



## **NAAPO (North American AstroPhysical Observatory)**

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## Notes From the Editor

There has been a longer than usual delay between issues of *Signals* this time. Many things have conspired to make this happen, but I won't bore you with the details. Hopefully we'll soon be back on the twice monthly schedule that is our goal.

There are no formal notes from the past two working sessions, although a lot is being accomplished. It seems that as we get more phases of the new SETI project operational we discover more things (both hardware and software) that need to be fixed. In recent discussions with Tom Van Horne, John Kraus implied that it has always been that way, and it probably always will be.

The energy of the staff and volunteers of the Radio Observatory have been directed toward the preparations for the upcoming conferences and the papers that are to be presented, as well as a "mystery" source that Tom Van Horne has located in the data from the past few months. It is too soon to discuss this source in any detail, but I hope to be able to do so in the next issue of *Signals*.

The next official working session will be at 10:00 Saturday Aug 6th.

## Grote Reber, Founder of Radio Astronomy

By John D. Kraus

Part 2

Continuing the reprint from the Journal of the *Royal Astronomical Society of Canada* that was started last issue. -ja-

World War II was then in progress and Holland had fallen under Nazi occupation. But eventually a copy of the *Astrophysical Journal* with Reber's article reached the observatory at Leiden. In reading the article, Jan Oort, observatory director, was quick to perceive that the cosmic radiation Reber and Jansky had reported must be a continuum extending over a broad spectrum. Further, he reflected that if some monochromatic line radiation existed, significant advances could result. He referred the matter to Hendrick van de Hulst, a young astronomer at Leiden, who considered various mechanisms for producing line radiation. In a 1944 colloquium at Leiden, van de Hulst reported that the 21-cm ground state transition of neutral hydrogen in

interstellar space was a possible source but the low probability of the transition and lack of knowledge of the hydrogen density in space made it uncertain whether the line could be detected. However, seven years later Harold Ewen and Edward Purcell at Harvard University detected the line and soon others did also. Observations of the 21-cm hydrogen line have been of immense value and constitute one of the most important phases of radio astronomy. In retrospect Reber's paper, which might not have been published at all, turned out to be one of the classics and an important catalyst in the birth of monochromatic radio astronomy.

The *Astrophysical Journal* tale illustrates a basic problem of doing research that bridges disciplines. Most astronomers were either skeptical of Reber's results or they were uninterested. Some stated that although Reber's measurements might be valid he should leave any theoretical interpretation to "real" astronomers. And, on the other hand, most engineers took little or no note of Reber's work. Reber was in between two groups speaking different languages.

Reber fills an important niche in the history of science.

- 1 He was the first to follow up in a significant way on Jansky's discovery.
- 2 He laid the foundation of the new science of radio astronomy. Whereas, Jansky expressed results in volts per meter, Reber related his results to the cosmos in terms of flux density (watts per square meter per hertz) and brightness (watts per square meter per hertz per steradian or equivalent).
- 3 He recognized the significance of a radio telescope as a radiometer in which the radiation resistance of the telescope antenna measures the equivalent temperature of distant regions of space lying within the antenna response pattern.
- 4 His measurements suggested that the galactic radiation is non-thermal.
- 5 He produced the first maps of the radio sky. According to George Southworth, famous for his wave guide research at the Bell Telephone Laboratory, it was not until after Grote Reber literally drew them a picture of the radio sky that astronomers began to take notice.

6 For a decade Grote Reber alone nurtured and developed the new science of radio astronomy, doing it in his free time at home while working during the day designing receivers at a radio factory.

7 His back yard dish was the largest of its kind in the world and is the prototype of the modern radio telescope. It is fortunate that in 1937 Wheaton had no ordinance against back yard dishes. Grote Reber was the right man, doing the right thing in the right place at the right time.

