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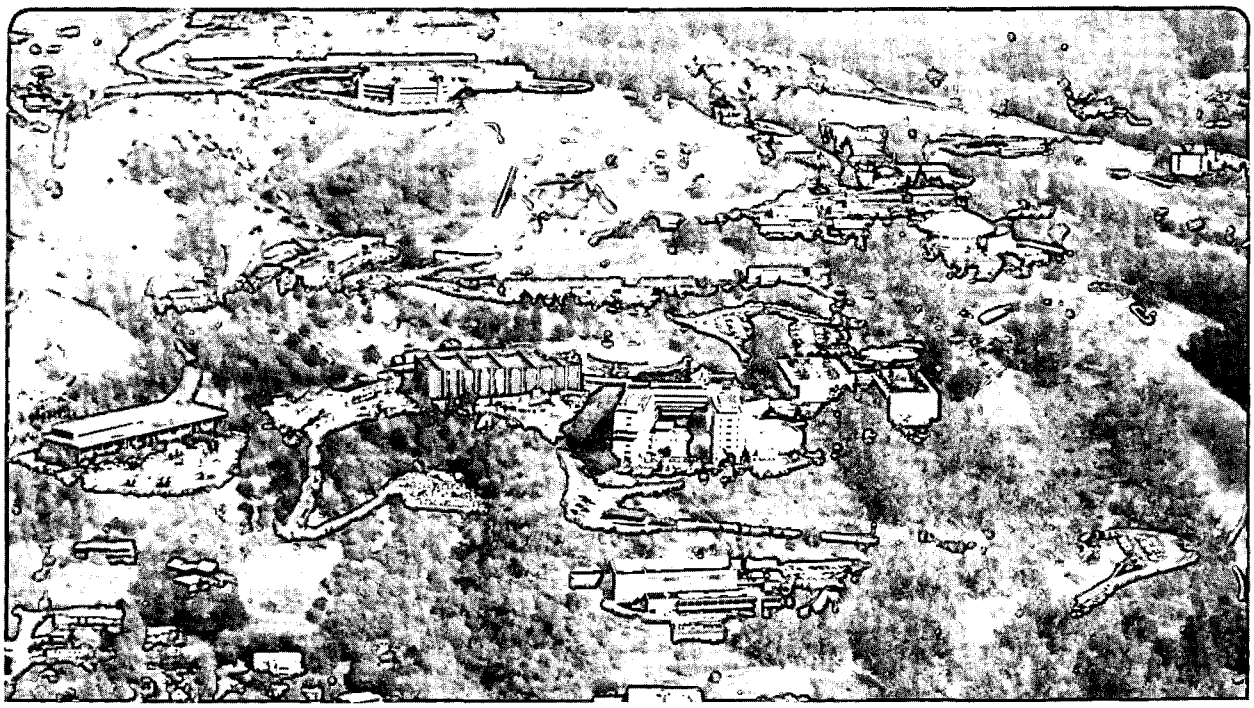

DISCLAIMER

LAWRENCE RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA

ENGINEERING NOTE

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AUTHOR	DEPARTMENT	LOCATION	DATE
R. Byrns	Mechanical Engineering	Berkeley	August 1, 1973

PROGRAM — PROJECT — JOB

BEVATRON VACUUM PUMPING SYSTEM

CRYOGENIC PUMPING

TITLE

HELIUM REFRIGERATOR CROSS-CONNECT STUDY

SUMMARY

It has been proposed that a cross-connect line be made between the two Helium Refrigerators for the Bevatron cryopump. This would permit single reefer operation and possibly provide more reliability and less outage, particularly during heavy-ion runs. Reliability becomes even more important during future time-sharing operation. Motivation source has been some refrigerator outage during last year heavy-ion runs. However, the record has been good considering the first year learning curve. Recent local refrigerator continuous operation records have been 16.7 weeks (2800 hours) (Hilac) and 9 + weeks (Bev. S.C. magnets). Estimated cross-connect transfer line cost is $25,000 ± 10%.

Recommendation is to leave the system as is, and seek to reduce outage. Scheduled refrigerator maintenance during regular Mondays should help as well as minimizing short on-off periods such as 24 hour PEP tests. Engineering design work could continue as back-up preparation if future reliability is still considered unacceptable.

