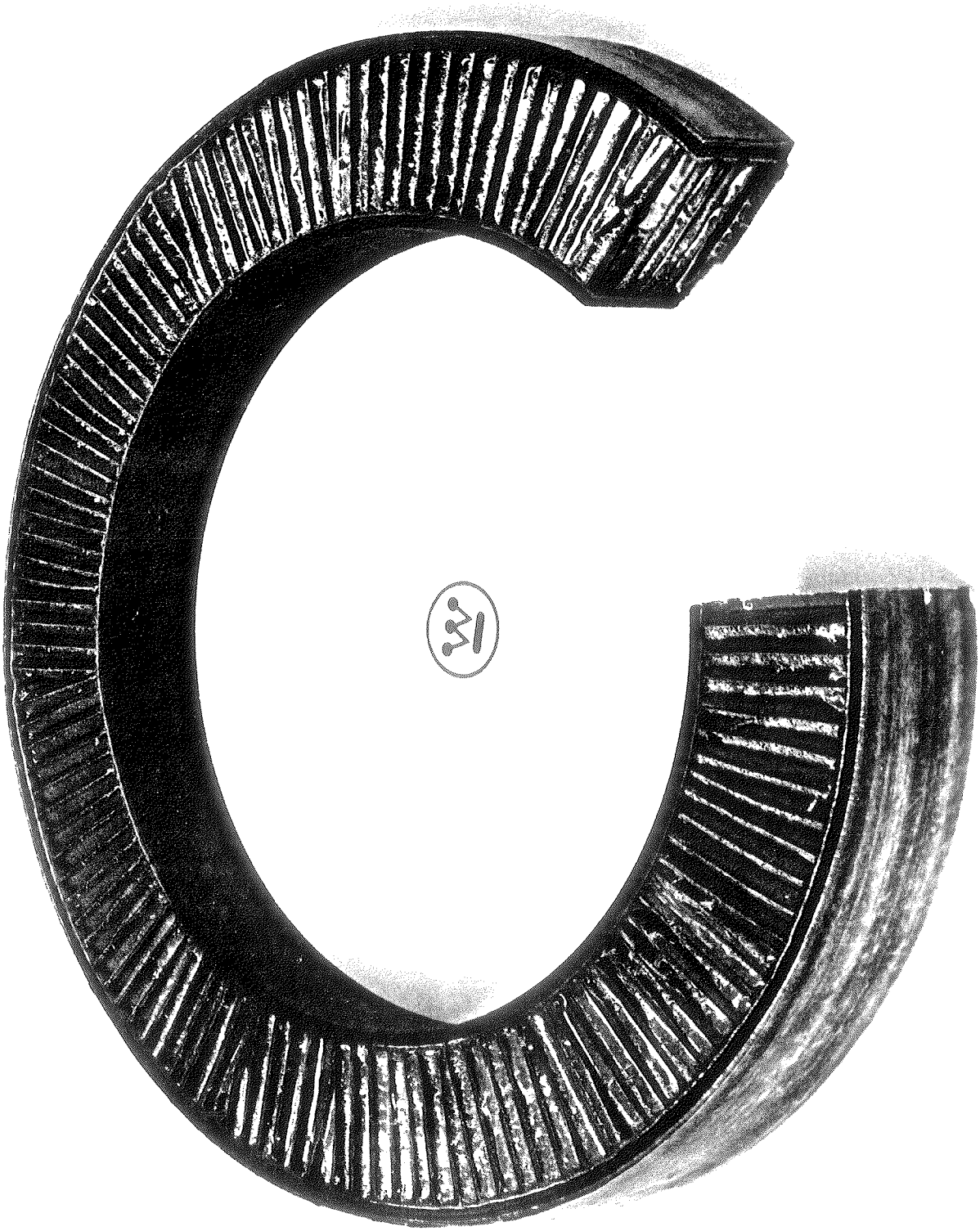
KEK MODEL COIL
WINDING IN PROGRESS AT TOSHIBA