8 And while most radio astronomers have moved to shorter wavelengths, Grote Reber has pioneered in long-wave radio astronomy first in his work atop Mt. Haleakala on the island of Maui, Hawaii, at 3 to 15 m wavelengths and later at 144 m in Tasmania and now at the same wavelength in Ottawa. Whereas birds migrate between hemispheres with the sun, Grote migrates opposite to the sun. In his observations at 144 m through occasional holes in the ionosphere, he has found a reversal in the appearance of the radio sky with the galactic poles being bright and the centre of the galaxy dim. To accomplish this work, Grote had to do extensive research on the earth's ionosphere and when and where he could find holes to observe in the cosmos at long wavelengths.

Grote's 144-m wavelength antenna which he designed and built in Tasmania covers an area of over 1 square kilometer and is physically one of the world's largest radio telescopes. In 1985 the shuttle Challenger's crew fired maneuvering engines while passing over Grote's telescope opening the ionospheric hole so that longer wavelengths could come through. And, while in Tasmania, Grote has also built a north-facing solar house.

For northern-hemisphere long-wavelength observations, Grote is now operating a counterpart of his Tasmanian array here at Ottawa, converting an abandoned ionosphere-scatter antenna array previously used to investigate potential military communications applications into a radio astronomical telescope — a swords into celestial plowshares project.

Did you know that there is a Reber-Hubble connection? As I relate in my book *Big Ear*, around 1900 the Hubble family lived in Wheaton, Illinois. As his 7th and 8th grade teacher young Edwin Hubble had a Miss Harriet Grote who later married

Schuyler Reber and bore Grote Reber as her first son. She often commented to Grote that young Edwin Hubble stood out from her other students in his class and that she felt he would go far. In later years, when Hubble's fame was spreading, she took special pride in his accomplishments and that she had been one of his teachers.

In addition to radio astronomy, Grote Reber has many other interests. For some years, especially while a guest radio astronomer at Ohio State in the early 1970's, he did cosmic ray research. While atop Haleakala he observed atmospheric pressure variations, publishing the results in a meteorological magazine. Grote is a keen observer of nature and has made observations on a number of plants finding that if you unwind a twining bean plant and wind it back in a reverse sense the ratio of bean to shuck weight is increased. Although many textbooks state that a plant which winds as a right hand helix in the northern hemisphere winds as a left handed helix in the southern hemisphere, Grote found that his plants wound the same way in both hemispheres.

Grote has published a series of articles on his botanical work and while in Australia visited prominent botanists to discuss his findings. While he was there, the new radio observatory at Parkes held a dedication ceremony which Grote attended. Many Australian dignitaries and scientists from many disciplines were invited. One of these was a famous botanist Grote had visited previously who came over to Grote and remarked "We botanists really don't belong here do we?"

Grote is a botanist, an engineer, an astronomer, a meteorologist, an archaeologist, and an explorer of the cosmos in its broadest sense. Grote is a renaissance man, a modern-day Michelangelo.

In 1962 Grote delivered the Russell Lecture to the American Astronomical Society and he also received the Bruce Medal of the Astronomical Society of the Pacific. The following year he received the Elliot Cresson Medal from the Franklin Institute.

A young student once asked Grote's advice about what to do to discover something really new. Grote replied: "Pick a field about which very little is known and specialize in it. But don't accept all current theories as absolute fact. If everyone else is looking down, look up or in a different direction. You may be surprised at what you will find".

Put another way, Grote was saying don't go with the buffalo herd. But I might add, if you do find something watch out because the herd may turn and trample you.

I have known Grote now for almost a half-century. I was his sponsor for an honorary doctor's he received from the Ohio State University in 1962. His citation reads, in part:

Grote Reber is America's pioneer radio astronomer who turned to the heavens and opened an unseen universe to the exploration of man. Today, Grote Reber is acclaimed by the radio and astronomical scientific communities as the foremost pioneer in this new field and as a productive research scholar whose leadership continues. This university, one of the first in the United States to undertake work in radio astronomy, honors the founder of this science and becomes the first university to recognize formally Grote Reber's brilliant contributions to knowledge.

