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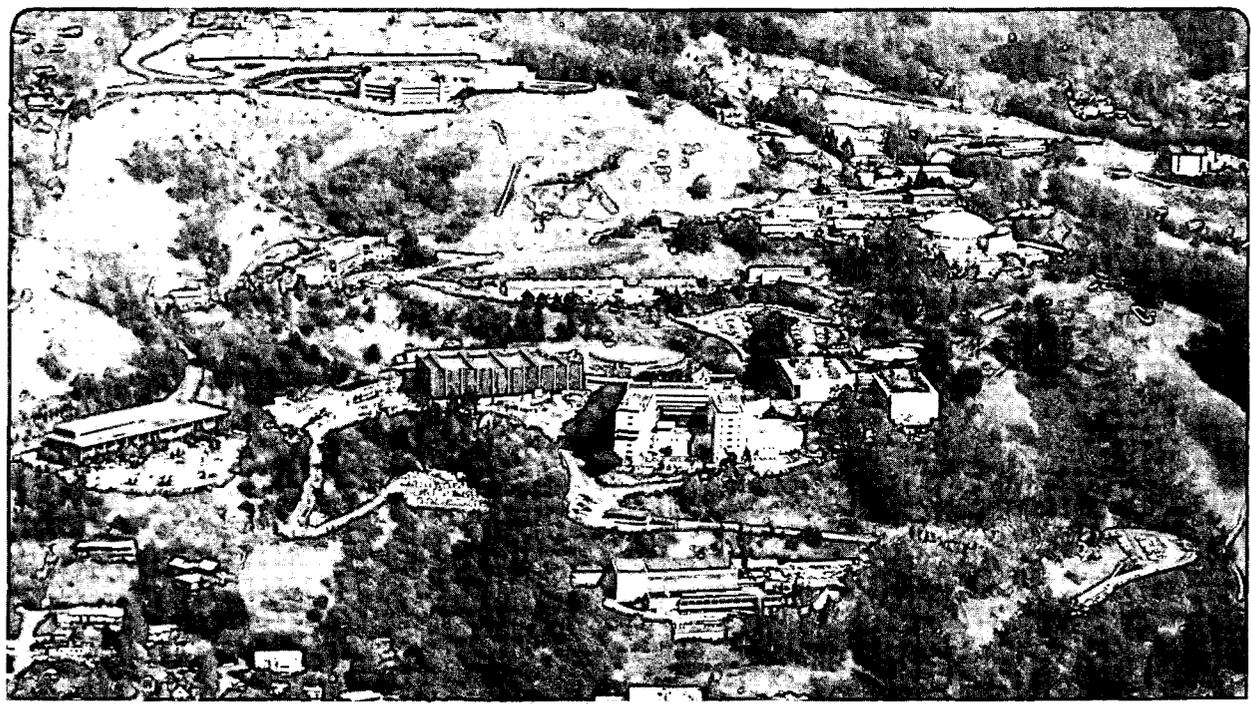
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AUTHOR	DEPARTMENT	LOCATION	DATE	
R. Byrns	Mechanical Engineering	Berkeley	20 February 1976	
PROGRAM - PROJECT - JOB		REV: 16 Feb 77 R.B		
ESCAR		B REV: Sept 8-78		
HELIUM REFRIGERATION		C REV: 5/23/79 <i>PL</i>		
TITLE		MISCELLANEOUS COST FACTORS		

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Limited Distribution

Dist.: K. Lou
 G. Lambertson
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 R BYRNS (3 cc.)