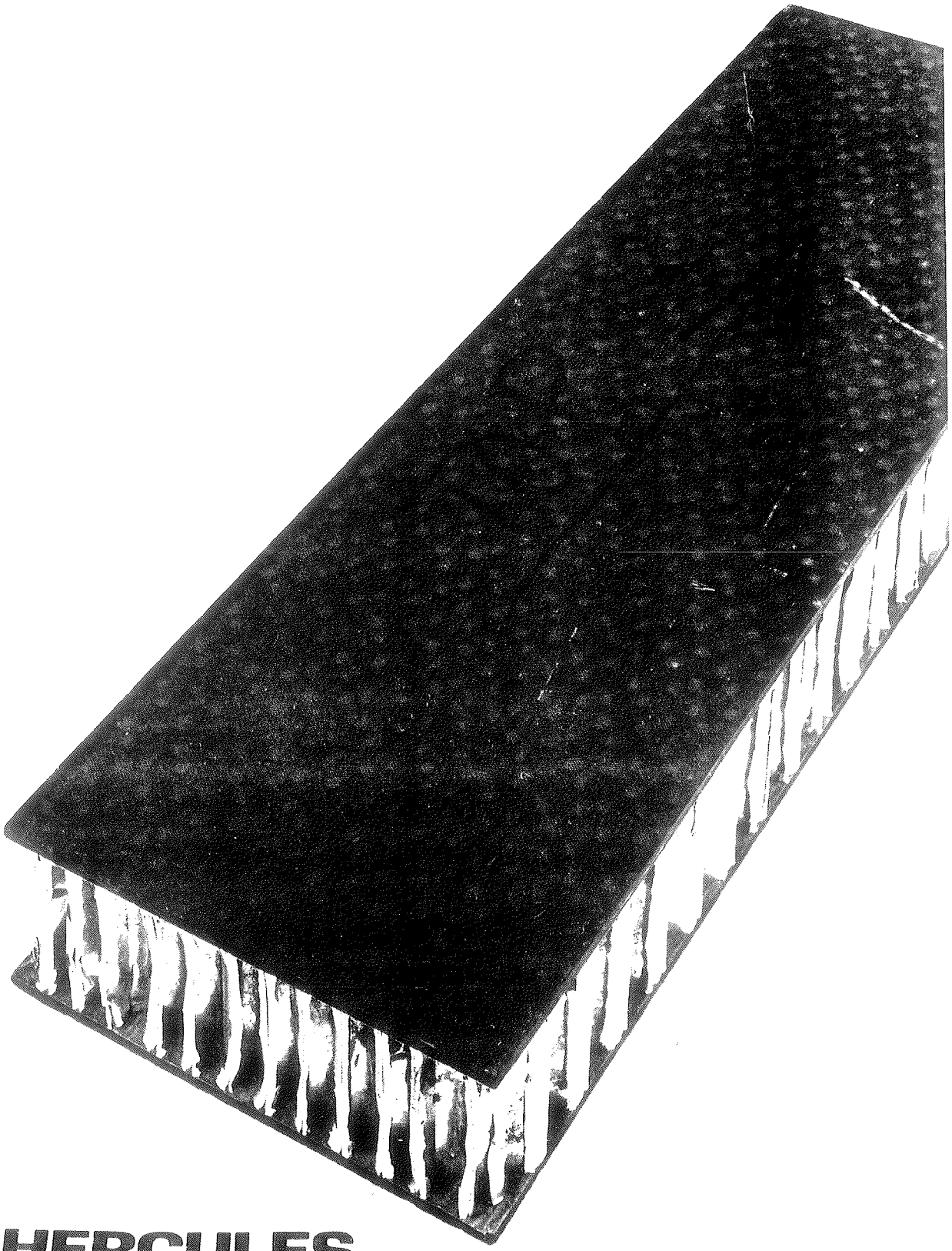






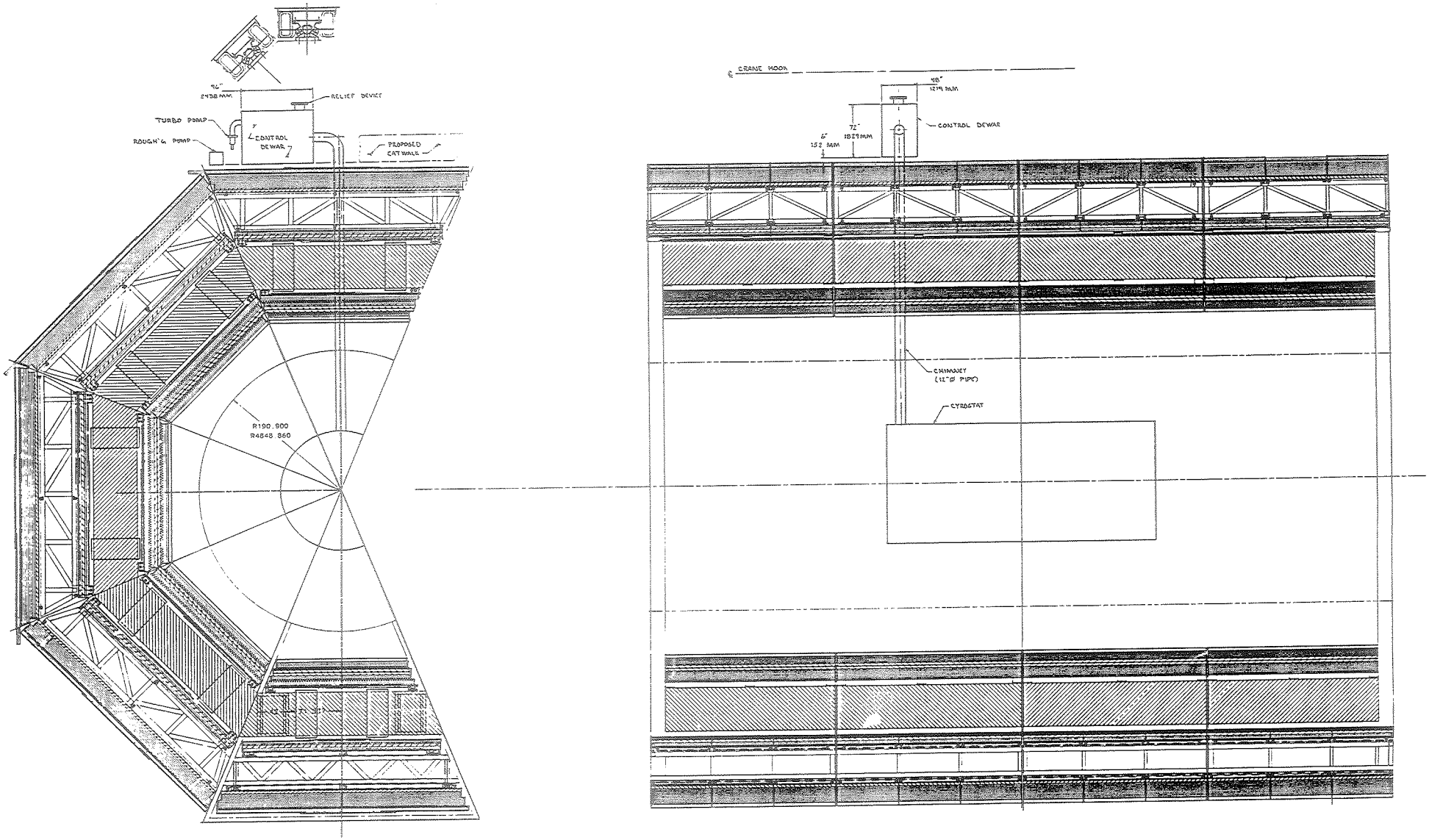

Radiation Length V.S. the Pseudorapidity
For Iso-Grid Plate (node spaceing = 5")
Radiation Length (Xo)
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Pseudorapidity
Iso-grid Plate


