SSC-N-72

DRAFT FNAL SSC CRYO. 85-4

LOW TEMPERATURE SHIELD COOLING

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INTRODUCTION

This third memo on the shield cooling draws heavily on the work done by K.C.Wu (Ref. 1). Three options are shown in Fig. 1 and the differences listed in Table I. We had concluded previously that the 15K option was not worthwhile; we still maintain this opinion, despite the coupling of the 5K and 10K heat loads. On the other hand we believe the 20K loop will prove to be both economically and technically practical. This report will concentrate on how to operate this for steady state, cooldown, quench recovery, and one ring off.

STEADY STATE

Figure 2 and Table II show the cycle below 25K for steady state two ring operation. The 20K shield operates very similarly to the 80K shield. Helium is expanded in turbine D_2 to 3.5 atm; it uses the two top magnet strings shields as supply headers. It returns through the bottom magnets, feeding the three atm refrigerator return flow. Contrary to the original saver design with it's 20 atm shield we need to run the shield at low pressure for quench venting.

This then fully decouples the 5K and 20K cooling systems. As the 5K heat load varies (sync. radiation, beam loss, ramp heating, injection quenches, etc); the 20K shield temperature remains constant. This is not the case for the 10K return, or 15K return systems, and therefore provides some additional refrigeraton turn down capability.

COOLDOWN

The cooldowns are still as described in the cooldown report (Ref. 2). The only addition is that after both top and bottom magnets are operating below 7K, the shield is switched at the turnaround location from cooldown duty to the 4 atm shield duty.

The first stage compressors are so small that during cooldown their suction must run at almost 2 atm. This should be no problem except their motors will be only half loaded during normal operation.

QUENCH RECOVERY

Figure 3 shows the location of the quench relief valves dumping to the 20K shield; normally the shield is running at a pressure half an atmosphere below the single phase pressure minimizing any problem with leakage.

D_2 is a variable nozzle turbine which in steady state is providing 3.3 KW for exchanger #5 and 6.6 KW for the shield. As a slug of liquid comes out of the shield the turbine flow is cut back and the bypass closes. As the 40 to 50K heat pulse arrives the turbine throughput is increased; the bulk of the additional flow passes through the bypass providing up to about 10KW to exchanger #5.

ONE RING OFF

If one ring has a section removed the good ring is operated in the 15K return mode. In the ends of the two strings around the section removed, L-tubes are plugged in to permit both of these to operate in the 15K return mode Fig. 4. If a cold compressor is used on the shield side of the coldbox, then each L-tube would also have a cold compressor (approx. 1.0 atm in 1.2 atm out).

REFERENCES

1) Brookhaven National Laboratory, "Low Temperature Heat Shield for the SSC Magnet Type D", K.C. Wu.

2) Fermi National Accelerator Laboratory, "Large Scale Warm Up and Cooldowns", C.H. Rode.