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AUTHOR	DEPARTMENT	LOCATION	DATE	
R. Byrns	Mechanical Engineering	Berkeley	2 February 1976	
PROGRAM - PROJECT - JOB				
NASA - LANGLEY Helium Refrigerator				
<p>The ESCAR Advisory Committee has advised against using this device, as "it's too complex and too costly." This advice is freely given without detailed study of a tangled problem. "Too complex," yes; it now operates with four helium pressure levels and a specialized, expensive compressor. We would operate with <u>one</u> of our compressors and only two pressure levels, in a very simple mode. "Too costly," perhaps to <u>reinstall</u> the whole plant, compressor and cold box. We must install compressors, LN supply, He supply and all other plant facility for the long ($\pm X$ years) delayed 1500 w cold box. The installation of the NASA cold box is a very small item in comparison to the rest of the system, which will be constructed anyway, however.</p> <p>The estimated cost of moving the NASA cold box from Hampton, VA to LBL and installing it here should be in the \$45,000 range - say \$15,000 to move here and \$30,000 to install. In today's market for Helium refrigerators (see page 3) this seems like an unusual bargain for a 700 - 1500 watt machine.</p> <p>Of course, if LBL doesn't want it (or can't afford it), many other laboratories (BNL, FNAL, LLL, SLAC) would be willing to assume such a "complex, costly" burden. A year or so ago, FERMILAB really looked at this unit, but it wasn't surplus then, so FERMI purchased an old Gardner Helium refrigerator for \sim \$200,000, which produces \sim 150 liters/hour and has just recently come out of litigation.</p> <p>The NASA refrigerator should produce \sim 750 watts @ 4.5° K (or 1500 watts @ 10° K), with one LBL compressor in a simple mode. With two compressors and more complexity it might yield its presently rated 1300 watts @ 4.5° K. It would provide: -</p> <ol style="list-style-type: none"> 1. A termination for the present compressor installation and final testing device for the oil removal system. 2. Operating crew training. 3. ESCAR flow and magnet pulse tests to one or two quadrants, at minimal power consumption. 4. Full back-up for ESCAR magnets held at static load only in the event of cold box outage. 5. Potential use at full load or back-up standby for Bevatron Cryopump. 6. Potential use for future large volume high field experimental physics program magnets. <p>Caution should be used in defining the projected use, because the value is $>$ \$500,000. In today's strange bookkeeping, we might be charged this full amount against capital and/or operating funds.</p>				

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R. Byrns

Mechanical Engineering

Berkeley

2 February 1976

BEVATRON CRYOPUMP HEAT LOADS

The estimated heat loads for the projected Bevatron Cryopump are ~ 1500 watt* at 20°K . This is roughly equal to a 450 watt refrigerator at 5°K . The hydrogen gas load is somewhat uncertain as well as the pumping method. It is reasonable to consider operating the cryopanel at 10°K for an equivalent load of 1500 watts.

HELIUM REFRIGERATOR COST ESTIMATES (Dec. 1975)

CAPACITY	K\$ RANGE	REMARKS
Cold Box Compressors 75 - 100 watts @ 4.5°K . 20 - 25 liters/hr	60 - 80 30 - 90 90 - 170 Total	60 - 90 Horsepower compressors Standard system - 3 to 6 months delivery from CTi, Model 1400. <u>More refrig @ higher temp. per Carnot,</u> i.e., 100 W @ 5°K ; 400 W @ 20°K .
Cold box Compressors 400 W @ 4.5°K ~ 100 liters/hr.	250 - 300 50 - 80 300 - 400	250 - 300 HP. Like present system on LLL Baseball(CTR) Could be contracted, bid or built in house.
Cold box Compressor 1,000 W @ 4.5°K	400 - 500 100 - 150 500 - 650	500 - 600 HP CTi Model 4000 - 12-18 months delivery
Cold box Compressor 1500 W @ 4.5°K ~ 400 l/hr	400 - 600 250 - 350 650 - 950	1000 HP Cold box 8' dia. x 15' high Present ESCAR - FERMILAB spec. - 14 months delivery after injunctions.

The BNL - PTL Helium refrigerator was ordered \sim Dec., 1974 and will be delivered soon. Price for the cold box with three turbines was \$406,000. Rating is 600 watts, @ $6^{\circ} - 8^{\circ}\text{K}$. Compressor is hermetic Screw compressor 100 gms/sec, 3 to 15 ATM, 350 HP, 204 mm/1.5, 760 CFM displacement, price from CTi, \$69,000 plus \$3000 for starter = \$72,000 8 months delivery.