31

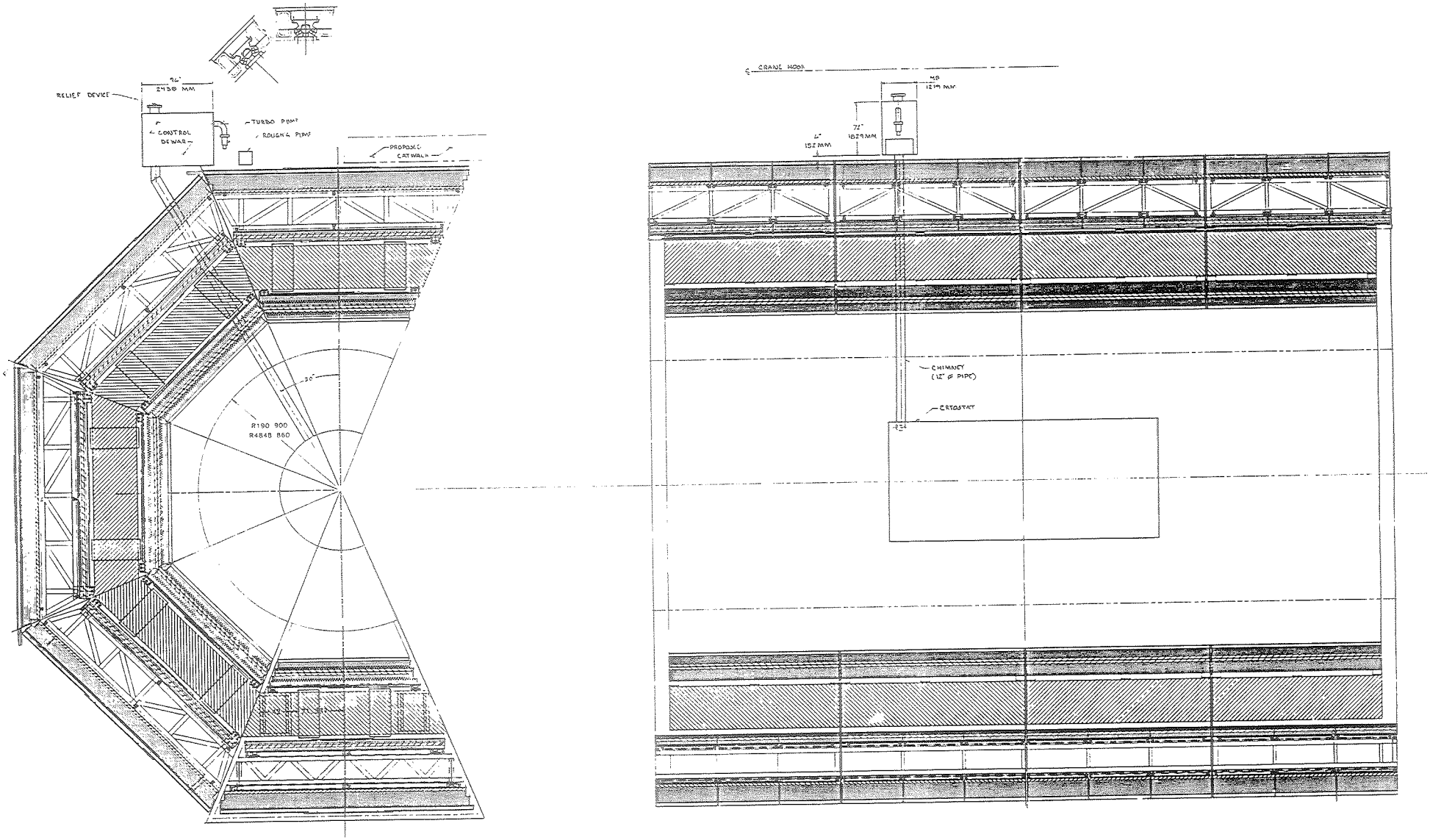


HERCULES

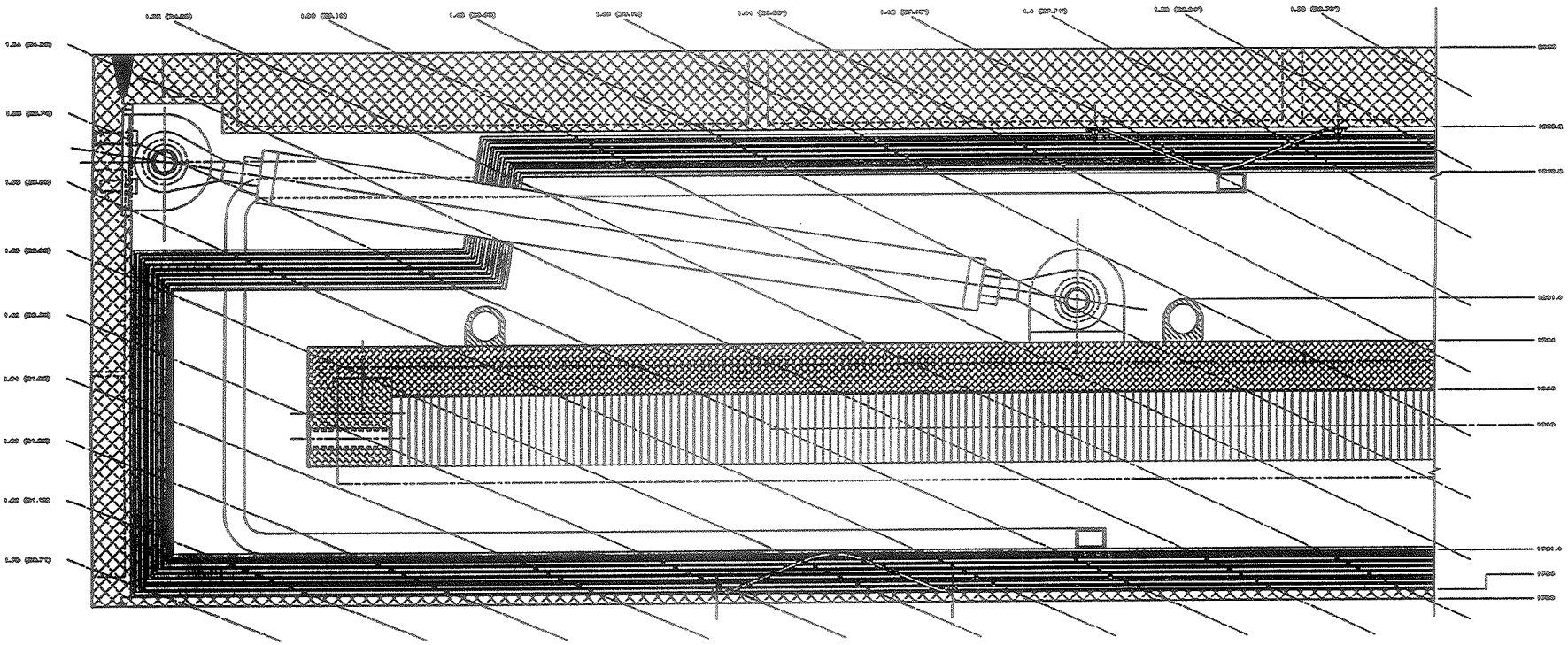
Chimney viewgraphs from DN #134 were shown here.



