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FERMILAB TEVATRON FIVE REFRIGERATOR SYSTEM TESTS

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INTRODUCTION

During the latter half of 1980 the Fermi Lab test program switched from stand alone refrigerator tests to a "Mini" system test, which now consists of two compressor buildings with 4 - two stage units each (final configuration is six buildings), five refrigerators (final is 24 refrigerators), and the Central He Liquifier (CHL). Each of the refrigerators cools two 125 M long strings of magnets.

SYSTEM DESCRIPTION

See paper ID 5 1979 CEC for details [1].

COMPRESSOR CONTROL LOOPS SUBSYSTEM

A) He inventory Control: A pair of valves either add gas to the suction or kick back gas to CHL compressor discharge or storage from the satellite compressor discharge.

B) Compressor Capacity Control: Each compressor has a suction slider valve which controls throughput. The four suction sliders plus a bypass per building regulate the compressor discharge pressure.

C) Interstage Control: Each compressor has a second stage slider valve which regulates interstage pressure.

REFRIGERATOR CONTROL LOOP SUBSYSTEM

A) Liquid N2 Control: Each refrigerator has three temperature servoed valves for refrigerator precooling, upstream magnet shield, and downstream magnet shield.

B) Liquid He Control: Each refrigerator has a temperature servo valve for providing the heat exchanger imbalance flow in satellite mode.

C) Warm End Flow Splitting Control: Each refrigerator has a pair of temperature servo valves to control the flow through the N_2 pot and thereby the $77^{o}K$ part of the plant.

D) Warm Expander Speed Control: The expander speed is servoed to keep the middle of the plant at constant temperature.

E) Magnet Liquid He Control: These are 5 very tightly coupled servo loops which maintain pressures and flows in the magnets.

1) Cold Expander Speed Control: This expander pressurizes the magnets and is servoed to maintain the pressure at 1.8 atm.

2) Coldbox JT Valve: This is a back up for the expander and is servoed at 1.7 atm

3) Coldbox Bypass Valve: This is an internal pressure clipping valve (or relief) set at 2.0 atm

4&5) Magnet Flow Control: Each magnet string has a JT valve at the far end which throttles the liquid from 1.8 to 1.2 atm and is temperature controlled.

MOBILE PURIFIER SYSTEM

Rather than building 24 stationary purifiers we have built 2 mobile units on trailers consisting of 3 trailers each. The first trailer contains 2 vacuum pumps, 2 dehydrators, and $77^{o}K$ charcoal bed with heat exchanger. The second trailer contains a small compressor. The third contains the contamination detection electronics including a cromatigraph.

The satellite refrigerators have auxiliary piping which permits us to derime individual exchangers and restart the refrigerator in a few hours.

TWO COMPRESSOR BUILDING RUN

The configuration for this test is given in Fig. 1; the two compressor buildings being located 1000 m apart. The A1, A2, A4, and B1 refrigerators ran with independent schedules.

The first test was to see if there were any control instabilities caused by the coupling; none showed up in this test. (Later tests showed several 8 to 24 hr. instabilities).

The major goal was to gain operating experience in contamination control: initial building decontamination, cooldown, long term operation, individual coldbox derime, and cold box warm up. We obtained several refrigerator - years of experience including twice crashing the entire system with contamination.

The final contamination detection evolved from this test; it is:

A) At each conpressor building:
   1) Water Detector
   2) N_2 Detector
   3) Oil Detector (future)

B) In the mobile purifier:
   1) Water Detector
   2) N_2 Detector
   3) Cromatagraph

C) At each refrigerator building: Nothing

SATELLITE REFRIGERATOR CONCEPT TEST

The goal of this test was to first measure the heat leak of the transfer line and second to get operating experience in the satellite mode.

The A1 refrigerator was run as a liquifier replacing the C.H.L., shipping cooling to A2; the A2 refrigerator was run as satellite to cool the load. Normally A2 was run with only the $6^{o}K$ expander running but for short periods even it was turned off and only the JT was used.

We tested the 266 meter line and measured a He heat load of 9. watts and shield load of 140 watts [2]. We had many problems with contamination plugging venturies as well as flow instabilities and reversals. By carefully choosing our operating pressures and temperatures in the line we were able to cool two 125 meter strings of magnets at A2.