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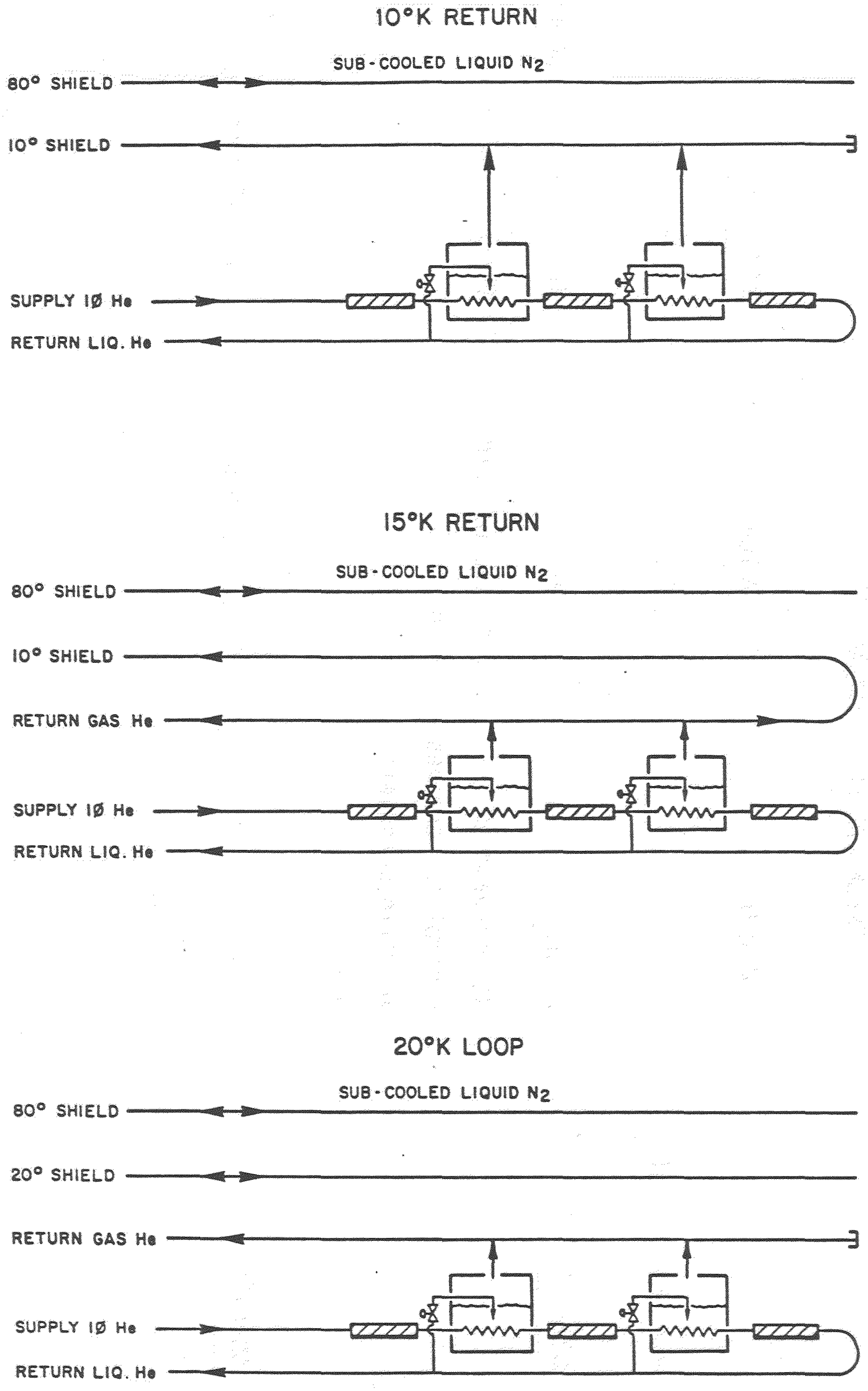

FIG.1

DESIGN "D" LOW TEMPERATURE SHIELD

	10K RETURN	15K RETURN	20K LOOP
MIN. NO. OF PIPES	4	5 (TAC)	5 (BNL)
DISADVANTAGES	Return too cold No independent control for changes in ratio 5K/shield heat leak.	One extra pipe Additional cold comp.	Two rings are coupled One extra pipe
ADVANTAGE	Simplest	Save $1M/annually	Save $3M/annually

