NATIONAL RADIO ASTRONOMY OBSERVATORY Charlottesville, Virginia

1998 April 1

MEMORANDUM

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To: CDL engineers

From: Larry R. D'Addario

Subj: Iwatani Pulse Tube Refrigerator -- visit from local rep

Attached is some data on a series of pulse tube refrigerators made by Iwatani Corp of Japan. These are not directly interesting to us because they're only 1-stage devices for 77K, but whereas they are the only commercially-produced PTRs that I know about, I thought we should have a lock. The US representative is nearby in Hampton, so they plan to visit here next Wednesday in the early afternoon (April 8). This should be pretty informal, so anyone who's interested is welcome to sit in on the discussion. They'll bring a sample device to look at.

See also 'http://www.kelvinic.com'.

ROBERT KILGORE



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April 1, 1998

Dr. Larry D'Addario N.R.A.O. 2015 Ivy Road Charlottesville, VA 22903

Tel: (804) 296-0245 Fax: (804) 296-0324

Dear Dr. D'Addario:

I enjoyed talking with you yesterday and look forward to meeting you soon.

Al Guerra and I would like to visit with you on Wednesday, April 8. Al is a bit pressed for time so we promise we will not overstay our welcome.

We will have with us a cold head and rotary valve for one of the Iwatani Pulse Tube Refrigerators.

We hope to learn more about your potential application for pulse-tube cooling. We also hope to be able to answer any questions you may have.

I have asked Al to send to you (by mail) a copy of a second paper describing another use of an Iwatani Pulse Tube Refrigerator. Collectively, the paper by Colin Aspin of NOT and the paper Al is sending should give you a reasonable idea of the characteristics and capabilities of the Iwatani Pulse Tube Refrigerator.

I am trying to arrange a second visit during our brief time in Charlottesville. Please let me know if an <u>early afternoon visit with you is acceptable and I will set our schedule</u> accordingly.

Sincerely,

Robert Kilgore Executive Director

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ROBERT KILGORE

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P.O. Box 4006 Hampton, Virginia 23664-0006

359 Marlfield Circle Hampton, VA 23669 March 30, 1998

Dr. Larry D'Addario N.R.A.O. 2015 Ivy Road Charlottesville, VA 22903

Tel: (804) 296-0245 Fax: (804) 296-0324

Dear Dr. D'Addario:

Thanks for your call earlier today. I am pleased to know our web site is generating some serious interest in Iwatani products.

Attached are three things to help inform you about the Iwatani Pulse Tube systems.

The first is a table of some of the Iwatani products we offer.

- The Cold Heads listed at the top are the single and double Solvay systems.
- The Pulse Tube Refrigerators are those we discussed.
- The LN_2 Generators are stand-alone systems that provide up to 30 liters of liquid per day from the atmosphere.

The second attachment is the article by Colin Aspin of NOT.

The third attachment consists of 4 charts from a talk we made in January at a meeting in California. We had a P050 Pulse Tube system in operation at the meeting. It was connected as shown in the final chart (no. 20).

We can sell you only the pulse tube and rotary valve. However, as I explained, there are considerable advantages to you if you buy the complete package.

Please call if you have any questions after reviewing the enclosed information.

Sincerely,

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Robert Kilgore *Executive Director*

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Listing of Mini PSA and Cryo Mini Products

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Item	n Head Q (Watts)		atts)	T ult	Comp.	Power	CWater
No	Model	@77K	@20K	к	Model	Watts	Lit/hr
1	D105	5	1	10	CA201	700	
2	D105	5	1	10	CW301	700	100
3	S007	9		28	CW301	700	100
4	S007	9		28	CA201	700	
5	D310	10	3	8	CW303	2200	200
6	D510	10	5	10	CW303	2200	200
7	D230	30			CW303		200
8	S030	33		22	CW303	2200	200
9	M310	35	8	6	CW303	2200	200
10	D440	40	4	10	CW303	2200	200
11	D840	40	8	10	CW306	4400	400
12	S050	62		25	CW303	2200	200



Pulse Tube Refrigerators

ltem	Head	Q (Watts)		T ult	Comp	Power	CWater
No	Madel	@77K	@20K	K	Model	Watts	Lit/hr
13	P005	5 @120K		77	CA101	800	
14	P005	5 @120K		77	CW301	700	100
15	P201	2		55	CA101	800	
16	P050	10		5 5	CW301	700	100
17	P050	10		55	CA101	800	
18	P050	25		45	CW303	2200	200
19	P201	2		55	CW301	700	100
20	P301	9		55	CW303	2200	200

LN2 Generators

ltern	Liquifier		Store	Capacity	Gen	Power	CWater
ON	Model		Liters	Liva	1410del	vvalls	
14	LNS-1	No PSA	28	3.5		700	100
15	LNS-1	w/PSA	28	3.5	GN-3	1,300	100
16	NL-50	new	40	16	GN-10	2,800	200
17	NL-100	old	80	15	GN-10	2,800	200
18	NL-1	(boat)	40	16	GN-10	2,800	200
19	NL-100W	old	80	28	GN-15	4,400	400
20	NL-300	new	80	30	GN-20	6,100	400

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Report on Lab Testing of the Iwatani Pulse-Tube Refrigerator Unit

Colin Aspin Senior Staff Astronomer Nordic Optical Telescope Canarias, Spain

1) Introduction: Why is cooling required?