MINI SECTOR POWER TEST

We are currently setting up for this test. The A1 refrigerator again is substituting for the C.H.L.; the magnet loads are connected to the A2 and A3 refrigerators. The A2 and A3 refrigerators will operate in a mixed mode producing 800 watts each with the A2 power leads cooled directly from the A1 refrigerator. This test will permit us to measure many parameters including AC heat loads.

A SECTOR TEST

This test is scheduled for mid summer with the CHL feeding liquid to 4 refrigerators running in satellite mode and a 5 th. running in stand alone mode. FIGURE 1

REFERENCES

1. C.H. Rode et al., Advances in Cryogenic Engineering, Vol. 25, Plenum Press, New York (1980) Paper ID 5

2. C.H. Rode et al., Fermi Lab Tevatron Transfer Line, this conference.

A SECTOR REFRIGERATOR SYSTEM

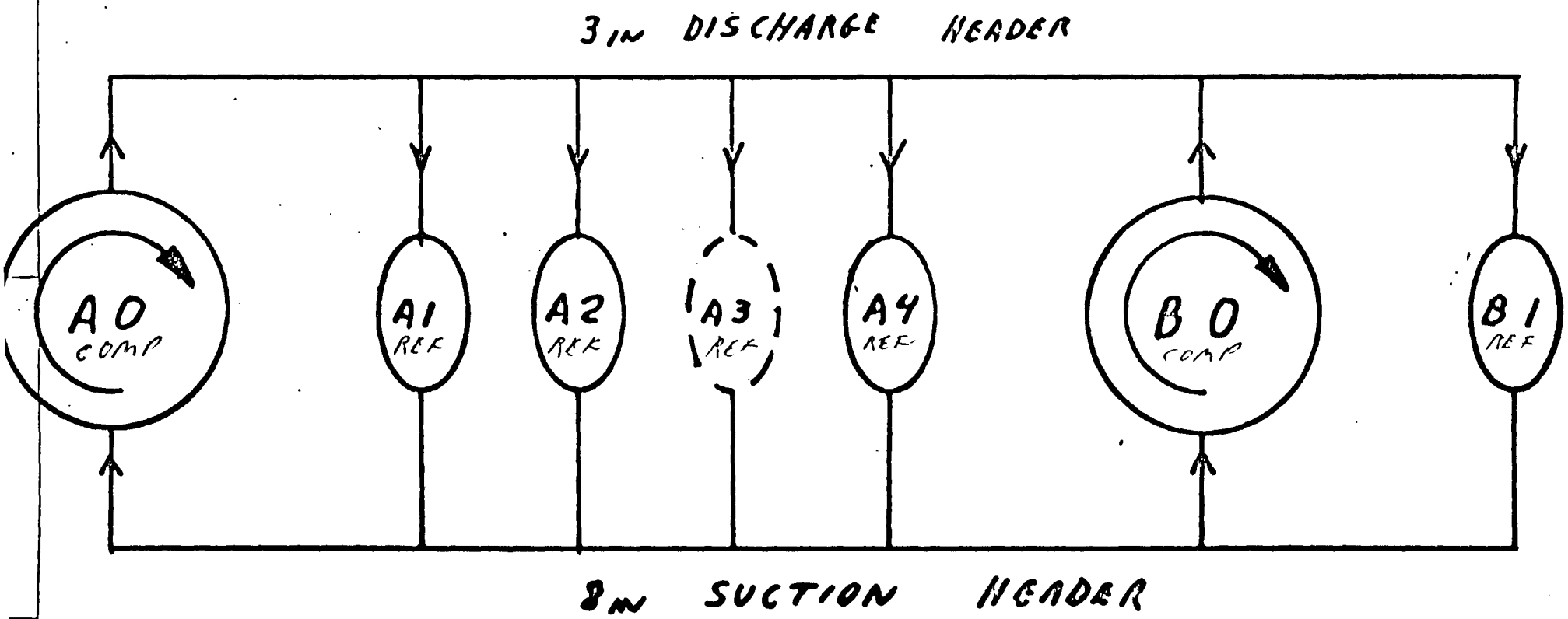

FIG I

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Fermilab Tevatron Five Refrigerator System Tests,

C. RODE, R. FERRY, M. LEININGER, J. MAKARA, D. MAZICKO
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