TABLE I

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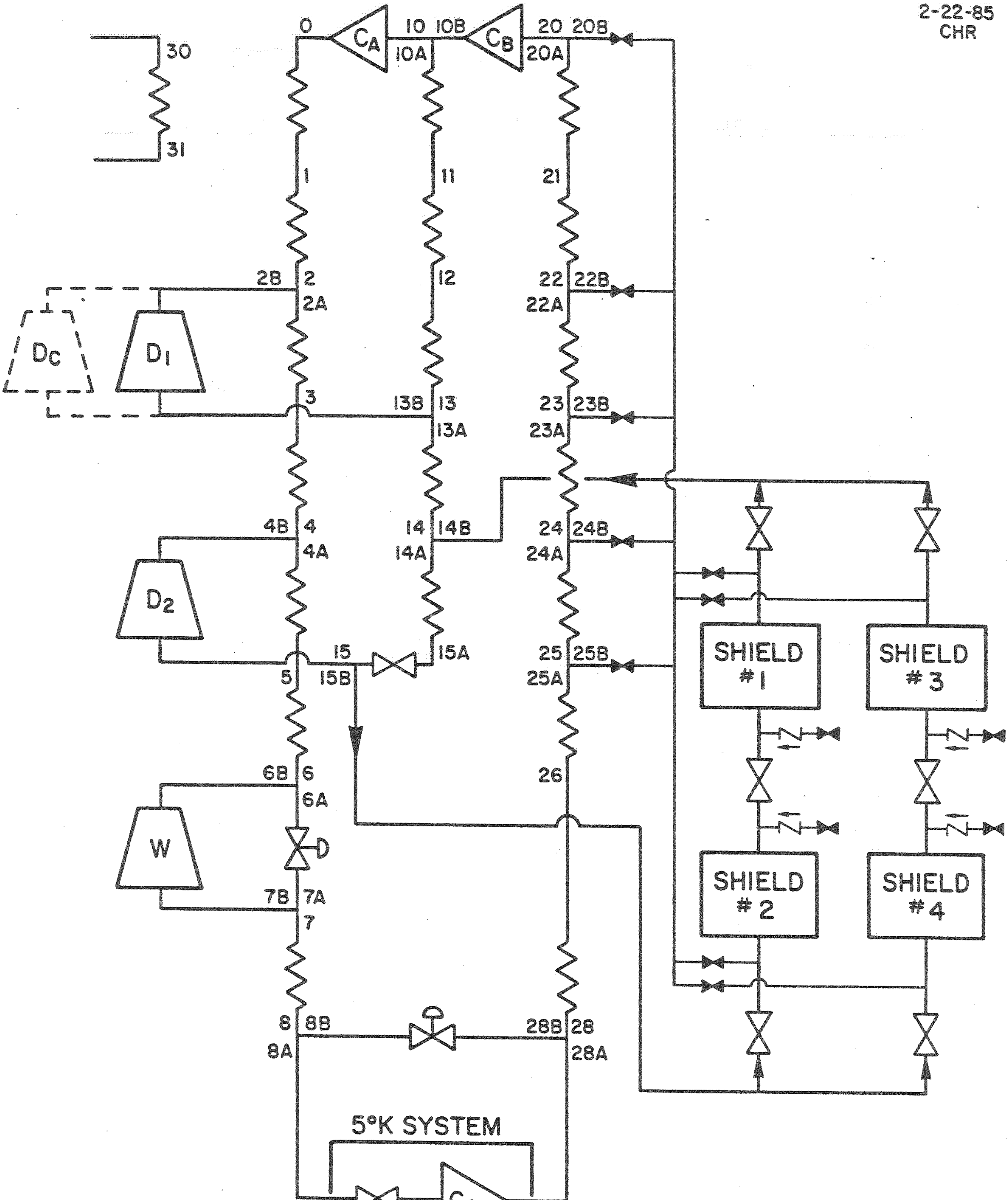


