Data Analysis on the PC
Spectrogram version 6.2.3
A Brief Tutorial

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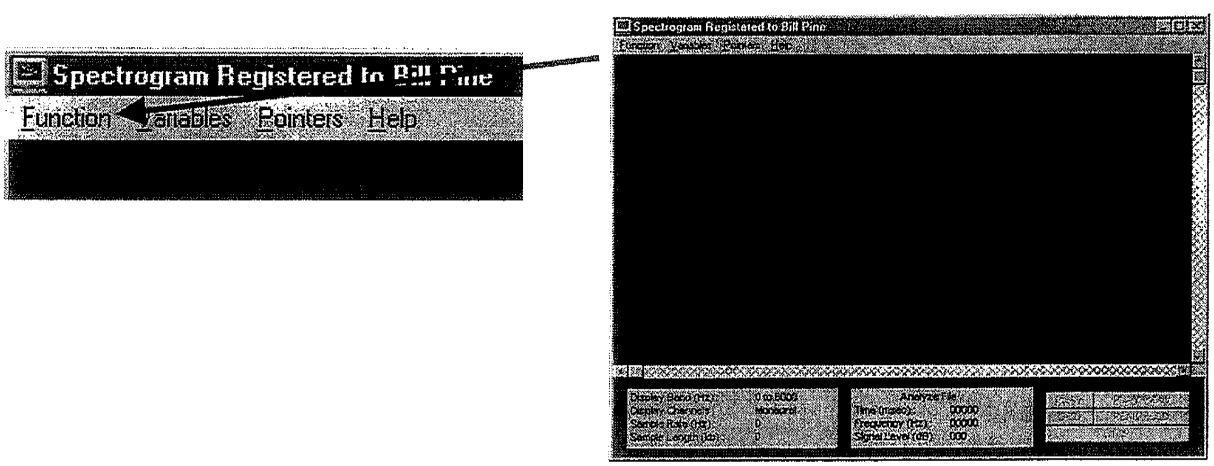
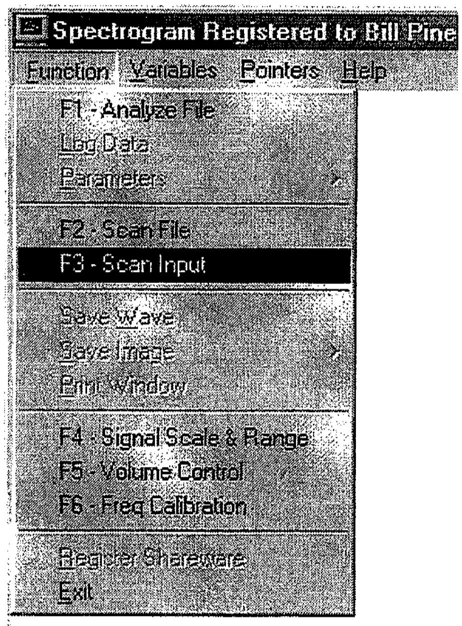
Spectrogram is a program for the PC for creating frequency-time spectrograms. It is ideally suited for analyzing INSPIRE data. The author, Richard Horne, has been a long-time supporter of INSPIRE. In the past he has allowed INSPIRE to distribute **Spectrogram** (or GRAM) to INSPIRE participants. As with many software programs, GRAM has evolved and improved over the years. The latest version is offered as a shareware program over the Internet for $25. Richard Horne is again making this software available at no cost to INSPIRE participants. You will find out how to take advantage of this generous offer at the end of this article.

What I would like to use as a format for this tutorial is the analysis of some actual INSPIRE data from the Coordinated Observations of April/2001. When Robert Bennett submitted his tapes and logs he said, in a note to the author, "<u>You have got to listen to this portion of the tape</u>!" in reference to recordings made from 6 AM to 7:30 AM on April 21. Now Robert is an experienced observer and has recorded many whistlers and other interesting signals from his remote location in the desert near Las Cruces, New Mexico, so when he made a special note about this session, I knew it would be special. I plan to transfer portions of his recordings to CDR and make them available to INSPIRE participants.

So here we go… We start with the opening screen of GRAM.

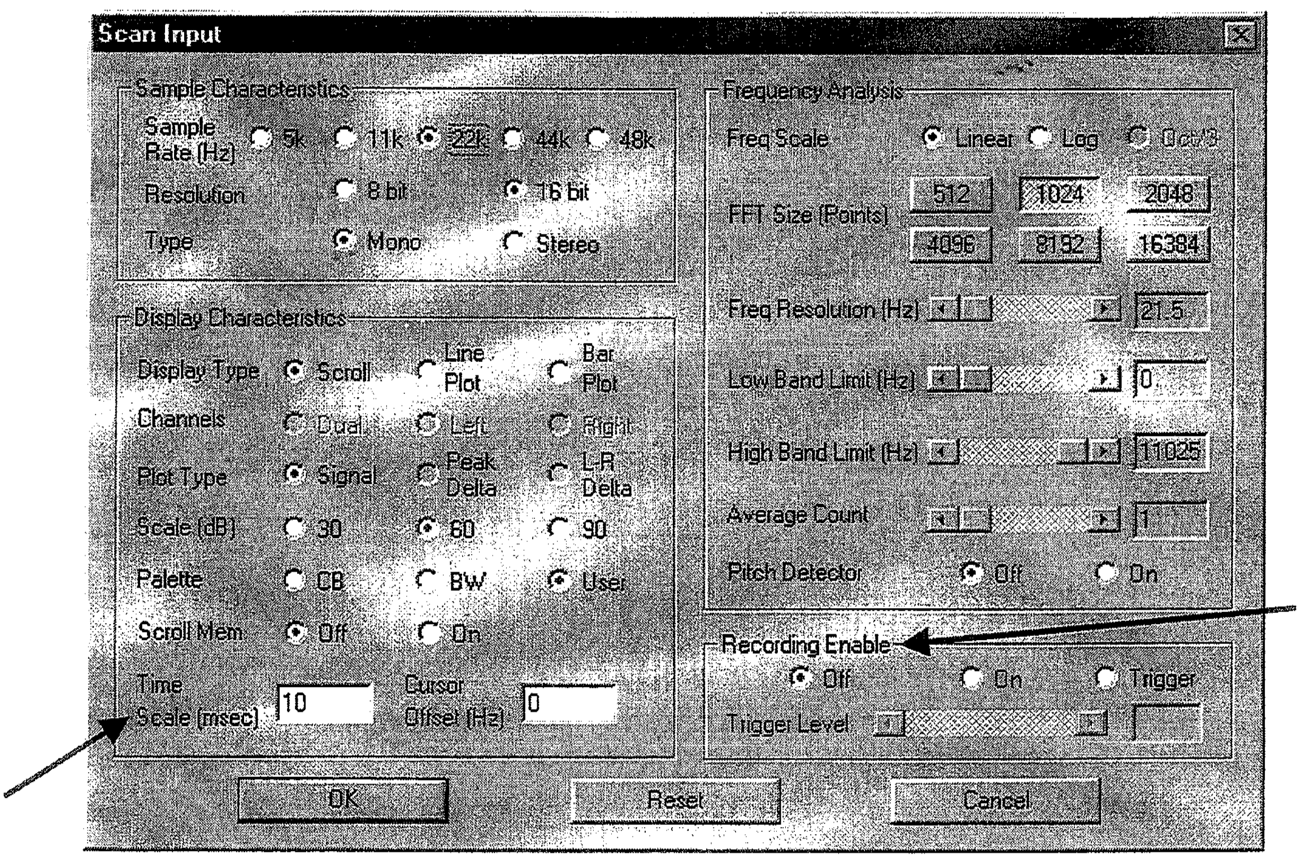


Select **Function**



Select **Scan Input**.

This will bring up the parameters window for Scan Input.

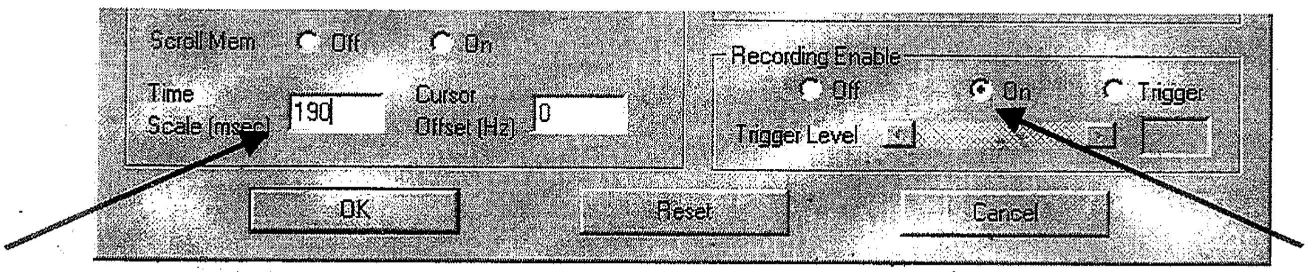


This will give you some idea of the things you can control with GRAM. The important entries for our purposes are Time Scale (msec) and Recording Enable.

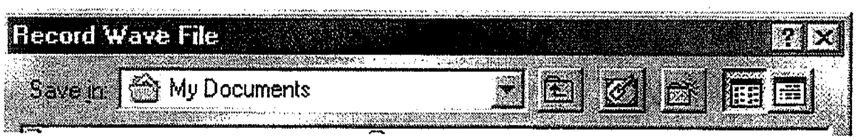
Time Scale (msec) indicates the time between displays of data points. What it really determines is how much time will fit in the GRAM display window. The default value is "10" which allows about 6 seconds to be displayed at a time. The following table shows the display time for various Time Scale settings.

Time Scale Setting	Display Time (seconds)
10	6
16	10
48	30
95	60
190	120

I usually make spectrograms of 2 minutes of a tape at a time. This keeps the .wav file size down and makes the data easier to work with. The default Sampling Rate is 22 kHz (upper left of the parameter window. At this setting you can display frequencies up to 11 kHz (half the sampling rate). A 2-minute .wav file size at these settings will be 5 MegaBytes.