INDEX

Ref. Dwg. 17K4666

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DISCUSSION

Historically, main sources of cryogenic refrigerator outages have been: 1. Compressors, and 2. Valve icing due to contaminants. Compressor trouble stemmed from poor lubrication with the lighter gases such as helium and hydrogen. The CTi Model 1400 compressor has essentially solved the compressor problem and gives reliable service for 3500-7000 hours continuous operation.

Contamination trouble can occur suddenly or over a long term progression. Contaminant sources are: 1. Supply gas, 2. Leakage during operation, 3. Residual gas due to insufficient purge, including gas left in charcoal traps and filters. Our helium supply gas has proven to be very clean and the vendor (Poxco) is reliable. We have no known history of dirty Poxco bottles (although we have from other vendors). The only logical source of air leakage during operation is the expander piston seal. This, we have protected with a helium back-up can and its pressure only seems to go negative during cool-down. We plan to improve purge procedures, using as many as 12-15 rapid pump and purges with careful pressure decay monitoring. This should delay valve icing and extend operations to 12 weeks or more.

Additionally, we have added a fast valve warm-up circuit which should permit valve de-icing and return to operation in 1 to 3 hours.

The enclosed estimate for the cross-connect transfer line of $25,000 is for the minimum, most economic option. There are some uncertainties in its operation.

1. Heat Load and Mass Flow

With the added lines and valves, the heat load may exceed the capacity of one compressor. Always with refrigeration, it is good to have more capacity than load by 50-100%, because things never get better (2nd Law). It might be necessary to operate with two compressors, or one compressor plus LN.

In any of these modes, balancing the flow to the four cryopanel circuits would be required. Presently, with one compressor (60 scfm) to 2 cryopanel circuits, the balance is automatic. One compressor to 4, may require some valve throttling and trimming. Two compressors to 4 could possibly be self-adjusting.

2. Outage Time

It might take as long to cool down the transfer line and balance the system for one refrigerator as it does to warm-up one sick reefer and de-ice (say 2 hours). However, on a planned change-over one reefer could be taken out of service for a complete warm-up and purge cycle. This would provide more flexibility and hence reliability. Also, emergency repair is more easily handled.

RB/ml

COST ESTIMATE OPTION I (min. cost)

4000 ACCT.

ENG'R & DESIGN 300 HRS @ $20.00 . . . . . 6000.00

TRANSFER LINE ~100 FT (DUAL LINE)

PARTS FAB. . . 160 HRS.
ASS'Y . . 160 HRS.
320 HRS @ 17.50 = 5600
MAT'L 800
} 6400

AUX. VAC SYSTEMS. 1500
(J.O. 38385 11/72 "CVI" XSFR LINE - $2000 FOR 35 FT. DUAL)

CONNECTOR BOXES, 2 REQ.

CONTROL, ISOLATION VALVES . . 600
BAYONET COUPLINGS 400
PARTS FAB 100 HRS @ 17.50 1750
MAT'L 300
ASSY FAB. 1050
2 each @ . . 4100 8200

INSTALLATION * (REQUIRES MACHINE ACCESS TIME)

INSTALL 2 BOXES + 100 FT XSFR LINE
160 HRS @ 17.50 2800

TOTAL ESTIMATED COST. . . . $24,900.00* (± 10%)

* SOME COST REDUCTIONS POSSIBLE IF OPR. CREW USED (BUT ONLY ~15-20%)