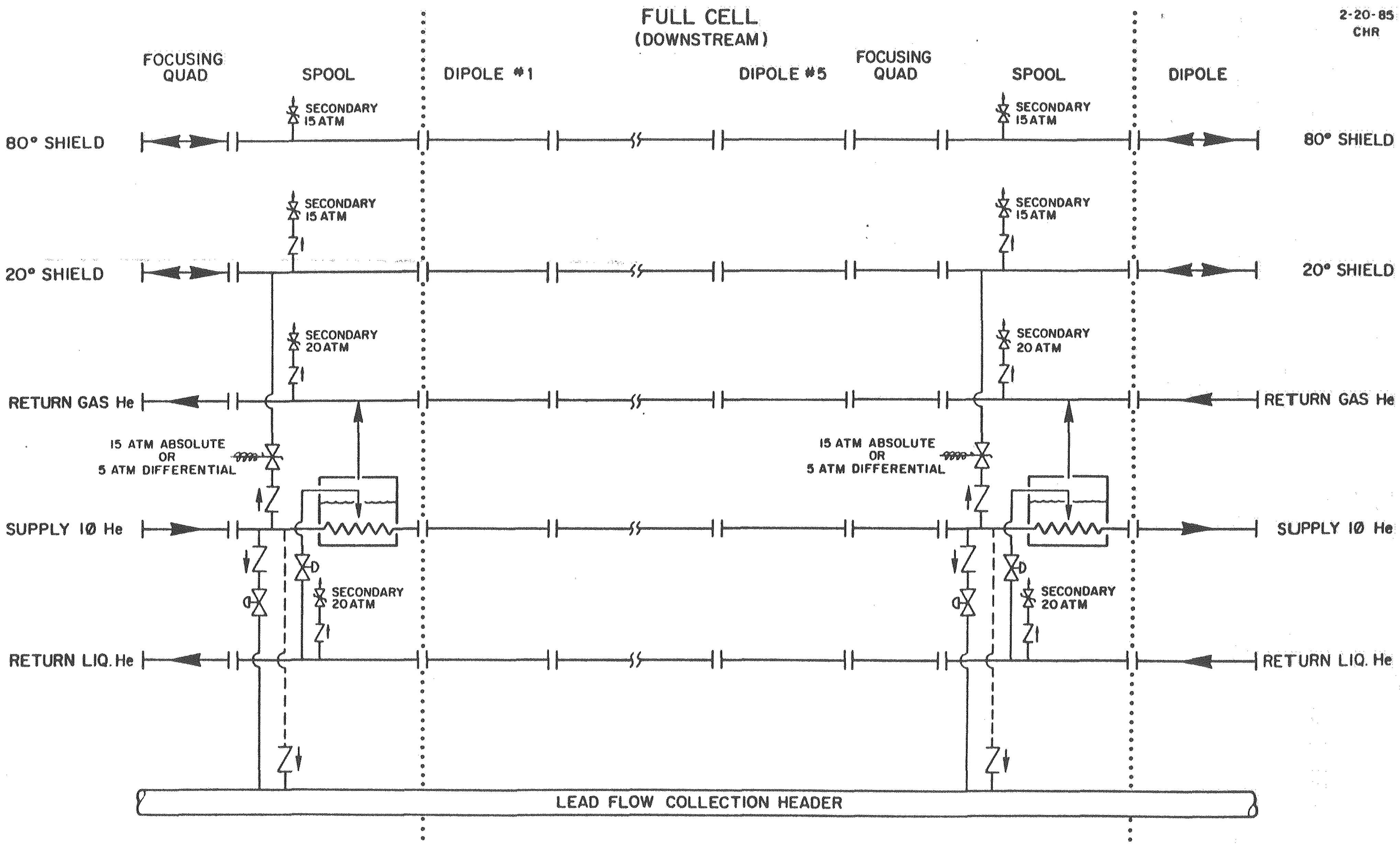
FIG. 2 - DESIGN "D" REFRIGERATOR

TABLE II FULL CAPACITY REFRIGERATION

	P atm	TK	H J/g	F g/sec	
0	15	300.00	1578.0	502	
1	15	80.00	433.3	502	
2	15	45.83	253.2	502	
2A	15	45.83	253.2	458	
2B	15	45.83	253.2	44	
3	15	30.00	167.6	458	
4	15	18.00	98.63	458	
4A	15	18.00	98.63	157	
4B	15	18.00	98.63	299	
5	15	12.00	60.49	157	
6	15	7.5	29.17	157	
7	4	5.895	21.94	157	
8	4	4.5	11.73	157	
8A	4	4.5	11.73	150	
8B	4	4.5	11.73	7	
9	1.0	4.224	30.13	150	
10	3	287.5	1509.0	345	
11	3	79.00	425.6	345	
12	3	44.43	245.4	345	
13	3	29.50	167.2	345	
13A	3	29.50	167.2	301	
13B	3	29.50	167.2	44	
14	3	16.93	100.24	301	
14A	3	15.94	94.85	101	
14B	3	17.34	102.96	200	6.6 KW

Table II (cont)

	P atm	TK	H J/g	F g/sec
15	3.5	11.59	69.96	301
15A	3.0	11.46	69.96	101
15B	3.5	11.59	69.96	200
20	1.2	287.50	1508.	157
21	1.2	79.00	425.2	157
22	1.2	44.42	245.4	157
23	1.2	29.50	167.6	157
24	1.2	15.65	94.85	157
25	1.2	11.50	72.72	157
26	1.2	5.93	41.33	157
28	1.2	4.52	31.12	157
28A	1.2	4.73	32.06	150
28B	1.2	4.424-20	11.73	7
30	1.0	285.00	295.54	74
31	1.0	77.36	-121.40	74



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FULL CELL
(DOWNSTREAM)
FOCUSING QUAD
SPOOL
DIPOLE #1
DIPOLE #5
FOCUSING QUAD
SPOOL
DIPOLE
80° SHIELD
SECONDARY 15 ATM
80° SHIELD
SECONDARY 15 ATM
20° SHIELD
20° SHIELD
SECONDARY 20 ATM
RETURN GAS He
RETURN GAS He
15 ATM ABSOLUTE OR 5 ATM DIFFERENTIAL
SUPPLY 10 He
SUPPLY 10 He
SECONDARY 20 ATM
RETURN LIQ. He
RETURN LIQ. He
LEAD FLOW COLLECTION HEADER

FIG. 3

DESIGN "D"
MAGNET REPAIR SEQUENCE (STRING #7-3, SECTION #B)
FIG. 4 WARM UP t = 6hr.

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