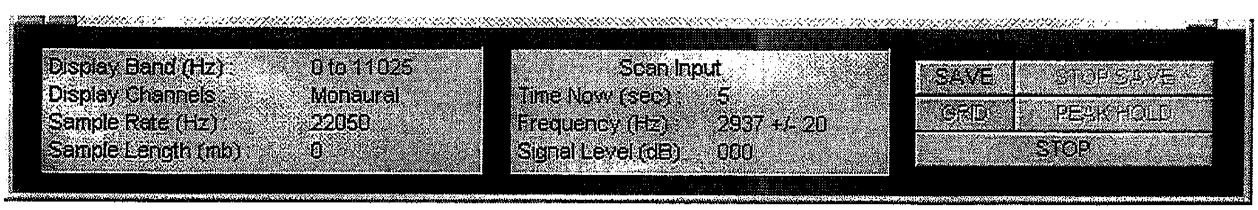


Click **OK** and you will see a directory window:

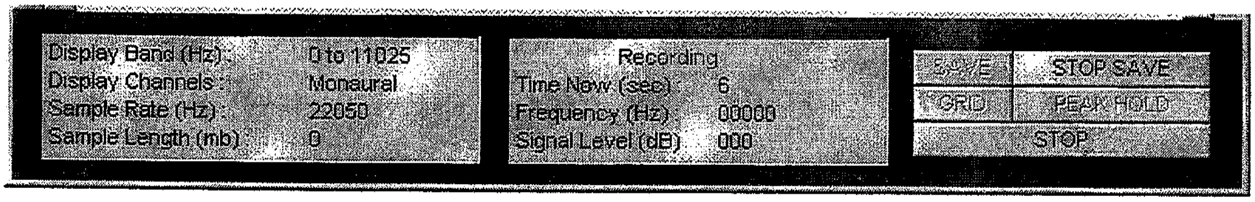


Choose a directory and file name for the .wav file that will be created.

Click **SAVE** and the directory window will disappear and you will se the Scan Input screen. If the tape recorder is playing into the microphone input of the computer, you will see a spectrogram slowly forming from the left edge of the screen. You are not creating a .wav file yet! The bottom area of the screen looks like this:



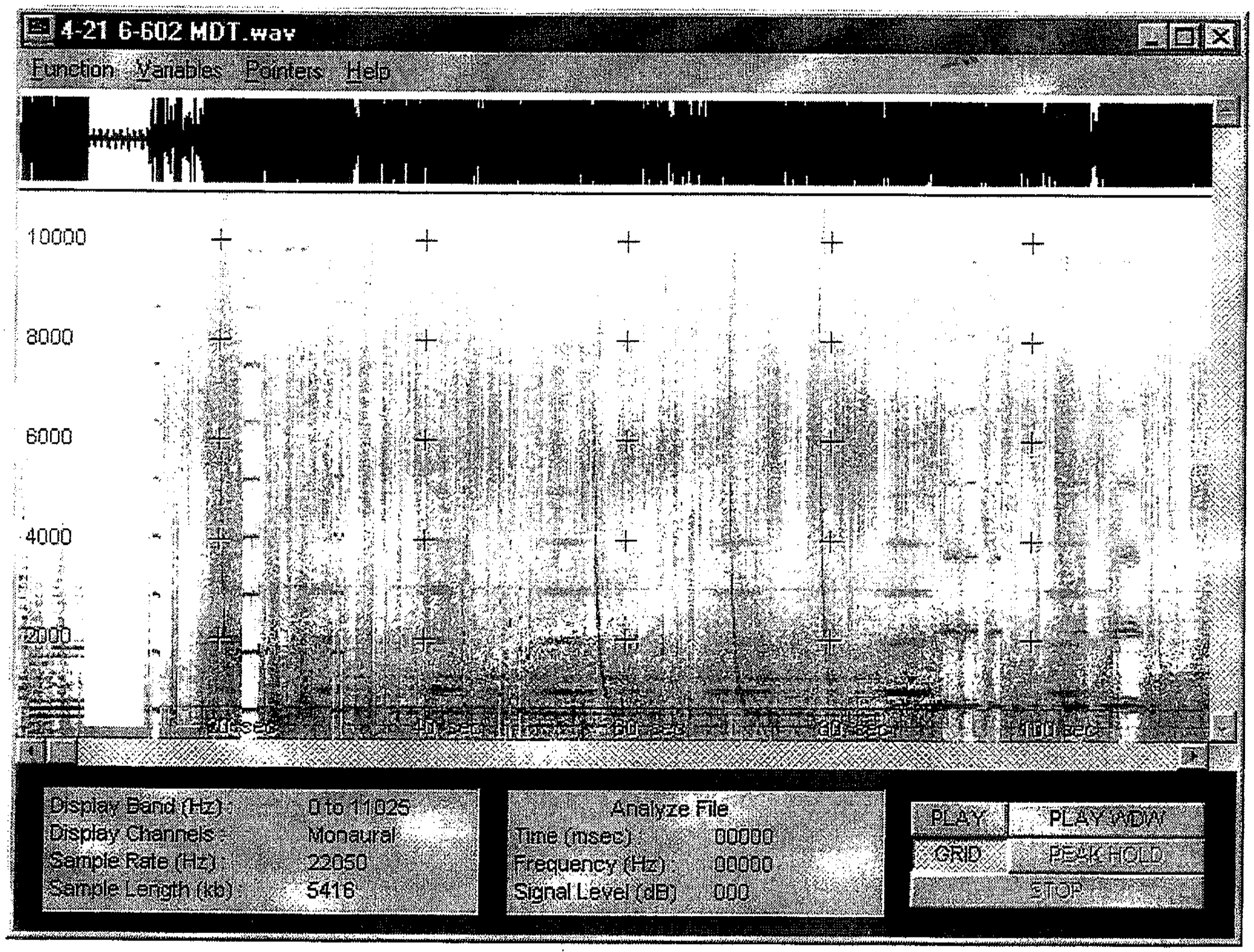
Click on **SAVE** and the bottom of the screen will change to this:



"Scan Input" in the center panel changes to "Recording" (in red) to indicate a .wav file is being created. NOTE: the default setting for Recording Enable is "Off", so if you do not get the **SAVE** option, go back to the Scan Input parameter screen and set Recording Enable to "**On**".

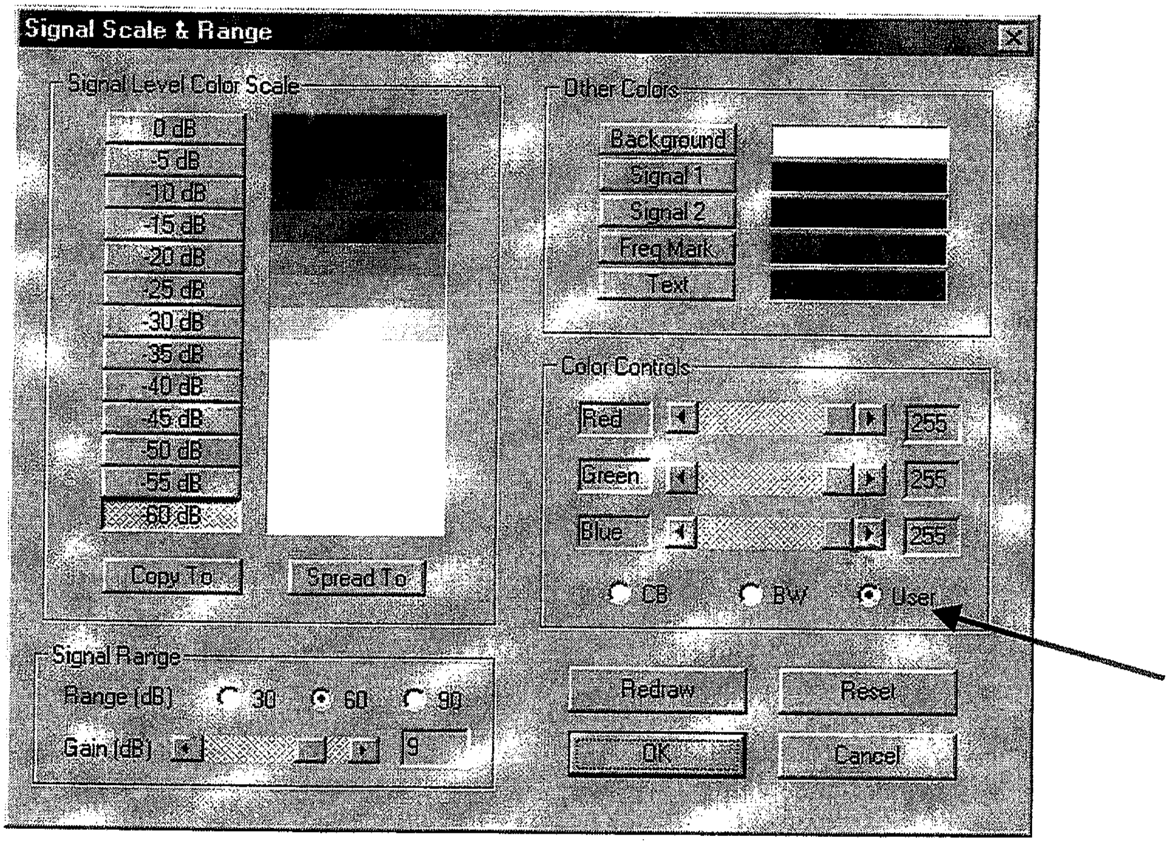
You will see the spectrogram being created as the tape is played. I am using a Radio Shack CTR-117 monaural recorder with the ALC set to "OUT". I use a "Y" connector at the "EAR" jack of the recorder with one output going to the computer and the other to headphones. This allows me to hear the tape and watch the spectrogram being created at the same time.