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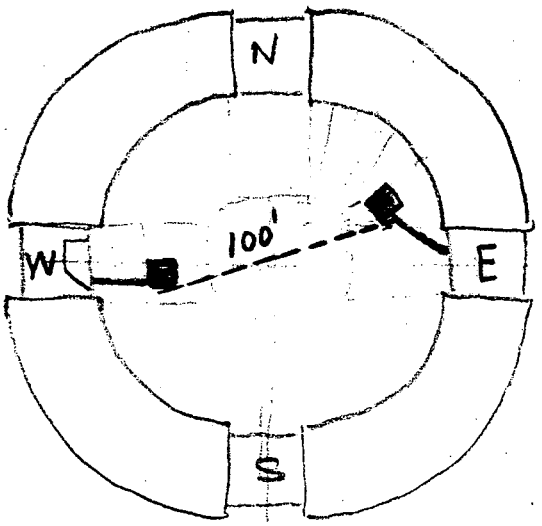
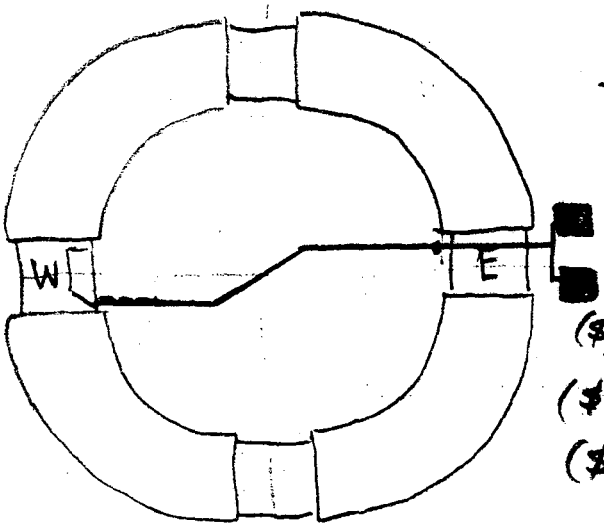
OPTIONS FOR REFRIGERATOR ARRANGEMENTS



I OPTION

Leave cold boxes as is.
Add ~100 FT X'SFR LINE, BAYONETS, VALVES
No change in compressor supply-returns
" " " Elec. Wiring & Conduit
Minimum heat load addition

Minimum Cost.



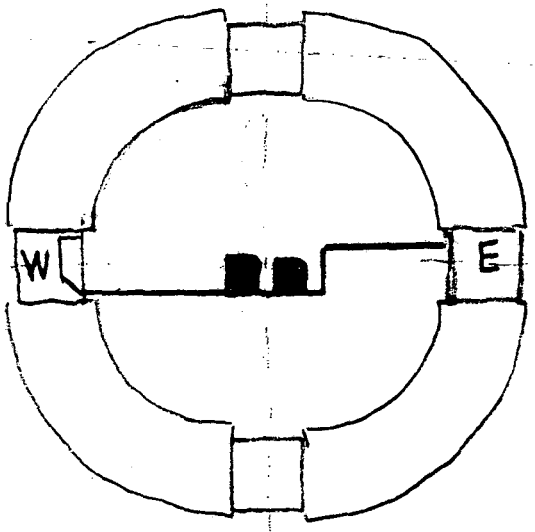
II OPTION

Move cold boxes outside shielding to EAST by Compressor room.
Better operating access (full time

($) Adds ~ 150/200 FT. X'SFR LINE, BAYONETS, VALI
($) MUCH CHANGE IN Compressor S+R piping
($) " " " ELEC, WIRING + CONDU