These statements are even truer today than they were 25 years ago in 1962.

Grote Reber is a living legend. He is my friend and fellow explorer of the cosmos and it is my privilege to participate today in his 76th birthday celebration in Ottawa. Congratulations and many happy returns!

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## **Radobs Notes**

**17 Jun 88 13:58:21-EDT**

From: Tom Hain

Subject: Icom computer interface

I recall the problems that Marc had trying to interface the Icom to the computer. By a pure accident, I recently came across some information on that particular interface called "CI-V" by ICOM. The information was put together by Carl Clawson, N7KBV. If anyone wants copies of this information, let me know. I will gladly get a Xerox copy in the mail for you.

**20 Jun 88 08:22:49-EDT**

From: BOLINGER-J

Subject: Icom S meter

The meter is already connected to an A/D channel. It results in a voltage proportional to the log of the received signal strength and is somewhat nonlinear at that.

For historical accuracy: Paul Ave built the interface between the Icom and the 11/23, Marc Abel wrote the programs.

Most of the CI-V info that we have seen has been almost worthless for programming the R7000, except for the crudest fundamentals, as it was written for other Icom products. Marc had to figure out most of the info himself, which was a quite formidable task.

**21 Jun 88 16:41:36-EDT**

From: Tom Hain

Subject: paint party

The girl scouts completed the painting as planned. They picked a 90 degree day and decided one of those was enough. So, they completed the task in one day!!! The two buildings absorbed the paint quite well. They consumed four gallons of paint. The entrance-way to the RO is now a light gray and not the old green. Don't look up though — one gallon didn't quite finish that job. But, I think it looks much better than it did. Other than being scared by a groundhog during a lunch break, the exercise was quite uneventful.

The girls were glad to help. We might get them to do another thing or two around the place. Any ideas??? Remember, these are 12 year old girls!

**22 Jun 88 08:31:45-EDT**

From: Bob Dixon

Subject: Mysterious Signal

I received a call last night from Paul Feldman, a well-known Canadian radio astronomer and SETI sympathizer. He relayed to me an IAU Circular describing an intense radio outburst from the Cygnus X complex that was accidentally observed at the radio observatory in Penticton, BC. This has everyone excited as such a thing has never been seen before. Apparently various other observatories are trying to see something now, but it is gone. The signal is broadband, and was discovered at 408

MHz. Position about +40 dec, 21 h RA. The only optical object nearby is a 16th magnitude star.

Paul Feldman says the OSU telescope is ideally suited for long-term monitoring of such things for a recurrence, and wants us to do it for a few months. He is sending me all the relevant papers, etc by express mail. He is very excited about this, and called me many times yesterday at all possible telephone numbers, so I got messages everywhere, including home. He says this would be a definitely publishable result, regardless of the outcome.

Ron Huck says it would be difficult to move the antenna to that declination. I know also that it would take a number of days to do so. But it would be exciting to do this, and would make a good friend of Paul. From the standpoint of current observations, we have little to lose. All current development could continue regardless. Assuming the written materials confirm all that Paul has said, should we do this?

**22 Jun 88 23:27:31-EDT**

From: Tom Van Horne

Subject: mysterious signal

If you're taking a vote Bob, I for one am very strongly in favor of pursuing this. Do you have more details on the signal, 40 degrees 21 hrs is a pretty imprecise location. Is that Epoch 1950? A quick check of SETI printouts around 40 degrees and approximately 21 hr from 1979 showed nothing unusual in our data except some minor broadband sources — presumably HI clouds. A striking anomalous single integration signal did appear at about 23 hr RA but was almost certainly local interference or equipment oriented (the only Z intensity I've ever seen).

**24 Jun 88 11:50:29-EDT**

From: Bob Dixon

Subject: Horn Cart Drive Chain

Bob Stephens called me and left a message saying that he has 250 feet of heavy-duty roller chain, and 6 sprocket drive wheels, 6" in diameter, for sale. I do not know the price, and I am trying to contact him for more details. This might be very useful for the horn cart motion project.