BNL has purchased 1100 ft. plus valves (4 x 300') of transfer lines for LHe and LN from MVA. Helium inner line is 1.8" dia. Invar, heat leak is 0.1W/per lineal ft., total ~ 150 watts, insulation ~ 44 layers of S. I. per inch... Lengths ~ 25 ft., with 24" long re-entrant ends, prefabbed for field weld assembly. Cost \$100/ft. \sim \$140,000.

*EN 4681 A page 5, "Bevatron Vacuum Pump for 10^{-9} Torr," R. Byrns, Nov. '74.

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Ref. Memo from C. Wise, LBL Purchasing, March 31, 1975

Liquid Nitrogen Tank Availability

Response to our February 6, 1975 letter of Inquiry 12775JD is a reflection of this age of uncertainty. As discussed with you, response from Lox was repeatedly delayed by reluctance to quote a price in inflationary price conditions.

There follows a summary of prices:

Company	Size in Gallons	Working Pressure PSI	Price	Est. Cost LBL
Union Carbide	9,000	125	\$39,700	\$45,000
Union Carbide	9,000	235	46,995	53,000
Liquid Air Inc.	9,000	?	46,000	52,000
Lox Equipment	10,000	25	42,000	43,000
Lox Equipment	10,000	68	48,000	50,000
Lox Equipment	15,000	25	56,000	60,000
Lox Equipment	15,000	68	65,000	70,000

Pacific Oxygen is an unknown quantity. Their prices will probably be best.... the problem is there is no way to know what, if anything, they will have available at that time.

Delivery on the above is 10 to 18 months.

Ref. Memo to T. Beales, LBL, from G. Coombs, CTi, June 10, 1975

CTi 1400 Helium Refrigerator

Gordon Coombs of CTi provided the following budgetary cost estimates.

Complete System - \$145 - 150 K

Consists of:

Cold box including startup assistance	\$60K
Dual Internal Purifier	10K
Special full flow precooler	6K
Cooldown package (special connections, internal valving so it can be efficiently operated at 80, 40, 20 & 4°K)	12K
One pair cryogenic adsorbers for makeup gas purification	6.5K
Piping kit to innerconnect system	3.5K
Pure gas storage tank, 500 scf tank	2 K
Compressors (3 @ \$14K each) (25 KW each)	42 K

These prices are good for about 3 months, thereafter, figure 10% per annum inflation factor. Delivery is 4-6 months FOB Boston, Mass. Estimated shipping is \$1500 to Europe.

Guarantee: 2 compressor = 60w, 3 compressors = 80w @ 50 hz (4.4 deg.K)

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Berkeley

8 February 1976

ESTIMATE FOR CTi - 1500 watt Refrigerator Screw Compressor Set for FNAL.

Suitable for Outdoor Service at Batavia, Ill.

CTi LOW	K\$	CTi HIGH	LBL
------------	-----	-------------	-----

2 compressors. "D - B" -

400 HP & 600 HP (?)	90	110	80
(200 HP & 800 HP - LBL)			

Engineering - 9-12 months	30	50	40
---------------------------	----	----	----

Oil Removal Equipment

one demister + 2 charcoal pots (one each - LBL)	25	40	20
--	----	----	----

Aftercoolers and oil coolers

(for 50% Glycol - (@ Batavia))	10	15	12
--------------------------------	----	----	----

Valves, Instruments, Electric

(for outdoors Batavia)	30	40	30
(inside LBL)			

Motor Starters, Contactors

(outdoors - Batavia)	20	30	10
(inside LBL)			

Assembly work - includes piping & wiring, skid (no skid - LBL)	30	40	30
---	----	----	----

Test operations @ 1.0 MW

(100 hour run-in and development)	25	35	20
-----------------------------------	----	----	----

Sub-total	260	360	242
-----------	-----	-----	-----

Contingency ~ 10%

	26	36	24
--	----	----	----

(Escalation?)