~50% HEAT LOAD INCREASE OVER I

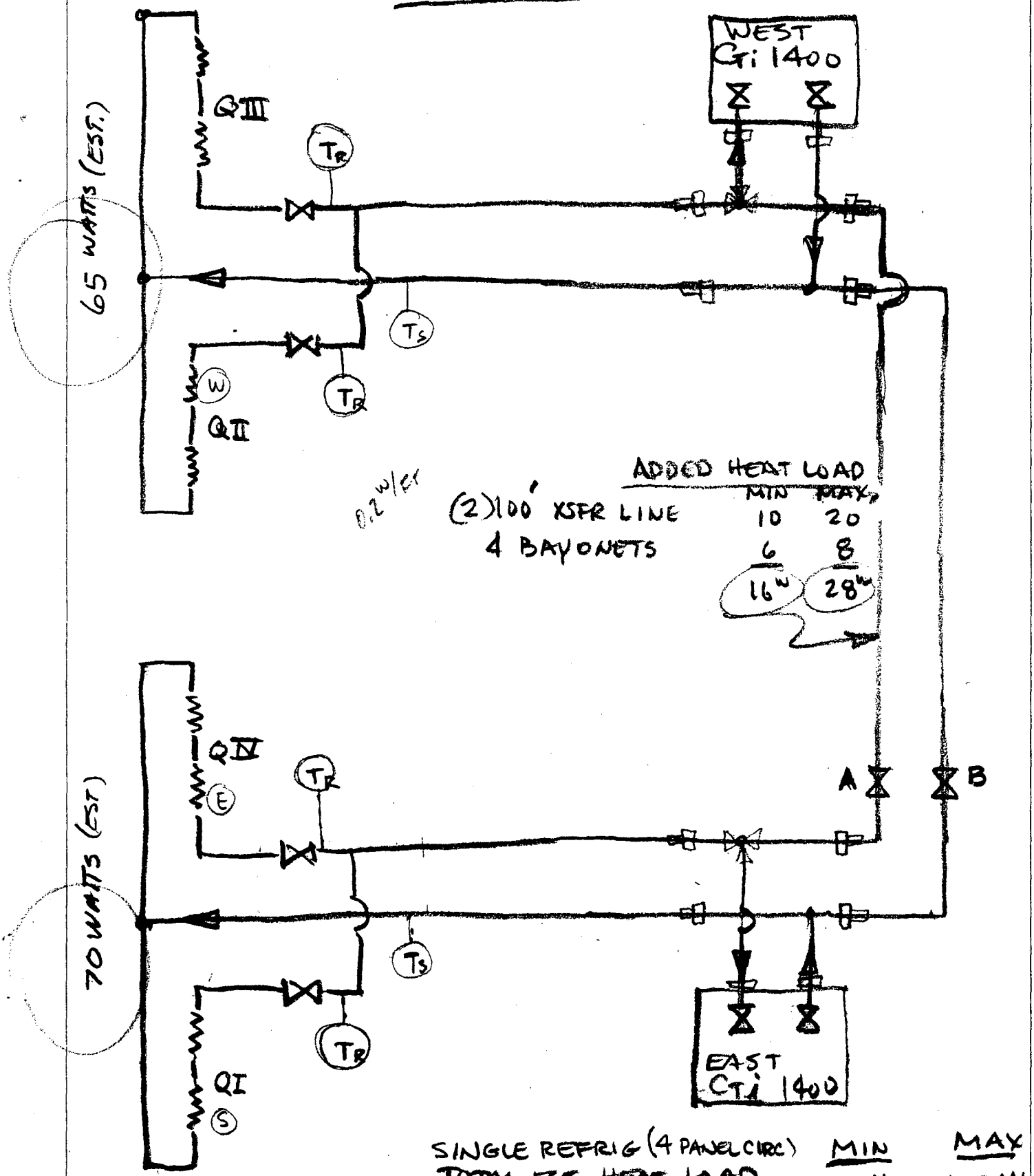
MAXIMUM COSTS.



III OPTION.

Move cold boxes to top center igloo
Gets out of crane way.
Adds ~ 120 FT X'SFR LINE
CHANGE Compr. S+R PIPING
" " ELEC. + CONDUIT
LARGE COSTS OVER I.

SCHEMATIC *



SINGLE REFRIG (4 PANEL CIRC) TOTAL EST. HEAT LOAD. MIN 151W MAX 163W

*(REF. SCHEMATIC LBL DWG 17C8196)

OPERATIONS.

WITH MINIMUM VALVES & XSFR LINE ADDED

MIN. NEW VALVES REQ'D - (2) A & B - ISOLATION ONLY

MODE I.

WEST REFER TO WEST
EAST ~~v~~ v EAST
VALVE A & B CLOSED.

MODE II. WEST OR EAST REFER TO BOTH EAST & WEST - VALVE A & B OPEN -
2 REFER. ISO. VALVES CLOSED IN OFFED REFER.
ONE (OR TWO) COMPRESSORS ON ACTIVE REFER.