**24 Jun 88 17:22:44-EDT**

From: Bob Dixon

Subject: Mysterious Signal

Paul Feldman called me from Ottawa again, but I still have not received the letter he sent special delivery. The exact position is 20h 41m 10.4s, +40 17' 13" (1950.0). I told Feldman about our radio archive, and he again got excited. He says various people are now searching optical plate collections for evidence of past outbursts, but nobody but OSU actually has an analogous RADIO archive. Note that this is not the SETI data, but the continuum data, accumulated over the past 20 years or more, all filed neatly away. We must search this now, and I can provide instructions.

He says he has also confirmed that nobody else is able to monitor this position like OSU can, and if we do it we will have no competition.

**25 Jun 88 01:55:41-EDT**

From: Tom Van Horne

Subject: Mysterious signal chasing

I am interested in diving into the archives yet again and would welcome the opportunity to get training from Dixon-R. Some of you in the quiet multitude have expressed an interest in data analysis so now's your chance. I would suggest, Bob, if it is convenient that we plan to do training after the meeting on Tuesday at Dreese. I would also like to take that occasion, or some earlier, to show you what seems to be mysterious activity on OUR continuum records of the last month or so in the region of Gal center.

**27 Jun 88 08:43:06-EDT**

From: Bob Dixon

1. We can talk about searching the archives for the Canadian signal Tuesday evening. The atmosphere is transparent in the radio region and so cannot cause any measurable variations.
2. Hugh Geary would be a great help if he is available.
3. Concerning the AIL amplifier -

- a. Find the documentation on it first. If Jim and Ron do not know where it is I will suggest a search pattern.
  - b. Use the sweep generator to measure its bandpass. There is no reason to suspect there is anything wrong with it because it has always worked fine before. I believe its band is 1-2 GHz. I will assist if you have trouble with the sweep generator.
4. The new galactic center source sounds incredible!!!! Please have all the new records available for viewing Tuesday Eve.
5. The 11/23 is off until the a/c gets fixed. I have told Jim and Ron this is their highest priority task. But this should not recent programming for the RFI project. There is a vast amount of planning that must be done before any programming. Let's get the block diagrams laid out NOW.
6. I got a letter from Cuyahoga Community College in Cleveland. Their Director of Human Relations saw the Flag of Earth on display at NASA Lewis, and wants to buy one to display in their Human Relations Resource Center. I originally supplied the one to NASA. The idea is spreading!

**27 Jun 88 10:17:12-EDT**

From: Bob Dixon

Subject: Replies to recent suggestions

1. Let's hold off on moving the antenna until I see the records Tom V is talking about. It is possible we ourselves have discovered an even more interesting object than the Canadian one. We should know by Thursday, so that will not delay Jim's suggestion of starting the move then in any case. But if we have discovered something new, we may want to stay there and watch it.

An alarmist would say the Galaxy has gone wild. The Canadians found an outburst in Cygnus (along our Galactic Arm). Tom V has found something toward the Galactic Center. The SARA Newsletter every month talks about a new intermittent object toward the Galactic Center. Even though these may be precursors to the Ultimate Galactic Stupendonova, let's hold off on the press release to the National Enquirer for a while yet.

2. While it is true that the Canadian outburst was discovered at 408 MHz, everyone

believes it is a continuum source, and hence visible at our frequency of 1400 MHz.

3. The VT240 does have video in/out that I have thought was interesting, but we have never had time to "look" into that. Steve's idea of an evolving video presentation is absolutely smashing, and would knock the socks off any astronomical audience I know of. Nobody has ever been able to do such a thing that I am aware of. One minor fatal flaw may be that not all the continuum data is available in digital form. This is caused by 2 problems:

a. The superficial problem was that the console terminal on the 11/23 used to jam, thereby preventing the continuum program from writing out its occasional "I am still alive and well" messages, and hence causing the program to wait forever for the terminal to get ready.

b. The deeper problem is that we still have nobody actually looking at the data and processing it on a day-to-day basis, so the above problem went undetected for a long time. Several people (Tom V, etc) are working toward this but we still have a ways to go. Jim Nugen is also working on related software.