CRYO CHIMNEY THROUGH DETECTOR--ROUTE A



CRYO CHIMNEY THROUGH DETECTOR--ROUTE B



WARREN TRUSS SUPPORT ON NEAR END PROVIDES AXIAL AND RADIAL STIFFNESS

PARTS LIST

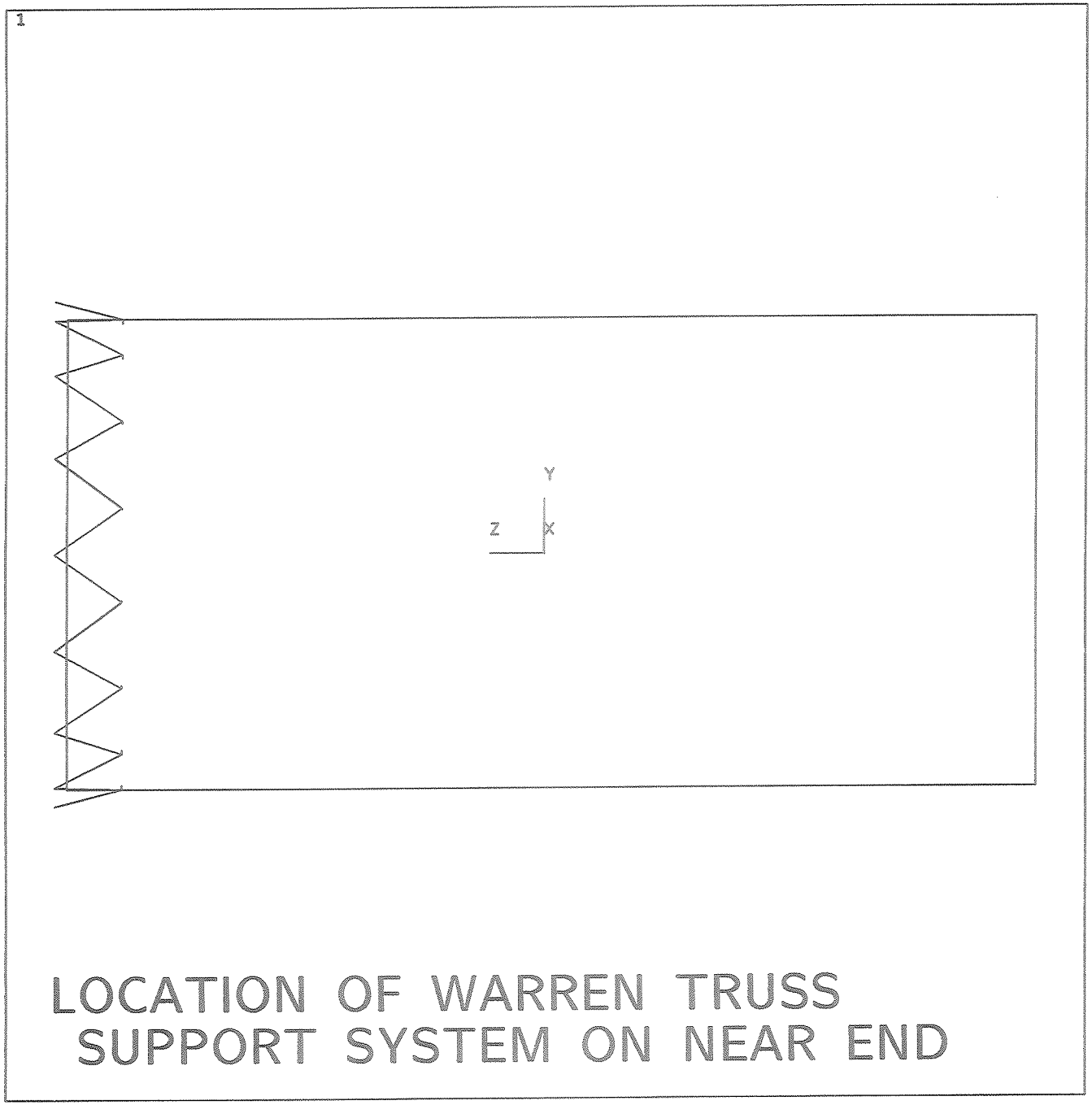
E

COLLEGE LABORATORY
DEPARTMENT OF ENERGY

TOR COLLABORATION
IOTING SOLENOID
D SHELL MODIFIED (A3)