The following is a spectrogram of the tape from 6 AM MDT to 6:02 MDT. After the file is created, from **Function**, select **Analyze File** and select the **filename** just created. You will see the Analyze File parameter window. Set the Time Scale to **195**, click **OK** and you will see the following.



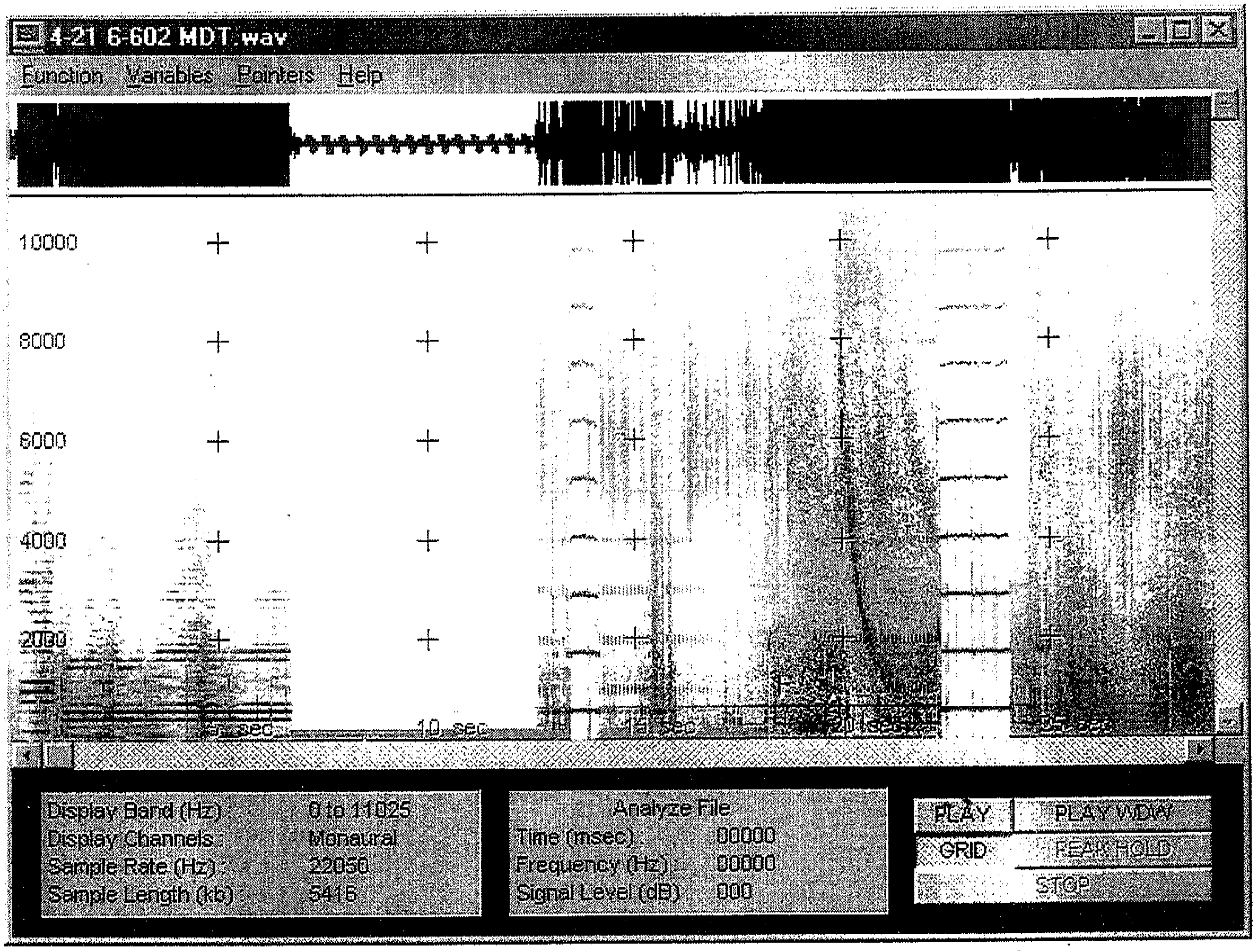
In this view, GRID is turned on showing the frequencies scale at the left and the time scale across the bottom. These grid markings can be hard to read and will not copy well for this article. On my computer screen, I set the color of the grid to red, which makes it easier to see.

The display for GRAM can be in color, or black-and-white. That selection is made using **F4** or **Function**, then **Signal Scale and Range.**

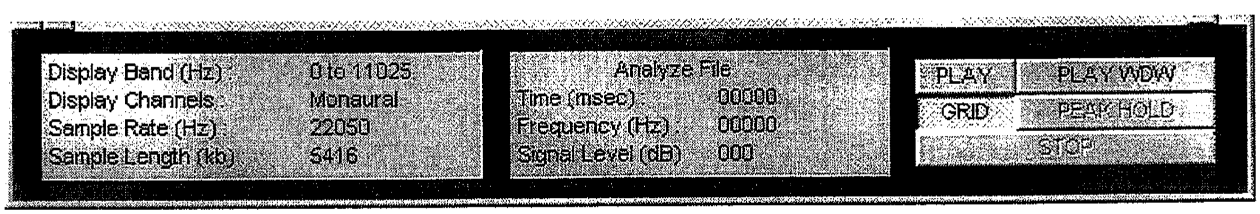


If you select User, you can customize the display. This shows the Signal Scale and Range panel I have created. I found that when using the default **BW** settings the spectrograms were very dark. By setting levels below 30 dB to "white" and using the gray scale above 30 dB, I get the spectrograms in this article. Setting Text to "red" gives the red grid and scale markings. You can experiment with the settings while you are scanning input and watch the changes happen on the spectrogram as it is being created.

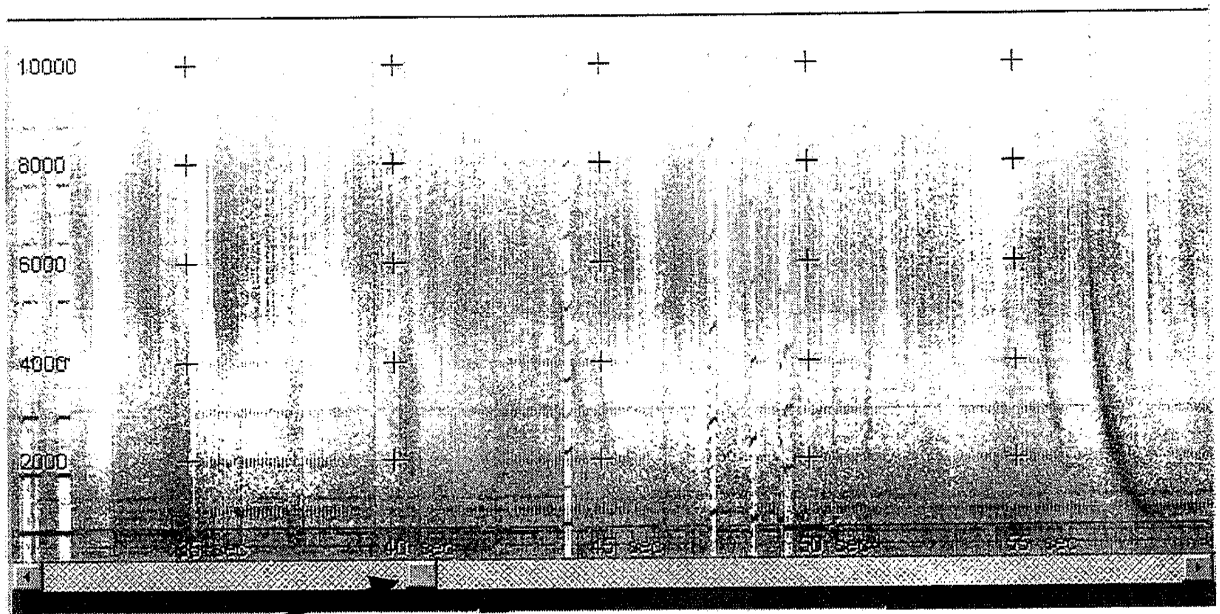
Whistlers (and there were many in the two minutes!) are not easy to see in the 2-minute display window. For a closer look at part of the spectrogram, go to **Parameters**, then **Change** and change the Time Scale to **48**, which will show a 30 second window. The 2-minute file is shown in 30-second segments next. Some of the screens have been trimmed to save space. Whistlers are easy to see in this display.



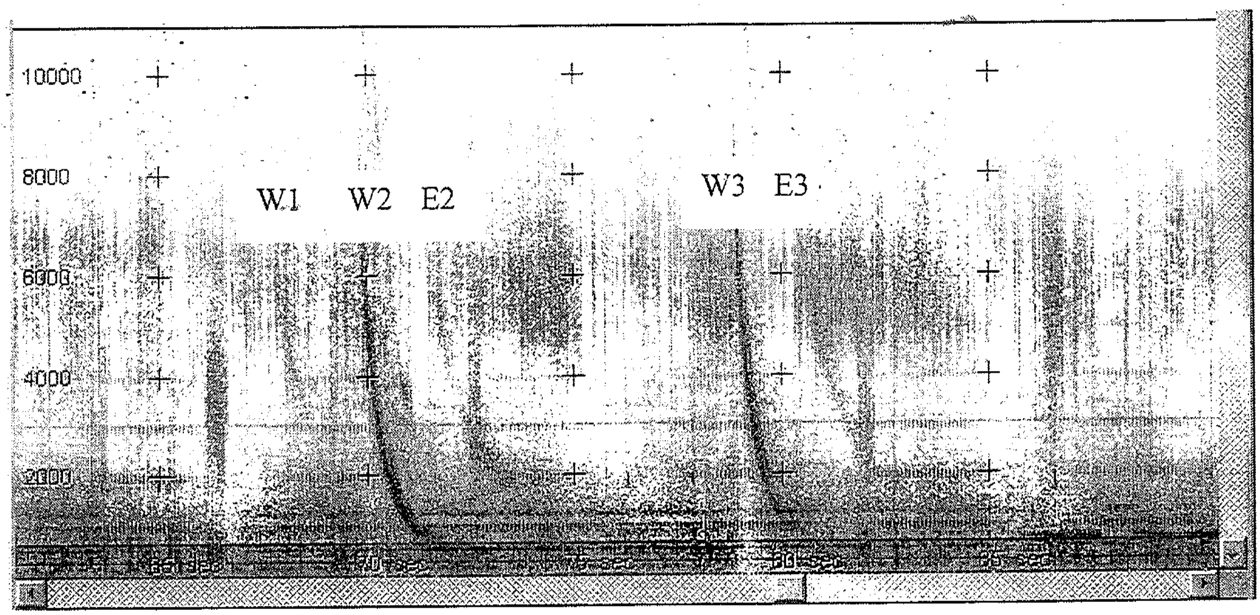
This is the first 30 seconds. You can use the PLAY button to play the entire file or the PLAY WDW button to play the part of the file that is displayed. The file starts with the 0600 WWV (1200 UT) tone. Notice that there is a gap from about 7 to 12 seconds as the cable was being transferred and some oscillation at about 13 seconds and 22-24 seconds as levels were being adjusted. A strong whistler appears at 20 seconds followed by an echo that is lost in a brief time of oscillation.