The requirement of the Nordic Optical Telescope (NOT) for a refrigerator unit comes from the necessity that the detectors in our astronomical instrumentation be cooled to reduce dark current buildup to a minimum. This produces astronomical images that are quickly dominated by sky photon statistical noise i.e. background limited. Clearly, the lower the detector dark current buildup the quicker one can become background limited in an astronomical exposure and hence, the more efficient data acquisition becomes.

In instruments that operate at optical wavelengths, i.e. from the ultra-violet (0.35 microns) to the far-red (1 micron), the detectors used are most often charge-coupled devices (CCDs). These require cooling to temperatures in the vicinity of -100°C (173K) to operate optimally. In instruments that operate at near-infrared wavelengths, i.e. far-red (1 micron) to the near-infrared (2.5 microns), detectors can be of various types but in our latest instrument, NOTCam, a Rockwell 1024x1024 'HAWAII' PACE array will be used. This detector requires cooling to temperatures in the vicinity of -196°C (77K) for optimum performance.

2) How is cooling achieved?

Traditionally, detector cooling has been achieved using liquid nitrogen, LN_2 , with a LN_2 can being an integral part of any instrument. A cold finger generally connects the LN_2 can to the detector and hence, provides a path for the heat removal. This LN_2 can often requires daily manual filling by staff members. In the worst case, filling may be required during the night thus interrupting the collection of astronomical data.

It has become much more common for instruments to eliminate the need for continuous manual filling of the cryostat by using a powered cooler unit which maintains operating temperatures steadily and automatically. This is the aim we are pursuing for NOTCam at NOT.

3) What options are available?

Three main electrically powered refrigerator models were considered, the CTI-Cryogenics refrigerator, the APD Cryogenics 'CryoTiger' refrigerator, and the Iwatani Pulse-Tube refrigerator (PTR). Although CTI-Cryogenic coolers are proven technology, provide sufficient cooling capacity at LN₂ temperatures, and are used on many current infrared instruments, they require a sophisticated and expensive anti-vibration mount to eliminate vibration on the instrument dewar. To minimize costs this unit was not therefore considered.

The ADP 'CryoTiger' and Iwatani PTR were therefore evaluated at the Copenhagen University Observatory laboratories to determine which best met the requirements for NOTCam. These two devices were considered since both do not have moving parts on the instrument itself and were compact and considered easy to use and maintain.

4) Experimental Results

Both the ADP 'CryoTiger' and the Iwatani PTR were subjected to the same laboratory tests.

A test dewar, seen in Figure 1, was used and a variable resistive load was placed in contact with the cooling heads of the devices. In this Figure we see the Iwatani PTR cold head extending from the test dewar containing the resistive load. Our aim was to achieve approxi-

mately 10 watts cooling capacity at an operating temperature of 77K.

The ADP 'CryoTiger' was found to have little (<1 watt) cooling capacity at this temperature. However, the Iwatani PTR provided ~8.5 watts at LN₂ temperatures.

Figure 2 shows a plot of temperature vs. thermal heat load for the Iwatani PTR. This level of cooling at 77K was considered acceptable. The Iwatani PTR was therefore adopted as the cooling engine for NOTCam.



Fig. 1 Iwatani PTR cold head extending from test dewar.



Fig. 2 Temperature vs. thermal heat load for Iwatani PTR.

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5) Other Application for the PTR

Clearly there are other areas of astronomy where the Iwatani PTR could be used. The facility to control multiple cold heads from one compressor, as the Iwatani PTR provides, allows operation of several devices at say, optical CCD operating temperatures. Thus, several optical CCD cryostats could be cooled simultaneously by one system with multiple heads. This option is currently being considered for the optical instrumentation at the NOT. Also, compact instruments that require cooling to temperatures colder than LN_{2} , say between 60 and 70K could use the PTR.

It is clear to us that using the Iwatani PTR is advantageous over other methods of long term cooling since it is very simple to use, requires little maintenance (MTBM is ~20,000 hours or over 2 years), has a MTBF for the compressor of >100,000 hours or over 10 years, and a MTBF for the cold head approaching infinity since there are no moving parts.

6) Areas for Improvement

Some additional refinements to the Iwatani PTR are currently being considered by the suppliers, Kelvin International. The line between the rotary value and the cold head currently has a maximum length of 2 meters. Also, this line is a relatively inflexible copper tube. Extending the length of this line (with a possible reduction in cooling capacity however) and using a more flexible tubing would greatly enhance the usability of the PTR.

Also, it would clearly be very advantageous to reduce the cost of the PTR cooler unit to a level whereby instrument smaller than NOTCam could cost effectively use this equipment. The cost of the unit we have purchased was \$25,000.

Finally, I would like to state that the staff of Kelvin International have provided assistance of the highest caliber throughout the evaluation and testing of the device. It has been a pleasure to work together with them on this project.

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Demonstrator Iwatani P050 PTR

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P050 PTR Cold Head

- 10+ watts at 77K
- No Maintenance Required
- UHV Capable Baked in Place
- Operates in Any Position

CA201 Compressor

- MTBF ~ 330,000 hours
- MTBM ~ 20,000 hours (Adsorber)
- 700 to 800 watts
- Air Cooled (Water Cooling is an Option)

M202 Rotary Valve

- No Failures to Date
- MTBM ~ 20,000 hours

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