FULL

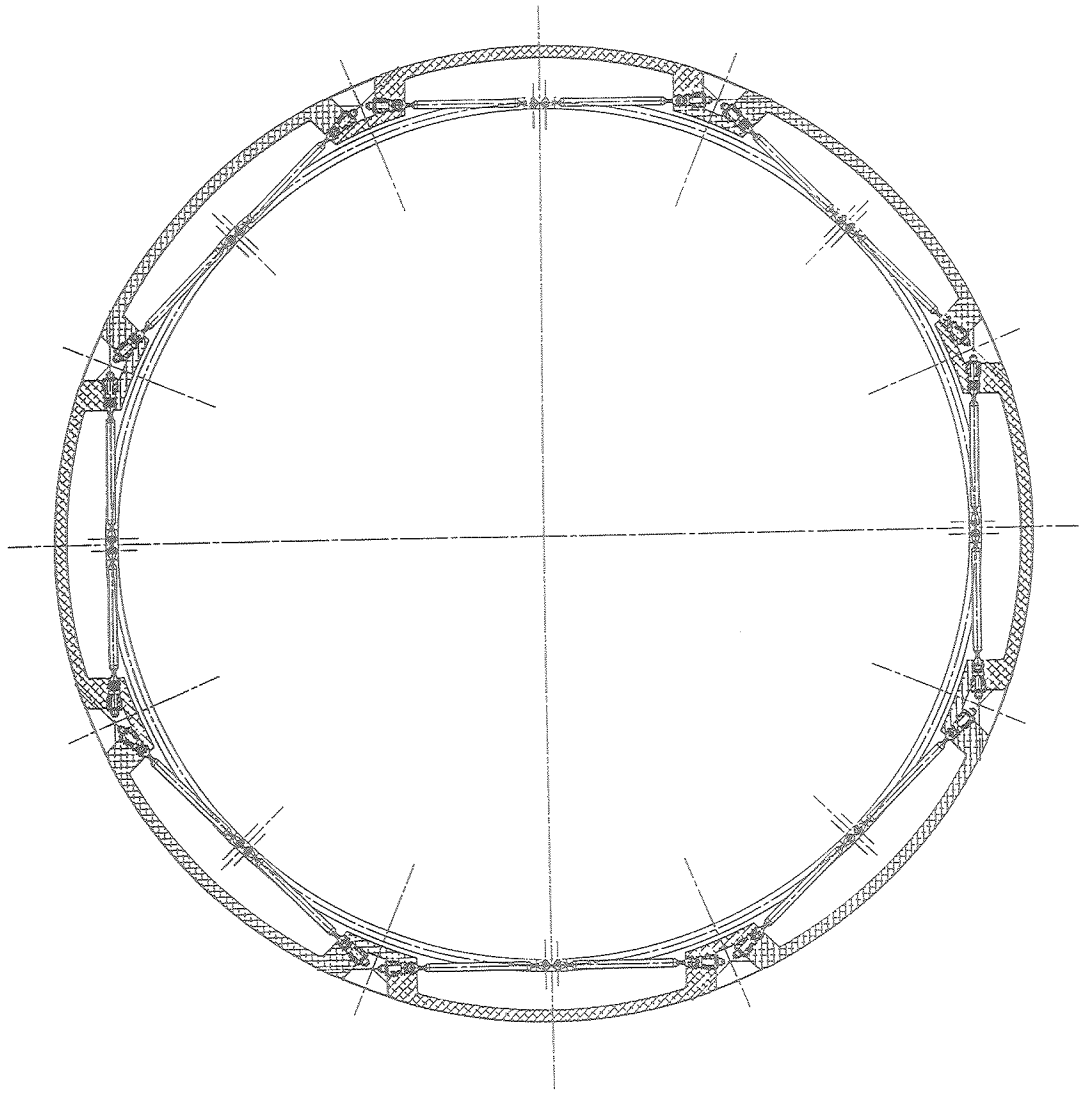
1



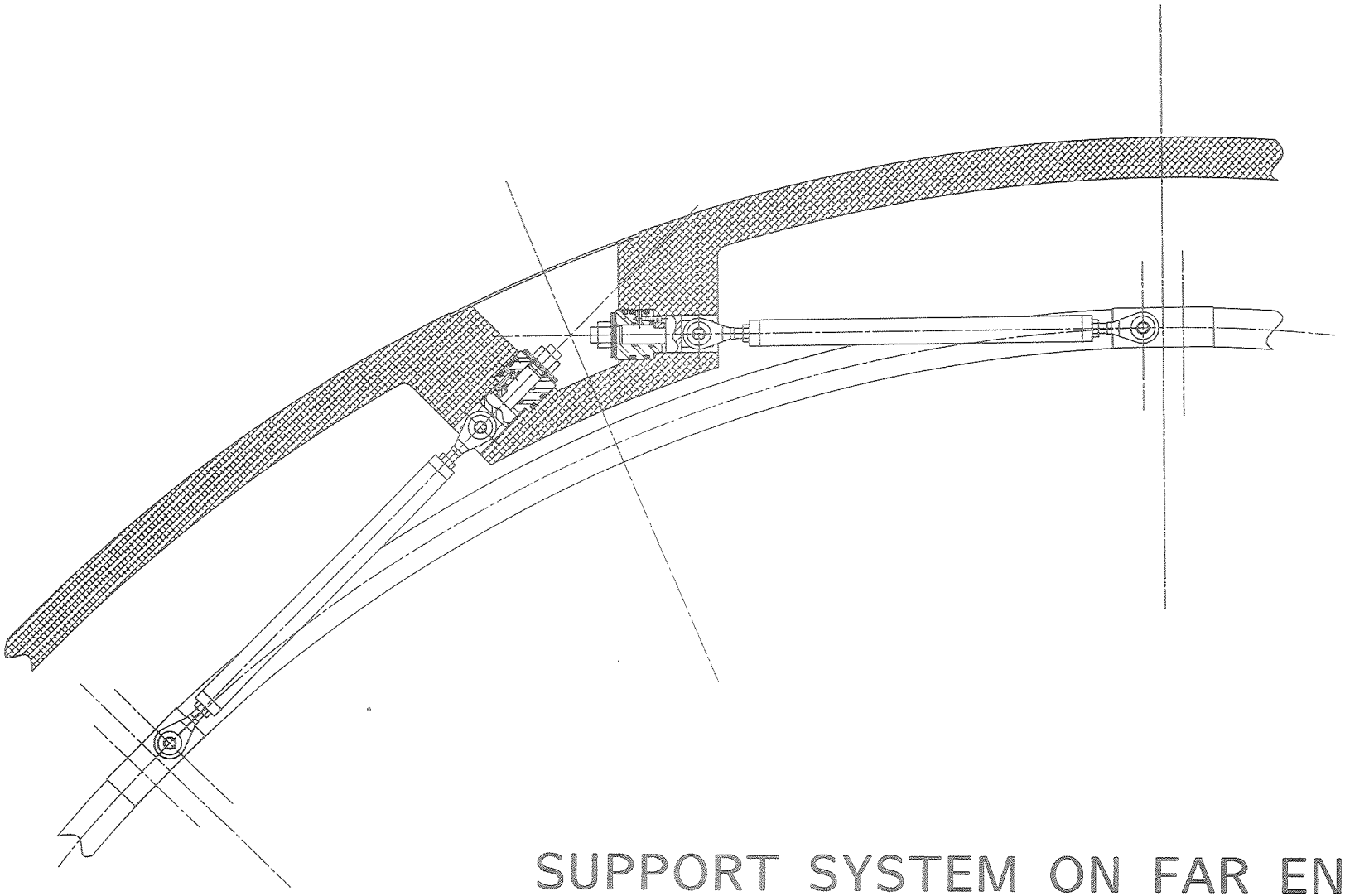
ANSYS 4.4A
APR 9 1991
9:02:24
PLOT NO. 1
POST1 ELEMENTS
TYPE NUM