Profit (if any) ~ 10%

	26	36	
--	----	----	--

	\$312	432 K	
--	-------	-------	--

The quoted figure was (\$280 K) - \$675 for one compressor and one cold box,
June, 1975 CTi

\$395 for another cold box.
\$1,070

ORNL - CONTRACT @ CTi about Jan 1976 ~ ~ ~ ~ ~ \$995,000
est. Deliv. ~ JUNE 77

- ONE COLD BOX @ ONE turbine ~ 1200W @ 3.5°K

ONE COMPRESSOR SKID. SULLAIR C25-LA-704-3.6-1000 HP

" C32-LA-704-3.6-400 HP

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Berkeley

February 10, 1976

ESTIMATE FOR LBL - 1500 watt HELIUM REFRIGERATOR PLANT\$KElectrical installation

Contactors, load center, wiring

20

Tower Water Supply200 - 400 GPM pumps, strainers, valves, piping \approx 4" dia.
(Look for surplus)

20

Instrument Air50 CFM with N₂ bottle back up

1.5

Liquid Nitrogen SupplyBldg. 51 now pays \$400/month for 8000 Gal Storage & Pump
\$70/month for 900 Gal (Price increase in Oct. '76)Aerojet Plant - 13,000 Gal LN - \$2,500 to move
(1956) \sim \$5,000 to repair

7.5

Langley - 5,000 Gal LN₂ - cost to move \approx \$1,000
(1965) (with pump)

1.0

Nevada - 1 - 28,000 Gal LN₂ - costs \sim \$25,000
1 - 8,000 Gal LN₂ ?He Gas Supply; High Pressure, 2,000 PSI

High pressure tube trailers -

Minimum of 2 - Req. Cost to service every 5 years, \$5,000
Use surplus?

10

He Gas Supply, Intermediate, 300 PSISurplus at Nevada1. Propane tank, 84" ϕ x 40 ft. long; test cell "C"
300 PSI @ 50°F
shell 0.734 head 0.363" \sim 1,500 ft.³2. Propane tank, 62" dia. x 22 ft. long \sim 375 ft.³
test cell "C"3. Propane tank, 10 ft. dia. x 42 ft. long \sim 3200 ft.³
"ETS-1"18 Feb. '76
ERDA gives
to B.I.A.
for political
reasons.

10

He Gas Supply - Low Pressure, 1 atm5,000³ ballon

5

House Vacuum PumpsKinney KT = 500 from NASA-Langley
or others

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May 1976

Fermilab Satellite He Refer. On Test: Fall 1976, Fab. Start: Fall 1975
Design by: P. Van der Arend

400 Watts at 4.5⁰K (80-100 l/hr)

350 HP } 200 + 150 Mass flow ~500 cfm. ~40 gm/sec with LN. Precool
400 HP } 2 recip. expanders. (no redundants)

Recip. York Compressors ~24 cyl. ~\$ 25,000
Installation-etc. ? ~ 30,000

\$ 55,000

Verbal guess on cold box cost, 250-300K
(Eng'r-Ass'y-Installation, extra) - (100-150K)

300,000

\$355,000

BNL-PTL CTi Cold Box

100 gm/sec at 15 atm → 3 atm, ~510 watts at 6-8⁰K,
3 turbines - Horiz. HX, No LN precool, Purchase Oct. 1974 \$406,000

Compressor CTi - Dunham Bush. Screw-Hermetic - 204/150 - 760 SCFM -
400 HP - 3 atm to 15 atm

\$69,000 comp.
3,000 starter

72,000

\$478,000

Purchase April 1975
Delivered Dec. 1975
Compr. First Operation Nov. 1976 (Engr. Installation, Assy, extra)
150-200K)

Plant Operation (est.) April 1977 +

BNL-HEUB - CTi 4000

~100 gms/sec - Big recip. expander engines. Dual sets expanders
~1200 watts 100% redundant. Dual internal purifiers. 3 J. T. valves.
at 4.5⁰K Cooldown bypass, extra bayonets.
with LN.

Ordered - Fall 1974. Original Spec. - \$325,000. New Spec. with extras - \$400,000.
Delivered - Dec. 1975 (Existing Norwalk compressors)

BNL ISABELLE Research Compressor (compare price with BNL-PTL)

Sullair C20LA-704-4.8-400HP \$ 36,000

Displ. 881 cfm. Order Jan. 1976. Deliv. Aug. 1976. OPR-2-77

Min Deliv. 600 cfm, 1-18 atm. (2 other bids were ~\$80,000) MYCOM and HOWDEN.