Yet deeper is the evolving area of failure tolerance at the RO. With more intelligent software, a complete failure of the console terminal could be tolerated with no loss of data, as could other failures.

Perhaps Steve Leibrand and Chris Winget can work on this.

**27 Jun 88 18:46:09-EDT**

From: Bob Dixon

Subject: Canadian signal

I received the papers from Paul Feldman today. The signal was originally discovered in 1985, but just realized and announced now. The International Astronomical Union has called for all holders of radio data to look for this object in their archival records. Little do they know that we probably have much more than anyone else. This declination zone (+40) is even better than average because that is where the Andromeda galaxy is, and we made several detailed surveys of that area, so there is lots of data to be studied.

**27 Jun 88 18:48:05-EDT**

From: Bob Dixon

Subject: Canadian Signal

Forgot one interesting note. Paul says they are calling it the "eh!" signal, in analogy to the "wow!" signal we found, but says "after all, this is Canada!".

**28 Jun 88 10:45:50-EDT**

From: Bob Dixon

Subject: Hard-Copy Terminals Available

We may be able to get a number of DEC LA-36 hard-copy terminals free, if we want them. These are the same as all the ones we already have.

In addition, we may be able to get some Anderson-Jacobson hard copy terminals. These are the same speed, but have near-letter-quality printing. They are about the same size, but somewhat less reliable than the DEC terminals.

Do we want any of these?

**28 Jun 88 11:51:42-EDT**

From: Steven Crawford

Subject: The verdict on the gophers

Well gang, Mr. Vaive went to the RO this morning. The first thing he said was that the piles of trash lying around aren't doing us any favors, and that we should remove them. Why didn't anyone ever mention that????

He says that there are a lot of burrows, although most of them are not active. The one under the shack and the meeting room front porch are active. As much as he hates to say it, there is no way to 100% assure that the old burrows will not be reactivated and to keep them away in the future. We could try mothballs down the active burrows, but again no guarantees. The best bet, he says, is to gas the burrows. He sells these gas grenades, says they are easy to use and quick. That would take care of it now, and might discourage future interlopers from re-entering those burrows.

Seems a shame, but he feels that it could become more of a problem in the years to come. "Look at it this way," he says, "Gophers are a member of the rat family, and no one feels bad about killing a rat." So, I throw this issue out for debate. If we want

to talk gassing them, he'll work up a price. He may even be willing to do some deal, also. We'll see.

**28 Jun 88 15:35:56-EDT**

From: Bob Dixon

Subject: Bob Stephens report

Bob Stephens from the Canadian North called me today. Thursday is his deadline to move out. He has a bus which is crammed with stuff, and he has built a trailer to pull behind the bus which is also crammed with things like his car! He is carting as much as he can carry to Ottawa, including the cooling system and drive chains we are interested in. He also has some nice drive motors and controllers that could be used to automate our system. He would like to come here to install all that, but he has other job possibilities that take priority. Apparently if he cannot find another job, he would be willing to come here in the Fall after Jim leaves, and work for what Jim now earns, for a few months in any case. He would like \$800 for the drive chain and motors, which is what he paid for it.

**29 Jun 88 19:21:43-EDT**

From: John Ayotte

Subject: PUBLICATIONS PROJECT LIST

The following is my current working list of publications group projects:

Fund Raising

- 1) General public relations piece (low budget)
- 2) NASTAR letterhead
- 3) Fund Raising letters
- 4) NAAPO brochure
- 5) T-Shirts, Buttons, Patches, etc
- 6) General Public relations piece (upgrade when funds available)

Misc.

