Fermilab

SDC SOLENOID DESIGN NOTE #182

TITLE: Notes from working group meetings, August 26 and 28, 1992

AUTHOR: Ron Fast

DATE: September 3, 1992

1. INTRODUCTION

There were two meetings of the SDC solenoid magnet working group at Fermilab during the week of the 1992 Applied Superconductivity Conference. Because he was attending the conference, Akira Yamamoto was able to attend both meetings. On Wednesday, August 26 the group met to discuss technical issues. The meeting was attended by persons from KEK, SSCL, and Fermilab. The agenda and my notes from this meeting follow as Section 2. The meeting on Friday, August 28 was with Tom Kirk, SDC Project Manager. The agreement resulting from this meeting is in Section 3 of this note.

2. TECHNICAL MEETING

Agenda
Status of KEK work
Status of Fermilab work on prototype
Discussion of shield/intercept cooling schemes
Status of EFD work on cryosystem
Electrical bus considerations

Figure 2-1 is the sign-up sheet for this meeting.

2.1 Status of KEK work

The general status of the KEK work was reported in a paper Akira Yamamoto presented at the ASC. His paper has been distributed as SDC Solenoid Design Note #180.

2.1.1 Prototype Coil Winding

Akira said the the practice winding with Al-Cu-NbTi conductor would take place in September and October, 1992. Several 30 cm (1 foot) long coils will be wound, then cut apart for inspection and testing. Winding of the prototype coil will take place in November and December. This is a schedule slippage of one or two months.

2.1.2 Prototype Cryostat

Akira showed a photograph of the completed outer support cylinder. The LHe cooling pipe will be welded to the OSC in the September-October time period. The radiation shields and chimney are in the engineering design phase. Akira asked about the distance from the end of the cryostat to the centerline of the chimney. Ron Fast has recently verified with the calorimeter engineers that this dimension for the detector magnet is 10"(254 mm). This dimension for the prototype is somewhat larger--it is 10"/254mm from the centerline to the end of the isogrid shell. The bulkhead is 31mm thick, so the total distance--for the prototype only--is 254 + 31 = 285 mm.

We discussed the bulkhead, its dimensions and the machining required for the radial and axial support attachments. There is a problem with the cut-out for the radial support brackets--the cut-out, as presently dimensioned, extends too close to the edges of the bulkhead and imposes very tight tolerances on the out-of-roundness of the inner and outer shells. Akira agreed to consult with Toshiba about this.

There is also a cost and schedule problem with the bulkheads. There is not enough AFY92 funding presently available at Fermilab to complete the vacuum vessel if the bulkhead is completely machined at Fermilab expense. We do not expect to receive our AFY93 funding from the SSCL until January 1st at the earliest, it will come later if the DOE budget is not passed by Congress in the next three weeks. We realize the importance of doing all the machining on the bulkheads at once and will be looking at several funding--machining scenarios in the next few weeks.

Akira reaffirmed that, in spite of his coil winding schedule slipping a month or two, he would like the vacuum vessel delivered by April 1, 1993. The funding situation mentioned above may make it difficult for Fermilab to meet this date.

Akira reported that he and Toshiba now plan to make the brackets at the warm end of the cold-mass supports out of 7075 aluminum rather than titanium.

2.1.3 Prototype Testing

Akira said that KEK is in the process of procuring the power supply for testing the prototype solenoid. It will be a 15 kA x 20 V supply and will have passive filtering of the output, but not an active feedback filter. He said that this supply is not good enough for the detector magnet.

Akira is not sure what refrigerator at KEK will be used for the prototype testing--there are several refrigerator options and the possibility of using purchased LHe.

2.1.4 Honeycomb Vacuum Shell R&D

Akira reported that IHI has successfully formed brazed honeycomb panels to the 2-m radius needed for the outer vacuum shell and has welded them into a 1-m long cylinder. They are fabricating a second 1-m cylinder which they will weld to the first in September. IHI plans to assemble this 2-m shell and leak test it in the September-November period.

2.2 Status of Fermilab Work

The Fermilab effort for the last several months has been concentrated on the vacuum vessel for the prototype solenoid. Figures 2.2-1 to 8 are the viewgraphs Chuch Grozis showed.

2.3 Cooling Medium for Radiation Shields of Detector Solenoid

2.3.1 Statement of Problem

The problem is to decide whether LIN or cold GHe is the preferred cooling medium for the shields of the magnet cryostat. This decision has an impact on both the shield design and on the refrigerator specifications. According to the schedule developed by Charles Collins and Matt Wilson, the order for the SDC refrigerator must be placed in October 1993. The experience at the SSCL is that it takes about one year to accomplish the work behind a refrigerator purchase order, i.e. to get bids and evaluate them and to secure all the necessary SSCL and DOE authorizations. Charles and Matt feel therefore that the request for proposal for the SDC refrigerator should go out around October 1st of this year and that they need to be working on the specifications now. They want to know now whether the refrigerator should include a cold-gas "spigot".

2.3.2 Discussion

We discussed the advantages and disadvantages of LIN and GHe cooling of the shields at length. Akira said that he needed some time to study the impact of this choice on the magnet. A show-of-hands vote among those present showed that 5 persons felt that the refrigerator should include a cold-gas spigot; one person felt it would "not be worth the bother".

2.3.3 Conclusions and Decisions

The results of the discussion were:

A. That the SSCL should include a cold-gas spigot as an option in the refrigerator specification for the RFP. The temperature of the shield cooling gas as it leaves the refrigerator should be in the 40 to 60 K range.

B. That the SSCL would start the DOE approval procedure in May of 1993 and that a decision to implement this option would be made at that time.

C. That Rich Schmitt would prepare a rough cost estimate for a 50-K stand alone cold gas refrigerator as an alternate to the cold-gas spigot in the main refrigerator.

D. That if the refrigerator purchased has a cold-gas spigot, there is always the option of using LIN instead. This statement is strictly true only if the cooling tube circuits are designed for either cryogen.

2.3.4 Supplementary Note

The proposal discussed at the Friday meeting--to have the refrigerator provided by KEK as an in-kind contribution to SSCL/SDC--may have some influence on the LIN-GHe decision and on the conclusions given above, especially B. However, since Akira has been in favor of GHe shield cooling for some time, a refrigerator supplied by KEK would probably have a cold-gas spigot.

2.4 Status of Cryogenic System Work by SSCL/Experimental Facilities Deptartment

Matt Wilson discussed the work he has recently done on the cryogenic system for the SDC solenoid, Figs 2.4-1 to 2.4-8. Among other things, he is looking at the function of the sub-cooler in the control dewar and whether it is really needed to meet Akira's quality requirements.

2.5 Electrical Bus Considerations

Ken Hess, who is in the Integration Group of the SDC Department at the SSCL, has proposed that air-cooled bus be considered for the run from the power supply to the service port of the cryostat. According to Ken this one-way distance is 630 ft. Charles agreed to talk with Ken about this and to think about whether air-cooled bus, which will be larger than water-cooled, will be acceptable from a space-in-the-shaft point of view.

We tried to list the magnet-bus-power supply interfaces that might influence the choice of water- or air-cooled bus. The voltage drop in the bus should be sufficiently small that the charging time for a given power supply is acceptable. The resistance of the bus also affects the slow discharge time.

3. Meeting with Tom Kirk

Tom Kirk, the SDC Project Manager and head of the SDC Department in the Physics Research Division of the SSCL, chaired the meeting. Also attending from the SSCL were Tim Thurston, deputy head of SDC Department; Bob Richardson, acting head of Experimental Facilities Department of PRD; and Charles Collins, EFD. Fermilab was represented by Bob Kephart, Rich Stanek, and Ron Fast. Akira Yamamoto reporsented KEK. There was no formal agenda for this meeting, but the principal item discussed was the possibility of the Japanese (KEK) providing the refrigerator and power supply as well as the solenoid magnet. Tom took notes which he typed and distributed to those attending. The final version of these notes, called, "A Concept for Cooperation by the U.S. and Japanese Partners in Providing a Superconducting Solenoid Magnet, Cryogenic, Power System and Controls for SDC" follows.