LBL Sullair - C25LA-704-2.6-200 (250 psia) \$34,000 Est. May 1976 + 10% \$ 91,000

C25LA-704-3.6-800 45,000

May 1977 est. ~\$100,000 +

LBL cost Oct. 1975 \$79,000
(+5% low 83,000)

Deliv Sept 76
opr. Feb 77

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Berkeley

May 1976

Budgetary Information from Gordon Coombes - CTi via telephone 3 May 1976
890-9400 FTS 223-2100

Helium Refrigerator at 15⁰K

3000 watts with LN precool. }
2000 watts no precool LN. } (no doubling as He liquifier)

$$3\text{KW} \cdot \frac{300}{15} \cdot \frac{100}{16} = 250\text{-}350 \text{ HP Compressor}$$

$$360 \text{ KW} = 480 \text{ HP}$$

Budgetary Price - Total System \$650-700K Compressor - \$250K, Cold Box-\$400K

N₂ Recondenser 30-40 KW Model C Phillips Stirling Cycle ~200 Hp ~25 KW at 80⁰K.

3 or 4 in production now - last one to be made, 30 or 40 have been built. \$400-450K

Alternate: Turbo Expander - Might as well go to 40 KW \$900-950K

N₂ compressor - comp. ratio constant }
On turbo expander - comp. ratio constant } change mass flow

Change suction by 1-2 atm. for Δ mass flow.

RB/km

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September 7, 1978

CTi-Cryogenics - Gordon Coombs
Kelvin Park, Waltham, Mass. 02154 (617) 890-9400

The Model 1400 cold box is a newer model now than our present 1400's. It has some changes, i.e., digital temperature read-out, variable speed expander motor, dual regenerative purifiers and better piston seals. It can be purchased with many added options, i.e., the 1410 is a lab liquifier with dirty gas clean-up, the 1430 is a 4.5K refer with dual purifier columns and the 1420 is a 20K unit with both engines in parallel and no JT valves. Basic cost of cold box is \$85,000 and with add-ons - up to \$120,000. It ranges from 6 to 40 liters/hr and 23 to 100 watts output, depending on compressors and LN pre-cooling. Costs are minimized if CTi is in competitive bidding with others. Deliveries are about 6 months.

The CTi Model 1400 compressor is the Dunham-Bush recip with oil clean up, 60 SCFM (4.6 gms/sec) and presently costs about \$16,000/17,000.

The CTi RS compressor is an oil flooded rotary screw with oil clean up, 195 SCFM (15 gm/sec) and costs \$35,000 - \$45,000 (depending on X\$ sheet metal covers).

CTi Model 2800 is a larger unit with fin-tube heat exchangers and two Sulzer turbines in series (not interchangeable). Spare turbine cartridges are \$30,000 each. CTi says they will stock spares at Waltham, Mass. Cold box capacity is 50-60 liters/hour or 190-200 watts at 4.5K. Cold box only cost is ~ \$200,000, as established at recent bidding at Stanford. SLAC has just ordered one of these for PEP.

Intermag - Bob Stuart, Gary Morrow
Guilderland, N.Y. FTS - 562-4411 (518) 456-5456

Intermag is competitive with CTi and produces two basic units, fabricated in New York with parts supplied by British Oxygen Corporation, London.

The Turbocool 40 has aluminum heat exchangers and two BOC turbines. Output is about like the CTi 1400 - 40 liters/hour and 110-120 watts at 4.5K. Pricing is about the same as CTi 1400 or a little more.

The Turbocool 100 has Al HX and two turbines also. Capacity is from 40-118 liters/hour and 115 to 335 watts at 4.5K depending on compressor flow. This is bigger than the CTi 2800, but in the price range of \$200,000 for cold box only. It can be purchased with a single turbine for less cost. Turbine cost is \$15-20,000.

The Turbocool units are installed in many places in Europe and have a good reputation for reliability. Their compressor is a Broom-Wade 2-stage recip with oil lube and purifier. LBL would probably buy their own screw compressor.

