NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

27 June 1997

MEMORANDUM

To: MMA File

From: Larry R. D'Addario

Subj: Visit to Princeton Physics Department about Cryogenics

On June 26 John Payne and I visited the Princeton University group that is building a CMBR experiment for installation near the MMA site in Chile. Our host was Thomas Herbig (609/258-5584). He works with Lyman Page (-5578) and several graduate students. They are collaborating with University of Pennsylvania on this project, so an engineer and one or two students from Penn were also present.

Our interest was primarily in a new refrigerator that they have purchased from Sumitomo Heavy Industries (SHI). This is a 2-stage Gifford-McMahon cryocooler specified to cool 1 W at 4.2K. (Several companies now make similar units, all based on replacing the usual Pb regenerator material of 20K G-M refrigerators with special rare-earth compounds whose heat capacity is much higher at low temperatures.) We examined this machine and its installation in their receiver dewar, and we discussed the design considerations and the Princeton experience so far. Following are some observations and points of information, in no particular order. Attached are copies of the basic data sheets.

1. The manufacturer is:
Cryogenics Department
Precision Products Division
Sumitomo Heavy Industries, Ltd.
2-1-1 Yato-cho, Tanashi-City
Tokyo 188, Japan
and they are represented in the U.S. by
Janis Research Company
2 Jewel Drive, P.O. Box 696, Wilmington, MA 01887-0696
508/657-8750, fax 658-0349
where the Princeton contact person is Scott Azer.

2. The system purchased by Princeton is the model SRDK-408BA, sold as a turn-key system and consisting of cold head RDK-408B and compressor CSA-71A plus interconnecting cables and hoses. The price for this is $38k. It is not clear whether the cold head is available separately. The system was delivered in April 1997 and has been subjected to only a few cooldowns, none of them of very long duration.

3. The specifications promise cooling of 1.0W at 4.2K on the second stage and 42W at 40K on the first stage. The second stage capacity is confirmed in Princeton's tests with the first stage loaded by a large radiation shield. The Princeton data gives 3.1K at 0W and 3.8K at 0.5W, in good agreement with SHI test data supplied by Janis (but not guaranteed by SHI).

4. For the CMBR application, there is considerable concern about SIS mixer gain variations induced by temperature cycling and/or vibration.

With a passive load consisting of a copper bracket, copper braid flexible coupling, and a copper plate, pk-pk fluctuations of 250mK are seen on the bracket about 2 cm from the refrigerator's cold finger, but only 30mK on the plate about 25cm away, all at 3K. These have rate 1.2 Hz, which is half the motor rotation rate (144rpm). The refrigerator is mechanically coupled to the dewar by an elaborate vibration isolation system based on bellows.

5. The compressor includes a single, sealed rotary pump, which looks very much like the Hitachi 5HP scroll units used by NRAO. It is packaged with the usual oil separators, filters, heat exchanger and electrical controls. The Princeton unit is air cooled; a water cooled version is also available. It is claimed that it will work at 18000ft altitude without modifications. Neither the data sheet nor the operating manual provides a number for the helium flow rate. Power required is 7.5kW nominal, 8.3kW maximum (25A at 200V 3ph), but there is a peak inrush current of up to 106A. (Cf. CTI 1020R compressor at 5kW, and Hitachi 5HP scroll pump at 3.5kW; but these have lower pressure ratios, see below.)

6. The nominal supply pressure of 22 atm is considerably higher than the 17 atm used with 20K G-M refrigerators from CTI, while the return pressure of 5.8 atm is about the same.

7. The manual says that replacing the "moving parts" of the cold head is "required" every 10,000 hours, and for this they want the unit returned to the factory. We suspect that this just involves replacement of the seals, and that the interval is conservative. But it might also involve the regenerator material.

8. The regenerator material is not disclosed in any literature that we saw, but it was reported in a trade journal (Superconductor Industry, Winter 1996) that the company was experimenting with ErNiCo and ErYbNi+ErCo.

9. To accommodate many bias and sensor wires into the dewar, low-thermal-conductivity ribbon cables are used. The Princeton system had some home-made cables, but ribbons with manganese or stainless steel (with Au flash) wire and PTFE insulation are available from TempFlex (www.tempflex.com). These are fine wires with close pitch (estimated .005in dia x .025in spacing).

We also learned about other details of the CMBR experiment (other than the cryogenics). It will be powered by a 50kW diesel generator, recently delivered. It will operate by azimuth-only scanning, with the receivers and all optics mounted on a turret that is part of very sturdy surplus trailer. It will be on a small mountain about 10km from the center of the MMA site, where it will have line of sight to San Pedro. Staging will be done in San Pedro, and data will be downlinked to there at L band, where a set of computers will analyze it. The system is scheduled for shipment in August 1997, and is expected to operate continuously for 4-5 months before being brought back.

Distribution:
CV - J. Webber
R. Brown
A. Kerr
S-K Pan
SOC- P. Napier
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Table 1.2 RDK-408B COLD HEAD SPECIFICATION

Refrigeration Capacity	
50Hz First Stage	50Hz 34 W at 40K
Second Stage	1.0 W at 4.2K
60Hz First Stage	60Hz 42 W at 40K
Second Stage	1.0 W at 4.2K
Orientation	Any Capacity Loss: Max 15%
Ambient Operating Temperature	5 to 28 ℃ 28 to 35 ℃ (5% Capacity Loss)
Helium Gas Pressure	
Static	16.5 bar(g) (235 psig)
Operating	
High	23 bar(g) (330 psig)
Low	6 bar(g) (85 psig)
Pressure Relief Valve Setting	19.6 bar(g) (280 psig)
Gas Supply Connector	1/2-inch Coupling
Gas Return Connector	1/2-inch Coupling
Dimension	
Width	180 mm
Length	291 mm
Height	557 mm
Weight (approximate)	18 Kg

Table 1.3 CSA-71A Compressor Unit Specification

Dimension	
Width	550 mm
Length	550 mm
Height	835 mm
Helium Gas Pressure	
Static	16.5 bar(g) (235 psig)
Normal Operation	
Supply	23 bar(g) (330 psig)
Return	6 bar(g) (85 psig)
Ambient Operating Temperature	5 to 28 ℃
	28 to 35 ℃ (5% Capacity Loss)
Weight (approximate)	140 Kg
Electrical Requirement	
Power Line Voltage (±5%)	AC 200V, 3 phase
Operating Current	25A
Power Requirement	9KVA
Power Consumption	
Maximum	8.3Kw
Steady State	7.5Kw
Control Voltage	DC 24V
Pressure Relief Valve Setting	27.3 bar(g) (390 psig)
Gas Supply Connector	1/2-inch Coupling
Gas Return Connector	1/2-inch Coupling

Peak inrush current 110A measured

Spec: 106A max, 6 sec max

Walks OK on 30A service in Calif