A Concept for Cooperation
by U.S. and Japanese Partners
in Providing a Superconducting Solenoid Magnet,
Cryogenic, Power System and Controls for SDC

August 28, 1992

It has long been agreed that the Superconducting Solenoid Magnet for SDC will be a Japanese contribution in kind to the experiment, hence totally funded from Japan. In May of 1992, Akira Yamamoto was asked to consider whether it was a practical possibility for Japan to provide funding for the cryogenic and power supply systems as well and under what conditions such goals could be realized.

On August 28, a group of SDC collaborators* met to discuss how the goal of providing such an expanded Japanese responsibility might be achieved. This note is a brief record of the conclusions reach during that discussion.

Before stating the conclusions, some of the present circumstances should be reviewed:

1) The conceptual design work already achieved on the magnet system has been and will continue to be carried out as a joint collaborative project undertaken by KEK, Fermilab, and SSCL.
2) The detailed engineering design of the magnet and its procurement will be the responsibility of KEK; This laboratory is pursuing the design and construction with its industrial firm (Toshiba).
3) The Engineering Facilities Department(EFD) of SSCL is presently preparing a performance specification for the 'turnkey' refrigeration system to be provided by an industrial vendor.
4) All parties agree that operations of the magnet for physics after its commissioning should be done by a crew of SSCL operators.
5) The power supply system is simpler and cheaper by a substantial amount than the refrigerator.
6) Controls for the magnet systems are a natural SSCL responsibility as they should be integrated into the SSCL system.

Given these points(and a number of other subsidiary ones) it seems that the goal for realizing Japanese funding of a refrigeration system that will meet SSCL acceptance criteria and also be operable by SSCL personnel could be realized by the following method:

EFD should complete a first draft of the performance specification for a turnkey refrigerator procurement. Then KEK (Mr. Doi) should critique and edit this specification from the perspective of KEK who would subsequently be acting as the procurement agent. After an agreed-upon final draft is reached, the specification would be released by KEK as a competitive international procurement with the expectation that a proper mix of Japanese and American subcontractors would assemble a winning team that would realize a successful technical result, not only from the point of view of technical performance and safety, but also with assurance that documentation, service and spare parts supply performance would be satisfactory.

KEK would then be providing the magnet and refrigerator as a Japan funded contribution-in-kind, but with a design that assures that the resulting system will meet SSCL technical and safety equipment. This latter point would be strongly aided by agreeing that EFD would provide detailed oversight of the refrigerator construction at SSCL and that Mr. Doi would visit SSCL for extended stays (~ one month each or more) at critical points in the refrigerator construction (prior to release of the RFP; midway through construction; commissioning period).

This process may take up the three years and the expectation that no Japanese funds for construction may be available before April 1994 will likely compromise the current turnon milestone for the detector (1999). This milestone is likely to slip a year anyhow as a result of other more global funding problems with SSC.

Fermilab's continued technical collaboration and close consultation with the other two partners should continue for as long as it is allowed by Fermilab management. This is because the continued success of the program is dependent on Fermilab experience for maintaining full technical strength of the program.

*persons present for the discussion

Charles Collins
Ron Fast
Bob Kephart
Tom Kirk
Bob Richardson
Rich Stanek
Tim Thurston
Akira Yamamoto

Attendance - Aug 26, 1992
SDC Solenoid Meeting

Name	Affiliation
Bob Kephart	FNAL
Akira Yamamoto	KEK
Yasuhiro Makida	KEK
Nobuhiro Kimura	KEK
Ron Fast	FNAL
CHARLES COLLINS	SSCL
Andy Stefanik	FNAL
RICH SCHMITT	FNAL
JOHN GRIMSON	FNAL
Chuck GROZIS	FNAL
MATT WILSON	SSCL
JOHN Krupczak	SSCL
ZHIJING TANG	FNAL
Bob Wands	FNAL
ANG [illegible]	FNAL

FIG 2.2-1

SSC - SDC SOLENOID VACUUM SHELL ASSEMBLY

PROGRESS REPORT

ISOGRID TEST PLATE

1) Isogrid test plate Drawing SSC-SDD-000017

   A) Machined by the Dial Company Rockford, Illinois.

   B) Isogrid test plate Stage 2 (formed), break formed by the AMRO Corporation to within .062" of the required radius. Subsequent dye penetrant inspection of the panel showed no indication of cracks.

2) The test plate is now back at the AMRO Corporation, Drawing SSC-SDD-000018WT.

   A) Test plate will be machined for the longitudinal weld prep and welded.

   B) Weld shrinkage will be measured and joint will be inspected and leak checked at Fermilab.

INNER VESSEL

1) Inner vacuum shell & flange weldment - cryostat assembly Drawing SSC-SDD-000380.

   A) Contract awarded to the AMRO Corporation. Material has been received, fabrication to start on August 24, 1992.

FIG 2.2-2

ISOGRID OUTER VACUUM SHELL

1) Isogrid standard panel Drawing SSC-SDD-000365.

   A) Contract has been awarded to the Camarillo Dynamics Company for the machining of the three (3) plates.

   B) Camarillo has received the material from Fermilab.

   C) Programming has started.

   D) Estimated machining start date of September 7, 1992.

   E) The machining of one plate is estimated to take 10 days at the machining rate of 22 hours a day.

BREAKFORMING OF THE ISOGRID PLATES

1) Isogrid panel bending Drawing SSC-SDD-000368.

   A) Contract has been awarded to the AMRO Corporation.

   B) Start date: as soon as completed plate is received from Camarillo.

CONTRACTS PENDING

1) Machining of Isogrid weld preps.

2) Welding and final machining of the Isogrid shell.

3) Bulkhead flanges (we have started to get estimates).

4) Bolt holes in inner shell, outer shell and flanges.

5) Assembly of shells with flange.

6) Vacuum leak testing.

7) Shipping Crate

8) Shipping to Japan

FIG 2.2-3

ENGINEERING ANALYSIS

CHIMNEY AREA

1) Flanges, bolts and welds have been sized per ASME Code.

BULKHEAD (FLANGES)

1) New Japanese thickness of 31.0 mm has been analyzed (design note established) EAR-42.

INNER VACUUM SHELL

1) Welds and sizing of material completed. (Design note established.)