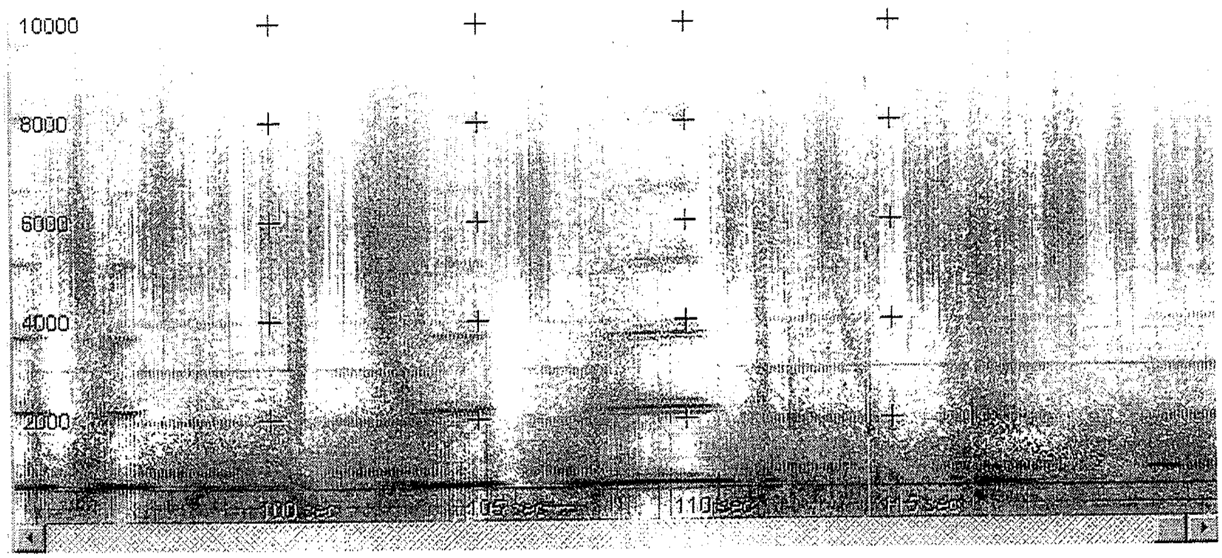
The bottom left panel shows information about the file. Notice that the entire file length is shown (5416 kBytes) even though only part of the file is displayed. The center panel shows the position of the cursor as it is moved by mouse to various parts of the display.



Use the slider below the spectrogram to move to the next 30 seconds of the file. A strong whistler appears at about 56 seconds preceded by a weaker one. A couple of weak ones appear at 45 seconds.

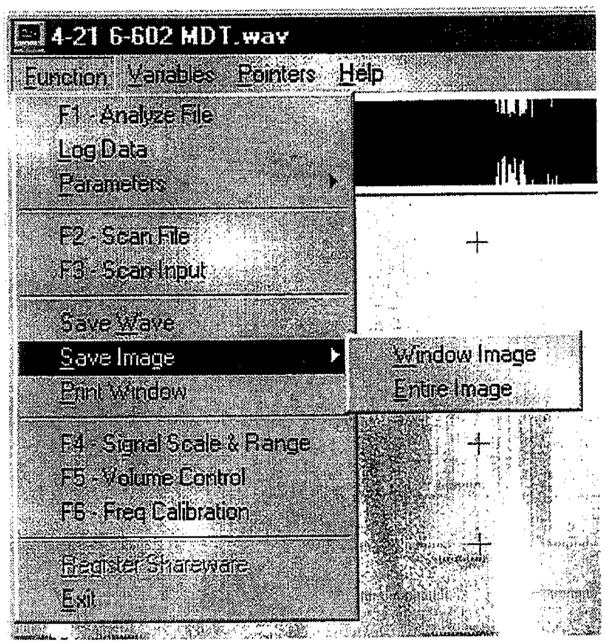


Time 60 to 90 seconds. Whistlers are labeled. W1 is weak. W2 is strong with an echo E2 following. W3 is strong with an echo E3 following. Note how the echoes follow the whistlers by the same amount of time and the shape of the echo is less steep indicating more dispersion resulting from the extra round trip in the magnetosphere.



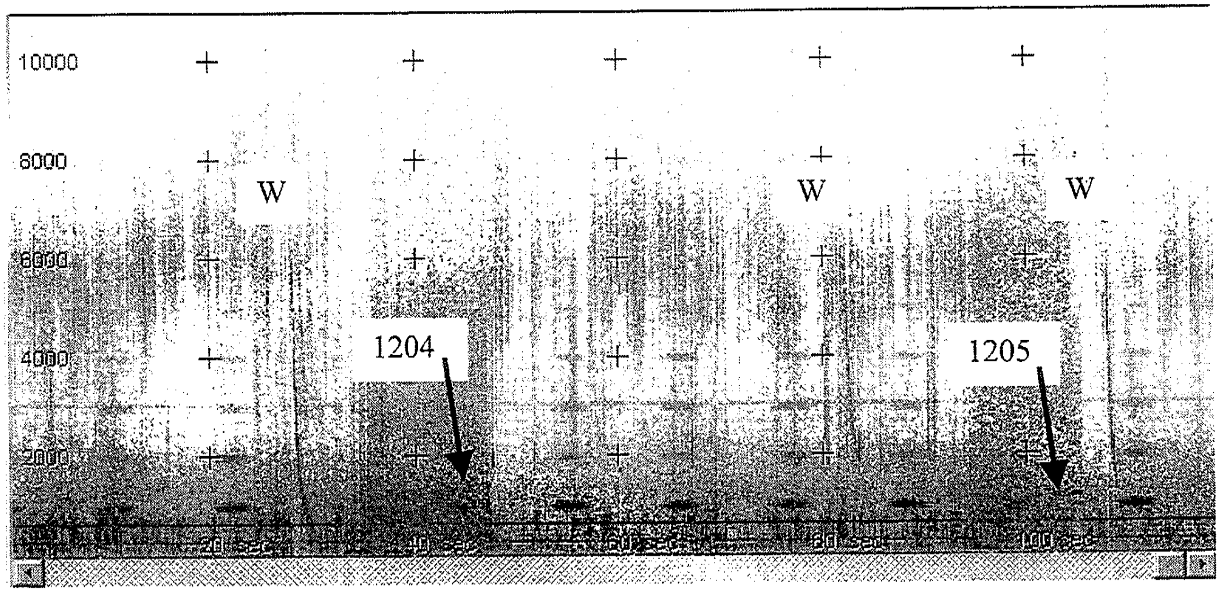
Time 90 seconds to 120 seconds. A couple of good whistlers are seen at 103 seconds and 114 seconds. The series of horizontal lines are from a strong LORAN signal at about 1 kHz and several harmonics of the signal. On the tape this sounds like a loud ringing.

To save images of the spectrogram you can use the **Function** menu from the main screen.

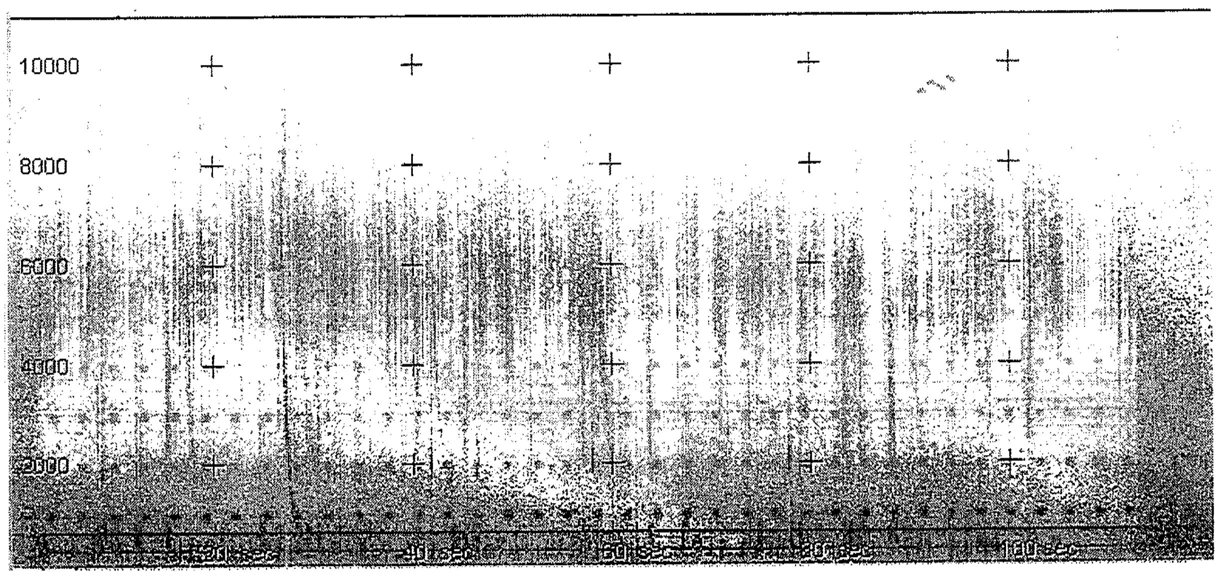


Select **Save Image** and then either **Window Image** or **Entire Image**. You will then be prompted to choose either **jpeg** or **bitmap** format and for a filename and location to put the file. Once saved the image can be inserted in a document and sized and cropped.