XV =1
DIST=168.806
XF =39
EDGE

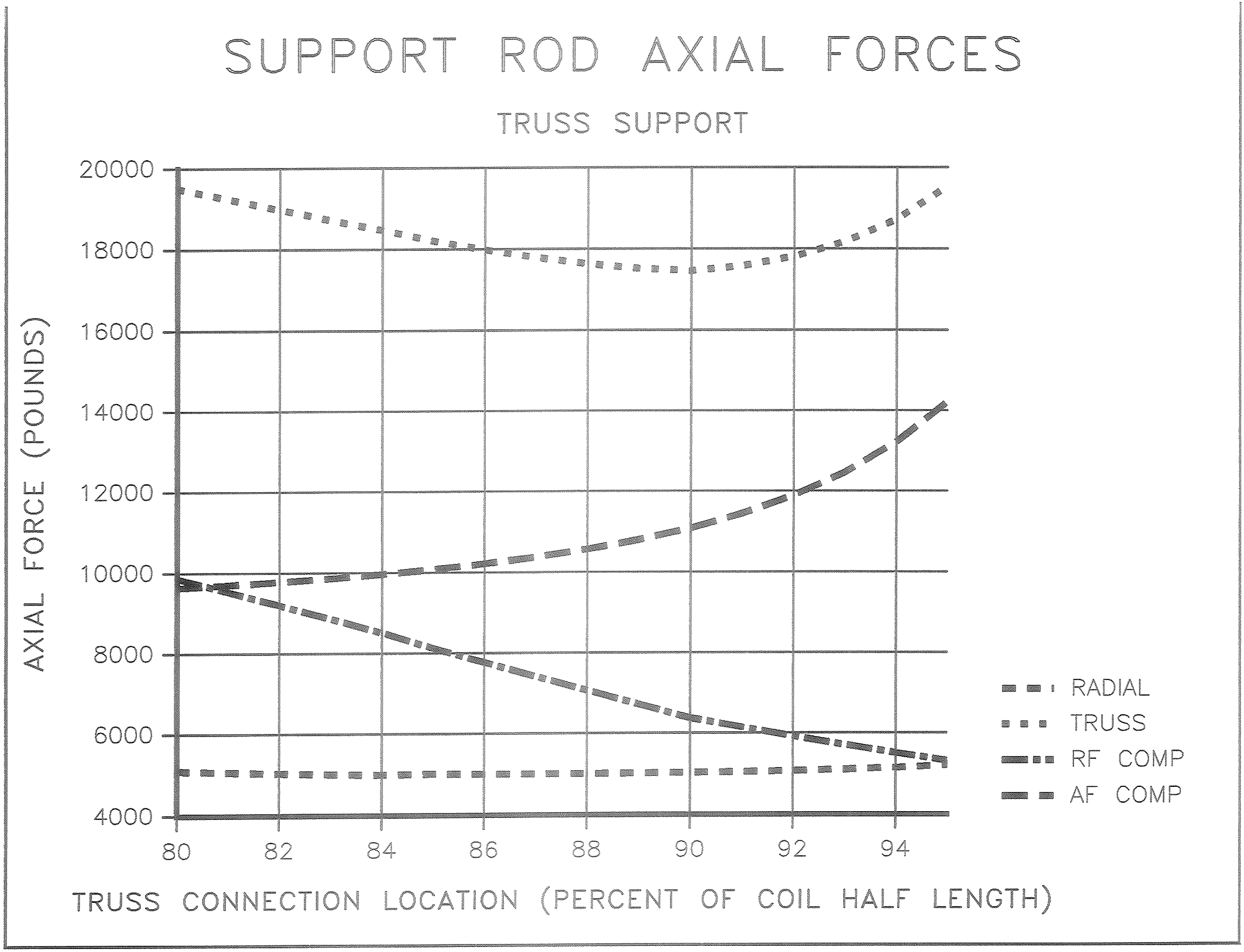
LOCATION OF WARREN TRUSS
SUPPORT SYSTEM ON NEAR END

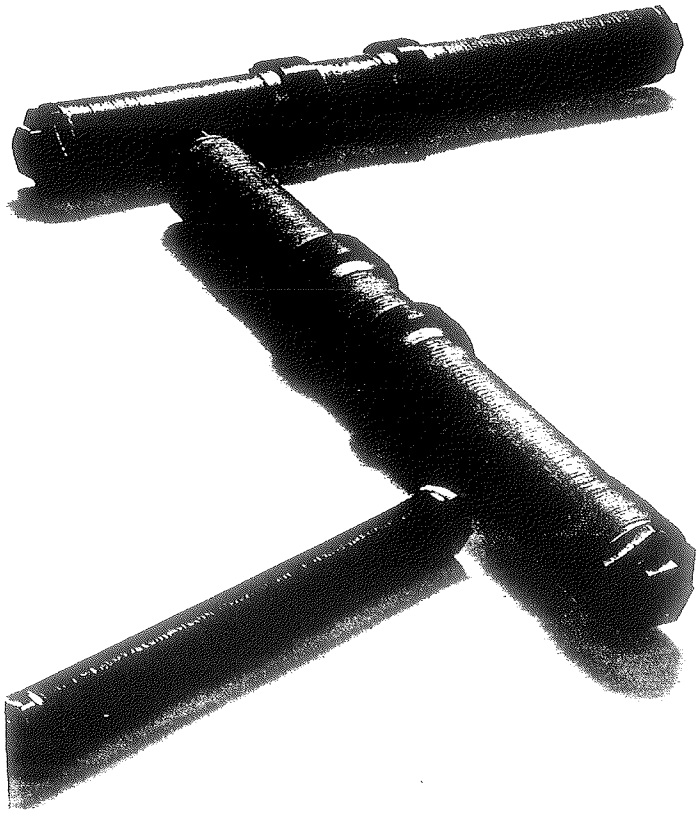


SUPPORT SYSTEM ON FAR END
PROVIDES RADIAL STIFFNESS ONLY



SUPPORT SYSTEM ON FAR END,
DETAIL

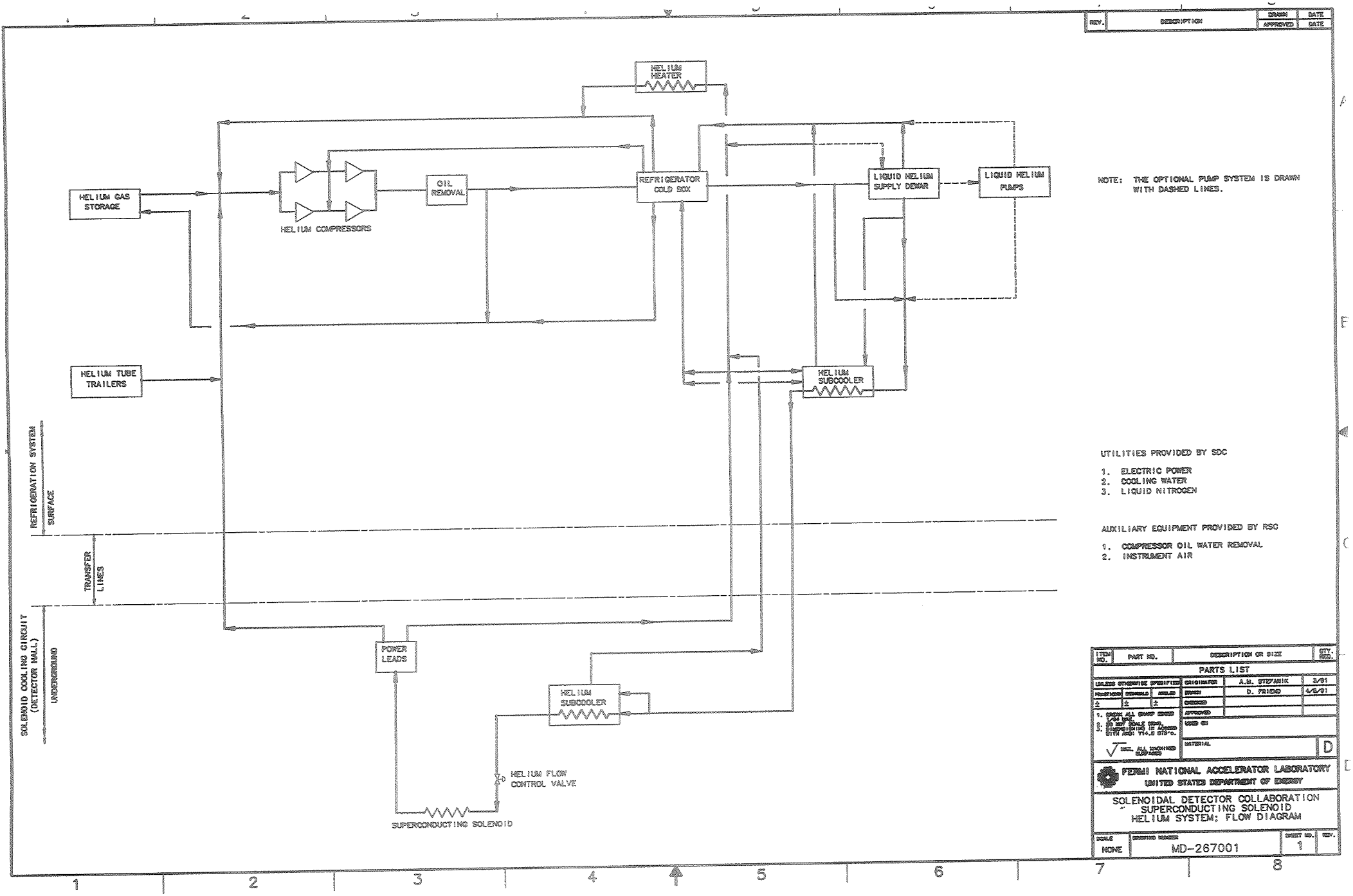

SUPPORT ROD AXIAL FORCES
TRUSS SUPPORT
AXIAL FORCE (POUNDS)
20000
18000
16000
14000
12000
10000
8000
6000
4000
80
82
84
86
88
90
92
94
TRUSS CONNECTION LOCATION (PERCENT OF COIL HALF LENGTH)
RADIAL
TRUSS
RF COMP
AF COMP



STRUCTURAL
COMPOSITES
INDUSTRIES

POSSIBLE COMPOSITE SUPPORTS

Refrigeration viewgraphs from DN #134 were shown here.



POSSIBLE FLOW SCHEMATIC OF HELIUM SYSTEM

ELECTRICAL EQUIPMENT

10-kA BUS

A copper area of 17 in^2 minimizes capital + 10-year operating cost.

Voltage drop: 5.5 mV/ft Power loss: 55 W/ft
Capital cost: 400 $/ft Operating cost: 40 $/ft-yr

10-kA, 30-V POWER SUPPLY

Four vendors located; cost $40,000 to $50,000

10-kA MECHANICAL FAST DUMP SWITCH

Three vendors located; cost $20,000 to $35,000

150-MJ, 50-mohm FAST DUMP RESISTOR

Two vendors located; cost $15,000 to $20,000

Viewgraphs of Fig. 2-6 from DN #138 were shown here.

R & D GOALS--BALANCE OF FY91

Toward Prototype Coil (3.6 m dia. x 2 m long)

Complete feasibility studies of isogrid and composite vacuum shells

Fabricate and test scale models of isogrid and composite shells

Choose shell material for vacuum vessel

Fabricate and test prototype composite and metal support elements