FIG 2.2-4

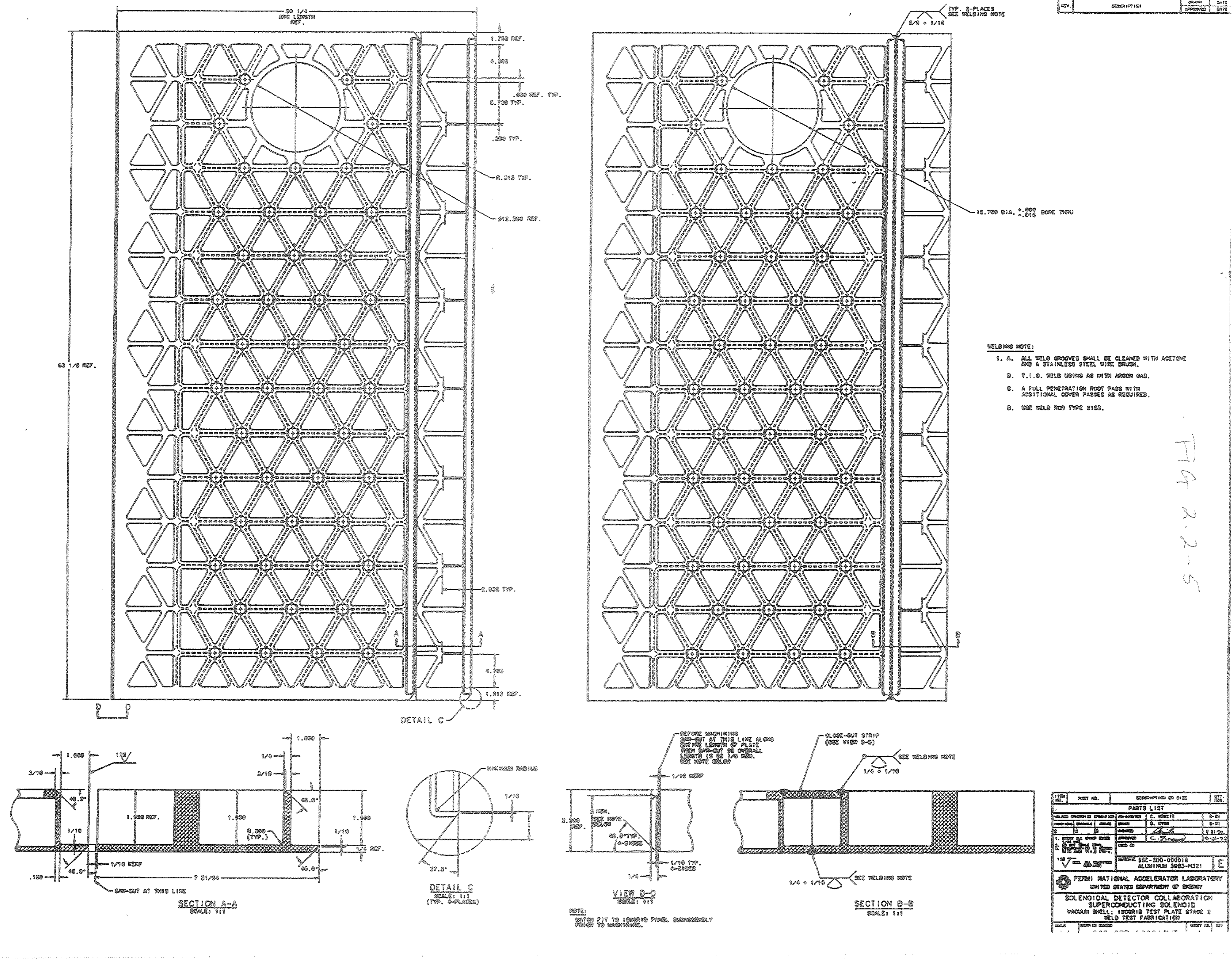
RECENT RESEARCH AND DEVELOPMENT

1) Machining of the Isogrid pockets has produced good results with the tolerances meeting specifications, all finishes are within specifications.

2) A total of 4 sample weld joints have been welded with no detectable leaks. The AMRO Corporation has welded the most recent weld joint.

3) The latest breakforming of the test plate was a complete success. (Work hardening seems not to be a factor.) Die marks to the plate edge were minimal. The radius is within .062" of the specified 78.902" radius.

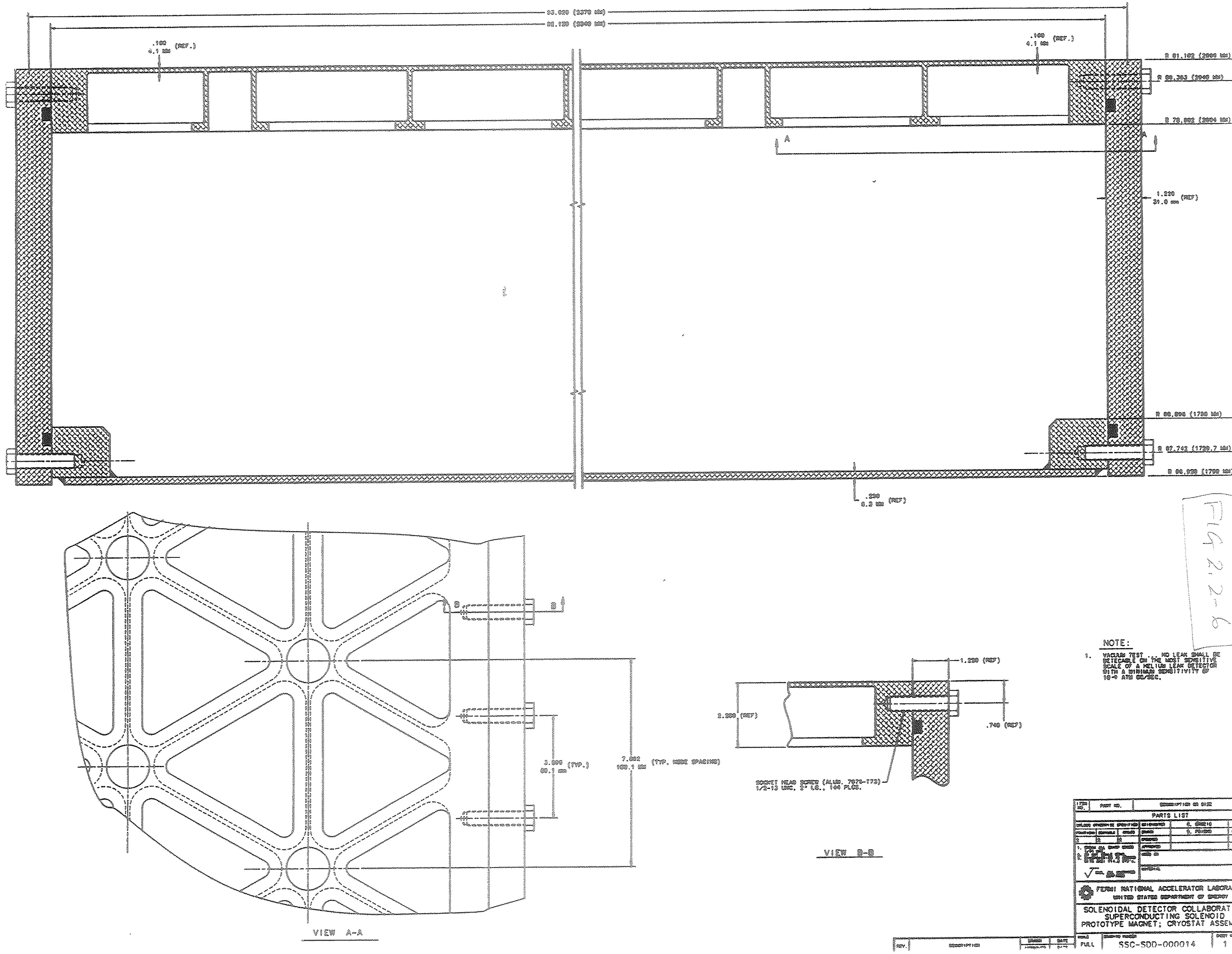
4) Torque tests using 2024-T4 aluminum and 18-8 stainless steel bolts have been evaluated with torque numbers and procedures being obtained.