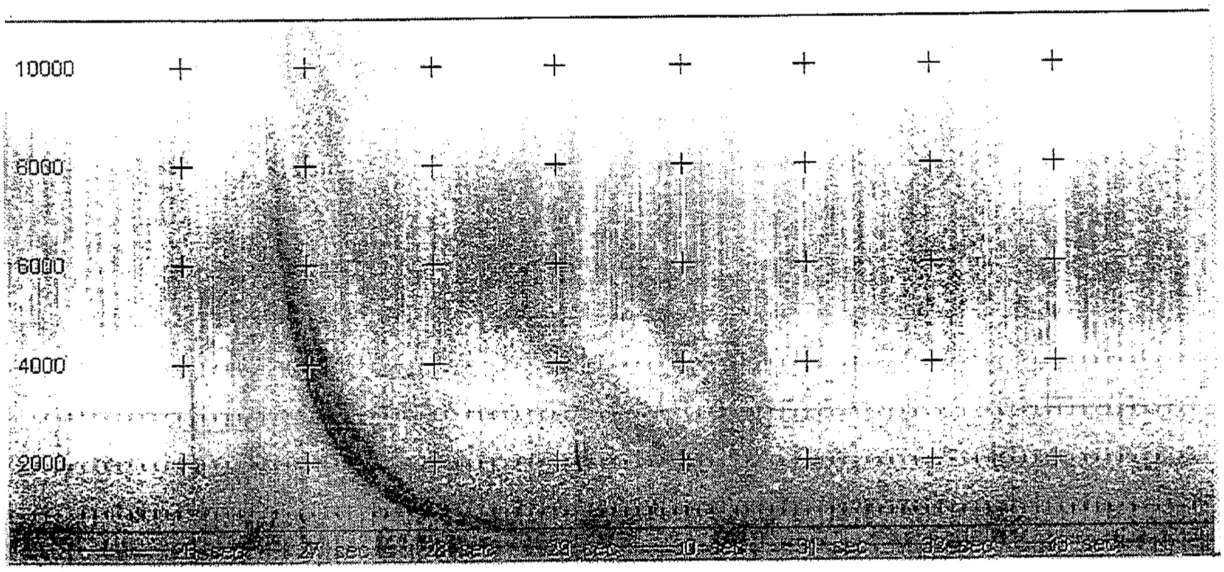
For this article, I have been using the Print Screen keyboard option (**Alt + Print Screen**) to place a screen image on the clipboard. It can then be pasted, sized and cropped any way you want. Print Screen copies an image of the GRAM screen, not the entire computer screen.



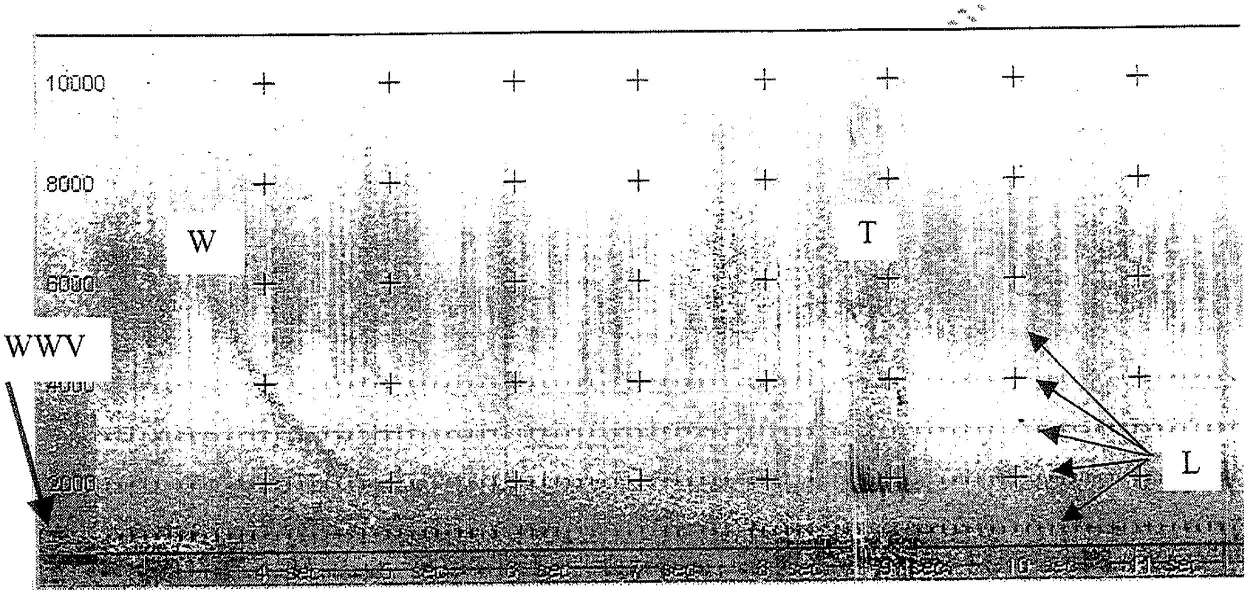
WWV time marks of 1024 UT (6:04 MDT) and 1205 UT are indicated. Even with 2 minutes displayed in the window, several whistlers are evident (W).



This file starts at 1207 and ends at 1209. A strong whistler appears at 25 seconds.



The Time Scale setting was changed to "16" making the display 10 seconds. The strong whistler (26.5 s) is followed by another (27 s) with echoes of each (28.5 s and 29.5 s). Notice that the whistler extends well below the tweek cutoff frequency of around 2 kHz. This indicates that the whistler arrived in the lower atmosphere near to observing site and was not ducted there by the Earth-ionosphere waveguide that would have cut off the portion of the whistler below 2 kHz.



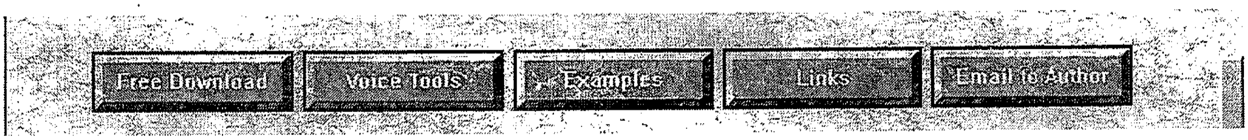
The first 10 seconds shows the WWV tone at 1207 UT, a good whistler (W) and a burst of tweeks (T). LORAN signals (L) appear as horizontal rows of dots and sound on the tape like a rapid series of clicks.

With the Time Scale set at **10** I played the file and watched the spectrogram roll by. In the 2 minutes I counted 11 strong whistlers, 2 echoes (described above) and 4 weak whistlers that were seen on the spectrogram but not heard. Robert Bennett certainly hit a gold mine of natural radio on the morning of April 21, 2001.

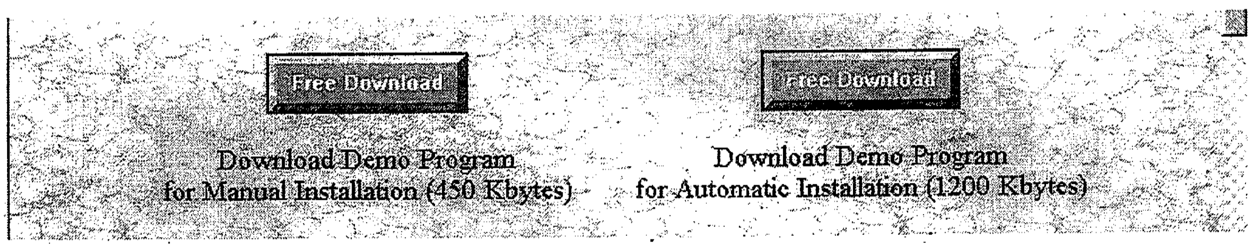
GRAM does an admirable job of analyzing the data. This latest version is a quantum leap ahead of previous versions and is being offered as shareware for $25. Go to:

http://www.visualizationsoftware.com/gram.html

Near the bottom of the opening screen, select **Free Download.**



I recommend the Automatic Installation option. GRAM installs in about a minute.



The free download gives you a version of the program that will work for 10 sessions. To get a permanent version, you need a User Name and User Key. To get these, send an email to Richard Horne at:

rshorne@mnsinc.com

Indicate that you are an INSPIRE participant and the $25 fee will be waived. Richard will send you the necessary information to register your copy of GRAM.

This tutorial was designed to get you started in natural radio data analysis. The capabilities of GRAM are much more extensive than those used for this article. This is an outstanding, user-friendly (and free!) program that will serve your analysis needs well.

INSPIRE COORDINATED OBSERVERS

April/2001

This is the first roster of all who have contributed observations since the end of the Mir-based INTMINS observations. New team numbers have been assigned in two categories: school teams are indicated with an "S"; individuals and non-school related teams are indicated with an "I".

(Unless noted otherwise, all longitudes are West and latitudes are North.)