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September 7, 1978

Air Products and Chemical, Inc. - Richard Rerig
Allentown, Pa. FTS 488-0181 (215) 398-8331

APCI makes a unit competitive with the CTi-1400. It has tube fin HX, capacity 22-25 liters/hour, 80-90 watts, with two Dunham-Bush recip compressors like CTi 1400. Cost is 85-90K but never able to beat CTi on bids. Have sold about 3 or 4 of these. Unit has two identical recip piston expanders and vari-speed drive.

APCI also is marketing some D-B vertical hermetic screw compressors like CTi RS ~ say 9 gms/sec or 150 SCFM, 47kW. (D-B 1020, 18 to 1 ratio)

APCI at present does not produce anything in the 200-300 watt range.

Cryogenic Consultants, Inc. - P. Van der Arend
Allentown, Pa. FTS 488-0181 (215) 439-0419

CCI is a small design firm with many years experience in the field. They have designed a unit for fabrication in any good shop. Last year they jolted the industry with a bid to LBL for a 400 watt or 80 liters/hour cold box and compressor for \$300,000. Last year CVi was 33% more, Interlag 50% more and CTi even higher.

The cold box is modular construction, tube-fin HX, capable of accepting any of one or two expanders and also purifiers (for less initial capital costs). Fermilab has built/purchased 5 or 6 of these units with different compressors and expanders.

The cold box for LBL NBSTF-TFTR will have two recip expanders, made by Gardner Corp. in Allentown, Pa. The recip is generally more efficient than a turbine and has a wider range of mass flow for turn-down ability. It is subject to wear and less reliability than a turbine, but it can be repaired by lab people. Turbines can be installed later by LBL with added funding.

Estimated cost for such a cold box (400W, 80 liters/hour potential with 200W to start) without an 80K charcoal purifier and only one piston expander is \$150-175K. The recip expander package is about \$15-20K.

Compressors - Sullair Corp. - Dave Mantei
Michigan City, Ind. FTS 386-2411 (219) 879-8211

LBL has purchased three Sullair rotary screw compressors for helium service and about 25 more have been sold since our first contract. LBL is familiar and satisfied with these machines. We know how to do the oil purifier, controls, etc. in house and this work can be done on operations.

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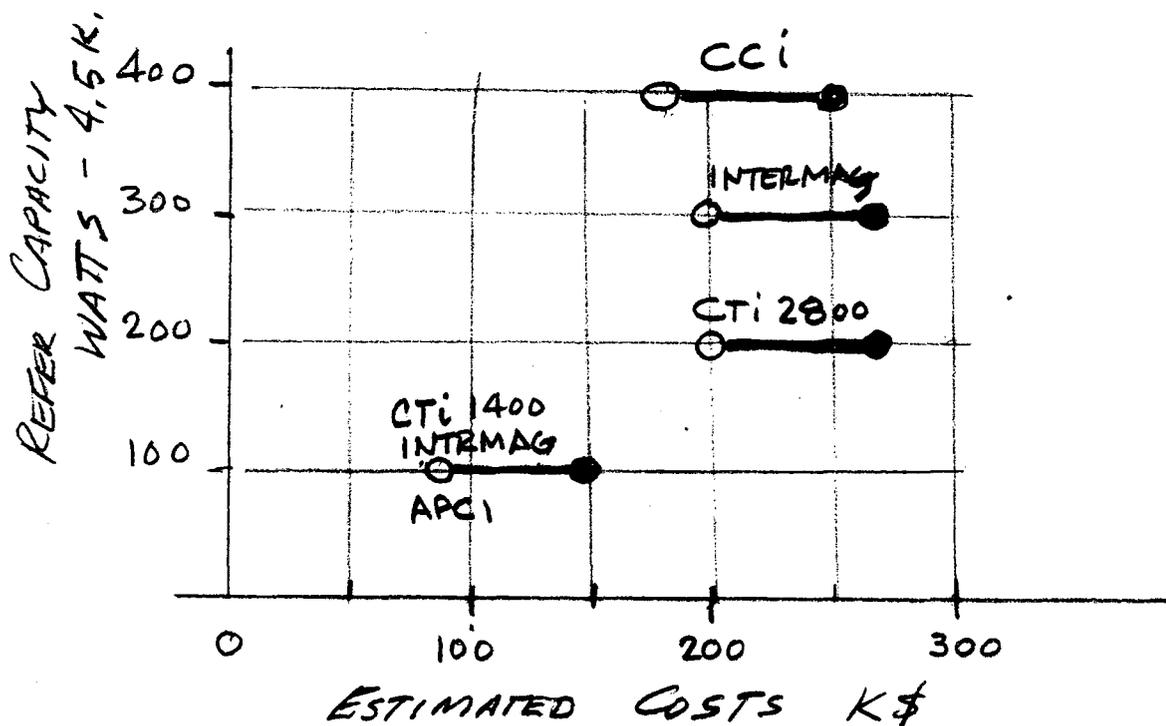
September 7, 1978