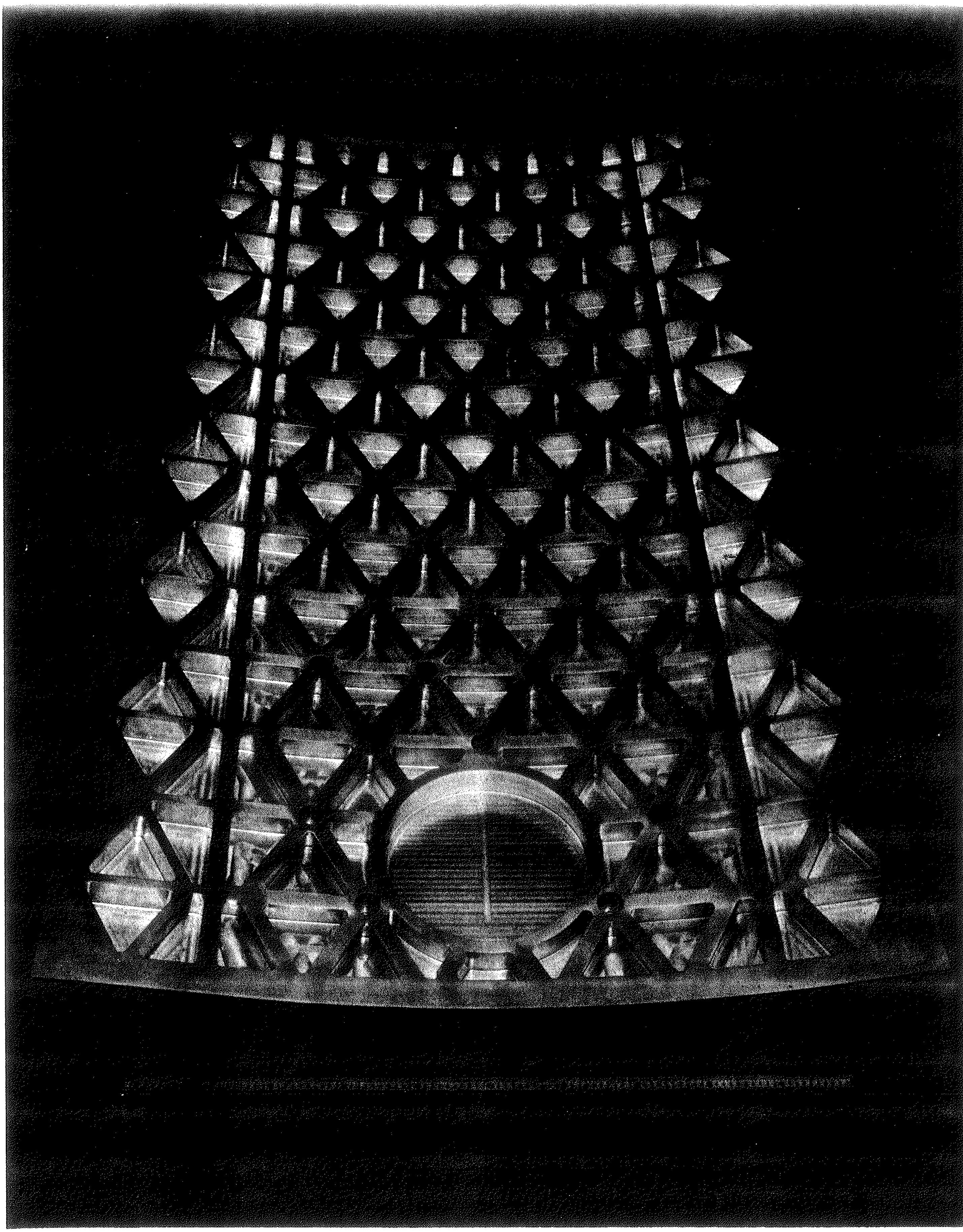


50 1/4 ARC LENGTH REF.
83 1/8 REF.
1.780 REF.
4.985
.690 REF. TYP.
3.720 TYP.
.380 TYP.
R.313 TYP.
Ø12.380 REF.
2.938 TYP.
4.785
1.813 REF.
DETAIL C
TYP. 8-PLACES SEE WELDING NOTE
3/8 + 1/16
12.780 DIA. +.000 -.015 BORE THRU
WELDING NOTE:
1. A. ALL WELD GROOVES SHALL BE CLEANED WITH ACETONE AND A STAINLESS STEEL WIRE BRUSH.
B. T.I.G. WELD USING AC WITH ARGON GAS.
C. A FULL PENETRATION ROOT PASS WITH ADDITIONAL COVER PASSES AS REQUIRED.
D. USE WELD ROD TYPE 5183.
SECTION A-A
SCALE: 1:1
SAW-CUT AT THIS LINE
1/16 KERF
7 31/64
R.090 (TYP.)
1.950
1.950 REF.
DETAIL C
SCALE: 1:1
(TYP. 6-PLACES)
MINIMUM RADIUS
37.5°
VIEW D-D
SCALE: 1:1
BEFORE MACHINING SAW-CUT AT THIS LINE ALONG ENTIRE LENGTH OF PLATE THEN SAW-CUT TO OVERALL LENGTH IS 50 1/8 MIN. SEE NOTE BELOW
1/16 KERF
1/16 TYP. 4-SIDES
45.0° TYP. 4-SIDES
NOTE:
MATCH FIT TO ISOGRID PANEL SUBASSEMBLY PRIOR TO MACHINING.
CLOSE-OUT STRIP (SEE VIEW D-D)
SEE WELDING NOTE
1/4 + 1/16
SECTION B-B
SCALE: 1:1
PARTS LIST
SSC-SDD-000016
ALUMINUM 5083-H321
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
SOLENOIDAL DETECTOR COLLABORATION
SUPERCONDUCTING SOLENOID
VACUUM SHELL; ISOGRID TEST PLATE STAGE 2
WELD TEST FABRICATION