Team #	Observer	Location	Longitude/Latitude
S-1	Kathryn Robinson. O'Connor High School	Helotes, TX	98° 47' / 29° 35'
S-2	Mark Mueller Brown Deer High School	Brown Deer, WI	87° 56' / 43° 10'
S-3	Elizabeth Quick John Marshall High School	San Antonio, TX	98° 72' / 29° 54'
S-4	Bill Pine Chaffey High School	Ontario, CA	117° 41' / 34° 14'
S-5	Jim Hoback John Jay High School	San Antonio, TX	
I-1	Shawn Korgan	Gilcrest, CO	104° 67' / 40° 22'
I-2	Linden Lundback	Watrous, Sask,	105° 22' / 51° 41'
I-3	Robert Bennett	Las Cruces, NM	106° 44' / 32° 36'

Report on Coordinated Observations 4/2001

By Bill Pine
Ontario, California

The purpose of the Coordinated Observation Program is to provide an opportunity for INSPIRE participants to gather data at convenient times for purposes of comparing the resulting signals and attempting to interpret them. Since there is no manmade source of VLF that is being studied here, the signals of interest are those of natural origin. As in most natural radio listening, we would like to hear something "interesting". Most of the time that would be whistlers, but other sounds such as tweeks, chorus, triggered emissions and even hiss are also interesting. Observing whistlers, however, remains the prize for faithful listening. The problem with whistlers is that they are not the most common natural radio signal. Since coordinated listening schedules are determined arbitrarily and in advance of the listening sessions, it is only a matter of luck if whistlers are available to be detected. The experience of the author is that whistlers are heard about once every four or five morning sessions. When they are present, you will probably hear a lot of them until the rotation of the earth carries the ducting magnetic field lines into an unfavorable alignment.

Conditions during April/2001 were mixed. Some observers were treated to an abundance of whistlers. This was especially true for those observers who listened earlier than just at the 8 AM and 9 AM times. When whistlers are present, it is more likely that they will be heard the closer to dawn that you observe. The following report includes sample spectrograms from contributing observers.

The following tables summarize the sessions monitored by observers.

Date	4/21					4/22				
Time	1200	1300	1400	1500	1600	1200	1300	1400	1500	1600
Team										
S-1										
S-2										
S-3	C									
S-4									P	P
S-5		C	C							
I-1										
I-2		C	C	C	C		C	C	C	C
I-3	M	M	M	M						

Date	4/28					4/29				
Time	1200	1300	1400	1500	1600	1200	1300	1400	1500	1600
Team										
S-1	C	C	C							
S-2		C	C							
S-3										
S-4				P	P				P	P
S-5		C	C							
I-1						M	M	M	M	
I-2							C	C	C	C
I-3	M	M	M							

Times indicated are UT times.
The letter in the box indicates the time zone of the observer:
E = EDT = UT– 4, C = CDT = UT – 5,
M = MDT = UT – 6 and P = PDT = UT – 7

Observers:

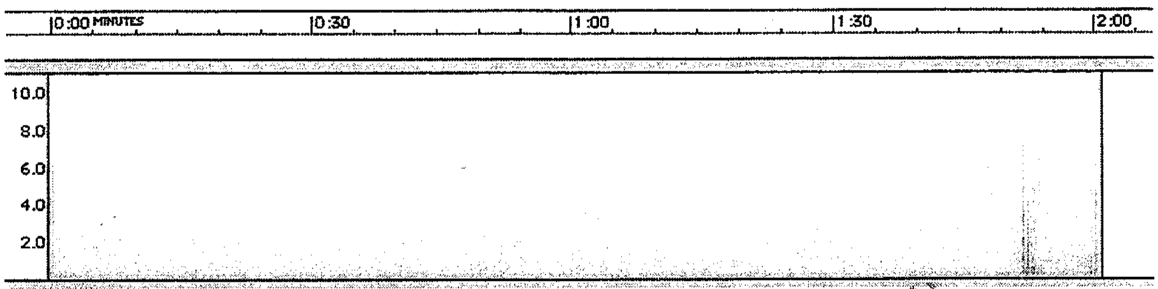
Team S-1	Kathryn Robinson, O'Connor High School Helotes, TX	(CDT)
Team S-2	Mark Mueller, Brown Deer High School Brown Deer, WI	(CDT)
Team S-3	Elizabeth Quick, John Marshall High School San Antonio, TX	(MDT)
Team S-4	Bill Pine, Chaffey High School Ontario, CA	(PDT)
Team S-5	Jim Hoback, John Jay High School San Antonio, TX	(MDT)
Team I-1	Shawn Korgan, Gilcrest, CO	(MDT)
Team I-2	Linden Lundback, Watrous, Sask,	(CDT)
Team I-3	Robert Bennett, Las Cruces, NM	(MDT)

For analysis purposes, a spectrogram was made of the first two minutes of each 12-minute hourly session. Additional spectrograms were made of any items of interest and of any segments requested by the observer. Time marks were placed on the tape every two minutes and a complete log was made of each session.

4/21/01 1200 UT

The first report on April 21 comes from John Marshall High School in San Antonio, Texas. Marshall High is the home of the "Thundering Rams" and they have adopted that name for their INSPIRE team. At 7:00 AM CDT the team was in place and observing. The team consisted of Elizabeth Quick, Physics teacher, and Paul Nolasco, Matt Fischel, Philip Vincent, Sarah Schott and Kevin Phipps.

The Thundering Rams fell victim to the INSPIRE corollary of Murphy's Law: Murphy goes on every trip! The team did a great job on the time marks and logging even though they heard not much more than sferics at low intensity levels. Unfortunately, no signal appears on the recorded tape. Below is a spectrogram of the first 2 minutes of the session.



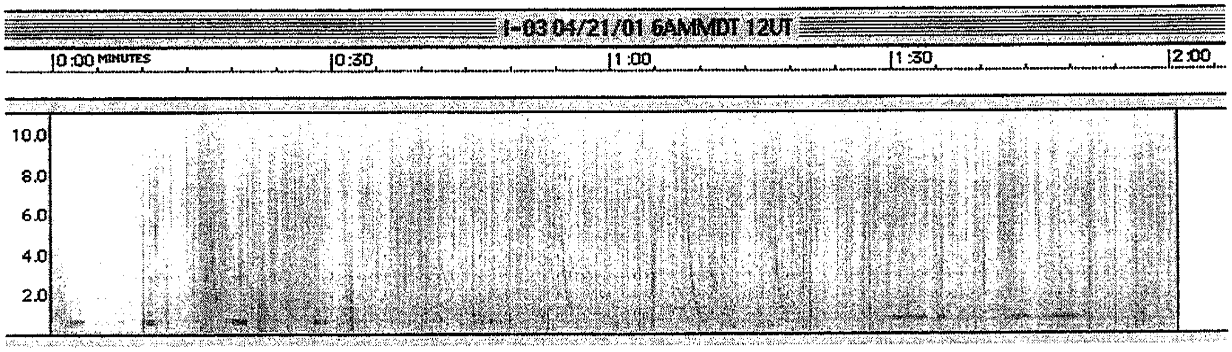
All that appears on the spectrogram is a voice print of Sarah Schott saying "12:02 Mark".

Sarah also provides an amusing narrative of the Thundering Rams' day of observing.

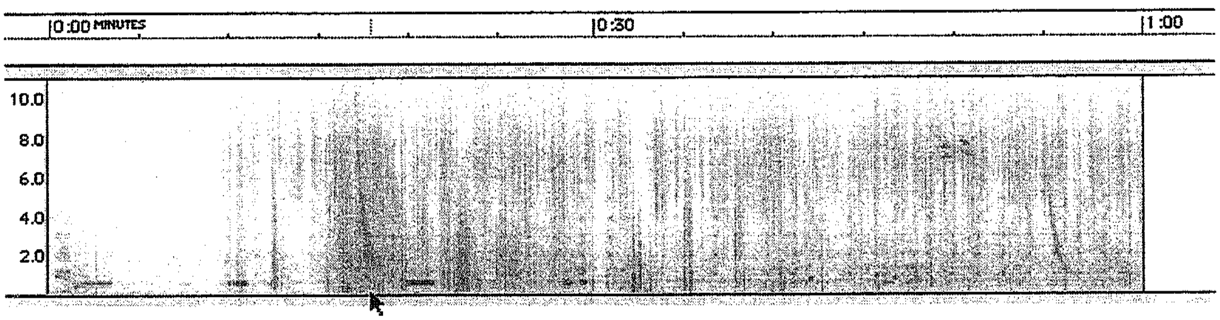
Donuts, Orange Juice, and Radio waves

John Marshall High School students and teacher set out on an adventure to collect radio waves on Saturday, April 21. Sarah Schott, Matt Fischel, Philip Vincent, Paul Nolasco, and their "fearless" leader Mrs. Elizabeth Quick started at 6:15 in the morning and brought along guest listeners Sarah Vincent (Philip's sister), Kevin Phipps (a fellow physics student), and Dr. Ralph Hill from Southwest Research. The adventure started when all tried someewhat successfully to awake to the sound of our noisy alarm clocks. Trying to wake up eight physicists at the crack of dawn on a Saturday morning is quite a difficult task. We met at Taft High School, at 6:30 precisely, then proceeded to approximately two and a half miles due west of San Antonio. Along our paved path to the middle of a wooded area we came upon a large tree strewn straight across our path. Sadly believing we would have to turn away from our perfect listening location, Matt Fischel came to the rescue. Jumping quickly from his truck, Matt lifted and moved the large tree with help from Paul Nolasco. Muscles bulging, sweat dripping from their foreheads, the two boys carried our intrusive obstacle away. As the rest of us got back into our cars, what did we come upon but an ox (funny that we live in Texas!). A large, black, mean bull stood about ten feet away. Most of us started shrieking and screaming except for Philip's older sister Sarah. The brave girl ran towards the bull flailing her arms. The poor bull was more scared of us than we were of it. We were relieved to witness the ox leave so quickly. When we finally arrived at our listening sight, we all helped to set up our equipment. Philip Vincent recorded our introduction. We all took turns marking time, listening to and observing the radio waves, and recording our data. We heard mostly spherics, although we were hoping for whistlers. Our INSPIRE team, the "Thundering Rams", recorded data for two intervals of twelve minutes. As we sat to eat donuts and drink orange juice, we smiled as we recalled the fun we had building the receiver. We just couldn't wait to help the new INSPIRE team next year.