(2) VALVES ON DISTRIB. BOX NEAREST
* TO ACTIVE ~~REFER~~. POSSIBLY THROTTLED FOR TEMP. BALANCE TO CRYOPANELS (IF ONE COMPRESSOR USED)

ADDITION OF VALVES A & B is minimum possible, hence cheapest
* IF BALANCING CIRCUIT IS NECESSARY - OPERATION IS ON INSIDE PLATFORM. BALANCING VALVES & TEMP. BULBS COULD BE ADDED TO TOPSIDE FOR MORE CONVENIENT OPERATION. ON SHIELDING ROOF.
(VALVE A COULD BECOME 2 - 3WAY VALVES ON RETURN LINE)

ADDITION OF ~100 FT OF CROSS-OVER XSFR LINE + BAYONET MEANS ADDED HEAT LOAD OF 16W min, 28W max.

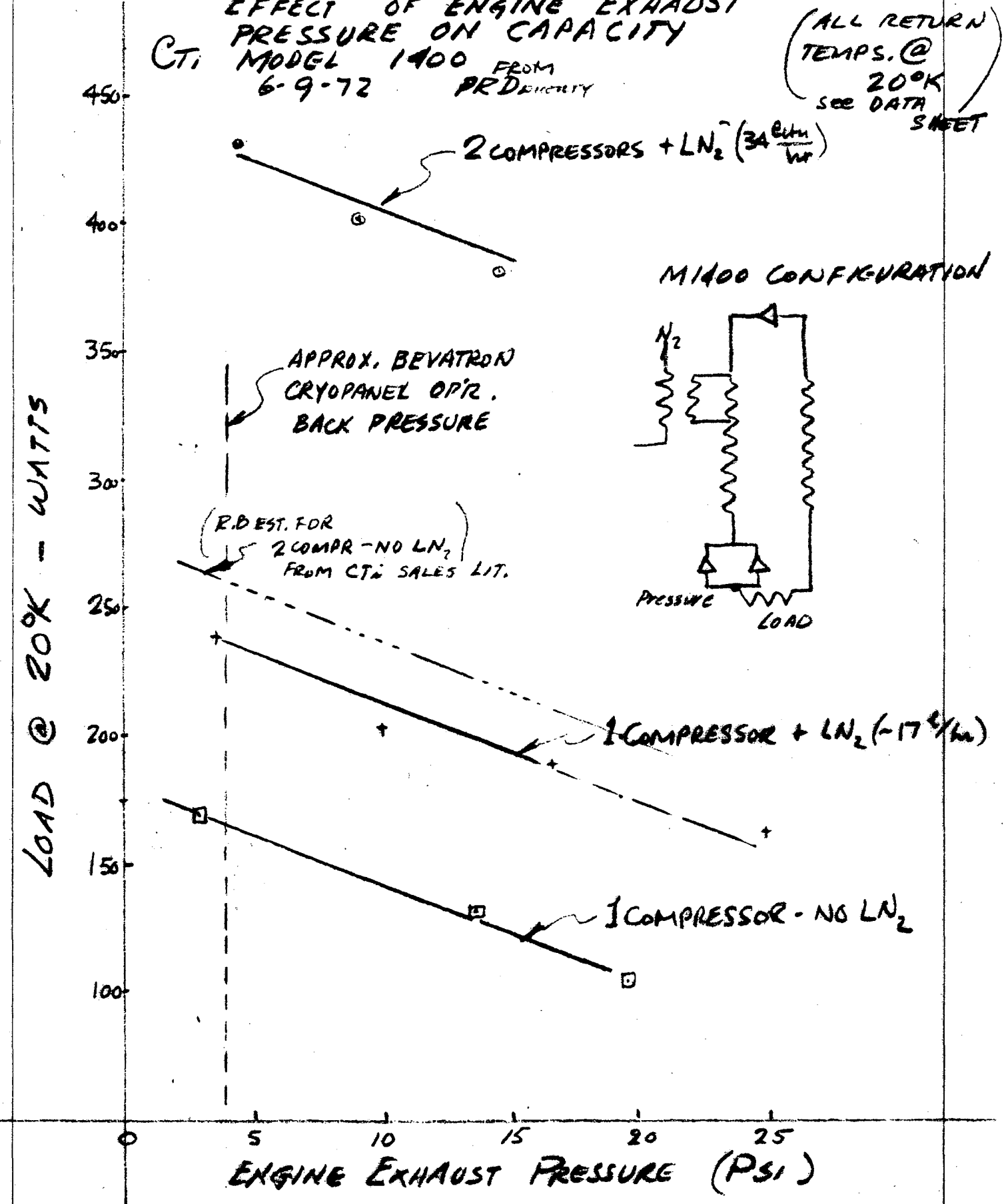
THIS, PLUS EXISTING LOAD APPROACH TOTAL → 150-160 WATTS & APPROACH MAX. He Refer OUTPUT FOR ONE COMPRESSOR
SEE GRAPH NEXT PAGE. - OUTPUT MAY DECREASE WITH TIME AS VALVES ICE & LEAK
MIGHT HAVE TO USE 2 COMPRESSORS FOR MORE OUTPUT, MORE