FIG 2.2-5

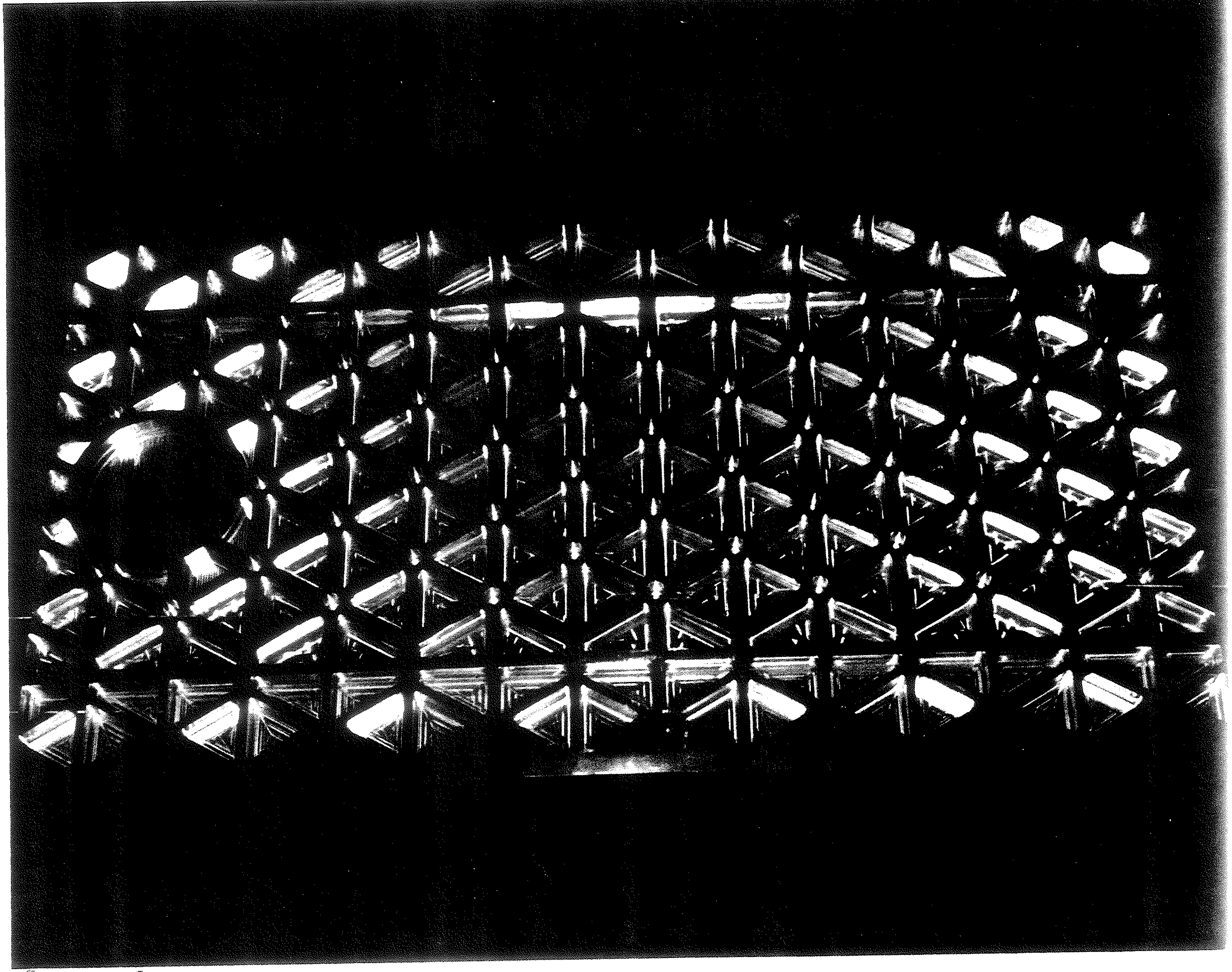
FIG 2.2-6


93.620 (2378 MM)
92.130 (2340 MM)
.160 (REF.)
4.1 MM
R 81.102 (2060 MM)
R 80.303 (2040 MM)
R 78.882 (2004 MM)
1.230 (REF)
31.0 mm
R 69.896 (1780 MM)
R 67.742 (1720.7 MM)
R 66.929 (1700 MM)
.250 (REF)
6.3 MM
A
B
3.860 (TYP.)
98.1 mm
7.882
196.1 MM
(TYP. NODE SPACING)
VIEW A-A
1.230 (REF)
2.280 (REF)
.740 (REF)
SOCKET HEAD SCREW (ALUM. 7075-T73)
1/2-13 UNC, 2" LG., 104 PLCS.
VIEW B-B
NOTE:
1. VACUUM TEST ... NO LEAK SHALL BE DETECABLE ON THE MOST SENSITIVE SCALE OF A HELIUM LEAK DETECTOR WITH A MINIMUM SENSITIVITY OF 10-9 ATM CC/SEC.
PARTS LIST
FERMI NATIONAL ACCELERATOR LABORAT
UNITED STATES DEPARTMENT OF ENERGY
SOLENOIDAL DETECTOR COLLABORATI
SUPERCONDUCTING SOLENOID
PROTOTYPE MAGNET; CRYOSTAT ASSEM
FULL
SSC-SDD-000014
1



92-789

FIG 2.2-7



92-722-9

FIG 2.2-8

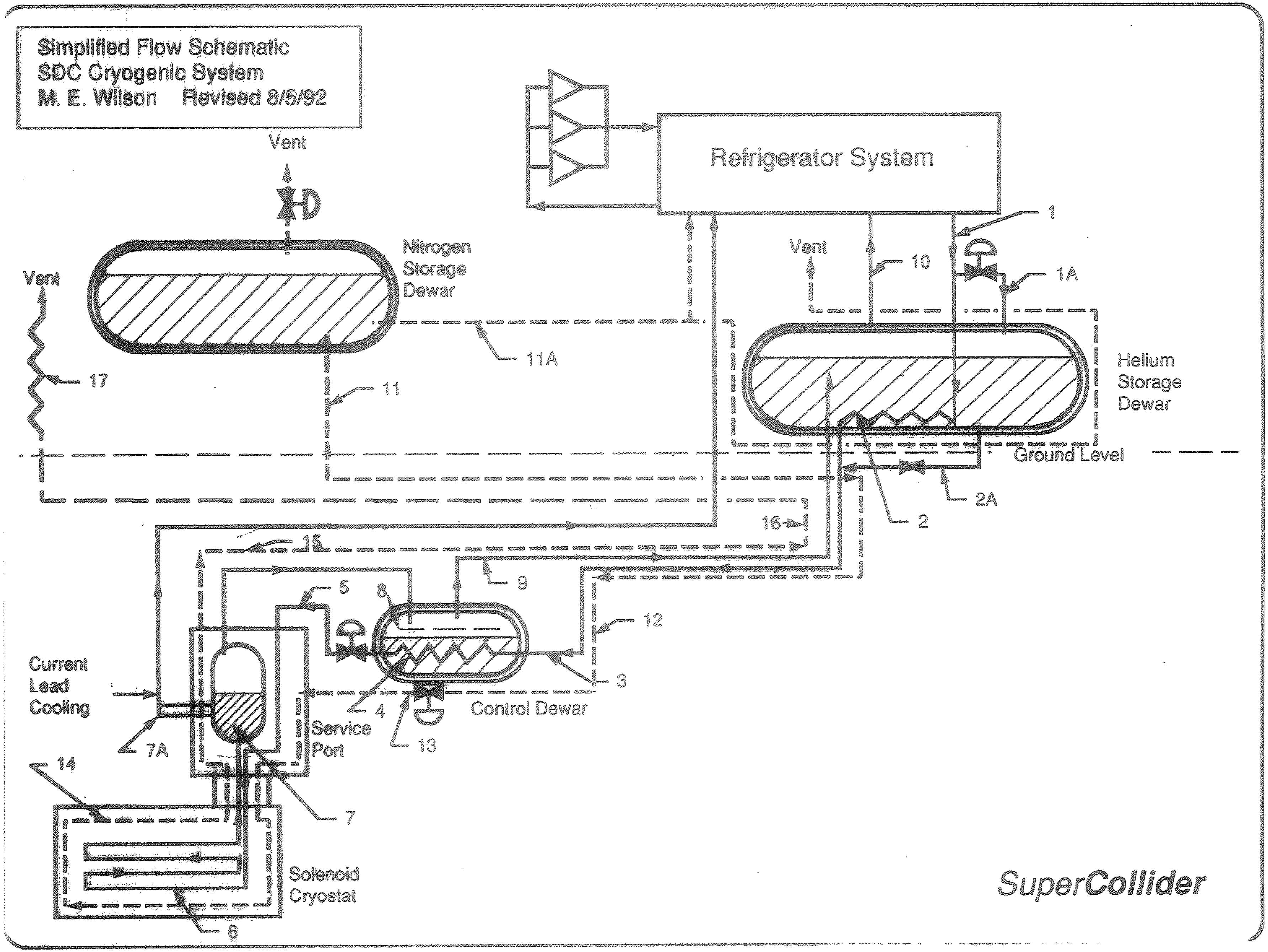

Simplified Flow Schematic
SDC Cryogenic System
M. E. Wilson Revised 8/5/92
Vent
Refrigerator System
Nitrogen Storage Dewar
Vent
17
11
11A
Vent
10
1
1A
Helium Storage Dewar
Ground Level
2A
2
16
15
9
5
8
12
3
Current Lead Cooling
7A
4
13
Control Dewar
Service Port
14
7
Solenoid Cryostat
6
SuperCollider