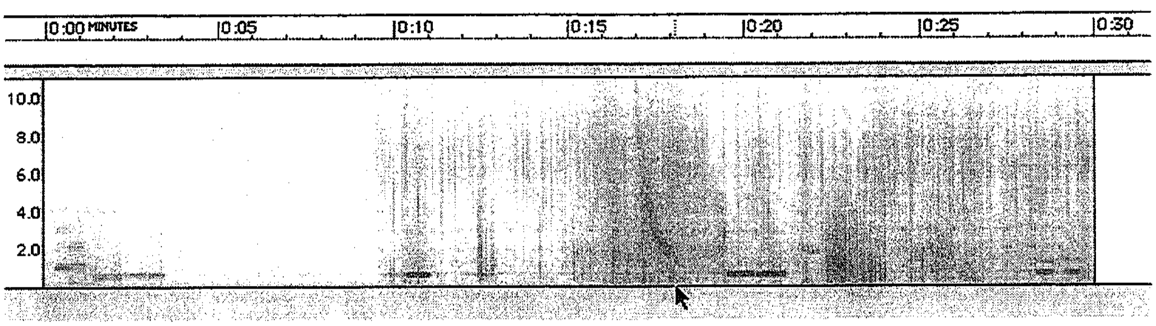
In Las Cruces, New Mexico, Team I-3, Robert Bennett was hearing quite a bit of activity.



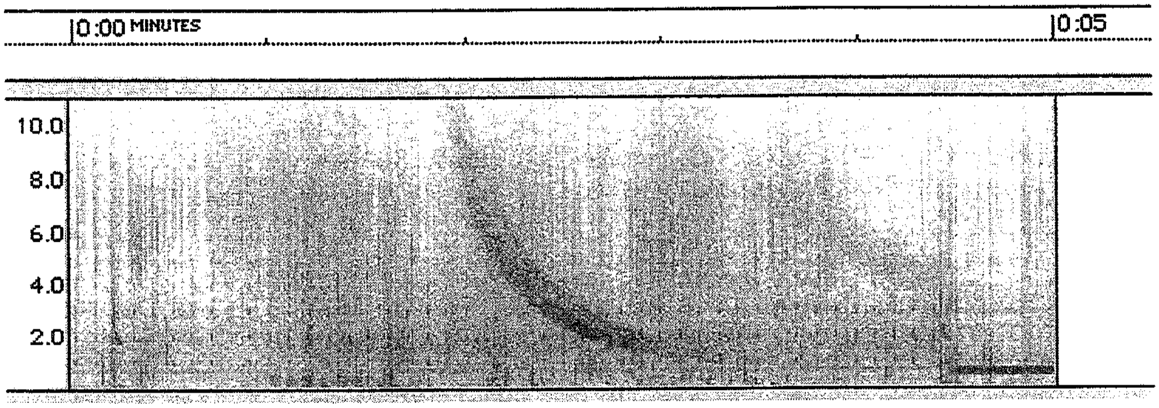
There are some intermittent tones of unknown origin below 1 kHz. LORAN is present. Virtually no power line hum audible. Strong whistlers. Another example of outstanding natural radio data, Robert!



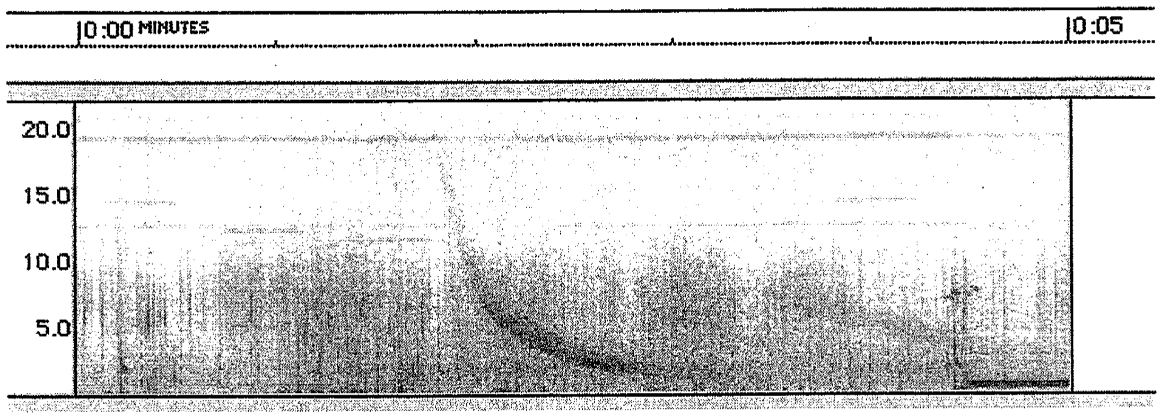
The arrow points to a whistler in the first 30 seconds.



Same whistler.



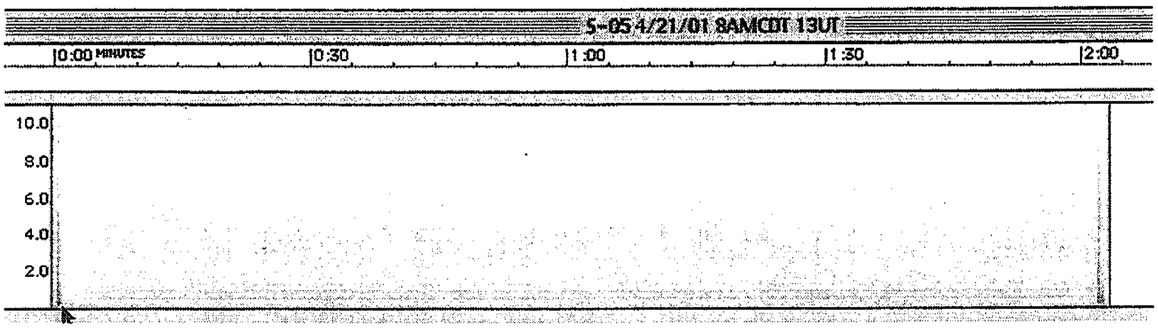
Closeup of the whistler and its echo.



I decided to increase the frequency range to 22.05 kHz to see what the top of the whistler looks like. ALPHA tones are visible (but not audible to these old ears!) and what is probably a communication signal below 20 kHz. The whistler starts at about 18 kHz.

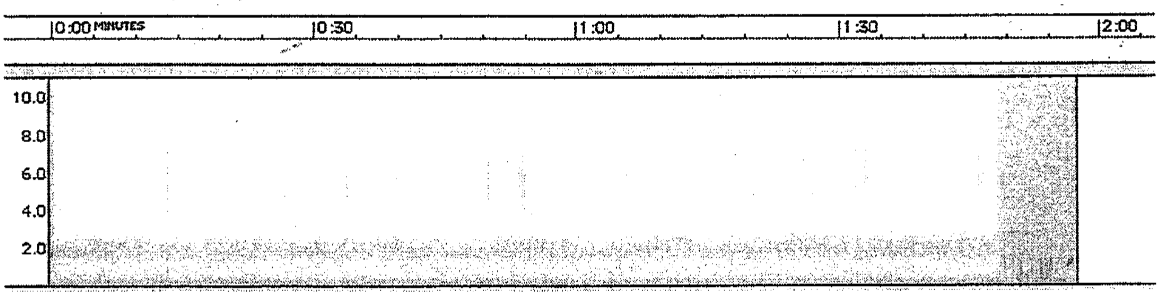
4/21/01 1300 UT

Jim Hoback of John Jay High School in San Antonio, Texas, and his students observed on April 21. The session was plagued by the constant presence of a strong commercial radio station. I have heard intermittent signals from commercial stations occasionally on tapes submitted by observers, but never this strong or continuous. The techniques of this team were good, but the result, unfortunately, was no natural radio.

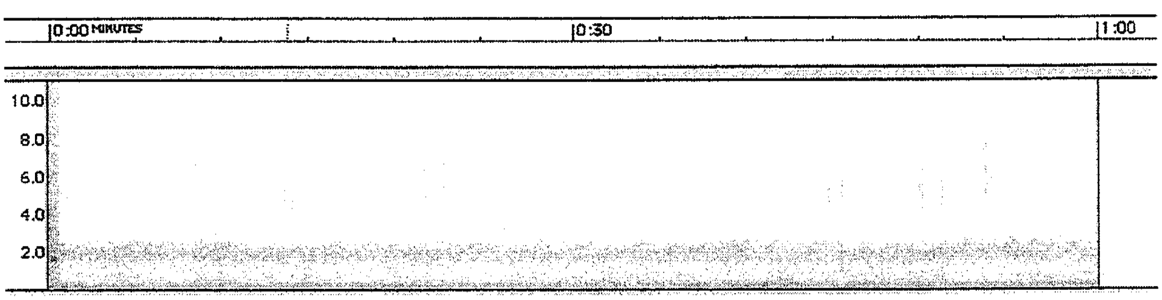


The arrow points to a voice print of the time mark "8 AM". A similar mark at "8:02" appears at the end of the spectrogram.

Linden Lundback and Brian Cowan in Watrous, Saskatchewan, CANADA, had quiet conditions with some sharp, clear sferics and persistent chorus. Chorus seems to be very common at their latitude.