- 1) Dramatic visualization of telescope (for use above)
- 2) Conceptualization of full scale radio camera

- 3) Tour handouts
- 4) Press kit (folder, photos, brochures, etc)
- 5) Press releases (as needed)
- 6) Dreese displays
- 7) Signs at the site
- 8) Membership cards
- 9) Site displays and graphics (for tours and visitors)
- 10) Map showing location of NAAPO organizations
- 11) Photos of people working at site
- 12) Interviews with trustees
- 13) Space Week flyers

### Project support

- 1) Photos of Discone
- 2) Photos of ICOM receiver
- 3) Block diagram of receiver and computer
- 4) Aerial photos and/or maps showing location of telescope, cities, buildings, RFI sources, power lines, etc
- 5) SWR plot of Discone
- 6) Data displays

If anyone wants to add to or subtract from this list, let me know. It is only to serve as a planning tool. We need to assign some deadlines to these projects and prioritize them so that I can try to utilize our limited resources of volunteer time most effectively.

**29 Jun 88 19:23:44-EDT**

From: John Ayotte

Subject: Publications support materials

If anyone has, or can tell me the source of, support materials for our publications activities I'd really like to hear from you. By support materials I mean photographs, sky survey maps, data charts, articles and the like.

**29 Jun 88 19:31:56-EDT**

From: John Ayotte

## Subject: PR piece content

Here is a first cut at defining and organizing the content of the public relations piece that we need to produce.

Please come to the meeting in Dreese 805 after the July 5th regular meeting, or get your comments to me before then.

- 1) Overview and History
- 2) OSU SETI Project
  - Phase III (SETI zoom)
  - Analysis of Phase II data (77-84)
- 3) New Sky Survey (to compare with 20 year old data)
- 4) Data Archives (support to the World astronomical community)
  - Further analysis of 30+ years of radio data
  - Master list of radio sources
  - World Optical Catalog of non-stellar objects
  - Optical Atlas (overlays to original sky survey photos)
  - Southern Hemisphere survey overlays
- 5) New Technology Development
  - Upgrades to Kraus telescope
    - Moveable Horn Cart (tracking and SETI zoom)
    - Multiple feed systems
  - Development of new receiver technology
    - Suitcase SETI
    - Multiple Channel Analyzers
  - Radio Camera
    - SETI instrument
    - Sky Archive
    - Detection of transient events
      - Early supernova detection
- 6) NAAPO activities

Mobilizing small college resources  
Undergraduate research  
Educational opportunities

**30 Jun 88 17:12:38-EDT**

From: Bob Dixon

Subject: News Items

I cannot keep up with everything, so some things are slipping and others must do them if they are to be done.

1. There is the usual meeting this Saturday at the RO and I plan to be there.
2. Sky and Telescope called again and wants their photos NOW.
3. Steve Janis asked VP Hollander for additional monies to continue paying for the phone at Delaware. They called me to say that not only will they pay for that, but they want to support things reasonably, say up to \$2000. We are to submit a request asap for things we need in basic support. Phone, water, paint, cleaning, anything we can justify. I need help with this.
4. Now that the chart recorder is going faster, the paper will run out every 2 days. Unless someone refills it regularly, there will be NO data.
5. I have not been aware of the chart recorder slippage problem. That is serious. All previous recorders have never had this problem, as constant speed is critical for comparing records.
6. I talked with the a/c people. They are charging us only for 3 hrs labor, at about \$16/hr, so the total bill is only about \$50! I expected much worse. To avoid problems like this in the future, we need a regular program of maintenance in such things as filter changing (also computer filters). Who will do that?

**1 Jul 88 08:44:29-EDT**

From: Bob Dixon

Subject: Synthesizer Tests

Here is another little task for Marc:



Add a test in Sensor to test the synthesizer in whatever mode the SETI program uses. That way a problem such as we have now should immediately be typed out on the console and made known to whoever is booting or using the machine.

There may be other conditions and devices which should be similarly tested as well.

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Designed by Jerry Ehman

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