AUTHOR R. Byrns | DEPARTMENT Mechanical Engineering | LOCATION Berkeley | DATE August 1, 1973

EFFECT OF ENGINE EXHAUST PRESSURE ON CAPACITY

CTI MODEL 1400 FROM PRELIMINARY 6-9-72

(ALL RETURN TEMPS. @ 20°K SEE DATA SHEET)



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PROGRAM — PROJECT — JOB

BEYATRON CTI MODEL 1400 - 20°K. TEST DATA @ BOSTON MAY JUNE 72

TITLE										
HEAD PRESS WARM	432	402	380	238	197	141	202	169	131	104
SHAFT RPM	28	"	"	30	"	"	"	30	"	"
MOTOR AMPS	30	30	30	20	"	"	"	20	"	"
ENGINE SPEED RPM	278	278	278	104	"	"	"	104	"	"
T1,2 RETURN TEMP °K	20	20	21	19.3	20	20.1	20	20	20.5	20.
T2-1 SUPPLY HEAD TEMP °K	13.7	13.8	15.0	12.2	13	14	13	14.7	16	16.6
ENGINE INLET PRESS PSIA	178	187	197	197	271	220	201	204	219	219
ENGINE INLET TEMP °K	27.6	23.7	23.9	22.6	23.4	23.1	23.1	27	27	24.8
REGEN TEMP °C	-12	-10	-10	-10	-10.5	-10.5	-10.7	+16.5	16.5	16.5
ENGINE EXHAUST PRESS PSIA	4.6	9.2	4.6	3.5	16.5	24.9	9.8	24	13.5	19.3
SUPPLY PRESSURE PSIA	213	221	231	218	230	237	221	228	241	237
LN	YES	YES	YES	YES	"	"	"	NO	NO	NO
COMPRESSORS	2	2	2	1	1	1	1	1	1	1
TEST NO DATE	#5	5-23-72		#1		7-6-7		#2		7-7-7

RL-3240 (Rev.8/63)

R. Byrns Mechanical Engineering Berkeley August 1, 1973

20°K HEAT LOAD ESTIMATE

EAST REFRIGERATOR

	WATTS LOW	WATTS HIGH
INTERNAL		
5 CRYOPANELS	15	25
TRANSFER LINE - 0.38 DIA × 300 FT.	15	30
4 FEED THRUS.	2	4
EDDY CURRENT	1	2
EXTERNAL		
TRANSFER LINE - 0.75 DIA × 70 FT.	4	7
4 BAYONET UNIONS	6	8
	43	76

OPERATIONAL (AUG. 72) SUPPLY TEMP. ~ 12°K
RETURN TEMP. ~ 15°K.

* $Q = MC_p\Delta T = (28)(3°K) \simeq$ 84 WATTS

(9-20-72) $\Delta T = 22 - 20 = 2°K \simeq$ 56 watts.

$Q_{\Delta T} \simeq$ 70 watts

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* C_p for He gas @ 1–2 atm between 10°K – 20°K = 5.5 $\frac{\text{watt-sec}}{\text{gm.°K}}$

The CTi Model 1400 compressor output = 60 SCFM (one compr.)

$\rho_{\substack{\text{latm.} \\ 300°K}} = 5.1$ gm/ft.³

FOR 60 SCFM (1 COMPR.) AND 1°C RISE

$Q = MC_p\Delta t = 5.1 \frac{\text{gm}}{\text{ft.}^3} \cdot 1 \frac{\text{ft.}^3}{\text{sec}} \; 5.5 \frac{\text{watt sec}}{\text{gm °K}} (1°K) = 28$ watts

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