Engineer radiation shields and support intercepts

Choose 4.5-K cooling scheme, diameter and spacing of LHe tubes on outer support cylinder

General

Assist integration efforts at SDC and SSCL

Continue magnetic, structural, and quench calculations

Secure cost and schedule for refrigerator and cryogenic components and for electrical equipment and controls

Obtain cost estimate from consultant for magnet coil and vessels

FERMILAB STAFF TO WORK ON SDC SOLENOID BALANCE OF FY91

% Time	Individual
0.25	R. Kephart (physicist), working group leader
0.10	B. Foster (physicist), liaison with calorimeter group
0.65	R. Fast (physicist), vacuum shell, cryogenics, project management and reporting
0.10	J. Grimson (engineer), calorimeter structures
0.15	R. Stanek (engineer), cryogenic system design
1.00	B. Wands (engineer), ANSYS solenoid magnetostatics and calorimeter structures
1.00	A. Stefanik (engineer), cryogenic system design, liaison to SSCL cryogenics group
1.00	A. Lee (engineer), ANSYS analysis of coil preloads, magnetostatics, quench analysis
1.00	J. Krebs (engineering-physicist), ANSYS design of supports, liaison to SSCL for building layout
0.75	C. Grozis (engineering associate), design of outer vacuum shell, liaison to SDC calorimeter and tracker groups
1.00	D. Friend (designer), cryogenic systems, supports, vacuum shell

Above effort is 6.0 FTE (engineers and designers) and 1 FTE (physicist). Two additional FTE drafters/technicians may be needed to meet the FY91 goals. The FY91 budget covers 3.5 FTE engineers.