FIG 2.4-1

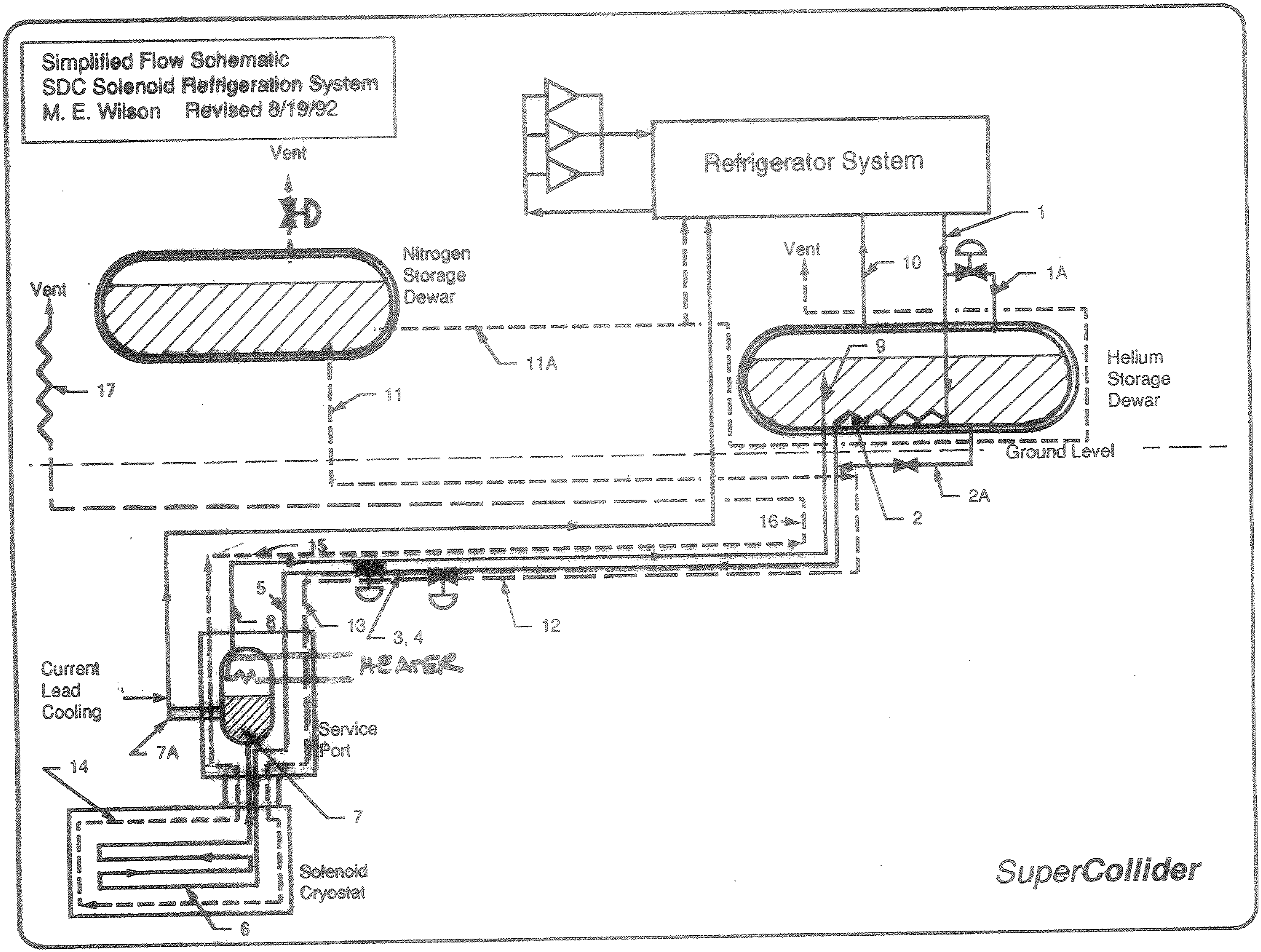
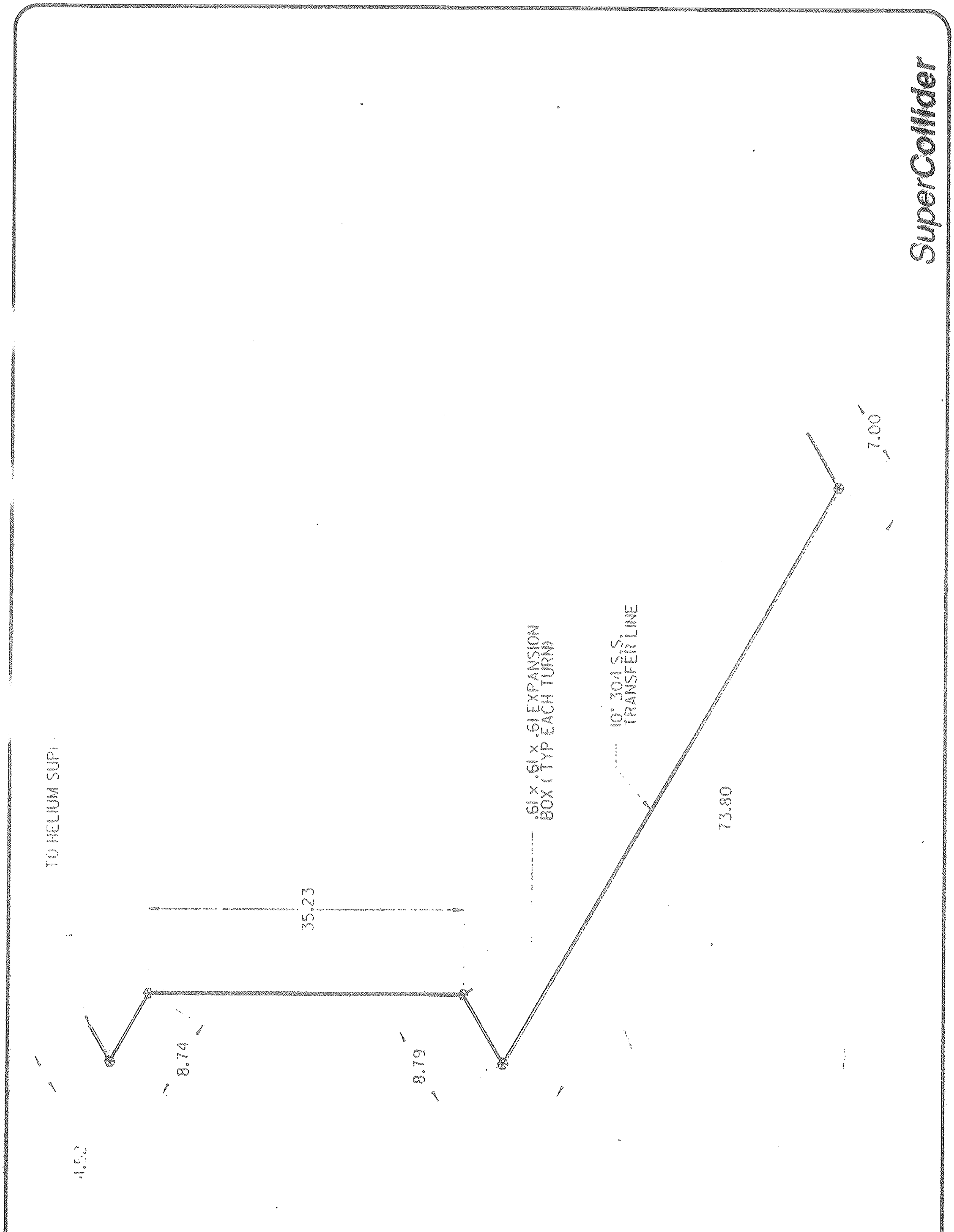

Simplified Flow Schematic
SDC Solenoid Refrigeration System
M. E. Wilson Revised 8/19/92
Vent
Refrigerator System
Nitrogen
Storage
Dewar
Vent
Helium
Storage
Dewar
Ground Level
1
1A
10
9
11A
11
17
2
2A
16
15
5
8
13
3, 4
12
HEATER
Current
Lead
Cooling
7A
Service
Port
14
7
Solenoid
Cryostat
6
SuperCollider

FIG 2.4-2

FIG 2.4-3



TO HELIUM SUP
35.23
.61 x .61 x .61 EXPANSION BOX (TYP EACH TURN)
10" 304 S.S. TRANSFER LINE
73.80
7.00
8.74
8.79
SuperCollider