Estimated cost range vs. capacity is:

SULLAIR CORP. COMPRESSORS - Helium Service.

Model	Displacement CFM	Delivery gm/sec	Motor House Power	Estimated Cost Compressor only K\$	Controls, Filters, Oil/etc.
CB-12	216	13		20	
C16L	445	27		35	3-6
C20S	597				
C20L	881	55	300-400	50-60	4-10
C25S	1162				
C25L	1710	113	600-800	60-80 (40 in 1976)	
B32SB	2343				
B32LB	3343				
C40L	3483				

MYCOM 2 STAGE - 350 HP - 50 gm/sec He Comp. ~ 68,000) 8/78
with controls + oil removal

REFER COSTS V.S. PRICE

○ - COLD BOX ONLY

● - COLD BOX PLUS COMPRESSOR

ES0510
R. Byrnes 9/7/78

Liquefier
liters/hr

Refrigerator
Watts

Mass Flow
SCFM

gms/sec

M4902B
12

Est.
Cost
K\$

CTi - CRYOGENICS

	Liquefier liters/hr	Refrigerator Watts	Mass Flow SCFM	Mass Flow gms/sec	Est. Cost K\$
<u>Models 1410 and 1430 (4.5°K)</u>					
Cold Box Only with 2 Recips and Freeze Out Purifier					
One Model 1400 Compressor	6	23	60	4.6	105
with LN ₂	12	32			
Two Model 1400 Compressor	12	57	120	9.2	120
with LN ₂	26	72			
Three Model 1400 Compressor	34	92	180	13.8	
with LN ₂					
One RS Compressor	12	57	195	15.0	145
with LN ₂	40	100			
<u>Model 1420 (20°K)</u>					
Cold Box Only with 2 Recips and Dual Absorbers					
One Model 1400 Compressor		200	60	4.6	
with LN ₂		310			
Two Model 1400 Compressor		225	120	9.2	
With LN ₂		420			
One Model RS Compressor		225	195	15.0	125
With LN ₂		480			
<u>Model 2800 (4.5°K)</u>					
Cold Box Only with 2 Turbines and Dual Absorbers					
One RS Compressor					
with LN ₂ (est.)	25	95	195	15.0	245
Two RS Compressor	20-30	60-100	390	30.0	275/300
with LN ₂	50	190			

Intermagnetics

Turbo Cool 40	20-40	110-120		Cold Box Only with 2 turbines	110
Turbo Cool 100	40-118	115-335		Cold Box Only with 2 turbines	200

Air Products & Chem. Inc.

HL-280	22-25	80-90			90
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Cryogenic Consultants, Inc.

400W	80-90	350-400		Cold Box only with 2 Recips	200
------	-------	---------	--	--------------------------------	-----

CVI

	80-90	300-400			400 (1977)
--	-------	---------	--	--	------------

LARGE SYSTEM PRICING

BNL. ISABELLE PROPOSAL BNL 50648 - JUNE 1977

Refrig. System	\$ K
Comp. Station	2,410
Refrig "	3,000
WARM PIPE & GAS	
Storage + gas	550
Low Temp Piping	1,600
Controls (12mm)	300
Labor + misc eqms	2,620
contingency (? 16%)	

1977 → \$10,500

escalate 10%/yr

1979 → \$12,700 K

FOR 25 KW

508 \$/watt.