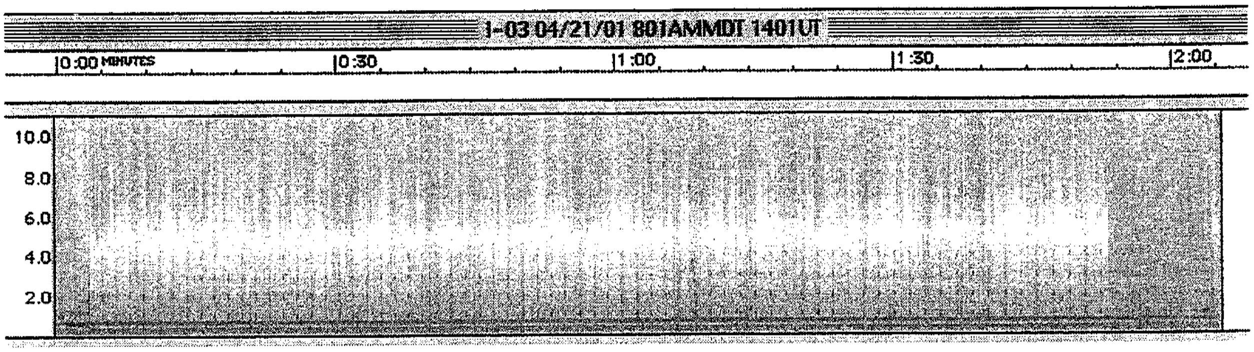
The first two minutes.



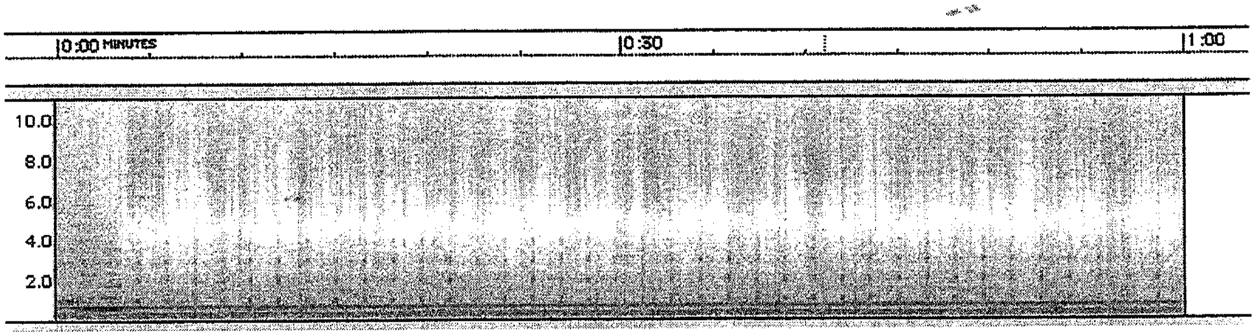
The first minute.

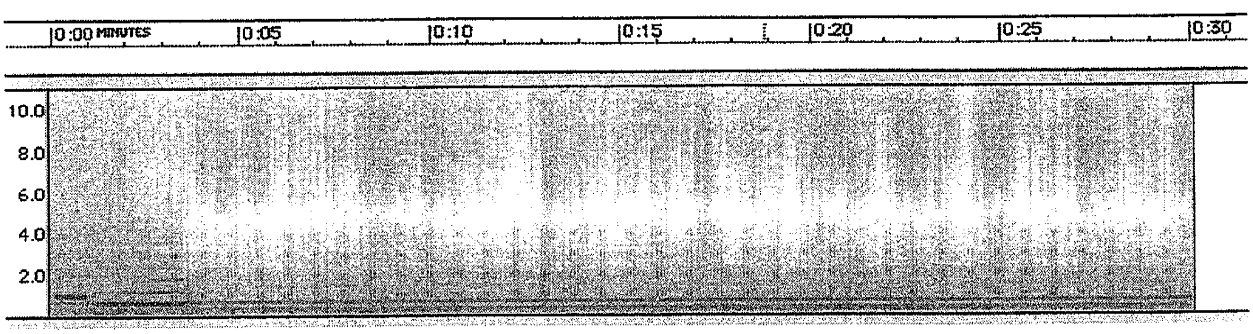
4/21/01 1400 UT

At 1400 UT we return to New Mexico and Robert Bennett. Robert changed to a long wire antenna, so the sensitivity was increased. That resulted in the appearance of a low level hum band at the low frequencies and the appearance of strong sferics. LORAN signals appear on almost all of Robert's data and can be seen as a vertical series of marks occurring at regular intervals of a little less than a second.



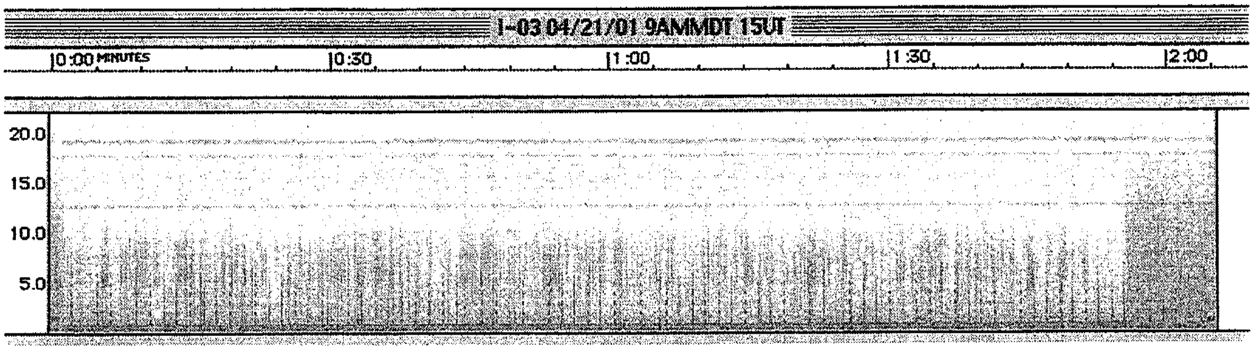
As noted in his log, hum is more pronounced, but still well out of the way of the action.



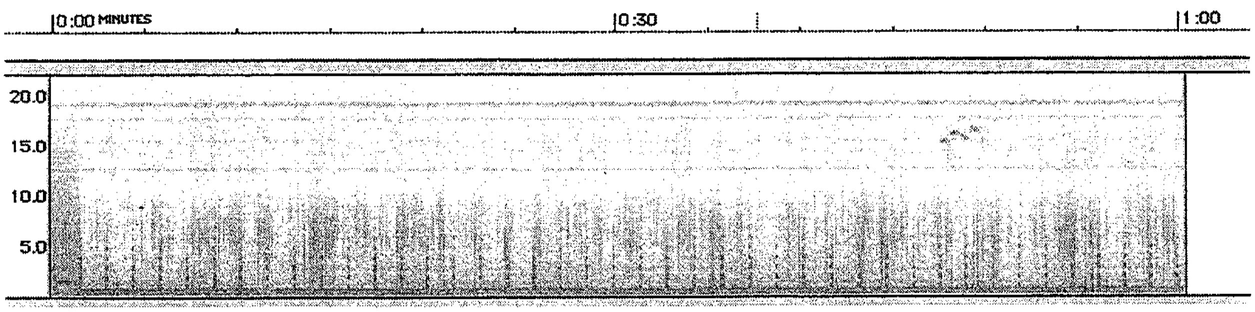


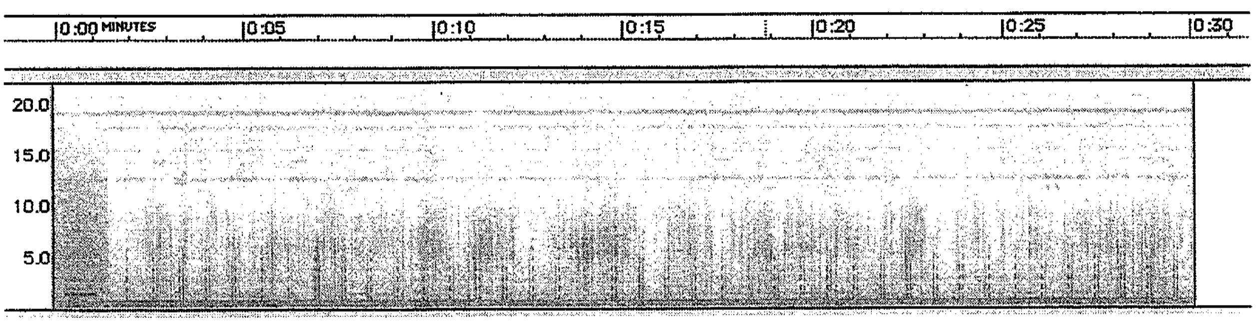
4/21/01 1500 UT

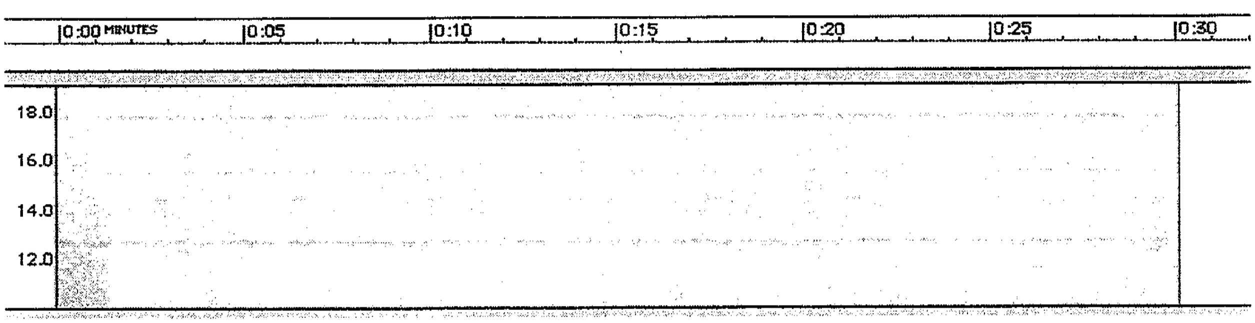
Robert Bennett, Las Cruces, New Mexico.



The full 0-22 kHz frequency range is show to include the Alpha navigation signals between 12 kHz and 15 kHz. A continuous signal just below 20 kHz is also present. A 60 Hz hum band appears at low frequencies.







A close up of the range from 10 kHz – 19 kHz showing ALPHA and the carrier at about 18 kHz