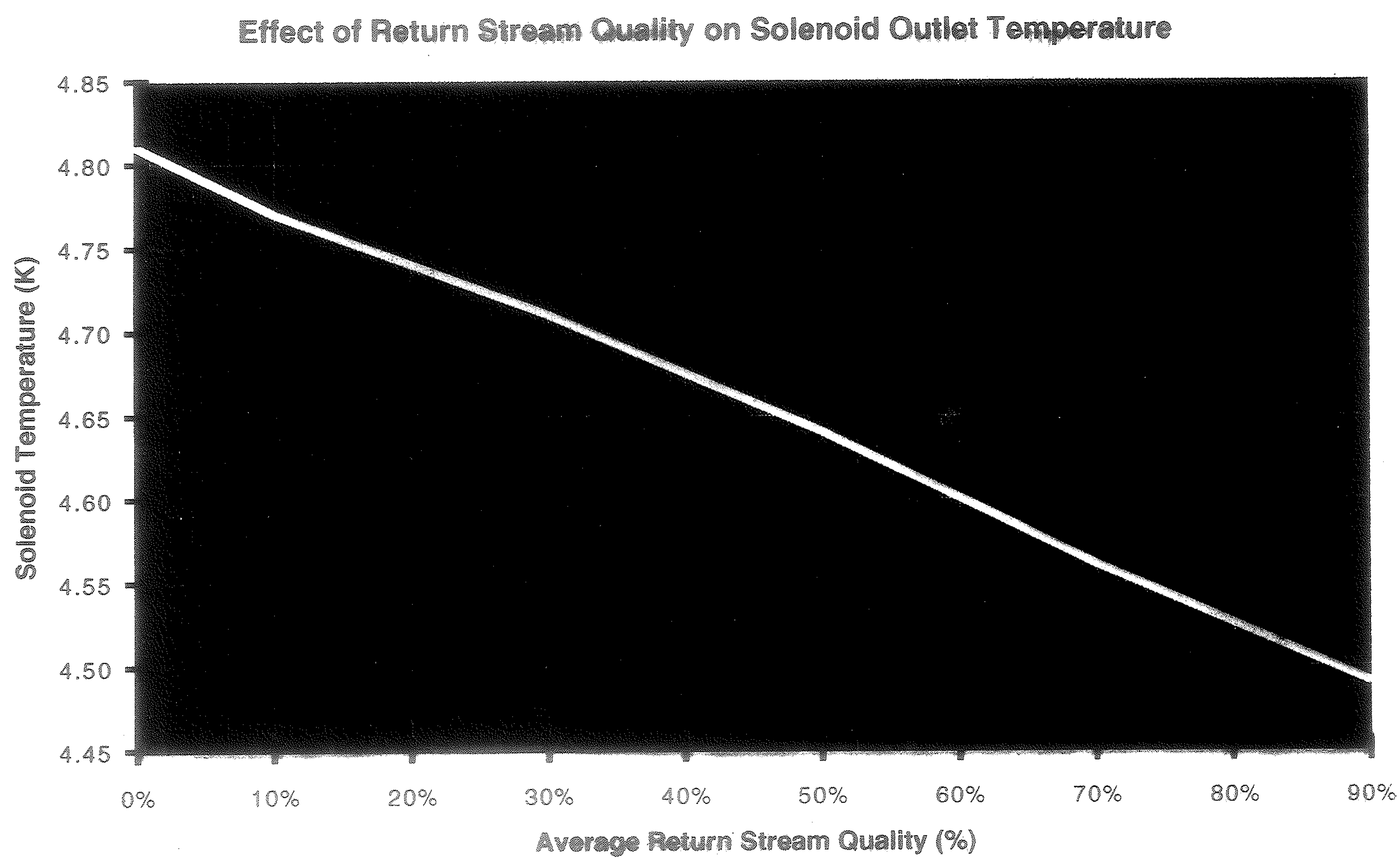
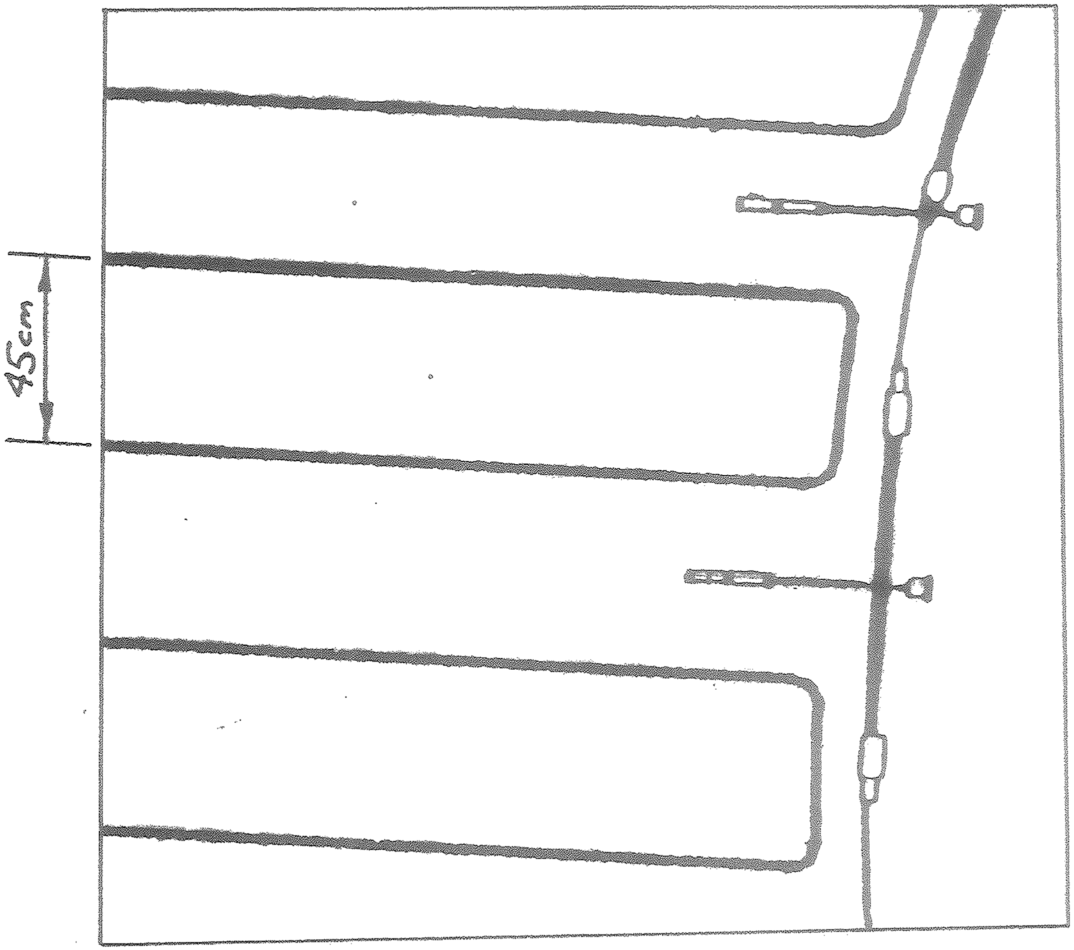