HEAT LOADS.	Watts
<u>MAGNETS</u>	
Support loss	3700 W
Vac Tank Rad.	3200
Beam Pipe "	1400
Corn piping	1200

XFER LINES	Watts
magnet power leads	5500
(TOTAL equiv. refer load)	
900 ^A Main current	115 W + 5,895 ^S
Correct coils	138 + 6.9
50 ^A Correct coils	2185
insert GUARDS	288 + 14.4

R FACTOR 1.5 → 15,600 W
 "ISA" REFR. DESIGN → 25,000 W

{30,000 @ LHe} ~ (10 MW comp. power.) → SED DIPOLE

Fermi LAB. est. Energy Saver/ Doubler (~1000 magnets.)

Central Liq.	\$ K
(1979) cold box	1500
Comp. (est)	3500
	5000

24 satellite refer @ 350 Ks ea	8400
(Rbest.) piping, xstr, controls	1500
labor misc ?	2,000

1979 (Rbest.) → \$16,900

LIQ, L/HR (3100?)	Ref Watts (est R _h)
2500 min (1500)	8000
(4000 MAX)	(12 KW)
(incentive contract.)	

80 %/h (R_h (Sat) 400-600 (15 KW)
 400 x 24 = 10000

Σ min → 18000 (max 22KW)
 18 KW min to 27 KW max.

$\frac{17}{18} \rightarrow \frac{17}{27} = 940 \$/w \text{ to } 630 \$/watt.$

THE BIG SINGLE PLANT IS LOWER \$/WATT THAN MULTIPLES, DUE CARNOT EFFICIENCY & PIPING COSTS.

AUTHOR: R. Byrnes DEPARTMENT: Mech LOCATION: Beck DATE: 5/20/79

SULLAIR COMPRESSOR BUDGET PRICE 9-78.

Item	Comp. Model	$R_c = 1 \text{ to } 18^{\text{atm}}$	Flow g/s	Power (BHP)	FOB \$
1	CB 12 LA-704-5-100 HP		9.98	91	22,721.00
2	C 16 LA-704-48-200 HP		26.3	207	33,809
3	C 20 SA-704-4.8-300 HP		35.3	278	39,634
4	C 20 LA-704-48-400 HP		52.0	409	46,891

(w) motor
NO AFTER COOLER

FOR ITEM	(RB)	DISPL (CFM)	(ACFM, 80% Ve)	g/s
1		216	173	13.8
2		445	356	28.5
3		597	478	38.0
4		881	705	56.4

SLAC PURCH. 2 C 20 LA-704-48-400 HP 2/1979
 with welded Attr coolers deliv 7/79
 one motor 480V, one 240V
 rated @ 655 CFM ~ 52 g/sec. ($V_{\text{eff}} = 74.4\%$ by Sullair)
TWO TOTAL - \$104,000

SLAC CTI Cold Box deliv Aug. 79.
 QUOTES Cold Box only. Sept. 1978. (10 month deliv.)

CTI-2800 - 200 watt	2 Sulzer Turbine	30K/CARTRIDGE	\$ 180 K
Inking Box 330 W	2 Boc Turbine	20K/ "	~ 200 K
CCI - 400 W	2 Air Lij. "	40K/ "	~ 210 K
CV i -	2 Air Liquid	" "	~ 212 K
			~ 240 K

NITROGEN PLANT AIR PROD + CHEM. INC / letter to C. Ward PPPL 9/78

2500 g/hr \approx 58.8 T/D
 APCI-LPRL-1800 \rightarrow 60 T/D + 6 T/D LOX
 CENTRIG. COMP. + EXPANDER, 4th post - reliable - 98% av air.
 COST INCL. 50,000 GAL STORAGE PLUS COOLING TOWER
 power 2,000 kW
 @ 31 M/KWH - \$43,400/MO
 EQUIP: 2.8 TO 2.9 M\$
 CONST. 0.60 M\$
\$ 3.5 mega \$

RENTAL - LBL supply site, power, permits etc
 \$55,000/MO.

This report was done with support from the Department of Energy. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the Department of Energy.

Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Department of Energy to the exclusion of others that may be suitable.

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