FY92 R & D PLAN--FERMILAB

A. For the Prototype Coil

(Components ready to ship in the Fall of 1992)

Engineer, design, procure and test vacuum vessel

Choose support scheme, engineer support members

Procure support system components

Procure radiation shields and associated piping

Assemble supports, shields and piping into vacuum vessel

Design and procure control dewar and chimney (if required)

B. For the Full-size Coil

Finalize 4.5-K cooling scheme, prepare flow schematic

Update heat load calculations, verify size of refrigerator

Finalize design of shield and intercept cooling system, prepare flow schematic

Design transfer line from surface to control dewar

Finalize chimney route through detector; design chimney

Continue ANSYS magnetostatic calculations

Assist calorimeter group with ANSYS structural calculations

Perform quench analysis with ANSYS to verify KEK coil design

Write magnet section of SDC Technical Proposal

Continue integration activities with SDC, e.g. cryostat to calorimeter interface and tracker mounts

Continue integration with SSCL facilities

Prepare cost and schedule information as requested

Write procurement design report for solenoid

FY 92 R & D BUDGET--FERMILAB

Item	Personnel	Man-yr	SWF (SDC) (k$)	SWF (FNAL) (k$)	M&S (k$)
A. For Prototype Coil					
Isogrid outer shell,	Grozis	0.50	25.0	0	200
inner shell,	Friend	0.25	12.5	0	50
annular flanges					
Radiation shields	Stefanik	0.25	12.5	0	25
	Friend	0.25	12.5	0	
	Tech #1	0.50	25.0	0	
Supports	Krebs	0.50	25.0	0	10
	Friend	0.25	12.5	0	50
	Tech #1	0.50	25.0	0	
Chimney, control	not				
dewar (if reqd)	included	0.0	0.0	0	(50)
Assembly	Stefanik	0.25	12.5	0	25
	Grozis	0.25	12.5	0	
	Tech #2	1.00	50.0	0	
	Tech #3	1.00	50.0	0	
Travel to Japan, six trips at $3000 each					18
Subtotal--prototype coil:		5.50	275.0	0	428

Item	Personnel	Man-yr	SWF (SDC) (k$)	SWF (FNAL) (k$)	M&S (k$)
B. For Full-size Coil					
Cryogenic system	Stefanik	0.25	12.5	0	
	Friend	0.25	12.5	0	
Chimney and control dewar	Stefanik	0.25	12.5	0	
Magnetostatics	Lee	0.50	25.0	0	15
	Wands	0.50	25.0	0	15
	Krebs	0.25	12.5	0	10
Quench analysis	Lee	0.50	25.0	0	10
Coil-calorimeter integration	Wands	0.50	25.0	0	10
Integration, reports, project mgmt	Kephart	0.25	0	12.5	
	Fast	0.75	0	37.5	
	Stanek	0.25	0	12.5	
	Krebs	0.25	12.5	0	
	Grimson	0.10	0	5.0	
Computing equipment (SGI work station)					25
Subtotal--full size coil:		4.6	162.5	67.5	85
Total for FY92:		10.1	437.5	67.5	513

KEK SOLENOID R & D PLAN

SDC THIN SOLENOID R&D SCHEDULE (PLAN)

ＳＤＣ薄肉超伝導電磁石の開発・建設スケジュール（案）		
	BASIC R&D	
ＪＦＹ１９９０ 4/1/90 – 3/31/91	高強度アルミ安定化超伝導線の基礎開発 コイルの巻線・電磁力支持技術の基礎開発	STRONG. COND. WINDING
	PROTOTYPE (1/4 L) DEVELOPMENT	
ＪＦＹ１９９１ 4/1/91 – 3/31/92	プロトタイプコイル用超伝導線材の開発 プロトタイプコイル巻線機の開発、コイル部品製作	LONG COND. WINDING FAC. PARTS.
ＪＦＹ１９９２ 4/1/92 – 3/31/93	プロトタイプコイル巻線、組立 クライオスタット部品製作	COIL WINDING. PARTS FOR CRYOS.
ＪＦＹ１９９３ 4/1/93 – 3/31/94	コイル、クライオスタット組立 冷却、励磁試験 評価、Ｒ＆Ｄ報告書作成、デザインレポート完成	ASSEMBLY COOL.D. EXCIT. TES REPORT
	MAIN MAG. FAB.	
ＪＦＹ１９９４ 4/1/94 – 3/31/95	超伝導電磁石・実機、製作 超伝導線材 コイル巻線 クライオスタット部品製作	MAIN COIL WINDING
ＪＦＹ１９９５ 4/1/95 – 3/31/96	超伝導電磁石・実機、組立 コイル・クライオスタット組立	ASSEMBLY
ＪＦＹ１９９６ 4/1/96 – 3/31/97	実機、冷却・励磁試験（空芯条件） ＳＳＣＬへの搬送 ＳＤＣ構造体・鉄ヨークへの組み込み	TEST IN AIR
ＪＦＹ１９９７ 4/1/97 – 3/31/98	鉄芯内での冷却・励磁試験 磁場測定 完成	TEST IN IRON

KEK R & D BUDGET (PROPOSED)

3．予算

プロトタイプ超伝導電磁石の開発計画を３年度計画を想定し、以下の予算を必要とする。

（単位：千円）

		JFY1991 4/1/91-3/31/92	JFY1992 4/1/92-3/31/93	JFY1993 4/1/93-3/31/94
ENG. DESIGN	設計費	20,000	20,000	10,000
SUPER COND.	超伝導線材	120,000	40,000	
COIL WINDING	コイル巻線			
WINDING FAC.	巻線機	60,000	20,000	
SUP. CYLINDER	シリンダー等	20,000	30,000	
WINDING	巻線		20,000	
ASSEMBLY	キュア、組立、試験		20,000	
CRYOSTAT	クライオスタト			
ELEMENT / PARTS	部品		30,000	
HONETCOMB	ハニカム		50,000	
ASSEMBLY	組立、試験		20,000	
GEN. ASS / INSP.	全体組立、試験			20,000
MONITOR	モニター			
SENSORS	センサー		10,000	
DAQ	データ収集機器		10,000	
P/S (≥12,000A)	電源			120,000
COOLING / DEW.	予冷機，デュワー等			60,000
TEST	冷却・励磁試験			50,000
COOL DOWN				
EXCIT.				
	年次経費	220,000	270,000	260,000
	全体額	≈180,000 assigned in last evening. ( )		750,000