FIG 2.4-4

SuperCollider

FIG 2.4-5

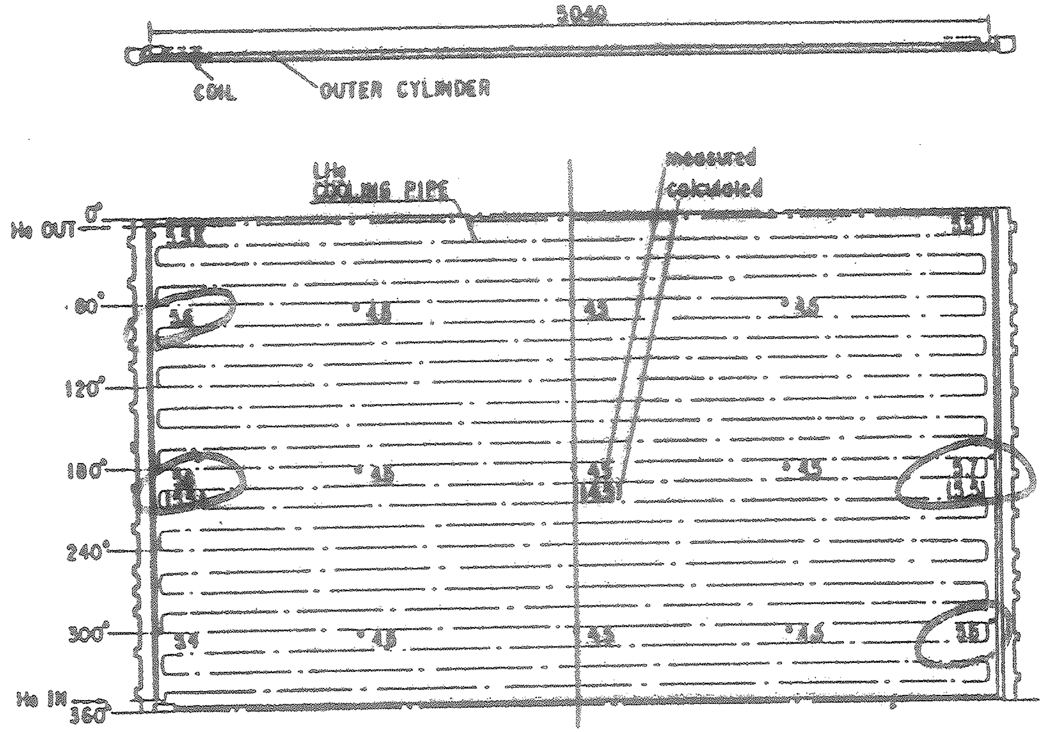
The SDC Solenoid



SuperCollider

Temperature Distribution in TOPAZ Solenoid

Ref. Yamamoto, et al 1987



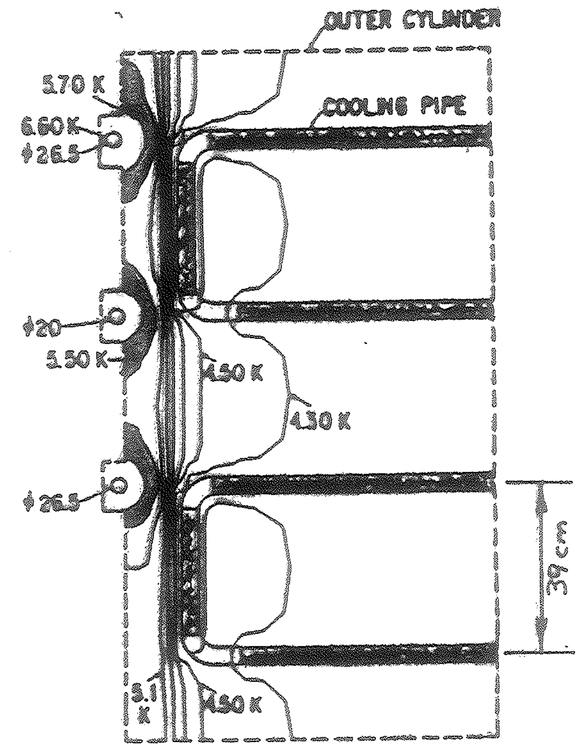


FIG 2.4-6

SuperCollider

FIG 2.4-7

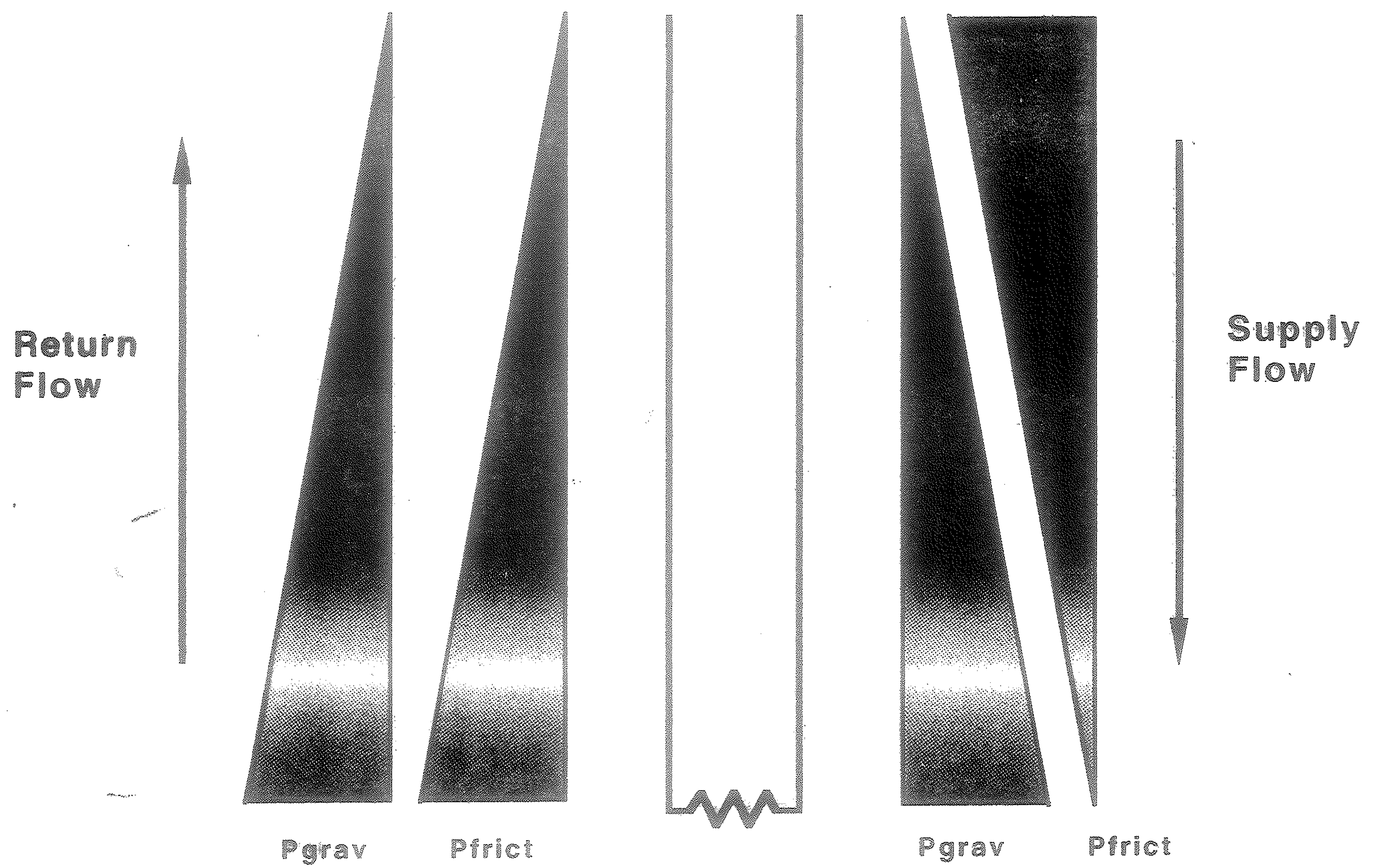
Heat Flux Required to Vaporize Saturated Liquid Helium at 1.1 atm

Latent Heat = 19.8 J/g   Heat Flux in Watts

Mass Flow (g/s)	Quality									
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
1	18	16	14	12	10	8	6	4	2	0
5	89	79	69	59	50	40	30	20	10	0
7	125	111	97	83	69	55	42	28	14	0
10	178	158	139	119	99	79	59	40	20	0
15	267	238	208	178	149	119	89	59	30	0
20	357	317	277	238	198	158	119	79	40	0
23	410	364	319	273	228	182	137	91	46	0
25	446	396	347	297	248	198	149	99	50	0
30	535	475	416	357	297	238	178	119	59	0
35	624	555	485	416	347	277	208	139	69	0
40	713	634	555	475	396	317	238	158	79	0
45	802	713	624	535	446	357	267	178	89	0
50	891	792	693	594	495	396	297	198	99	0
55	980	872	763	654	545	436	327	218	109	0
60	1070	951	832	713	594	475	357	238	119	0
65	1159	1030	901	772	644	515	386	257	129	0
70	1248	1109	971	832	693	555	416	277	139	0
75	1337	1188	1040	891	743	594	446	297	149	0
80	1426	1268	1109	951	792	634	475	317	158	0
85	1515	1347	1179	1010	842	673	505	337	168	0
90	1604	1426	1248	1070	891	713	535	357	178	0

SuperCollider

Gravitational and Frictional Effects



SuperCollider

FIG 2.4-8